EQT
Where energy meets innovation.

The Evolution of the PI System at EQT in Support of our Digital Transformation

Presented by

Oscar Smith
Sr. Principal Engineer
EQT Midstream

Brian Morel
Manager Drilling Engineering
EQT Production

Overview of Presentation

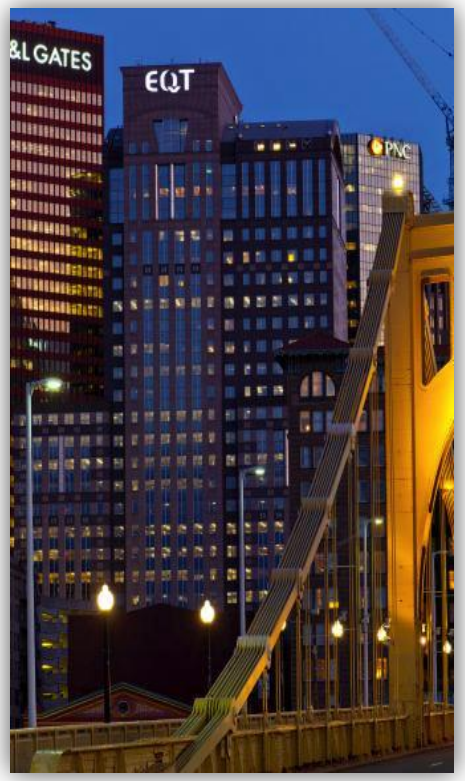
- EQT Corporation Overview
- EQT Midstream Objectives
- The Journey
- Example Case Studies and Benefits
- Next Steps
- EQT E&P's Journey

EQT Corporation Overview

Two Integrated Business Units

Natural Gas Exploration, Development, and Transportation

- Headquartered in Pittsburgh, PA
- 2018 marks our 130th Year in Business.
- Operations Across Appalachian Region & Texas
- Largest Natural Gas Producer in the United States
- More than 1,800 Employees
- Innovative Techniques & Strategies Employed Across Two Distinct Business Units
    - **EQT Production-Natural Gas Exploration, Drilling, & Development**
    - **EQT Midstream-Natural Gas Gathering, Transportation, & Storage**



Role in the Natural Gas Value Chain

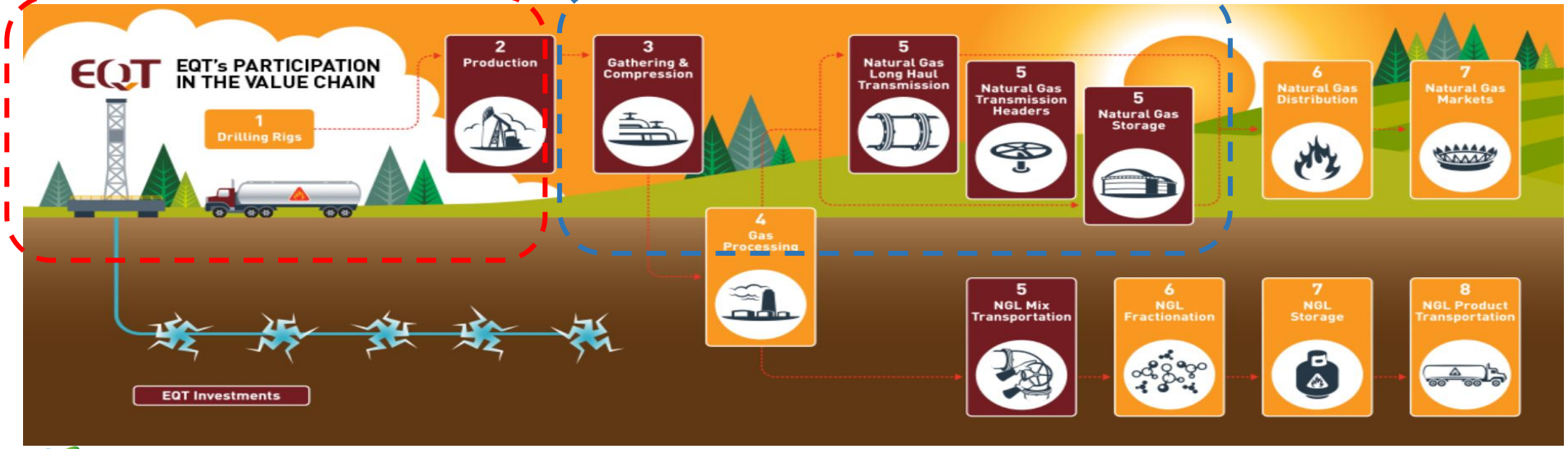
EQT Midstream PARTNERS, LP

- **Approximately +2.0 BCFD Marcellus Gathering Capacity**

- **Gas Gathering**
  - Reciprocating Compressors/Engines
  - Pipelines
  - Measurement

- **Transmission & Storage**
  - Reciprocating & Centrifugal Compressors
  - Large Pipelines
  - Storage Facilities

Brian **Oscar**

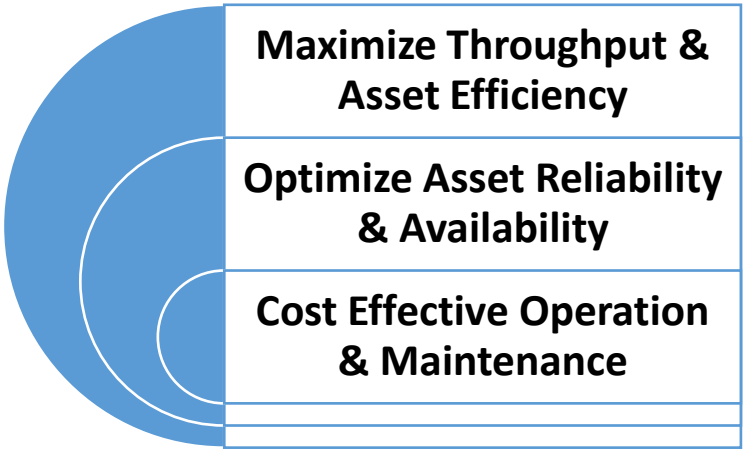


EQT Midstream Objectives

Midstream Goals & Focus

Objectives – Build Exceptional Operational and Business Intelligence

- **Provide Natural Gas Gathering & Transportation Services**
  - Health & Safety #1 Priority
  - Customer Service Focus
  - High System Availability & Capacity
  - Provide Value for Customers & Shareholders
- **Strategy**
  - Operate & Maintain Assets Efficiently & Cost Effectively
  - Apply Innovative Technologies to All Facets of the Business
  - Maintain High Expectations of Quality & Integrity
- **Plan & Implementation**
  - High Reliability – Compressors & Pipelines
  - Data & Analysis for Operational Awareness & Excellence
  - Transform the Business from Reactive to Proactive (Predictive) Model



EQT

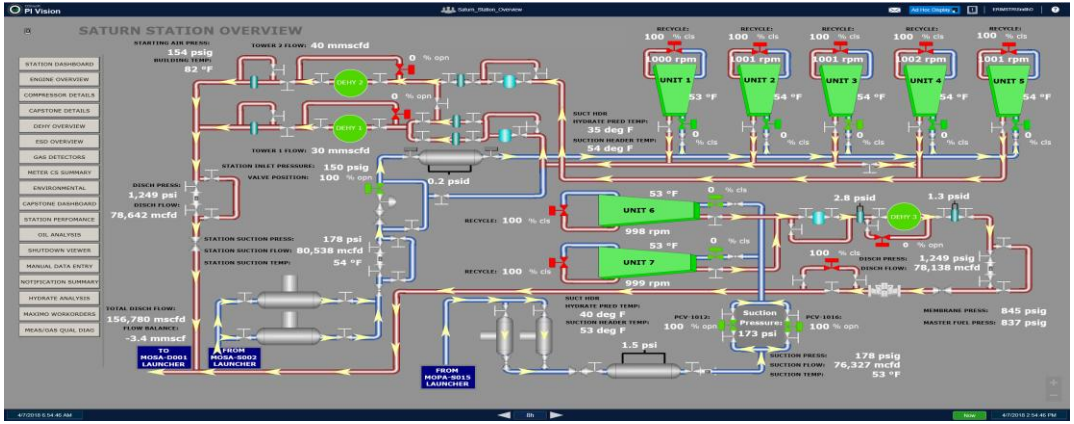
Where energy meets innovation.

The Journey

EQT Midstream's PI Implementation Journey Started in 2015 with Proof of Concept Project

ONE Gathering Facility – Saturn Compressor Station

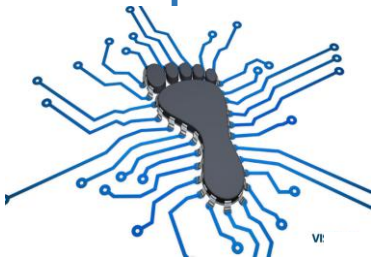
YEAR	STATION	ENGINE/COMP UNITS	TAGS
2015	Saturn	7	9287



EQT Midstream's PI Implementation Journey

By End of 2018 Significantly Increased PI Digital Footprint

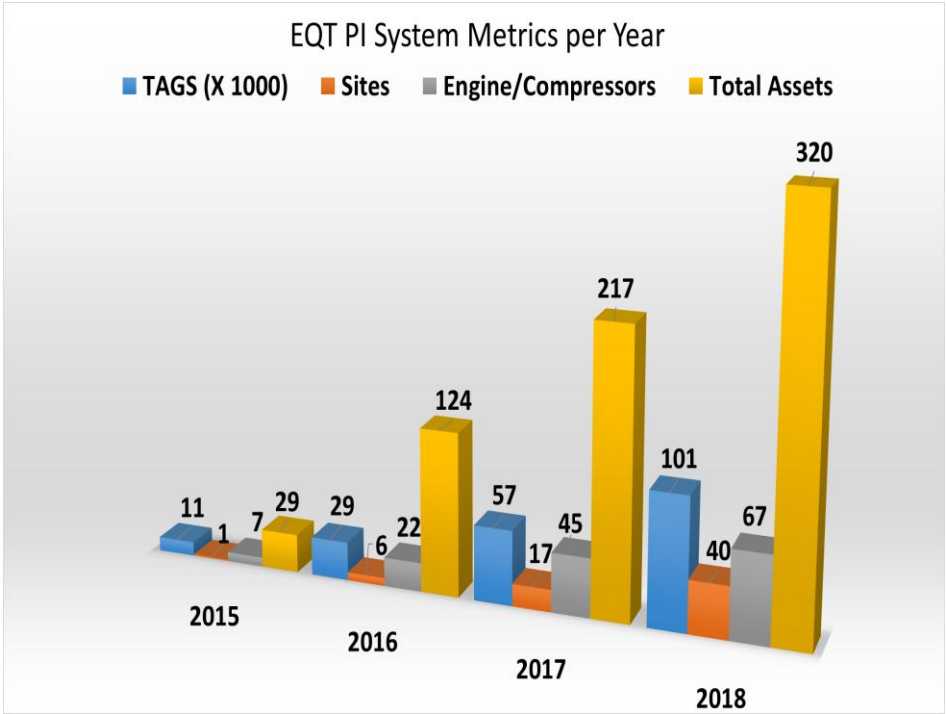
1. **40 Locations**
   - 16 Gathering Facilities
   - 9 Transmission Facilities
   - 1 Storage Facility
   - 10 M&R Sites
   - 4 Interconnect/Distribution Sites

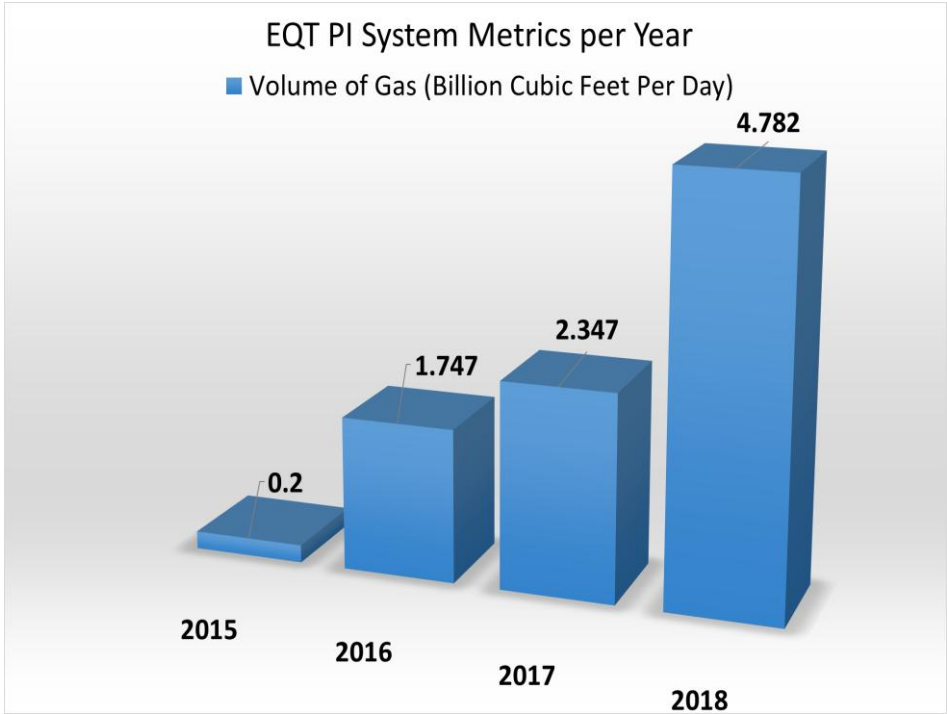


2. **More than 100,000 Tags every Second**

3. **PI AF Metrics to Date:**
   - 1397 Analysis Templates
   - 16751 Analysis
   - 186 Element Templates
   - 4173 Elements
   - 828 Notification Rule Templates
   - 9160 Notification Rules

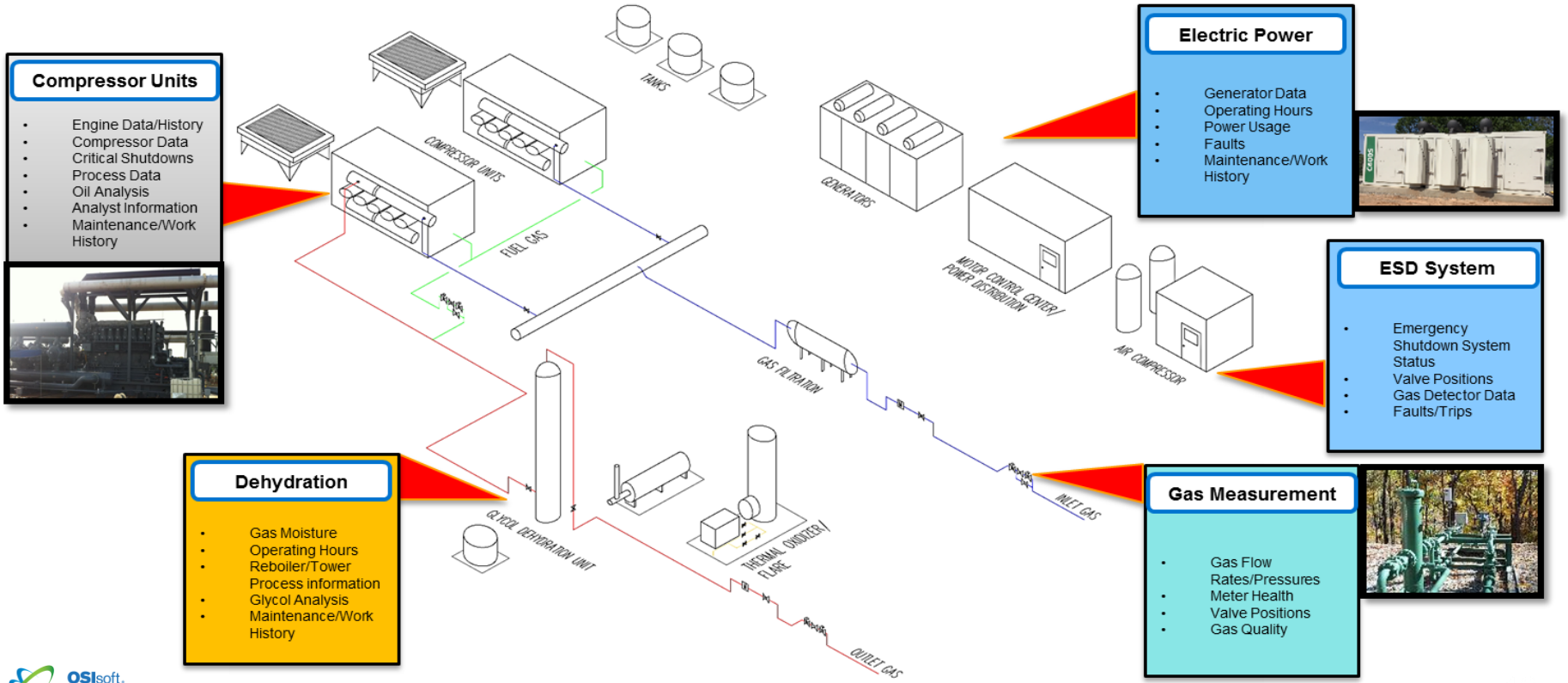
EQT Midstream's PI Implementation Journey
PI System Digital Footprint



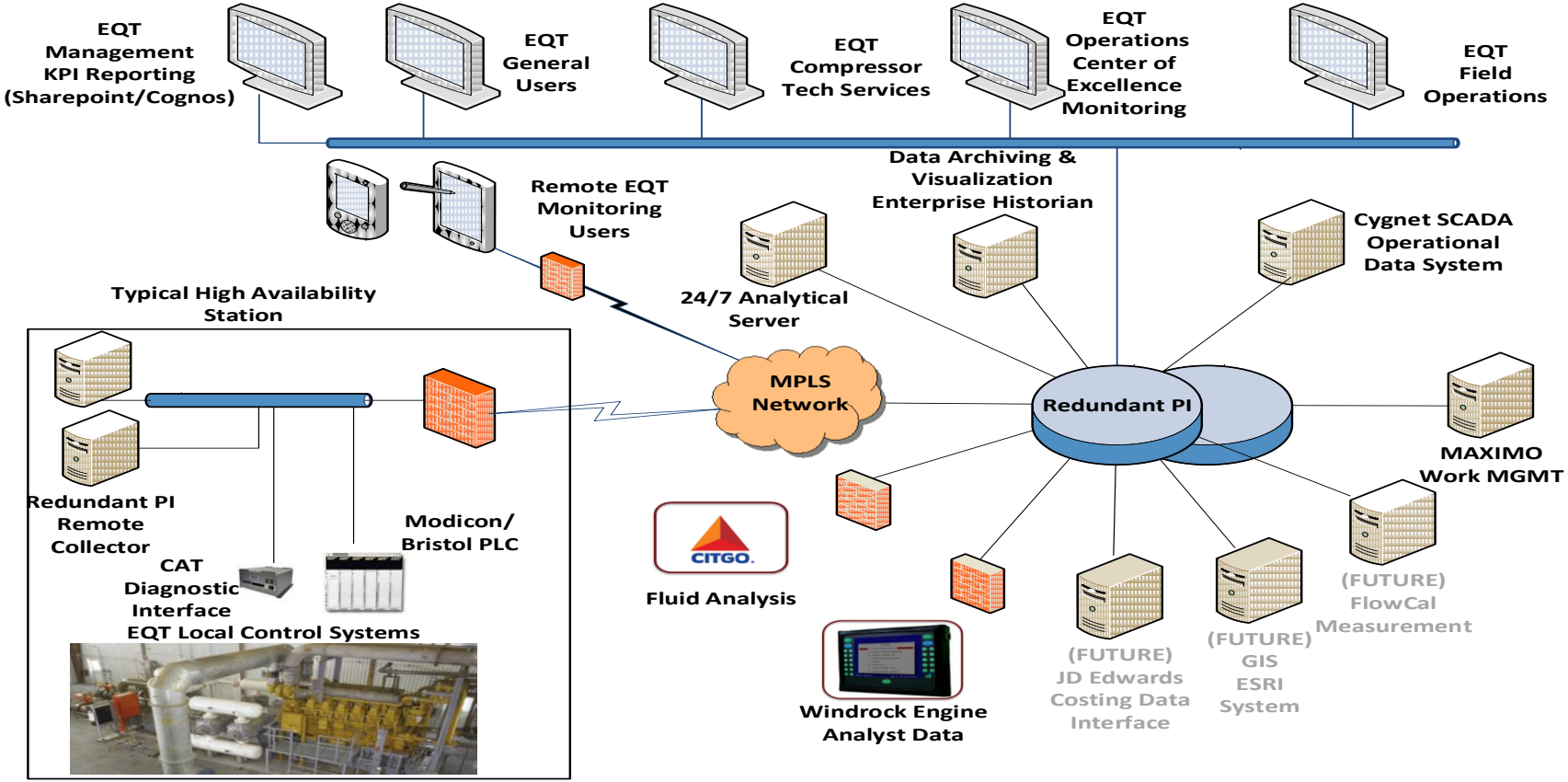


Typical Facility Overview

Multiple Data Sources – One Point of Access with PI



EQT Midstream's PI Network Architecture

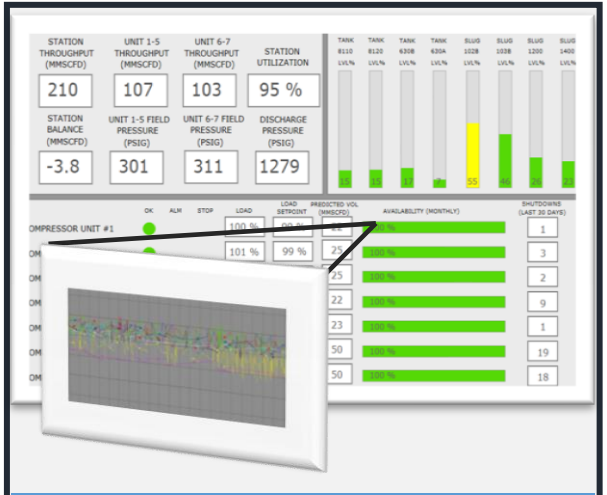


EQT Midstream PI System Development

Building the Tools for Reliability

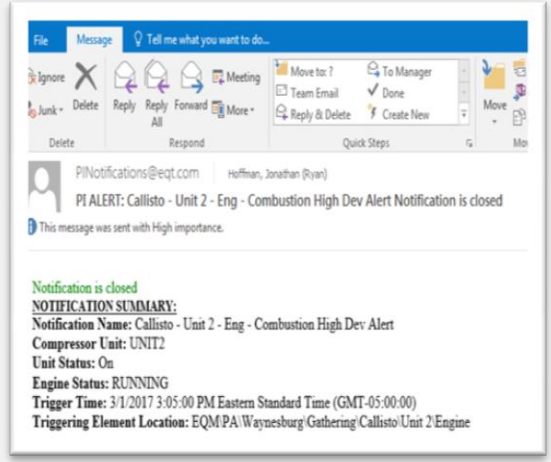
PI Asset Framework (PI AF)

- Develop Hierarchy of Compressor Station Assets
- Organization of Data Into Useful Sets
- Standardization Across Sites
- Templates for Scalability
- Translation/Integration With Other Business Systems



PI Vision

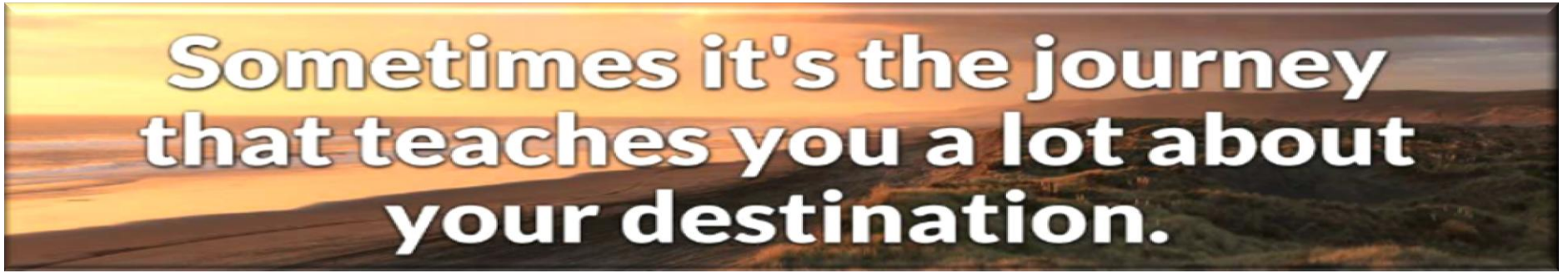
- Dashboards for Operational Monitoring
- Multiple Sources of Data Combined Into Single View
- Pair Analytics w/Real-Time Values
- Single Point Access Across Organization



PI Event Frames & Notifications

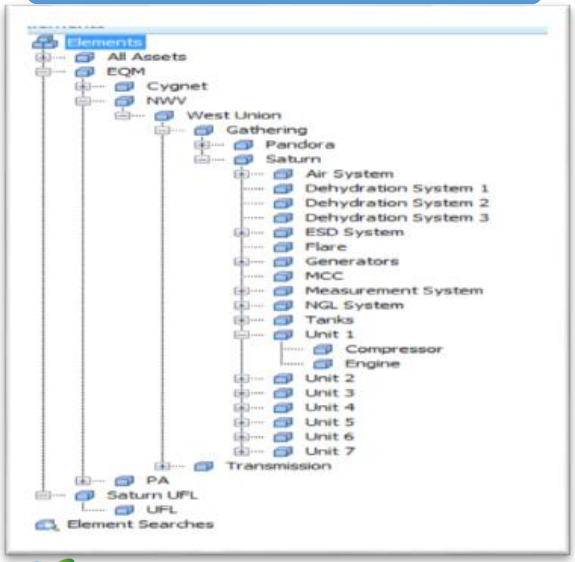
- 24/7 Monitoring & Communication of Anomalies
- Failure Detection, Efficiency Monitoring, Work Mgmt.
- Improve Operational Awareness
- Eliminate “Digging” for Issues

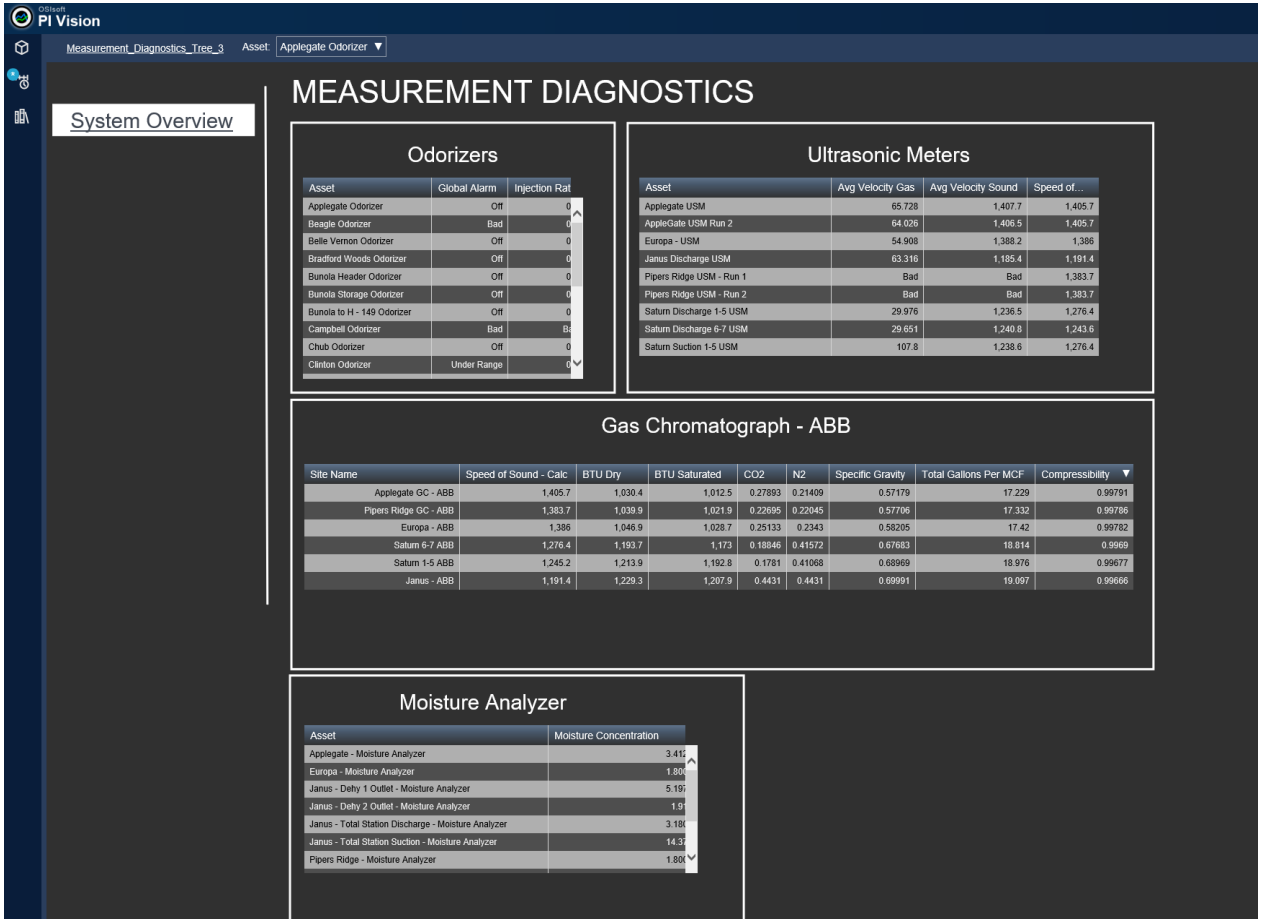
Original PI Business Justification was based on savings realized by event prevention primarily for Engine/Compression Assets



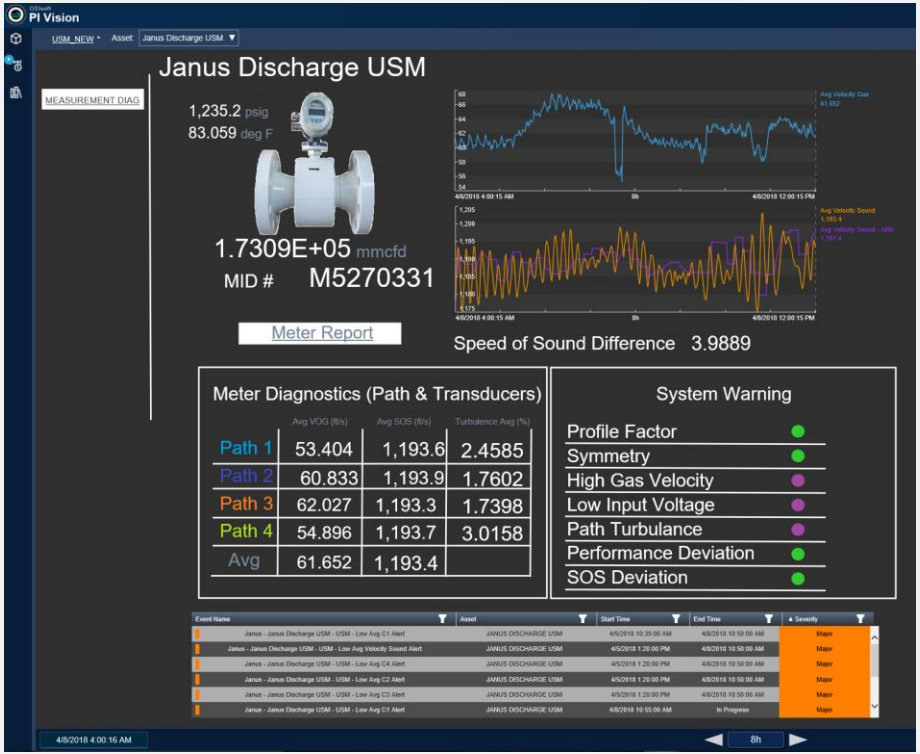
Gas Quality and Measurement

Gas Quality and Measurement

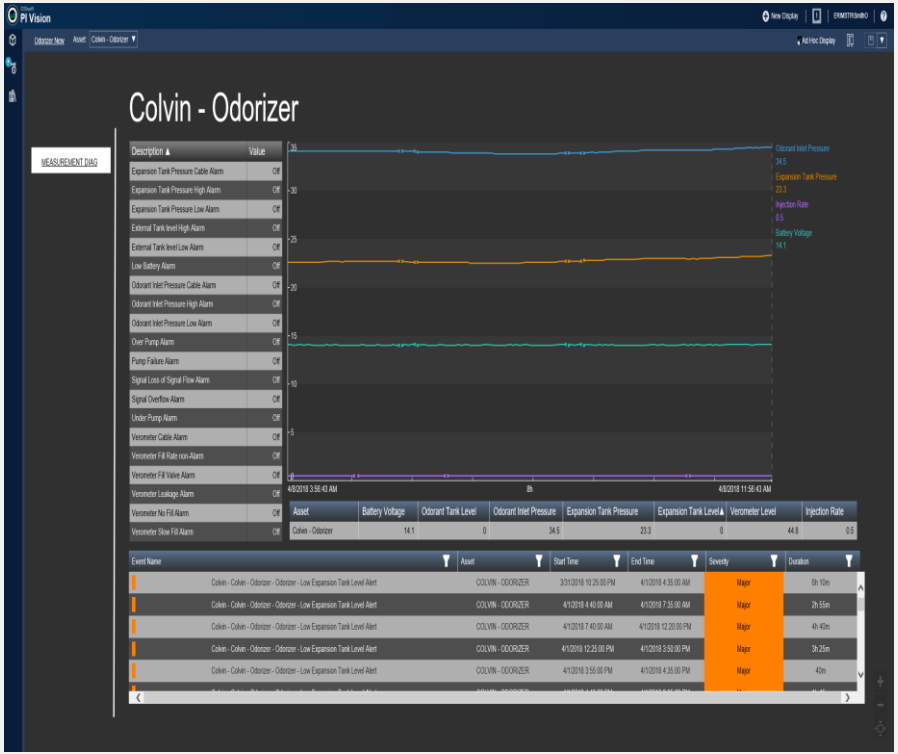




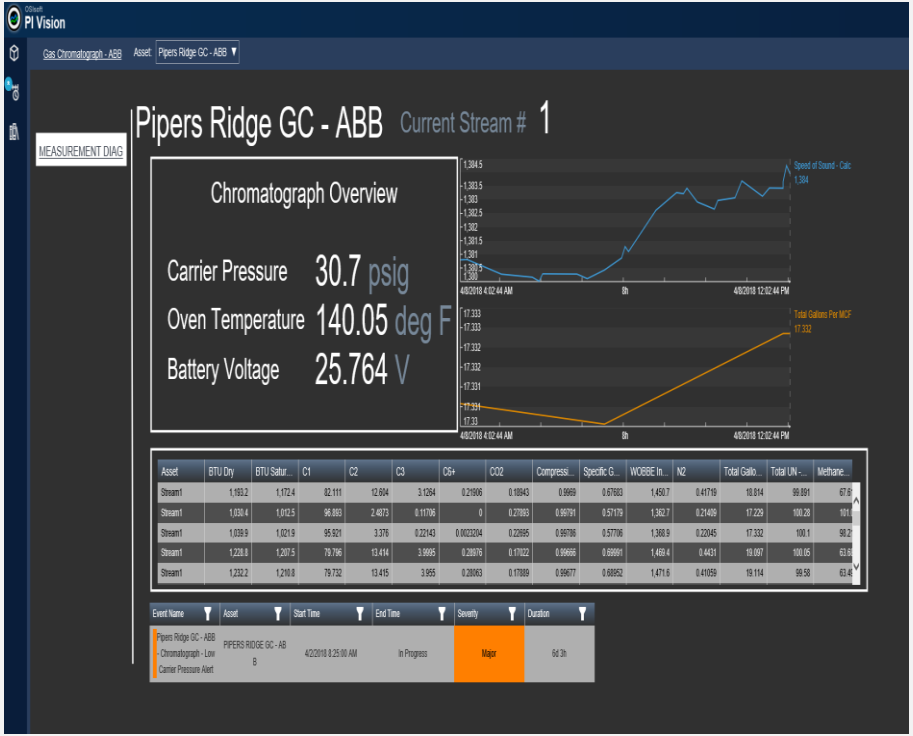
Ultra Sonic Meters



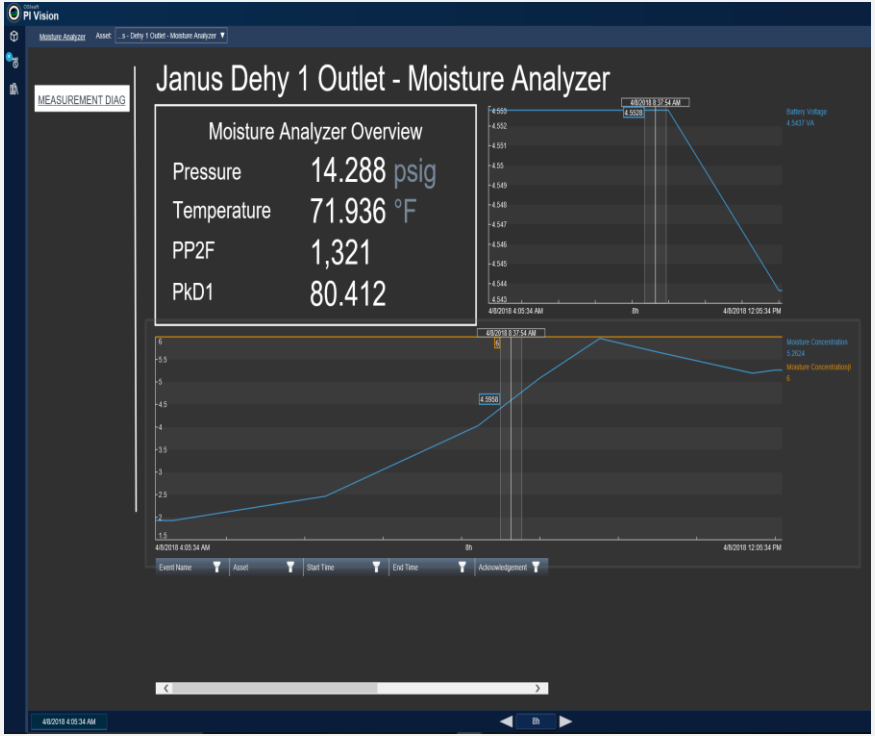
Odorizers



Chromatographs



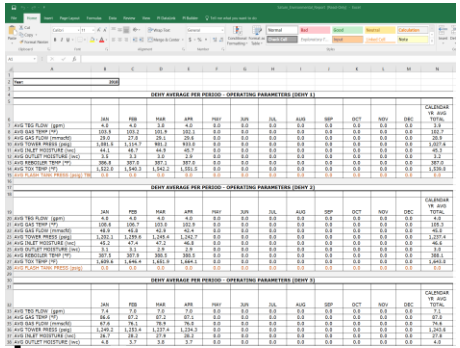
Moisture Analyzers

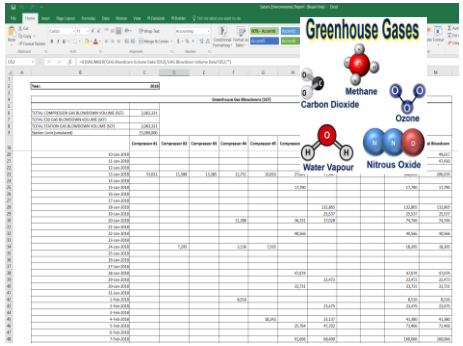


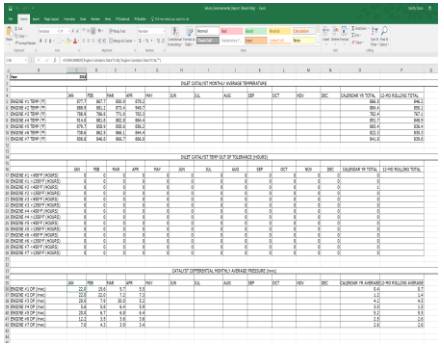
Environmental Compliance Assurance

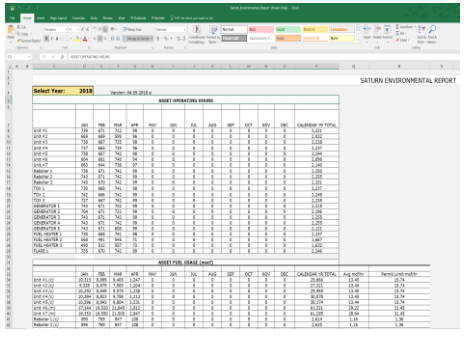
COMPLIANCE

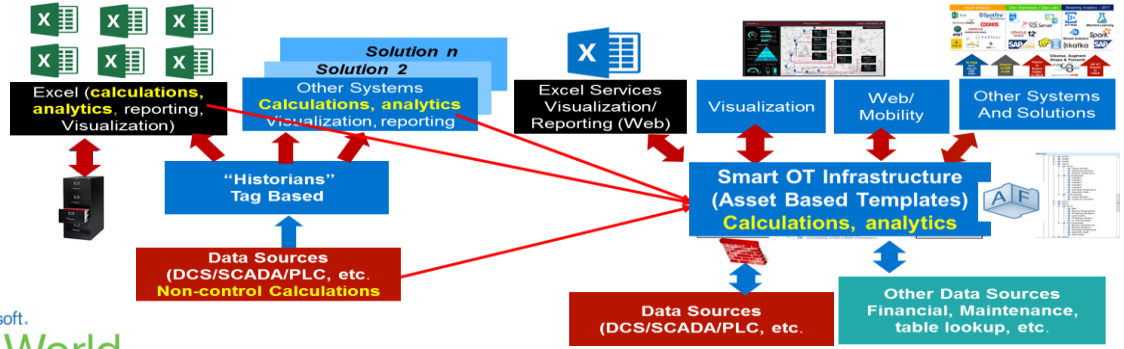
ENVIRONMENT, HEALTH, & SAFETY

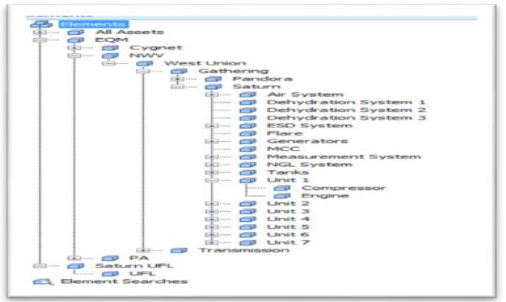








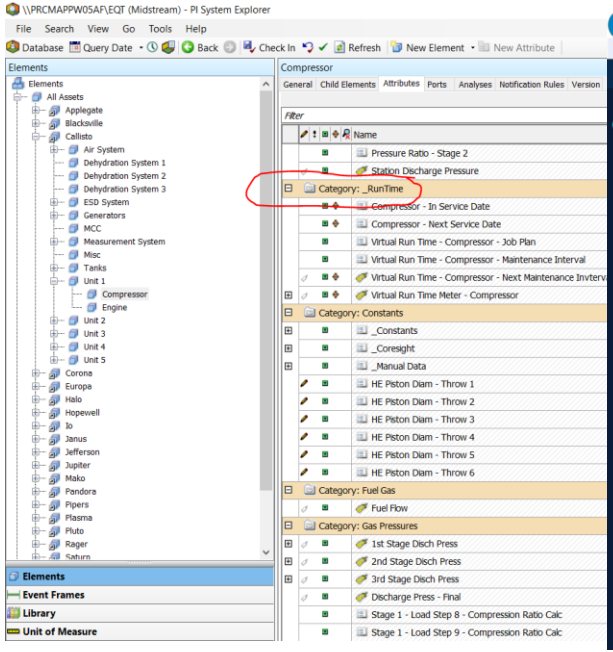


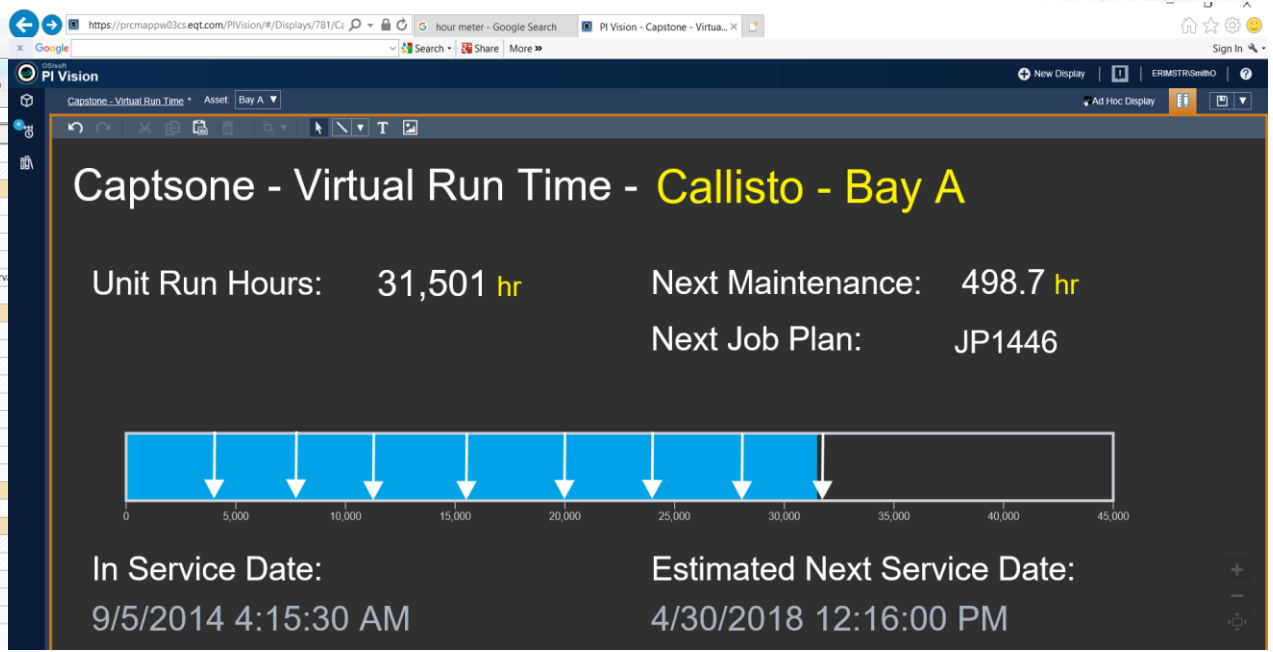


OSIsoft. PI World SAN FRANCISCO 2018

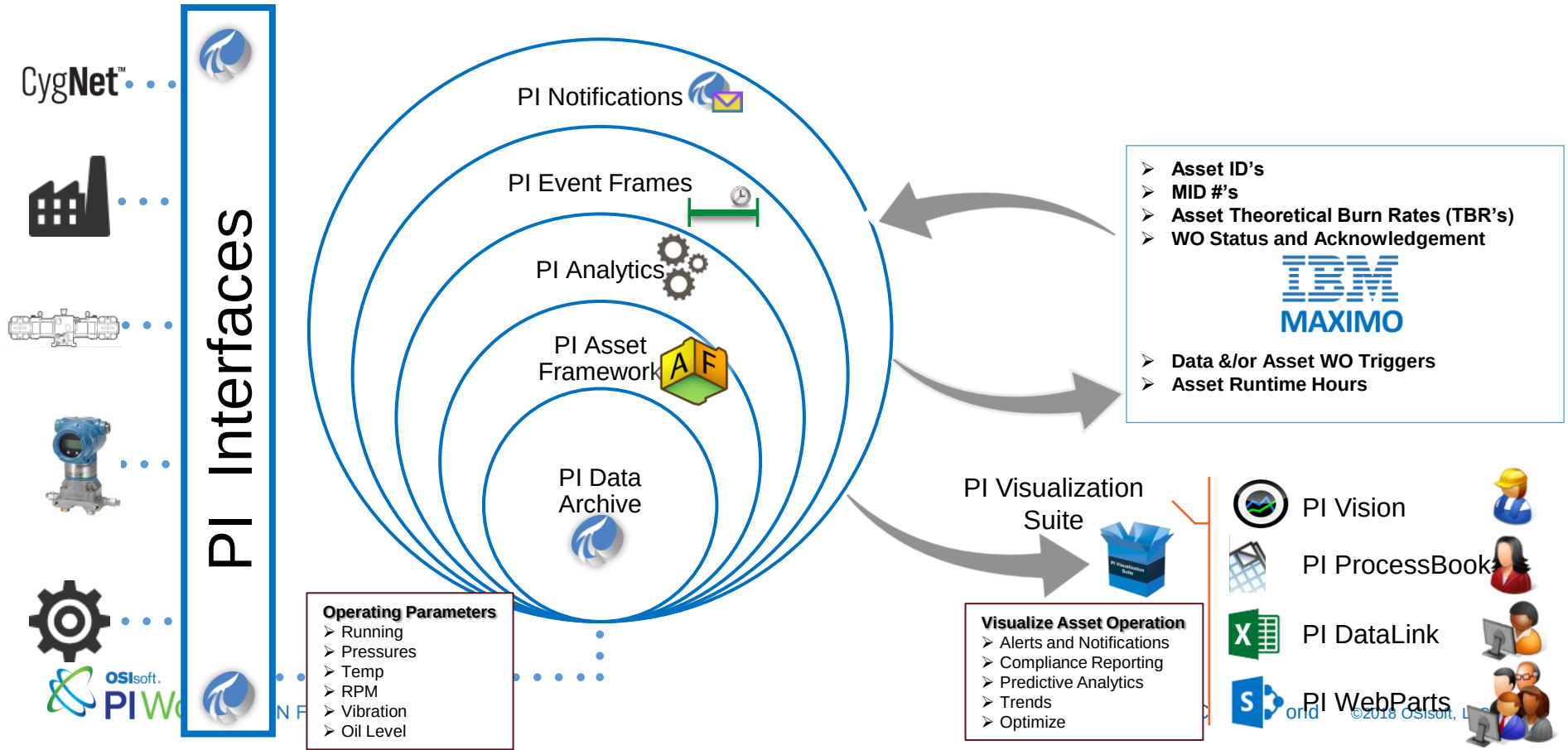
#OSIsoftUC #PIWorld

Scheduled / Condition Based Maintenance





EQT PI Preventive Maintenance / Work Management
Data Flow and Infrastructure Diagram



Case Studies and Benefits

Identification & Diagnosis of “Bad Actors”

Using PI Analytics & Notifications to Identify & Diagnose Recurring Issues

Case Study: Engine Load/Speed Control - Improve Equipment Availability & Reliability

Notification Name	Occurances in Last 24 Hours	Occurances in Last Week	Occurances in Last Month	Occurances YTD	Date of Last Occurance	Level
Saturn - Unit 3 - Eng - Speed High Delta Alert	7	64	169	410	10/3/2016 7:26	Level 1
Saturn - Unit 3 - Eng - High Fuel Position % Alert	0	8	11	11	10/1/2016 14:03	Level 1
Saturn - Unit 3 - Comp - Throw High Disch Temp Theo v Actual Alert	0	6	14	275	10/1/2016 21:15	Level 2
Saturn - Unit 3 - Comp - Shutdown Alert	0	4	10	51	9/29/2016 20:15	Level 1
Saturn - Unit 3 - Comp - Low Speed Alert	0	2	4	17	10/1/2016 11:25	Level 3
Saturn - Unit 3 - Eng - Load % Alert	0	1	1	6	9/29/2016 19:08	Level 2

Background

- Frequent Deviations Indicate Underlying Issues
- Identifying & Detecting Correlation of Deviations Improves Effectiveness of Diagnostics
- Prior to PI – Limited Visibility into Assets

Solution

- Leverage PI Analytics to Monitor Critical Parameters
- Develop PI Notifications to Alert & Track Deviations
- Reliability Review of “Bad Actors”

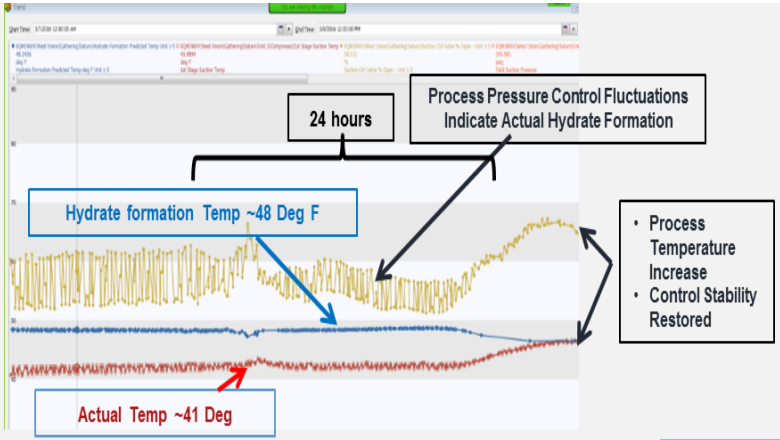
Results

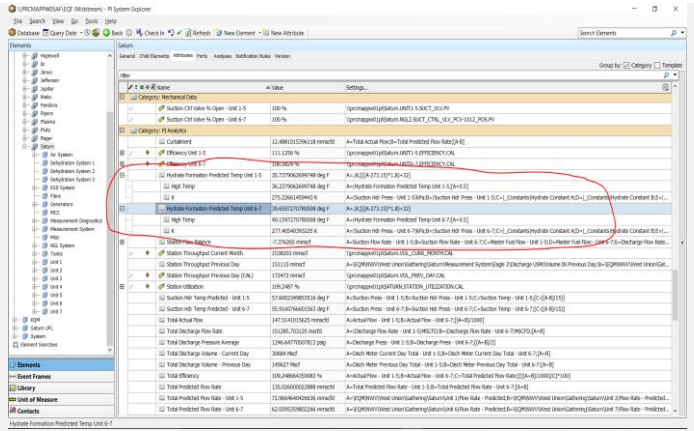
- Reduced Identification & Troubleshooting Time
- Reduce Repeat Shutdowns
- Eliminate Parts Consumption – Replace to Troubleshoot

Analysis of Trends & Operational Issues

Using PI Analytics & Notifications to Detect & Prevent Process Upsets

Case Study: Hydrate Formation : Reduce Process Interruptions & Optimize Assets





Background

- EQT Midstream Transports "Wellhead" Gas with High Concentration of C3+ Hydrocarbons
- Hydrates Can Form in "Heavy" or "Wet" Gas Applications
- Hydrates Can Interrupt/Block Gas Flow in Piping & Equip.
- Eliminate or Affect Hydrate Formation Line Via:
  1. Introduction of Inhibitor/Methanol
  2. Change Process to Avoid Hydrate Formation Area

Solution

- Leverage PI Analytics to Predict Hydrate Formation Temperature
- Use PI Notifications to Monitor Process/Hydrate Formation Temperature
- Alert Key Personnel to Potential Hydrate Formation
- Modify Process Accordingly to Avoid Interruptions/Upsets

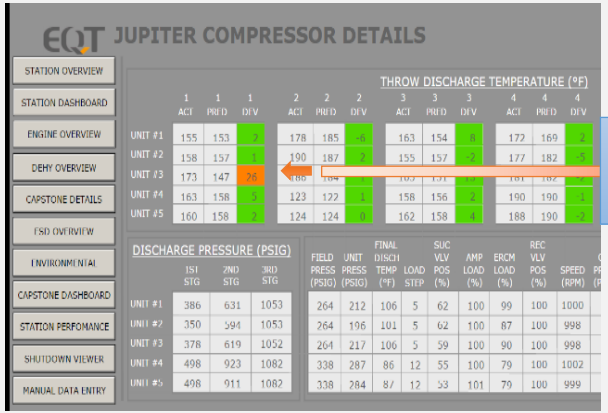
Results

- Modify Operations in Response to Notifications
- Reduce Operating Pressures to Avoid Hydrate Formation
- Reduced Capacity Vs. Complete Outage
- Minimize Dependency on Hydrate Inhibitor
  - Reduce Costs & Consumption
  - Eliminate Secondary Impacts of Inhibitor

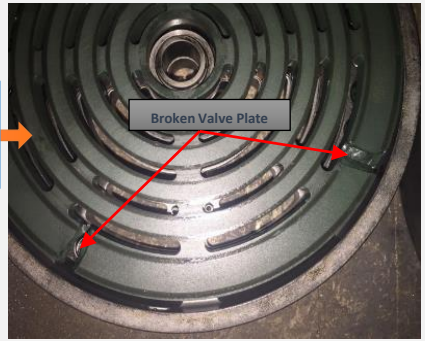
Engineering & Analysis to Maximize Resources

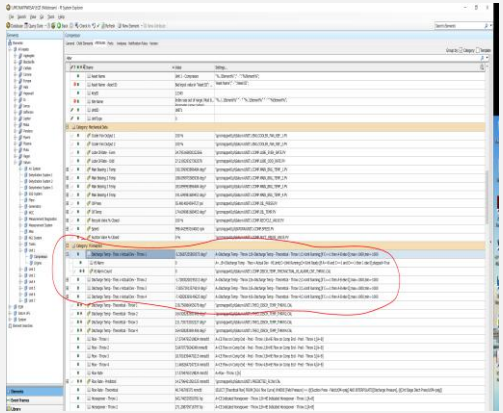
PI Analytics & Notifications to Reduce Field Data Collection Time

Case Study: Compressor Valve Condition – Targeted Use of Resources



High ΔT (Predicted vs. Actual)





Background

- Compressor Valves – High Frequency Failure
- Affect Compressor Performance & Efficiency
- Typically Identified by Equipment Analysts on Weekly/Semi-Weekly Field Analysis
- Equipment Analyst Time Valuable & Limited

Solution

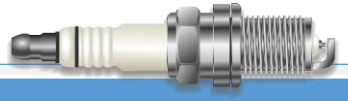
- Leverage PI Analytics to Predict Theoretical Gas Discharge Temperature
- High Deviation in Actual Temp. w/Predicted Indicates Potential Valve Issue
- Condition Based Analysis Vs. Time Based

Results

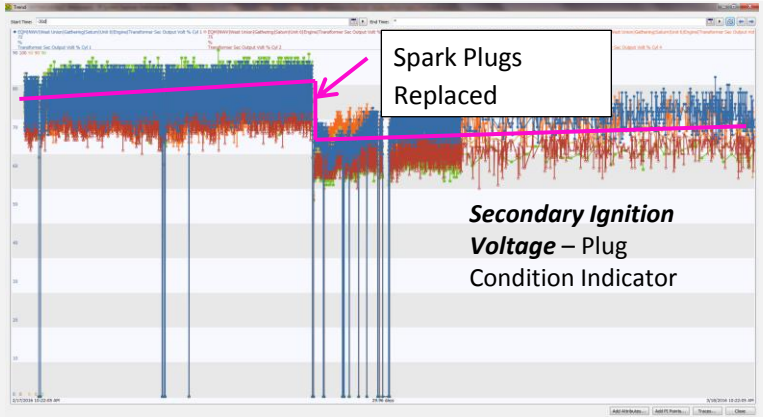
- Reduce Data Collection Time - Equipment Analyst
- Use PI as 1st Tier Approach to Focus Resources
- Repurpose Analyst Time to Other Areas of Condition Monitoring
- Provide Operations With Tools to Detect Issues Prior to Analyst Visit

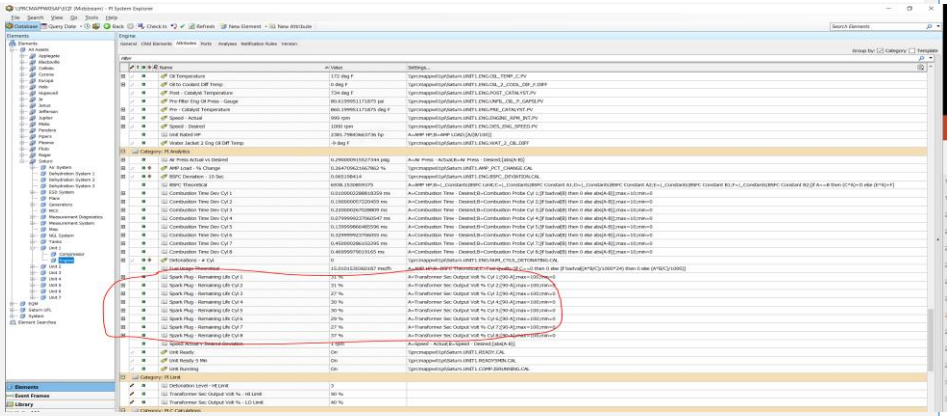
Data & Trends for Condition Based Maintenance

PI Trends & PI Analytics to Maximize Component Life & Value



Case Study: Spark Plugs – Insight into Equipment Condition





Background

- Spark Plug Life Varies by Application/Site
- Secondary Ignition Voltage – Leading Indicator of Plug Condition
- Voltage Increases Slowly as Plug Decays Over Time
- Plugs Represent Challenge with Utilizing Condition Monitoring & Maintenance

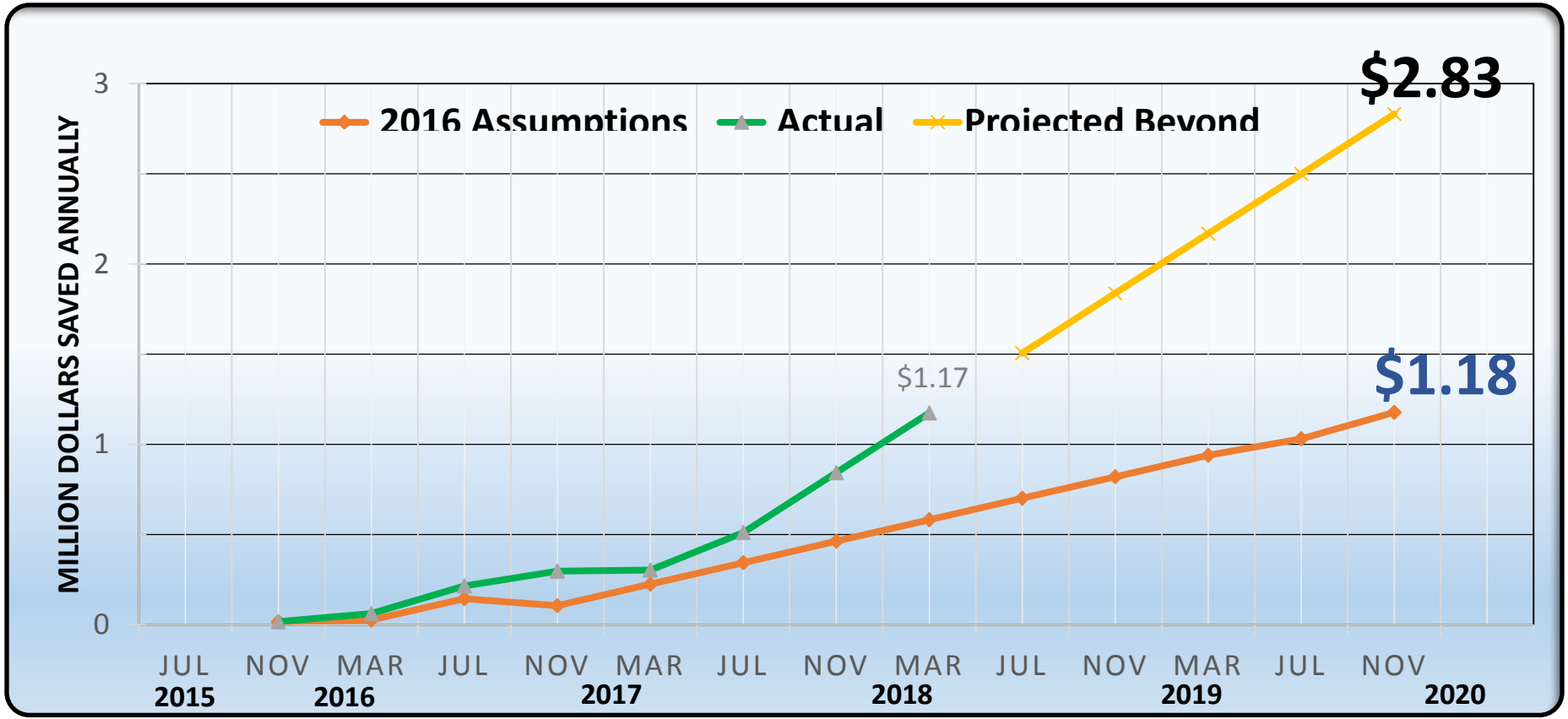
Solution

- Use PI Vision & Notifications to Trend Increase in Leading Indicator Value
- Integrate PI AF & Maximo to Generate WO at Defined Conditions
- Apply Spark Plug Philosophy to Other, Higher Impact Systems

Results

- Reduce Frequency of Spark Plug Changes
- Eliminate Downtime & Cost of Unnecessary Plug Changes
- PI/Maximo Integration – Develop Tracking System for Reliability Analysis
- Foundation to Begin Assessment of Condition Indicators & Application to Overarching Systems

EQT PI ANNUAL TANGIBLE SAVINGS FROM EVENT PREVENTION



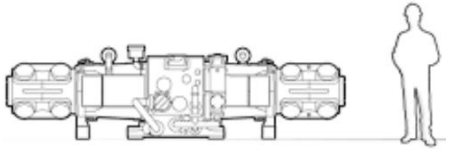
EQT

Where energy meets innovation.

Next Steps

Where are We Headed?

Digital Transformation



Digital Products → Product Innovation → Revenue Improvement

Data Driven Services → New Services → Revenue Improvement

Digitally Enabled Operations → Operational Excellence → Cost Reduction

A Cultural Change: People, Processes, & Technology

A Sustainable PI System Begins With Details

Long Term Vision & Management Support

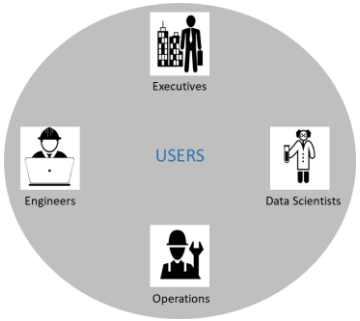
- Support Business Case w/Value
- Communicate Strategy
- Identify Resources
- Utilize PI System as Tool for a Culture Shift

Identify Critical Data & Build Foundation

- Data to Support Business Case
- Focus on Data Quality & Integrity from Beginning
- Develop Manageable Scope and Scale Up
- Develop AF to Support Long Term Strategy & Sustainability

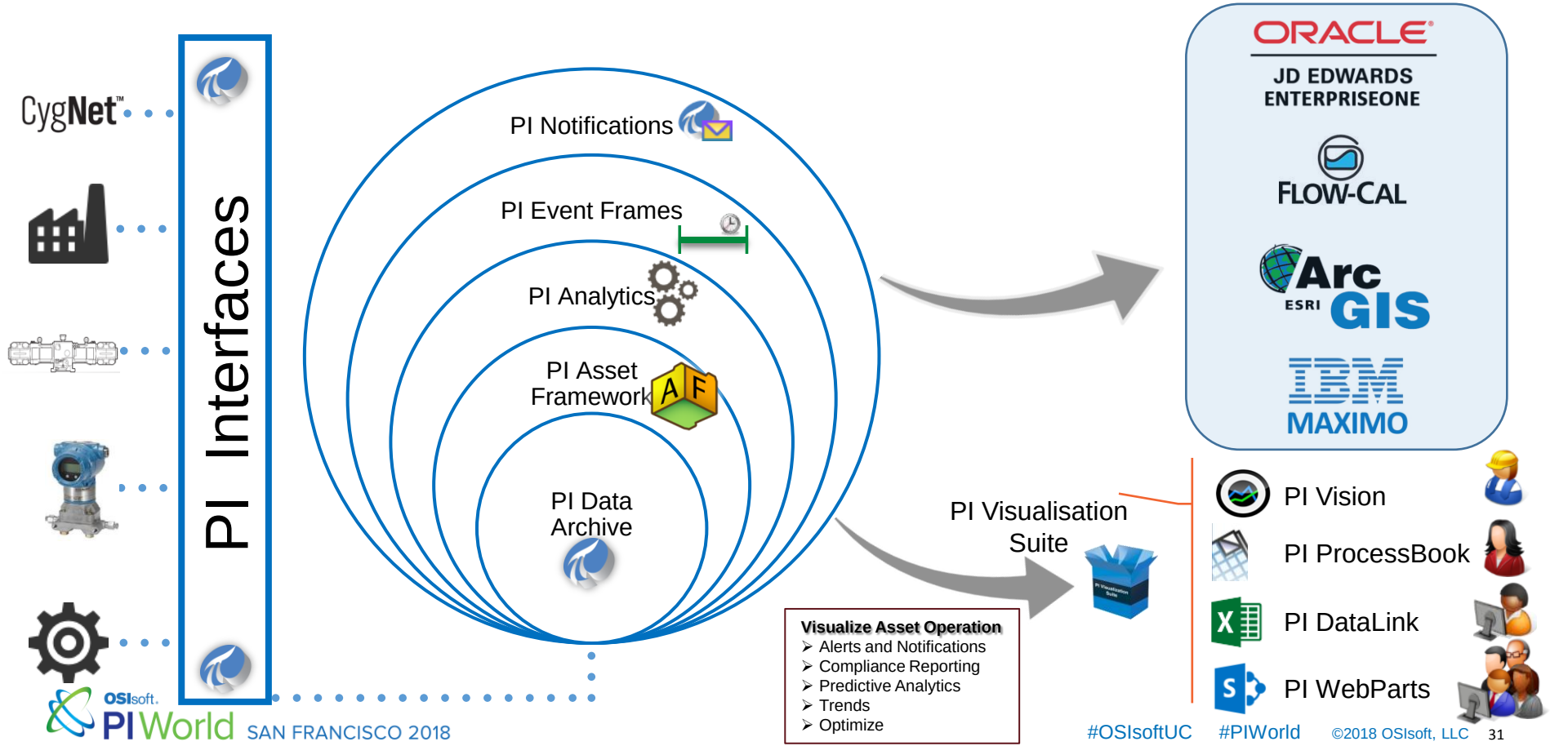
Communication & Feedback

- Engage Users in Development
- Build Tools & Process with Users in Mind



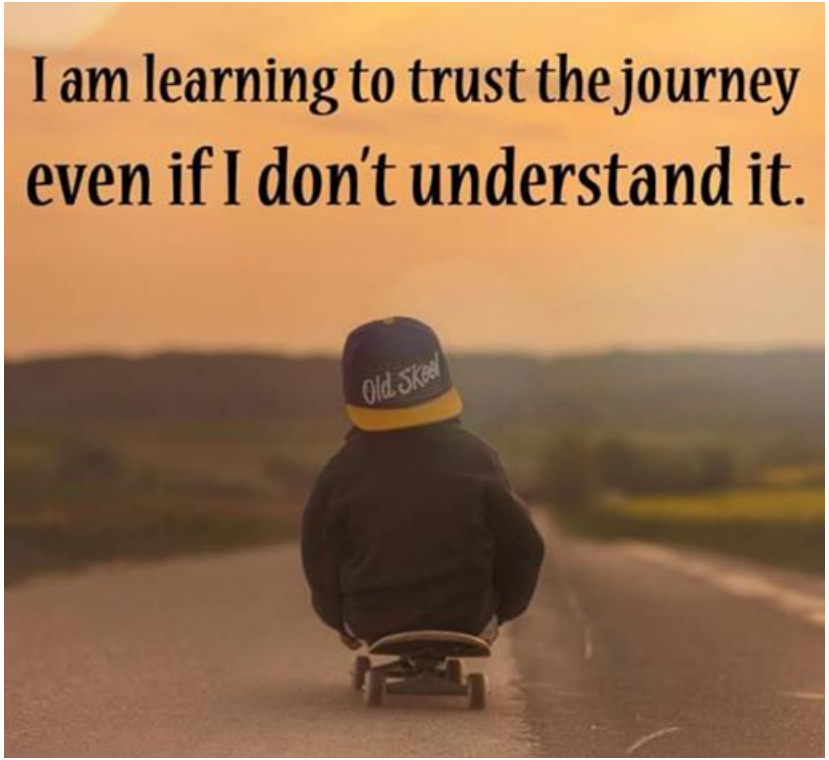
- Feedback Loop for System Improvement & Value

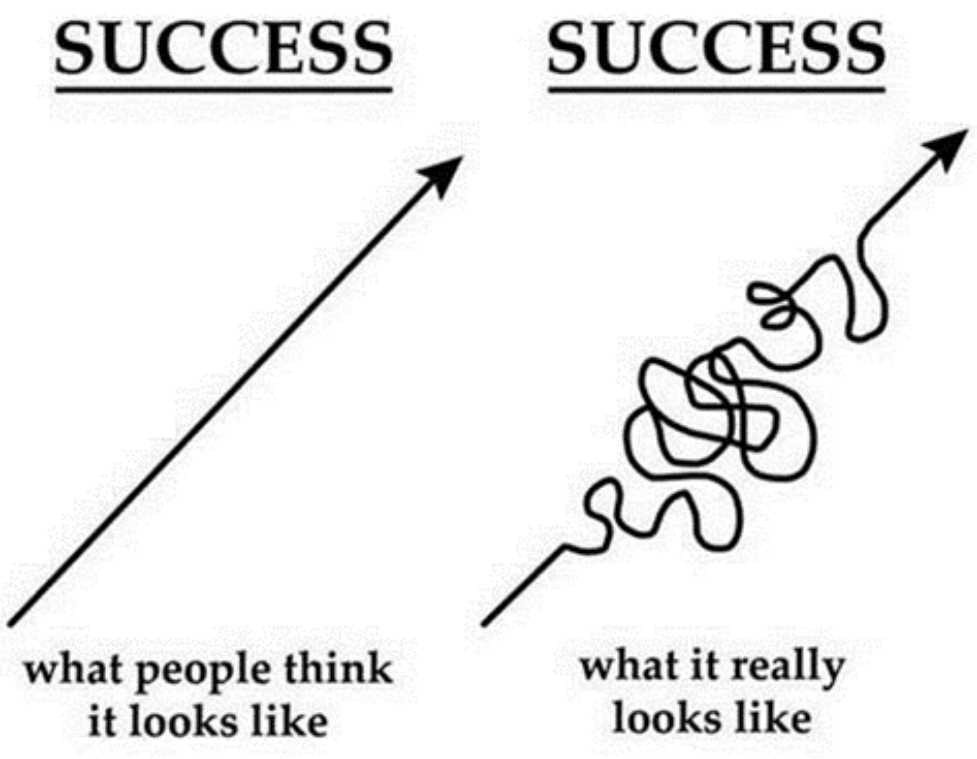
Looking Ahead: EQT Midstream & The PI System



Looking Ahead: EQT Midstream & The PI System

The Next Steps in the Journey Towards Digital Business Transformation





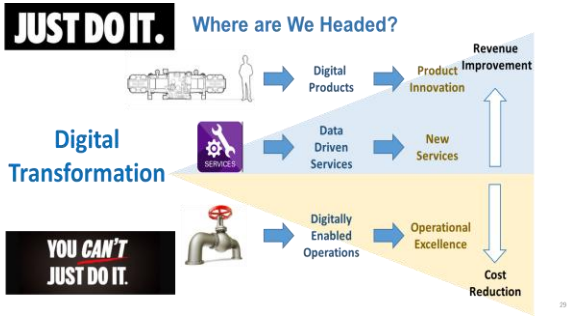
Enabling Business Transformation with the PI System

EQT Midstream PARTNERS, LP

Leverage normalized & contextualized OT data to enable a culture of operational excellence and continuous improvement

COMPANY AND GOAL

EQT Midstream provides NG gathering & transmission services. **Desired to transform their business to reduce costs & improve revenue** by supporting a culture of digital enablement and empowerment coupled with work process redesign



CHALLENGE

Desire to leverage digital technology to enable operational excellence to deliver transformative business value

- Maximize Throughput
- Optimize Asset Reliability & Availability
- Lower O&M Costs thru cost effective operations & maintenance
- Improve asset integrity and overall safety and environmental performance

SOLUTION

Selected the PI System as a strategic enterprise OT infrastructure to provide the foundation for our business transformation journey

- Initial POC on a compressor station
- Grow capabilities and awareness of the power of the PI System
- SME enablement and empowerment
- Work process redesign leveraging normalized, contextualized data

RESULTS

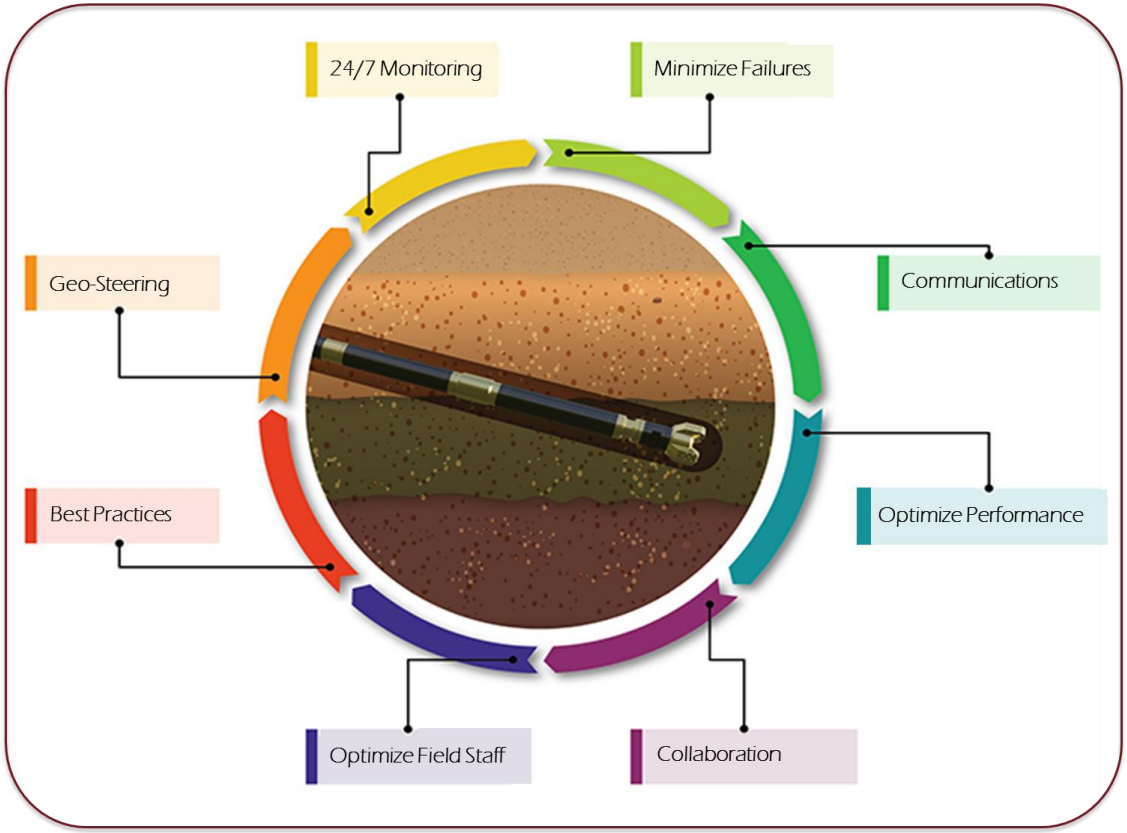
An estimated Annual Cumulative Tangible Savings from event prevention was estimated at **$1M** is now projected to be an annual savings of **$3M** by 2020.

- Rollout to 40 locations
- Reduced O&M cost, safety and environmental incidents
- PI AF templates enable rapid scale and SME enablement
- Changing culture and work processed – a true transformation

EPC Real Time Data

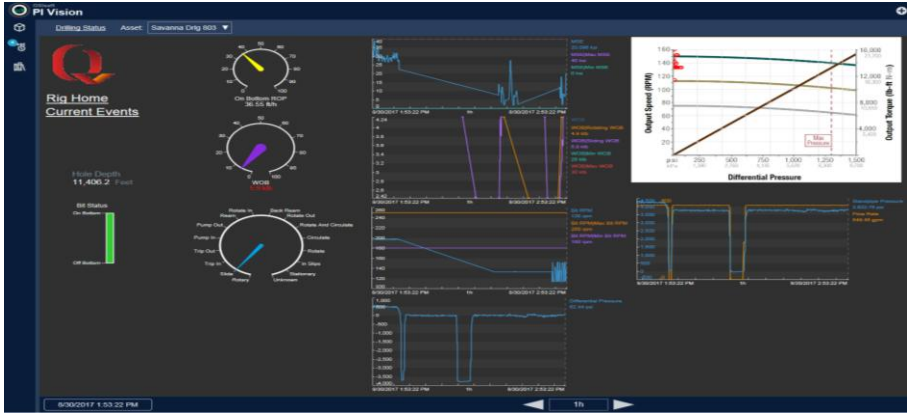
EQT Real Time Operations Center

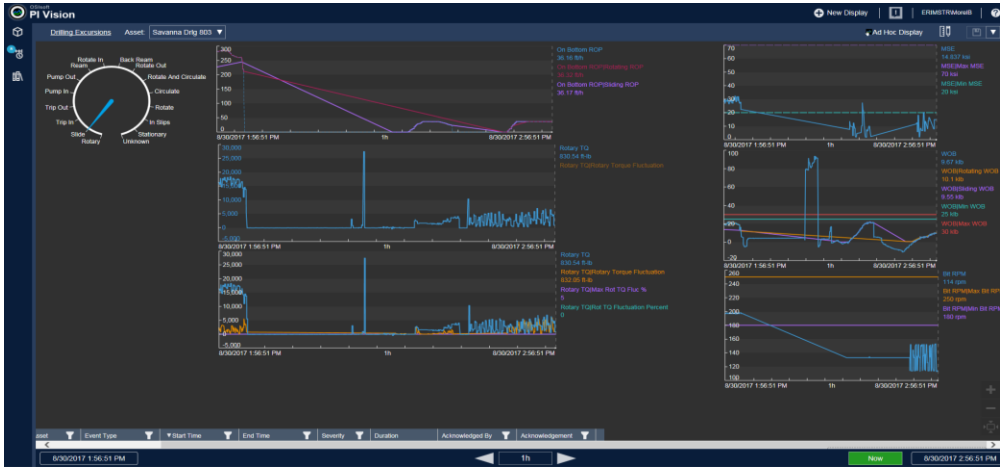
- RTOC Goals
  - Minimize People on Locations
  - Optimize Field Resources
  - Enhance Collaboration
  - Reduce Inefficiencies & Failures
  - Improve Consistency
  - Maintain Low Costs
- Upstream Direction
  - Drilling
  - Completions
  - Production
  - Logistics
    - Water
    - Construction



Drilling – OSIsoft PI System Trial

- 2016 – Strategy Developed
  - Focused on resource allocation & data driven decisions
- 2017 – Completed 3 Month Trial
  - Resources allocated by OSI and Midstream
  - Completed all trial targets
  - Single EQT resource to develop
- Event Frames - Alerts
  - Performance Roadmaps
  - Best Practices
  - Trend changes
  - Failure Analysis Feedback Loop
  - Drilling State Analytics
- Automated Performance Metrics
  - Footage / ROP details
  - On/Off bottom time

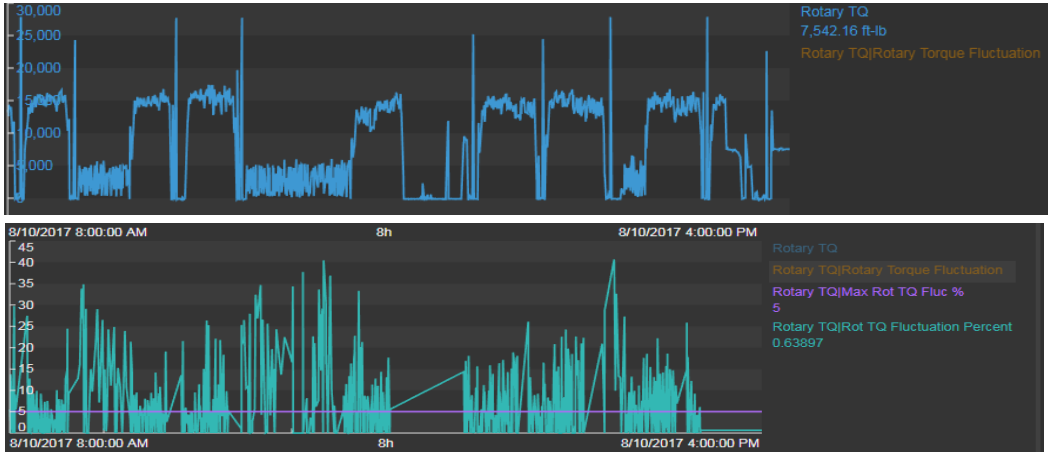




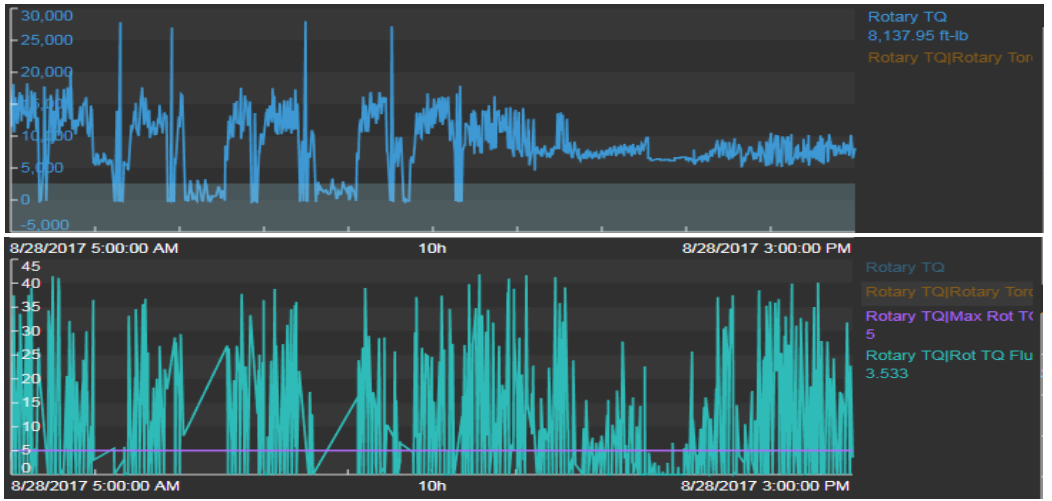
Failure Prediction

- Torque Fluctuation
  - Bit Failure Occurred
  - Surface Measurement
  - Target Value Exceeded
- Alerts
  - RTOC Staff
  - Elevated Alerts
  - Acknowledge

Example 1



Example 2

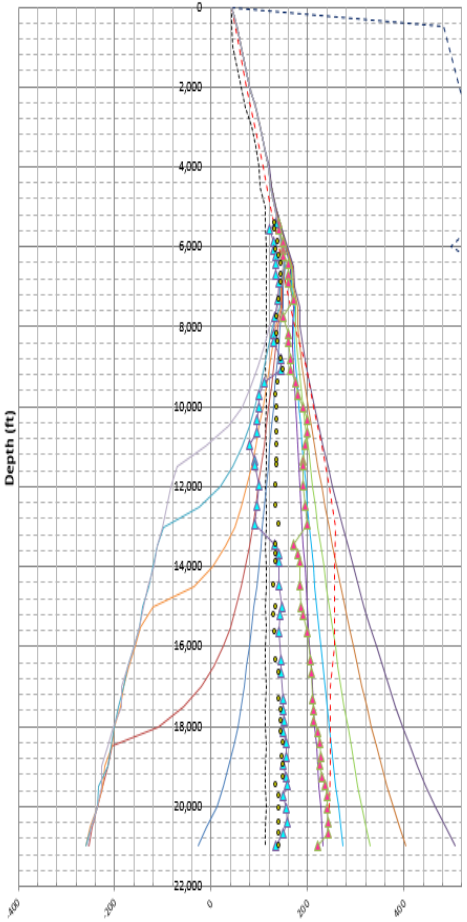


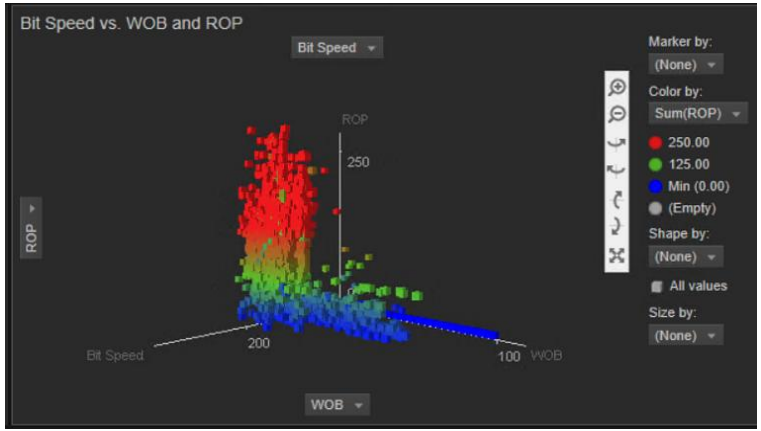
Failure Prevention

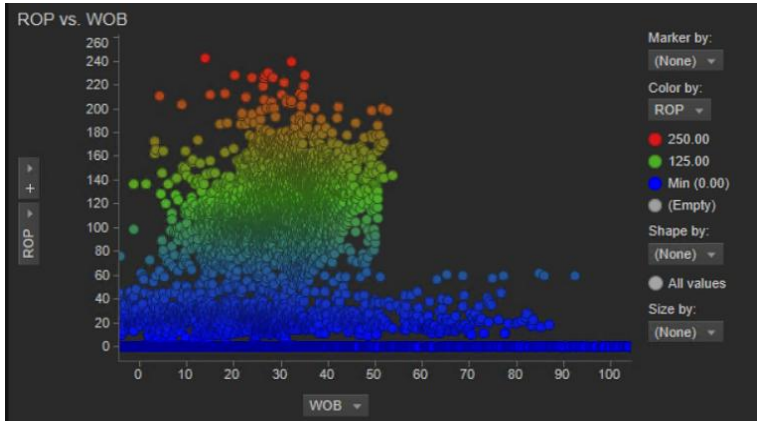
Event Name	Asset	Event Type	▼Start Time	End Time	Severity	Duration	Acknowledged By	Acknowledgement
Torque Excursion Savanna Drlg 803 2017-08-31 04:56:26	SAVANNA DRL G 803	Torque Excursion	8/31/2017 4:56:26 AM	8/31/2017 5:17:59 AM	Warning	21m 33s		Acknowledge
Rotary RPM Excursion Savanna Drlg 803 2017-08-31 04:52:00	SAVANNA DRL G 803	Rotary RPM Excursion	8/31/2017 4:52:00 AM	8/31/2017 5:18:41 AM	None	26m 40s		⊘
UCS Decrease Savanna Drlg 803 2017-08-31 04:50:59	SAVANNA DRL G 803	UCS Decrease	8/31/2017 4:50:59 AM	8/31/2017 4:56:56 AM	None	5m 56s		Acknowledge

Future Additions

- Optimization Design Tool
  - Roadmaps
  - Inefficiencies
  - RT Parameter Guidance
    - Machine Learning
- Failure Analysis
  - Event Alerts
- Robust Data Connections
- Collision Avoidance
- Automated Drilling Tools
  - Live Performance Metrics
  - Drilling Parameters
  - Real Time Engineering Tool

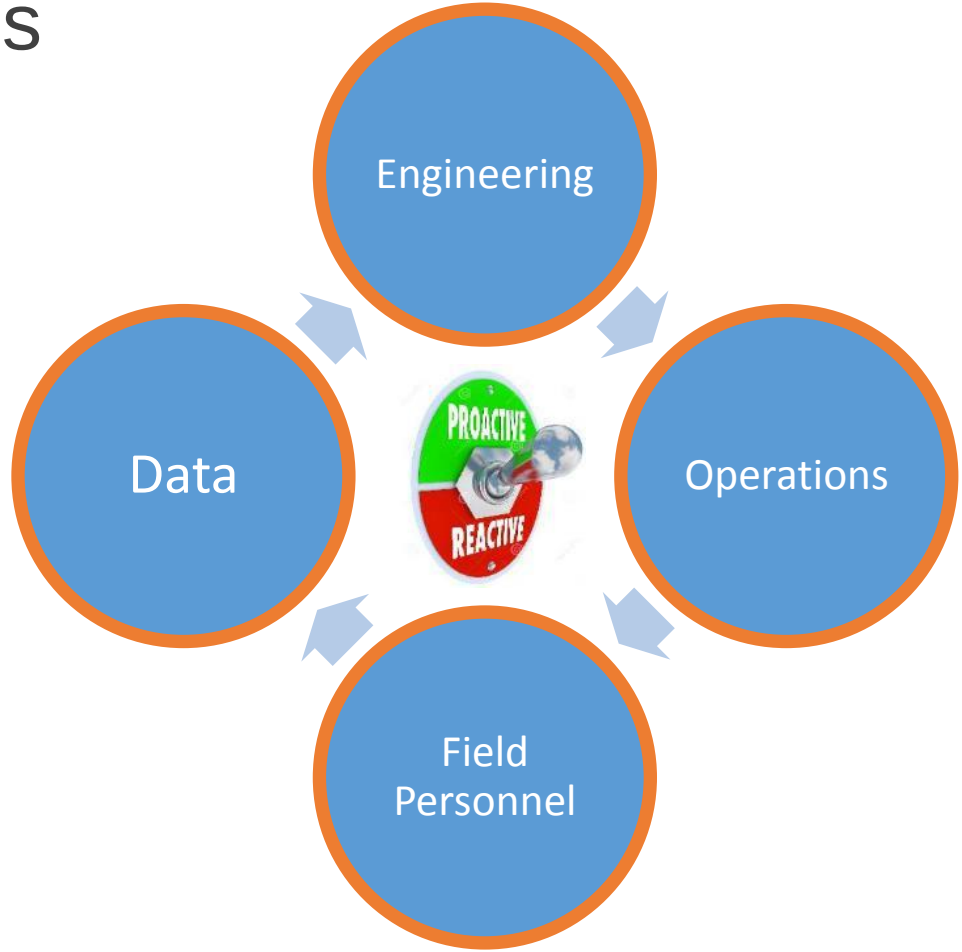




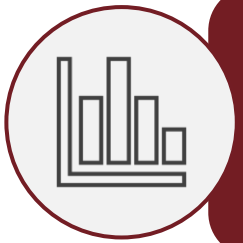


Organizational Challenges

- Culture Change
  - Vendor Buy In
  - Field Personnel
  - Effective Communication Plan
- Managing Issues
  - Power / Facility Interruptions
  - Office Distraction
  - Failures / Hole Problems / NPT
- Data / IT Requirements
  - 24/7 Office & Field Support
  - New Technology / Architecture Solutions
  - Data Speed / Volume Requirements
  - Data Sources
- Field Communications
  - Standardization
  - Reliability
  - Consistency
  - Push / Pull Capabilities
  - Transcripts



Production Engineering & Operations

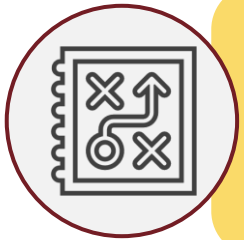


Historian

- Real time data for existing facilities in Cygnet

Analytics

- Development of alarms that require trending or addition computation out of the traditional high/low bounds
- WMO – Asset tracking and automated work order creation with real time data
- Condition based maintenance

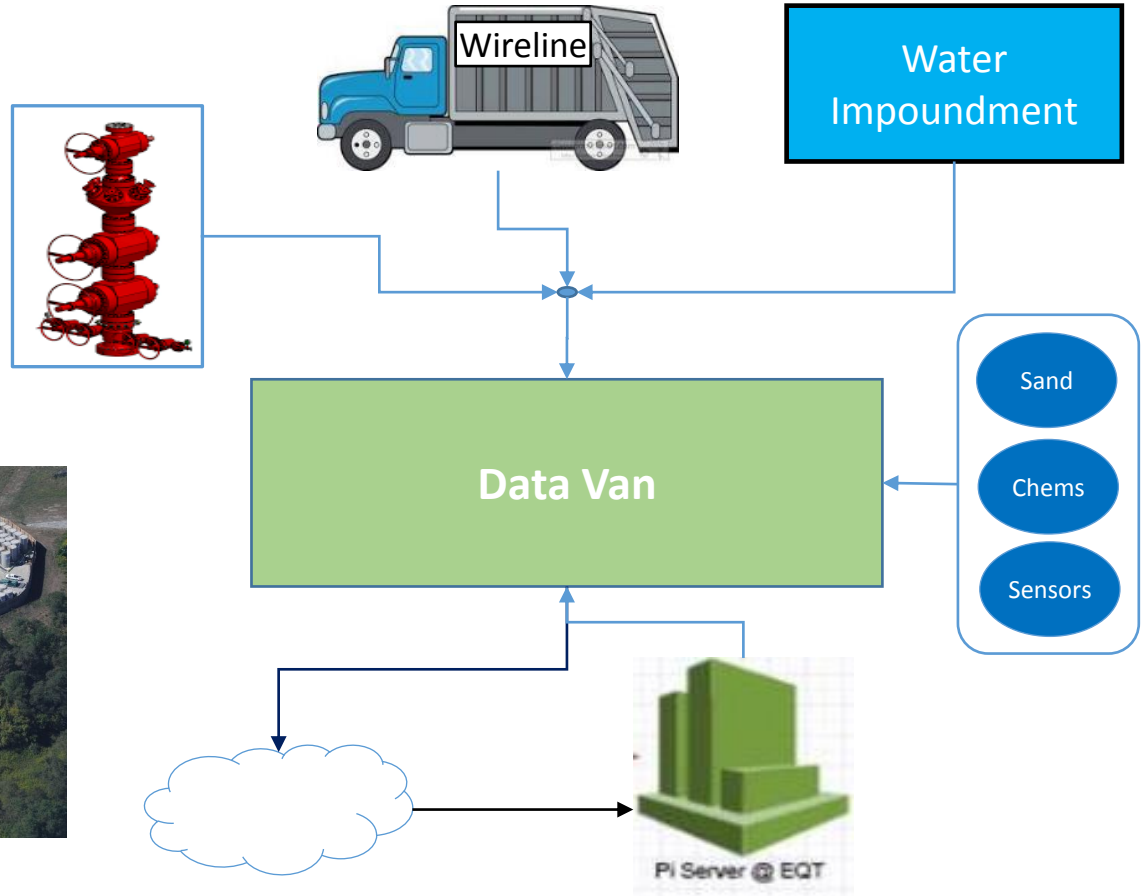


Optimization

- Reduce downtime when utilizing event frames coupled with Maximo data
- Employing Event Frames to automate artificial lift intervention including but not limited to tubing and plungers
- System volume optimization based on current conditions

Completions RTOC Pilot

- Data Collection
- Scoping Details
  - Chemical Optimization
  - Performance Roadmaps
  - Standardization
  - Basic Failure Prediction



Enabling EQT E&P's RT Operations Center with the PI System

EQT
Where energy meets innovation.

Moving from reactive to proactive operations in EQT's E&P to drive transformative business value

COMPANY AND GOAL

Leverage the PI System and partnerships to **maintain and improvement upon low development cost model** through minimizing people on locations, optimize field resources, enhancing collaboration, reducing inefficiencies & failures, and improving consistency, while minimizing EHS and safety incidents.

CHALLENGE

Main challenges in implementing the RT Operations Center and accomplishing the E&P goals included:

- Cultural Change & Alignment
- Management of "issues"
- Data & IT Requirements
- Remote operations communications

SOLUTION

Leveraged the PI System and experience gained in EQT Midstream to expand into the E&P Division

- Conducted POCs in drilling
- Leverage PI AF to support decisions from new EQT Operations Center
- Developed PI AF templates, analytics, event frames, notifications, and PI Vision displays.

RESULTS

Validated the PI System's ability to support drilling and completions with real-time situational awareness, analytics, and decision support.

- Expanding portfolio of drilling functionality
- Expanding into Production & Completions
- Addressing challenges to enable a full use of the Real-time Operations Center

The Evolution of PI at EQT

- **Oscar Smith**
- osmith@eqt.com
- Senior Principle Engineer
- EQT Midstream

- **Brian Morel**
- bmorel@eqt.com
- Director Drilling Engineering
- EQT Production

Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

Please remember to…

Complete the Online Survey for this session

Merci

谢谢

Danke

Спасибо

Gracias

Thank You

감사합니다

ありがとう

Grazie

Obrigado

Optional: Click to add a takeaway you wish the audience to leave with.