

SMART SIGNAL

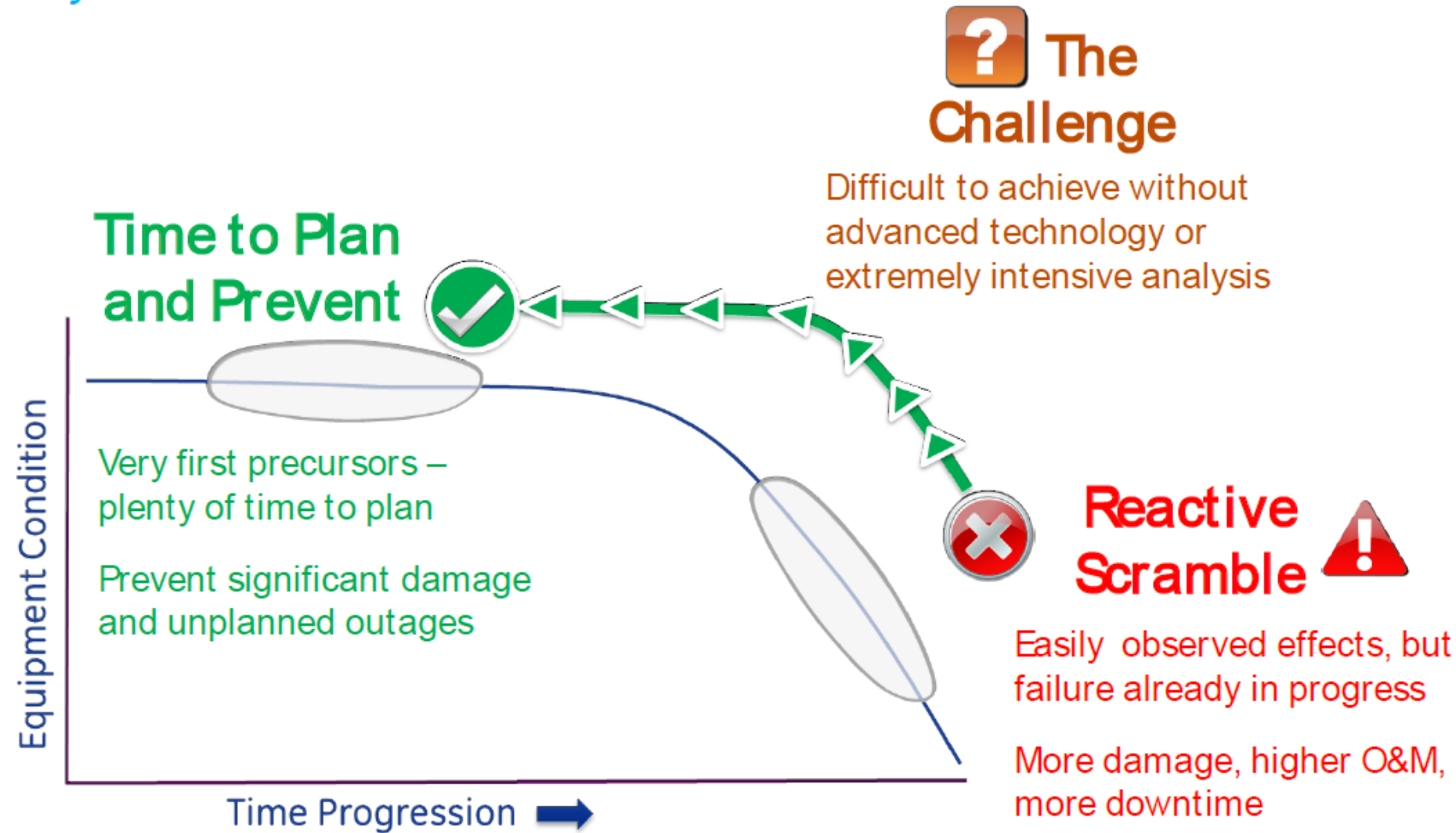
Sharing session





Move Up the Curve

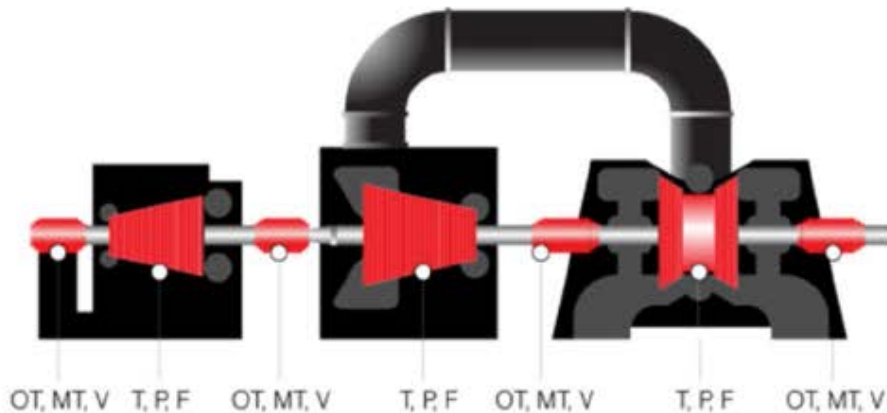
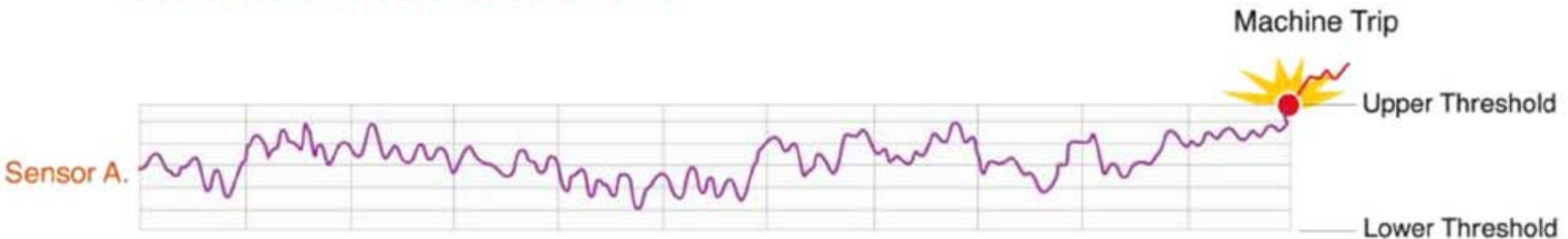
Stay Ahead of the Game





Conventional Monitoring

Uses Hard Thresholds...

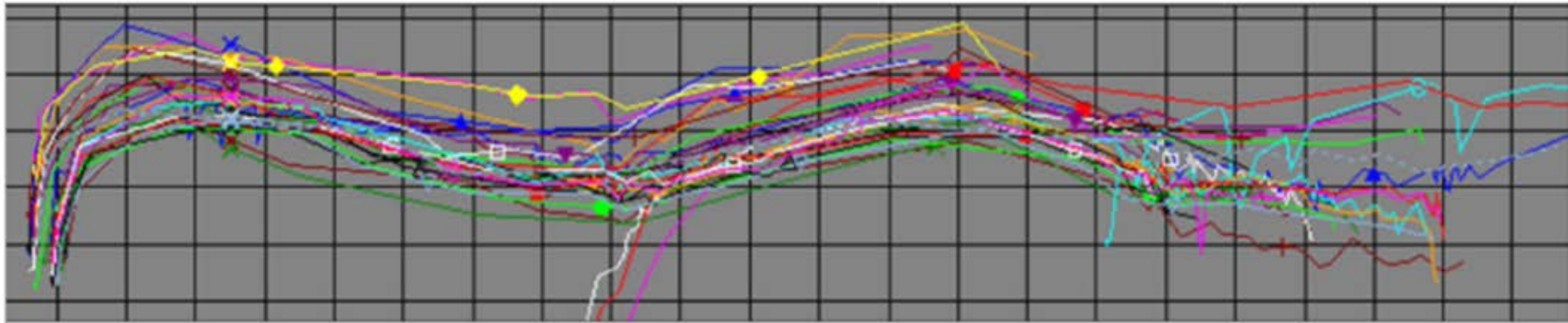


Based on MFGR Specs

Based on Plant Experience

Encompasses all Modes of Operation

Challenge: Change is ambiguous in complex environments



Are hard alarm limits proactive?



**Need Advanced
Automated Analytics!**

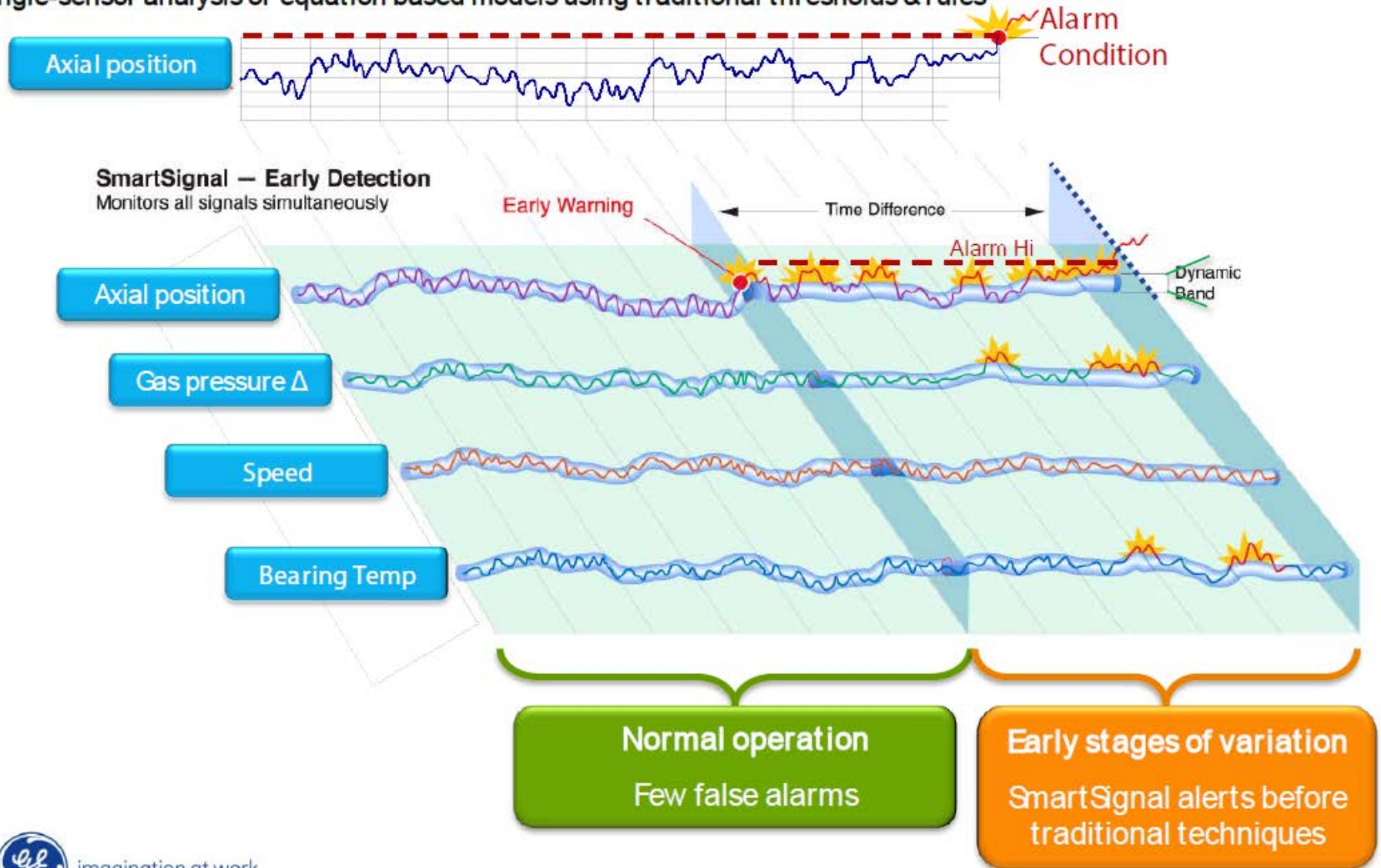


imagination at work

The SmartSignal Difference

Multiple Variable, Dynamic Empirical Analysis in Real Time (5 Min Resolution)

Single-sensor analysis or equation based models using traditional thresholds & rules

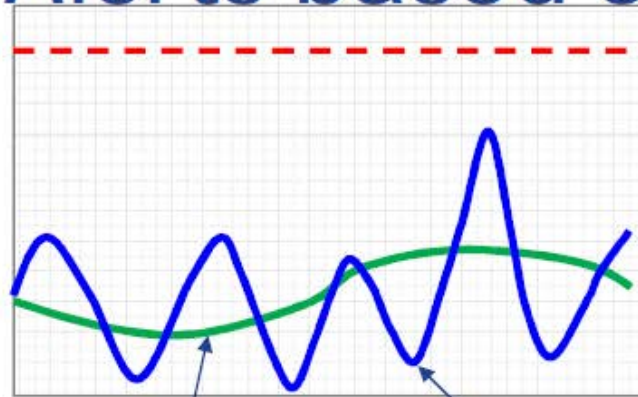


Overcome the challenges

Alerts based on residuals

The dynamic band takes into consideration:

- ❖ Historical behavior
- ❖ Operational States
- ❖ System Conditions
- ❖ Ambient temp etc...

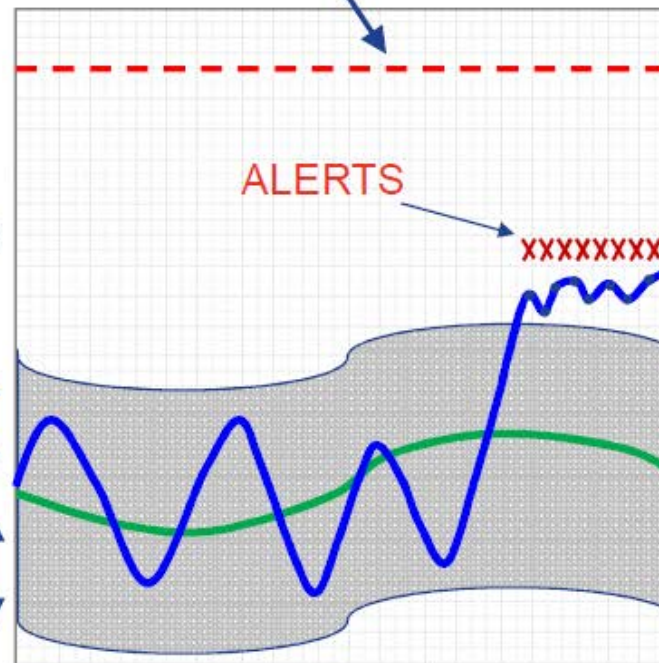


Fixed alarm level

ESTIMATE

ACTUAL

$$\text{ACTUAL} - \text{ESTIMATE} = \text{RESIDUAL}$$



ALERTS

INCIDENT

XXXXXXXXXX

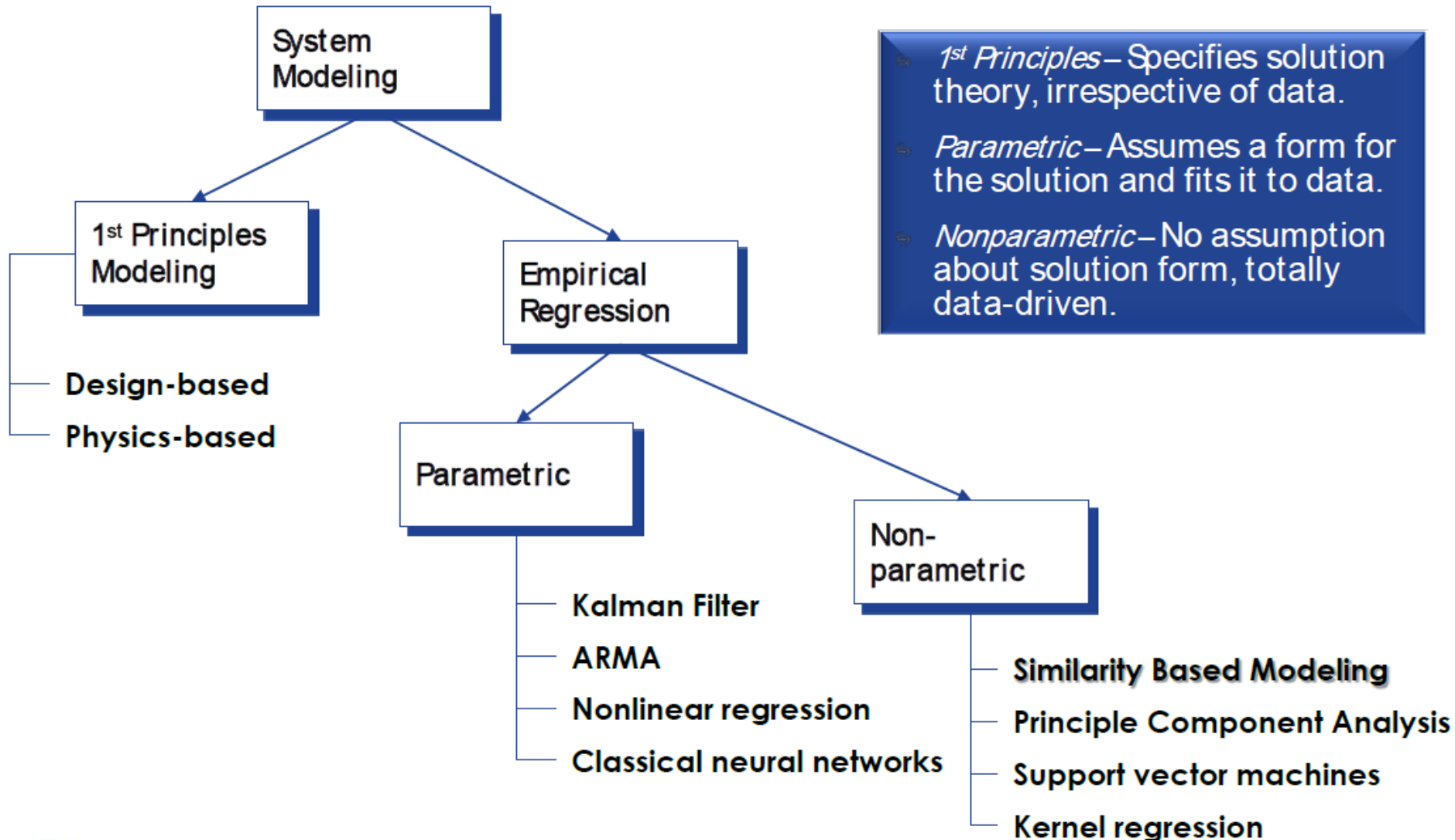
Positive threshold

Negative threshold

Dynamic band



Taxonomy of Modeling Techniques



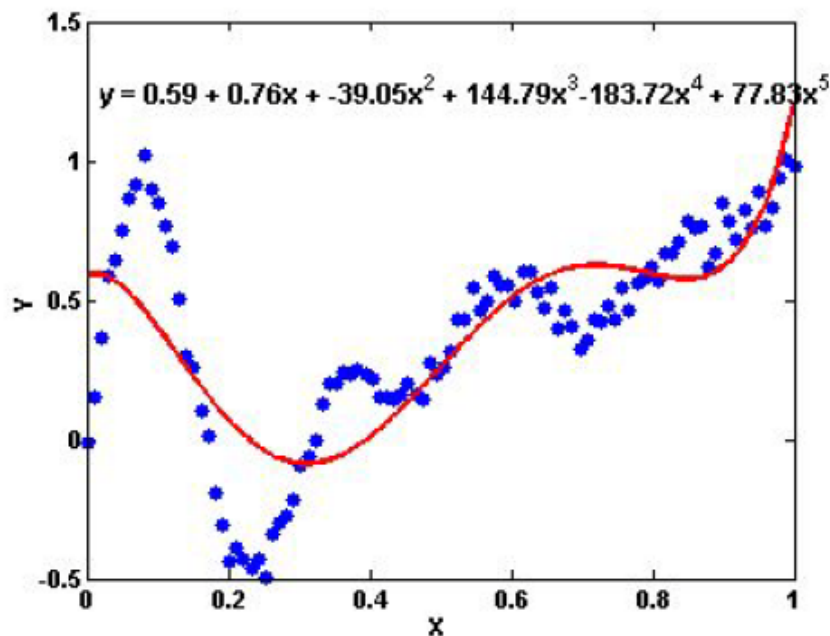
- *1st Principles*– Specifies solution theory, irrespective of data.
- *Parametric*– Assumes a form for the solution and fits it to data.
- *Nonparametric*– No assumption about solution form, totally data-driven.



Differentiated Data Technology

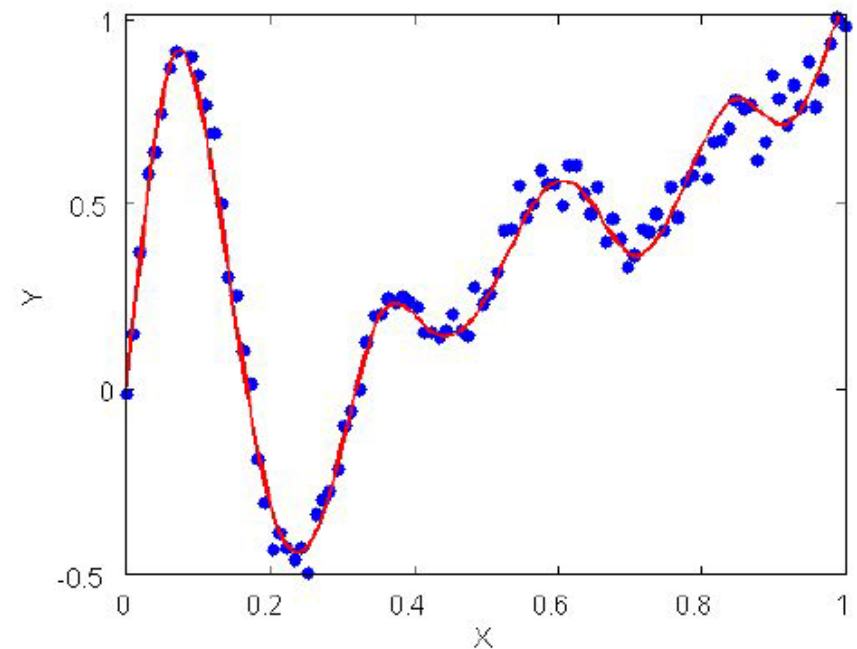
Curve Fitting

- First Principles Equations
- Parametric Modeling
- Neural Networks



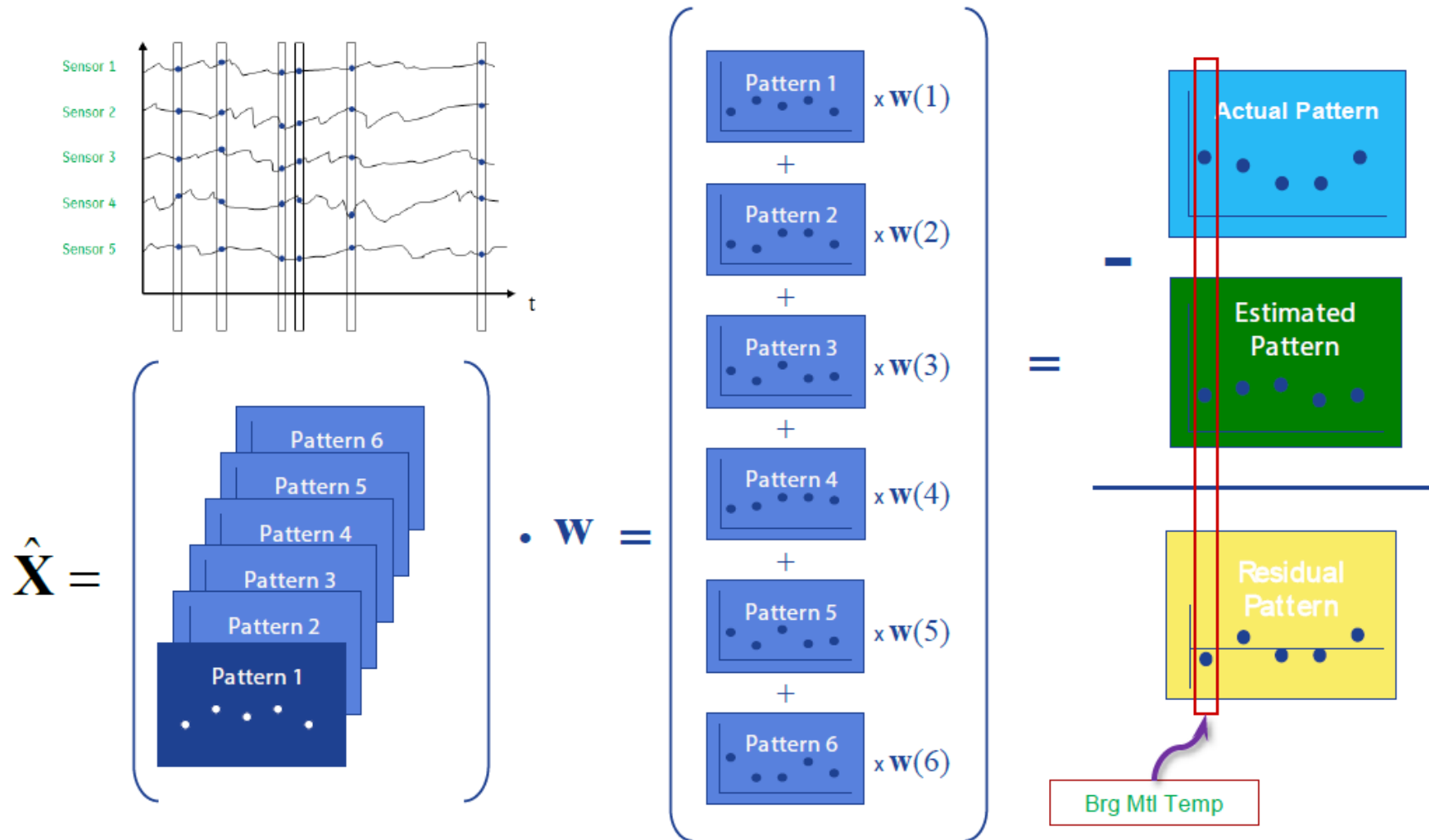
Pattern Reconstruction

- Similarity Based Modeling
- 'n' Dimensional State Matrix
- Variable Based & Auto-Adaptation



Pattern Reconstruction in Action...

Informed by Data Modeling, Physics Models and/or Commissioning Curves



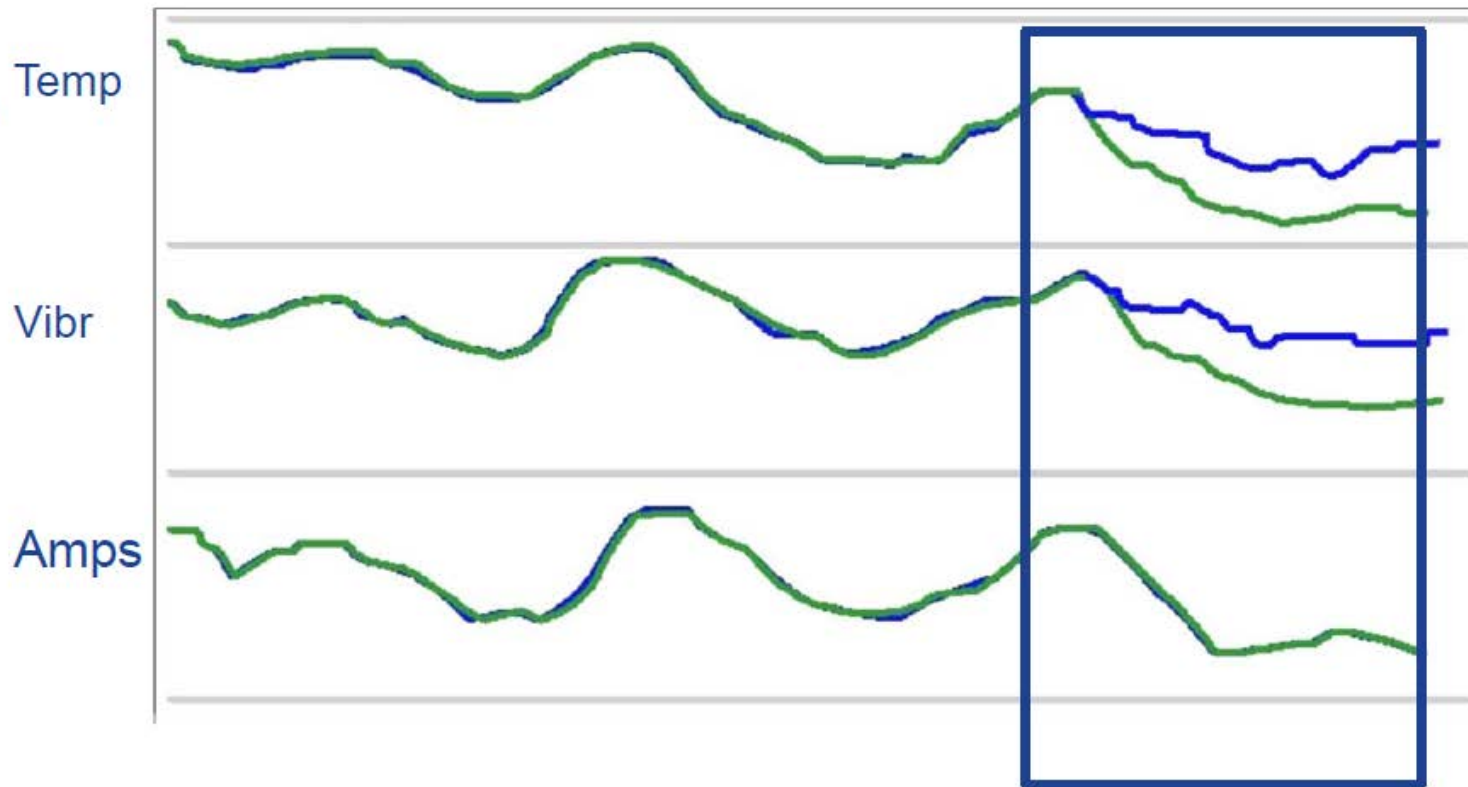
Easy User Interaction with Normalized Data

“Blue is True”

Where Your Data Is

“Green is Good”

Where Your Data Should Be



Deviations from
Healthy Patterns





SBM Summarized

1. Built on historical data, customized to a particular piece equipment
2. Summarizes normal, healthy equipment behavior
3. Represents many different operational states and ambient conditions
4. Takes advantage sensor relationships inherent in equipment and processes
5. Not OEM specific
6. Predicts what the data should be reading, based on the current operation and its history for this type of operation

Diagnostic advisory

A notification of a change in equipment behavior that conforms to a fault pattern.



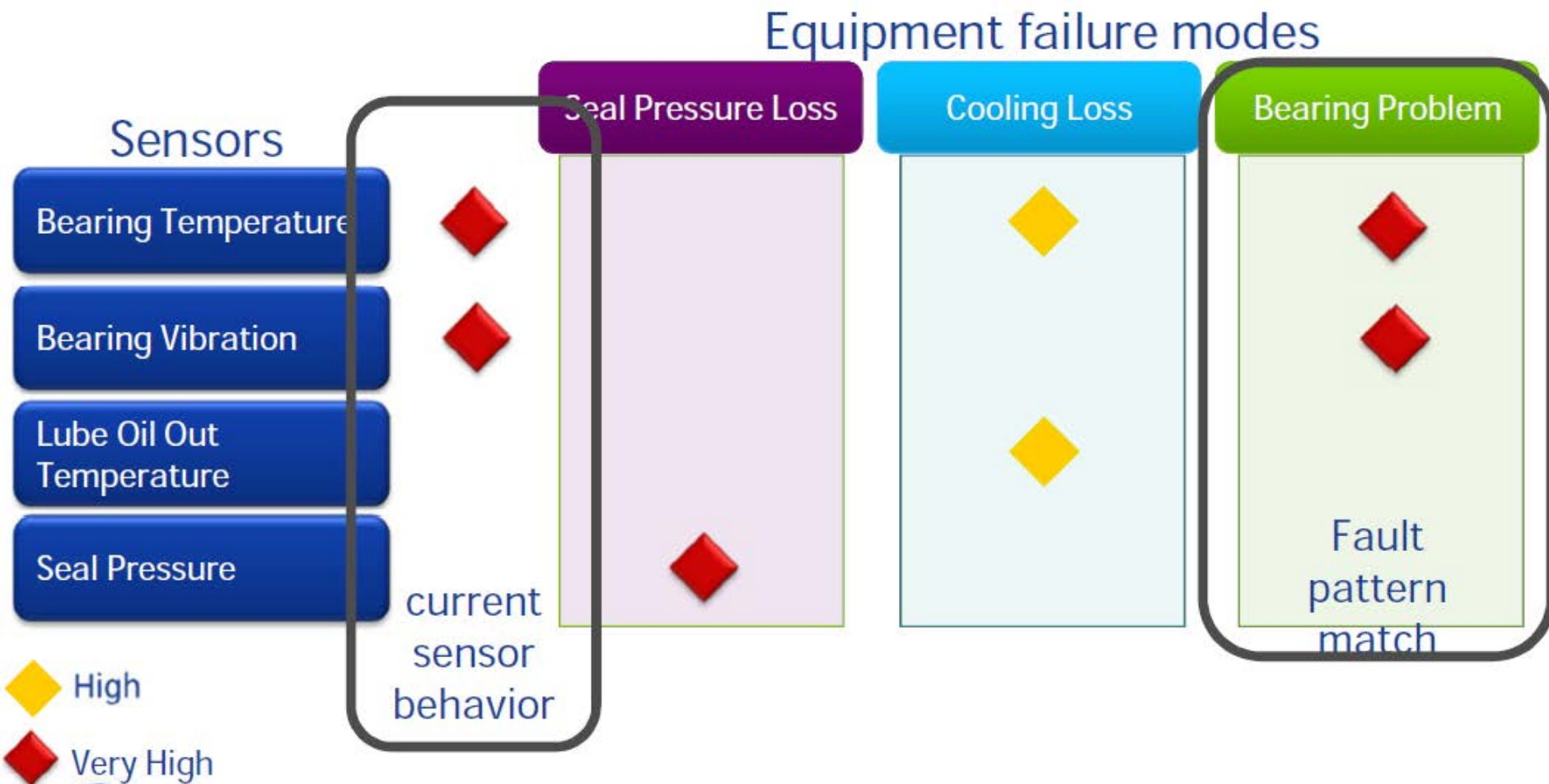
matches a fault pattern

persistence

significant deviation

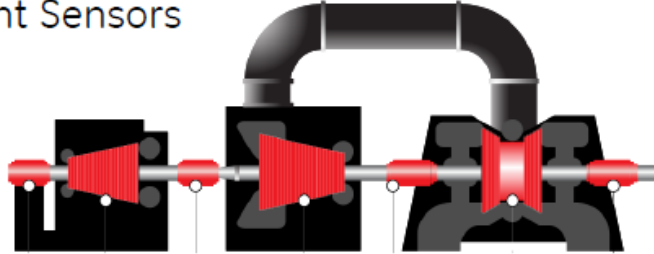
equipment is operating

Fault patterns are a signature set of behavior specific to an equipment failure mode



The SmartSignal process

Equipment Sensors



Personalized Empirical Models

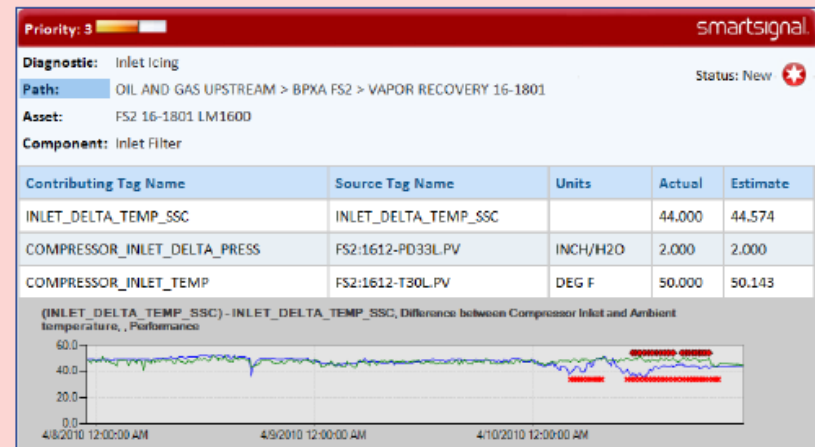
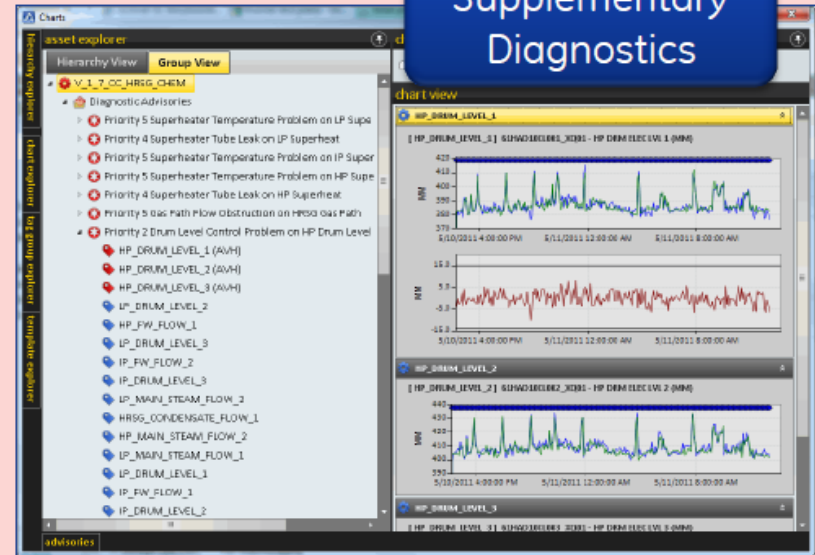


Similarity Based Modeling

Fault pattern diagnostics

Prioritized
Diagnostic
Information

Supplementary
Diagnostics



Proficiency SmartSignal Suite



Design



Blueprint
Center

Build



Asset
Center



Connection
Center



Transfer



Translation

Monitor



Gatekeeper



Sentinel

Maintain



Asset
Center

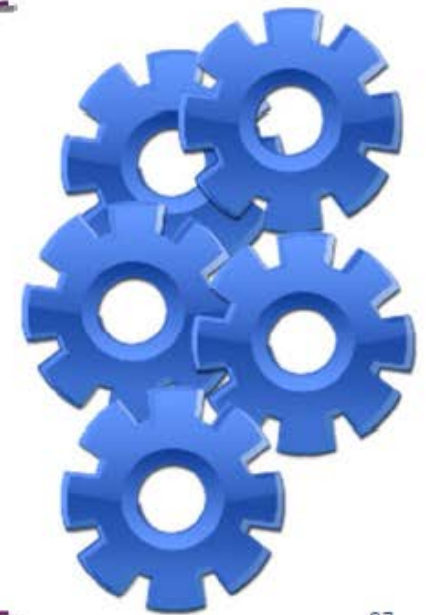
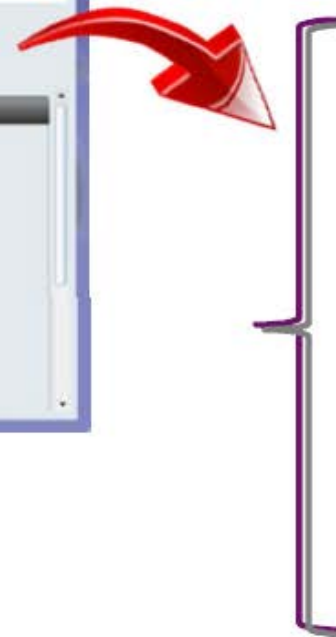
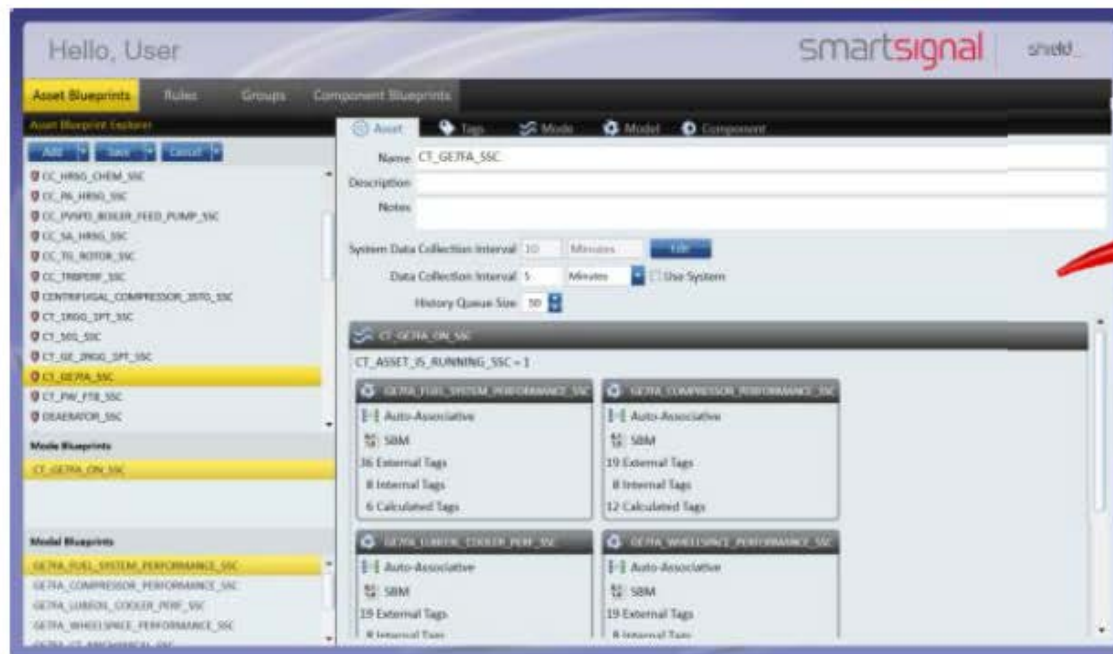
Infrastructure



Core
Center

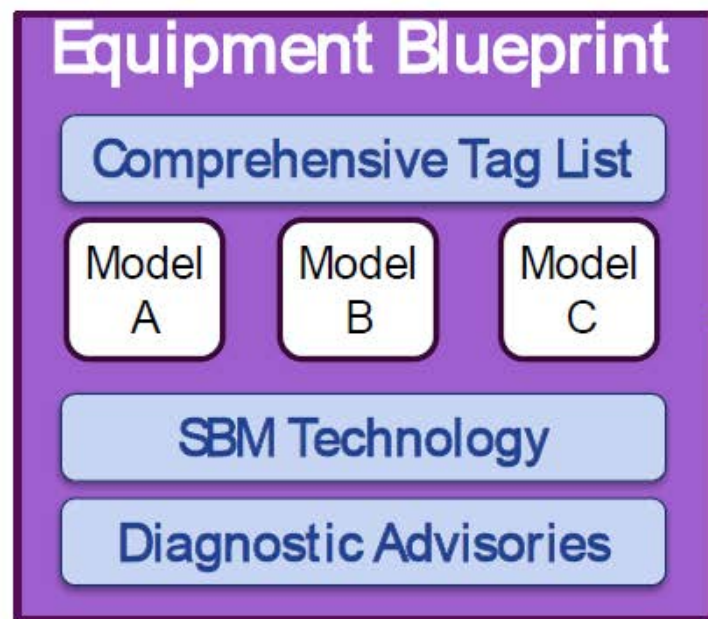
Easy to Deploy, Manage at Scale

Define Blueprint Templates, Globally Manage Designs



“Blueprint” Templates

Fast and Reliable Implementation



For each asset:

- Map specific tags to the blueprint
- Import and filter data
- Customize deviation allowances

Individual pieces of equipment



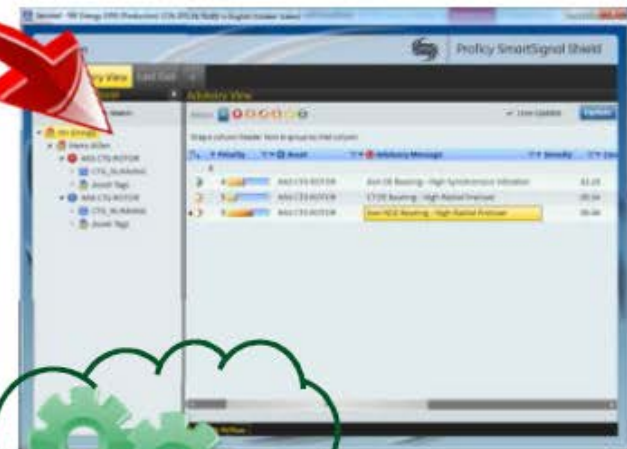
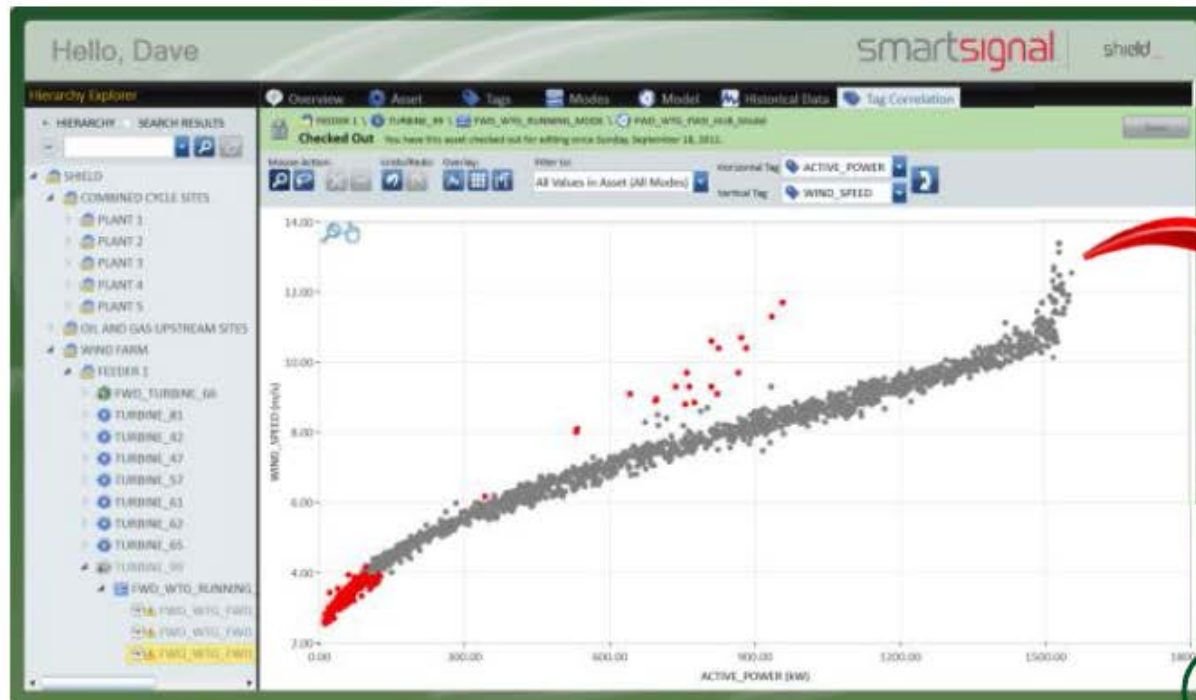
Example : ST Blueprint

System	Sub System	Diagnostic
Performance	HP Performance IP Performance LP Performance Control Valves	Efficiency Loss Control Valve Problem
Steam Seal System	Gland Seals	Gland Seal Steam Problem
Lubrication Oil System	Oil tank Oil filter Oil Cooler Oil Pump	Fouling Pump Problem Oil Leak Filter Pluggage Temperature Control Problem Vapor Pressure Loss
Rotor	Journal Bearing (11) Thrust Bearing	Local Bearing Problem Cooling Loss Axial Position Shift Sensor Problem Generator Rotor Thermal Problem Exciter Rotor Problem



Asset Center

Easy to Instantiate, Maintain, and Manage at Scale
Import Templates for Assets, Individualize, Train, Maintain

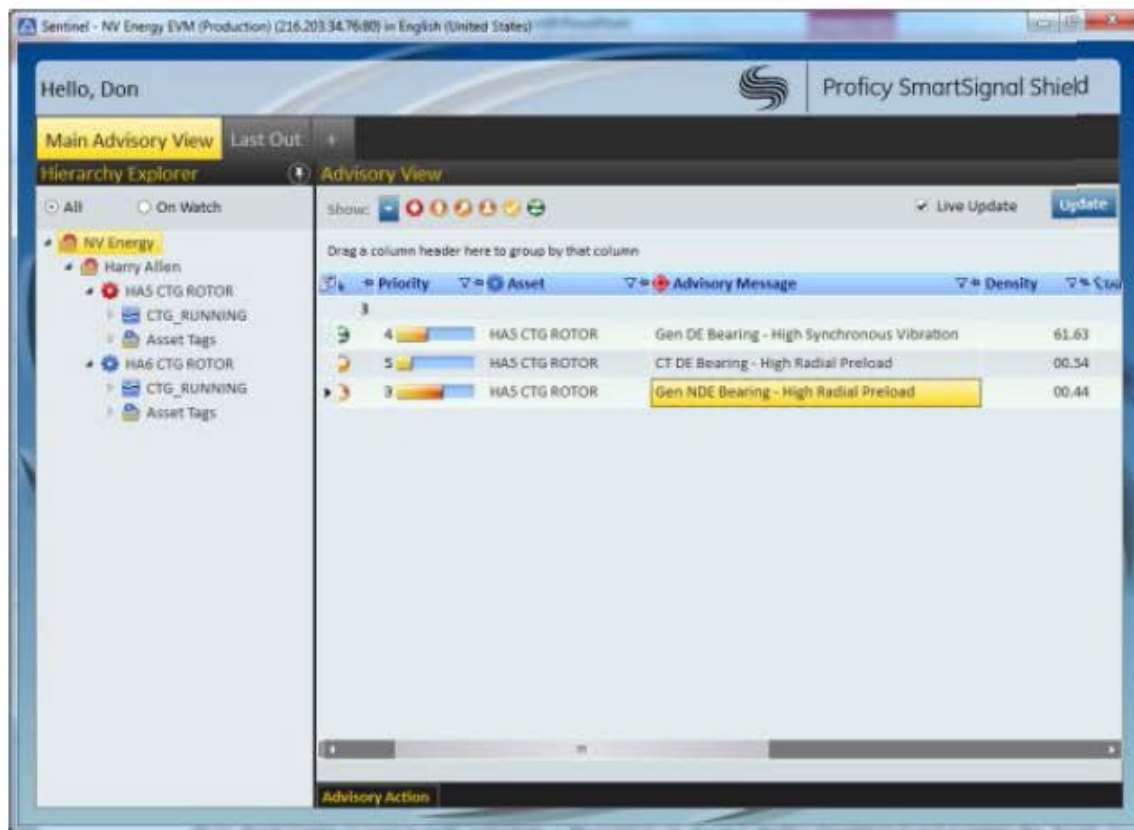


Sentinel



Advisory List, Access to Charts and Metrics

The central application of P-SS for user's





Gatekeeper

Gatekeeper - NV Energy EVM (Production) (216.203.34.76:80) in English (United States)

Hello, Don

Proficy SmartSignal Shield

My Account Users User Permissions Subscriptions General Security Connection History

Refresh Edit View Grid View Create User Delete User Disable User Activate User

Last Name	First Name	Log On ID	Title/Position
Account	System		
Admin	Admin	Customsupport	
Down	Don	ddown	
Gaither	Joseph (Andy)	jgaither	
Hampton	Ryan	Rhampton	Lead Combined Cycle
Patzold	Bitan	bpatzold	
Schreiner	Chris	CSchreiner	

Access Rights for Joseph (Andy) Gaither

Feature	Allow Access	Read Access	Write Access	Delete Access
Asset Add	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asset Blueprint Add	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asset Blueprint Data Collection Interval Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asset Blueprint Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Asset Chart Template Group Add	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asset Chart Template Groups Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Asset Data Collection Interval Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Datafeed Connection	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Default Tag Filter Parameter Maintenance	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global and Blueprint Chart Template Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Group Add	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Group Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rollback Asset	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rule Add	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rule Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
System Data Collection Interval Maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Check All Clear All Set Defaults Restore

OK Cancel

☒ Password must be changed upon next log on

Created 10/25/2012 3:18:27 PM

Unique ID 96705de1-6c75-4aa3-805e-e3a309184ef0

Legacy ID 7

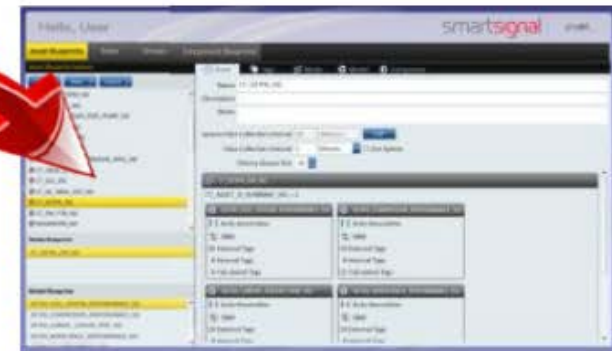
☐ Send an email containing Account Information

Update User Cancel

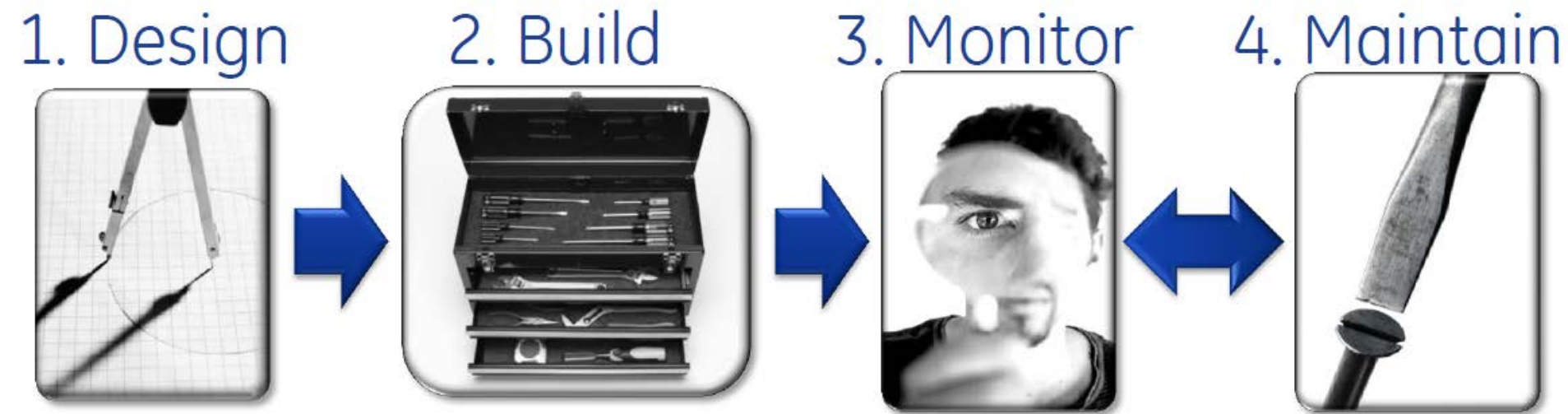


Transfer Center

Export and Import Assets across sites
Collaboration / Deploy new designs



Modeling lifecycle





1. Model design for assets

Template or blueprint of engineering information

Unique to each equipment type

Comprehensive and flexible list of tags

Calculation syntax

Model breakdown

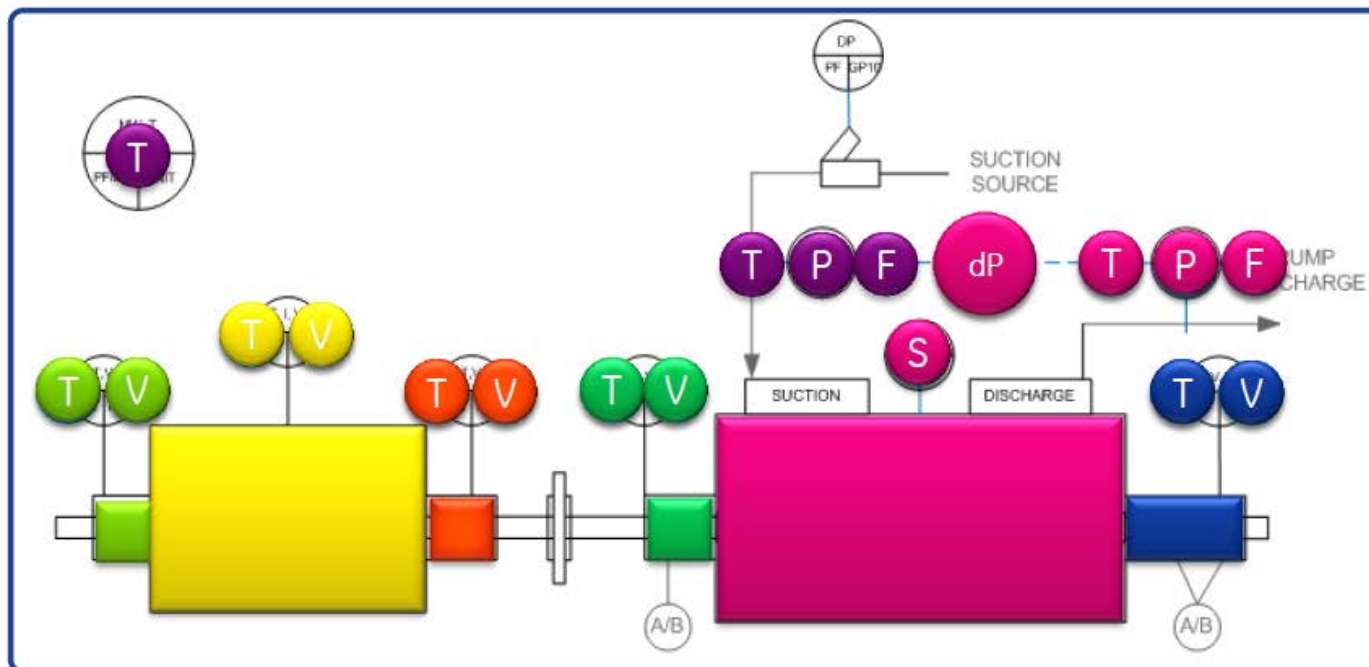
Default threshold and model settings

Diagnostic fault pattern criteria

Model design process



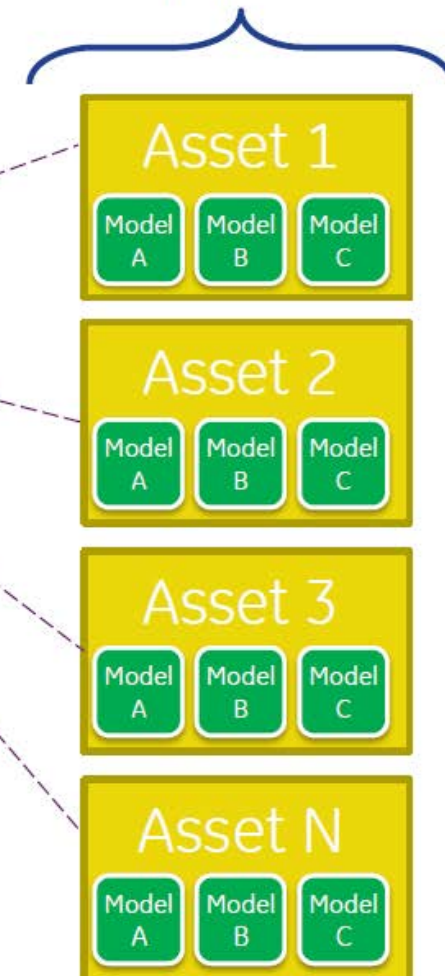
1. Draw a boundary around Equipment
2. Identify model inputs
3. Establish equipment faults
4. Identify fault identification tags
5. Identify key calculated variables
6. Group related fault identification tags



2. Asset and Model building



Individual Pieces of Equipment



For each Asset:

- Map specific tags to the blueprint
- Import and filter data
- Customize deviation allowances

Tag mapping



<div> <div>Overview</div> <div>Asset</div> <div>Tags</div> <div>Modes</div> <div>Model</div> <div>Historical Data</div> <div>Tag Correlation</div> </div>													
<div> <div>✓</div> <div>FEEDER 3 \ TURBINE_13 \ WTG_RUNNING \ HUB</div> <div>Checked Out</div> <div>You currently have this asset checked out for editing.</div> <div>Save</div> </div>													
<div> <div>Columns</div> <div>Filters</div> <div>Reset to Blueprint</div> </div>													
Tag Alias	Type	Active In Asset	Source Tag	Description	Units	Standard Units	Actual Low	Actual High	Active In Model	Residual (Negative)	Residual (Positive)	Alarm Type	
ACTIVE_POWER		<input checked="" type="checkbox"/>	P_ACT.10MinAvg	Power	kW	None	20		<input checked="" type="checkbox"/>	0	0	None	
AIR_TEMP_1		<input checked="" type="checkbox"/>	T_AIR_1.10MinAvg	Outside Temperature 1	DEG C	None	-30	50	<input checked="" type="checkbox"/>	10	10	Residual Threshold	
AIR_TEMP_2		<input checked="" type="checkbox"/>	T_AIR_2.10MinAvg	Outside Temperature 2	DEG C	None	-30	50	<input checked="" type="checkbox"/>	10	10	Residual Threshold	
BLADE_1_PITCH_POSN		<input checked="" type="checkbox"/>	BL1_ACT.10MinAvg	Blade 1, actual value	DEG	None	-1	85	<input checked="" type="checkbox"/>	2.5	2.5	Residual Threshold	
BLADE_1_SET_VALUE		<input checked="" type="checkbox"/>	BL1_SET_V.10MinAvg	Blade 1, set value	DEG	None	-1	85	<input checked="" type="checkbox"/>	0	0	None	
BLADE_2_PITCH_POSN		<input checked="" type="checkbox"/>	BL2_ACT.10MinAvg	Blade 2, actual value	DEG	None	-1	85	<input checked="" type="checkbox"/>	2.5	2.5	Residual Threshold	
BLADE_2_SET_VALUE		<input checked="" type="checkbox"/>	BL2_SET_V.10MinAvg	Blade 2, set value	DEG	None	-1	85	<input checked="" type="checkbox"/>	0	0	None	
BLADE_3_PITCH_POSN		<input checked="" type="checkbox"/>	BL3_ACT.10MinAvg	Blade 3, actual value	DEG	None	-1	85	<input checked="" type="checkbox"/>	2.5	2.5	Residual Threshold	
BLADE_3_SET_VALUE		<input checked="" type="checkbox"/>	BL3_SET_V.10MinAvg	Blade 3, set value	DEG	None	-1	85	<input checked="" type="checkbox"/>	0	0	None	
BLADE_MOTOR_TORQUE		<input checked="" type="checkbox"/>	M_ACT.10MinAvg	Torque, actual value	%	None	0.01	102	<input checked="" type="checkbox"/>	30	30	Residual Threshold	
BLADE_MOTOR_TORQUE_SP		<input checked="" type="checkbox"/>	M_SET.10MinAvg	Torque, set value	%	None	0.01	102	<input checked="" type="checkbox"/>	0	0	None	
BLADE_POSN_SPREAD_CV		<input checked="" type="checkbox"/>				None			<input checked="" type="checkbox"/>	0.1	0.1	Residual Threshold	
GEN_SPEED_1		<input checked="" type="checkbox"/>	N_GEN_CCU.10MinAvg	Generator speed (CCU)	rpm	None	50	1600	<input checked="" type="checkbox"/>	0	0	None	
GEN_SPEED_2		<input checked="" type="checkbox"/>	N_GEN_PLG.10MinAvg	Generator speed (PLC)	rpm	None	50	1600	<input checked="" type="checkbox"/>	0	0	None	
HUB_SPEED		<input checked="" type="checkbox"/>	N_ROT_PLG.10MinAvg	Rotor speed (PLC)	rpm	None	10	22	<input checked="" type="checkbox"/>	0	0	None	
POWER_CURVE_CV		<input type="checkbox"/>				None	0	0	<input type="checkbox"/>	0	0	None	
TIP_SPEED_RATIO		<input checked="" type="checkbox"/>	TSR.10MinAvg	Tip speed ratio		None			<input checked="" type="checkbox"/>	0	0	None	
WIND_SPEED		<input checked="" type="checkbox"/>	V_WIN.10MinAvg	Wind speed	m/s	None	0.01	23	<input checked="" type="checkbox"/>	0	0	None	
WTG_EFFICIENCY_CV		<input checked="" type="checkbox"/>				None			<input checked="" type="checkbox"/>	0.2	1	Residual Threshold	

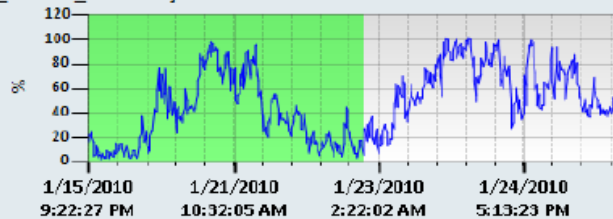
Data selection



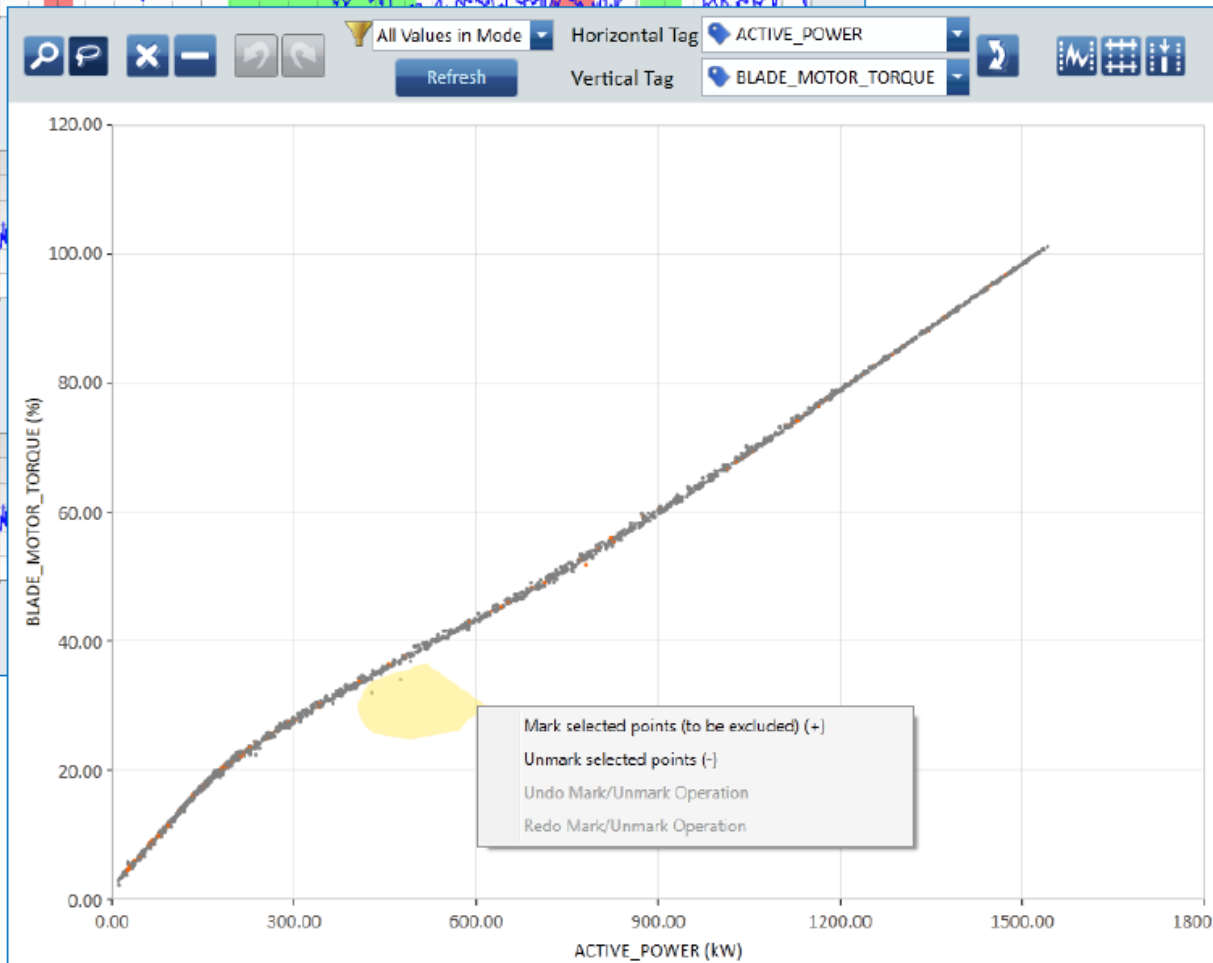
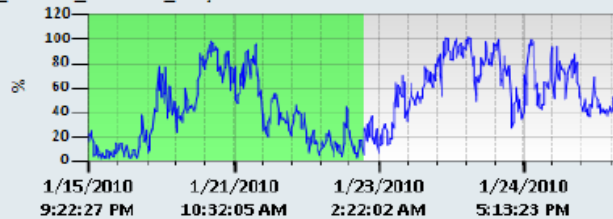
[ACTIVE_POWER]



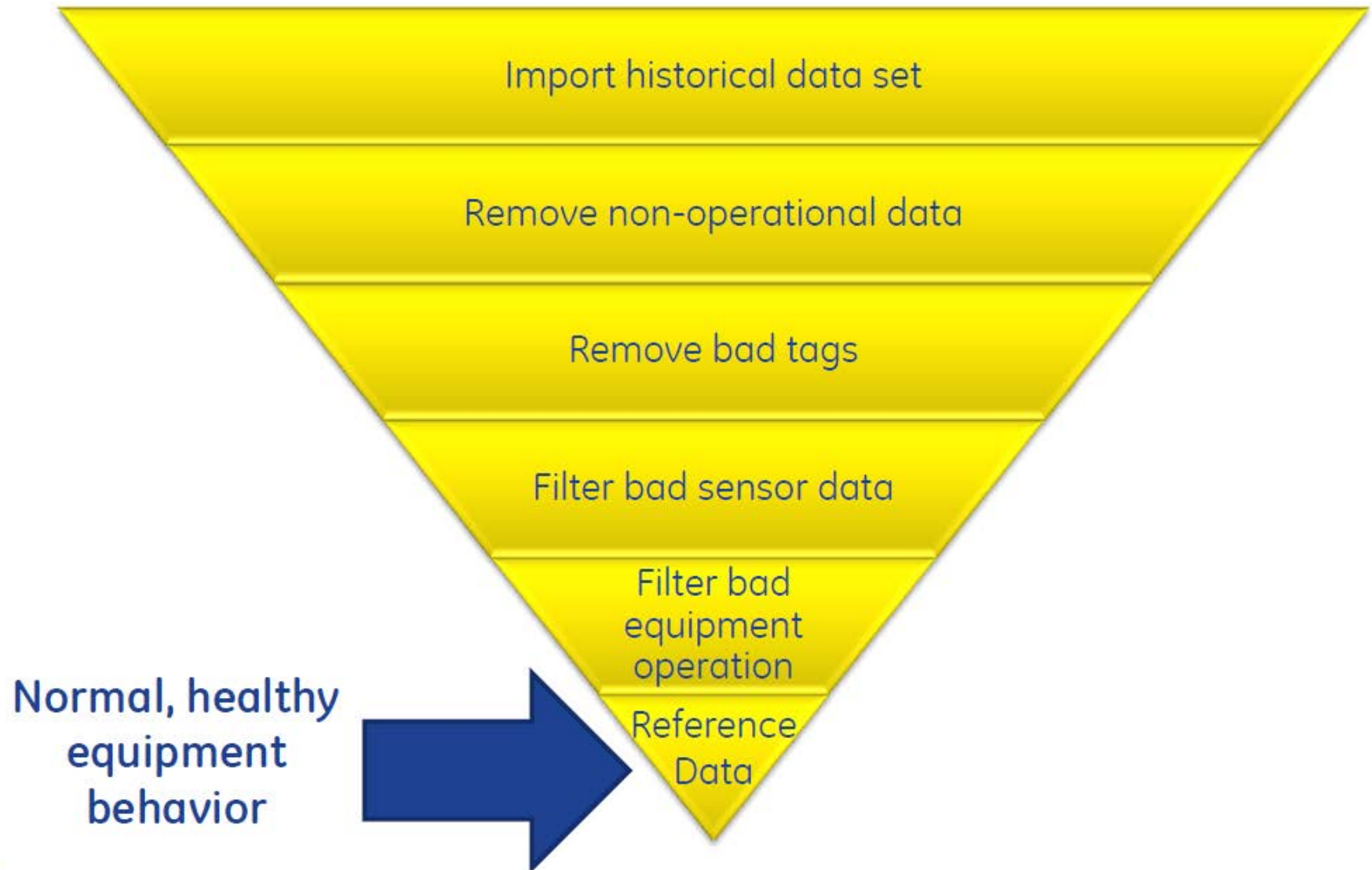
[BLADE_MOTOR_TORQUE]



[BLADE_MOTOR_TORQUE_SP]



Data selection for each asset





Completing the asset build

Customize deviation settings, as appropriate

Test

- Test results replicate run-time results
- Normal data and faulted data are used during testing
- Iterative process
- Provides confidence in monitoring results



3. Equipment monitoring

Real-time monitoring to provide early warning of equipment faults

- Deviation
- Persistence
- Fault patterns

Diagnostic tools

- Dynamic charting
- Historical information

Workflow management



Equipment notifications



Asset organization (red means "on watch")

Diagnostic advisories put the asset on watch, indicating potential problems

Priority and advisory message information help with advisory analysis

Sentinel - Installation Name (DV-ENG-IIS.smartsignal.dq:80) in English (United States)

Hello, Analyst

Proficy SmartSignal Shield

Advisory View

Show: [Icons] Live Update Update

Drag a column header here to group by that column

	Priority	Asset	Advisory Message	Count	Last Data Collection
35				25,500	
<input type="checkbox"/>	4	Turbine B	GG Rotor - Rotor Bow	4,341	3/28/2012 11:54:51 PM
<input type="checkbox"/>	5	Turbine B	GG Bearing 1 - High Synchronous Vibration	759	3/28/2012 11:54:51 PM
<input type="checkbox"/>	5	Turbine B	Turbine Wheelspace - Wheelspace Temperature Problem	405	3/28/2012 11:54:51 PM
<input type="checkbox"/>	3	Turbine B	GG Bearing 2 - High Synchronous Vibration	4,838	3/28/2012 11:54:51 PM
<input type="checkbox"/>	4	Turbine B	GG Rotor - Rotor Dynamic Problem	41	3/28/2012 11:54:51 PM
<input type="checkbox"/>	4	Turbine B	GG Bearing 1 - Local Bearing Problem	25	3/28/2012 11:54:51 PM
<input type="checkbox"/>	3	Turbine B	GG Thrust Bearing - Axial Shift	33	3/28/2012 11:54:51 PM
<input type="checkbox"/>	5	Turbine B	GG Bearing 1 to Driven Shaft Coupling - Misalignment	501	3/28/2012 11:54:51 PM
<input type="checkbox"/>	4	Turbine B	GG Bearing 2 - Local Bearing Problem	457	3/28/2012 11:54:51 PM
<input type="checkbox"/>	3	Turbine A	Combustion	440	2/11/2012 9:30:00 AM
<input type="checkbox"/>	1	Turbine A			2/11/2012 9:30:00 AM
<input type="checkbox"/>	5	Turbine A			2/11/2012 9:30:00 AM
<input type="checkbox"/>	3	Turbine A			2/11/2012 9:30:00 AM
<input type="checkbox"/>	2	Turbine A			2/11/2012 9:30:00 AM

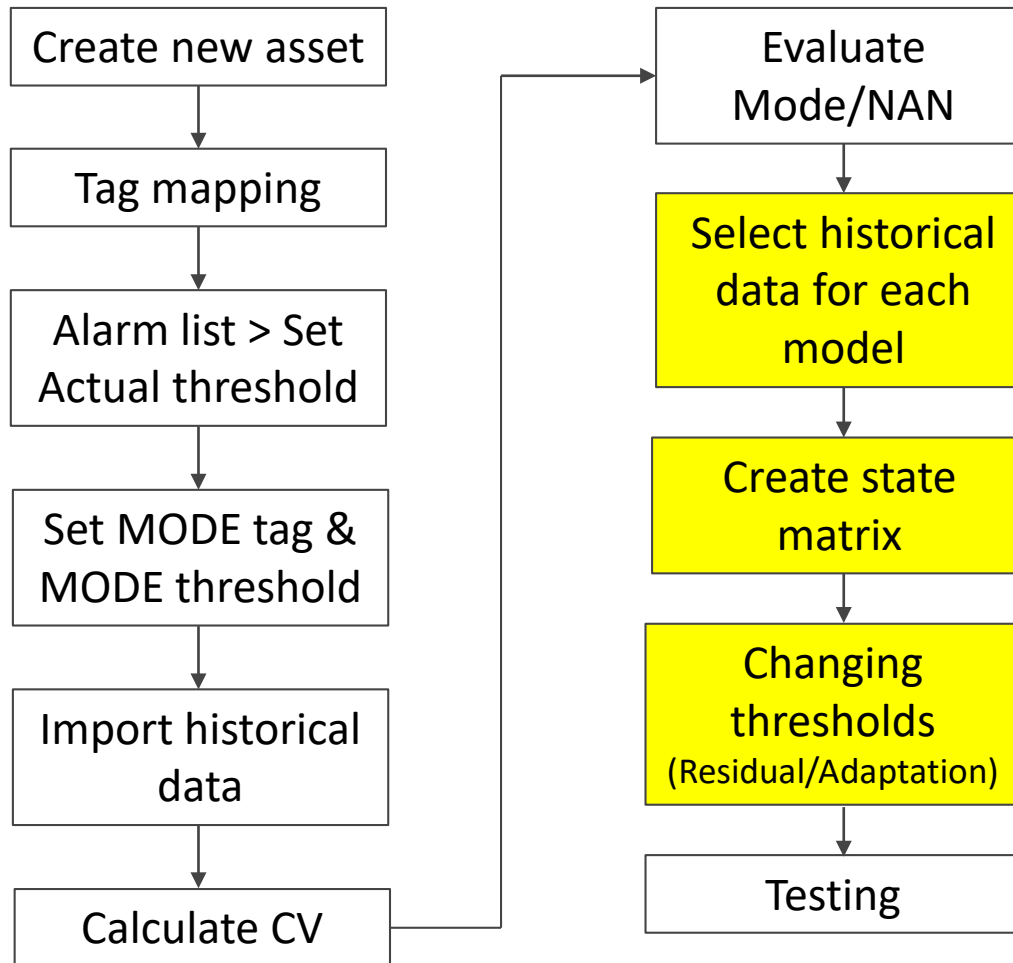
Advisory Action



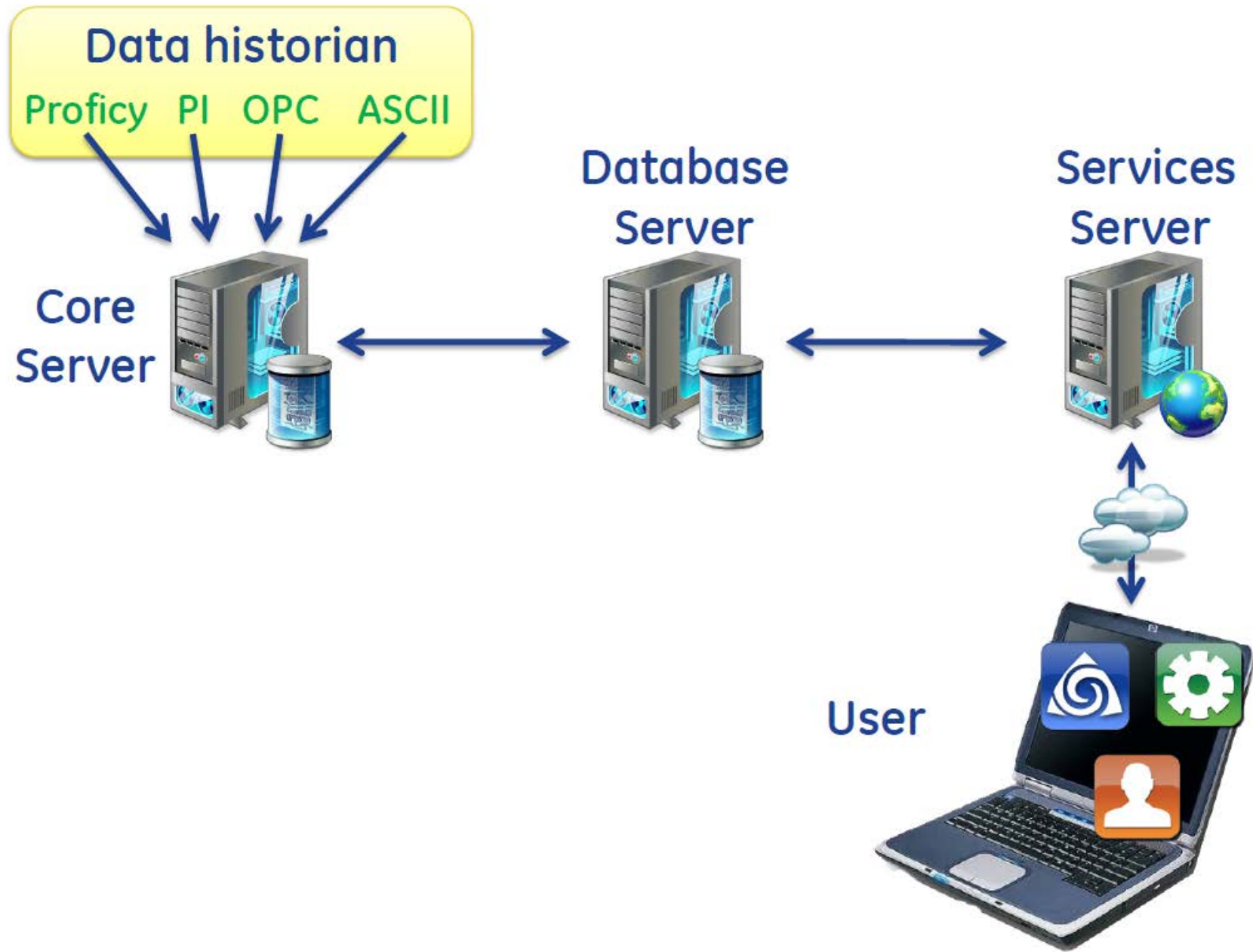
4. Maintain the asset and models

- Adapt new data into the model
- Account for sensor availability
- Adjust performance deviation settings
- Change operating mode criteria
- Modify diagnostics

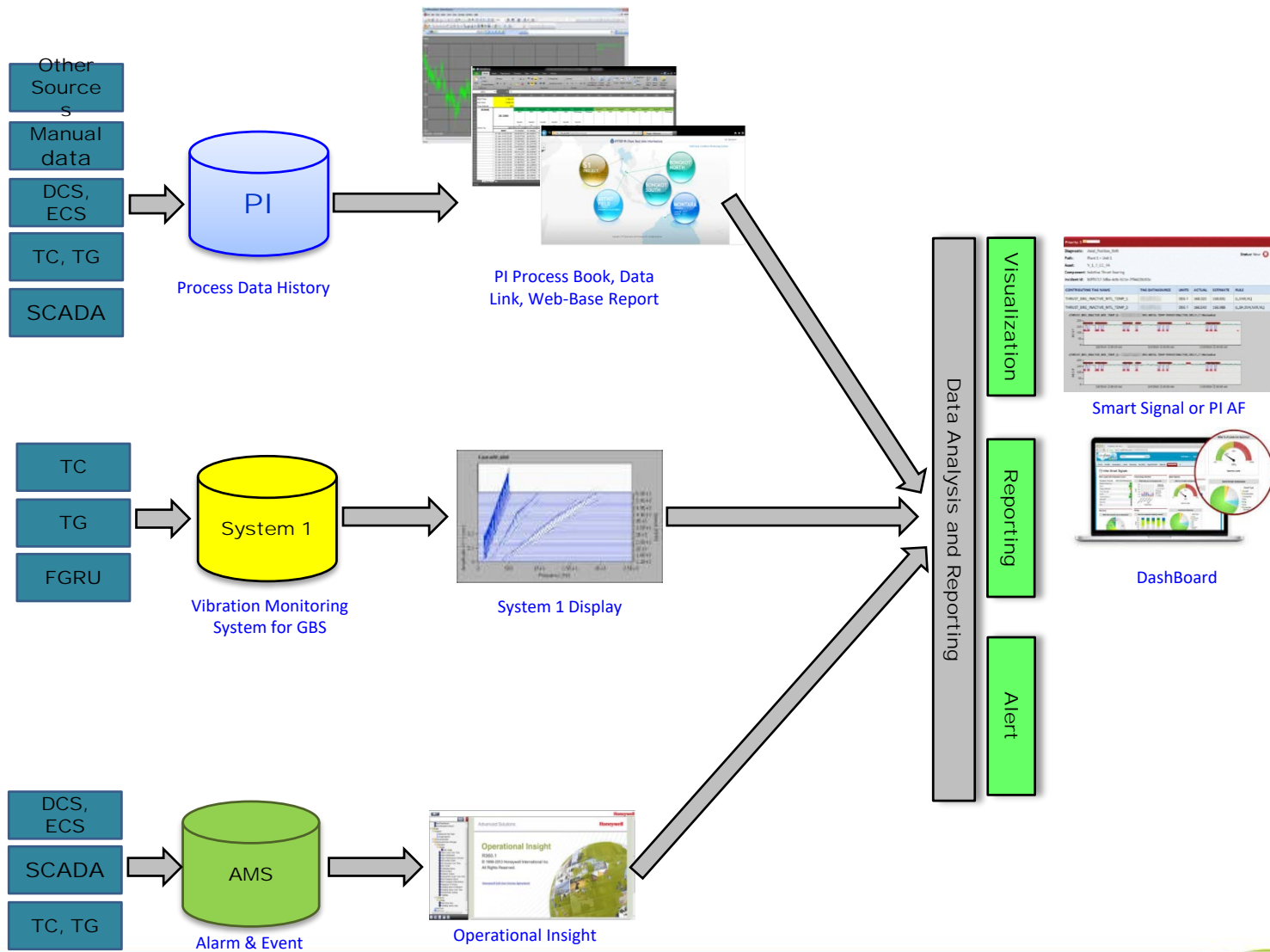
Model building steps



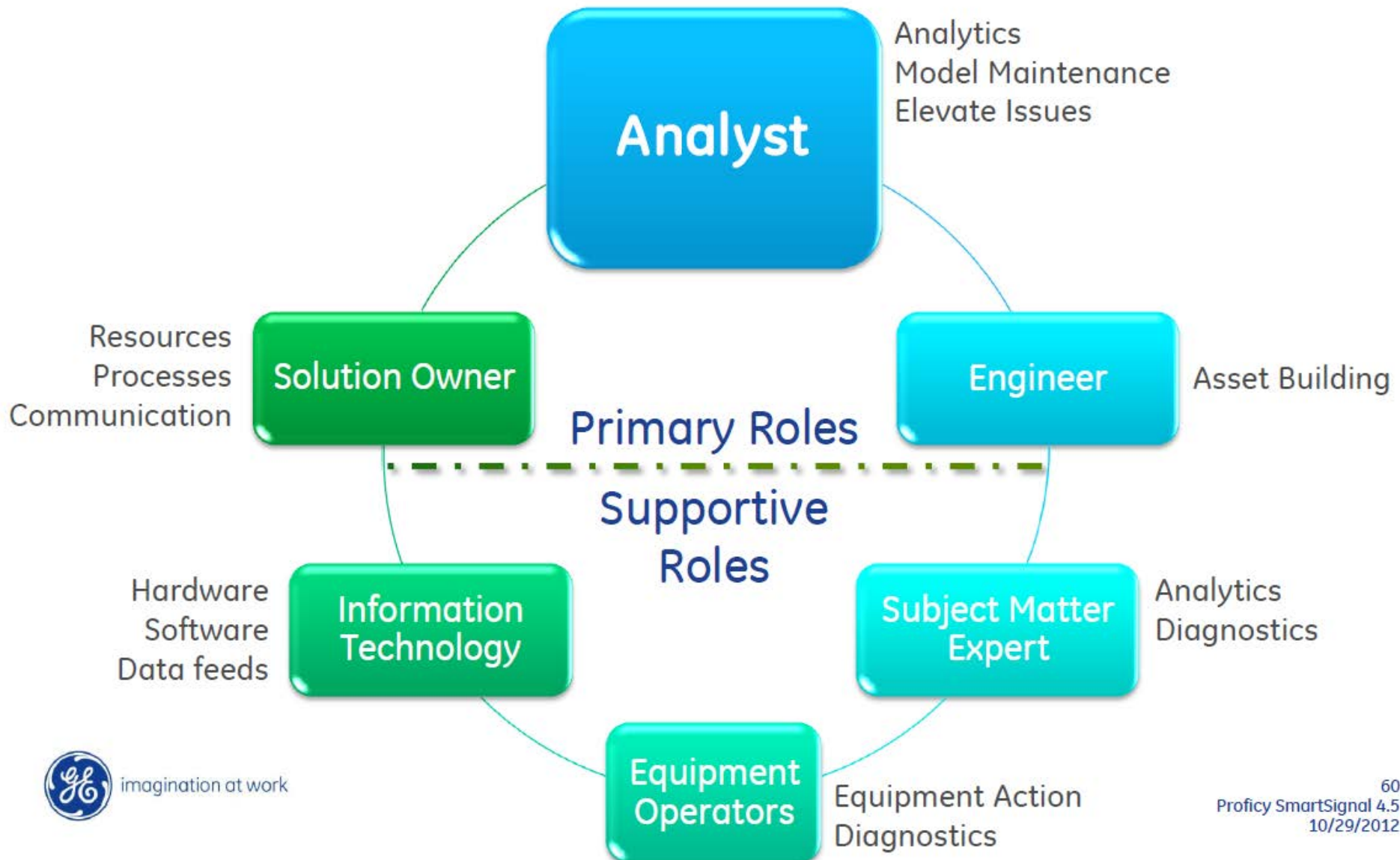
Proficy SmartSignal system configuration



RM&D – System architecture



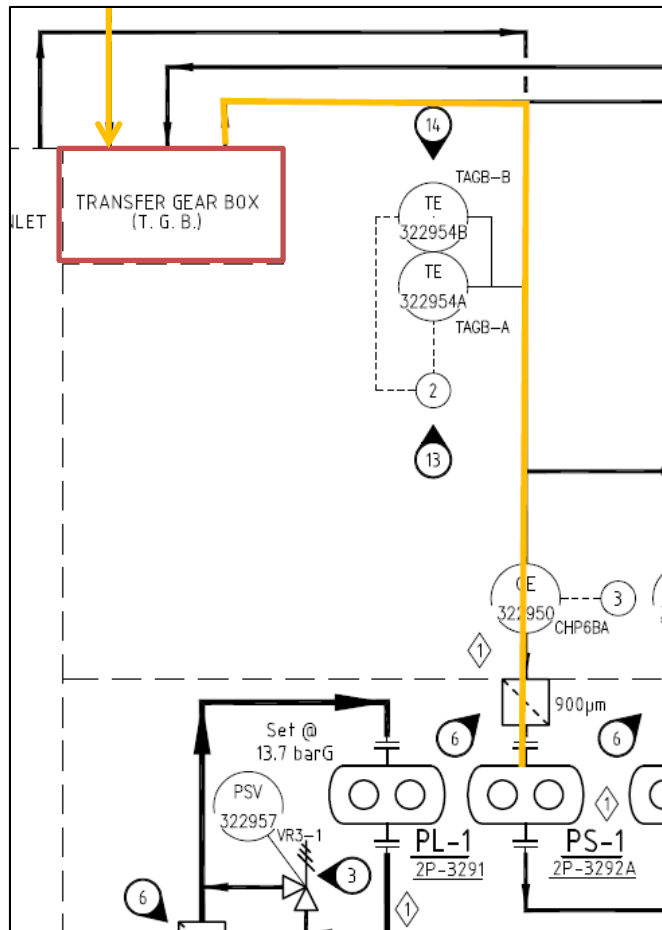
Multiple experienced functional Roles provide analysis



Workflow and knowledge capture



RM&D – Achievement Case study



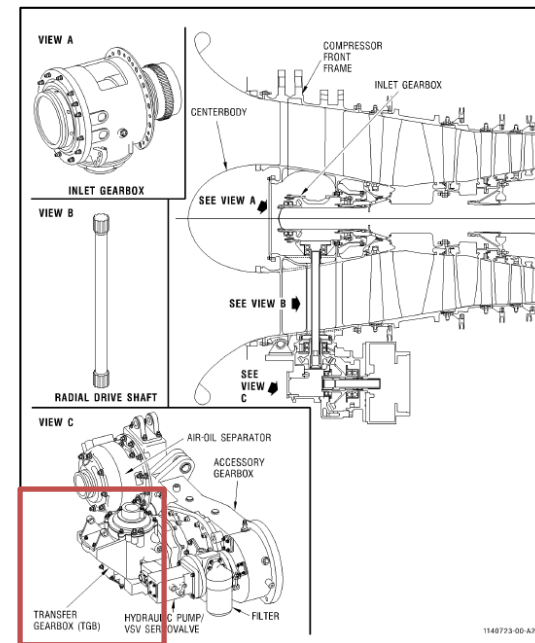
TGB Synthetic lube oil diagram

Location:

GBS Turbo compressor#1 (2X-3200); Gas generator
Transfer gear box drain temperature 2TE-322954A/B

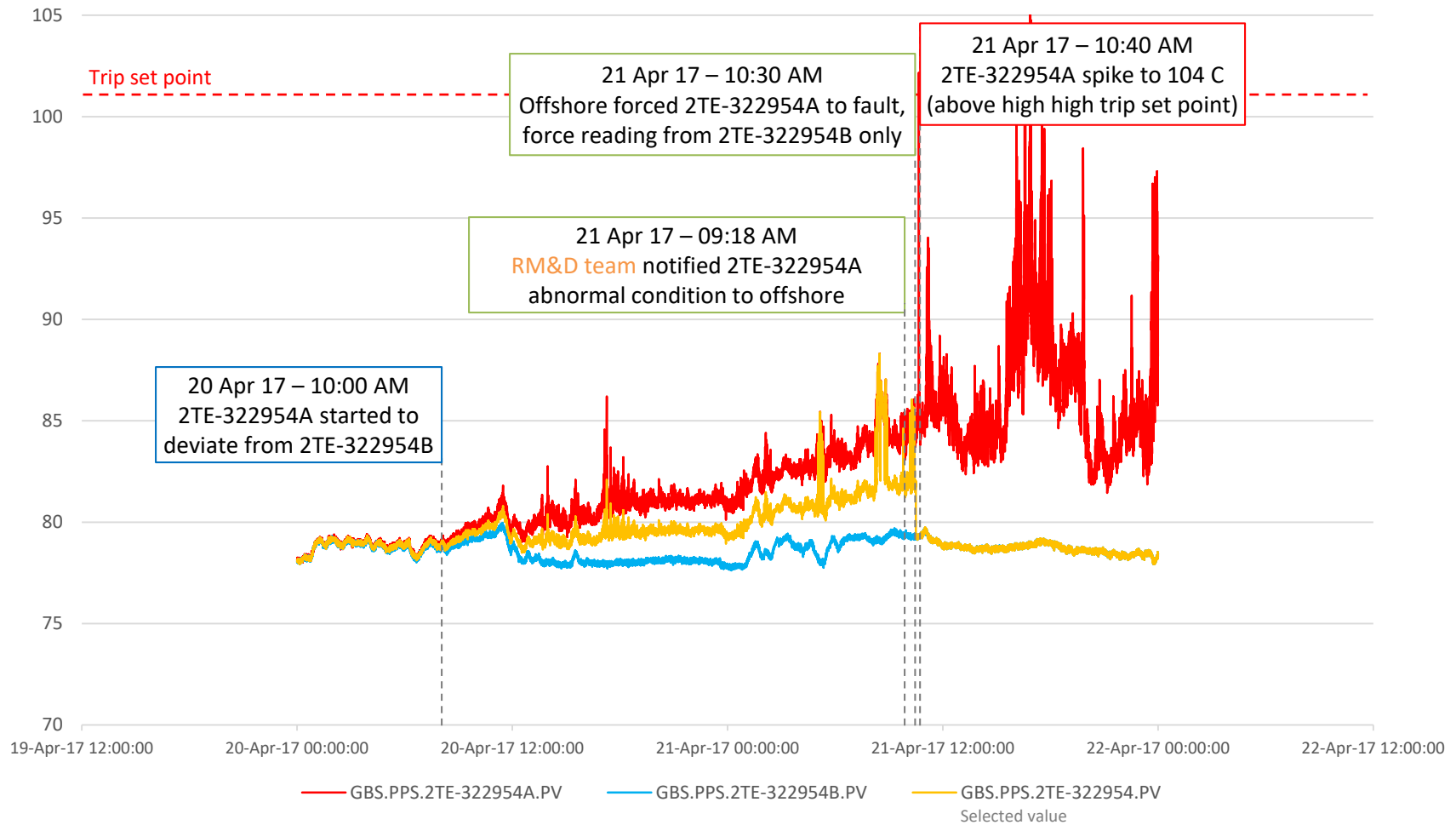
Effect:

2TE-322954A/B High High (101°C) -> Compressor DM
-> 1 compressor train production loss



Transfer gear box

RM&D – Achievement Case study



Production opportunity loss saving

227,382 USD

2017: Total Production opportunity loss saving = 1,437,805 USD
Total Mechanical loss saving = 252,000 USD

RM&D team keeps improving knowledge/monitoring skill set to achieve more saving which benefit the company wide.