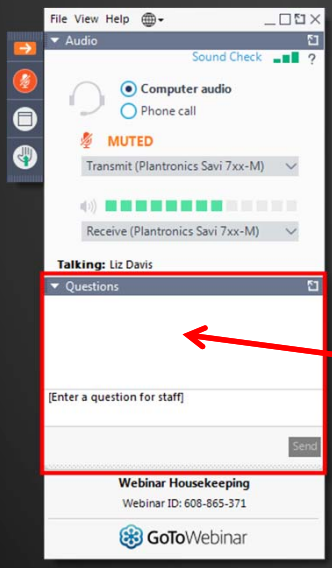
The Fundamentals of Predictive Maintenance: Finding Problems Before You See Smoke

Thursday, August 8, 2019
1:00 – 3:00 PM ET

How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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Today's Moderator

Fred Edgecomb

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Today's Speakers

- Andy Page
  - Condition Monitoring: An Introduction to Reliability Concepts and Predictive Maintenance
- Tacoma Zach
  - Predictive Maintenance: Supporting Asset Management
- Theresa Bruton
  - Establishing a Foundation for PdM Technology: A Case Study

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Allied Reliability

- Broad focus across a wide variety of machinery and end-markets
  - Over 1,400 benchmarked sites
  - 16 industry verticals
  - Combined 5,000 years of experience in maintenance and reliability
  - Led the Reliability Journey for over 400 clients, including 20 Fortune 500 companies
- Approximately 350 employees throughout North and South America

Andy Page, Ph.D.
Vice-President, Operations
Allied Reliability

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Condition Monitoring

An Introduction to Reliability Concepts and Predictive Maintenance

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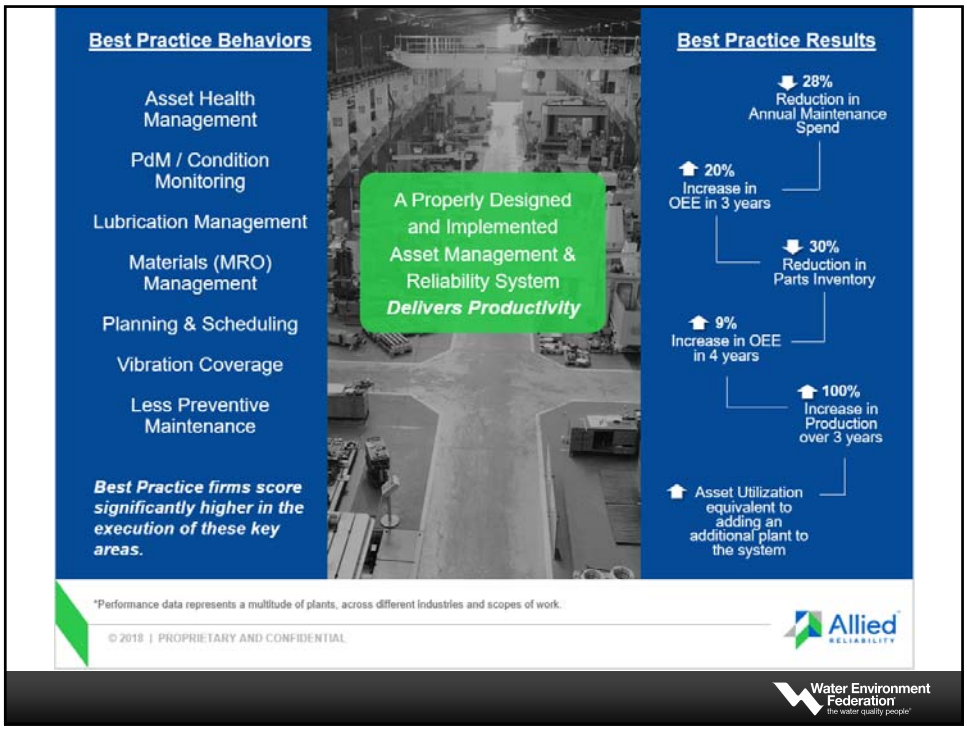

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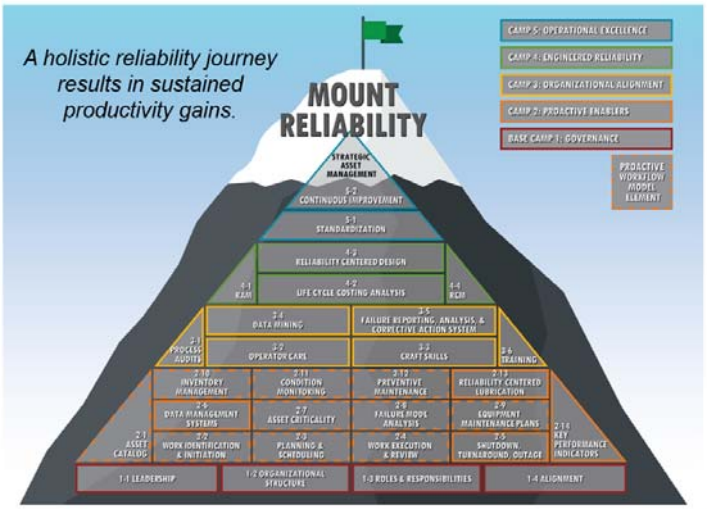
A Reliability Systems Model



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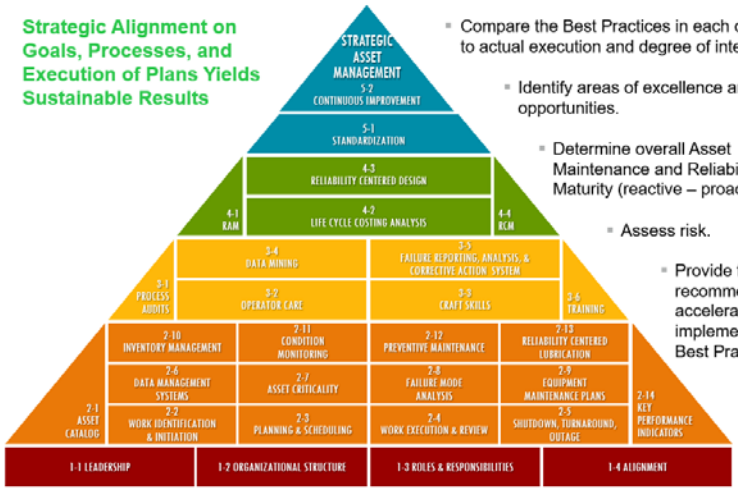
M&R System Assessment

Strategic Alignment on Goals, Processes, and Execution of Plans Yields Sustainable Results



- Compare the Best Practices in each category to actual execution and degree of integration.
- Identify areas of excellence and opportunities.
- Determine overall Asset Maintenance and Reliability Maturity (reactive – proactive).
- Assess risk.
- Provide findings and recommendations to accelerate implementation of Best Practices.

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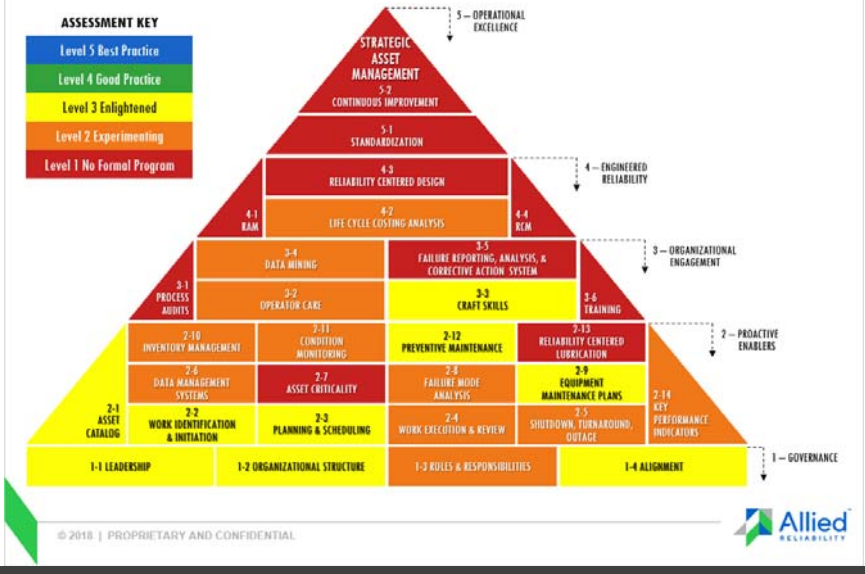
Current State (EXAMPLE)



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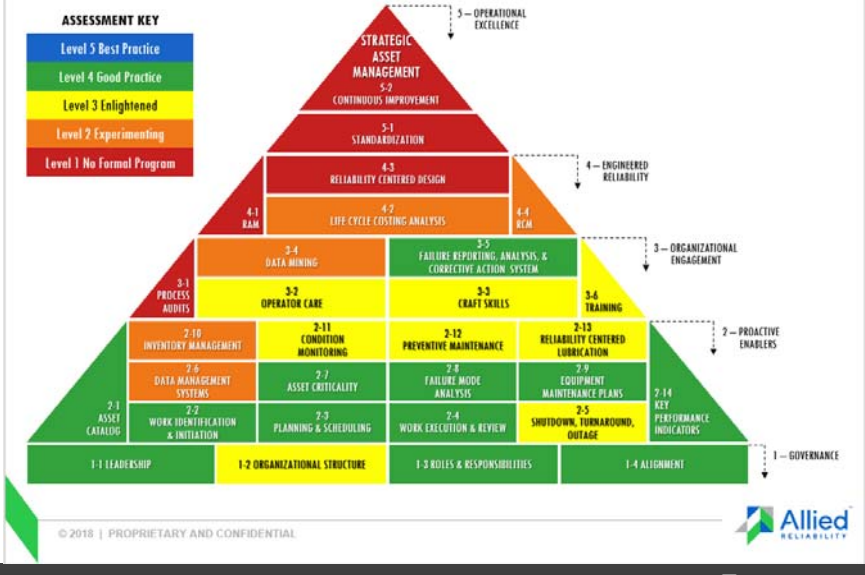
Future State (EXAMPLE)



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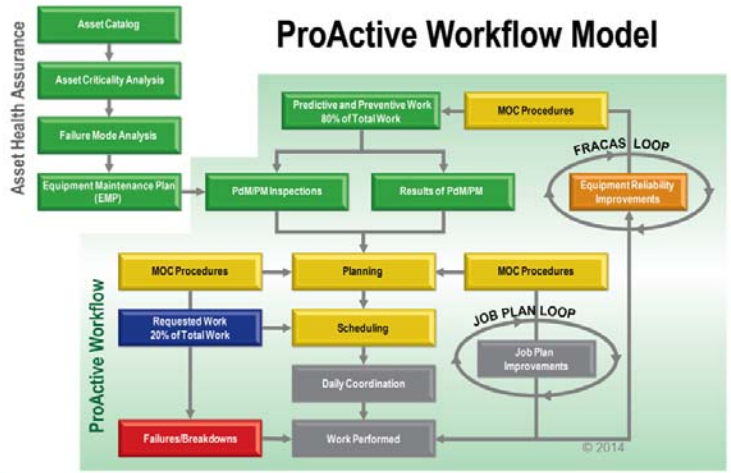
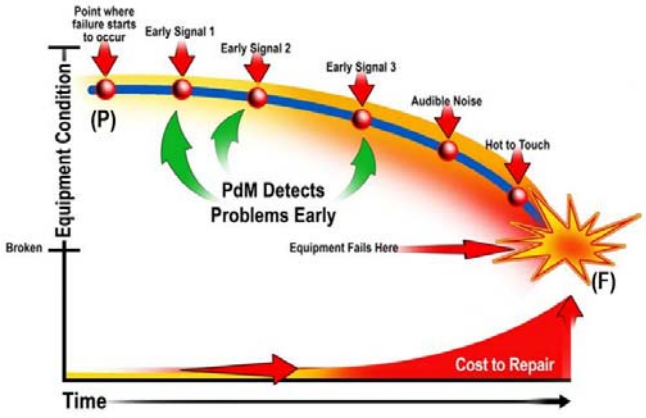
ProActive Workflow Model



How PdM Works - Early Identification of Defects



Asset Health

- A metric showing the % of machines in the plant that are defect free
- True "leading indicator" of Maintenance Costs and Emergency Downtime

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How Much PdM?
100% Coverage Model

Equipment Type Versus Technology Application(s)	MECHANICAL				ELECTRICAL				STATIONARY			
	Vibration	Ultrasound	Infrared	Oil Analysis	MCA Online	MCA Offline	Infrared	Ultrasound	Visual Inspection	Ultrasonic Thickness	Dye Penetrant Testing	Eddy Current
Chiller	X	X	X		X	X		X	X			X
Centrifugal Pump	X	X	X	X	X	X	X		X	X	X	
Air Compressor	X	X	X	X	X	X	X	X	X			
Tank			X						X	X		
Evaporator			X				X		X			

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100% Theoretical Model

Coverage by Technology	Vibration	Mech UE	Elect IR	MCA Offline	MCA Online	Oil Analysis	Mech IR	Elect UE
100% Theoretical	3,400	3,078	5,016	2,939	2,939	2,869	4,179	5,016
1st Quartile	2,720	2,155	4,815	1,470	1,470	1,492	2,925	4,815
2nd Quartile	2,312	1,693	4,364	1,176	1,176	1,090	2,298	4,364
3rd Quartile	1,530	1,077	3,862	882	882	717	1,463	3,862
4th Quartile	680	369	3,260	588	588	344	501	3,260
Existing Coverage	220	0	0	0	0	135	0	0

Mech – Mechanical UE – Ultrasound IR – Infrared Thermography
Elect – Electrical MCA – Motor Circuit Analysis

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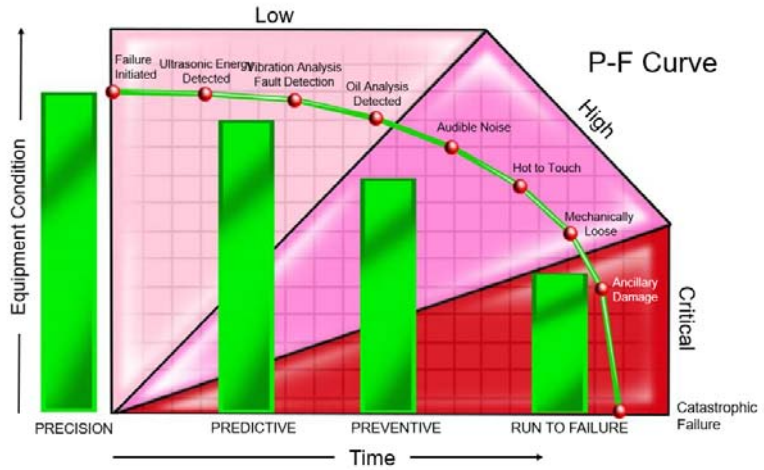
Defect Severity



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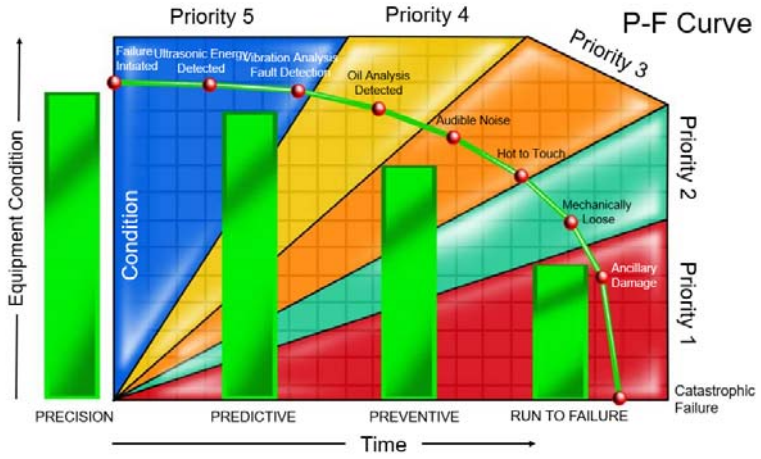
Urgency



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Failure Modes for Bearings

Bearing Failure Categories and Common Causes

Improper Installation	Inadequate Lubrication	Operating Conditions	Adverse Environment
Bad Shaft Fit	Wrong Type	Misalignment	Improper Seals
Bad Housing Fit	Too Little	Imbalance	External Vibration
Improper Handling	Too Much	Belt Tension	Electrical Current
Hammer Rash	Wrong Relube Frequency	Overload	Contaminants
Wrong Clearance		Overspeed	
Dropsy Syndrome			
Wrong Type			
Wrong Place			
Cage/Seal Damage			

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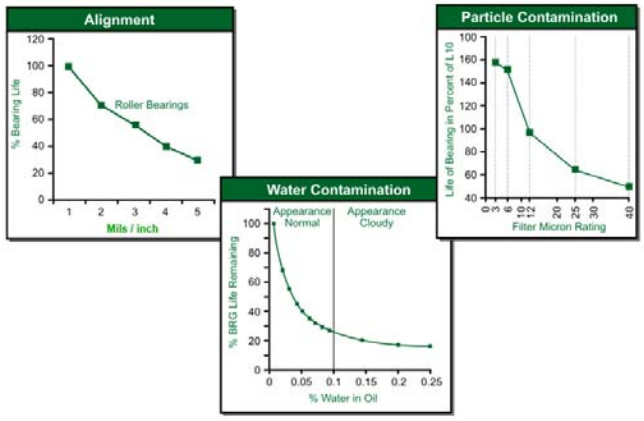
Root Causes of Bearing Failure



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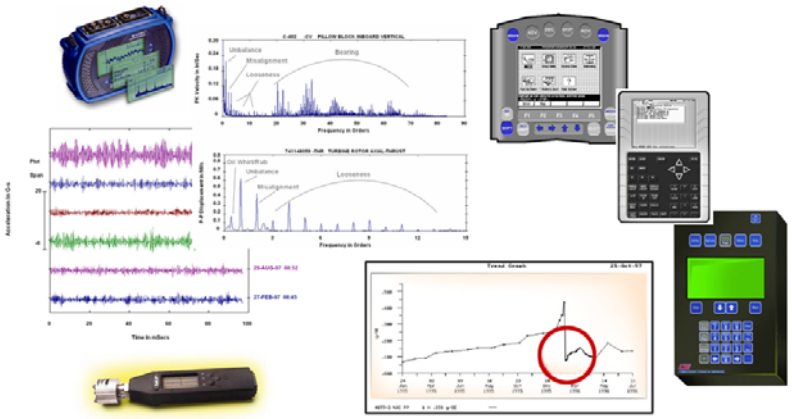
Vibration Analysis Failure Modes and Technologies



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Airborne/Structure-borne Ultrasound Failure Modes and Technologies

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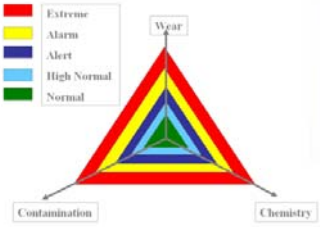
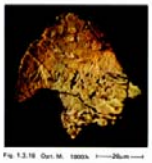
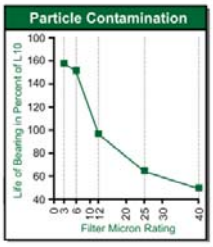
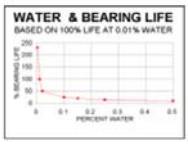
Oil Analysis Failure Modes and Technologies









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Infrared Thermography Applications

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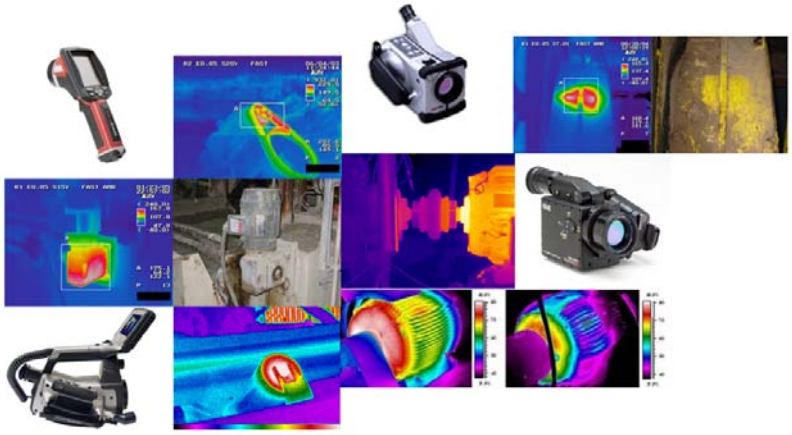
Infrared Thermography Failure Modes and Technologies



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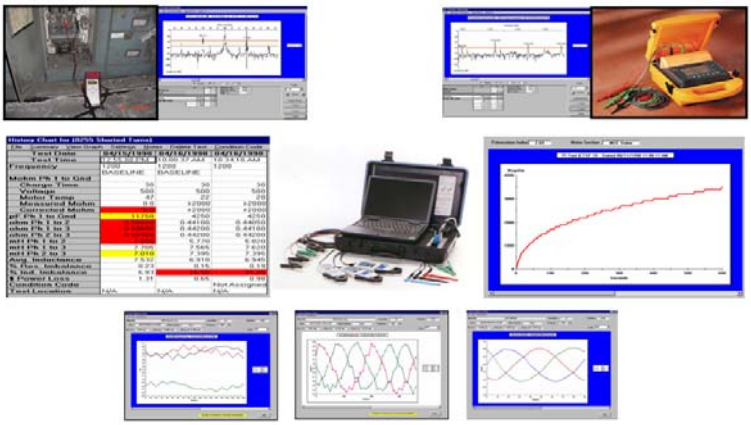
Motor Circuit Analysis Failure Modes and Technologies



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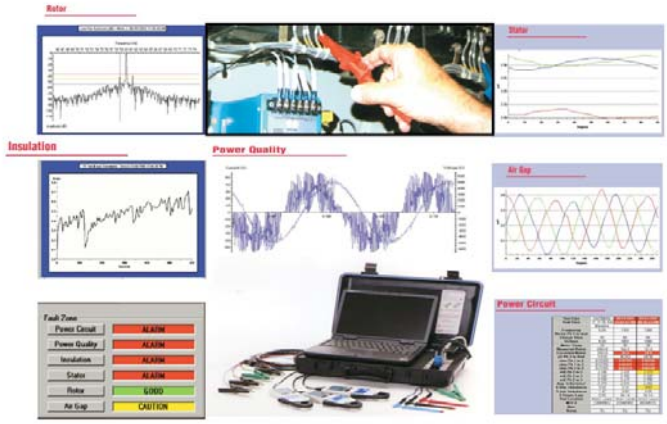
Motor Circuit Analysis Failure Modes and Technologies



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Secret to Reliability

- Early Identification and Early Elimination of Machinery Defects
  - For the applicable failure modes…no inspection method is more effective than PdM

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Uses of PdM

- Enhance failure modes analysis
- Enable development of Equipment Maintenance Plans
- Enhances Root Cause Analysis
- Drives Maintenance Planning by means of identification of known defects

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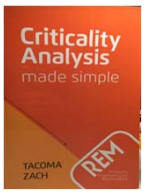
Tacoma Zach, P.Eng.

- President of Uberlytics,
- Experts and Innovators in
  - Risk Based Decision Support and Criticality Analysis
  - ISO55000
  - Asset Management
- Senior Fellow of the Asset Leadership Network and Training Provider Co.
- Institute of Asset Management Certified Training Provider Co.
- Formerly Area Manager and Vice President with Veolia with P&L West
- BASc. & MASc. in Chemical Engineering University of Toronto
- P.Eng. Canada

Uberlytics™

MentorAPM



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Predictive Maintenance: Supporting Asset Management

Guided by Criticality & Failure Modes

Uberlytics MentorAPM

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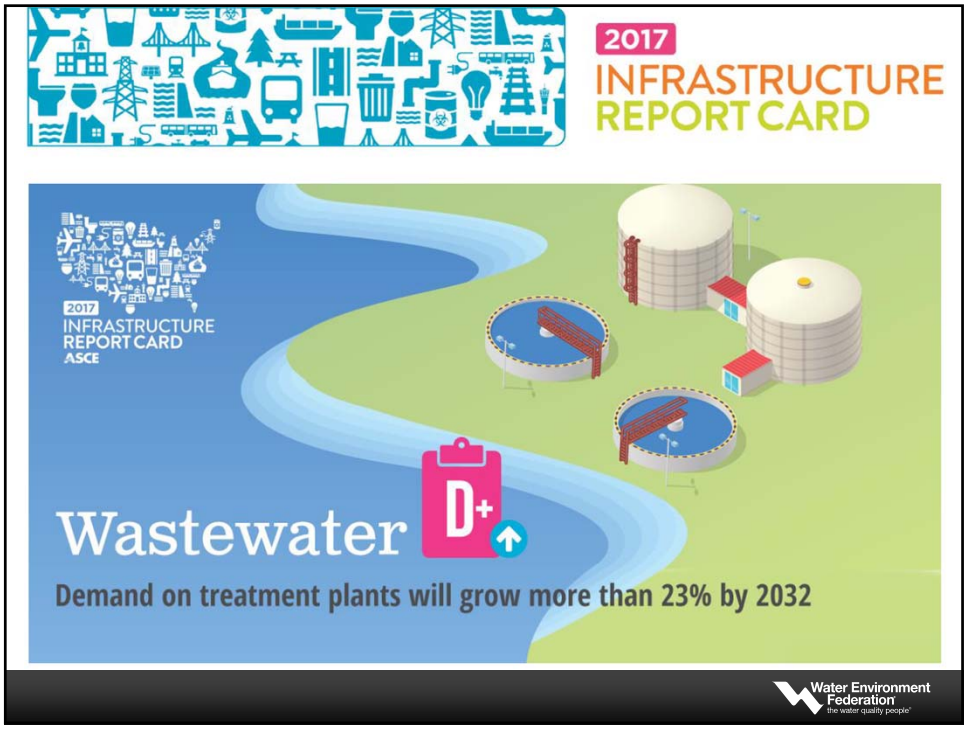

Valhalla

- Everyone's Budget is unlimited
- Everything is equally critical, no need to prioritize
- Everything fails the same way, one size fits all

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There is way to really FOCUS the resources to pick the right PdM

Deals with efficient: Budget, Focus, Tactical

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4 Pillars of Asset Management

Derive maximum value from assets	Lowest Spend for LOS
Risk Based decisions	LOS Assurance
Have corporate line of sight to the field level	Alignment (often misunderstood)
Have executive support and sponsorship	Leadership

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Means…

- Discover When & Where Your Mission is at Risk
  - What impacts your Level of Service, and how badly
- Manage Assets Appropriately
  - Based on Criticality and Risk
  - Correct Asset Strategy per asset
  - R.R.R.R.
- Minimum spend to maintain LOS
  - Maintain/refurbish/replace

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MENTORAPM PLAYBOOK

A Plan for Managing Assets within Asset Management

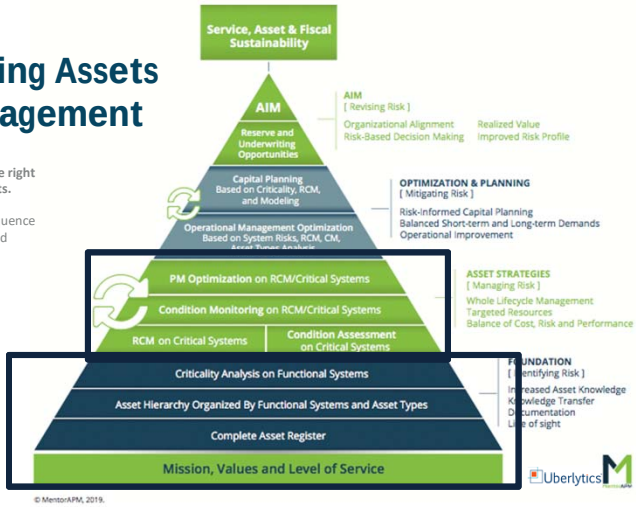
Asset Management is **doing the right things, in the right order, for the right reasons, to get the right results.**

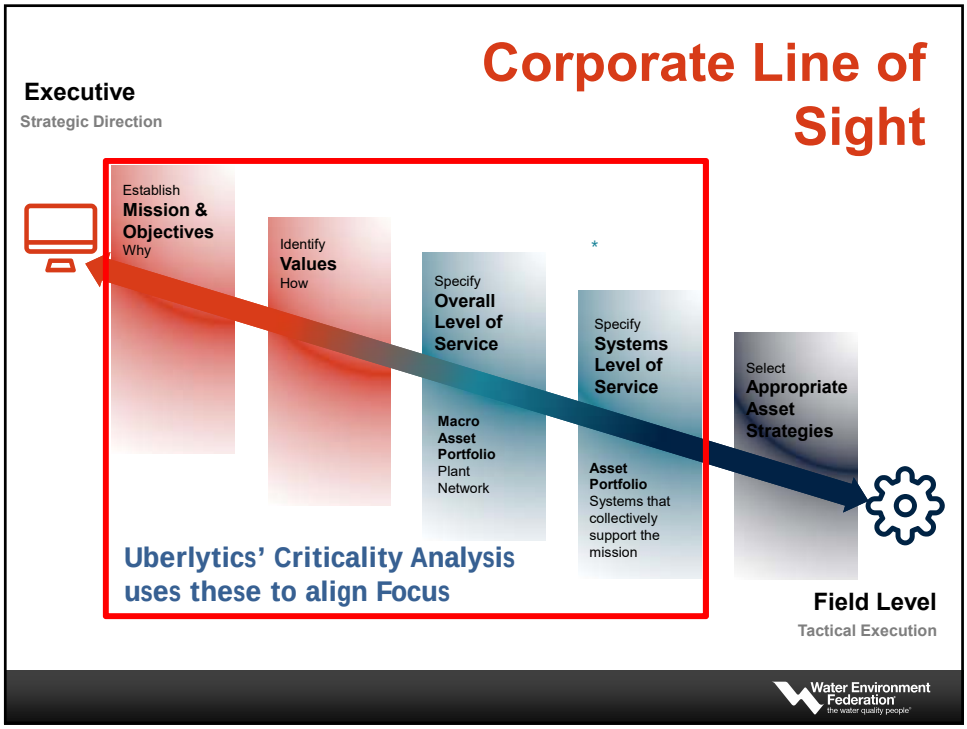
This pyramid shows an outline of activities in a sequence that drives you toward the aim of service, asset and fiscal sustainability.

To begin, you need to understand why you exist.

Figure out What is most important

Select the right Asset Strategy for each asset




Corporate Line of Sight
Executive
Strategic Direction
Establish
Mission & Objectives
Why
Identify
Values
How
Specify
Overall Level of Service
Macro Asset Portfolio
Plant
Network
Specify
Systems Level of Service
Asset Portfolio
Systems that collectively support the mission
Select
Appropriate Asset Strategies
Uberlytics' Criticality Analysis uses these to align Focus
Field Level
Tactical Execution
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Little about Criticality and How to do it "Smart"

Criticality vs Risk: there's a difference

- **Criticality**: "Is a measure of the relative importance of something, usually a tangible system or asset, to the corporate mission, objectives and values of the organization", (incl. minimum acceptable Level of Service (LOS))
- **Risk:** The likelihood of an event X the criticality of the event.

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How most people approach it… asset by asset

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The Most Useful Level of Focus for Entire Asset Portfolio

Asset Level too Granular

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…Forest for the Trees

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Rather

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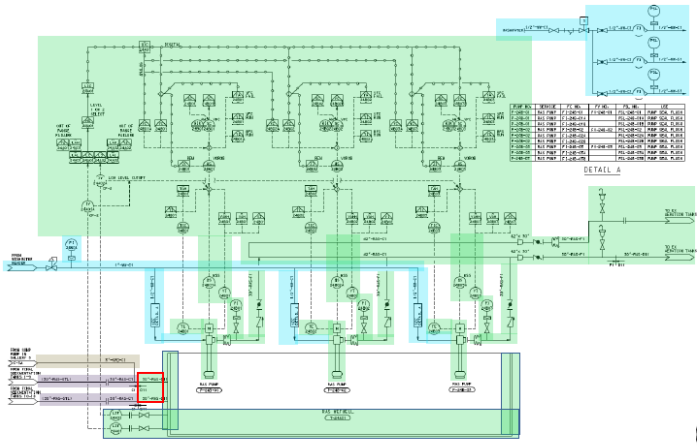
Functional Systems: LACSD RAS



Relate SYSTEM to:
Mission
All Values
– otherwise incomplete

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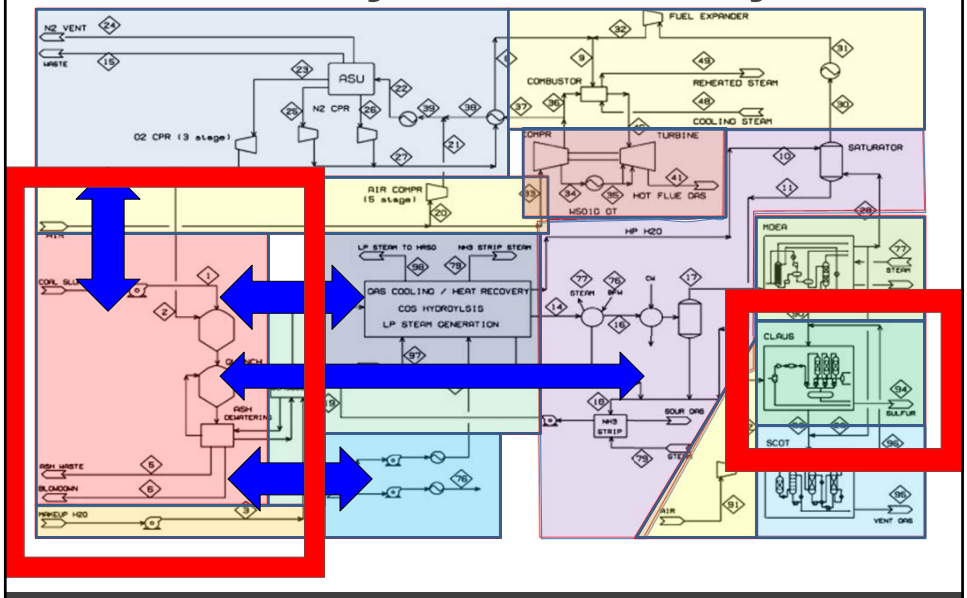
Functional System Criticality



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Only critical systems have critical assets

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A little about 'Order of Operation' to save Budget

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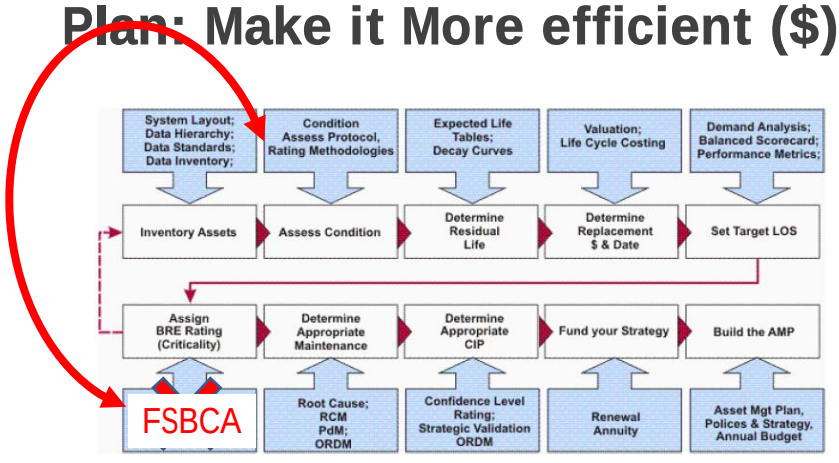
EPA 10 Steps Asset Management Plan: Make it More efficient ($)



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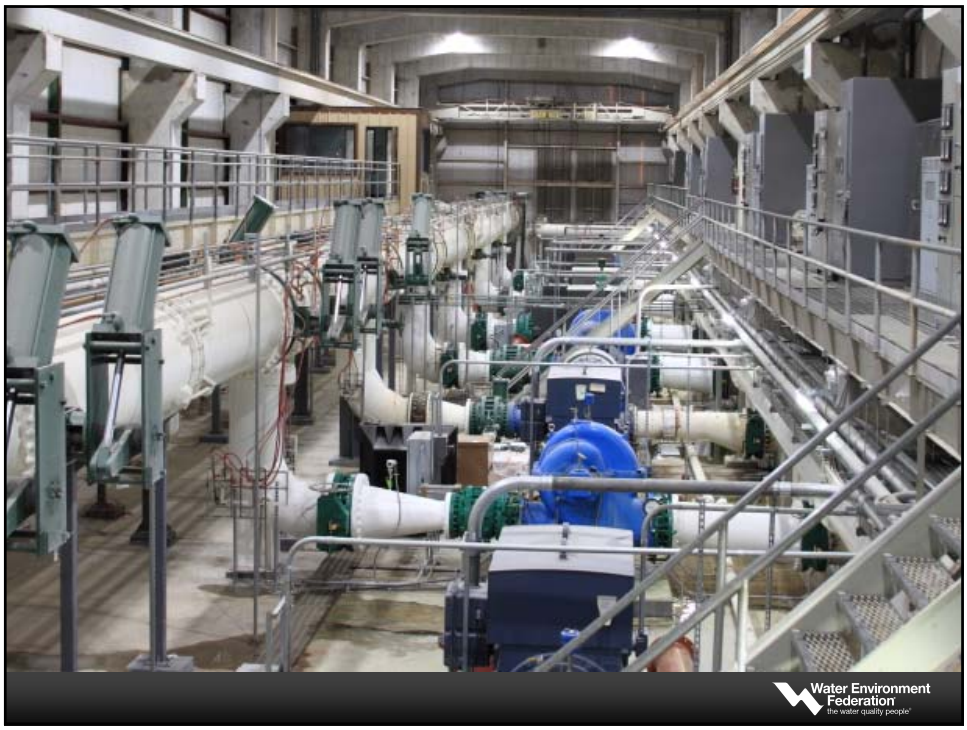
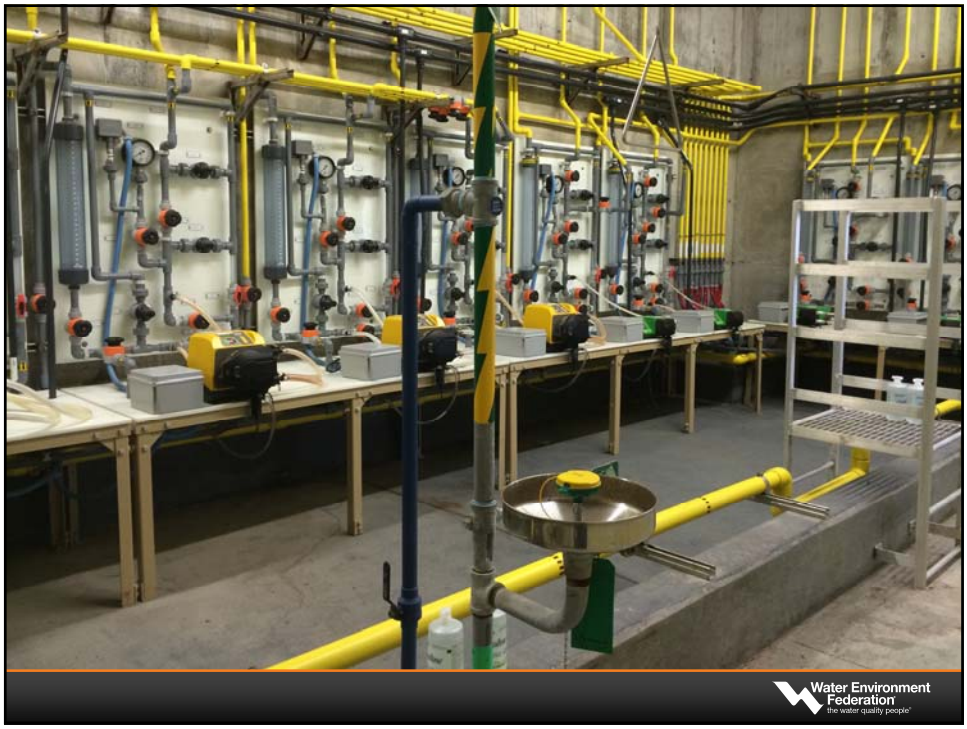
"ARE WE THERE YET?"

Not Just Yet…

- Factors to Consider
  - Cost of Failure
  - Cost of Consequential Failure
  - Impact of Down-time
  - Impact on LOS
  - Resiliency of the System
  - Others…



Critical Part: Gas Conditioning



If it's Critical, & Worth it…

- Condition Monitoring to detect early enough
  - Tailor to FM
  - Consider <u>first</u> the symptoms as direct result of the FM,

    Then indirect or secondary symptoms; as there might be from another FM
- Adjust PMs to catch early enough to minimize overall cost, and reduce Risk to LOS

Keep Your End Goal in Mind

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Summarize

- AM Pillars:
  - Make Risk Based Decisions
  - Extract Max Value from your Assets
  - Get Line of Sight and Alignment: everyone working on the right things:
    - Define Your Mission, Values and LOS
- Functional System CA First: brings focus
- Execute with Focus: @ risk, develop the correct strategy for each asset

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Thank You

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Uberlytics MentorAPM

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DC Water – Blue Plains WWTP

- Asset Management and Reliability Group
  - CMMS Business Practice
  - CMMS Analysis and Metrics
  - RCM Workshops
  - Oil Analysis
  - Ultrasound lubrication and Analysis
  - Vibration Analysis

Theresa Bruton, PE, CMRP, CRL, MLT 1
Asset Manager, Blue Plains WWTP
DC Water

dc water is life®

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Establishing a Foundation for PdM Technology: Case Study

Blue Plains Advanced Wastewater Treatment Plant

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Background Information

- The largest Advanced Wastewater Treatment Plant (AWTP) in the world
- Design capacity of 555 mgd (4 hours) then 511 mgd. Separate wet weather plant 225 mgd
- Effluent TN 3.74 mg/L (load based) and TP 0.17 mg/L (rolling 12 month avg)
- Services 2.2 million people
- Occupies about 150 acres
- 5,000 rotating equipment and 36,000 assets

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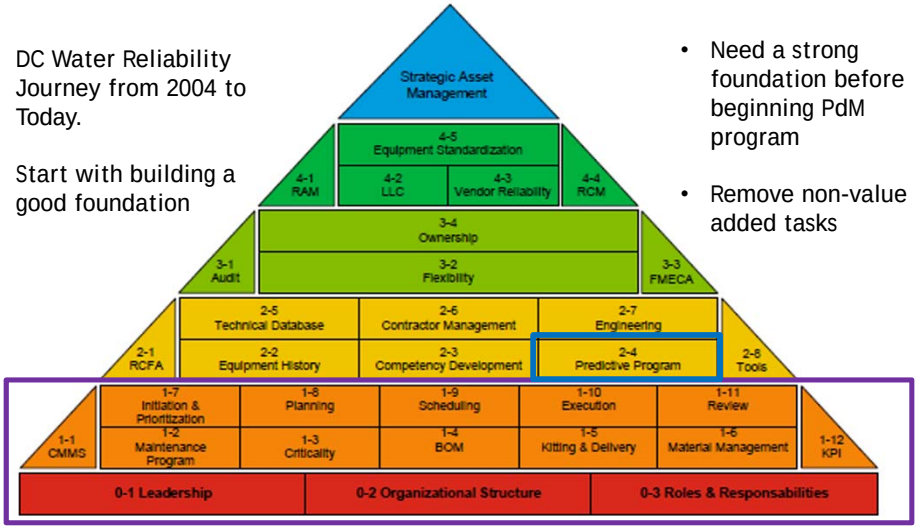
Reliability Journey: How to Start

DC Water Reliability Journey from 2004 to Today.

Start with building a good foundation



- Need a strong foundation before beginning PdM program
- Remove non-value added tasks

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Building a Foundation -

- Asset Registry
- Roles and Responsibility flowchart and RASCI
- Work Execution Data Used For:
  - Planning and scheduling
  - Reliability metrics (MTTR, MTTF, bad actors ect)
  - Risk and CIP planning
  - Auditing
  - MOC documentation

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Building a Foundation: Timeframe

- 2004 – Started using Maximo for work execution. Location based system
- 2005 – Started creating PMs for inspection
- 2010 – Hired EMA to coach, audit and improve Maximo. Changed to asset based approach and started using workflow
- 2013 – Hired Planners
- 2014 – Good data entered for work orders, labor, material and services

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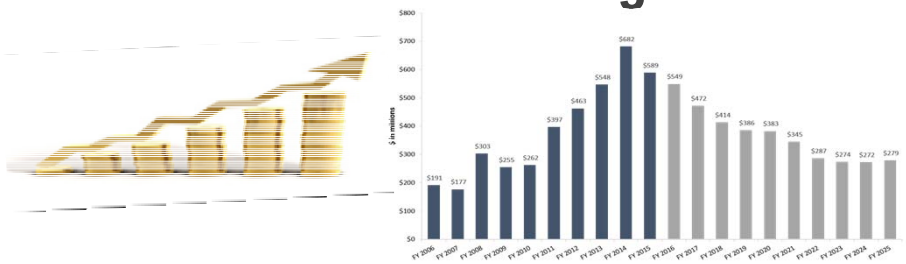
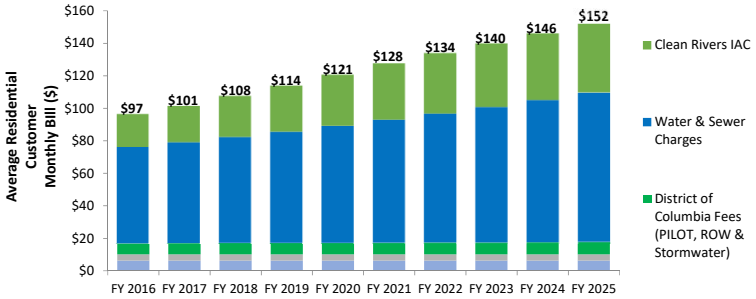
2016 Driver for Change





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Building on the Foundation

- Education
- Level of Service
- Risk
- PMO
- RCM
- Work execution – continuous improvement
- PdM Program

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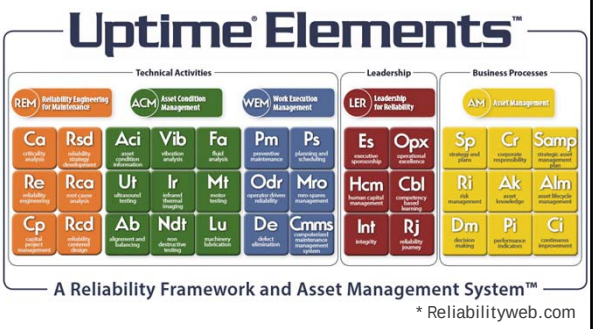
Education/Training/Communication

- Education
  - Authority wide effort to set base understanding
  - Uptime elements (280 users; 260 finished)
- Training
  - Work Execution
  - Predictive Technologies
  - RCM Fundamentals
- Communication
  - Operations
  - Procurement
  - Engineering
  - Finance
  - Safety
  - Facilities



* Reliabilityweb.com

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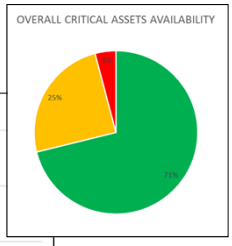
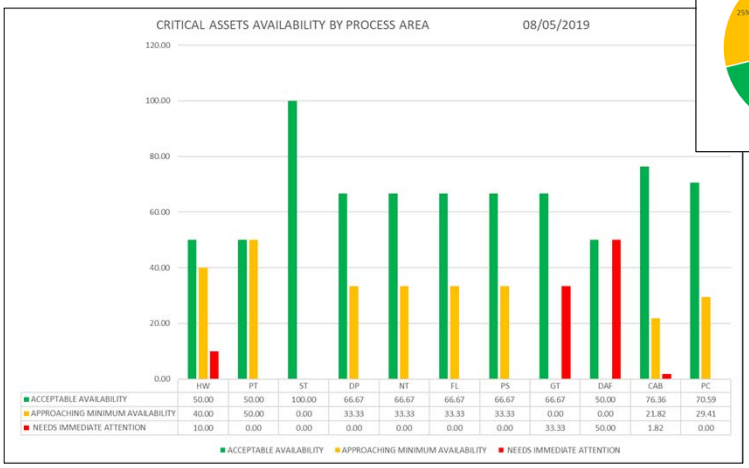
Minimum Level of Service (LOS)





	HW	PT	ST	DP	NT	FL	PS	GT	DAF	CAB	PC
ACCEPTABLE AVAILABILITY	50.00	50.00	100.00	66.67	66.67	66.67	66.67	66.67	50.00	76.36	70.59
APPROACHING MINIMUM AVAILABILITY	40.00	50.00	0.00	33.33	33.33	33.33	33.33	0.00	0.00	21.82	29.41
NEEDS IMMEDIATE ATTENTION	10.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	50.00	1.82	0.00

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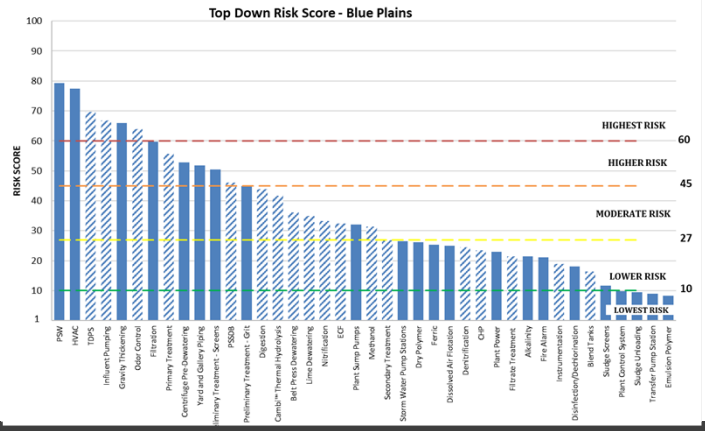
Risk (LOF vs COF)

- 2016 – Original COF and LOF based on tribal knowledge. Updated annually



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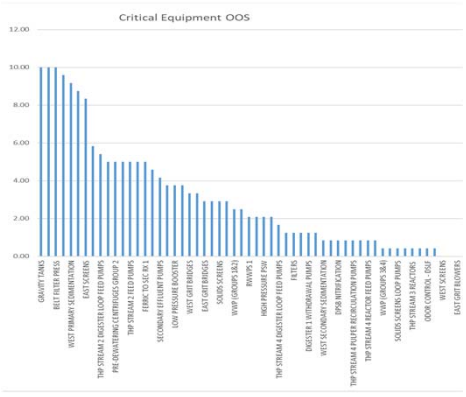
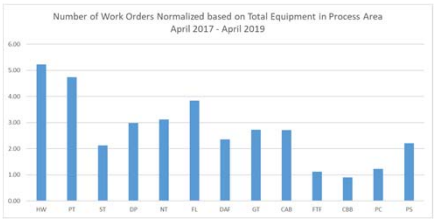
Risk (LOF vs COF)

- 2019 – Generate LOF from Maximo data
  - Proof of Concept: Convert wkly LOS and MTTF





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Preventative Maintenance Optimization (PMO)

- Why Improve PMs?
  - In 2017 36% of the labor was performing PMs but only generated 7% of the CM labor. ie not value added
- Duplicates had built up over time due to various projects, and some tasks did not reflect O&M changes
- CMMS Based Review
  - Removed duplicate PMs, non-value added tasks, checked consistency, and revised PM frequencies
  - Reviewed 2500 PMs on 7000 assets over 8 months
  - Modifications to over 1000 PMs or Job Plans
- Reduced the annual estimated CMMS PM labor by 58,000 hours. Potential savings of $2M. Allows better PM calendar loading. The actual PM labor was reduced from 36% to 23% with the same CM generation.
- Use RCM to replace remaining tasks with value added tasks

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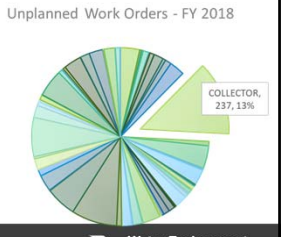
FMEA -> RCM

Fmea
failure mode effects analysis

Rcm
reliability centered maintenance

- An FMEA is a structured approach to identify failures within a system and the consequences of those failures.
  - Relies on input from trade technicians and operations staff to develop the why and how systems fail
- Done only on critical systems



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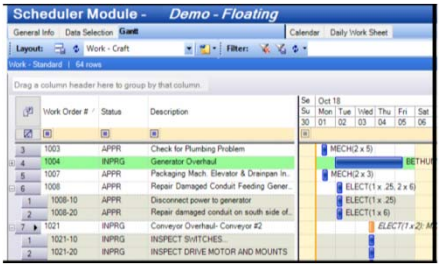
Work Execution Improvements

- Coaching Users and Training
- 2019 - Scheduler
- 2019 - Mobile CMMS



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Predictive Technology Program

- Oil Analysis
- Vibration
- Ultrasound Lubrication
- Thermography

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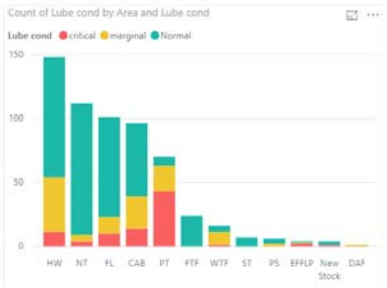
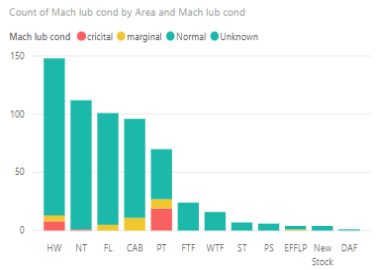
Oil Analysis

- 294 units covered
- 80% of the volume of oil but only 20% of the equipment that has oil
- Significantly reduce time based oil changes
- Lubricant consolidation project 100 to 7 lubricants





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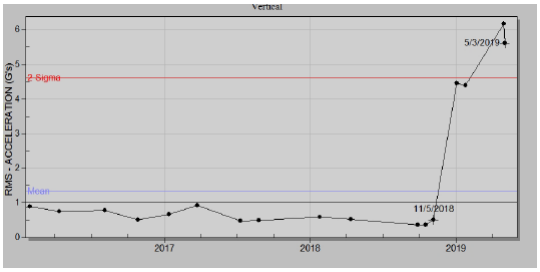
Vibration Analysis

- 291 units covered
- Outside contractor analyzes the data
- Trending over time catches failures early



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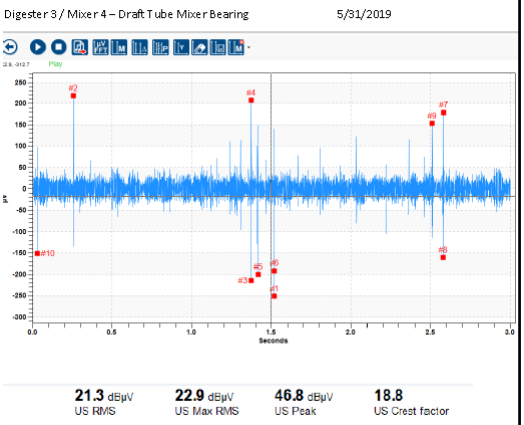
Ultrasound Lubrication

- 157 units covered and increasing
- Applied to rolling element bearings



Thermography

dc water is life®

THERMOGRAPHIC REPORT

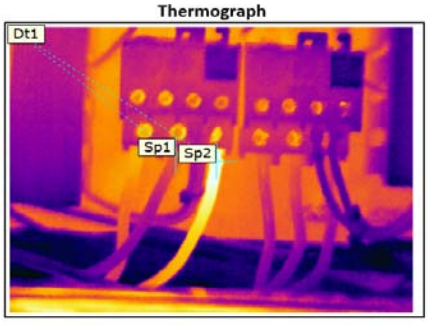
DC WATER/ BLUEPLAINS
5000 OVERLOOK AVE. SE
WASHINGTON D.C. 20032

Asset #:	210895	**Date/ Time:**	06/13/2016 0900	**Equipment Name:**	Sump Pump #1 & 2
W.O. #:	16-335804	**Thermographer:**	T. Belt/ R. Reyes	**Location:**	MCC A/ "A" House

Problem Description:

The left contactor which is #1 Sump Pump has a temperature gradient on its "C" phase indicating a possible loose connection at that specific connection point. Other possibilities could be bad wiring or windings on that phase.

Thermograph



Temperature Measurement

Emissivity	0.95
Object Distance	3.3 ft
Reflected Temp.	68.0 °F
Atmospheric Temp.	68.0 °F
Relative Humidity	50.0 %
Sp1 Temperature	71.9 °F
Sp2 Temperature	83.6 °F
Dt1 Delta T	-11.7°F

Conclusions

- Patience - It takes time
- A good asset registry and risk values helps determine the PdM technologies and resources needed
- Budgets are shrinking and reliability is becoming a life line.
- Removing non-value added tasks is key

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Questions?

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