



# Delivering Transformative Business Value in O&G with the PI System

## 7 Key Differentiators

Presented by: Craig Harclerode - O&G Industry Principal

# Key Differentiator #1

They recognize the focus is delivering **business value** defined by a **business case** and the **time value of money**, not **technology** or necessarily the **cost of the technology** .....they are guided by the “4M” strategy

**Make Me More Money!**

# Delivering \$1B Business Value from Digital Transformation in ~5 years

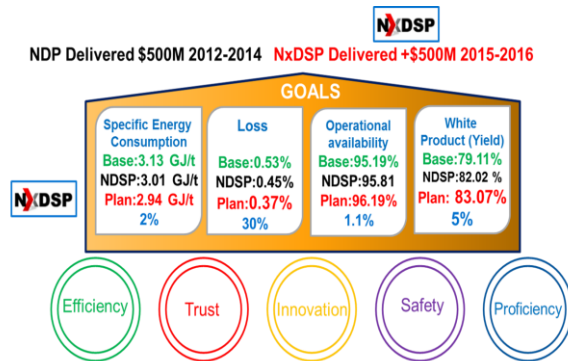
## COMPANY and GOAL

Deliver \$1B in EBITDA by a business transformation enabled by a digital transformation leveraging the PI System as a strategic OT data infrastructure for advanced predictive and proactive analytics



## Presentation

2016 Analytics, IOT, Big Data



## CHALLENGE

Deliver strategic business value to respond to increasing competitive threats; **Change a diverse culture to “act as one”** with Operational Excellence & continuous improvement enablement.

- Increasing competitive environment in Eastern Europe
- Variable cracked spread
- Diverse culture across 8 countries
- Low use of data and analytics
- Poor business performance 4<sup>th</sup> Qtle

## SOLUTION

Evolved the use of the PI System as a tag based historian to an asset based infrastructure to **support cultural change and data based decision making and support** with advanced predictive and proactive analytics.

- Evolved from Tag to PI AF based infrastructure across the MOL fuels value chain
- Normalized tag, asset, UOM, and time using PI AF as an abstraction layer
- Used data and information to support business transformation

## RESULTS

Delivering on the MOL Downstream business transformation goal of \$1B and more importantly, a sustainable **cultural change based on data and information** to drive **operational excellence** going forward into the 21st century.

- Leading Process Safety Management
- 1<sup>st</sup> Quartile in energy, yields, loss, and utilization
- OT infrastructure enabling time to value and value momentum with advanced analytics including machine learning

## Key Differentiator #2

They **leverage PI AF element templates** like lego blocks **owned by SMEs** and in doing so, **redefined the roles between OT and IT** and enabled OT/IT collaboration via a common language – **“the language of the PI System”**

# TransCanada Anomaly Detection & Predictive Analytics



## Physical Compressor Stations



Item	Value
Item 1	Value 1
Item 2	Value 2
Item 3	Value 3
Item 4	Value 4
Item 5	Value 5
Item 6	Value 6
Item 7	Value 7
Item 8	Value 8
Item 9	Value 9
Item 10	Value 10



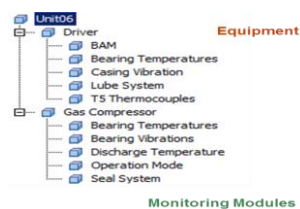
## Centrifugal Compressor Templates

Item	Value
Item 1	Value 1
Item 2	Value 2
Item 3	Value 3
Item 4	Value 4
Item 5	Value 5
Item 6	Value 6
Item 7	Value 7
Item 8	Value 8
Item 9	Value 9
Item 10	Value 10

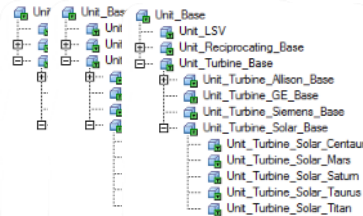
Availability	Performance	Quality
<b>Downtime</b> ✓ Event Frames ✓ Downtime classification ✓ Planned vs. unplanned ✓ Maintenance data	<b>Runtime</b> ✓ Event Frames ✓ RACR ✓ Horse power usage ✓ Efficiency	<b>Anomaly Detection</b> ✓ Sensor data behavior based on historical normal ✓ Oil analysis ✓ Equipment analysis reports
<b>Health Index</b>		

## Health Index Templates

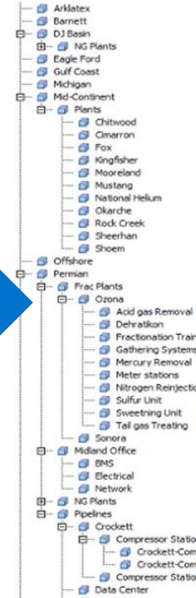
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## Anomaly Detection Templates



## Digital Compressor Stations

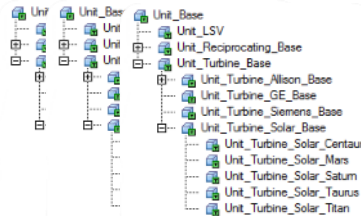


## TransCanada Smart OT Infrastructure

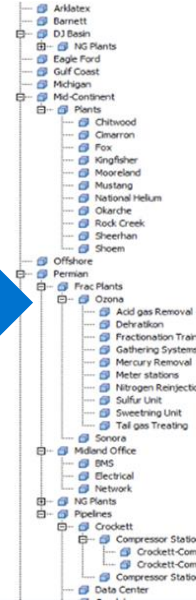
# TransCanada Anomaly Detection & Predictive Analytics



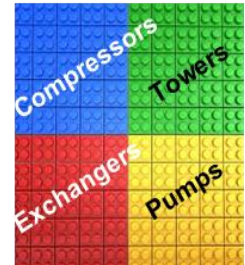
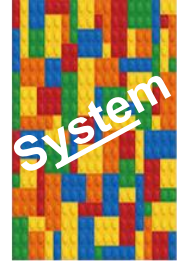
## Physical Compressor Stations



## Digital Compressor Stations



## TransCanada Smart OT Infrastructure



Equipment	Location	Status
Compressor	Station 1	Operational
Compressor	Station 2	Operational
Compressor	Station 3	Operational
Compressor	Station 4	Operational
Compressor	Station 5	Operational
Compressor	Station 6	Operational
Compressor	Station 7	Operational
Compressor	Station 8	Operational
Compressor	Station 9	Operational
Compressor	Station 10	Operational
Compressor	Station 11	Operational
Compressor	Station 12	Operational
Compressor	Station 13	Operational
Compressor	Station 14	Operational
Compressor	Station 15	Operational
Compressor	Station 16	Operational
Compressor	Station 17	Operational
Compressor	Station 18	Operational
Compressor	Station 19	Operational
Compressor	Station 20	Operational



## Centrifugal Compressor Templates



Performance	Quality
<ul style="list-style-type: none"> <li>Efficiency</li> <li>Power usage</li> <li>Capacity</li> </ul>	<ul style="list-style-type: none"> <li>Anomaly Detection                             <ul style="list-style-type: none"> <li>Sensor data behavior based on historical normal</li> <li>Oil analysis</li> <li>Equipment analysis reports</li> </ul> </li> </ul>

## plates

Equipment	Location	Status
Compressor	Station 1	Operational
Compressor	Station 2	Operational
Compressor	Station 3	Operational
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Compressor	Station 5	Operational
Compressor	Station 6	Operational
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Compressor	Station 10	Operational
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Compressor	Station 12	Operational
Compressor	Station 13	Operational
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Compressor	Station 17	Operational
Compressor	Station 18	Operational
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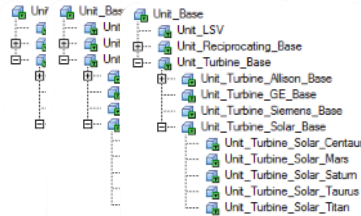
## Monitoring Modules

## Anomaly Detection Templates

# TransCanada Anomaly Detection & Predictive Analytics

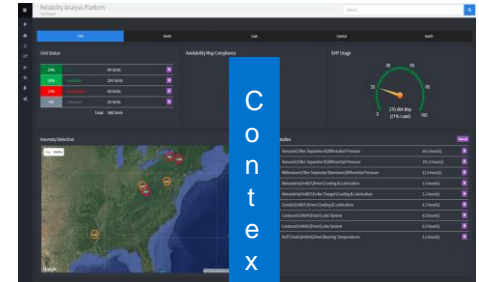


## Physical Compressor Stations



## Digital Compressor Stations

Exception based KPI Dashboard system



Contextual Drill Down

Compressor	Model	Capacity	Efficiency
101	101	101	101
102	102	102	102
103	103	103	103
104	104	104	104
105	105	105	105
106	106	106	106
107	107	107	107
108	108	108	108
109	109	109	109
110	110	110	110



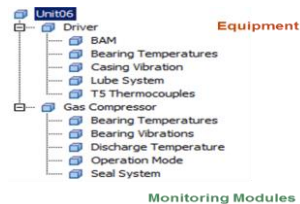
## Centrifugal Compressor Templates

Compressor	Model	Capacity	Efficiency
101	101	101	101
102	102	102	102
103	103	103	103
104	104	104	104
105	105	105	105
106	106	106	106
107	107	107	107
108	108	108	108
109	109	109	109
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Availability	Performance	Quality
<b>Health Index</b>		
<b>Downtime</b>	<b>Runtime</b>	<b>Anomaly Detection</b>
<ul style="list-style-type: none"> <li>Event Frames</li> <li>Downtime classification</li> <li>Planned vs. unplanned</li> <li>Maintenance data</li> </ul>	<ul style="list-style-type: none"> <li>Event Frames</li> <li>RACR</li> <li>Horse power usage</li> <li>Efficiency</li> </ul>	<ul style="list-style-type: none"> <li>Sensor data behavior based on historical normal</li> <li>OI analysis</li> <li>Equipment analysis reports</li> </ul>

## Health Index Templates

Compressor	Model	Capacity	Efficiency
101	101	101	101
102	102	102	102
103	103	103	103
104	104	104	104
105	105	105	105
106	106	106	106
107	107	107	107
108	108	108	108
109	109	109	109
110	110	110	110



## Anomaly Detection Templates

## TransCanada Smart OT Infrastructure

# Portfolio of Templates for Drivers & Compressors

## Library

- Cooler
- Driver\_
  - Driver\_Electric
  - Driver\_Recip
    - Driver\_Recip\_Ajax\_
    - Driver\_Recip\_Cat\_
    - Driver\_Recip\_Clark\_
    - Driver\_Recip\_Cooper\_
    - Driver\_Recip\_Enterprise\_
    - Driver\_Recip\_IngersollRand\_
    - Driver\_Recip\_Waukesha\_
    - Driver\_Recip\_WhiteSuperior\_
    - Driver\_Recip\_Worthington\_
  - Driver\_Turbine
    - Driver\_Turbine\_Allison\_
    - Driver\_Turbine\_GE\_
    - Driver\_Turbine\_Pratt\_
    - Driver\_Turbine\_RollsRoyce\_
    - Driver\_Turbine\_Siemens\_
    - Driver\_Turbine\_Solar\_
- FilterSeparator
- GasCompressor\_
  - GasCompressorCylinder\_
- Gearbox
- SuperCharger
- TurboCharger
- MonitoringModule\_
  - MonitoringModule\_Compression\_Unit\_
    - MonitoringModule\_BAM\_Solar
    - MonitoringModule\_BearingTemps\_Compressor\_Centrif
    - MonitoringModule\_BearingTemps\_Compressor\_Recip\_
    - MonitoringModule\_BearingTemps\_Driver\_Electric
    - MonitoringModule\_BearingTemps\_Driver\_Recip\_
    - MonitoringModule\_BearingTemps\_Driver\_Turbine
    - MonitoringModule\_BearingTemps\_Driver\_Turbine Allison



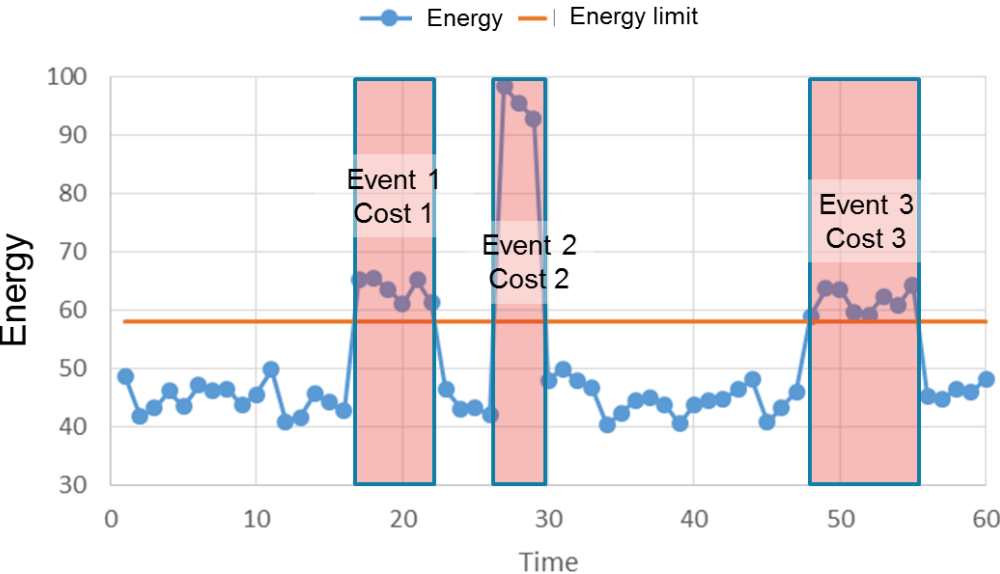
## Elements

- Unit07
- Unit08
- Unit09
- Unit10
  - Driver
    - Casing Vibration
    - Cooling & Lubrication
    - Exhaust Temperature
  - Gas Compressor
    - Cylinder1
    - Cylinder2
    - Cylinder3
    - Cylinder4
    - Cylinder5
    - Discharge Temperature
    - Operation Mode
  - Turbo Charger
    - Casing Vibration
    - Cooling & Lubrication
- Unit11
- Unit12
  - Driver
    - BAM
    - Bearing Temperatures
    - GP Bearing Vibrations
    - Lube System
    - PT Bearing Vibration
    - T5 Thermocouples
  - Gas Compressor
    - Bearing Temperatures
    - Bearing Vibrations
    - Discharge Temperature
    - Operation Mode
    - Seal System
- Unit13



# PI Event Frames – Energy Over consumption events

Ability to create Event Frame Templates and apply retroactively..ie – “IF I have this event definition, how many times in the past would I have seen it?”



**Library**

- Assets
  - Templates
    - Element Templates
      - Event Frame Templates
        - BazsolajBatch
          - BazsolajBatchTartaly
          - BazsolajBatchTartalyISOPetr
          - BazsolajBatchTartalyHRIGTer
          - BazsolajBatchTartalyMekFin
          - BazsolajBatchTartalyOkRaF
          - BazsolajBatchTartalyOkRaFag
          - BazsolajBatchTartalyOkRaFamFin
          - BazsolajBatchTartalyOkRaFm
          - BazsolajBatchTartalyPamAag
          - BazsolajBatchUzem
          - BazsolajBatchUzemDKOH
          - BazsolajBatchUzemDMK1
          - BazsolajBatchUzemDMK2
          - BazsolajBatchUzemDOKP
          - BazsolajBatchUzemDPAM
          - Coke Drum change
          - Coke drum preheating
          - Energy KPI System Deviation (Tier6)
          - Kanracklus
          - Operating mode
          - Operation
          - Phase
          - PhaseState
          - PhaseStep
          - Procedure
          - shift
          - Tank Overheat
          - TechnologyDataSheet Exceedance
          - Template66
          - UnitProcedure
- Model Templates
- Notification Templates
- Transfer Templates
- Enumeration Sets
- Reference Types
- Tables
- Table Connections
- Categories
- Analysis Categories

**Energy KPI System Deviation (Tier6)**

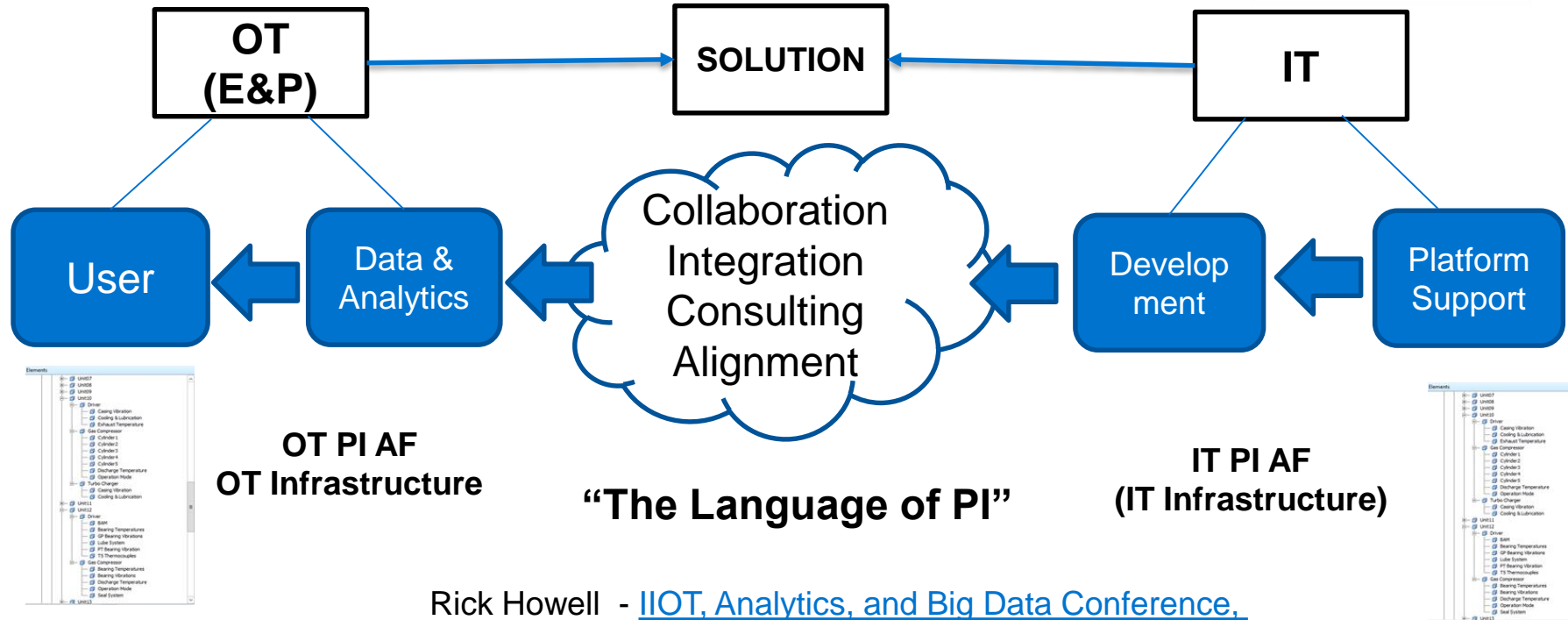
General | Attribute Templates

Filter

Name	Description
<b>Category: General Attributes</b>	
Asset ID	Készülék azonosító
Asset Name	Készülék neve
Asset Type	Készülék típusa
Block ID	Üzemcsoport azonosítója
Block Name	Üzemcsoport neve
Energy Type	Energia típus
KOI ID	
KOI Name	
Unit ID	Üzem azonosítója
Unit Name	Üzem neve
Usage Type	Felhasználási fajta
Utility Type	Segédenergia típus
<b>Category: Operational Parameter</b>	
Energy relevant	Energia túlfogyasztás
Limitation	Figyelembe vett határérték
<b>Category: Time Aggregated Data</b>	
Deviation Increment Total	KOI által okozott TS szintű eltérés (dőben integrálva)
KOI Cost Increment	KOI eltérés költséghez való hozzájárulása
KOI Cost Increment Ratio	KOI eltérés költséghez való hozzájárulása
TS Deviation Cost Total	TS Eltérés költsége (dőben integrálva)
TS Deviation Total	TS Eltérés (dőben integrálva)



# Devon's Digitally Enhanced Business Transformation- "Our Secret Sause"



Rick Howell - [IIOT, Analytics, and Big Data Conference, Houston, October 12, 2016](#)

# Key Differentiator #3

They leverage a “**hybrid data lake strategy**”  
and the ability to **leverage cleansed,  
augmented, and shaped high fidelity historical  
and future data** to improve their “big data”  
applications with “**self service**” capabilities

# Hybrid “Data Lake”- Leveraging Fit for Design Technologies

“Data Lake”

“Data Warehouse”

“Big Data”

“Cloud”



New Sensor  
Technology



DCS, SCADA, PLCs, &  
other OT data sources



Remote & Mobile Assets

# Hybrid “Data Lake”- Leveraging Fit for Design Technologies

IT Data Lake/Data Warehouse/Big Data

Batch and Streaming Integration

OT Data Lake/OT Infrastructure



New Sensor  
Technology



DCS, SCADA, PLCs, &  
other OT data sources



Remote & Mobile Assets

# Hybrid “Data Lake”- Leveraging Fit for Design Technologies

IT Data Lake/Data Warehouse/Big Data

Batch and Streaming Integration

OT “Data Lake”- Optimized for real-time data & streaming analytics

Physical  
Physical & Virtualized  
Remote DC & Virtualized



Private Cloud  
PI System Components  
Hosted via Private, AWS, Azure, etc



New Sensor  
Technology



DCS, SCADA, PLCs, &  
other OT data sources



Remote & Mobile Assets

# Hybrid “Data Lake”- Leveraging Fit for Design Technologies

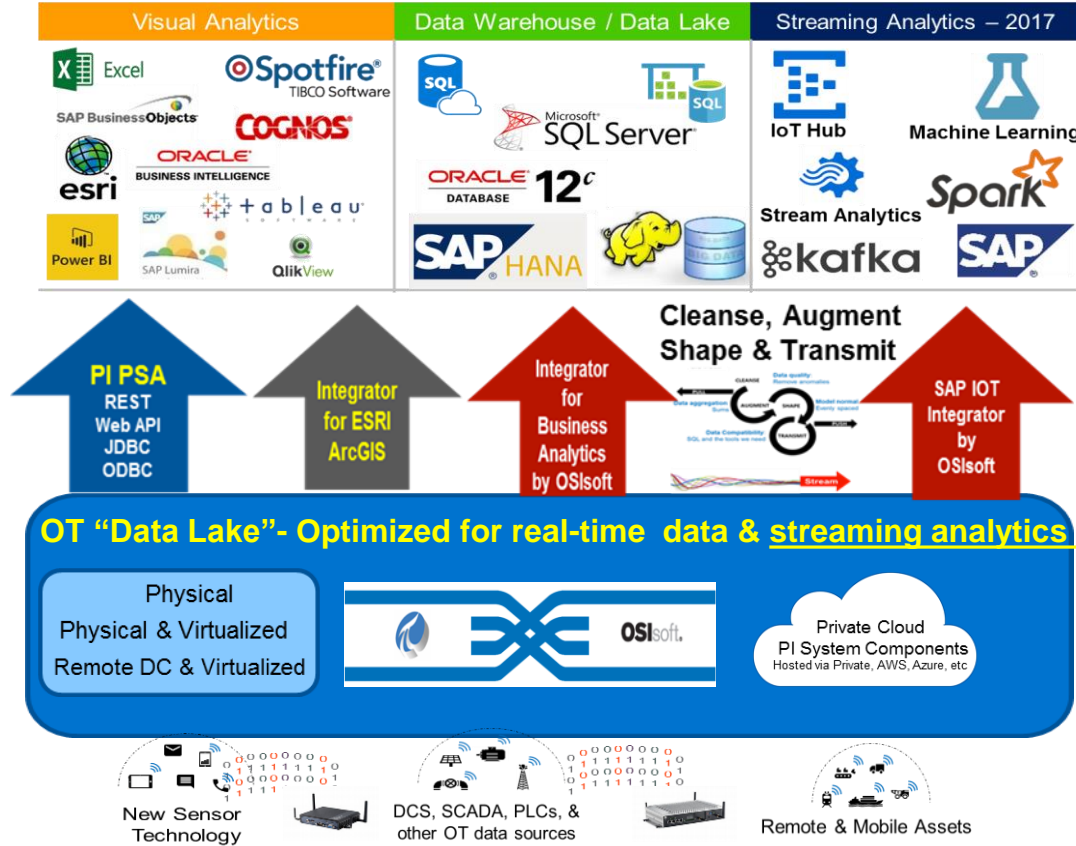


## Batch and Streaming Integration

### OT “Data Lake”- Optimized for real-time data & streaming analytics



# Hybrid “Data Lake”- Leveraging Fit for Design Technologies

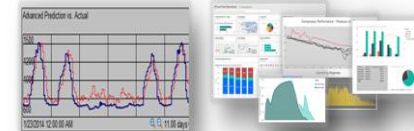




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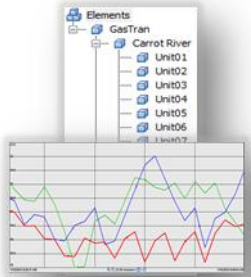
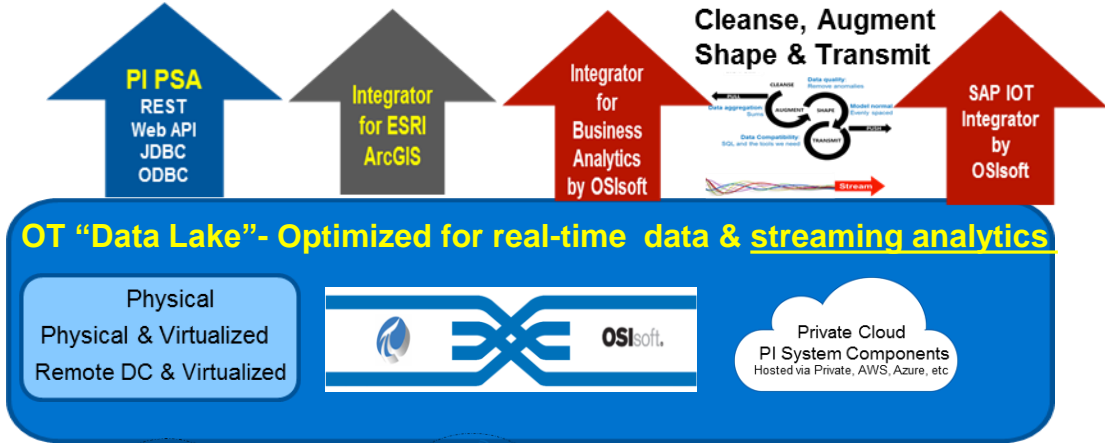


Tabular & Unstructured +



Predictive Statistical Modeling ML/AI

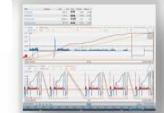
Dashboards Geospatial & multi-dimensional assessment



Linear/Time, Event, Asset Context Structured

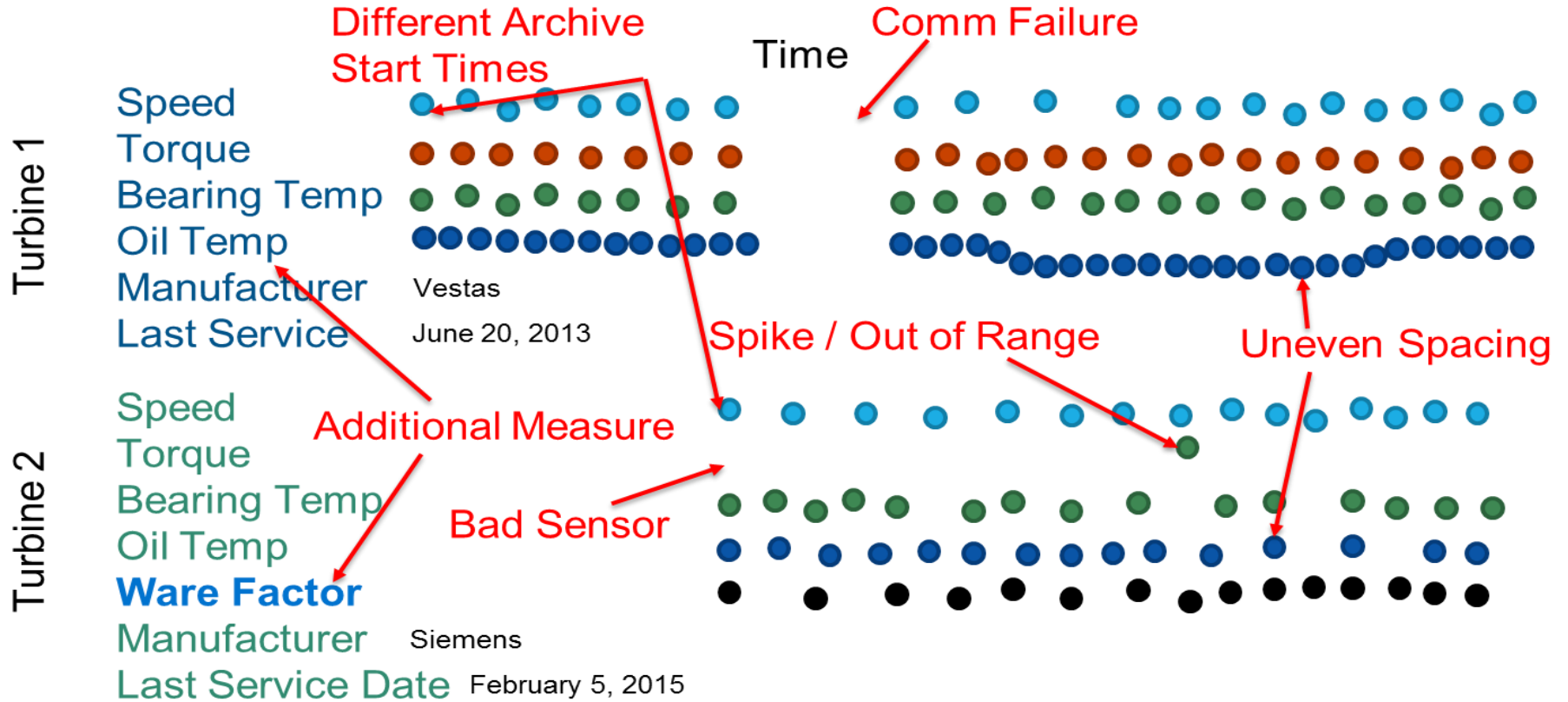


$$Q = \frac{\Delta P_{DD} * kh}{141.2\mu B_0 \left\{ \ln \frac{r_e}{r_w} - \frac{3}{4} + S \right\}}$$



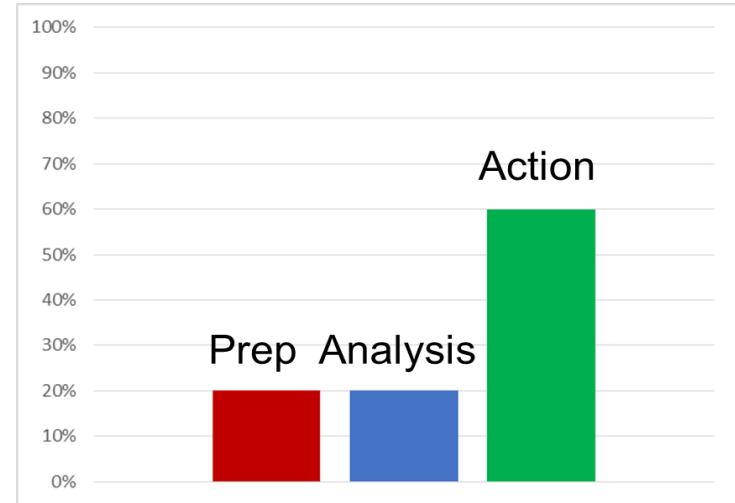
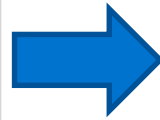
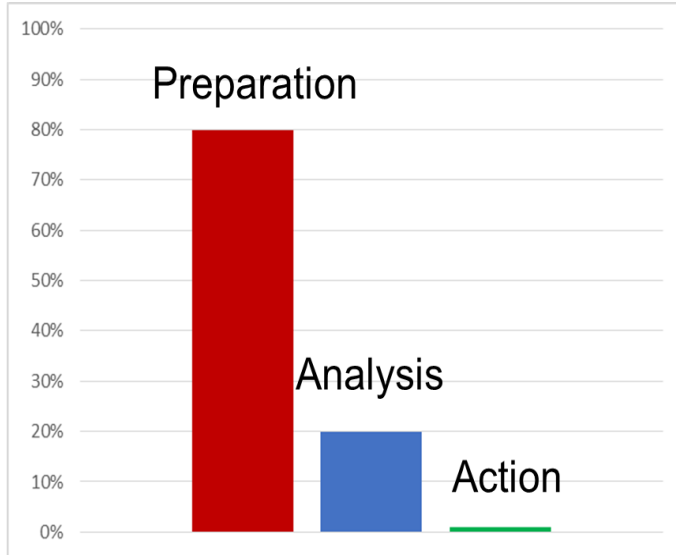
Prescriptive, Empirical, & Physics based Streaming Analytics

# The Smart OT Infrastructure is Designed to Deal with the Unique Characteristics of Time Series data and Metadata



# Refocusing on Data Use vs Cleansing and Preparation

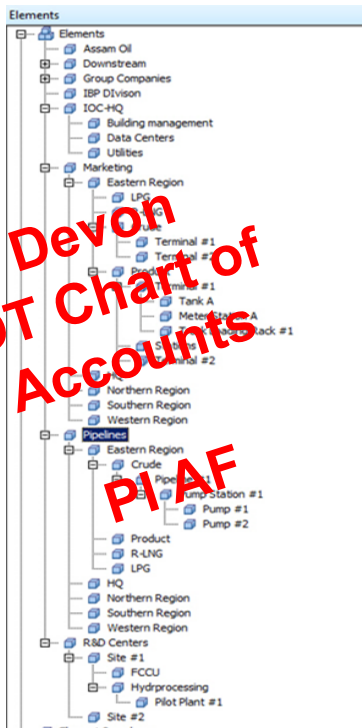
## Hybrid “Data Lake” Approach vs a pure RDB “Data Lake” Approach



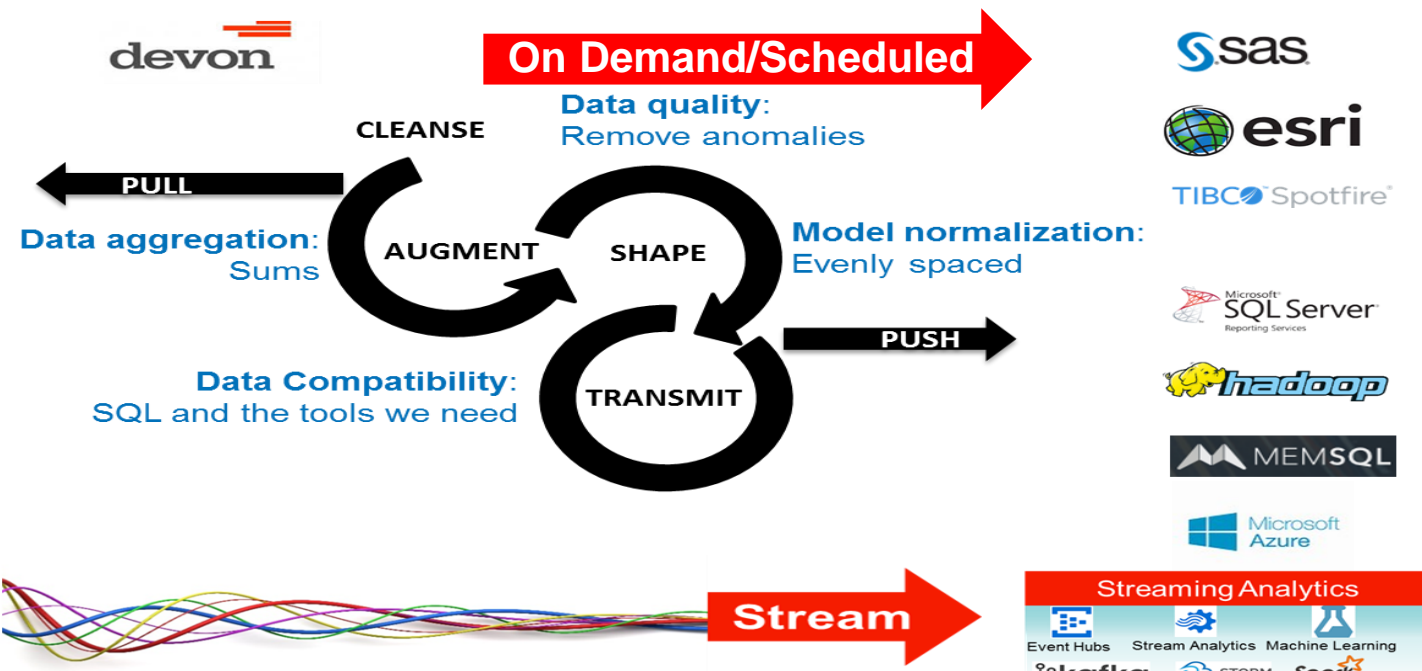
Data cleansing and preparation tasks can take 50-80% of the development time and cost

Spending more time getting new, actionable insights from existing data sets....minimizing the “lost opportunity costs”

# The OT Data Model(PI AF) is Foundational for Higher Level Analytics & The Power of Choice and Self-Serve BI



Devon  
OT Chart of  
Accounts  
PI AF



# Key Differentiator #4

They define **“analytics”** and **“Layers of analytics”** as a framework for their **analytical journey** with a mapping of examples and use an **infrastructure approach leveraging the OT Infrastructure**

# An Evolutionary Approach to Analytics

## Laying the Analytical Foundation with PI AF



Real-time Streaming Analytics

Human Analytics

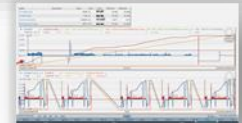


Time, Event  
and Asset  
Context

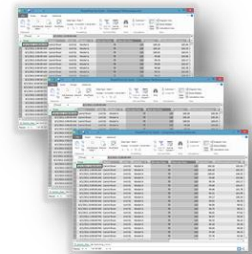
Descriptive & Prescriptive  
**Level 1 Predictive**

Real-time, contextual, exception  
based decision support

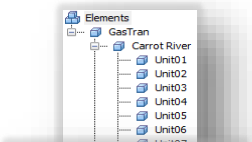
$$Q = \frac{\Delta P_{DD} * kh}{141.2 \mu B_0 \left\{ \ln \frac{r_c}{r_w} - \frac{3}{4} + S \right\}}$$



# Evolutionary Approach to Analytics- Moving up the Ladder



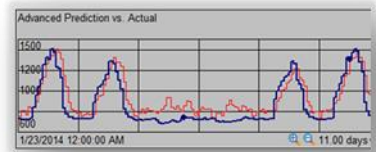
Tabular Context



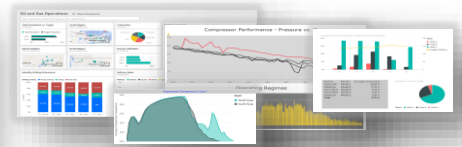
Time, Event and Asset Context



**Predictive**  
Statistical Modelling & Machine Learning/AI (Pattern Recognition)  
**Level 2+ Predictive**



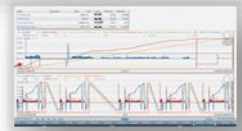
**Visual**  
Dashboards & Multidimensional Assessment



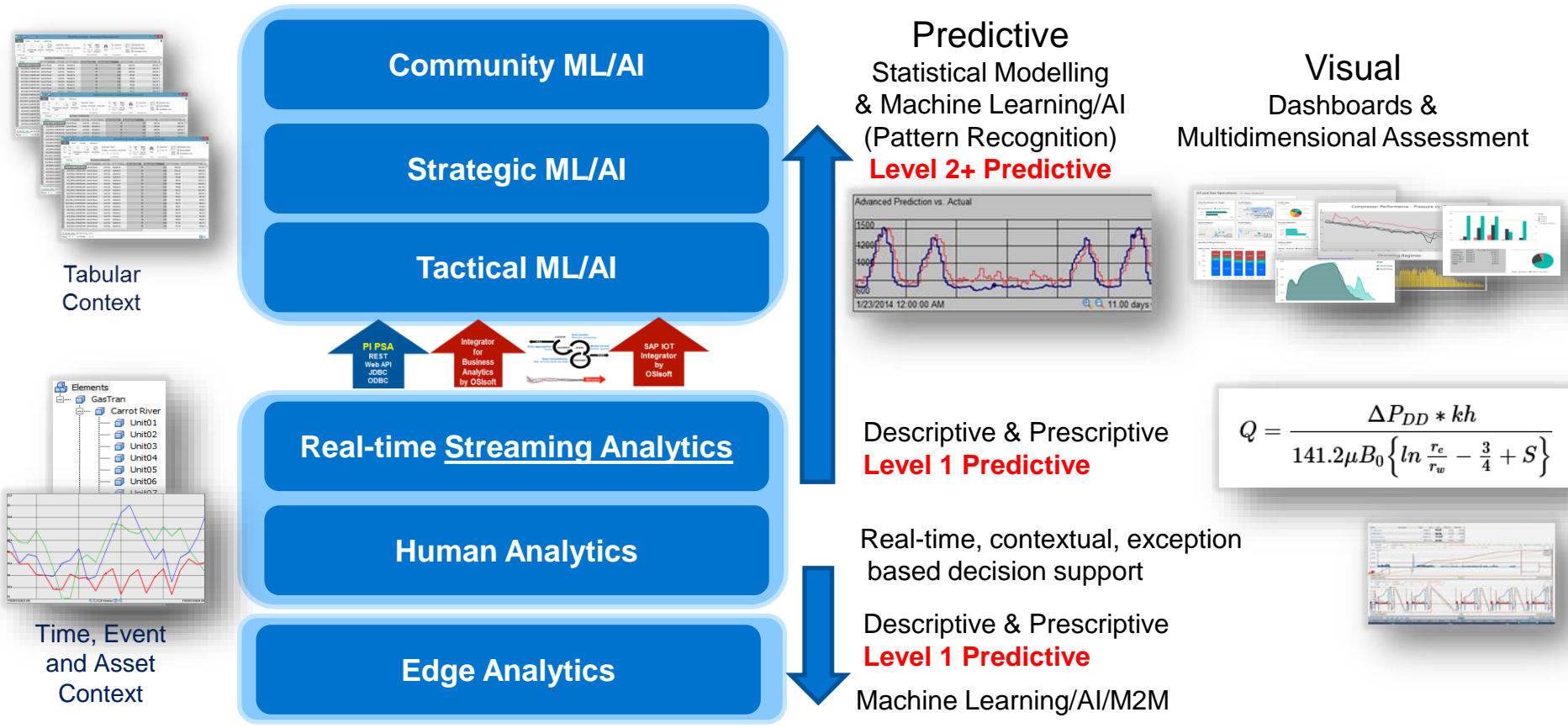
**Descriptive & Prescriptive**  
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Real-time, contextual, exception based decision support

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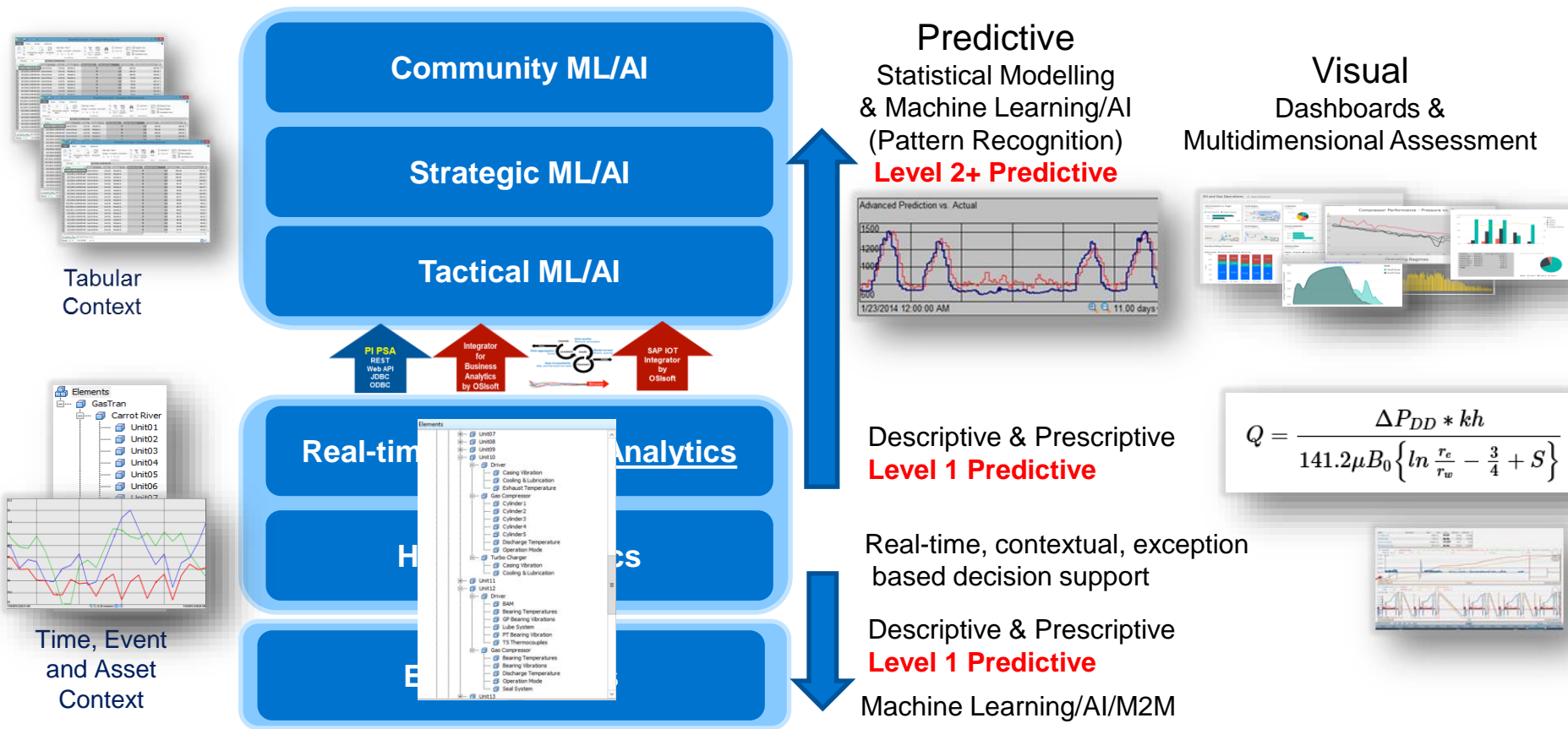


# An Evolutionary Approach to Analytics- Moving to the Edge

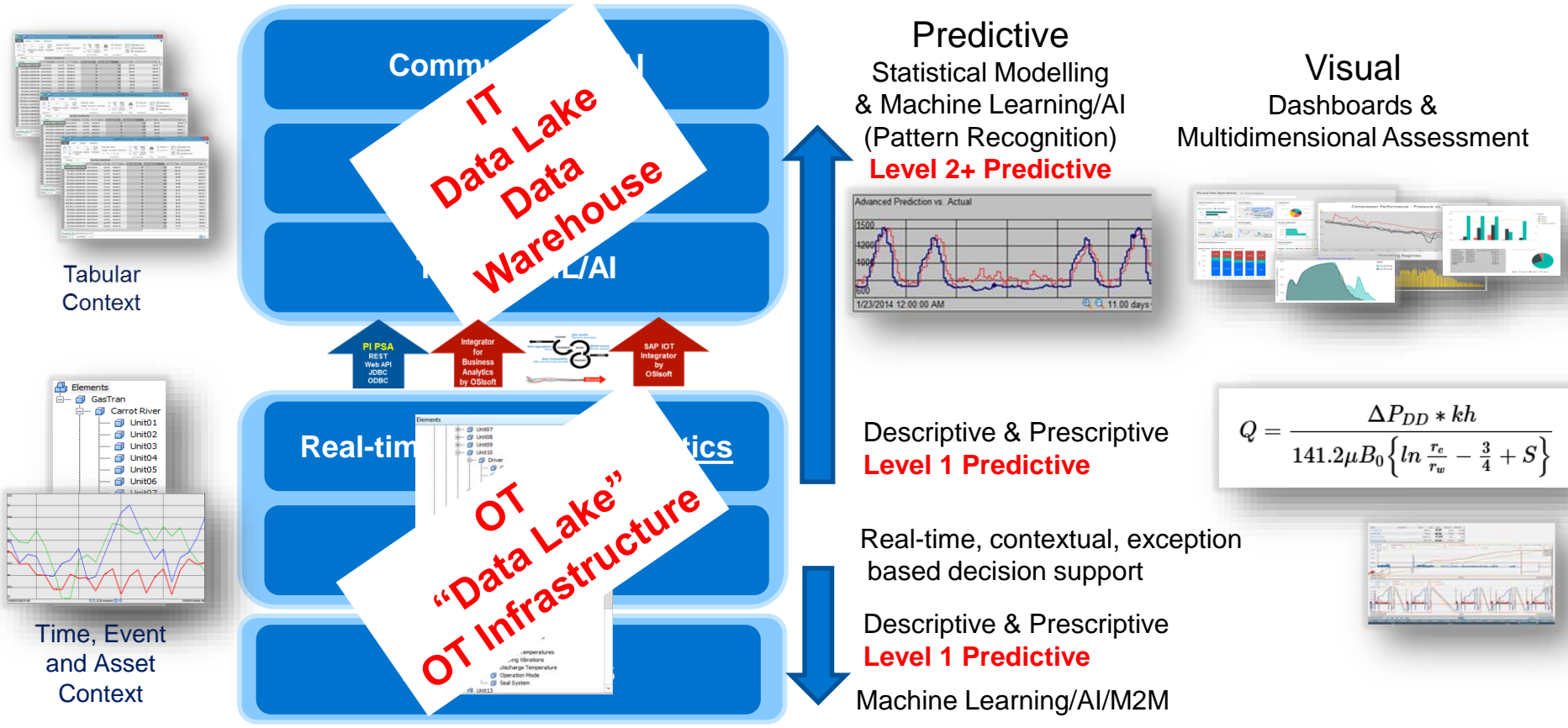




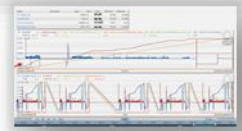
# An Evolutionary Approach to Analytics- Enabled by PI AF



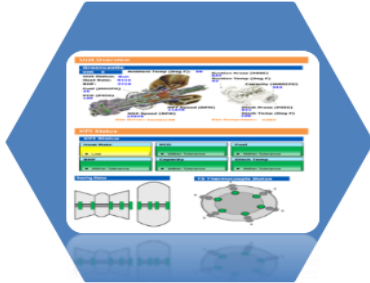
# Evolutionary Approach to Analytics- The Hybrid Data Lake



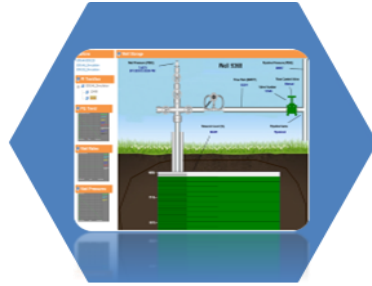
$$Q = \frac{\Delta P_{DD} * kh}{141.2 \mu B_0 \left\{ \ln \frac{r_e}{r_w} - \frac{3}{4} + S \right\}}$$



# Our Focus Over Time



**Compression Reliability**



**Storage Analytics**



**Gas Quality**



**Enterprise Analytics**



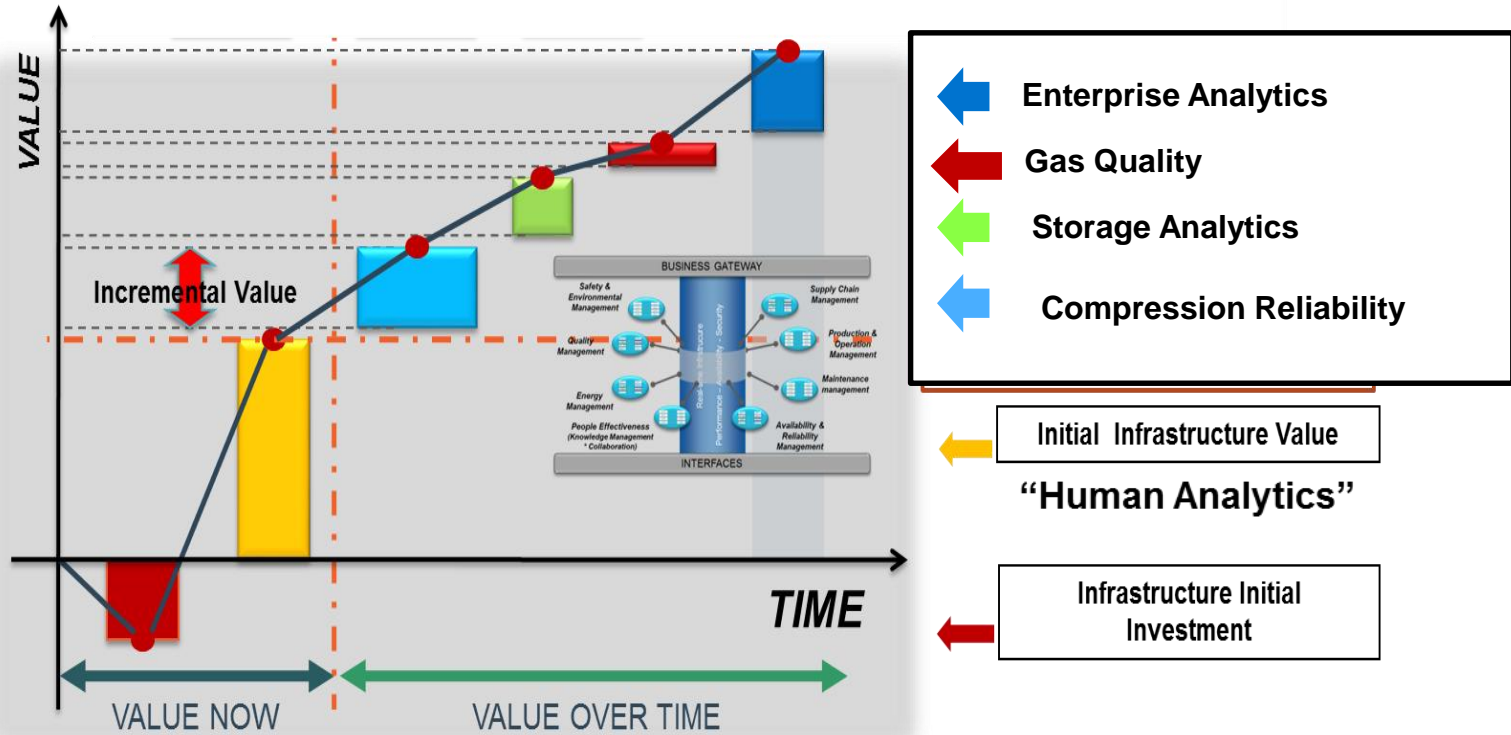
**Executive Dashboards**

2012 - 2013

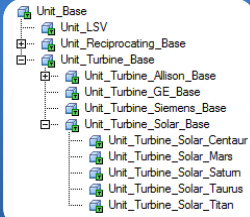
2013 - 2014

2015 - 2016

# An Infrastructure Investment Approach - "OT Data Utility"

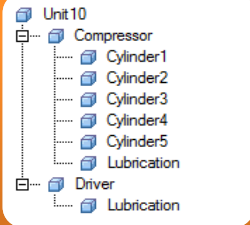


# Why Leverage the Smart OT Infrastructure?



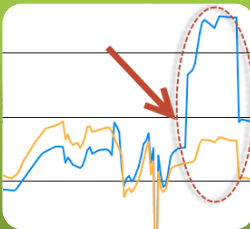
## Scalability

- Highly Scalable
- Smart Asset Objects (Element Templates)
- Inheritance – Ability to modularize and shape



## Dynamic, Logical Asset Structure

- Model our equipment fleet using a logical structure that is familiar to our engineers and analysts – “in context”
- Bring operational time-series data and relational asset data together to implement complex calculations & analytics



## Test and Validate- Ability to Evolve Over Time

- Develop hypothesis for anomaly and modify analytics
- Run the analytics back in time to test and validate the revised algorithms
- Once validated in template, rapidly propagate to all instances

# Calculating Expected Heat Rate

_CoeffType	ECMax
A	3.01916
B	0
C	-140.82336
D	0
E	3431.05804
F	0
G	-39811.23565
H	0
I	226037.87046
J	0
K	-524290.83316
L	0
M	0
N	0
O	0
P	0
Q	0

Lookup curve-fit coefficients from SQL Table  
(Manufacturer Performance Curves)

Data Reference: Table Lookup

Settings...

```
SELECT CoefficientValue FROM PerformanceCentrifEff WHERE PerformanceModelID = @[PerformanceModelID] AND CoefficientType = @_CoeffType AND CoefficientOrder = 1
```

Apply curve-fit to calculate Nominal Heat Rate

Data Reference: Formula

Settings...

```
S=.,|Driver|Steady Speed;A=.,|A;B=.,|B;C=.,|C;D=.,|D;E=.,|E;F=.,|F;G=.,|G;H=.,|H;I=.,|I;J=.,|J;K=.,|K;L=.,|L;M=.,|M;N=.,|N;O=.,|O;P=.,|P;Q=.,|Q;X=FC_MaxSpeed;[if not(S) then 0 else (A + C*X + E*X^2 + G*X^3 + I*X^4 + K*X^5 + M*X^6 + O*X^7 + Q*X^8)/(1 + B*X + D*X^2 + F*X^3 + H*X^4 + J*X^5 + L*X^6 + N*X^7 + P*X^8)]
```

Category: Nominal Values	
BHP_Nominal	8710.27322604474 BHP
FuelRate_Nominal	71.1036975854648 MCFH
HeatRate_Nominal	8163.19944739005 BTU(LHV)/BHP-hr
PCD_Nominal	205.15303353481 psi
T5_Nominal	1394.59524035539 °F
T7_Nominal	925.386891989674 °F

Calculate Actual Heat Rate

Data Reference: Formula

Settings...

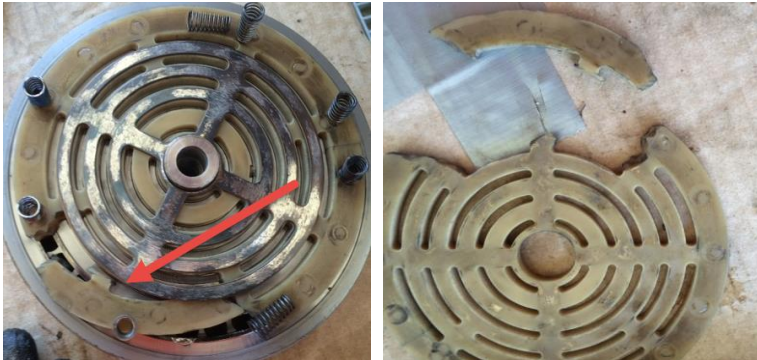
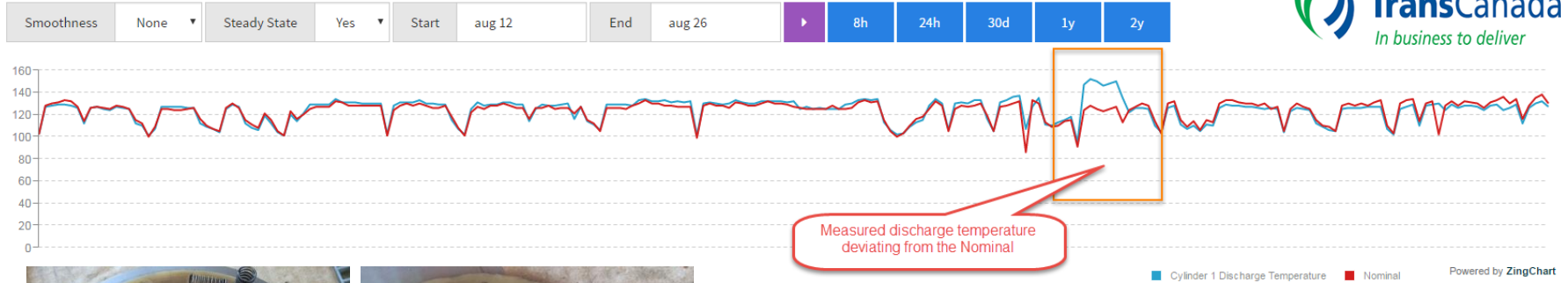
```
A=Unit_BHP;B=Unit_Fuel;C=Unit BTU;[if badval(A) or badval(B) then 0 else if A <= 30 then 0 else (B*(1000*C*0.915))/A]
```

Unit_Heat_Rate_Actual	9843.68334570345 BTU(LHV)/BHP-hr
-----------------------	----------------------------------

# Example of Predictive Analytics in PI AF – Expected vs Actual

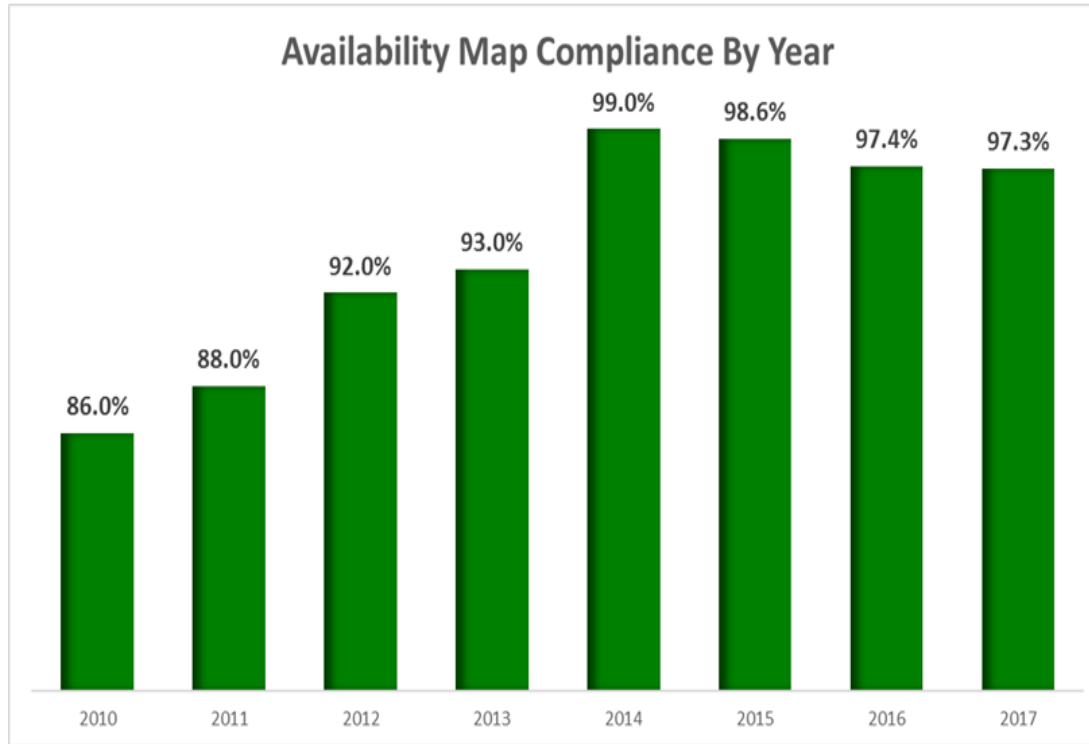
## EA Finding using KPI Strategy

Compression\Houma\Unit01\Gas Compressor\Discharge Temperature\Cylinder 1 Discharge Temperature



Found partially damaged compressor valve.  
The valve was replaced in a planned & controlled manner.

# Compression Availability Compliance



## Visibility

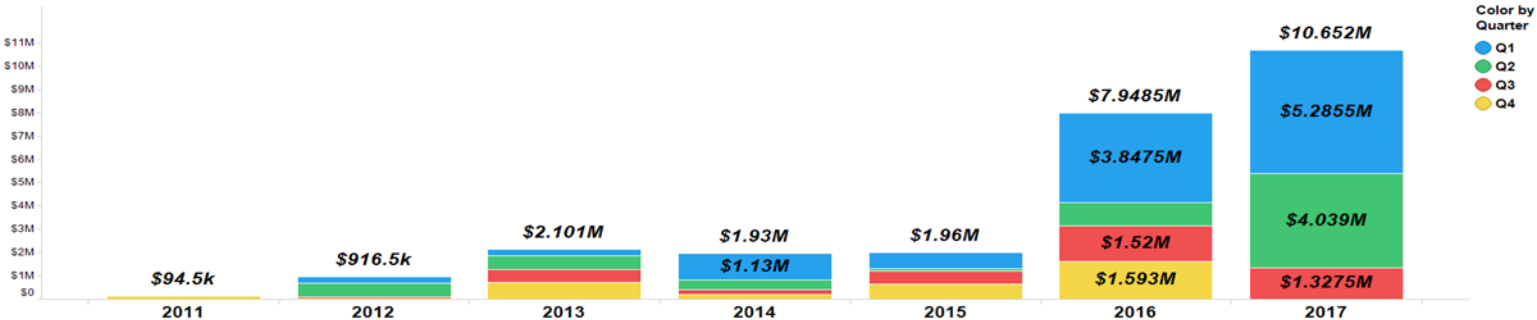
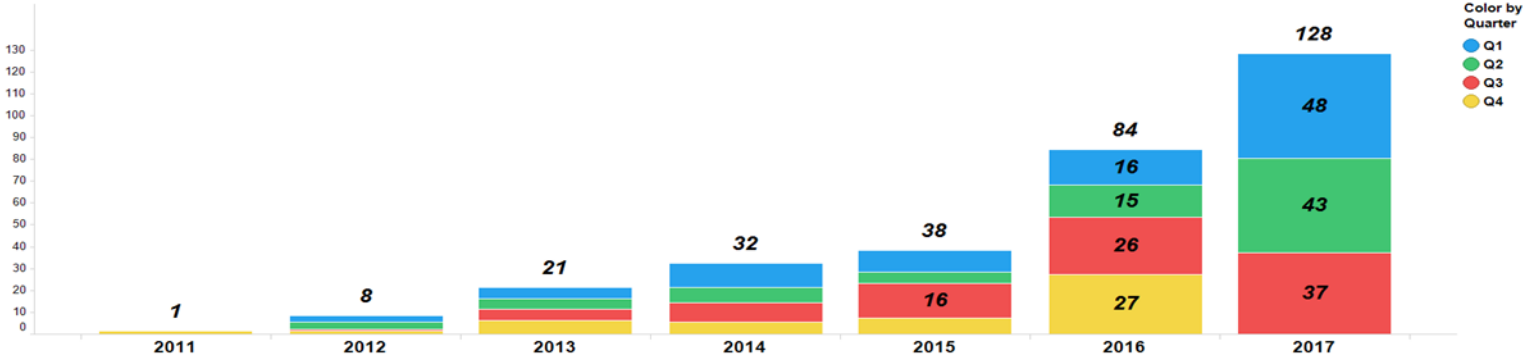
- Real-time dashboard



- Monthly scorecard reporting to president



# Delivering ~\$25M since EA in 2012 from Anomaly Detection

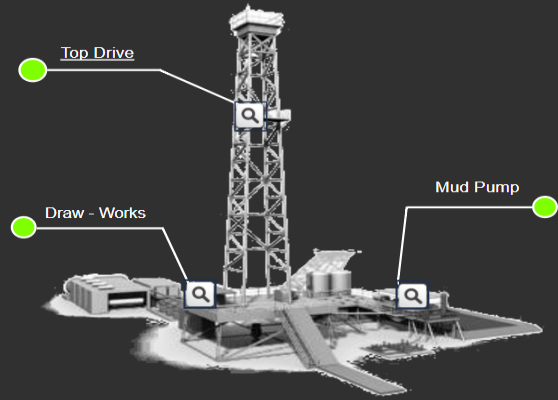
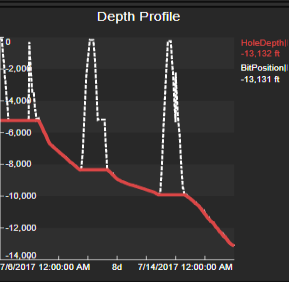




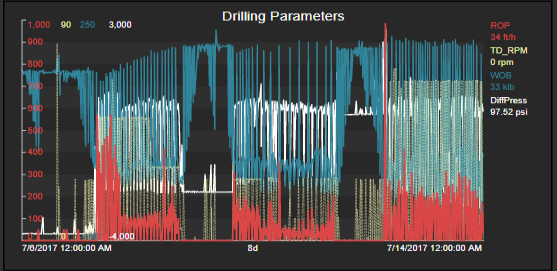
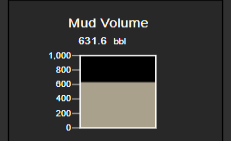
# DrillingRig1 - Rig Overview

- Home
- Reports
- Land Rigs
- Rig Overview
- Mud Motor Performance
- Drilling Efficiency Dashboard

Well	
Description	Value
Current Well ID	Well ID-105
Hole Section	Lateral
Phase of Current Hole Section	Drilling
Rig State	InSlips

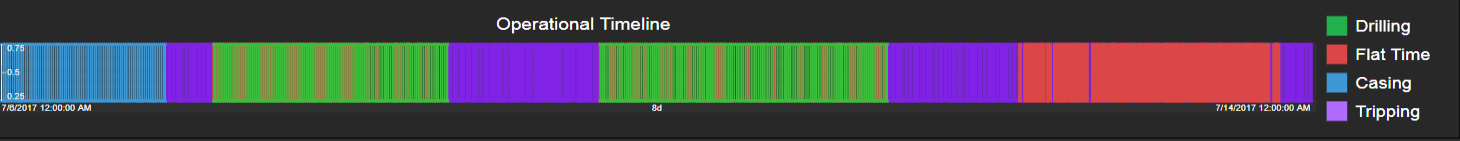


Current Drilling Parameters		
Description	Value	Units
WOB	33	kib
Top Drive RPMs	0	rpm
ROP	34	ft/h
Hole Depth	13132	ft
	97.52	psi



Event Name	Event Type	Start Time	End Time	Duration
DrillingRig1.Crew C Events	Drilling Crew	1/1/2017 12:00:00 AM	1/1/2017 6:00:00 AM	6h
DrillingRig1.Crew D Events	Drilling Crew	1/1/2017 6:00:00 AM	1/1/2017 6:00:00 PM	12h
DrillingRig1.Crew C Events	Drilling Crew	1/1/2017 6:00:00 PM	1/2/2017 6:00:00 AM	12h

Crew A | Shift Night



7/6/2017 12:00:00 AM

8d

Now

7/14/2017 12:00:00 AM

Name	Expression
DSSlope	$(\text{TagVal}(\text{'Drill Strength'}, '*') - \text{PrevVal}(\text{'Drill Strength'}, '*-1m')) / (* - \text{PrevEvent}(\text{'Drill Strength'}, '*-1m'))$
DSSlopeCheck	$\text{BadVal}(\text{'Drill Strength Slope'}) \text{ or } \text{'Drill Strength Slope'} = 0$
MSESlope	$\text{If MSECheck} = \text{True Then NoOutput}() \text{ Else } (\text{TagVal}(\text{'MSE'}, '*') - \text{PrevVal}(\text{'MSE'}, '*-1m')) / (* - \text{PrevEvent}(\text{'MSE'}, '*-1m'))$
MSESlopeCheck	$\text{BadVal}(\text{'MSE Slope'}) \text{ or } \text{'MSE Slope'} = 0$
MSEDS	$\text{If DSSlopeCheck} = \text{True or MSESlopeCheck} = \text{True Then NoOutput}() \text{ Else } \text{MSESlope} / \text{DSSlope}$
RatioSlope	$\text{If RatioCheck} = \text{True Then NoOutput}() \text{ Else } (\text{'MSE_DS_Slope'} - \text{PrevVal}(\text{'MSE_DS_Slope'}, '*-1m')) / (* - \text{PrevEvent}(\text{'MSE_DS_Slope'}, '*-1m'))$
UCS	$\text{If MSECheck} = \text{True or DSCheck} = \text{True or RatioCheck} = \text{True Then NoOutput}() \text{ Else } \text{If MSESlope} > 0 \text{ and DSSlope} > 0 \text{ and RatioSlope} < 0 \text{ Then } 0 \text{ Else } \text{If MSESlope} < 0 \text{ and DSSlope} < 0 \text{ and RatioSlope} > 0 \text{ Then } 1 \text{ Else } \text{NoOutput}()$
BitBalling	$\text{If MSECheck} = \text{True or DSCheck} = \text{True or RatioCheck} = \text{True Then NoOutput}() \text{ Else } \text{If MSESlope} > 0 \text{ and DSSlope} > 0 \text{ and RatioSlope} < 0 \text{ Then } 1 \text{ Else } \text{NoOutput}()$
Vibration	$\text{If MSECheck} = \text{True or DSCheck} = \text{True or RatioCheck} = \text{True Then NoOutput}() \text{ Else } \text{If MSESlope} > 0 \text{ and DSSlope} > 0 \text{ and RatioSlope} > 0 \text{ Then } 1 \text{ Else } \text{NoOutput}()$
Wear	$\text{If MSECheck} = \text{True or DSCheck} = \text{True or RatioCheck} = \text{True Then NoOutput}() \text{ Else } \text{If MSESlope} > 0 \text{ and DSSlope} > 0 \text{ and RatioSlope} < 0 \text{ Then } 1 \text{ Else } \text{NoOutput}()$
DrillingDysfunction	$\text{If UCS} = 0 \text{ Then } 0 \text{ Else } \text{If UCS} = 1 \text{ Then } 1 \text{ Else } \text{If BitBalling} = 1 \text{ Then } 2 \text{ Else } \text{If Vibration} = 1 \text{ Then } 3 \text{ Else } \text{If Wear} = 1 \text{ Then } 4 \text{ Else } \text{NoOutput}()$

**OSIsoft PI Vision** | New Display | OSIBharclerode | Ad Hoc Display

RealTime\_Land\_Drilling\_Dashboard | Asset: **DrillingRig1**

<b>Hole Depth</b> 13196 feet	<b>Block Height</b> 92.165 feet	<b>Rotary RPMs</b> 65 rpm	<b>WOB</b> 12 klbs	<b>SPP</b> 2,362.7 psi
<b>Bit Depth</b> 13196 feet	<b>Hookload</b> 231.79 klbs	<b>Rotary Torque</b> 16,431 ft-lbs	<b>ROP</b> 58 ft/hr	<b>Diff</b> 68.896 psi

**Rig State**  
Rotary Drilling

**Hole Section**  
Lateral

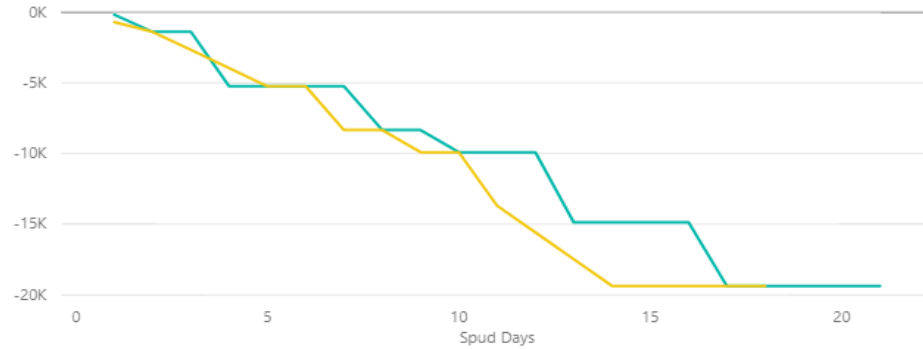
**Hole Section Phase**  
Drilling

**Back**

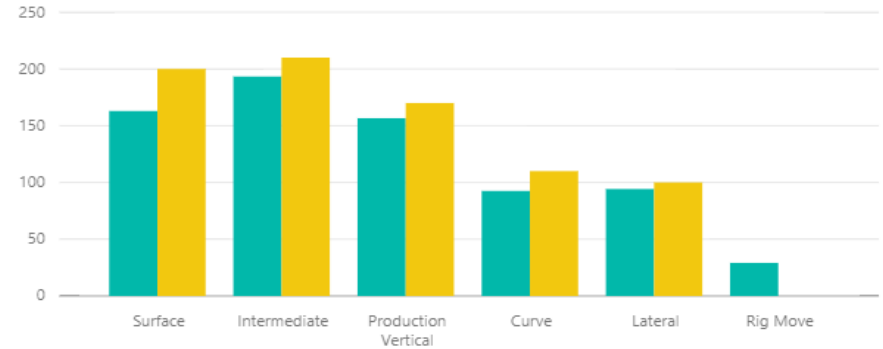
7/13/2017 5:00:00 PM | 8h | Now | 7/14/2017 1:00:00 AM

# Well Phase Analysis

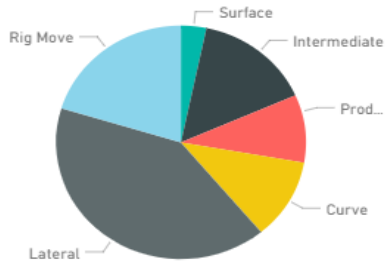
Days vs Depth with Composite Best



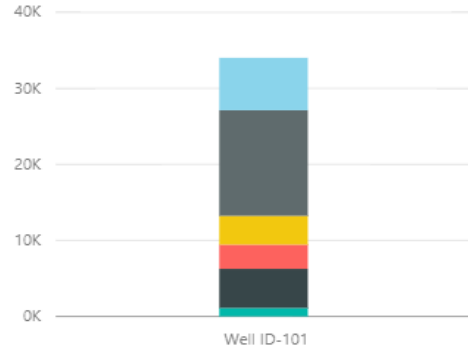
Hole Section ROP vs Composite Best



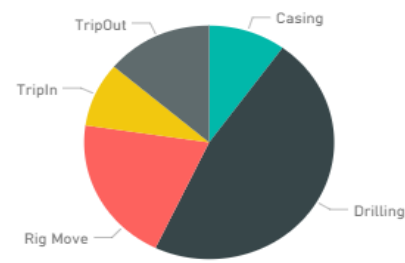
Hole Section Percentage



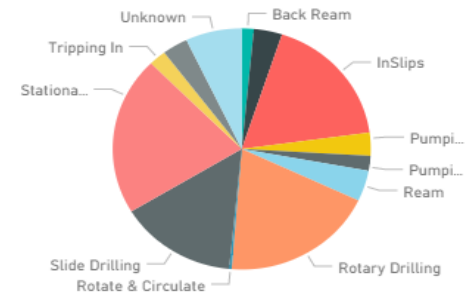
Hole Section Duration By Well



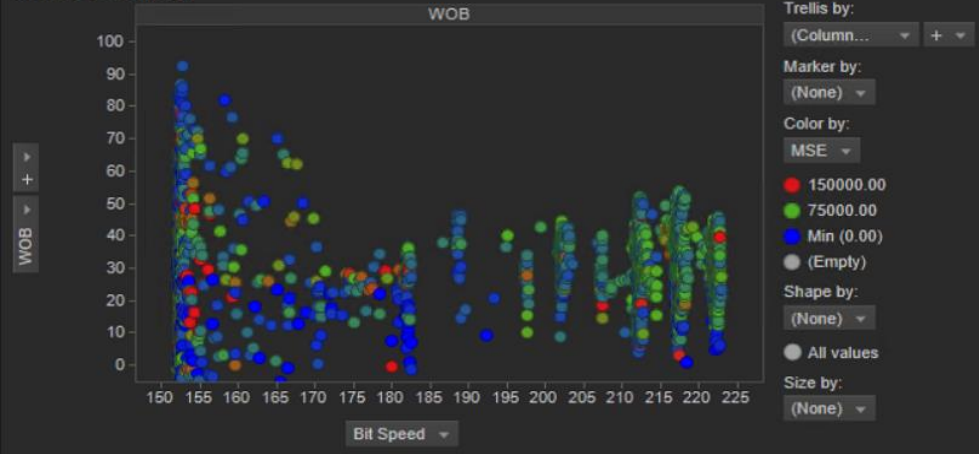
Hole Section Phase Percentage



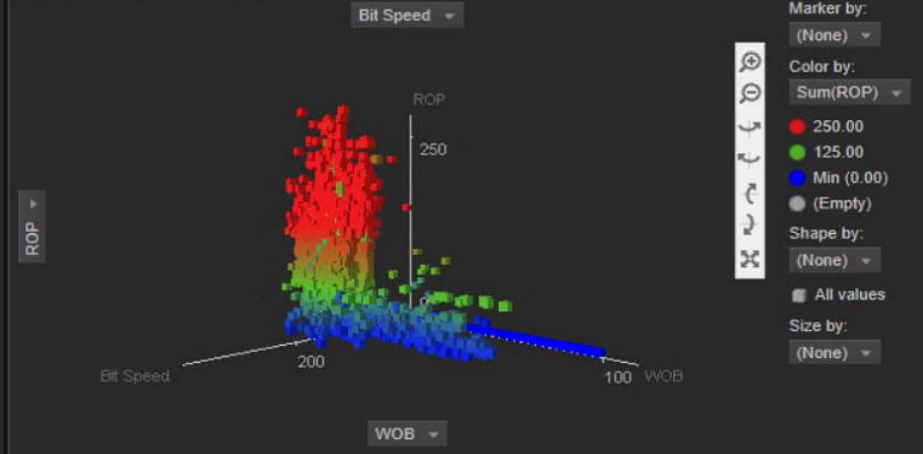
Rig State Percentage



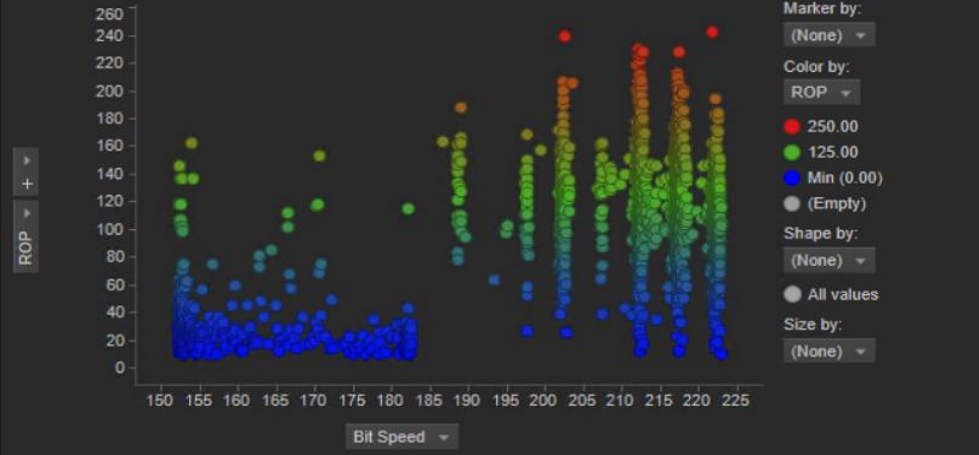
WOB vs. Bit Speed



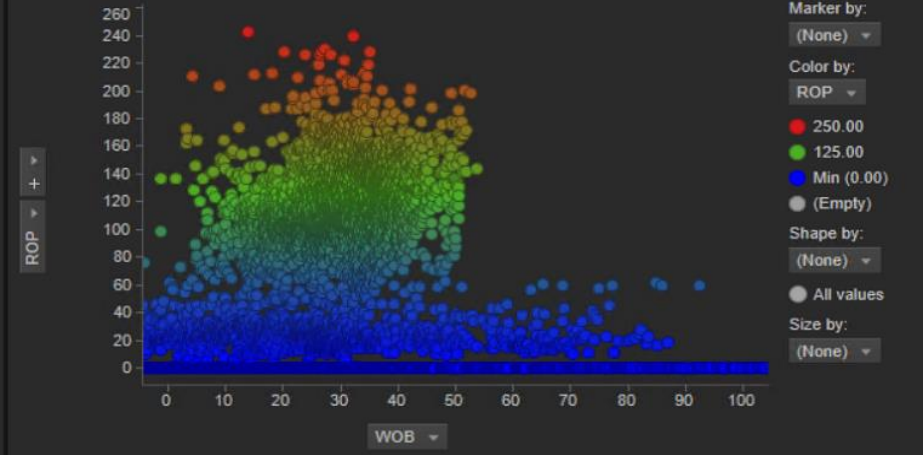
Bit Speed vs. WOB and ROP



ROP vs. Bit Speed



ROP vs. WOB



# Defining, Rationalization & Distribution of “Analytics”

## .....“Layers of Analytics”



**Strategic Machine Learning/Big Data/Advanced Analytics**  
**Enabled by the OT Infrastructure**

### Analytics and Predictions for :

- Dynamic or “smart” IOW/targets/APM/PSM
- “How do you “smooth” operations?”
- How do you optimize the yields?
- How do we optimize the fuels value chain?

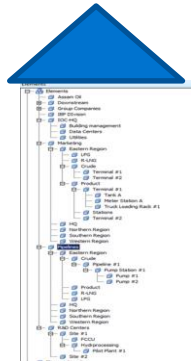


**Tactical Machine Learning/Big Data/Advanced Analytics**  
**Enabled by the OT Infrastructure**

### Analytics & Predictions for :

- Coker Hotspot
- Hydro treater sulfur in product
- Hydro treater cloud point
- Bromine Index Benzene
- Coke drum filling & removal

**27+ Tactical ML Apps in production**



**Real-time Analytics – In the OT Infrastructure**

### Analytics and Predictions for:

- Corrosion analytics (HTHA, chlorides, etc.)
- Natural gas & electrical peak exceedances
- CBM – exchangers, rotating equipment, etc.
- Environmental Limit predictions.

Integrated Control & Safety Systems  
 Excel Files

**Human Analytics**  
**Enabled By and In the OT Infrastructure**

### Enablement of:

- Data Based Decisions
- Real-time situational awareness
- Management by exception

**61,000 Event frames across 6 plants**

# Natural Gas Consumption Prediction



## BackGround

- Huge saving possibilities in the decrease of contracted natural gas daily maximum amount

## Problem

- High penalty on daily amount exceedance
- Alerting system was needed

## Solution

- Consumption prediction calculations in PI Analysis
- Detailed information on PI Vision display (about consumption, prediction, contacts of decision makers)
- E-mail alerting system in Notifications

The screenshot shows the PI Analysis software interface. On the left is a tree view of elements, including APC, ARGUS, Control loops DR, Danube Refinery, Energy Consumption Predictions, MOLHU NatGas Cons (with sub-items like DF C3 compressor stop, DF Fuel Oil Burning in BoilerPlant, etc.), Energy KPI System, Flare Monitoring, IOW, Siófo, System, Tanks, Technology DataSheet, Tisza Refinery, Zala Refinery, and Element Search 1. On the right is a table with columns for Name and Value. The table is categorized into Auxiliary Calculations, Consumption Calculations, Exceedance Calculations, and Limits. The Consumption Calculations section shows:

Name	Value
Cumulated Daily Consumption	18723164 MJ
Current Consumption	1991855,5 MJ/h
Predicted Daily Consumption	49276016 MJ

The screenshot shows the PI Analysis software interface with a table of calculations and their expressions. The table has columns for Name, Configuration, Schedule, Output(s), and Backfilling. The calculations are:

Name	Configuration	Schedule	Output(s)	Backfilling
Auxiliary Calculations	RemainingDayRatio := In...	Frequency=120...	RemainingDayPart; RefD...	
CumulatedDailyConsumption	CumulatedDailyConsump...	Frequency=120...	Cumulated Daily Consum...	✓
CurrentConsumption	CurrentConsumption := T...	Frequency=120...	Current Consumption	✓
PredictedDailyConsumption	SecondsToNextGasDayTu...	Frequency=120...	Predicted Daily Consump...	✓

Below the table, the expressions for the calculations are shown:

Name	Expression
SecondsToNextGasDayTurn	$\text{Int}(\text{Bod}(* * - 6\text{h}^*) + * + 30\text{h}^* - **)$
PredictedDailyConsumption	$\text{Cumulated Daily Consumption} + \text{Current Consumption} * \text{SecondsToNextGasDayTurn} / 3600$



# Integration of the OT Infrastructure & SAP PM

## Smart OT Infrastructure

- Process database
- Online analysis of process information
- Calculation of asset health
  - Asset condition
  - Number of Cycles
  - Running hours
  - Performance
- User Interface
  - PI Coresight
  - PI DataLink

## Connection (WebLogic)

Calculated asset  
health



Maintenance  
related information



## SAP PM

- Technical database
- Management of maintenance processes
- Creation of work orders or notifications
- Trigger maintenance strategies based on asset health

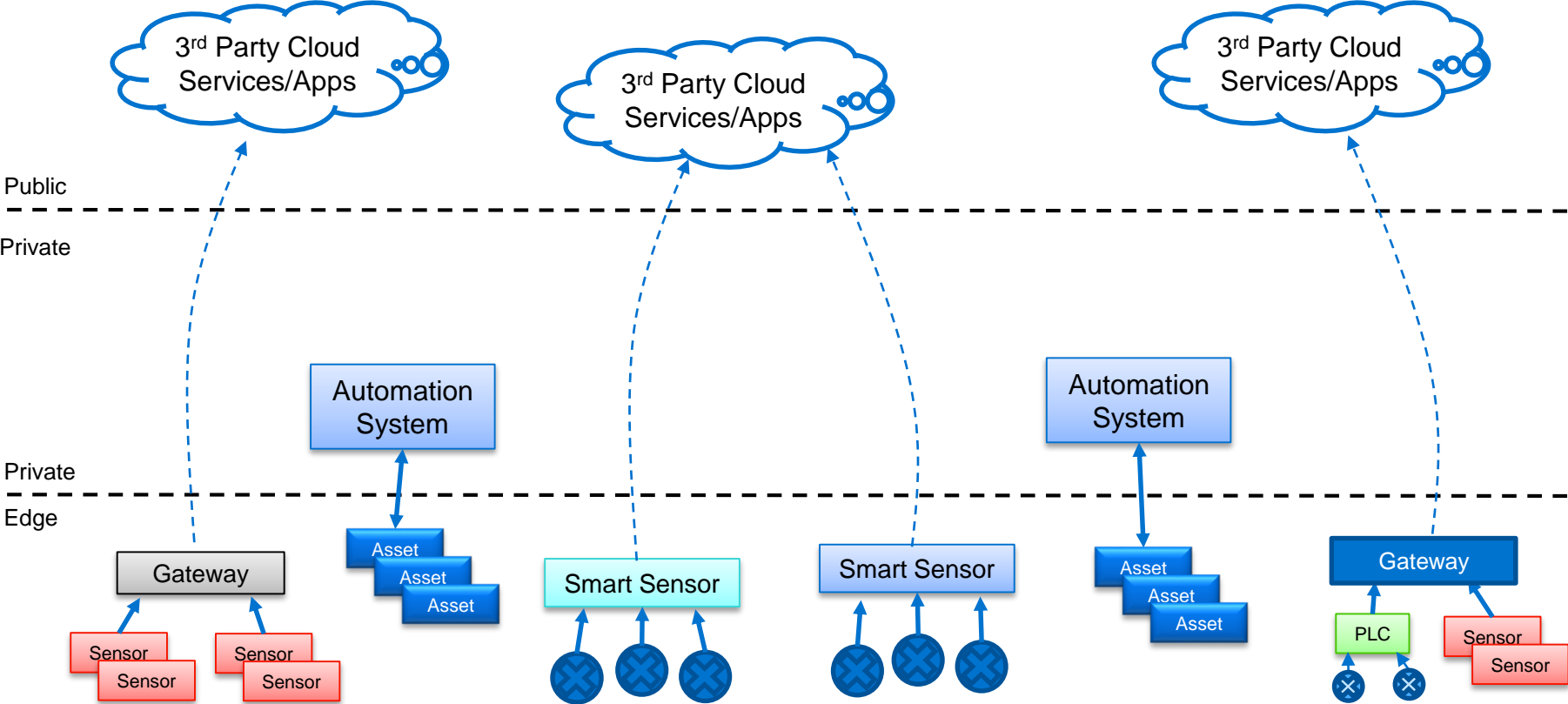
All Rotating Equipment, Exchangers, Critical Valves, critical equipment etc. are now on CBM vs Time Based and use a Health Index that MOL Subject Matter Experts Maintain in the asset template – Changes propagate across the MOL Enterprise



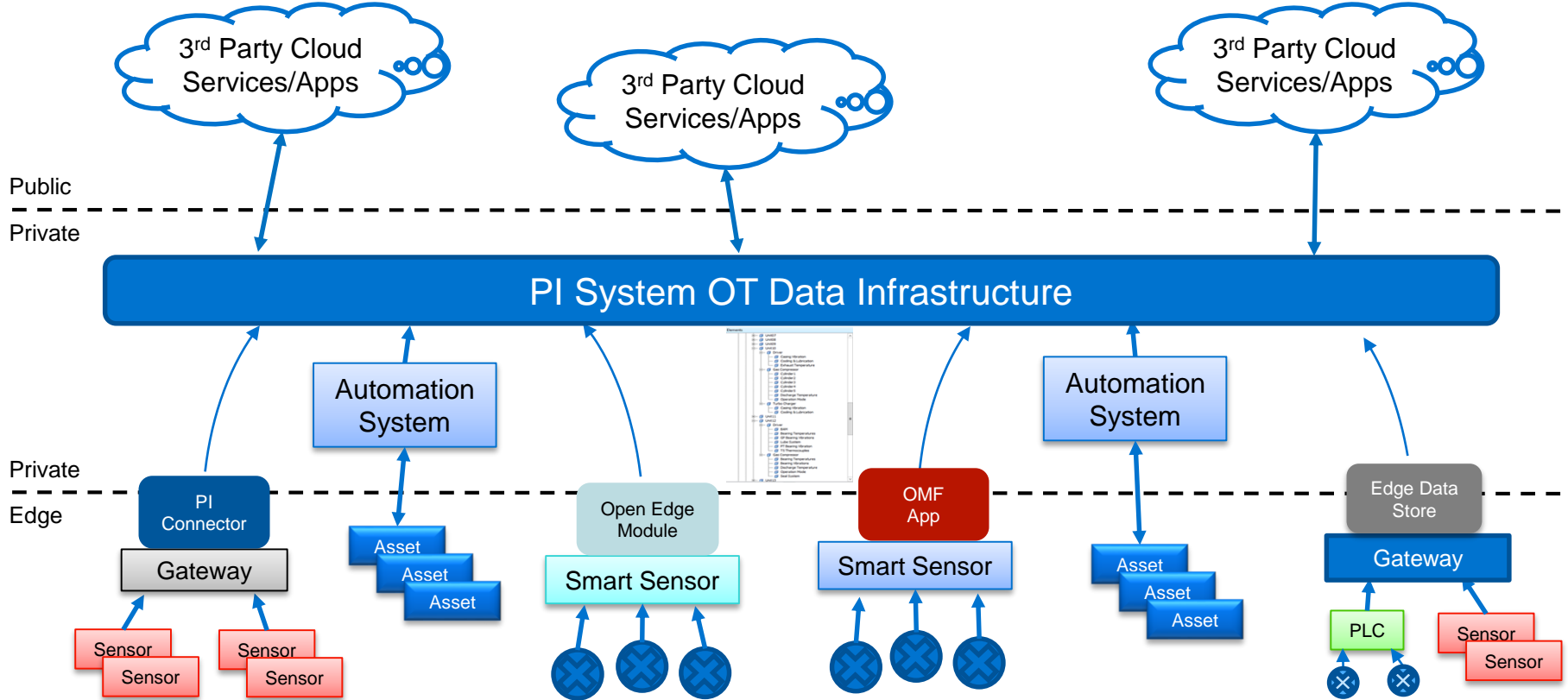
# Key Differentiator #5

They see **IOT as an extension of the PI System Infrastructure** via IOT connectors as required to **mesh IOT data with the wired sensory data..not a rush to “the cloud”**

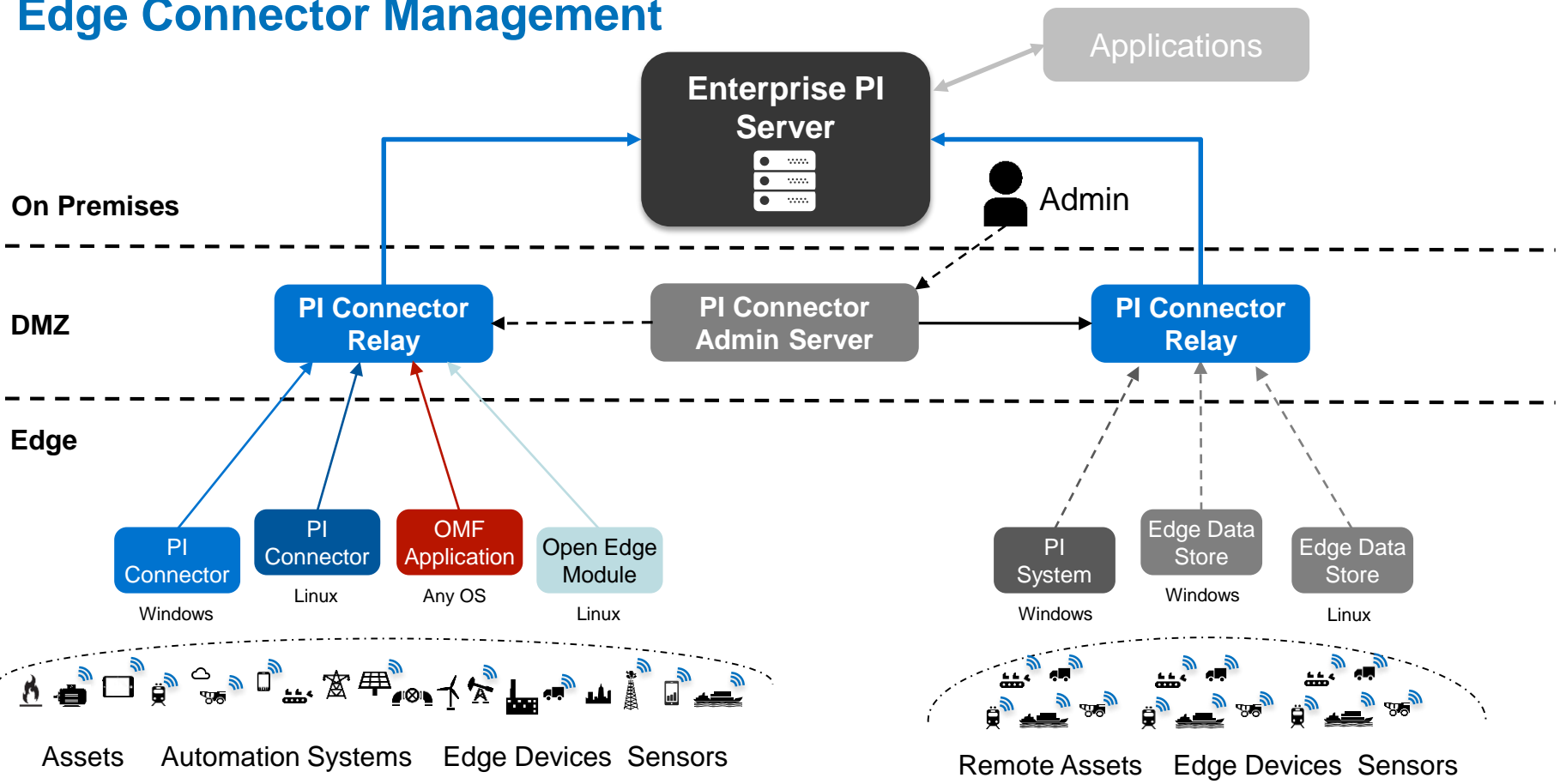
# Typical Industrial IoT Architecture



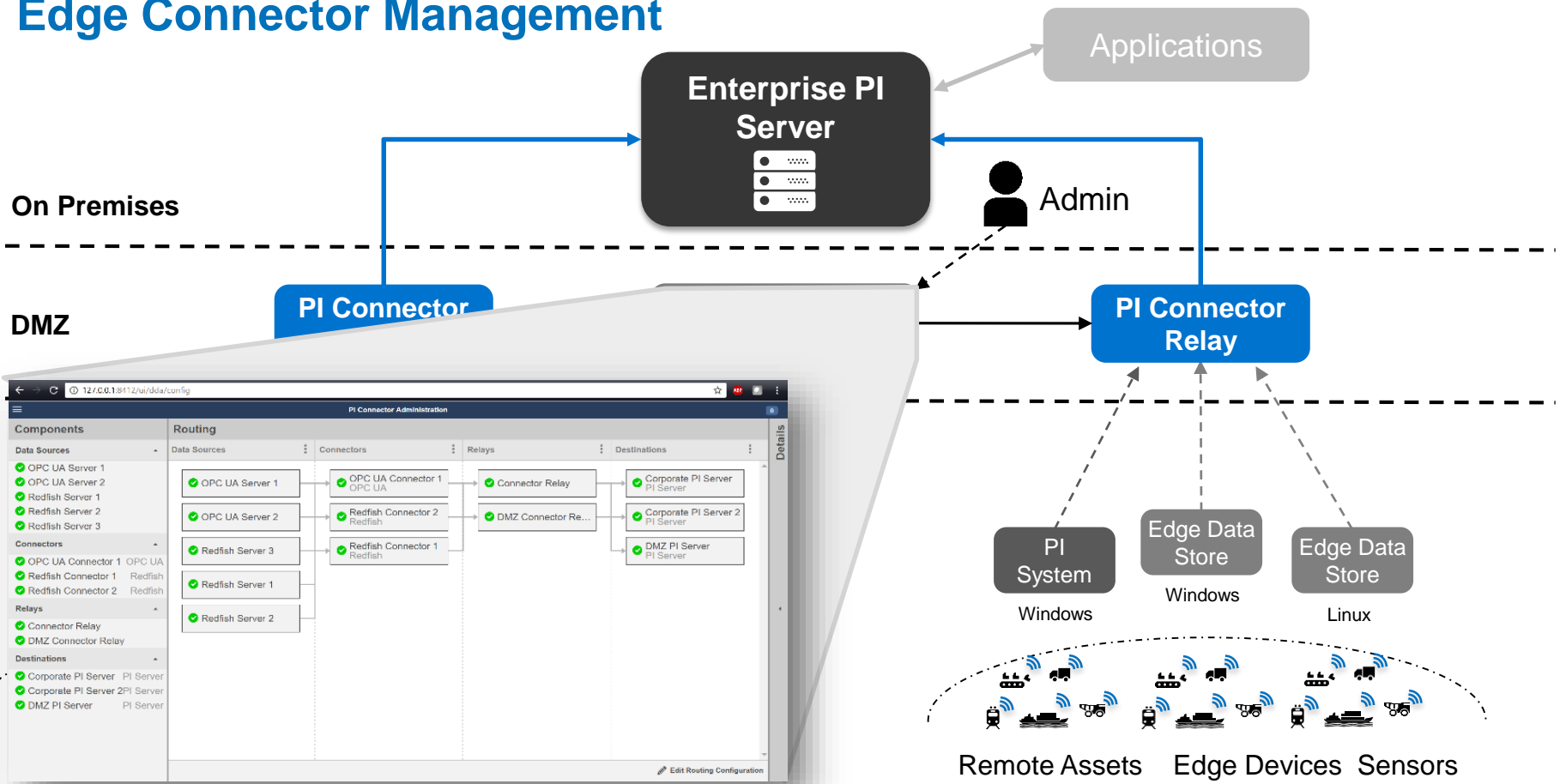
# Bringing DCS/SCADA and IOT/Edge Data together in Context



# Edge Connector Management



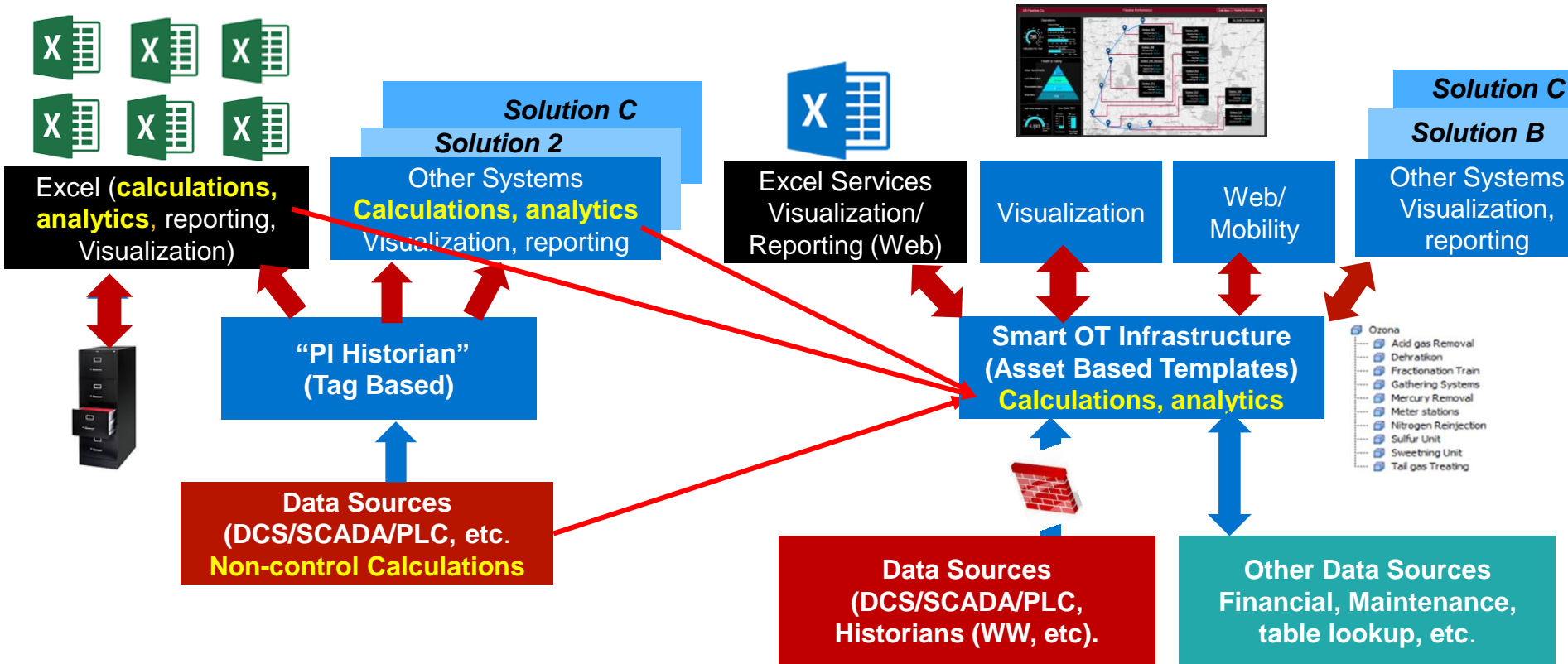
# Edge Connector Management



# Key Differentiator #6

They **simplified and standardized calculations** and analytics by **migrating to the PI System OT infrastructure**

# Standardizing Calculations & Analytics





# PI System Used for Eliminating Spreadsheets (cont'd.)



Using PI Vision to **ELIMINATE Excel** all together from the equation

Well Name	Above Critical?	Over Under Critical	Allocation Meter Cu	Critical Velocity	Gas Lift Injection	Injection Set Point
Timbro LC13-73HN	No	-159.75 mcf/d	520.83 mcf/d	486.35 mcf/d	301.78 mcf/d	400 mcf/d
Timbro L...74-1HN	Yes	-42.592 mcf/d	846.58 mcf/d	516.08 mcf/d	291.43 mcf/d	400 mcf/d
Timbro LC13-74HN	Yes	-170.67 mcf/d	332.12 mcf/d	471.5 mcf/d	182.03 mcf/d	400 mcf/d
Timbro L...75-1HN	No	-147.54 mcf/d	458.79 mcf/d	482.43 mcf/d	282.8 mcf/d	400 mcf/d
Timbro LC13-75HN	No	-63.856 mcf/d	0 mcf/d	65.622 mcf/d	0 mcf/d	0 mcf/d
Timbro L...76-1HN	Yes	44.696 mcf/d	705.1 mcf/d	504.19 mcf/d	261.42 mcf/d	400 mcf/d
Timbro LC13-76HN	No	-92.636 mcf/d	0 mcf/d	99.572 mcf/d	0 mcf/d	0 mcf/d
Timbro L...77-1HN	No	-977.98 mcf/d	0 mcf/d	977.98 mcf/d	0 mcf/d	0 mcf/d

# PI Asset Analytics for Well Performance Calculations

General Child Elements Attributes Ports Analyses Version

Name	Backfilling
f(0) Casing Pressure Yesterday Avg	✓
f(0) Critical Velocity	✓
f(0) Critical Velocity Yesterday Avg	✓
f(0) Net Gas	✓
f(0) Over Under PACR	✓
f(0) PACR Yesterday Avg	✓
f(0) Tubing Pressure Yesterday A...	✓

Name: Critical Velocity  
 Description:   
 Categories:   
 Analysis Type:  Expression  Rollup  Event Frame Generation

Name	Expression	Value	Output Attribute
Ptbg	'Tubing Pressure'	117.94 psi	<a href="#">Map</a>
dt	'Tubing Size'	2.441 in	<a href="#">Map</a>
T	if BadVal('Allocation Meter Temperature') then 90 else 'Allocation Meter Temperature'	43.925 deg F	<a href="#">Map</a>
Z	0.97	0.97	<a href="#">Map</a>
p1	7	7	<a href="#">Map</a>
ColemansCV	$4.434 * (((7.481 * p_1) - 0.0031 * (P\_TBG))^{0.25}) / (0.0031 * P\_TBG)^{0.5} * (\pi() * 3.067 * (P\_TBG) * (d\_t^2) * 1000) / (576 * Z * (T + 460))$	473.57	<a href="#">Map</a>
TurnersCV	$5.62 * (((7.481 * p_1) - 0.0031 * (P\_TBG))^{0.25}) / (0.0031 * P\_TBG)^{0.5} * (\pi() * 3.067 * (P\_TBG) * (d\_t^2) * 1000) / (576 * Z * (T + 460))$	600.24	<a href="#">Map</a>
CalculatedCV	if(P_TB G<1000)then(Colemans_CV)Else(Turners_CV)	473.57	<a href="#">Critical Velocity</a>

[Add a new expression](#)

# Key Differentiator #7

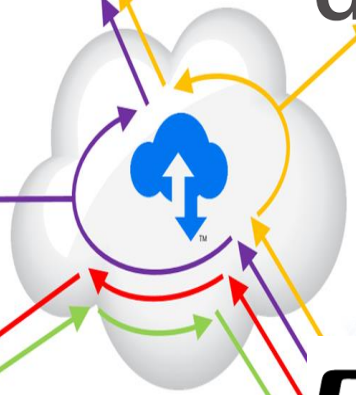
They see new value from applying **analytics** and **outsourcing** via the **digital value chain** – the community model

# Integrating the Digital Value Chain with PI Cloud Connect

PI Cloud Connect



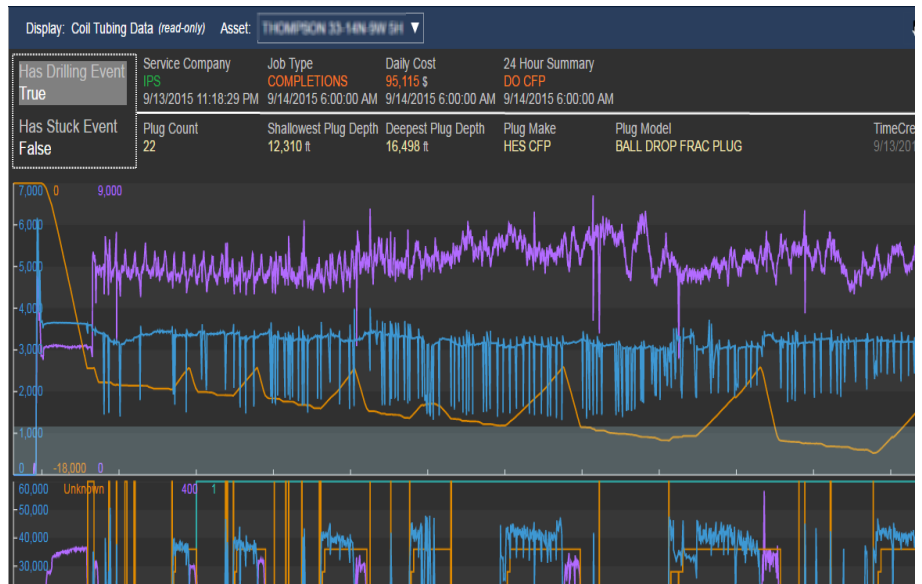
Solar Turbines  
*A Caterpillar Company*



- Quality
- Production
- Equipment
- Performance



## Coiled Tubing Analytics &



## Community Model

# Summary - Key Differentiators

1. **Guided by the 4M Strategy – “Make Me More Money”**
2. **Leverage PI AF element templates.... owned by SMEs**
3. **Use a “hybrid data lake strategy”**
4. **Define and leverage “Layers of analytics”..and work up and down**
5. **See IOT as an extension of the PI System Infrastructure**
6. **Simplified and standardized calculations and analytics in PI AF**
7. **Moving to analytics on the digital value chain – the community model**

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O&G Industry Principal

OSIsoft

