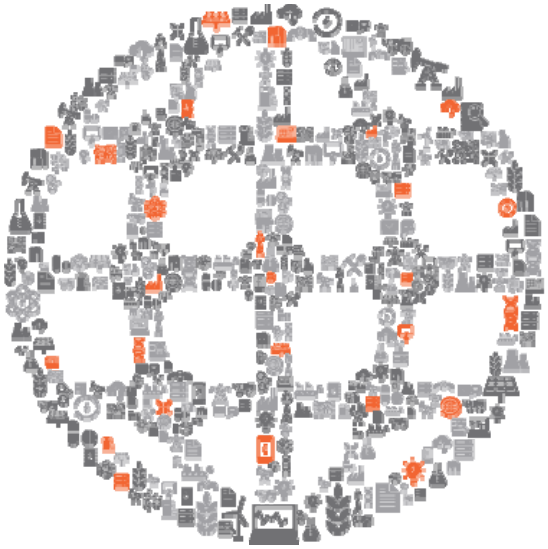


OSIsoft.

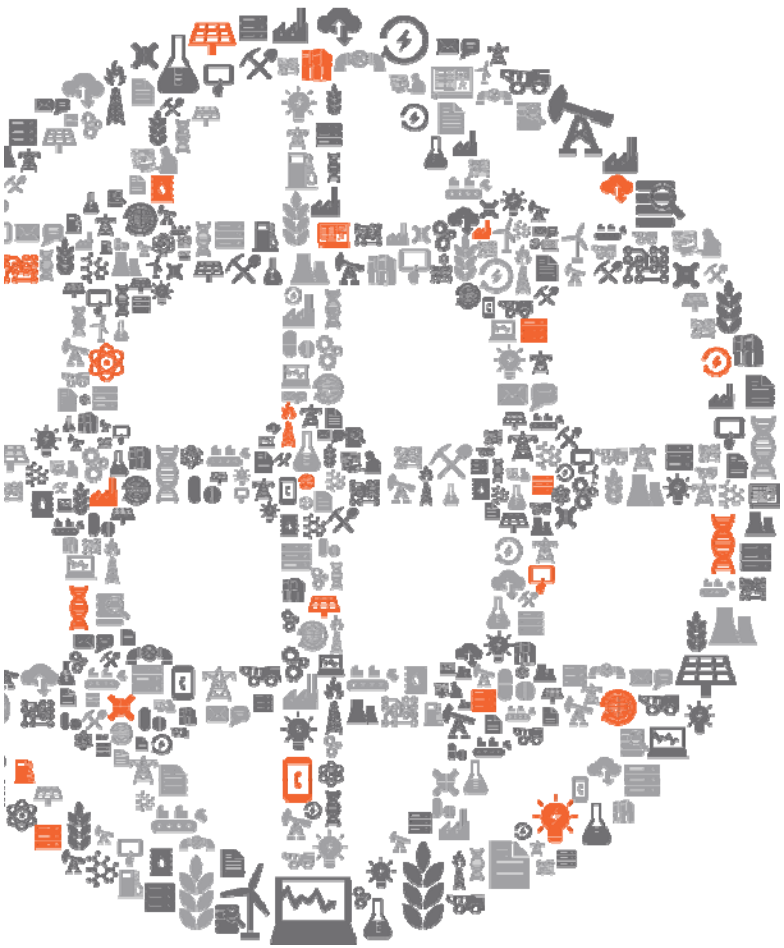
REGIONAL SEMINARS

The Power of Data

THRIVING IN A WORLD OF CHANGE

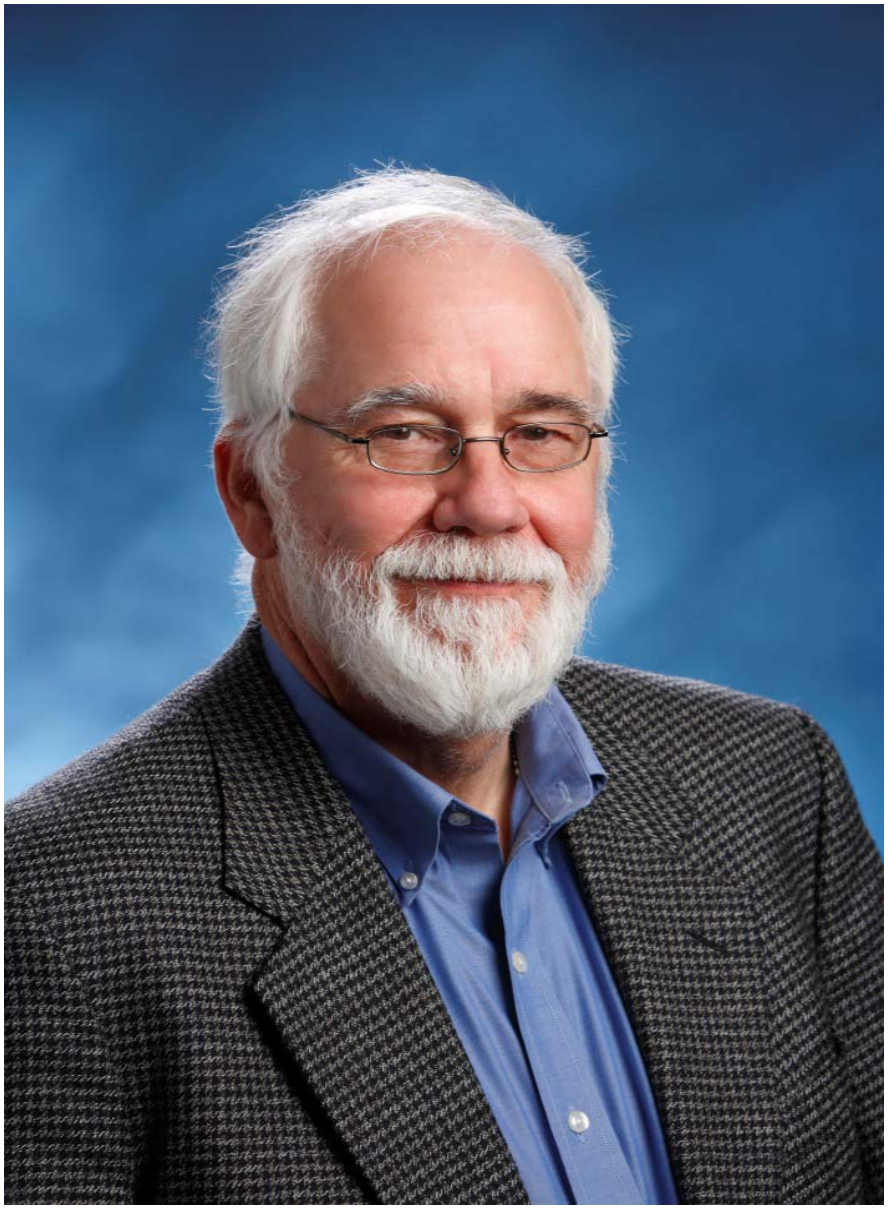
I N D I A

August 22 - 23, 2013
Mumbai, India



Power Generation Condition-based (SMART) Maintenance Update

Presented by **Chris Crosby**
Power Generation Industry Principal
23rd August, 2013



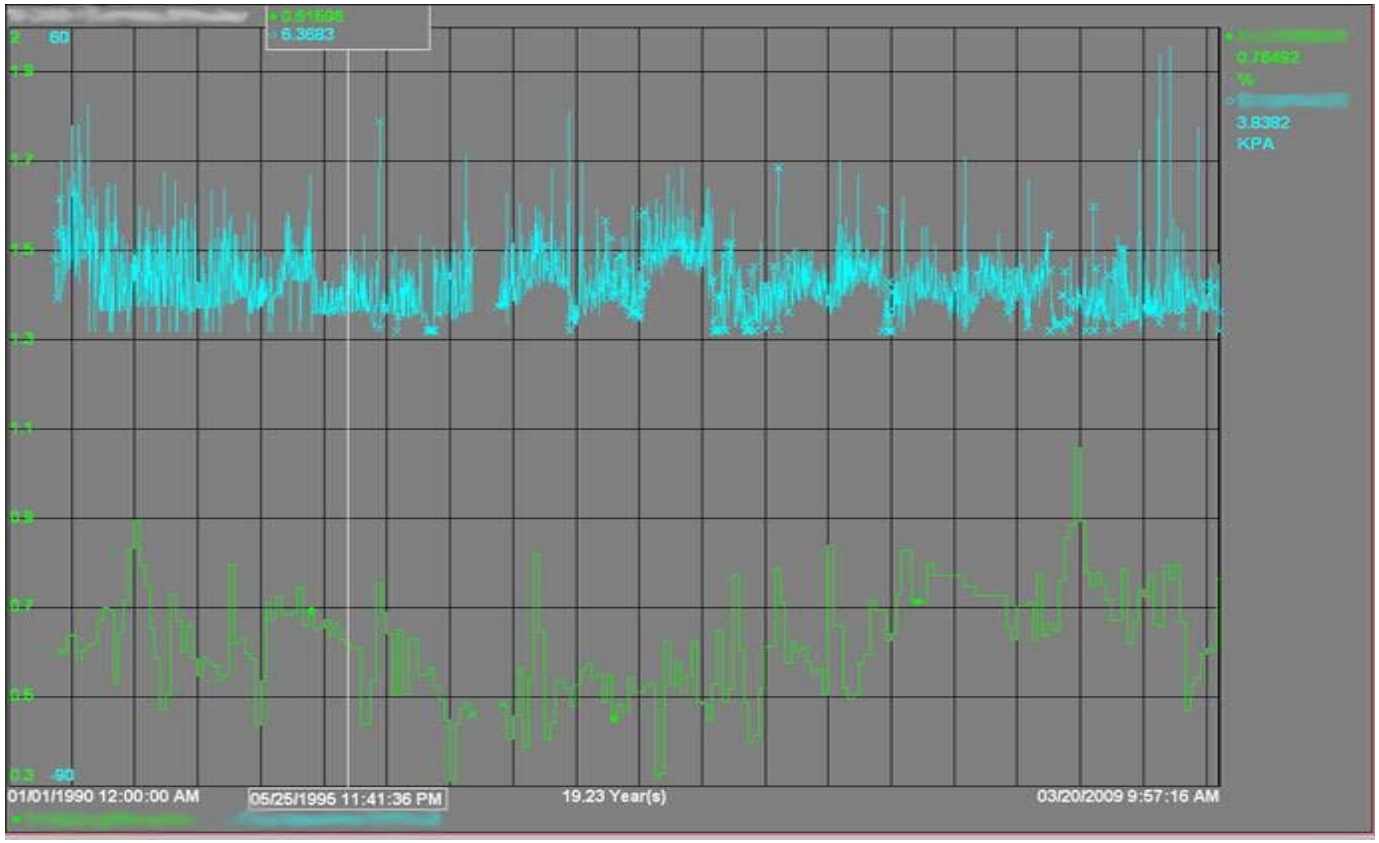
"Our mission is to maximize the VALUE our customers get from our product and services."

Dr. Patrick Kennedy

"OSIsoft and the PI System exist to make you smarter, enabling better decisions."

Interesting Statistics…Customer 104, Abitibi Paper: 19 years of continuous data; tag history preserved through 4 control systems and 8 operating systems

"Ninety four of OSIsoft's first one hundred customers that are still in business today are still using PI."



"17 of the first 20 installations of PI software in manufacturing facilities are still current on support and running today!"

"Through all of the 33+ years of technology change, customers who purchased PI have been able to keep all of their PI Archive data through HP, VMS, UNIX, NT and Windows 8 – and soon cloud. Not once have they had to repurchase the software that housed their data and not once have they lost data due to system changes that did not include a seamless migration forward."

Chris Crosby
Power Generation Industry Principal

- Humanitarian
- Energy Scientist
- Technologist

The Humanitarian View

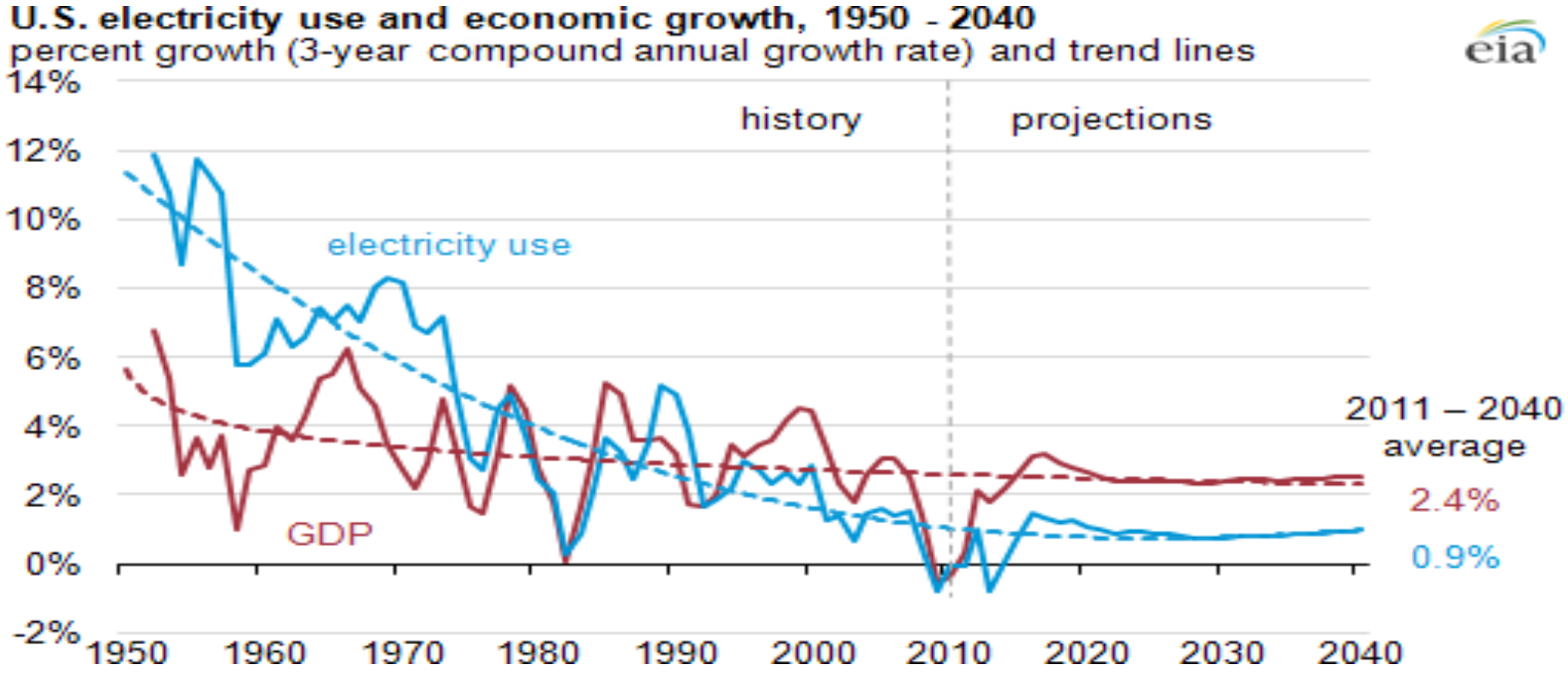
"*Household electricity consumption is widely viewed and accepted as providing substantial standard of living (quality of life) gains.*

by

Roselyne Joyeux and Ronald D. Ripple in *The Evaluation of Standard of Living and the Role of Household Electricity Consumption*

The Economic View

"A country's economy and its energy use, particularly electricity use, are linked. Short-term changes in electricity use are often positively correlated with changes in economic output (measured by gross domestic product (GDP))." US Energy Information Agency



Nuclear Power - The Safety View

"*We need to work together--both domestically and internationally--to reduce the potential for another accident…I believe industry should consider international cooperation and essential component of ensuring nuclear safety*."

by

Allison Macfarlane, NRC Chairman

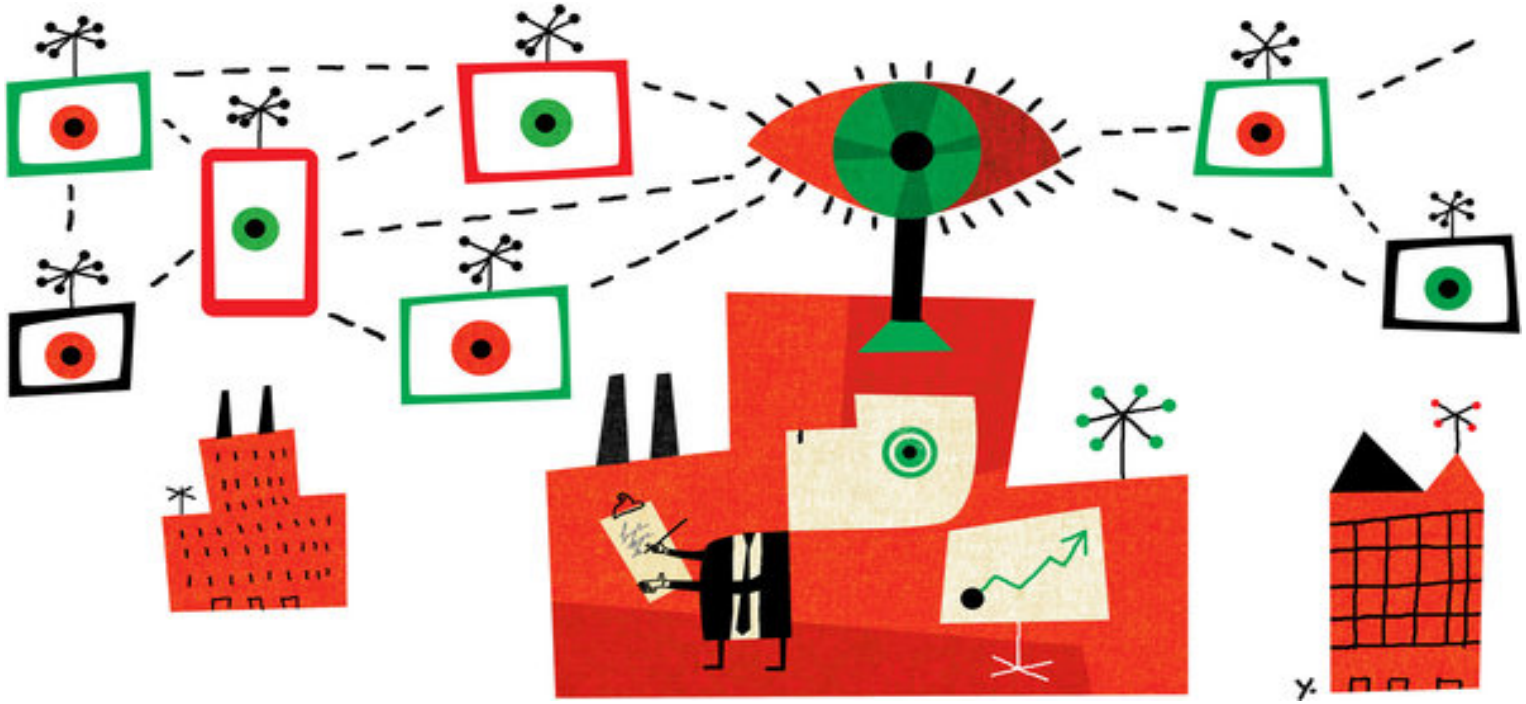
Why Should You Care?

"In this background, people who have decades of experience in project execution and technology experts who can increase the efficiency of the plants to deliver the highest (utilization)…are in high demand for the key positions."

- Essar Power is expanding its capacity…
- Monnet Power Company commissioning 535MW power plant next month…
- Jindal Power Ltd. is strengthening its team…

Reghu Balakrishnan, *Business Standard*, 21st August

No Such Thing as Too Much Information



“Data Driven Decision Making Results in a Net Gain of 5 to 6 % on Output and Productivity.”

Reference: Brynfjolfsson, et al., MIT, How does Data-Driven Decision making Affect Firm Performance, 2011.
http://www.nytimes.com/2011/04/24/business/24unboxed.html

PI System Overview

Highly scalable and secure real-time event infrastructure that connects people and systems with the right operational information at the right time — in order to **analyze, collaborate,** and **make smart decisions.**

Asset Health – The Big Opportunity - RAM

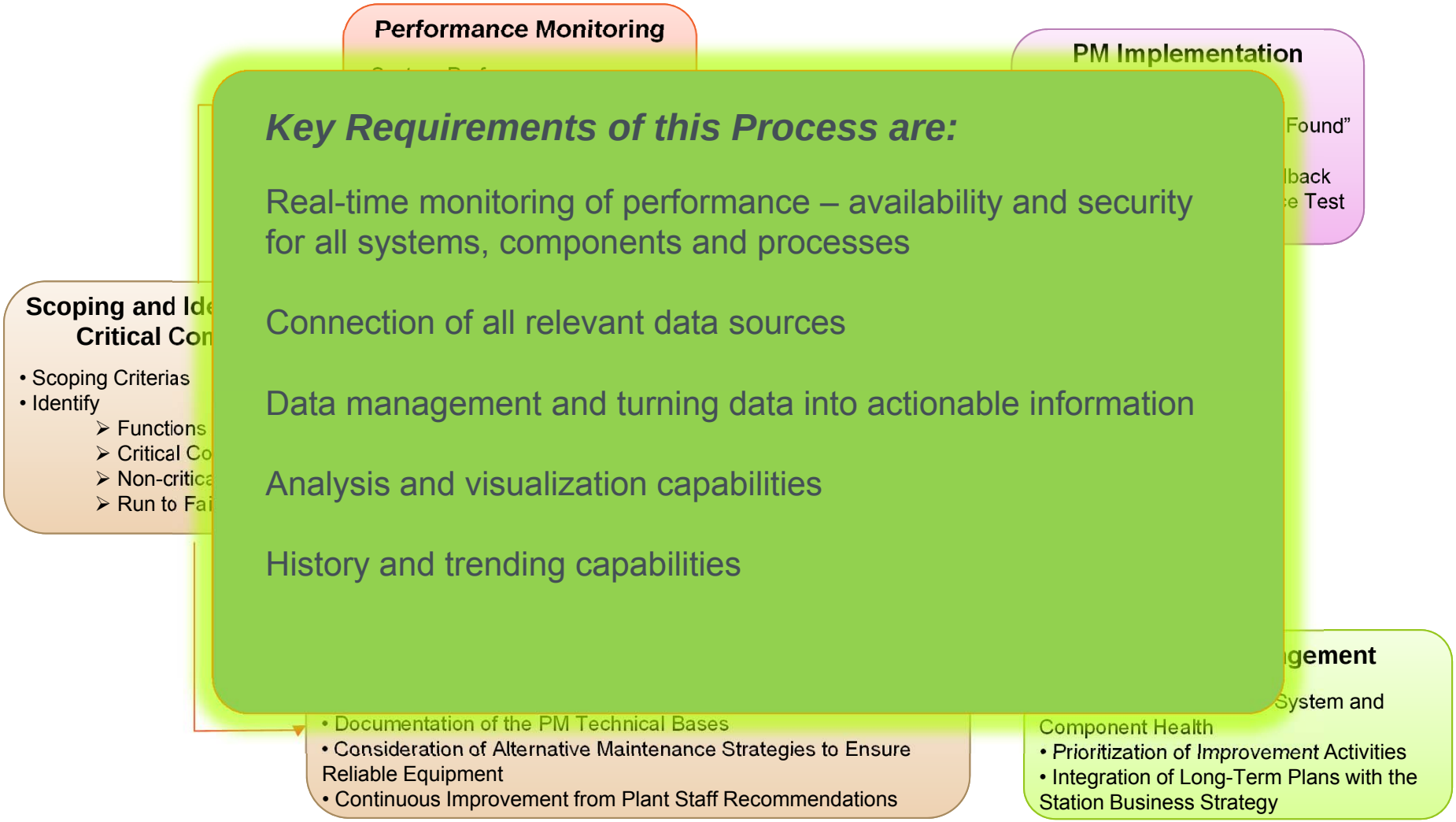
Nuclear Specific Driver - Equipment/Asset Reliability…

- *Cornerstone* of Operational and Reliability Excellence in NPPs
- Critical for NPP Life Extension and *License Renewal*
- Heavily *regulated* by international standards (10CFR50.65)
- INPO AP-913 (Equipment Reliability Process Description) *endorses* 10CFR50.65
- Requires Real-time Data

Nuclear Specific Driver - Equipment/Asset Reliability…

- NEI "Standard Nuclear Performance Model"
- INPO AP-928 "Work Control Process Description"
- INPO 01-004 "Achieving High Equipment Reliability – A Leadership Perspective".

INPO AP-913 Business Process



Technology Trends Meet CBM

With a combined view of asset availability and other operational constraints, workers can make **information-driven decisions**.

…it appears that utilization of **predictive modeling** as a predictive maintenance technology is not yet mainstream.

Ideally, all solutions should be connected in real time.

help drive appropriate workforce actions.

Condition-based maintenance (CBM) is a methodology that combines predictive and preventive maintenance with **real-time monitoring**.

ARC Insights (ARC and Plant Services), June 28, 2012

Technology Trends Meet CBM

With increased data throughput and higher data resolutions, historians have evolved to become a tool for managing plant assets thanks in part to **new visibility and trending tools**.

Today's historians also support techniques, such as **complex event processing**, which can analyze multiple streams of plant data in real time to identify and diagnose emerging problems **before they can disrupt production**.

Remote access to historian data via the Web enables central management of assets, whether within a single plant or across multiple plants.

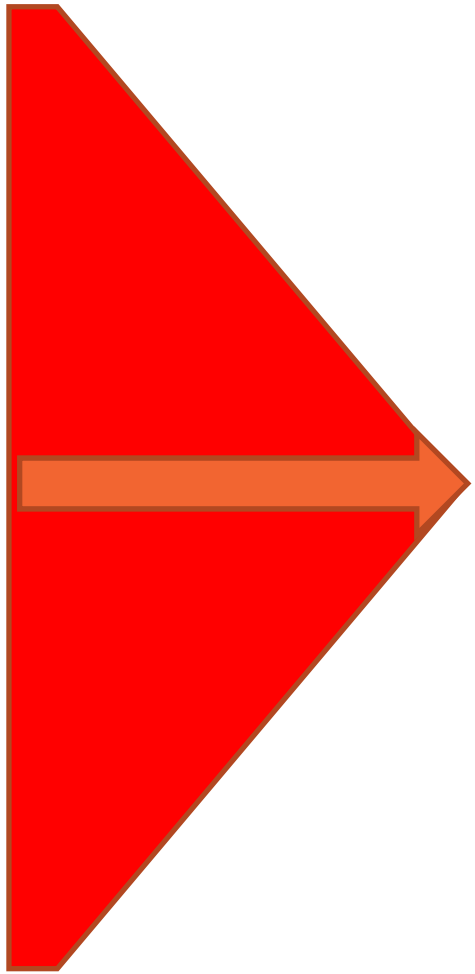
ARC Recommends…

Invest in predictive maintenance solutions with **real-time analytics functionality** that provide the ability to **perform dynamic or real-time calculations** and to **compare current and historical data.**

ARC Insights (ARC and Plant Services), June 28, 2012

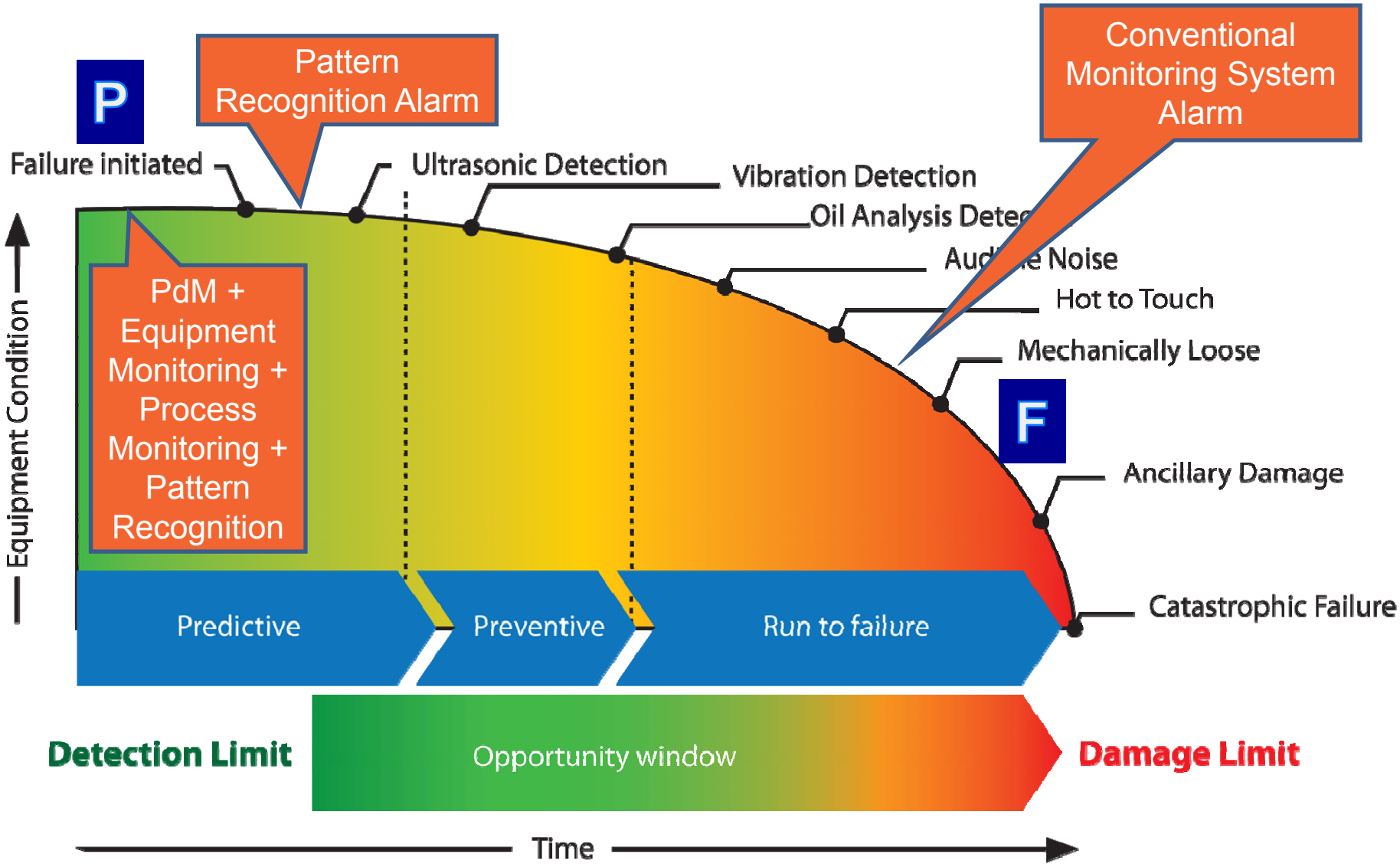
Technology Trends

- Digitalization
- Sensors costs dropping
- Wireless more secure
- Historian evolution
  - Asset perspective
  - Complex event streaming
  - Multiple data types
  - Thick and thin client visualization tools
- Interfacing made easy and standard
- OT to IT T integration
- Advanced pattern recognition



Lower cost & time saving methods to improve equipment reliability!

P - F Curve



Differences from Preventive Maintenance

Preventive Maintenance: The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection, and correction of incipient failures either before they occur or before they develop into major defects.

Two Subgroups:

1. Planned (time-based)
2. Conditioned-based

Wikipedia

The difference between Preventive and Predictive Maintenance is that Preventive Maintenance tasks are completed when the machines are shut down and Predictive Maintenance activities are carried out as the machines are running in their normal production modes.

Ken Staller, Senior Maintenance Consultant

Differences from Predictive Maintenance

Predictive maintenance involves applying condition-based monitoring techniques to collect and analyze asset data to better understand asset performance and perform appropriate maintenance before impending issues can negatively impact plant performance, availability or safety.

- Experts estimate that the global process industries lose $20 billion due to unscheduled downtime and poor quality
- 87 percent of the survey respondents indicated that improving uptime was the primary driver for deploying predictive management

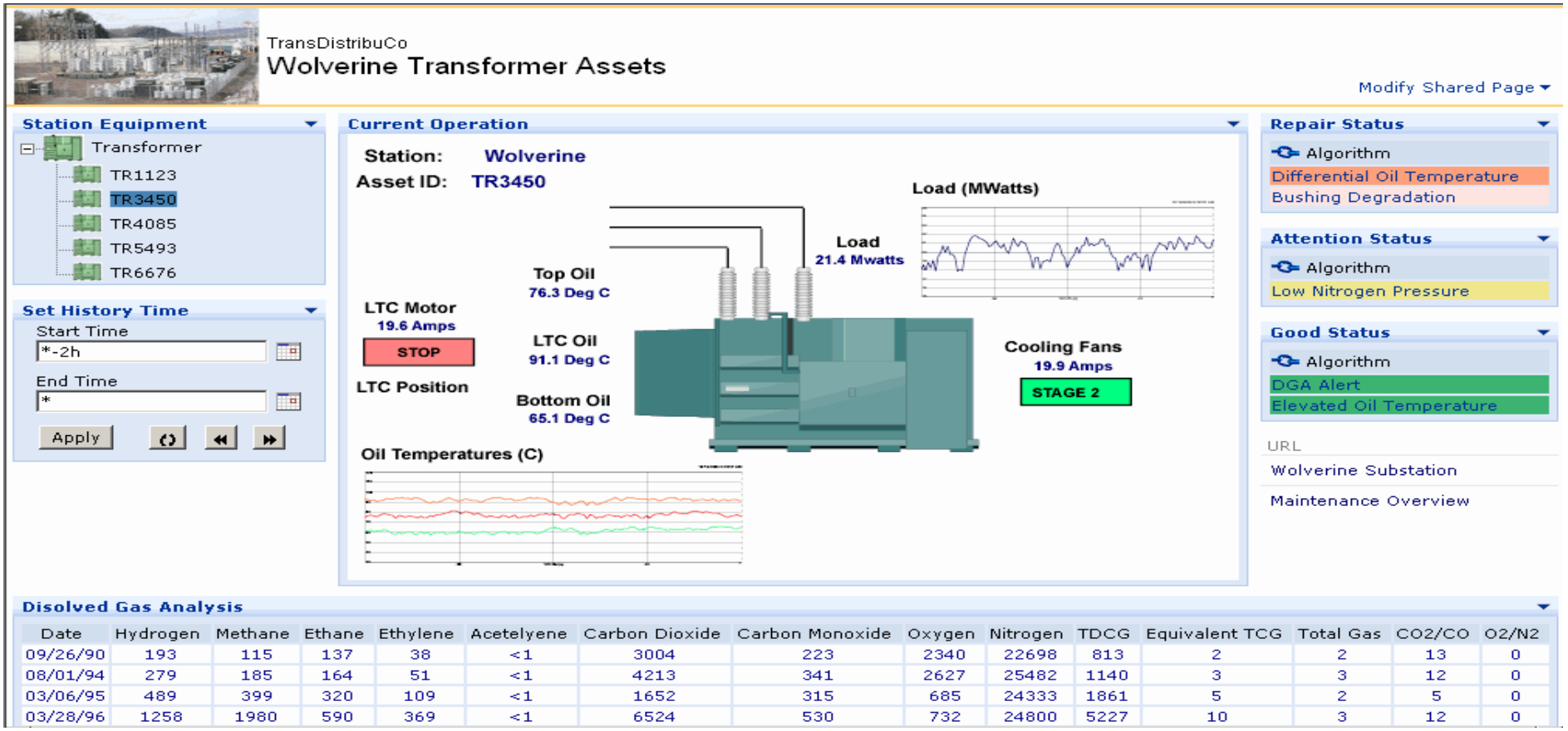
ARC Insights (ARC and Plant Services), June 28, 2012

Link to Asset Health

Condition monitoring provides the data (real-time equipment, real-time process, results from predictive) to feed condition algorithms residing in asset health applications – in either the CMMS, EAM system or in a separate application.

Condition monitoring enables asset health determinations to be dynamic and holistic; **asset health systems have the potential to predict remaining asset life, in real-time**.

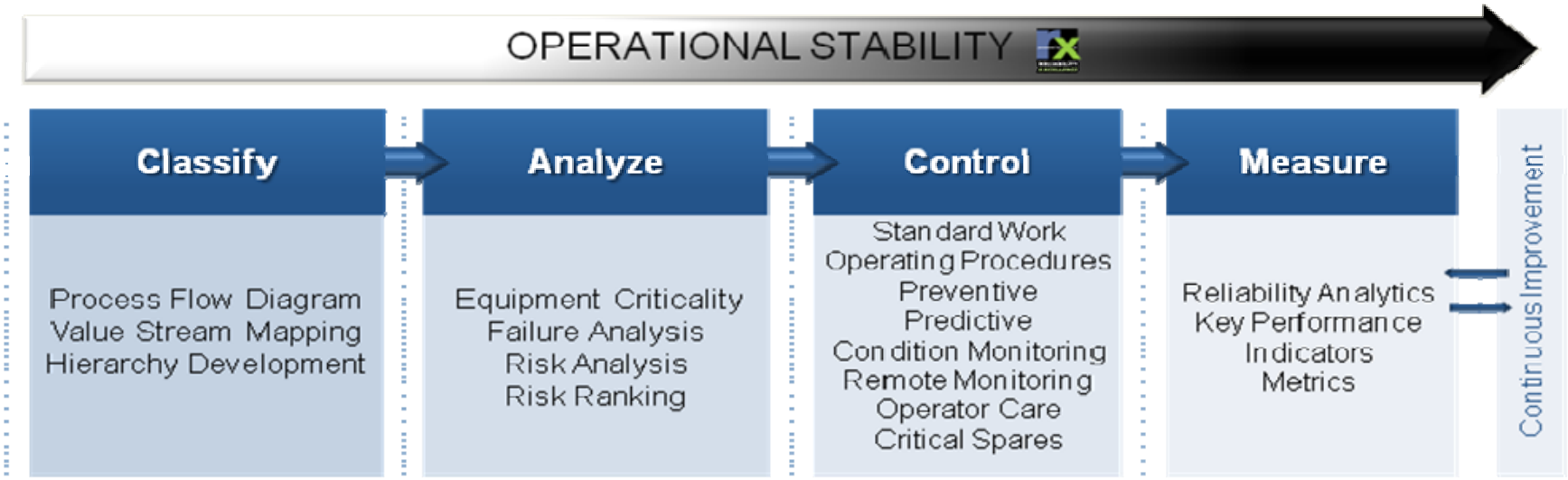
CBM - Asset Detail



Date	Hydrogen	Methane	Ethane	Ethylene	Acetelyene	Carbon Dioxide	Carbon Monoxide	Oxygen	Nitrogen	TDCG	Equivalent TCG	Total Gas	CO2/CO	O2/N2
09/26/90	193	115	137	38	<1	3004	223	2340	22698	813	2	2	13	0
08/01/94	279	185	164	51	<1	4213	341	2627	25482	1140	3	3	12	0
03/06/95	489	399	320	109	<1	1652	315	685	24333	1861	5	2	5	0
03/28/96	1258	1980	590	369	<1	6524	530	732	24800	5227	10	3	12	0

The Asset Detail shows the current operation and alert status of each maintenance algorithm used to assess the asset's condition. Note that the graphic displays all the key operating variables that contribute to the asset's maintenance health assessment.

Link to Risk-based Asset Management (RBAM)



LCE's Risk-based Asset Management Model

Now more than ever, our reliability and operations professionals must join with our information technology professionals to ensure the linkages of our data entry, storage and reporting are consistent and well-defined, from pumps and compressors, to programmable logic controllers, to the distributed control system, to our process intelligence, then to our enterprise asset management system…and finally all the way up to the general ledgers and balance sheets managed within our enterprise resource planning application.

Credit Life Cycle Engineering

“PI and PI AF Systems: A Dynamic Solution for Maintenance Management” by: Nicolas Di Gaetano, ing. Project IMAGINE – Hydro Quebec

Abstract: With over 500 substations and 33,600 km of high-voltage lines, Hydro-Québec's transmission system is one of the most extensive in North America. To meet the

The IMAGINE project (automated maintenance and remote monitoring data management) aims to automate the collection, analysis and archiving of equipment maintenance data from transformers, tap changers, relays, circuit breakers and disconnect switches. OSIsoft’s PI System technology…serves to analyze and archive automated maintenance data. Specifically, the PI AF model, which will include up to 60,000 intelligent electronic devices, will allow modeling of Hydro-Québec TransÉnergie's infrastructure.

include up to 60,000 intelligent electronic devices, will allow modelling of Hydro-Québec TransÉnergie's infrastructure. It will act as an integration layer for signals collected in its facilities and systems such as Maximo, aging analysis systems, database controls, etc. Hydro-Québec TransÉnergie's IMAGINE team will present the odyssey of the IMAGINE project and its advantages.

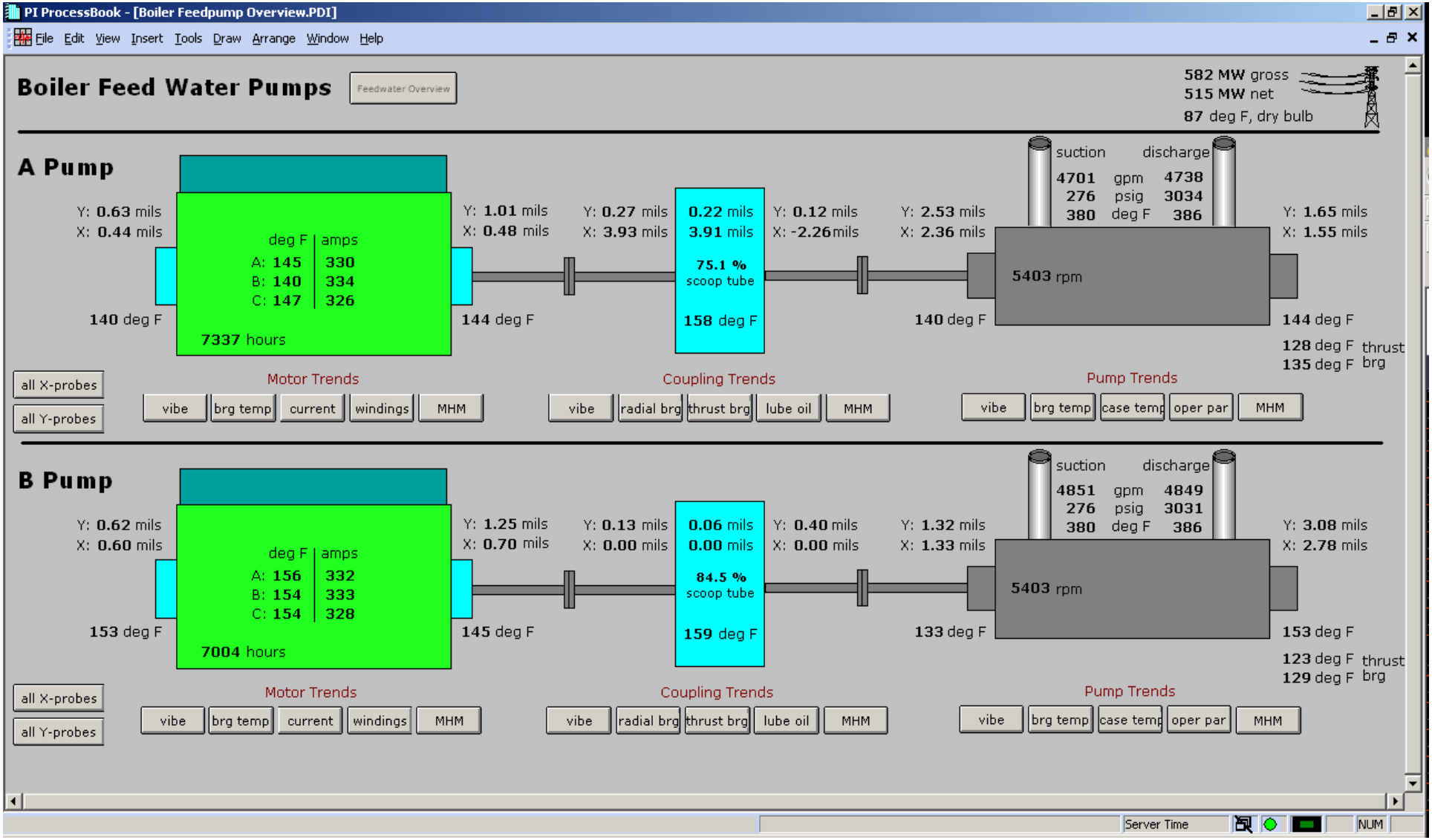
“Asset Management and Strategy for Operational Excellence and Grid Modernization” by: Richard Wernsing, Manager Electric Asset Strategy – Public Service Electric and Gas Company

Abstract: The calendar-based preventive maintenance & reactive corrective maintenance face challenges, i.e. no predictive maintenance strategy, significant liability risk and system outage potential from equipment failure, and limited assessment for determining asset condition and maintenance efficiency. PSE&G PI System-based CMMS (Computerized Maintenance Management System) brings together the existing and new technologies to address these challenges. This presentation will describe evolution of CMMS by correlating transmission and distribution SCADA data, substation

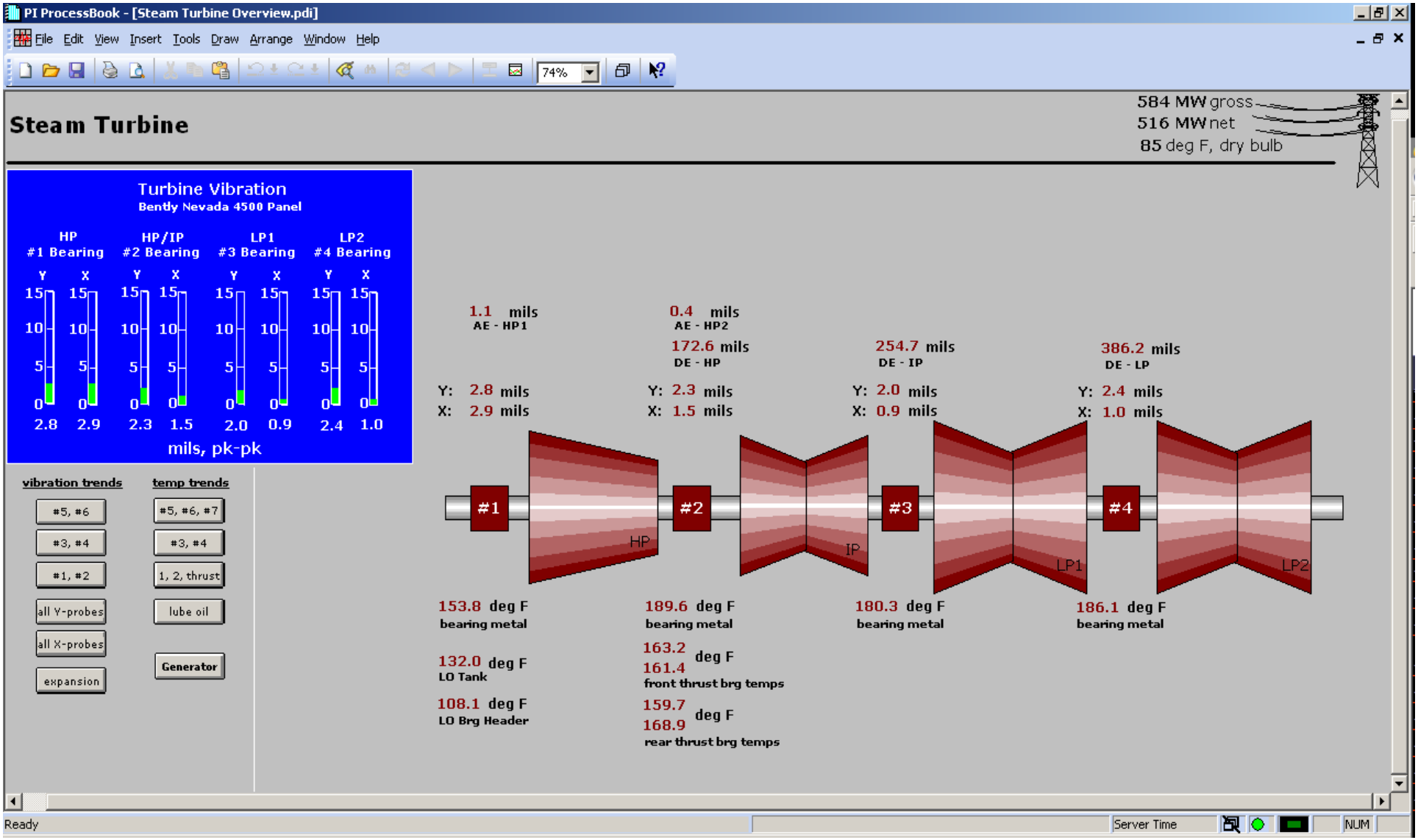
The CMMS provides the mechanism to shift maintenance activities from reactive to proactive through the use of multiple-method condition monitoring and analysis. It is a decision support system that assists repair/replace/maintain decisions. PSE&G was able to utilize the PI System analytics and visualization tools to transform the data into intelligence, and present it in a dashboard web portal form.

enterprise information center which enables concise decision making and is capable of automated work order generation. The system delivers the great results and cost savings, also improves the reliability, maintenance effectiveness and capital replacement strategy. CMMS achieves the corporate mission-to optimize the investment in assets while improving the overall system reliability of electric delivery, and the corporate vision-to perform the right maintenance at the right time based on the consistent analysis to ensure a safe, reliable, and cost effective approach. Based on CMMS, PSE&G now has launched grid modernization by utilizing the smart grid technologies to improve the distribution system and further deliver the operations excellence.

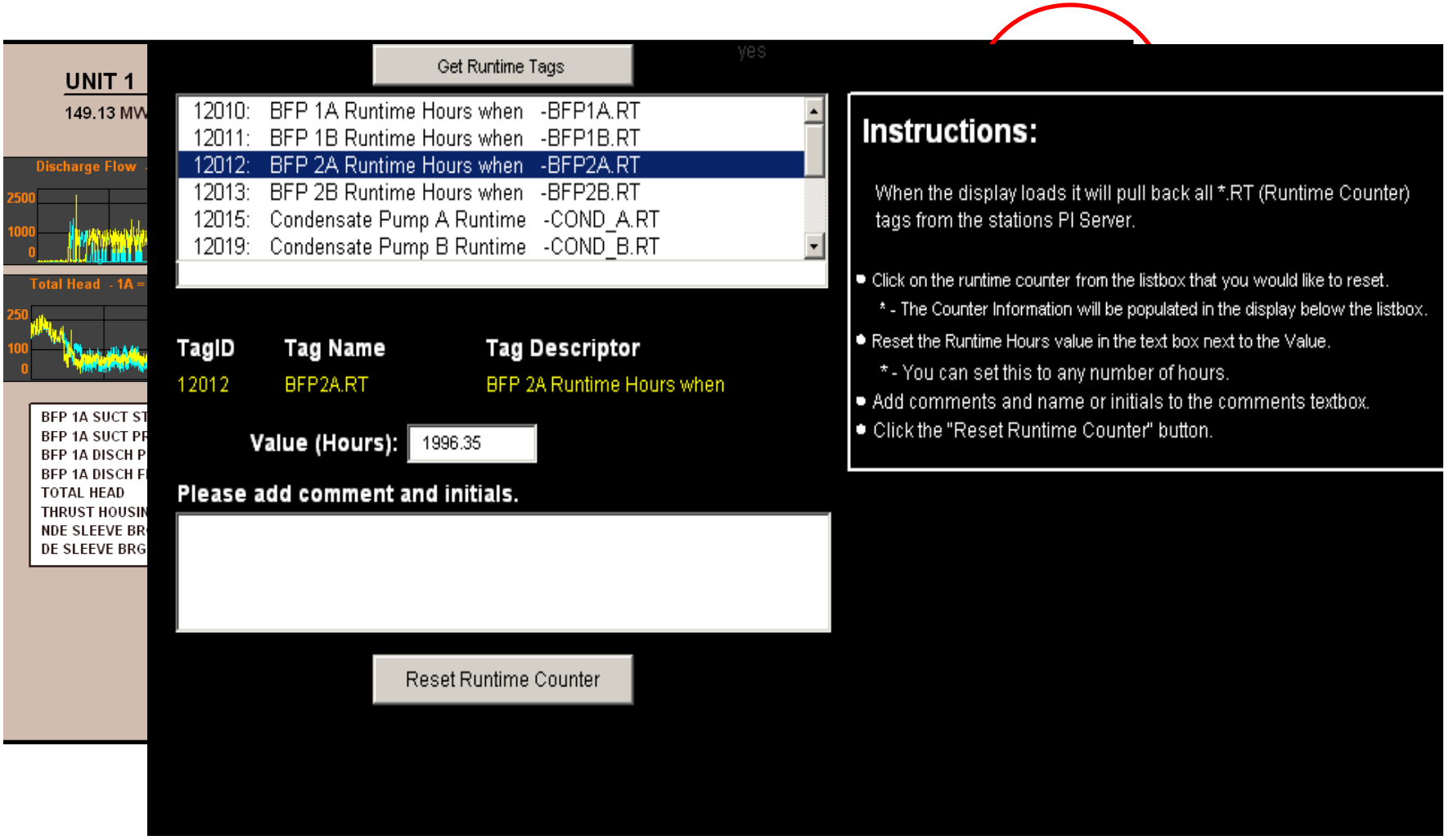
Proactive Maintenance Monitoring



Proactive Maintenance Monitoring



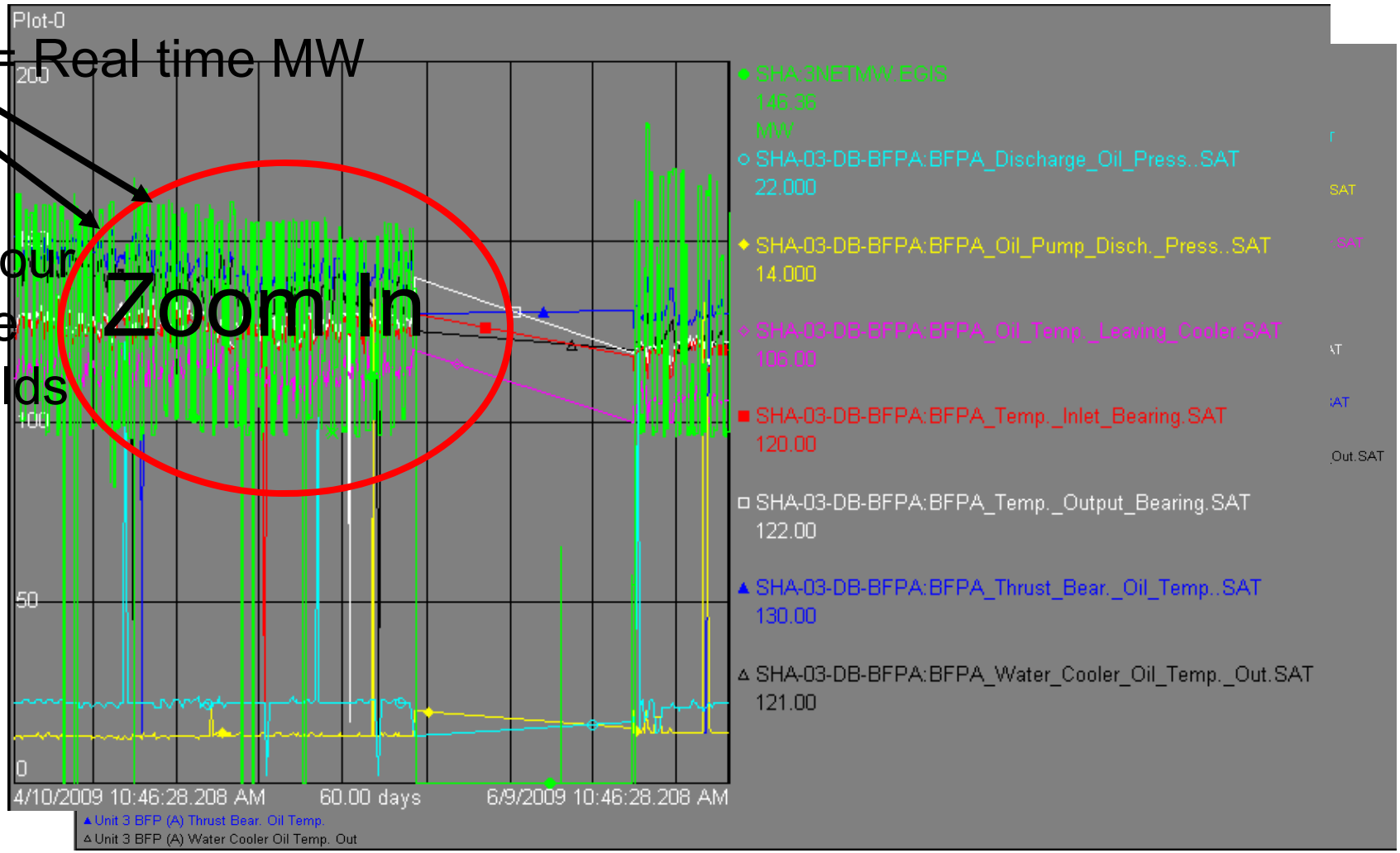
Condition Based Maintenance Screens



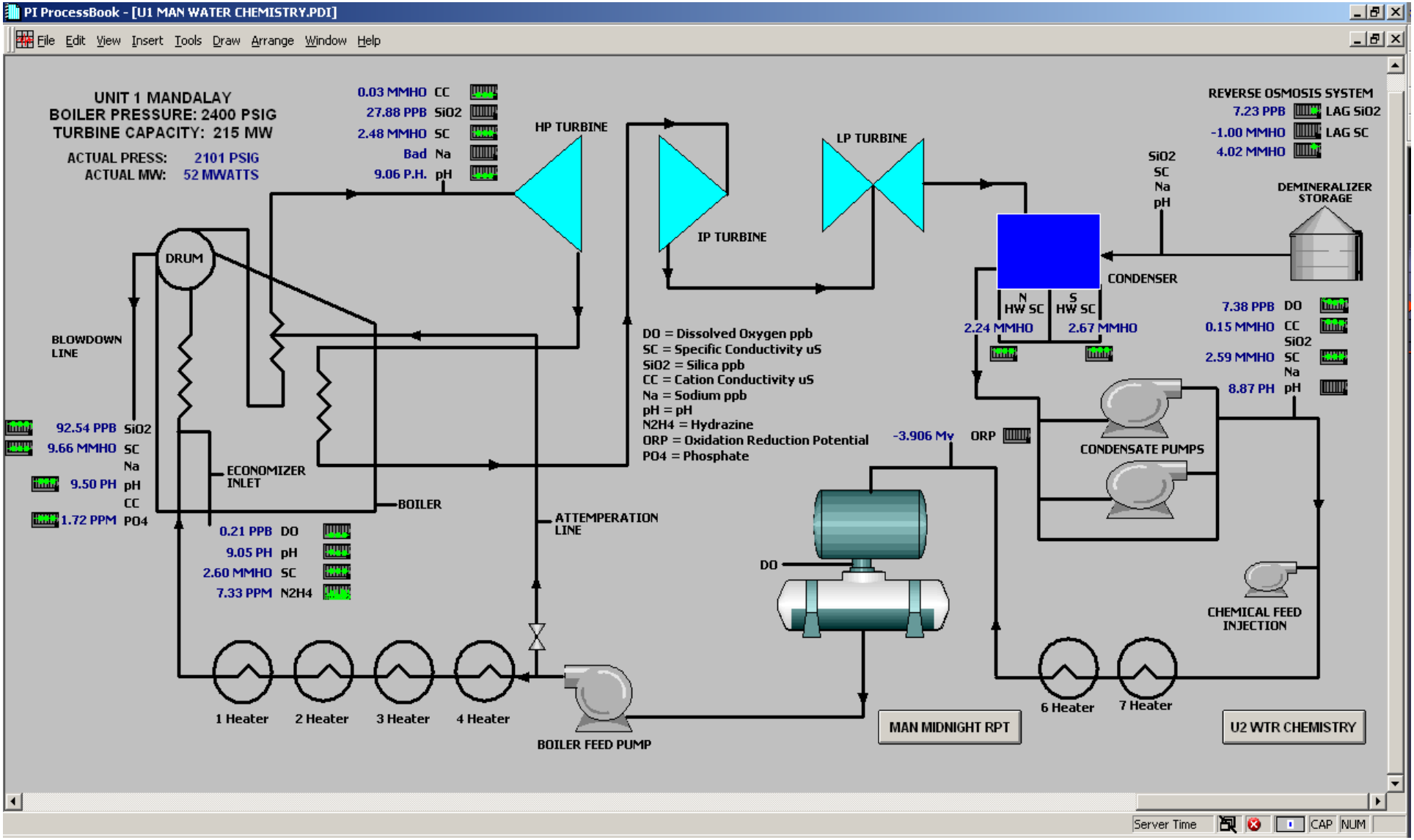
Manual Round Data Correlation

Green = Real time MW

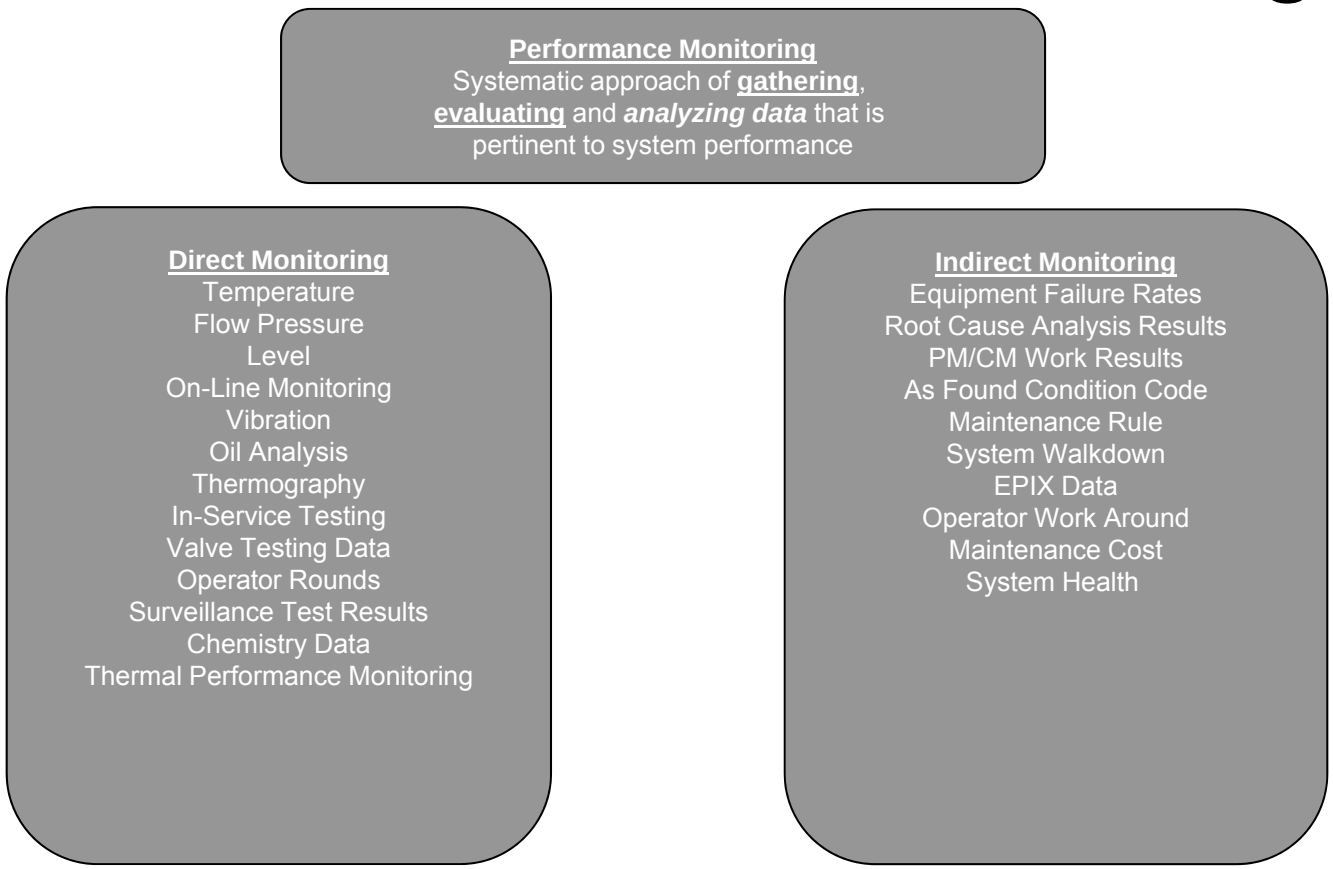
Data Taken every hour from the handhelds



Water Chemistry Displays



What is Performance Monitoring



- Plant experts spend too much time in Direct Monitoring …. Not enough time for diagnostics and analysis
- Direct Monitoring can be done automatically utilizing PI

Purpose

- Build Advanced Performance Monitoring (APM) infrastructure capable of significant advancement in system monitoring, diagnostics and prognostics capabilities
- Leverage technology for system and component monitoring and obtain critical plant data on-line
- Utilize critical plant resources for data analysis and diagnostics rather than data collection
- Utilize wireless infrastructure for equipment monitoring
- Optimize Exelon preventive maintenance (PM) strategy
- Operate nuclear plants sustainably protecting public safety and gain public trust

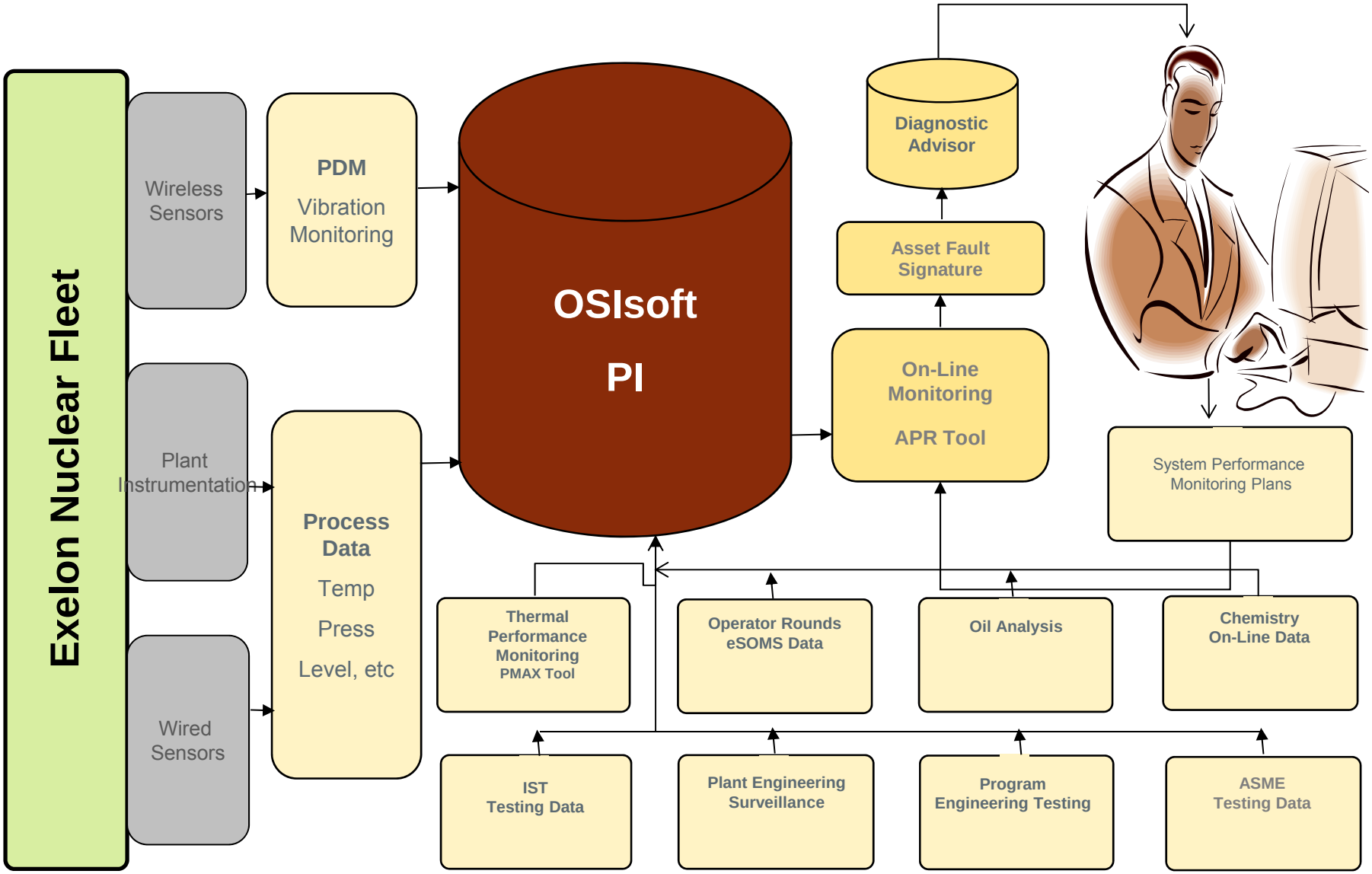
Drivers

- Valuable resources are spend in data collection … Suffers data analysis
  - Leverage technology for data collection
  - Need a cost effective smart remote monitoring system
- Lack of Subject Matter Experts
  - Experienced plant staff are retiring
  - New people joining organization takes time to build up skills
- Poor data fusion due to discrete databases
  - Data resides in separate databases
- Difficult to manage all Time Based PMs
  - Condition Based Monitoring is not effective due to lack of monitoring capabilities
- On-Line Monitoring is incomplete
  - Plants are not adequately equipped with wired sensors

Benefits

- **Engineering**
  - Approximately 10% system engineer's work load reduction by transferring engineering monitoring and trending function to On-Line Monitoring
  - Approximately 10% unexplained equipment failure reduction by increased monitoring capabilities
  - Approximately 1 Rem dose reduction since data will be available in On-Line monitoring tools
  - Better analysis since Chemistry data will be available in PI
- **Maintenance**
  - Approximately 60% vibration specialist work load reduction by eliminating vibration rounds through wireless monitoring
  - Approximately 5% PM reduction by switching time based PM to Condition based PM
  - Approximately 2 Rem dose reduction since vibration data will be available in PI
- **Operations**
  - Approximately 10% operator rounds reduction by aligning local panel data to data historians
  - Approximately 1 Rem dose reduction by eliminating rounds in high dose areas of plant

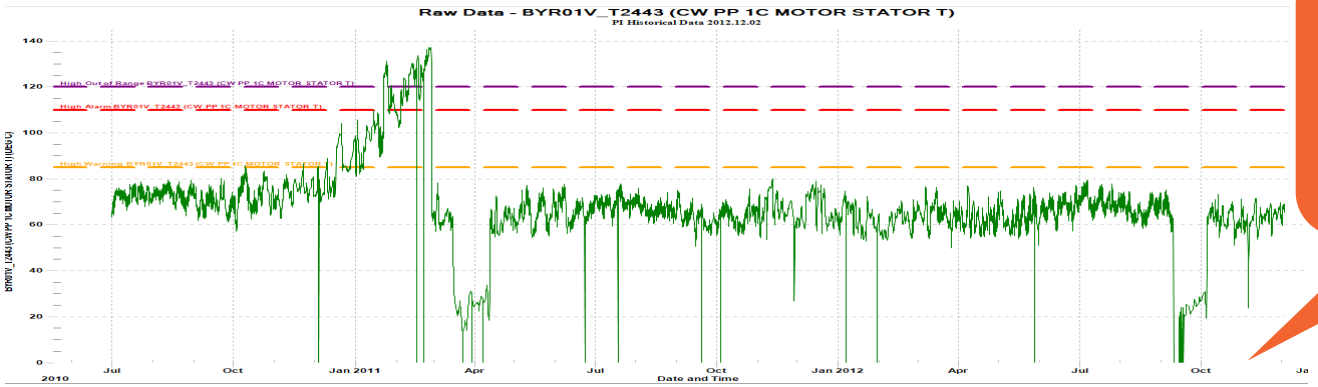
Advanced Performance Monitoring View



On-Line Monitoring (OLM)

- The OLM program is a pattern recognition application that monitors the plant parameters in real time
- The OLM program acquire the raw data from PI
- The program provides an early identification of degrading trends
- The real time plant data is continuously compared with historical good data
- Any deviation identified by the program is notified automatically to plant staff via email or pager
- The program is currently used by engineering, maintenance and operations

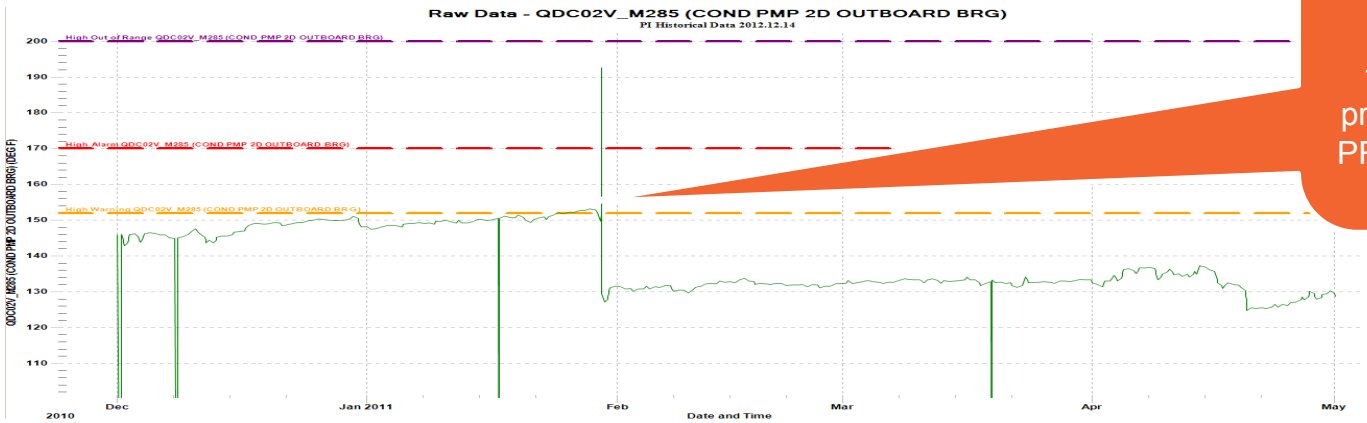
OLM Catches



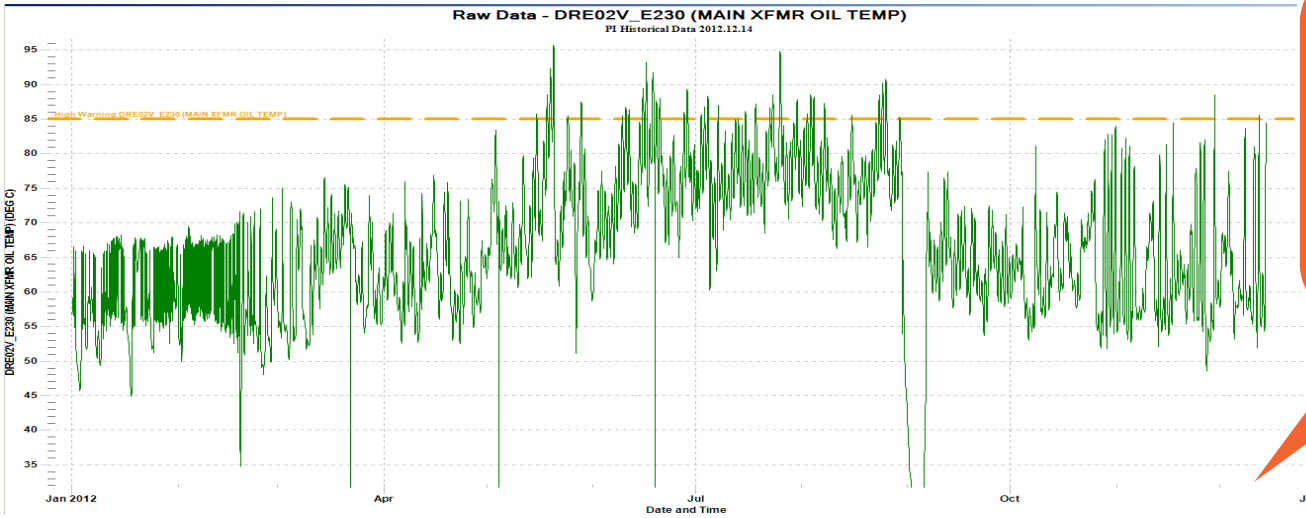
Program identified CW motor degradation at an incipient stage. PREVENTED UNIT DERATE

Program identified SG level control card failure. The early identification help operators to control level in manual. PREVENTED UNIT TRIP

OLM Catches



Program identified deviating condition of Condensate Pump outboard bearing temp. The mitigation help prevent bearing degradation. PREVENTED UNIT DERATE



Program identified plugged Main Transformer cooler before summer readiness period. PREVENTED UNIT DERATE

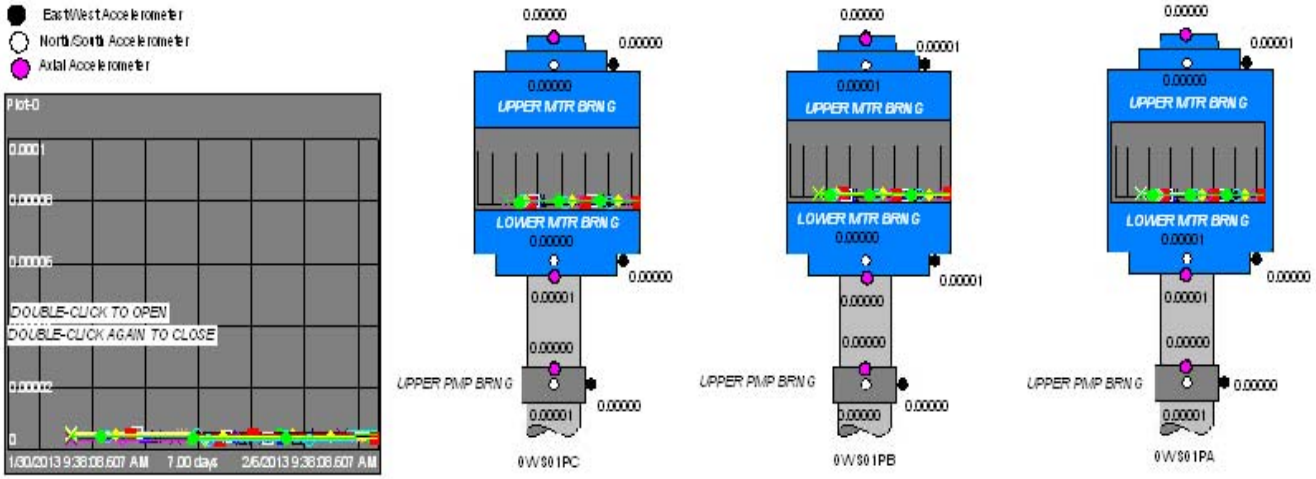
Real–time Component Operations Health Projects

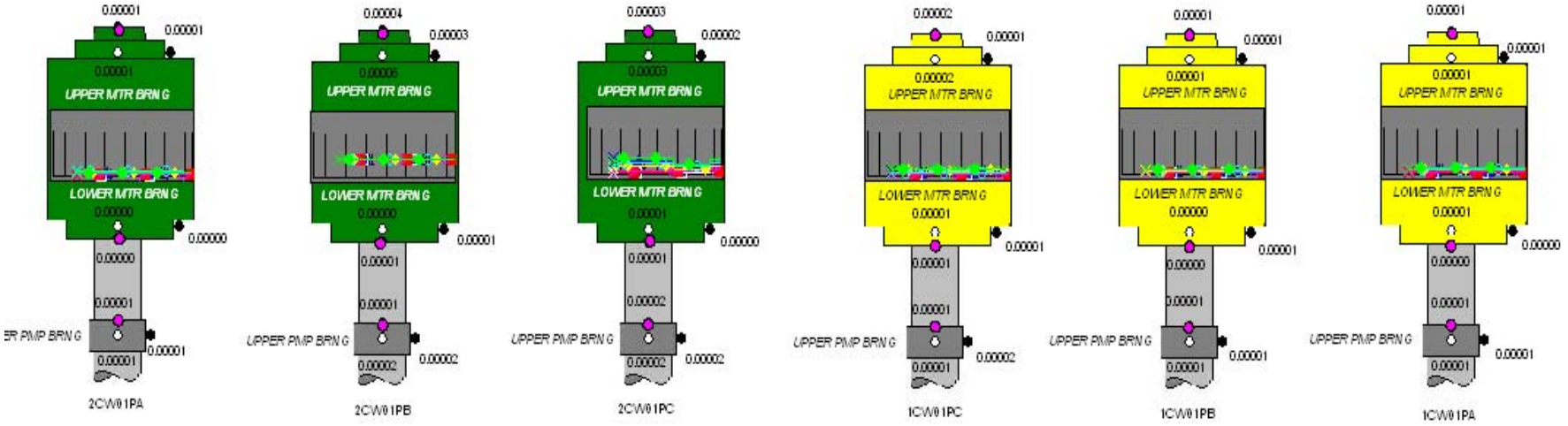
- Develop advance monitoring application to automatically diagnose anomalies identified by OLM program (Fault Signature)
- Provide initial recommendations to plant staff to mitigate the deviating condition (Diagnostic Advisor)
- Automize initial troubleshooting
- Help with knowledge transfer due to retiring experienced work force

Wireless Equipment Monitoring

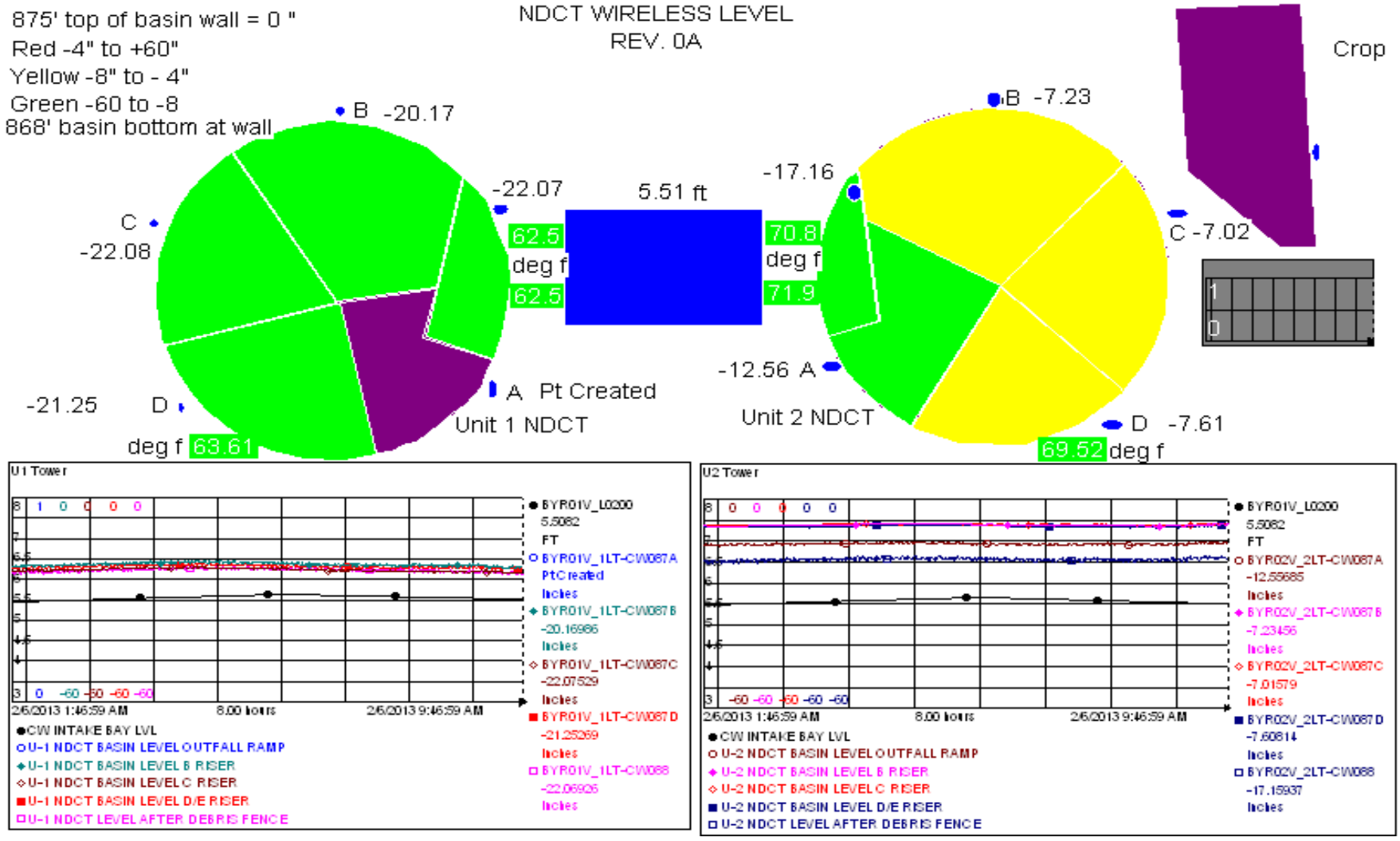
- The Exelon plants are equipped with less than optimal instrumentation for equipment monitoring
- The available sensors are good to operate plants safely, however does not provide data for diagnostic and analytical purposes
- Plant staff utilizes significant resources and time in data collection to assess real time equipment health
- The time spent in data collection keep the experts away from data analysis and prognostics
- Adding wired sensors in plants are not cost effective
- Wireless equipment monitoring is the solution
- Pilot projects at Byron and Limerick are in progress to prove the concept of wireless equipment monitoring

Circ Water Pump Wireless Monitoring





Cooling Towers Wireless Monitoring



Wireless Monitoring Architecture

Circulating Water Pump

National Instruments Compact RIO

PC-based Server Application

Data Historian

Analysis & Visualization

OPC

OSIsoft PI

Business Network

Existing 802.11 Access Points

Intro to PredictIT

Statistical Approach

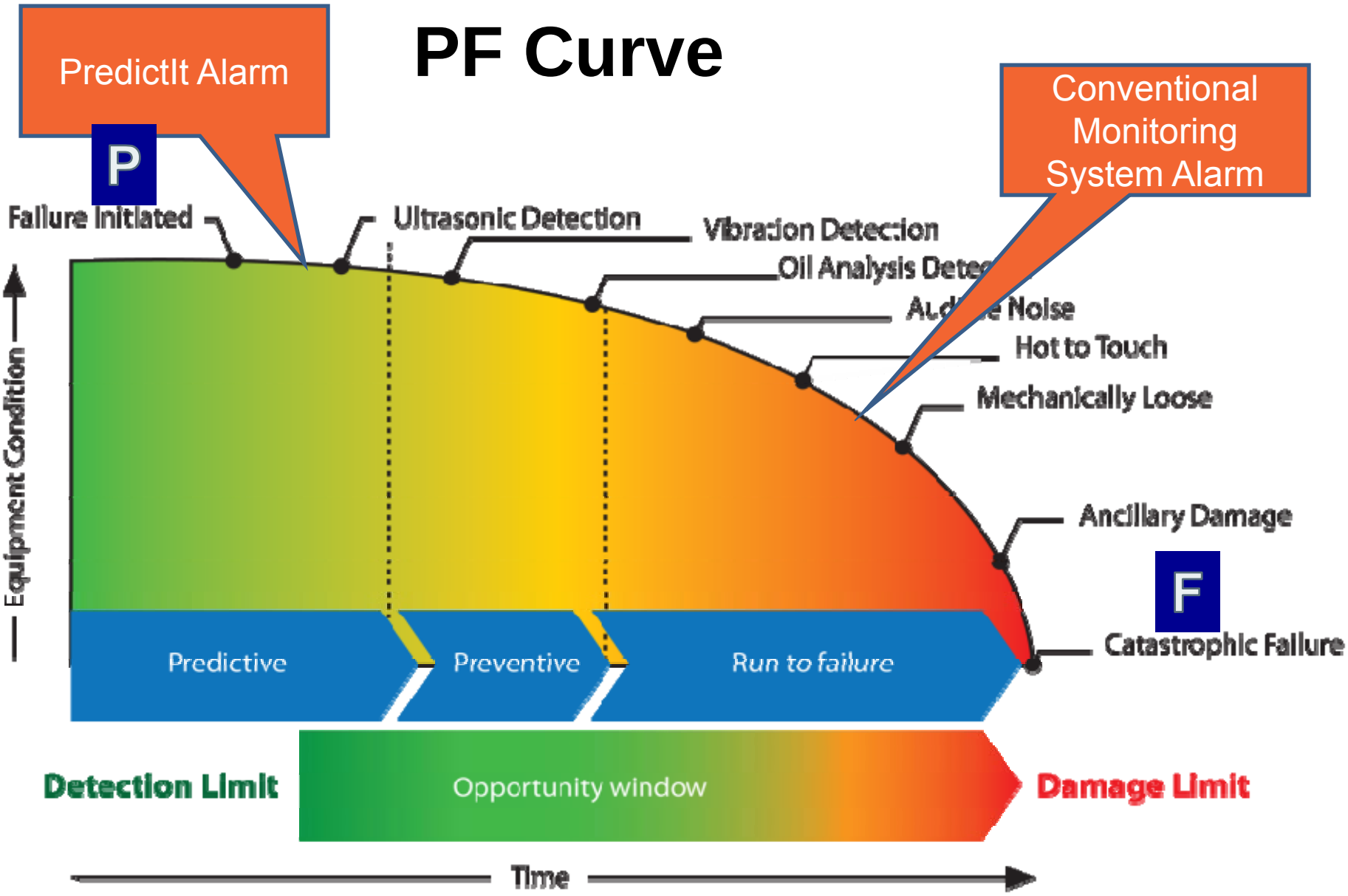
- What are the pressures of the other tires?
- Use correlated sensors to determine where the subject sensor should be
- Expected values generated from history (PI Archive)
- Includes all higher order effects

Similarity Based Modeling:

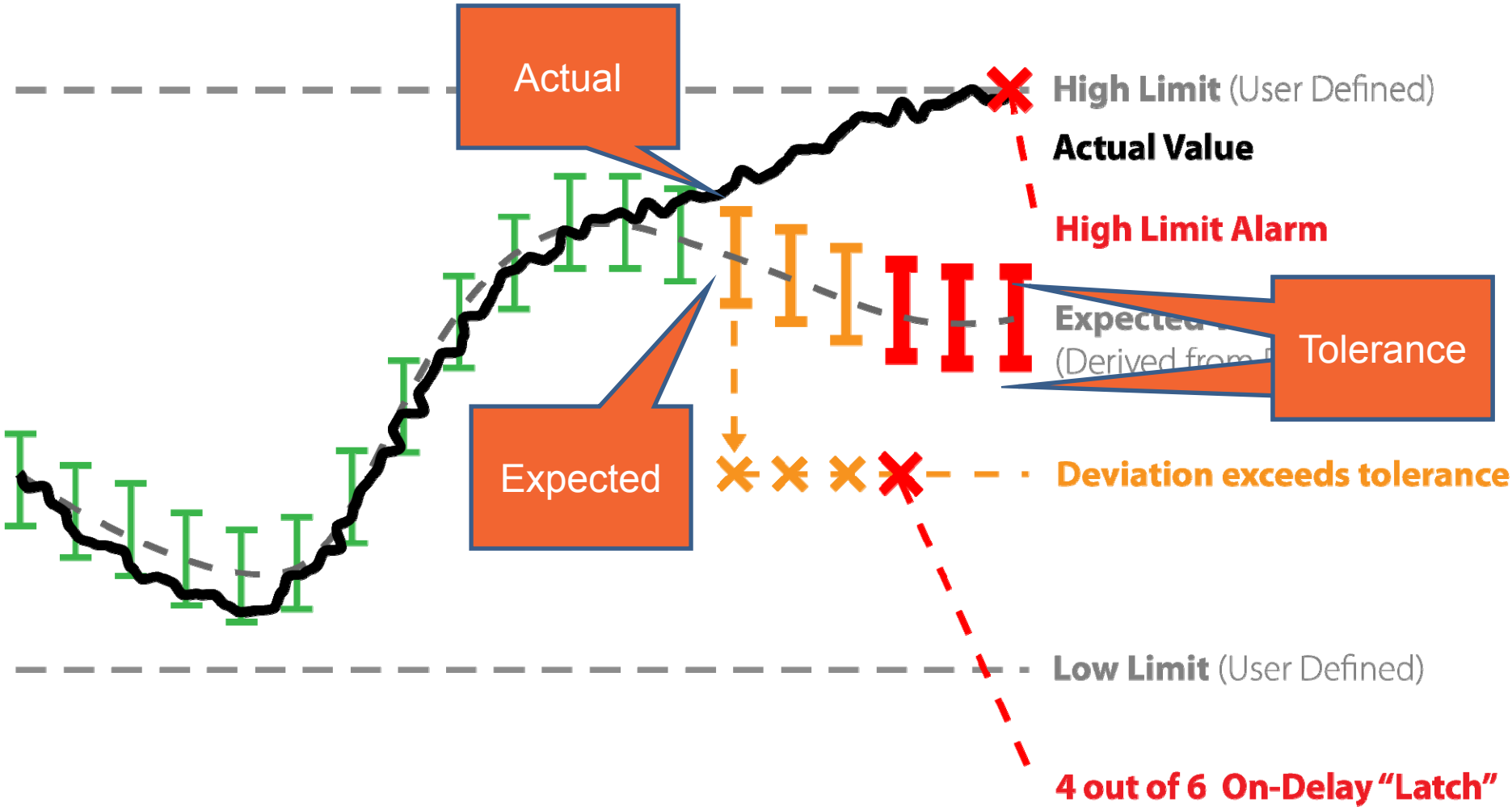
- Relies on the correlation between variables, not the variables themself
- Uses own history which incorporates all the “flaws” in the data and higher order effects
- Robust - Can run with missing inputs
- Precise – Can detect small disturbance in process ie. “Slow Leak”
- Pressure = F(History : Press_Tire1, Press_Tire2, Press_Tire3, Press_Tire4)

- Other Factors including, wear, Passengers, road condition, etc. are already included!

PF Curve



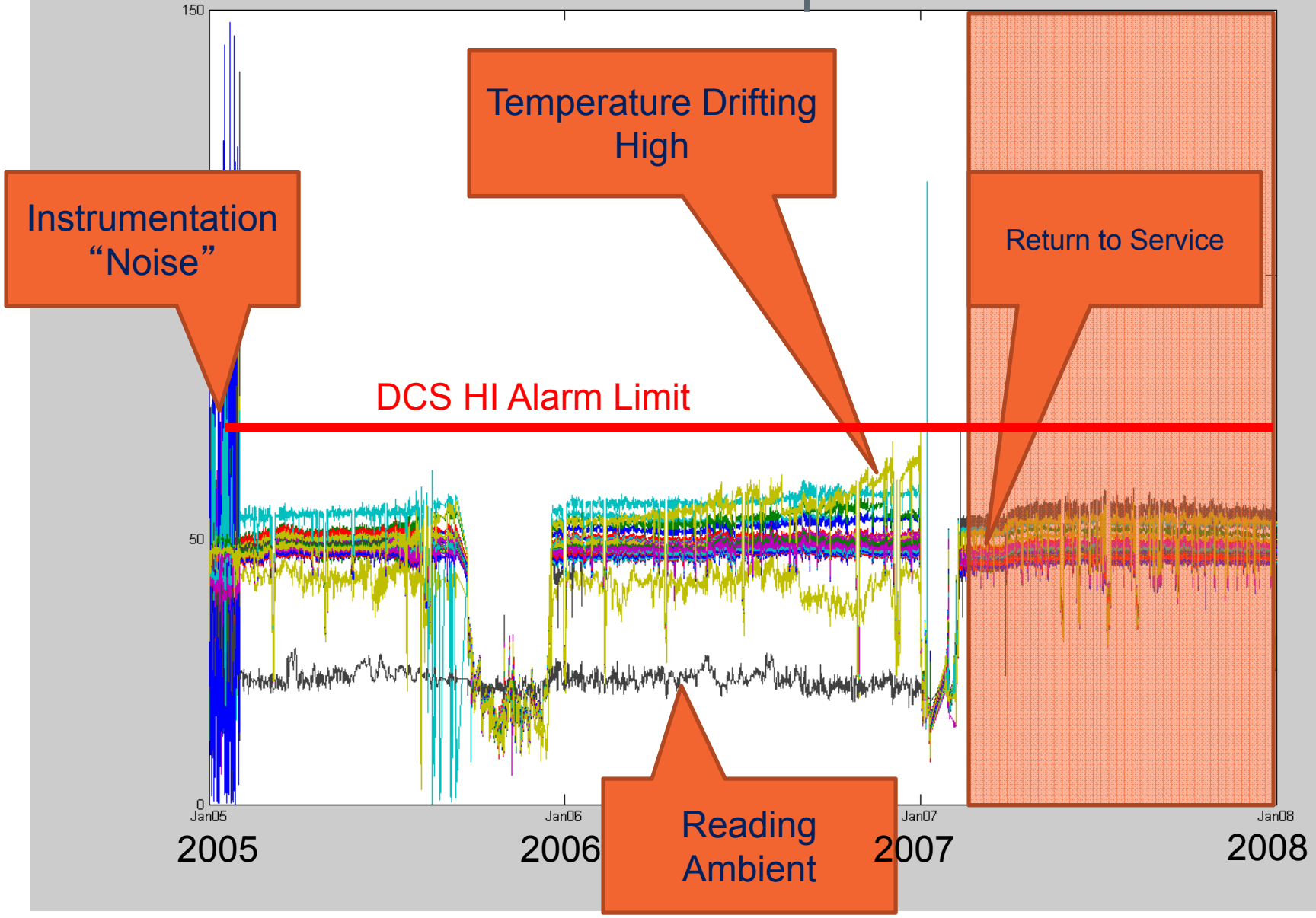
enotification + PREDICT it (2010)



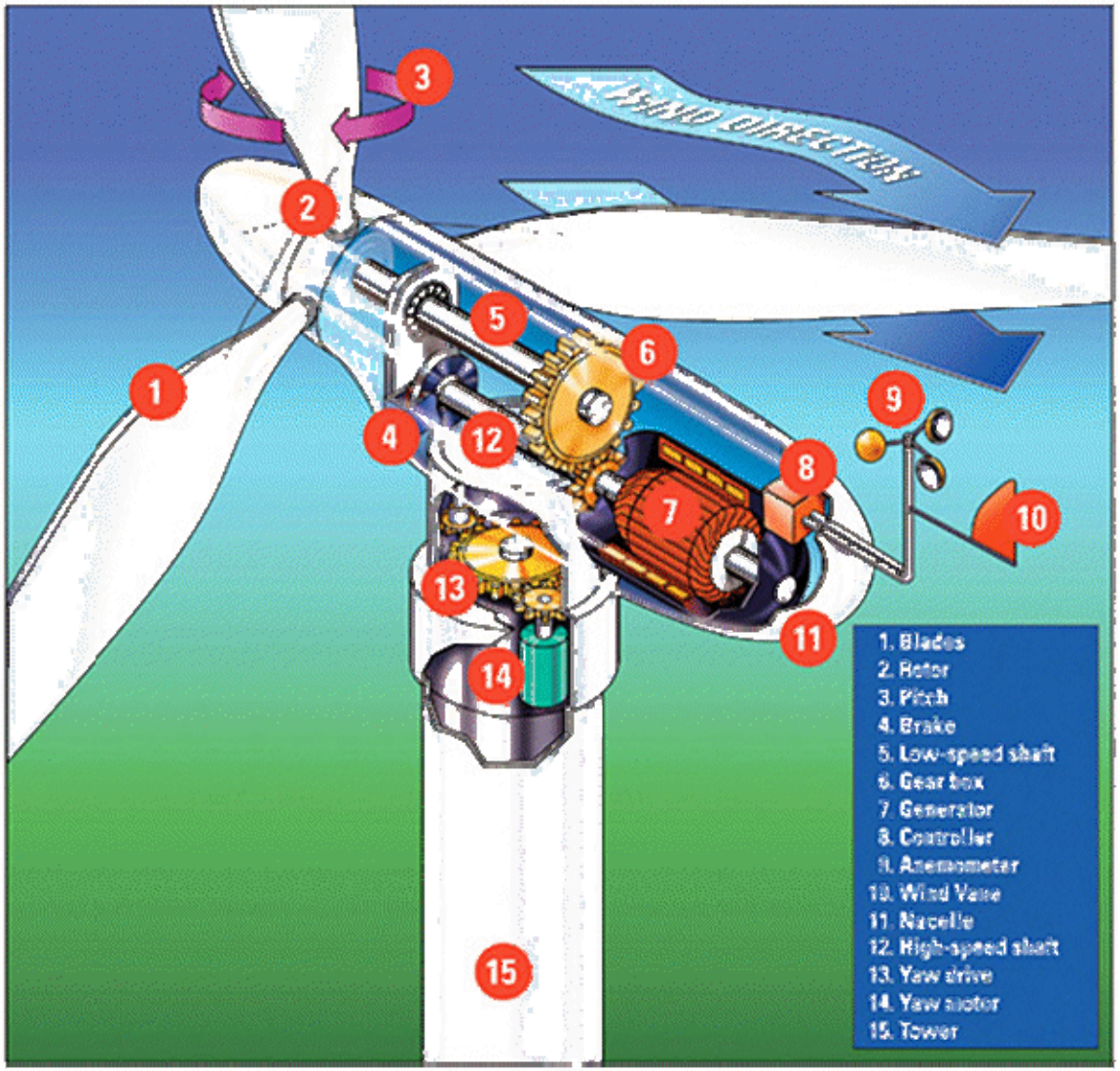
Predict-It Post Mortem Case Study
Generator Winding Failure

- Generator: H2 cooled rotor and water cooled stator.
- Build up of Cupric Oxide inside water passage resticts flow which eventually overheats Stator Bar Insulation

Generator Stator Temperatures



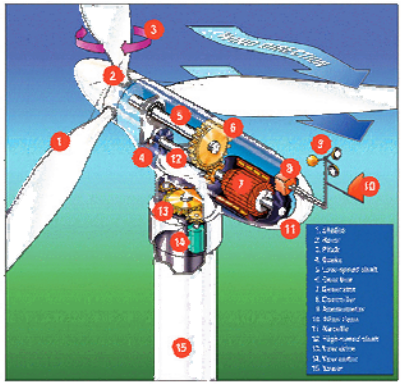
Wind Turbine Application



Critical Components

- Rotor
- Blades
- Pitch Mechanism
- Gear Box
- Generator
- Hydraulics/Lubrication
- Yaw System

Wind Turbine Application



Pitch Systems

- Pitch Angle
- Current to Blade Pitch Servo Motor
- Pitch Angle Velocity
- Pitch angle set point
- Servo Speed Set point
- Servo Motor Temperature
- Servo brake

Turbine System

- Rotor Speed
- Electrical Power
- Wind Speed at Tower
- Wind Speed at Met Tower
- Wind direction
- Yaw Alignment
- Air Temperature

Main Bearing & Gear

- Bearing Temperatures
- Bearing Vibrations
- Gear Vibration
- Lube Oil Data

Generator

- Stator Temperatures
- Stator Currents
- Bearing Temperatures
- Bearing Currents

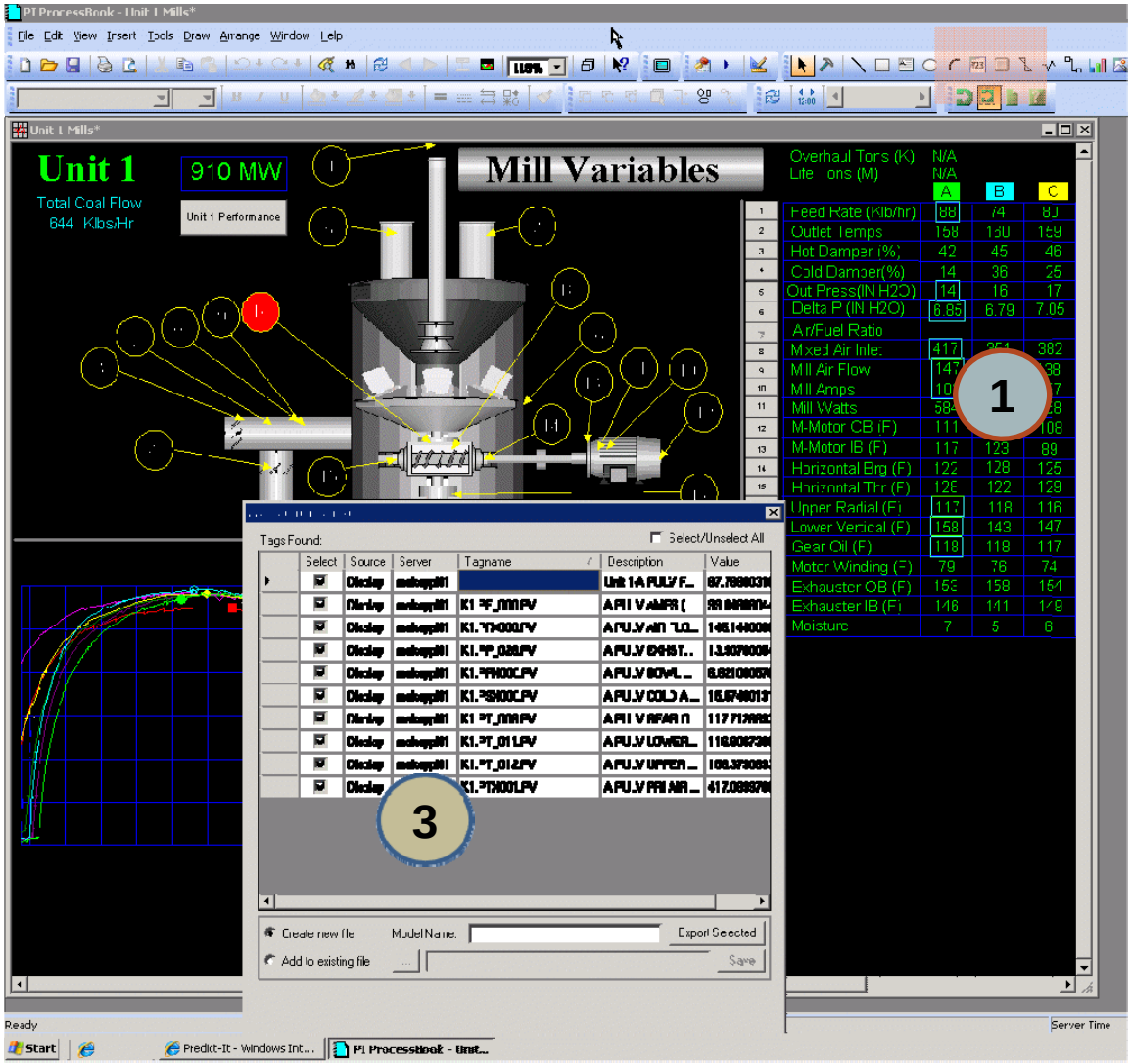
ProcessBook AddIn

2

OSISoft Technology:

OSISoft Processbook with Add-On “Selector” Tool

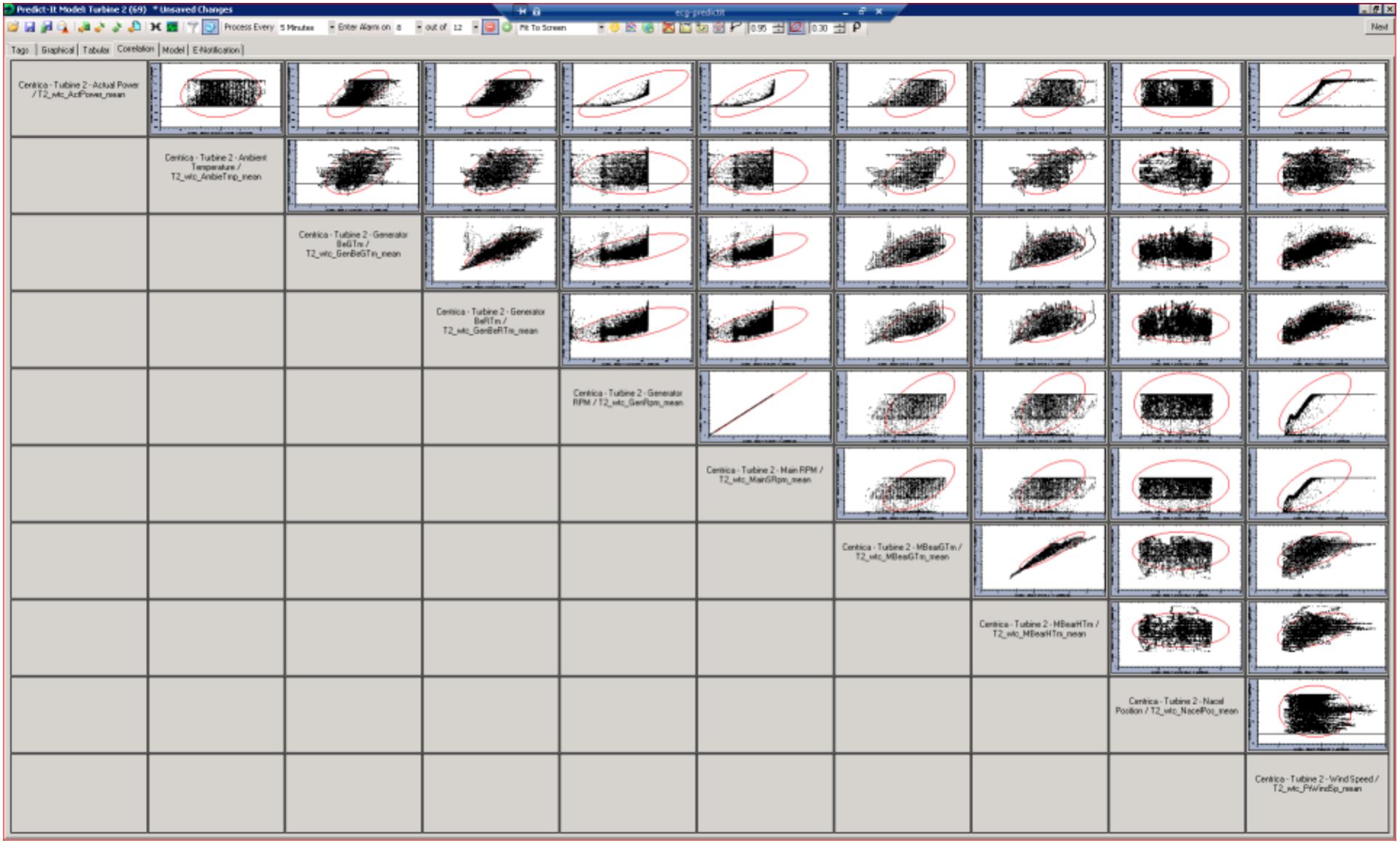
1. Select Tags from Displays or Trends
2. Use Predict-It Tool Bar Icon to add Tags to “3”
3. Export Model Definition to Predict-It



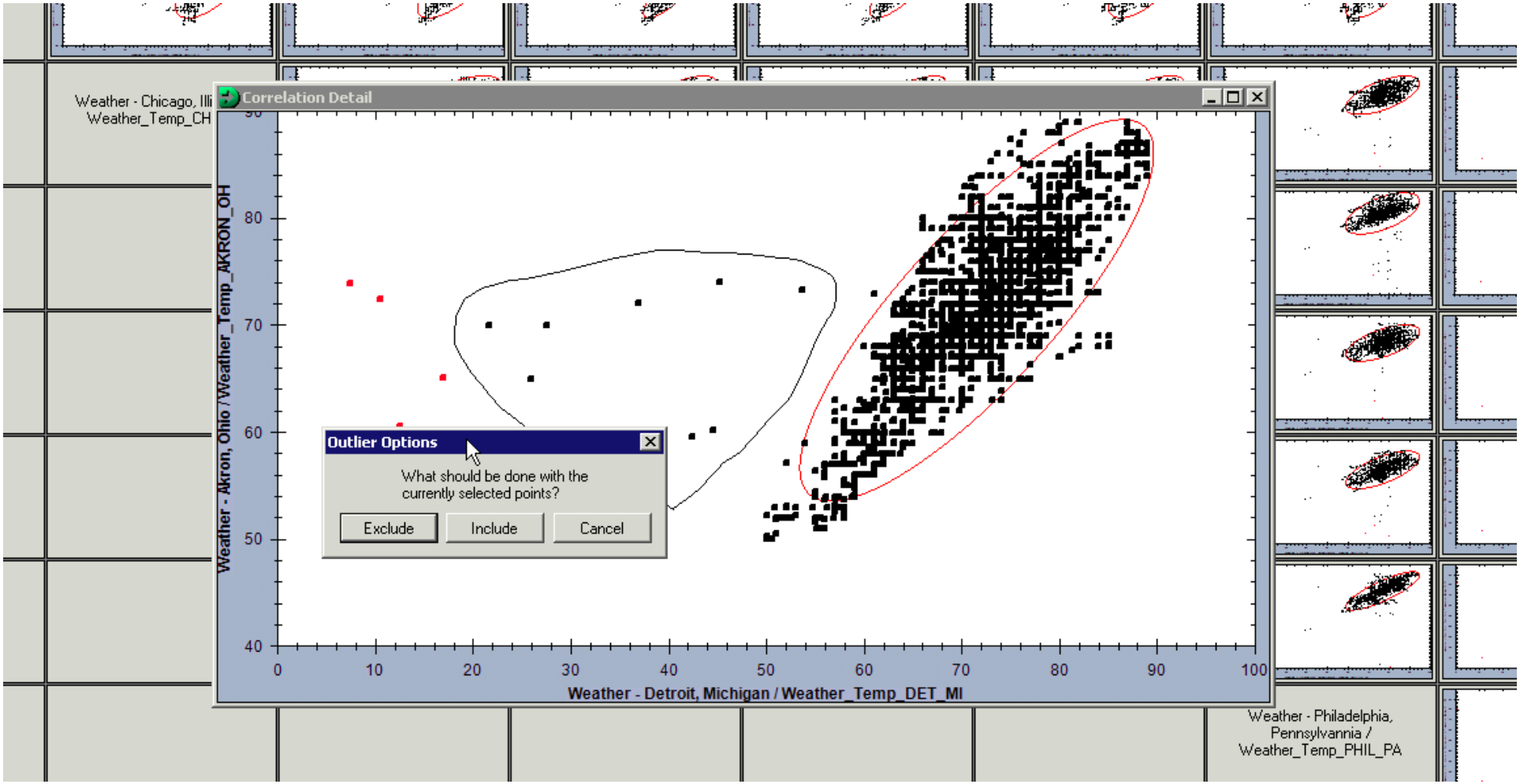
Wind Turbine Example

- 10 Turbine Variables Selected
- Training Data from 10/1/2010 to 3/1/2011
- Test Data from 9/1/2009 to 4/1/2010

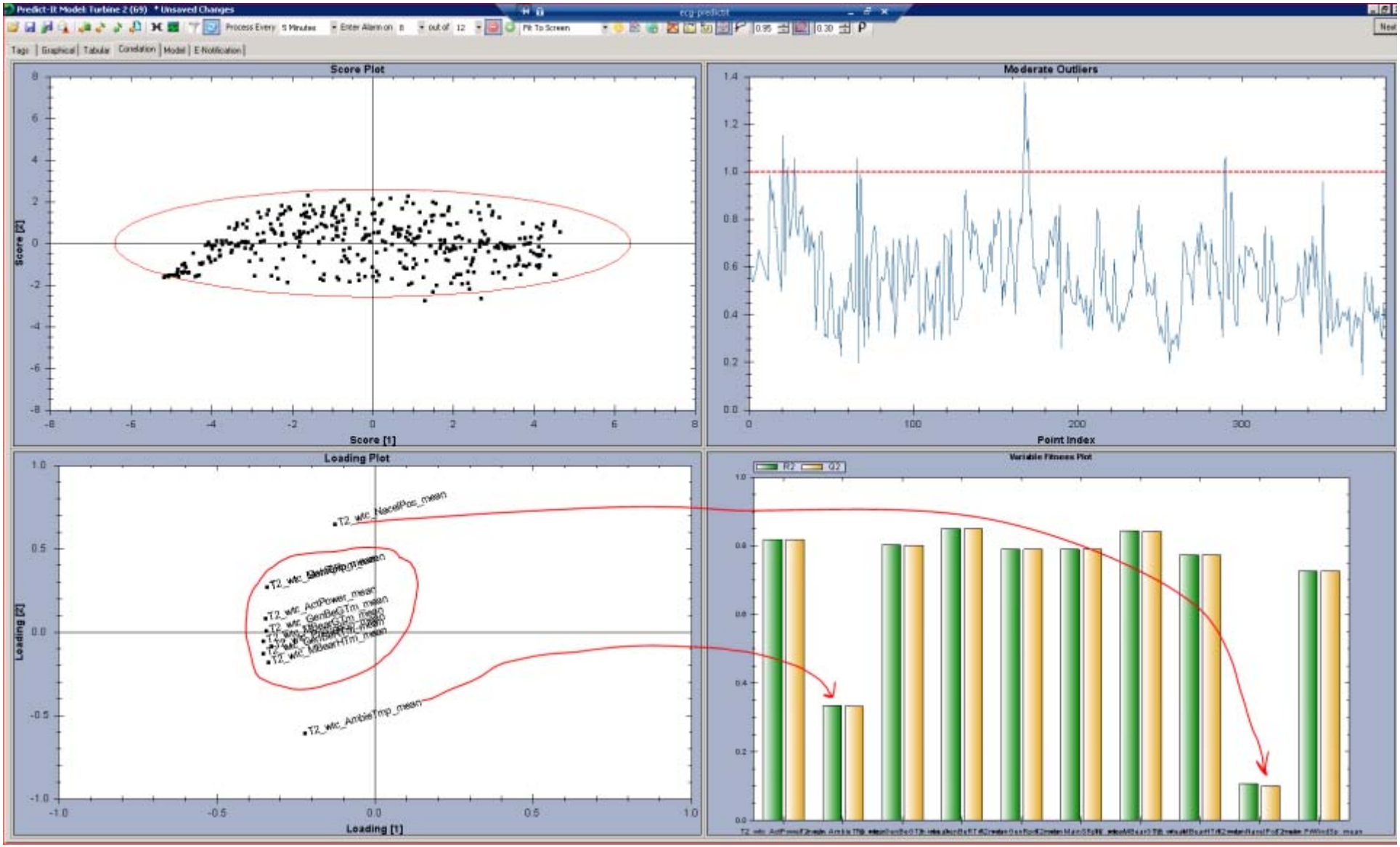
Turbine Training Correlations



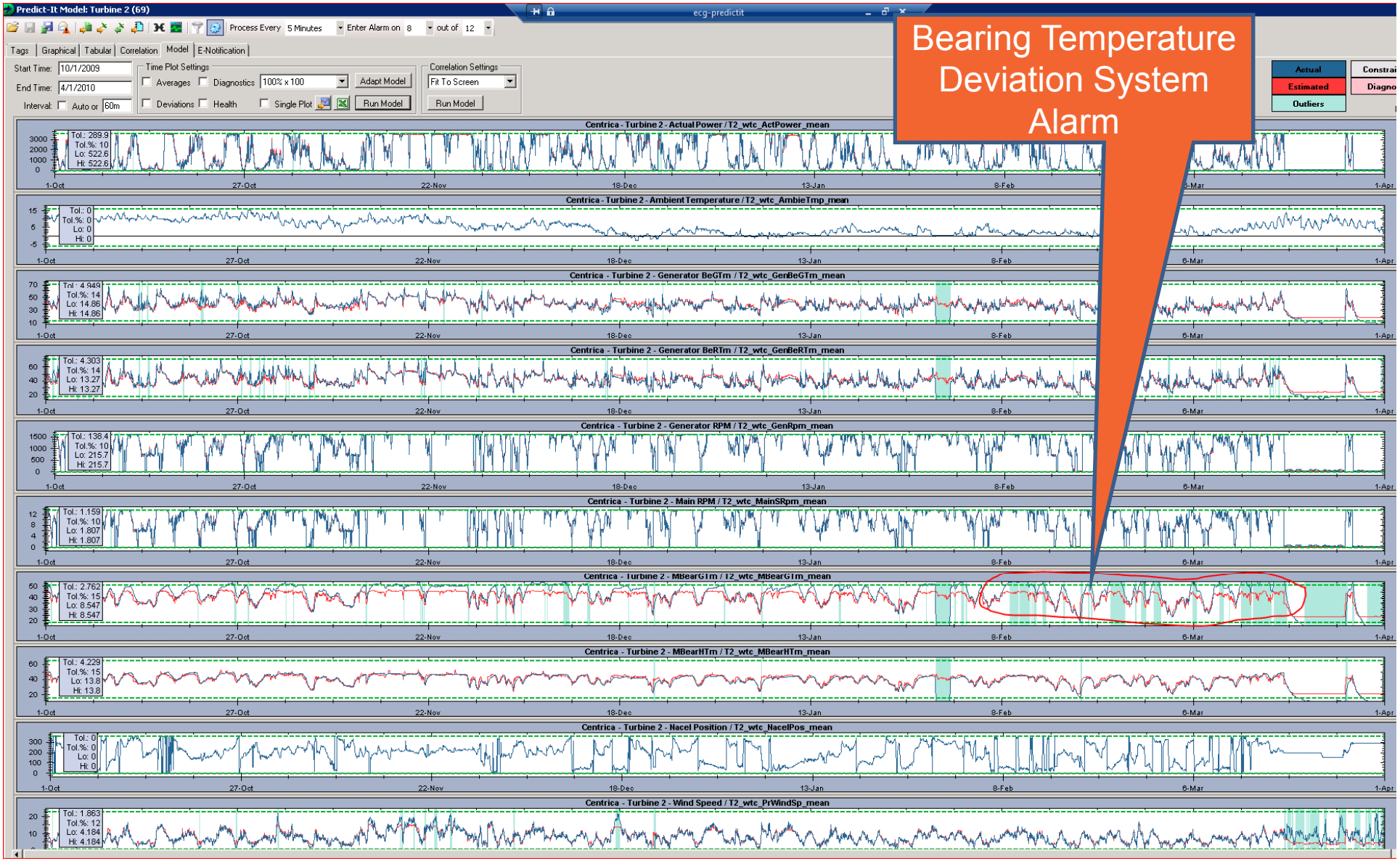
Remove Outliers



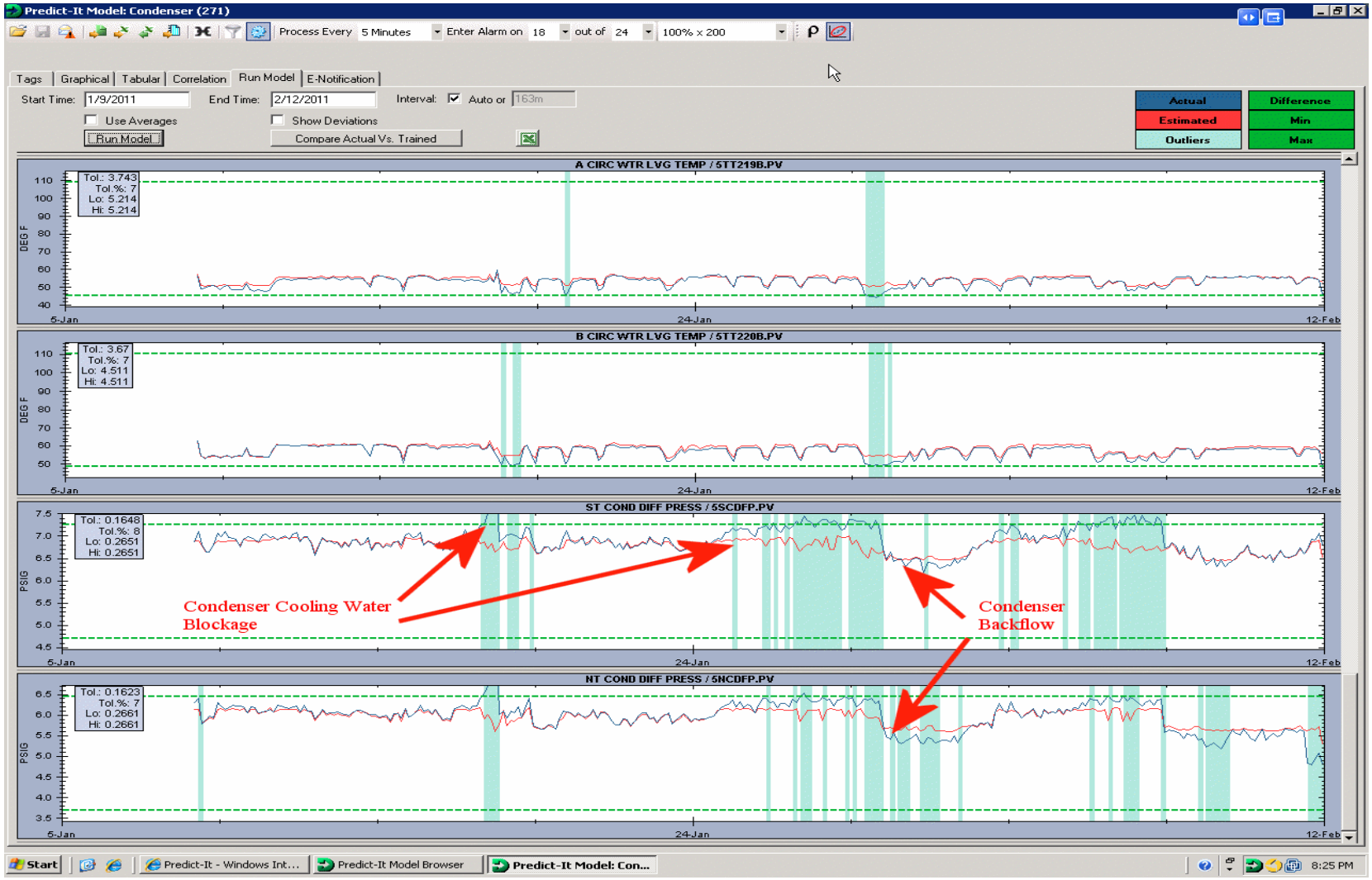
Turbine Training Analysis



Turbine Test Data – Bearing Failure

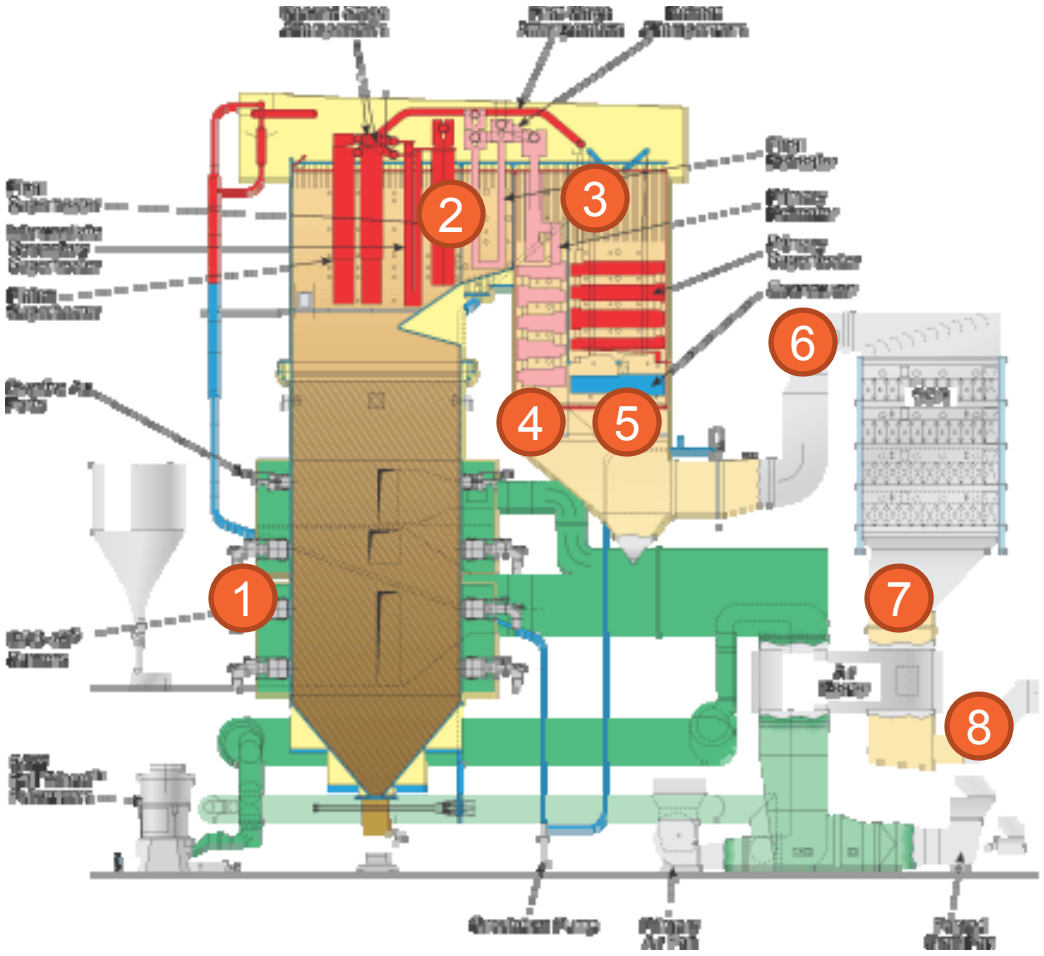


Predict-It Model Case Study
Condenser Pluggage



Predict-It Model Case Study
Boiler Flue Gas Pressure Drop

- Boiler Slagging and Fouling deposits insulate heat transfer surface.
- This model shows the ability to detect minor deviations in flue gas temperature. While injecting sorbent to control emmisions.

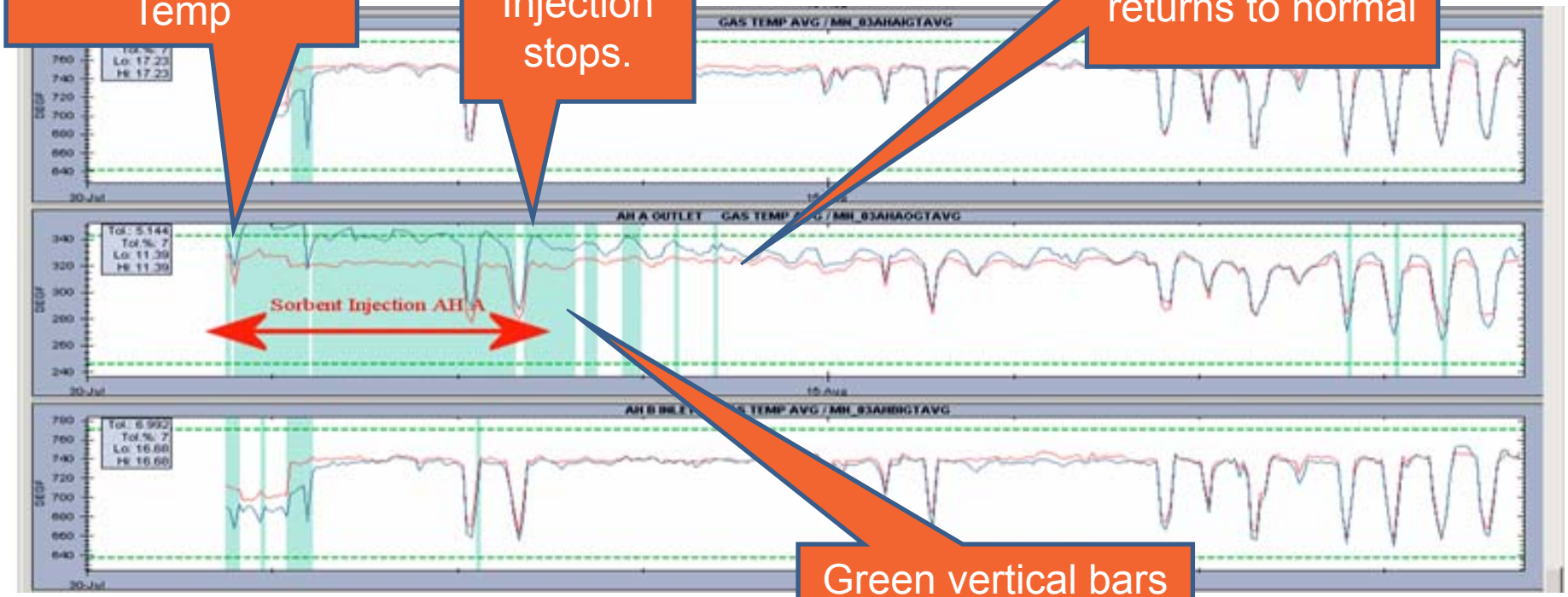


Model Showing Trends of Three Variables
Air Heater Fouling

Blue "Actual" Temp is above Red "Expected" Temp

Injection stops.

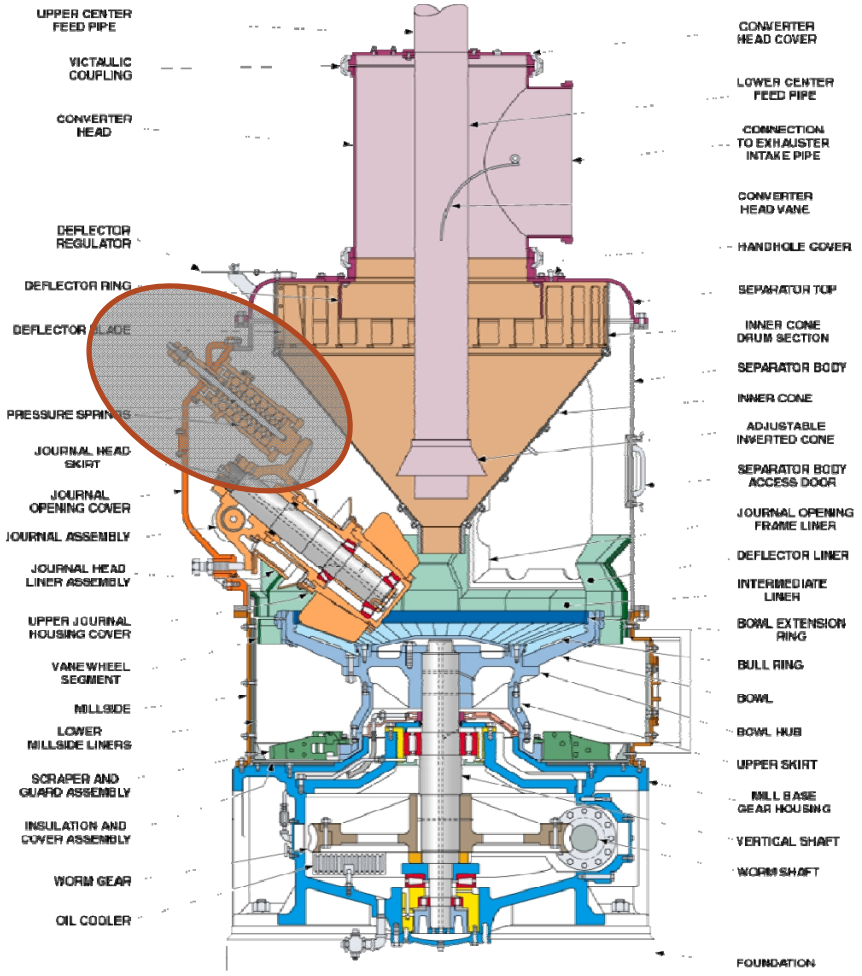
Soot is cleaned and Temperature returns to normal



Green vertical bars indicate Act-Exp is greater than the tolerance.

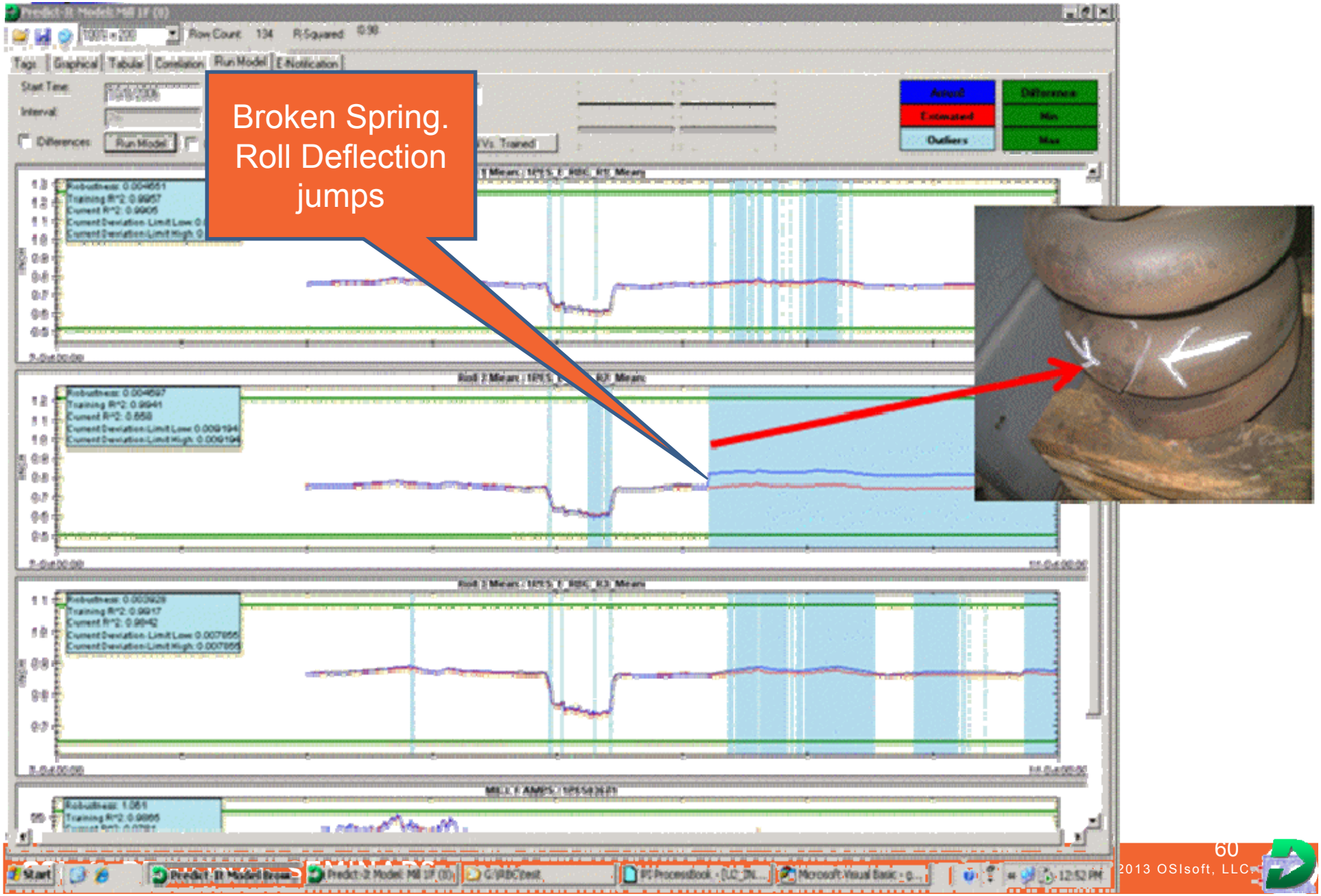
Predict-It Model Case Study
Pulverizer Failed Spring

- Pulverizer Spring loads the roll that crushes coal
- A broken spring can cause uneven loading on the vertical shaft that can result in fatigue failure.



RPS PULVERIZER

Pulverizer Roll Failed Spring



Predict-It Summary

- Leverage existing PI data
  - Need history
  - Need continuous process system
- Scalable - supporting multiple users and enterprise deployment
- Models conform to *your* operational criteria
- ECG continues support after the sale

Value of OSIsoft PI System

PI System provides the real-time infrastructure to collect, analyze, visualize and historize time-series, relational and unstructured data. This data may include real-time asset data, data from predictive technologies (batch or continuous) and real-time process data. Further, PI System provides access to this data for dynamic, pattern recognition applications and asset management/performance systems. The result is a 'holistic systems view' of the assets.

- *Ease of creation, deployment, and maintenance* of a real-time CBM solution, for all of the assets in your enterprise.
- Ready availability of *on-demand, intuitive visualizations of asset condition* to support *real-time condition assessment and decision-making*
- *Reduced down time of systems* resulting from *timely awareness of asset condition* due to workflow and notifications triggered by accurate real-time data
- *Optimized maintenance costs* resulting from working on the right equipment at the right time and avoiding maintenance induced failures
- *Enhanced organizational capability and resource efficiencies* driven by a framework for capturing asset data, characteristics, and performance, and reuse of asset models
- *Increased customer satisfaction overall* due to higher returns on the asset base
- Enables the delivery of Reliability, Availability, Maintainability, Profitability and Safety!

THANK YOU

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