Asset Optimization for the Process Industries: From Data to Insights to Actions

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Aspen Technology, Inc.

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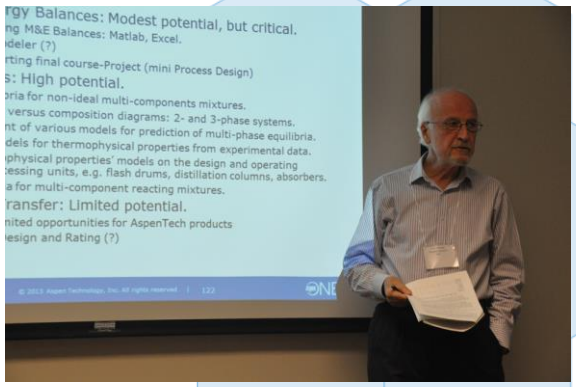
AspenTech recognizes George Stephanopoulos

Founding Chair, AspenTech Academy

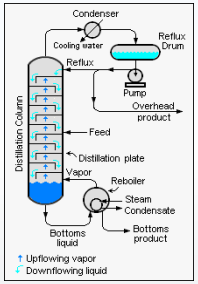


Established in 2012 to

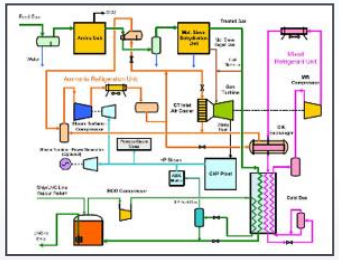
- Accelerate application of research innovations in Process Engineering software
- Promote the use of Process Systems Engineering software in universities

Evolution of Process Systems Engineering

Unit



Process



Plant & Sites

70's — 80's & 90's — 00's to Today

ENGINEERING - DESIGN & OPTIMIZE THE ASSET

MAINTENANCE - MAINTAIN THE ASSET

MANUFACTURING - OPERATE THE ASSET

SUPPLY CHAIN - OPTIMIZE THE SUPPLY CHAIN

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Technology Trends

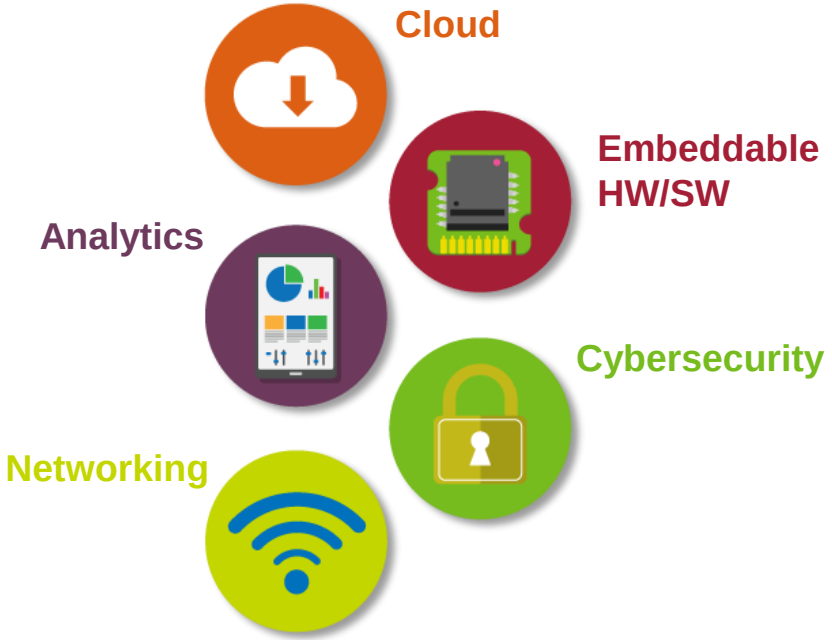
The Industrial Internet of Things (IIOT) is changing the world as we know it!

By 2020 - over 7 billion Internet-connected industrial devices

*** Gartner 2015**

Market Trends

- Connected industrial devices will proliferate worldwide
- Sensors and equipment will become increasingly "smarter"
- Industrial information systems will move to the cloud
- Connected devices will generate massive amounts of condition data
- Manufacturers will look to analytics to provide deep process insight



http://www.gartner.com/newsroom/id/3165317

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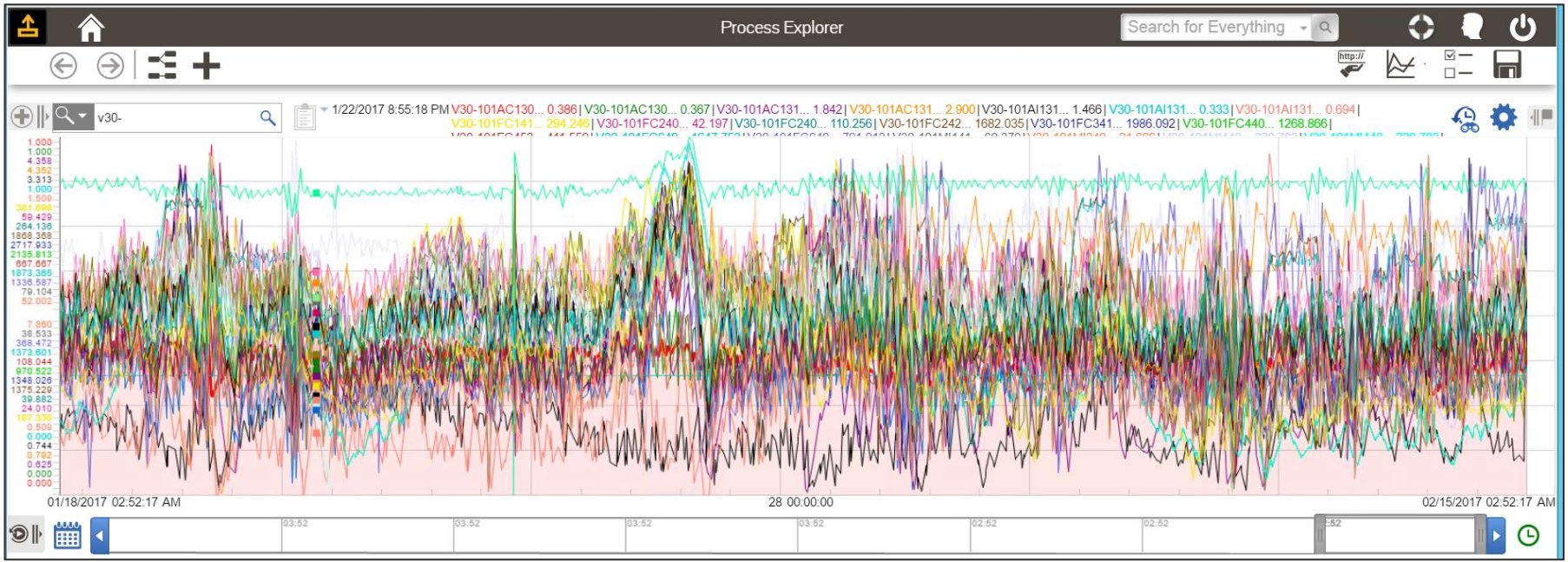
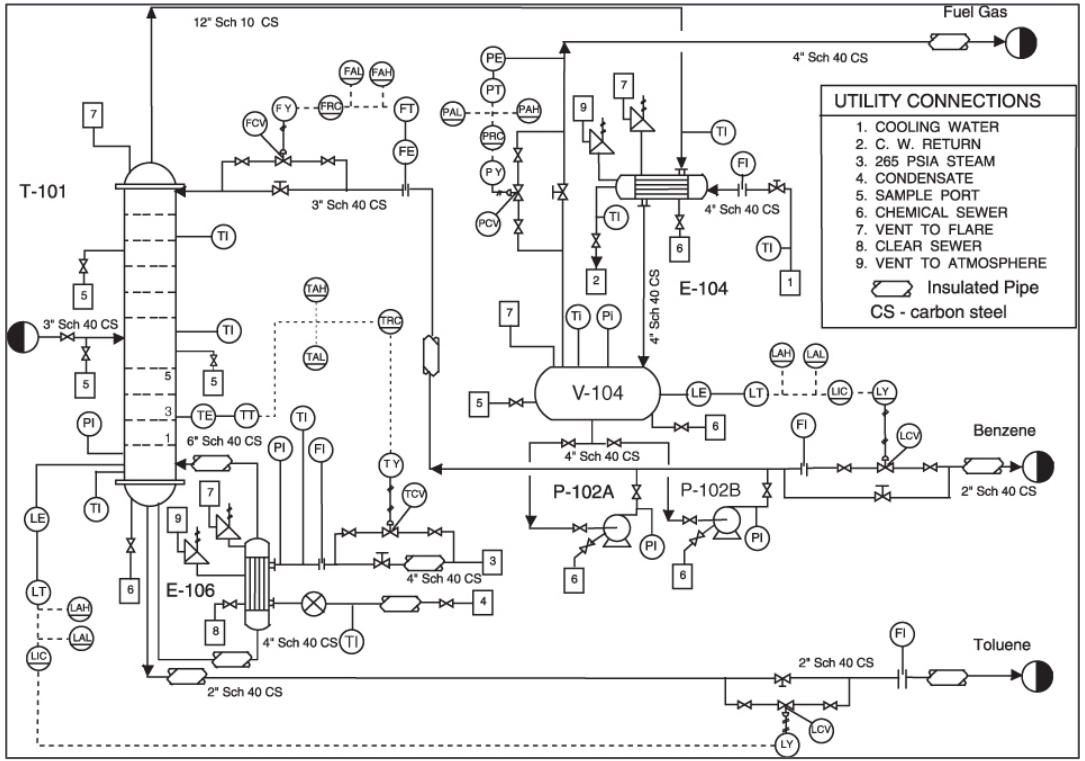
Example: Wealth of Sensor Data in Plant Historians



Example: P&IDs and Equipment Datasheets



CLIENT — CONTRACT — REQUISITION — DATE 11/24/97
SITE — ITEM(S) P-148
MATERIAL CENTRIFUGAL PUMP(S) — NO. REQ'D. ONE
SERVICE EMERG. BOILER FEED
MFR. B-J/FLOWSERVE — SIZE & MODEL 3X4X9LL DMMX

OPERATING CONDITIONS, EACH PUMP		PERFORMANCE	
LIQUID: FEEDWATER	U. S. GPM, RATED 210	PROPOSAL CURVE NO. PC-066-042A	
	NORM. 210	RPM 3600	NPSHR, FT. (WATER) 11
P. T. °F 350 (400 MAX.)	MIN.	MIN. ALLOW. CONTIN. GPM 100	
S. G. 0.891 (MAX.)	DISCH. PSIG 1341	RATED EFF., % 59 %	RATED BHP 254
VAP. PRESS., PSIA 135	SUCT. PSIG, RATED 120	MAX. BHP (RATED IMP.) 290	
VISC., (CKS)(CP) 0.22 CKS	MAX. 150	MAX. HEAD, FT. (RATED IMP.) 3660	
CORR./EROS. CAUSED BY:	DIFF. PRESS., PSI 1221	MAX. DISCH. PSIG (RATED IMP.) 1562	
	DIFF. HEAD, FT. 3166	QUOTE API 610 WEAR-RING CLEARANCES	
	NPSH AVAIL., FT. 25	CONNECTIONS: SUCT. 4" 900 # RF SIDE; DISCH. 3" 900 # RF SIDE	

CONSTRUCTION		DRIVER(S)	
NO. STAGES 12	ROTATION (FACING CPLG.) CCW	SUPPLIED BY [X] PUMP MFR. [ ] OTHERS	
CASING: SUPPORT [X] CENTERLINE [ ] BRACKET		MOUNTED BY [X] PUMP MFR. [ ] OTHERS	
[ ] VERT. IN-LINE [ ] FOOT		[ ] MOTOR ITEM(S) N/A	
SPLIT [ ] RADIAL [X] AXIAL		HP RPM SF	
VOLUTE [ ] SINGLE [X] DOUBLE [ ] DIFFUSER		REF. REQN. (DIESEL P-4)	
CONNS. [X] VENT [X] DRAIN [ ] GAGE		[ ] TURBINE ITEM(S) N/A	
MAX. ALLOW. PRESS. 2000 PSIG @ 400 °F		HP RPM	
HYDROTEST. PRESS. 3000 PSIG		REF. REQN.	
IMPELLER, DIAM., INCHES: RATED 8.7 MAX. 9.0		PUMP THRUST, LBS. UP DOWN	
MTG. [X] BETWEEN BRGS. [ ] OVERHUNG			
TYPE [X] CLOSED [ ] SEMI-OPEN [ ] OPEN			
[ ] W/INDUCER [ ] DOUBLE SUCTION			
WEAR RINGS [X] CASING [X] IMPELLER [ ] NONE			
[X] FRONT [X] BACK			
BRGS. TYPE RADIAL BALL THRUST BALL			
LOCATION: [X] PUMP [ ] MOTOR [ ] GEARBOX			
LUBE: [X] RING [ ] FLOOD [ ] SPLASH			
[ ] MIST [ ] GREASE [ ] PRESSURE			
COUPLING: MFR. THOMAS SIZE & MODEL SERIES 71			
DRIVER-HALF MOUNTED BY [ ] PUMP MFR.			
[X] DRIVER MFR. [ ] OTHERS			
CPLG. GUARD [X] NON-SPARKING [ ] OSHA			
BASEPLATE: [X] EXTENDED FOR DRIVER [X] DRAIN RIM			
[ ] PACKING MFR. TYPE			
[X] MECH. SEAL MFR. J. CRANE TYPE 8B1-BP			
CODE: MFR'S. X47F1210151 API BSTEL			
SHAFT SEAL API PLAN(S) 23 [ ] BY OTHERS			
[ ] CS [X] SS [X] TUBING [ ] PIPING			
[ ] DIAL THERMOMETERS [ ] PRESS. SWITCH			
EXTERNAL FLUSH FLUID NONE			
°F PSIG GPM			
QUENCH FLUID NONE			
°F PSIG			
COOLING WATER API PLAN X (2) [ ] BY OTHERS			
[X] CS [ ] SS [ ] CU [ ] TUBING [X] PIPING			
[X] BRG. HSG. [ ] OIL COOLER [ ] PEDESTALS			
[X] FLUSH CLR. [ ] STUFF BOX JKT. [ ] GLAND			
TOTAL COOLING WATER REQ'D. GPM			

MATERIALS--API CLASS	
CASING 12 % CHR.	IMPELLER 12 % CHR.
(API C-6)	
BASEPLATE: FABR. STEEL	

WEIGHT, LBS. EACH	
PUMP 3000	BASEPLATE 2000 EST.

SITE & UTILITIES	
[X] INDOOR [X] OUTDOOR [ ] UNPROTECTED	
ALT., FT. 600 AMB., °F 40 MIN. 104 MAX.	
[ ] CL. GRP. DIV. [X] NON-HAZ.	
COOLING WATER DESIGN 125 °F 125 PSIG	
COOLING WATER SUPPLY: 100 PSIG 85 DEG. F	

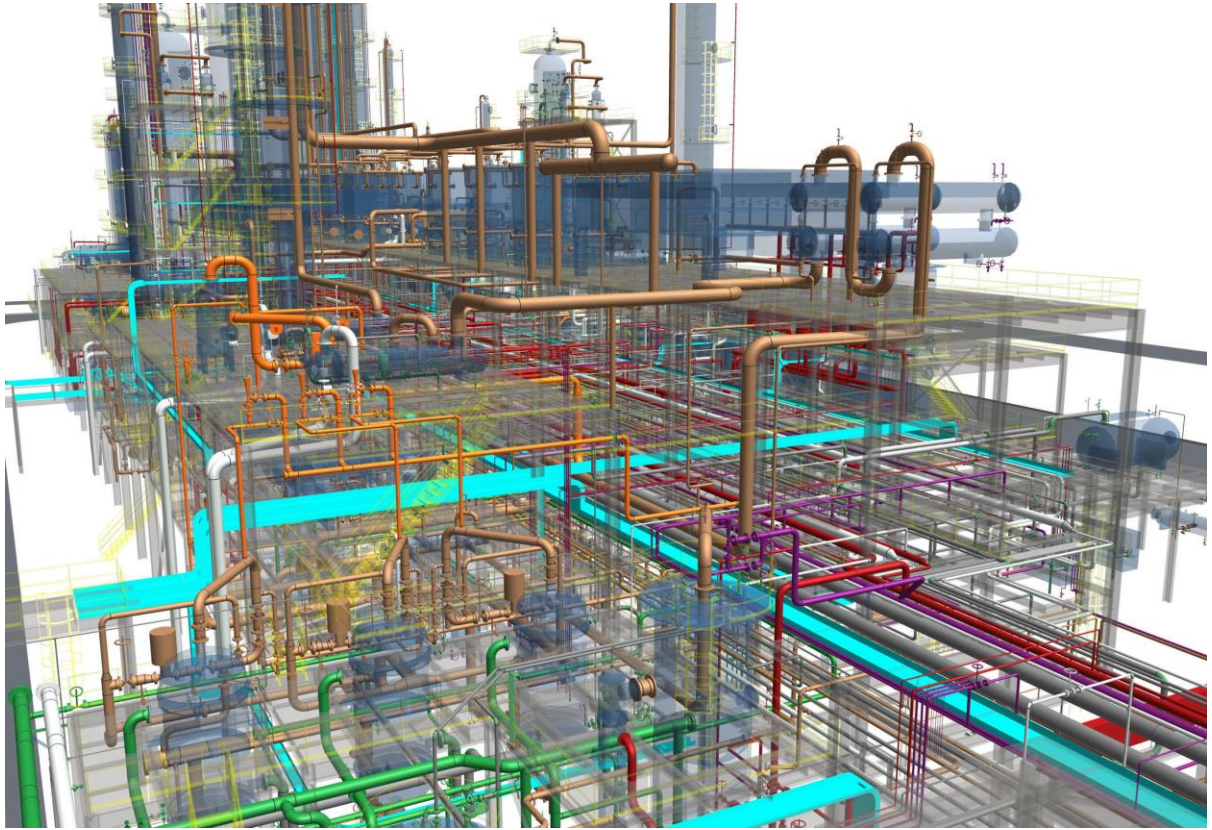
APPLICABLE DOCUMENTS
(SEE PAGE 2)

TESTS	REQ'D.	WITND.	CERTD.
PERFORMANCE	[X]	[ ]	[X]
NPSHR	[ ]	[ ]	[ ]
HYDROTEST	[X]	[ ]	[X]

A NON-WIT 2-HOUR MIN. STRING TEST INCLUDED

NOTES: (1) FLANGED VENT AND DRAIN VALVES ARE FURNISHED (2) CW TO BEARING HOUSING AND PARALLEL FLOW TO SEAL COOLER. (3) EQUIPT TO BE SUITABLE FOR HOSE DOWN, WATER SPLASH. (4) TEMPORARY SUCT. STRAINER INCLD

Example: 3D Plant Model



Example : Maintenance Data

Refinery Critical Centrifugal Machinery Score Card									April 2017
Area	Section	# Critical Centrifugal Machines	Forced Outages (Month)	Forced Outages (YTD)	Section MTBFO (Months)	Area MTBFO	12 Month Rolling Reliability	12 Month Rolling Availability	YTD LOT Target = 0 ($k)
Light Oils	Hydrocracker	1	0	0	6	11.0	96%	98%	0
	Reformers	0							
	Light Ends Frac	2	0	1	0				
	Catalytic Cracking	4	0	0	17				
Heavy Oils	Hydrotreating	2	0	0	7	8.0	98.0%	94.0%	0
	CDU	2	0	1	4				
	Coker	0							
	Lubes	4	0	0	14				
Refinery		21	1	4	Target: 12 Months	9.0	97.0%	96.0%	0

Refinery Critical Reciprocating Machinery Score Card									April 2017
Area	Section	# Critical Recip Machines	Forced Outages (Month)	Forced Outages (YTD)	Section MTBFO (Months)	Area MTBFO	12 Month Rolling Reliability	12 Month Rolling Availability	YTD LOT Target = 0 ($k)
Light Oils	Hydrocracker	3	0	4	3	4.2	97%	94%	0
	Reformers	1	0	0	0				
	Light Ends Frac	3	0	0	22				
	Catalytic Cracking	0							
Heavy Oils	Hydrotreating	4	2	1	3	4.8	96.1%	98.1%	0
	CDU	1	0	0	0				
	Coker	0							
	Lubes	1	0	0	0				
Refinery		13	2	5	Target: 12 Months	4.6	97.0%	95.2%	0

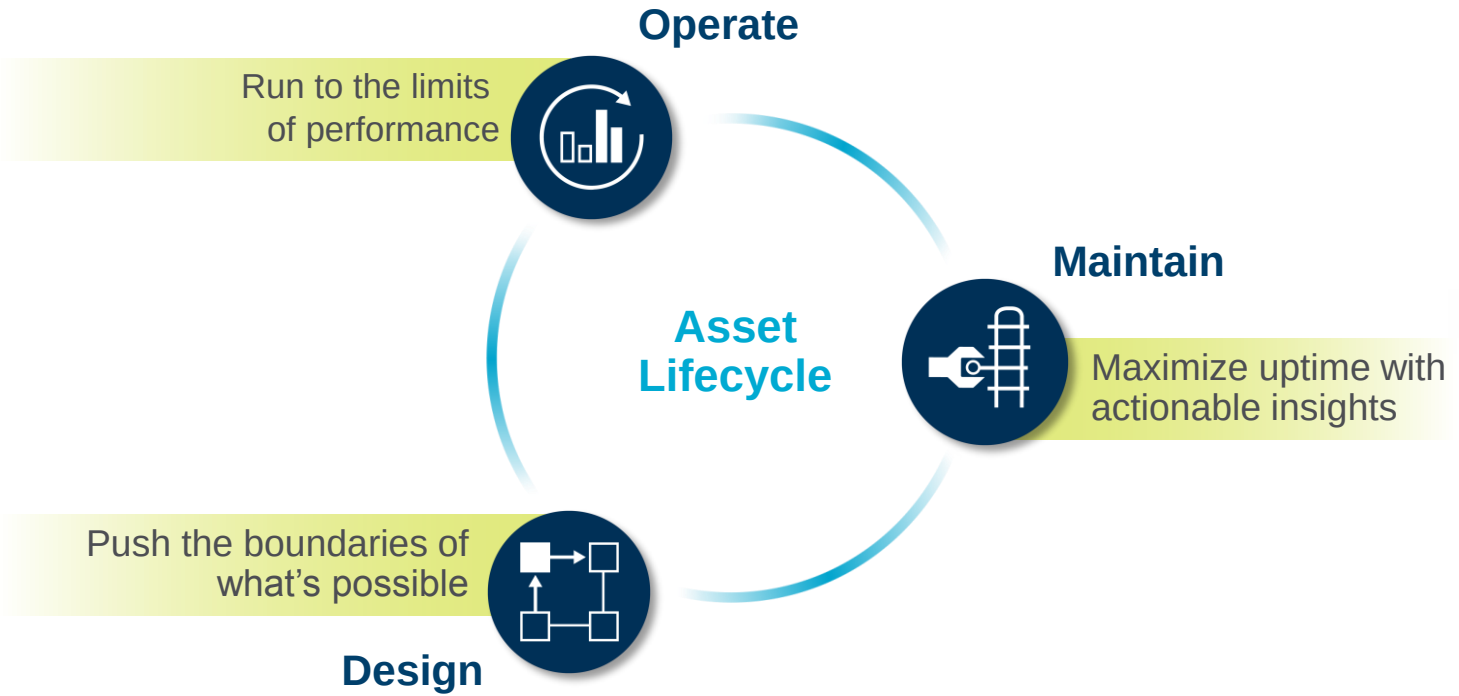
Example: Textual / Unstructured data

Date of Shutdown	Asset ID	Team	Section	UNIT	Comp Description	Engineering Findings/Summary
1/3/17	F0111	Heavy Oils	Crude Units	Crude B	Effluent Gas Compressor (C-152)	The suction valve on the 3rd Stage took a step change increase in temperature on the evening of 1/3/17. The suction valve is running approximately 150-155 deg. F, ~25 deg. F higher than the other suction valves in the cylinder. The relief valve has not been lifted, but the cylinder was unloaded and the machine continues to run. The step change in temperature does not mean an immediate failure, but based the historical data it may lead to a bigger issue in the near future. It is recommended to replace all the valves in the cylinder. Also, further evaluation revealed that the 1st Stage discharge valve also had increased temperatures and seems to be leaking. Again, it is recommended to replace all of the valves in the cylinder. Both sets of valves have been in service since the beginning of July 2016 (6 months).
1/20/17	F0112	Heavy Oils	Crude Units	Crude B	Effluent Gas Compressor (C-153)	The discharge valve on the 1st Stage took a step change increase in temperature on the morning of 1/20/17, reaching 290 deg. F and hitting the Danger Alarm. The RV did not lift, but the cylinder was unloaded and the machine continues to run. Being unloaded, the discharge valve is currently running at approximately 230 deg. F. It is recommended to replace all the valves in the cylinder. The valves have been in service since the mid-August 2016 outage (5 months).

Asset Optimization

A comprehensive, holistic approach to driving the highest possible financial return over the entire asset lifecycle

What if you could leverage the rich wealth of **asset data** to ……



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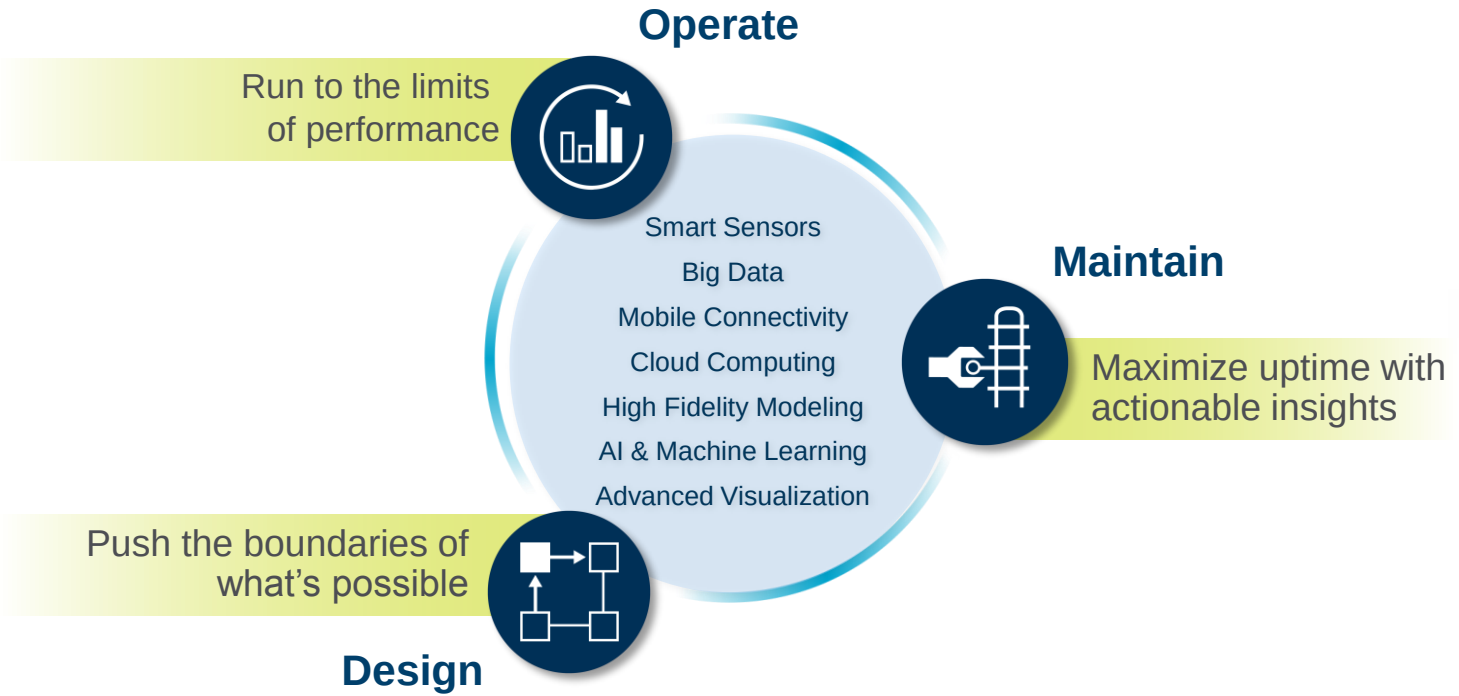

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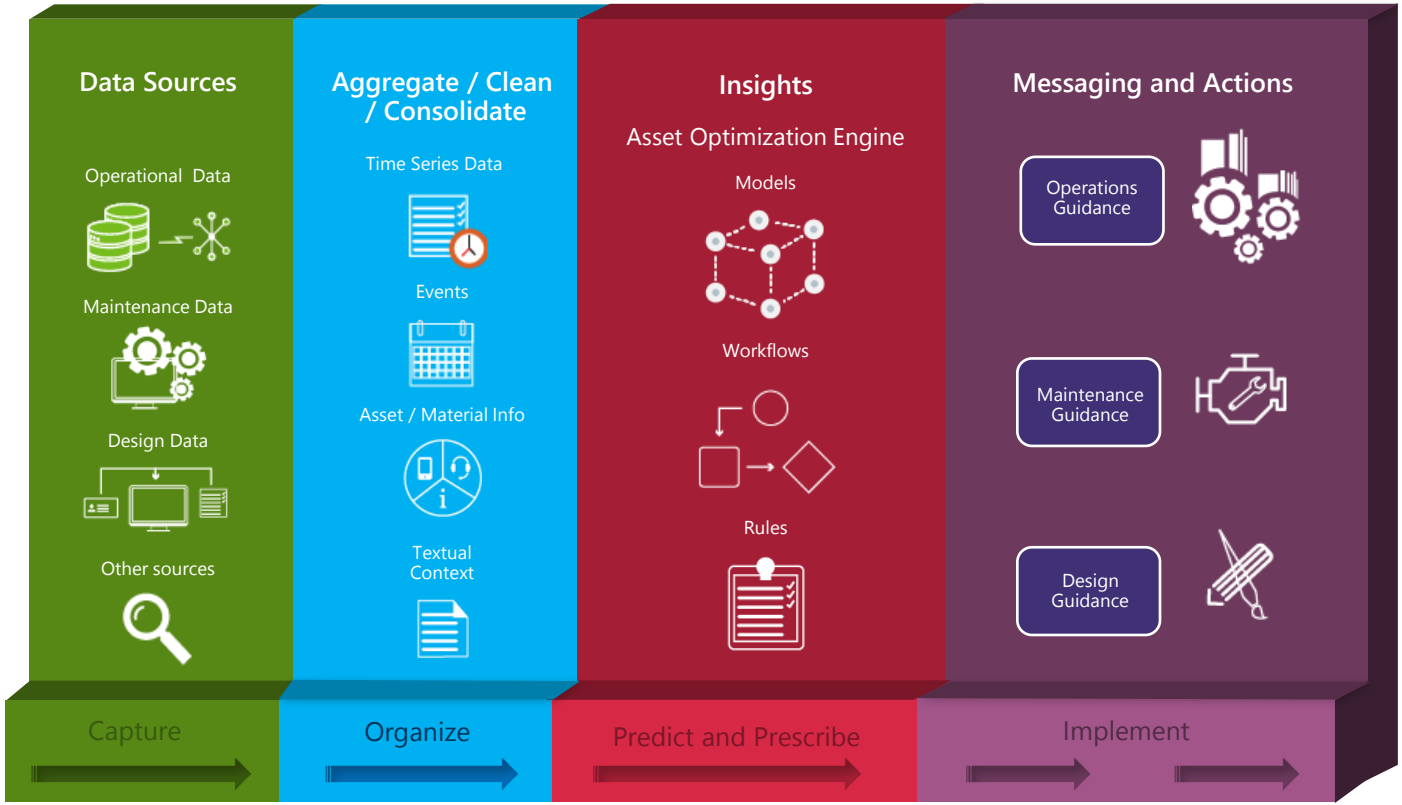
Solution Vision



- Data sources that span time series, maintenance records and textual content like operating manuals
- Insights by bringing together design, operations and maintenance domains, and automation of complex analyses and workflows
- Guidance with an objective to minimize plant lifecycle costs subject to the level of risk the organization can tolerate

Enabling Technologies

Data Sources

Operational Data

Data Historian | LIMS | Sensors

Maintenance Data

Enterprise Asset Management | Asset Breakdown Data | Operator Records

Design Data

Datasheets | P&IDs | 3D Modeling

Other Sources

literature

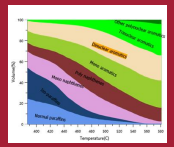
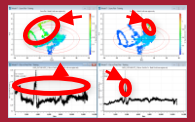
Aggregate / Clean / Consolidate

Spark | HIVE | OPENTSDB | APACHE HBASE | Distributed Filesystem | HDFS | Hadoop core

Big Data Ecosystem

AWS | Azure | Google Cloud Platform

Insights


Analytics Engine

- Cognitive Computing
- Machine Learning
- Knowledge Graphs
- Natural Language Processing

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- Process Modeling
- Molecular Modeling
- Ensemble Modeling
- Prescriptive Guidance

Visualization

PC / Mobile | VR | AR

Messaging and Actions

Closed Loop Control

Sensor Needs

Spare Parts

Work Orders

Design improvements

Capture → Organize → Predict and Prescribe → Implement

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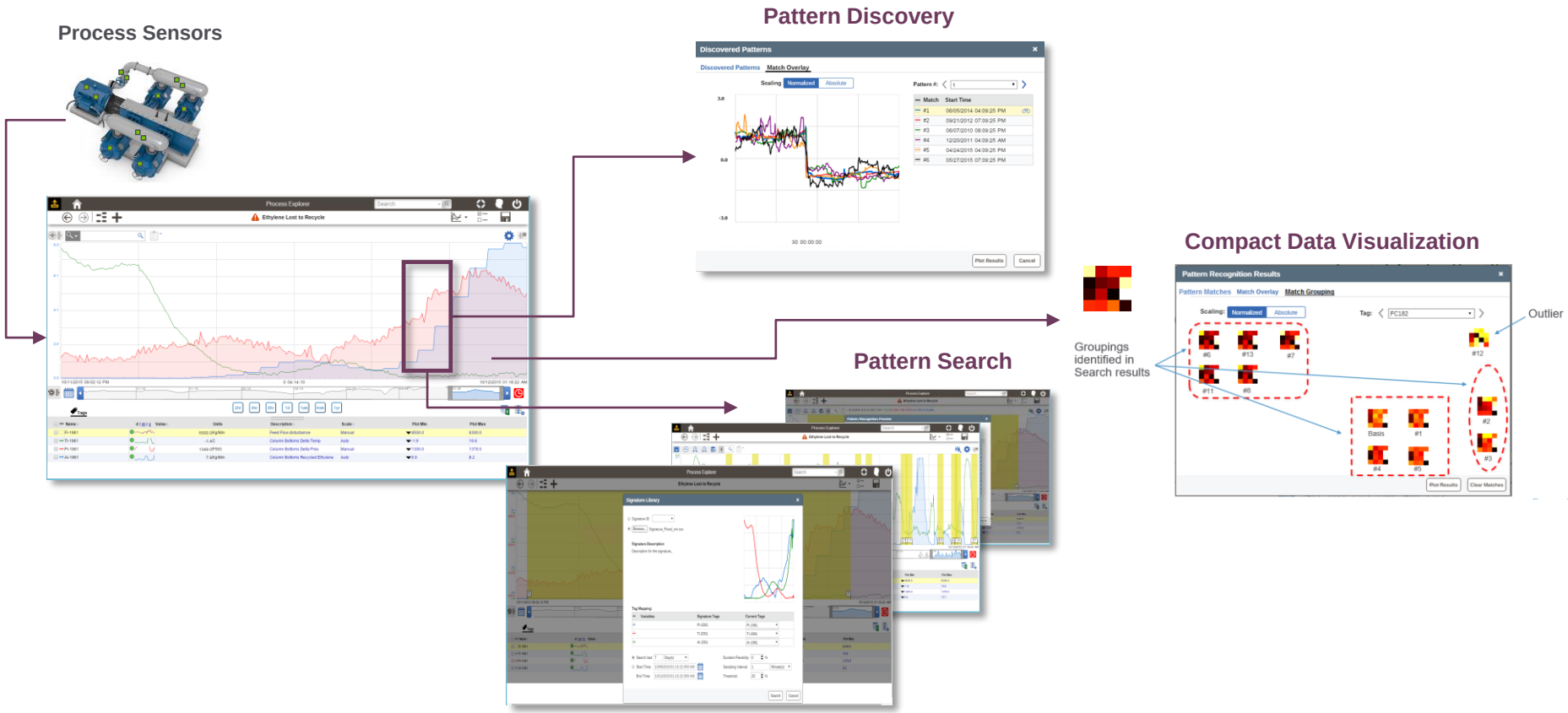
Data Science – Pattern Discovery, Pattern Search, and Process Data Visualization



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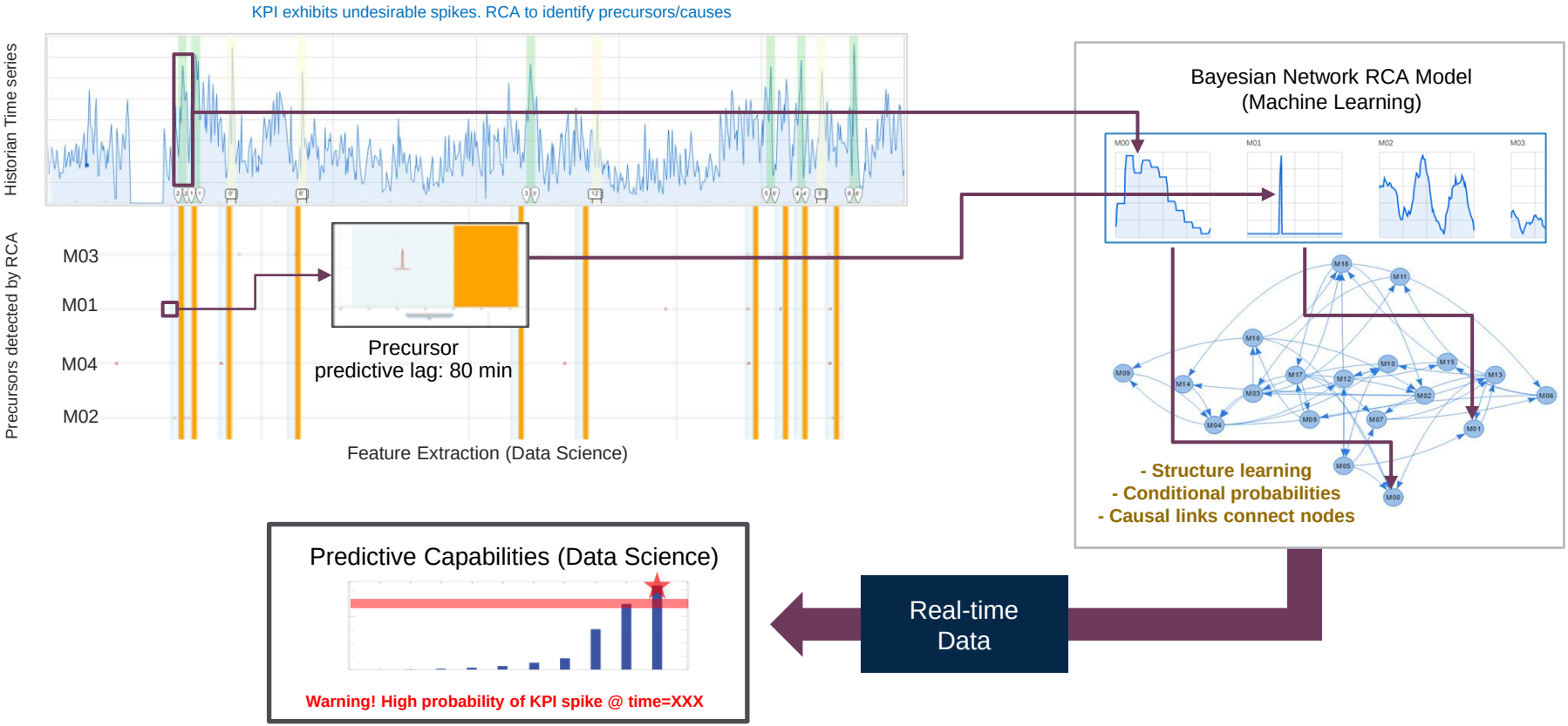
Data Science – Root Cause Analysis (RCA)



Empirical Modeling – Multivariate Analysis

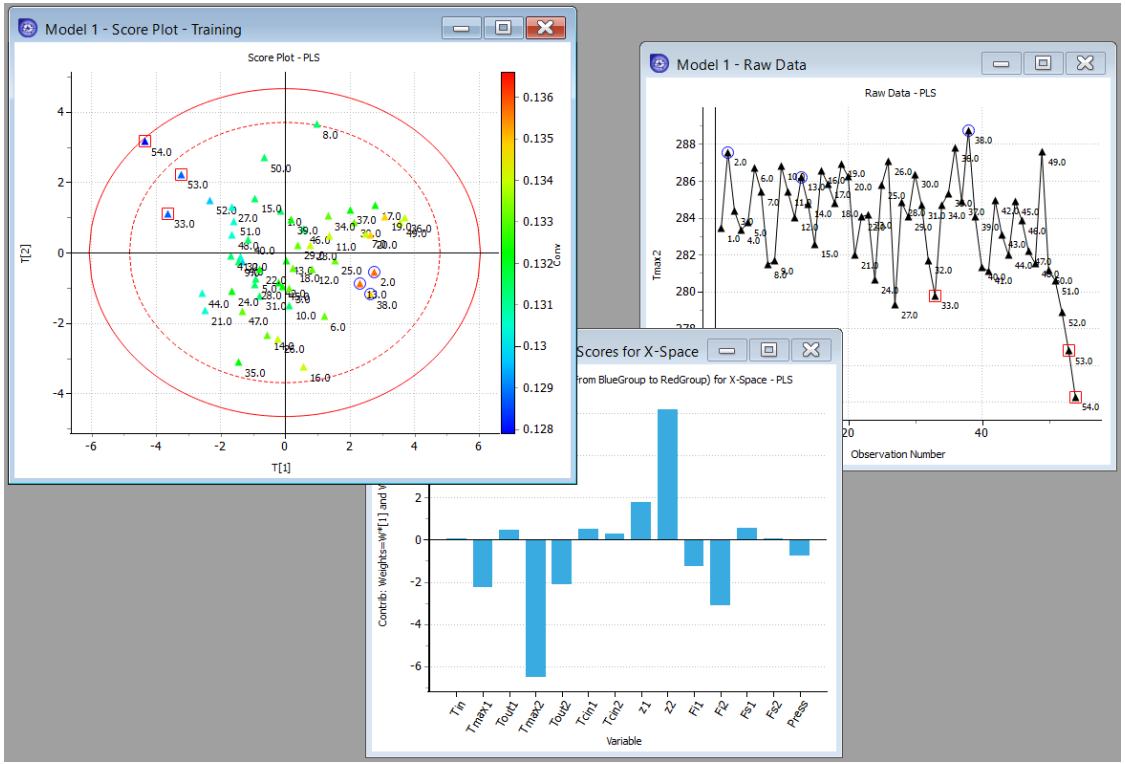
Data Conditioning

Anomaly Detection

Key Contributions

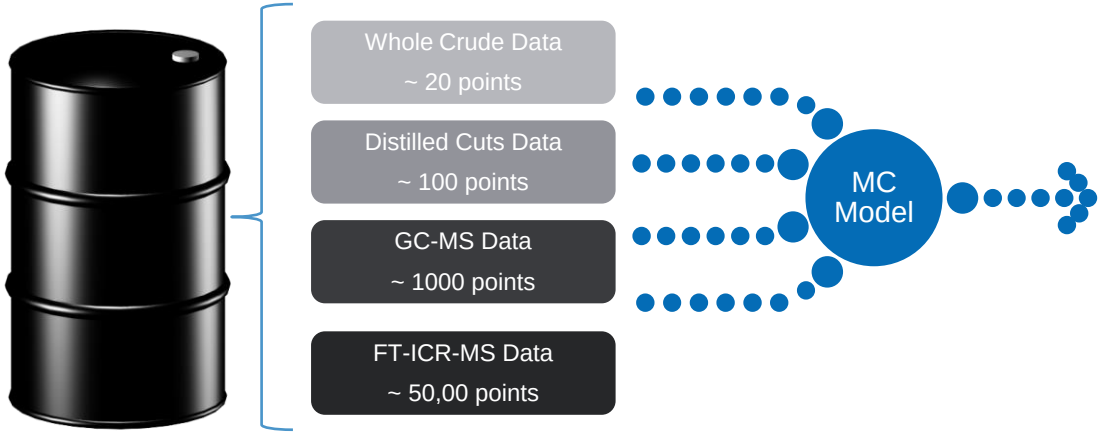
Operational Guidance

Optimization of Operation

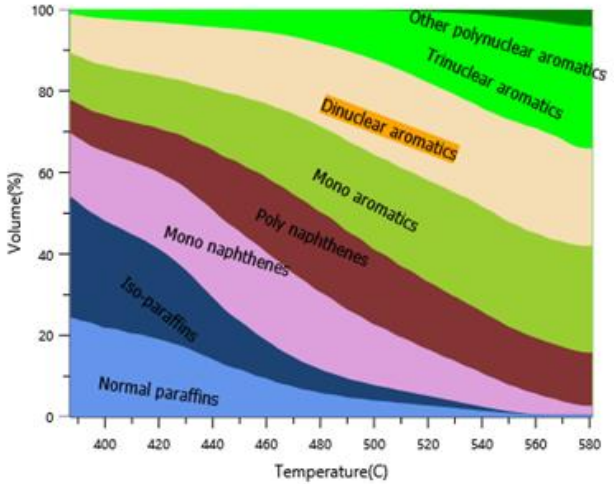


PLS / PCA Modeling isolates the most important data dimensions

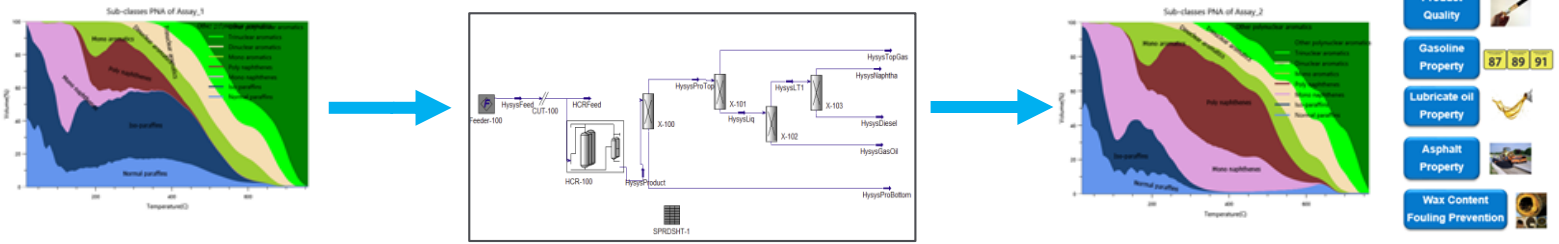
Molecular Characterization – From Analytical Data to First-Principle Molecule-based Process Models



Molecular Distributions

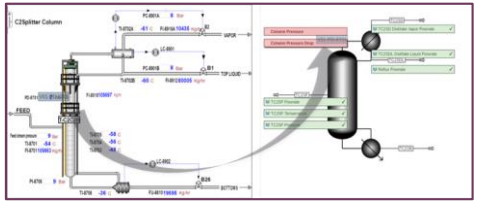


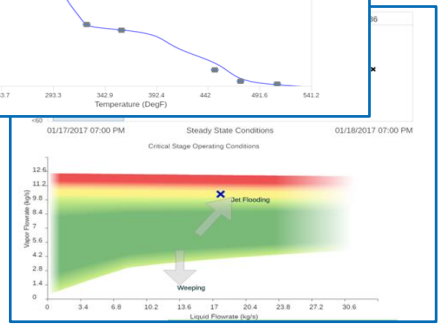
Molecule-based Process Model



Operations Analytics – Combining Data Science, 1st Principle & Empirical Modeling for Equipment Analytics

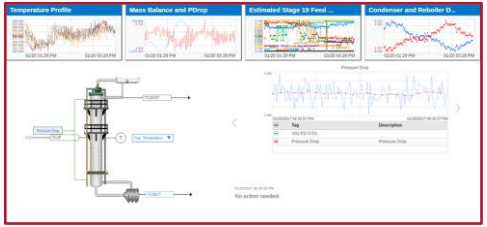
Connect plant measurements to simulation model





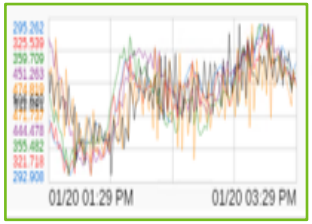
Auto tune model with historical plant data

Deploy column model and monitor plant operation

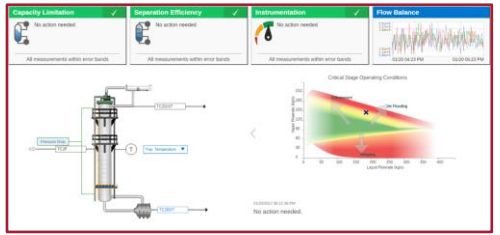


Display measured and calculated values (predictions)

Connected historian as historical and real-time plant data source



Monitor operation using real-time data



Real time dashboard

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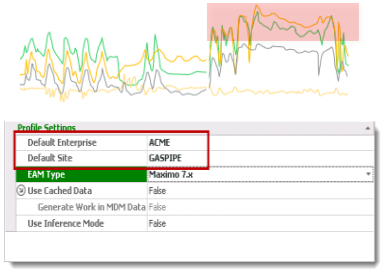
Maintenance Analytics – Training of Agents from Maintenance and Historical Data to Monitor Plant Operation

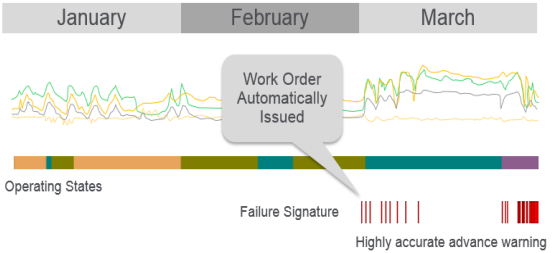
Sensor Data



Asset Work History

Smart Trained Agents

Asset Monitoring and Failure Prediction



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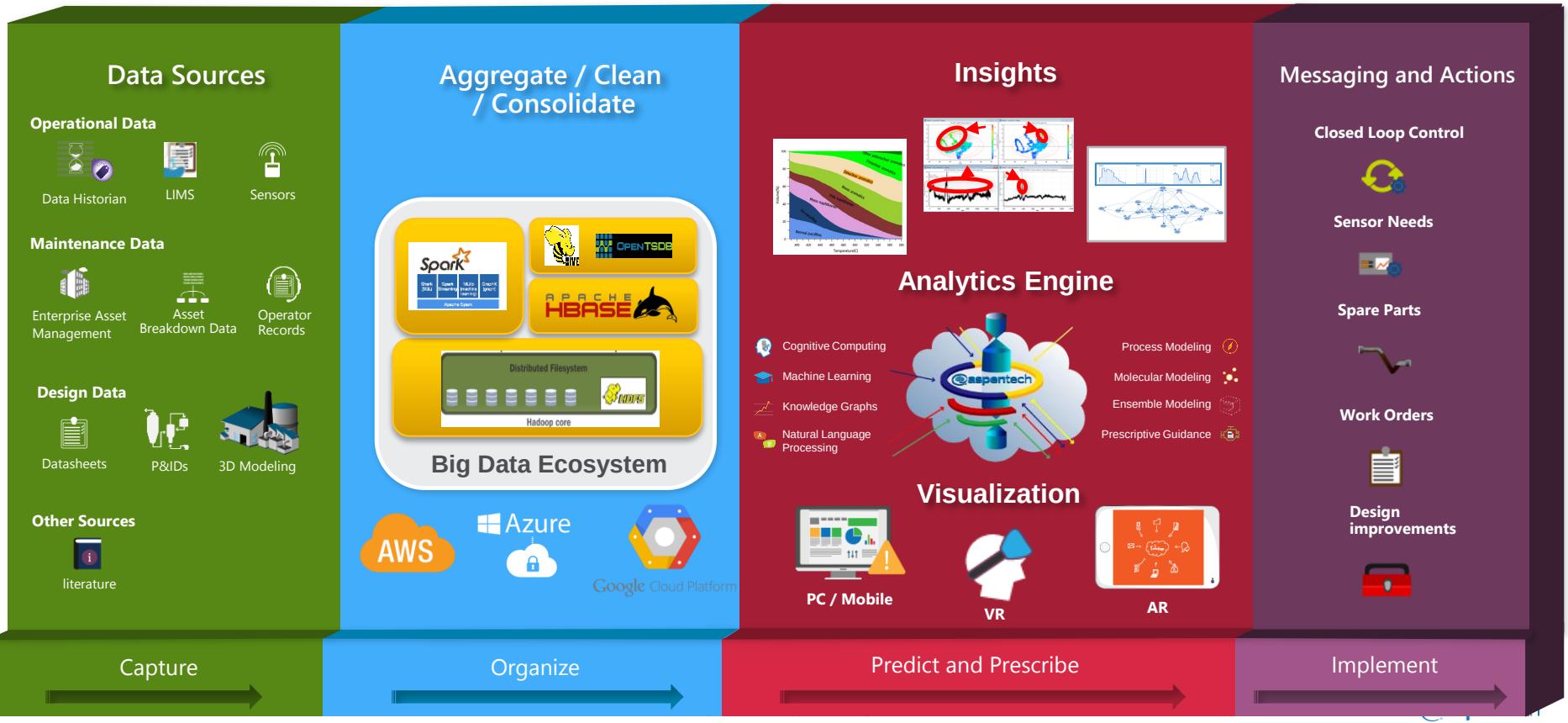
Areas for Future Research & Development



Empowering the Next Generation of Process Engineers

- Engineering
- Modeling
- Optimization
- Data Science
- Machine Learning
- Analytics