PI System Analytics, Fit for Purpose

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PI System Analytics – Fit for Purpose

ABSTRACT

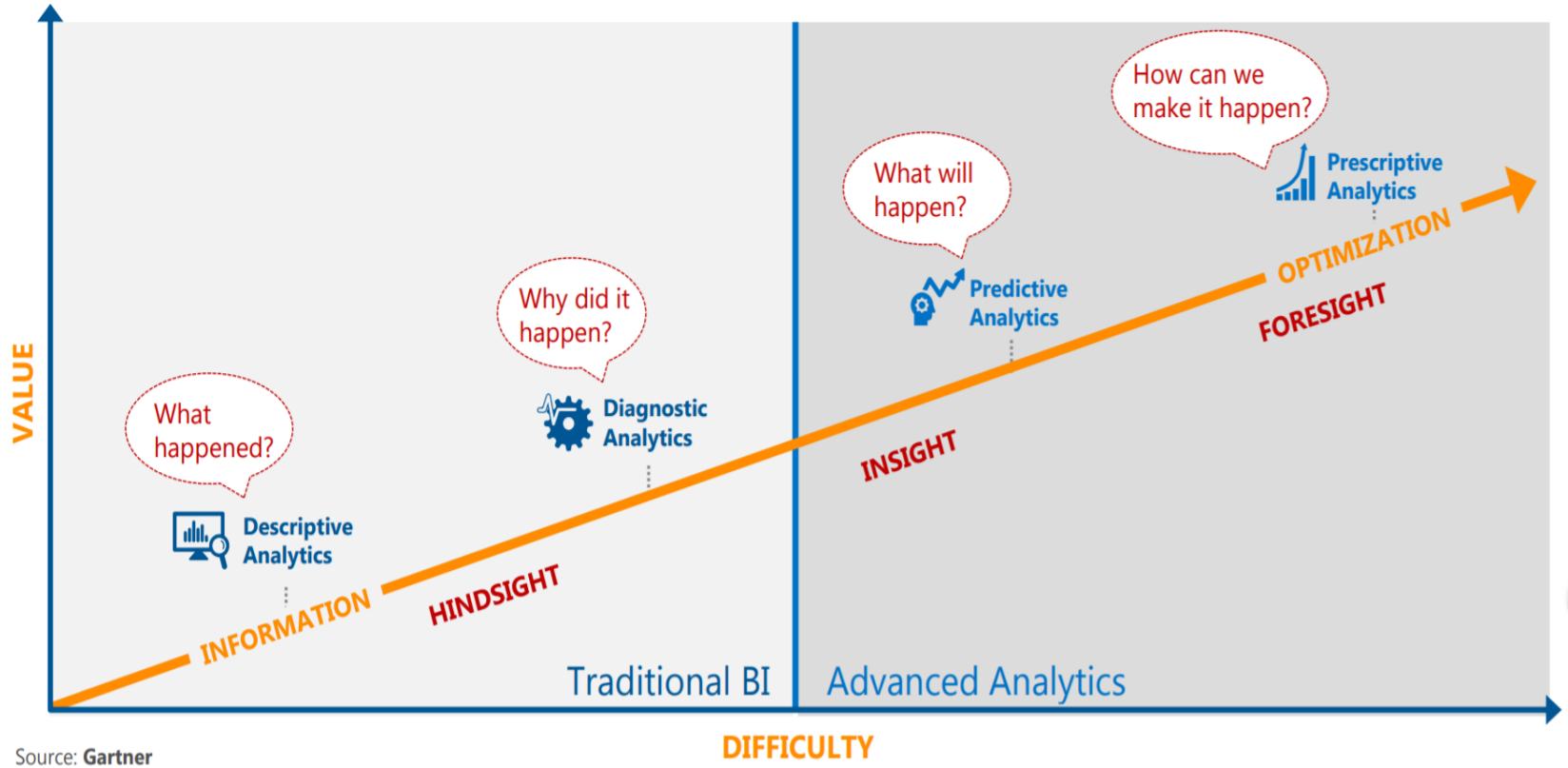
Attend this talk as we cover scenarios to illustrate the different levels of analytics that are fit-for-purpose when using the PI System - for example, what calculations and analysis do you do in AF, when do you use MATLAB for advanced calculations that hook into AF and when do you call on “data science and machine learning ”.

Use cases will focus on equipment i.e. pump or motor or compressor etc. as well as on a process.

Layers of Analytics – View Thru' Multiple Lenses

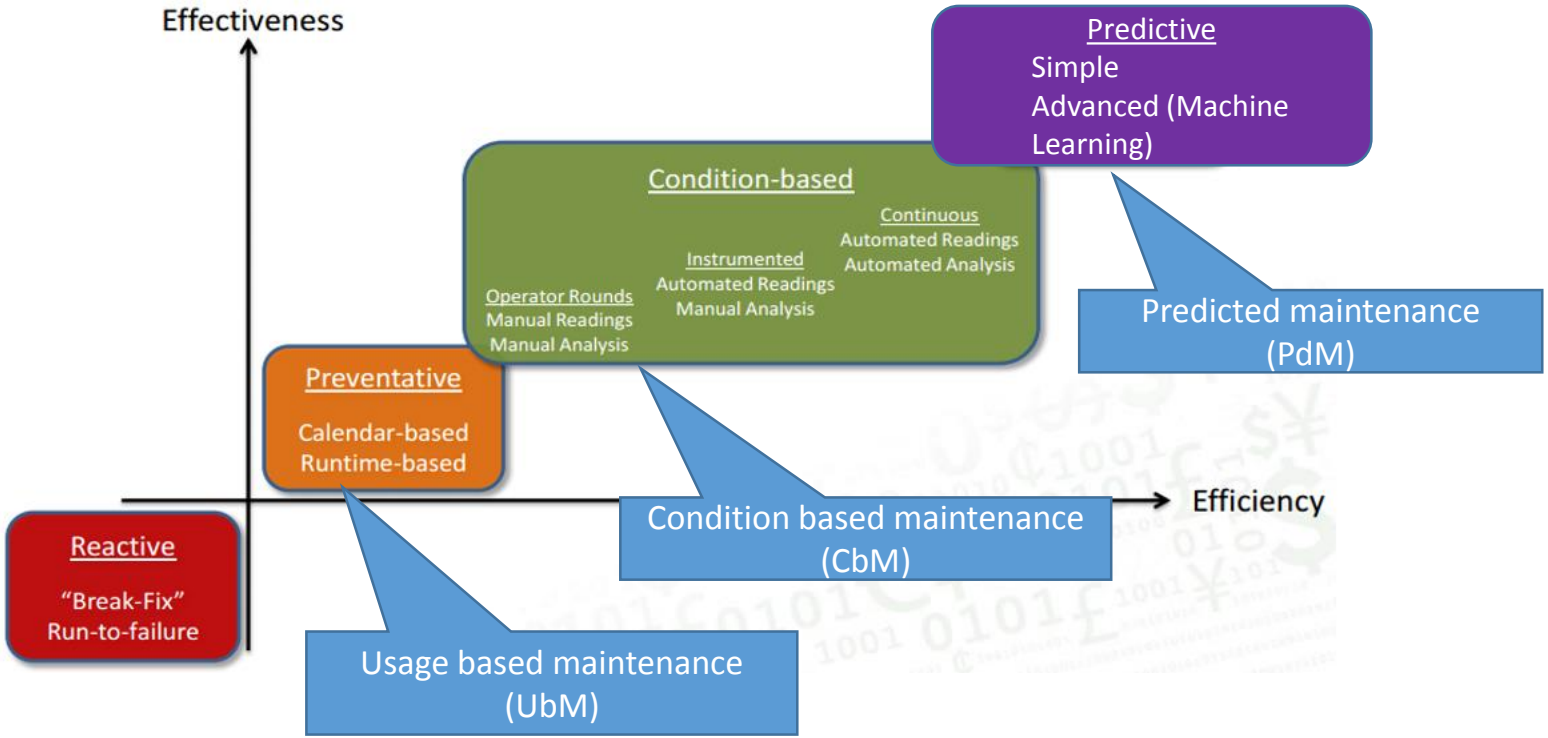
- Functional Scope - *Process Insight & Excellence*
  - Descriptive, diagnostic, predictive, prescriptive
- Business Scope - *Improved Reliability*
  - **U**sage-**b**ased **M**aintenance - UbM
  - **C**ondition-**b**ased **M**aintenance - CbM
  - **P**re**d**ictive **M**aintenance – PdM
    - *Simple predictive (Advanced CbM)*
    - *Advanced predictive - Statistical, Machine learning…*
- Architectural Location
  - Edge device, Server or cloud based
  - Analytics during data collection?
- …

Layers of Analytics - Process Operations



Source: **Gartner**

Layers of Analytics - Maintenance & Reliability



Layers of Analytics – View Thru' Multiple Lenses

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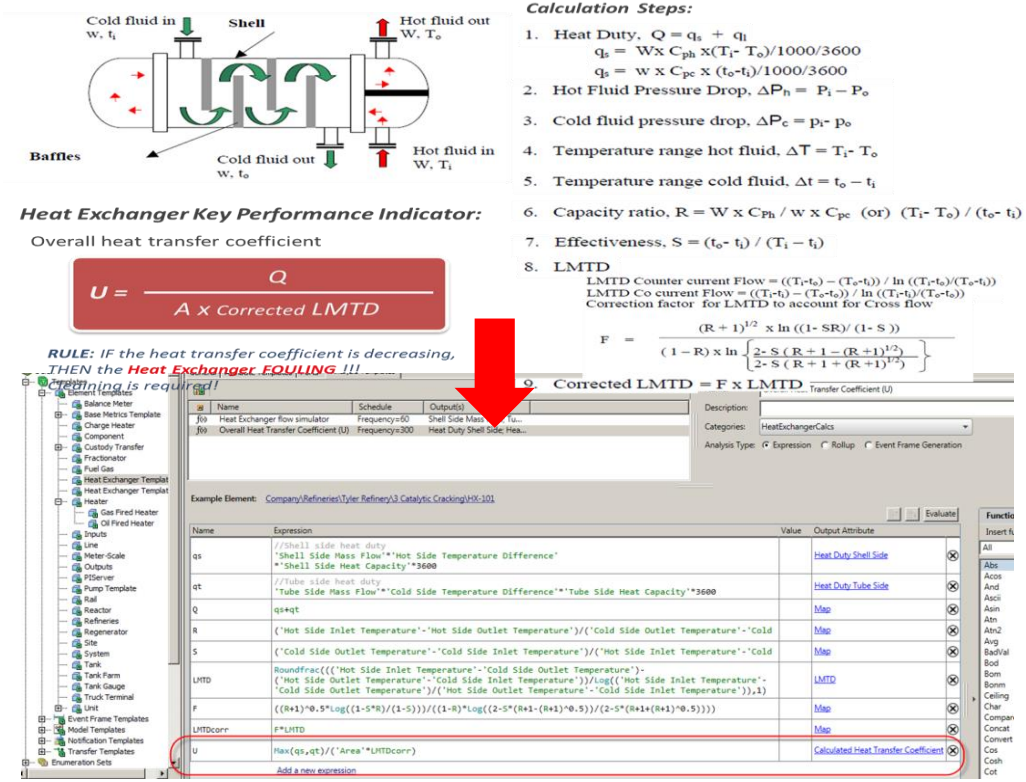
  - Edge device, Server or cloud based
- …

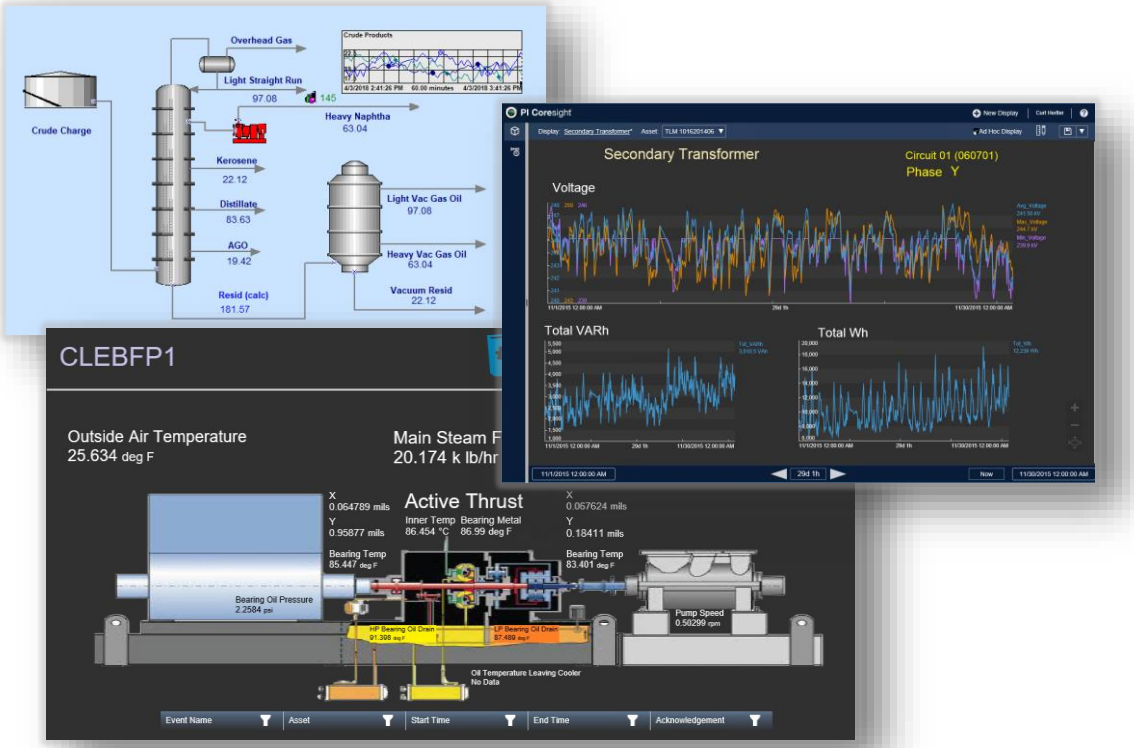
Descriptive Analytics – *PI Asset Analytics*

- *Configure* calculations for transparency and scale
- Math, statistical, and time-based functions
- Integration with MATLAB
- Testing and operationalization of predictive analysis models
- Condition-based notification
- Supports future data for forecasting



Diagnostic Analytics – *Trending and Event Awareness*

- Access to operational data in real-time with tools suited to Operations.
- Supports ad hoc, self-service investigation.



Real-time Data is Different

- Transactional data is recorded in a tabular format with values associated by columns in each row.
- Real-time data is recorded with only time context, i.e. value and timestamp.

	leakno	compute_0002	city	grade	read_locat	map	plat	block	date_reptd
1	7800201621	00201621	San Jose	3	Under Drway o/m	3411	F07	040	11/28/2000 14:00:00
2	7801200081	01200081	Santa Clara	3	o/m in s/e cor of Humbolt Ave	3411	B08	010	1/5/2001 11:00:00
3	7801200091	01200091	Santa Clara	3	o/m 2' into property	3411	D06	028	1/4/2001 01:30:00
4	7801200121	01200121	Santa Clara	2	o/m, 3' from sidewalk	3411	D06	012	1/16/2001 10:00:00
5	7801200841	01200841	Santa Clara	3	1% o/m under concrete pkstrip at e/end of drway	3411	A07	028	8/27/2001 11:00:00
6	7801200851	01200851	Santa Clara	3	1% under drway at curb & Gutter	3411	A08	015	8/28/2001 10:00:00
7	7803200121	03200121	San Jose	3	1575 Parkveiw Ave.	3411	H07	044	3/23/2003 09:48:00
8	7803200461	03200461	Santa Clara	3	1% in svc tee area o/main	3411	C07	026	11/10/2003 07:33:00
9	7806200241	06200241	Santa Clara	3	s/w cor Princeton Wy x Princeton Ct on main	3411	C07	012	2/6/2006 13:15:00
10	7806200271	06200271	Santa Clara	3	S/E cor Homestead x Lawrence Exwy valve frme&cover	3411	C07	016	2/7/2006 11:40:00
11	7806200351	06200351	Santa Clara	2	O/M @ svc tee (Longside)	3411	C08	037	2/16/2006 10:00:00
12	7806200441	06200441	Santa Clara	3	over main next to srvc tee	3411	D07	048	3/8/2006 13:00:00
13	7806200481	06200481	Santa Clara	2	on main or tee	3411	D08	052	3/10/2006 09:45:00
14	7806200491	06200491	Santa Clara	2	on main ovr sewer not venting to house	3411	D08	053	3/10/2006 10:00:00
15	7806200501	06200501	Santa Clara	2	btwn #s 3145 & 3155 Mauricia Wy on main or tee	3411	D08	008	3/10/2006 11:25:00
16	7806200511	06200511	Santa Clara	3	on tee S/O driveway	3411	D08	056	3/10/2006 14:00:00
17	7806200541	06200541	Santa Clara	3	on tee	3411	D08	049	3/15/2006 13:30:00
18	7806200561	06200561	San Jose	2	ovr main btwn Greendale & Auburn on Albany	3411	E08	014	3/16/2006 13:45:00
19	7806200611	06200611	Santa Clara	3	15' from drway about 15" in parkstrip @svc tee	3411	F07	041	3/22/2006 13:45:00
20	7806200641	06200641	Santa Clara	3	3% OVER MAIN NEXT TO SEWER	3411	G08	012	3/23/2006 14:00:00
21	7806200651	06200651	San Jose	3	on main or srvc tee	3411	F08	072	3/24/2006 11:15:00
22	7806200681	06200681	Santa Clara	2+	5" in parkstrip fr/swk over tee on main 6' from...	3411	G07	006	3/28/2006 13:40:00
23	7806200701	06200701	Santa Clara	3	36' EO W p/l Olympus. 2% In water box	3411	G08	053	3/28/2006 13:00:00
24	7806200711	06200711	Santa Clara	2	F/O o/main (under tree)	3411	H06	023	3/29/2006 11:00:00
25	7806200721	06200721	Santa Clara	2+	o/svc/tee about 3' from drway in parkstrip	3411	G07	014	3/29/2006 13:10:00

56.902 03-SEP-2016 11:23 AM

Real-time Data Requires Context

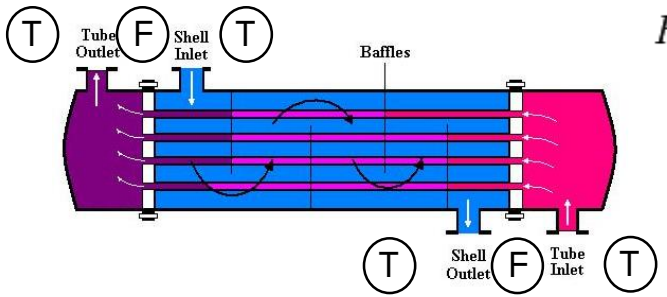
Time

63.781 03-SEP-2016 11:19 AM → 56.902 03-SEP-2016 11:23 AM → 58.341 03-SEP-2016 11:41 AM

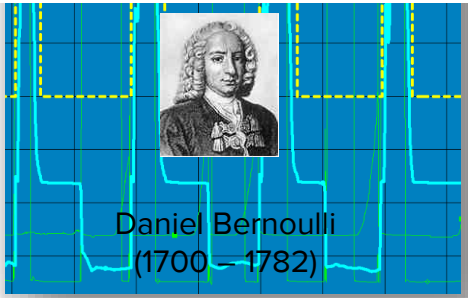
Asset

Process Actions

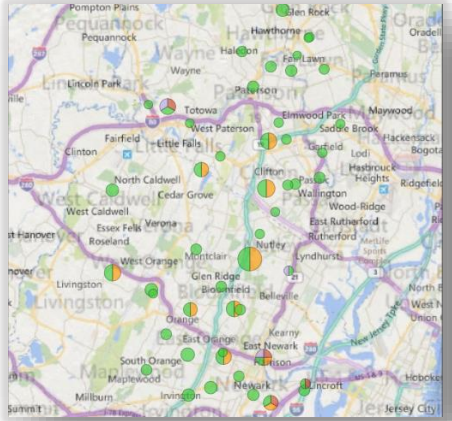
Location



$$H = z + \frac{p}{\rho g} + \frac{v^2}{2g} = h + \frac{v^2}{2g}$$



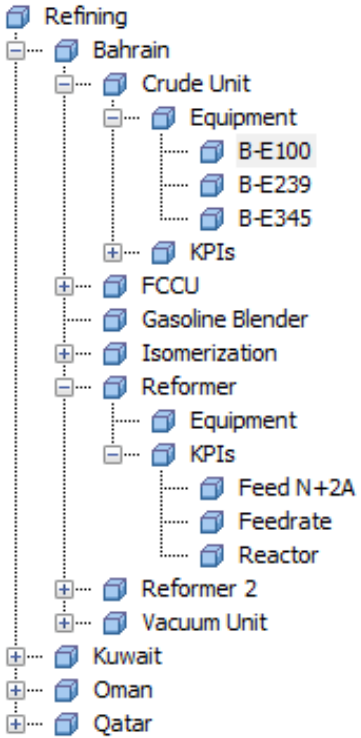
Daniel Bernoulli
(1700 – 1782)



Real-time Data Requires Context

Asset Hierarchy

- Plant
- Process
- Assets
- Process Context
- Location
- Specifications



Process Context

Category: Process Data	
Cold Side Inlet Temperature	77.1157989501953 °F
Cold Side Outlet Temperature	131.192291259766 °F
Hot Side Inlet Temperature	374.601501464844 °F
Hot Side Outlet Temperature	292.926361083984 °F

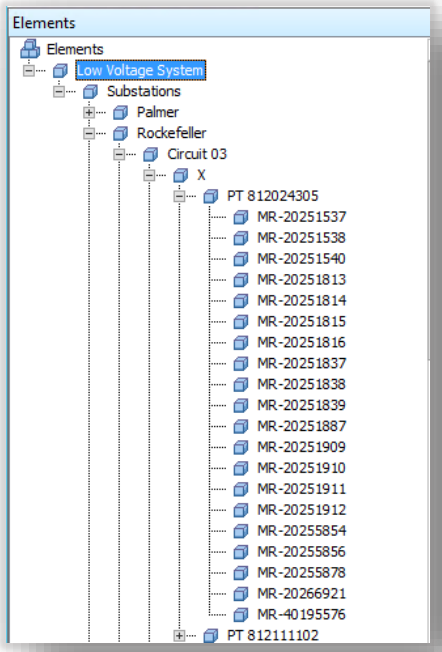
Location

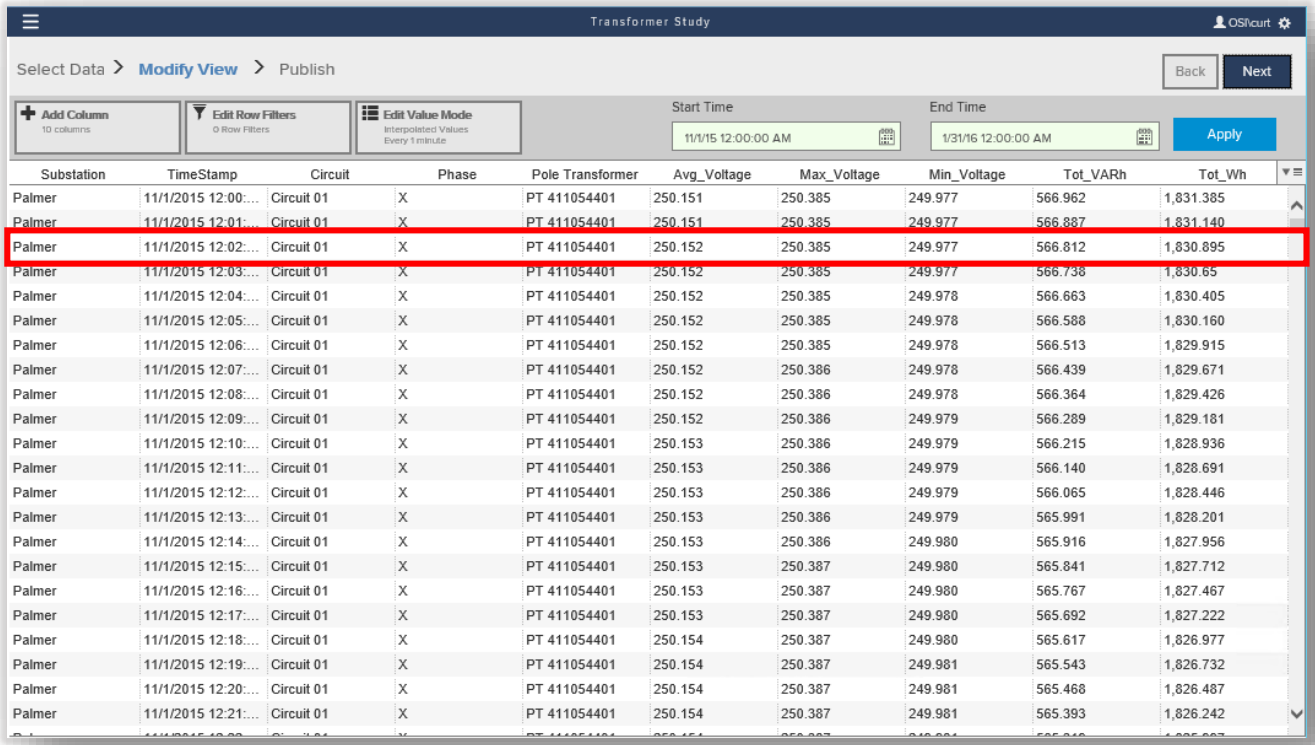
Category: Location	
Address	2265 W Salinas St, San ...
Latitude	29.43027
Longitude	-98.518172

Specifications

Category: Specifications	
Area	1200 ft2
Coefficient	75.66 BTU per F ft2 Hr
Service	Crude vs. Naphtha

PI AF Provides Context to Real-time Data





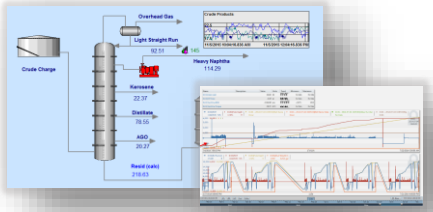
Substation	TimeStamp	Circuit	Phase	Pole Transformer	Avg_Voltage	Max_Voltage	Min_Voltage	Tot_VARh	Tot_Wh
Palmer	11/1/2015 12:00:...	Circuit 01	X	PT 411054401	250.151	250.385	249.977	566.962	1,831.385
Palmer	11/1/2015 12:01:...	Circuit 01	X	PT 411054401	250.151	250.385	249.977	566.887	1,831.140
Palmer	11/1/2015 12:02:...	Circuit 01	X	PT 411054401	250.152	250.385	249.977	566.812	1,830.895
Palmer	11/1/2015 12:03:...	Circuit 01	X	PT 411054401	250.152	250.385	249.977	566.738	1,830.65
Palmer	11/1/2015 12:04:...	Circuit 01	X	PT 411054401	250.152	250.385	249.978	566.663	1,830.405
Palmer	11/1/2015 12:05:...	Circuit 01	X	PT 411054401	250.152	250.385	249.978	566.588	1,830.160
Palmer	11/1/2015 12:06:...	Circuit 01	X	PT 411054401	250.152	250.385	249.978	566.513	1,829.915
Palmer	11/1/2015 12:07:...	Circuit 01	X	PT 411054401	250.152	250.386	249.978	566.439	1,829.671
Palmer	11/1/2015 12:08:...	Circuit 01	X	PT 411054401	250.152	250.386	249.978	566.364	1,829.426
Palmer	11/1/2015 12:09:...	Circuit 01	X	PT 411054401	250.152	250.386	249.979	566.289	1,829.181
Palmer	11/1/2015 12:10:...	Circuit 01	X	PT 411054401	250.153	250.386	249.979	566.215	1,828.936
Palmer	11/1/2015 12:11:...	Circuit 01	X	PT 411054401	250.153	250.386	249.979	566.140	1,828.691
Palmer	11/1/2015 12:12:...	Circuit 01	X	PT 411054401	250.153	250.386	249.979	566.065	1,828.446
Palmer	11/1/2015 12:13:...	Circuit 01	X	PT 411054401	250.153	250.386	249.979	565.991	1,828.201
Palmer	11/1/2015 12:14:...	Circuit 01	X	PT 411054401	250.153	250.386	249.980	565.916	1,827.956
Palmer	11/1/2015 12:15:...	Circuit 01	X	PT 411054401	250.153	250.387	249.980	565.841	1,827.712
Palmer	11/1/2015 12:16:...	Circuit 01	X	PT 411054401	250.153	250.387	249.980	565.767	1,827.467
Palmer	11/1/2015 12:17:...	Circuit 01	X	PT 411054401	250.153	250.387	249.980	565.692	1,827.222
Palmer	11/1/2015 12:18:...	Circuit 01	X	PT 411054401	250.154	250.387	249.980	565.617	1,826.977
Palmer	11/1/2015 12:19:...	Circuit 01	X	PT 411054401	250.154	250.387	249.981	565.543	1,826.732
Palmer	11/1/2015 12:20:...	Circuit 01	X	PT 411054401	250.154	250.387	249.981	565.468	1,826.487
Palmer	11/1/2015 12:21:...	Circuit 01	X	PT 411054401	250.154	250.387	249.981	565.393	1,826.242

Supporting Analytics with Contextualized Data

Real-Time Decision Analysis

Retrospective & Predictive Analysis

PI Integrator for Business Analytics

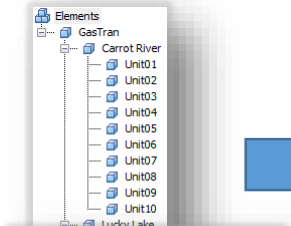


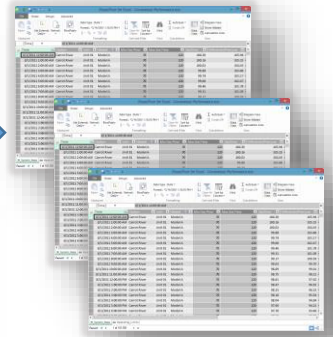
Time and Event
Trending & Awareness

Specialized Models
Simulation & Optimization

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

Descriptive
Condition & Performance

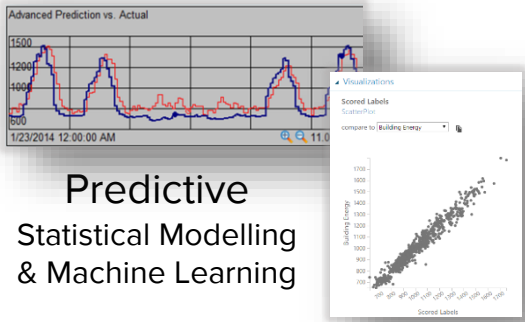




Time, Event and Asset Context

Tabular Context

Visual
Dashboards & Multidimensional Assessment

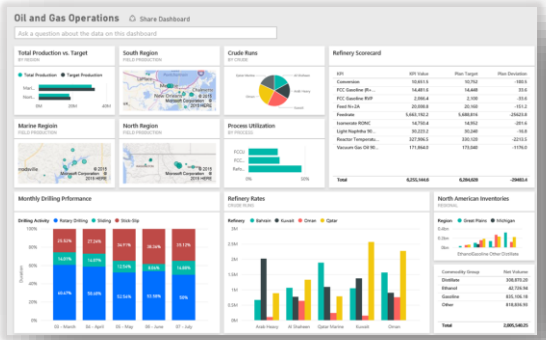


Predictive
Statistical Modelling & Machine Learning

Common Ground between Technological Contexts

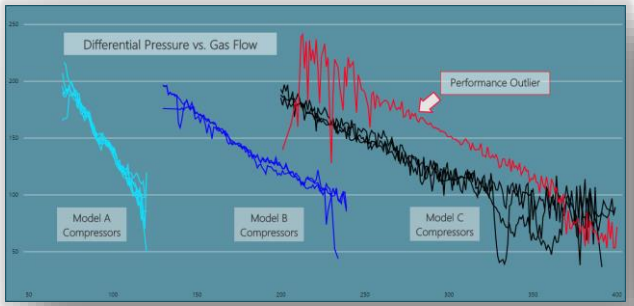
Diagnostic Analytics – *Multidimensional Visualization, Dashboards*

Business Analysis
Product inventories



Dashboards
Collaboration

Asset Performance
Benchmarking



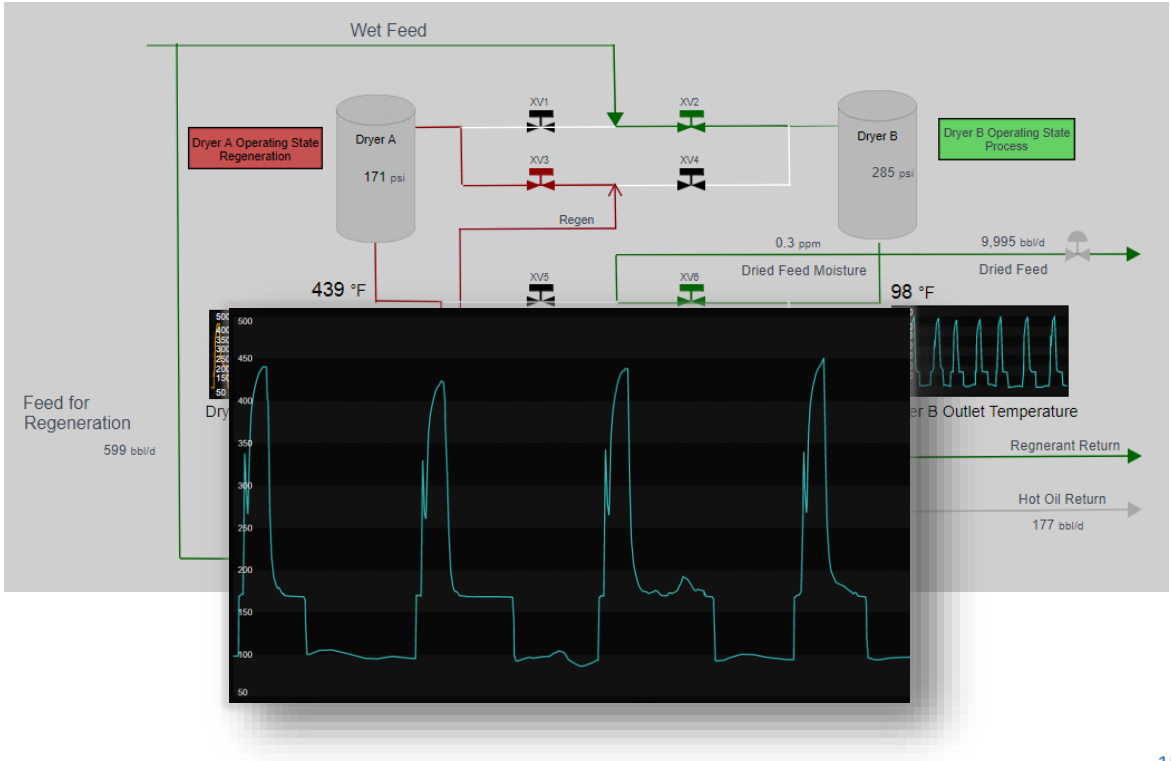
Analytics
Measurement
Correlation

Feed Drying Process - *Process and Regeneration Cycles*

Also see PI World 2018 Layers of Analytics Hand-on Lab

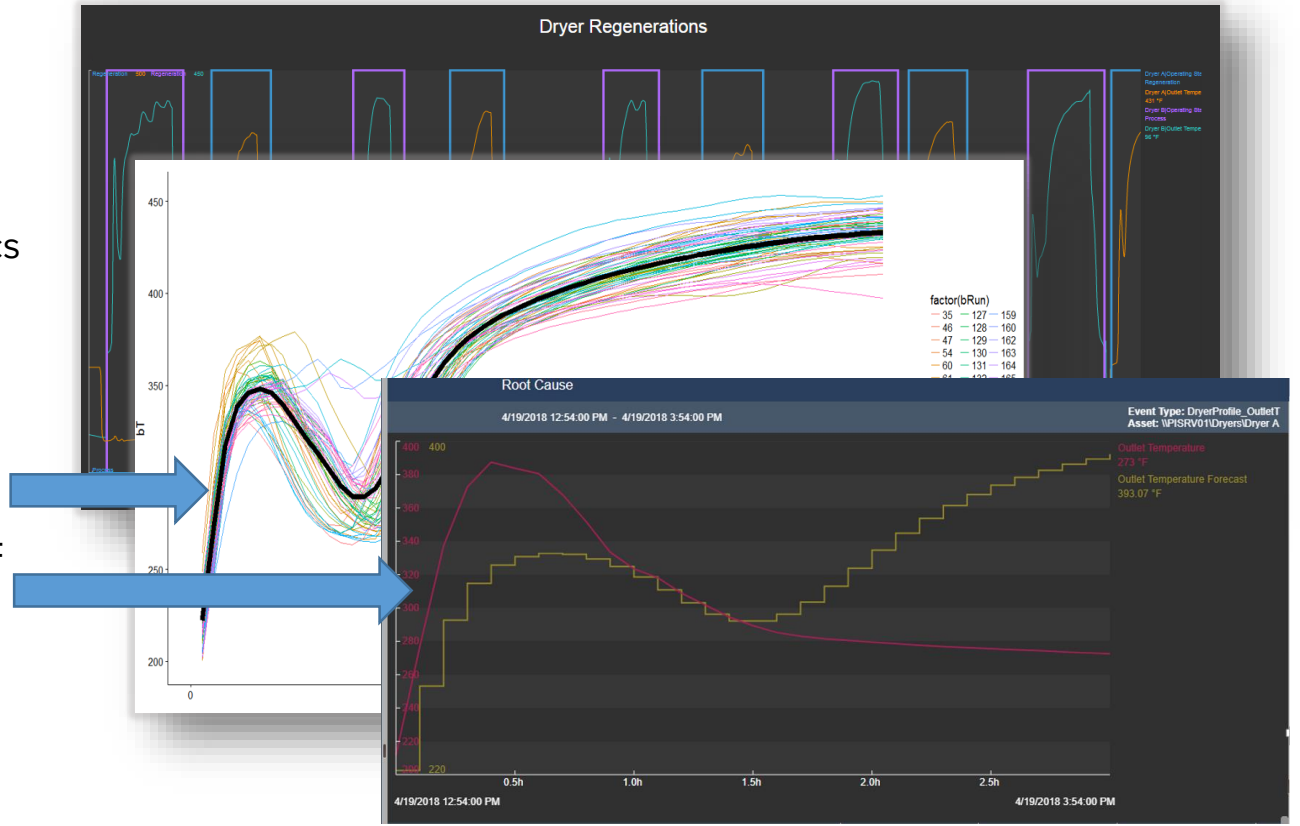
- Molecular sieve dryers remove water from hydrocarbon feedstock before entering reactor
- Proper regeneration is critical to avoid corrosion in acidic reaction
- Cyclic operation between Process and Regeneration cycles
- Regeneration cycle is indicated by high be outlet temperatures

Dryer A Regeneration **Dryer B Regeneration**



Predictive Analytics – *Dryer Regeneration Guidance for Operations*

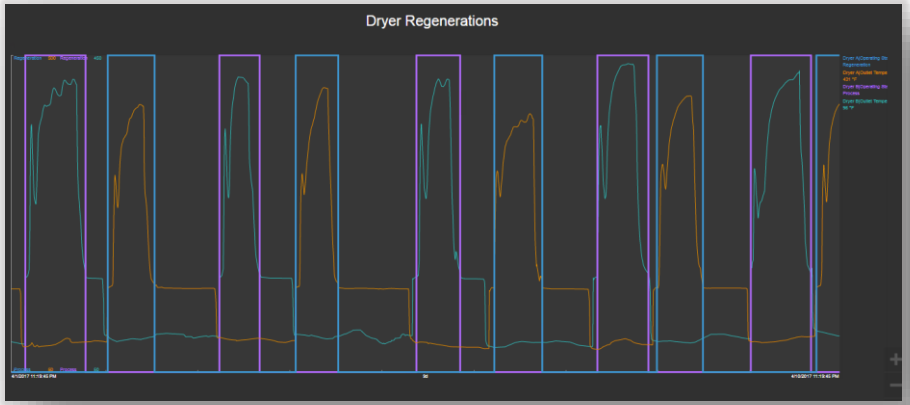
- During Regeneration, monitor bed Outlet Temperature against a modeled profile, notify operator of deviations
- Prepare data using AF Analytics and Event Frames
- Publish dataset for model development and training
- Develop model in R/MATLAB
- Operationalize model using AF Analytics and R/MATLAB



Feed Dryer Status – Regeneration Event Frames

- AF Analytic defines the beginning and end of regeneration cycle
- Digital state for each dryer with Process of Regeneration states
- Start temp. = 170 F,
  End temp = 175 F
- Confirm five hours since last regeneration to avoid short cycles caused by initial temperature fluctuation
- Backfill through 2017

```
If('Outlet Temperature' >= 'Outlet Temperature|Start of Regeneration Temperature'
   And PrevVal('Operating State', '*-5h') = "Process")
Then (If PrevVal('Operating State', '*')="Regeneration"
      Then NoOutput()
      Else "Regeneration")
Else
  (If('Outlet Temperature' <= 'Outlet Temperature|End of Regeneration Temperature'
      And PrevVal('Operating State', '*-5h') = "Regeneration")
   Then (If PrevVal('Operating State','*') ="Process"
         Then NoOutput()
         Else "Process")
   Else NoOutput())
```

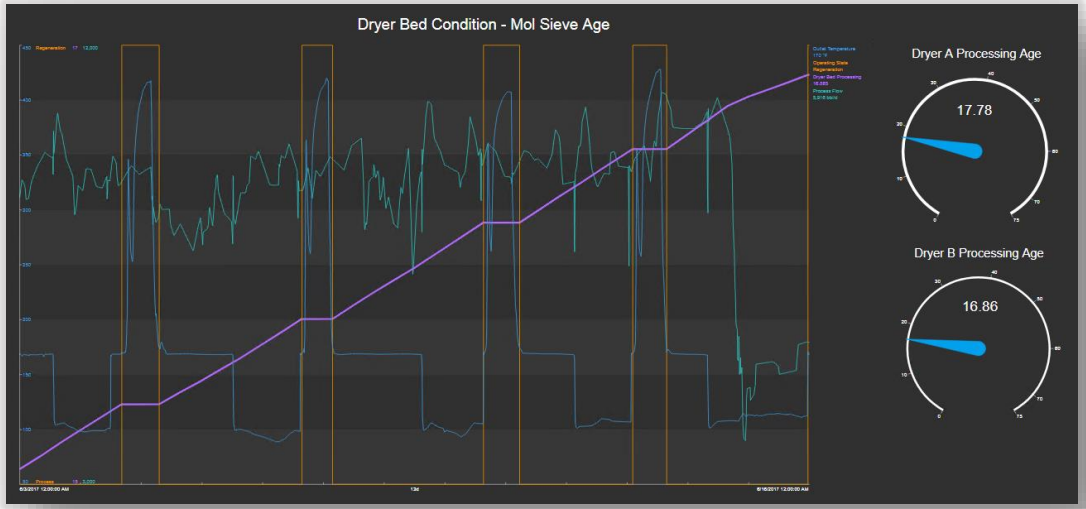


Feed Dryer Bed Age – "*Dryer Bed Processing Age*"

- AF Expression analytic determines processing age of molecular sieve desiccant
- Enables bed balancing for maximum service
- Calculate Lifetime Total Dried Feed, converts total volume from a volumetric rate
- Processing age :

$$\frac{\text{Lifetime Total Dried Feed}}{\text{Loaded Wt. of Mol. Sieve}}$$

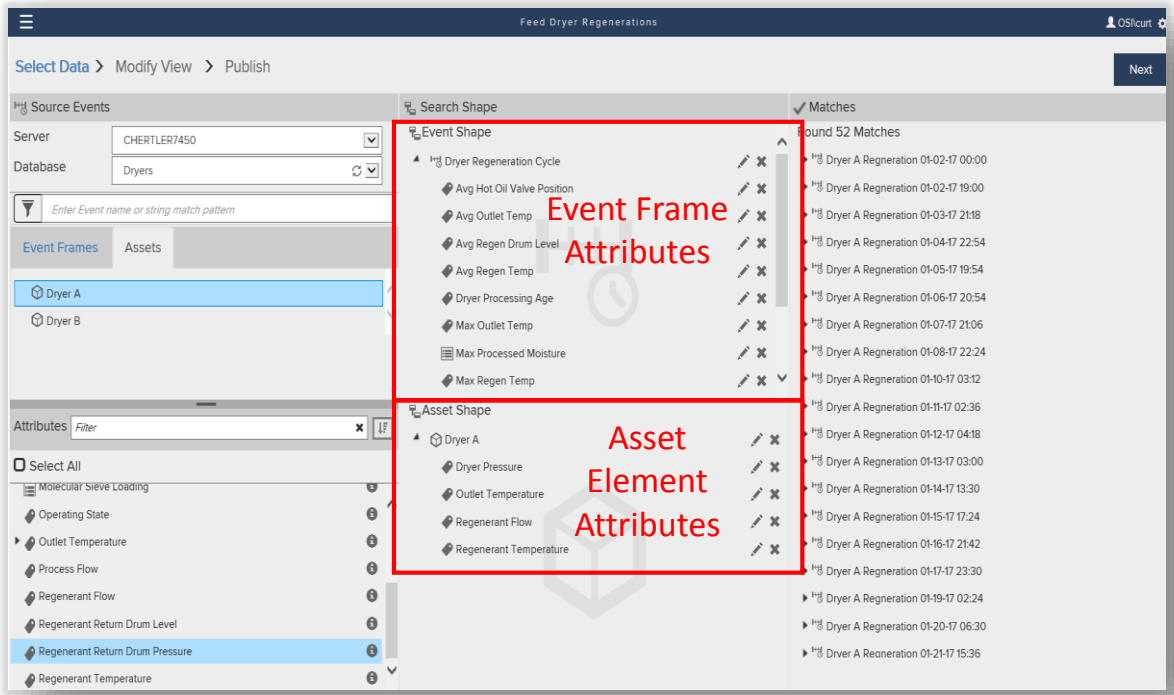
- Backfill through 2017




```
If ('Operating State' = "Process"
     And Not(BadVal('Process Flow'))
     And Not(BadVal(PrevVal('Process Flow','*'))))
 Then 'Lifetime Total Dried Feed' +
    TagTot('Process Flow', PreviousProcessFlowTime,'*')
 Else NoOutput()
```

Dryer Regeneration – *Publishing Summarized Dataset*

- Leverage AF model to Select, Shape and Publish tabular views to a variety of endpoints
- Event Views publish Event Frame data in either Summarized or Sampled structures
- Sampled view combines aggregations taken over the Event Frame duration with Asset data sampled at intervals throughout the duration



Dryer Regeneration - *Sampled Event Publication*

Event Frame

Event Frame

Event Frame

Event Frame

Interpolated Values – 6 min.

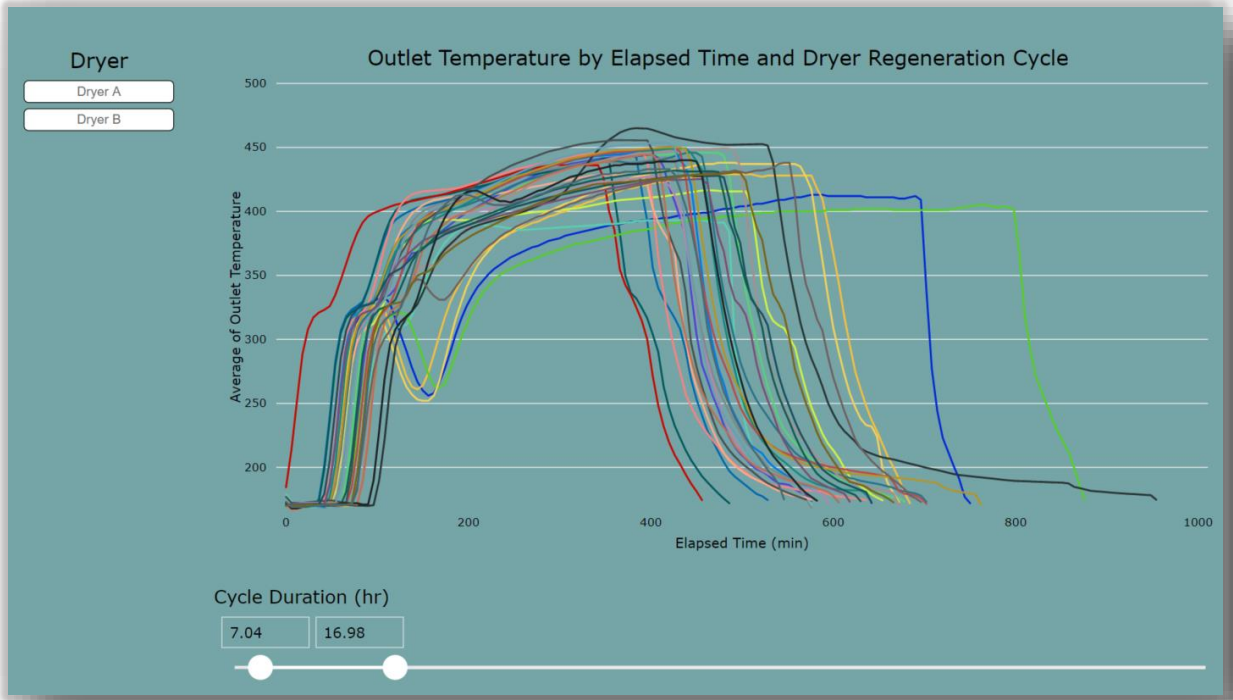
Dryer	Time Stamp	Duration	Elapsed Time	Dryer Pressure	Outlet Temperature	Regenerant Flow	Regenerant Tempe
Dryer A	1/2/2017 12:00:00 AM	5.3	0	170.4697	436.9	603.2525	496.1
Dryer A	1/2/2017 12:06:00 AM	5.3	6	170.4824	437.8	603.6448	496.2
Dryer A	1/2/2017 12:12:00 AM	5.3	12	170.495	438.6	605.063	496.4
Dryer A	1/2/2017 12:18:00 AM	5.3	18	170.5076	439.5	599.6411	496.8
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Dryer A	1/2/2017 5:18:00 AM	5.3	318	204.1571	173.8	314.5962	287.9
Dryer B	1/2/2017 7:00:00 AM	9.6	0	169.723	170.2	596.6678	480.7
Dryer B	1/2/2017 7:06:00 AM	9.6	6	170.4792	170.3	598.8013	484.8
Dryer B	1/2/2017 7:12:00 AM	9.6	12	171.0217	170.4	597.2024	487.9
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Dryer B	1/2/2017 4:36:00 PM	9.6	576	168.8051	174.9	896.8521	173.8
Dryer A	1/2/2017 7:00:00 PM	11.3	0	169.5046	170	596.4086	425.6
Dryer A	1/2/2017 7:06:00 PM	11.3	6	170.3642	170.1	598.5709	442.7
Dryer A	1/2/2017 7:12:00 PM	11.3	12	170.2456	170.2	600.7331	466.3
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Dryer A	1/3/2017 4:54:00 AM	11.3	594	167.147	196.4	547.8572	173.4
Dryer B	1/3/2017 8:48:00 AM	9.3	0	169.3378	170.2	592.8909	491.6
Dryer B	1/3/2017 8:54:00 AM	9.3	6	168.1517	171.1	617.2303	490
Dryer B	1/3/2017 9:00:00 AM	9.3	12	167.7706	205.2	617.502	488.7
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Event Frame Attributes\Features

Dryer Regeneration Cycle	Avg Outlet Temp	Avg Regen Temp	Dryer Processing Age	Total Processed Feed
Dryer A Regneration 01-02-17 00:00	319.9179	229.7132	0.0005072668	4474.716
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
Dryer B Regneration 01-02-17 07:00	357.6974	404.2589	0.05128649	2742.962
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
Dryer A Regneration 01-02-17 19:00	332.5292	364.0818	0.1004348	5302.277
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
Dryer B Regneration 01-03-17 08:48	357.8753	399.4613	0.1699348	6347.083
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"

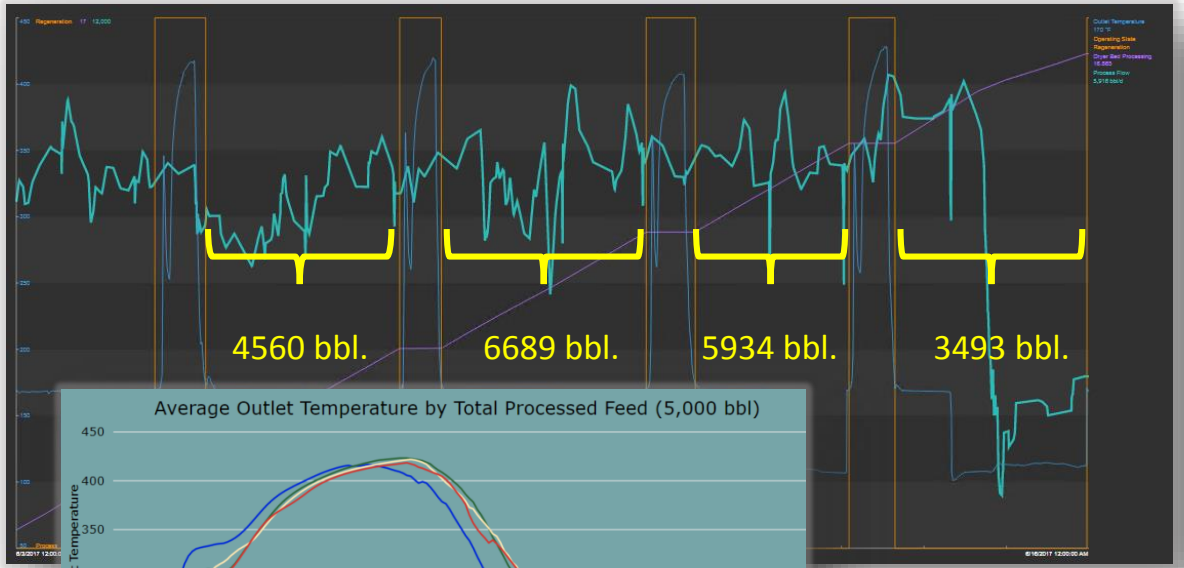
Diagnostic Analysis - *Event Frame Evaluation*

- Sampled Event View dataset imported into Power BI.
- Shows outlet temperature profiles for all Event Frames with filters for dryer asset and cycle duration.
- Filter Event Frames to remove outliers from analysis.
- Acceptable Regeneration cycle durations between 7 and 17 hours.



Dryer Regeneration - *Additional Feature for Refinement*

- Determine if total barrels of feed processed during the Process cycle prior to each regeneration affects outlet temperature profile
- Analysis in Power BI



Layers of Analytics – View Thru' Multiple Lenses

- Functional Objective - *Process Insight & Excellence*
  - Descriptive, diagnostic, predictive, prescriptive
- Business Scope - *Improved Reliability*
  - **U**sage-**b**ased **M**aintenance - UbM
  - **C**ondition-**b**ased **M**aintenance - CbM
  - **P**red**i**ctive **M**aintenance - PdM
- Architectural Location
  - Edge device, Server or cloud based
- …
- …

Predictive and Prescriptive - Shape Metrics – Golden Run

Dryer Regenerations.txt

Id	Dryer	TimeStamp.StartTime.Local	TimeStamp.EndTime.Local	TimeStamp.Local	Duration	ElapsedTime	Dryer Pressure	Outlet Temperature	Rege
1	Dryer A	1/2/2017 12:00:00 AM	1/2/2017 5:18:00 AM	1/2/2017 12:00:00 AM	5.3 0	170.4697	436.9	603.2525	496.1	Dryer A Regenerat
2	Dryer A	1/2/2017 12:00:00 AM	1/2/2017 5:18:00 AM	1/2/2017 12:06:00 AM	5.3 6	170.4824	437.8	603.6448	496.2	Dryer A Regenerat
3	Dryer A	1/2/2017 12:00:00 AM	1/2/2017 5:18:00 AM	1/2/2017 12:12:00 AM	5.3 12	170.495	438.6	605.063	496.4	Dryer A Regeneration 01-0
4	Dryer A	1/2/2017 12:00:00 AM	1/2/2017 5:18:00 AM	1/2/2017 12:18:00 AM	5.3 18	170.5076	439.5	599.6411	496.8	Dryer A Regenerat
5	Dryer A	1/2/2017 12:00:00 AM	1/2/2017 5:18:00 AM	1/2/2017 12:24:00 AM	5.3 24	170.5202	440.3	604.8259	496.8	Dryer A Regenerat
6								600.6193	496.2	Dryer A Regenerat
7								.64	497.2	Dryer A Regeneration 01-0
8										
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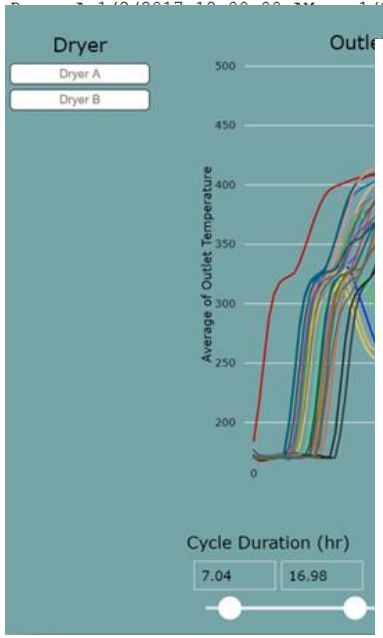
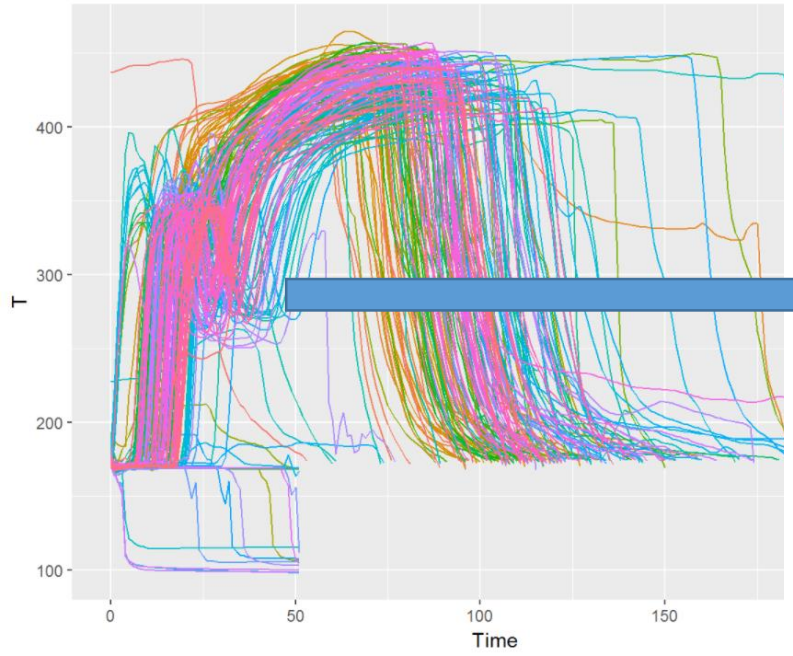
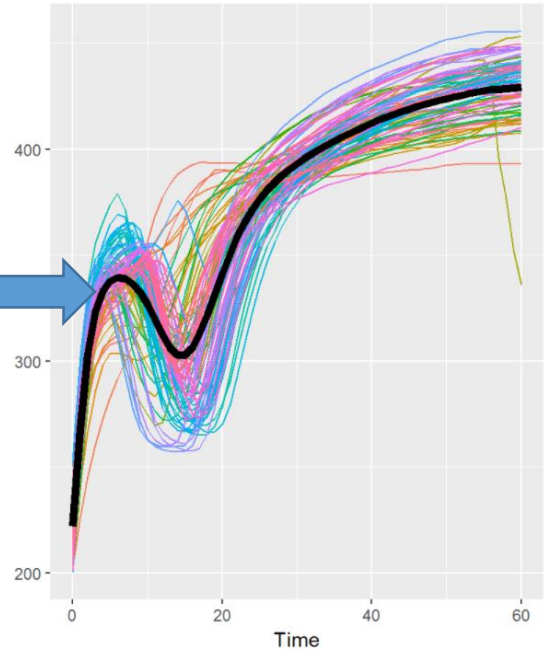
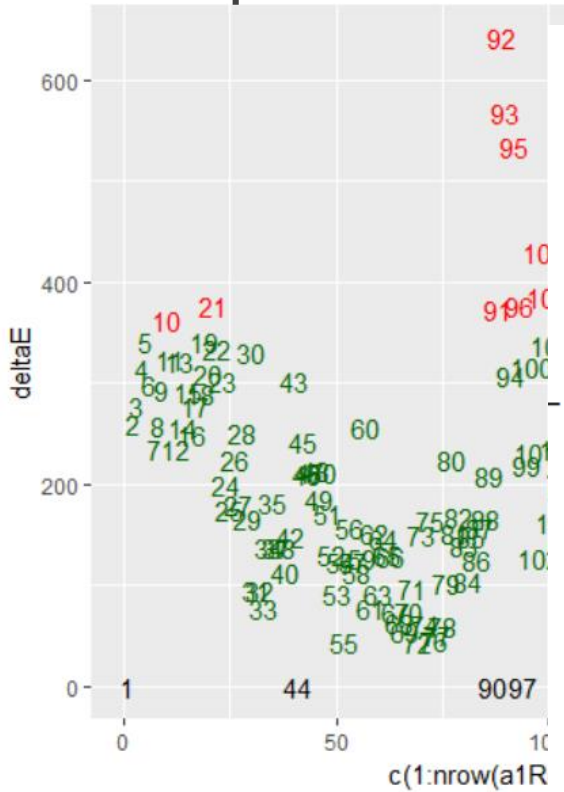
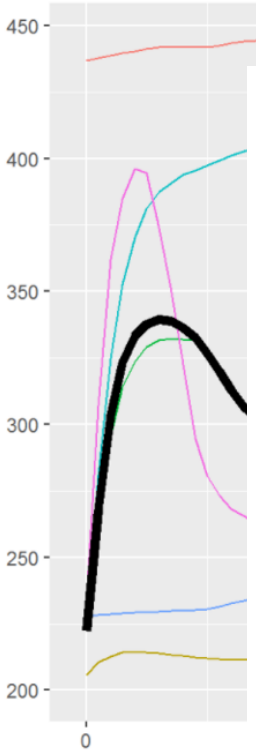


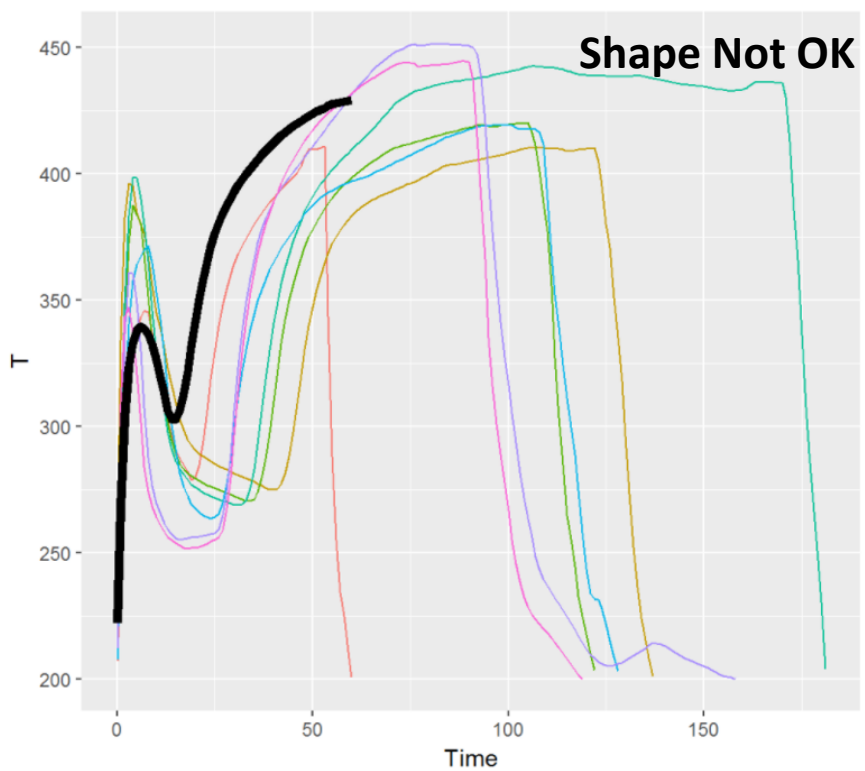




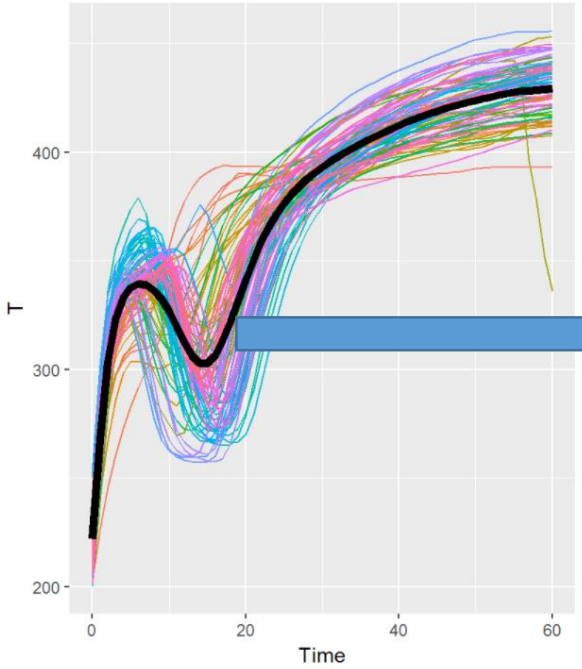
Shape Metrics - Regen Cycles Not OK or Bad Data



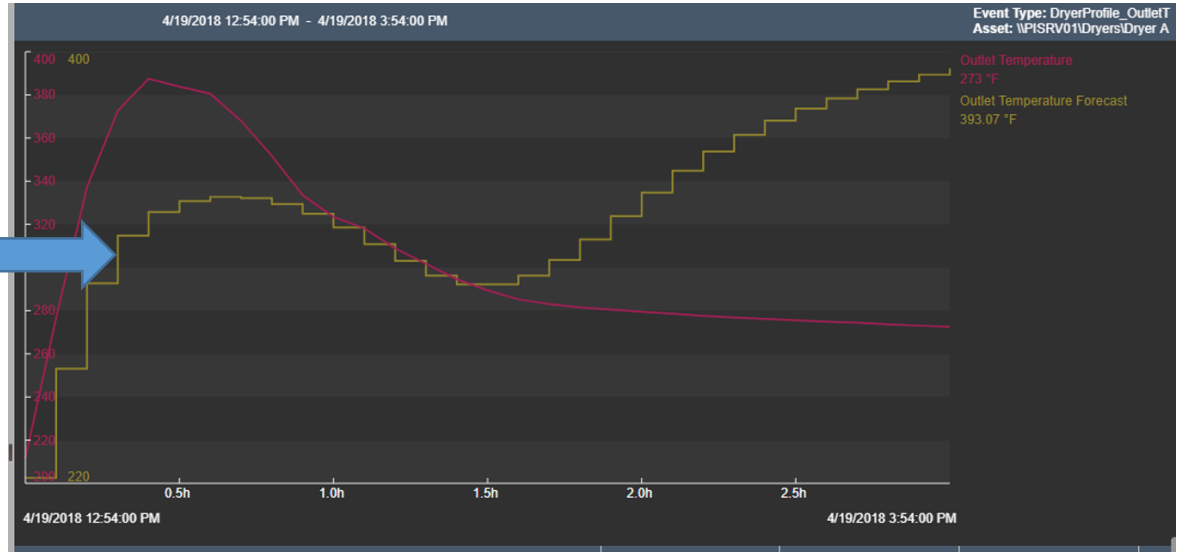




Operationalize - Expected Temperature Profile (Prescriptive)



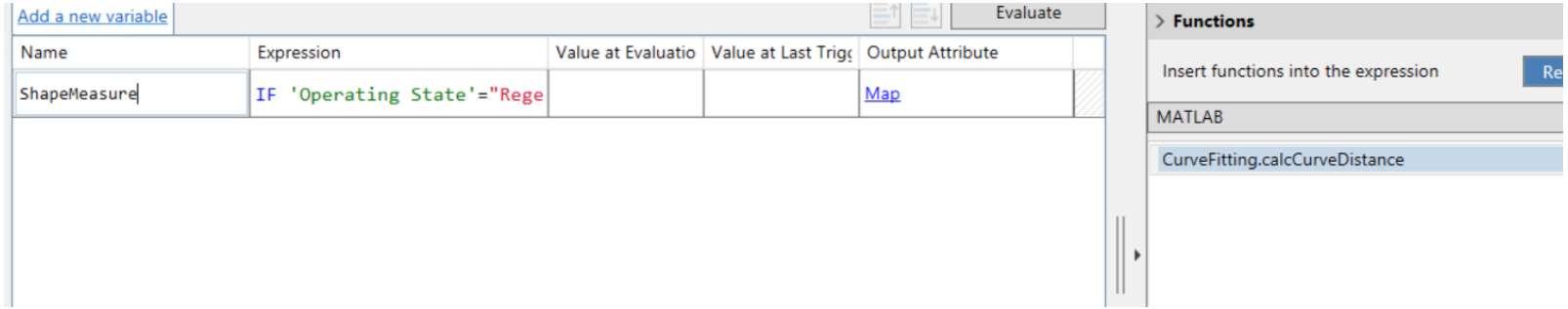
Via Future data tag



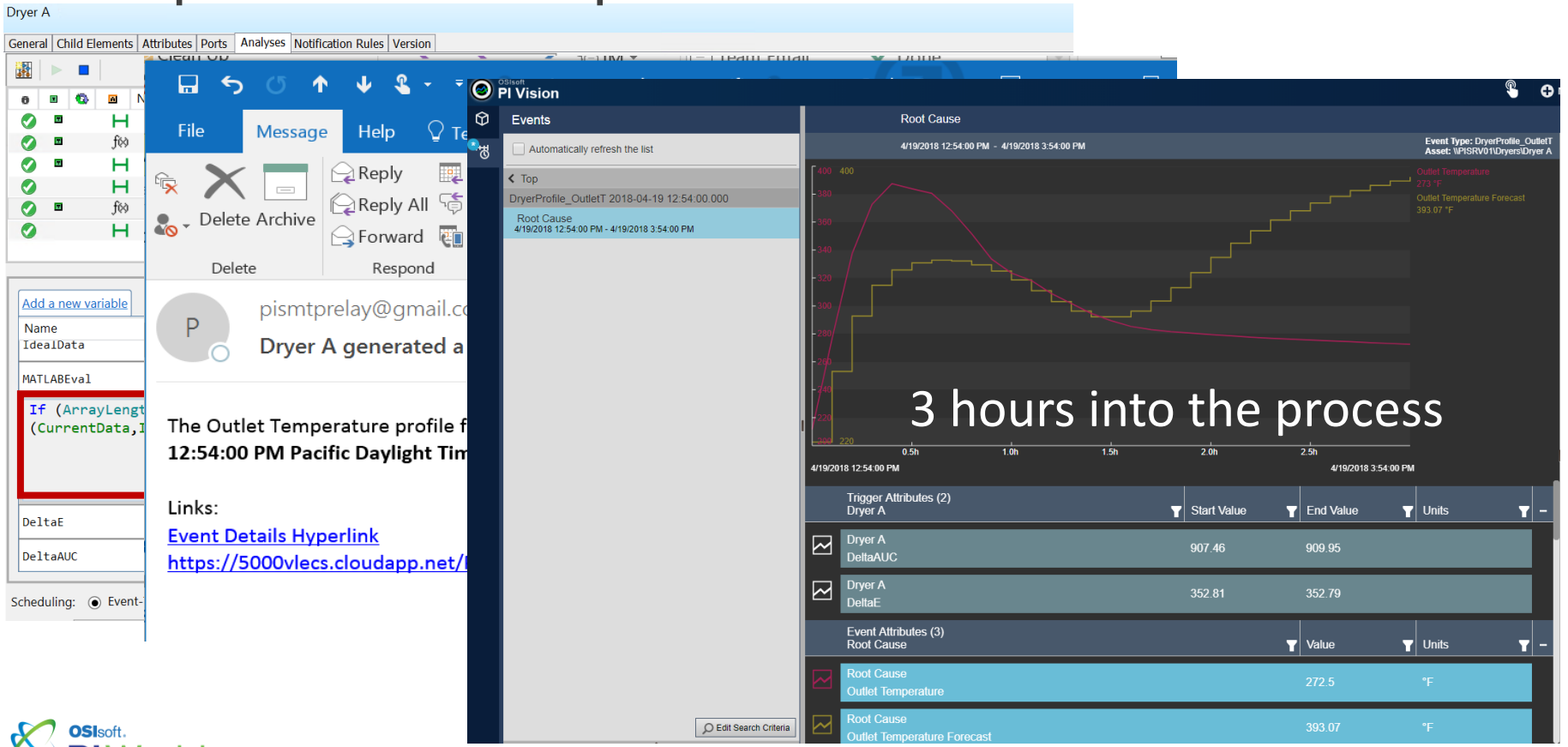
Shape Metrics - Operationalize the Model

Score the real time Temperature profile data

- is the Temperature profile as expected?
- can the difference from ideal be stated quantitatively?
- even if dissimilar, did we deliver enough energy?
- what false alarms can I avoid?
- after an alert, what corrective actions can I take?



Shape Metrics - Operationalize the Model



Layers of Analytics – View Thru' Multiple Lenses

- Functional Scope - *Process Insight & Excellence*
  - Descriptive, diagnostic, predictive, prescriptive

- Business Scope - *Improved Reliability*
  - **U**sage-**b**ased **M**aintenance - UbM
  - **C**ondition-**b**ased **M**aintenance - CbM
  - **P**re**d**ictive **M**aintenance – PdM
    - *Simple predictive (Advanced CbM)*
    - *Advanced predictive - Statistical, Machine learning…*

- Architectural Location
  - Edge device, Server or cloud based
- …

Maintenance – Usage and Condition based

- **U**sage-**b**ased **M**aintenance - UbM
  - **Motor Run-hours**
  - **Compressor starts/stops**
  - **Transformer – Load Tap Changer – Counts of Operations, Count thru' Neutral**
  - **…**

- **C**ondition-**b**ased **M**aintenance - CbM
  - **Delta P across a filter**
  - **High bearing temperature**
  - **High vibration**
  - **…**

Maintenance – Usage based

See PI World 2018 CBM Hand-on Lab

\\PI1\PI World 2018 - PI System Explorer (Administrator)

File Search View Go Tools Help

Database Query Date Back Check In Refresh New Element New Attribute

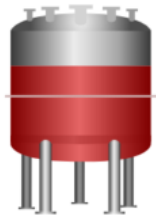
Elements

- Elements
  - Data Archive
  - Exercise 1
    - Process Area
      - Line 1
        - Mixer 1
        - Mixer 2
      - Line 2
  - Exercise 2
  - Element Searches

Mixer 1

General | Child Elements | Attributes | Ports | Analyses | Notification Rules | Version

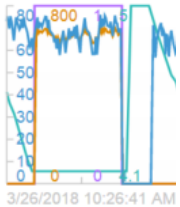
Filter



Mixer 1

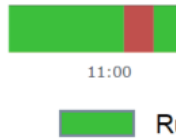
509

Name	Value
Mixer 1|Last Maintenance Date	3/26/2018 12:00:00 AM
Mixer 1|MTD Run Hours	55.643
Mixer 1|Previous Day Run Hours	16.244
Mixer 1|Run Hours Since Maintenance	14.827
Mixer 1|Valve Actuation Count Since Maintenance	16
Mixer 1|YTD Run Hours	55.643



Name	Value	Units
Mixer 1|Last Maintenance Date	3/26/2018 12:00:00 AM	
Mixer 1|MTD Run Hours	55.143	h
Mixer 1|Previous Day Run Hours	16.244	h
Mixer 1|Run Hours Since Maintenanc	14.327	h
Mixer 1|Valve Actuation Count Since	16	count

Name	Value	Units
Mixer 1|Last Maintenance Date	3/23/2018 12:00:00 AM	
Mixer 1|MTD Run Hours	7.5494	h
Mixer 1|Previous Day Run Hours	0	h
Mixer 1|Run Hours Since Maintenanc	7.5494	h
Mixer 1|Valve Actuation Count Since	62	count

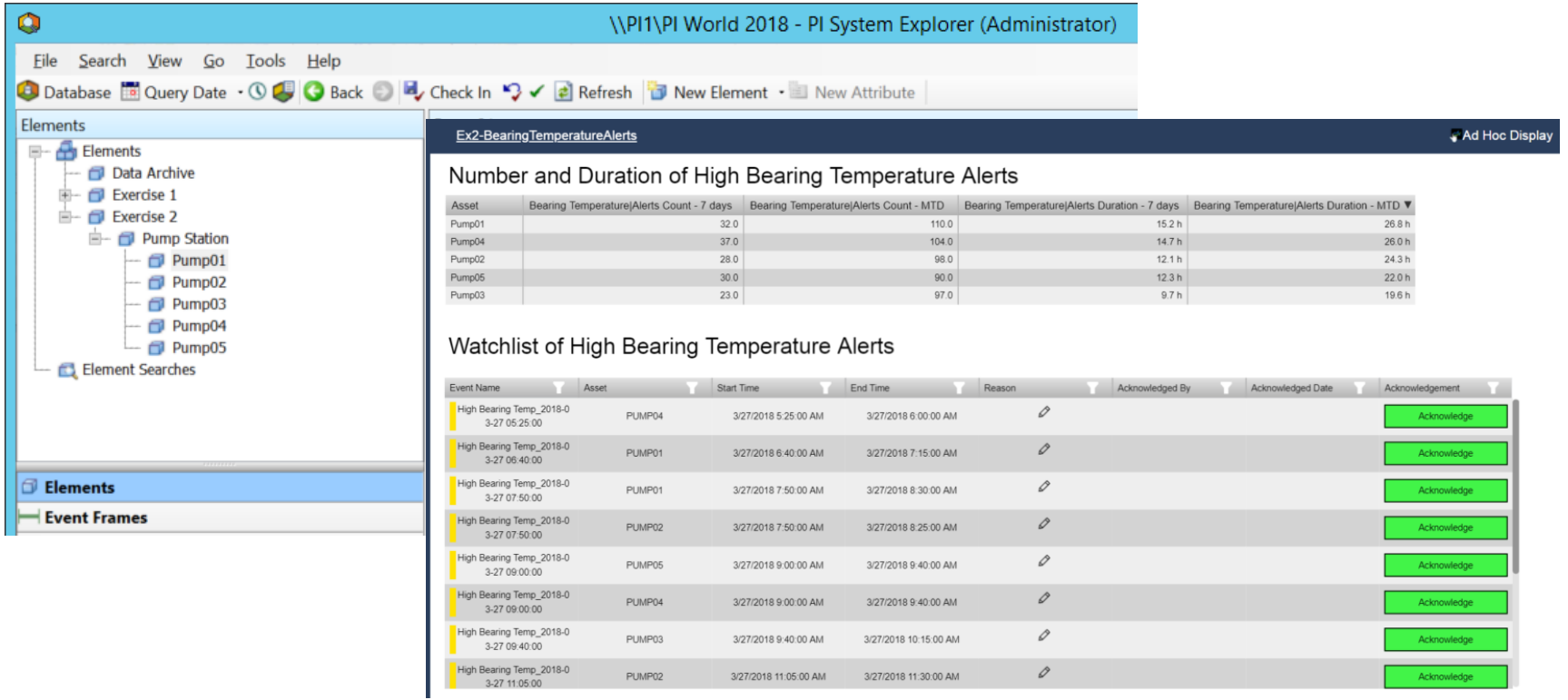


Name	Value	Units
Mixer 2|Last Maintenance Date	3/25/2018 12:00:00 AM	
Mixer 2|MTD Run Hours	55.889	h
Mixer 2|Previous Day Run Hours	16.317	h
Mixer 2|Run Hours Since Maintenanc	30.733	h
Mixer 2|Valve Actuation Count Since	34	count

Name	Value	Units
Mixer 2|Last Maintenance Date	3/24/2018 12:00:00 AM	
Mixer 2|MTD Run Hours	7.4606	h
Mixer 2|Previous Day Run Hours	0	h
Mixer 2|Run Hours Since Maintenanc	7.4606	h
Mixer 2|Valve Actuation Count Since	53	count

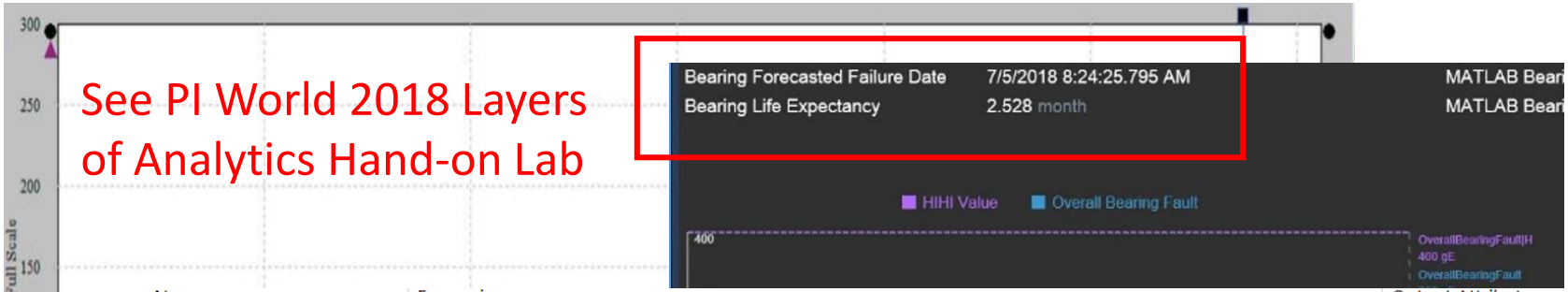
Maintenance – Condition based

See PI World 2018 CBM Hand-on Lab



Maintenance – Predictive – RUL (remaining useful life)

See PI World 2018 Layers of Analytics Hand-on Lab



Name	Expression	Output Attribute
NatLog	`if 'OverallBearingFault'>0 then Log('OverallBearingFault') else NoOutput()`	OverallBearingFault|Natural Log
Time12back	`'*-12w'`	Map
LinearRegr	`if EnableFit then LinRegr('OverallBearingFault|Natural Log', Time12back, '*',50)`	Map
Fit	`if BadVal(LinearRegr) Then NoOutput() Else LinearRegr`	Map
m	`if EnableFit AND Not(BadVal(LinearRegr)) then Convert(Fit[1]*24*3600, "gE/day") e`	OverallBearingFault|m
b	`if EnableFit AND Not(BadVal(LinearRegr)) then Convert(Fit[2], "gE") else NoOutput`	OverallBearingFault|b
rsquared	`if EnableFit AND Not(BadVal(LinearRegr)) then Convert(Fit[3],"ratio") else NoOutp`	OverallBearingFault|r_squared
LifeExpectancy	`if EnableFit AND Not(BadVal(LinearRegr)) and m>0 and rsquared>.400 then Convert((`	BearingLifeExpectancy
ForecastedFailDate	`if EnableFit AND Not(BadVal(LinearRegr)) and m>0 and rsquared>.400 then TimeStamp`	BearingForecastedFailureDate

Predictive – Statistical, Machine Learning …

Predict engine failure – Principal Components - TechCon 2016 Link

100 engines, 20+ sensors per engine, aggregated data per cycle
~200 cycles of operation per engine
how long to failure?

Anomaly detection (HVAC - Air Handler) - Support Vectors - TechCon 2017 Link

7 sensors
~6 months of operations, 5 minute data
damper stuck open? temperature transmitter failed? air supply fan constraint?

Shape Metrics (profiles of operating variables) - PI World 2018 Lab

…

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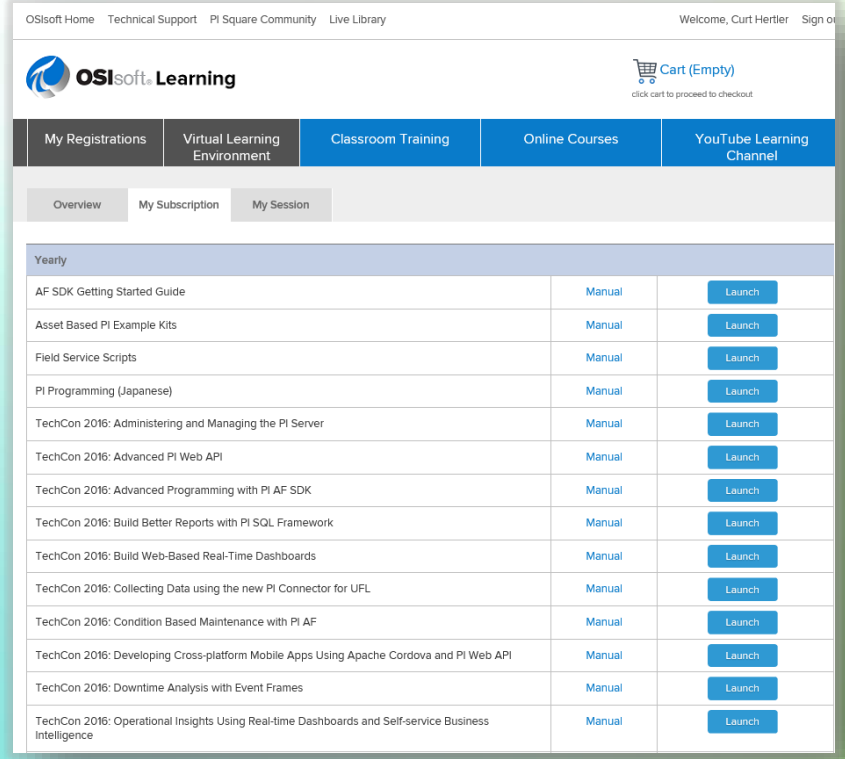
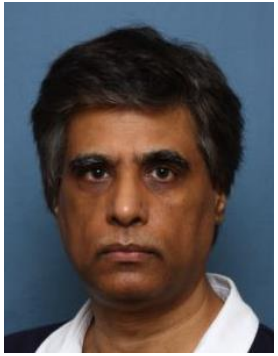
  - **P**red**i**ctive **M**aintenance – PdM
    - *Simple predictive (Advanced CbM)*
    - *Advanced predictive - Statistical, Machine learning…*
- Architectural Location
  - Edge device, Server or cloud based
  - Analytics during data collection? (National Instruments, InsightCM)
- …

OSIsoft Virtual Learning Environment

- Access to the hands-on labs developed for the past two Users Conferences (~40)
  - PI Products
  - PI System Development
  - Condition Based Maintenance
  - Analytics with PI System Data
- Hosted PI System on the Microsoft Azure Cloud
- Monthly or Yearly Subscription
  - Available to all customers via credit card payment
  - Free to EA Customers and Dev Club Members
- Great for Customer Demos
  - Elevate Awareness for OT and Data Science (IT?)
- https://learning.osisoft.com



Thank You



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- **Curt Hertler**
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- Principal Technical Advisor
- OSIsoft, LLC

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