PI System – From Education To Application

Klaus Blache (UTK) & Rick Baldridge (Cargill)

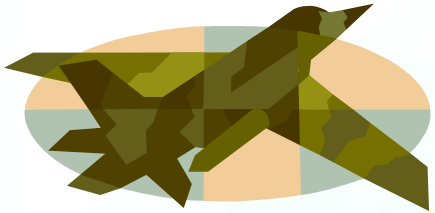
THE UNIVERSITY OF TENNESSEE KNOXVILLE

Cargill Helping the world thrive

RMC Purpose

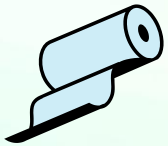
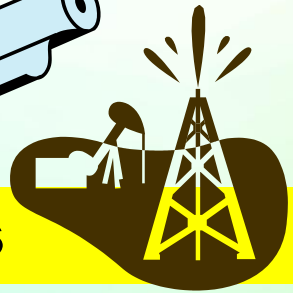
University Knowledge + RMC Practical Implementation = Business Results

The Reliability and Maintainability Center is a university - industry association dedicated to improving industrial productivity, efficiency, safety, quality & profitability through advanced reliability and maintenance practices, technologies and management principles.

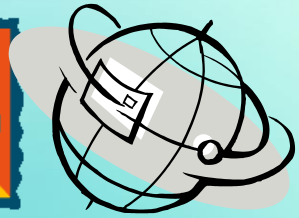







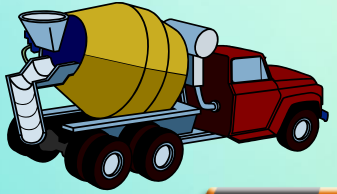








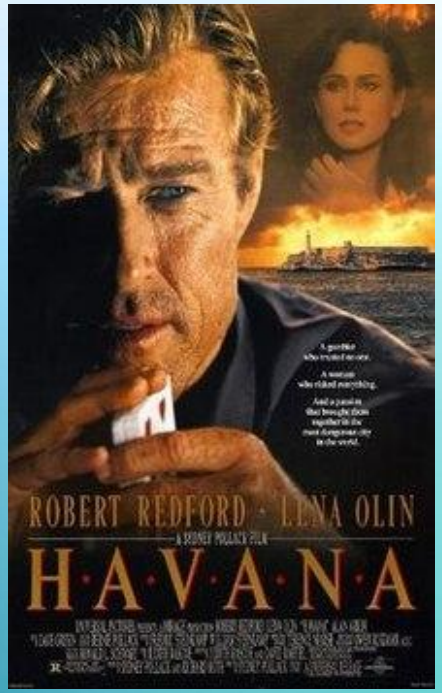





The purpose of this presentation is to:

- **Raise the level of understanding of R&M in industry, current trends and where PI can help**
- **Show how PI system is being learned by students and used at UTK**
- **Provide some insights on how students are further learning and implementing PI at Cargill (and taking this vital hands-on knowledge into companies all over the world)**

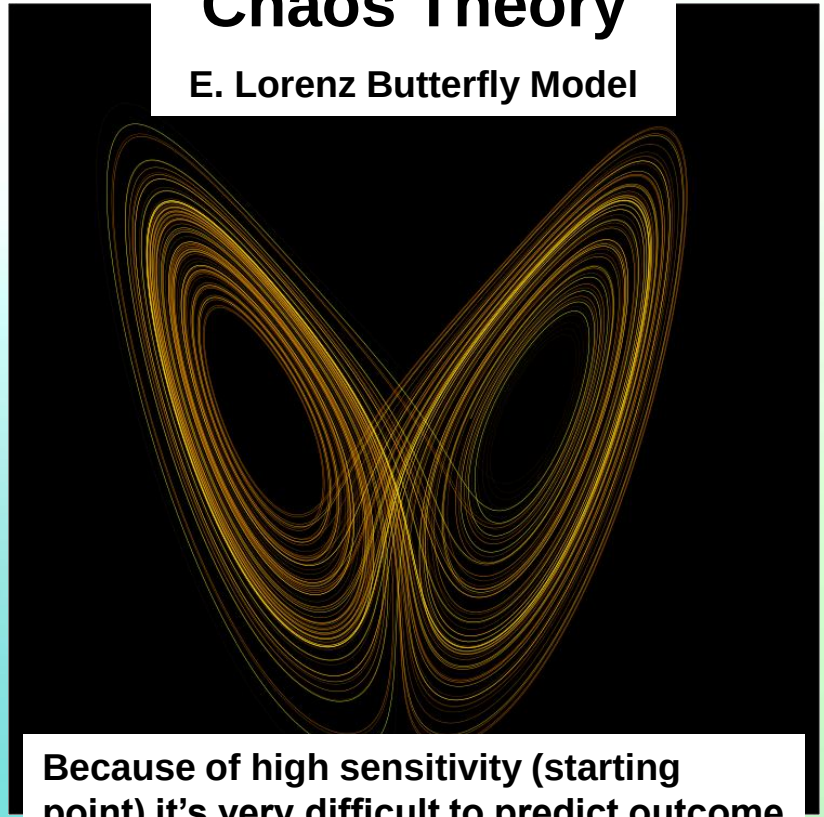
“A butterfly can flutter its wings over a flower in China and cause a hurricane in the Caribbean.”



Source: https://en.wikipedia.org/wiki/Havana_(film)

Chaos Theory

E. Lorenz Butterfly Model



Because of high sensitivity (starting point) it’s very difficult to predict outcome of complex systems

Source: https://en.wikipedia.org/wiki/Butterfly_effect#/media/File:Lorenz_attractor_yb.svg

What presumed little things go on in your Maintenance Department that can have a "Butterfly Effect" on your organization?

Consider Trades/technicians that:

- **Take verbal job requests that should be formal work orders**
- **Sometimes gets to job site and discover that operations personnel won't allow the machine to stop**
- **Receive unclear maintenance tasking direction, so they improvise**
- **See most jobs prioritized as Safety /High Priority just to get to the top of the list**

Source: *Efficient Plant* , Maintenance and the Butterfly, June 2018, K. Blache

What presumed little things go on in your Maintenance Department that can have a "Butterfly Effect" on your organization?

Consider Trades/technicians that:

- **Skip less-critical PM checks because many can't be finished in time and/or on a monthly schedule (they are often reported as completed, thus making the KPI's look good**
- **Struggle to find the correct part, because all parts are not coded with a standardized system, a problem that also effects reordering/procurement**
- **Learn that only some of the asset history is captured because Work Orders are not closed with enough detail or at all**

Source: *Efficient Plant* , Maintenance and the Butterfly, June 2018, K. Blache

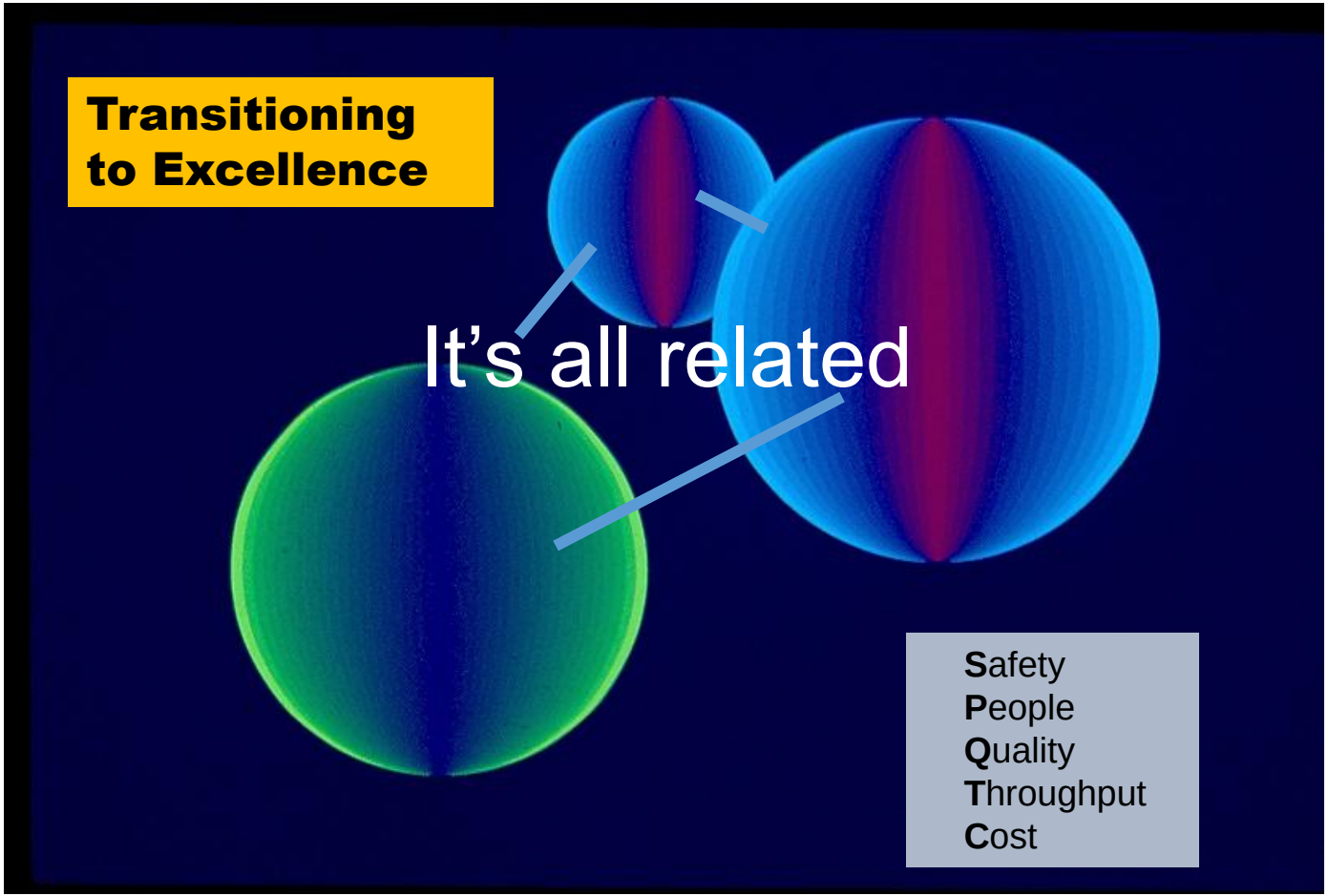
What presumed little things go on in your Maintenance Department that can have a "Butterfly Effect" on your organization?

Consider Trades/technicians that:

- **Hoard parts because they don't trust stock room data**
- **Do not perform root-cause, trending, and reliability growth tracking analysis because they lack quality asset data**
- **See continuous backlog growth, assuming you are counting all Work Orders not performed**
- **Are unable to predict costs other than that they continue to go up**
- **Doubt data validity/accuracy, though KPI's look good (for the most part, looking at daily plant-floor practices reinforces their distrust)**

Source: *Efficient Plant* , Maintenance and the Butterfly, June 2018, K. Blache

Compiling Good Data



R&M Benchmarks to Top Quartile

What is R&M Doing for Your Business TODAY ?

Safety

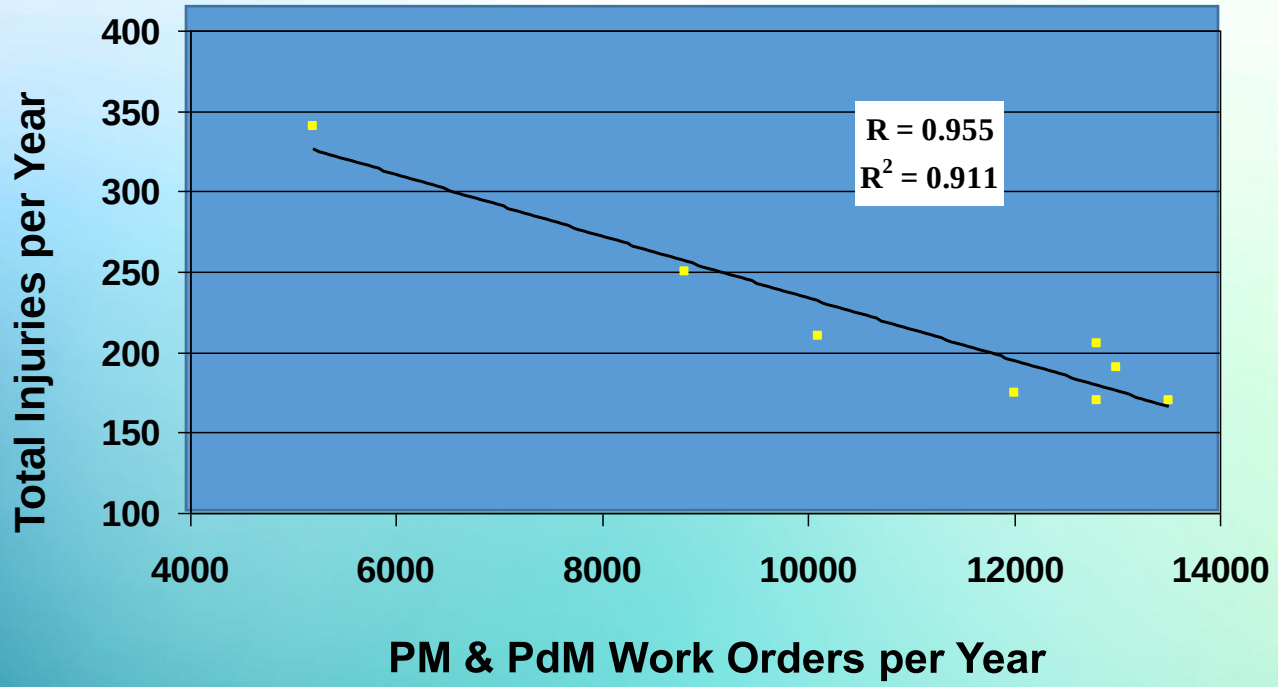
People

Quality

Throughput/Uptime

Cost

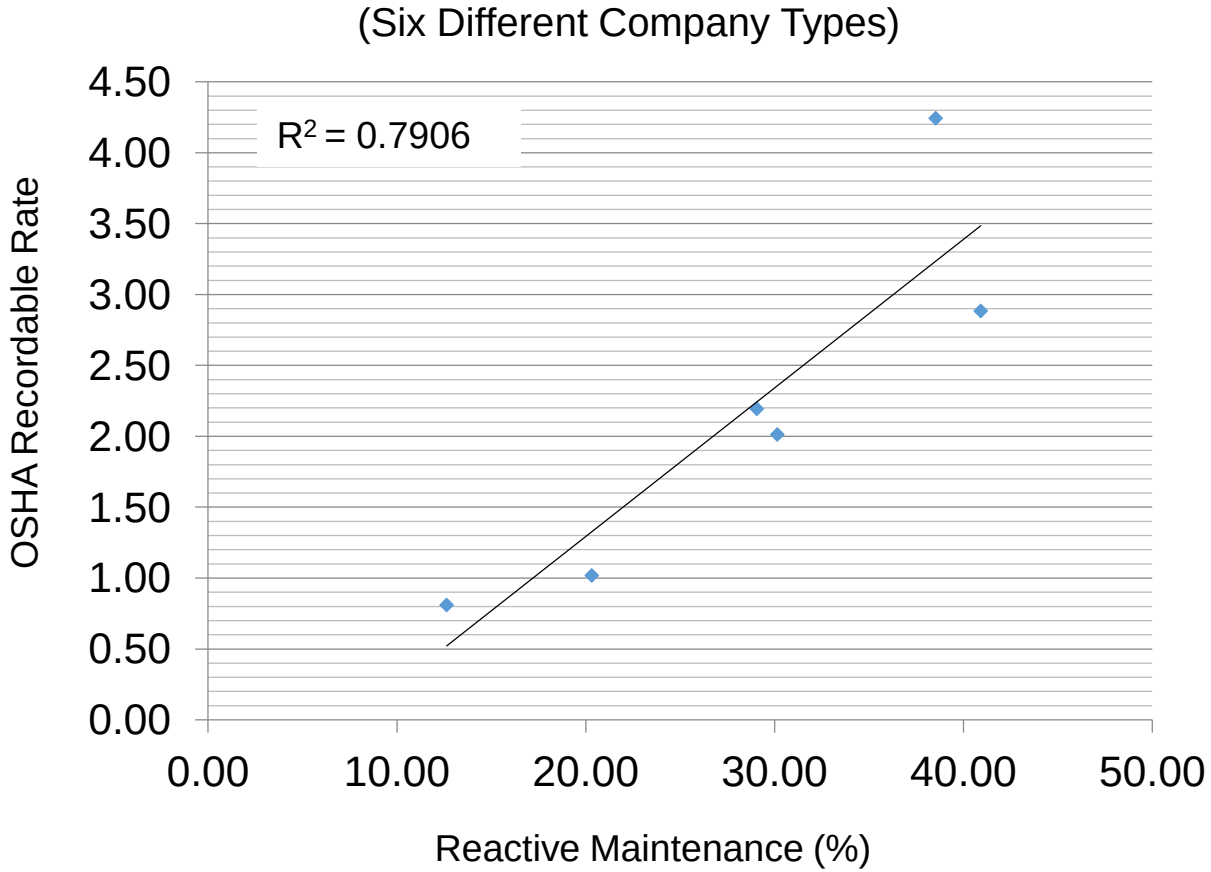
Correlation of PM & PdM Work Orders with Injury Rate



Source: Large Chemical Plant - A

(MARCON Conference, The RM Group, Inc.)

Impact of Reactive Maintenance on OSHA Recordable Rate

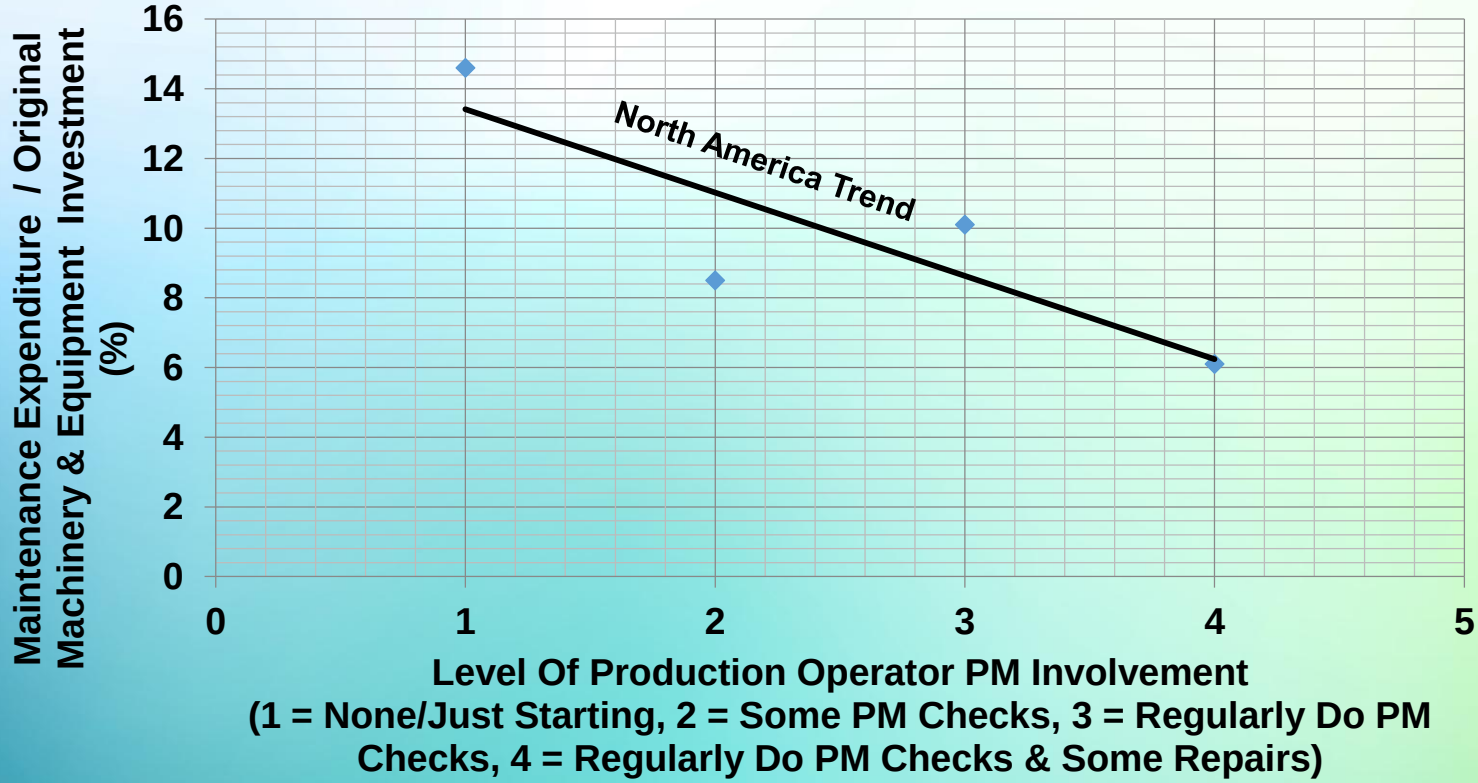


Dr. Klaus Blache, 2017 Study, B&A LLC data

People

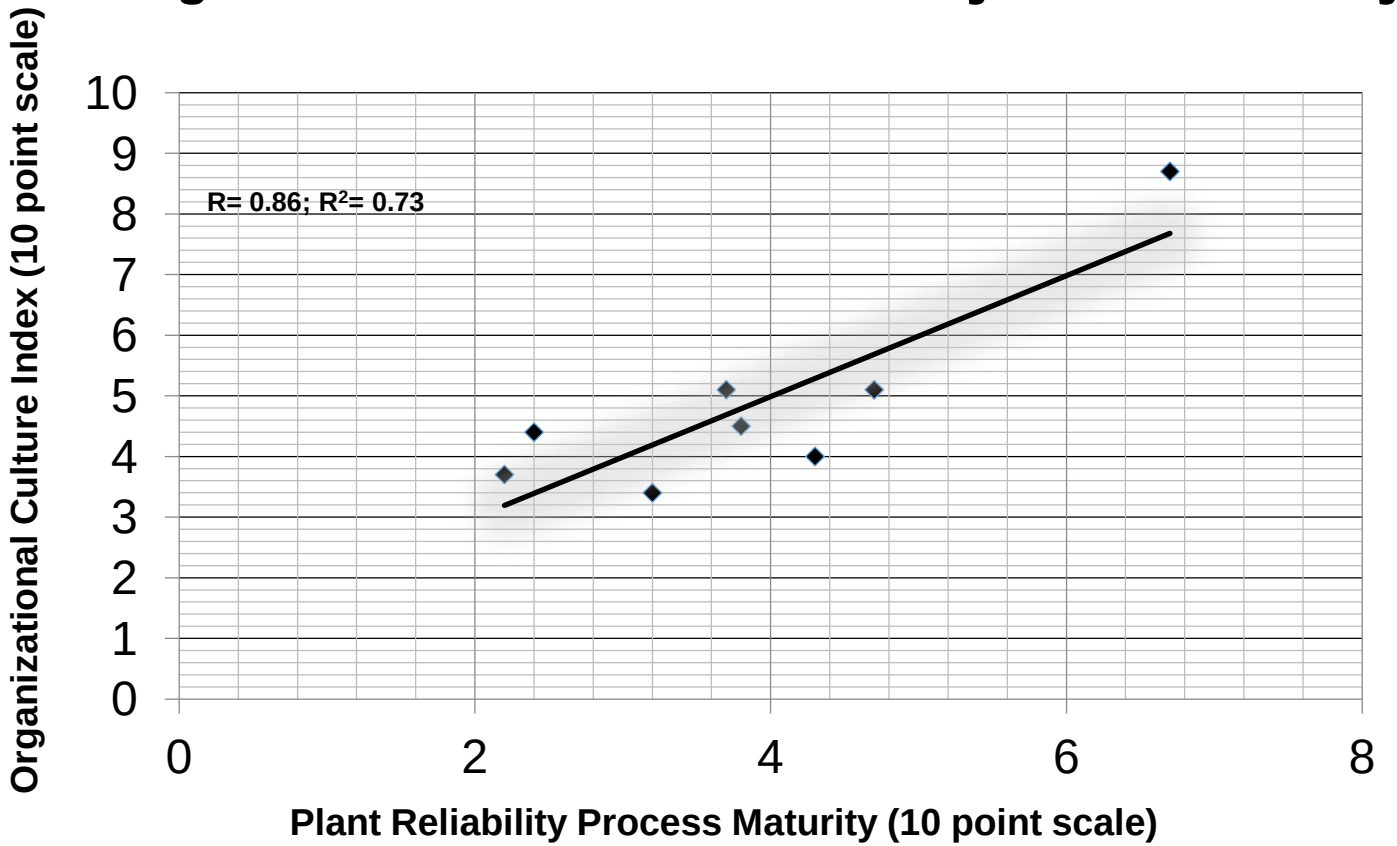
Positive impact of production operator PM involvement on maintenance expenditure

(Each of the 4 points represents 40-60 plants)



Source: Book: *The Relativity of Continuous Improvement*, Dr. Klaus Blache, Dec., 2015

Organizational Culture and Reliability Process Maturity

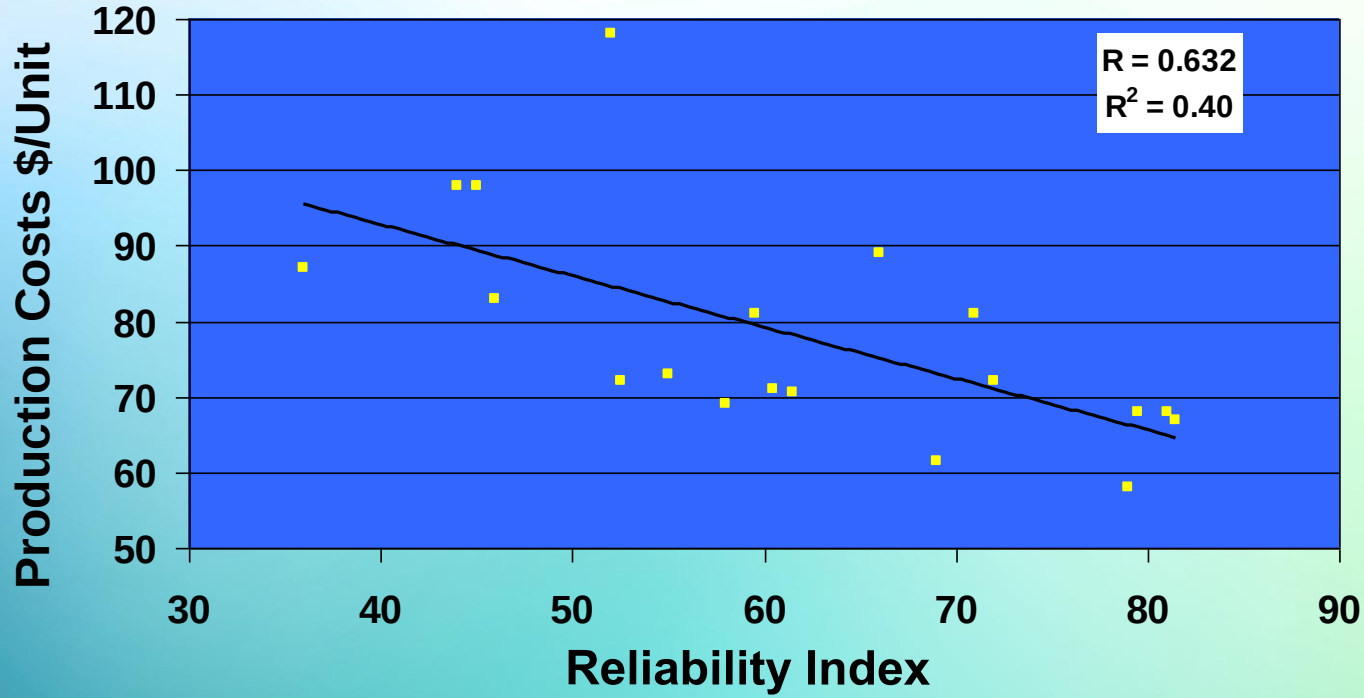


Source: Book: *The Relativity of Continuous Improvement*, Dr. Klaus Blache, Dec., 2015

Cost / Throughput

A Reliable Plant is More Cost Effective - Reliability Index v. Production Unit Costs

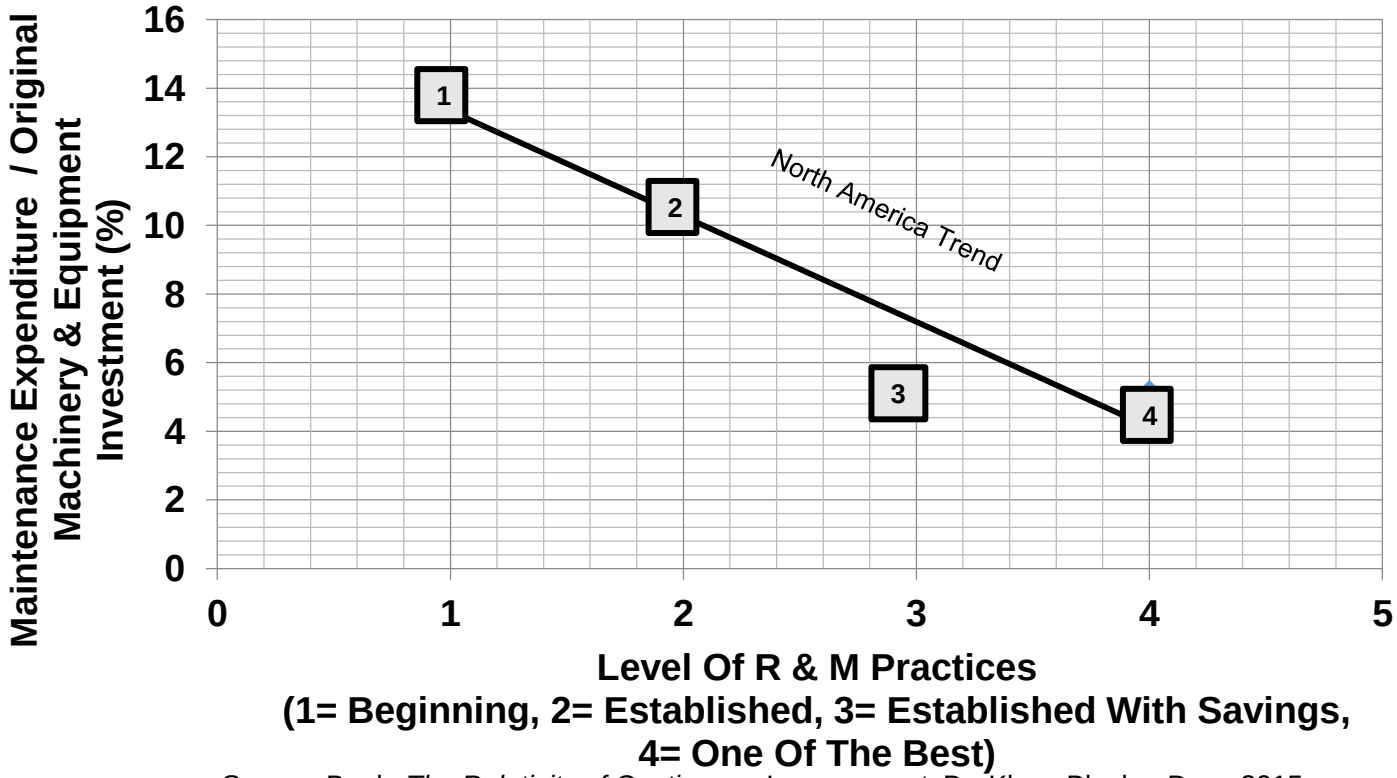
(As reliability increases, costs decrease)



Source: Large Industrial Manufacturer, The RM Group, R&M Bootcamp

Positive Impact of Reliability & Maintainability Practices on Maintenance Expenditure

(Each of the 4 points represents 40-60 plants)



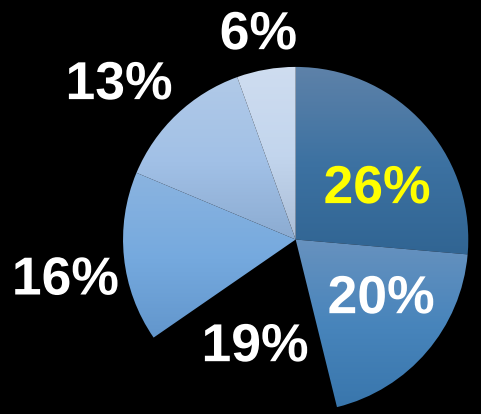
Source: Book: *The Relativity of Continuous Improvement*, Dr. Klaus Blache, Dec., 2015

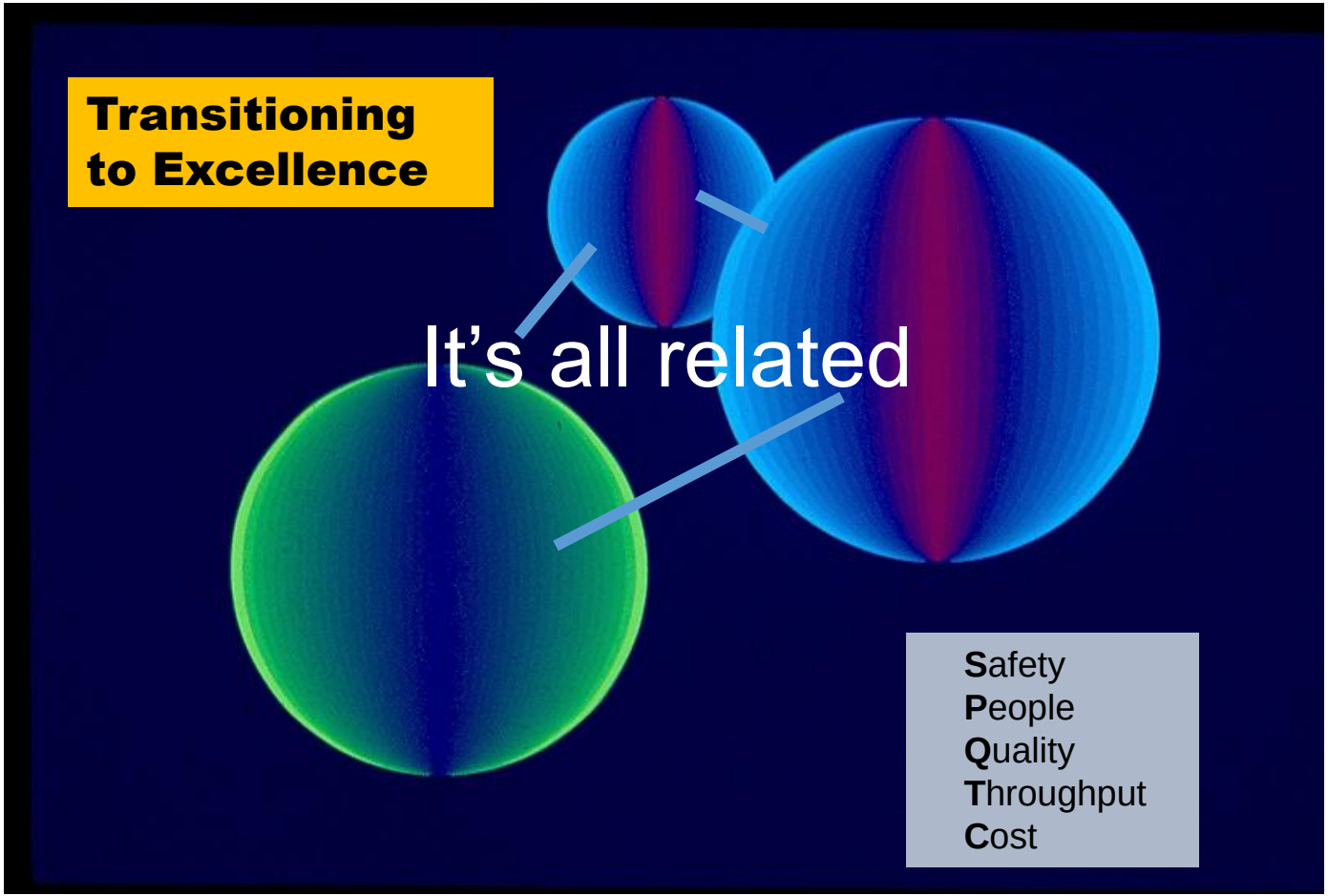
Major Changes In Reliability & Maintainability Envisioned In Next 10 Years

- People & Cultural Improvements

PI Opportunities

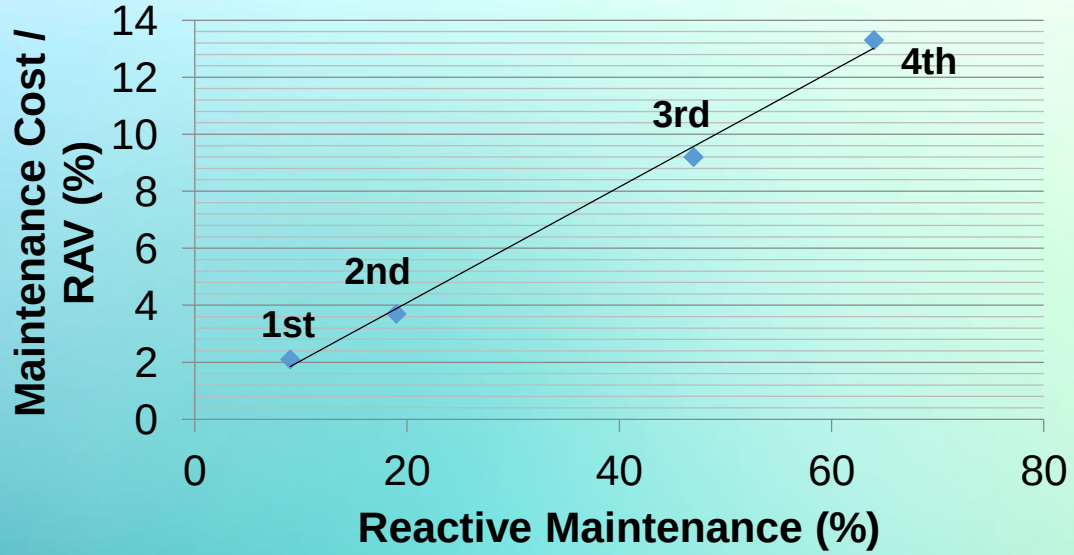
- More Design-In Reliability & Maintainability
- More Data Driven Processes & Tools (including Predictive)
- Maintenance Process Improvements
- Specific Maintenance Improvements
- More Sensors & Timely Feedback





What is your Quartile ?

	1st	2nd	3rd	4th
Reactive Maintenance (%)	9	19	47	64
Maintenance Cost / RAV (%)	2.1	3.7	9.2	13.3



Dr. Klaus Blache, 2017 Study, UT-RMC

Asset Management Lab Set-up and Facilities Pilot Project

Michael Keesee and Mitchel Porter
University of Tennessee, Reliability and Maintainability Center

THE UNIVERSITY OF TENNESSEE KNOXVILLE

Project Purpose

- To expand the PI footprint at UTK by installing and using PI in the Reliability and Maintainability Center (RMC).

THE UNIVERSITY OF TENNESSEE KNOXVILLE
FACILITIES SERVICES

(Data)

TICKLE COLLEGE OF ENGINEERING
RELIABILITY AND MAINTAINABILITY CENTER

(Analysis)

Data Sources

- **Strong Hall (BACnet Source)**
  - **5867 total points**
  - **Valves (supply, exhaust, etc.)**
  - **Air handling units**
  - **Variable air volume controllers**

- **Steam Plant (UFL Source)**
  - **Coal and natural gas boilers**
  - **Natural gas fired turbine generator**

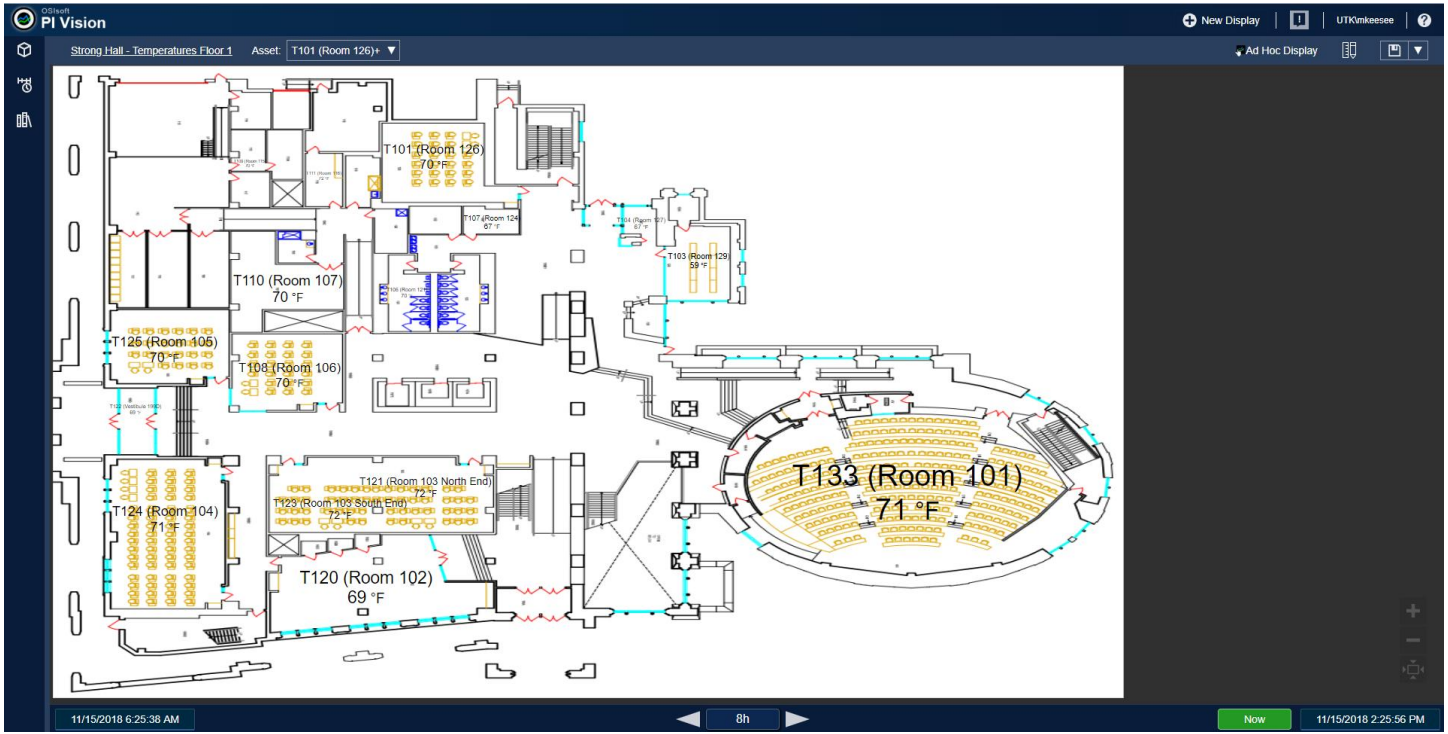
Objectives & Scope

- Become trained on the basics of a PI system and how to install a PI system
- Install a practice PI system on internal VMs at OSIsoft
- Install PI system on UTK VMs:
  - Connect Data Sources
  - Develop data consumption/usage methods useful to the end users
  - Build AF Hierarchy, build PI Vision displays, and apply predictive maintenance strategies

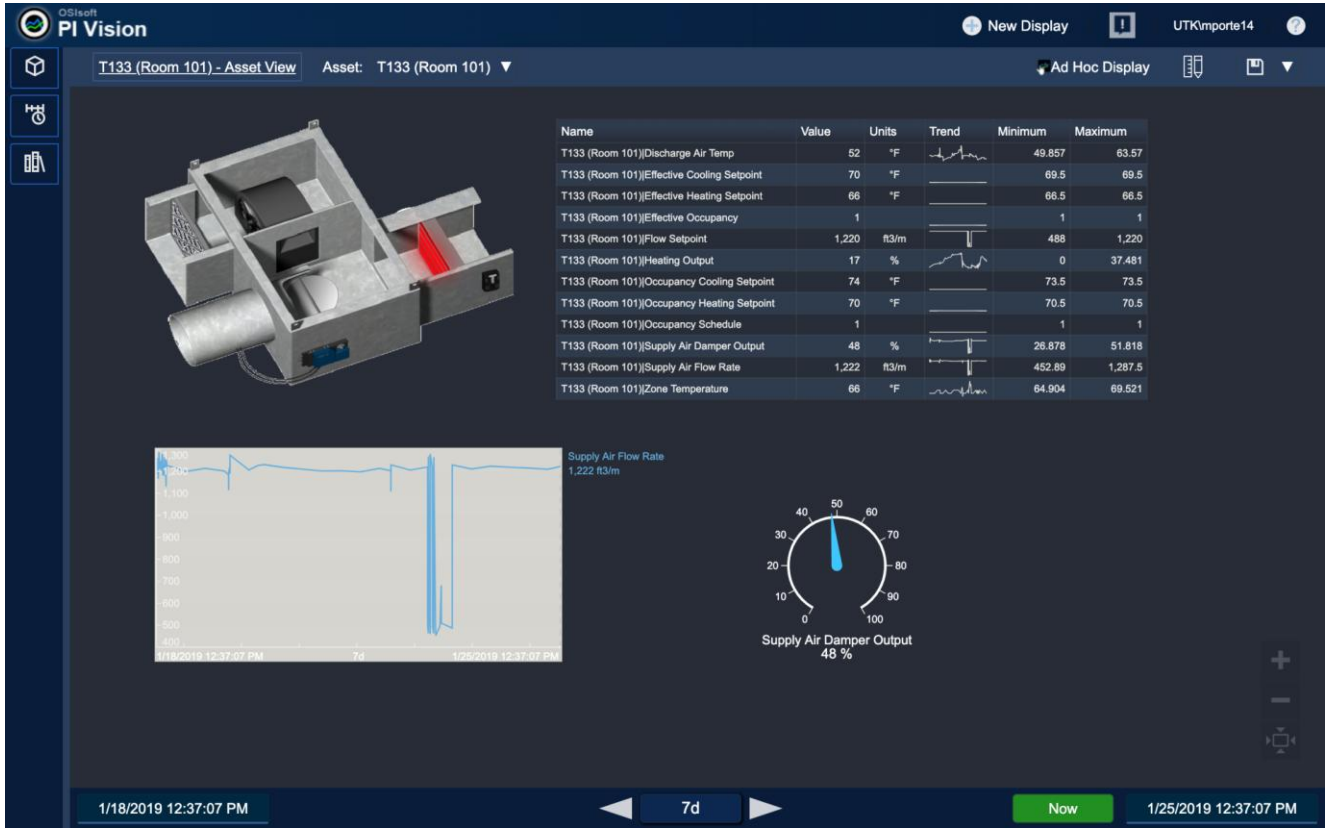
Our Virtual Server

- PI Asset Framework & PI Data Archive
- PI Interfaces/Connectors – BACnet Interface & UFL Connector
- PI Vision and PI Process Book
- PI OLEDB Enterprise 2017 R2

Current PI Vision Displays



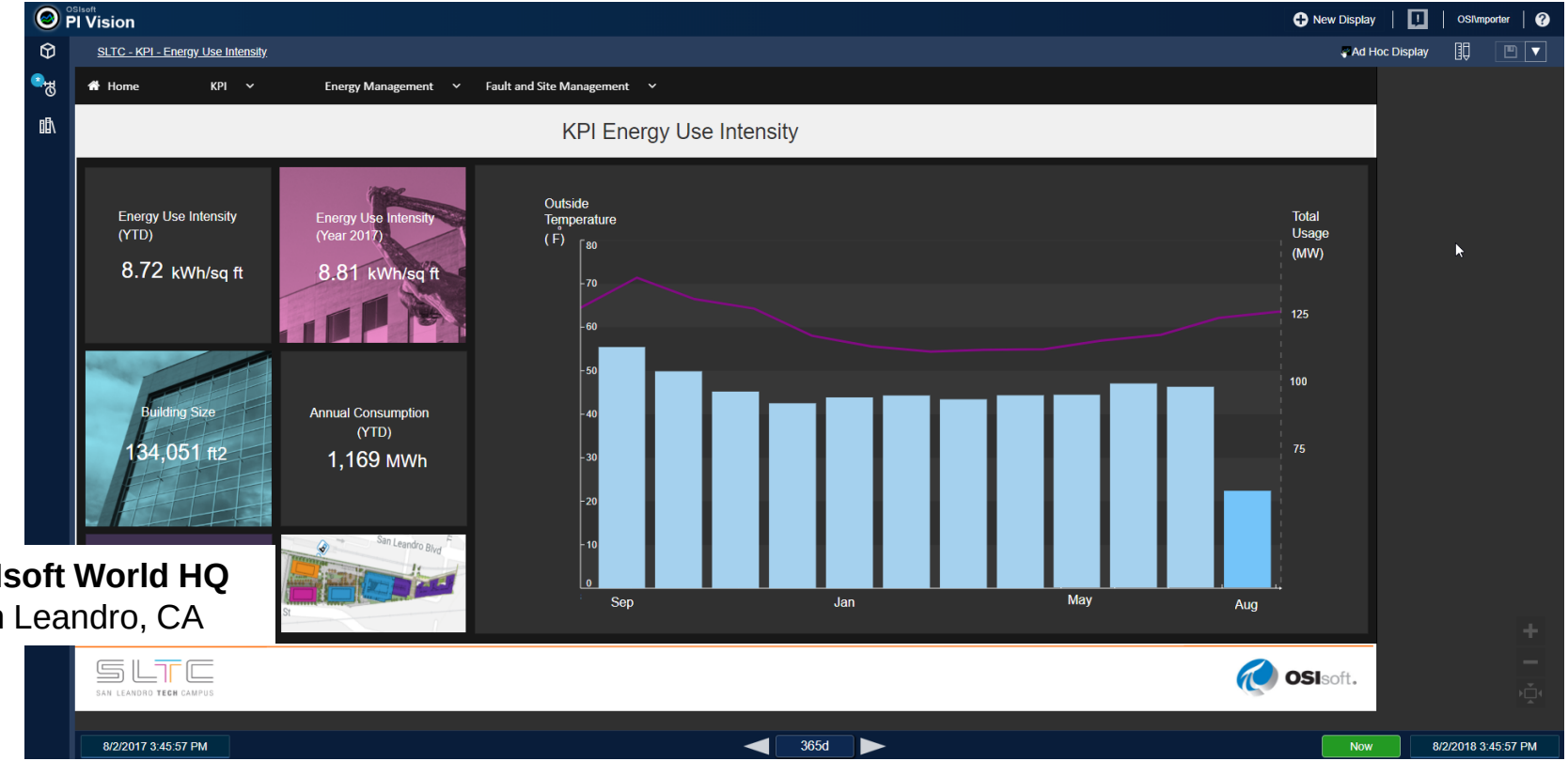
Current PI Vision Displays



Project Summary

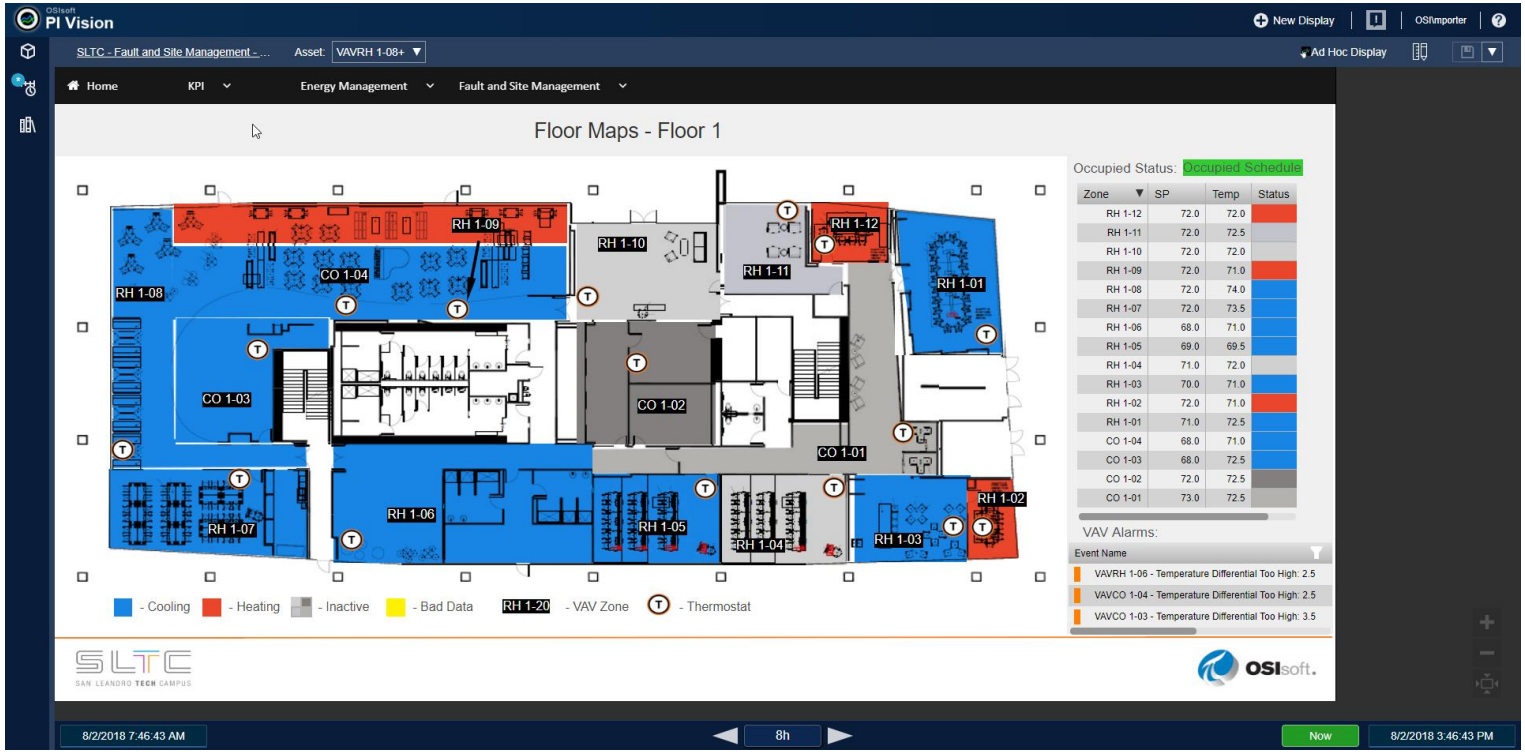
- Created an asset hierarchy and some desired PI Vision displays for Strong Hall's Building Automation Control Network.
- Developed a program in Python to convert historical Steam Plant data from Excel files to CSV files

Future PI Vision Displays

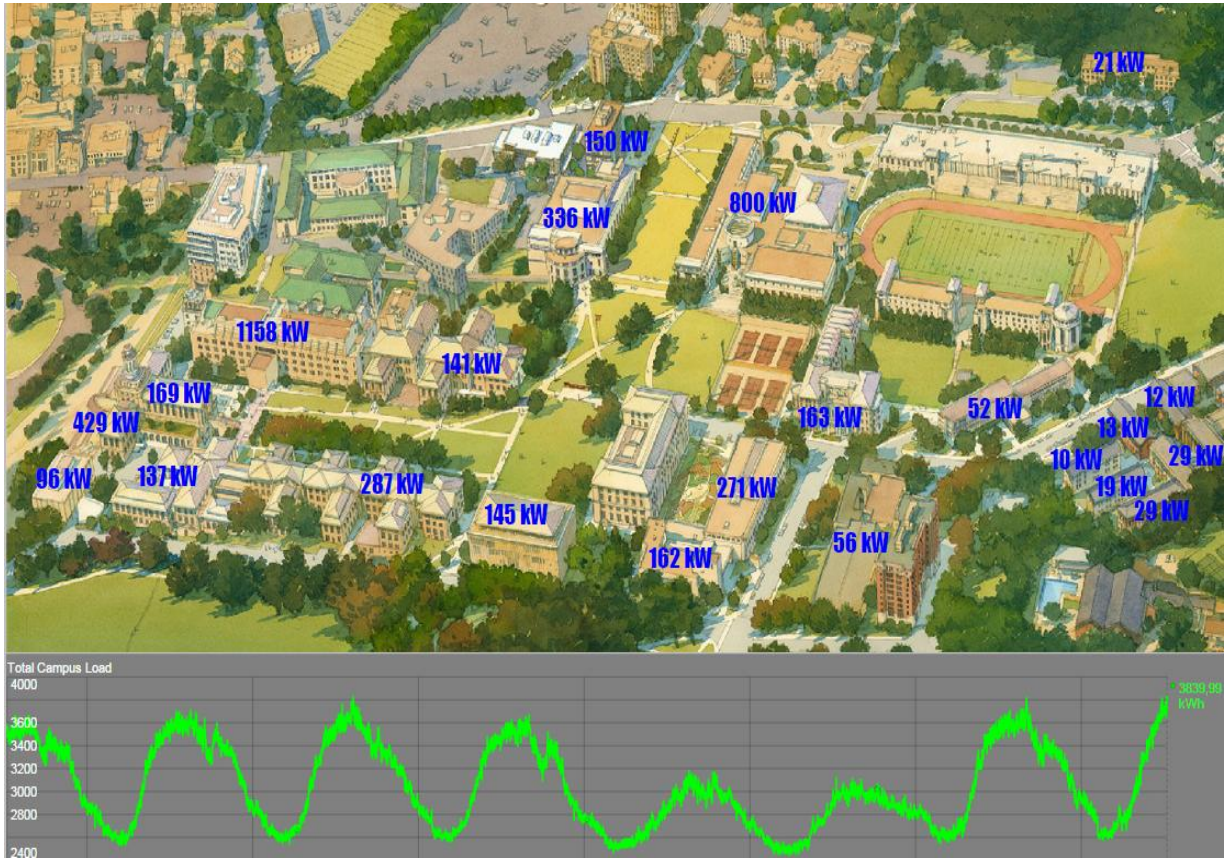


OSIsoft World HQ
San Leandro, CA

Future PI Vision Displays



Campus Wide Load Prediction



Moving Forward

- Help prepare the RMC for managing PI themselves after we graduate
- Will introduce some virtual models to generate data to aid in predictive maintenance.
- Plan to use PI OLEDB to create work orders for Facilities Services in their CMMS Archibus.

STUDENTS and PI

How are students learning the PI system at the University and applying it?

Students are using OSIsoft's self-guided training programs. Specifically, they are configuring a Simple PI System, Visualizing PI System Data with PI Vision, PI System Administration for IT Professionals, and Building PI System Assets and Analytics with AF.

The students are applying this knowledge at the University by using Facilities Services Data as an example of the potential of PI.

Why is it important to engage with industry for academic research and RCM activities?

Engaging with industry for academic research and RCM activities is a mutually beneficial relationship. **Industry is getting help with their real problems, the academics are getting access to real world data and issues** that can be hard to duplicate in a lab whether it be due to cost or run time.

Why is working with industry important for student education?

Student are more than likely going to move into industry after they graduate. Therefore, it is important to get them exposed to this environment as soon as possible. **The more exposure they have to industry environments and problems the more likely they are to succeed when they get into these real situations**. It is hard to prepare a student for everything they will face in the "real world" but exposing them to industry in their education can give them a base to build a successful career.

STUDENTS and PI

Value proposition in working with companies and OSIsoft

The value proposition for working with companies and OSIsoft is twofold. Most OSIsoft customers are not using PI to the fullest extent possible. By working with OSIsoft via student interns these companies are learning how to best improve their PI system to create more useful data for their company**. Often times it is hard to have PI admins and employees using PI improve PI past the bare bones whether it be to time or knowledge base.** By working with OSIsoft directly they're able to explain what they want to get out of PI to the interns while still running the PI system and maintaining day to day activities. **The interns are also able to relay capabilities of PI that the companies may not have known about or may not have thought about using in a specific way.**

What students are doing to learn the PI system/gaining experience to shape their future?

By actively learning and using PI students are preparing themselves to face real world problems. Whether these problems be in PI or managing data, the **students are learning the importance of data and how best to access it.** Using OSIsoft's self-guided training sessions the students are learning directly from the source how to best manage a PI system and system data all at the same time.

How is the PI system is helping transform the knowledge and capabilities of UT facilities?

PI provides a structure and availability to data that UT Facilities has been lacking. Data historians can be very expensive and with Facilities Services being so busy it can often times be hard for them to find the time to justify the cost of one.

All Involved are getting more knowledgeable on PI

Project Support Team

Facilities Services

1. Derek Bailey – Zone Maintenance STAR Team General Superintendent
2. Terry Ledford – Zone Maintenance Director
3. Steve Costner – Utilities Service Senior Control Specialist
4. Tommy Oakley – Utilities Service Steam Plant Superintendent
5. Steve Kopp – Steam Plant Electronic Specialist III

Office of Information Technology

1. Alex Trowbridge – IT Administrator II, Windows Systems Group
2. Larry Jennings – IT Associate Chief Information Officer
3. Kevin Frye – IT Manger, Windows Systems Group
4. Gerald Derthick, Jr. – IT System Administrator III, Database Administrator
5. Eric Travis – IT Administrator II

Project Sponsor Team

Reliability and Maintainability Center

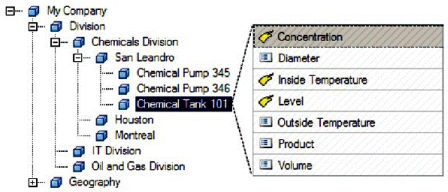
1. Kim Kallstrom – Assistant Director of the UTK Reliability and Maintainability Center
2. Javad Seif – UTK Reliability and Maintainability Center Lab Coordinator

OSIsoft Mentors

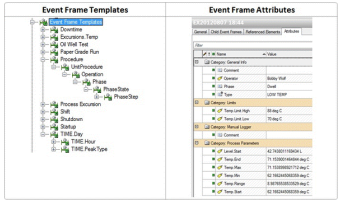
1. Mike Mihuc – Market Principal - Academic Programs
2. James Owens – Product Support Engineer II
3. Javin Spann – Product Support Engineer II
4. Caleb Steiner – Product Support Engineer II
5. Erica Trump – Program Manager, Academic Learning

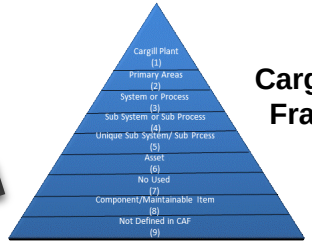
OSI PI Enabling Cargill *Condition Based Maintenance*

OSI Pi Asset Framework and Templates

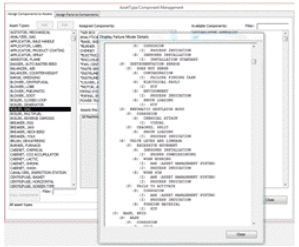


OSI Pi Event Frames Templates





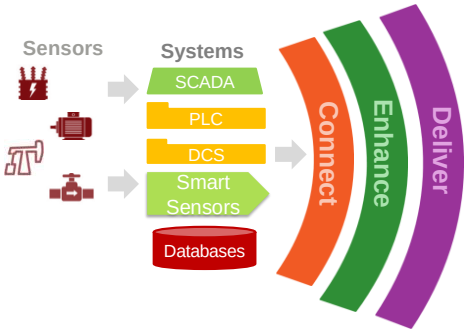
Cargill Asset Framework



Cargill AHM FMEACA

Visualization

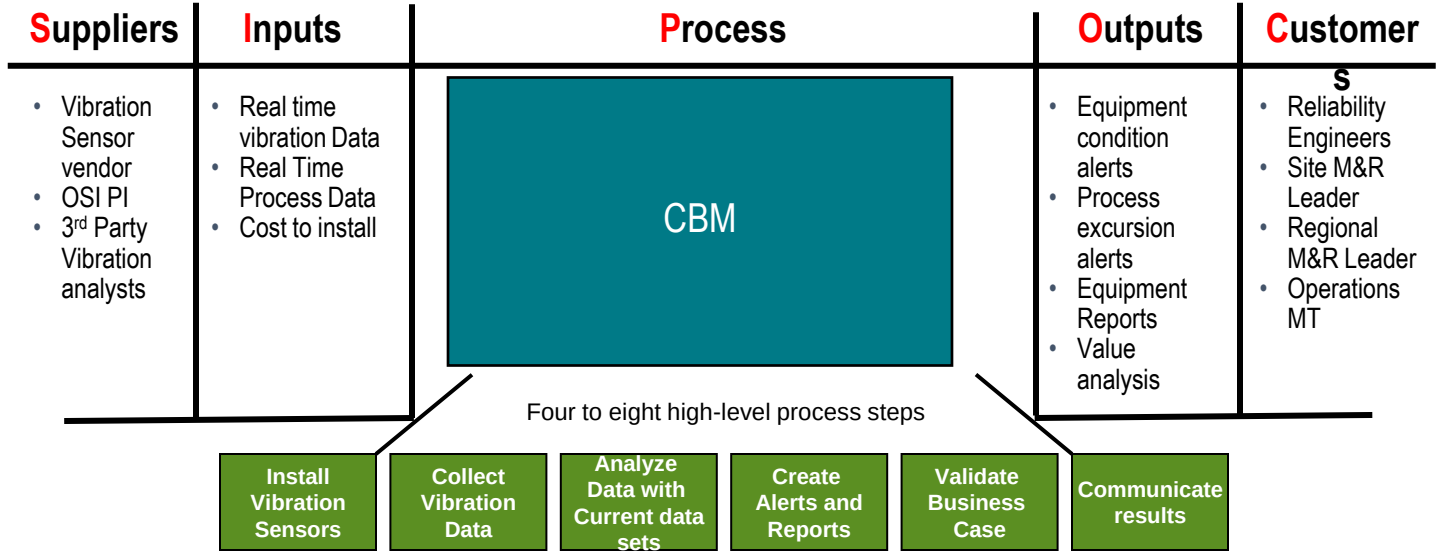
Condition Based Maintenance
Vertical Centrifuge



It's a losing gamble in operating a centrifuge by just pressing "Start" and leave unattended until the next scheduled "tear down"

Challenge	Proposed Solution	Targeted Results
• Running a centrifuge with unbalanced load or condition could permanently damage the centrifuge. It could cause injury and/or property damage. • Repeated cyclical stretching and relaxation changes the metal's microstructure which can result in cracks and eventual failure • Calendar based "Minor" and "Major" intervention not as effective in addressing random nature of failure modes and patterns	• Combine sensor on-condition asset component data with instrumentation process indication data • Combined data to targeted Pi-AF FMEA templates captured with Pi Event Frames • Captured data of interest to algorithms and visualization	• Avoidance of violent movement of the unit itself causing injury or damage to equipment; and flying shrapnel causing personal injury or facility damage • Intervention through conditional data instead of periodic expensive and intrusive recondition and rebuilds • Cost Optimization in early detection and elimination of defects prior collateral damage • Predictability of machine output and performance

SIPOC for "Condition Based Maintenance"



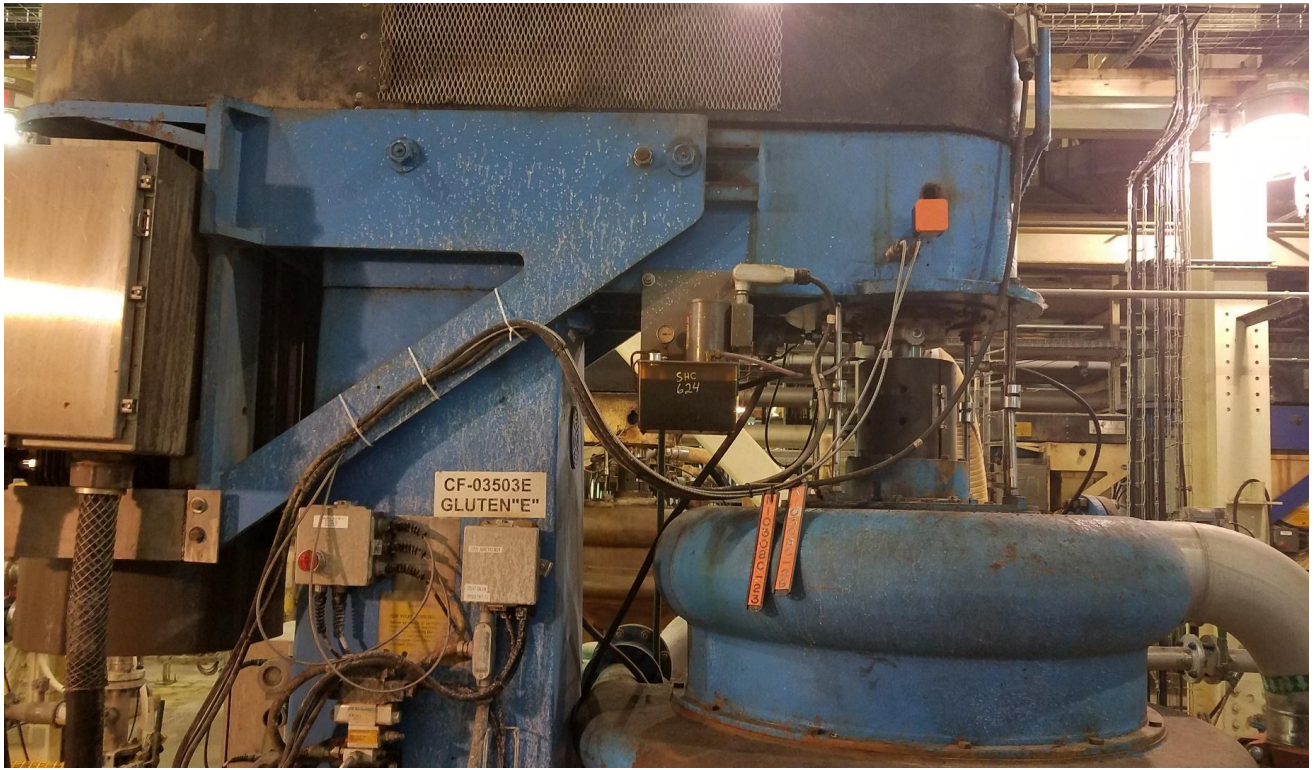
Metrics

- Equipment alarm values
- Cost of sensors and installation

- Near Real time Vibration Data
- Real time process data

- Equipment Alerts
- Equipment Status reports
- Process Status alerts
- Cost per point to scale-up to large facility

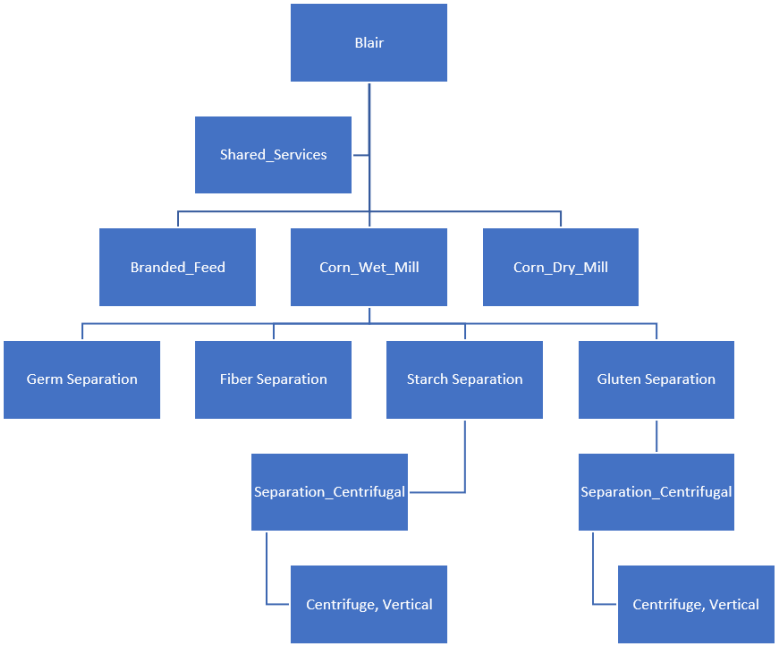
Vertical Centrifuge (separates gluten and starch in corn)



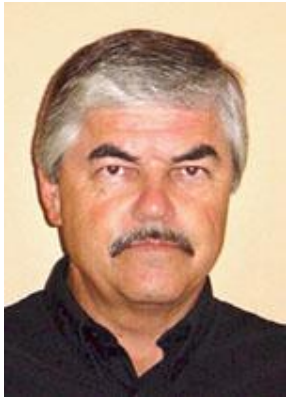
Failure Mode Data Identification Templatizing

- The Asset Health Matrix (AHM) tool was constructed from various Failure Mode and Effects Analyses (FMEA's) to understand how/why a failure occurs
- Develop Cargill Asset Framework (CAF) model to create template for equipment type similar to ISO 14224 model
- Collect data related to the predominant failure mode indicators
- Apply vibration, oil, power consumption data analysis to correct templates accordingly and apply predictive maintenance strategies
- Develop a control station to perform predictive analytics, diagnose issues, and to define envelopes of normal operation for multiple locations
- Expand template to encompass more of our operations with start to finish process templatization in mind

Failure Mode Data Identification Templatizing – CAF



PI System – From Education To Application



Dr. Klaus Blache
Director - Reliability & Maintainability Center (RMC)
and Professor
University of Tennessee Knoxville
kblache@utk.edu

Rick Baldridge
Corporate Reliability Excellence Leader
Cargill
rick_baldridge@cargill.com

Questions?

Please wait for the **microphone**

State your **name & company**

Please remember