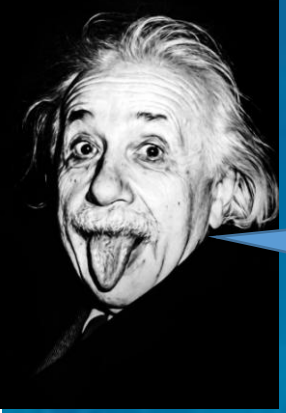

"It's the DATA, Stupid!"

How PI Asset Analytics Rescued Our Real-time Multivariate Process Monitoring

Presented by: Matthew Morrow and Bing Zhang

Bristol-Myers Squibb Company

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Agenda

- **Company Overview**
- Business Problem
- Multivariate Modeling Overview
- SIMCA-online/PI System Integration Challenges
- Business Benefits
- Future Capabilities

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Our Mission

To **discover, develop** and **deliver** innovative **medicines** that help patients prevail over serious diseases.

WHO ARE *you* WORKING FOR?

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How does real-time multivariate process monitoring benefit the business?

- **Business Benefits:**
  - Optimize process performance
  - Proactively monitor multivariate process against historical performance
  - Empower operators with real-time fault detection
  - Reduce risk of batch loss

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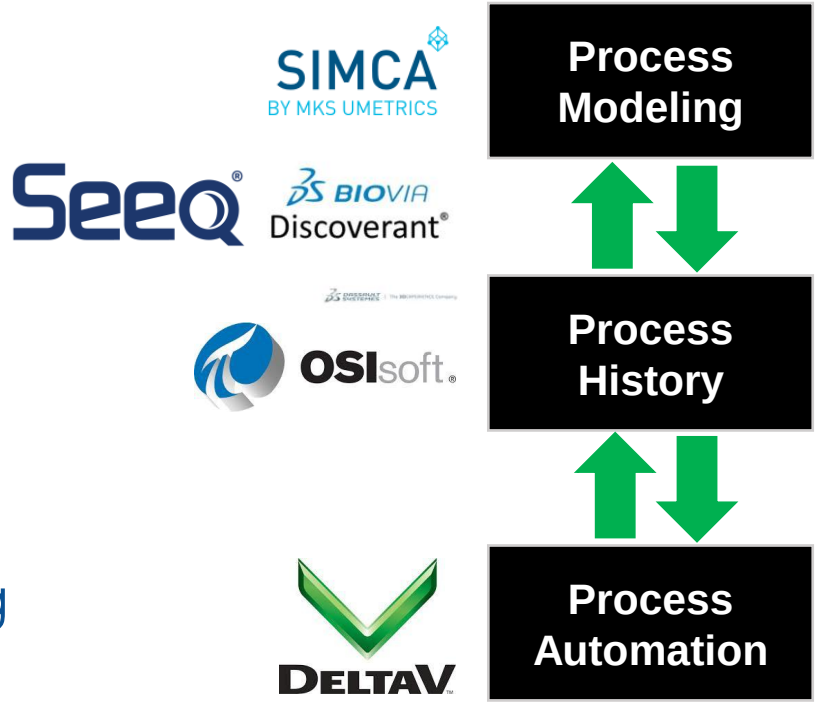
How does real-time multivariate process monitoring benefit the business?

- **Opportunity:** Leverage data infrastructure and data availability in data sources to enable new capability

- **Problem:** Data latency and lack of data context did not enable real-time multivariate monitoring of manufacturing process



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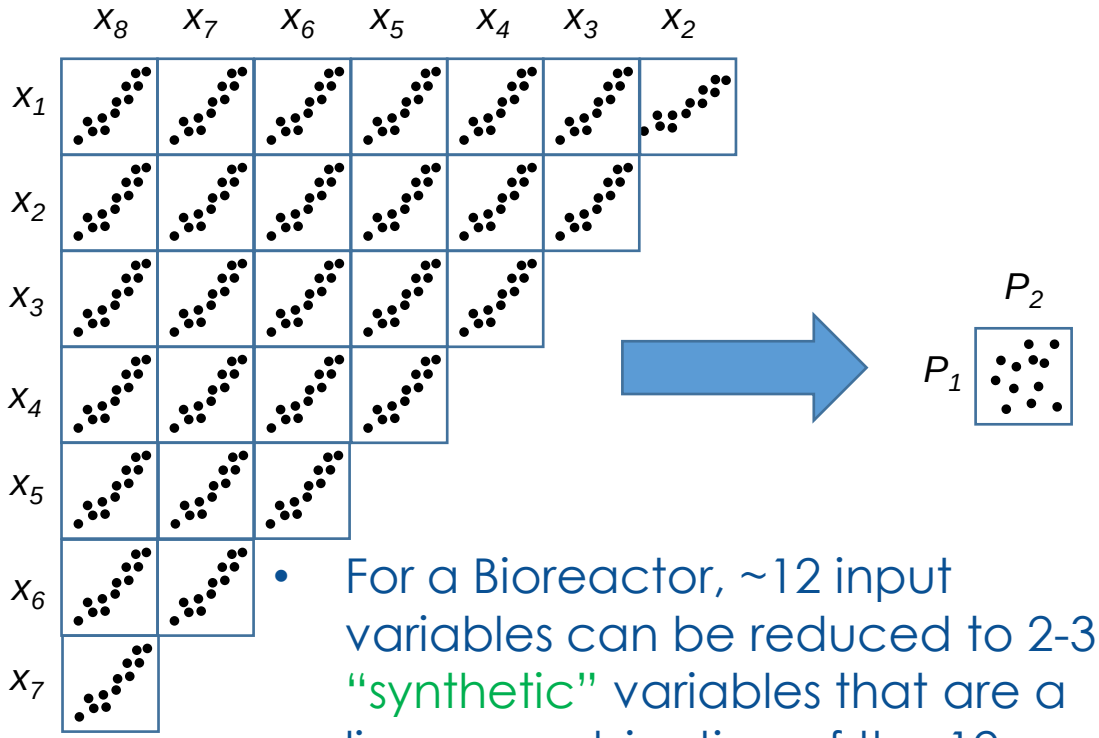
Multivariate Process Analysis Background

- **What is it?**
  - Transform a large number of highly correlated process variables into a small number of uncorrelated "synthetic" variables (principal components) that still fully describe the process



- For a Bioreactor, ~12 input variables can be reduced to 2-3 "synthetic" variables that are a linear combination of the 12 process variables

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Multivariate Process Analysis Background

- **Why is it useful?**
  - Can monitor a process using 1 or 2 "synthetic" variables instead of a dozen or more process variables

    vs… operator overload with individual trends/alarm banners/graphics
  - Past experience can be used to define a multivariate batch tunnel with high and low limits that specify normal process operation

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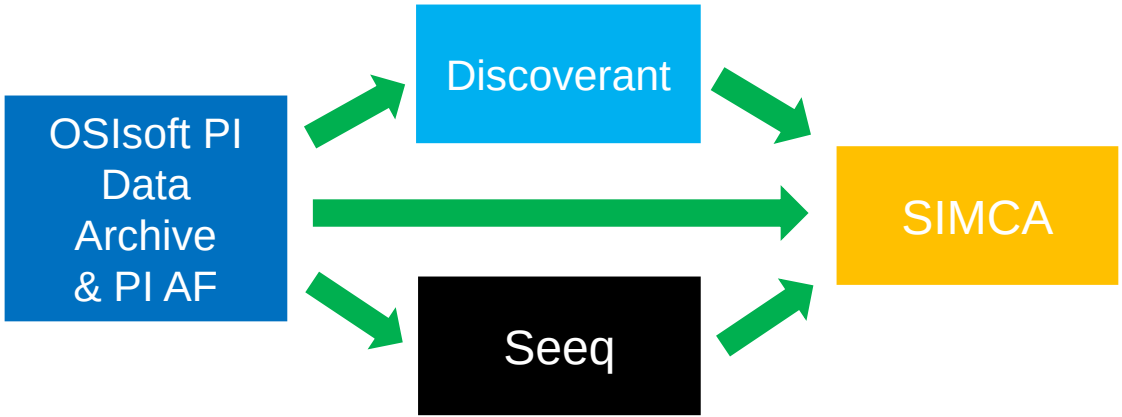
Domain Knowledge

(1) Process Modeling



OSIsoft PI Data Archive & PI AF	Data Historian and Context
Discoverant	Statistical Data Aggregation
Seeq	Real-time Event Capsules
SIMCA	Modeling

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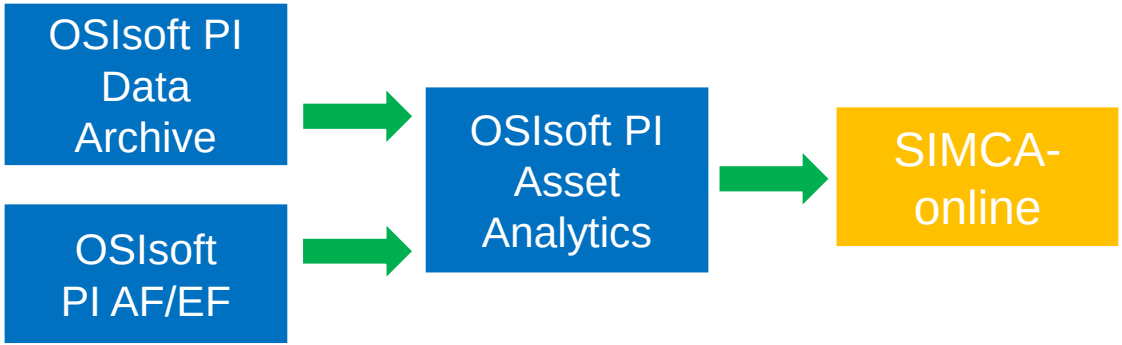
Domain Knowledge

(2) Process History



OSIsoft PI Data Archive	Data Historian
OSIsoft PI AF/EF	Batch and Asset Context
OSIsoft PI Asset Analytics	Real-time Derived Data
SIMCA-online	Real-time Monitoring

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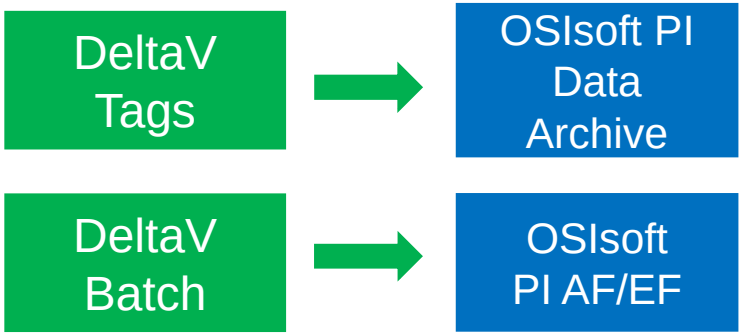
Domain Knowledge

(3) Process Automation



DeltaV Tags	Control System Real-time Sensor Data
DeltaV Batch	Control System Batch Context
OSIsoft PI Data Archive	Data Historian
OSIsoft PI AF/EF	Batch and Asset Context

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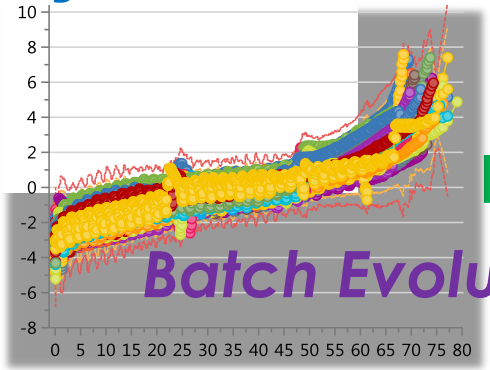
How are multivariate models developed and deployed?

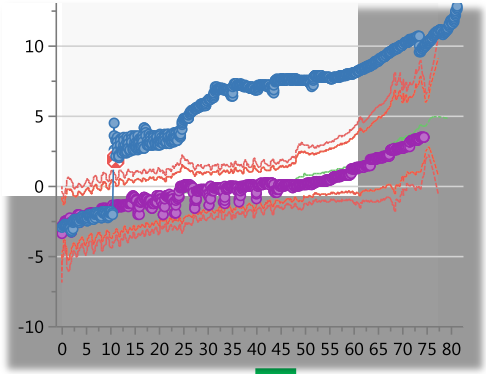
Seeq /SIMCA_exporter

OSIsoft

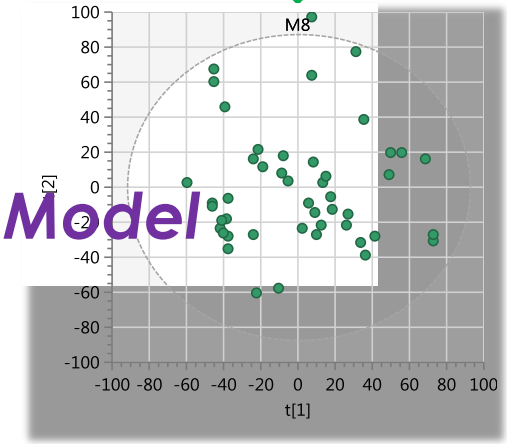
BIOVIA Discoverant

SIMCA BY MKS UMETRICS

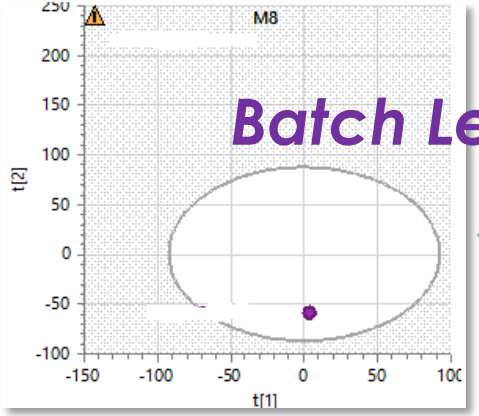




Batch Evolution Model



Batch Level Model



CHALLENGE: Configuring Offline Models to Real-time Monitoring

OSIsoft → SIMCA®-online

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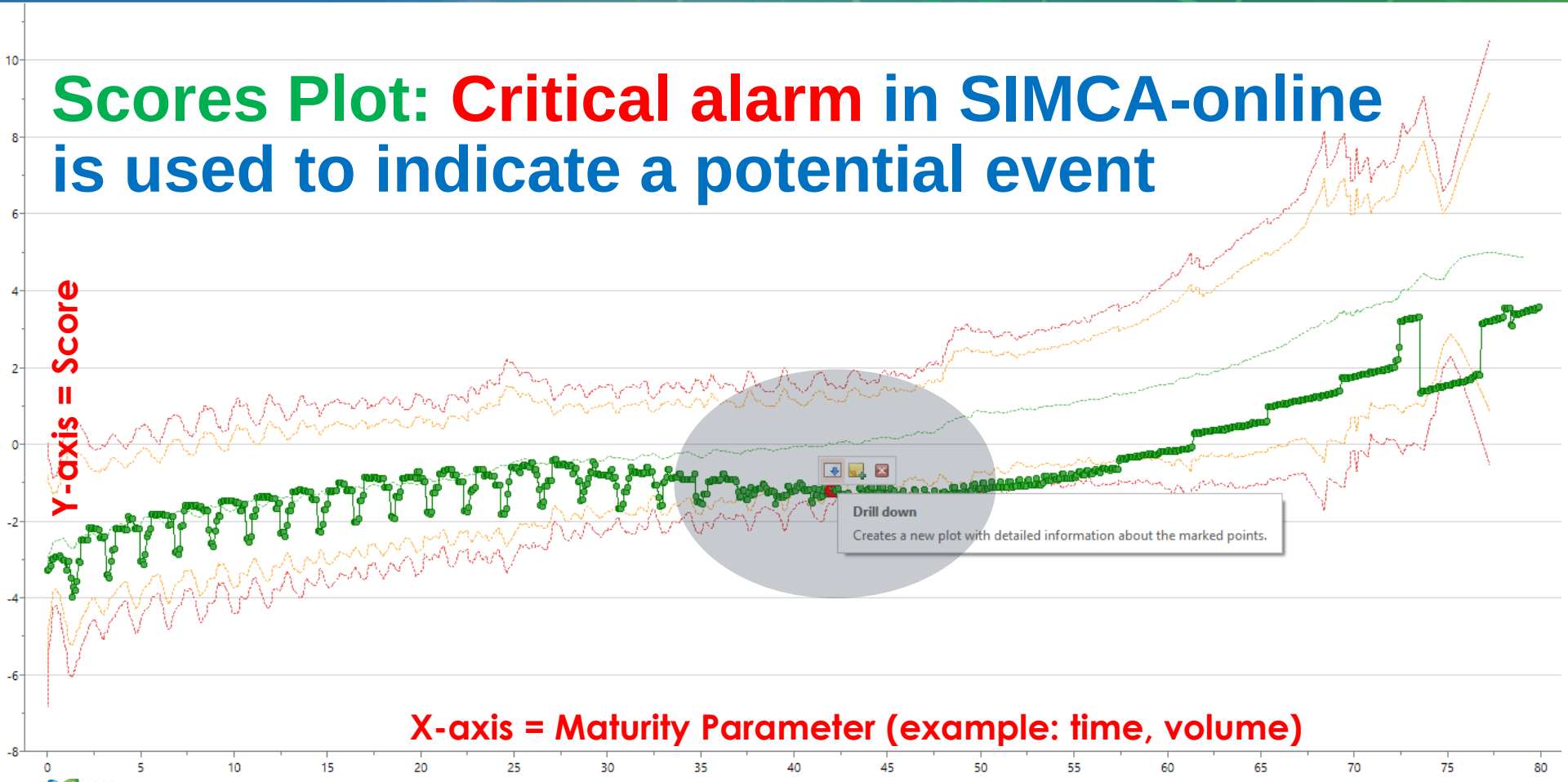
Scores Plot: Critical alarm in SIMCA-online is used to indicate a potential event



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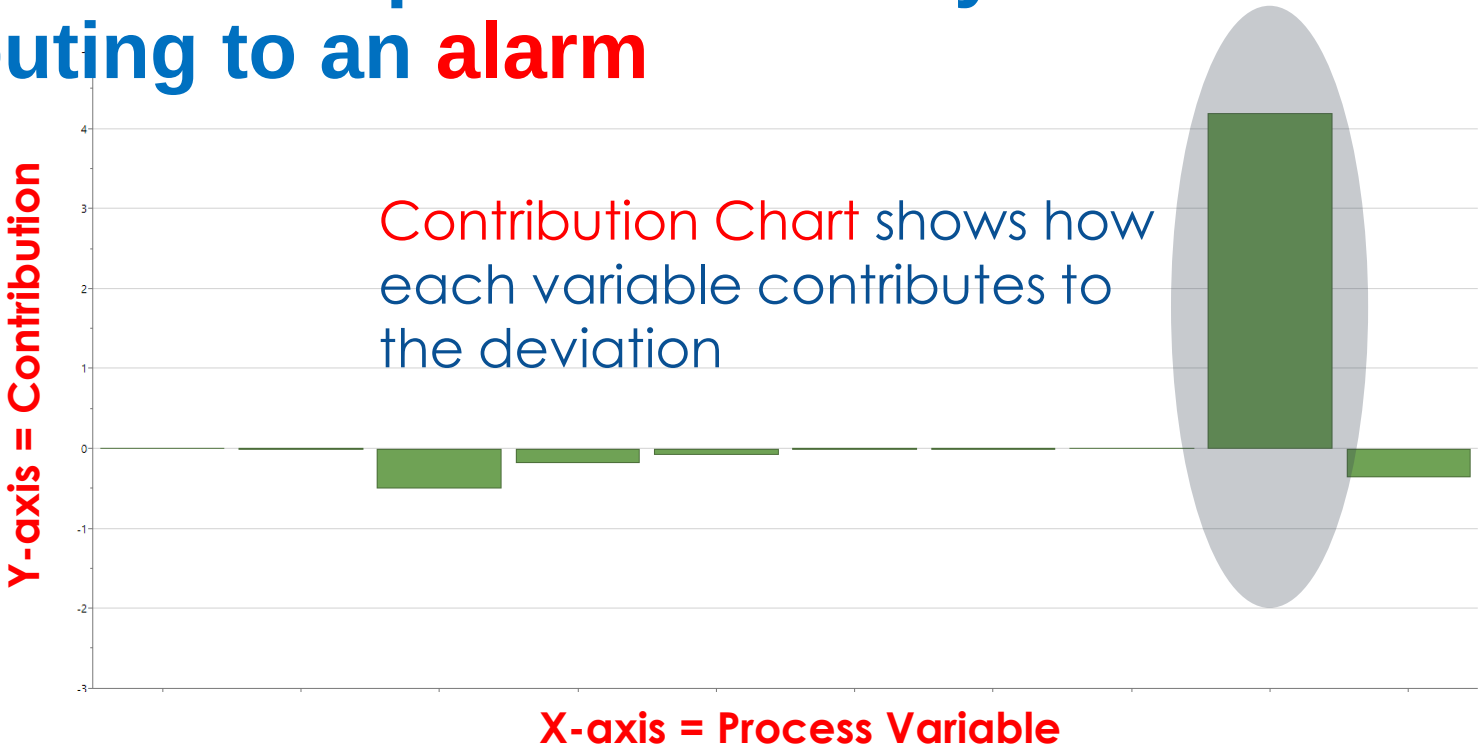
Contribution Chart: Used to determine which parameters may be contributing to an alarm



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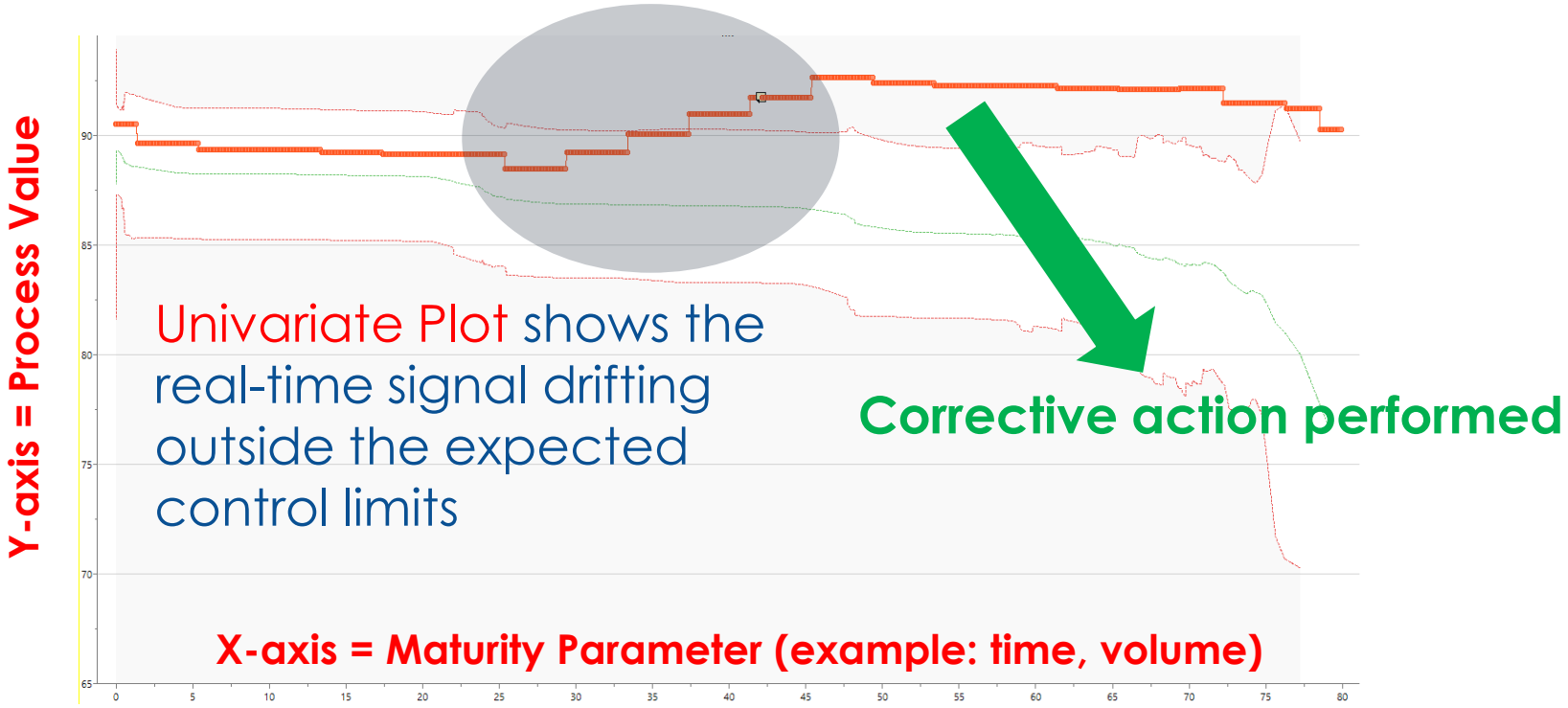
Univariate Plot: Zooming in to look at single parameter performance



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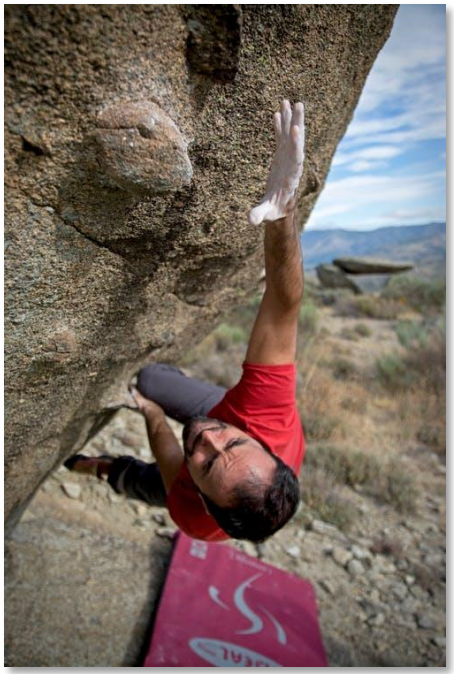
Challenge: Provide Real-time Batch Context to SIMCA-online

- SIMCA-offline models – data manually sourced from PI System, Seeq and Discoverant
- IPC and release testing data guide batch selection for process model
- Batch time context is implicitly built into the data sets that feed the models
- **Challenge:** Transitioning from static model development to real-time data and batch context for process monitoring



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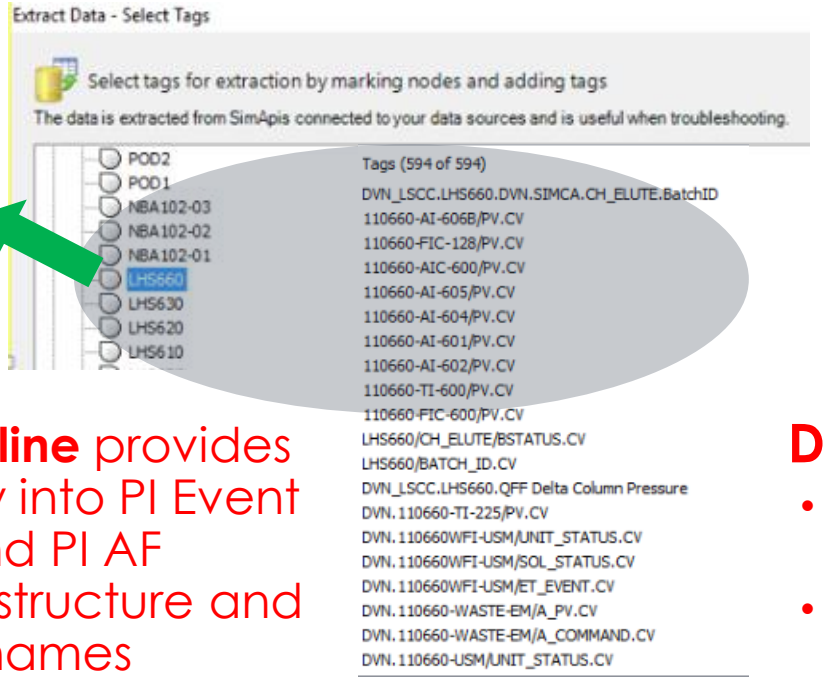
Challenge: Provide Real-time Batch Context to SIMCA-online

SIMCA-online shows flat PI AF hierarchy structure with links to PI tags



SIMCA-online provides no visibility into PI Event Frames and PI AF hierarchy structure and attribute names

Data latency

- PI Interface for Emerson DeltaV Batch (PI EMDVB)
- Continuous data if sourced from Enterprise PI System

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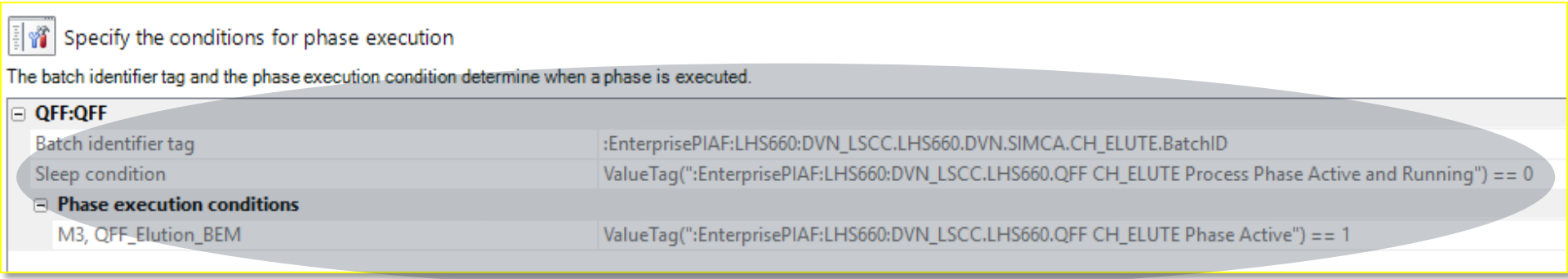
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics



Real-time batch context triggers in SIMCA-online

- Phase execution condition: Phase Active == 1
- Sleep condition: Process Phase Active and Running == 0
- Batch identifier tag: Batch ID

This looks so simple!!!

What the $@#%! Is this a joke?!?

Why are you wasting my time???

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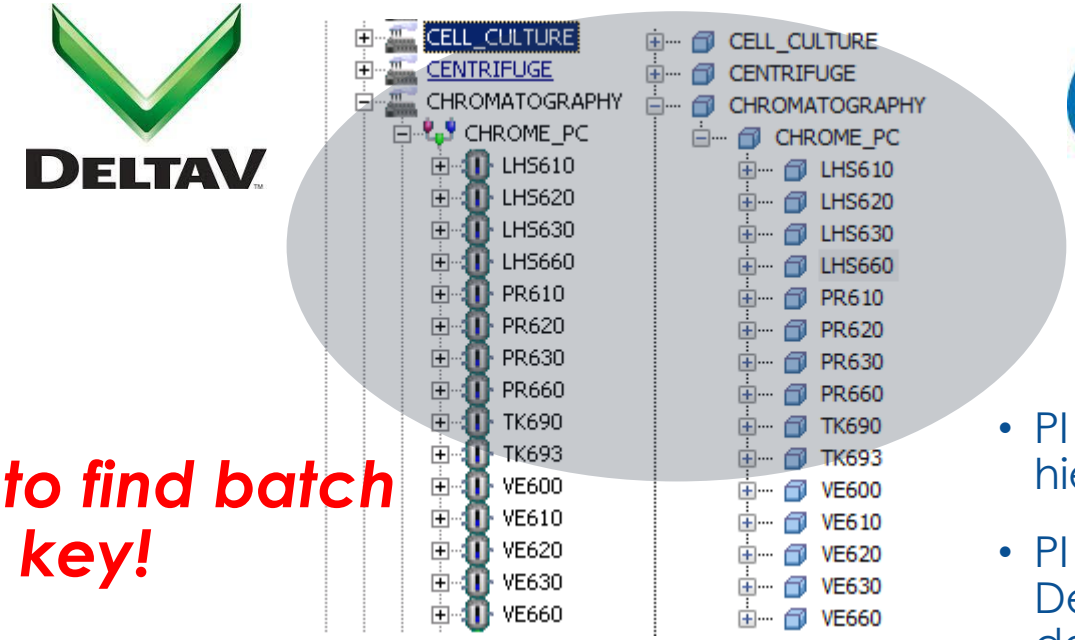
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics



Ability to find batch data is key!

- PI AF and DeltaV equipment hierarchies are aligned
- PI Interface for Emerson DeltaV Batch and user-defined metadata write to identical PI AF equipment hierarchy

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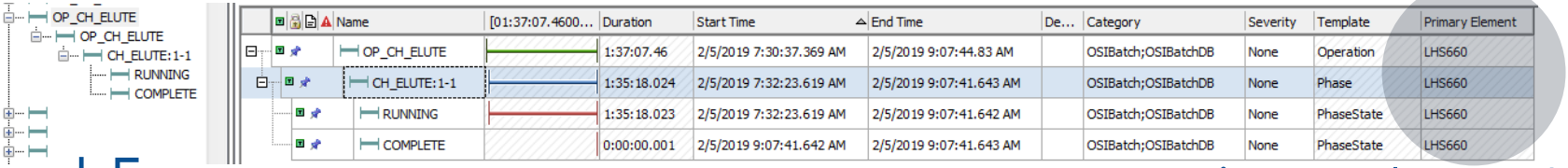
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics

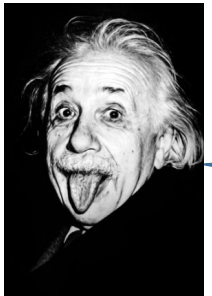


PI Event Frame = Primary Element

PI AF Attribute - BatchID + **BatchID PI tag – PI EMDVB interface**

PI AF Attribute - Phase State + **Phase State PI tag – PI EMDVB interface**

Batch data latency issue identified!



"It's the DATA, Stupid!"

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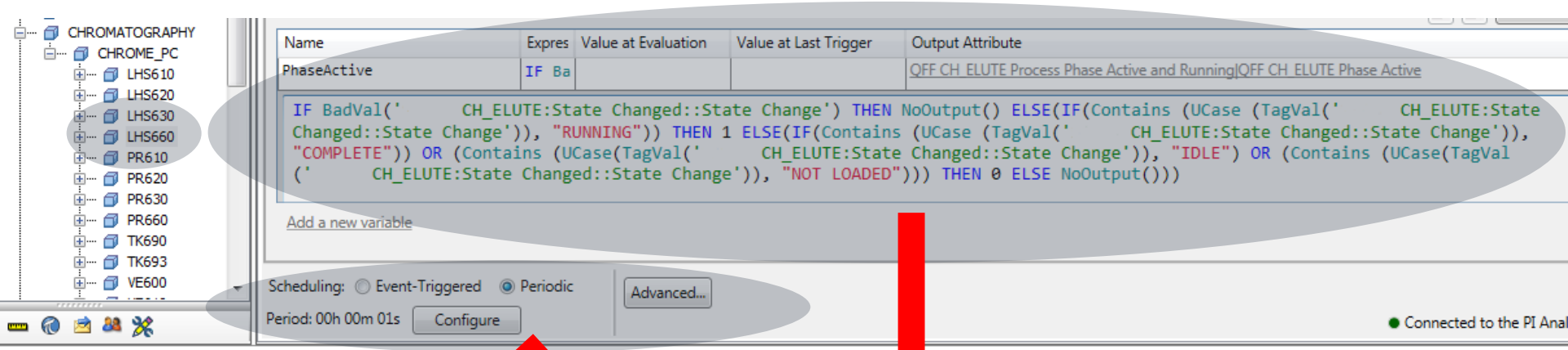
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics



Example PI Asset Analytics with data latency

- Equation inputs sourced from PI EMDVB tags
- Periodic scheduling: 1 second period
- **Observation:** Equation provides desired phase stage change with a **undesired delay** versus DeltaV
- Can tolerate offset in slower upstream phases but not faster downstream phases

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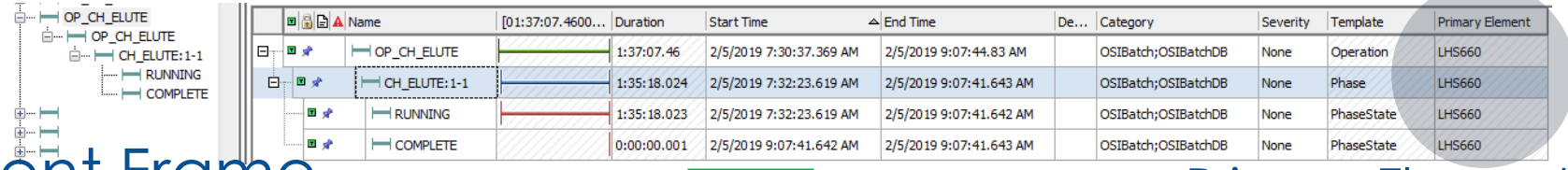
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics

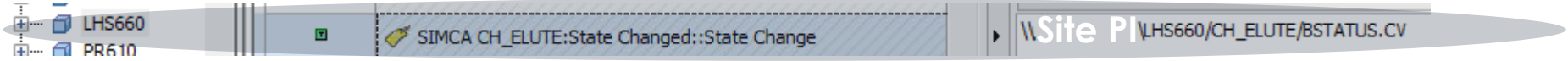


PI Event Frame

Primary Element

PI AF Attribute - BatchID

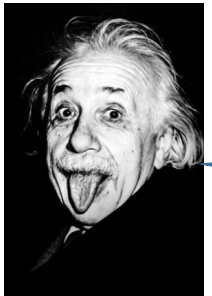
BatchID PI tag – historized DeltaV BatchID tag



PI AF Attribute - Phase State

Phase State PI tag – historized DeltaV BSTATUS tag

Batch data latency issue resolved!



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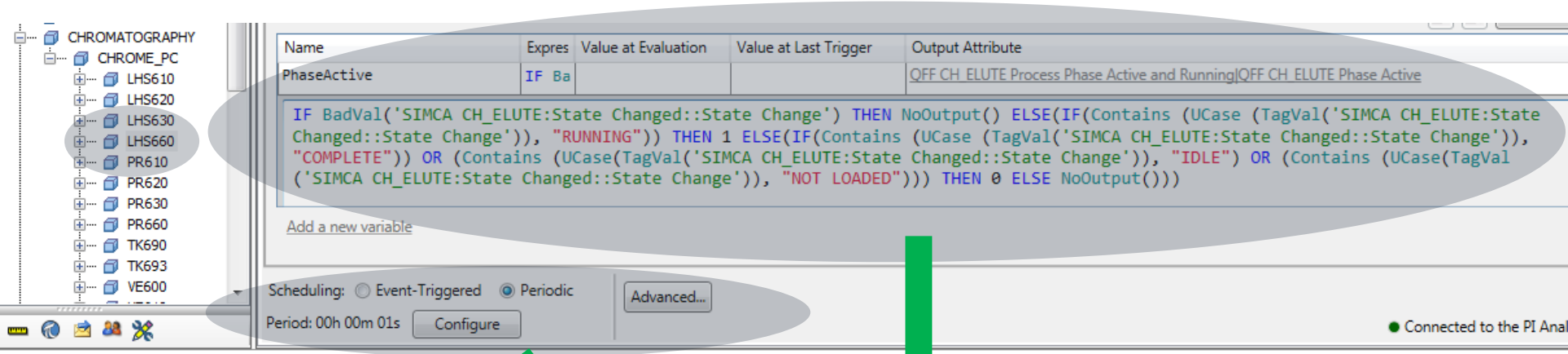
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics



Example PI Asset Analytics without data latency

- Equation inputs sourced from historized DeltaV tags
- Periodic scheduling: 1 second period
- **Observation:** Equation provides desired phase stage change with **near-zero delay** versus DeltaV

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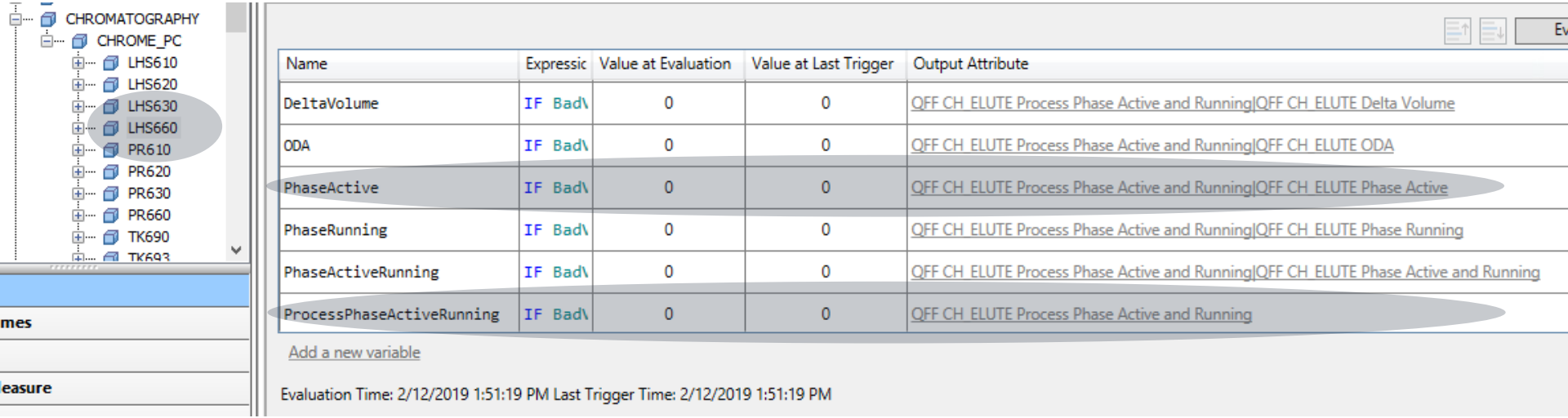
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics



Example PI Asset Analytics showing Boolean outputs

Phase Active and **Process Phase Active Running** are triggered in real-time by PI Asset Analytics

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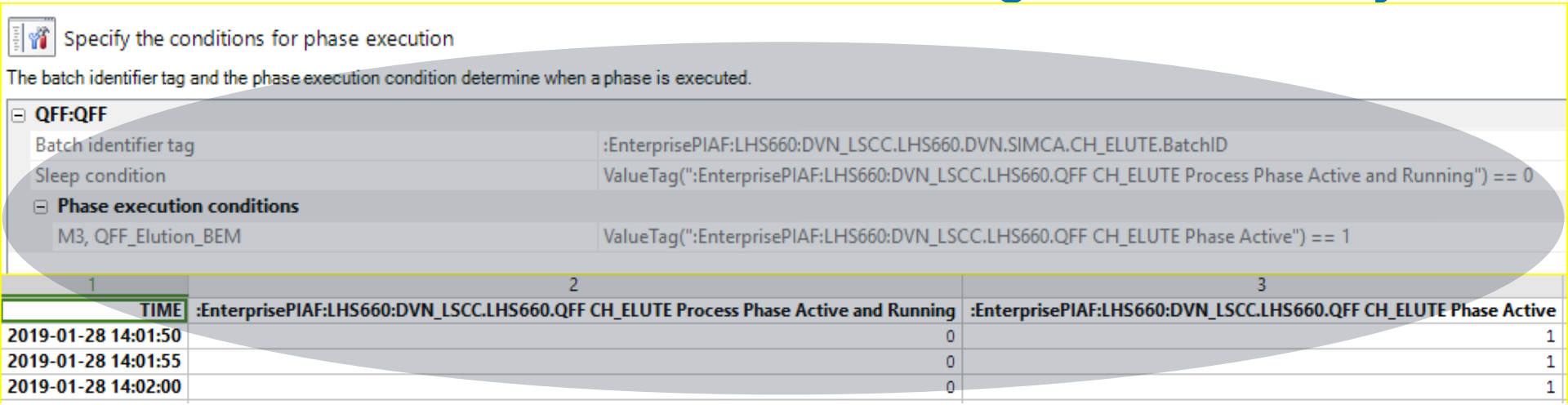
SIMCA-online/PI System Integration Workaround: Created Real-time Batch Context using PI Asset Analytics



1	2	3
TIME	:EnterprisePIAF:LHS660:DVN_LSCC.LHS660.QFF CH_ELUTE Process Phase Active and Running	:EnterprisePIAF:LHS660:DVN_LSCC.LHS660.QFF CH_ELUTE Phase Active
2019-01-28 14:01:50	0	1
2019-01-28 14:01:55	0	1
2019-01-28 14:02:00	0	1

Real-time batch context triggers in SIMCA-online

Phase Active and **Process Phase Active and Running** are read as Booleans from PI Asset Analytics in real-time

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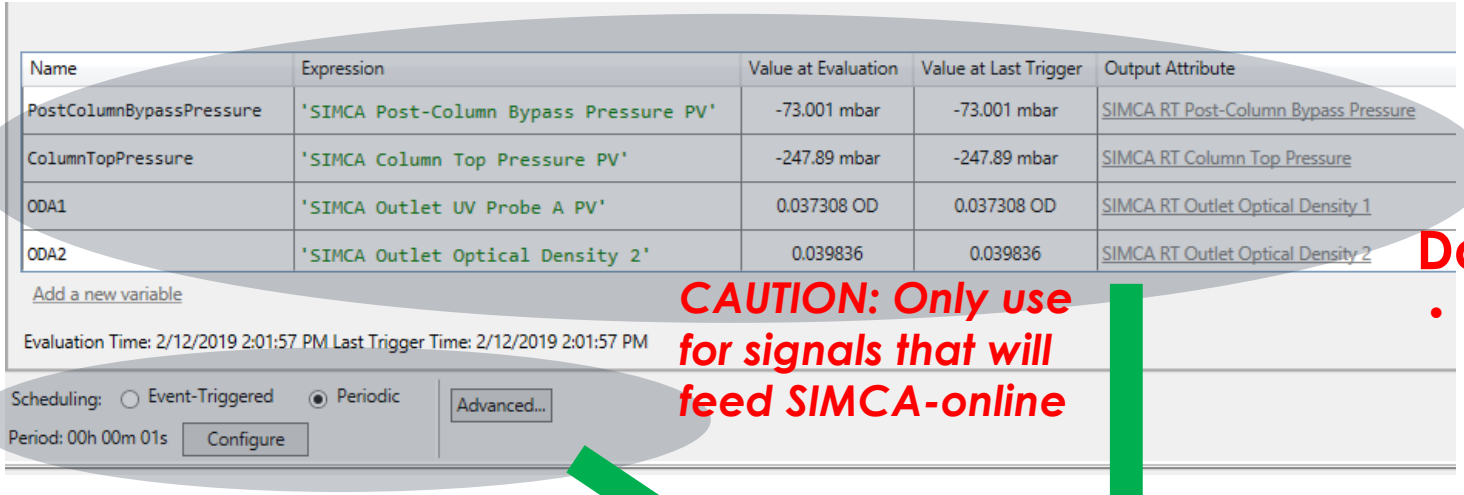
SIMCA-online/PI System Integration Workaround: Sourced Real-time Data using PI Asset Analytics



Name	Expression	Value at Evaluation	Value at Last Trigger	Output Attribute
PostColumnBypassPressure	'SIMCA Post-Column Bypass Pressure PV'	-73.001 mbar	-73.001 mbar	SIMCA RT Post-Column Bypass Pressure
ColumnTopPressure	'SIMCA Column Top Pressure PV'	-247.89 mbar	-247.89 mbar	SIMCA RT Column Top Pressure
ODA1	'SIMCA Outlet UV Probe A PV'	0.037308 OD	0.037308 OD	SIMCA RT Outlet Optical Density 1
ODA2	'SIMCA Outlet Optical Density 2'	0.039836	0.039836	SIMCA RT Outlet Optical Density 2

CAUTION: Only use for signals that will feed SIMCA-online

Data latency

- Cannot source archive data from Enterprise PI System (via PI to PI interface)

SIMCA-online real-time data needs

- Need to source high-frequency snapshot data

- PI Asset Analytics provides **centralized, flexible solution** to replicate snapshot data from Site to Enterprise PI System

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SIMCA-online/PI System Integration Workaround: Best Practices

- Use PI Asset Analytics equations to define real-time batch context
- Source phase state/batch ID from historized DeltaV tags

- Use DeltaV equipment modules to simplify equations
- Build solution at Site PI System and not Enterprise PI System
- Source real-time continuous data from snapshot data

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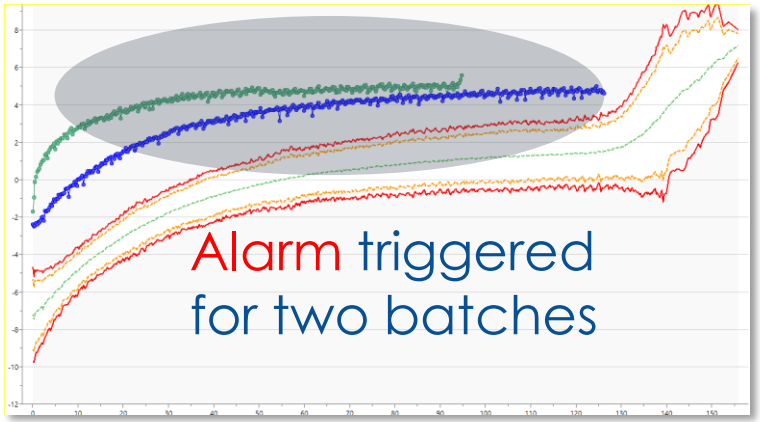
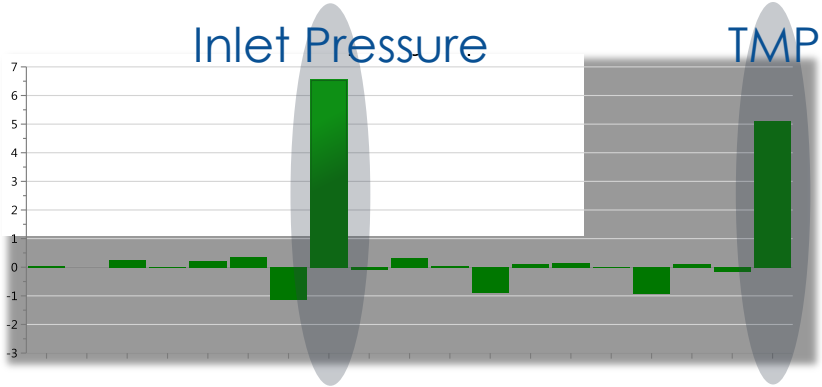
Business Benefit Example #1: UF Diafiltration – Adjusted Transmembrane Pressure to Comply with Allowable IPC Limit





- High TMP was detected during a UFDF step
- New protocol was implemented to reduce TMP within IPC limits
- Prevented potential deviations

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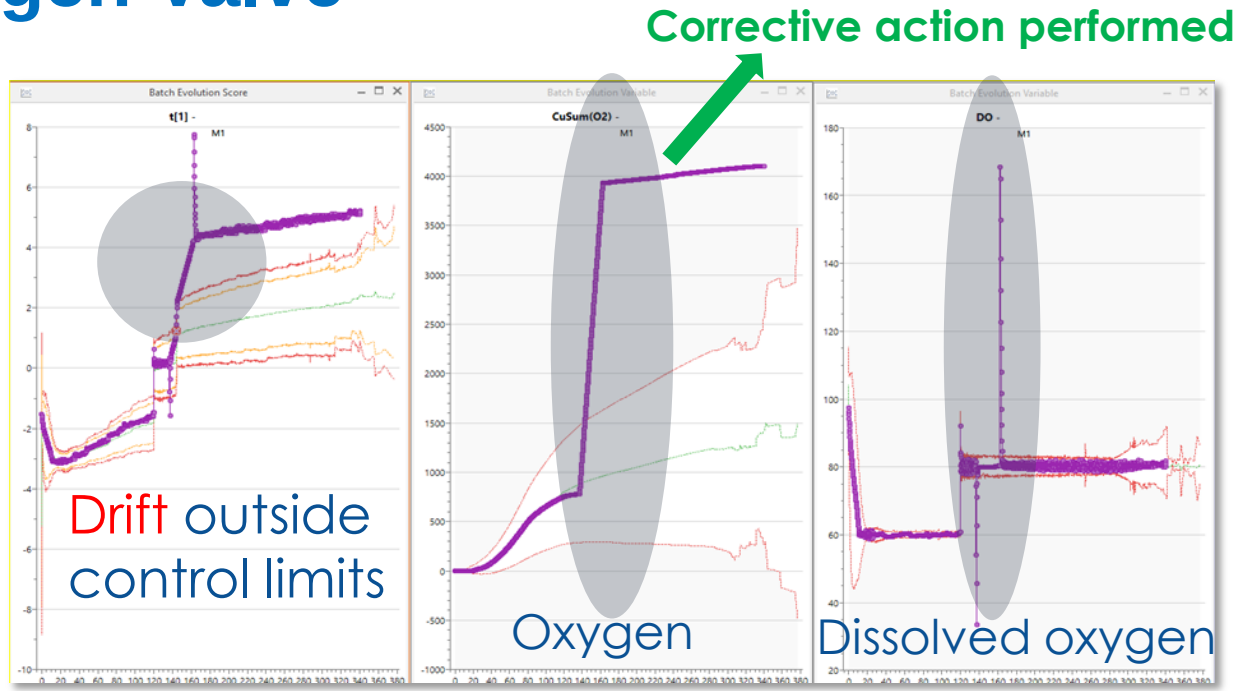
Business Benefit Example #2: Bioreactor – Fixed Open Oxygen Valve

- Abnormally high usage of O2 in a bioreactor was identified
- Cause was O2 escaping through an room
- Valve was closed which prevented waste of O2 (an expensive utility)
- Early fault detection averted maintenance issue by enabling the leak to get fixed promptly



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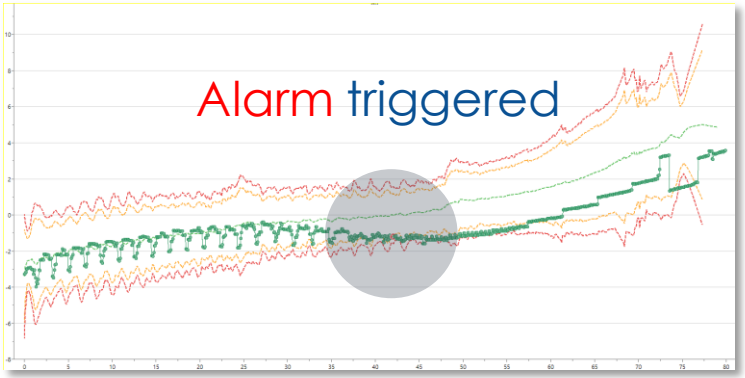
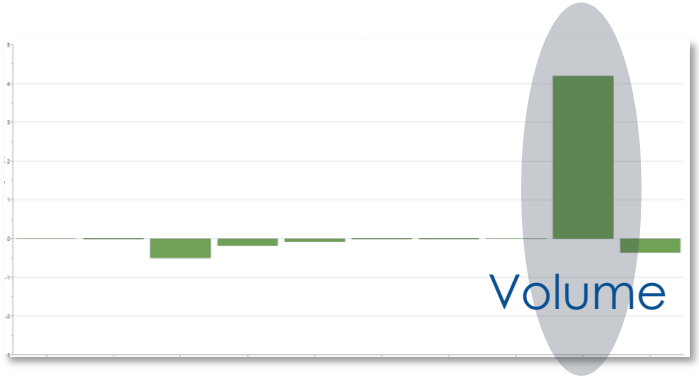
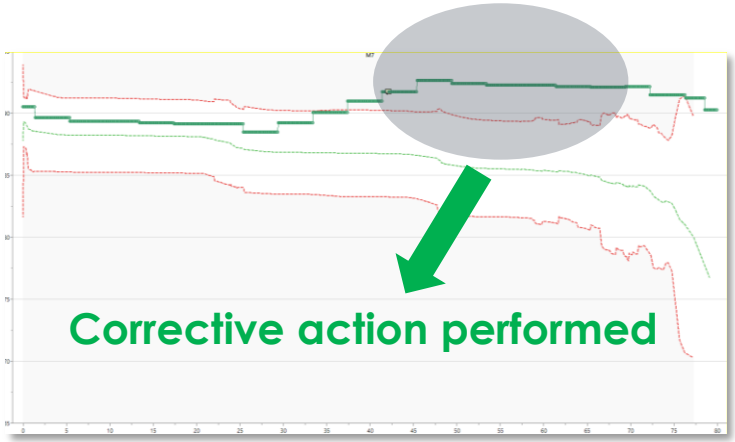
Business Benefit Example #3: Bioreactor – Leaking Steam Valve







- Increasing volume trend detected in a bioreactor
- Investigation identified the cause as a leaking valve
- Proactive identification and correction of this leak prevented potential impact to the process

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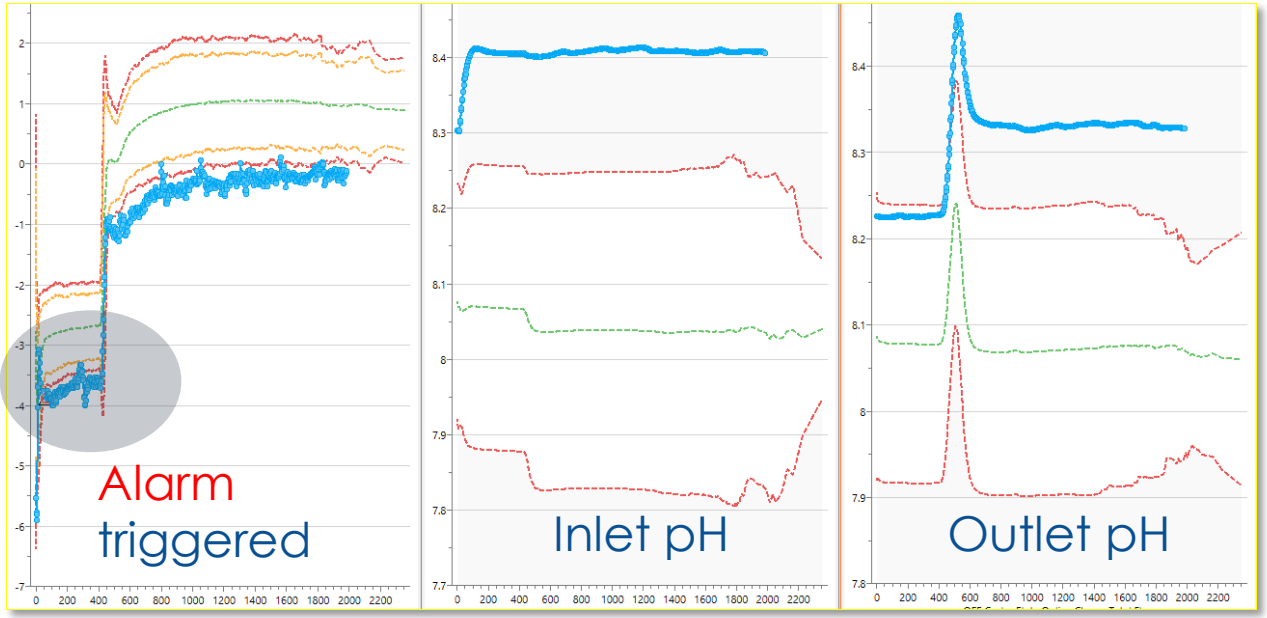
Business Benefit Example #4: Chromatography – Drifting pH

- High Inlet pH and Outlet pH on the skid were detected
- Recipe for transition to next process phases did not proceed due to "high" pH
- Root cause was drifting pH probes



- More frequent replacement of pH probes was implemented to ensure accurate pH reading and streamline recipe execution

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Future Capabilities

- Upgrade to SimAPI 3.0.0.7271 (released Feb 2019)
- Expand multivariate modeling:
  - Additional biologics process stages
  - Equipment Monitoring
  - Pharmaceutical products
  - Other biologics sites

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Acknowledgements: A Great Collaborative Effort

Data Systems, Monitoring and Analytics

GPS IT Process Robustness

GPS IT PI Build/Run

Manufacturing Technology Process Engineering – Upstream

Manufacturing Technology Process Engineering – Downstream

Manufacturing Operations

Manufacturing Science & Technology

IT/Automation

Quality Assurance

Deadline Solutions

OSIsoft Tech Support

Sartorius Stedim

Seeq

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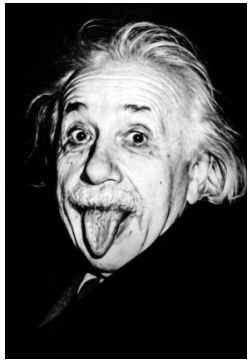
"It's the DATA, Stupid!" How PI Asset Analytics Rescued Our Real-time Multivariate Process Monitoring



CHALLENGE

Transitioning from offline model building to real-time multivariate monitoring requires batch time triggers to frame the dataset of interest

- Our real-time Multivariate Process Monitoring tool is not PI Event Frame aware – no direct way to mark batch time triggers to instruct multivariate monitoring when to start/stop

SOLUTION

Identified substitutes for PI Event Frames within the raw batch data brought into PI via PI Interface for Emerson DeltaV Batch (PI EMDVB)

- Created PI Asset Analytics to transform raw batch data into Boolean batch time markers that SIMCA-online could easily parse

RESULTS

Real-time Multivariate Monitoring enabled across the company provided Operations a tool to monitor the process against historical performance and enable real-time fault detection

- Prevented potential batch impact
- Averted maintenance issue
- Prevented potential deviations
- Streamlined recipe execution

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"It's the DATA, Stupid!" How PI Asset Analytics Rescued Our Real-time Multivariate Process Monitoring

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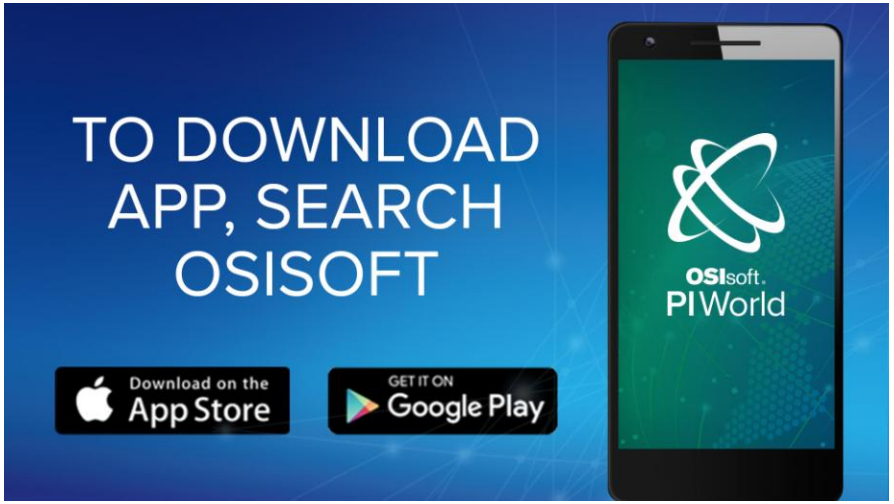
Questions?

Please wait for the **microphone**

State your **name & company**

Please remember



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