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The Pursuit of Continuous Improvement in Asset Management

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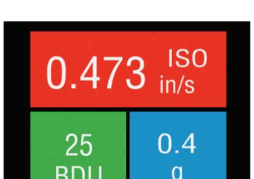
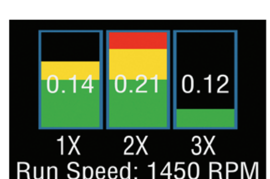
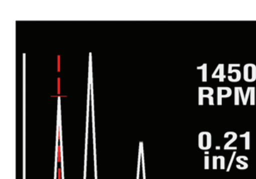


Color coded to ISO alarm levels
› Overall velocity
› Bearing damage
› Acceleration



Diagnose
› Unbalance
› Looseness
› Misalignment



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ISO 55000: Asset Management System	Operations Managers, Maintenance Managers, Reliability Engineers, Capital Project Engineers, Asset Owners, Asset Managers, Organizational Development, Quality Personnel	See examples of asset management strategies, learn the asset management policy components, and develop a draft policy for your organization.	Apr 5-6, 2016 (CHS) Oct 4-5, 2016 (CHS)	2 consecutive days 1.4 CEUs	$1,495
Maintenance Planning and Scheduling	Planner/Schedulers, Maintenance Supervisors, Maintenance Managers, Operations Coordinators, Storeroom Managers and Purchasing Managers	Apply preventive and predictive maintenance practices. Calculate work measurement. Schedule and coordinate work. Handle common maintenance problems, delays and inefficiencies.	Feb 22-26, 2016 (CHS) Apr 18-22, 2016 (CHS) Jul 25-29, 2016 (CHS) Sep 12-16, 2016 (CHS) Nov 14-18, 2016 (CHS)	5 consecutive days 3.2 CEUs	$2,495
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Materials Management	Materials Managers, Storeroom Managers, Planner/Schedulers, Maintenance Managers and Operations Managers	Apply sound storeroom operations principles. Manage inventory to optimize investment. Understand the role of purchasing. Implement effective work control processes.	Jul 19-21 2016 (CHS)	3 consecutive days 2.1 CEUs	$1,495
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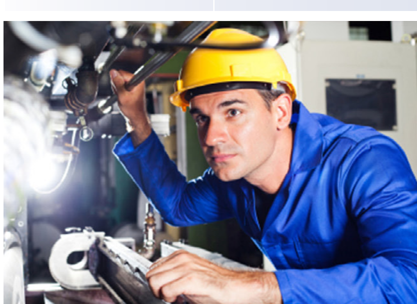
Reliability Excellence for Managers	General Managers, Plant Managers, Design Managers, Operations Managers and Maintenance Managers	Build a business case for Reliability Excellence, learn how leadership and culture impact a change initiative and build a plan to strengthen and stabilize the change for reliability.	SESSION 1 DATES: Mar 22-24, 2016 (CHS) Aug 9-11, 2016 (CHS) (Sessions 2-4 dates are available on the website)	12 days total (4, 3-day sessions) 8.4 CEUs	$5,995
Risk-Based Asset Management	Project Engineers, Reliability Engineers, Maintenance Managers, Operations Managers, and Engineering Technicians.	Learn to create a strategy for implementing a successful asset management program. Discover how to reduce risk and achieve the greatest asset utilization at the lowest total cost of ownership.	Jan 26-28, 2016 (OSU) Mar 8-10, 2016 (CU) Jun 14-16, 2016 (KU) Sep 13-15, 2016 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Root Cause Analysis	Anyone responsible for problem solving and process improvement	Establish a culture of continuous improvement and create a proactive environment. Manage and be able to effectively use eight RCA tools to eliminate latent roots and stop recurring failures.	Mar 22-24, 2016 (OSU) Jun 14-16, 2016 (CHS) Aug 16-18, 2016 (CU) Nov 1-3, 2016 (KU)	3 consecutive days 2.1 CEUs	$1,495



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***LOCATION CODES:** (CHS) = Charleston, SC | (CU) = Clemson University in Greenville, SC | (KU) = The University of Kansas | (OSU) = The Ohio State University | (UT) = University of Tennessee

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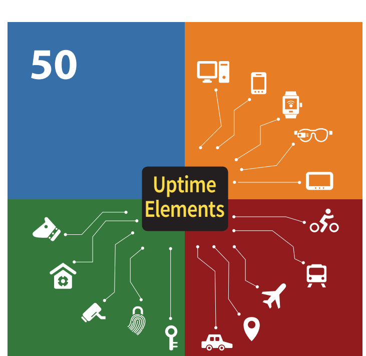

Elements

Editorial

How To Bend The Universe

We have spent that last two months much like we have spent the last two years. The team at Reliabilityweb.com travels to various industrial facilities, user group meetings and conferences to learn, to share and hopefully, to create change. Personally the only reason I want to go anywhere is to collaborate with people to bring something new forward – something new that we create out of work together.

Some highlights in our efforts to bend the universe in the past 60 days alone include the 5-day Certified Reliability Leader event in Fort Myers, Florida; a Honda Alabama manufacturing plant visit; a LUDECA sales meeting in Miami; the SDT global meeting in Mons Belgium; IBM Insight (Big Data and IoT); Lakeside Controls User Exchange; The IoT World Congress in Barcelona; Minds + Machines 2015 by GE; the Emerson Exchange; SMRP's Annual Meeting; The Caribbean World Reliability Conference; Bentley Systems Year in Infrastructure 2015; The Infrastructure Asset Performance Summit London; the Certified Reliability Leader London meeting; the Dubai Airshow; and finally, the 3 day Certified Reliability Leader workshop in Dubai. (Can you say Frequent Flier Miles?)

Another way we are bending the universe is by creating nothing short of a leadership revolution at headquarters in Fort Myers with a reorganization to eliminate the world's smallest bureaucracy to a flatter holocratic model of empowered self-leadership at Reliabilityweb.com. I have always lived by the Japanese koan, "You work for me – I work for you!" The team is best I have ever been on and I am grateful and thankful for this opportunity to lead this special group of people.

OK time out O'Hanlon. Bending the universe? Seriously?

Yes, that is the term I like to use for calling forth something that previously did not exist, creating something new – like a new future, a new way to move through each day, a new way to create results.

I have come to realize that even though for years I had some strongly held beliefs and I thought some really deep thoughts. The fact is that my beliefs and thoughts did not change anything. The universe is 100% ambivalent to what I think and what I believe. Nothing will change as a result of your thoughts or beliefs no matter how pure they are.

If you doubt what I am saying – I suggest you go outside on the next clear evening and look up at the stars and let them know what you think and what you believe. Let me know what changes results the next day from your deeply held beliefs and incredibly brilliant thoughts.

My point is that the universe will only bend – will only allow change – will only allow something new to be called forth from committed action.

Mahatma Gandhi said, "Be the change you wish to see in the world," and I offer a few steps in that direction.

1) Take a stand for something (like reliability).
2) Find others who may share that stand and create a declaration (for reliability).
3) Follow that declaration with committed action.
4) Practice integrity. Keep your word and do what you say you will do.
5) Restore your integrity by cleaning up the mess you make at the earliest possibility when you do not keep your word.
6) Align stakeholders on the destination.
7) Lead by engaging, empowering and enlightening stakeholders.

If you want to know why Reliabilityweb.com is able to attract the best companies, the best thought-leaders, the best solution-providers, the best speakers, the best session chairs and the best conference team in the entire world to the 30th International Maintenance Conference, take a look at all the dents in the universe that have been created from the first 30 years of this global reliability phenomenon. People, at least those with common sense, know the difference between the real deal and the derivative and IMC-2015 is the real deal.

In 2016 we are committed to creating new ways to act that make life better for our families, our companies, our communities and the world.

How will you bend the universe in 2016?

Warmest regards,

Terrence O'Hanlon, CMRP
CEO and Publisher
Uptime Magazine
www.uptimemagazine.com

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RELIABILITY® IN THE NEWS

Jim Nyquist, *Emerson*; Eyad Al-Basrawi, *Saudi Aramco*; Ibrahim Naimi, *Saudi Aramco*; Ron Martin, *Emerson*

Emerson Reliability Program Awards

Saudi Aramco Ras Tanura Refinery in Saudi Arabia has won the 2015 Emerson Reliability Program of the Year award. They were one of four finalists that presented reliability programs to conference attendees and a panel of judges including our own CEO, Terrence O'Hanlon, at the Emerson Global User Exchange in Denver, Colorado. Saudi Aramco's reliability program helped reduce rotating equipment maintenance and failures and eliminated 50,000 man-hours of preventative maintenance activities. Also nominated for the award were CMC Steel in South Carolina, Corbion in Nebraska, and Exelon in Illinois.

To learn more, visit: www.uptime4.me/SAramco

Bentley's Be Inspired Awards

The Year in Infrastructure Conference is a global gathering of leading executives in the world of infrastructure design, construction, and operations. One notable aspect of the conference each year is the Be Inspired Awards. These awards honor the extraordinary work of Bentley users improving the world's infrastructure. This year, SA Water won the Innovation in Asset Performance Management award for the Predictive and Operational Analytics Tools, Adelaide Metro Water Distribution Network. Ten independent panels of jurors, comprised of distinguished industry experts including Uptime Publisher, Terrence O'Hanlon, who selected the winners from 54 project finalists.

Sandra DiMatteo, *Bentley Systems;* Rowan Steele, *SA Water;* Alan Kiraly, *Bentley Systems*

To learn more, visit: www.uptime4.me/SAWater

Upcoming Certified Reliability Leader Events

December 7-11, 2015
IMC-2015 Conference
CRL Workshop and Exam
Bonita Springs, FL

February 15-19, 2016
Uptime Elements
CRL Workshop and Exam
Fort Myers, FL

February 23, 2016
MARCON
CRL Workshop and Exam
Knoxville, TN

April 11-15, 2016
The RELIABILITY Conference
CRL Workshop and Exam
Las Vegas, NV

May 9-13, 2016
Uptime Elements
CRL Workshop and Exam
Fort Myers, FL

June 20-24, 2016
Uptime Elements
CRL Workshop and Exam
Fort Myers, FL

September 12-16, 2016
Uptime Elements
CRL Workshop and Exam
Fort Myers, FL

October 10-14, 2016
Uptime Elements
CRL Workshop and Exam
Fort Myers, FL

JUST ANNOUNCED! SDT LUDECA

SDT is thrilled to announce the appointment of LUDECA as exclusive distributor for their portable and online ultrasound condition monitoring technologies in the United States.

See www.reliabilityweb.com for full details.

The Certified Reliability Leader New Places, New Faces!

The team at Reliablityweb.com and the Association of Asset Management Professionals took the CRL workshop and exam around the world, and we welcome all new Certified Reliability Leaders.

Uptime Elements CRL Workshop

Fort Myers, Florida • London, England • Dubai, UAE

Xcelerate Conference

Bonita Springs, Florida

London, England

Congratulations to the newest CERTIFIED RELIABILITY LEADERS!

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CSM Bakery Solutions
Saleh Al-Khammas
SABIC
Nelson Alves
Bristol Myers Squibb Company
James Aymond
Weyerhaeuser
Warren Behlau
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Cindy Biegley
Bristol Myers Squibb Company
Robert Bober
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Steven Carden
Southern Company
Randy Carithers
Olin
Michelle Caruso
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Ramón Cátala
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Boeing
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Raul Fernandez
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Amy French
Barrick Golden Sunlight Mine
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Luminant Kosse Mine
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SRP/Navajo Generating Station

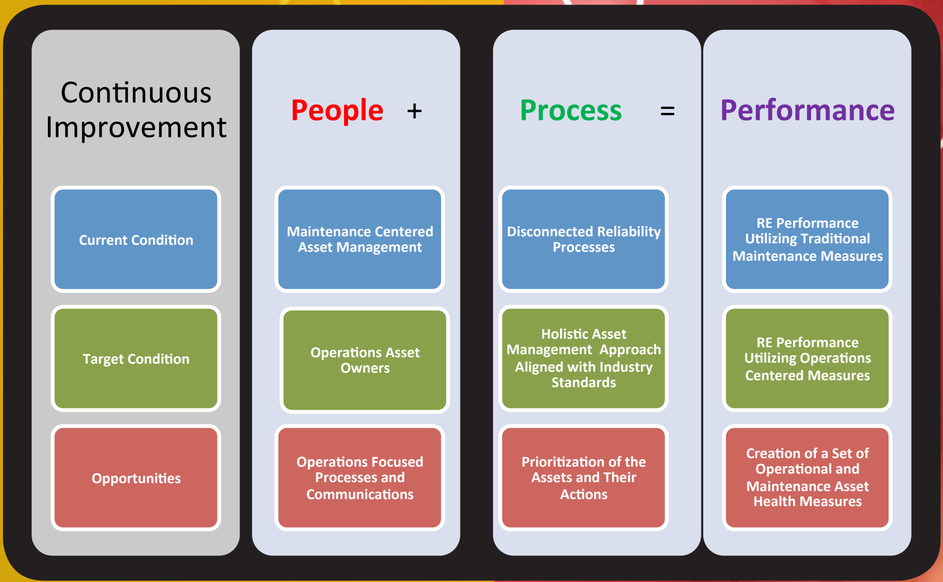
CONGRATULATIONS

The Pursuit of Continuous Improvement in Asset Management

by Mike Rose and Chris Gould

As an organization, Merck & Co., Inc.'s core values are driven by a desire to improve human life, achieve scientific excellence, operate with the highest standards of integrity, expand access to its products and employ a diverse workforce that values collaboration. To support these values, Merck & Co., Inc. strives to deliver strong operational performance supported by cost-effective asset utilization over the entire asset's lifecycle. Merck & Co., Inc., in West Point, Pennsylvania, is a multi-divisional, 397-acre site that produces a diversified portfolio of vaccines and sterile products. As such, asset management is critical to successful, sustainable performance.

In 2010, Merck & Co., Inc.'s West Point facility re-established a strategic focus on reliability engineering by re-chartering the department and installing a senior leader. A simple framework was established utilizing a continuous improvement methodology integrated with a people, process and performance model. The figure to the right shows how the framework functions at a high level to identify areas for improvement and what levers would be pulled in the people and process space in order to achieve the desired performance.



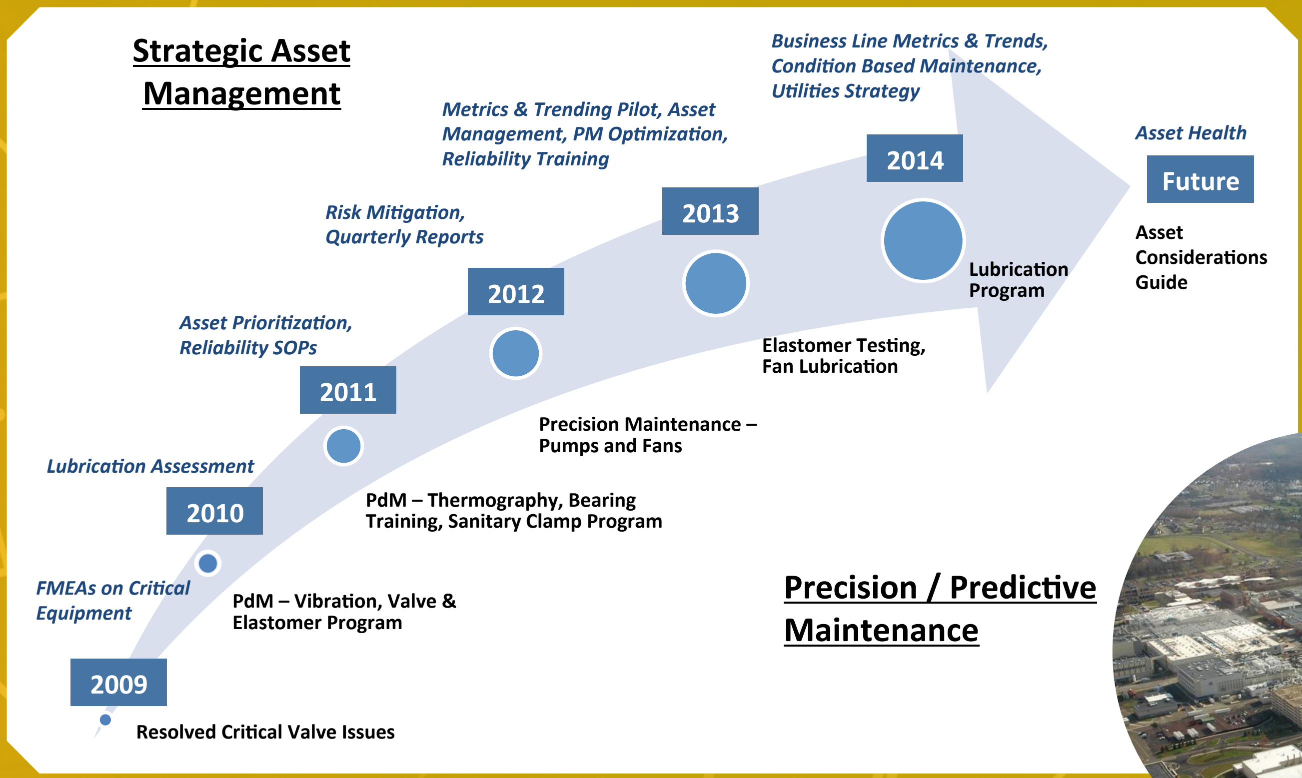
Merck & Co., Inc., West Point's Journey

The Approach

This article presents Merck & Co., Inc.'s, West Point journey in implementing an asset management and reliability strategy, including initiatives in various stages of completion. It is important to note that at the beginning of the journey, the initiatives were performed in reaction to specific events or immediate needs. However, as time progressed, the thought process evolved into supporting a proactive, holistic vision of reliability and, ultimately, asset management.

These initiatives support management of its physical asset portfolio throughout the lifecycle and are in alignment with Merck & Co., Inc.'s goal of assuring supply targets are met with the highest degree of regulatory compliance:

1. **Prioritization** of assets was performed based on their failure probability, coupled with their impact to compliance, supply, strategy and budget.
2. **Risk control strategies** were developed to mitigate or eliminate identified risk, considering continuity, redundancy and contingency.
3. **Predictive maintenance** technology use was expanded to identify risks prior to failure.
4. **Precision maintenance** programs were standardized to help assure lean, "right the first time" execution.
5. **Utility strategies** were developed whereby target conditions were established, gaps assessed and improvements prioritized.
6. **Asset health** was determined by comparing actual key indicators to targets and addressing gaps.
7. **Asset management playbook** was created and adopted, in line with ISO55000, to guide the site's overall asset management plan.
8. **Metrics, trending and reporting** processes were developed to reflect the new initiatives, drive continuous improvement and confirm results.



Prioritization

Prioritization is the foundational methodology that West Point deploys to establish equipment criticality. This process was developed using a continuous improvement methodology that would be implemented during facilitation.

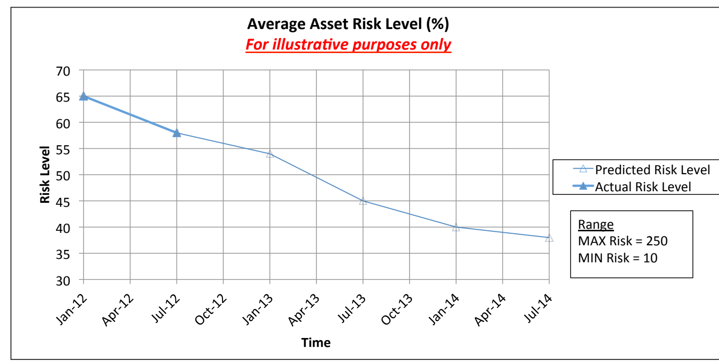
A criterion was established by a team comprised of operations and reliability engineering personnel. The criterion considered the impact to the value stream by determining failure probability and evaluating the risk of a failure to Merck & Co., Inc.'s four priorities: compliance, supply, strategy and budget. This criterion was then used to create a risk matrix to prioritize assets and actions within the lines of business.

Prioritization is a team-based initiative, whereby members from operations, technology, maintenance and reliability evaluate assets using a structured process. The team evaluates each asset as follows:

1. Identify issues or improvements based on downtime, deviations and corrective maintenance.
2. Determine actions to address issues or improvements, including risk control strategies.
3. Prioritize assets according to the specified criteria.

Continuity, redundancy and contingency are considered part of this activity. A single point accountable person and due dates are assigned to each action. Complex actions are given tracking numbers to be vetted through the portfolio and capital planning processes to track and update through implementation. Operations risk profiles are then developed and communicated.

The prioritization process is updated annually, but the status of actions is monitored quarterly to understand and communicate progress.



Impact Assessment						
Failure Probability	Probability of equipment having a failure based upon historical events. [NOTE: Failure = Inability to perform designed function]					
Compliance	If asset fails, impact on GMP compliance, product quality, environmental compliance, personnel safety.					
Supply	If asset fails, impact on the ability to meet supply requirements, considering product impact, discards and/or critical path production time lost.					
Strategy	Determination of Asset Obsolescence					
Budget	If asset fails, impact to Profit Plan considering cost impact of a failure (e.g. discards or lost transfers) and savings benefits due to improvements.					
Impact Scores						
	Failure Probability [% per lot / run]	**Compliance [Impact of a single failure]**	**Supply [Impact of a single failure]**	**Strategy**	**Budget [Impact of a single failure]**	
Multiplication Factor	**N/A**	**4**	**3**	**2**	**1**	
1	Insignificant	None	None	Not Obsolete	None	
2	≤ LOW	≤ LOW	≤ LOW		≤ LOW	
3	LOW < Failure Rate ≤ MEDIUM	LOW < Impact ≤ MEDIUM	LOW < Impact ≤ MEDIUM	Obsolete in 5 years	LOW < Impact ≤ MEDIUM	
4	MEDIUM < Failure Rate ≤ HIGH	MEDIUM < Impact ≤ HIGH	MEDIUM < Impact ≤ HIGH		MEDIUM < Impact ≤ HIGH	
5	> HIGH	> HIGH	> HIGH	Obsolete	> HIGH	
Risk Level						
Failure Probability x [Compliance x 4 + Supply x 3 + Strategy x 2 + Profit Plan x 1]						
	Total Score		**Risk Level**			
	Min	***Max***	***Symbol***	***Description***		
	10	**99**	**L**	**Low**		
	100	**129**	**M**	**Medium**		
	130	**250**	**H**	**High**		
For illustrative purposes only. Criteria actually more granular.						

People +	Process =	Performance
Team-based collaboration resulted in a true picture of the health of each asset.	**Prioritization criteria and the evaluation process were standardized across the site.**	**Better understanding of each asset's criticality to the business and the urgency to address asset issues.** **Reduction in asset overall risk.**

Risk Control Strategies

A risk control strategy is a means to understand asset risks and then develop actions to mitigate those risks. Risk control strategies were developed from information derived from failure mode and effects analysis (FMEA) and simplified maintenance reviews (SMR). FMEA is a team-based, structured way of assessing risk through identification of failure modes and reducing the chance of failures through development of actions to control the risk, such as preventive maintenance (PM) activities. The FMEA process is based on the International Electrotechnical Commission's IEC 60812: Analysis techniques for system reliability – Procedure for failure mode and effects analysis. The SMR was developed internally and is a team-based, structured way of creating a risk control strategy based on a review of vendor recommendations and asset history.

Both contain the following:

1. Gap analysis;
2. Maintenance strategy;
3. Preventive maintenance and job plans;
4. Replacement spare part identification;
5. Spare parts availability.

FMEAs have been completed, with actions implemented for many key assets, including autoclaves, controlled temperature units (CTUs) and inspection machines. SMRs have been completed on numerous processing skids. FMEAs or SMRs are now developed when identified through the prioritization process.

People +

Team-based collaboration resulted in a true picture of the health of each asset.

Process =

FMEA and SMR procedures were developed to standardize and document the analytical techniques.

Performance

FMEAs and SMRs have been completed and utilized to identify/ mitigate failure modes.

Predictive Maintenance

The predictive maintenance (PdM) program was initiated and currently consists of vibration analysis and thermography. Over 1,000 assets are currently contained in a vibration route and over 3,000 assets are covered by thermography. The predictive maintenance faults are categorized as extreme, serious, moderate, or slight. These categories are tied to the National Electrical Testing Association's (NETA's) maintenance testing specifications for thermography and to the Naval Sea Systems Command's (NAVSEA's) technical specification S9073-AX-SPN-010/MVA for vibration. These categories then define the urgency of the actions needed to correct the faults. All corrective actions resulting from the PdM program are entered and tracked within the work order system or computerized maintenance management system (CMMS). The action status is tracked closely with overdue repairs discussed weekly at the maintenance tier and communicated at the operations tier meeting.

3Q 2014 VIBRATION Failed Scan Status

Areas of Business	Total	Extreme	Serious	Moderate	Slight	Extreme & Serious Repairs Overdue
A	321	0	4	25	64	0
B	201	0	3	16	39	0
C	66	0	0	9	21	0
D	41	0	3	2	12	0
E	141	0	6	5	42	0
F	268	0	0	17	38	0
TOTALS	1038	0	16	74	216	0

For illustrative purposes only.

People +

Faults are communicated to maintenance. Results are discussed weekly at maintenance tier and quarterly at the operations tier meeting. Fault status is published in the quarterly report.

Process =

A systematic, standardized procedure has been developed. Threshold criteria determine the timeliness for corrective action.

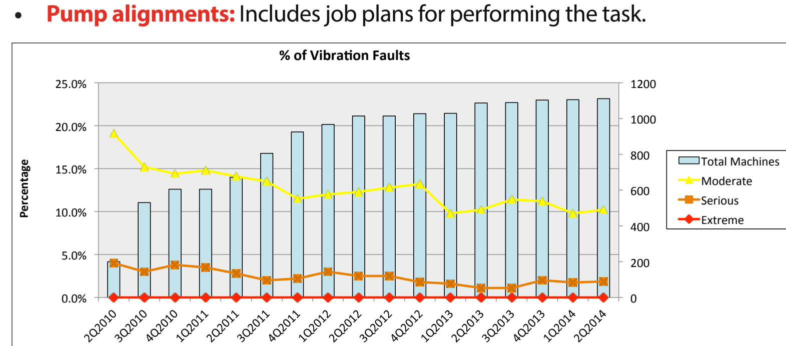
Performance

The PdM program has been adopted site-wide. There has been a reduction of failures, as well as extreme and serious faults.

Precision Maintenance

Predictive technology results, in conjunction with input from mechanics, indicated that although maintenance was adequately performed, there was an opportunity to optimize certain programs. As a result, based on potential impacts to compliance and supply, the following core maintenance programs were standardized, proceduralized and systematically rolled out with training and/or communications:

- **Lubrication:** Includes types, quantities, frequencies and technology by equipment.
- **Fan maintenance:** Includes belt and sheave alignments and shaft runout. This has been shown to significantly reduce fan performance issues.
- **Elastomers:** Includes specific preventative maintenance and single use requirements.
- **Valves:** Includes rebuild requirements, preventive maintenance, post maintenance testing and parts listings.
- **Sanitary clamps:** Includes material requirements, installation and assembly criteria.
- **Pump alignments:** Includes job plans for performing the task.



For illustrative purposes only.

People +

Significant change management was performed, including obtaining input from mechanics, live training, lunch and learns, and field observations.

Process =

Each initiative has been standardized and documented via procedure.

Performance

Reduced number of equipment issues results in increased asset availability. For instance, the vibration fault chart indicates the reduction in vibration faults.

Utility Strategies

A utility strategy was developed to understand utility risk and opportunity to the process and, ultimately, to product compliance, supply and budget. Continuity, redundancy, contingency and impact minimization criteria were developed and each utility in each building was assessed against this criteria. Gaps were determined and actions to close gaps were identified, planned and are in various stages of implementation.

Using electrical reliability as an illustration, examples of scoring criteria include:

- **Continuity:** UPS systems for critical controls/monitoring;
- **Redundancy:** Double ended substations with automatic transfer;
- **Impact minimization:** Medium voltage cascaded substations;
- **Contingency:** Electrical contingency procedures.

For illustrative purposes only.

	ELECTRICAL	CHILLED WATER	PLANT STEAM	GLYCOL	POTABLE WATER	COMPRESSED AIR	WATER FOR INJECTION	HVAC BAS
CONTINUITY	3.71	3.71	4.00	4.00	3.89	4.00	4.00	3.72
REDUNDANCY	4.00	4.00	4.00	3.25	3.88	4.00	3.67	4.00
MINIMIZE IMPACT	3.36	4.00	4.00	2.81	4.00	4.00	4.00	3.83
CONTINGENCY	3.32	2.29	4.00	4.00	4.00	4.00	3.69	3.74

Score	Risk
<2	High
2 to 3.99	Medium
4	Low

People +	Process =	Performance
The process has been rolled out to senior leadership and now adopted site-wide.	A utility strategy with defined threshold criteria for each level of risk has been developed and will be documented in a playbook.	This process has been used to identify areas of high risk and to take actions to mitigate this risk.

Asset Health

Asset health determination is the site's method of pulling all pertinent information together to understand the health of an asset in relationship to specific targets. These targets were developed in alignment with the division's four priorities. The optimal asset performs within the targets.

For illustrative purposes only.

Priority	Attribute	Ranking Legend		
		Undesirable	Marginal	Acceptable
Supply	Uptime *	<80%	80-89%	90-100%
Compliance	Equipment Deviations	3 or more	1 to 2	0
Strategy	Risk Prioritization Failure Probability	5	4	1 to 3
Compliance	Corrective Maintenace Count	Top 20 Count on site	21-100 Count on site	Not in Top 100 Count on site
Budget	Work Order Man-Hours	Top 20 Count on site	21-100 Count on site	Not in Top 100 Count on site

***Note**: Uptime = Asset availabile when needed for operation.

People +	Process =	Performance
This process has been rolled out to site leadership, and each business line via face-to-face communications.	The process has been standardized, with targets developed in alignment with the division's four priorities.	This process is used to discuss asset performance with each business line and to take actions as needed.

The focus on **people, process and performance** was essential to successful implementation of each initiative and the reliability program

Asset Management Playbook

As the risk-based asset management strategy matured, an overall asset management playbook was created to support the site's five- and 10-year strategic plan and business objectives. This asset management playbook, based on the British Standards Institution's Publicly Available Specification 55 and the draft copy of ISO55001 – Asset management standards, is expected to provide positive business impact. The asset management playbook is organized with each element fully defined with acceptance criteria.

The elements are being addressed as part of the journey, but in various stages of completion. Reliability is far along the journey, but as with all elements, will be continuously improving.

Asset Support
- System Support
- Asset Lifecycle Management
- Capital Management
- Organization Design
- Connection with External Groups

Asset Operation
- Communication
- Work Execution
- Configuration Management
- Compliance
- Maintenance

Asset Utilization & Performance
- Planning & Scheduling
- Subject Matter Expertise

Asset Improvement
- Continuous Improvement
- Reliability

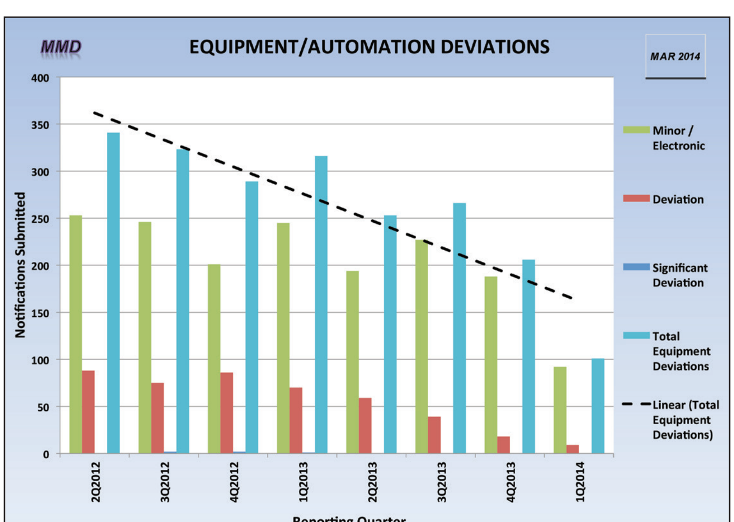
People +	Process =	Performance
Asset management has been communicated and endorsed by the site.	A comprehensive asset management playbook has been developed with evaluation criteria to provide a high level road map.	TBD: In process of being implemented.

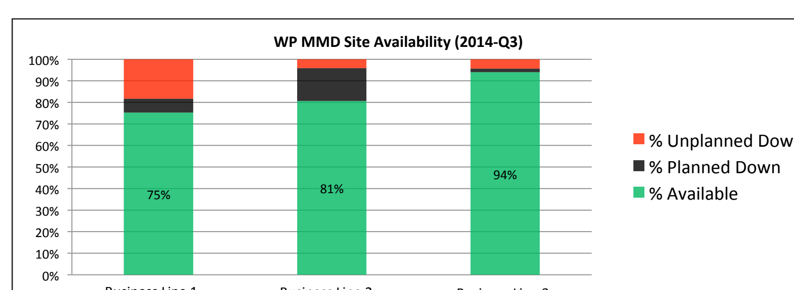
Metrics, Trending and Reporting

Metrics, trending and reporting are actually the tools to tie **people, process and performance** together. The entire purpose of the metrics, trending and reporting process is to be able to communicate progress in a clear, concise and structured manner. The reliability report is presented via e-mail and face-to-face on a quarterly basis. This report has become a key component of the reliability program by providing a tailored report for each line of business (four at the site) and a roll up of the entire site. It includes:

- Prioritization results, including action status;
- Predictive maintenance results (thermography and vibration);
- Availability of key assets;
- Metrics on assets, including man-hours spent, deviations, corrective maintenance, etc.;
- Utility strategies;
- Trends of asset risk, deviations, manpower spent;
- Reliability metrics.

This process is being implemented site-wide.

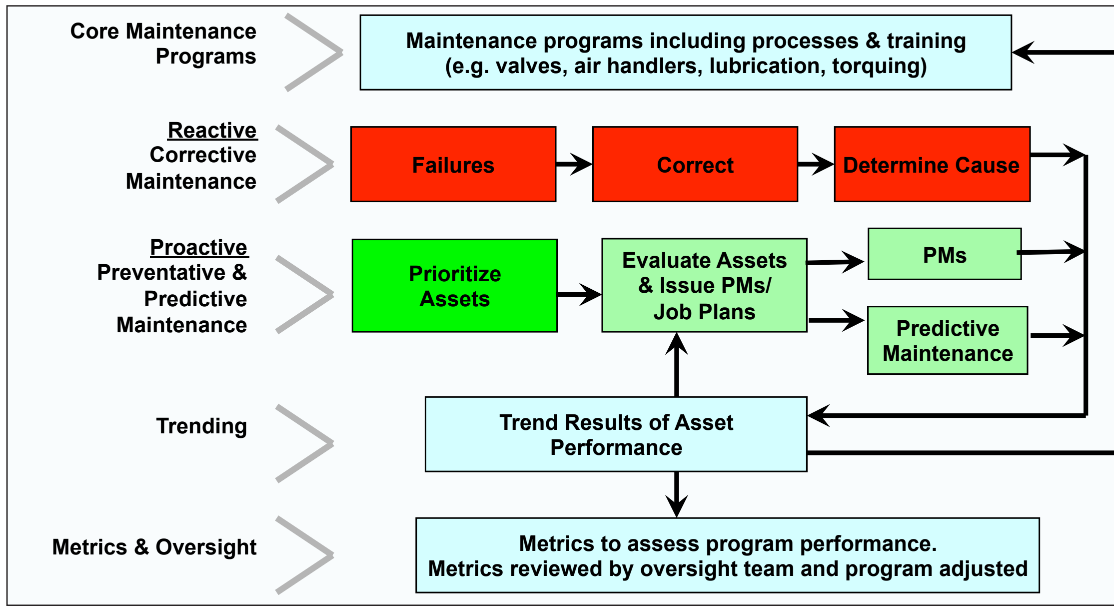




For illustrative purposes only.

People +	Process =	Performance
Communicate progress in a clear, concise and structured manner.	Reliability report is presented via e-mail and face-to-face on a quarterly basis.	This process is being implemented site-wide.

Conclusion and Takeaways



The focus on **people, process and performance** was essential to successful implementation of each initiative and the reliability program in general.

- **People:** Don't underestimate the people component of any initiative. The best of processes will not succeed without proper buy-in.

  Change Management: This is of the highest priority, therefore, a simple plan, a simple model and continual communication in the language of the audience is critical.

  For instance, an initial step to assist change management was to create a simple model to visualize and communicate the actions needed to evolve from a reactive to a proactive culture. This model helped communicate that there was a "bigger picture" and the initiative was part of the plan. Ultimately, this model was incorporated into an even bigger picture – asset management.

  Operations Involvement: All proactive enhancements in the area of reliability and asset management would not be possible without a strong partnership with operations (the asset owners). These employees recognize the importance of strong asset management programs and understand it is their role to endorse/sponsor the path forward.

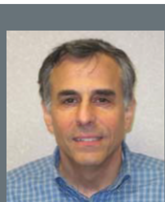
  Mechanic Engagement: Input from mechanics/technicians is valued. They truly understand the condition of the asset. Their active involvement is crucial to the health of the equipment and sustaining asset performance.

- **Process:** All initiatives need to be well documented, clear and concise, with standardized practices. Each initiative should have a method of measuring success of the implementation and its effect on the end game, which is improved compliance and supply.

- **Performance:** In order to determine if Merck & Co., Inc., is on the right track of its journey, the areas of deviations, transfers to inventory, proactive maintenance and total maintenance man-hours are evaluated for their performance over time. The three high impact areas all had similar results: (1) Reduced equipment/automation related deviations, (2) Increased transfers, and (3) Improved ratio of preventive versus corrective maintenance. As expected, maintenance manpower was lagging. In two of three cases, maintenance manpower decreased, but in one case, manpower had increased slightly. This assessment provided three data points, but also substantiated the need for robust metrics.

In conclusion, continuing to mature the asset management program at West Point and leveraging action oriented, risk-based asset management methodology will enable a culture to realize the benefits of improved asset health, including:

- Reliable supply;
- Greater utilization of installed capacity;
- Greater personal and environmental safety performance;
- Lower energy costs;
- Reduced deviations, providing improved current good manufacturing practices (cGMP) compliance.



***Mike Rose** is an Associate Director - Engineering at Merck's Manufacturing Division (MMD), West Point Facility. He is responsible for the development and execution of the site's Reliability Centered Maintenance (RCM) program and supervises a team responsible for the site's asset management and risk mitigation program. www.merck.com*

***Chris Gould** is an Executive Director at Merck's Manufacturing Division (MMD), West Point Facility. Chris and his team are responsible for the site's reliability and capital programs as well as engineering and project support for critical GMP utility systems. They are also facilitating the site's transformation to a proactive asset management program tied to the asset's life cycle. www.merck.com*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Reliability Engineering for Maintenance

RPM Method + RCM = Reliability

by Fred J. Weber

Picture this: It's Monday morning and you're the maintenance manager of an industrial plant. On your desk is a printout of 432 open work orders and the operations manager is screaming because air compressor #2 just tripped for the third time this month. To make matters worse, you just remembered two of your technicians went fishing for the week. The question is: "What can this maintenance manager do to improve this situation?" The obvious answer is to go fishing with the two technicians. Maybe a better question to ask is: "What can be done to improve plant performance?"

Do the math: RPM method + RCM = Reliability.

The RPM method and RCM are two proven reliability techniques to improve plant performance. Reliability centered maintenance (RCM) is a structured methodology developed to review the design, operation and maintenance of a system and associated equipment. This technique is used to locate known and unknown failures jeopardizing the safety and reliability of a system. The basic procedure uses seven questions to identify the equipment's function, failures, consequences of failure and tasks to prevent failures. The answers to the questions are generated by the feedback of operators, maintenance personnel, plant engineers, equipment design engineers, or other end users of the equipment. Although this process may be considered time-consuming by some people in industry, the benefits would always outweigh the time spent. The process forces you to dig down deep into every aspect of the equipment and find the hidden failure that could jeopardize the plant's safety and equipment reliability.

On the other hand, the RPM method is a work priority system that grew out of personal frustration with many of the existing work priority systems. Make no mistake, there are countless other work priority systems. There is the famous first in, first out (FIFO), or the 20 code priority system, so complicated that a special decoder ring is required to decipher it! And finally, the familiar HWSL method that most companies use. Not familiar with HWSL? Sure you are, it stands for "he who screams loudest!"

A work priority system is required to prioritize work and get everybody on the same page. The RPM method is based on the actual definition of the word maintenance in the dictionary, which is *to maintain; to repair or preserve*. But anyone working in maintenance today knows the real definition of maintenance as "any work that no one else wants to do!" Simply put, RPM stands for repair, preventive and modify.

"R" (Repair) – Classified as any work required to place an **existing** piece of equipment into its original operating condition while meeting all safety and environmental requirements. Examples of repair work may include a leaking valve, a knocking pump, or a conveyor that won't start.

"P" (Preventive) – Considered the minimum amount of work needed to keep equipment safe, reliable and environmentally friendly. Examples of preventive work include adjusting a setting, monitoring vibration, lubricating a pump, or calibrating a transmitter. Preventive/predictive work should be a scheduled and/or defined task by the equipment manufacturer, maintenance personnel, or engineering designed to keep the equipment running safe.

"M" (Modify) – Any task loosely considered non-maintenance. Examples include installing a new welding machine in the shop or redesigning an existing service water piping system. Quite simply, if it's not an "R" or "P" type work order, it must be an "M."

Now that you know what RPM stands for, how do you apply it? It can be as simple as this: Assume you go to work tomorrow morning as usu-

What can be done to IMPROVE plant PERFORMANCE?

al. First, locate five boxes, labeling them New, "R" (repair), "P" (preventive), "M" (modify) and Closed, shown in Figure 1.

Next, get copies of all your open work orders. Using your knowledge of RPM, classify all your work orders as to whether they are "R," "P," or "M" and place the work orders in the appropriate box. The New box will hold work orders that need a little more information in order to categorize them, while the Closed box will hold work orders that are completed.

So, what box of work orders should maintenance do first? It should be obvious from the definition of maintenance that the "R" and "P" boxes are the priority. But it's not so easy. Maintenance is being pulled in different directions by operations, engineering, purchasing and management. However, the RPM method informs the other departments and management that maintenance's priorities are the repairs and preventive maintenance tasks in the plant.

While the RPM method outlined here is certainly the core of the system, there is much more involved. You shouldn't think that the only thing required to manage your maintenance function is the ability to locate five empty boxes!

Besides managing work orders, the RPM method can be used as a pre- and post-RCM function. As a pre-RCM function, the RPM method supplies the analysis with the "R," "P" and "M" tasks/costs associated to each piece of equipment. This valuable historical data provides maintenance management with the information to justify the cost of an RCM analysis or a system modification. Typically, it's not cost-effective to do RCM analysis on all the plant's equipment. The RPM method points to the part of the plant that would benefit the most and that is the system or equipment with the high "R" and "P" costs associated to them.

As a post-RCM function, the RPM method checks the benefits of the RCM analysis. From the maintenance perspective, the RCM analysis is considered successful if maintenance doesn't have to fix the same piece of equipment over and over again. The RPM method will display the success of the RCM analysis simply by the lack of "R" work orders in six months. Of course, there are other benefits from the RCM analysis, such as locating hidden failures, but most maintenance managers are concerned with how to eliminate the pile of 432 open work orders sitting on their desk.

Another known fact to improve the reliability of a plant is to have maintenance and engineering working in the same direction. Therefore, "Maintenance + Engineering = Reliability."

Earlier it was stated that: "RPM method + RCM = Reliability." Now you have two departments that have an impact on reliability and two proven methods to improve reliability. All you need to do is define who is responsible for what. A simple way to do this is to define who does what by asking the following questions:

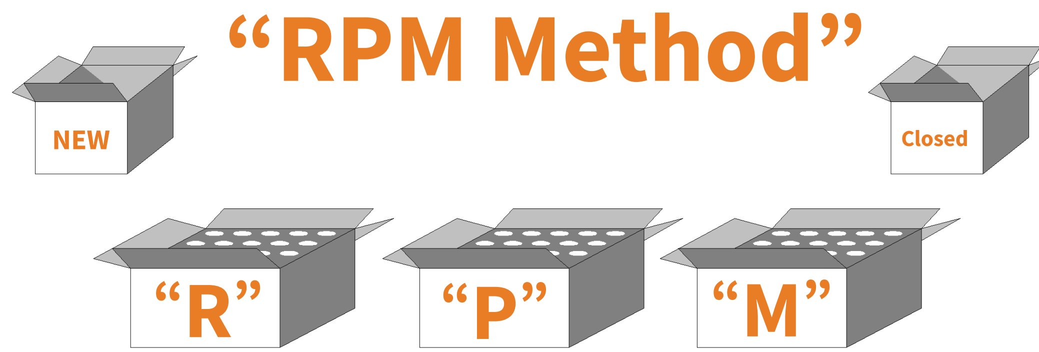


Figure 1: RPM method

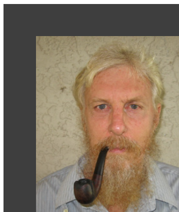
- ☑ Who should be responsible for the hands-on work required for "R," "P" and "M" on the equipment? The answer would be the maintenance staff because it's the reason they were hired in the first place. Does this mean engineering can't help maintenance troubleshoot a piece of equipment? No, it just means that maintenance is responsible.
- ☑ Who should be responsible for keeping track of the material and labor costs associated with each "R," "P" and "M" work order? The answer is maintenance personnel because they are doing the task, so they should be responsible for keeping track of the data.
- ☑ Who should be responsible for justifying and implementing the RCM analysis? Engineering is responsible for showing management the benefit of the RCM analysis. The engineering justification needs to look at the maintenance benefit of a potential reduction of an "R" work order and operational savings from an increase in production or reduction in scrap.
- ☑ Who is responsible for the final approval of all design changes developed from the RCM analysis? The answer is engineering. Does this mean that engineering should be the only decision maker of design changes and preventive maintenance tasks? Of course not, but engineering needs to take the responsibility for the final approval. Engineering has access to design information, such as load, stress and flow calculations. Engineering personnel are also familiar with engineering codes and standards that the equipment must meet.

The best way to show the benefits of maintenance and engineering applying the RPM method and RCM analysis strategies is with an example. Assume there is a problem with a plant's wastewater system. The first thing to do is implement the RPM method to make sure there is a problem in the wastewater system. After applying the RPM method, the problem with the wastewater system becomes obvious by the number of "R" and "P" work orders recorded in the system. This high number of "R" and "P" work orders can be used as a pre-RCM function by engineering to support the need for an RCM analysis on the wastewater system. Once an RCM analysis is approved, maintenance needs to generate an "M" work order to record time spent supporting the RCM analysis on the wastewater system. Why is an "M" work order generated? As stated earlier, since it's not repair or preventive work on the wastewater system, it must be an "M."

Now it's time for the RCM analysis. The RCM analysis reviews the design, operation and maintenance of the wastewater system. Assume during the analysis that the root cause of the problem with the wastewater system and some hidden failures turn up. These findings would have affected the safety and reliability of the system, such as a missing check valve in the system. All the maintenance and engineering time associated to this analysis and insulation of equipment is accumulated on the "M" work order to track costs to this modification.

Was the RCM analysis a success? Using the RPM method as a post-RCM function, you can now define maintenance success of the analysis simply by no more "R" work orders in the wastewater system. If "R" work orders start to show up, it's time for engineering to revisit the RCM analysis.

So, how is success defined by the maintenance manager with 432 open work orders, a screaming operations manager and a tripped air compressor #2? The ability to go fishing with the other two technicians without worrying about the plant safety and reliability!



Fred J. Weber, *P.E., is President of Wrench Time, Inc. He has over 35 years of experience working with and learning from maintenance and construction people in the mining, manufacturing and power generation industries. Fred is the author of the books, "Wrench Time…using the RPM method to manage maintenance" and "Weber's Thermodynamics Notes." www.wrenchtime.com*

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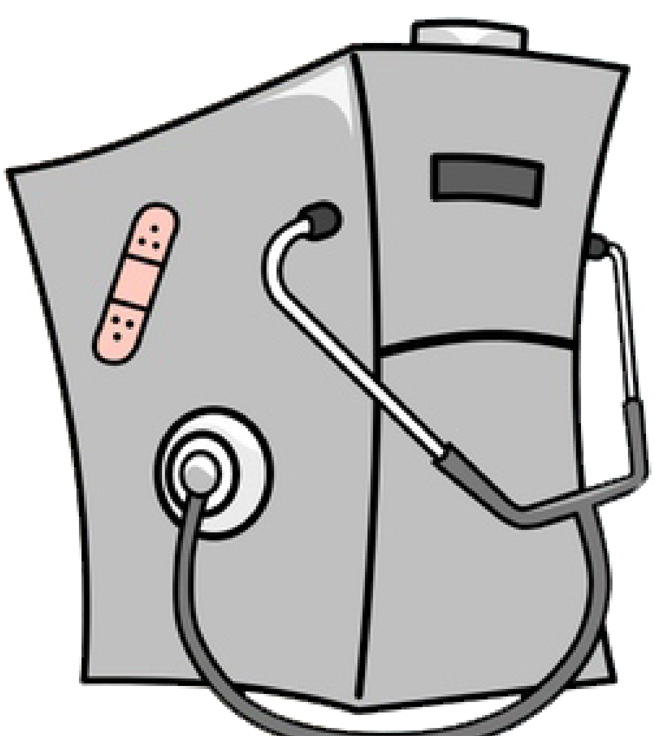
Repair vs Replace

by Andy Page IMC Presenter

How to use Lifecycle Cost Analysis to Determine the Threshold Limit



Introduction

"If maintenance costs get high enough, we'll just replace it." This phrase represents the prevailing attitude about asset management that is taught in graduate business schools and heard in conference rooms in most, if not all, manufacturing and production facilities around the globe. From the perspective of reliability concepts, the phrase is a manifestation of a belief system that represents an inaccurate understanding of where high maintenance costs come from and what the proper method for reducing them would be. From a financial perspective, the phrase is correct at face value, but the actual threshold limit for the replacement decision point is substantially higher than what is commonly used in industry. This article contains an explanation of the logical pitfalls of the commonly held beliefs, as well as an explanation of the calculation of the threshold limits for the replacement decision.

The Existing Paradigm

Though it has been proven wrong many times over since engineers F. Stanley Nowlan and Howard Heap produced their seminal work on reliability analysis in the 1960s, many asset managers still operate under the mistaken impression that older assets exhibit higher failure rates. This mental paradigm, while correct for approximately 11 percent of the failure modes for a sufficiently large group of assets, is inaccurate for the other 89 percent of the failure modes for that same group of assets. The mountain of evidence that clearly demonstrates the majority of failure modes for any given asset are a function of how the machine is treated and not a function of how old the asset is continues to grow. Quite simply put, a well-treated asset will have a lower failure rate than an ill-treated asset, regardless of age. The treatment, in this context, speaks to how machines are operated, lubricated, cleaned and maintained, as well as how the parts for those machines are designed, selected, transported, stored and installed.

Further, financial managers make capital monies more easily obtainable than additional budgetary monies, thereby allowing the ingression of maladaptive behaviors into the organization. The behavior these policies encourage is one of deferment instead of vigilance. There is no doubt financial managers are not consciously encouraging these behavioral choices. Surely, the act of making budgetary monies more difficult to acquire is intended to force asset managers into a behavioral pattern of caring for their assets so additional budgetary monies are not needed. However, making capital monies easier to obtain allows for an unhealthy option of just buying a new one when the maintenance costs are too high. As a result, many asset managers choose the easier route of buying a new asset rather than changing the behaviors of their personnel to force a higher grade of care for the assets. This is a financial mistake. This financial policy costs the organization even more money than the higher maintenance costs, as can be easily seen in lifecycle cost (LCC) modeling.

The Hard, Cold Truth

Lifecycle cost models are designed to help asset managers understand the entire cost of an asset rather than just its initial purchase price. The use of LCC models encourages the consideration of all aspects of the costs and benefits of selecting a given asset among multiple choices. Well-defined models include both the costs and benefits of aspects, such as design, manufacturing, acquisition, storage, installation, commissioning, operations, maintenance, decommissioning, removal and disposal. Typically, LCC models are built within

Many asset managers still operate under the mistaken impression that older assets exhibit higher failure rates

spreadsheets and each of these aspects can have their own row or multiple rows to model those costs and benefits. The models cover several years to completely cover the lifecycle of the aspect. Typical models range from seven to 15 years, but can go up to 25, 30, or even 50 years, depending on the estimated lifecycle of the asset. Most model lengths are more dependent on technological obsolescence than on end of useful life estimations for the reasons noted in this article. These costs and benefits are then summed to a total for each time period and then divided by a factor to account for the time value of money. This factor is often called the hurdle rate and represents the profit the organization could make using that same money in other ways. It should be noted that the hurdle rate for different alternatives can be different, depending on whether the alternative requires capital monies or not. The sum total of annual totals once the time value of money

Option A - *Buy New*		Option B - *Keep Old*	
Initial Purchase Cost	-$250,000	Initial Purchase Cost	$0
Annual Benefit	$40,000	Annual Benefit	$40,000
Maint%RAV	4.11%		
Estimated Annual Maint. Costs	-$10,275	Annual Maint. Costs	-$32,607
NPV (10-year)	-$112,611	NPV (10-year)	-$112,611
		Maintenance Costs Multiplier	3.17

FIGURE 1

Option A - *Buy New*		Option B - *Keep Old*	
Initial Purchase Cost	-$250,000	Initial Purchase Cost	$0
Annual Benefit	$48,000	Annual Benefit	$40,000
Maint%RAV	4.11%		
Estimated Annual Maint. Costs	-$10,275	Annual Maint. Costs	-$28,658
NPV (10-year)	-$61,270	NPV (10-year)	-$61,270
		Maintenance Costs Multiplier	2.79

FIGURE 2

Option A - *Buy New*		Option B - *Keep Old*	
Initial Purchase Cost	-$250,000	Rebuild Cost	-$137,426
Annual Benefit	$40,000	Annual Benefit	$40,000
Maint%RAV	4.11%		
Estimated Annual Maint. Costs	-$10,275	Annual Maint. Costs	-$10,275
NPV (10-year)	-$112,611	NPV (10-year)	-$37
		Maintenance Costs Multiplier	1.00
ROI	(0.45)	ROI	(0.00)

FIGURE 3

has been accounted for is called the net present value (NPV), as the evaluation of future events needs to be performed in present day dollars.

It is the NPV by which project alternatives are supposed to be evaluated, though most organizations manage themselves into a financial corner where they have to succumb to the most immediate needs of the moment in order to survive. These organizations do not make decisions on NPV as much as they make decisions on initial purchase price. Making decisions on initial purchase price is an excellent way to ensure the organization will always be in that financial corner. To break out of that corner, start making decisions on the NPV of the LCC. The difference is usually *more* immediate and *more* impactful than most decision makers believe it will be.

The use of computer spreadsheets dramatically increases the usefulness of NPV calculations in LCC models with respect to asset management decisions. Asset managers can use some of the spreadsheet functions to easily analyze what-if scenarios and find the repair versus replace threshold limits quite easily.

Step 1: Create an LCC model in a spreadsheet for the replacement of the existing asset. Call this model Option A: *Buy New*.

Step 2: Create an LCC model in the same spreadsheet for keeping the old asset. Call this model Option B: *Keep Old*.

Step 3: Use the spreadsheet tools to vary the maintenance costs of Option B until the NPV for Option B is equal to Option A.

Step 4: Divide the annual (or total) maintenance costs for Option B by the annual (or total) maintenance costs for Option A. This is the maintenance costs multiplier or the threshold limit for the repair versus replace decision. See Figure 1 as an example.

In Figure 1, the organization would have to spend more than 3.17 times as much on maintenance for the old asset as they expect to spend on maintenance for the new asset, making the purchase of the new asset a sound financial decision.

Option A - *Buy New*		Option B - *Keep Old*	
Initial Purchase Cost	-$250,000	Rebuild Cost	-$68,703
Annual Benefit	$40,000	Annual Benefit	$40,000
Maint%RAV	4.11%		
Estimated Annual Maint. Costs	-$10,275	Annual Maint. Costs	-$10,275
NPV (10-year)	-$112,611	NPV (10-year)	$68,686
		Maintenance Costs Multiplier	1.00
ROI	(0.45)	ROI	1.00

FIGURE 4

Lifecycle cost models are designed to help asset managers understand the entire cost of an asset rather than just its initial purchase price

Argument #1:

The new asset will be more productive.

Even if the new asset is 20 percent more productive, the additional benefit does not offset the initial purchase price (see Figure 2). Further, to offset the effect of the initial purchase price in the scenario noted in Figure 2, using a maintenance cost for Option B that is twice that of Option A, the productivity of the new asset would have to be 61 percent more than the existing asset. Rare is the case that the asset upstream can provide that much more input and the asset downstream can accept that much output. If that is the case, then it is a sound financial decision; if not, reconsideration is necessary.

Argument #2:

Did your model account for the downtime being caused by the old asset?

No, downtime is not in the model, nor should it be in most instances. There are two reasons for this. Reason #1, with the inspection methods available today, the detectability of most machinery defects is over 95 percent. This degree of detectability means that the vast majority of machinery defects can be found and corrected long before emergency downtime is required. Thus, downtime is more a function of the quality of your inspection program and the maturity of your asset management schema and not a function of the asset's age or condition. Reason #2 is that very few systems suffer downtime from one and only one asset. Rare is the case for a system that does not have a backlog of work, therefore, decisions to schedule downtime are shared across multiple assets and not a single asset.

Argument #3:

The old one will require a rebuild to get it to a maintainable condition.

Many times, the conversation between the reliability engineer and the asset manager is around the cost of rebuilding the old asset versus the cost of buying a new one. The model in Figure 3 shows this precise scenario. You can see that if the maintenance costs are expected to be the same, which is logical for a like-for-like replacement, then for a return on investment (ROI) of 0.00 (breakeven), the rebuild costs of the old one can be as much as 55 percent of the purchase and installation costs of the new one. Setting an ROI of 1.00, the rebuild costs can be only 27 percent of the costs of getting a new one (see Figure 4). Remember, these threshold limits will change as the initial purchase cost of the new system changes. To model each scenario correctly, the what-if scenario has to be run in your spreadsheet each time for each new value. There is no universally accepted ROI for such calculations. The required ROI is dependent on the financial manager and, of course, the financial climate at the time of the request.

As the initial purchase cost of the asset changes, so do the threshold limits. Using the scenario in Figure 1, a set of tables and a graph can be created to represent the variation in threshold limits. See Figures 5 through 7. Note the lower right-hand value in the tables in Figures 5 through 7. Even with a $1M proj-

FIGURE 5

Option A Installed Price

Option A Maintenance Cost: Maint $/RAV	$25,000	$50,000	$100,000	$250,000	$500,000	$1,000,000
1.40%	53.22	30.98	19.86	13.18	10.96	9.85
3.10%	24.35	14.30	9.28	6.27	5.26	4.76
4.11%	18.51	10.93	7.14	4.87	4.11	3.72
5.70%	13.50	8.04	5.31	3.67	3.12	2.85
7.11%	10.94	6.56	4.37	3.09	2.62	2.40
8.90%	8.85	5.36	3.61	2.56	2.21	2.03
10.81%	7.39	4.51	3.07	2.21	1.92	1.77
13.70%	5.95	3.68	2.54	1.86	1.63	1.52

Option B Annual Maintenance Spend Multiplier

FIGURE 6

Option A Installed Price

Option A Maintenance Cost: Maint $/RAV	$25,000	$50,000	$100,000	$250,000	$500,000	$1,000,000
1.40%	$18,627	$21,686	$27,804	$46,130	$76,720	$137,900
3.10%	$18,871	$22,165	$28,768	$48,593	$81,530	$147,560
4.11%	$19,019	$22,461	$29,345	$50,039	$84,461	$152,892
5.70%	$19,238	$22,914	$30,267	$52,298	$88,920	$162,450
7.11%	$19,446	$23,321	$31,071	$54,925	$93,141	$170,640
8.90%	$19,691	$23,852	$32,129	$56,960	$98,345	$180,670
10.81%	$19,971	$24,377	$33,187	$59,725	$103,776	$191,337
13.70%	$20,379	$25,208	$34,798	$63,705	$111,655	$208,240

Option B Total Annual Maintenance Spend

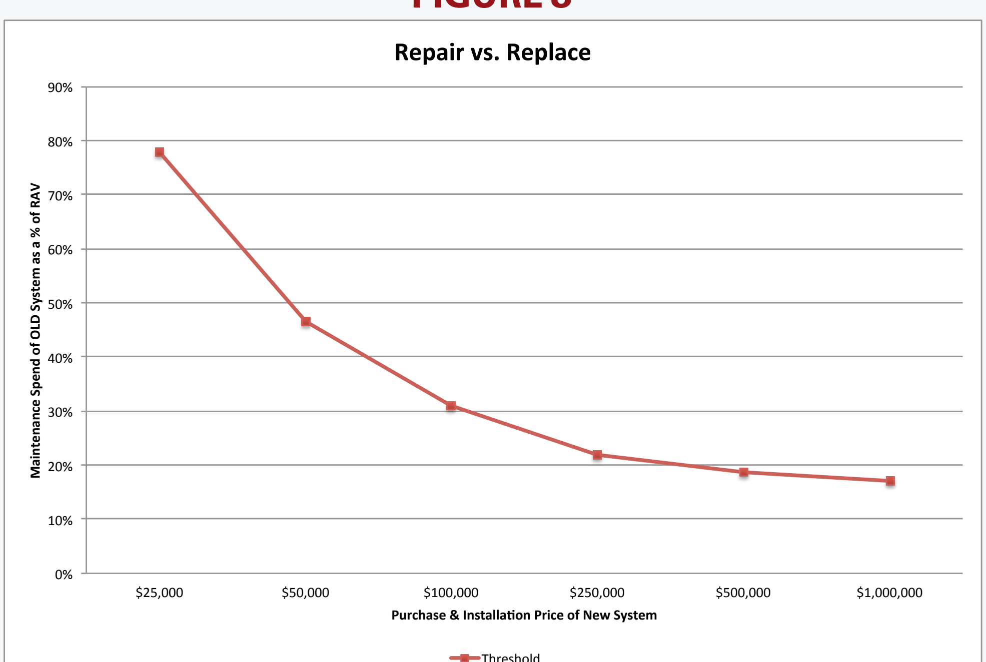
FIGURE 7

Option A Installed Price

Option A Maintenance Cost: Maint $/RAV	$25,000	$50,000	$100,000	$250,000	$500,000	$1,000,000
1.40%	75%	43%	28%	18%	15%	14%
3.10%	75%	44%	29%	19%	16%	15%
4.11%	76%	45%	29%	20%	17%	15%
5.70%	77%	46%	30%	21%	18%	16%
7.11%	78%	47%	31%	22%	19%	17%
8.90%	79%	48%	32%	23%	20%	18%
10.81%	80%	49%	33%	24%	21%	19%
13.70%	82%	50%	35%	25%	22%	21%

Option B Annual Maintenance Spend as % RAV

FIGURE 8



ect and horrible maintenance costs, the threshold limit is still around 1.5. You can go out to $100M for the initial costs and down to a maintenance cost of 25 percent of replacement asset value (RAV) and still the threshold limit will be 1.03.

Figure 8 has the handy graph for a simple analysis with no rebuild costs, just higher maintenance costs. If the project is below the red line, keep the old one. If the calculation puts the project over the red line, buy the new one.

Implications of the New Paradigm

There are several implications of these threshold value calculations.

Implication #1, in a repair versus replace scenario, there is virtually no practical maintenance cost for the old one where the purchase of a new one is a sound financial decision.

Implication #2, where a high initial rebuild cost is concerned, the desired ROI determines the threshold limit for rebuild costs.

However, the most challenging implication, given what is now known about threshold limits, is that asset managers are always money ahead to keep the assets in a maintainable state and not let them degrade to the point where a rebuild versus replace scenario has to be calculated. This implication is proven true since there is no practical limit to maintenance costs that would be greater than overcoming the initial purchase price of a new one. This leads to the final implication that is almost exclusively for financial managers. Without calculating threshold limits, do not make capital monies more readily available than expense monies, as that policy drives financially unsound decisions.

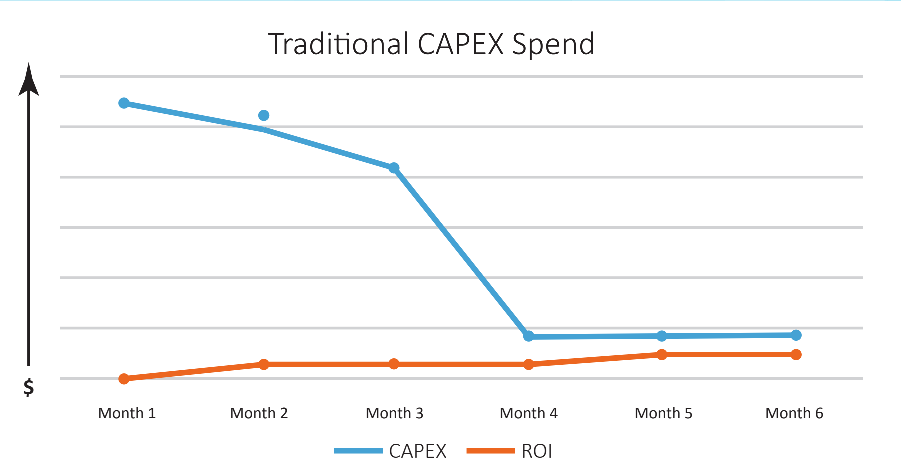
In short, this entire article is just one more piece of compelling evidence that it is always cheaper to keep the asset maintained than it is to allow it to degrade and then try to repair or replace it.

Andy Page, *Principal Consultant for Allied Reliability Group, has over 20 years in the maintenance and reliability field, helping organizations with unique and advanced maintenance system and organizational problems, from identification and analysis through successful solution deployment. He is well grounded in reliability and maintenance engineering topics, with particular emphasis on PdM technologies, continuous improvement processes, and education. www.alliedreliabilitygroup.com*

Captial vs Operational Expenditures

Companies that follow a traditional CAPEX model when implementing ultrasound to their reliability strategy face high risks, big up-front investment, and longer wait times for ROI. The risks are 100% borne by the customer with no guarantee for success.

Without SDT's roadmap to world-class, up to six months may pass before your team even finds its first air leak or acoustically greases their first motor bearing. The chart "Traditional CAPEX Spend" illustrates how ROI is still below CAPEX six months after deployment. That's unacceptable.



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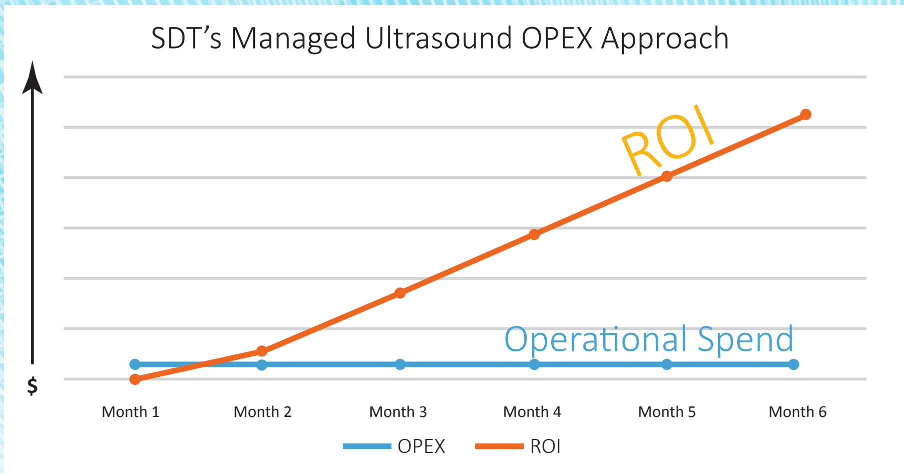

A New Way of Thinking

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10 Components of a Successful VIBRATION PROGRAM

by Alan Friedman

IMC Presenter

Understanding the 10 components of a condition monitoring (CM) program is the first step in making them work to support you and your organization's goals. The 10 main components comprising a condition monitoring program are shown in Figure 1. Each of the components relates to and affects all of the others. Like the supports of a structure, they all must be balanced for the structure to stand. This is the introduction to a multi-part series covering each of the 10 components of a successful program. A more in-depth handling of the subject matter can be found in the book, *Audit It. Improve It! Getting the Most from Your Vibration Monitoring Program* by Alan Friedman, available at the MRO-Zone Bookstore.

You cannot succeed without clearly stated goals, but you would be surprised at how many programs do not have clearly defined goals! If you believe your program has clear goals, take a moment right now to write some of them down on a piece of paper. If you can't write them down, then you probably don't have them! If you don't have the ***right goals***, you cannot come up with concise strategies and tactics for attaining them. You will not know what people, tools, data, analysis, etc., are required and you will not be able to easily measure if your goals are being met.

> Each of the components relates to and affects all of the others.

You need the ***right people*** in place to carry out the action plan and keep the program running year in and year out. Your people will need to be trained, certified and given the time, tools and support they need to be successful. You will need to get buy-in from managers and other stakeholders to keep the program staffed and funded. You can leverage outside expertise to help get the program running, to provide training and to step in when internal personnel are reassigned or leave. No program can be successful without support and contribution from the right people.

Not only does a program require the right goals, it requires the ***right leadership*** to state these goals in a way that everyone can understand and inspire the right people to put the plan in action. If a program is going to change the way the plant operates, then it will surely meet with opposition. People do not like change. The journey from the reactive to the proactive is a difficult one that requires an unwavering commitment and consistency over a long period of time. A strong leader is needed to keep the ship pointed into the wind.

Only after you really understand what you wish to accomplish should you select the ***right tools*** to employ. The tools need to be appropriate for the people who are using them. Higher technology is not always better if it is not appropriate for the skill levels of the users. The right tools facilitate the right data, the right analysis and the right reporting. You should have a precise idea of how you want these three aspects of the program to work before purchasing any tools. Often times, the capabilities of the software are more important than the bells and whistles on the data collector, so don't be distracted by the gloss and glitter, make sure the tool does what you need it to do before you buy.

You need the ***right understanding*** to know how to best maintain the asset. In the case of condition monitoring, the right understanding determines what to measure and when to measure it. You need to understand how the machine and its components fail, how quickly they fail and the consequences of their failure *before* you can determine how best to maintain them and avoid failure. If condition monitoring is applicable to the failure mode, then you will

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.

need to understand how the failure mode presents itself before determining which technology to use to monitor for it and what specific data to collect and tests to take. You will need to know how quickly the component will fail in order to determine how frequently to conduct the tests. Understanding the consequences of failure helps to define your goals and calculate the return on investment associated with avoiding the failure or planning for it.

The ***right data collection*** is directly based on the right understanding. If you have done the work required to understand the asset and its failure modes, you should know exactly what data to collect to detect the presence of the failure modes. In vibration analysis, the right data collection includes the types of measurements taken, the type of sensor used, and how and where the sensor is mounted. Multiple test points, axes and test types are typically associated with a vibration test on a typical machine.

In a condition monitoring program, you are trending or looking for change. Therefore, the ***right analysis*** is often a matter of developing baselines or alarms based on prior data collected under the same conditions (the right data) and looking for change. If you have the right tools, the software should be good at detecting this change for you in an intelligent and sophisticated way. If you are spending an hour looking at data from each machine every month, then you are doing something wrong. Analysis should be efficient and mostly automated. Most of your machines should not have defects in them, so you should not have to spend tons of time analyzing data from healthy machines month after month. Your software should tell you which problem machines to focus on.

Decision makers don't need data or alarms; they need actionable information. The right analysis is about turning the right data into fault diagnoses and the ***right reporting*** is about turning analysis into actionable information. This tells the decision makers what to do with the information. Reports need to be delivered to the right people at the right time and in the right format. Different people may require different levels of detail in the reports and may require the report at different times in order to make timely decisions. Reports should have priorities or severity levels associated with them. There should be a clear understanding that defects are reported at an early stage. Priority or severity levels should be increased as the problem worsens over time. Planners can then determine the optimal time to carry out the repair.

After a report has been issued and action taken, the ***right follow-up and review*** is required. You need to know if the report was correct and if the action taken was the correct action. There needs to be a feedback mechanism in the process so those doing the analysis learn to do it better and those making the decisions know whether they made the correct ones. If a bearing defect was diagnosed, the bearings should be cut open and inspected and an "as found" condition report generated. Not only do you want to know if the analysis was correct, but you also want to ask, in a formal way, what caused the bearing defect? There needs to be a formal mechanism in place to remove the root cause of the failure. The right follow-up and review is also where you measure to determine if your goals are being met. This is where you gather the data for your key performance indicators (KPIs) and calculate your return on investment. The right follow-up and review helps you audit and improve the program.

The ***right processes and procedures*** is the thread that ties the 10 components together. A good program is not dependent on any individual. Often times, what is supposed to be a condition monitoring program is actually just a person with a tool and the so-called program fails when the individual leaves. Condition monitoring programs are based on an understanding of the assets (the right understanding) and trending. Trending is based on the right repeatable data, which means the data is collected in the same way each time no matter who collects it. All of this implies that well-documented processes and procedures are the cornerstone of a successful program. They are what keep the program running, evolving and continuously improving over time, even as personnel come and go.

Vibration or CM program audits help you verify that these 10 elements are in place in your program and that your program follows ISO guidelines and accepted best practices. This is the best way to make sure you are getting the most from your program. So, now is the time to audit it and improve it!

Alan Friedman *is the founder and CEO of Zenco, a provider of vibration monitoring program audits and training. Alan has more than 24 years experience in helping people set up and manage vibration monitoring programs. Alan is the author of the book, Audit it. Improve it! Getting The Most from Your Vibration Monitoring Program. (www.mro-zone.com). www.zencovibrations.com*

Reduce REACTIVE Maintenance

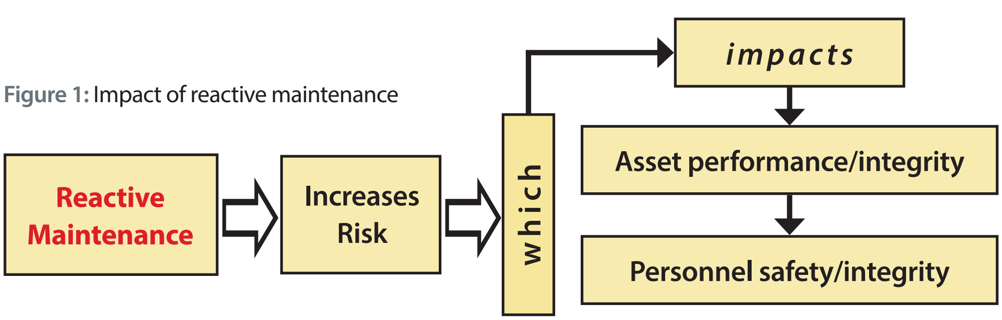
by John Reeve
IMC Presenter

For purposes of this article, reactive maintenance is any planned or unplanned work with a priority designation of emergency or urgent, therefore requiring immediate attention. Plus, there could be work of any priority that is "worked on" outside of the weekly schedule, which this author calls "self-inflicted reactive maintenance."

Problem Statement

Organizations that are predominantly reactive typically *do not believe* it is possible to perform work any other way. Overall, they are frustrated, which in turn impacts morale. Maybe it is a training issue or maybe it is a leadership issue. Either way, it is affecting worker productivity due to the majority of work being unplanned. Unscheduled work also affects job safety. When workers feel rushed, bad things happen. Lastly, those organizations with poor reliability typically waste 10 percent of their revenue.

Figure 1: Impact of reactive maintenance



Ten Actions Worth Considering

This article provides 10 distinct actions you can take to become more proactive. As you will see, the asset management system (AMS) plays a major role. Typically, users struggle to leverage the AMS in support of asset reliability, but the reason for this simply may be because you need a more encompassing set of instructions. So, here they are.

1

Establish a solid preventive maintenance (PM) and/or predictive maintenance (PdM) program. Where possible, establish maintenance strategies using formal reliability centered maintenance (RCM) analysis. Otherwise, rely on manuals from the original equipment manufacturer (OEM) and staff experience. Place emphasis on condition monitoring technologies, such as PdM, which makes it easier to recognize defects. With early identification, the staff can prevent unplanned breakdowns and collateral damage. By proactively planning needed repairs, the organization saves cost. In support of your PM/PdM program, you should ensure that some maintenance staff members have certifications in PdM technologies (e.g., vibration, ultrasound, infrared, tribology), as well as knowledge in precision maintenance skills.

Tip: Link PM/PdM to failure modes and store this relationship inside the AMS in the failure mode and effects analysis (FMEA) register where they are easily referenced.

2

Establish a reliability team. It helps to have more than one person focused on asset reliability and plant availability. This group would rely heavily on the AMS system for failure analysis, as well as decisions pertaining to root cause analysis, RCM and localized FMEA.

3

Perform root cause analysis (RCA) on worst events to identify the true cause based on the trigger point.

4

Perform a localized FMEA where needed, for instance to evaluate a specific system or asset to isolate a problem and validate failure modes by comparing AMS failure history (failure modes) to the FMEA register.

5

Utilize defect elimination techniques, such as brainstorming, quality circles and kaizen events, all of which involve working level and cross-functional groups. Conduct system walk-downs and record problems as a group. Summarize findings and propose solutions.

6

Establish a core team to manage the complete AMS system. Train the staff, establish business rules, build standard operating procedures (SOPs), set up mandatory fields and choice lists, run error checks, survey the users for problems and conduct periodic audits. Most importantly, set up the AMS with the endgame in mind (e.g., failure analysis). The core team should maintain a five-year plan for direction/guidance in support of operational excellence.

7

Perform formal job planning to provide sequenced steps, material/craft requirements, safety/hazard precautions, as well as reference materials and permits. This is being "fully planned." Job instructions help keep workers safe, organized and informed. Job plans also help the craft follow standardized actions to ensure asset performance. The planner role is multifaceted, but key points include a job plan library, backlog management, foundation data accuracy and a maintenance of asset-to-spares library.

8

Create a formal weekly schedule process by selecting the fully planned work that can be relied on by operations, maintenance, warehouse/purchasing, and health, safety and the environment (HSE). Some schedulers also attempt to bundle like work from the backlog, or they may perform plant system window scheduling.

Tip: If the organization is mostly reactive, it may be good to create a reactive maintenance team and let the others focus on proactive work. Oddly enough, this action will help management emphasize the weekly schedule with "no excuses not to perform." Lastly, train maintenance to not perform self-inflicted reactive maintenance whereby they purposely decide to do unscheduled, low priority work.

9

Trend percent reactive to manage reactive work. Be sure you can extract reactive maintenance using structured query language (SQL). This can be an important metric for trending and comparison. Reactive work is usually Priority 1 (emergency), Priority 2 (urgent) and any other work order that breaks into the schedule. Otherwise, if you are repairing an asset, such as a condition based maintenance discovery, you should have time to properly plan and schedule this work. Therefore, it is not reactive.

10

Capture good failure data, specifically failure modes. Use this failure data in failure analysis (e.g., asset offender report) to determine worst offenders. Properly stored failure data (e.g., validated fields) can reduce failure analysis time by up to 90 percent if it is actionable (e.g., retrievable via SQL) as opposed to pure text. Inaccurate/incomplete data, however, can severely limit the ability to extract meaningful reports (e.g., failure analytics). By combining the failed component, component problem and cause code, you can create the failure mode that is used to identify optimum maintenance strategy.

Tip: Failure data should also include work order feedback (e.g., suggestions from the maintenance technicians), such as issues pertaining to ergonomics, maintainability, safety and design flaws.

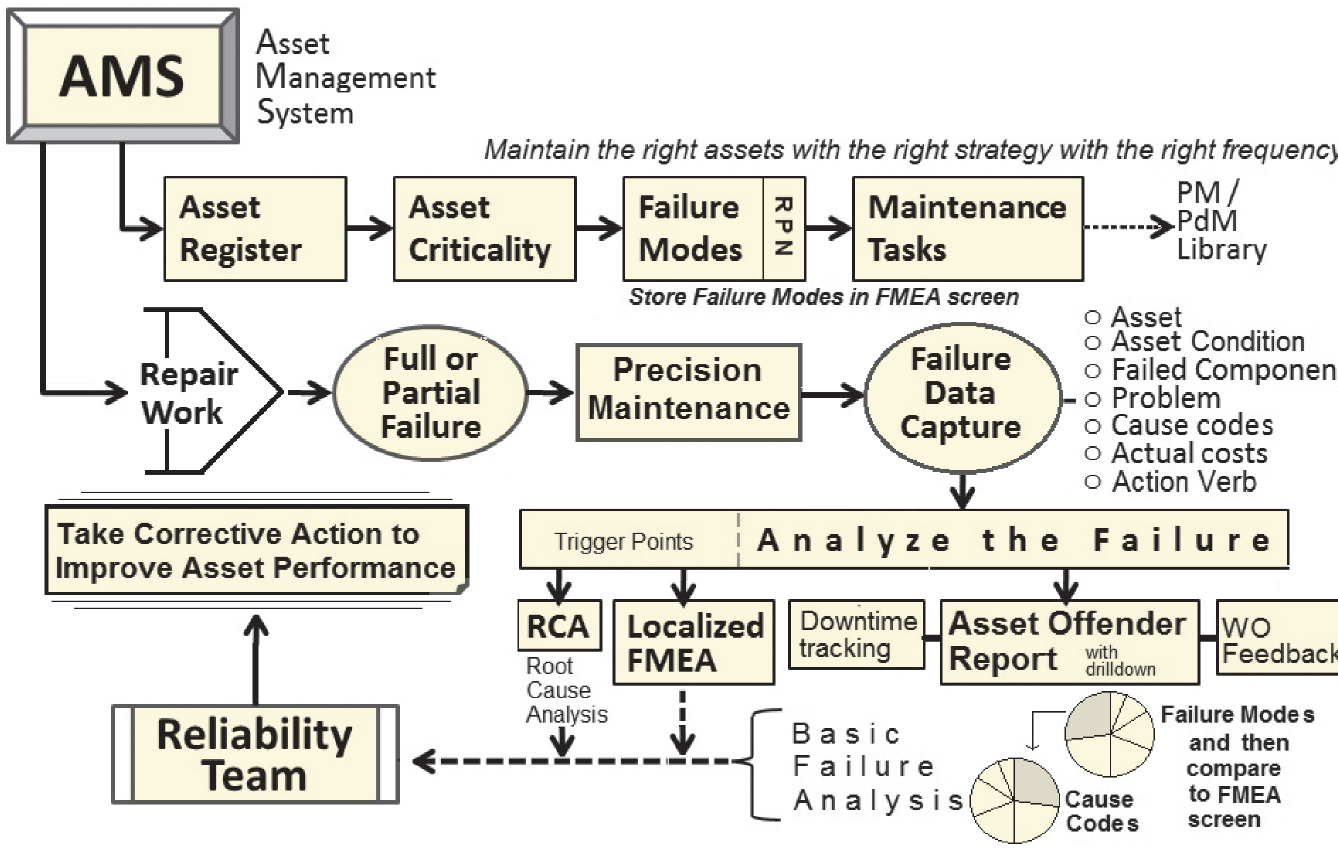


Figure 2: Asset management system workflow

Precision Maintenance Needs Precision Data

In Figure 2, you see an ideal design for setting up an AMS with emphasis on failure analysis. Also note the unique design for building the failure mode, which is the combination of (1) failed component, (2) component problem and (3) possibly the cause code, depending on how you stored this data in the FMEA register. Other key elements of this process include the trigger points for RCA, work order feedback, a reliability team and the asset offender report, such as the mean time between failures (MTBF) analytic. With the asset offender report, you can focus on "bad actors" and manage by exception.

According to RCM expert Jack Nicholas, "The single most important thing to assure reliability is to rely on procedures, staff feedback with follow-up and reinforcement. Good procedures help ensure precision."

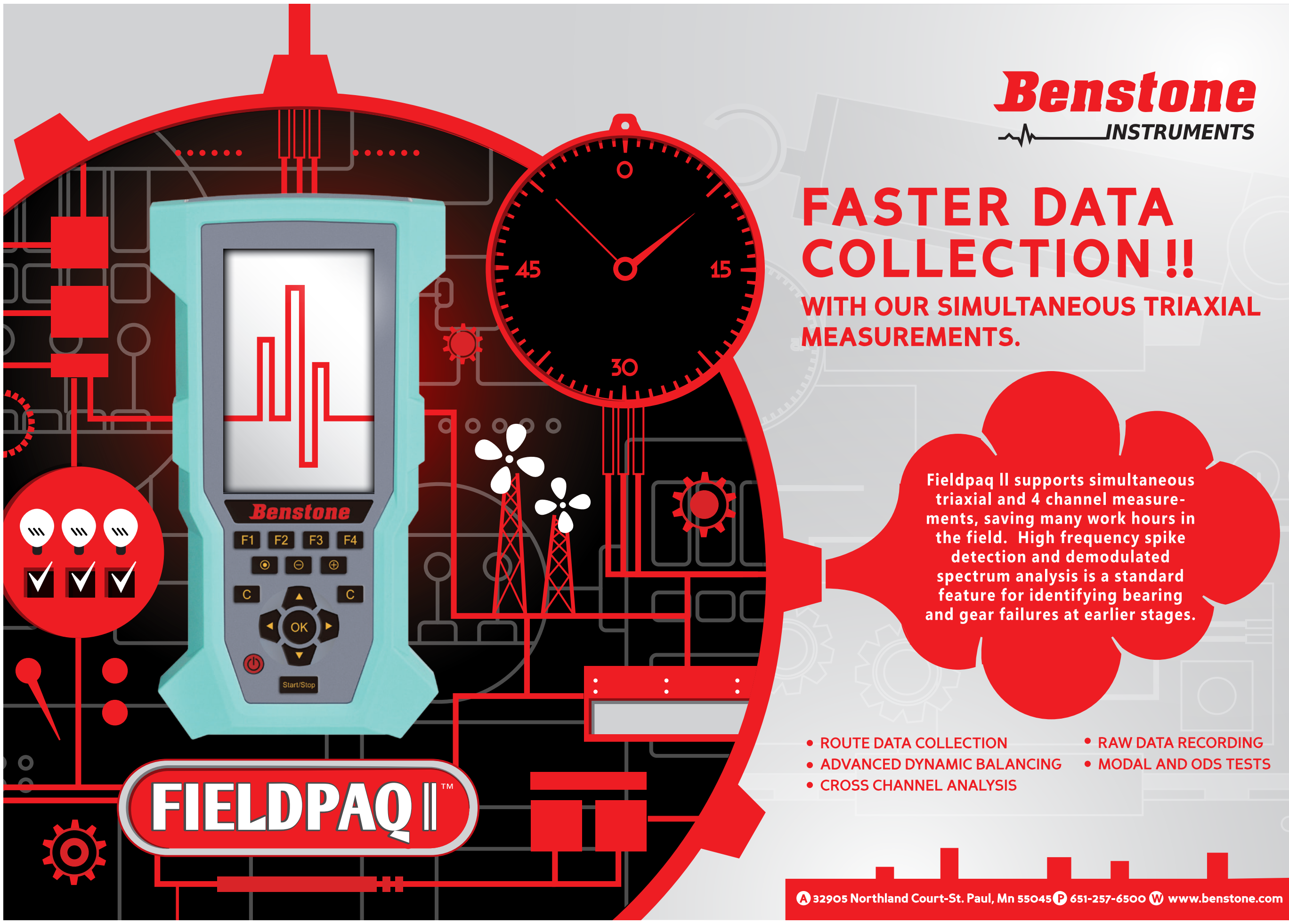
Work order feedback can capture suggestions for improvement. Although not shown in Figure 2's diagram, there also needs to be process audits, data error checks and business analyst (working level) surveys.

"The single most important thing to assure reliability is to rely on procedures, staff feedback with follow-up and reinforcement. Good procedures help ensure precision."

Conclusion

Reducing reactive maintenance is not an impossible task. The trick, however, is to start small. Perhaps you'll focus on the critical assets first. The AMS software may need to be configured and training will be required. Asset reliability and job safety is everyone's job. All that is needed is a roadmap to get there.

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 United States Patent for maintenance scheduling. www.trmnet.com*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A Journey to Shape Reliability Excellence at

Bristol-Myers Squibb - Part 1

by IMC Presenter George Williams and IMC Presenter Robert Bishop

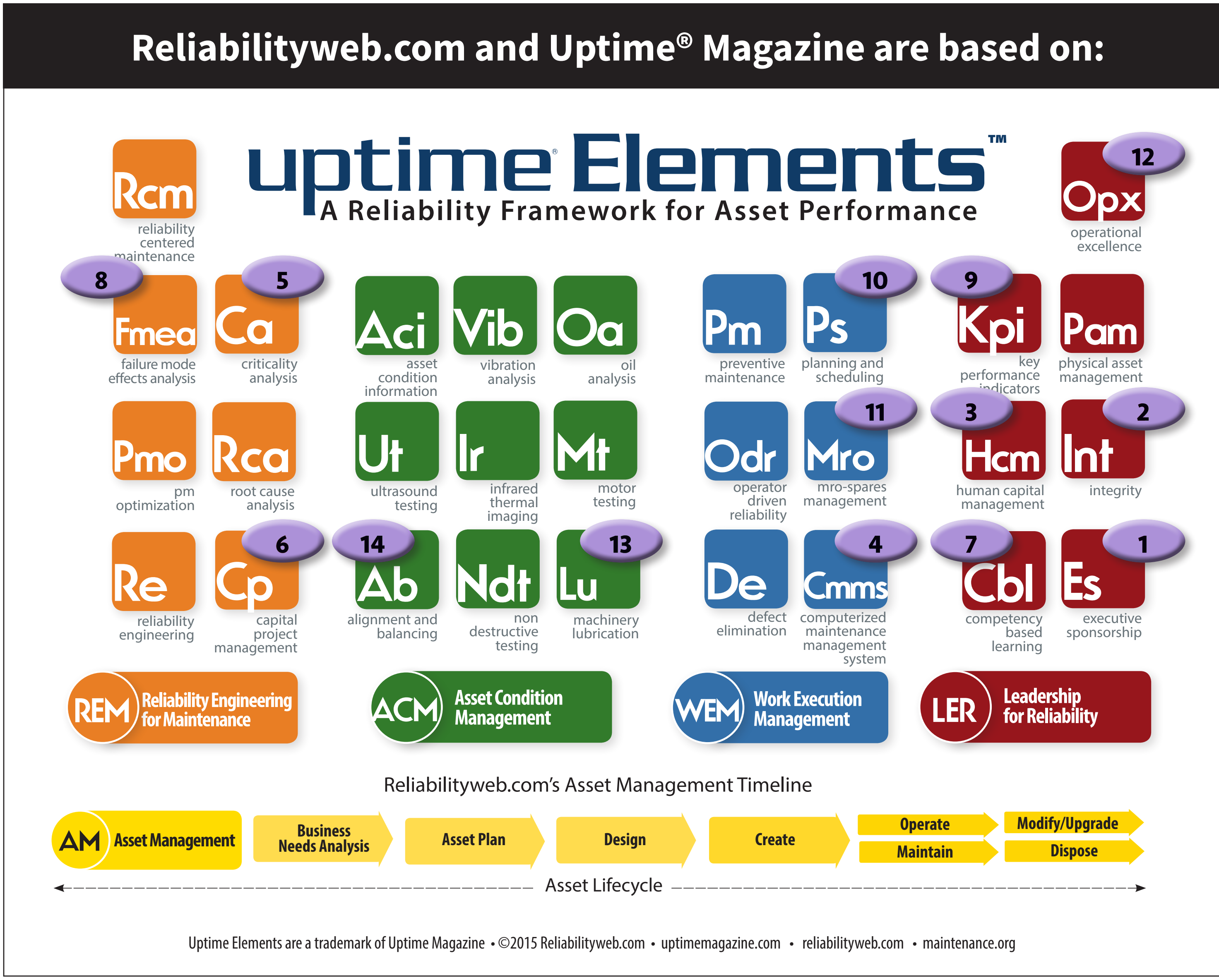
The journey of reliability at Bristol-Myers Squibb Company (BMS) is not unlike that of many other companies. We have seen great successes, missed opportunities, supported reliability efforts and a focus on various initiatives. Like others, our journey continues as it always has….or not. There is a changing atmosphere developing. A paradigm shift, if you will. The culmination of many small changes coming together to create something special. Our global community of reliability professionals, a talented and special group of people, were ready when the opportunity presented itself. Ready to take the next step in our journey to excellence. Ready to collaborate on our direction as a community. Ready to transform from reliability professionals into reliability leaders. Ready to provide a sufficient benefit to fellow employees, shareholders, the environment, our community and the patients we serve.

In October of 2014, BMS adopted Uptime Elements as our framework for asset management. At our first Global Reliability Excellence conference, over 50 employees and service partners came together to learn, network and set our direction. It was here that many were introduced to the Uptime Elements for the first time. On our first conference day, an introduction to the Uptime Elements was provided, along with the announcement that this would be our framework moving forward. The week progressed with tours of local businesses, as well as sessions from both internal employees and service providers on specific topics of learning. But it was on day four when things changed. We were scheduled to discuss our path forward as a global community. What would be our direction for the future? What would we focus on? How do we intend to add value to the company? All difficult questions, particularly when there are several sites, countries, languages and cultures involved.

How do you facilitate such a discussion and ensure the team leaves feeling inspired about the future, knows the direction and has a sense of ownership? Not an easy task, but certainly a critical one. So as the group of 50 gathered in anticipation, we were all a bit nervous. No one knew the agenda of the discussion or the approach to be taken except George Williams, Associate Director and Reliability Excellence Lead for BMS. We were about to embark on a four-hour journey to set our future with nothing more than the certainty that when a great group of dedicated people gather and are empowered to determine their own path, extraordinary things will happen.

The group was randomly divided into four working groups. Each group was provided markers, sticky notes, pens, scissors and the Uptime Elements poster before heading off to a private room. They were then asked one simple

Figure 1



question: "If you wanted to ensure that from this day forward reliability was embedded in our culture and regardless of leadership and employee changeover, BMS would always manage its assets effectively, which Uptime Elements, in order of priority, must be in place?"

The groups were given two hours and complete creative freedom to develop their priority of elements in any method they chose. Along with George, Terrence O'Hanlon, CEO of Reliabilityweb.com and publisher of *Uptime* magazine, was on hand to witness the exercise and provide guidance on Uptime Elements as a holistic framework for reliability. As the exercise began, the groups started to take form. Leaders emerged, strategies developed and posters were mutilated. Group 1 sat around a table and began a lengthy debate on each element, its importance and how it relates to other elements in the framework. Group 2 handed out sticky notes for use in a voting methodology where each team member was given three votes of priority one, two and three to stick on the poster for tallying. Group 3 cut each element out of the poster and began to rearrange the elements on the table, eliminating elements they felt were less critical based on the guiding question. Group 4 began writing on flip charts, having open discussions and debating priorities.

Amazingly, each team went on similar journeys during the exercise. The first half hour was extremely active as groups spent time understanding the framework in totality. This was followed by questions to better understand the task at hand. Groups questioned the facilitators to better understand the expectation and become grounded in the true meaning of the question. How do we embed a culture where proper asset management practices are simply how we do business? Regardless of personnel turnover, regardless of leadership changes, regardless of business changes.

When the exercise began, each person went into the team room with preconceived notions of which elements were important to his or her site. Which were needed, which were already in place and which did they need a better understanding of to truly appreciate? Initial discussions were focused on trying to convince peers of the importance of elements that were important locally. As the task became clearer, the groups began to evolve. The groups moved from individuals from independent sites into teams. The thought process of what my site needs moved to what does BMS need. This led to a shift from task-related elements, such as vibration analysis, to more culture-based elements, such as executive sponsorship. A shift from reliability improvement to reliability sustainability.

The teams began to restart the process. Re-voting, open dialogue discussions and focused efforts began to take shape. The next hour was full of feverous progress. As the facilitators traveled from team to team, they were amazed at the progression taking place. Things were taking shape and coming together for each team, but what would happen when the teams presented their findings? Would this simply lead to more debate? We were excited to see the results and digest the conclusions.

The next two hours were spent with presentations, discussions and deep thought. As the teams regrouped and the first team prepared to present their priorities, you could sense the anticipation in the room. Would this exercise prove valuable? Would we know our direction or simply be back at the beginning with an unsure direction? Team 1 took the front of the room and began to present its strategy, providing an explanation as to why the elements chosen where selected, how they relate to one another and how they ensure reliability sustainability. Each subsequent team provided similar explanations, detailing the chosen elements, providing justification for their selections and presenting an understanding of how the selections fit together. One team even developed a slide presentation. To everyone's amazement, there were incredible similarities in the content and conclusions of the presentations. Each team presented their priorities and spoke about culture, leadership and people and did not put much focus on the more technical elements.

After the four teams presented, we began the exercise of prioritizing elements based on those selected by multiple teams and how high a priority they were. Amazingly, there was very little variation between the teams. Think of it, four teams of roughly 12 people each from varying sites, countries and backgrounds came to dramatically similar results. Not just similar, nearly matching perfectly.

As we finalized the exercise, we decided we needed to account for elements that were currently being worked on or recently worked on by the global community. Taking the teams' prioritized elements and incorporating the elements already being addressed was a short exercise and then…there it was. In all its glory was our future. A vision of prioritization to strengthen our already successful reliability journey, developed by all of us. A framework to embed a culture of reliability excellence and ensure long-term reliability sustainability. As the event came to a close, the team was invigorated and energized to begin working on our new direction.

The actual prioritization developed by the team is shown in Figure 1. Considering the large and diverse group that participated in this exercise and the uncanny similarities of their prioritized elements, it begs one to consider if there is a linear approach to a successful reliability journey. Perhaps we will revisit this in a few years to determine if our approach results in sustainability.

For now, you are encouraged to do the same. Regardless of the directional outcome of the exercise, you and your team members will accomplish a sense of ownership. Moreover, the teams will provide confirmation of the direction by selecting the same elements, even if not to the extent we did. This event proved to be a huge success, even if it began with a vision and a lot of faith. Lead by getting out of the way and letting the self-motivated team create the future.

In our future installments, we will cover how this exercise translated at the site level, how the central team's efforts aligned with our strategy, how we obtained 100 certified reliability leaders (CRLs) and how to manage all these efforts.

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-Tame Your Transient Operations, Chemical Processing June 2010.

1/2

PROFITABILITY

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- U.S. National Response Center

$8.4 Million

PER YEAR

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- Doug White, Emerson Industry Expert – Based on Current Refinery Economics.

AVAILABILITY

5%

PRODUCTION **CAPACITY LOST**

Production capacity is lost to as much as 5% every year as a result of unplanned shutdowns.

- Asdza Nadleehe, "Engineering & Maintenance: Prevention Is Better Than Cure," Oil & Gas IQ, October 2011.

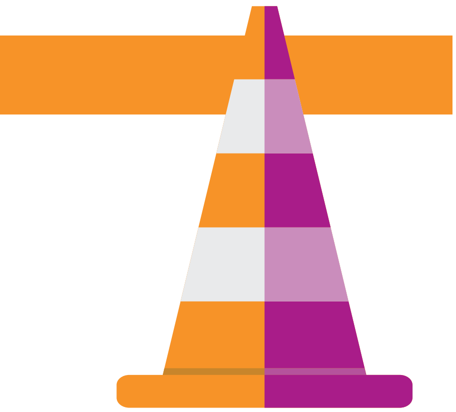
43%

DOWNTIME

As much as 43% of unplanned downtime is caused by equipment failure.

- Large Property Damage Losses in the Hydrocarbon-Chemical Industries, 17th Edition.

ITY DIFFERENTLY



ACCIDENTS
DURING TRANSIENT TIME

Improve Your Reliability to Achieve Bottom Line Results

Studies* show that companies reach the top-performing quartile when they have less than 3 percent unplanned downtime and maintenance costs less than 2 percent of plant replacement value (PRV). For example, a $1 billion top-performing plant spends $12 to $20 million per year on maintenance expense. By contrast, poor performers spend two to four times more per year.

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> By reducing scheduled and unscheduled downtime, companies can reduce their maintenance spend by 50 percent or more.
>
> *– Solomon Associates*

Emerson's success stories include Corbion, a global food and biochemical company. Corbion implemented standardized best practices of reliability over several years and reduced its global maintenance expense by one third while dramatically increasing availability. These actions enabled the company to capture millions of euros in increased profits and sustained increases in capacity and production.

**2013 Solomon RAM Study, Solomon Associates, LLC.*

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

by IMC Presenter Grahame Fogel and Johann Stimie

Part 1

This two-part article forms the basis of findings from PhD research conducted by Johann Stimie into the factors that prevent successful execution of asset management strategic initiatives.

Introduction

Organizations the world over are increasingly becoming more and more capital and asset intensive. Various studies show that spending on assets and asset performance has been increasing steadily over the past number of decades.[1] However, within the context of the very uncertain macroeconomic landscape, the largest challenge facing these organizations is the necessity to maintain and increase operational effectiveness, and manage a whole variety of risks while driving revenue and customer satisfaction. Organizations need to achieve these objectives while simultaneously reducing capital, operating and support costs. The contemporary business environment has thus raised the strategic importance of asset management, which is growing in significance as a professional and managerial discipline.

The recognition among organizational stakeholders that the management of assets is important and requires an integrated and strategic focus is indeed a very 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 intents is going to become an increasingly more important differentiator. This is Part 1 of a two-part article in which the authors have gathered the knowledge of global experience in strategy execution and focused it specifically around the challenges surrounding strategic asset management in order to provide readers with a framework for asset management strategic execution success.

The Increasing Importance of Taking a Broad View of Asset Management

The new ISO55000 standard on asset management states that organizations invest in assets to achieve organizational objectives. Asset management is the management and engineering science of how to align the capital investment associated with assets to a predictable and aligned return on capital. To achieve this, organizations initiate and invest in asset management improvement initiatives, with goals of getting a better risk managed return on assets.

The opportunities for asset management (AM) are substantial. Indications are that industry could recover between a third and a half of annual maintenance expenditure, increase production and free capital by improving AM practices. The size of the asset maintenance industry in the United States in 2005 was already $1.2 trillion, of which $750 billion was a direct result of poor AM.[2]

These realities have forced organizations, professional bodies, academics and practitioners to reevaluate and redefine their views on asset management.

Like CVD, ASEF is also largely preventable if and when the risk factors and causes are detected early and managed

There is agreement that AM requires a far more strategic approach and highlights the importance of a multidisciplinary skill set and cross functionality, and targets organizational synergies. The prevalent threats, from traditional paradigms such as a silo mentality and communication deficiency, shifted toward an integrated view that especially emphasizes the strategic and human dimension.

The collective recognition among AM stakeholders for the need to optimize the mix of cost, risk and performance over the asset's entire lifecycle and to do so in a governable and sustainable manner has been the biggest catalyst for the changes in the landscape. The recognition for the need to change led to a number of attempts in the last decade to standardize the field. These attempts led to the all-important publication of the ISO55000 standard in 2014. ISO55000 is the first set of international standards for asset management. The AM focus, according to The Institute of Asset Management, has shifted from *"doing things to assets"* to *"using assets to deliver value and achieve the organization's explicit purposes."*

The conclusion reached after assessing the literature and global experience is that organizations, in general, and AM organizations, specifically, are faced with numerous strategy execution challenges.

For the purpose of this article, these challenges will be divided into two main categories:

1. **Strategy formulation challenges** – On the business strategy, action planning and governance level, the contemporary business landscape requires organizations to continuously redefine and adjust their strategies and action plans to maintain and increase operational effectiveness, revenue and customer satisfaction, while simultaneously reducing capital, operating and support costs. This implies that executives need to regularly rethink and realign their position and plans regarding market segmentation, product development, product mix and market penetration and distribution.

2. **Strategy execution challenges** – The second category of problems relate to the inability of executives and practitioners to implement and execute strategies and plans effectively. This may lead to a fundamental misunderstanding of the definition of strategy execution and the problematic and often incorrect assumption that there is a direct correlation between organizational performance and strategy execution. For example, organizations often assume they have good strategy execution when markets are buoyant, but when markets change, organizations are left exposed.

The interplay between these two categories is illustrated in Figure 1.

Strategy formulation has been the topic of a great number of research projects and articles. Strategy execution, particularly in the AM environment, demands more cohesive attention. The amount of in-depth analysis and thought on the factors contributing to strategy non-execution is far less understood and thought out than those focusing on strategy formulation.

Asset Management Strategy Execution – A Bleak Picture

For the purpose of this article, asset management strategy execution (AMSE) refers to the continuous process during which an organization critically evaluates and adjusts three key factors to ensure that assets contribute to the creation of a sustainable competitive advantage.

1. The alignment, effect and orientation of its asset management strategy (AMS) relative to the organizational strategy;
2. The applicability of the AM organizational design and management systems, including control mechanisms;

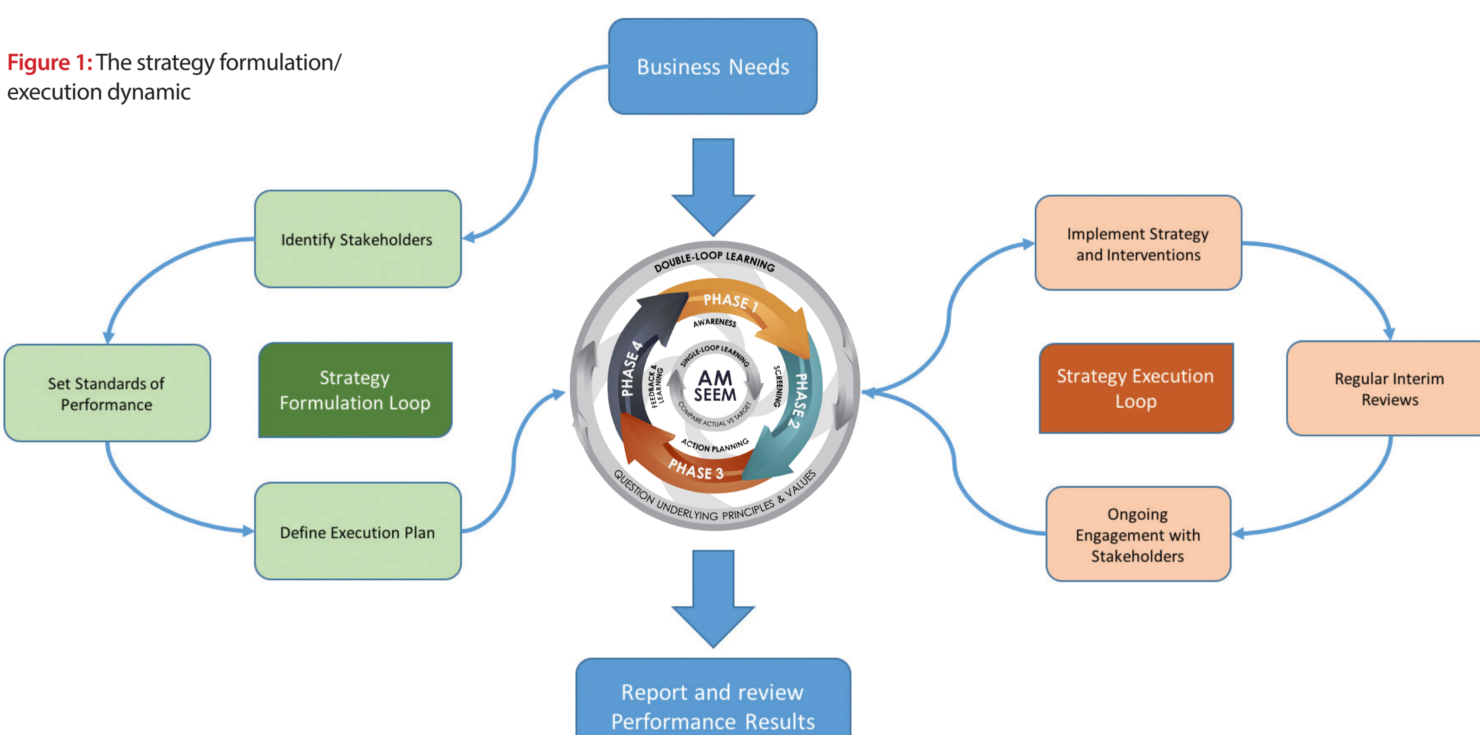

Figure 1: The strategy formulation/ execution dynamic

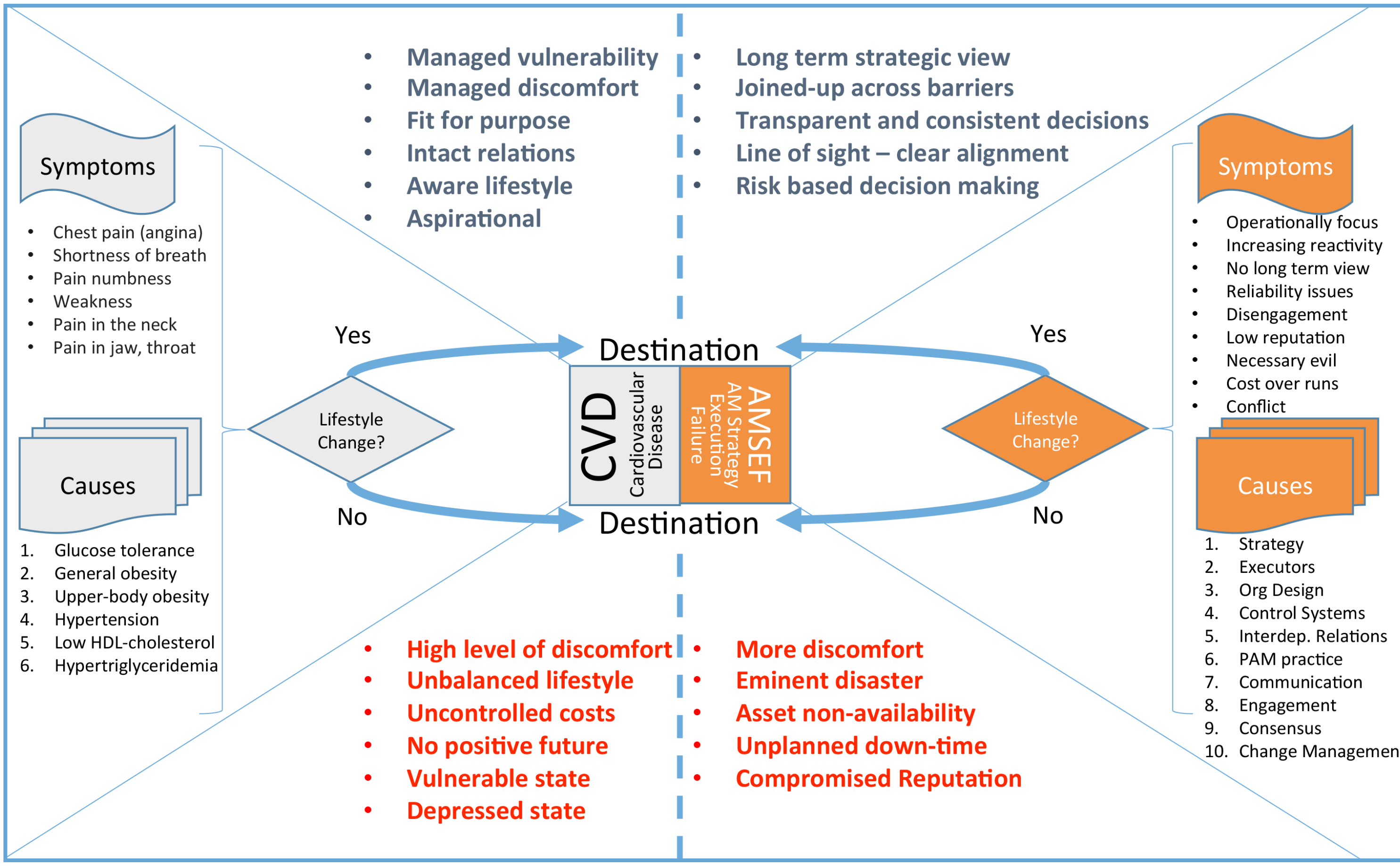

Figure 2: Comparison of cardiovascular disease and asset strategy execution failure (See "A Remarkable Analogy"- page 39)

3. The readiness of its interpersonal processes, such as strategic consensus, behaviors, organizational climate, cross-functional coordination and communication activities.

Global experience paints a rather bleak picture on the state of AM strategy execution. It is important to understand the scope of the problem, so here are a number of examples where companies had a fairly dispiriting experience:

- A study of 358 decisions made in medium to large organizations in the U.S. and Canada, found that 50 percent of the strategic decisions failed.[3] Another study found that 66 percent of corporate strategy is never implemented.[4]
- A study conducted by *The Economist* over a three-year period found a discouraging 57 percent of firms were unsuccessful at executing strategic initiatives.[5]
- A Mankins and Steele report[6] finds that companies only realize 63 percent of the financial performance promised by their strategies. In a survey of 156 large organizations, also conducted by Mankins & Steele, it was found that executives often make strategic decisions outside the planning process in an ad hoc fashion and without rigorous analysis or productive debate.
- Results of a study conducted by Kaplan and Norton[7] found that up to 95 percent of company employees were unaware of the strategy. The results of far more recent surveys confirm the strategy execution challenges contemporary organizations are facing.
- In its 2014 Global Performance Alignment Survey, PwC found that although 76 percent of global CEOs agree that their leadership team shares a consistent view of the strategic priorities, only 54 percent believe their strategy has been sufficiently translated into clear actions that will achieve their objectives.
- Another study of more than 400 global CEOs[8] found that the most important challenge facing corporate leaders in Asia, Europe and the United States is the issue of strategy execution.

Failure of strategic initiatives, such as implementing asset management improvement programs, bear not only the input costs and energy from the investment, but inevitably failure alters both the psychology and culture of an organization to huge negative effects.

The impact of asset management strategic execution failure (AMSEF) can vary from a mere "slap on the management team's wrist" to major loss of life, environmental damage, financial loss and reputational damage that might take years to rebuild, if at all possible.

One of the most extreme examples of a failed AM strategy is the Deepwater Horizon explosion and oil spill that resulted in the deaths of 11 people. At its peak in 2010, the response effort involved the mobilization of approximately 48,000 people, the coordination of approximately 6,500 vessels and the deployment of about 1500 kms of boom to contain or absorb the oil.

This also wiped out half the value of BP, which will take decades to recover.

A review of the global knowledge base reveals that the focus of most existing efforts to address the strategy execution challenge seems to be on the development of better management control mechanisms. These mechanisms are essential and provide useful feedback when actual results are compared to strategic objectives. They are, however, reactionary in nature and the feedback is often too little and too late, which, by definition, is a lagging indicator.

Many organizations find themselves in a strategy crisis not because executives and practitioners are unable to develop quality strategies, but because these organizations fail to execute strategies effectively.

With the strategy execution challenge clearly defining objectives, a series of business-oriented discovery exercises, combined with fundamental research, provided insights on how to manage through these challenges. This thinking led to an enforcement mechanism referred to as the asset management strategy execution enforcement mechanism (AMSEEM), which provides a quick and effective diagnostic indication as to whether your strategy execution is on track. The AMSEEM has been developed on the basis of best published knowledge, combined with practical experience, to align the success factors necessary to manage through to the achievement of the defined goals.

On the basis of extensive research into the factors that will align strategic success, a health checkup is recommended for execution success. This checkup should form part of your key performance indicators (KPIs) and be a key navigational instrument in bringing the initiative home.

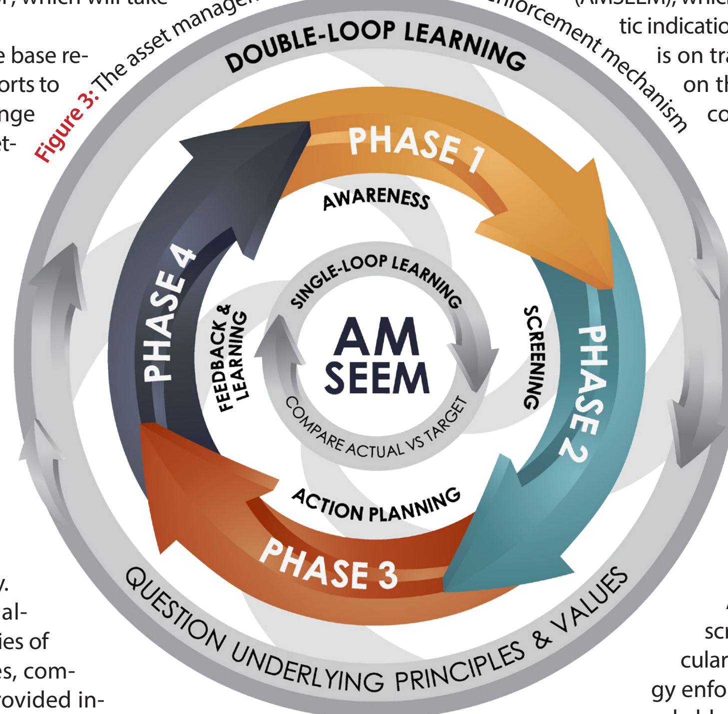

Figure 3: The asset management strategy execution enforcement mechanism

A Remarkable Analogy

During the development of the AMSEEM, the characteristics of the screening and management of cardiovascular disease (CVD) and the proposed strategy enforcement mechanism were found to be remarkably similar and the intuitiveness of the former provides a great platform to explain the latter. CVD is the single biggest cause of deaths worldwide. More than 17 million people die every year from cardiovascular disease. CVD undermines

Table 1 – Abridged AMSEEM Introduction

PHASE	MAJOR DECISIONS	PROCESSES
PHASE 1: Awareness	The most important decision during the Awareness Phase is regarding the need to optimize.	Step 1 – Constitute steering committee Step 2 – Evaluate PAMs Step 3 – Create Statement of Direction Step 4 – Introduce generic PAMSEEM Step 5 – Develop PAMSE calendar Step 6 – Continuous stakeholder communications
PHASE 2: Screening	The most important decision during the Screening Phase is the acceptance of the results of the screening process.	Step 1 – Contextualize the generic screening model Step 2 – Gather data Step 3 – Complete the model and calculate scores Step 4 – Interpret the results Step 5 – Present the results
PHASE 3: Action Planning	The most important decision during the Action Planning Phase relates to the prioritization of action plans. A number of methods to assist decision makers during the prioritization process is introduced.	Step 1 – Develop action plans Step 2 – Implement action plans
PHASE 4: Learning and Feedback	The most importance decision the PAM organization can take is to embrace the principles of continuous learning.	Step 1 – Data acquisition Step 2 – Data analysis Step 3 – Trade-off recommendations

health, shortens life expectancy and causes enormous suffering, disability and economic cost. The same is true of asset failures. CVD is largely preventable, and early detection and management can result in a major reduction in the burden caused by the disease.

Asset strategy execution failure (ASEF) undermines organizational performance and has major implications for the long-term sustainability of organizations. Like CVD, ASEF is also largely preventable if and when the risk factors and causes are detected early and managed. Addressing the underlying causes of ASEF and improving systems to detect and manage early indications of ASEF when interventions are most effective will ensure the desired outcomes.

The Asset Management Strategy Execution Enforcement Mechanism- *AMSEEM*

The AMSEEM has been developed to assist asset dependent organizations with early detection and management of factors contributing to strategy execution failure (SEF). The AMSEEM is illustrated in Figure 3.

The AMSEEM is essentially a double-loop feedback system consisting of four iterative phases, four major decisions and a number of implementation processes or steps. The AMSEEM is a practical mechanism that should ultimately become part of the organization's standard operating procedures and DNA. An abridged version of the decisions and processes involved in the AMSEEM is presented in Table 1.

The operationalization of the AMSEEM will be described in Part 2 of this article.

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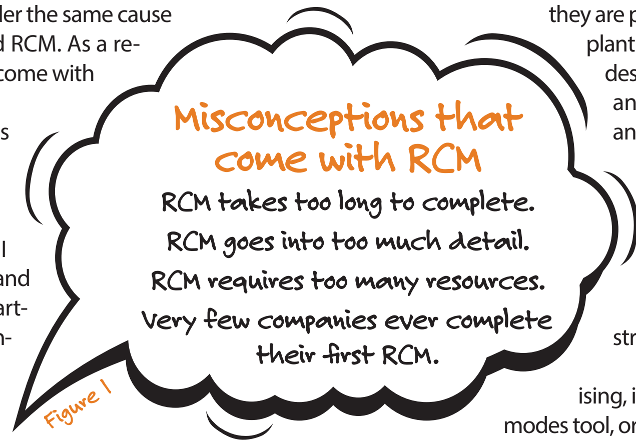
Why Are People Afraid of RCM

A Viewpoint from a Student Turned Facilitator

by Douglas Plucknette

It's been nearly 20 years since I first learned about reliability centered maintenance (RCM). As part of the Kodak Park Maintenance and Reliability Team, I was one of a few people who volunteered to take a few courses in RCM and report back to the team on the viability of the tool. I had no idea at the time that two decades later, I would be facilitating and instructing RCM at companies in nearly every country around the world. It's strange sometimes how quickly things change; one minute you're a maintenance team leader and the next you're facilitating reliability centered maintenance for a living.

One thing that hasn't changed in 20 years is that RCM is a very hard tool to sell. While I could list a dozen things that scare people away from starting an RCM effort, they all roll back under the same cause or fact: very few people really understand RCM. As a result, there are several misconceptions that come with RCM, as well. (Figure 1)



The sad thing is these misconceptions could be all easily resolved if those in need of a good RCM effort took the time to research or vet the people they select to instruct and facilitate their RCM effort. As I said before, very few people really understand RCM and many of those who don't work part-time as RCM facilitators, filling in to compensate for demand. Some may lack facilitation skills or have little experience actually working in the field of maintenance; in the long run, they hurt the effort.

On the other hand, the practitioners and facilitators who really understand RCM are so good that they make the process of facilitating and mitigating failure modes look simple. So simple, in fact, that many who observe them facilitating can be led to believe that any warm body could stand in front of a group and facilitate an RCM analysis. Having the belief that the facilitation process is simple, they now attempt to move forward and this is where RCM becomes dangerous. Inexperienced facilitators miss critical failure modes, failure modes that could result in catastrophic failure of your equipment.

If your RCM facilitator doesn't understand what a real failure mode is, how your parts and components work together, how they functionally fail, and the different types of maintenance and technologies available to mitigate failure modes, you can waste a lot of time and end up with less than acceptable results.

If you're going to invest in RCM, spend your money wisely and research not only the methodology, but the facilitator/practitioner to ensure success.

Those with an intermediate understanding of reliability engineering tools look at the RCM process and see a simple, 7-step process that addresses failure modes with some type of mitigating task. If these same people believe a pump is a pump and all its components have a set list of possible failure modes, you now have the second largest reason why people are afraid of reliability centered maintenance.

Some people believe the RCM process or exercise is unnecessary because the same thing can be accomplished with a library of failure modes and corresponding mitigating tasks.

Interesting concept really, just make a list of all possible failure modes for that part or component and match the best task to each failure mode. Why in the world would anyone sit through another RCM analysis when all that needs to be done is to load a list of your components, press one button on your computer and out comes a list of everything you need to do?

If it were only that easy. In reality, this is proof once again that very few people really understand reliability centered maintenance.
Let me explain why.

First, I would be a fool to say that failure modes lists or libraries and the tools people are using to match engineered failure modes to mitigating preventive maintenance (PM) and predictive maintenance (PdM) tasks are of no value. That statement could not be further from the truth. A list of common or engineered failure modes can help develop a sound maintenance strategy, provided the equipment is installed and operated within designed specifications. Using the tool will generate a list of PM and PdM tasks to mitigate these common or engineered failure modes. What the tools won't do is discover the failure modes that result from the environment, culture and operating context of the equipment. These failure modes libraries, listed under a growing list of trademarked names or software tools, can deliver value to your organization if they are properly applied to non-critical or the balance of plant equipment. In other words, if the company that designed the tool really understands failure modes and has the knowledge to understand what PM and PdM tasks are best suited for mitigating each failure mode at your site, and each task is both applicable and cost-effective, and you have the resources to implement this initiative full-scale across your site, then the process will help to improve the reliability of your assets at a level above your current maintenance strategy.

If that last paragraph doesn't sound too promising, it's because it shouldn't. The reality of any failure modes tool, or even RCM for that matter, is that if your company's maintenance program has not matured to a point where you have a core of three to five PdM tools in place and are able to plan, schedule and execute your PM and PdM tasks at the required intervals, the exercise will only create more chaos and frustration. Add to this the fact that the failure modes that occur most often, those that result from operating context, operating environment and culture, are not and cannot be included in the library.

Now don't get me wrong, I'm not saying you shouldn't use a tool that addresses engineered or common failure modes to help build your maintenance strategy. I'm saying, if you think you want to go in this direction, make sure you have the resources and infrastructure in place to support the tool. I know and have worked with several companies who have had tremendous success with the right tool, but they understood the difference between the tools and used both a failure modes library tool and RCM to build their strategy.

In closing, I know RCM isn't an easy pill to swallow. It takes time and experienced people to perform a good RCM. Plus, it takes a great facilitator to work with your team to complete a great reliability centered maintenance. Understand when it comes to the tools available to help improve reliability at your site, each has its applications and limitations. I happen to believe that RCM should be performed on somewhere between five and 20 percent of your critical assets, and the balance of your plant would be well served by a well-designed failure modes tool.

While it would be wonderful to be able to improve the reliability of all your equipment with the push of a button, the reality is that improvement comes through education, being able to identify your losses and selecting the right tool to eliminate the loss and sustain the gain.

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Ultrasonic Superheat Bypass Valve Inspection

by IMC Presenter Jim Hall and Jim Cerda

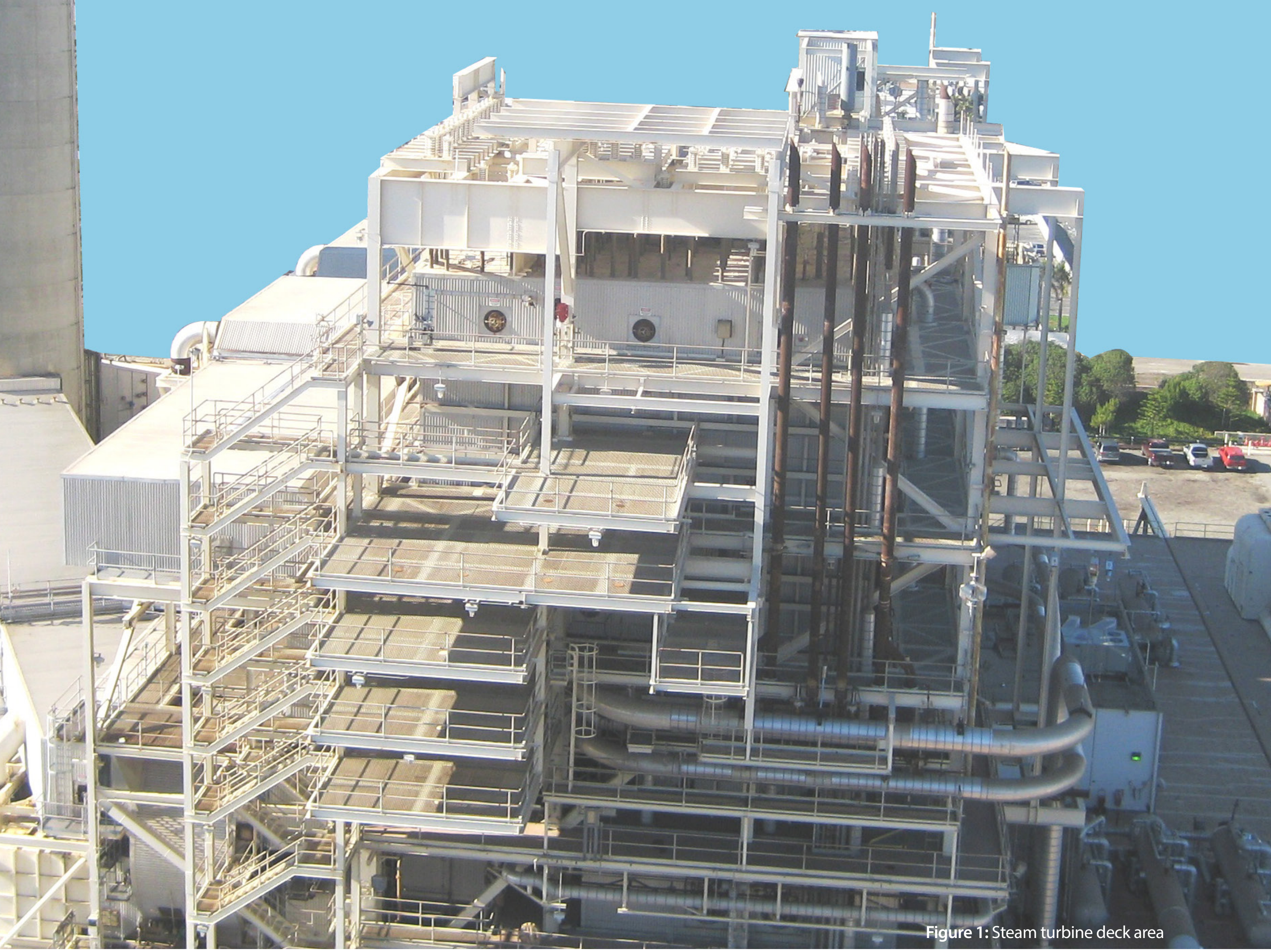


Figure 1: Steam turbine deck area

If you've attended ultrasound training courses, then you most likely learned about how to use a four point inspection for valves, no matter the valve type. However, the discussions within this practice or application always lead to other valve inspections. Among them is the use of ultrasound to listen to a valve through non-contact, or simply aiming the instrument at the valve to determine its condition. This would be like having an inverted bucket steam trap that has a "blow-by" condition (steam blow through). By simply aiming the ultrasound at the inverted bucket trap, the user would be able to hear the steam rushing through the valve and creating enough high frequency to determine its condition. However, a more favorable practice is making contact with the trap.

Ultrasound detects friction within the air, such as the sound a compressed air leak would make. Turbulent flow within a pipe or through a valve may also create sound audible to the ultrasound instrument, whereas a laminar flow may not produce enough friction to be audible to the instrument.

Ultrasound is high frequency and defined as sound above 20,000 hertz or 20 kHz. Today's ultrasound instruments have little trouble defining ultrasound in a noisy environment.

Figure 2: Three superheat bypass valves, where the valve bonnets and CV diaphragms are the only parts of the valves that are exposed

Airborne Ultrasound

Another ultrasound practice, referred to as airborne ultrasound, is non-destructive testing (NDT). NDT instruments commonly use a split transducer that sends a signal through the medium being tested. As it reflects back, that signal is calculated internally to detect thickness or location of a crack or anomaly within the metal or materials. This method is known as pitch-catch technology. Very short ultrasonic pulse waves have center frequencies ranging from 0.1 to 15 MHz and occasionally up to 50 MHz.

There are two ultrasound methods for predictive maintenance (PdM) or condition monitoring: airborne and structure borne. Airborne ultrasound uses the transducer as an open, high frequency receiver to detect a leak or electrical leakage (e.g., arcing, tracking and corona) within the surrounding air or atmosphere.

Structure borne refers to a transducer that is mounted to a magnetic base or a probe that receives the high frequency and amplifies then heterodynes the signal to a low frequency audible sound that can be discerned by the user.

This practice of using ultrasound for reliability and PdM is a practice that should never be underestimated. It should go without saying that you cannot have a world-class maintenance program without ultrasound.

The High Pressure Turbine Bypass System

The high pressure turbine bypass system provides an alternate flow path at the boiler's primary superheat section, taking the steam from the primary superheat section and bypassing the secondary superheat section and turbine and directing it into the main condenser.

This bypass system permits stable operation of the boiler when the turbine trips off-line or during start-up operations. Steam flowing through the high pressure bypass control valve is throttled and cooled to a temperature slightly above the HP turbine exhaust temperature by spraying feedwater at the outlet of the bypass control valve. The control system must provide the logic to open the valve quickly and modulate the feedback control to pressure and temperature set points.

During operation, the HP bypass provides the same expansion and cooling that would have happened in the HP turbine.

Ultrasonic Inspection Bypass Valves

Jim Cerda, a process engineer at AES Southland with Ultrasound Level 1 training, had been requested to "help" find a superheat bypass valve leak or "leak-thru" that may be leaking within the facility's Unit 3 superheat steam bypass system.

Here is Jim's account of the inspection as it took place:

The leak-thru was affecting the unit heat rate as superheat steam was leaking through and bypassing the turbine and going back into the condenser. The turbine bypass system is a basic component of the power plant that has evolved over the years to increase oper-

Figure 3: Flowchart of bypass system

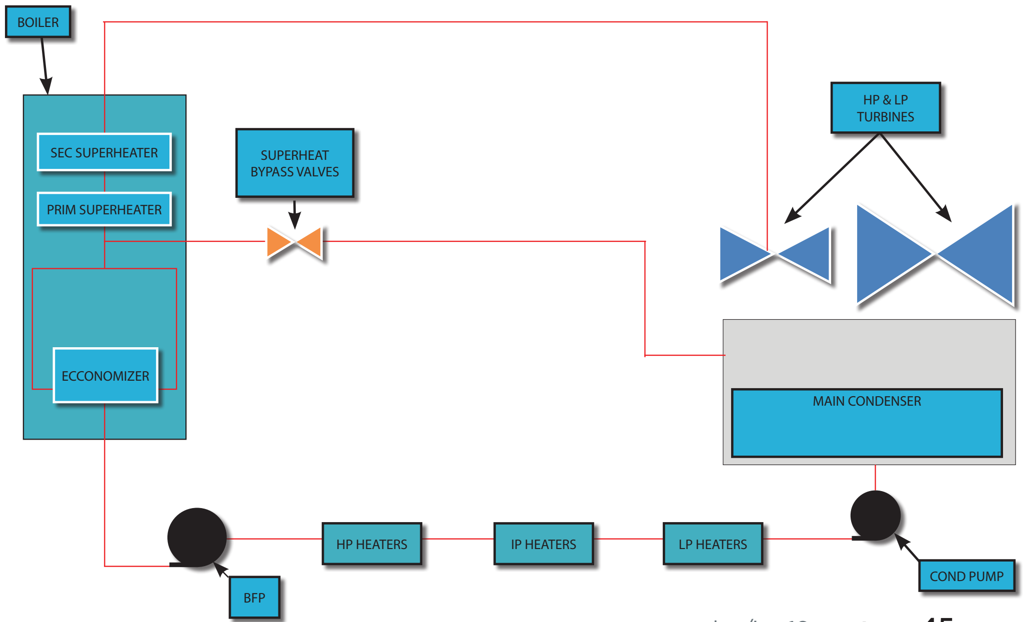


Figure 4: An instrument similar to this was used to locate the leak on the superheat bypass valves

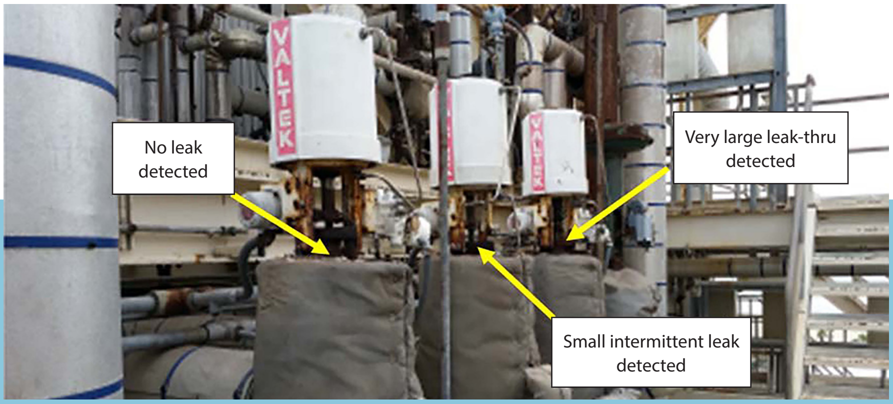


Figure 5: Even with insulated blankets in place, bypassing steam could be detected using a contact probe between openings

ational flexibility and plant life, protecting its components during start-up mode. Each unit at this plant has a total of seven superheat bypass valves, commonly nicknamed the "seven sisters." They bypass the turbine during start-up. The boiler's primary superheater is rerouted back to the condenser during start-up until steam conditions are met to roll the turbine. Also during start-up, the bypass valves maintain boiler pressure until control is sent back to the boiler feed pump.

This particular Unit 3 was entering its planned outage season, so there was a very limited window to locate the source of the leak and take care of the problem. The "help request" was issued by a maintenance technician that had planned to use infrared thermography (IR) technology to look for the leaking valve. But, it was decided to bring in an ultrasound instrument with a contact probe to listen to the valves.

The turbine bypass system enables independent activity of the steam generator and the turbine during start-up, load rejection, shutdown and variable pressure operation.

Upon reaching the location of the superheat bypass valves, it was noticed that the valves were almost completely covered with insulation and aluminum lagging, as well as insulated blankets. The valve bonnets and the upper sections of the control valve diaphragms were the only parts of the valves that were exposed.

The maintenance technician had already turned on the thermography camera while the ultrasound instrument with the contact probe (Figure 4) was being set up. While the maintenance technician scanned the superheat bypass valves, the ultrasound technician worked in the opposite direction, slipping the contact probe between the insulated blankets and testing each valve.

The ultrasound instrument used for this application was an analog instrument. Either an analog or digital instrument can be used for this application, both are equally effective. This particular instrument, which is still available from the manufacturer, is widely used for hydrogen leaks in power plants. It has an FM rating, Class I, Division I, Groups A, B, C and D, and is also intrinsically rated (IS).

After finishing the testing of each valve, the maintenance technician using infrared thermography had no conclusion. Looking through the IR camera, the three valves looked the same.

On the other hand, the ultrasound technician had much better results using ultrasound technology. It revealed that the north valve was not leaking, the center valve had a small intermittent leak and the south valve was definitely the leaking valve.

With these results, the maintenance technician took another look through the IR camera. Again, nothing could be seen or detected. The maintenance technician switched to the ultrasound instrument and listened. With the instrument set at the same settings as before (maybe slightly higher for effect), the north valve was checked again and the technician nodded that he heard nothing. Next, the center valve was checked and with a small smile on his face, the maintenance technician said he could hear the small intermittent leak. Then, he listened to the south valve. As he placed the contact probe through the insulation and squeezed the ultrasound instrument's trigger, the look on his face read, "Are you kidding me?"

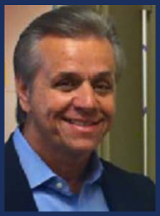
The sound, he said, was so loud that "it sounded like a continuous explosion" and it was very clear that it was the leaking valve of the system. He then admitted that the ultrasound instrument was "way cool."

Since that superheat bypass valve inspection, other superheat bypass valves on the other unit pair (Unit 4) were found leaking during the next few outages. Again, ultrasound was used. These problems were also a major source of heat rate loss.

Usually, heat rate loss is an accumulation of many small leaks that must be all repaired to have a full impact on heat rate dollars. With fixed contracts, companies have to look for these types of savings to retain projected profits. Heat rate dollars are dependent on fuel and prices, and the price of megawatts at that time.

The power plant has since sent four of its operators and maintenance technicians, as well as a couple of other technicians, to acquire ultrasound Level 1 certification. Through their successes, they have found many leaks throughout the plant, which included compressed air, fuel gas, hydrogen gas (H2), nitrogen gas (N2), water and steam. Ultrasound is also being used during the electrical IR/thermography scans, for nitrogen blanket leaks on transformers and is part of the facility's reliability maintenance program.

Ultrasound is just part of an effective reliability program. It complements vibration and infrared programs. Remember: *You cannot have a world-class maintenance program without ultrasound.*



Jim Hall, *Executive Director of The Ultrasound Institute (TUI) and Ultrasound Technologies Training Systems (USTTS), has over 25 years of experience and operates as a vendor-neutral company, providing on-site ultrasonic training and consultation. Mr. Hall is the author of the free biweekly newsletter, Ultrasonic War Stories, and is a regular contributing author for Uptime Magazine. www.Ultra-SoundTech.com*

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Solving the Mystery of Integrated Supply for MRO

by George Krauter

What Is It? What Is It NOT?

It is becoming increasingly evident that the lack of world-class support from the maintenance, repair and operations (MRO) stores is having a significant and detrimental effect on maintenance reliability programs. Fill rates (i.e., availability of needed parts from stores) average less than 75 percent. This means the availability factor of parts needed is not reliable. A reliable plant requires all functions in maintenance's lean reliability programs to be reliable. Since availability of parts needed is a component of the reliability program, an unreliable MRO storeroom becomes detrimental to reliability goals.

Critical spares must be available in the quantity required 100 percent of the time, otherwise mean time to repair (MTTR) is extended, causing uncontrolled downtime and a drain on profitable operations. The insecurity that maintenance managers have regarding MRO stores causes them to create a buildup of sub-stocks (e.g., spares stored in desks, closets, etc.) to be used as a buffer against out of stock situations. This causes unnecessary consumption of budget dollars and duplication of uncontrolled inventory because of the inefficient and uncoordinated MRO stores procedure.

While plant personnel are continually confronted with MRO challenges that detract from reliable goal achievement, suppliers are generally not forthcoming with methods to improve the supply chain and reduce their clients' total cost of ownership [TCO]. They have quotas to meet and want to sell as much as they can. It's the mentality, "We have the best price and best delivery, give me the order…it's my turn." Get the order and move on is the sales mantra, never mind proposing changes in the supply chain that benefits clients and American industry overall. The result is a stagnant MRO situation that remains unchanged.

So, what is the solution? Is there a process in the MRO supply chain that satisfies the needs required to achieve a reliable plant? What changes should occur to solve the problem and still maintain cost control at optimum? In the quest for solutions, MRO has become one of the focal points for opportunity. Internally, these questions arise: What statement of work will work for us and effect the needed change?...How do we change?...How do we implement?... Who would be in charge?...Will everybody agree to the change?...Can we do it ourselves?...Why haven't we?...Is there a provider who has the solution we need with the commitment to sustain the benefits?

Solutions to the MRO problem emerged in the early seventies when an industrial distributor established a storeroom on-site within a manufacturer's facility. The effect eliminated duplicated steps in the MRO supply chain and provided the needed MRO support for a reliable plant. Over the years, this process became known as integrated supply. Various industrial distributors attempted to become providers of integrated supply, forced to do so as a defensive measure. There is no clear definition of the term, so as a result, integrated supply means many things, many times negative, based on who is talking.

Choosing a process labeled as integrated supply is dangerous because of the diverse definitions that exist. (There is one distributor with nine different definitions). If an inadequate MRO change process is selected and installed under the name integrated supply and it fails to meet the reliability goals set forth, the company will not try that "BAD" thing called integrated supply again.

The goal of this article is to define optimum integrated supply as it should be in relationship to plant reliability and provide an outline of the advantages and disadvantages that exist within the process.

Integrated supply should:

- Provide a 25 percent plus inventory reduction.
- Increase fills rates to 98 percent with 100 percent availability of identified critical spares.
- Eliminate uncontrolled sub-stocks.
- Maintain 99 percent plus inventory accuracy.
- Reduce transactions to just two invoices per month.
- Control price and share savings with the provider.
- Establish mutual sharing of all costs.
- Maintain a company required audit trail.
- Reduce freight costs.
- Provide optimum computerized maintenance management system (CMMS) capabilities.
- Arrange product seminars to connect maintenance personnel with manufacturers' engineers.
- Offer reengineering services.
- Coordinate MRO operations and communications with plant reliability efforts.

Pure integrated supply is accomplished by utilizing a committed provider operating the MRO supply process on-site while eliminating the waste in the existing supply chain.

Here is an example of the effects of PURE integration properly applied by a food company:

Senior management required purchasing and operations to remove $20 million from next year's spend. The reduction goal assigned to MRO was a $2 million total cost of ownership cost recovery amount. The MRO portion of the overall cost reduction goal equaled 10 percent, even though MRO was only five percent of the company's spend.

This is what happened:

- Upgraded CMMS including management of MTTR, failure mode and effects analysis (FMEA), reliability maintenance, master equipment list (MEL) and bill of material (BOM): Not Valued
- Price reduction…Guaranteed 5%; Shared Savings 3%.......... Savings: $358,000
- Inventory recovery…..30%.....Savings: $410,000
- Fill rates…..98.6%, up from 76%.....Not Valued
- Inventory accuracy….99.7%……Not Valued
- Transaction elimination…..75,000…..Savings: $225,000
- Freight savings….3%.....Savings: $18,000
- Downtime…..Zero……Not Valued
- Productivity programs…..Savings: $853,000
- Personnel reassignment…..Savings: $180,000
- Warranty recovery…..Savings: $276,000

This food processing company experienced a total measured savings in excess of $2.3 million. While the financial goal was achieved, the non-valued functions and processes help establish improved service benefits.

What pure integrated supply is not:

- Vending machines;
- Vendor managed inventory (VMI);
- Blanket orders;
- Long-term agreements (LTAs);
- Electronic data interchange (EDI);
- E-catalog;
- Pricing consortiums;
- Systems contracting;
- Etc., Etc.

These services should not be labeled integrated supply because they fall far short of the disciplined processes required to change the MRO situation to optimum support for plant reliability.

Here is an example of the dangers of a failed program that was labeled integrated supply:

A health care company experienced excessive downtime caused by a lack of MRO parts. MRO inventory had a negative stock turn rate, uncontrolled sub-stocks exceeding $200,000 and growing, and long-term price agreements that were ineffective. Change was essential to stop the drain on reliability.

The company asked its major suppliers to share solutions. Upon review, the company selected Distributor A's plan called integrated supply. The result was a disaster because Distributor A is a DISTRIBUTOR with little knowledge as to what is necessary to implement, operate and sustain a pure on-site integrated supply program. The distributor operated under the belief that, "It's like a hardware store; how tough can it be?"

Here's what happened:

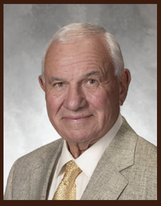
- Inventory was not reduced because Distributor A still had off-site inventory costs.
- Prices were not reduced long-term because of added operational costs.
- Programs installed were shortsighted and did not solve the problems the company had that instituted the need for change in the first place.
- The traditional distributor's salesperson could not be reassigned, which added unnecessary costs.
- Distributor A was unaware of the commitment necessary to implement and sustain.

The company terminated the agreement with Distributor A and attempted to solve the MRO situation internally. Some improvements occurred, but fell far short of the potential available.

All this failure in the name of integrated supply.

To say the least, this situation was costly in itself, however, the major cost was the lost opportunity. The integrated supply approach failed and will never be tried again by this company. If pure integrated supply had been initiated by a "pure" integrator, then benefits would still be in place and the company would be free to concentrate on its core competency.

MRO change is critical for reliability. Pure integrated supply provides the optimum solution when properly applied and sustained. But the BIG question is: Can the change be established and sustained in-house or does success require that a third-party expert be employed to ensure success?



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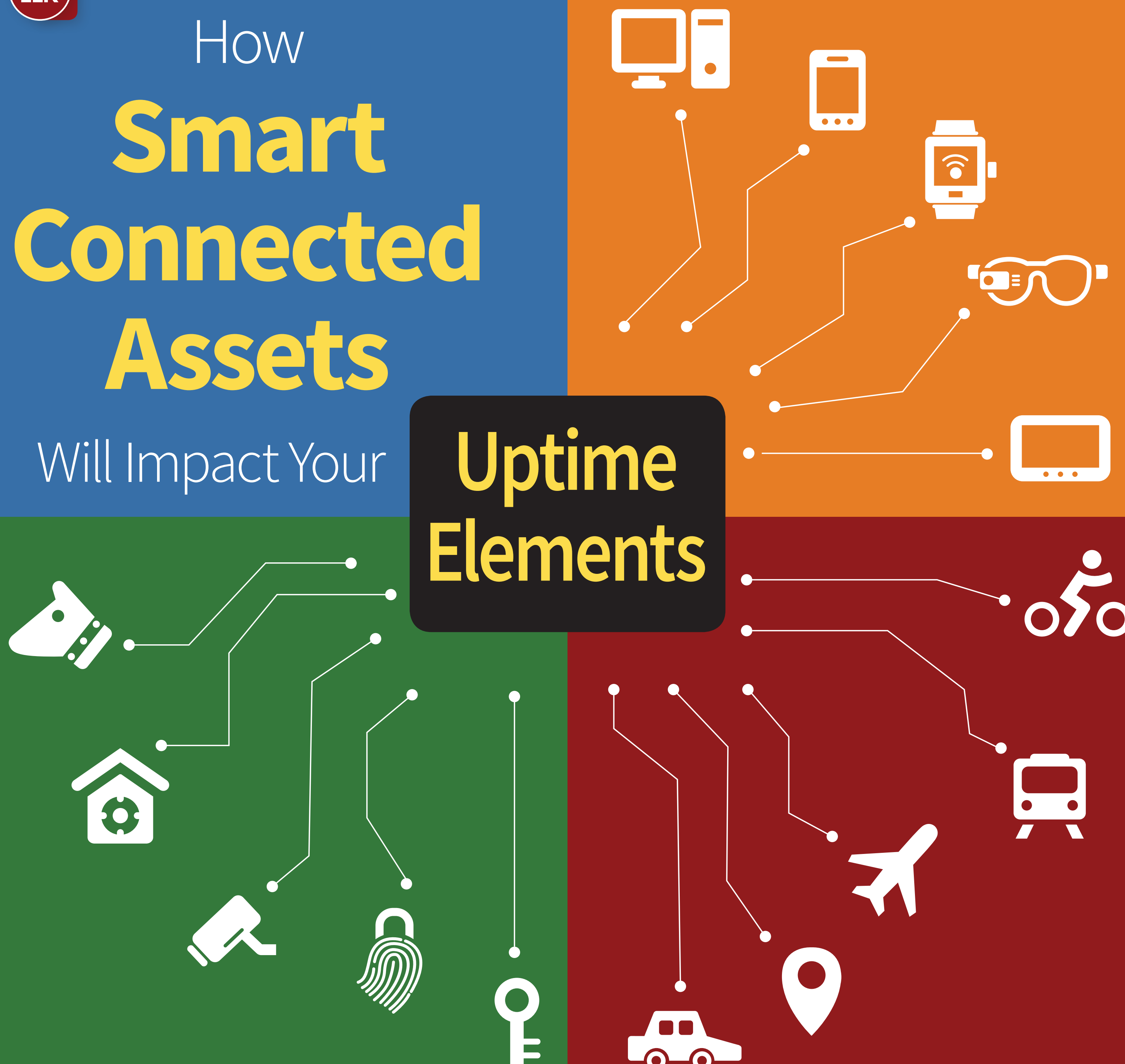
Leadership for Reliability

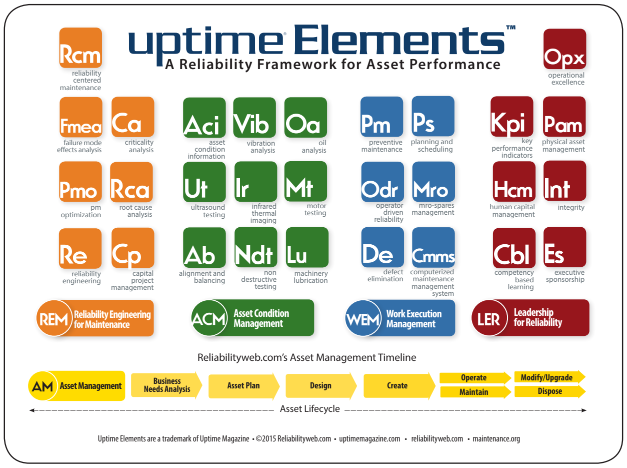
How Smart Connected Assets Will Impact Your Uptime Elements



by Dan Miklovic

Smart connected assets are going to change the way people view asset performance management

Whether you call it the Internet of Things (IoT) or the Industrial Internet of Things (IIoT), the simple fact is everyone is talking about the technological shift taking place today that is creating previously unimagined connectivity between myriad of devices. Many say IIoT isn't actually new, as sensors have talked to controllers and other systems for decades and maintenance technicians have used tablets for at least 15 years. However, there is a different viewpoint, which this article explores.



It's true that manufacturing has long had connected devices and it's also true that there have been plant networks for just as long. Manufacturers and field service organizations, in particular, were early adopters of mobility solutions, though there are some fundamental differences today than in the past.

There is the simultaneous convergence of the aspects of connectivity, embedded computing, wireless technology, the Cloud, and big data and predictive analytics that presents something completely new. If you consider IIoT as representative of the convergence of wireless, universal connectivity and embedded computing, then when you add in the Cloud and big data with analytics, you end up with smart connected operations and the plant level equipment that supports that environment. This is referred to as smart connected assets.

Smart connected assets are going to change the way people view asset performance management (APM). As smart connected assets become more prevalent, you will see a whole new range of business models emerge, from selling reliability focused predictive analytics services to business processes and from outsourcing of maintenance activities to ultimately selling capacity instead of capital. These views are echoed by a number of industry luminaries, including GE CEO Jeff Immelt and Harvard Business School's Michael Porter.

Asset Condition Management

Today, a large percentage of ACM activities are performed using off-line, batch type processes, such as oil analysis, thermography, ultrasound testing, vibration analysis and other non-destructive testing. Asset condition data collection can be either online and in real time or, like other tools in ACM, off-line and batch oriented. As smart connected assets start to proliferate, many of the measurements taken today by operators or inspectors making rounds will be available in real time. Even when information is still collected by humans performing inspections, the capture of the data and its uploading into systems that make real-time use for predictive analytics will change the way the data is used.

When measurements are actually made instead of just moving on to the next device, a real-time predictive engine may return a request for further data collection to better define the reliability risk. It may make a recommendation of how to change the operational profile to reduce the risk or even suggest some remedial maintenance action on the spot to reduce failure risk. This type of predictive capability will depend extensively on real-time data collected via the IIoT, as well as big data and predictive analytics delivered either locally or via a cloud service based on equipment class, location and access to communications.

Work Execution Management

It may seem at first that smart connected assets will not have substantial impact on work execution management activities, but the opposite is actually true. Almost every element in the WEM area will see changes brought on by the growth of predictive analytics and greater mobility of the workers actually servicing the equipment.

Framing APM and Reliability With the Uptime Elements Model

The Uptime Elements model of *Uptime* magazine and Reliabilityweb.com is one of the more widely accepted models of how to frame the activities associated with APM and reliability. If you want to understand where smart connected assets will impact your own operations, one assessment method is to use the Uptime Elements model and consider each activity and how smart connected assets play into that element.

At the center of the Uptime Elements model are asset condition management (ACM) and work execution management (WEM). Let's take a look at how smart connected assets will impact each.

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Perhaps the greatest impact will be the advent of new maintenance services by original equipment manufacturers (OEMs), ranging from predictive analytics that notify end users when to schedule and perform maintenance to full business process outsourcing of the servicing of process equipment. This will change the scheduling and reporting functions to those of coordination and contract management. In this scenario, parts management also changes from owner to service provider managed.

Even in a scenario where the OEM is not providing enhanced services, smart connected assets will definitely change many of the WEM functions. Using the richer data, preventive maintenance will be more precise, spares can be better managed with more accurate service forecasts and defect elimination will be enhanced with greater details on performance-related issues. Operator driven reliability will also change as operators gain greater visibility into actual machine performance with data instead of just their observations.

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Looking beyond these core elements are the process and leadership aspects of reliability engineering for maintenance and the leadership for reliability activities. Much of APM has been focused on the technology, but the convergence of people, processes and technology is the way to truly reap the benefits from APM, and the Uptime Elements model does an excellent job of capturing this. Taking a look at each area, you will see smart connected assets as having a substantial impact.

Reliability Engineering for Maintenance

In the REM arena, as with operator related reliability, smart connected assets enable engineers to have much better information to make RCM related decisions, particularly root cause analysis. Failure mode, effects and criticality analysis (FMECA) also will be enhanced in an environment that has smart connected assets, as these assets can provide information related to their configuration and position in a given process train in real time, making failure mode and effects analysis (FMEA) and FMECA less of a human intensive, batch oriented process and more automation enabled. Even capital project management will change in a smart connected asset world as some OEMs opt to sell capacity instead of capital.

To draw an analogy to a different industry sector altogether, the manufacturing facility of the future may be more like the film industry today than the pre-World War II years of Hollywood. In that era, giant studios controlled every aspect of making a movie, whereas today, movies are made through loose and fluid associations of producers, directors and other specialists who all converge to accomplish a task and sell their services rather than being specific studio employees.

This model could well be the way factories of the future operate, where OEMs sell "holes" instead of drills and bits, adhesive applicator OEMs sell joints instead of machines, and so on. This will ultimately alter how we look at capital investment and, consequentially, change the whole project management paradigm.

Leadership for Reliability

One might expect the least impact from smart connected assets in the LER sector of the Uptime Elements. While this might appear on the surface to be the case, as with WEM, nothing could be further from the truth. Starting with operational excellence (OE), smart connected assets will drive whole new levels of performance and set new definitions of what excellence actually *is*. Indeed, with smart connected assets ultimately capable of autonomous operation, you can expect a major upheaval in how operational excellence is defined and measured.

With APM being one of the five basic pillars of overall operational excellence, delivering on OE will be essential for organizational operational excellence. Essentially, every other area in the LER part of the Uptime Elements table will be directly impacted by smart connected assets, with the exception of executive sponsorship. Ironically, this will still remain a purely cultural issue, but the nature of that support will need to shift from just endorsing APM as a strategy to fully endorsing the investment in technology that makes APM a cornerstone of operational excellence. It requires a fundamental understanding that *healthy assets are the foundation of a healthy business* and that smart connected assets are the best path to achieving that reality.

Though there are some who contend that IIoT is merely an extension term to the connectivity that has existed in maintenance for more than a decade, others believe smart connected assets will have an impact unlike any to date in the APM space. An understanding of how this trend will affect your Uptime Elements will go a long way to helping you take advantage of what smart connected assets can offer.

Dan Miklovic *is Principal Analyst for LNS, with a primary focus being research and development in the Asset and Energy Management practices. Dan has over 40 years of experience in manufacturing IT, R&D, engineering and sales across several industries.*
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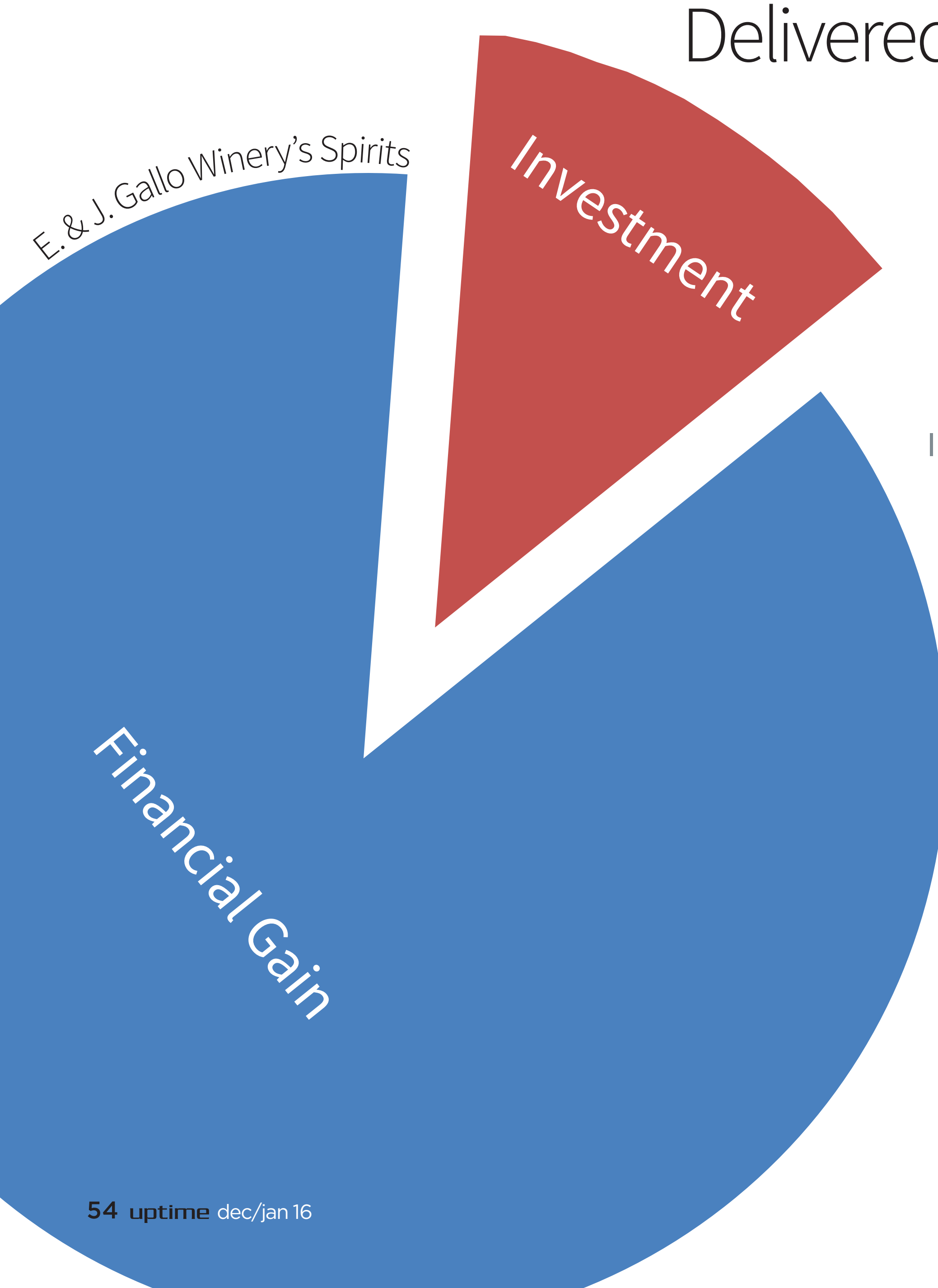
How a New Reliability Maintenance Program Delivered a 705% ROI



by Clay Calk

In 2012, E. & J. Gallo Winery's spirits making plant committed time and resources to transition its current asset management and lubrication program to a world-class reliability maintenance program utilizing professional services and enhanced lubricants. Plant management's key objectives for the new reliability maintenance program were targeted to accomplish three plant goals: improve overall equipment effectiveness (OEE), reduce cost and increase plant profitability. Here's how the successful transition took place.

Key objectives: Improve overall equipment effectiveness, reduce cost and increase plant profitability

Preliminary Information

In the strategic planning phase, six key areas were targeted for review and evaluation prior to the new program's implementation.

1. Understand current costs associated with the existing program, including electrical energy usage, cost of unscheduled downtime, annual lubricant expenditures, prevention of historic major failures, frequency of repairs/rebuilds and labor costs associated with reactive maintenance.
2. Perform a comprehensive detailed asset inspection. List current lubricants used, parts to lubricate, method of application, fill quantities, and service and change interval. Verify whether or not current lubricants meet or exceed operations and maintenance (O&M) specifications for each asset.
3. Inspect each critical asset and identify the appropriate lubricant sampling hardware as part of a new condition-based program. Identify the appropriate contamination control hardware required to protect the asset and lubricant from particulate and moisture ingression so as to maximize each asset's lifecycle.
4. Inspect current lubricant storage and handling conditions and determine if they comply with Gallo's 5S system (**sort/straighten/shine/systemize/sustain**) for workplace organization initiatives.
5. Set up metrics for performing a gap analysis to document before and after program savings to justify the return on investment (ROI).
6. Improve the level of knowledge and education of Gallo's maintenance personnel to aid in changing the culture and drive lubrication and asset reliability methodologies for continuous improvement.

Phase I – Program Evaluation

In 2012, Phase I began with the performance of a comprehensive reliability assessment and equipment and lubrication survey of all lubricated assets to understand the process, current lubricants and current practices in order to establish the program's baseline.

Macro overview of survey's findings:

- Inspected and evaluated approximately 1,820 lubricated components.
- Discovered that:
  - Twelve percent of the application points were being lubricated with the wrong viscosity or wrong type of additive system per O&M specifications.
  - Consolidation opportunities existed to reduce lubricant products at Gallo by 31 percent.
  - Lubrication storage, handling and transfer facility required improvement per 5S initiatives.
  - Filtration, oil analysis monitoring and contamination control required attention.

Plant Area Location	Equipment ID	Description	Make & Model	Part to Lubricate	LE Product	Method	Fill Qty	Service Interval	Change Interval	Analysis Interval	LEAP Test Kit Type	OEM	Current product
Line 21 Bottling	ID: Beer GMBH Belomat Foiler	Beer GMBH Belomat Foiler	Baldor Electric Motor	Electric Motor		Sealed							
Line 21 Bottling	ID: Beer GMBH Belomat Foiler	Beer GMBH Belomat Foiler	Dodge Tigear 2 Gear Reducer	Gearbox	9460	Fill	1 Pint	12M	12M			Mobil SHC 634, ISO VG 460, SAE 140W	Lubriplate SFGO Ultra 460, SAE 140W, AGMA 7S, PAO
Line 21 Bottling	ID: Beer GMBH Belomat Foiler	Beer GMBH Belomat Foiler	Chain	Chains x 2	4059	Spray	Coat	12M				ISO VG 68, SAE 20W	Lubriplate FMO-350-AW-Spray, ISO VG 68, SAE 20W, Mineral
Line 21 Bottling	ID: Beer GMBH Belomat Foiler	Beer GMBH Belomat Foiler	Column Bearing	Ball Bearings x 3	4025	Grease Gun	1-2 Shots	12M				NLGI #2 EP	Lubriplate Puretac #2, NLGI #2 Non-EP, Aluminum Complex, Mineral
Line 21 Bottling	ID: Beer GMBH Belomat Foiler	Beer GMBH Belomat Foiler	Chain & Sprocket	Chain & Sprockets x 2	4059	Spray	Coat	12M				ISO VG 68, SAE 20W	Lubriplate FMO-350-AW-Spray, ISO VG 68, SAE 20W, Mineral
Line 21 Bottling	ID: Beer GMBH Belomat Foiler	Beer GMBH Belomat Foiler	Open Gears	Open Gears x 2	4025A	Spray	Coat	12M				ISO VG 68, SAE 20W	Lubriplate FMO-350-AW-Spray, ISO VG 68, SAE 20W, Mineral

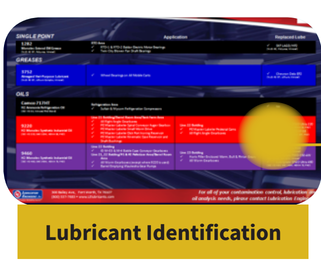
Figure 1: Reliability assessment

Figure 2: Before and after lubricant storage room

Figure 3: Before and after lubricant utility carts

Phase II – Program Transformation

Phase II of the program transformation was to focus efforts on the lubrication storage and handling area to eliminate contamination where it originates (new lubricants). Furthermore, the existing lubricant storage and handling facility required improvement to Gallo's 5S initiatives, making this change a priority before moving the initiative downstream. The plan would include adding proper lubricant storage with three-way filtration and desiccant breathers, lubricant product identification and color-coding to mitigate cross contamination and lubricant misapplications on the plant floor. Organization and procedures for sustainability also would be part of the plan.



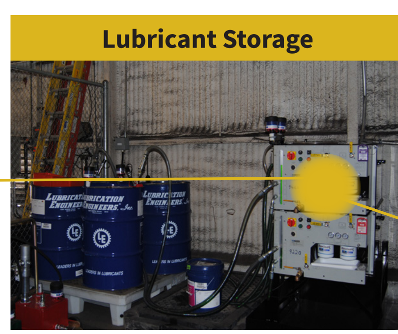


Figure 4: Lubricant color mapping for lubricant storage room

Phase III – Program Transformation

In the next phase of the transformation, Gallo's 5S initiatives that began in the new lubrication storage and handling facility were applied downstream to each asset on the plant floor, with proper lubricant identification and color mapping for both oils and greases.

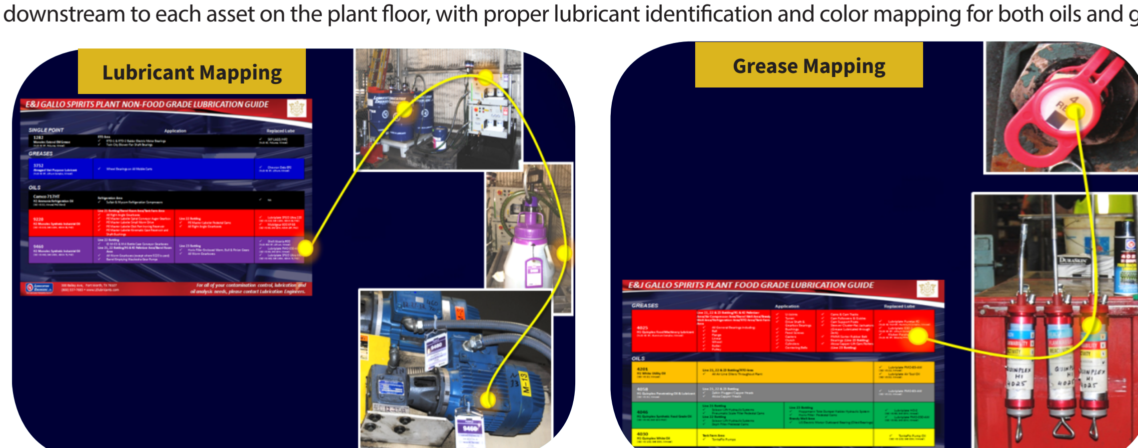


Figure 5: Lubricant color mapping from lube room to application point (oils and greases)

Figure 6 (a-c): Reliability hardware asset modification

Phase IV – Program Transformation

After completing Gallo's 5S initiatives downstream, Phase IV centered on two critical areas that would extend the lifecycle of each critical asset, as well as provide longer oil life, reduce costs, increase overall equipment effectiveness (OEE) and provide tangible and measurable bottom-line returns.

First, moving from a time-based to a condition-based lubrication program, Gallo installed lubricant sampling valves in the primary sampling zone on all critical assets. This provided Gallo technicians the capability to pull accurate, representative lubricant samples on the fly while equipment was running to eliminate unnecessary downtime. Second, the program had to address the contamination control program for all critical equipment. This step was crucial in order to mitigate the most destructive particulates (e.g., dirt and water) that led to frequent oil changes and reduced asset lifecycle.

Protecting these assets from these destructive particulates, coupled with condition monitoring, ensured multiple benefits, including: 1) longer oil and asset life, 2) less oil waste disposal, 3) reduced downtime, 4) less reactive maintenance and 5) improved electrical, asset and overall equipment effectiveness. These benefits yielded measurable cost savings that will continue to pay dividends perpetually.

Phase V – Program Transformation

The number one reason new program transformations are unsuccessful is the culture of the organization. Gallo's strategy to drive this culture change was by increasing the level of knowledge and education of its people. The type of education and training body of knowledge that would be required to support its culture change and new reliability maintenance program initiatives included these six topics: 1) *Introduction to Reliability Centered Maintenance (RCM)*, 2) *Oil Analysis 101*, 3) *Lubrication Fundamentals*, 4) *Contamination Control: Building Asset Reliability and Lubrication Excellence*, 5) *Understanding Friction & Types of Wear Generation* and 6) *Understanding Filtration and Filter Media*. Furthermore, the training materials were the catalyst for select Gallo personnel to obtain machinery lubrication technician (MLT) level I and II, and machinery lubrication analyst (MLA) level I and II professional certifications.

Figure 7: On-site education and training

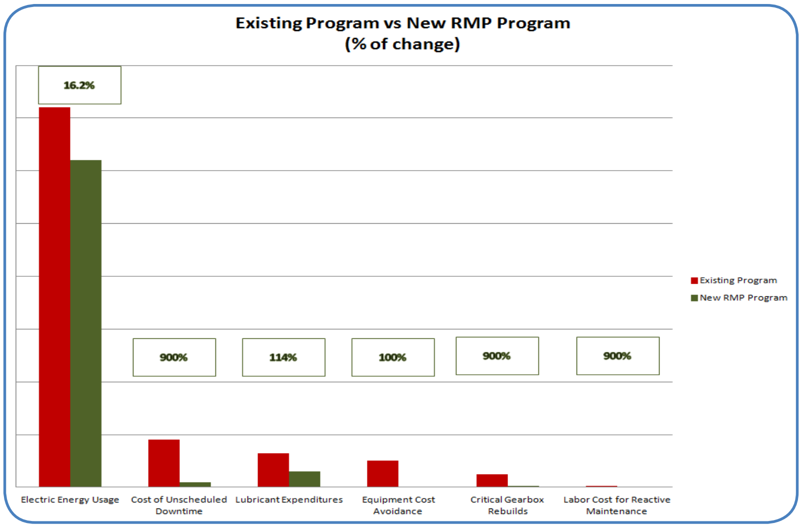


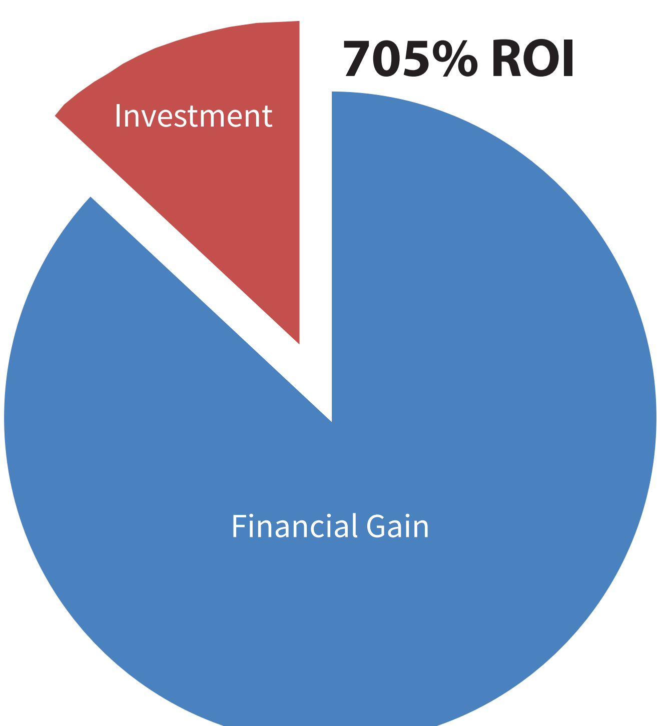
Figure 8: Program savings and variables measured

Phase VI – Program Documentation

The data in Figure 8 demonstrates the existing program and associated costs for years 2011 and 2012 and compares this data to the new reliability maintenance program and associated costs for years 2013 and 2014. Overall plant equipment effectiveness improved by nine percent.

Calculating ROI

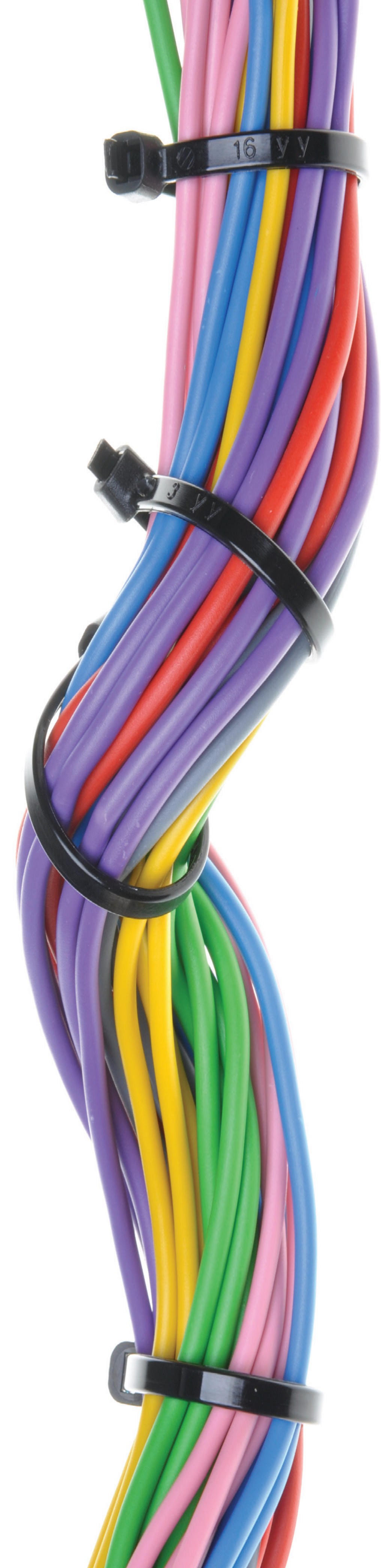
In performing the ROI calculations, the amount of financial gain achieved by Gallo was divided by its total program investment. The substantial and perpetual savings yielded a return on investment of 705%.



> The number one reason new program transformations are unsuccessful is the culture of the organization.

Credits: Special thanks to E. & J. Gallo Spirits Plant and Mr. Freddy Delgado for the support and information documented over the past two years to prepare this executive summary.

Clay Calk, *Department Manager – Business Solutions, has worked for Lubrication Engineers, Inc. for 16 years. Mr. Calk oversees all administrative and sales functions in the Inside Sales Department, which encompass order processing, customer service, inside sales, and national strategic accounts. Clay is CLS, MLT II and MLA II certified. www.LElubricants.com*



Not Safe to Work Here?

You can rest assured knowing that in a safety and reliability poll of 1,000 industry chief executive officers, all 1,000 professed the desire to lead and/or head safe and reliable companies. But there is a gap between aspiration and achievement, and there is much work to be done in closing that gap, as an Uptime reader's letter shows. The reader asked for direction, which this article will try to provide.

The reader expressed frustration working as a maintenance manager in a factory, writing:

"I see unsafe actions or conditions every day. Whenever I then confront the responsible unit supervisors, they tell me that's how it has always been done here. Or, if I explain to the employees involved that such and such is not a safe practice, they threaten me or yell in my face while the production manager stands by and laughs it off. My sense of self-respect tells me to fight back, but my manager's training and sense of self-preservation take over and I follow the chain of command.

"But nothing happens. I have been here for only nine months and am already looking for a new job. I love what I do, but I cherish working in a safe environment more. I don't want anyone to get hurt or worse. I have brought up some big equipment safety issues with management and even with the company's vice president. The inevitable answer mentions budget constraints and affordable cost run-ups. I know that's not a sensible answer.

"What advice would you give me?"

First of all, thanks go out to the reader for relating his experience and reaching out for a solution. We all know quite well that he's not the only one facing this dilemma. The reader is very concerned, and rightly so, with the inevitable cause and effect relationships that pertain to all industrial incidents. These incidents range from the simple and inconsequential to the catastrophic and life changing.

That said, these six tangible steps are recommended. A more specific example follows, which highlights how the reader could move from what is perceived as mere opinion to unassailable hard facts.

- Start keeping a pocket-size journal quietly and make detailed notes when you see something unsafe. Write down what it is, what risk results from it and what you suggest may solve the issue.
- Always follow-up by informing a supervisor or boss about the situation and your suggestion. Do it in writing and safeguard your own copy of the communication.
- Write down the recipient's reply, date and time of response. Do not leave the journal laying around anywhere. Get a new pocket-size journal when the old one is full. This also will keep your head clear and ensure you do not lose sensitivity to violations.
- Continue to commit details to your journal no matter what. This is extremely important. While it may not change anything, it will, nevertheless, protect you in case something bad happens. And something *will* happen, sooner or later.
- Remind yourself to stay focused on finding a new opportunity.
- Give your new ideas to your next opportunity.

In addition to these recommendations, this reader and others in similar lower management job functions should intuitively ask why safer and more reliable work processes and procedures are often hard to sell to superiors. The answer usually is that people tend to convey opinions instead of facts. Opinions can be right or wrong; they can and will be disputed. In sharp contrast, facts are facts, regardless of how they are attacked or disputed. That's where this example on the next page comes in.

Fact-based recommendations are far more likely to carry weight, especially if you also explain both costs and benefits in quantifiable ways. So, with regard to our reader's question, if he gives fact-based and quantitative recommendations and his organization still disregards him, he should take it as a signal to switch jobs.

This may be a good time for the reader and others facing a similar situation to review the current job postings on reliabilityweb.com. Click on the jobs menu to view the listings. You can also use the Reliability Resume Matching service. Just be sure to indicate in your resume if you wish to travel or stay local.

Bright and highly motivated employees should endeavor to work only for someone who is delighted to have them.

This article is based on a letter to the Publisher. The result and reply was crafted by Terrence O'Hanlon with review and suggestions by Heinz Bloch. We acknowledge Heinz Bloch as our guide to doing things right and his amazing ability to create clarity in the fog that arises on the road to reliability. His guidance has proven invaluable for thousands in the reliability community.

EXAMPLE

Examine the two illustrations. You will perhaps express the *opinion* that the oil ring in **Figure 1** moves back and forth and will probably abrade. But, if you go the additional step and measure a new oil ring before you start the machine, as in **Figure 2**, left side, and remeasure after operating it for a few months, as in Figure 2, right side, you will capture the difference between the two measurements. The difference is converted into abrasion product. At that point, you are dealing with an *indisputable fact* and should recommend highly tangible remedial steps or actions to prevent this from ever happening again. To make these recommendations, you have to read a few pages in one of many reputable sources, such as books or scholarly journals, which provide more in-depth details and explanations. If you don't have time to read and absorb the information, you revert to being an opinion giver and will not mature to becoming a fact-based submitter. The choice is yours.

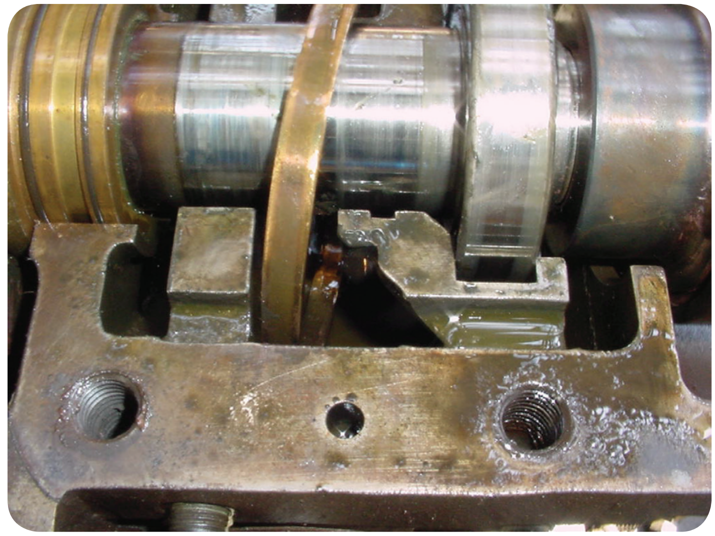


Figure 1: An oil ring which tends to move around and touch the inside of the bearing housing

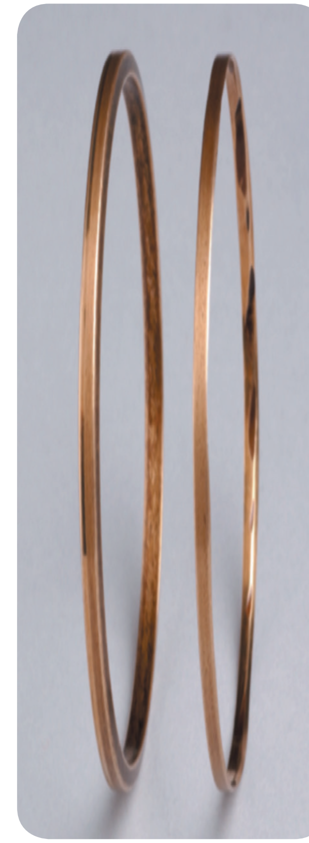


Figure 2: If this is the before versus after oil ring condition and a measurable amount of metal is missing, abrasion becomes an indisputable fact

An Interview with Saar Yoskovitz Co-Founder and CEO of Augury Systems

Mr. Yoskovitz, an avid entrepreneur, has extensive experience in Machine Learning, Signal Processing Algorithms, and System Architecture. Prior to founding Augury Systems, Saar worked as an Analog Architect at Intel. Saar holds a B.Sc. in Electrical Engineering and a B.Sc. in Physics from the Israel Institute of Technology (Technion). During his studies, Saar initiated a voluntary project called "Select - Students for Technological Advancement," for which he received the Israel's Council of Higher Education (MALAG) award for social involvement.

Augury Systems brings Internet-age technologies into the maintenance world and combines them with the gold-standard practices of Predictive Maintenance. Ideal for use in factories, commercial buildings and even homes, Augury's platform enables facility owners and service companies to deploy quick, cost-efficient and scalable predictive maintenance strategies that reduce environmental impact, energy usage and operational costs. Augury teamed up certified Vibration Analysis experts with Machine Learning algorithm experts - in order to build the mechanical diagnostics platform of the Internet of Things.

Uptime: Many people talk about the Internet of Things (IoT). What is your vision for it and where do you see it going?

Saar: IoT is overhyped. It is just a "new" Internet with new things attached. It is really an issue of consumer focus versus manufacturing focus. When we use the term "manufacturing," we are really looking at the human to machine interface (HMI) and data systems that already exist in many plants today. If you can break the data down to the component level and detect a machine's conditions, then you are able to make changes based on the data.

There is a tremendous amount of data existing in plants today that is not being mined. This data has not been made available for analysis decision-making. The real issue is how to connect to the machines and their sensors and know what to do based on what knowledge can be gleaned from the data. For example, consider that almost everyone that works in a plant today has a typical smartphone. We want to make it possible for them to connect their phones to the sensors and bring asset condition management (ACM) data into the hands of the technicians.

Consider a used car. The onboard computer says we have a problem. We take the car to a repair center and plug it in; we then would know what to do based on the advanced diagnostics. We are simply taking this concept to the industrial environment.

Imagine what the IoT allows us to create. Another example is the jet engines on aircraft today. The engines are serviced based on flight hours and the real-time condition of the engine. This is enabled by continuous monitoring. When an airline receives the alarm, "aircraft on ground," it's already too late.

There have been many interesting developments in the maintenance reliability industry recently. Based on the rate at which companies are increasing automation in their plants, the number of devices with Internet Protocol (IP) addresses in their plants are also increasing. Uptime recently caught up with Saar Yoskovitz, CEO and co-founder of Augury, (www.augury.com) who has an interesting approach to capitalizing on these devices.

The airlines provide continuous engine monitoring during normal flight operations. The engine data of the aircraft in the fleet is constantly transmitted to the airline's repair center. If there is any sign of irregularity, immediate action can be taken before any serious damage occurs.

On average, each aircraft that is linked to a system transmits a comprehensive batch of data to the ground every three to four hours. Also, if pilots notice anything out of the ordinary, they press a button that sends data to the repair center for examination. From the ground, the experts at the repair center are also able to call up data from aircraft in flight.

This same concept is being brought into industry.

Uptime: How would this work?

Saar: Since sensors already exist or can easily be installed on most plant equipment, they can be utilized for this purpose. Off-the-shelf sensors, whether vibration, ultrasound, etc., can be supported. The data collected from these sensors is then sent to a server in the Cloud. There, the machine specific data is analyzed to look for any developing problems. The data from the equipment also can be taken and compared to other similar machines around the world, again looking for any anomalies that indicate the start of a developing problem.

We are able to use information from a growing database to compare the equipment's current performance to what it was designed to be. We start out at a high level, such as the size of a pump, manufacturer, model, etc. Then, we can quickly drill down to more granular data specific to that piece of equipment.

Uptime: This is very interesting; has it been actually utilized by any plants?

Saar: We currently have two of the largest facilities contractors that are using our product, helping us build the machine specific data even faster.

Uptime: What are some other uses for this type of product or service?

Saar: The product can be used with operator or maintenance inspection rounds. While some organizations use outside contractors to collect and analyze this type of data, eventually companies will be able to bring this type of work back in-house due to its simplicity. It really will help companies with a shortage of skilled personnel within their current in-house maintenance and operational staff since they will not need the higher level technical skills required to perform this type of analysis. When companies are faced with a skills shortage due to retirements, they can leverage this technology to help them lessen the impact of the loss of these skills.

Uptime: Where do you see the application of this type of service?

Saar: Initially, we have started with commercial buildings, such as data centers, government buildings, universities and hospitals. It is a good place to start since 88 percent of commercial facilities don't use ACM. However, as the number of devices connected to the Internet continues to grow, we expect to see this type of service grow to include utilities, especially turbine related equipment, and typical manufacturing plants.

Uptime: How does a client invest in this service?

Saar: We will offer a pay-as-you-go service. The amount of investment will be based on the number of equipment items included in the program. This allows clients the flexibility to start small, generate some benefits and then grow their programs.

Uptime: What about the data? What happens to it?

Saar: When clients have their data stored in the Cloud, they always have access to it. They don't lose it when someone leaves or if they decide to change ACM vendors.

We have standard algorithms that help analyze the stored data. We also use military grade hardware to ensure it will stand up to almost any industrial environment. We have developed this system in-house using a very high level of subject matter experts (SMEs). Computerizing this data with our SMEs allows our clients to reduce the necessity to have their own human expert.

Uptime: How does the service work? How does the client gather the data and get the results?

Saar: Our device has a five second read time. This is important since it allows them to rapidly gather the data. It is put up in the Cloud, which allows us to quickly know what the problem is and determine what to do to solve it. We provide alerts for at least four levels: acceptable, alert, alarm and danger. As a measured condition moves from acceptable to one of the other levels, the monitoring frequencies are increased, tracking it until it gets bad enough to require correction.

Uptime: It sounds like if this technology is not adopted soon, the industrial side of things will be left behind in the IoT. What do you envision for the future?

Saar: Imagine for a moment the possibility of everyone being a vibration analyst. What would happen to reliability centered maintenance (RCM) if it was relatively economical to do? Would it change how we apply some of these existing tools that we already have today? Would it change how we view reliability? How could continuous monitoring make a difference? These are questions that will only be answered as we continue to move into the future of the IoT.

Uptime: We are looking forward to see how Augury makes inroads with this very interesting product and service.

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