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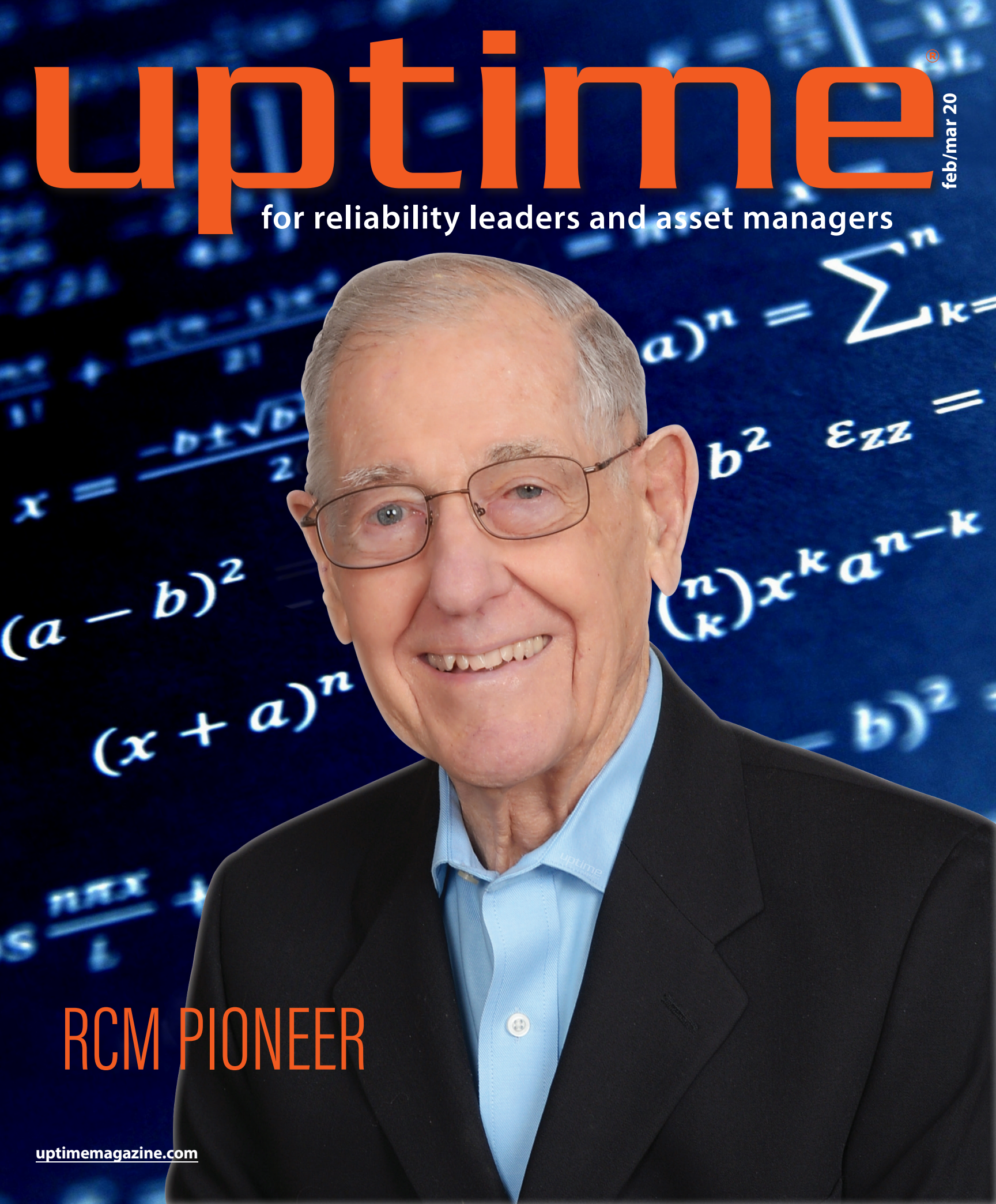
for reliability leaders and asset managers

feb/mar 20



RCM PIONEER

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~ Terrence O'Hanlon

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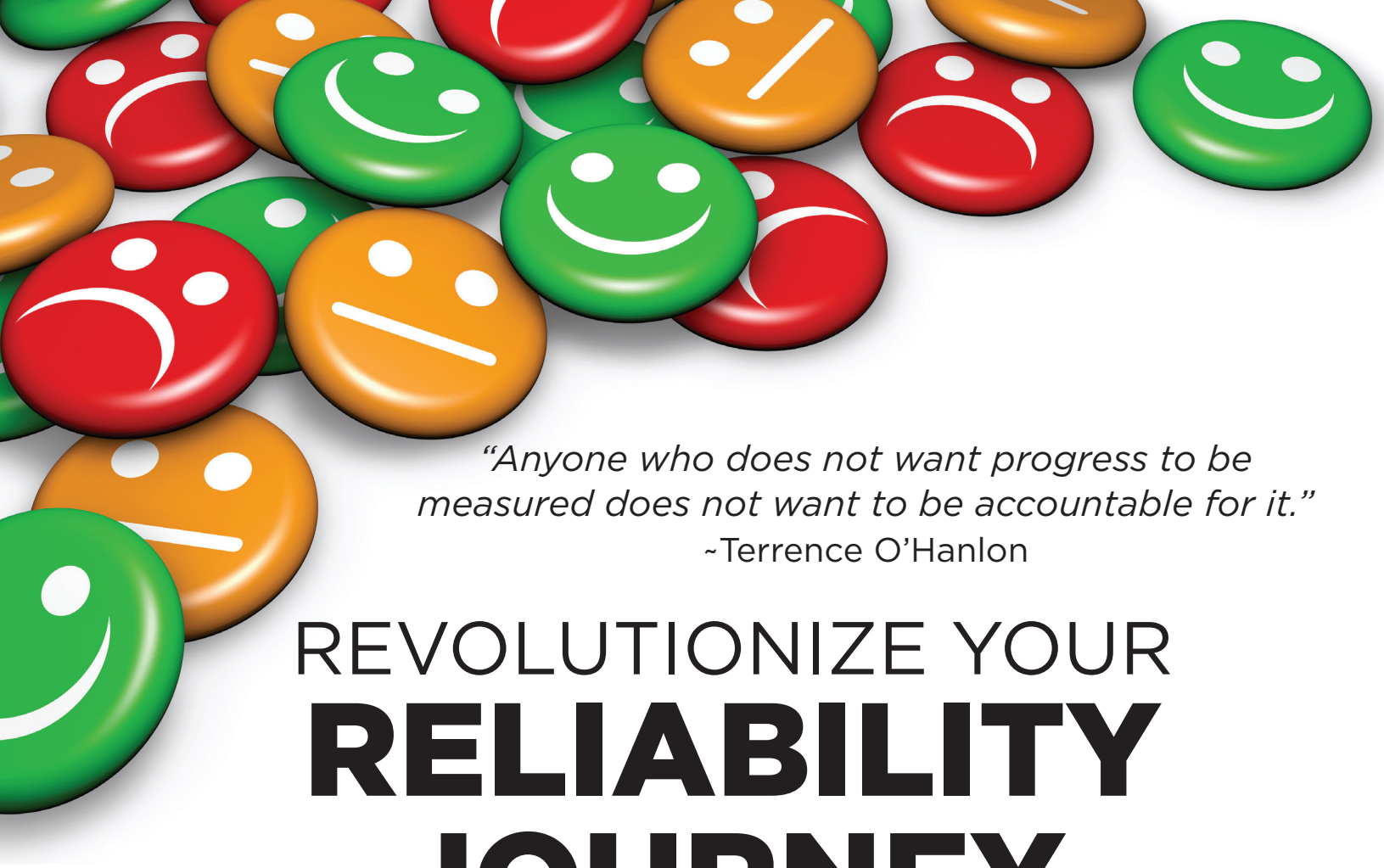

"Anyone who does not want progress to be measured does not want to be accountable for it."
~Terrence O'Hanlon

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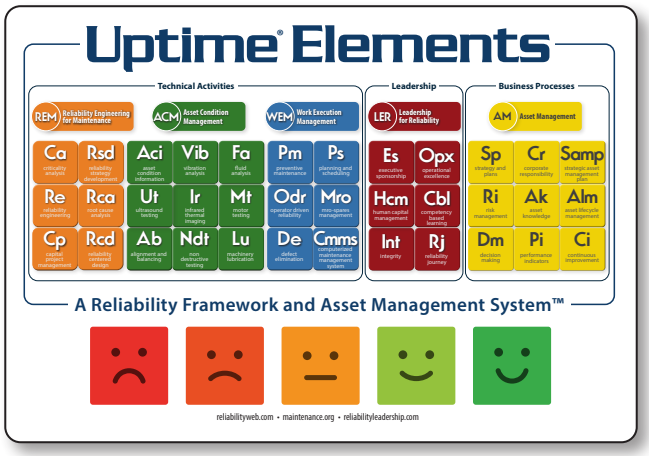

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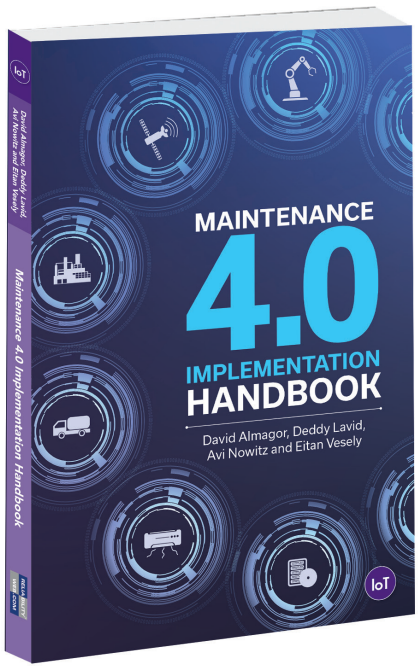

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David Almagor, Deddy Lavid, Avi Nowitz and Eitan Vesely

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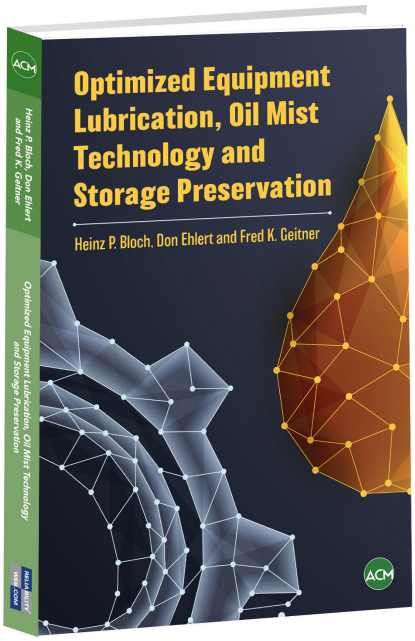

Optimized Equipment Lubrication, Oil Mist Technology and Storage Preservation

Heinz P. Bloch, Don Ehlert and Fred K. Geitner

This extremely user-friendly book addresses lubrication issues from the vantage point of three experts. In addition to giving previously unavailable statistics, the book describes the methods and procedures employed by best-in-class companies. It also describes and details many cost justification calculations used by those companies.

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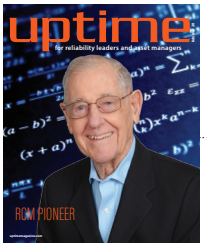

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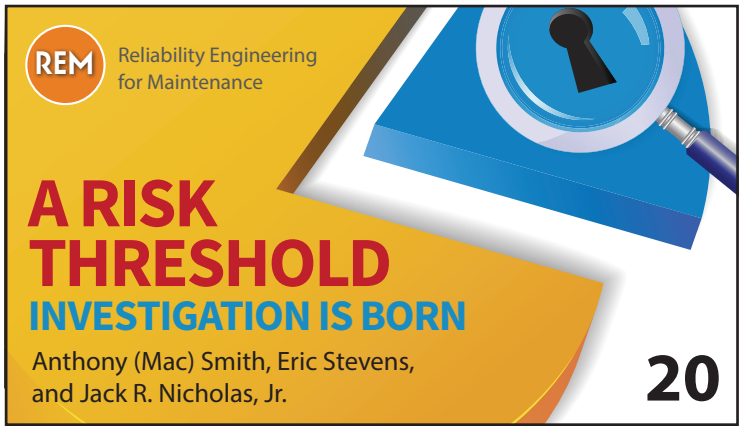
for reliability leaders and asset managers

ON THE COVER
Can you find the hidden Uptime logo on the cover? uptime



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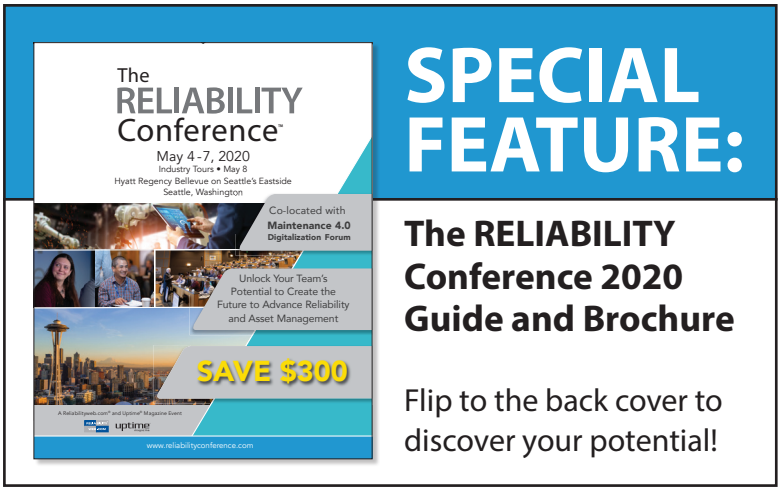

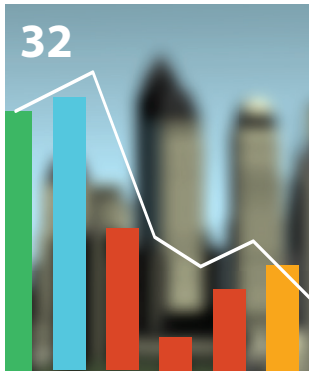

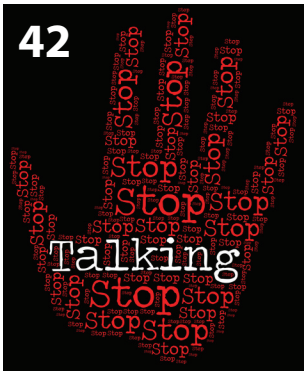

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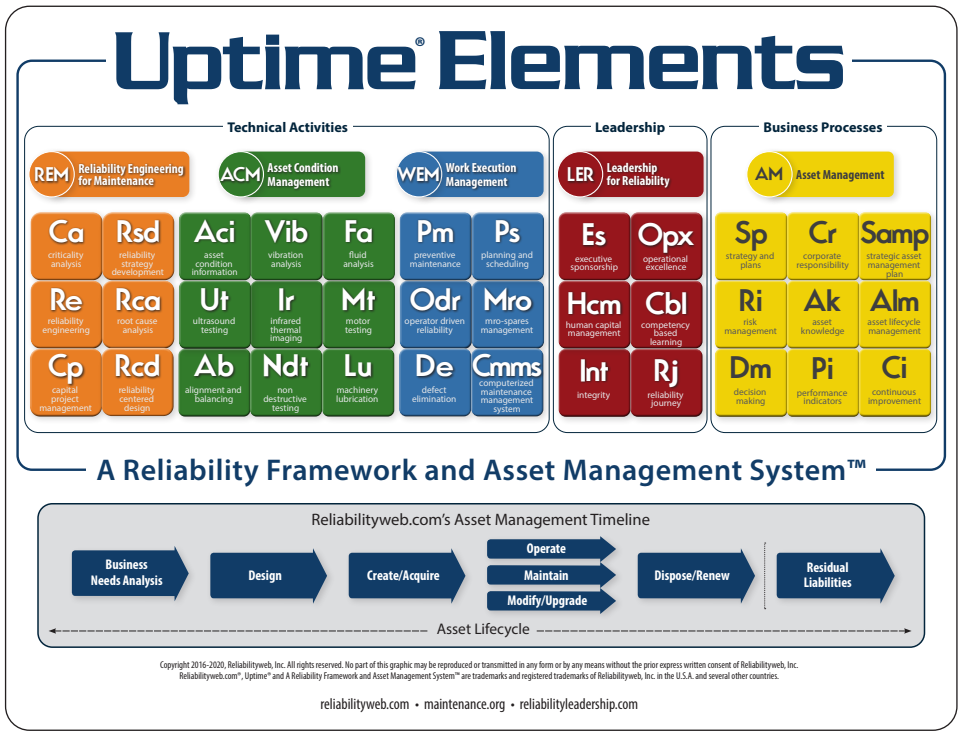

Uptime® Elements - A Reliability Framework and Asset Management System™ is in use at over 2,800 organizations around the world to engage and empower reliability culture.

uptime®

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I Am a Reliability Leader

But what the heck is a reliability leader?

In 2013, the team at Reliabilityweb.com® introduced Uptime® Elements - A Reliability Framework and Asset Management System™ to address some of the gaps and challenges we observed within our community of practice and the wider industrial markets over the past 18 years of research and field studies. Since then, we have trained 30,000+ people on six continents. Currently, there are approximately 3,500 people from around the world who have obtained the Certified Reliability Leader® certification.

The framework and workshops are designed to allow participants to not only learn and "know" about reliability leadership, but also to discover for themselves how to "be" reliability leaders and "do" reliability leadership. Reliability leaders are empowered to create new futures that were not going to happen anyway. Truth be told, everyone who fully participates benefits from the framework and the workshops, but not everyone wants to be empowered to create a new future that was not going to happen anyway, at least, not at this particular moment in time.

The fantastic news is that there are enough effective and empowered reliability leaders that occasionally drift close enough for us to catch up with, and they allow us to learn from them. We enjoy checking in to see how they are applying their new discoveries. Here are some things I noticed that the top performing reliability leaders have in common:

1. **THEY FEED THEIR MINDS.** They never stop learning. They spend at least 30 minutes per day reading a book, listening to podcasts or audio books, participating in an online or live training course, or doing some other learning activity. New ideas come to them in this way.
2. **THEY FEED AND ACTIVATE THEIR BODIES.** They tend to take slightly better care of themselves than others do. They drink, but in moderation, they eat normally, but do not overeat. They get enough sleep. They spend at least five minutes per day (many spend much more) doing something physical that their bodies consider "challenging," including walking or simple stretching. New ideas come to them in this way.
3. **THEY HAVE GREAT ROLE MODEL(S).** In this day and age, it is a good idea to have multiple role models for different aspects of life. For example, you may admire a special musician for his or her guitar talents, however, that does not mean you should develop the same substance abuse issues they have. Follow the people you admire for the elements you admire in them. There is no need to copy the other parts of their life that may be less desirable.
4. **THEY GET OUT OF THE PLANT OR OFFICE AND INTO THE WORLD TO SPEND TIME WITH AN INTELLECTUALLY CHALLENGING PROFESSIONAL NETWORK.** There are a number of excellent networks in the reliability and asset management world, including formal communities of practice like the Reliability Leadership Institute® or the University of Tennessee's Reliability and Maintainability Center. There are more informal networks you can be part of by participating in The RELIABILITY Conference™, the SMRP Symposium, Reliable Plant or the International Maintenance Conference. They learn that being around the right people is leverage, knowledge and power. Perspective, access and proximity are valuable.
5. **THEY GIVE MUCH MORE THAN THEY EVER HOPE TO GET.** These reliability leaders work to make things better. They look for opportunities to coach their teams for progress, they reinforce wins (even small ones), they change the prevailing state or mood when needed, they align and unite the team, they teach, they care, they are authentic and they have uncomfortable, but crucial conversations when they are needed. They praise and reinforce effort as much as they praise result.

Do you know any effective and empowered reliability leaders? How do they move through their work and lives? What can we learn from these reliability leaders? Are you one? What will you share with us?

The team of leaders at Reliabilityweb.com collaborated with some fantastic thought leaders and created another superb issue of Uptime magazine. I hope you get as much value and learning from it as I did. I invite you to see yourself on the pages of a future issue of Uptime so that your program and your team gets the acknowledgment that is well deserved, while inspiring and teaching others what it takes to make the next step in the reliability journey.

I am grateful,

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

LER

RELIABILITY

IN THE NEWS

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Reliabilityweb.com visits the reliability team at Metropolitan Sewer District of Greater Cincinnati (MSDGC), Cincinnati, Ohio - January 9, 2020

Reliabilityweb.com visits Projetech, Cincinnati, Ohio - January 9, 2020

Reliabilityweb.com visits and hosts the Reliability Leadership® Game for the reliability team at Honda, Marysville, Ohio - January 10, 2020

DP World, Dubai - December 16, 2019

Going Digitalization Roundtable hosted by Reliabilityweb.com, Dubai - December 17, 2019

The first Diversity in Reliability and Asset Management Hackathon, Fort Myers, Florida - December 6-7, 2019

Asset Analytix, Pune, India - December 19, 2019

Reliabilityweb.com's Asset Management Roundtable, Mumbai, India - December 27, 2019

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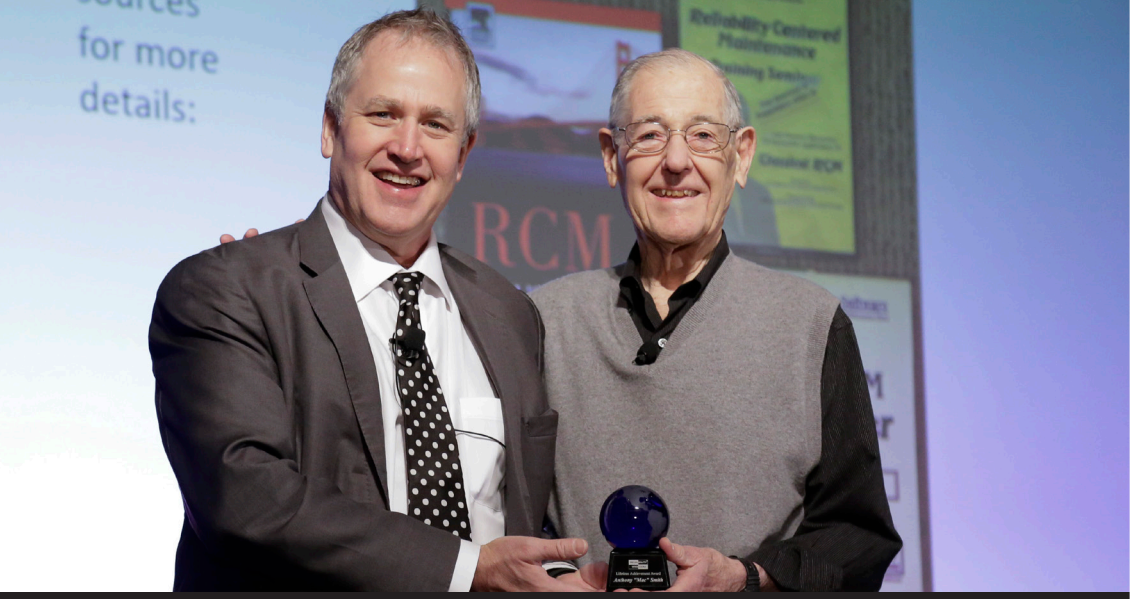


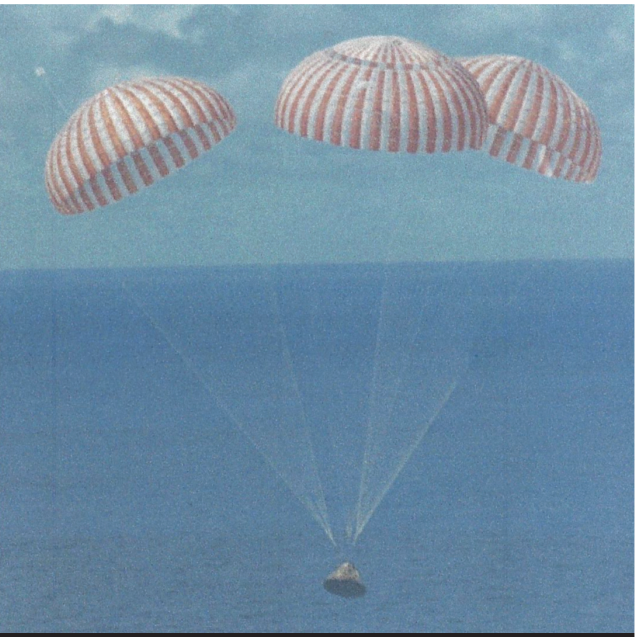
Terrence O'Hanlon presenting Mac with the Lifetime Achievement Award – 2017

Mac presenting a RAP Talk at TRC-2017

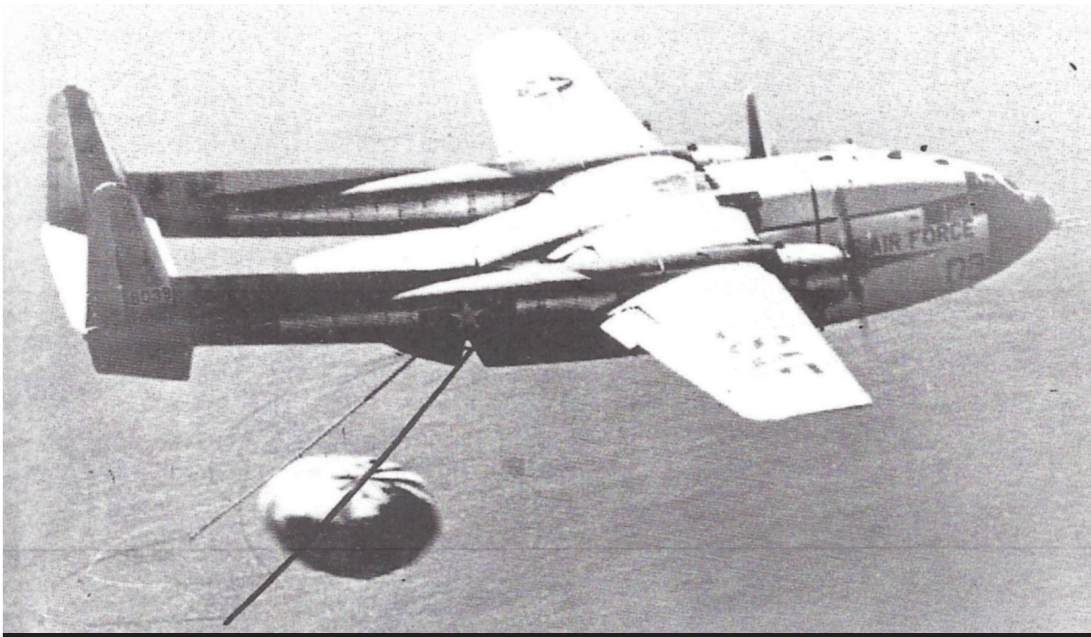
2nd LT. Smith,
U.S. Army
Engineers - 1953

Mary Lou and Mac - 64th Anniversary

Pre-RCM Smith Family - 1967



Apollo 11 splashdown - July 1969



C-119 Corona capsule air snatch recovery - July 1960

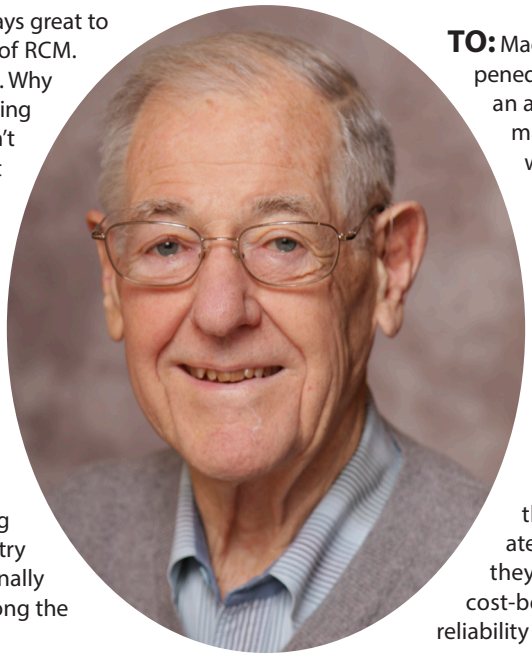
RCM PIONEER

ANTHONY "MAC" SMITH

Uptime® magazine recently had the pleasure to speak with reliability-centered maintenance (RCM) pioneer and expert, Anthony "Mac" Smith. Terrence O'Hanlon, Publisher, sat down with Mac to discuss his life and the career that led him to be recognized as one of the early leaders and advocates for RCM. The complete video interview is available in this issue at www.reliabilityweb.com/uptime.

TERRENCE O'HANLON (TO): It's always great to have the chance to hear about the beginning of RCM. You were already very established when we met. Why did you get involved with me? This crazy guy getting on the Internet way back when the Internet wasn't anything. I was fascinated with your work. What did you see in where we were going?

MAC SMITH (MS): Well, to a certain degree, I think you can answer that question because it was my thoughts, initially, when we first started getting to know each other that you found out that I was doing some of this kind of work and became interested in following it and I was happy to have you do that. One thing led to another over the years, with papers and conferences and conversations, both private and public with us, and it sort of evolved along those lines. I think it evolved because our chemistry just went together and our objectives professionally went together and our friendship developed along the lines that sort of naturally came together.



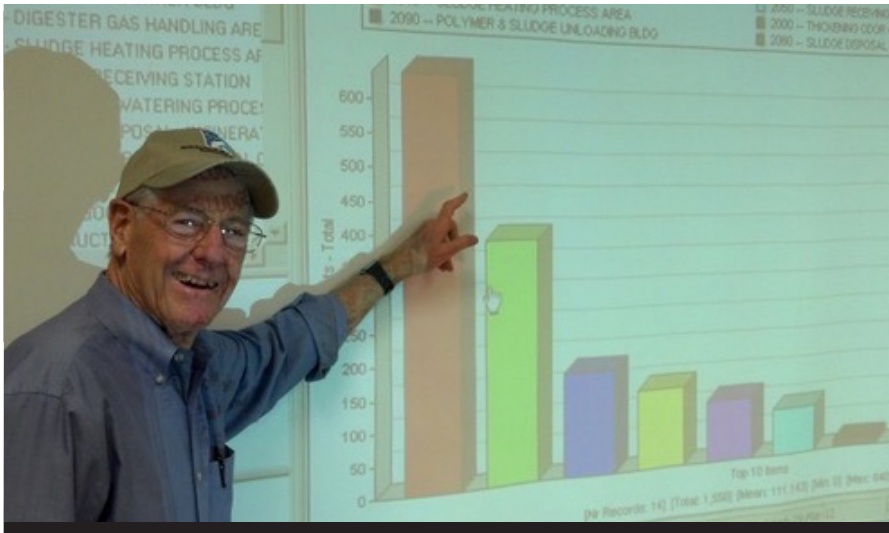
TO: Mac, I saw a movie where the Beatles had never happened in history and it made me wonder, what if Nowlan and Heap had never penned reliability-centered maintenance in December 1978? How would the world be different in 2020 if we were still doing maintenance the way we did prior to RCM?

MS: This answers another question, too. What is missing in most places to achieve sustainable reliability? I have, really, three things to cite as reasons why it wouldn't be a very pleasant situation, so to speak. The first one is I don't think without RCM many of the businesses today that we've dealt with, and there's a number of which are Fortune 500 companies for sure, would be profitable. It took some time for them to really own up to the cost benefit associated with RCM and, therefore, if there was no RCM, they never had that path to pursue to deal with the cost-benefit side of their business as it relates to how reliability can beneficially impact it.

Mac talks about his publications throughout the years

Mac's first RCM seminar for a hospital group - 2019

The 'Rat' Pack – Jack R. Nicholas, Jr., Terrence O'Hanlon, Ramesh Gulati, Mac Smith



Mac teaching the 80/20 Rule

The second thing is, in the absence of RCM, there would be a very different culture in industry today. Down in the technician ranks, look at the culture among the maintenance technicians, the operator technicians, those who haven't been exposed to RCM versus those that today have been exposed to it. I think in my experience, and probably in yours, also, there's two different cultures involved. One is very, very oriented toward what they do and how they impact the people they work with, the products they're working with and the company they work for, versus people who have not had that benefit – not really understanding and appreciating that relationship.

The third thing that would perhaps be absent is the support from management for the work that we do in the maintenance and operations areas with these technicians that exists today, specifically in the areas where people have gone through an RCM program and understand that relationship and understand the meaning of an available champion who is going to make sure that culture is maintained.

So, I think we would see a very different set of people in the way they react to business challenges.

TO: Reliabilityweb.com's conferences are filled with people who have been influenced by you and your work. How does it feel knowing your work has had such a major impact on the reliability and asset management community and, often times, national security?

MS: In the beginning, I probably did not realize what we had and the degree of impact that it could have on people and the business environment in which we were working. But, I found out about that pretty quickly after I got into it and worked, especially with Tom Matteson from United Airlines* in the beginning. He had a lot of the culture and benefits that had been derived in the aircraft industry from RCM. I have an extremely satisfied feeling with what I've done for the last 40 years, with RCM being the basis for a lot of what I've done. I feel rewarded a good bit by the success that we've had with what the people have learned and how they have taken what we've done and implemented it and had an impact on the companies they work for and the people they work with.

* United Airlines was one of the first companies to integrate and promote the RCM process. Deceased,

Sam Paske
Metropolitan Council
Environmental Services

Over the years, Mac has had tremendous reliability impacts that stand out to me. Of particular note was his involvement in designing a reliable parachute recovery system for a photo capsule on the U.S. Corona Spy satellite which helped the U.S to prove that the USSR did not have ICBM launch capability (1960), and later discovered the Russian shipment of nuclear missiles to Cuba (1962). He then played a key role in the design of the parachutes for the Apollo earth landing system on the return splashdown from the moon.

Mac was also involved in a 5-year failure analysis project with NASA Kennedy Space Center to identify and prevent the recurrence of Space Shuttle failures post the Challenger disaster. He also led the implementation of several Classical RCM studies at the Three Mile Island nuclear power plant Unit #1 after the meltdown accident on Unit #2.

In 2009, Mac brought Classical RCM to the water/waste water facilities at Metropolitan Council Environmental Services (MCES), St. Paul, Minnesota. His approach again proved successful in focusing our available resources by harnessing the collective knowledge of our maintenance and operations staff in a collaborative team process. The success of this work has been shared as an industry best practice in several major water/waste water utilities including DC Water, Metropolitan Sewer District of Greater Cincinnati (MSDGC) and Contra Costa County Sanitation District (California).

I am impressed by Mac's dedication to his craft. Just the fact that he is still teaching others about RCM (when he does not need to be) tells you something about how much he enjoys what he does. Mac has been my mentor for over 20 years and I have learned so much from him. Despite all his knowledge, when we attend a conference together, I hear him say, "I always learn something new at one of these events." This attitude of his helps me stay grounded and to remember that there are always ways that we can improve our knowledge and craft.

Mac has always impressed me with his directness. He says whatever is appropriate, no matter who is challenging him and the level they may hold in their organization. He wants to make sure they understand that reliability is something they need to pursue, and that cutting maintenance budgets or staff is not good for the company's bottom line.

An example of this is when I was at a presentation of Mac's and there was a person presenting prior to him. This individual discussed a very elaborate process for doing a reliability program. When Mac got up to speak, he starts by saying, "I wouldn't touch what he is doing with a ten-foot pole." A definite cringeworthy moment, but it was true. His point was don't overthink the process.

Nick Jize
JMS Software

John Shinn, Jr.
Metropolitan Sewer
District of Greater
Cincinnati (MSDGC)

While attending an International Maintenance Conference (IMC), I sat in on one of Mac Smith's presentations, and then ran into Mac the next morning eating breakfast. I immediately was impressed on how he was able to understand the issues and possible solutions for our organization. My company then hired Mac to perform RCM training and analysis on one of our processes, resulting in a very successful output. That led into Mac continuing to assist us on our journey. He assisted us in transforming our organization from a reactive to proactive culture, as well as winning an Uptime Award. One of the most impressive things I have observed in Mac is, if you listen to him talk (or tell a story), he is very crisp, accurate, to the point, and says a lot in very few words. Additionally, you can believe what he says (it just makes sense). I have been fortunate to have had the opportunity to cross paths with Mac; he is a very nice, considerate, intelligent, and structured person who brings a ton of wisdom to everyone he comes into contact with, as well as the reliability world.

Uptime Awards

2019

RECOGNIZING THE BEST OF THE BEST!

Uptime magazine congratulates the following outstanding teams for their extraordinary reliability programs.

2020 Uptime Awards Submissions: Open April 2020!
Visit: uptimeawards.com

Best Work Execution Management

MEDTRONIC

The Medtronic mission is to contribute to human welfare by application of biomedical engineering in the research, design, manufacture, and sale of instruments or appliances that alleviate pain, restore health, and extend life. Today, our technologies are used to treat nearly 40 medical conditions. The Medtronic products and therapies improve the lives of two people every second.

The North Haven, plant opened in 1982 and has more than 1,100,000 square feet of operating space. The site employs more than 2,500 people, and the key products manufactured are Endo-stapling, sutures, needles, fixation devices and hemostatic, which generate more than $2 billion dollars in sales.

HIGHLIGHTS:

The North Haven plant implemented the maintenance excellence (MEx) effort approximately two years ago. The plant is focused on: "Introducing and instilling a culture of maintenance excellence at an enterprise level through standardized processes, common systems, and organizational effectiveness to deliver world-class performance."

As part of this MEx implementation, training was implemented using the Uptime® Elements framework and has resulted in 87 people with Uptime Academy certificates—21 with the Certified Reliability Leader® (CRL) designation, one Black Belt, one Orange Belt, one Blue Belt, and one Green Belt.

Key focus areas: The Work Execution Management domain. Listed below are just a few key highlights:

Cmms Element: Maximo® 7.6 is our current CMMS and is being utilized at all levels. There are 1,321 active users; 43,426 service requests; 71,844 completed work orders; 3,862 active PMs; and 2,828 active job plans.

Mro Element: The MRO staff are fully integrated into the planning and scheduling process. There are currently 24,821 inventory items; 6,609 purchase requests; and 49,036 inventory transactions. An inventory reduction initiative was implemented and resulted in a reduction of over 6% of inventory items in 2019. Additionally, work orders are kitted based on scheduled equipment shutdown schedules, parts pulled by storeroom personnel, and issued out to individual work orders and inspected for accuracy.

Pm Element: A key focus of the MEx effort was in review of the PMs and performing preventive maintenance optimization (PMO) to optimize activities using cross-functional teams. The key focus was eliminating unnecessary maintenance activities, utilization of predictive technologies, and effective utilization of operators to perform some of the duties. To date, there have been over 30 PMO projects performed, resulting in major cost savings or cost avoidances.

Ps Element: Quarterly planning and scheduling meetings were set up with cross-functional teams, including operations, engineering, technicians, maintenance planners, and middle management. The three-month shutdown window allows us to adequately plan necessary resources and limits equipment downtime for all maintenance activities.

De Element: Defect elimination (DE) was a key area focus. Each of our Certified Reliability Leaders are accountable to identify and perform a minimum of one major defect elimination project per year. To date, there were 28 defect elimination projects identified, resulting in major cost savings or cost avoidances related to improved uptime, reduced scrap, labor utilization, and reduced materials usage.

Odr Element: The operator-driven/autonomous maintenance process was reviewed and focused on strategic areas. Standard work instructions were developed. In addition, standard operating procedures were developed, including cleaning, inspection and lubrication, autonomous maintenance task cards, and a self-audit process. Formal training was developed and provided for the operators and manufacturing technicians.

"Being recognized by Reliabilityweb.com® is like icing on the cake! The Uptime® Elements framework has allowed us to focus on the proper ingredients of asset management to drive our work execution teams to become best in class."

Best Leadership for Reliability

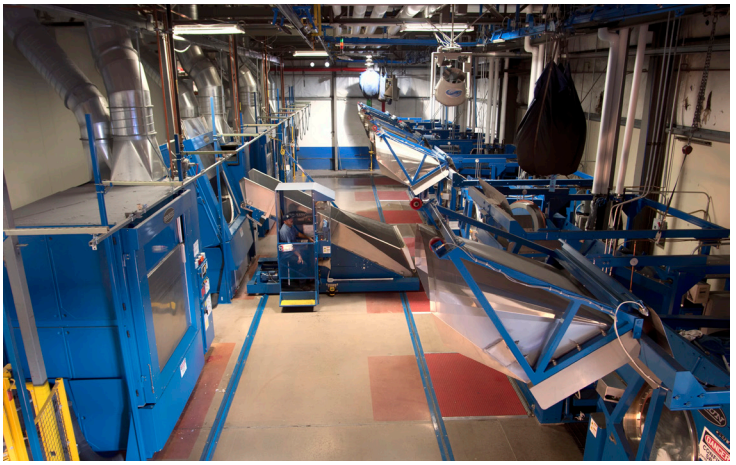
CINTAS CORPORATION

Headquartered in Cincinnati, Ohio, Cintas Corporation provides highly specialized products and services to over one million customers that range from independent auto repair shops to large hotel chains.

Cintas leads the industry in supplying corporate identity uniform programs, providing entrance and logo mats, restroom supplies, promotional products, first aid, safety, fire protection products and services, and industrial carpet and tile cleaning. We operate more than 400 facilities in North America, including six manufacturing plants and eight distribution centers.

HIGHLIGHTS:

Cintas launched a reliability and asset management effort around the time of the 2008 financial crisis. Like many other businesses, Cintas had to learn to make assets last longer and for equipment and maintenance costs to be more efficient. Since then, the company has embarked on a reliability learning journey to identify and implement industry best practices, methods, tools and solutions. The technical leaders at the company gained internal executive and frontline support for implementation of the various reliability solutions considered. As the company's reliability improvement efforts produce results, company representatives share their lessons learned at IMC conferences, Uptime® magazine, and most recently, by partnering with some engineering colleges to introduce reliability and asset management as an option to enhance their curriculums.



"Winning the award also means that the reliability community believes that our reliability leadership efforts, both within our company and outside of our company, are making leading contributions that can serve as an example for other organizations."

Best Asset Condition Management

MERCER CELGAR

Mercer Celgar Limited Partnership, being one of the largest pulp mills in Canada, recognizes the importance of Asset Condition Management (ACM) and the potential implications if this program is compromised. We take upon ourselves a responsibility toward our customers, community and staff of producing high quality Northern Bleached Softwood Kraft in the safest and most sustainable processes. This, consequently, dictates the need to put together a team of people who are passionate about maintaining the high standards of our ACM program that our various stakeholders expect and demand.

Mercer Celgar's mission—"to provide sustainably sourced fibers, renewable energy and chemicals for essential human needs"—is the main driver behind the devotion of our maintenance department personnel in empowering our ACM program.

Operating principles, such as "Mill reliability is a core driver of our business" and "Prevention and early detection/control of failures are vital," further emphasize our unwavering commitment to proper ACM. Our ISO9001 and ISO14001 certifications, coupled with our company's safety culture and the streamlined reliability-centered maintenance approach that we have adopted, means we are committed to the utmost ACM standards.

HIGHLIGHTS:

The Mercer Celgar ACM program has a long history and tradition beginning in 1970. The program started with vibration analysis and continued by adding condition-based technologies until the present. Major upgrades started in 2006 with the introduction of automated diagnostic systems, development of a wireless network and continuous monitoring systems. Always relying on the latest technologies, the company also realizes that without highly motivated, skilled and trained tradesmen, results will be limited. Accordingly, all our tradesmen/engineers are certified by recognized institutions, like Technical Associates, Noria or SKF. All of the above actions resulted in a significant reduction of rotating equipment failures and increased savings. Today, we have an AI pilot project that's been in place for the last 18 months and a clear vision on the future of condition monitoring systems.

This award will be used as a booster toward accomplishment of our next targets, like the award for Best Asset Management Program in 2022, which includes fixed assets, and the award for Best Reliability Engineering for Maintenance Program in 2025.

We believe these awards are just pointers, ensuring us that we are on the right path to be one of the most efficient and productive pulp mills in the world.

"As W. Edwards Deming famously said, 'If you can't describe what you are doing as a process, then you don't know what you are doing.' Our Uptime® program with its defined processes gives us the confidence that we know what we are doing. Our Uptime program strategies have moved us from reactive response to intentional and planned execution. Our most recent element, condition monitoring, is the newest piece of the puzzle that we have pressed into position. We are now poised to implement operational excellence on our journey to manufacturing excellence. We are extremely pleased with this program and the business results that we are achieving as a result of this work."

Best Reliability Engineering for Maintenance

SAN JOSE WATER

Founded in 1866, San Jose Water (SJW) is an investor-owned public utility, and one of the largest and most technically sophisticated urban water systems in the U.S. We serve over one million people within California's Silicon Valley and the greater San Jose metropolitan area with high quality, life-sustaining water, while maintaining an emphasis on exceptional customer service.

SJW's water system consists of 2,400 miles of pipe, 300 pumps and motors, 100 groundwater wells, 100 tanks and reservoirs, 3 water treatment plants, and hundreds of thousands of meters, service lines, valves and hydrants. Our Mission is: "Trusted professionals, passionate about delivering life-sustaining, high quality water and exceptional service to families and communities while protecting the environment and providing a fair return to shareholders."

HIGHLIGHTS:

SJW has successfully leveraged advanced engineering criticality analyses to enhance infrastructure reliability and improve maintenance strategy. With the overall goal of providing reliable service to customers and communities, SJW developed a risk framework under which all major asset types were evaluated. The probability of failure, consequence of failure, and business risk exposure for every pipe, valve, pump, motor, well, tank, reservoir, control valve, MCC, and generator were calculated using numerous tools, methodologies, algorithms and modeling engines, including, but not limited to, the following:

- Artificial Neural Network (Machine Learning Algorithm)
- Survival Curve and Failure Curve Analysis
- Seismic and Geographic Correlation Analysis
- Spatial Flooding Modeling
- Hydraulic Pressure and Flow Impact Modeling
- Environmental Impact Modeling

SJW's enhanced capability to predict failure and forecast system risk has been integral to both determining 100-year capital renewal projections and strategizing maintenance investment to enhance long-term system reliability. SJW's engineering and O&M departments have also engaged in reliability-centered design, using a modified version of the RAMS2 method to ensure engineers design projects using a total asset lifecycle perspective.

"We are very excited by this recognition. Winning the Best Reliability Engineering for Maintenance award validates the quality and effectiveness of SJW's hard work and labor to provide outstanding, reliable service to our customers and communities."

Special Recognition Award

CHUGACH GOVERNMENT SOLUTIONS, LLC

Chugach is a proud provider of services to the federal government. For over two decades, we have been delivering the men and women of our military and other essential agencies with superior services that support their mission and provide safe, healthy, comfortable living environments for their personnel. Our exceptionally trained workforce performs their assignments under the direct supervision of our experienced senior managers, often in remote and challenging locations, to ensure facilities like ports, airfields, and hospitals operate at peak performance. To ensure our clients receive best in class service consistently and reliably, Chugach utilizes an ISO55000 Asset Management approach based on innovative best practices to optimize safety and performance. Chugach specializes in the following services: facilities operations and maintenance, airfield management, vehicle and heavy equipment maintenance, fuel/oil storage and distribution, readiness and disaster preparedness, security, educational services, technical services, hospital maintenance, military family housing management and maintenance, and the repair, alteration and construction of real property facilities.

HIGHLIGHTS:

Chugach built our Chugach Asset Management Program (ChAMP) using the Reliabilityweb.com® Uptime® Elements framework. Other than translating the ISO55000-based framework and its associated strategy to fit our company's business model, deviations from the Uptime Elements framework were kept to a minimum. Our development approach required that we first focus on defining and adopting best practice processes before turning our attention toward the adoption of technology. ChAMP is a continuous improvement program currently, undergoing its second scheduled revision update. We also developed an accompanying internal, role-based training program, called ChAMPion, where employees learn about asset management and how to effectively apply it to their work environment. ChAMP successfully complements our already strong safety culture and epitomizes our core behaviors: we do things the right way; we offer the best value; we build community; and we leave things better than we found them. ChAMP brings a standard system of processes and performance metrics to bear, which aligns our performance with the goals and objectives of our customers. While still young in field deployment, ChAMP has reduced backlog by 6.17% at one contract location and eliminated over 5,400 unnecessary preventative maintenance actions at another.

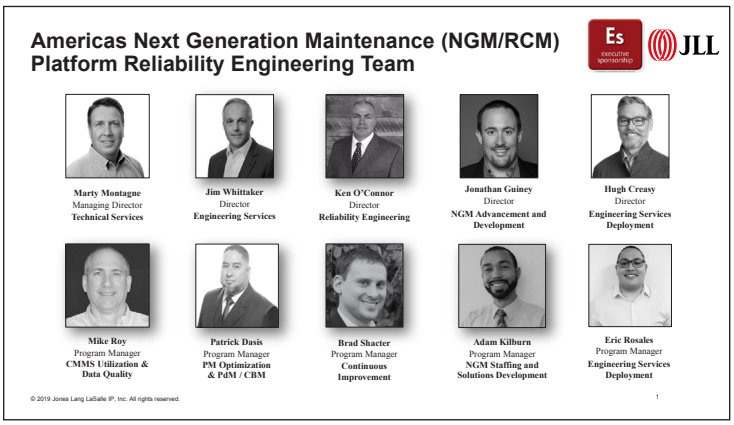
"At Chugach, we live and work daily by our core behaviors: 1) we do things the right way; 2) we offer the best value; 3) we leave things better than we found them; and 4) we build community. This award recognizes the significant work and effort put into developing and deploying Chugach's asset management program, ChAMP, which epitomizes Chugach's core behaviors and rewards our customers."

Special Recognition Award: Innovation Champion

JLL ENGINEERING SERVICES

We're here to create rewarding opportunities and amazing spaces around the globe where people can achieve their ambitions. In doing so, we're building a better tomorrow for our clients, our people and our communities. We're a world leader in real estate services, powered by an entrepreneurial spirit. We want the most ambitious clients to work with us, and the most ambitious people to work for us. It's as simple as that. We buy, build, occupy and invest in a variety of assets, including industrial, commercial, retail, residential and hotel real estate. From tech start-ups to global firms, our clients span industries, including banking, energy, healthcare, law, life sciences, manufacturing and technology.

JLL offers a comprehensive engineering services platform that enables building owners and investors to drive maximum value out of their assets, mitigate their risks, and run their assets at optimal efficiency. We're not only helping our clients achieve the greatest return on their investments through this offering, we're providing them with real peace of mind knowing their occupants are safe and properties are 100% compliant. Composed of industry leading experts in such areas as energy management, safety, and environment, our centralized engineering services team creates and implements solutions that optimize efficiency, ensuring the environmental health and safety of our clients' facilities worldwide.



HIGHLIGHTS:

What is Next Generation Maintenance?

Unique to the JLL integrated facilities management offerings, Next Generation Maintenance (NGM) is a comprehensive and holistic maintenance management system, delivering cost-effective equipment reliability matched to a client's risk mitigation requirements. NGM is aimed at operational efficiency over the lifecycle of facility equipment. It leverages and aggregates the breadth and depth of JLL's experience into a living continuous improvement knowledge base that produces consistent standards and proactive best practices. Seamlessly incorporated into JLL's maintenance management system (Corrigo) - or combined with a client's system - NGM utilizes a streamlined reliability-centered maintenance (RCM) approach based on asset reliability and productivity. It optimizes the operational plan, providing a reliability-based maintenance strategy that delivers the right-condition and criticality-based maintenance regime at the right frequency. NGM is sustained by a comprehensive set of standards and procedures, which are reinforced by a continuous improvement philosophy. Scalable to all facilities, NGM is adaptable to changes in business requirements and will produce consistent results against key performance indicators, allowing JLL account and regional performance reporting.

"Thank you for recognizing JLL's innovation in successfully implementing a globally standardized lifecycle asset management program, aligned with the Uptime® Elements Reliability Framework, and designed to maximize the value of assets, mitigate risk, and operate buildings at optimal efficiency."

Special Recognition Award: Best MRO

MA'ADEN ALUMINA REFINERY RELIABILITY DEPARTMENT

In 2009, Ma'aden established a joint venture with Alcoa, the world's third largest aluminum producer, to build the world's most efficiently integrated aluminum project in Saudi Arabia. This USD 10.8 billion (over SAR 40 billion) project includes a bauxite mine, a refinery, a smelter and one of the world's most advanced rolling mills. Its product, aluminum of the highest international standards, is sold to both domestic and global markets.

Ma'aden Alumina Refinery refines Saudi Arabian bauxite; the refinery capacity is 1.8 million mtpy of alumina. The alumina is transported by conveyor to the adjacent smelter to produce 740,000 mtpy of high quality aluminum products for customers in the Gulf region and in international markets.

HIGHLIGHTS:

Maintenance, repair, and operations (MRO) could be a major business waste if it is not properly managed, monitored, and controlled in its lifecycle.

An MRO lifecycle should follow the asset's lifecycle, starting from acquiring to replacing or disposing. Many companies overlook such a crucial approach that has one of the highest impacts on asset and plant reliability and profitability matrices.

MRO costs normally represent 40-60% of the work order maintenance cost, so any improvement initiative or waste elimination effort could lead to recognized savings, cash generation, and plant asset reliability performance improvement.

The Ma'aden Refinery reliability team recognized the impact of the MRO lifecycle on plant reliability performance. Starting the improvement journey from the operation readiness phase (before plant start-up), the team had been able to set up an MRO reliability road map to control, monitor, and improve the MRO lifecycle. This road map drove the success of saving almost 13.3 MUS over the last three years.

"We are one of the most reliable organizations; we are Uptime® winners. Winning an Uptime Award is testimony to the Ma'aden operational excellence DNA in all business aspects. We are implementing reliability excellence core operating standards in 13 physical asset management (PAM) dimensions as part of our reliability framework. Lean reliability and continuous improvement integration on our day-to-day business activities are the drivers to achieve business excellence."

REM

A RISK THRESHOLD INVESTIGATION IS BORN

Anthony (Mac) Smith, Eric Stevens,
and Jack R. Nicholas, Jr.

The risk threshold investigation (RTI) approach was developed by Anthony (Mac) Smith to support the Metropolitan Sewer District of Greater Cincinnati Wastewater Treatment (MSDGC WWT) Division in its quest to improve reliability. This article takes you through the birth of RTI, explaining what RTI is, why it was created, where it fits into a maintenance reliability program strategy, how it is conducted and showing it in action with some actual results.

Introducing RTI

The thought process of RTI began with this question:

"Are there some potential equipment problems or failures in systems that, individually, could be quite serious even though a system, as a whole, is 'well-behaved?'"

Well-behaved systems (i.e., 20/80) typically exhibit a relatively small number of serious problems. Troublesome systems (i.e., 80/20) have, by contrast, many more components, perhaps 50 percent or higher, in their boundaries that could be classified as contributing to showstopper problems. The purpose of RTI is to ensure that while reliability-centered maintenance (RCM) is being conducted on troublesome systems, some serious problems are not being overlooked in relatively well-behaved systems that may never be subjected to any form of RCM analysis.

The RTI process is conducted at the system level, not the component level. This is because it is already known that the 20/80 systems have a failure history that is relatively benign. This is not so with the 80/20 systems,

> The 20/80 systems needed a simple way to "find the needle in the haystack"

which have a history of "eating our lunch." The 20/80 systems needed a simple way to "find the needle in the haystack." Thus, RTI was born.

RTI came to be because the criticality approach was found wanting in several aspects. In one component-based criticality study, a component could collect enough points from its 23 criticality criteria questions to be considered "critical" by its definitions, but would not necessarily be a "risk" because the consequences of its failure to the plant are relatively benign. The majority of consequences of component failures are not really risks in the true sense of the word. The idea is to concentrate on identifying the problems that could really be showstoppers and try to avoid them.

In RTI analysis, only seven consequence areas are considered: safety, environment, downtime, operations, regulatory requirement, single point failure and economics. The RTI approach relies on the experience of system expert maintenance technicians, operators and reliability engineers to con-

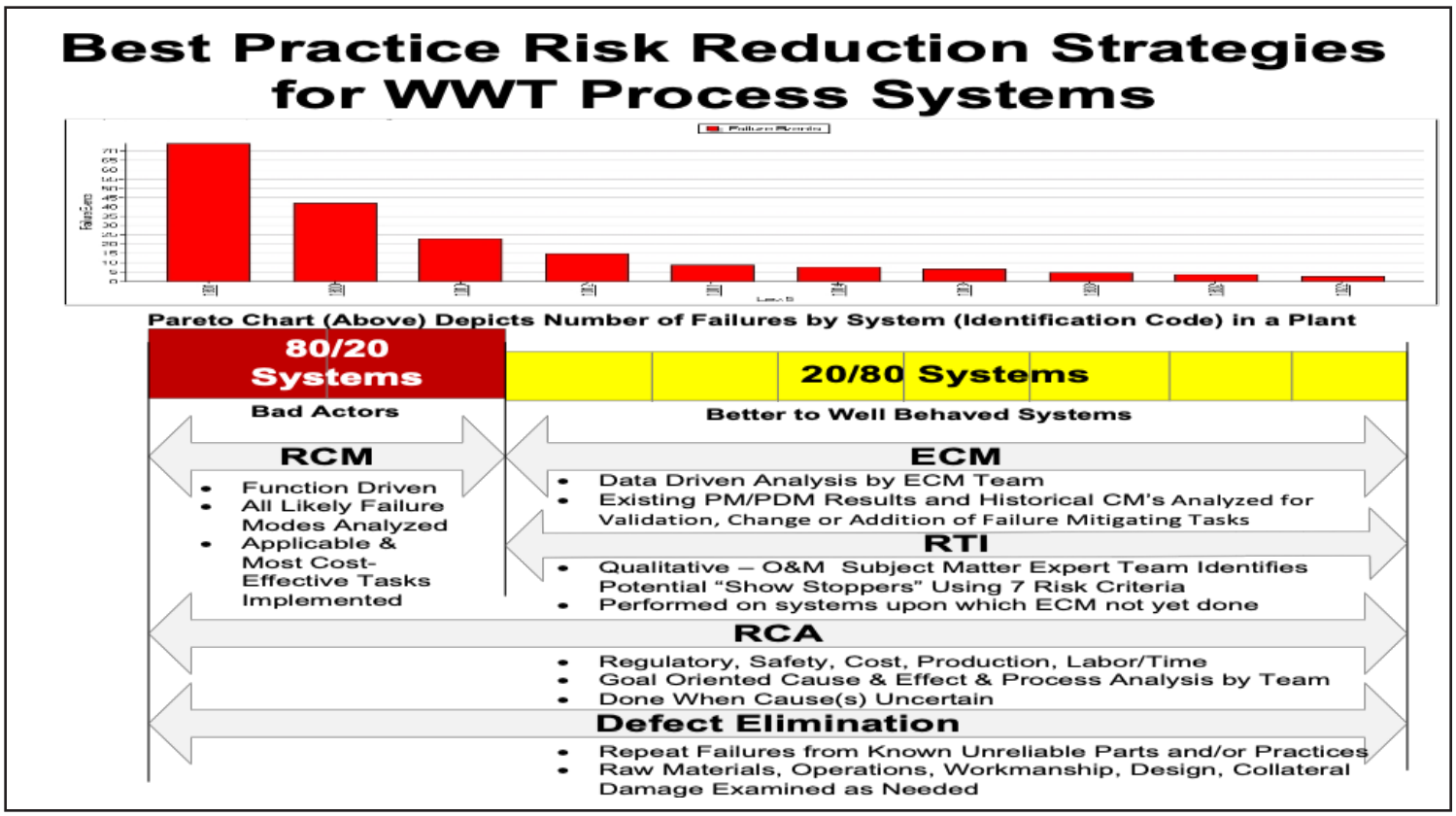


Figure 1: The reliability engineering portion of the R & M strategy

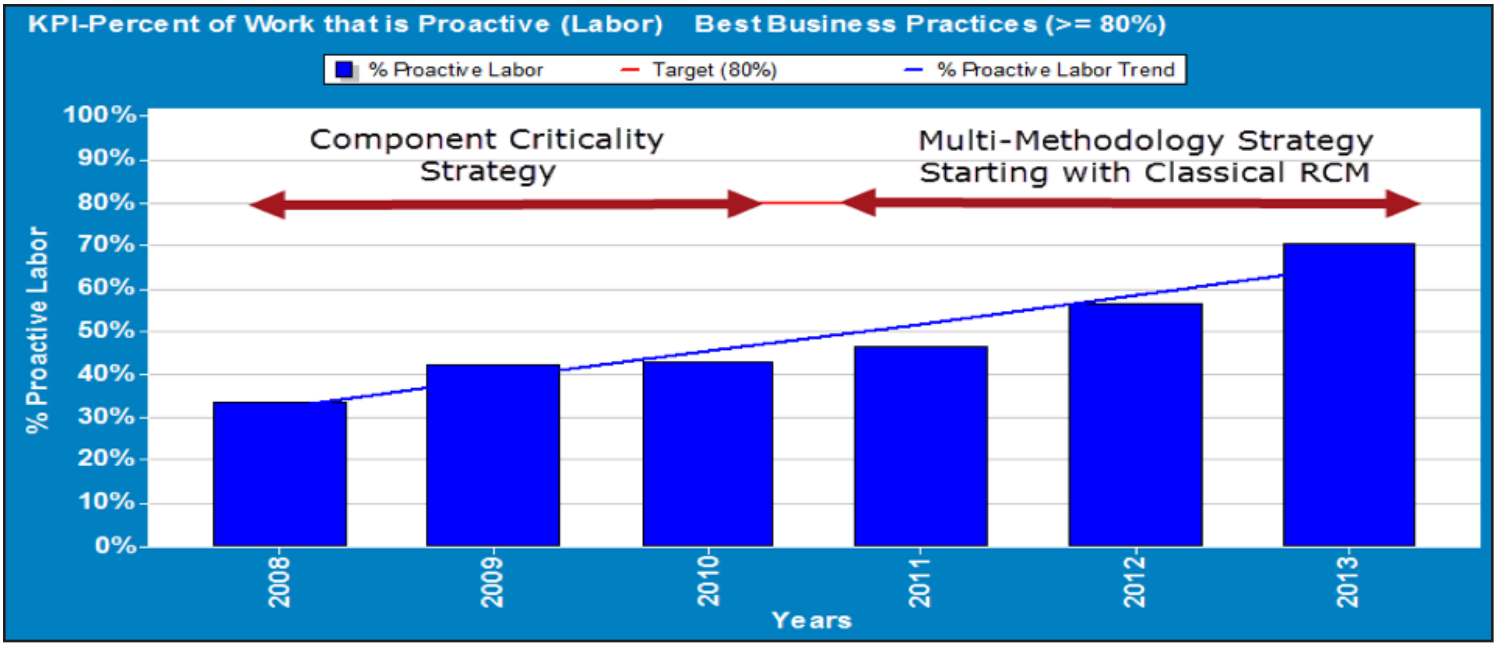


Figure 2: Results of applying ACM strategies

sider if any specific problem in the 20/80 system boundary could be a risk in one or more of the seven designated consequence areas.

The basic idea is to qualitatively identify potential problems or failures in the 20/80 systems that could realistically occur and result in a problem in one or more of the seven consequence areas and also cross a threshold that is judged to be sufficiently severe to warrant special attention to mitigate or eliminate risk.

How RTI Fits Into the R&M Strategy

In 2011, the MSDGC WWT Division formulated a reliability and maintenance (R & M) strategy and formed teams to improve three key areas:

- Reliability engineering, with special emphasis on environmental protection and risk reduction using RCM, experience-centered maintenance (ECM), risk threshold investigation (RTI), root cause analysis (RCA) and defect elimination (DE);
- Planning and scheduling of maintenance work, with emphasis on increasing proactive and decreasing reactive maintenance;
- Monitoring asset condition, with a focus on internalizing and expanding coverage to all applicable assets using as many predictive, condition monitoring technologies and related capabilities (e.g., machinery laser alignment) as cost-effectively feasible.

The reliability engineering element of the overall strategy is depicted in Figure 1.[1]

Let's take a look at each best practice noted in Figure 1.

Pareto Analysis to Identify Systems for RCM, ECM and RTI Analyses – The bar chart at the top depicts the number of failures in the top 10 systems (identified by code numbers) in the largest of seven MSDGC WWT plants. This is done to direct action first on the most troublesome systems. Variations on this approach to rank the systems employ cost analysis, maintenance labor hours, downtime hours, or other measures affecting the organization's goals and objectives.

The highest bars to the left of the graph, called a Pareto chart, identify the 80/20 systems or bad actors. They represent the roughly 20 to 30 percent of systems that produce roughly 70 to 80 percent of failures. Those bars for systems to the right of the graph show fewer failures and are called 20/80 systems. The majority of those systems, roughly 70 to 80 percent, produce only 20 to 30 percent of the failures.[2,3]

RCM Analysis for Bad Actor Systems – MSDGC WWT personnel chose classical RCM as the methodology for bad actor systems. They are the roughly 20 percent of all WWT systems where 80 percent of the problems affecting environment, safety and overall plant performance and cost occur. Classical RCM analysis on a major system may take two to three weeks to perform using an experienced facilitator (i.e., a consultant specializing in RCM until an employee gains enough experience to perform the task) and a team of in-house subject matter experts in maintenance, operations and reliability.

ECM Analysis[4] – ECM was adopted for the better to well-behaved systems (i.e., the 20/80 systems where only about 20 percent of all problems develop). This was done to minimize the impact of MSDGC WWT personnel engaged in the overall reliability improvement initiative and reduce the financial impact on the plant's budget for the improvement initiative. Each system requires a quick look, about two to four days, by an in-house, multidiscipline analysis team led by a specialist in facilitation that answers the following questions:

1. Are current tasks (if any) performed on the system really worth it in terms of applicability (i.e., they work and actually do or can find failure modes) and is each task cost-effective relative to some alternative, such as allowing the asset to run to failure?
2. Could any of the corrective maintenance events performed on the system in the past five years (more or less) been avoided or mitigated if a proper or applicable preventive or predictive maintenance task been in place?

3. Can the team hypothesize any failure modes not already covered in the first two questions that could potentially produce severe consequences, such as affecting safety or have outage consequences requiring substantial downtime and/or forced outage for maintenance?

RTI for 20/80 Systems That May Never Be Subject to RCM –MSDGC WWT personnel conduct a short, one day or less, RTI analysis for 20/80 systems on well-behaved systems. Under some circumstances of unacceptable risk due to two or more risk factors, RTI may trigger a more in-depth look using ECM analysis. RTI results are used to prioritize the systems identified for ECM analysis.

RCA for All Systems When There Is Uncertainty – All plant systems are subject to root cause analysis when problems occur that demand attention to mitigate or eliminate them and there is uncertainty about all the contributing causes. MSDGC chose the cause and effect approach to RCA. Courses on the methodology were held for prospective investigation team participants and facilitators.[5]

RCA is needed because RCM and ECM can't be expected to identify all the contributing and/or latent factors that result in failures occurring in a system's lifecycle, especially those involving humans. Poorly documented maintenance processes, procedures and work instructions all can be contributing causes to failures even after the most thorough RCM or ECM analyses are completed. New personnel lacking proper training and experience who are rushed into a crisis situation can overlook critical steps in completing repairs, resulting in infant failures shortly after resumption of operations.[6] Other causes that contribute to a failure include changes in replacement parts, lubricants and other items from the organization's supply chain and changes in operating conditions, system configuration, or practices.

> They (bad actors) represent the roughly 20 to 30 percent of systems that produce roughly 70 to 80 percent of failures

Additional reasons beyond the scope of RCM or ECM that deal with asset conditions and system configuration at the time of analysis also need RCA as a tool for mitigating or eliminating significant, unexpected failures after the aforementioned analyses are completed. It is also needed when neither of the analysis methods is performed for whatever reason and a significant event occurs. RCA investigations may take several days and the report of findings and recommendations for corrective action can be lengthy.

Defect Elimination – This is the last tool applied in the MSDGC WWT Division's maintenance reliability strategy. The methodology and rationale for including DE in addition to RCA is to eliminate known defects caused by aging, wear and tear, careless or poorly executed work habits, changed operating conditions requiring more robust components, or inadequate replacement parts that don't meet current stress levels present in an asset. DE analysis meetings can be typically completed in a day because they deal with known defects. The report of findings and recommended action(s) is intentionally limited to one page.[7]

RTI Methodology

At the point where it was decided to employ RTI, a total of eight classical RCM analyses had been conducted at MSDGC WWT. This was at a rate of only two analyses per year due to many constraints, including, but not limited to, the flow rate of funds available to hire a facilitator and a lack of available man-hours for in-house subject matter experts to serve on the analysis teams. In addition, the implementation of results from the RCM analysis was lagging. Demands for man-hours to attend to other maintenance reliability initiatives being introduced at the same time, including a different approach to asset condition monitoring, was making life difficult for staff personnel who still had to deal with day-to-day workloads of corrective and preventive maintenance. The desire to account for all systems that might affect wastewater treatment goals and objectives in a way that minimized impact of personnel and maximize impact of their efforts led to the decision to look again at how to prioritize staff activity.

The issue relates directly to the subject of risk. Conceptually, risk is thought of in terms of failure (e.g., hardware and/or software) in a plant system and its equipment, and is measured in terms of failure probability and failure consequence. Unacceptable risk is considered to be a combination of significant consequence and a realistic chance (i.e., probability) that it could actually happen. Some industries, for example nuclear power generation and petrochemical processing, spend large sums of money to quantitatively define risk factors and then take great care to design and operate plants so as to mitigate the risk of accidents. Many of the same design features are found in the MSDGC and most other WWT plants. These include equipment redundancies, adequate design margins and backup operating capabilities that can prevent personnel casualties, spills and releases of untreated wastewater into the environment.

MSDGC WWT Division personnel had recognized for several years the need to define an effective strategy to eliminate, or at least mitigate, the effects of unexpected failures in the plants and systems they operate. In 2007, the organization employed a component criticality scoring method in an attempt to identify just where such risks and criticalities reside, and to then use that process to specify where selected predictive tasks should be employed to reduce these risks. The component criticality approach used a multidimensional criticality index applied at the component level. Criticality was assessed using a composite weighted score based on the answers to 23 questions about safety, environment, maintenance and operations

Figure 3: The five risk threshold investigation steps

TABLE 1 – Failure Criteria Areas Matrix

FAILURE CRITERIA AREAS		CRITICAL SYSTEM FACTORS	THRESHOLD MEASURES	THRESHOLD DECISION
1.0	**SAFETY** Results in personal injury, health hazard, or property damage	Likely Personnel Injury	In-Plant Treatment	Acceptable
			Hospital Treatment	Unacceptable
		Property Damage	< 50K	Acceptable
			> 50K	Unacceptable
2.0	**ENVIRONMENT** Results in non-permit impacts to soil, water, atmosphere, or community	Unexpected Spill	Local/Minor	Acceptable
			Ordinance Violation; Cleanup Costs >$50k	Unacceptable
		Lose Odor Control	On-site	Acceptable
			Off-site	Unacceptable
3.0	**DOWNTIME** Results in system, process, or plant forced outage (downtime)	Duration	< 2 days	Acceptable
			> 2 days	Unacceptable
4.0	**OPERATIONS** Results in reduction in design capacity leading to impaired throughput, decreased efficiency, or system damage	Capacity Reduction	0 - 20%	Acceptable
			> 20%	Unacceptable
5.0	**REGULATORY REQUIREMENT** Results in a permit-related excursion	System Involvement	Non-Permitted/Non-Excursion or Internally Reportable	Acceptable
			Permitted/Excursion or State Reportable	Unacceptable
6.0	**SINGLE POINT FAILURE** One thing can go wrong and shut down the system and maybe the entire process or plant)		Backup Available	Acceptable
			No Redundancy or Backup	Unacceptable
7.0	**ECONOMICS** Results in a costly repair or replacement to the component, including consequential damage	Repair/Replace $$	< 5K	Acceptable
			> 5K	Unacceptable

consequences of failure. A component's score was then used to assign predictive maintenance (PdM, now also called asset condition monitoring or ACM) strategies from a consultant-provided library. This produced some benefits, as evidenced in Figure 2 by an increase in proactive maintenance for years 2008 and 2009. Proactive maintenance increased from a little over 30 percent to over 40 percent, but then leveled at the higher figure in 2010.

In 2009, management looked into a different process to get at this issue, namely, a reliability program that uses Pareto analysis to identify plant systems (not components) that were the major culprits causing excessive corrective maintenance and system downtime costs, and then applies a combination of methodologies, starting with classical RCM, to define a maintenance strategy to eliminate or mitigate these failures. By the end of 2013, this approach was showing significant additional results, adding more proactive maintenance beyond the earlier one based on component criticality. This is illustrated in Figure 2 by the increase in maintenance labor (hours) that were proactive from just over 40 percent in 2010 to just over 70 percent in 2013.

So, the MSDGC WWT Division used the classical RCM methodology for the 80/20 systems, identified through Pareto analysis of system failures and maintenance labor costs. Risks for the 20/80 systems are addressed using the RTI approach. RTI results may trigger more detailed analysis, such as ECM. Therefore, the RTI approach is considered to be in the RCM family of methodologies because it addresses systems, their functions and specific failure modes that can defeat those functions or cause other safety or environmental problems.[8]

The decline in failure events requiring corrective action that had not previously been anticipated through the right PM or PdM tasks and overall failure events started to decline, resulting in a reduction in cost of reactive maintenance in excess of $1.2 million in 2011, $528,000 in 2012 and $752,000 in 2013.[9]

The RTI process utilizes the experience and judgment of a team of experienced technicians and/or first-line maintenance supervisors and an operator to do the analysis. It is facilitated by a specialist in RTI methodology conducting the five-step process shown in Figure 3. These steps mimic, to a certain degree, the analysis employed in classical RCM studies, but stops far short of the comprehensive information collected and the deliberation conducted in classical RCM.

The five steps of RTI are:

1. Select the 20/80 system. This can be determined from a Pareto analysis.
2. For the selected 20/80 system, reach a collective team decision on the boundaries of that system. The purpose of this step is to establish a common team understanding of what is included or excluded during the analysis. Usually, this will be quickly achieved.

> ...A reduction in cost of reactive maintenance in excess of $1.2 million in 2011, $528,000 in 2012 and $752,000 in 2013

3. List the system functions for the selected 20/80 system. Listing functions helps identify impacts tied to functions with specific consequences worth considering. The functions are listed on a board or flip chart by the analysis facilitator and captured with a camera when complete. This data is used for the RTI report.
4. List the major components that reside inside the boundary, including instrumentation, if necessary for control or safety.
5. The team, using its collective experience, discusses each component inside the boundary to determine whether it had or could have any kind of reasonably possible problem or failure that would lead to one or more of the seven consequences in Table 1. The team tries to answer the question:

   Could such a problem or failure be the source of an unacceptable risk in terms of system function?

If the answer is ***yes***, the discussion then turns to whether that consequence would cross an agreed upon threshold measure, acceptable or unacceptable, and if the latter, should be deserving of further attention to eliminate or mitigate the risk before an actual event occurs.

The identification of problems and/or failures and their potential to produce one or more severe consequences is best done by tapping the experience and judgment of ACM/PdM specialists who monitor the system, craft technicians and supervisors who maintain it, and an operator who runs it. Best results will come if the most experienced personnel participate in the analysis.

ACTUAL RTI RESULTS

Case Study of Two MSDGC WWT Systems

System Names:

- Return Activated Sludge (RAS) at Mill Creek Wastewater Treatment Plant
- Waste Activated Sludge (WAS) at Mill Creek Wastewater Treatment Plant

Date Conducted: March 19, 2013

Team Members
- Plant supervisor for liquid stream
- Mechanical crew leader
- Instrumentation crew leader
- Operator
- RTI specialist and MSDGC WWT reliability engineer (facilitators)

System Boundary
- Starts With: Thin wall overflow out of aeration tank
- Ends With: Return pipe at entrance to aeration tank
- WAS: Output of pumps to secondary thickening and eventually the incinerator

System Functions
1. Proper return of activated sludge to the aeration tanks
2. Proper wasting of activated sludge to secondary thickening
3. Flow signals to programmable logic controller (PLC)

Table 2 provides the results of this analysis.

TABLE 2 – Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) Systems Analysis

COMPONENT	PROBLEM	CONSEQUENCE	RISK
1. RAS pumps (18 total), including motor and variable frequency drive (VFD), flow meter on discharge side	Worst case: no redundancy, lose one pump	Has PdM Vibration; On-line and Off-line Motor Testing; Ultrasound Analysis; Spares on hand; Can replace in less than 2 days	Acceptable
2. WAS pump (6 total), including motor and VFD	Pumps are redundant Worst case: lose two pumps	Has PdM Ultrasound Analysis; No spares; Simultaneous loss of two pumps unlikely	Acceptable
3. RAS & WAS electric operated suction and discharge valves, discharge check valves (WAS discharge valve has "medium" criticality index of 700)	Fail open on WAS discharge control valve will shut the system down; Ditto for level switch; Failed open check valves are no problem	In worst case scenario, system downtime would be greater than 30 days for discharge control valve problem	Unacceptable
4. Manual flow control valves and bypass valves	These are normally open and may become stuck open without exercise	Cannot isolate for maintenance work	Acceptable if PM to periodically exercise is added
5. RAS discharge piping to aeration (criticality 0)	Water trapped in U section freezes, cracks open	Costly fix and significant downtime (greater than 30 days)	Unacceptable
6. Manual sampling ball valves	None	None	Acceptable
7. Programmable Logic Controller	All digital failures unpredictable	Have spares; Downtime is less than 12 hours	Acceptable

System Results

- The team spent about four hours developing the information summarized in Table 2.
- From a risk point of view, **two unacceptable** problems were identified in this system: The WAS discharge valve with medium criticality and the RAS discharge piping to aeration. Both could result in prohibitive costs and system and/or plant downtime.
- A third potentially unacceptable problem could develop in the manual flow control valves (RAS to aeration tank manual flow control valve, medium criticality index 1200) and bypass valves (low criticality index 450) if a PM task was not initiated to periodically exercise the valves to preclude a failed open condition.

All three problems should be further reviewed by the plant supervisor of maintenance and appropriate technicians, and results reported to the reliability engineer.

References

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Anthony "Mac" Smith *is an internationally recognized expert in the application of classical RCM. His engineering career spans over 60 years, including 24 years with GE. For the past 40 years, Mac has concentrated on providing RCM consulting and education services to more than 75 clients in the Fortune 500. He is the author or co-author of two of the industry's best referenced books on RCM.*

Eric Stevens, *CRL, CMRP, has been a member of the Metropolitan Sewer District of Greater Cincinnati maintenance and reliability team since 2009, where he participated in the first Classical RCM study. Eric has been a driving force in the program leading the RCM portion. Since 2015, he has been the supervisor over the reliability group and the asset condition monitoring team.*

Jack R. Nicholas, *P.E., CMRP, CRL, CAPT USNR (Ret.), became an internationally experienced and recognized author, workshop leader, advisor and consultant on reliability and maintenance, asset management and related subjects since retiring after 35 years from U.S. government service in 1988. He holds a certificate in Asset Management from the Institute of Asset Management in the United Kingdom.*

OBSERVATIONS of an RTI Team Participant

Eric Stevens, CMRP, CRL

Just like an RCM study, RTI puts all the players into a room and everybody learns information about how the system operates and how it is maintained. Operations and maintenance do not know enough of what the other crafts are doing. Getting everybody together in one room and discussing the functions of the system gets everybody on the same page. At the Mill Creek WWT plant, when we did the RAS system, most of the team did not think that we would find anything that would be a showstopper. We were wrong and found the few issues identified in Table 2. These were addressed in the MSDGC WWT continuous improvement program.

The RTI process is also a great way for a plant to address the 20/80 systems. It is faster and cheaper than doing a full-blown RCM on each system. While a company may want to do a full RCM on every system, that takes time and money. An organization should do an RCM first on the 80/20 systems and in parallel, if possible, do an RTI on the 20/80 systems. Pareto analysis is used to prioritize the systems. RTI quickly points out any assets that could be showstoppers of the entire system. Once the RTI process is done, we could do an ECM study on the systems that had anything that would defeat a function of the process.

Having sat through the criticality process and being asked 23 questions that seemed to focus more on the asset than the function of the system, the RTI process was a welcome change. It directly related to system functions, such as safety, and gives more concrete answers as to which assets are really more critical from a risk standpoint.

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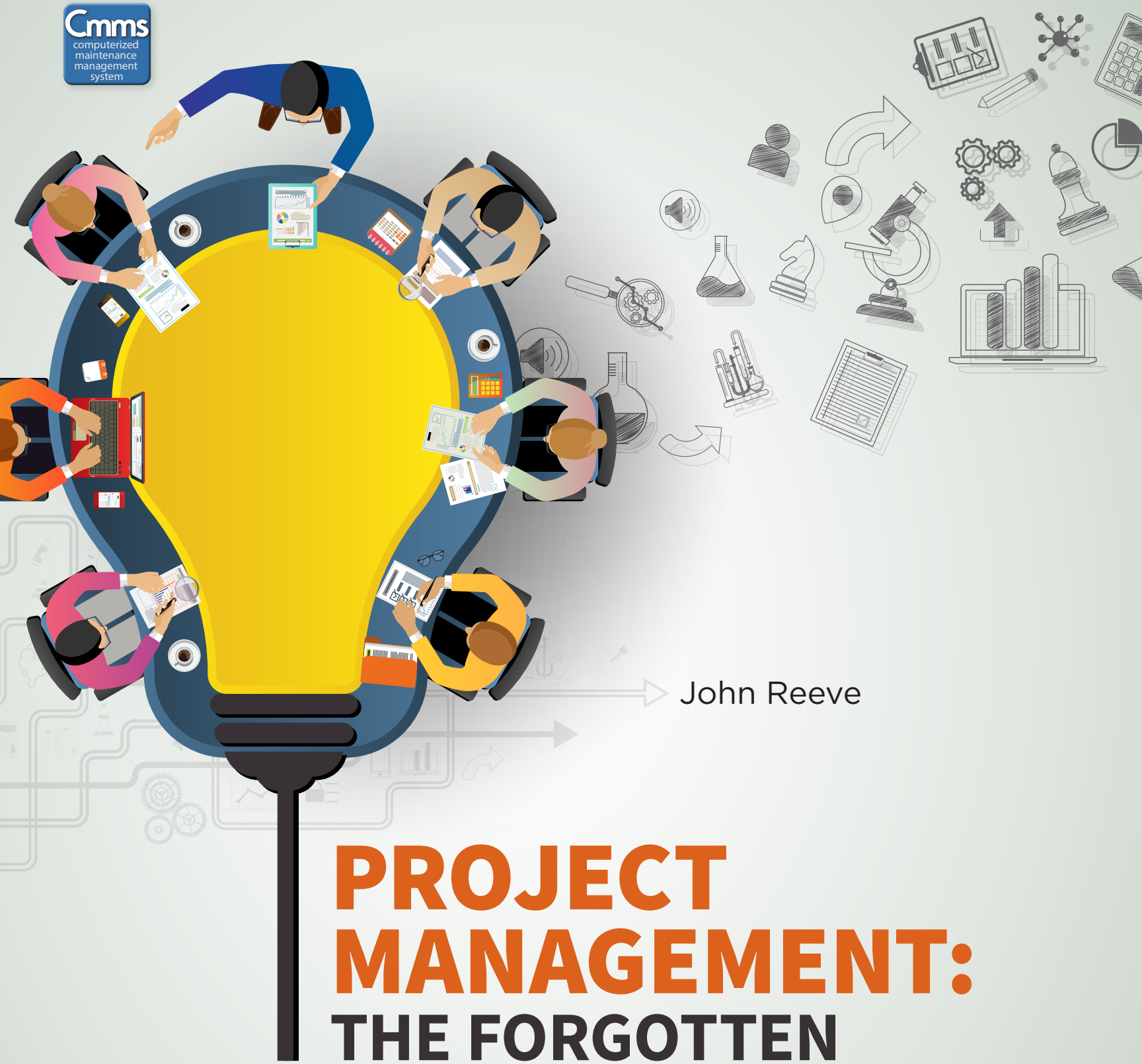

John Reeve

PROJECT MANAGEMENT: THE FORGOTTEN TOOL KIT

The Larger the Project, The Greater the Chance of Cost Overrun

All you have to do is look at the headlines:

- Navy Carrier Cost Overruns May Hit $1.1 Billion, January 2012
- Lockheed Martin F-22 Raptor, October 2014
- Navy's $115 billion Price Tag for New Submarines Will Probably Grow Higher, April 2019

Have the project management skills of the DoD become too lax? Within the world of asset management, construction and alterations are also part of the budget. As asset management professionals , are we paying attention?

Scheduling is a Lost Art

Many decades ago, I left a scheduling career to become a CMMS professional. The world of asset management of course was much more expansive – and interesting. The odd part about this journey is how the CMMS community talks about scheduling but knows very little about the subject. This is where the statement, "You don't know what you don't know" applies.

Natural Intersection

There is a natural intersection between the computerized maintenance management system (CMMS) and project management. If you link the WBS with the work order and the work order with the schedule, you have all of the data elements you need. The WBS provides a summary hierarchy which provides the ideal structure for cost reporting. Senior management does not want to see work order details let alone a 1000 activity schedule.

Facility project managers and architects manage new construction and alterations. They would benefit from having a WBS connected to work orders, and a construction schedule. When a new building is delivered, there can be thousands of assets. These new assets need to be registered and given the right maintenance strategies and scheduled. In the utility and oil/gas industry, shutdown/turnaround/outage (STO) management is a primary concern. Regardless, cost/schedule management starts inside the CMMS.

The Elusive Weekly Schedule

There are many reasons why this process can go sideways. Consequently, 90 percent of all sites have never successfully created a resource-level weekly schedule. Some just print out a list of open work and hand that to the maintenance staff to figure out. Some just focus on emergency and urgent work blended with generated preventive maintenance (PM) work orders. The problem lies with all the other work in the backlog as to how best to manage. And even if all the work orders had a craft estimate, questions still exist as to which ones should be done first and how much work should be scheduled based on craft availability.

Once Upon a Time

Once upon a time, there was a company that marketed project management software. It sold scheduling software and project cost tracking. These two products could be integrated through a work breakdown structure (WBS) at the cost account level to provide the ideal project management system. This software included a full function scheduler that could manage any size project and plot graphics of all types (e.g., bar charts, histograms and network diagrams). At one time, about 50 percent of all the U.S. nuclear power plants in construction/start-up and operational phase used this software.

Then the Mainframe Died

Change happens. For the most part, mainframe software did not convert over to today's technology. Software companies were in a rush to release and decided to build from scratch. Although the new technology is absolutely brilliant, there was some loss of functionality. The current CMMS

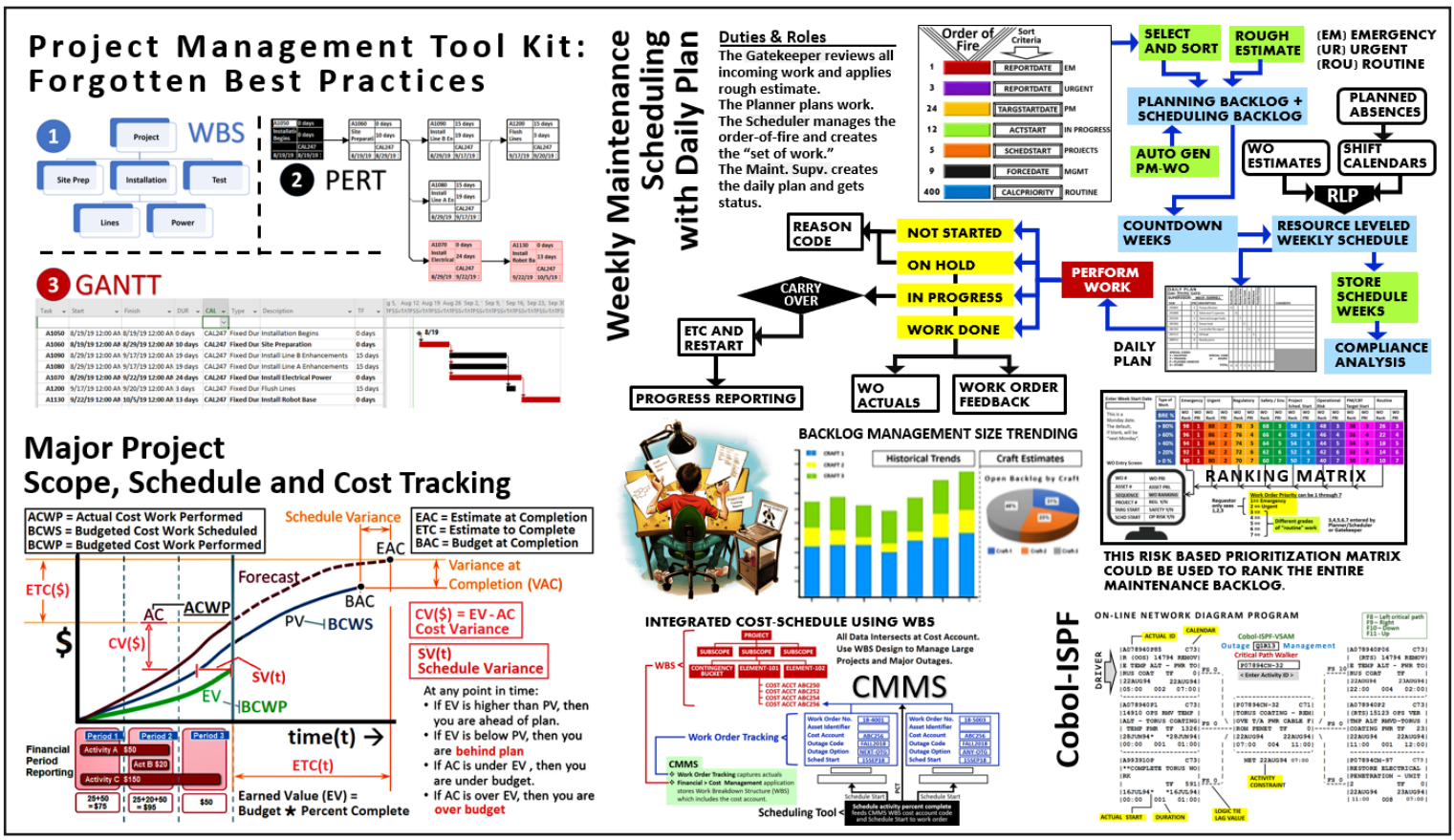

Figure 1: Project management tool kit

products there are weak scheduling interfaces. Beyond that, there is also a general lack of knowledge in the CMMS community regarding project management.

Project Management Best Practices: 1-2-3

The project management concepts taught 30 years ago in project management classes still hold true today. Rule number one was if you build a large project (e.g., construct a nuclear power plant), you should first create a WBS. This design ensures that no scope is forgotten and it provides scope tracking (i.e., additions) once underway. The cost account (CA) element typically stores the budget values. The WBS is also a good place to capture dollar transactions (i.e., movement between cost elements). Lastly, it is the WBS-CA that provides an intersection point for CMMS work order actuals and schedule activity percent complete for cost reporting.

The second rule states that the scheduler must build the story just like a newspaper reported. He cannot build a schedule just because he is a scheduler. He must conduct research, create fragnets, and piece things together – similar to a newspaper reporter.

Once the schedule is assembled, then it is time for reviews. In a nuclear power plant, the scheduling group will have a senior reactor operator, shift supervisor, and outage manager at hand. This person will ask for a print-out (or graphic) showing the critical path. Once validated, then the scheduler will perform resource leveling. The finish date may move further out (very likely) and once again an iterative review process is conducted.

Once the schedule is finalized, a nice looking logic bar chart under a timeline is produced for readability purposes so all stakeholders can clearly see dates for intermediate milestones and, of course, the project's finish date.

10 Requirements for the Ideal Project Management System

In a perfect world, it would be much easier if the CMMS [green] could be set up to support project management best practices – starting with a WBS option [blue]. The CMMS however should be able to do resource-leveling as this is basic math. All that is needed then is an integration to a formal scheduling tool [tan].

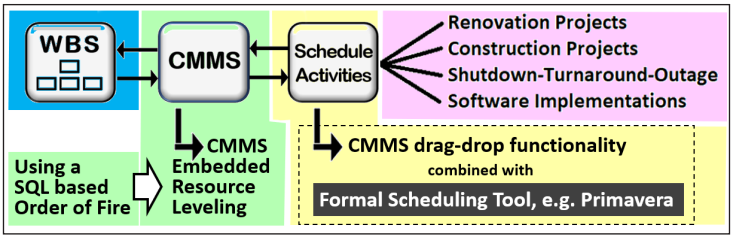

Figure 2: Integrated scheduling solution

Here Are 10 Future World Requirements:

1. Allow for a countdown scheduling design. The scope would be tied down for several weeks in advance. The T-0 week is the execution week. The weeks would be stored/managed inside the CMMS.
2. Some organizations only want a resource-leveled weekly schedule. This should be a single-click action direct from the CMMS creating a tabular report. The weekly maintenance schedule could also feed the daily plan, showing a 2-dimensional report design.
3. The CMMS work management product would provide a capability to generate and store a rough estimate.
4. In the case of a weekly maintenance schedule, ability is needed to properly capture carryover work, which includes estimates to complete (ETC) by craft and an optional restart date, against the work order. The ETC values, if entered, would then be used in subsequent resource leveling calculations.
5. Provide ability to store major projects inside the CMMS as a WBS and graphically display the WBS chart. Users should be able to graphically build a WBS using drag-and-drop tools.
6. Provide ability to link WBS-CA to work orders, capture actuals on work orders (CMMS), store budgets in WBS, and roll up percent complete from the project scheduling tool integrated with WBS-CA codes. An example scheduling tool would Primavera.
7. Provide ability to produce a project cost tracking report using indented levels. The moment an outage finishes, the chief financial officer (CFO) wants to see total costs.
8. With access to a formal scheduling tool provide ability to create and plot WBS hierarchies, bar charts, and network diagrams.
9. The project scheduling software would have the ability to perform advanced progressing techniques, i.e., progress against a data date. Additionally, it would provide the ability to add work to the CMMS from the scheduling tool.
10. Provide the ability to display a work schedule in a compatible calendar format.

Outage Manager Requirements

For outage managers, these 10 actions represent the best use of project management software.

1. **Create an initial outage schedule** showing all required activities with milestones by interviewing all stakeholders. Note that this scope control starts many months/years in advance of a scheduled outage.
2. **Use an iterative review process** to bring total cost down to CFO allowed expenditures and duration based on prioritization by removing/adding scope.
3. **Validate critical paths** by analyzing driver activities using a critical path walker tool. Perform automatic resource leveling and final validation of milestones.
4. **Assess risk points** by identifying ways to mitigate risk.
5. **Create mock-ups** to test areas of risk and complexity. Validate craft skills.
6. **Review safety measures** for all, including contractors.
7. **Freeze the schedule and outage scope** by establishing outage scope control measures. Track scope additions and approvals.
8. **Establish procedures for capturing outage progress.** This should be done on a daily basis by shift.
9. **Transfer contingency funds** and document movement.
10. **Output an indented project cost tracking report** at any time, especially right after the outage's completion.

How Much Software Do You Need?

You can buy software to do anything. But, first, take a hard look at your CMMS to determine what can be configured internally. And through clever use of applications, output can be generated that promotes project management best practices.

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

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Ci
continuous improvement

Operations-Led Reliability Effort: 10 YEARS LATER

Brett Stephens and Joe Mikes

In 2009, Cameco Corporation's Port Hope Uranium Conversion Facility in Port Hope, Canada, launched a new approach to continuous improvement. It was documented and presented in the Aug/Sept 2012 issue of *Uptime* magazine titled, "*Operations-Led Reliability*." Now, 10 years later, here is an update on how it has evolved through multiple improvements.

SOME BACKGROUND

Back in 2009, Cameco partnered with an engineering solutions firm to guide it through the launch of a full reliability excellence program. The firm assigned a senior leader who worked on-site with Cameco's leadership and staff to lead multiple teams in addressing multiple aspects of the program simultaneously. One of the teams was in charge of upgrading the downtime tracking process to a continuous improvement program.

The main idea of the continuous improvement program was to switch from driving improvements from the equipment's downtime records to improving the operations based on all the reasons why production losses were occurring. Cameco named the new program: Production Loss Elimination Process or PLEP.

Unlike the previous downtime meetings, where all solutions were focused on maintenance, engineering, or capital projects, the new meet-

ings result in requests for any department that can help solve problems faced during production. Now, the review meetings have just as many employees from operations as maintenance. Problems, such as leadership communications, consistent operator training, shift to shift communications, supplier issues, or no demand for product, all occur as often as equipment breakdowns.

DURING THE 10 YEARS

PLEP has grown and matured over the years. Before the operations-led reliability program, the plant would prioritize its maintenance, time, money and resources based on the opinions and experiences of senior staff, including multiple versions of a downtime log.

The teams have since been mentored on how to use the existing approach alongside an unbiased data gathering approach. As a result, PLEP version 1 was developed on-site. It was a spreadsheet tool for tracking production losses when production targets were not met. The reasons for missing production targets were entered into the spreadsheet by operators. This data was analyzed and the top three causes for losses were reviewed by management and then appropriate corrective actions were assigned. Along with the technical changes, the plant embraced the cultural change of working with this program.

After using PLEP version 1 for several months, it was determined the tool was too difficult to audit and verify operators who were entering data each time a target was missed. Therefore, the system was improved by incorporating an SQL database with an operator user interface. The teams were advised to keep things simple, start small and keep it easy for operators. In particular, they learned that there should be no more than three clicks; if there are more, operators will not provide quality data. This is something the teams found to be very true. All operator interactions with the system are simple and quick, so they get valuable data. With these changes, PLEP version 2 was created.

After a couple of years of gathering and analyzing data, it was determined that Cameco could eliminate 50 percent of its production monitoring points and automate one of the remaining two. Reducing collection points also improved the quality of data gathered by operators. It also took advantage of the SQL database and created a generic report using an SQL reporting suite. With these improvements, PLEP version 3 was created.

PRESENT DAY

Today, the facility is currently using PLEP version 3. The data is still analyzed and reviewed monthly by management and corrective actions are generated and tracked.

There is a PLEP version 4 in the works. This version focuses on improving the SQL reports. The development team envisions daily and crossover reports that are automatically generated to communicate recent losses to operations. Another planned improvement involves developing a dashboard for its monthly analysis that can drill down several different ways.

THE RESULTS

Over the decade, the facility has learned that it has two main sources of production losses. One is process related and the other is incident related. The plant is addressing the process related issues by improving its maintenance practices and MRO kitting processes. This process has resulted in about three major corrective actions per year, boosting the plant's capability.

For example, early on, PLEP proved that the plant had issues with production targets due to a lack of fluorine gas. A lot of resources were allocated to improving maintenance and storeroom practices in this area. Along with improving the control strategy, this area of the plant is no longer the bottleneck of the operation. It used to lose product because of this, but now it is no longer an issue.

> **Over the decade, the facility has learned that it has two main sources of production losses. One is process related and the other is incident related**

Also, PLEP illustrated how important it is to prevent incidents. An incident in the plant can result in a temporary shutdown. Most incidents are related to product stream blockages and undesirable chemical mixtures. The operations training and communication teams are always working to prevent these types of incidents.

As critical as any launch, PLEP also helps sustain the changes. As an example, the on-site industrial control equipment/network is used to compare any year-to-year downtime coded to a particular area. This ensures implemented corrective actions are improving the overall uptime of the equipment.

Finally, as part of the effort, the Cameco PLEP development team met with other industries. It became very clear that the lessons learned applied whether you were a nuclear engineer, a process engineer, a mechanical engineer, or a chemical engineer.

For example, leaders from a major grain company developed a PLEP process and the similarities to Cameco's process for a nuclear facility were clear.

It is evident that the principles of production loss elimination can be applied to any industry.

Brett Stephens, *Senior Controls Engineer at Cameco's Port Hope Uranium Conversion Facility in Ontario, Canada, has over 12 years of experience in the nuclear processing industry. He has a bachelor's degree of applied science in chemical engineering and a bachelor's degree of science in computer science. www.cameco.com*

Joe Mikes *is an Executive Reliability Trainer based in Phoenix, Arizona. He has consulted in over 40 industries, including over 120 business locations in five countries. Driving operational reliability is his passion.*

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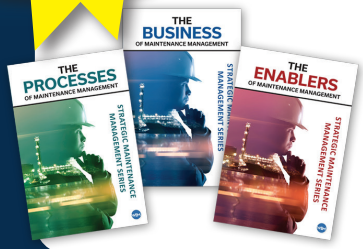

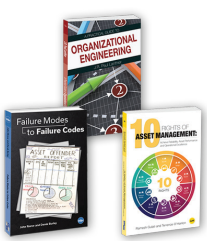

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Figure 1 shows actual results obtained by implementing and **insisting** on precision installation and maintenance at the world's largest pulp and paper mill.

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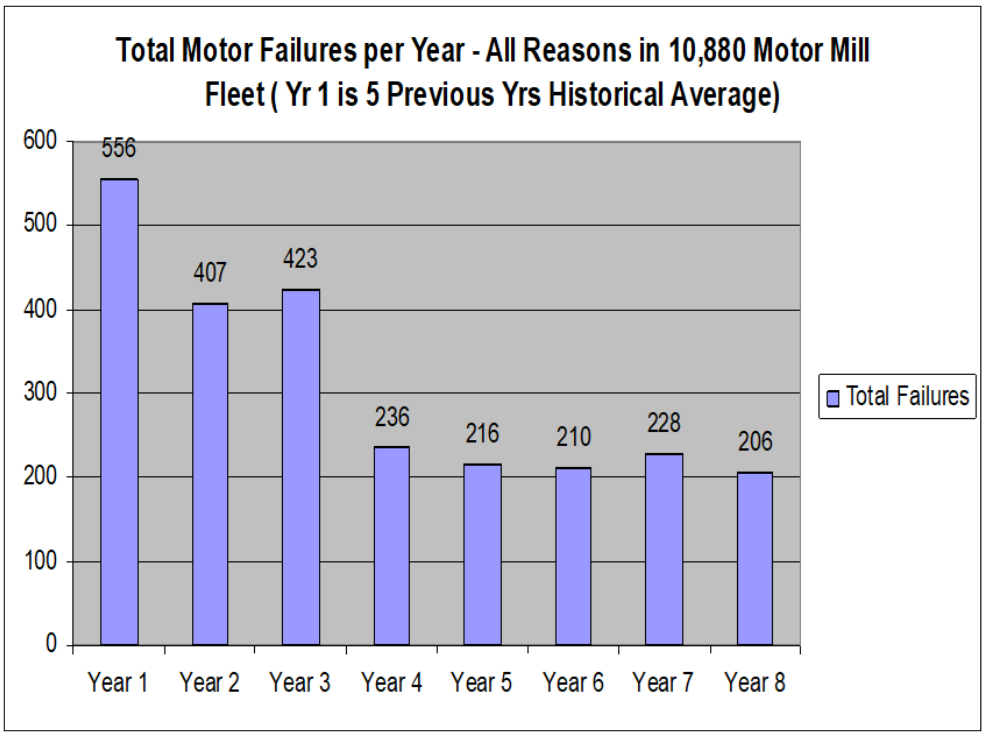
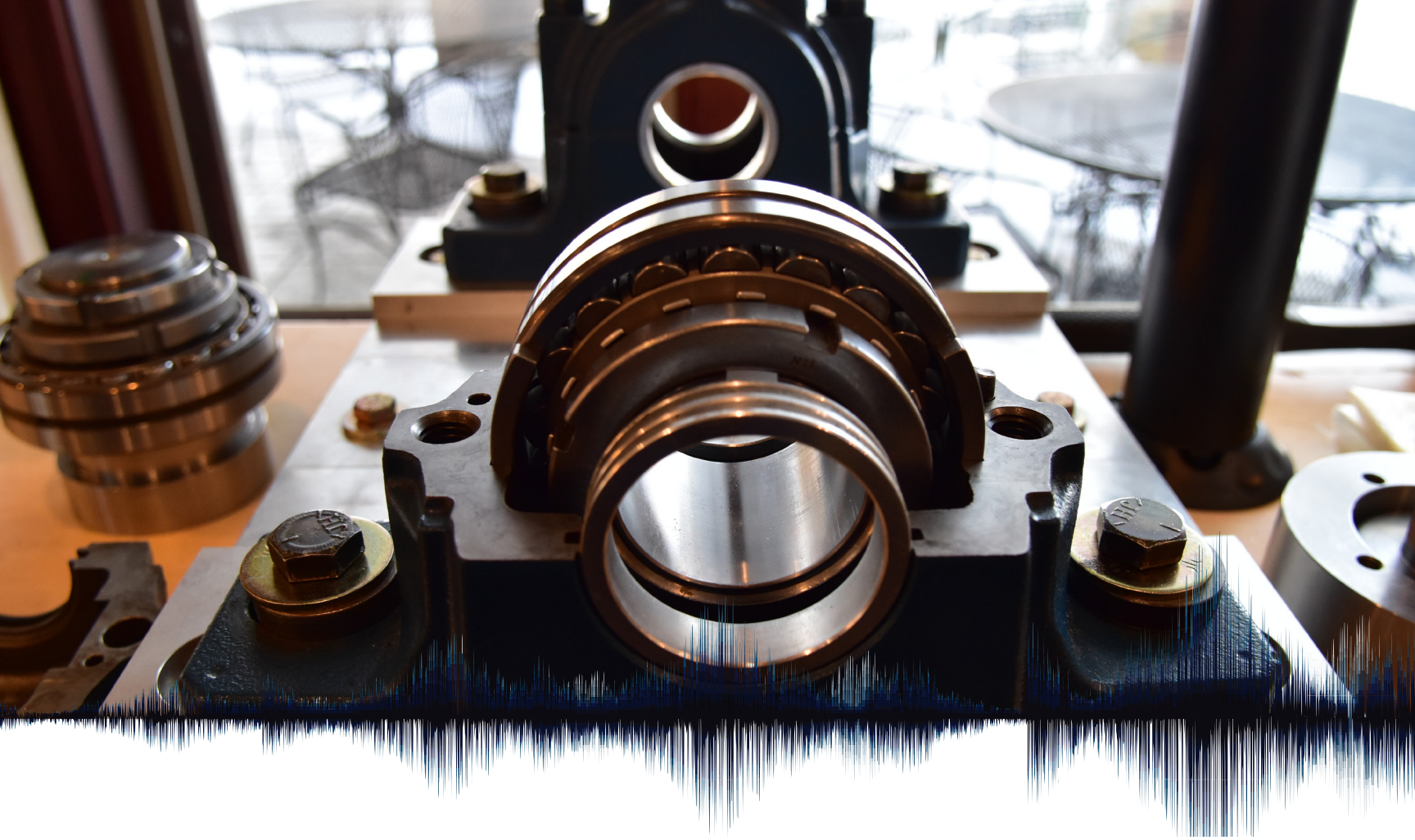


Figure 1: The yearly decline in total motor failures following precision installation and maintenance



of others vibrating at higher than new minimum acceptable levels be put into a precision state, the mill could easily double the life of its electric motors. Conversely, the mill could cut the failure rate in half in just four years, which it did, achieving an average life of 46.1 years. Some eight years later, the rate has been sustained and now reflects an even higher average motor life of 52.8 years

Reducing vibration will exponentially improve bearing life and, since bearing clearances control most of rotating equipment's components' life, by association, rotating equipment life is also increased. For every 20 percent that you lower vibration, you easily double the life of the bearings. Do this on a systematic basis across the plant and you will not believe the other costs that will go down and the uptime that will go up. This is accomplished by applying the following vibration and precision actions and using the plant's fleet vibration, downtime, cost, or similar metrics.

1. Identify the Top 10 equipment vibrations in each area. Assign responsibility to individual mechanics to put the equipment in precision state after defining proper expectation settings of what precision state is and how to get it without spending more than a few hours of mechanical downtime.
2. Go beyond the Top 10. Some plants make the huge mistake of only working on the Top 10.
3. Set monthly or quarterly expectation goals. For example, in one company, crew leads were expected to put a certain amount of additional equipment in a precision state each quarter and the results were audited (i.e., no pencils or keyboards "whipping the number").
4. Be sure to eliminate errors. Mechanics responsible for precision expectations should identify and eliminate common assembly errors made daily in every plant by mechanics and construction workers.
5. Work to establish **strict** precision measurements for fit and tolerance in plant repair shops and audit outside repair shops, bringing along mechanics and one engineer, to ensure these shops work to your standards not theirs, unless their standards are better.
6. Ensure all field installs have zero pipe strain, no soft foot and are aligned for thermal growth, if needed, and to precision alignment expectations.
7. Purchase new and rebuilt rotating equipment to G 1.0 balance specs.
8. Ensure mechanics fill out and submit to the planner a precision field maintenance worksheet stating whether or not equipment was left in a precision state. This is most important and vital. No one should be scolded if the equipment isn't left in a precision state, but they should note why they weren't able to do so. Some reasons might be pipe strain; no time to correct; bearing housing worn out, none in storage, need to order; or precision alignment not possible because 60-year-old base is corroded away.
9. Emphasize follow-up on the problems turned in by mechanics and first-line personnel of emergencies. It is vital that the planner, superintendent, or whomever knows that they have the responsibility to order parts and get back on schedule for repair.

It is a proven fact that vibration significantly decreases the overall life of all rotating equipment, including, but not limited to, bearings. If you want to dramatically reduce your overall maintenance costs and substantially increase uptime and profits, start by lowering the overall vibration of your plant's equipment.

***Phil Hendrix**, is Co-Founder and Owner of Hendrix Precision Maintenance. Phil has 47 years of successful experience performing and leading heavy industrial maintenance in all industries, and has been a reliability consultant and trainer at over 250 companies. His passion for the last 15 years has been teaching these skills to younger maintenance people. www.hendrixprecisionmaintenance.com*

De
defect elimination

BECOMING A HIGH RELIABILITY ORGANIZATION THROUGH DEFECT ELIMINATION

Tim Rice

High reliability organizations (HRO) are those that effectively manage risks by identifying and controlling probability and consequence. They are error-free, with systems in place that make them exceptionally consistent in accomplishing their goals and avoiding potentially catastrophic events.

The airline industry is an HRO. There is a one in 11 million chance of a plane crash with major commercial airlines. Why is the probability so low? Because it needs to be. The airline industry is heavily regulated because the outcome of a plane crash has devastating consequences for all involved. They need to be an HRO in order to survive.

HROs are not just concerned with physical asset reliability. They ensure systems, processes, people and physical assets are running in harmony with each other. They have recognized the need for a shift from traditional asset reliability to organizational reliability. Organizational reliability requires input from everybody within the organization. It's long been said that safety isn't just the responsibility of the safety department, yet organizations seem to continue to place the responsibility of reliability on the reliability department.

The 5 HRO Traits

The five traits an organization must have for becoming an HRO are: a preoccupation with failure, a reluctance to simplify, a sensitivity to the operations, a commitment to resilience, and the humility to defer to the experts.

A **preoccupation with failure** means an HRO is fixated on how things could fail, even when they haven't yet. It also means that when something does fail, they have the desire to find out why.

HROs never ignore a failure, no matter how small it is, because any deviation from the expected result could snowball into tragedy – perhaps not in this specific event, but potentially the next time it happens. Remember, it's not just about asset failures anymore; it's about anything that has impacted the organization's goals and caused it to no longer be consistent on its journey to achieving them.

Having a **reluctance to simplify** means the HRO rejects the simple diagnosis and digs deep to find the real source of a particular problem.

HROs stop explaining away their problems. This can be a regular occurrence in many non-HROs. The undesirable event is brushed aside or flimsy explanations are given. HROs conduct rigorous root cause analysis and do not simplify the controls they put in place to prevent recurrence.

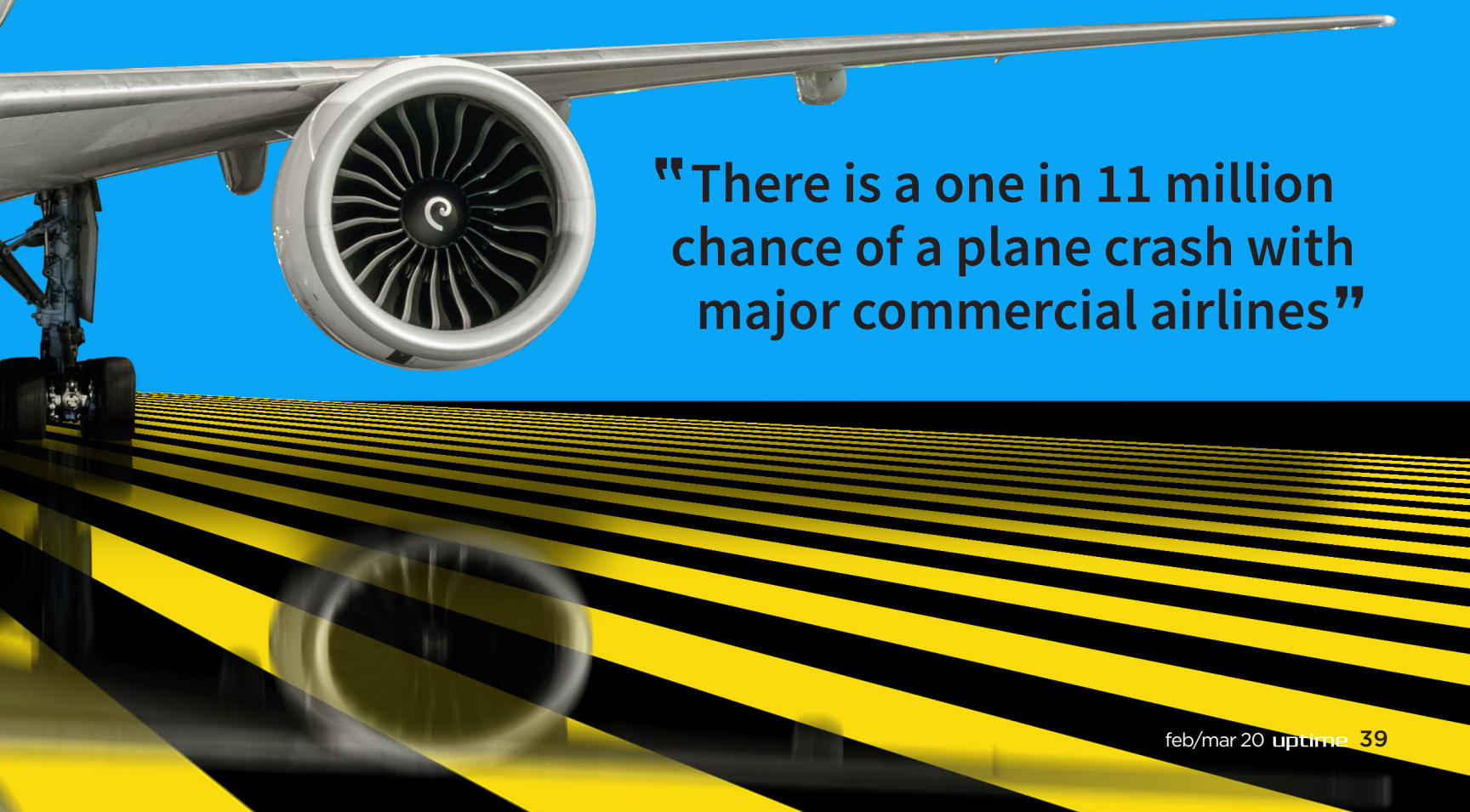
It's okay to have a healthy dose of skepticism. It helps create a **sensitivity to the operations**. Each employee in an HRO pays close attention to the operations and maintains an awareness as to what is and isn't working.

HROs create a sense of chronic unease by not allowing themselves to become complacent. This allows them to look for the weak signals that are alerting them that failure is imminent.

When there isn't a sensitivity to the operations, people tend to take things for granted; they stop paying attention to them and they normalize their deviant behavior. Even in HROs, there are a lot of preexisting conditions and all it takes is a single action to align them all, resulting in an undesirable event occurring. This is sometimes referred to as the Swiss cheese model.

An undesirable event can be prevented by identifying the early signs and making the corrections.

A **commitment to resilience** allows an HRO to anticipate trouble and prepare a response plan. HROs improvise more or quickly develop



"There is a one in 11 million chance of a plane crash with major commercial airlines"

new ways to respond to the unexpected. Not only do they find new ways to respond, they also look for ways to prevent the unexpected.

Traditionally, a fire department's role is to put out fires. Firefighters train and practice, have all the right equipment, and are ready to respond when they need to put out a fire. However, they also work to prevent fires by educating the public and performing regulatory inspections.

Defer to the experts means an HRO listens to the expert rather than the authoritarian figure or those that are most vocal. HROs identify highly skilled individuals within their organization or know who to consult outside of the organization.

These people are the subject matter experts and are utilized. They are one of the greatest assets an organization has.

Defect Elimination at the Core

In each of these five HRO traits, defect elimination (Uptime® Element, De) is present and at the core of any organization wanting to improve or simply sustain its organizational reliability. De won't be the only thing you need to do to get HRO status, however, it can be a large piece of the puzzle for getting there.

De is a program for eliminating defects that are significantly impacting the operating capacity of a business. It's applicable to anything that disrupts the harmonious rhythm of your organization. To shorten Winston Ledet's definition of a defect, a defect is anything that erodes value.

De is a never-ending process. Organizations that have been HROs for many years still have defects within their day-to-day operations today, however, they acknowledge this and constantly work toward eliminating them. They identify the defects, prioritize them, analyze them, develop solutions, implement the solutions, and verify the improvement.

So, how can you make sure your De program puts your organization on the right path to becoming an HRO? The link to De and the five HRO traits are as follows.

A **preoccupation with failure** requires you to analyze the defects to find out why they exist. A **reluctance to simplify** also calls for you to analyze the defect. Root cause analysis is the only way you are able to identify the true root causes and what you ultimately need to eliminate. Developing robust solutions and challenging them against how effective they will be in the long term is also crucial. The hierarchy of controls (Figure 1) indicates that the higher the solutions sit in the hierarchy of controls, the more effective they will be in the long term.

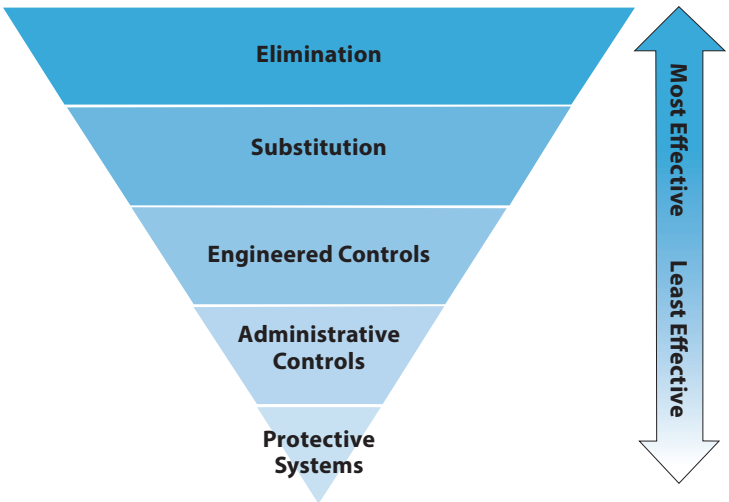


Figure 1: Hierarchy of controls

Don't just be worried about the defects that are currently impacting your organization – be worried about those that could impact your organization. This is having a **sensitivity to the operations**. The data systems your organization has in place must be used to identify defects. Using the people within your organization to be the eyes and ears for finding defects or to notice a change before it becomes an impacting defect is very effective. Know what your trigger points are for identifying when something has or is on the way toward deviating from the norm.

When you know what your organization is sensitive to, develop solutions with cross-functional teams and have the end users involved. This will create a **commitment to resilience**. There is a much better chance the solutions will be successful and sustained if you involve them.

> "To shorten Winston Ledet's definition of a defect, a defect is anything that erodes value"

Don't be afraid to challenge the status quo and change if the solutions are no longer working. The definition of insanity is doing the same thing over and over and expecting different results. Develop new ways to respond to the unexpected events.

In De, you always **defer to the experts**. If you want to find out the real cause of the defect, you ask the expert. This might be the person who deals with the defect every day, like an operator or maintainer. It also may be someone who has seen or dealt with the defect somewhere else. These experts need to be part of your De teams.

In reality, though, is becoming an HRO even possible? It's been proven to be possible by heavily regulated industries, but what about those that are not?

Yes, it will be resource intensive.

Yes, it will be a long journey.

Yes, it will be sustainable – but only if you do it right.

Do not expect the reliability department to be able to do this on its own. Do not expect that you can make this happen quickly. Do not expect it to be sustainable if you try to cut corners or do not have the entire organization engaged and committed to it.

If it was easy, then every organization would be doing it and every company already would be an HRO. But, being an HRO requires a lot. It requires engagement, a dedicated focus, a long-term plan, and an absolute willingness from everybody in the organization to change.

Is your organization up to the challenge of becoming an HRO?

Tim Rice *has spent the last 15 years working in the in the reliability realm, with a majority of that time in mining and mineral processing industry. Tim focuses on driving a whole life asset management process and how a reliability mentality can deliver positive gains, especially when utilizing a defect elimination program.*
www.thedefecteliminationproject.com

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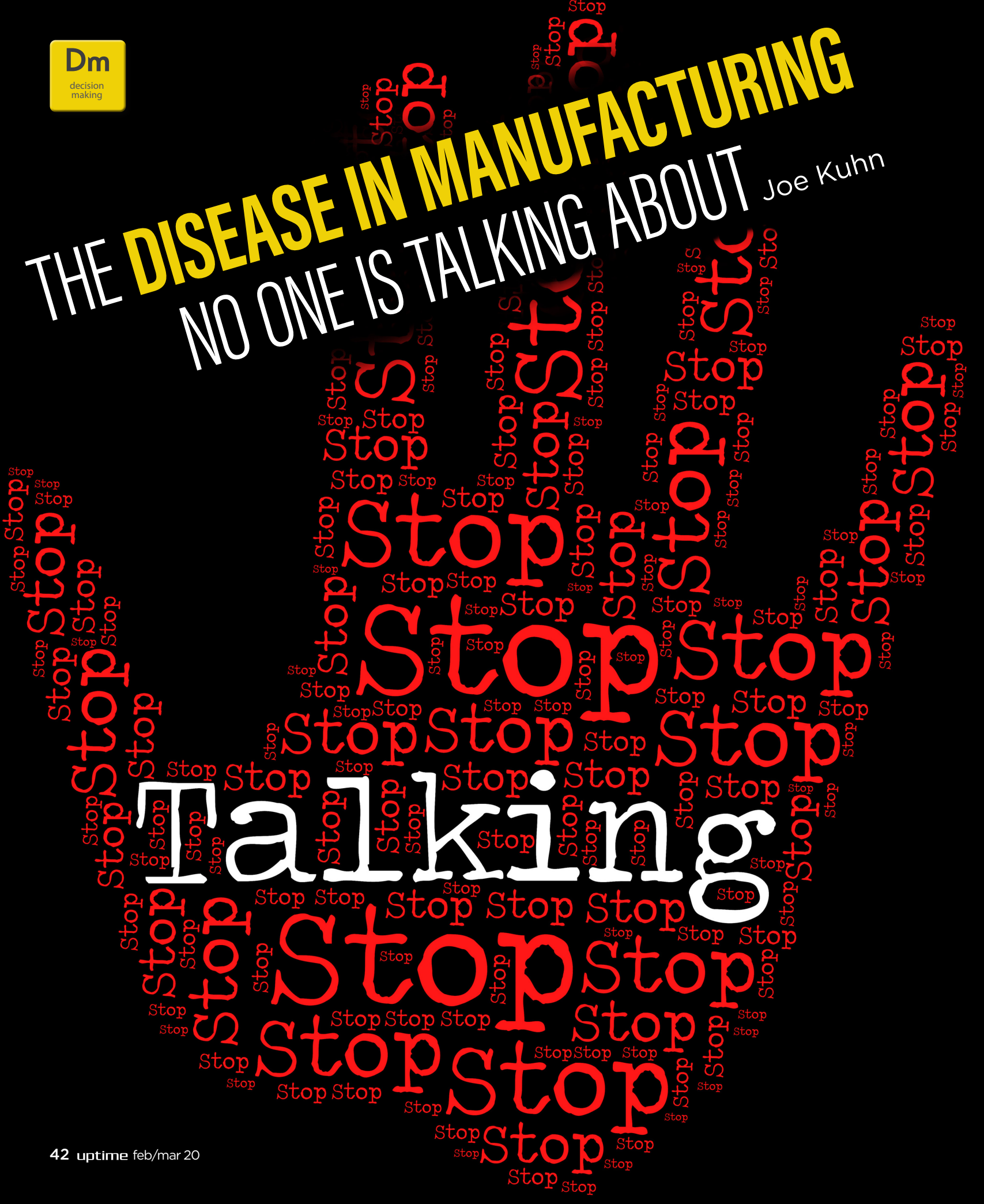
THE DISEASE IN MANUFACTURING NO ONE IS TALKING ABOUT

Joe Kuhn



In one recent reliability trade magazine, there were 34 advertisements for new and improved tools or training for improving your reliability program. The tools included software, new condition monitoring gadgets, and training and certifications on best practices. Further, the magazine included eight articles on such topics. However, there were zero articles and zero advertisements on the biggest lever by far for rapidly and sustainably improving equipment reliability, cost, quality, safety and throughput – shop floor observation.

With shop floor observation, there is nothing to buy. But by leaving this tool out, vendors are misleading countless practitioners on what really gets a reliability program up and going. Longtime engineers, managers and plant managers will tell you that nothing comes even close to the impact firsthand observation has on operations, yet no one talks about it. Instead, vendors invent new tools to keep you in the office tied to your computer or smartphone looking at biased data with intoxicatingly beautiful graphics. This, coupled with the fact that you are already overwhelmed with e-mails, conference calls and daily management meetings, has resulted in nearly zero firsthand observations of reality.

Data and metrics are biased. All data is subject to filters, manipulation and interpretation, yet most people swallow it hook, line and sinker as the truth. Data granularity is also lost when you lump all numbers together and take averages and totals. Let's look at three examples.

EXAMPLE #1: PREVENTIVE MAINTENANCE (PM) PERCENT COMPLIANCE: Did you know that you get the same "credit" for the monthly inspection of fire extinguishers, ladders, extension cords, ground-fault circuit interrupters, and drinking water fountain filters as you do for lubricating the bearing on a critical production center? It's true. A plant can be at 99 percent Pm compliance while not lubricating a single bearing in the plant, giving the leadership a false sense of reliability.

EXAMPLE #2: PREDICTIVE MAINTENANCE (PdM) PERCENT OF TOTAL WORK HOURS: Full-time PdM technicians are routinely pulled off their planned jobs to support emergency work and outages. As high as 80 percent of the time, these technicians are not doing PdM work. Supervisors who are strapped for resources to support the urgent emergency work quickly pull these strategic work resources. Hard to blame them though, they are often the highest trained, hardest working and passionate workers. Nevertheless, the metrics nearly always credit these technicians for 40 hours of PdM work. This practice also greatly understates the amount of unplanned work.

EXAMPLE #3: SCHEDULE COMPLIANCE: It is common to audit an outage and find some discovery work has changed the critical path. Resources are moved off of less critical jobs to complete the work. Consequently, these less critical jobs are not fully completed, and since they will be on the schedule again for the next outage, they are closed out as complete. The raw data and key performance indicators (KPIs) reflect 100 percent completion.

These are not hypothetical examples nor extreme cases, but rather common ones. No one is trying to be malicious; most often, they believe they are doing, in the moment, what is best for the company. Regardless, the metrics are not accurate. What decisions are the leadership team making with this bad data? Are they working on root causes with faulty PM data? Are they thinking they are better than they are with PdM, yet failures continue to happen? Bad data leads to bad decisions, plain and simple.

But, not all is lost. While KPIs are biased, they are not worthless. They actually provide good insight into what to go and see via firsthand observation. Observation, however, does not mean the five-minute snapshot. It refers to the chalk circle observation exercise pioneered by Taiichi Ohno, considered the father of the Toyota Production System that inspired lean manufacturing. Strictly speaking, chalk circle observation is one in which the observer stands in a small imaginary circle on the shop floor and observes the seven forms of waste and standard work. These observations are at least four hours in duration and are best when they occur over multiple days. By doing such a sustained observation, the leader gains insight into simple changes that can prevent waste and lead to new action plans. If done correctly, most actions can be completed in 30 days. Imagine the impact on both the organization and sponsors if for zero dollars you produce significant results in just days.

Here are three examples of chalk circle observations that lead to actions that deliver impressive results.

EXAMPLE #1: FULL JOB KITTING: If you are tracking kitted jobs, you will most likely see that only the major parts are actually kitted. For example, the job is to replace a pump. Ten times out of ten, only the pump will comprise the kit. The planner assumes it is insignificant for the craftsperson to find a coupling, shim stock, gasket material, or any other shop part. Observed in practice, a fully kitted job often increases wrench time by as much as 50 percent.

EXAMPLE #2: STAGING OF PARTS AND EQUIPMENT: At the beginning of a shift, there is a mad dash to find a fork truck to move parts or to try and locate a 10-ton mobile crane and a welder. Often, one fork truck is shared among five teams of craftspeople. The crane was not left where it was supposed to be (it's in the shop getting its monthly PM) and the welder is not working due to a damaged cable. This scenario is more common than you may think. You act and create a kitter/stager position to stage all the parts and equipment at the job site during the previous shift. By doing so, 100 percent of the morning chaos can be prevented, impacting wrench time as much as 50 percent.

EXAMPLE #3: STANDARD WORK FOR TAKING CRAFTS OFF PLANNED WORK: Your PdM technicians begin work at 7 a.m. on Monday and are called to support an emergency job until 2 p.m. With chalk circle observation, you see that the work they were called off to support was critical, but those crafts assigned to do emergency work were actually working on a job that could wait at least 24 hours. The supervisor, in an effort to please, pulled the team of people working on preventing next month's emergency work. A simple fix is to create an approval process to pull these resources into the urgent work. By seeking second level approval, you can realize at least a 90 percent reduction in these events.

Note how simple, low or no cost, and impactful these changes will have on results. Also, reflect on the ability of KPIs to highlight these wastes.

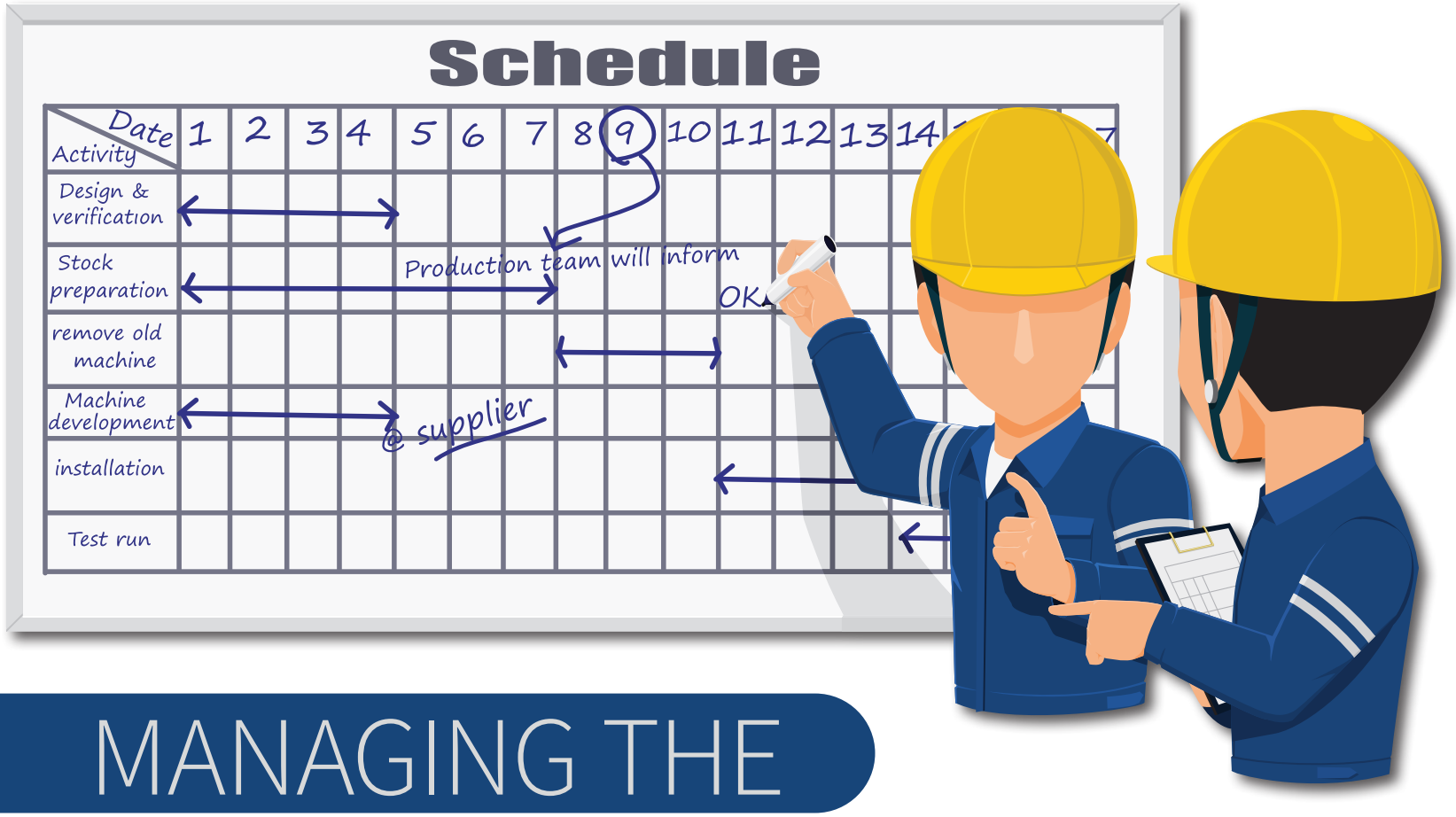
Without a doubt, tools, training and certifications are critical parts of a reliability plan best serving those organizations well into their reliability journey. However, they are not a substitute for your most impactful action – observation. Further, highlighting only the cutting-edge tools and training is misleading those in the early phases of their reliability journey. Tools are not a substitute for firsthand observation.

Is this disease in your plant? In your next meeting, keep track of talking points that are based on biased metrics/KPIs, biased opinion and firsthand chalk circle observation. Expect to be amazed.

***Joe Kuhn** has 33 years of experience as a practitioner in heavy industry with a Fortune 200 company. Joe achieved dramatic results in reliability as a department manager, global director of reliability and plant manager. He is currently the owner of Lean Driven Reliability and host the YouTube channel titled "Reliability Man."*

Ri
risk management

Luiz Verri



MANAGING THE RISK OF THE SCHEDULE USING MONTE CARLO SIMULATIONS

Consider this scenario: You are finalizing the planning of your company's next major maintenance outage or capital project and are concerned the timeline is too tight and your team is small. You communicate this to management and recommend increasing the size of the contracted teams by 20 percent to secure the deadline. The manager then asks, "But what is the real chance of delay? And what will be the chance of delay after the change? If I invest in increasing the team, what will my return really be?"

Instead of answering that "the risk of delay will decrease," what if you could answer: "Currently, the probability of not meeting the deadline is 50 percent. With the suggested recommendations, the probability of delay falls to less than 15 percent." Much more convincing, don't you think?

Monte Carlo simulations for schedule risk management enable this type of response, as well as give detailed information on the success and delay of the various tasks, allowing for better decision-making and, consequently, increasing the gains.

Risk Management Methods

Major maintenance shutdowns (e.g., large production units once every five years) resemble large projects, with a dedicated staff and often a Project Manager, as well as procurement, planning and scheduling, and other staff.[1] Smaller turnarounds (e.g., machine stops every four months) are usually already planned and performed by day-to-day maintenance personnel. In both cases, good schedule risk management helps to avoid delays.

Given the similarity between turnarounds and projects, good project management practices also apply to outages.

According to the Project Management Institute, risk management is one of the 10 areas of knowledge that constitute effective project management.[2] The methods used may be qualitative or quantitative. In qualitative, risks are described in terms like very low, low, medium, high and very high. Quantitative methods, however, involve the calculation of probabilities and the estimation of the impact of different scenarios. In this way, it is possible to "identify the risks that require the most attention because of the impact on the final outcomes of the project" and "it is possible to identify realistic and achievable scope and chronogram objectives, timeframes and timelines."[3] The main quantitative method is Monte Carlo.

> **...Identify the risks** that require the most attention because of the impact on the final outcomes of the project

The Monte Carlo simulation method was initially proposed by mathematician Stanislaw Ulam[4] in the 1940s and was used in the first electronic numerical integrator and *computer* (ENIAC) during the Manhattan Project,

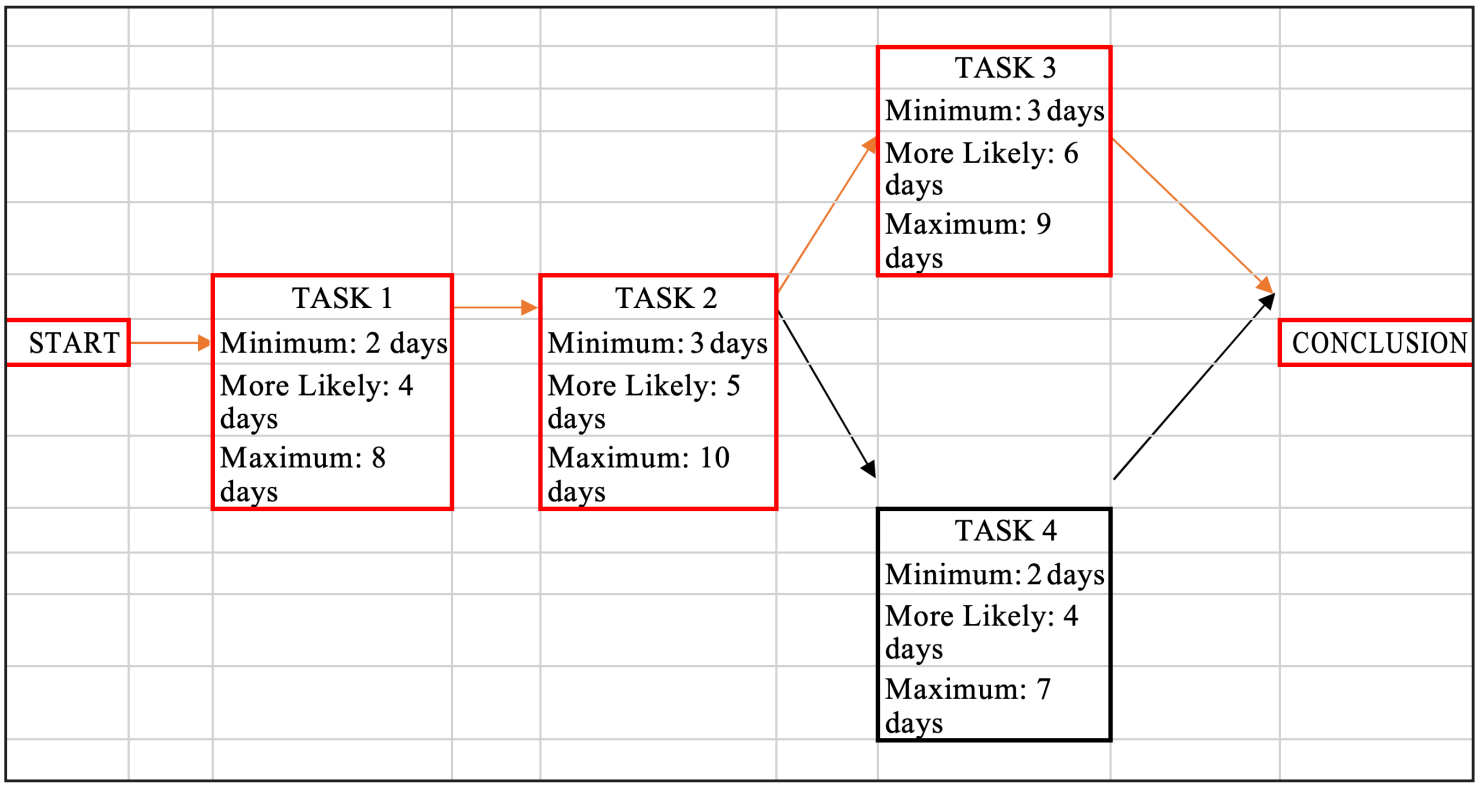


Figure 1: A project schedule with four tasks

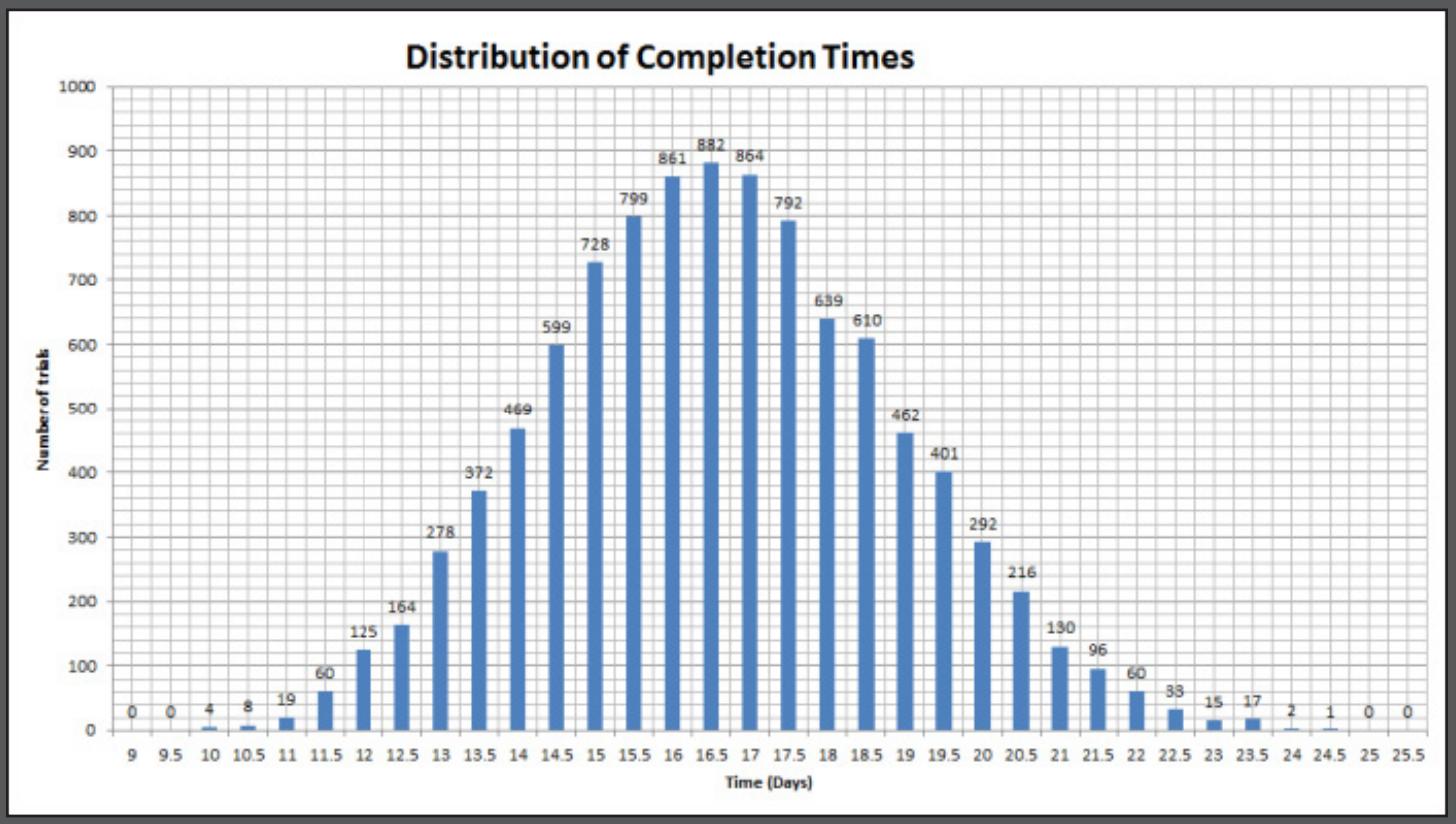


Figure 2: Distribution of possible execution times[5]

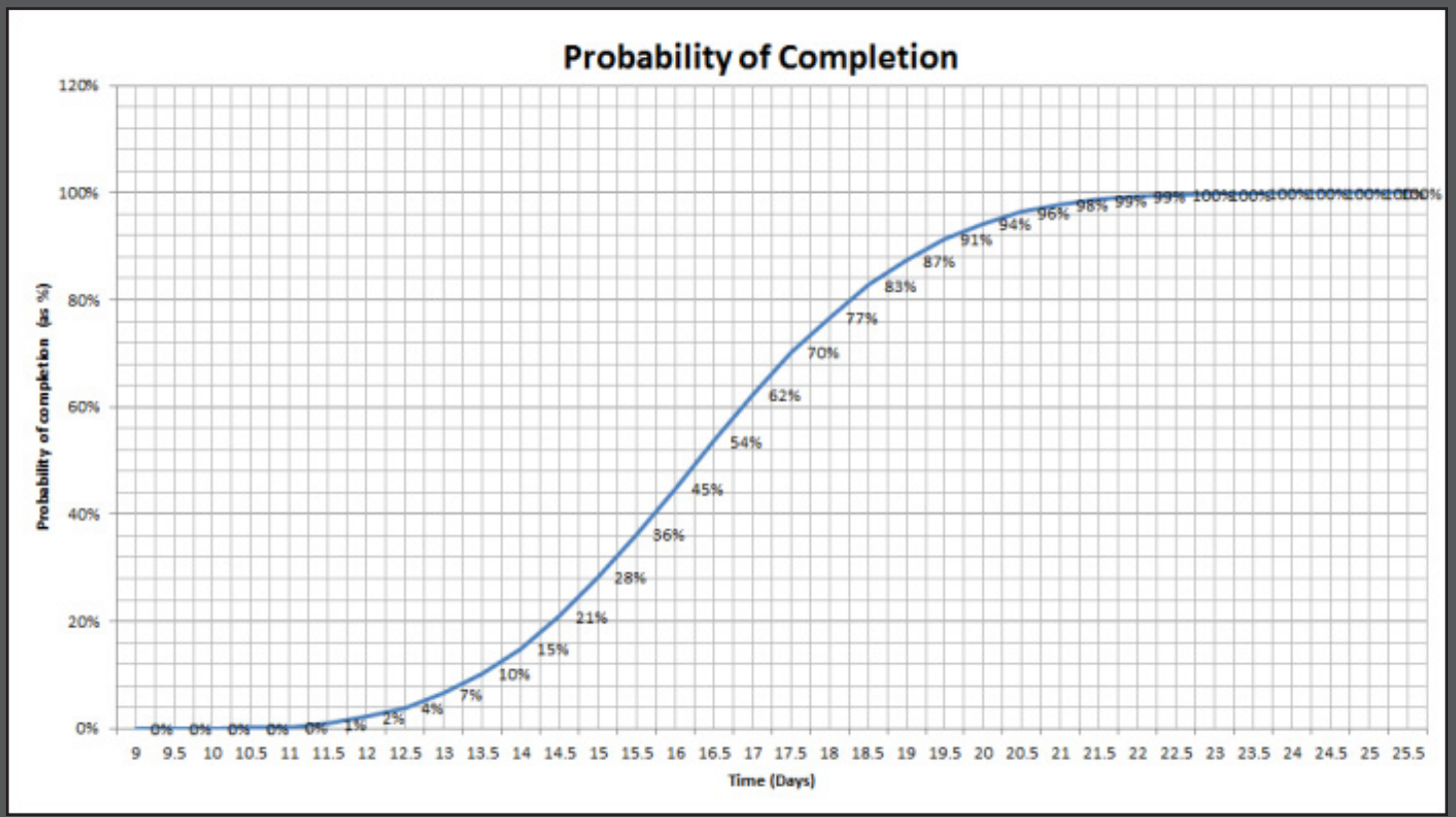


Figure 3: Deadline x likelihood to fulfill[5]

The idea behind Monte Carlo is to simulate the entire project (i.e., all four tasks) using a large number of N times (10,000, for example) and get N durations for the project

which developed the first atomic bombs. Nowadays, any personal computer has the ability to process the method using specific software.

How Do Monte Carlo Simulations Work?

The best way to explain Monte Carlo is with an example, as shown in Figure 1.[5] The schedule shows four tasks. The most likely duration estimates are four, five, six and four days, respectively. Therefore, the total duration of the project would be 4 + 5 + 6 = 15 days (Task 4 occurs in parallel with Task 3, and since it has a shorter duration, it does not interfere with the total duration).

But, the duration estimates are, as the name says, estimates, and the task will hardly end at this time. A more accurate alternative is to estimate using three points, with minimum, most probable and maximum durations.

How long is the project now? With only four tasks, it is no longer possible to calculate manually. To know the answer, you need to do a simulation.

In proposing Figure 1, Kailash Awati, consultant and senior lecturer in the Faculty of Transdisciplinary Innovation at the University of Technology Sydney, explains, "The idea behind Monte Carlo is to simulate the entire project (i.e., all four tasks) using a large number of N times (10,000, for example) and get N durations for the project." In each of the N trials, a probabilistic mathematical method establishes a duration for each task, according to the minimum, most probable and maximum estimates. In the case of Task 1, for example, the method will "sort" a duration between two and eight days, with four days being the most likely. Then the "draw" durations of all tasks are summed up to get the total duration of the project. At the end, you will have N total durations for the project, ranging from the minimum possible and the maximum possible. That is, you will obtain the probability distribution of the duration of the project, represented by Figures 2 and 3.

Thus, the probability of completing this project or turnaround by up to 15 days (sum of the most probable times of each task) is only 28 percent, or a 72 percent chance of taking more time. What would you do if you knew your project or turnaround has a 72 percent chance of being late? You would probably act to prevent this from happening.

On the other hand, there is only a 10 percent probability of termination in more than 19.5 days.

The good part of all this is if the duration estimates are updated, for example, due to a change in team size, the simulation can be easily updated and the new result can be compared to the previous one.

It is interesting to note that the sum of the maximum durations is 27 days, but according to the simulation, the maximum duration of the project is 24.5 days (that is when the probability reaches 100 percent). Why is this? Because probabilities do not add up; probabilities combine through union and intersection. So, simply adding the durations can lead to big mistakes.

Obviously, the simulation of a real project involves a much larger number of tasks and the complexity of the simulation is much greater. But the principle does not change.

Conclusion

In addition to the time management application, Monte Carlo simulation can be applied in any situation that involves probabilities and uncertainties, including:

- Project cost management;
- Analysis of the need for equipment redundancy;
- Reliability and availability analysis.

For companies that already have a good maturity in planning for maintenance projects and outages, the Monte Carlo method helps drive performance to even higher levels through more accurate information that leads to better decision-making.

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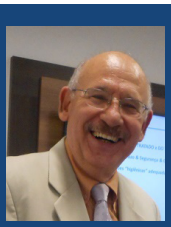

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Suzane Greeman, CMQ/OE, CAMA, CAMP, CMRP is the President and Principal Asset Management Advisor of Greeman Asset Management Solutions Inc (GAMSINC). An accomplished asset management leader with over 22 years of experience, Suzane has worked across several asset management disciplines to implement asset management strategies for cement manufacturing, power generation, wastewater treatment and airport assets. She is also a member of the Empowering Women in Industry 2020 Steering Committee and Women in Reliability and Asset Management (WIRAM). *Uptime*® magazine was fortunate enough to speak with Suzane about her company, asset management and the role of diversity in the industry.

Q. As President and Principal Asset Management Advisor for your company, what is the aim of your organization?

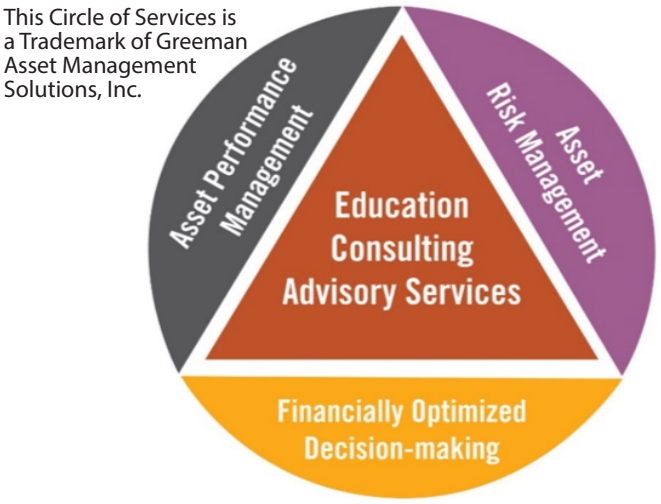
A. Greeman Asset Management Solutions, Inc. (GAMSINC) provides asset management advisory, consulting and educational services to organizations with large portfolios of equipment and infrastructure. We help companies develop asset management strategies and lifecycle management plans; manage asset information to improve decision-making; manage asset risks; and align roles and deliver asset management courses to build organizational capability. We offer courses at the professional and C-Suite executive levels to prepare leaders to sponsor, lead and participate in their asset management transformation. Our courses include Executive Leadership in Asset Management (ELiAM™), Essentials of Asset Management & ISO5500x (EAM™).

Q. How do you define asset management? What are the benefits of asset management?

A. Asset management is about delivering stakeholder value through the asset portfolio. It is easy to think that value is maximizing output, but this may not be affordable, or delivering maximum service may put the asset and the organization at risk and increase operational costs. Value comes when asset performance is balanced against the associated risks and costs to deliver performance and treat risks.

Some benefits of asset management are:

- Improved risk management, with a better understanding of the organization's risk appetite;
- Improved return on asset, effective total expenditure (TotEx) budgeting and alignment of operational expenditure (OpEx) and capital expenditures (CapEx);
- Assurance that asset management activities are financeable over the long term.



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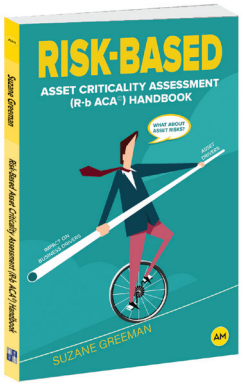
Q. You work with numerous companies in a variety of industries. What are the biggest challenges for companies implementing asset management strategies?

A. Significantly, culture comes in at the top of the list for me. I have noticed, for example, highly independent teams with very little interactivity of information or connection to a central strategy. It is, in turn, very difficult to bring these stakeholders to the table or to even get them to agree that their decision-making is not optimal and that the organization needs asset management. There is also the perception that asset management will be implemented successfully without any structural changes to the organization. Another significant obstacle for companies is the lack of asset information of a high enough quality to be used for decision-making.

Q. Your book, *Risk-Based Asset Criticality Assessment (R-b ACA©) Handbook*, focuses on developing a methodology that is aligned with an organization's business and asset drivers. Explain this methodology. What are the benefits?

A. Asset criticality is a fundamental decision-making tool that supports the prioritization of assets for investments, maintenance strategies and repair/replace decisions. R-b ACA© demonstrates how business and asset drivers may be converted into factors of failure and, ultimately, into asset risks. In that regard, the Handbook addresses structural deficiencies in the traditional approach to asset criticality, such as its inability to provide "on-demand" asset risk information. The aim is to give the reader a set of tools to critically examine their organizations and develop their own methodology based on their context rather than present a prescriptive list of what criticality needs to be for every company.



Q. How do you define risk?

A. I like the ISO31000:2018 definition of risk: The **effect** of **uncertainty** on **objectives**. This means that for there to be risk, there must be uncertainty and there must be objectives, and the uncertainty must have an impact on the objectives if the risk materializes. When speaking of asset risks, we are not only speaking of risks triggered by asset activities, such as aging assets, or by organizational activities, such as a change resistive workforce. We are also speaking of externally triggered risks at the organizational level, for which the assets must provide suitable response. Examples of these risks are legal or regulatory complexity and climate change.

Q. You have been an active member of Women in Reliability and Asset Management (WIRAM). How has WIRAM influenced your career?

A. WIRAM has been successfully raising the profile of women in asset management and reliability and bringing recognition to our work. I have had the opportunity to learn from speakers at the gatherings and had the distinct honor of also being a keynote speaker at the gathering at IMC-2018. It is quite a supportive environment that offers such great professional exposure.

Q. What are the benefits of diversity?

A. I believe diversity enhances the overall outcomes for companies and teams by increasing the pool of available talent. From a professional perspective, it seems senseless to me to not want to benefit from all available perspectives. Access to diverse perspectives comes from creating space for diversity and being inclusive at all levels of the organization. In addition to the standard indices of diversity, we also need to pay attention to the minority voice in team settings, particularly when we are dealing with asset risks. Properly harnessed, both diversity and inclusivity will improve organizational morale.

Q. What do you see as specific challenges related to the lack of diversity in reliability and asset management? How can this industry better support diversity?

A. One of the main challenges is that we seem to have changed policies, but are struggling to change our minds. The second may be related, but there also seems to be a shrinking pool of candidates as we move up organizational levels. To move diversity beyond fascinating conversation pieces, a combination of top management exposure, workforce education and structural changes are needed. Indeed, more top management mentorship and advocacy for minority groups are needed. As I have been extensively mentored by men and women, I also aim to be a global professional, providing value and creating space for others, regardless of who they are.

Q. In addition to your career and work, you have written a book and spoken at several conferences. What is your passion and how do you see this affecting your future?

A. I am very excited about asset management education and coaching. I get unbelievable joy from teaching. I have opened myself up to eclectic professional experiences and they have provided me with plenty of examples to share when teaching. Conferences are also among my favorite things to do. They give me the opportunity to take in a large amount of relevant information over a short space of time, providing a better value for the money than if I tried to chase all that knowledge in individual courses. I enjoy the networking and making friends; I believe I am still in touch with people from the very first conference I attended.

WIRAM Women in Reliability and Asset Management

For more information: maintenance.org

Solution AWARDS 2020

Recognizing the BEST innovative products, software, training and services for reliability and asset management

NOW ACCEPTING SUBMISSIONS!

CATEGORIES:

- Reliability Engineering for Maintenance
- Asset Condition Management
- Work Execution Management
- Leadership for Reliability
- Asset Management
- Digitalization
- Sustainability

Submissions are open to any company who offers services to the reliability and asset management industry.

BENEFITS:

- Acknowledgement at The RELIABILITY Conference Solution Awards Ceremony (includes company video highlighting product or service, award presentation during full conference lunch ceremony)
- Solution Awards logo polo shirts
- Use of Solution Awards Winner 2020 logo for marketing and advertising
- Winners highlighted on conference website
- Winners highlighted in Uptime® Magazine and optional article

WE NEED YOUR VOTE!

Public voting for Solution Awards 2020 opens March 18th. Official announcement and details coming soon!

HURRY! SUBMISSION DEADLINE: MARCH 6, 2020

For official rules and to submit:
www.reliabilityconference.com

Brought to you by

RELIABILITY WEB.COM

uptime®

The RELIABILITY Conference™

May 4 - 7, 2020

Industry Tours • May 8

Hyatt Regency Bellevue on Seattle's Eastside

Seattle, Washington

Co-located with

Maintenance 4.0
Digitalization Forum

Unlock Your Team's Potential to Create the Future to Advance Reliability and Asset Management

SAVE $300

A Reliabilityweb.com® and Uptime® Magazine Event

RELIABILITY WEB.COM

uptime magazine

www.reliabilityconference.com

The RELIABILITY Conference™

Master Reliability

to Get More Done and Achieve More Meaningful Results in 2020

"Life is hard. Reliability is harder!" *- Terrence O'Hanlon*

Assets, digitalization and technology are more complex than ever. The paradigms that may have worked 20 years ago do not work today. A new breed of reliability leaders, maintenance managers, digitalization leaders and asset managers is needed for today's complex and competitive industrial world.

The RELIABILITY Conference™ (TRC) includes seven main stages:

Stage 1: Reliability Leadership Experience
Stage 2: Maintenance 4.0 Digitalization Forum
Stage 3: Leadership for Reliability and Asset Management Case Studies
Stage 4: Reliability Engineering for Maintenance, Asset Condition Management and Work Execution Management Case Studies
Stage 5: Certified Reliability Leader® (CRL) Workshop and Optional Exam
Stage 6: Certified Maintenance Manager™ (CMM) Workshop and Optional Exam
Stage 7: Innovative Reliability Solutions

WHY should your organization care about **RELIABILITY?**

- Reduce CO_2
- Improve Process Safety
- Improve Electrical Safety
- Right MRO Spares Inventory
- Improve Asset Performance
- Enable Asset Condition Management
- Advance Asset Knowledge
- Achieve Sustainability Goals
- Reduce Waste Disposal
- Stress Defined Workflow, Roles and Responsibilities
- Eliminate Defects Using Frontline Cross-Functional Collaboration
- Reduce Maintenance Repair and Operating Cost
- Create an Empowered Leadership Culture
- A Recruitment and Retention Tool

Register today, so you and your team can secure seats and become one of the world's best-run companies.

RELIABILITY LEADER: Someone who delivers a new future that was not going to happen anyway.

Innovative Maintenance 4.0 / Industrial Internet of Things technologies like wireless sensors, machine learning and artificial intelligence are going to help you advance asset management; however, they will not make your plants reliable by themselves. You still need strong leadership models and a healthy culture to ensure adoption of the positive behaviors that drive sustainable asset performance.

On the other hand, a healthy workplace culture without the latest digitalization business models to support machine-assisted decision-making will struggle to keep up with the velocity of asset decisions required to be a high reliability organization.

Attending The RELIABILITY Conference will provide insight on how companies are leveraging proven technology combined with new business models and effective reliability leadership to drive asset performance and sustainable cultural change.

WE UNDERSTAND:

- You want to make the most of your spare time away from work and family;
- You want to meet people who share the same challenges that you do on a daily basis;
- You expect high-quality, unlimited opportunities to learn and share your knowledge and experience when you choose to attend a conference.

You can rely on the Reliabilityweb.com team to deliver everything you need for a great conference while you focus on discovering new ideas, gaining new skills and meeting the people you need to meet to advance your journey. Compared to the random design of some industry events, we believe you will appreciate the curated program created to address current challenges faced by our members and industry.

The community of knowledge at The RELIABILITY Conference has deep experience and knowledge to share in traditional learning sessions; however, the event is also designed to provide numerous peer-to-peer exchanges in order to share information and ask questions directly with the people who face the same challenges you do.

Now in its 15th year, The RELIABILITY Conference invites you to an open and powerful community of knowledge that understands the ways to advance reliability and asset management are aligned to and delivered by an organization's culture. The agenda has been carefully crafted and designed to inform and advise on the latest digitalization technology case studies, precision work practices, leadership skills and cultural change management.

The Reliabilityweb.com team is a professional group dedicated to creating a context for you to discover ways to make your team safer and more successful. We take care of you, so you can focus on learning, what you came to learn and meeting who you came to meet.

In fact, we are so confident in that outcome that we offer an industry-best **100% No Hassle Promise: "Learn what you came to learn or your money back - no hassle."**

The Hyatt Regency located in Bellevue, Washington, on Seattle's high-tech Eastside, is a great location on the shores of Lake Washington, conveniently connected to shopping, dining and entertainment via elevated walkways.

Please consider having you and your team join us to discover powerful new ideas for advancing reliability and asset management.

See you in Seattle!

I am grateful,

Terrence O'Hanlon
Conference Producer
CEO and Publisher
Reliabilityweb.com and Uptime® Magazine

HIGHLIGHTS | KEYNOTES, AWARDS AND TOURS

Get a front row seat to interact and learn from great minds in the realm of reliability.

KEYNOTES - TUESDAY, MAY 5

Digitalization Keynote

BEN PRING

Sustainability Keynote

KEITH CLARKE

RELIABILITY AND ASSET PERFORMANCE (RAP) TALKS

18-minute TED-like talks designed to replace outdated concepts with new ideas that you can put to use immediately.

- Amy Lindblom, Sound Transit
- Jeff Smith, Reliabilityweb.com
- Phil Hendrix, Hendrix Precision

Wednesday, May 6

RAP™ talks
RELIABILITY AND ASSET PERFORMANCE

WANTED: INNOVATIVE SOLUTIONS

Uptime Magazine and Reliabilityweb.com are proud to bring you the **Solution Awards** to recognize innovative products, software, training and services for reliability and asset management.

Dedicated to rewarding innovation in asset performance management, the Solution Awards acknowledge companies who are committed to delivering the best in their industry.

Solution Awards Ceremony • Tuesday, May 5

Does your company have a new innovation to showcase? Don't wait...enter today!

Submission deadline: March 6
Voting opens to the public: March 18
See website for more details.

TOURS

Friday, May 8

Take an opportunity to experience real-world examples of how reliability is a core system in well-known organizations.

- Boeing
- Costco Optical
- Fluke Infrared
- Sound Transit

SPACE IS LIMITED, register early to save your spot! Requires additional registration fee, see website for details.

SCHEDULE-AT-A-GLANCE

MONDAY, MAY 4

- Reliability Today Show
- Short Courses
- Reliability Leadership Experience
- Certified Reliability Leader Workshop
- Certified Maintenance Manager Workshop
- Women in Reliability and Asset Management (WIRAM) Lunch (by invitation only)
- Reliability Leadership Game Show

TUESDAY, MAY 5

- Sustainability Keynote by Keith Clarke
- Digitalization Keynote by Ben Pring
- Learning Sessions
- Reliability Leadership Experience
- Certified Reliability Leader Workshop
- Certified Maintenance Manager Workshop
- Solutions Expo Welcome Reception

WEDNESDAY, MAY 6

- RAP Talks
- Diversity Panel (Sponsored by WIRAM)
- Learning Sessions
- Reliability Leadership Experience
- Certified Reliability Leader Workshop
- Certified Maintenance Manager Workshop
- Solutions Expo Reception
- Entertainment Night at Lucky Strike with bowling, games and food

THURSDAY, MAY 7

- Keynote Presentation
- Solution Award Winners Panel
- Learning Sessions
- Reliability Leadership Experience
- Certified Reliability Leader Workshop and Exam
- Certified Maintenance Manager Workshop and Exam
- Closing Keynote and Prize Giveaways

FRIDAY, MAY 8

(Optional – Separate registration fee required.)

- Tour Experience

3 WAYS TO EXPERIENCE TRC-2020

*All experiences are designed around TRC-2020 keynotes, expo hall hours and social/networking events.

CONVENTIONAL LEARNING

*TRC-2020 Registation.

Experience **The RELIABILITY Conference 2020** in a traditional conference structure. A variety of topics are covered, and attendees are free to select presentations based on their interest. Presentations range from 45-minute sessions to 3-hour short courses. Teams can take advantage of this structure and cover all subject areas!

STAGES: Maintenance 4.0 Digitalization Forum • Reliability Engineering for Maintenance (REM), Asset Condition Management (ACM) and Work Execution Management (WEM) Domains Case Studies • Leadership for Reliability (LER) and Asset Management (AM) Domains Case Studies • Innovative Reliability Solutions

THE COMPETENCY FRAMEWORK FOR EFFECTIVE LEADERS TODAY INCLUDES A BROAD UNDERSTANDING OF:

- Reliability Leadership
- Business Management
- Financial Management
- Relationship Management
- Cultural Health
- Asset Lifecycle Management
- Digitalization, Digital Twin and Industrial Internet of Things (IIoT)
- Asset Information Management
- Human Capital Management
- Competency Development
- Decision Making
- Strategy and Planning
- Capital Project Development
- Reliability Centered Design
- Reliability Strategy Development
- Scheduled Maintenance Program Management
- Precision Maintenance and Work Practices (Asset Care)
- Work Execution Management
- Asset Management
- Change Management
- Procurement
- Specifying

You can do it! So can your team!

Master every area of reliability and asset management. Discover solutions that are right for your team with a proven framework supported by a community of practice made up of the world's best-run companies.

MAINTENANCE 4.0 DIGITALIZATION FORUM

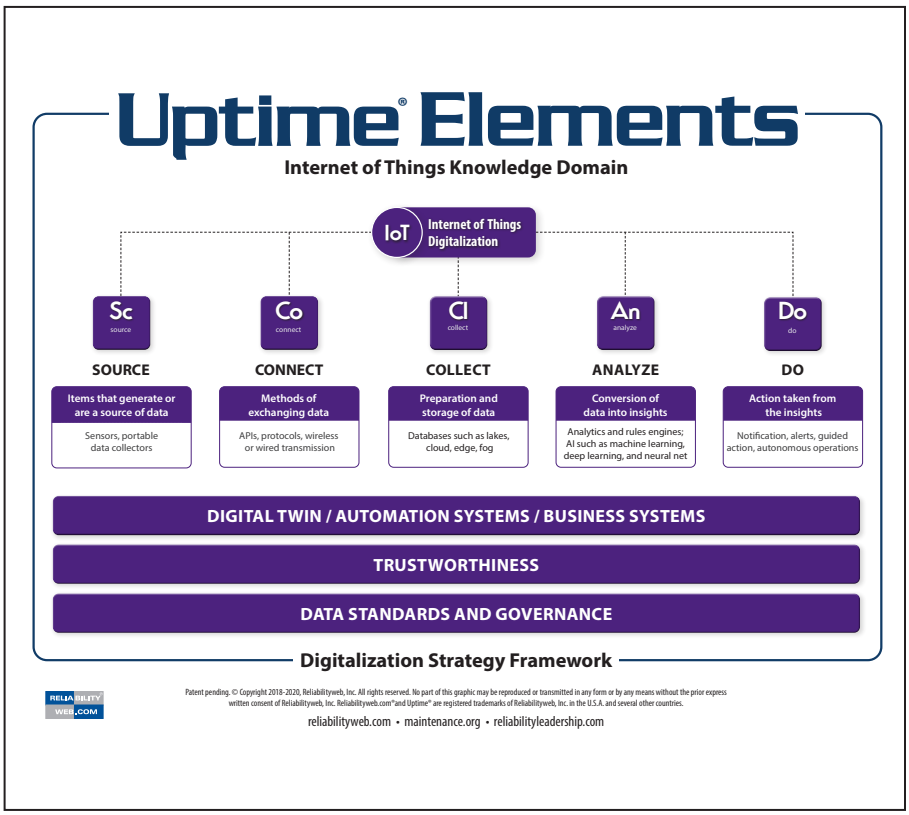
WHAT IS **MAINTENANCE 4.0**?

Industry 4.0 is a name given to the current trend of automation and data exchange in industrial technologies. It includes digital twins, the Industrial Internet of Things (IIoT), wireless sensors, cloud computing, edge computing, artificial intelligence (AI) and machine learning.

Industry 4.0 is commonly referred to as the fourth industrial revolution. **Maintenance 4.0** is a machine-assisted digital version of all the things we have being doing for the past forty years as humans to ensure our assets deliver value for our organization. Maintenance 4.0 includes a holistic view of sources of data, ways to connect, ways to collect, ways to analyze and recommended actions to take in order to ensure asset function (reliability) and value (asset management) are digitally assisted.

Reliabilityweb.com created the **Maintenance 4.0 Digitalization Forum** to focus on the technologies for advancing reliability and asset management rather than the broad and general concepts and systems referred to in most publications, reports and conferences.

Co-located with **The RELIABILITY Conference**, the **Maintenance 4.0 Digitalization Forum** offers a rapid way for you and your team to explore what technologies and approaches have produced the best results while still in the early phases of technology diffusion. Dozens of **Maintenance 4.0** solution providers will be available in The RELIABILITY Conference Expo, so please make plans to attend now.



DIGITALIZATION FOR ADVANCING RELIABILITY

Maintenance 4.0 Digitalization Forum	
Reliability Leader Guide to the Industrial Internet of Things Analytics Framework by the Industrial Internet Consortium (IIC)	Blair Fraser, Quartic.ai
Uptime Elements Digitalization Framework	TBD (Visit conference website for presentation details.)
Maintenance of Level 2 Equipment: Case Studies in Subscription IIoT	Wade Wessels, Donaldson Company
The Future of Work for Your Maintenance Technicians	Heena Purohit, IBM Watson IoT
What to Do When Sites Are Like Snowflakes? Integrate Machine Learning with Physics.	Jon Herlocker, Tignis
APM 4.0: How to Connect Technologies and Shape Priorities for Prescriptive Actions	Petra Nieuwenhuizen, AVEVA
Roadmap to Artificial Intelligence: You Are Ready!	Blair Fraser, Quartic.ai
Digital Inspection Twin Case Study	David Tran, Optelos
Models, Replicas, Simulations: The Evolution of Digital Twins and the Reshaping of Infrastructure Asset Management	Michael Mulcare, Mott MacDonald
Applying Analytics for Asset Monitoring	Robert Skeirik, Emerson Automation Solutions
The Future of Manufacturing	Kevin Clark, Fluke
Optimizing Asset Care Supported by Machine Learning	Malcom Werner, Worley
Visual Asset Performance Management: How to Achieve a Maintainable Digital Twin	Matheus Figueiredo, AVEVA
Automated Design for Reliability (ADR): An Approach for Applying Artificial Intelligence to Design Failure Mode Effects Analysis	Hubert McLeod, Reliability Technologies Consultant
Probabilistic Sequence-to-Sequence Learning Based Digital Twin	Kuilin Chen, University of Toronto
Lessons Learned from Smart Reliability Pilots: Planning and Execution	Preston Johnson, Allied Reliability
Reliability Engineering for Maintenance (REM), Asset Condition Management (ACM) and Work Execution Management (WEM) Domains Case Studies	
Uptime Elements Machinery Lubrication Framework	Reliabilityweb.com
Uptime Elements Vibration Framework	Dan Ambre, Full Spectrum Diagnostics
Successful Off-Site Criticality Analysis	Wayne Dipnarine, Atlantic Methanol Production Company
Developing Effective and Optimized Reliability and Maintenance Strategies	William Closser, NSGI
Preventive Maintenance Optimization (PMO): All Things Considered?	Paul Durko, Consolidated Nuclear Security, LLC

Reliability Engineering for Maintenance (REM), Asset Condition Management (ACM) and Work Execution Management (WEM) Domains Case Studies (Continued)	
Vibration + Lubrication = Reliability	Doug Elam, Nikola Labs
AI for Condition-Directed Bearing Reliability Strategy	Allan Rienstra, SDT
Plant and Equipment Cost and Operational Benefits of Breaking the 10 Micron Filtration Barrier (Case Studies)	Jason Kulsky, Black Powder Solutions
Can I Error Proof My Electrical Maintenance Inspection Program?	Martin Robinson, IRISS
Optimize Hydraulic System Reliability with Precision Fluid Management	Jarrod Potteiger, Des-Case Corporation
The Impact of Maintenance Planning and Scheduling	Rene Hernandez, Newport Beach Marriott Bayview
Practical Thermal Imaging	Jay Bowen, Bowen & Associates LLC
The Reliability Weakest Link: Power Systems Safety, Quality, Life Cycle and Maintenance Management	Alan Ross, SD Myers
Assessing Electrical Asset Health	Rudy Wodrich, IRISS
How to Globally Deploy Optimal Maintenance Strategies	Geron Davis, Outokumpu
Offline Condition Monitoring, Continuous Condition Monitoring, or APM 4.0? That Is the Question!	Johan Ferket, Stork
Leadership for Reliability (LER) and Asset Management (AM) Domains Case Studies	
Why Execution Fails and What to Do About It	John Fortin, Jacobs
Reliability and Operational Excellence	Ron Moore, The RM Group
Achieving Lowest Cost of Ownership in Maintenance: Documenting Cost Savings through Reliability Training	L.J. Andreuzzi, Henkel Loctite
Developing Your Asset Management Strategy, Roadmap, and Getting It out to the Field	Scott Stukel, Total Resource Management
The Triple Bottom Line: People, Planet and Prosperity	Doug Wolfe, Sound Transit
Holistic Organizational Health Check: A Clear Solution for Your Evolution	Armando De La Ree, Raytheon
Five Steps to Justify Reliability Improvement Initiatives	Sean Rosier, PinnacleART
Integrity: Do What You Say!	Malcolm Werner, Worley
Advances in APM: How Organizations Are Managing Smarter and Realizing Better Outcomes	David Drerup, Operational Sustainability LLC
Performance Indicators, KPIs, Metrics and Performance: Getting Started and Creating Value from an Unknown State and with Bad Data	Joe Lonjin, Cohesive Solutions

Leadership for Reliability (LER) and Asset Management (AM) Domains Case Studies (Continued)	
Connecting the R's: Risk, Reliability and Real-Time	Curtis Wilson, Lloyd's Register
How Does Your Culture Define You?	Ed Duda, Des-Case Corporation
The Era of Data Paralysis: The Fear of Poor Quality and Insufficient Data	Johan Ferket, Stork
Asset Strategy Management (ASM) for Reliability Leaders	Jason Ballentine, ARMS Reliability
Leadership, Legacy and Longevity: Maintenance Reliability Journey	Michael Guns, University of Delaware
Applying the Uptime Elements as an Integrated Asset Management Solution	Marie Getsug, Jacobs
Innovative Reliability Solutions	
How to Consolidate Lubricant Inventory	Jarrod Potteiger, Des-Case Corporation
Compensation of Thermal Growth in Rotating Equipment Alignment	Daus Studenberg, Ludeca Inc.
The Sensor of the Future: How Motion Amplification Has Paved the Way for Camera Based Sensors in the Reliability Industry	Jeff Hay, RDI Technologies
Do Bearings Fail Us, or Do We Fail Them?	Adam Bednarzyk, Technical Associates of Charlotte
Enhance Equipment Reliability Through Intelligent Sensors, Analytics and Web Technology	Bhanu Srilla and Andy Zimmerman, Grace Engineered Products
Philosophy of Reliable Machinery Installation	Roman Megela Gazdova, Easy-Laser AB
Catching a Silent Killer: Finding and Eliminating Varnish	Jay Cooper, Des-Case Corporation
Using Technology to Enhance Plant Electrical Safety and Maintenance Operations	Bhanu Srilla, Grace Engineered Products
Detective-Like Inspections: Becoming the Sherlock Holmes of Your Reliability Program	Matthew Adams, Noria Corporation
Integrated Asset Health as a Driver for Organizational Efficiency	David Drerup, Operational Sustainability LLC
Making the Breadth of Vibration Technology Work for You	John Bernet, Fluke
RCA: Finding Success Through Defect Elimination	Francis Concemino, Inland Empire Utilities Agency
Implementation and Use of Infrared Thermography at Blue Plains Advanced Waste Water Treatment Facility, Washington DC	Tim Belt, DC Water
Stop Blaming Your Process Seal!	Chris Tindell, SEPCO
Solution Technology Showcase	

RELIABILITY LEADERSHIP EXPERIENCE

*Pre-registration required. No additional fee.

Transforming **Reliability Leadership**

The **Reliability Leadership Experience** is a four-day immersive event that puts you face-to-face with the industry's top reliability leadership experts and side-by-side with world-class thinkers. You'll venture deep into your personal and professional growth through new experiences that will broaden your perspective and add value to you as a reliability leader.

Join us to experience the intersections of:

Reliability Culture • Asset Management Processes • Asset Performance Technology • Workplace Diversity • Environmental Sustainability • Human Capital Management • Change Management.

EXPOSURE
TO EXCELLENCE AND EXPERTISE

Gain an in-depth, hands-on perspective on your own reliability leadership challenges and strengths through formal teachings by industry experts, group discussions, experiences, exercises and individual time to process what you're discovering and learning.

Gain exposure to experts from the world's best-run companies, admired for their world-class approaches to reliability and asset management, laser-focused to align and deliver organizational objectives and aim.

Go back to your organization empowered. You will not only get the tools needed to progress, but you will be coached on how to coach and lead your company on a reliability journey.

EXPERIENCES
YOU'LL NEVER FORGET

We believe that when it comes to reliability leadership, creating experiences for one to discover what it is to "be" a reliability leader and to "do" reliability leadership, is the most effective way to ensure that the discovery lasts and turns into action.

Mastering the context that you work in is the key to the reliability culture you desire and for the reliability leader you were created to be. Before you do anything, it is important to understand how to create a new context and to be aware of the principles of reliability leadership.

Go all in for Reliability Leadership 2020!

RELIABILITY LEADERSHIP EXPERIENCE

Dear Reliability Leader,

Discover your potential to transform the reliability culture in your organization. The key to unlocking that potential lies in you as a reliability leader. Reliability leaders are unstoppable change agents—a transformed you creates a transformed workplace.

I stand for reliability, and my work is all about transformation. That's why the Reliabilityweb.com team and I are committed to providing you the content and resources you need to discover for yourself the power of "being" a reliability leader and "doing" reliability leadership. We are all-in on helping you discover the right changes that change everything.

My name is Terrence, and I stand with you to advance reliability and asset management to make a more satisfying workplace, a more sustainable organization, a safer organization, a compliant organization, a lower cost producer and a more profitable operation.

I also invite you to fulfill your potential; I want to help you make the world work better for everyone. It starts with opportunity for growth.

Potential, my friend, is one of the most wonderful words in any language. It's optimistic. It's hopeful. It hints at greatness. It's full of possibility. It's inside of you. How do you develop your potential? You grow as a person and as a reliability leader.

Being a reliability leader is the only guarantee that you will create a new future that was not going to happen anyway.

It's up to you. The ball's in your court. Are you going to take it or leave it? But know this: you don't have to take the journey alone.

It's my purpose in life to be that guide, to know the way and help you go after it. My desire is to help you develop a new context for reliability leadership, to discover your strengths, tap into your passion, make gains in your work and life like you've never seen, and become more in touch with what you're naturally designed for, so you can live a happy, healthy and full life. That's what I want for you, and I want to see you get there.

I'll walk with you. I'll talk with you. I'll share stories with you to help it all make sense. It won't all be easy, but it doesn't have to be lonely. It will be work, but it doesn't have to be a one-man show. It will take you far from where you are now.

So, are you ready? Let's start our journey together.

I am grateful for the opportunity to collaborate.

Terrence O'Hanlon
Reliability Leadership Foundation

AGENDA | RELIABILITY LEADERSHIP EXPERIENCE

The Reliability Leadership Experience is a 4-day seminar built into The RELIABILITY Conference schedule. Attendees who register for this course will be committed to attend all 4-days, but will participate in conference keynotes, general sessions and evening networking events.

TOPICS INCLUDE:

- AIM Exercise
- Successful/Validated Project Execution
- Reliability Leadership Fundamentals
- Reliability Leadership Game
- Quantifying the Impact of Reliability and Maintenance
- Asset Lifecycle Management Strategies
- Asset Condition Management
- Digital Twins
- D-I-P-F Curve
- Mapping Objectives, Value, Reliability Strategy, Work Management, Asset Condition Management, Asset Information and Asset Lifecycle Management Exercise
- Reliability Leadership
- RAMS GPS Assessment Methodology Overview
- Working Group Discussion
- Integrity, Authenticity, Responsibility and Taking a Stand
- Reliability Philosophy to Reliability Strategy to Scheduled Maintenance Program
- Asset Lifecycle Management Strategies
- Cultural Change Management for Reliability and Asset Management
- Maintenance 4.0
- IoT System Mapping Exercise
- Precision Lubrication
- Reliability and Operational Excellence
- Leadership Forward

SPECIAL GUESTS AND COACHES:

- Keith Clarke
- Ben Pring
- Jeff Smith
- Ron Moore
- Ramesh Gulati
- Jack Nicholas
- John Fortin
- Inderpreet Shoker
- Dr. Jezdimir Knezevic
- Marie Getsug
- Sunil Kamerkar
- Matt Boehne
- Nick Jize

REGISTRATION TO THIS GROUNDBREAKING SEMINAR INCLUDES:

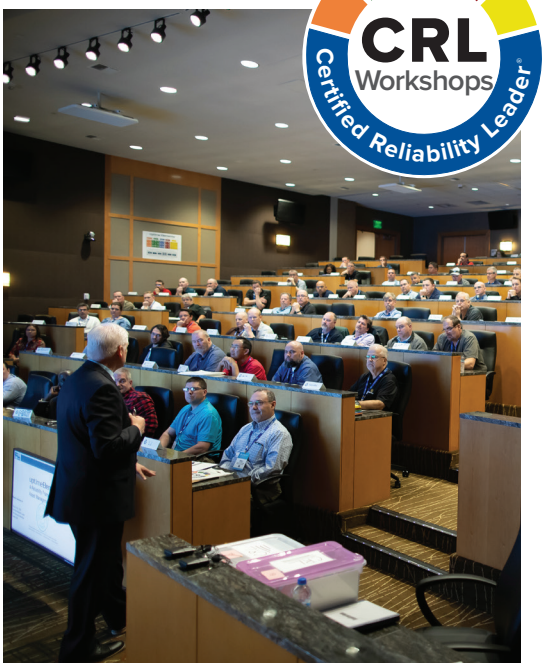
- Reliability Leadership Coaching (3 months following seminar)
- Uptime Elements Assessment (3 months following seminar)
- RAM-GPS Tool
- 90-Day Rapid Reliability Impact Plan

> "Our biggest obstacles are the cultures we allow to create the boundaries and limitations of what is possible."
>
> *- Terrence O'Hanlon*

*Separate registration required. See website for details.

Co-located at TRC-2020

May 4-7



CRL Workshop/Exam

The Certified Reliability Leader® (CRL) Workshop is designed to allow attendees to take back to their organizations some of the industry's most advanced thinking in reliability and immediately begin to utilize it. The workshop is an excellent primer for anyone interested in sitting for the exam. (optional)

Why Choose the CRL Workshop?

1. Learn Uptime Elements, the world's most adopted Reliability Framework ad Asset Management System.
2. Create an engaged, empowered and cross-functional reliability leadership culture.
3. Discover for yourself what it is to "be" a reliability leader and to "do" reliability leadership.
4. Be included in a community of thousands of reliability leaders from the world's best-run companies.
5. Advance your career with professional certification and accomplish even more professional validation with the Uptime Elements Black Belt program.

The workshop breaks and lunches coincide with the conference, and you will be able to participate in all evening social events.

CMM Workshop/Exam

The Certified Maintenance Manager™ (CMM) Workshop is a groundbreaking course that will transition the way you think about asset management. You will leave this session with a clear understanding of how to align with operational expectations and attain the stability and control that is required to enable maintenance. This 4-day course is constructed of 18 modules aligned with the skills required to become a Certified Maintenance Manager. The CMM exam will be offered at the end of the workshop (optional).

The workshop breaks and lunches coincide with the conference, and you will be able to participate in all evening social events.

Unlock Your Potential

SOLUTIONS AND INNOVATION

RELIABILITY Expo features the best solutions under one roof!

PLATINUM

ARMS RELIABILITY

GOLD

DES-CASE

EMERSON

IRISS

Lubrication Engineers, Inc.
ASSET RELIABILITY SOLUTIONS™

40 LUDECA YEARS Keep it running.

RDI TECHNOLOGIES

SILVER

AQUITAS SOLUTIONS

AssetAnalytix
DATA • INSIGHT • ACTION

Banetti

CiM ACHIEVE MAINTENANCE EXCELLENCE

COHESIVE solutions

CTC CONNECTION TECHNOLOGY CENTER, INC.
CONNECT TO CONFIDENCE

GRACE ENGINEERED PRODUCTS, INC

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Lloyd's Register

Mechanical Solutions, Inc.
Engineering Analysis, Test & Technology

Megger
Baker Instruments

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SDMyers ACTS 4:12

Technical Associates of Charlotte

STANDARD

- AMRRI
- Allied Reliability
- Everactive
- Generation Systems
- IMI Sensors/PCB Piezotronics, Inc.
- Interloc Solutions
- MOONS
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- SDT Ultrasound Solutions
- Tignis
- UE Systems

REGISTER EARLY! $300 off*

Special Offers: Government employees and international attendees (outside U.S. and Canada) - Save $100.

Companion Pass: Options available. See website for more details.

Event Hotel

Hyatt Regency Bellevue
on Seattle's Eastside
900 Bellevue Way NE
Bellevue, Washington 98004

Discounts for Teams!

Bring your team for an opportunity to attend multiple tracks, participate in numerous training short courses and go back to work with an enhanced and enthusiastic workforce. Special group pricing for teams of five or more. Visit website to request more information from a Reliabilityweb.com team member.

LEARN WHAT YOU CAME TO LEARN — NO HASSLE PROMISE — OR GET YOUR MONEY BACK

VIP REGISTRATION

$2499

Per Person • 4-Day Pass

Visit website for full list of benefits.
May not be combined with any other discounts.

What's Included:

- Four-day conference pass
- Guaranteed hotel reservation at the event hotel (Hyatt Regency Bellevue) from Sunday - Friday with room & tax to be paid by attendee
- Private VIP lounge access with refreshments and snacks
- $200** off one conference pass if you register within 30 days of this conference (IMC-2020, MaximoWorld 2020, TRC-2021)

INDIVIDUAL

4-Day Pass

$1799

$300 off standard individual rate*

RELIABILITY LEADERSHIP EXPERIENCE

$1799

$300 off standard individual rate*

TOUR EXPERIENCE

$299

Friday, May 8
Optional

CERTIFICATION WORKSHOPS

Individual
4-Day Pass

CRL — $2199

May 4-7 Workshop
May 7 • CRL Exam
(optional - cost $299)

CMM — $2199

May 4-7 Workshop
May 7 • CMM Exam
(optional - cost $299)

*Prices reflect savings. Valid thru February 29, 2020. Must be paid in full by end of promo date.

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