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METALS & MATERIALS

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Jonathan Alexander, Manufacturing AI & Advanced Analytics Manager

ALBEMARLE

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FONTAINEBLEAU, LAS VEGAS MAY 13-15, 2025

Albemarle Intelligence

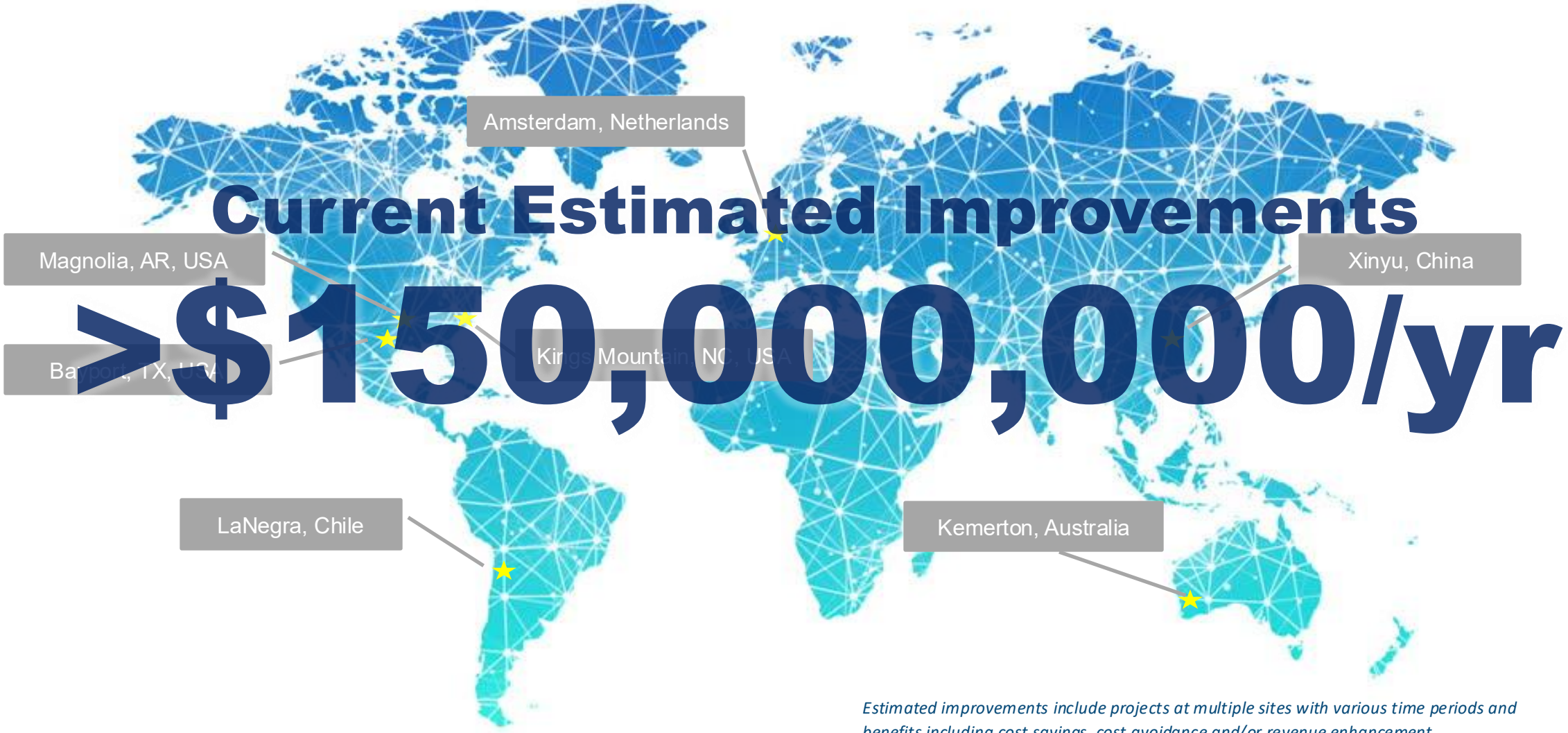
Top 10 Reasons Why You are Stuck in Pilot Purgatory:

Preventing ROAI & Realizing Economies of Scale

Presented by: Jonathan Alexander

Albemarle

ALBEMARLE INTELLIGENCE

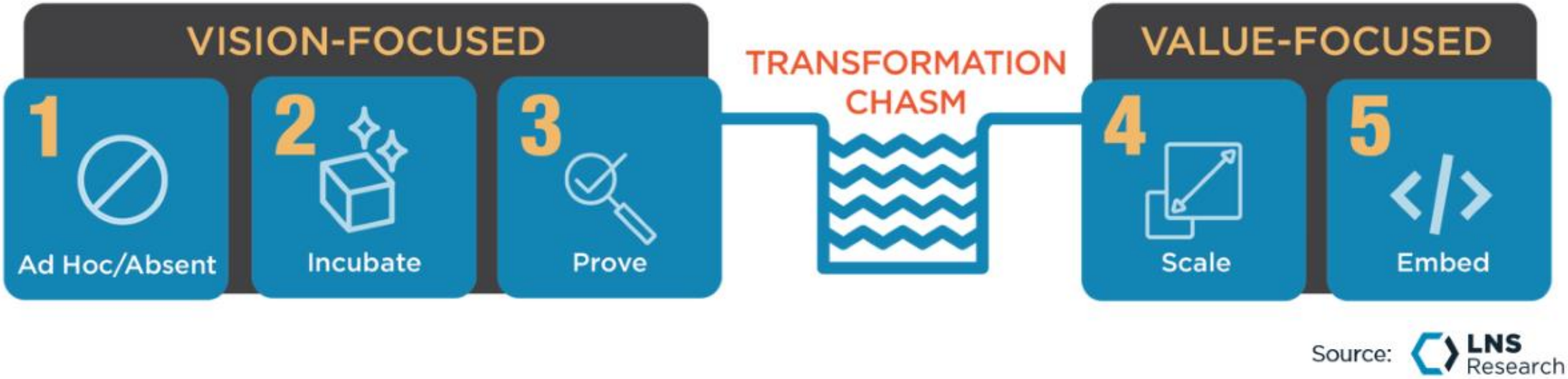


Current Estimated Improvements

>$150,000,000/yr

Estimated improvements include projects at multiple sites with various time periods and benefits including cost savings, cost avoidance and/or revenue enhancement.

Five Stages of Transformation Maturity




Top 10 Reasons
you're stuck in
Pilot Purgatory

Reason #1


Rome wasn’t
built in a day

The Journey to Realizing Economies of Scale

Competing on Analytics - Five Stages of Analytical Maturity

AI Maturity Transformation

Stage 1

Analytically Impaired

The company has some data and management interest in analytics.

Stage 2

Localized Analytics

Functional management builds analytics momentum and executives' interest through applications of basic analytics.

Stage 3

Analytical Aspirations

Executives commit to analytics by aligning resources and setting a timetable to build a broad analytical capability.

Stage 4

Analytical Company

Enterprise-wide analytics capability under development; top executives view analytic capability as a corporate priority.

Stage 5

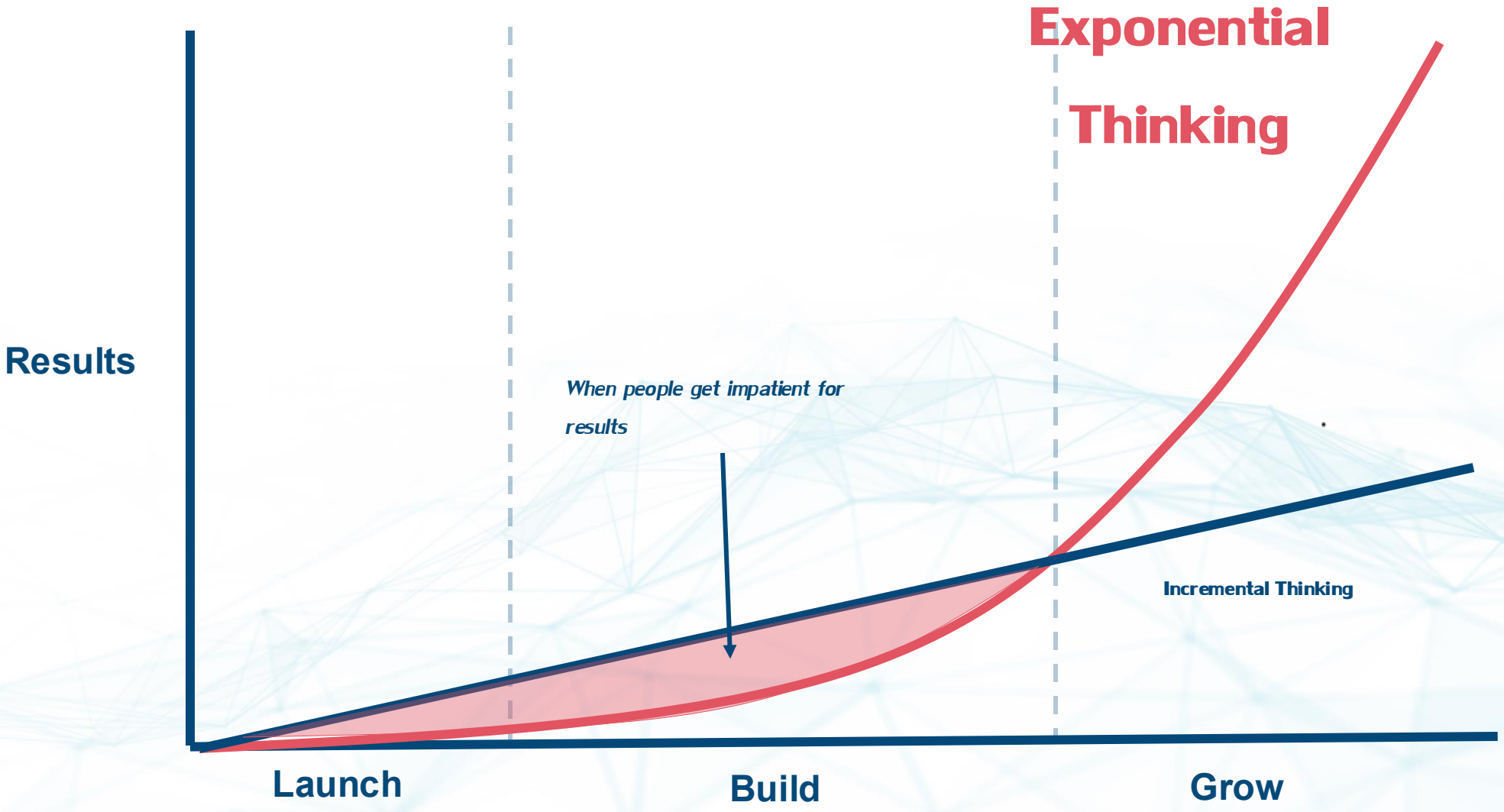
Analytical Competitor

The company routinely reaps benefits of its enterprise-wide analytics capability and focuses on continuous analytics review.

AI Maturity Index

ALBEMARLE INTELLIGENCE	Beginner	Foundational	Advanced	World Class
Data Governance	Minimal data governance; siloed and unstructured data.	Basic data management policies in place; some centralized storage.	Enterprise-wide data governance framework; standardized data practices.	Fully integrated, automated data governance with real-time compliance.
Statistical Process Control	No formal SPC; reactive quality control.	Basic SPC tools implemented; manual monitoring.	Automated SPC with real-time alerts and analytics.	AI-driven SPC with predictive quality insights and autonomous adjustments.
Machine Learning	Limited awareness; isolated experiments.	Early adoption; ML models used for specific tasks.	Scalable ML models integrated into workflows.	AI-powered decision-making with continuous learning and optimization.
Predictive Analytics	Basic dashboards with historical data analysis.	Simple trend analysis and forecasting.	Predictive models guiding business decisions.	AI-driven prescriptive analytics optimizing operations in real-time.
Generative AI	No generative AI implementation.	Experimentation with text/image generation in isolated use cases.	Generative AI integrated into product design and optimization.	Fully autonomous generative AI creating insights, reports, and designs with minimal human input.

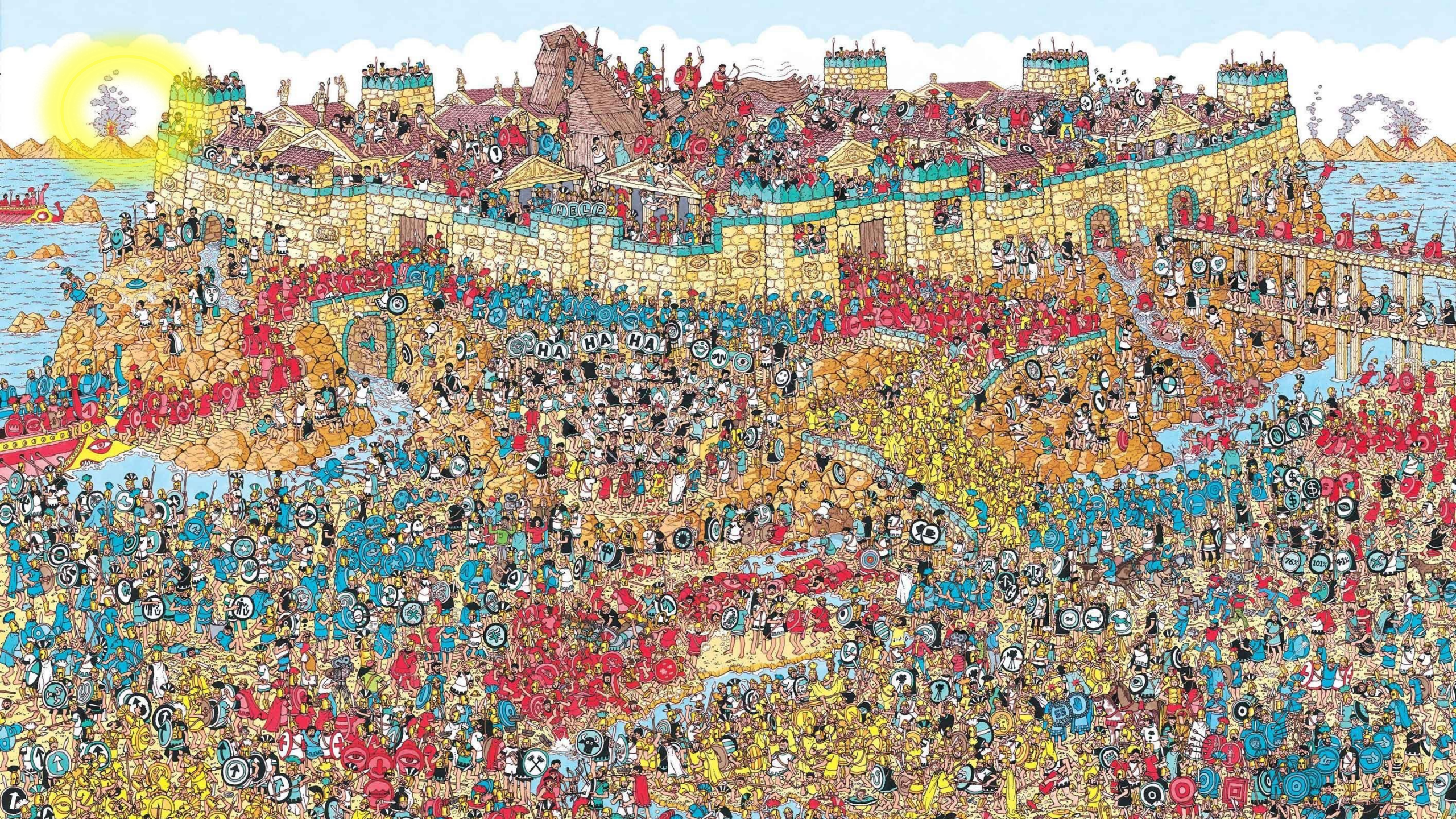
Phases of Digital Transformation – Incremental vs. Exponential



Reason #2


Garbage In,
Garbage Out

THE FANTASTIC
FLOWER
GARDEN


HELP
HA HA HA


MAX
55
SPEED

ChatGPT 4.5

What can I help with?

Ask anything

Search

Deep research

Create image

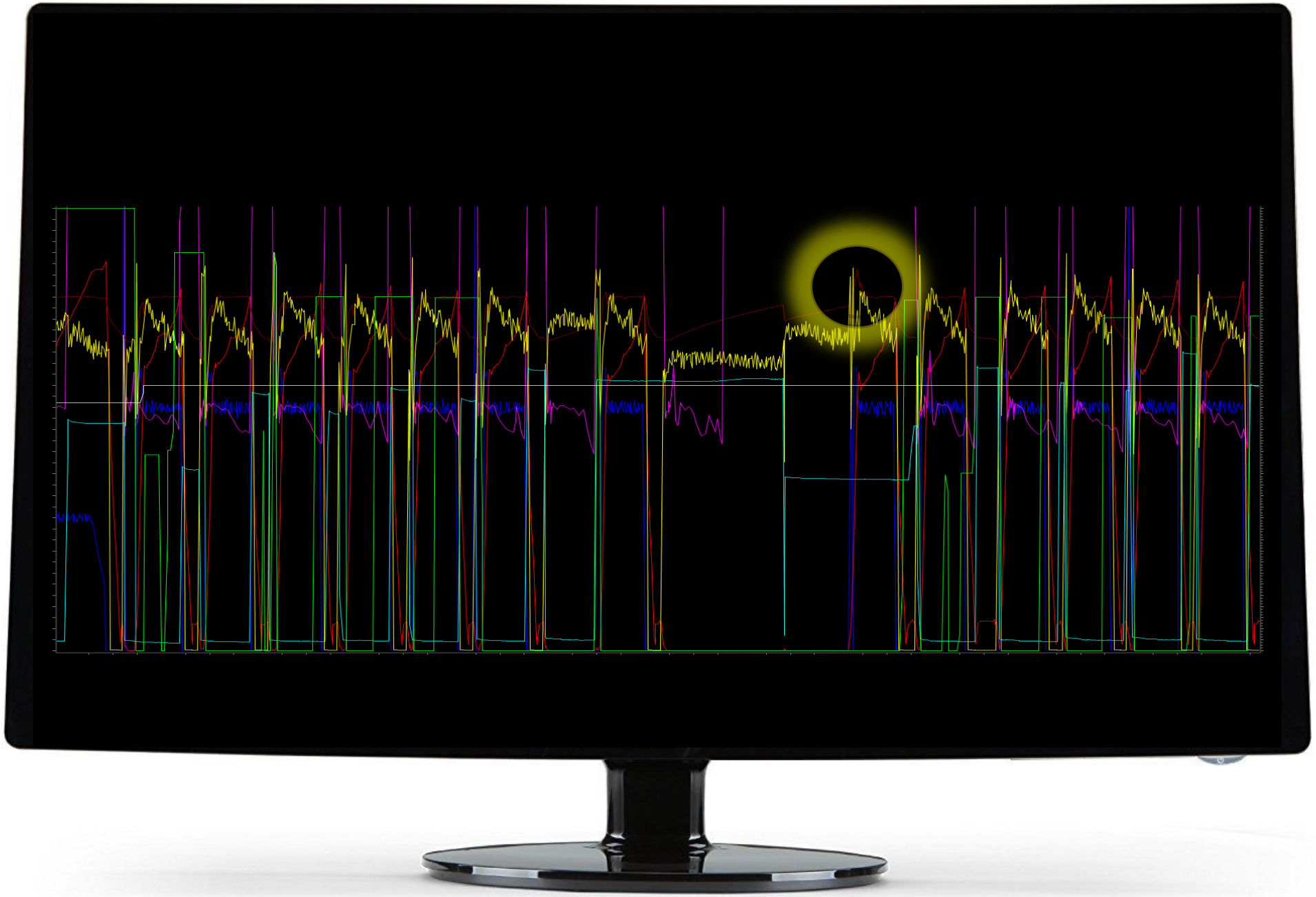
Help me write

Summarize text

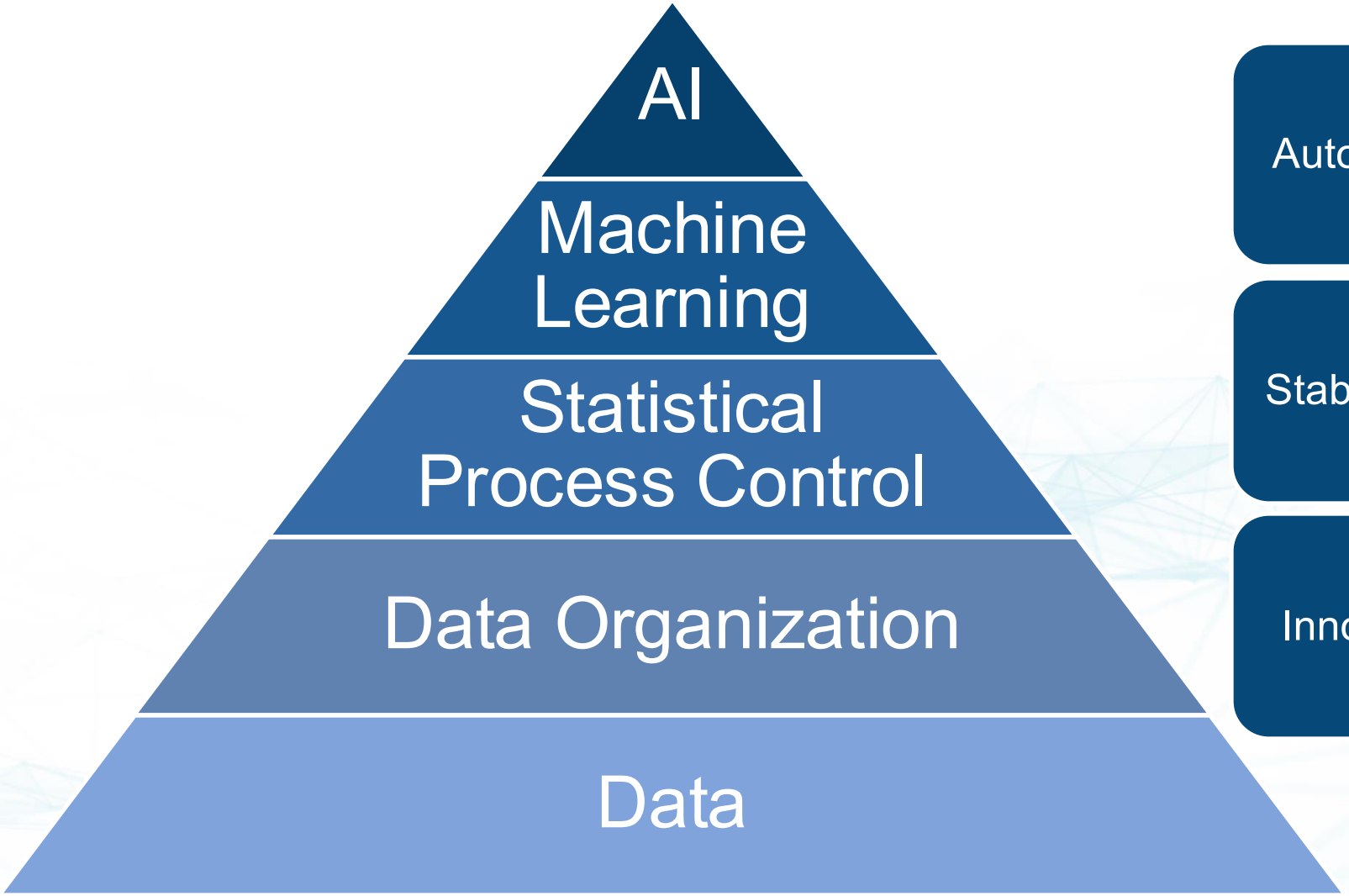
Code

Brainstorm

More



AI Strategy



Automation

- Key Process Variables Monitored Automatically
- Standardized Global Data Structure
- Supports Global Growth & Economies of Scale

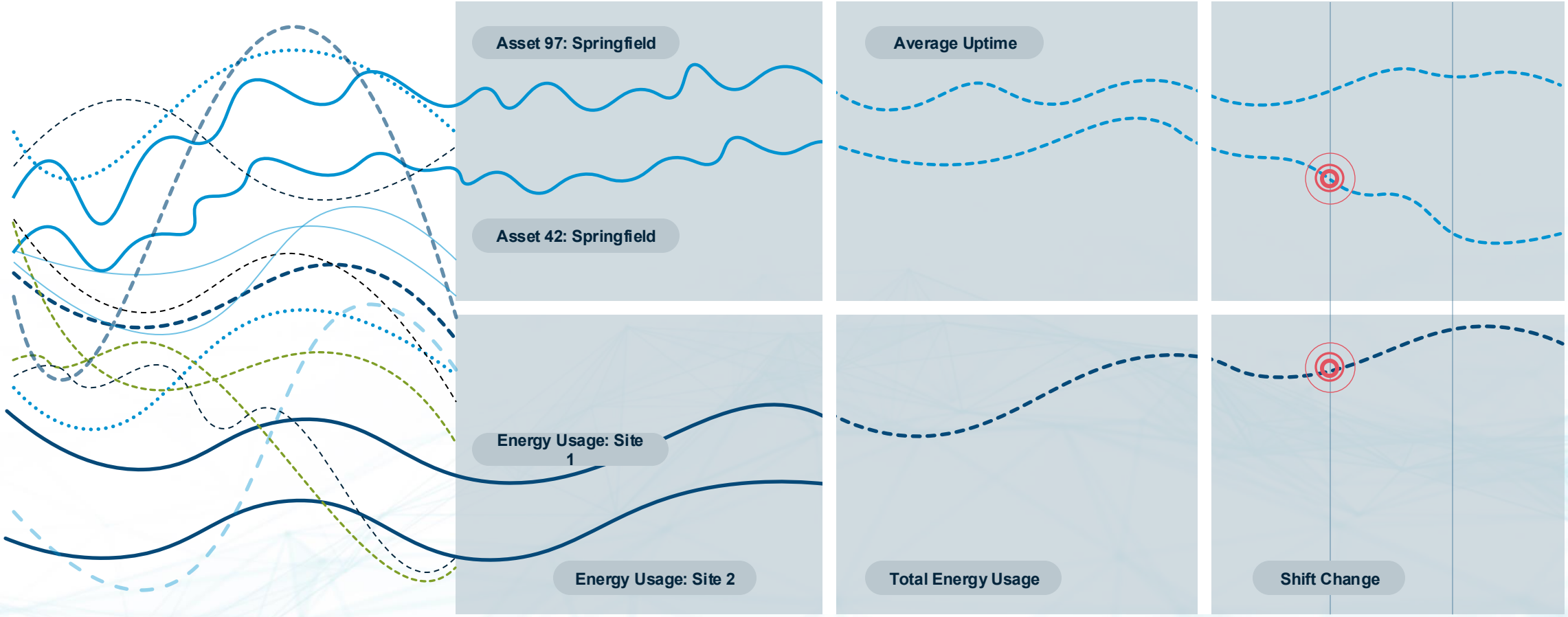
Stabilization

- Statistical Actionboards enable Engineers & Operations to minimize Firefighting
- Improved Process Control
- Improved Equipment Reliability

Innovation

- “Data at your fingertips” enables Engineers to do more Engineering
- Advanced Analytics & Machine Learning techniques unlock unknown correlations and pre
- Positions Albemarle as a global leader in Digital Manufacturing & Industry 4.0

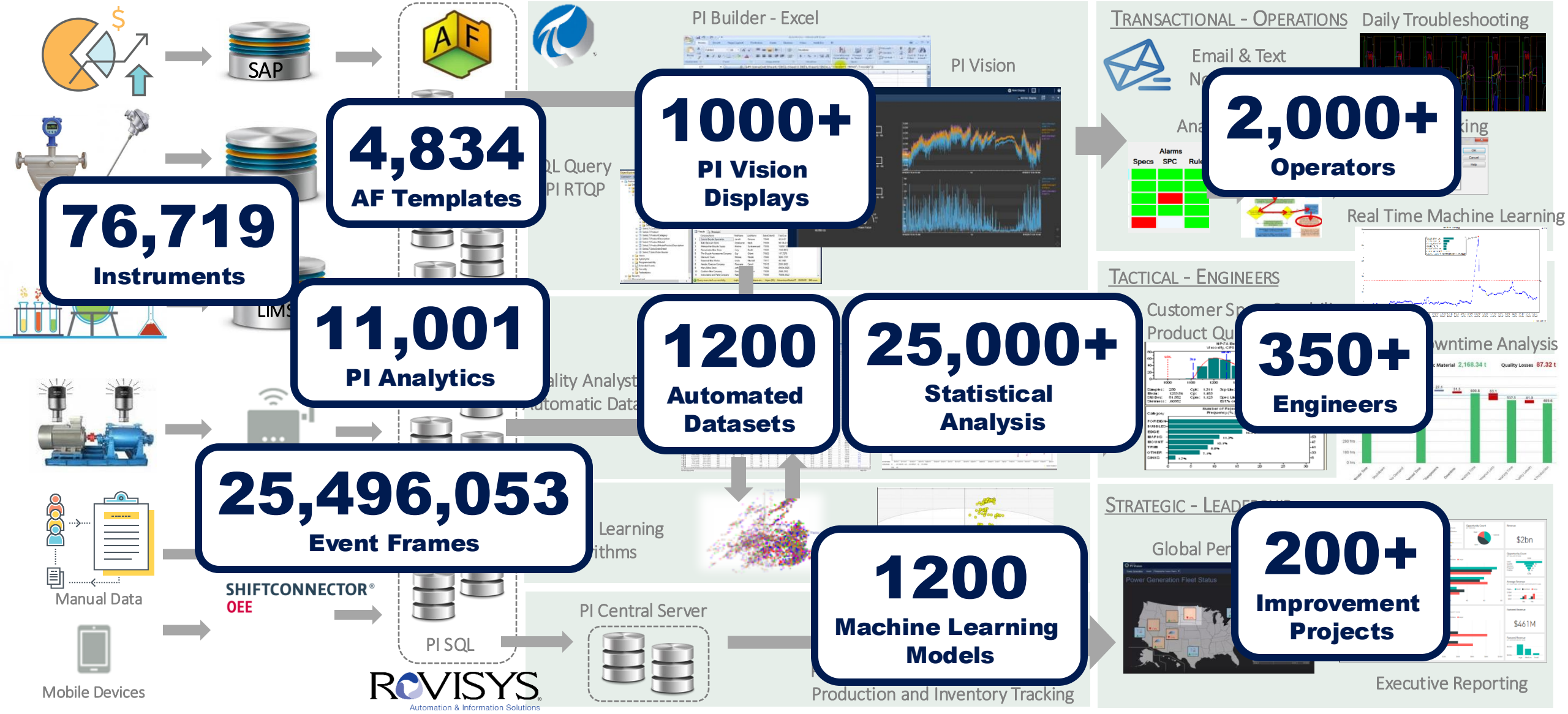
Scaling Event Frames as an Analytical Engine



DATA ARCHIVE | ASSET FRAMEWORK | ASSET ANALYTICS | EVENT FRAMES

ALBEMARLE INTELLIGENCE

Data Sources	AVEVA PI Asset Framework	Data Analytics Suite	User Roles

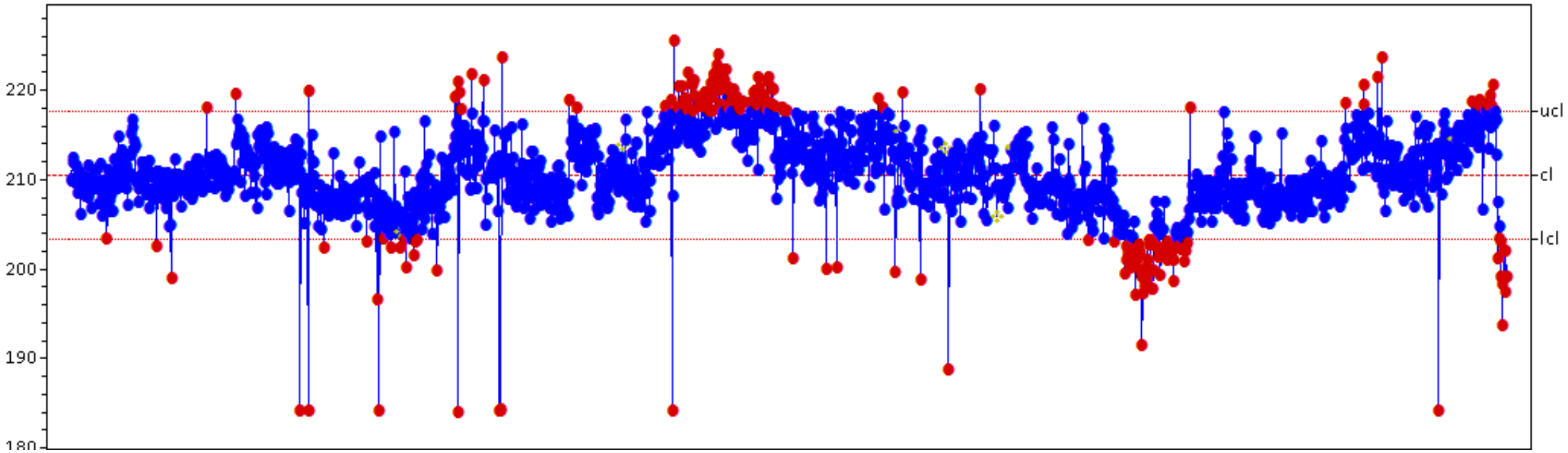


Reason #3

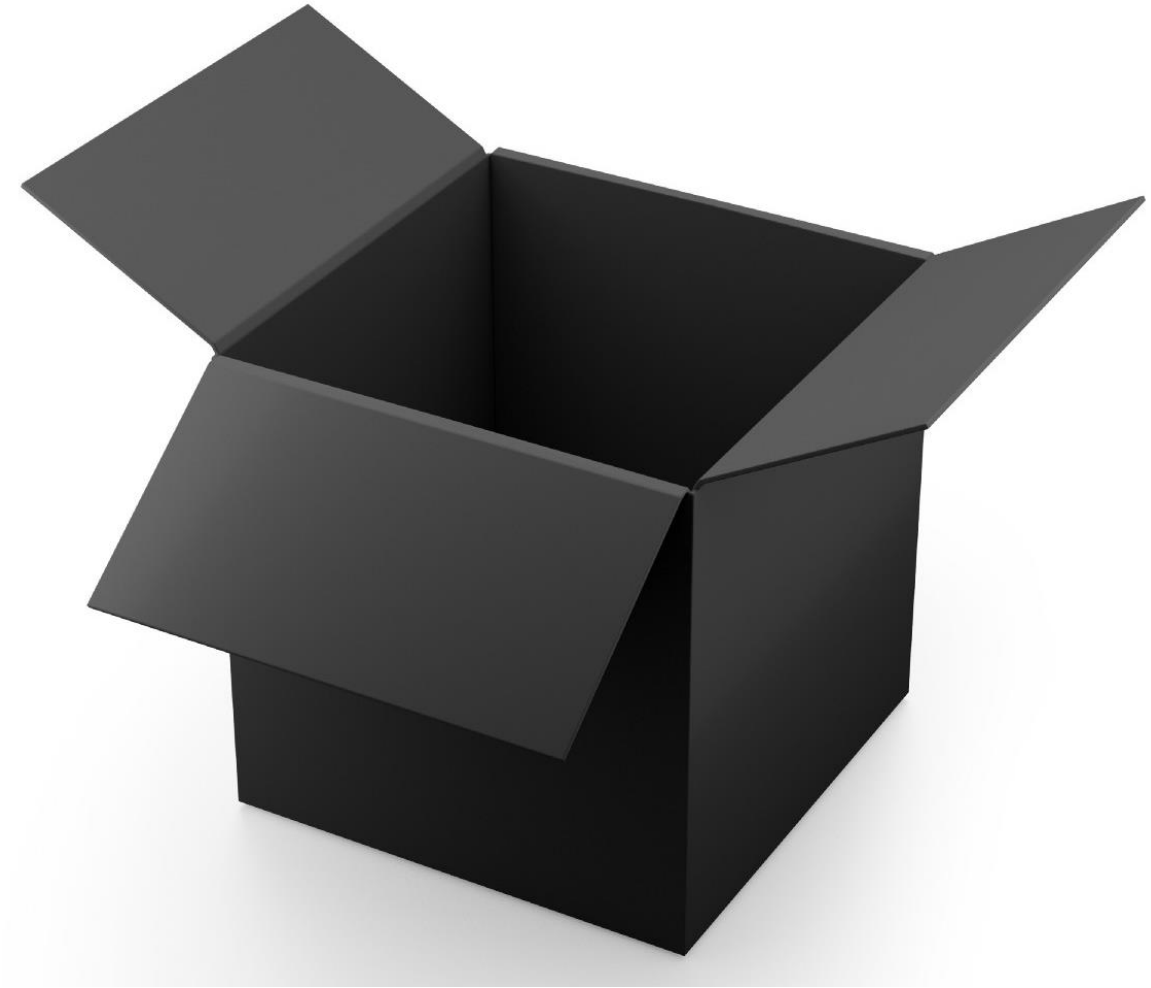

You miss the
forest from
the trees


A-Shift vs C-Shift

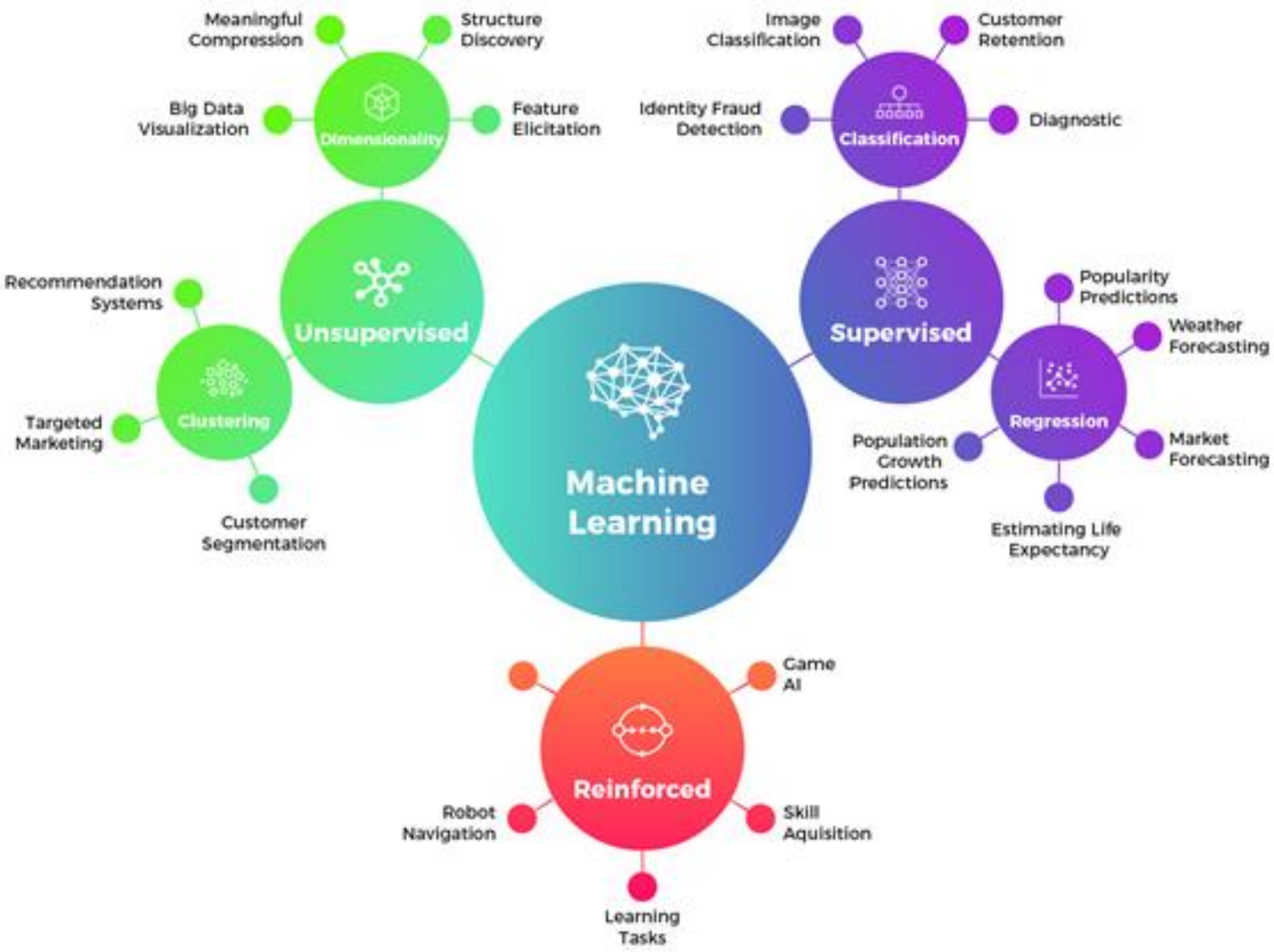
3 Month Statistical Analysis – w/ Event Frames



Dissecting the “Black Box” with Machine Learning



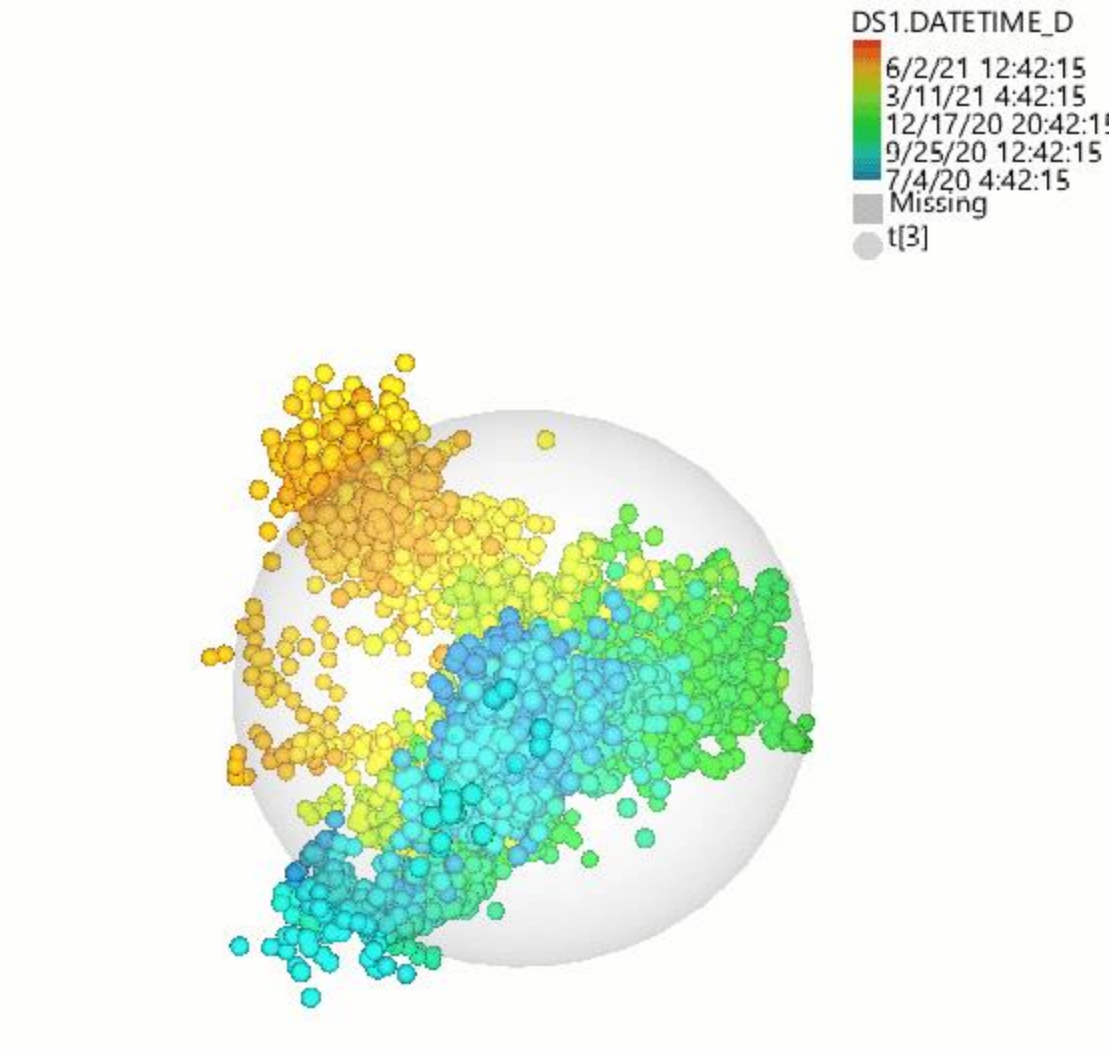
DIFFERENT TYPES OF MACHINE LEARNING



Principle Component Analysis

DATA EXPLORATION

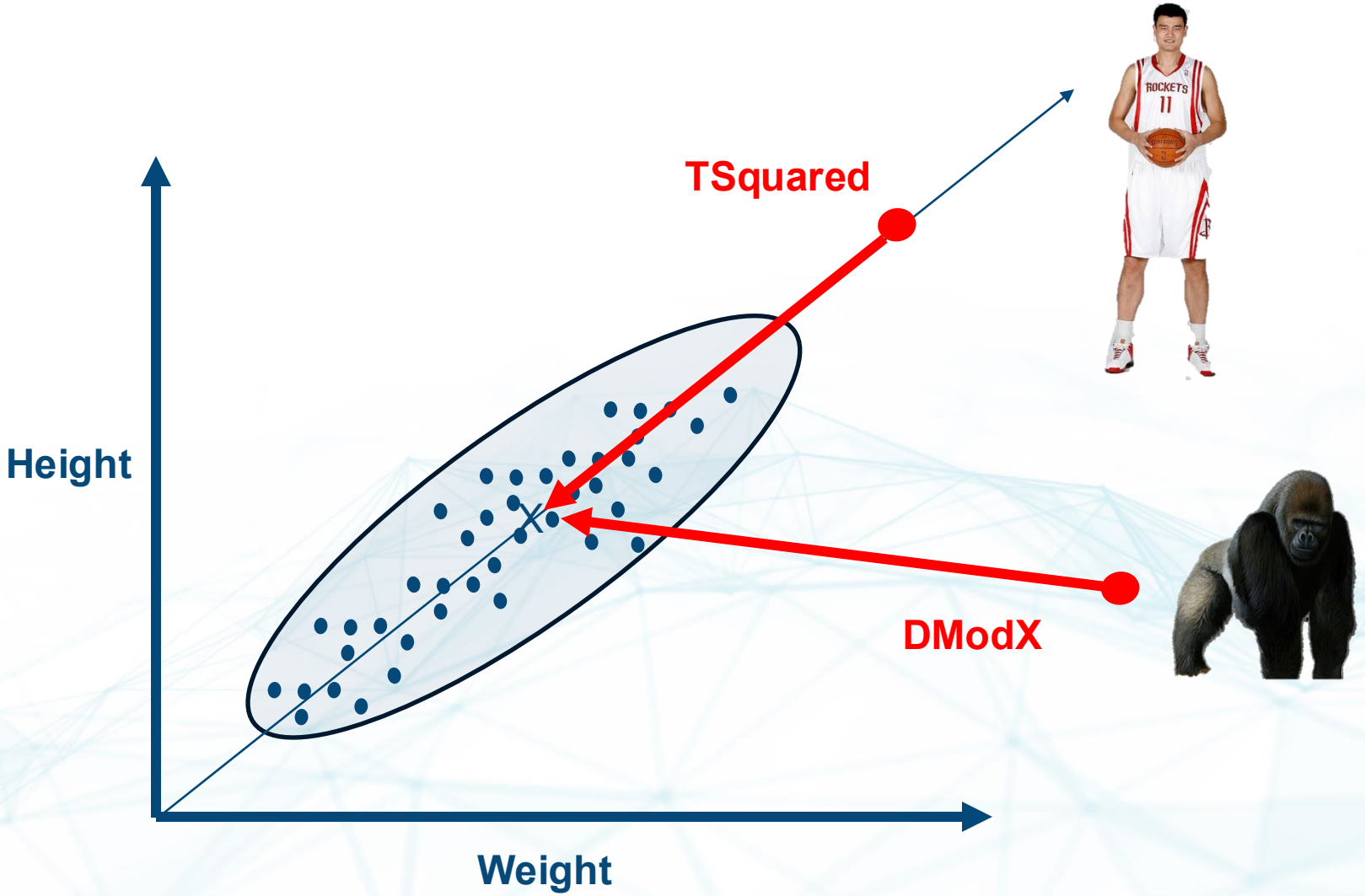
FINDING HIDDEN PATTERNS / STRUCTURE

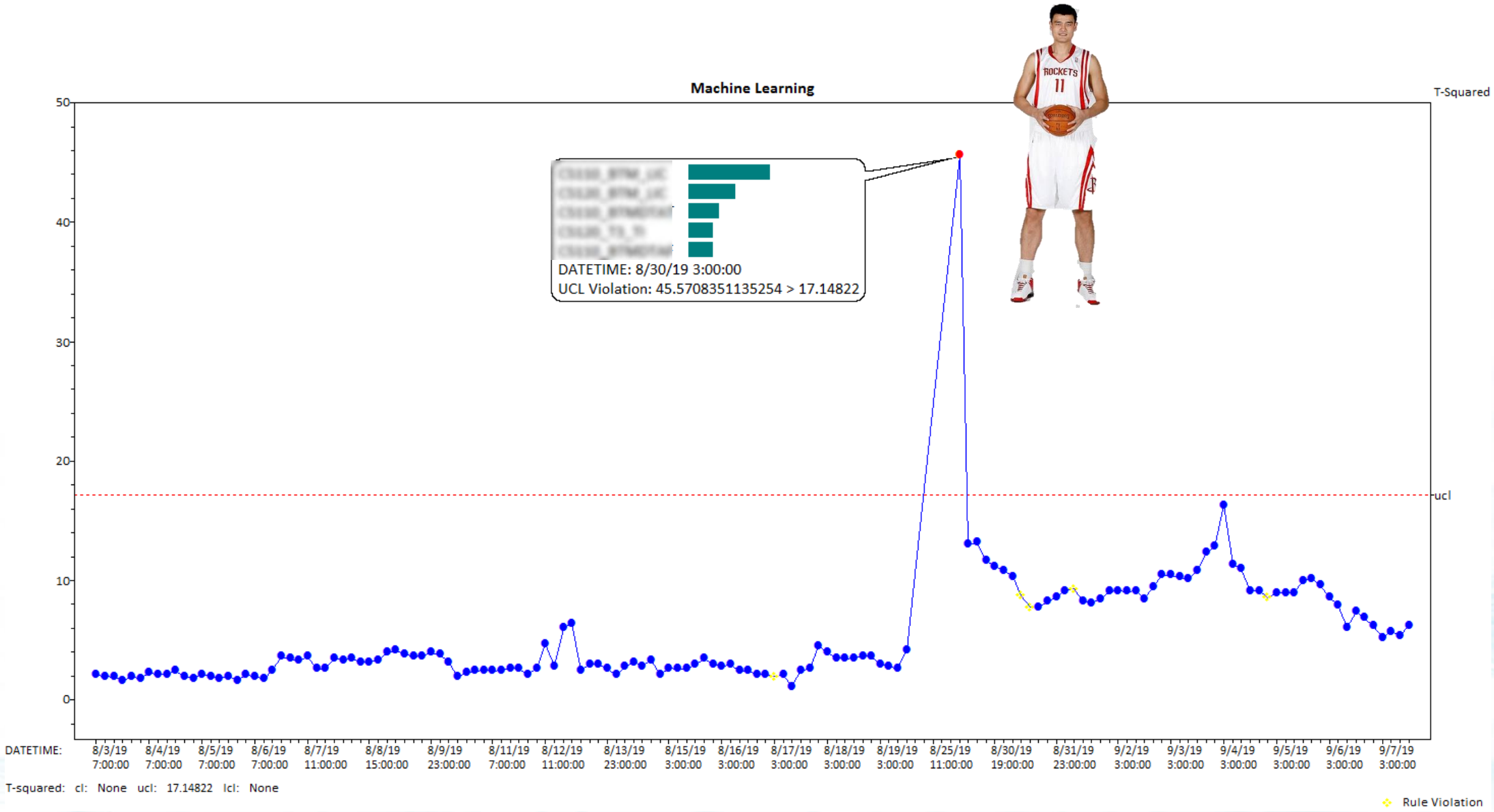


ANOMALY & OUTLIER DETECTION

CHANGE IN OPERATING CONDITIONS

Machine Learning – Outlier & Anomaly Detection





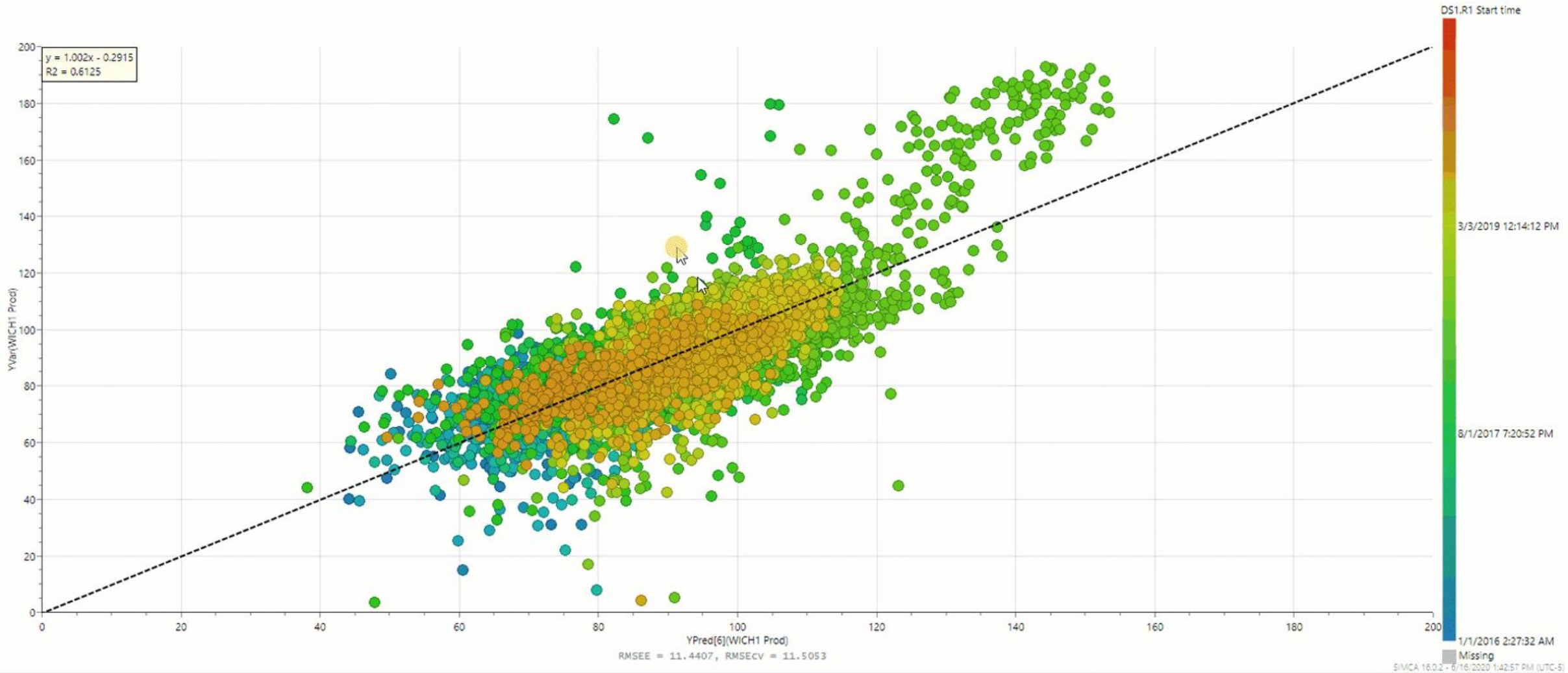
File | Home | Data | Analyze | Predict | View | Tools | Marked items

Project: Dataset
Workset: New, New as, Edit, Delete, Statistics
Model: Model type, Autofit, Two first, Add, Remove, Summary of fit
Diagnostics & interpretation: Overview, Scores, Loadings, Hotelling's T2, DMod, Obs. vs. pred., Coefficients, VIP
Plot/list: Create

Project Window - M20 (PLS) - Up to Dec '19

Number	Model	Type	A	N	R2X(cum)	R2Y(cum)	Q2(cum)	Date	Title	Hierarchical
17	M17	PLS	5	641	0.294	0.302	0.254	4/30/2020		
18	M18	PLS	10	641	0.526	0.299	0.241	4/30/2020		
19	M19	PLS	10	639	0.537	0.306	0.251	4/30/2020		
20	M20	PLS	6	7230	0.337	0.389	0.385	6/16/2020	Up to Dec '19	

Observed vs. Predicted [M19] | Loading Scatter Plot [M19] | Score Scatter Plot [M19] | Contribution Plot [M20] | Observed vs. Predicted [M20] | Contribution Plot [M20] | XVar Plot [M20] | Contribution Plot [M20] | XVar Plot [M20]



File | Home | Data | Analyze | Predict | View | Tools | Marked items

List | Scatter | Line | Column — Create from marked items
Plot XObs | Plot YObs — Drill down
Exclude | Include | Class — Modify model
Labels | Hide | Show all | Unlock column — Layout
Format symbol | Format label

Project Window - M20 (PLS) - Up to Dec '19

Number	Model	Type	A	N	R2X(cum)	R2Y(cum)	Q2(cum)	Date	Title	Hierarchical
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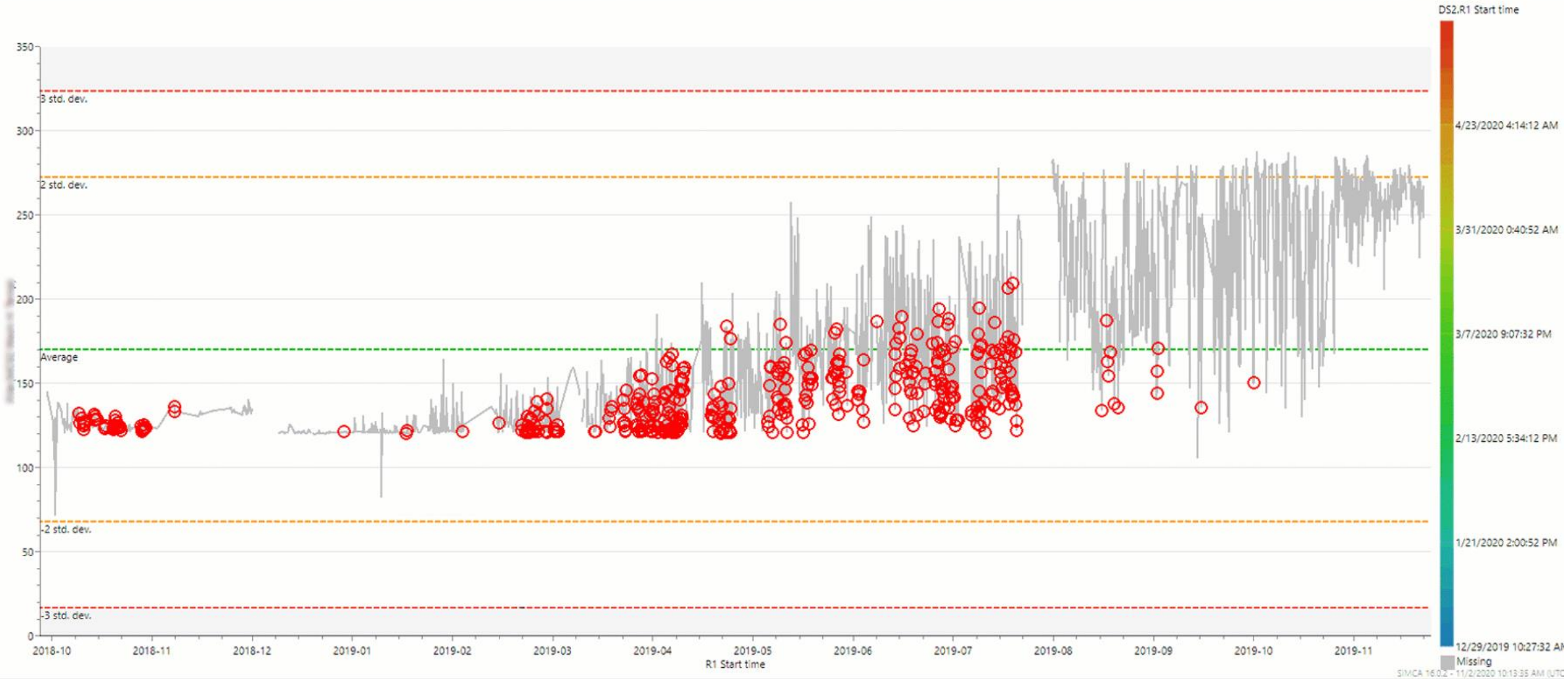


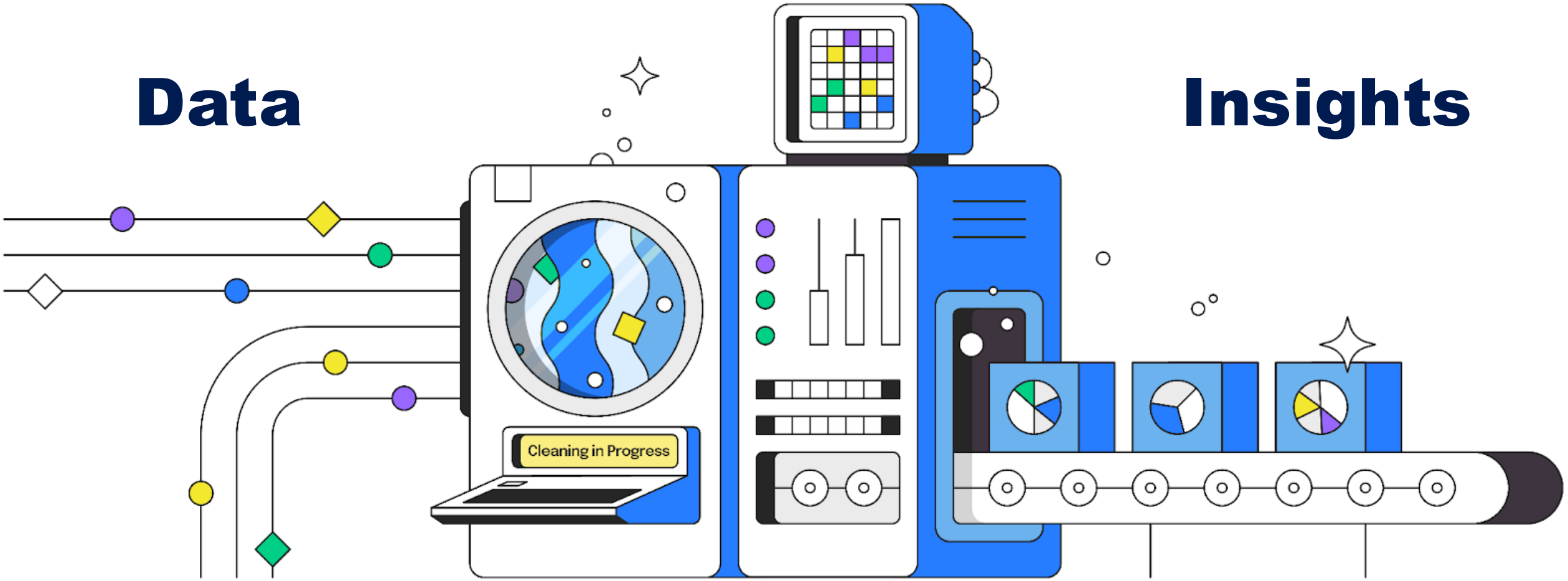
Reason #4


Your Insights
never convert
to Action

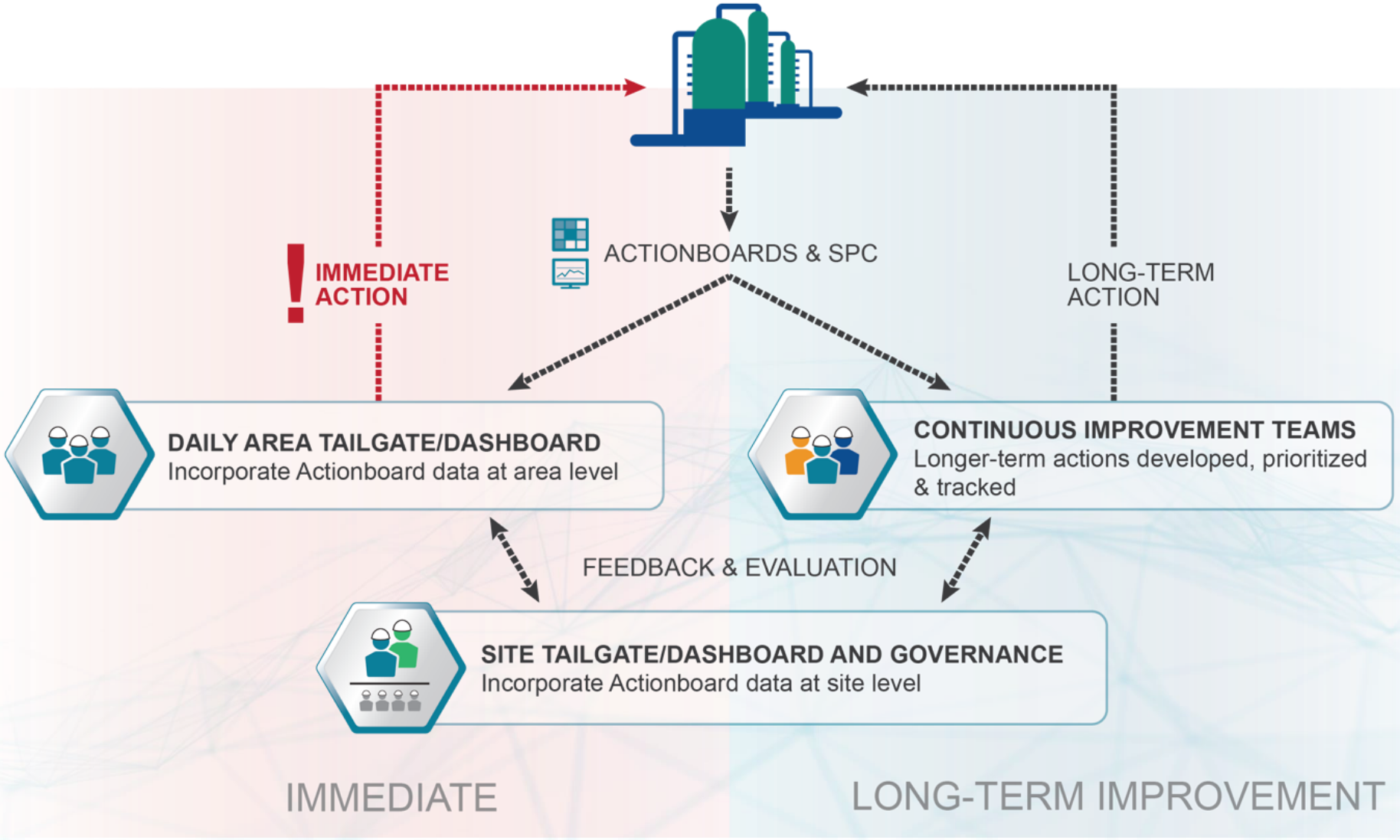
ALBEMARLE INTELLIGENCE

Data

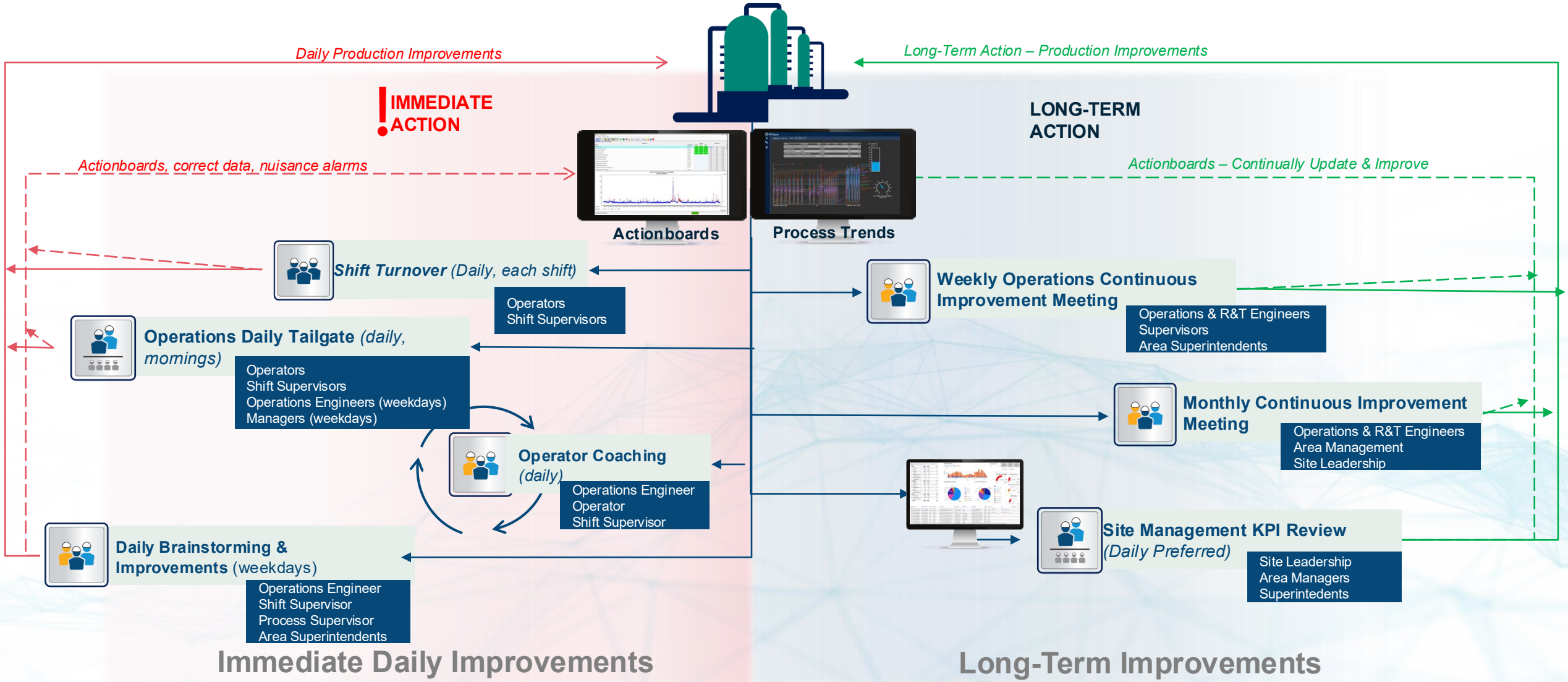
Insights



AI-Powered Continuous Improvement

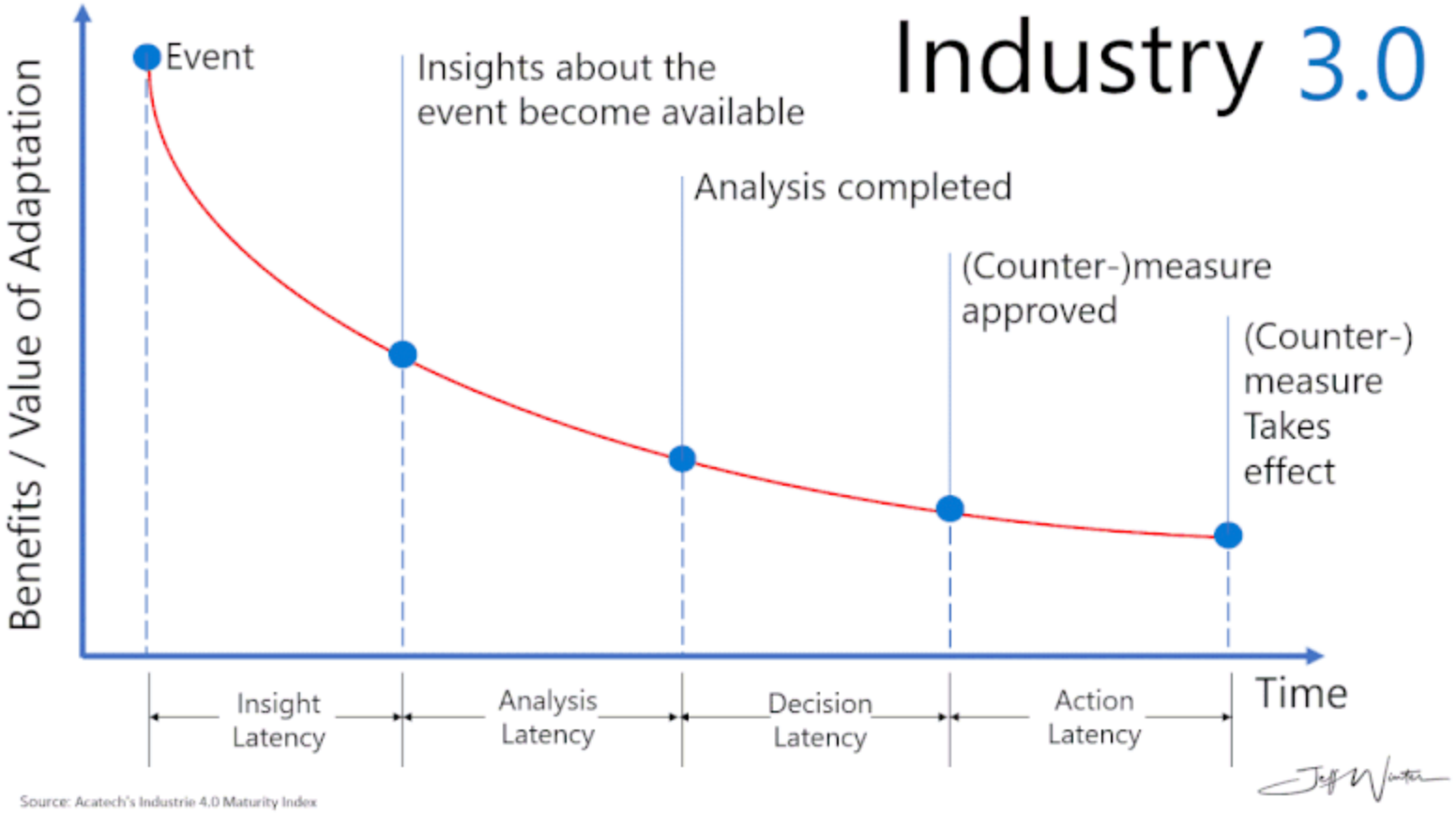


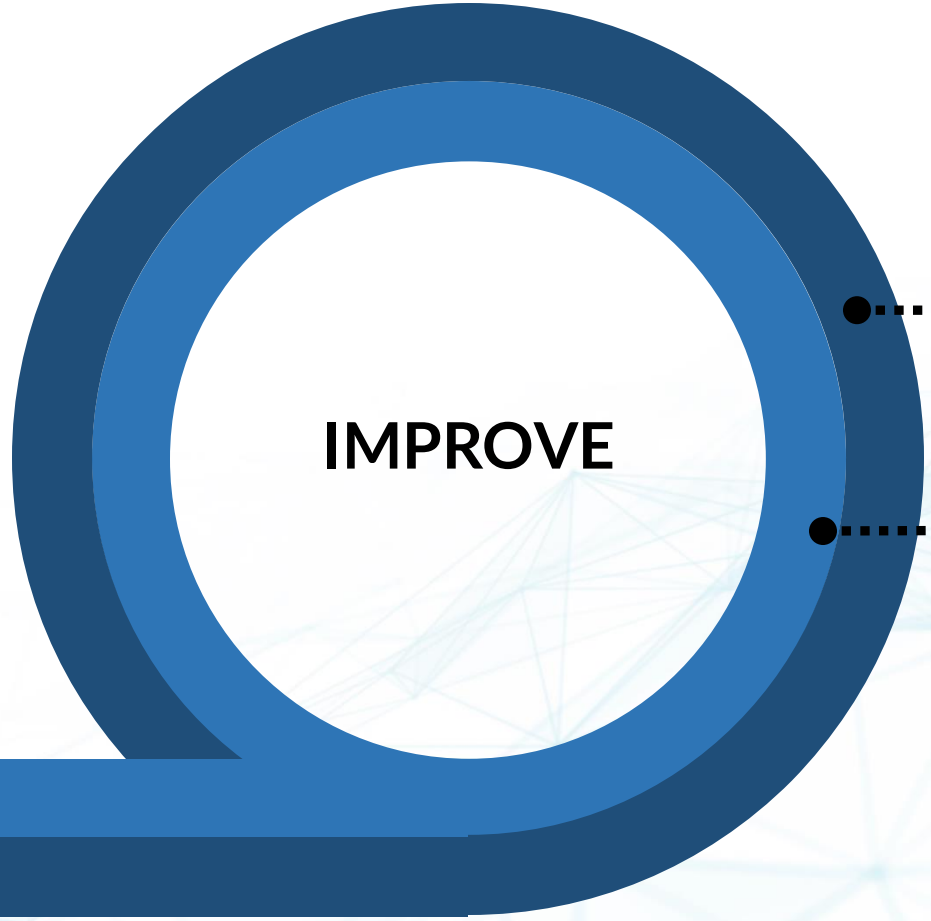
Actionboard Standard Work – Continuous Improvement



Reason #5


Shiny Object
Syndrome

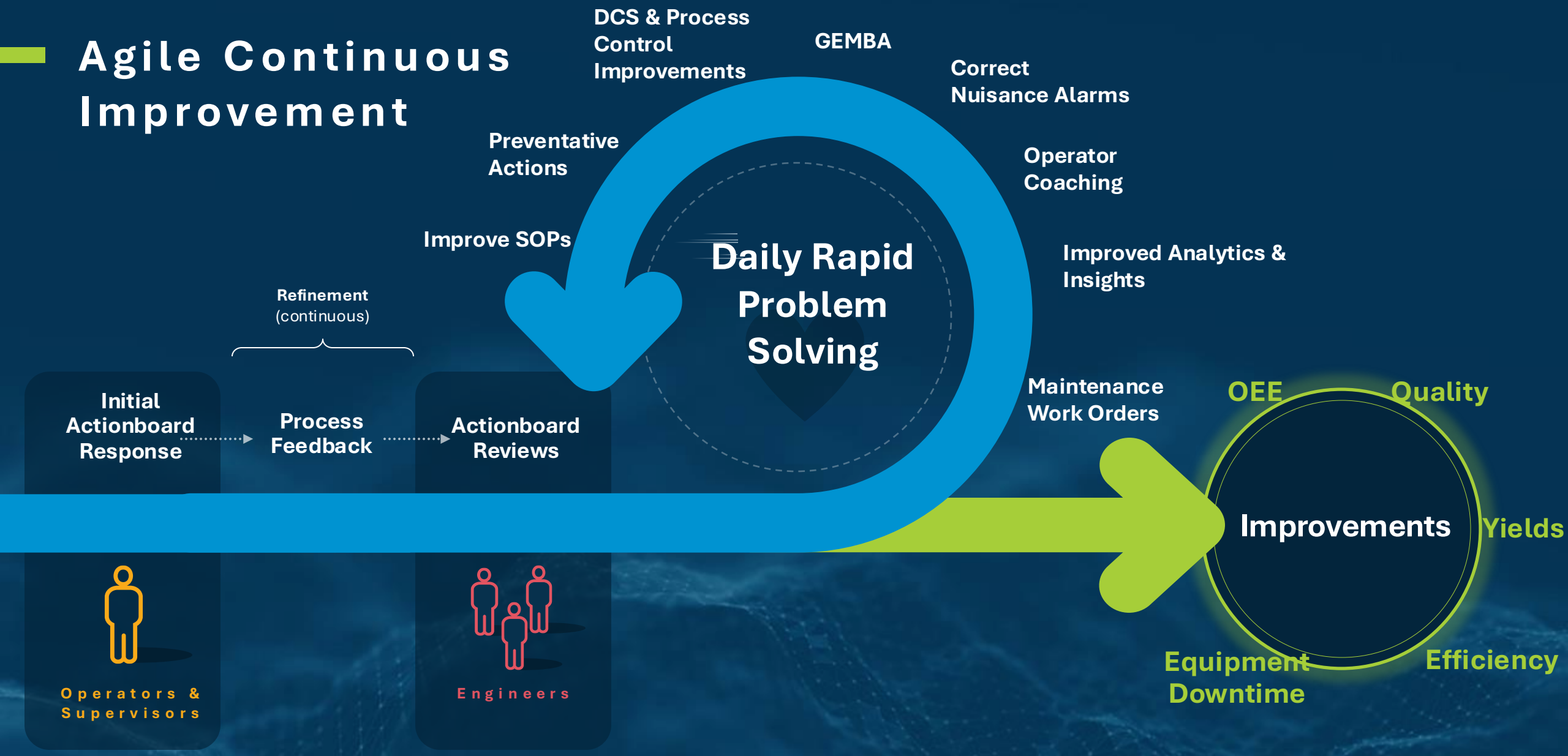




1 Reduce Variation

2 Change the Average

Agile Continuous Improvement



ALBEMARLE INTELLIGENCE

Define

Define the Problem
- Business Opportunity
- Stakeholder Alignment
- Problem Statement
- PI Asset Framework
- Process Knowledge

Measure

Quantify the Problem
- PI AF Event Frames
- Critical to Quality Control
- SQL Queries
- Data Quality & Fidelity
- Automated Datasets

Analyze

Identify the Cause
- Statistical Process Control (SPC)
- Quality Analyst
- SIMCA Machine Learning
- Principle Component Analysis
- Partial Least Squares

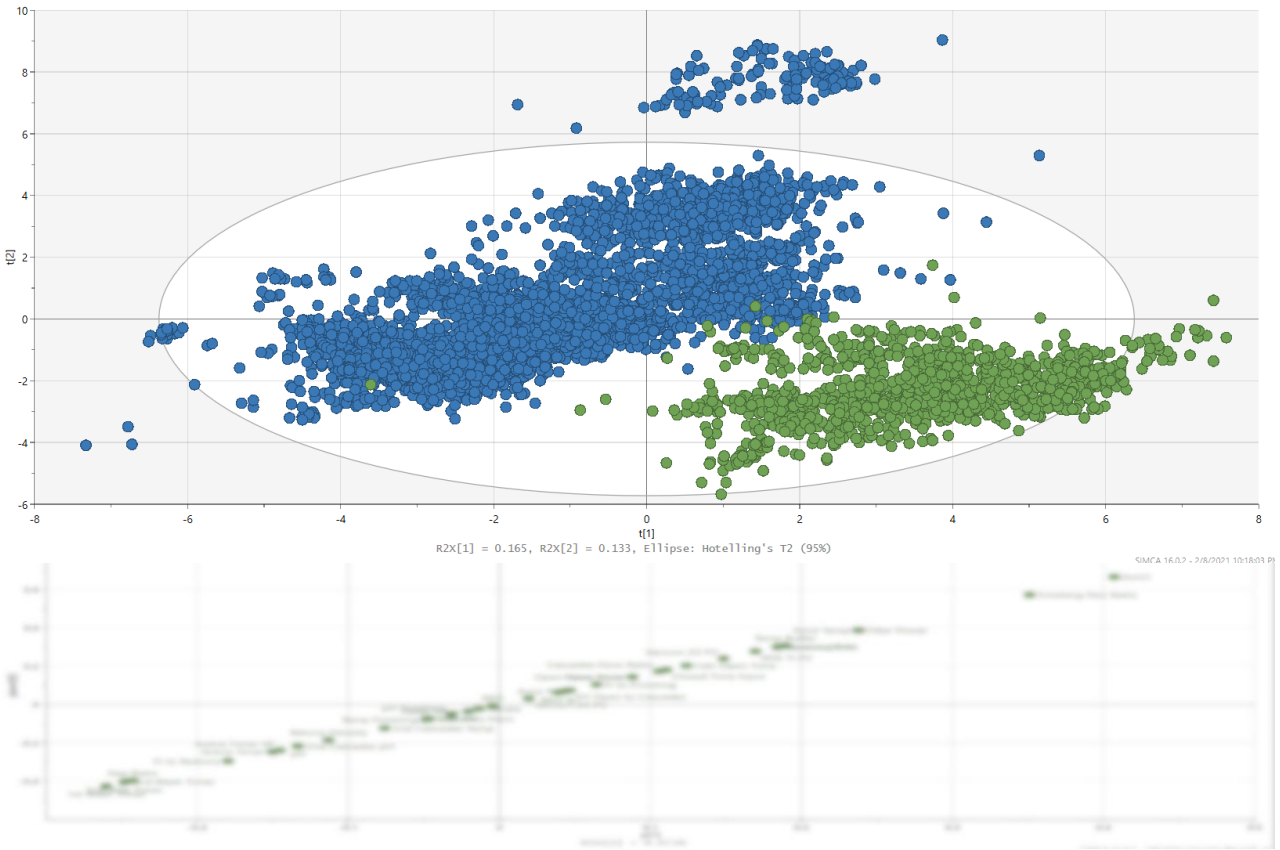
Improve

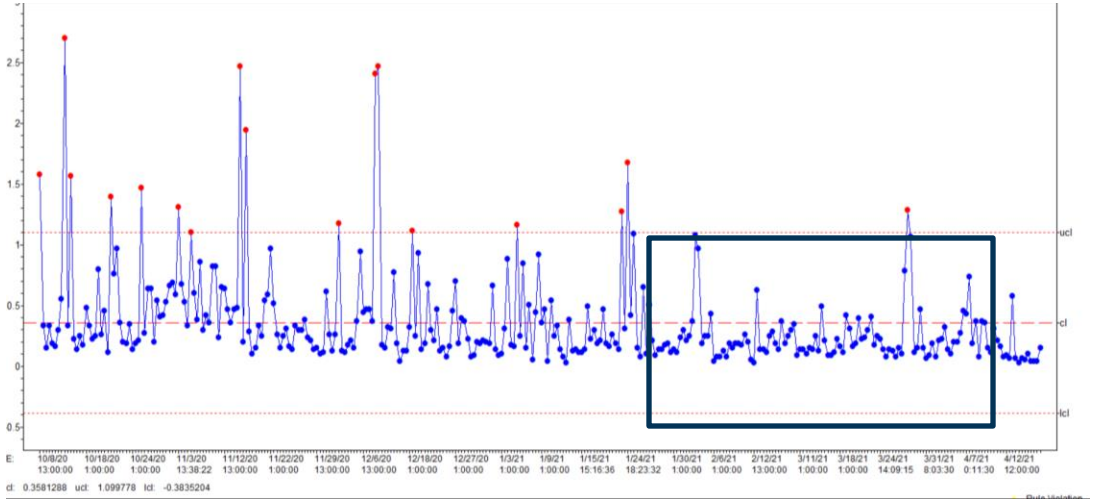
Implement the Solution
- Variation Reduction
- Design of Experiments
- Brainstorming
- 5 Why Analysis
- Cause & Effect
- DCS Process Control Improvements

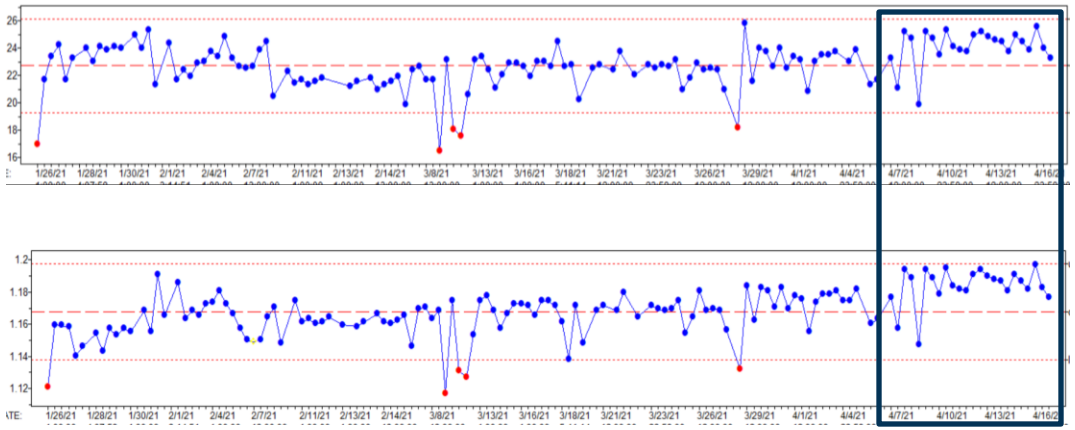
Control

Maintain the Solution
- Sustainability
- Actionboards
- Procedures & Guidelines
- Governance
- Roles & Responsibilities
- Change Management

Albemarle Intelligence – Engineer Improvement Project







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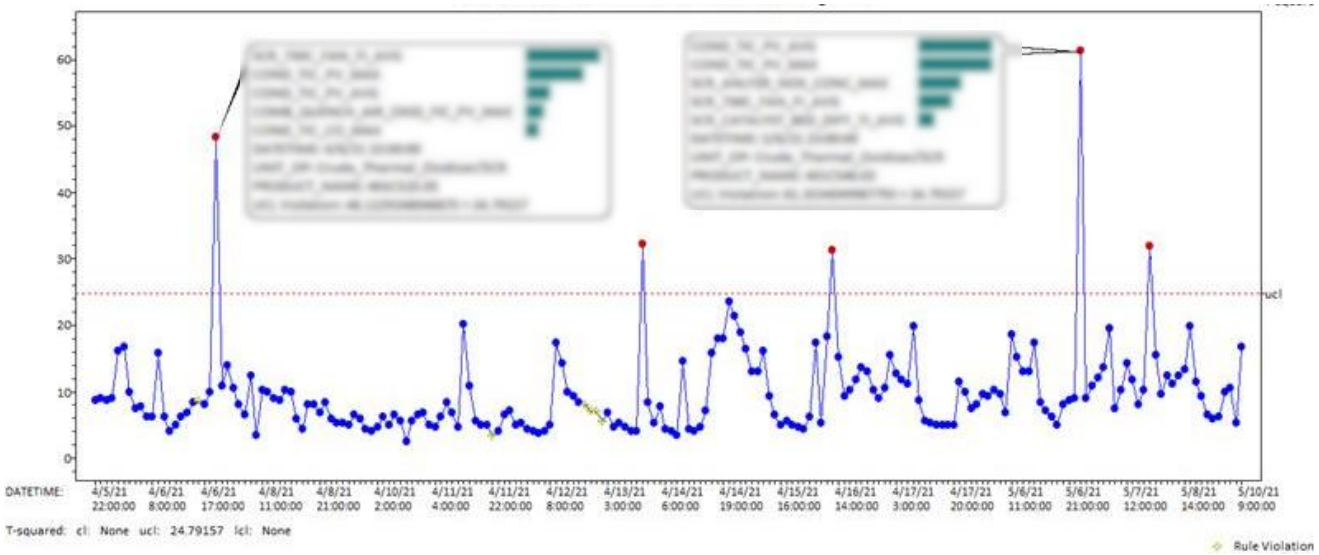

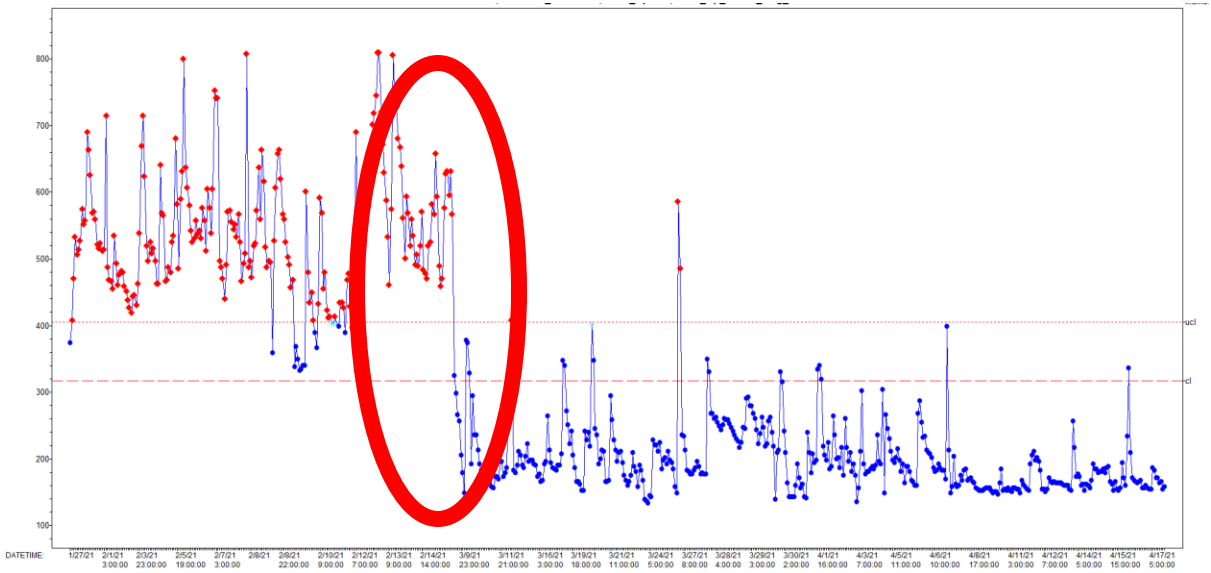

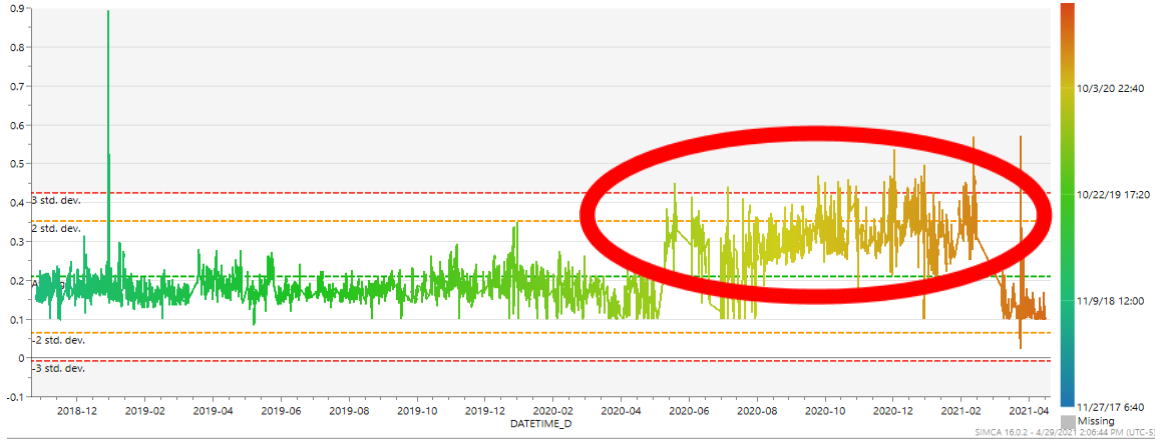

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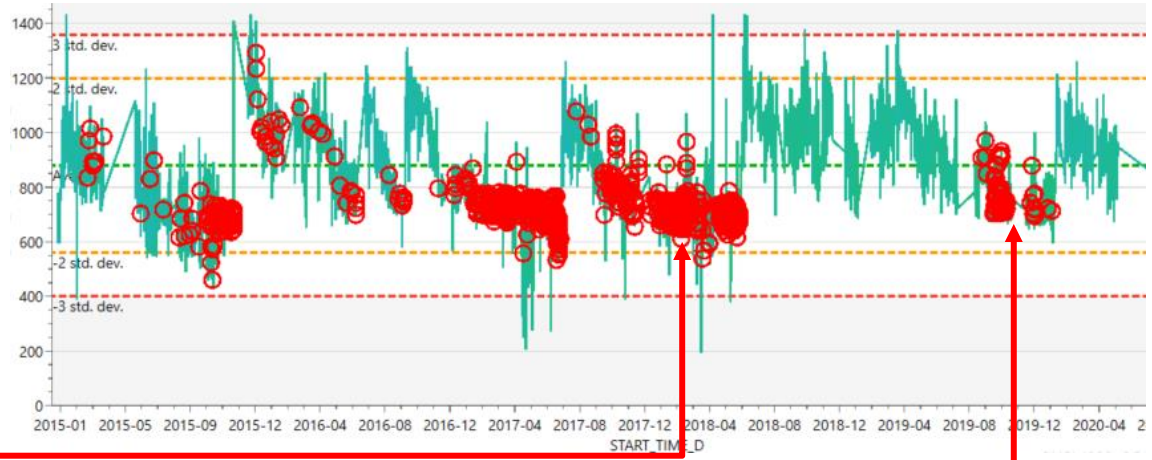

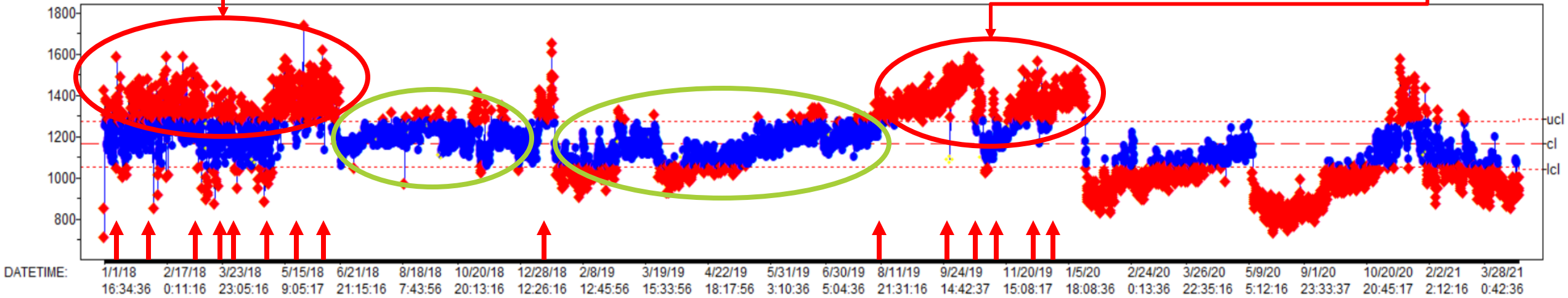

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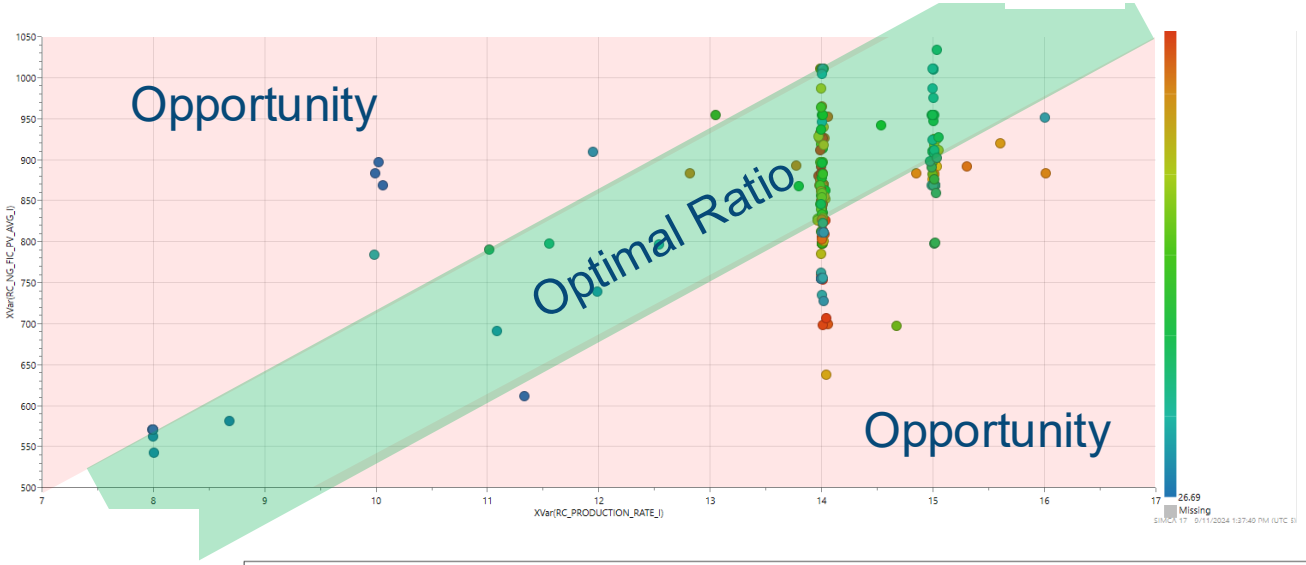

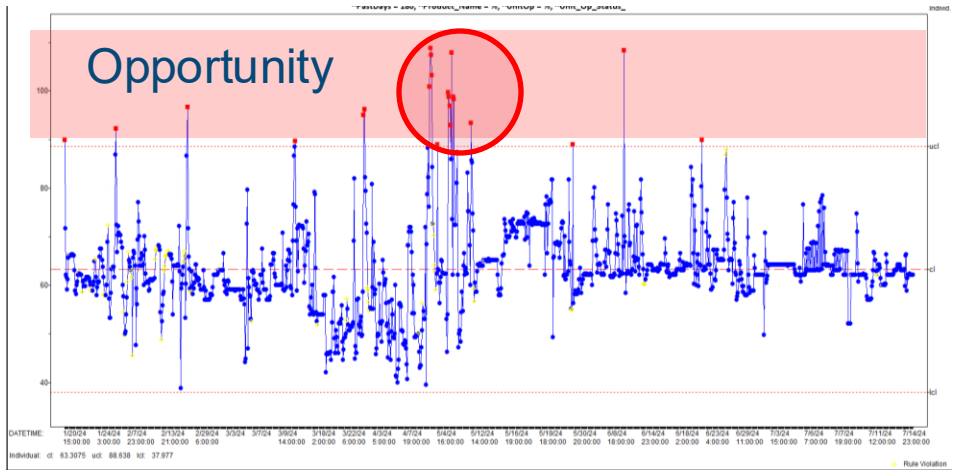

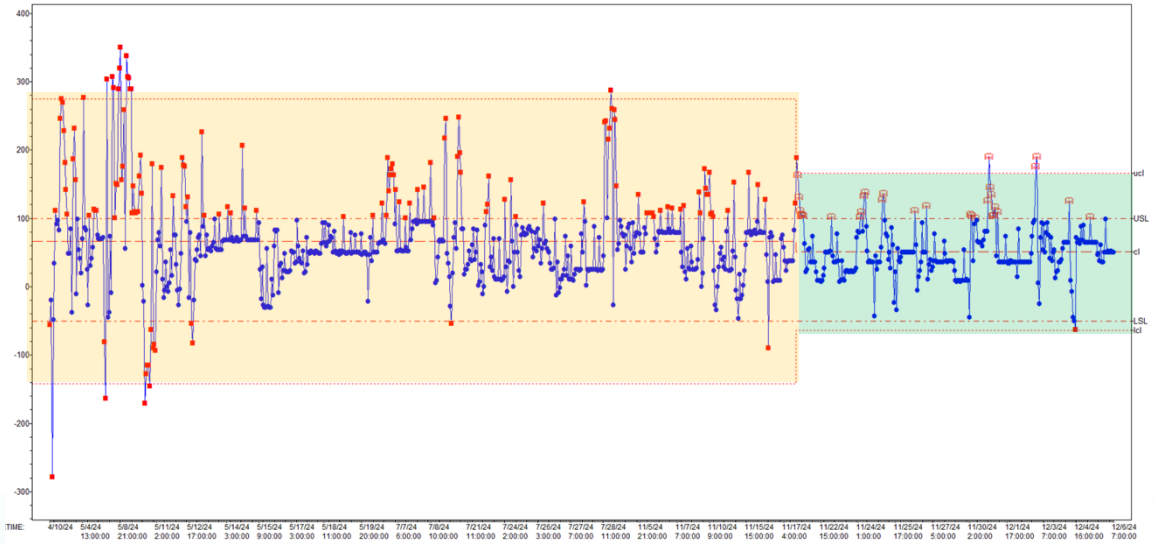

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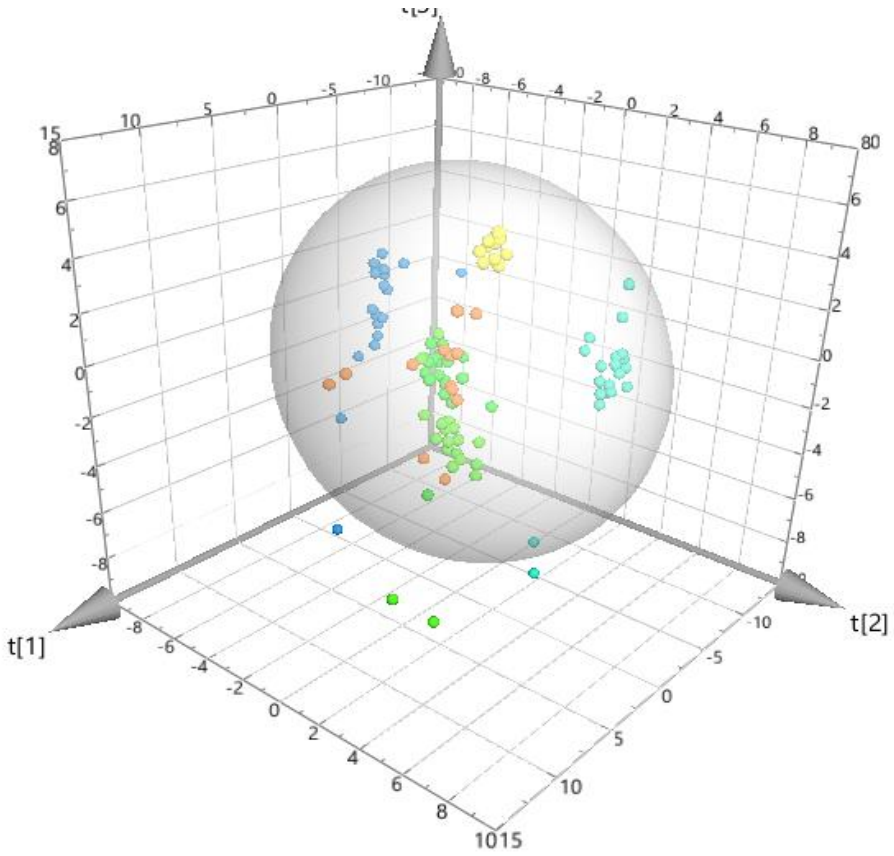
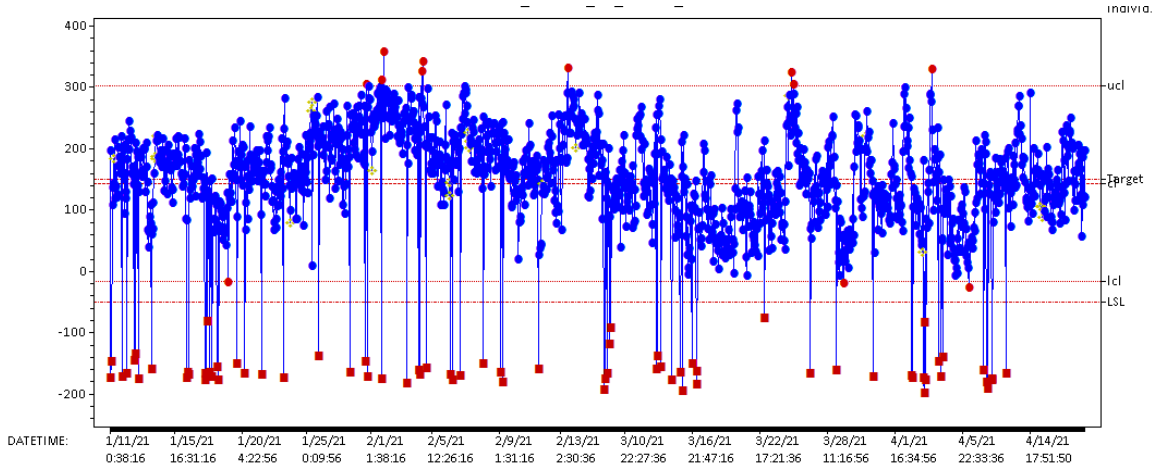
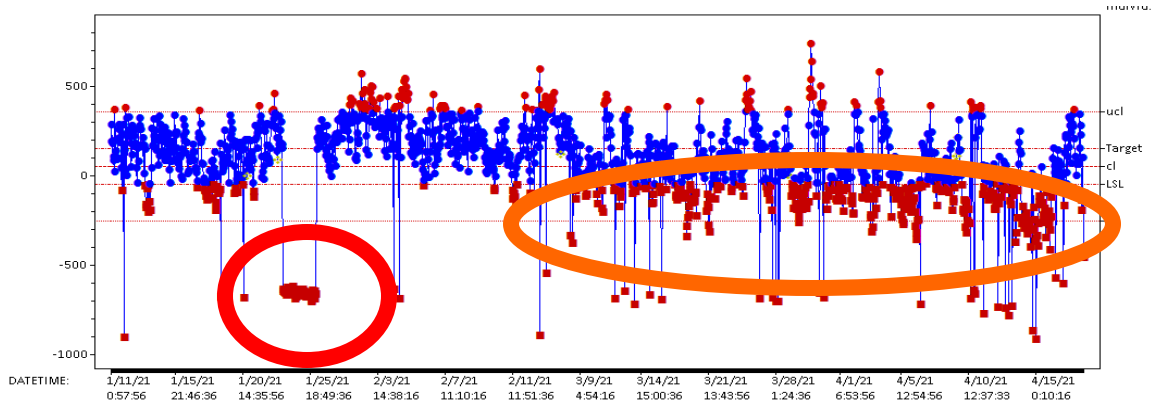
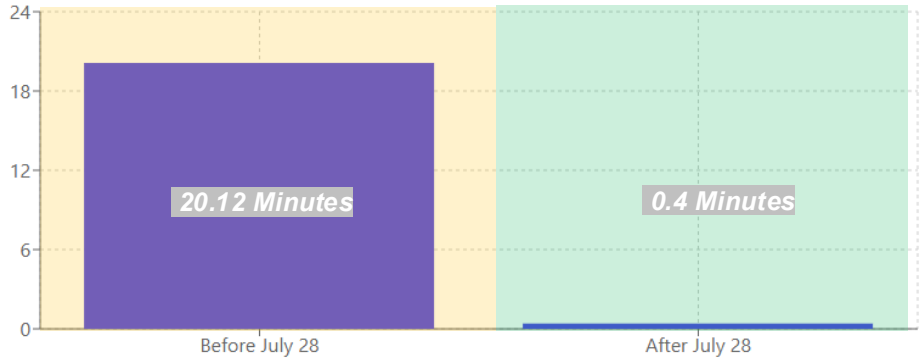




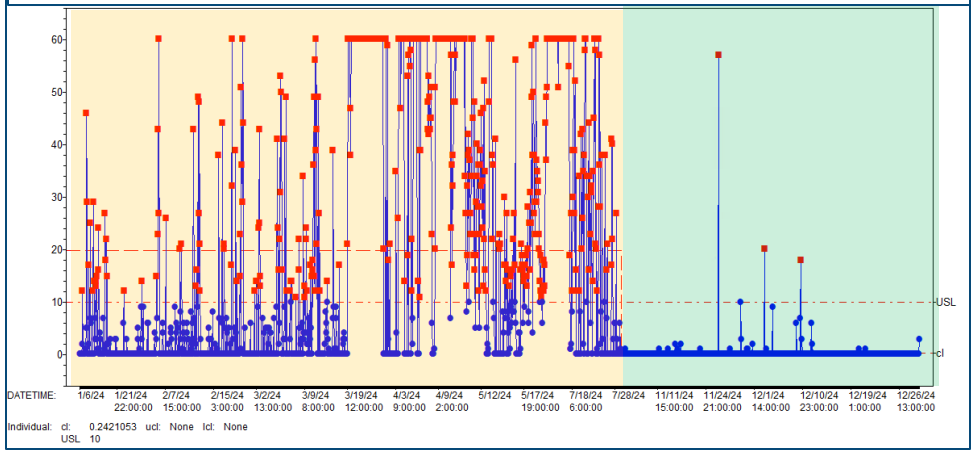


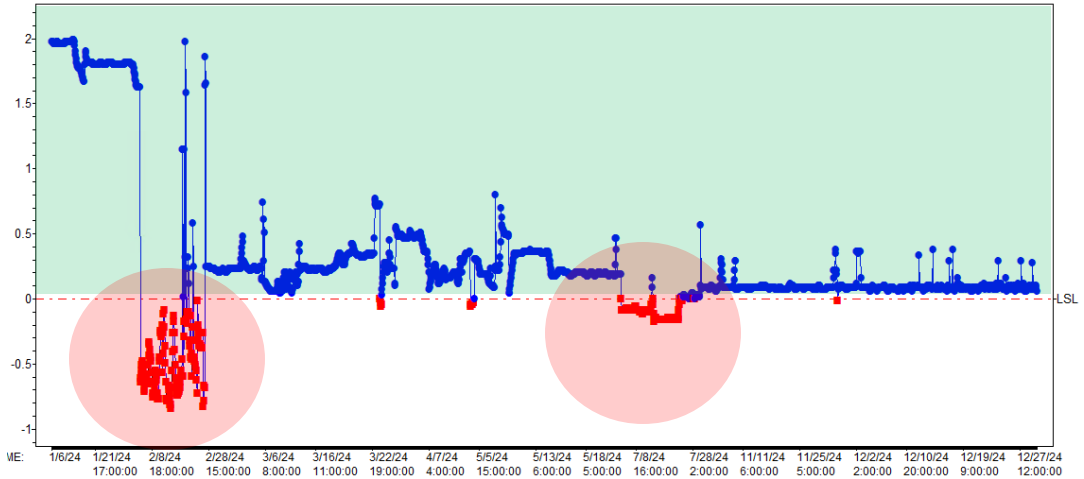
Albemarle Intelligence – Engineer Improvement Project

Avg Minutes per Hour Where Ratio Was Out Of Optimal*

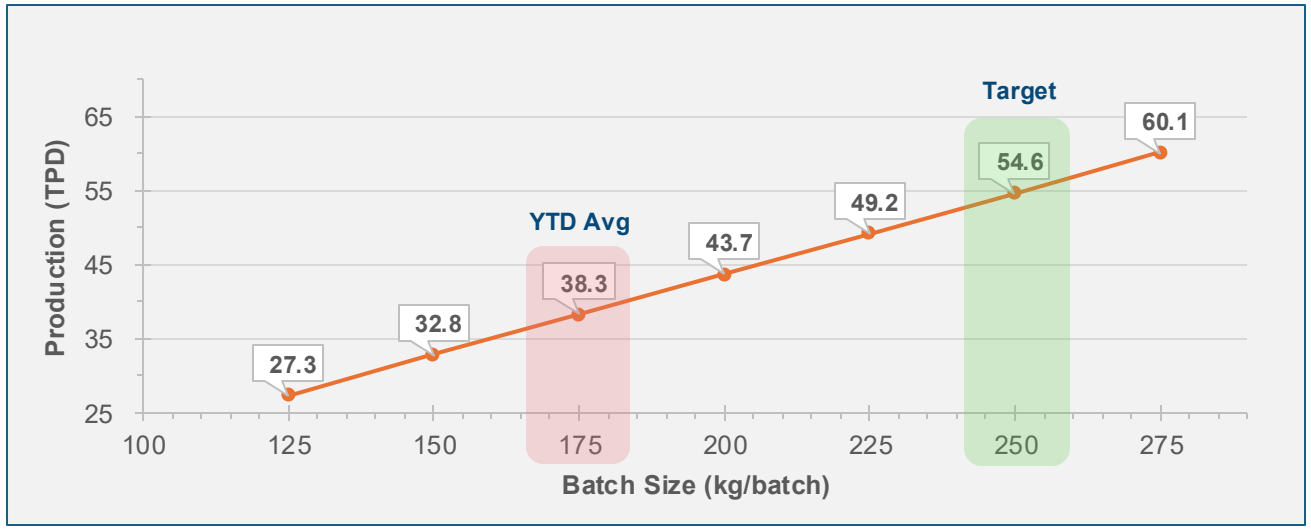


Minutes per Hour Where Ratio Was Out Of Optimal



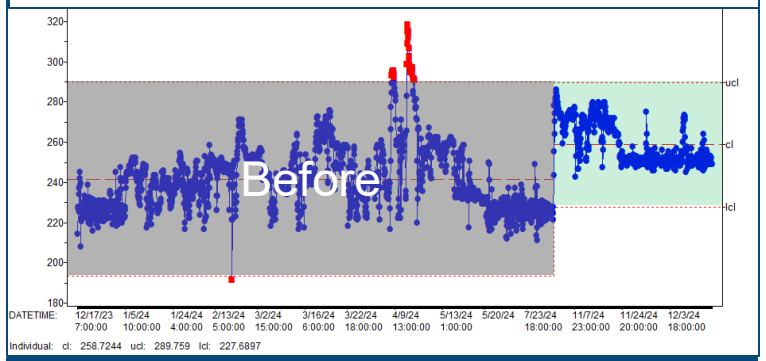


Albemarle Intelligence – Engineer Improvement Project

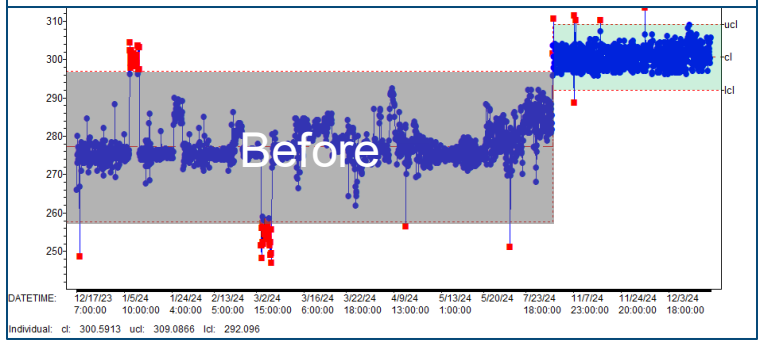


Albemarle Intelligence – Engineer Improvement Project

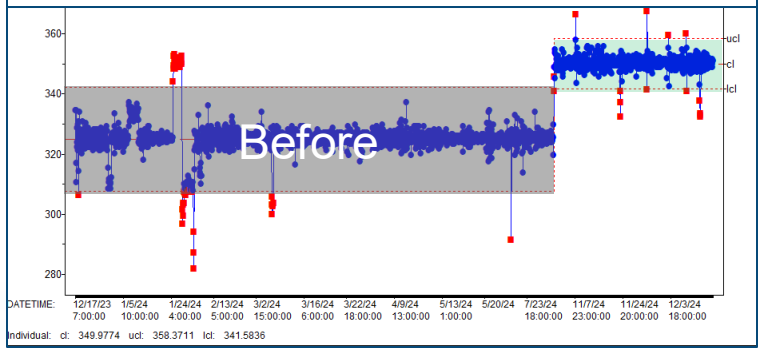
Temperature 1

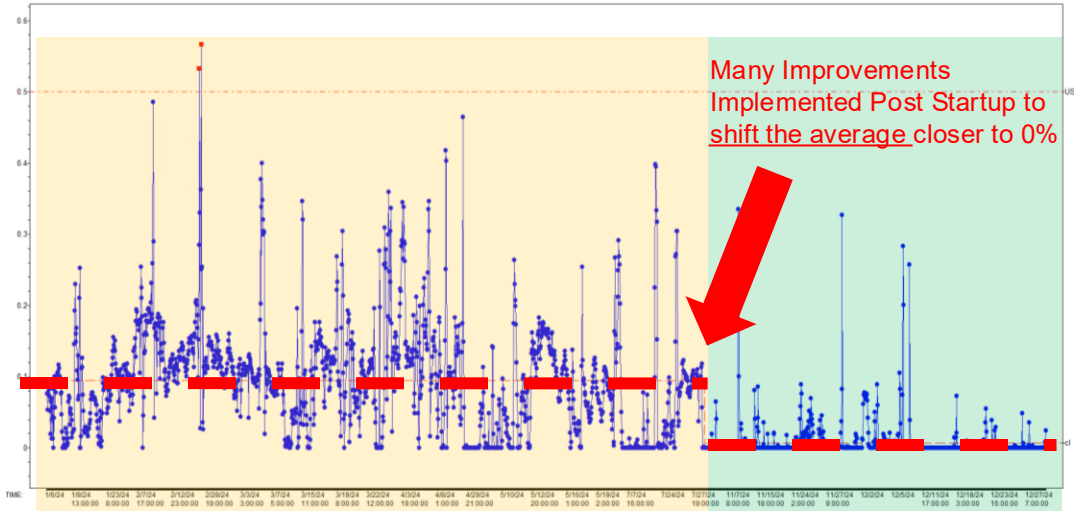


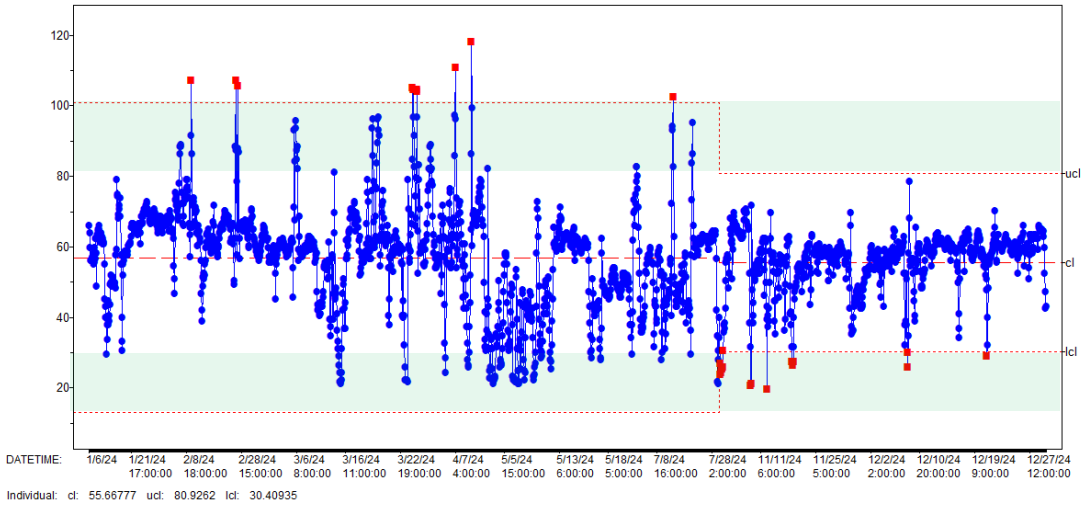
Temperature 2



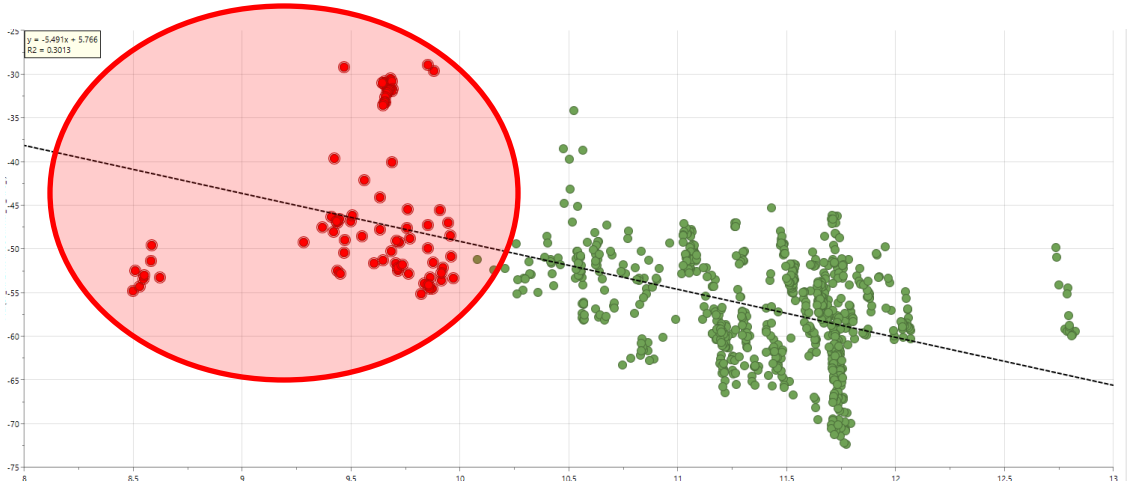
Temperature 3

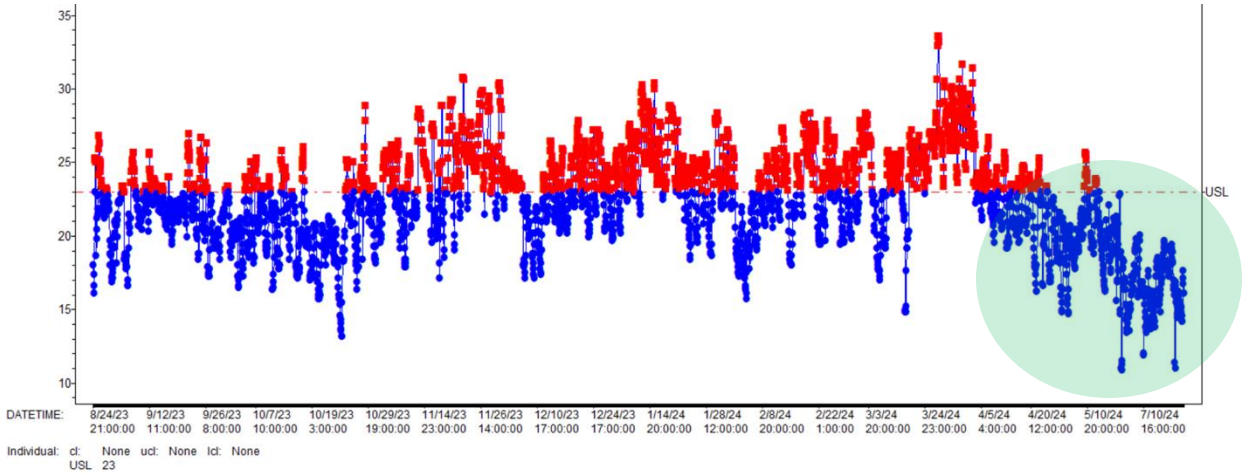


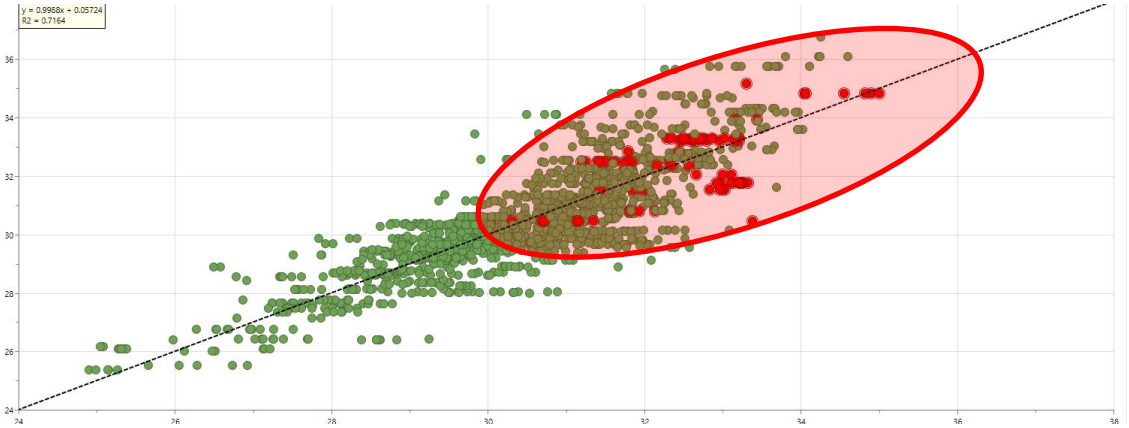


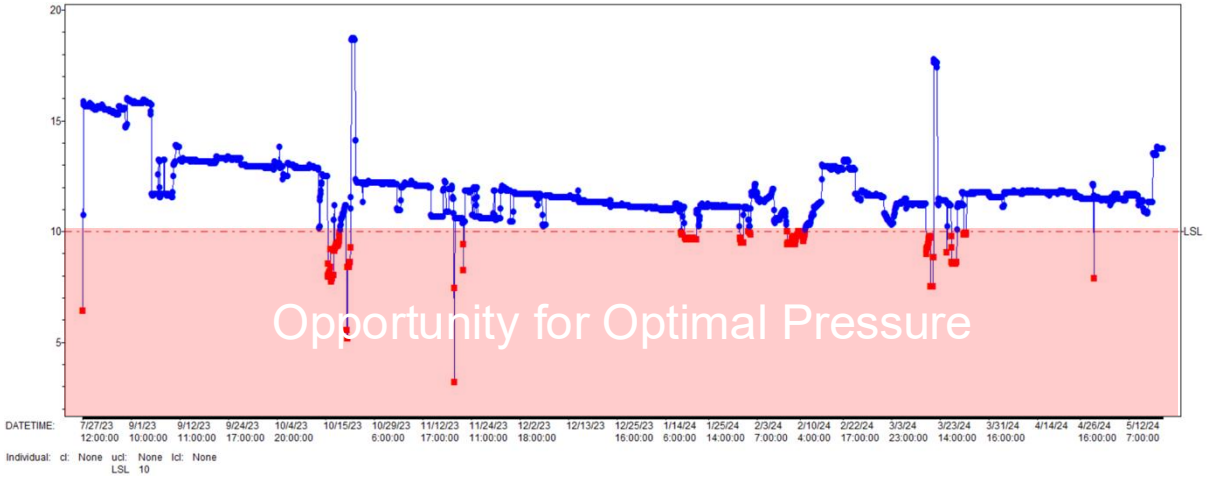


Albemarle Intelligence – Engineer Improvement Project









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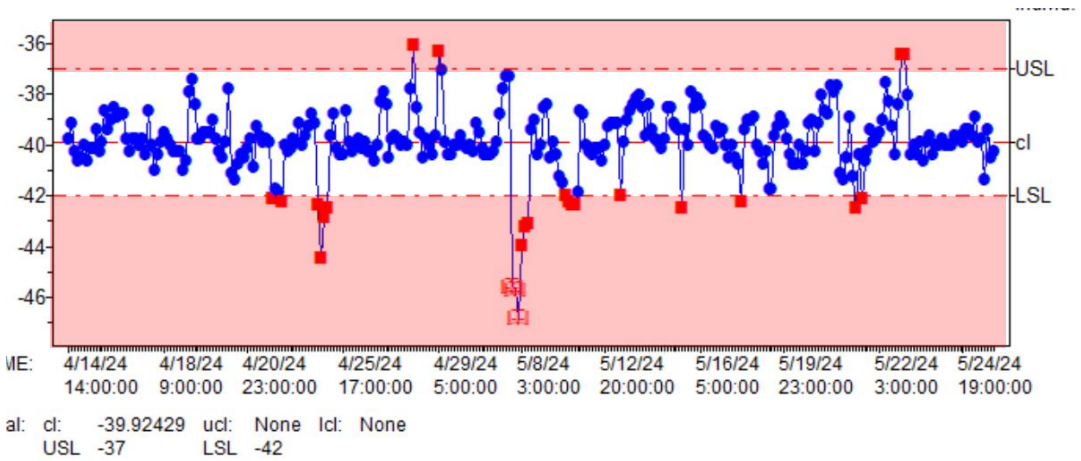

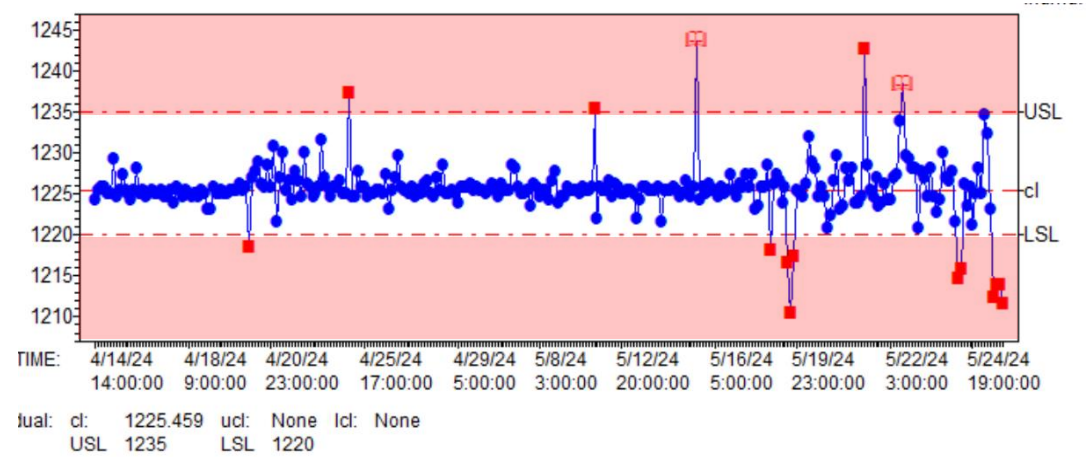

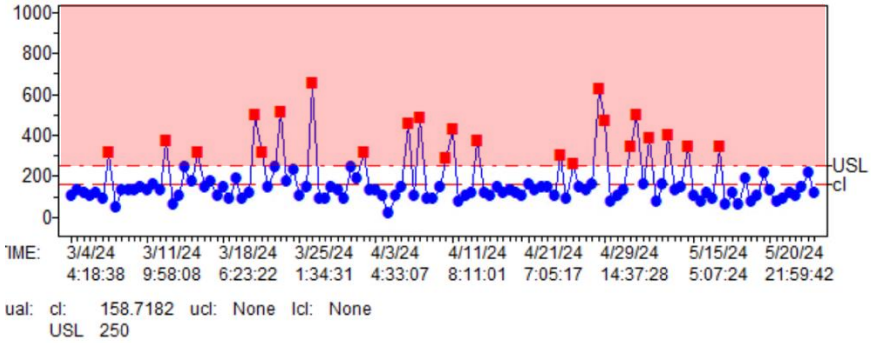

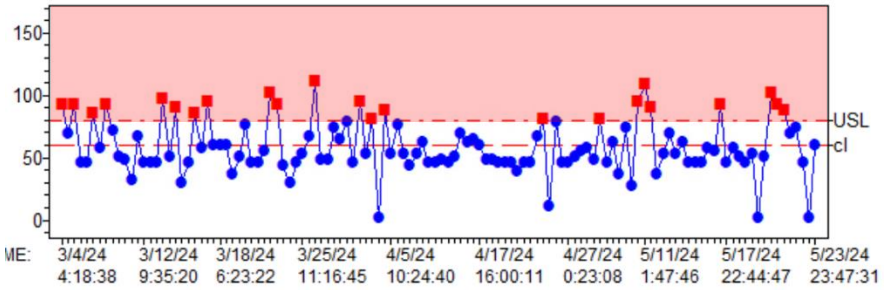

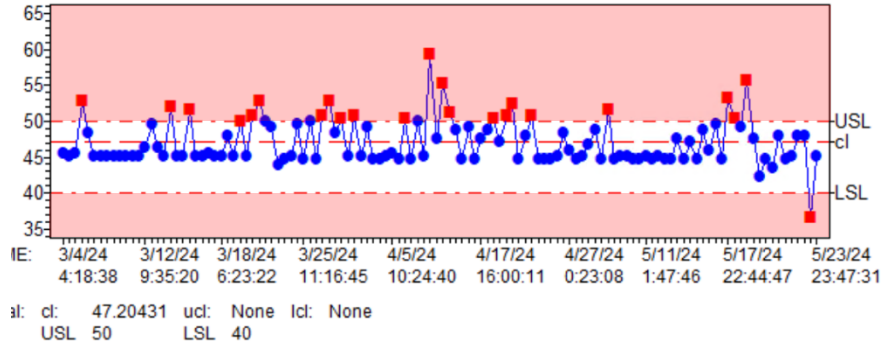

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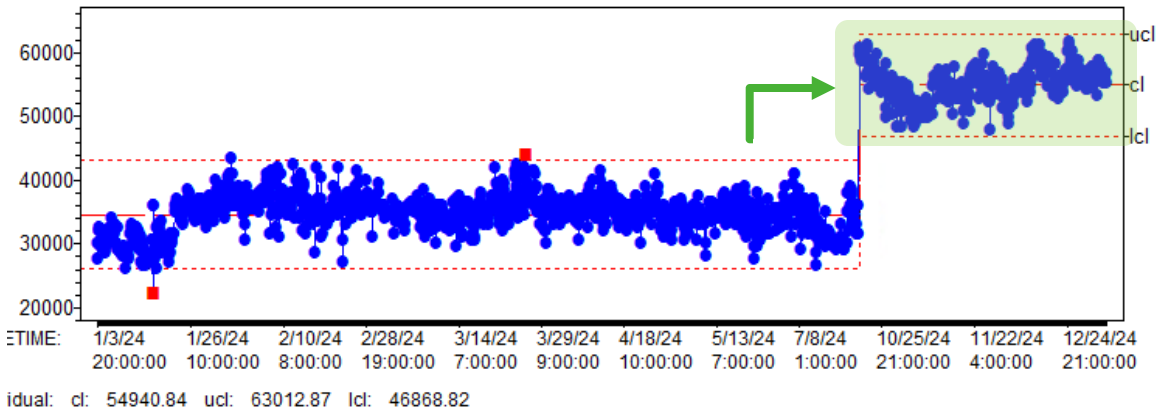

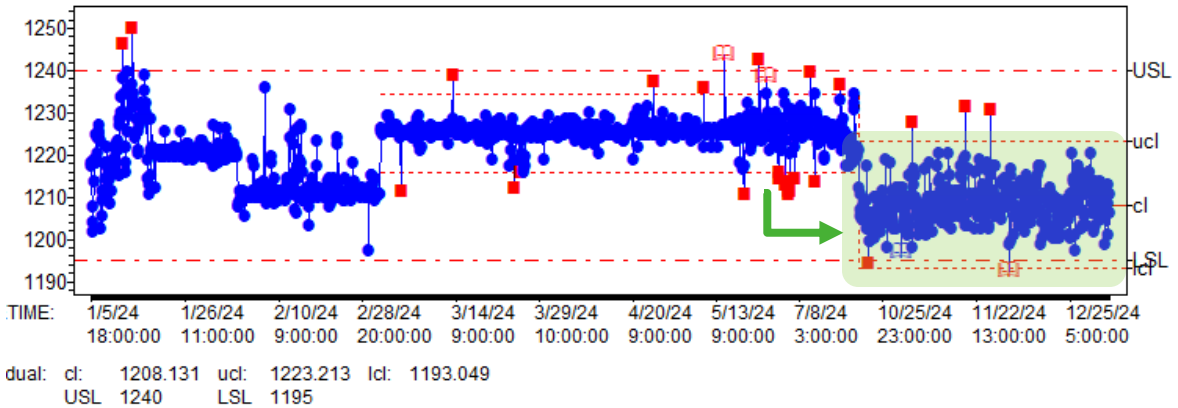

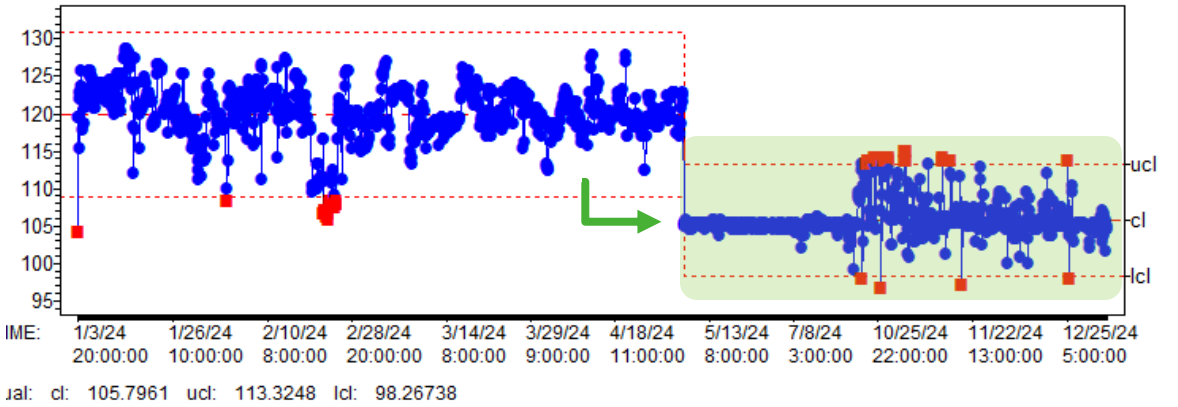

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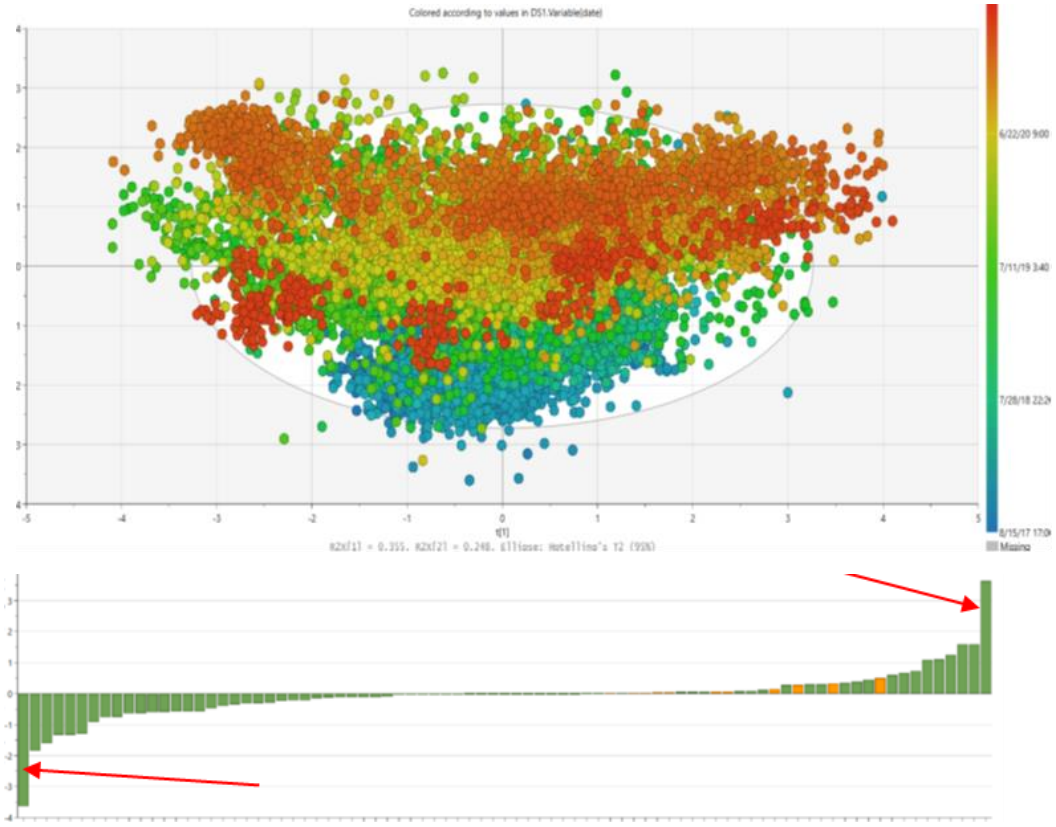
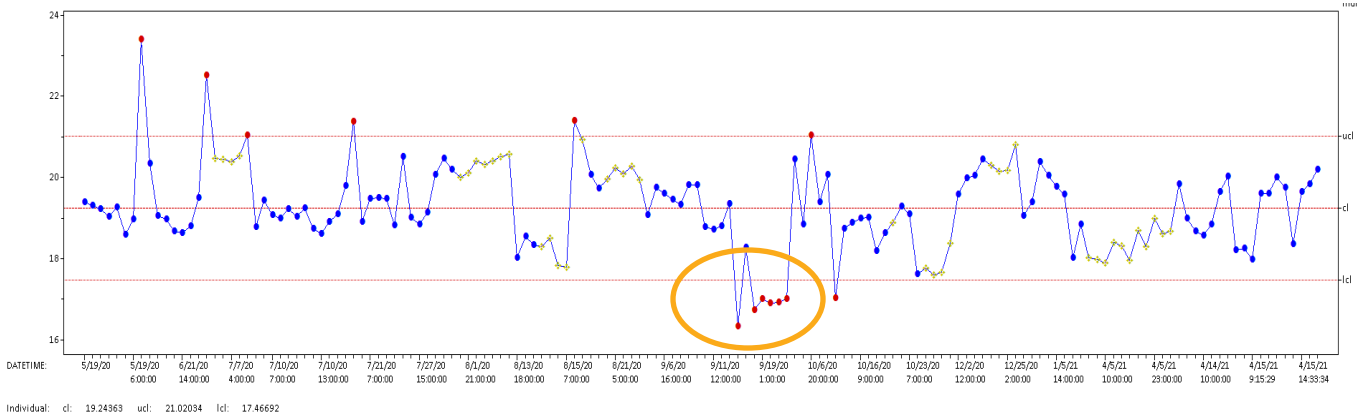
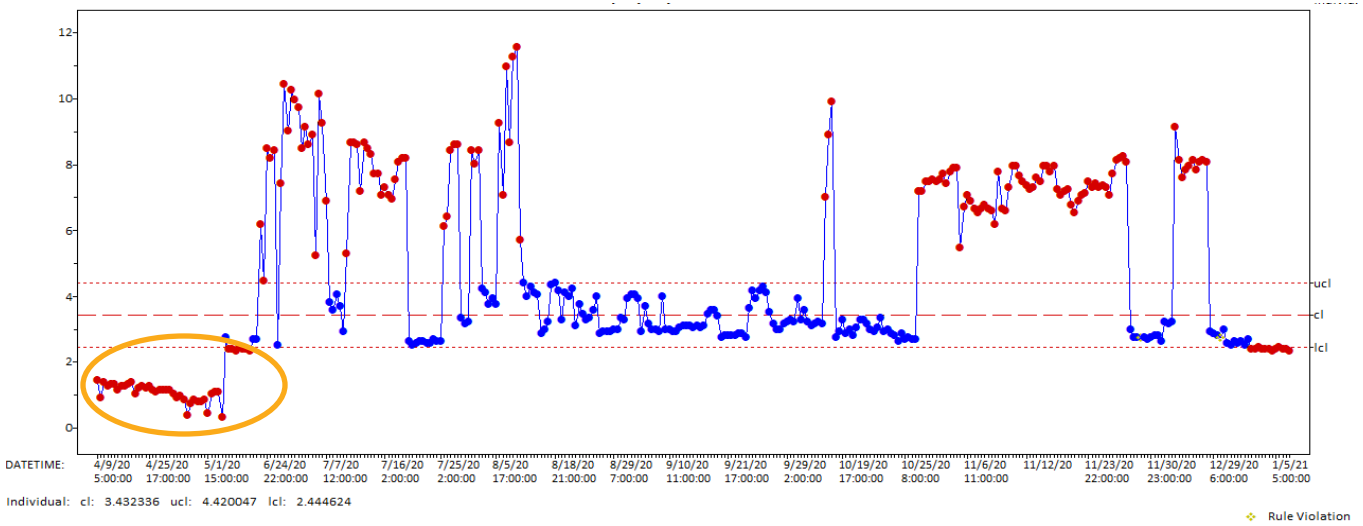
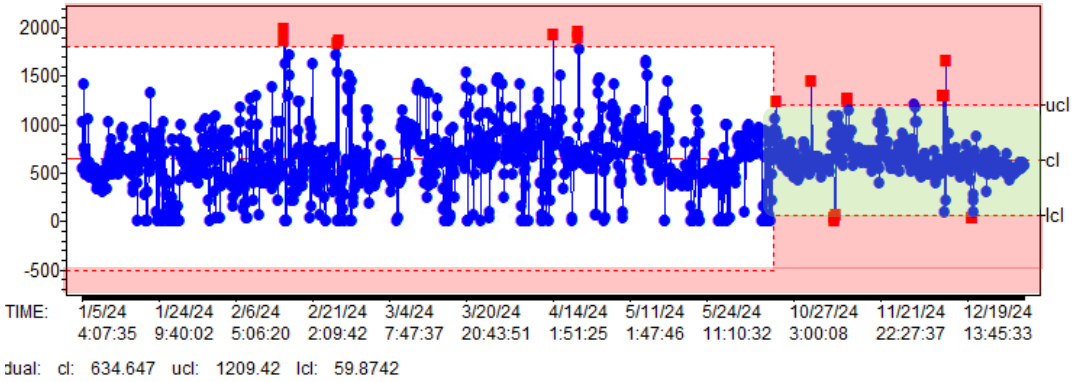
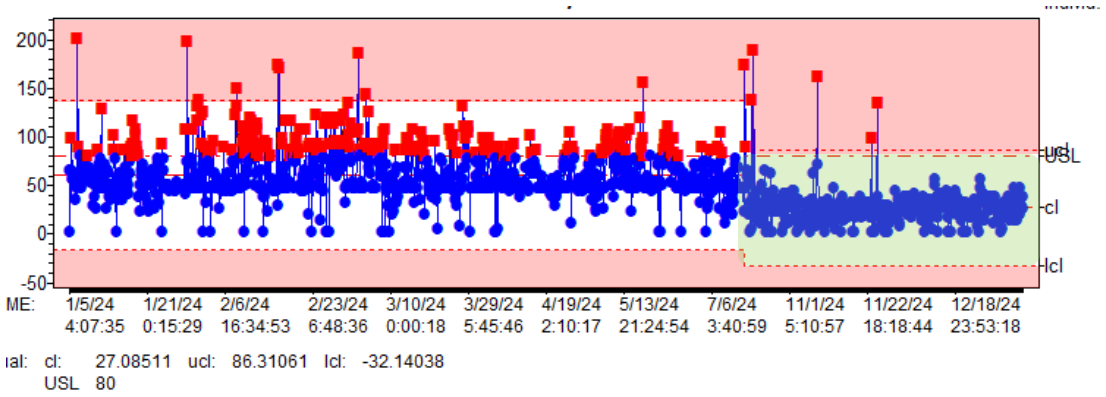


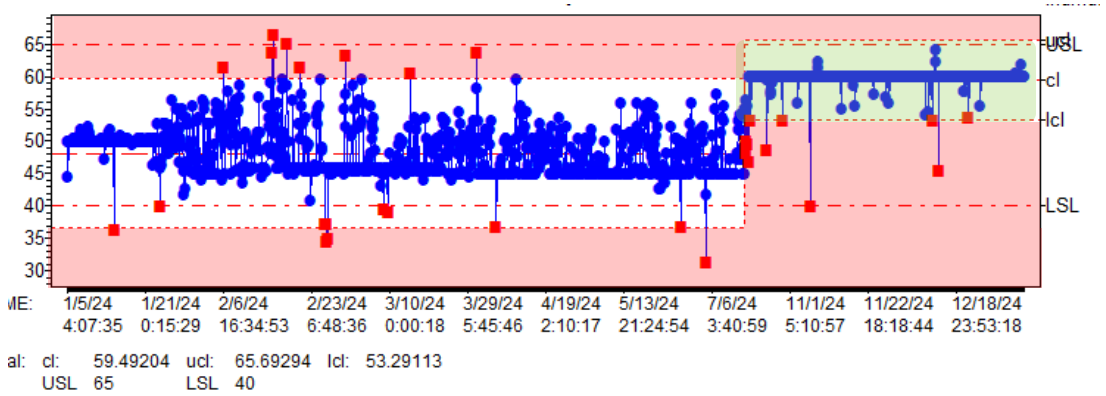




Albemarle Intelligence – Engineer Improvement Project







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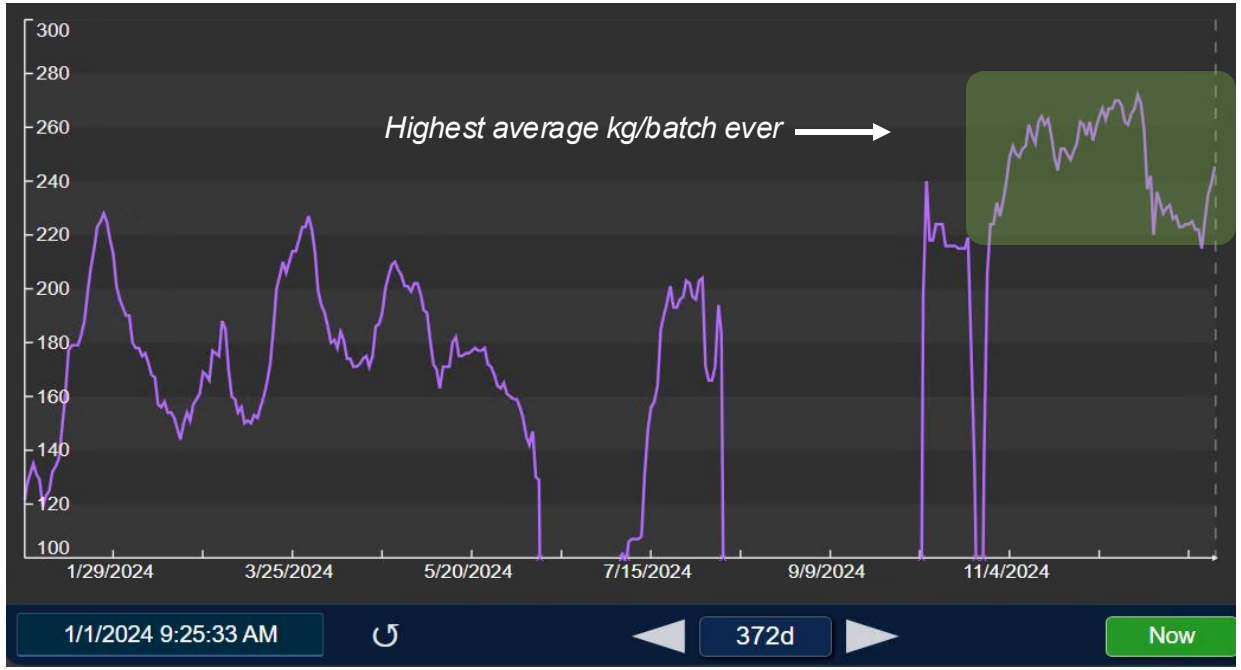

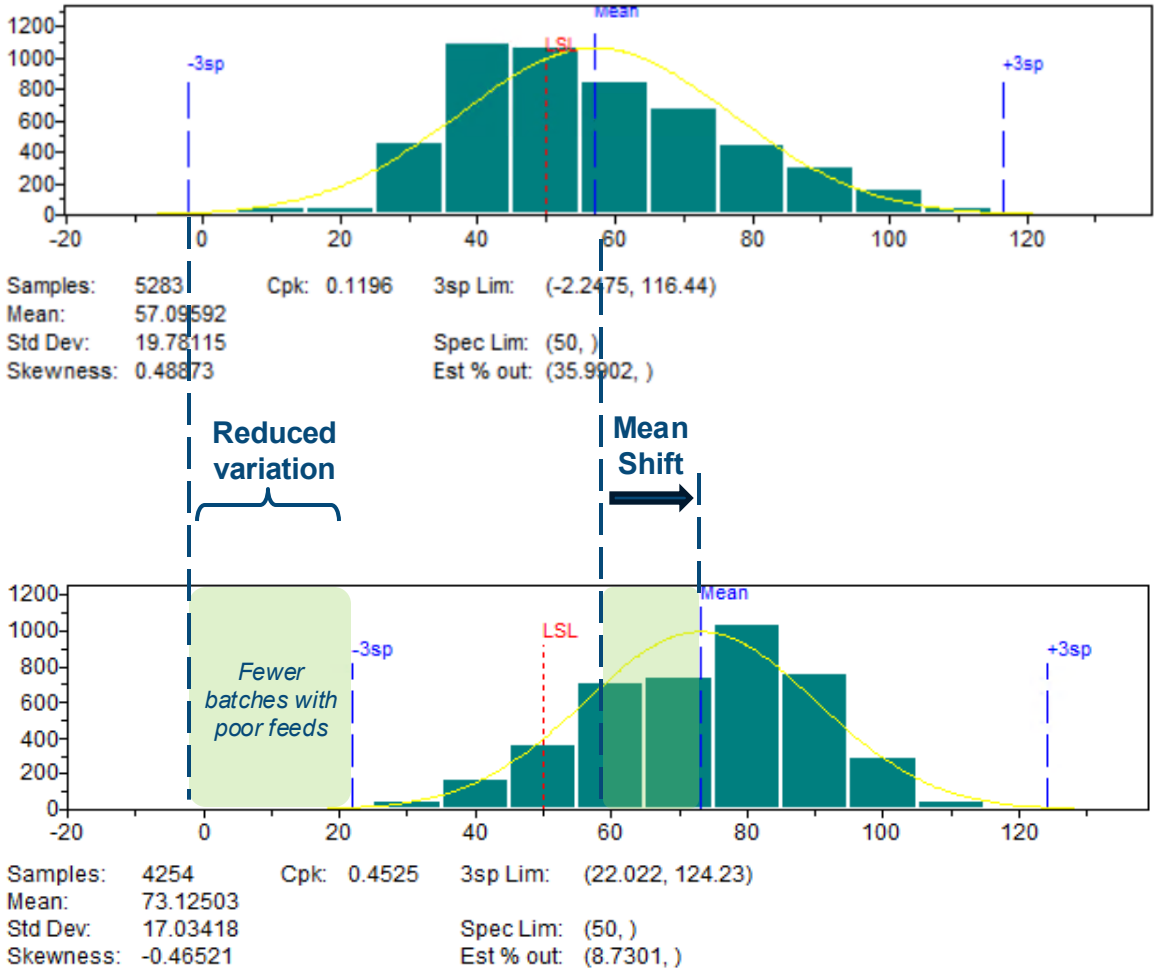

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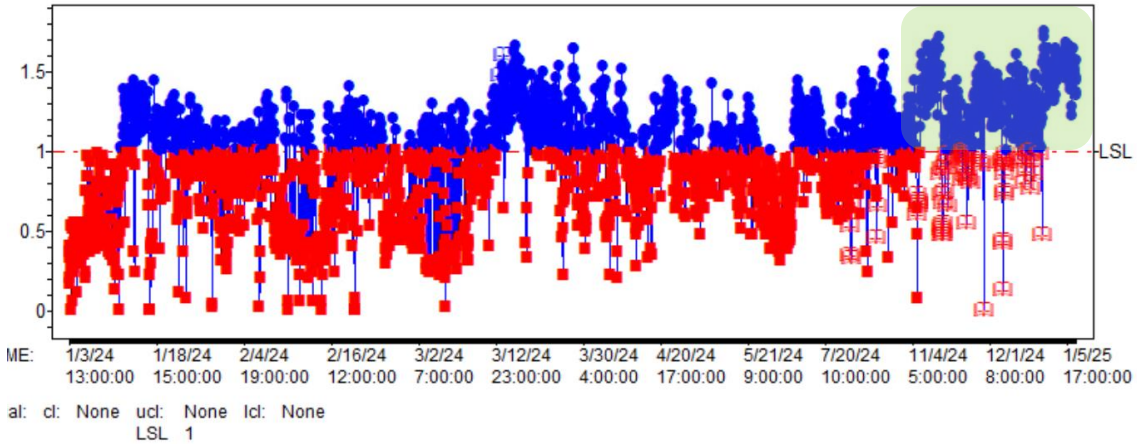
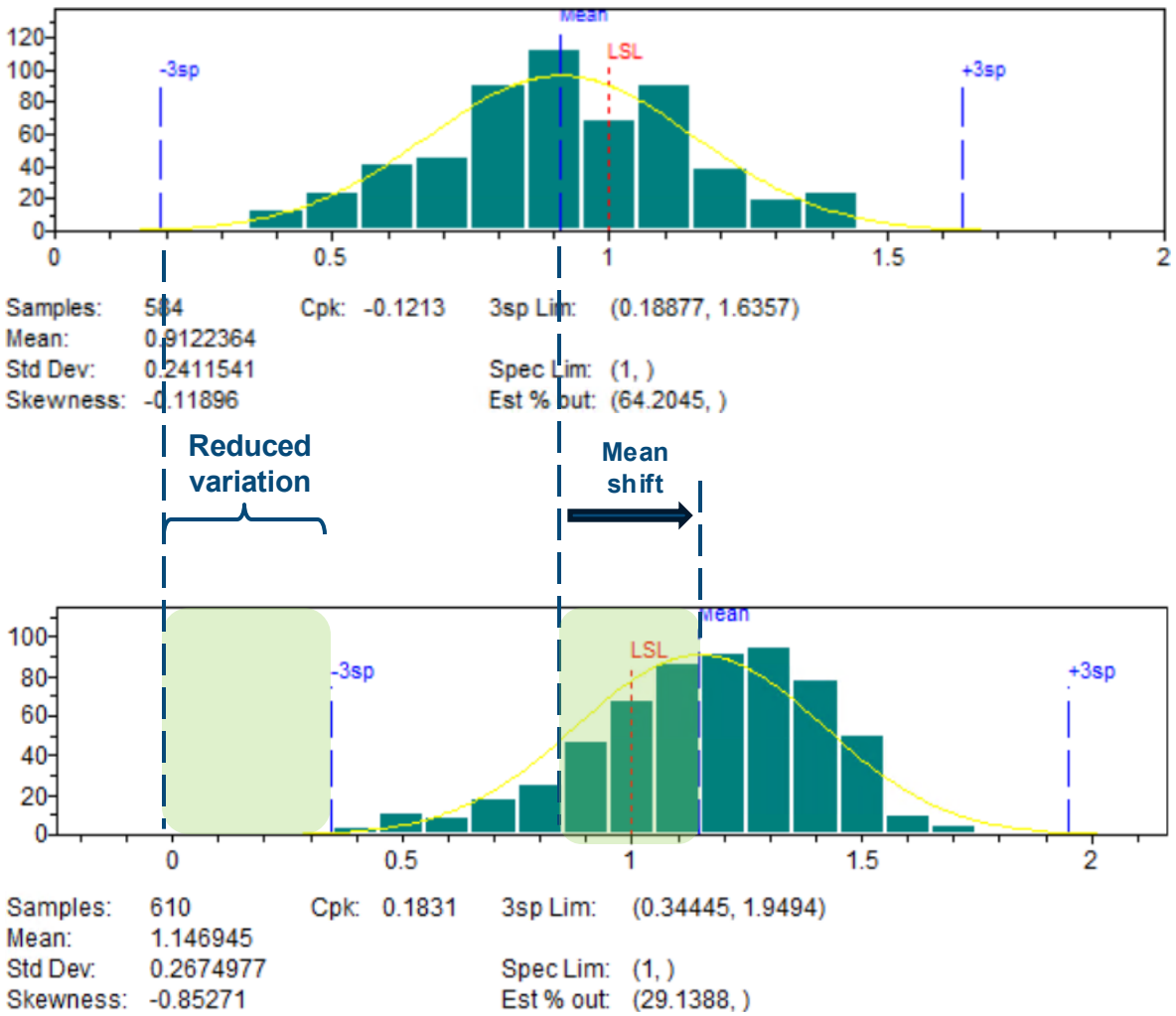
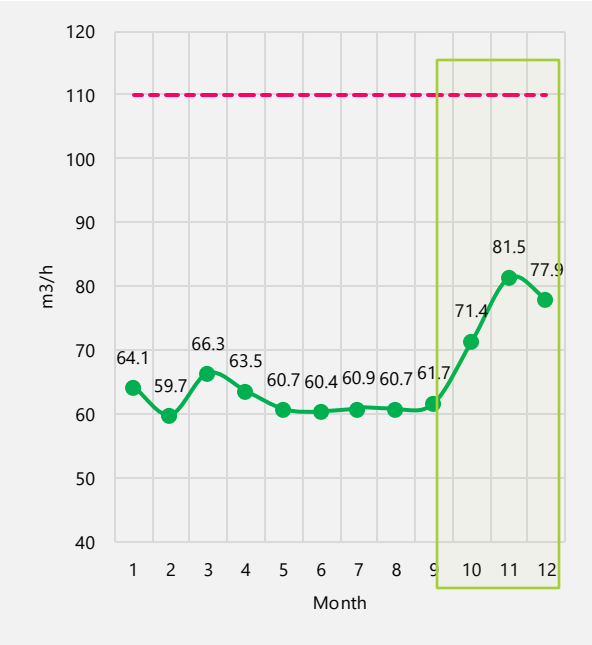
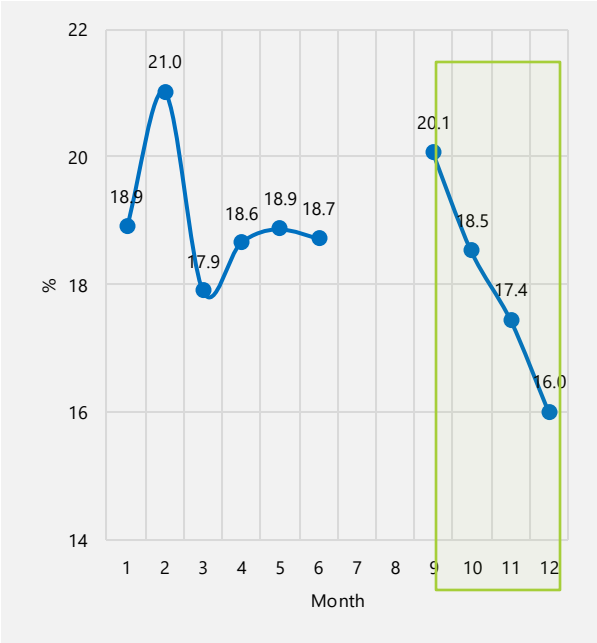
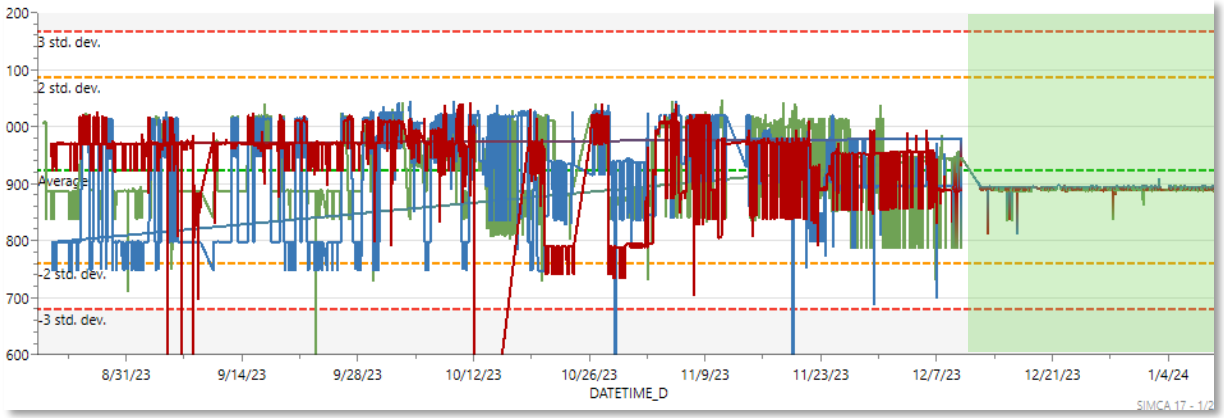


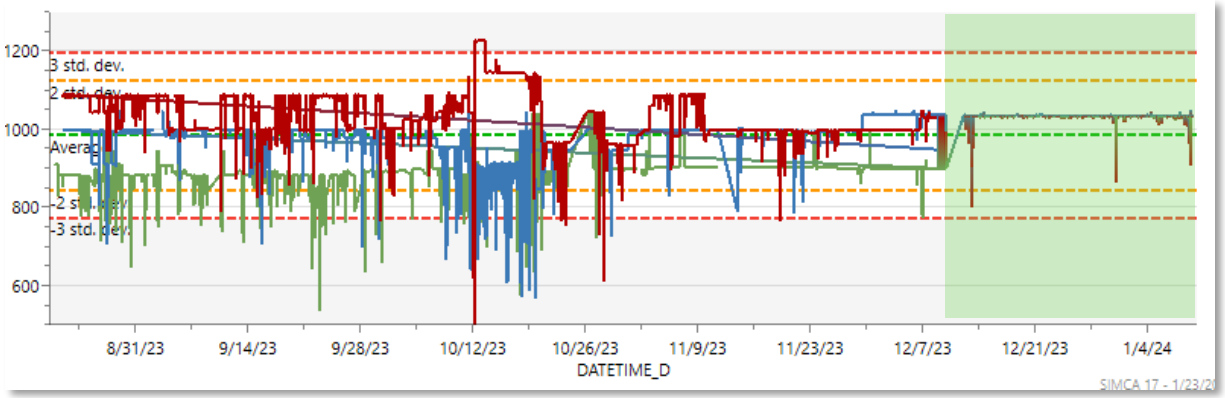


Albemarle Intelligence – Engineer Improvement Project









Increase in production rate

Quality Improvement

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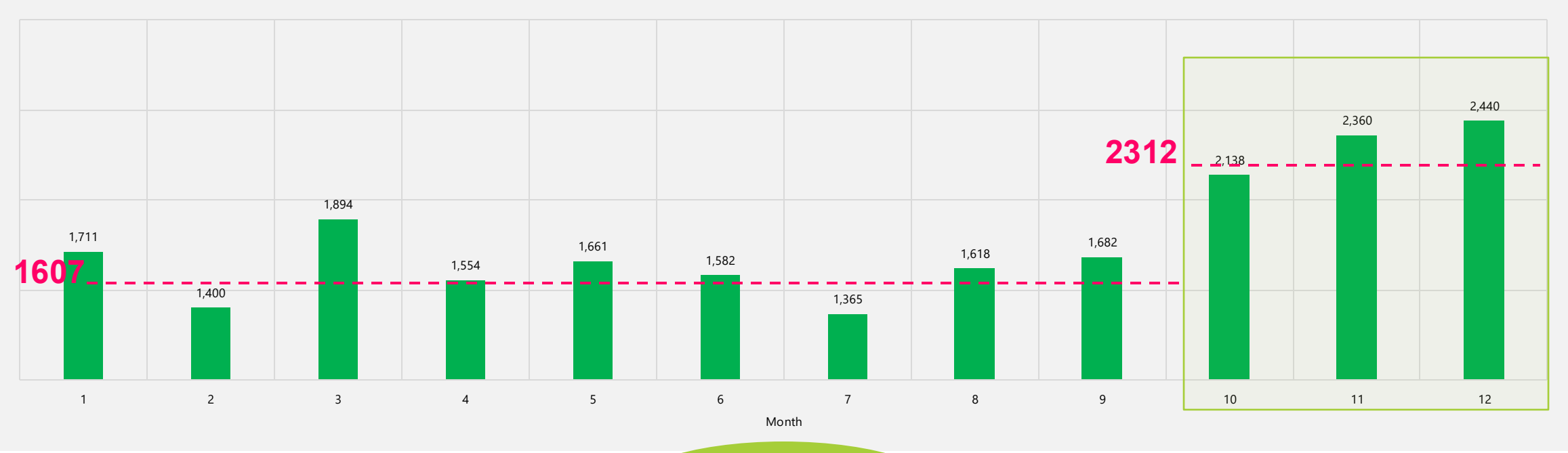

Increase in the monthly production

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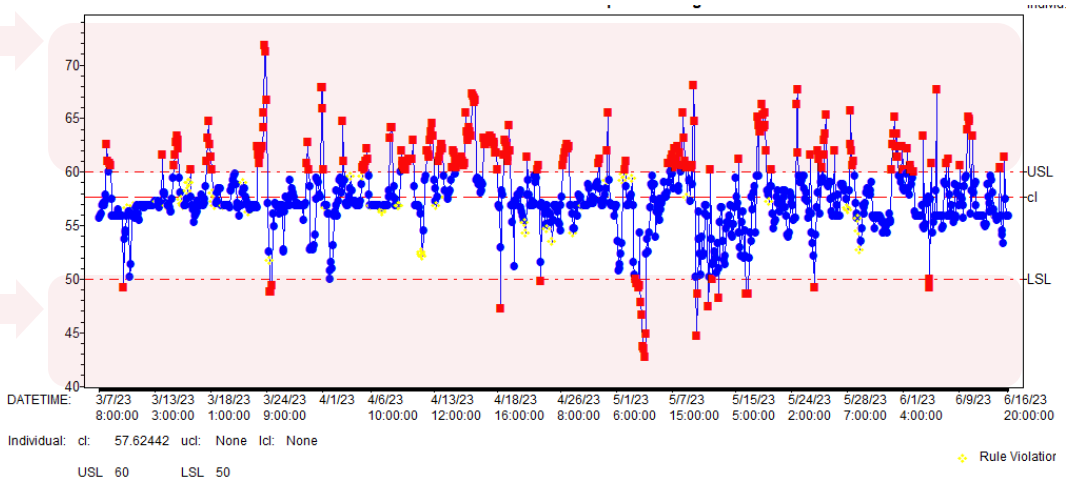
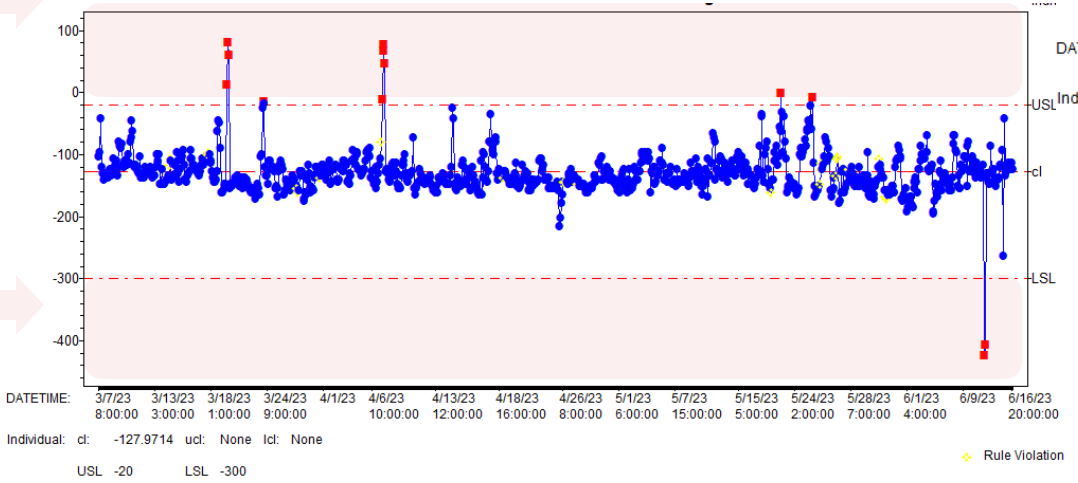
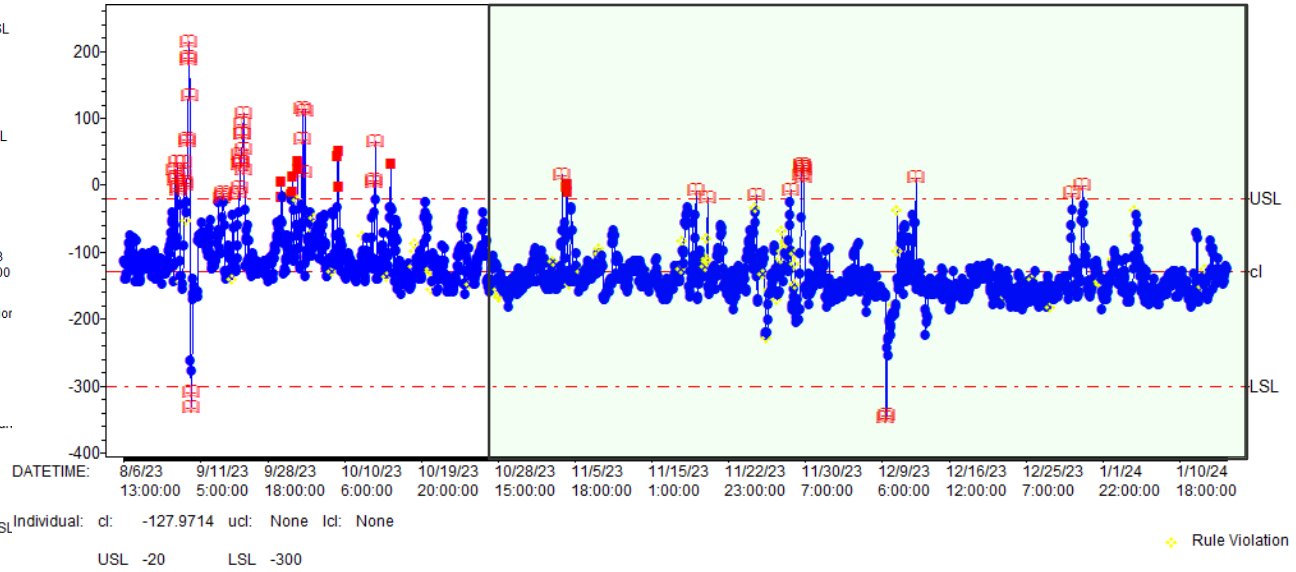
Opportunities







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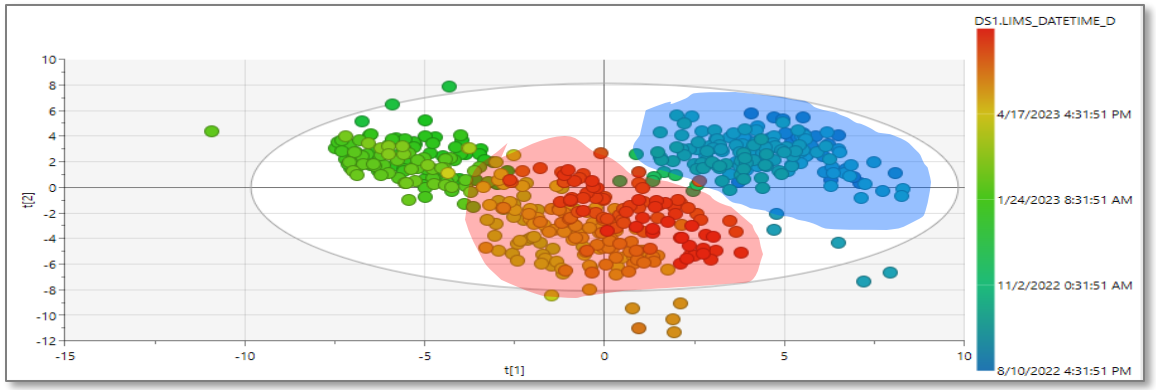

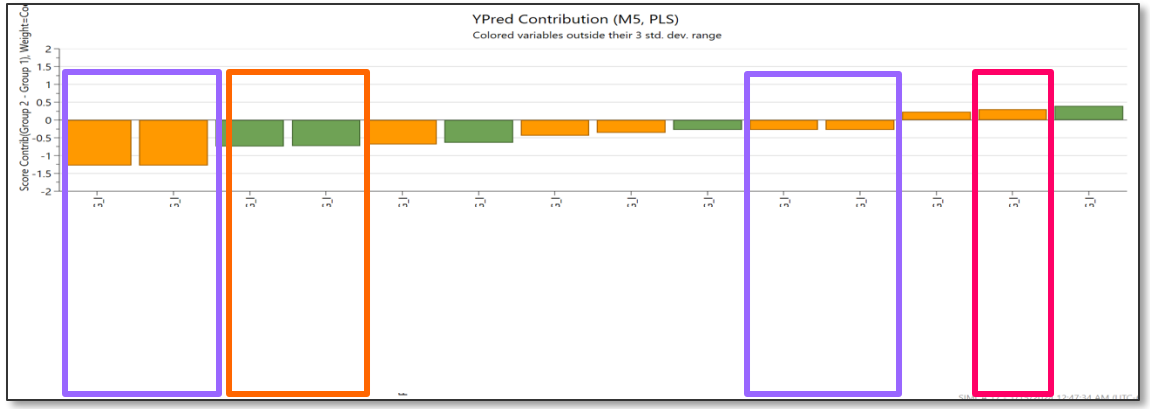

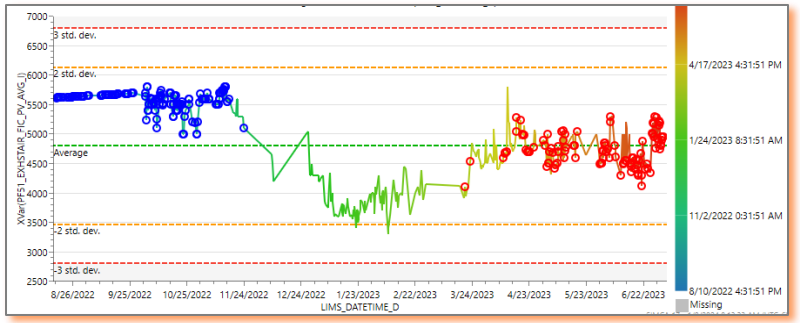

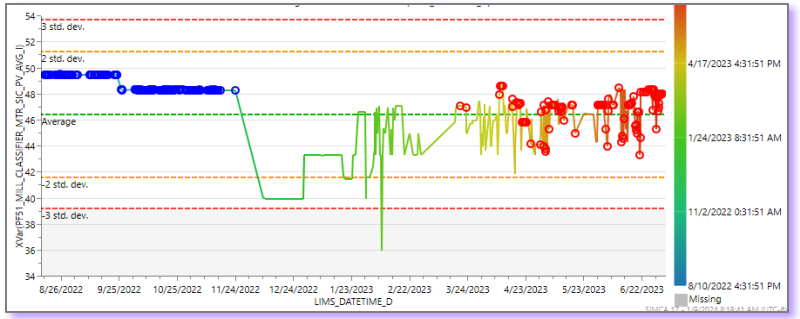

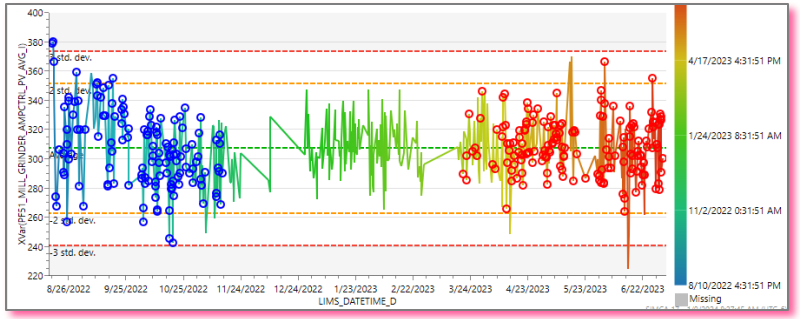

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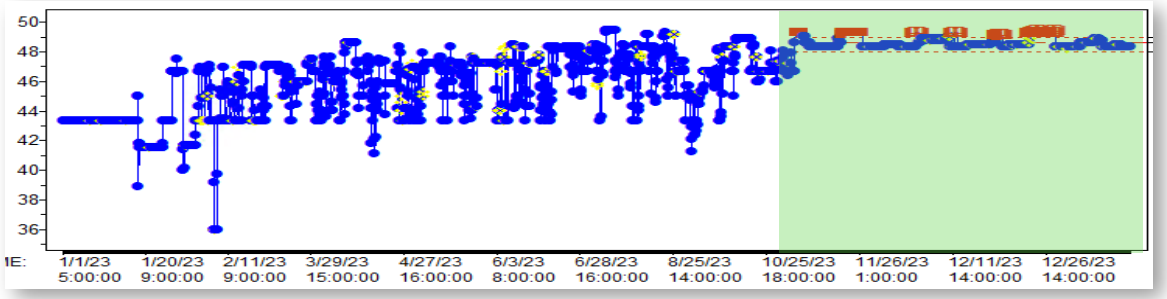
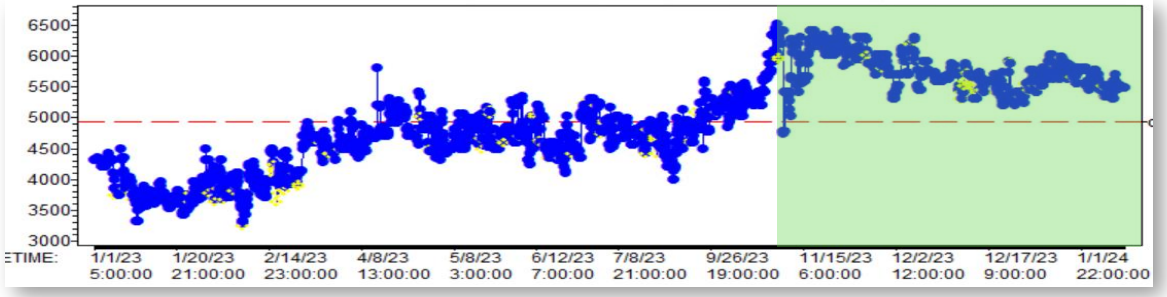
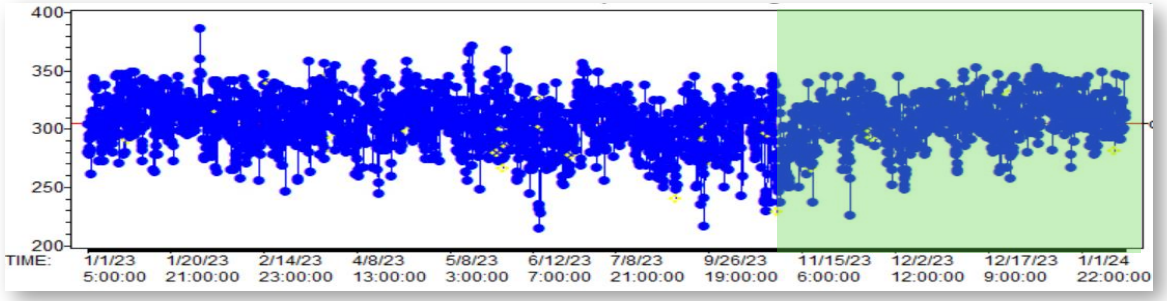
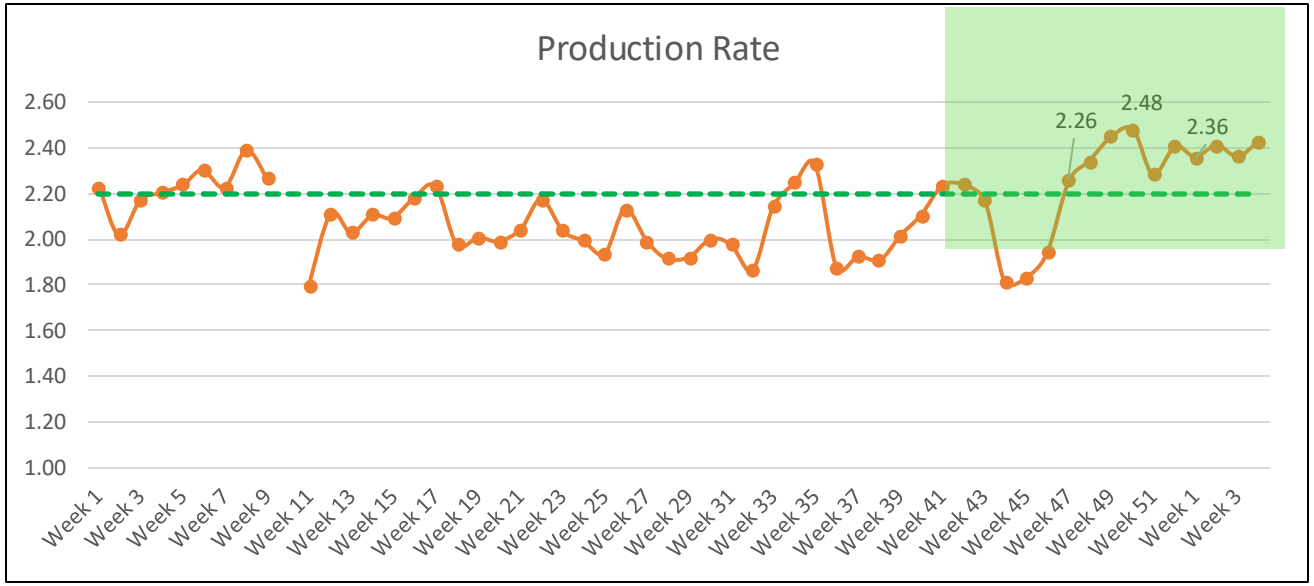
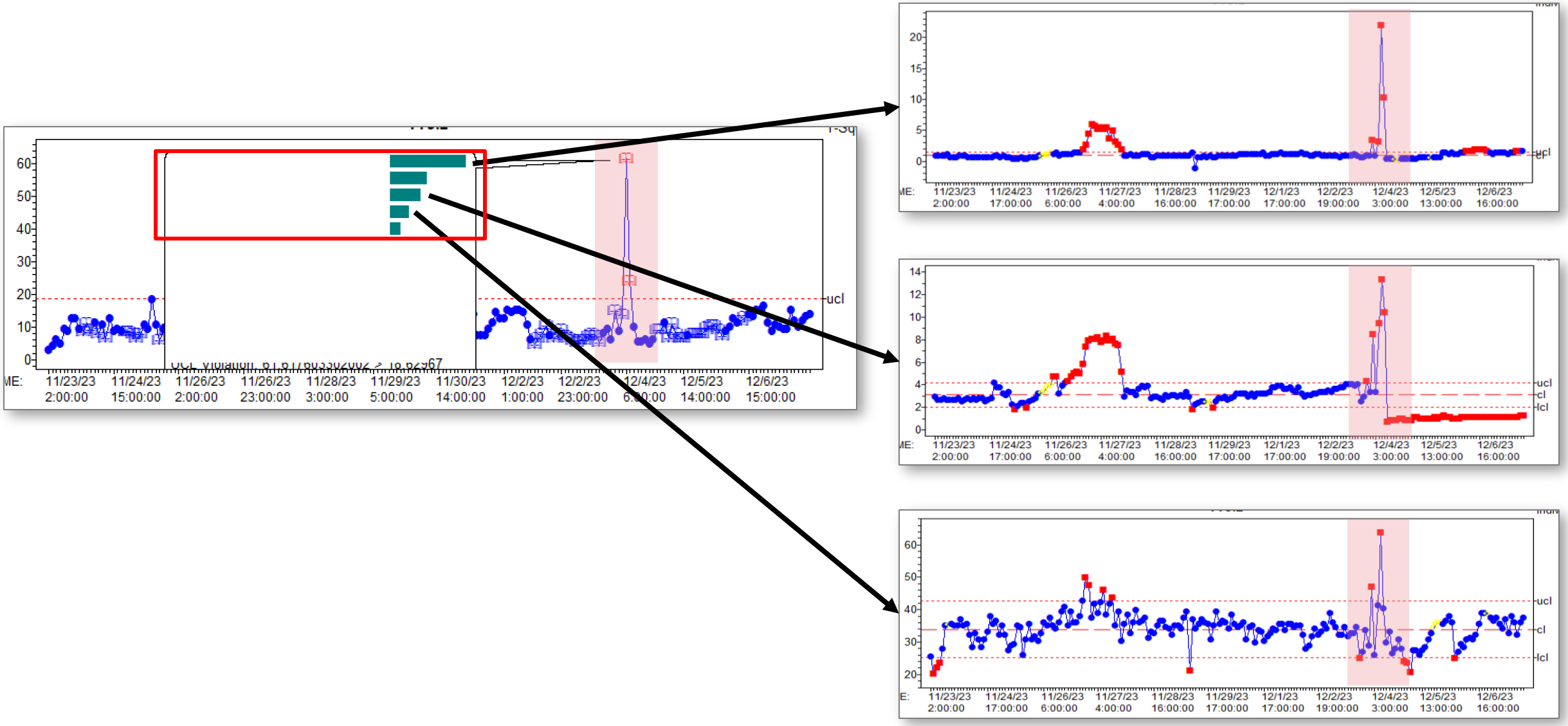




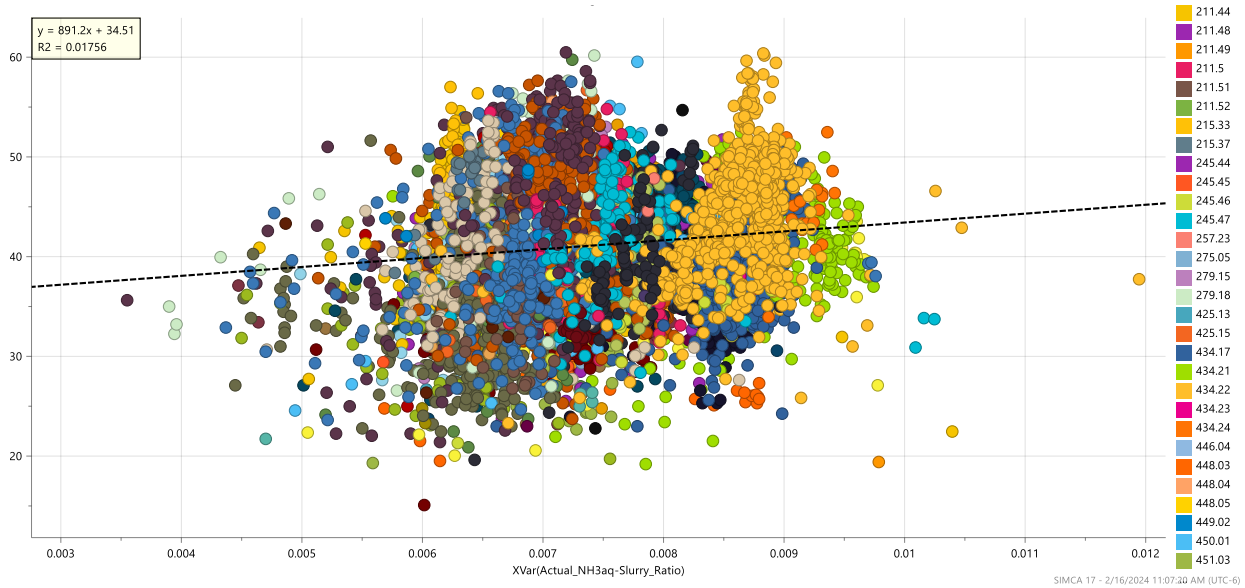


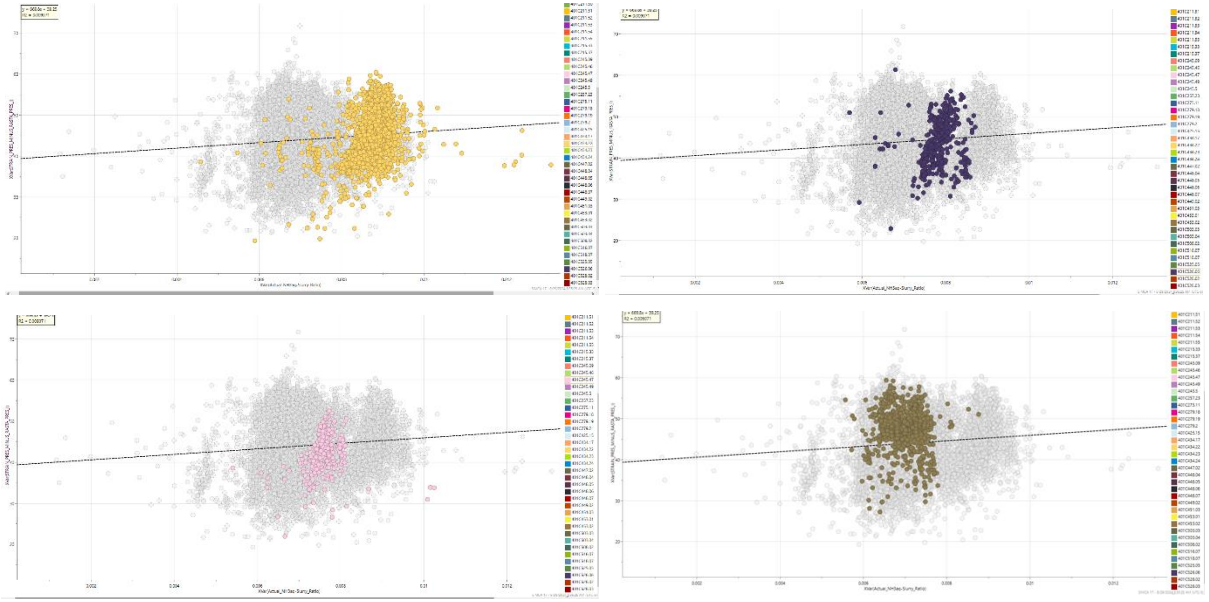


Albemarle Intelligence – Engineer Improvement Project



Albemarle Intelligence – Engineer Improvement Project



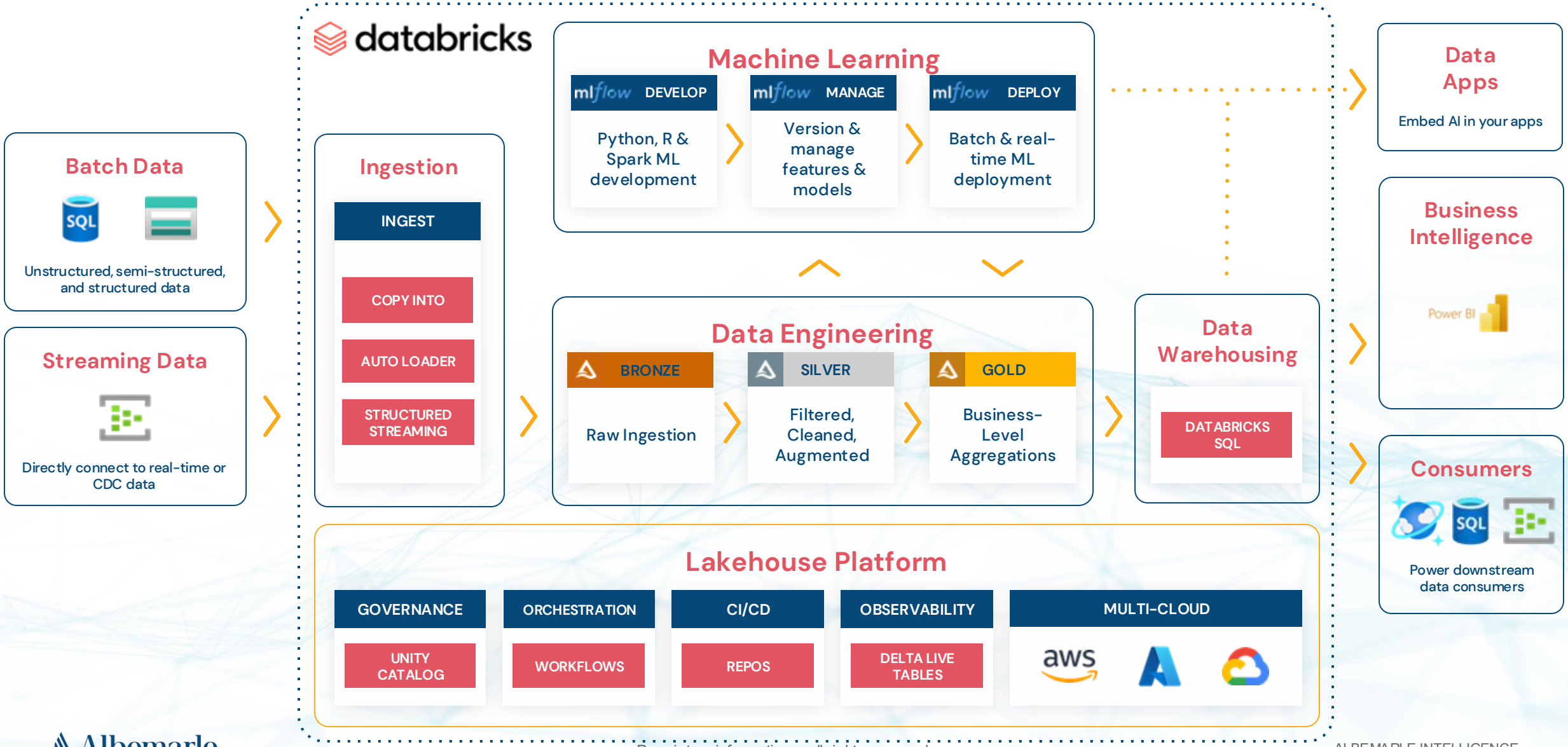


Reason #6

Fragmented Technology, Fragmented Results

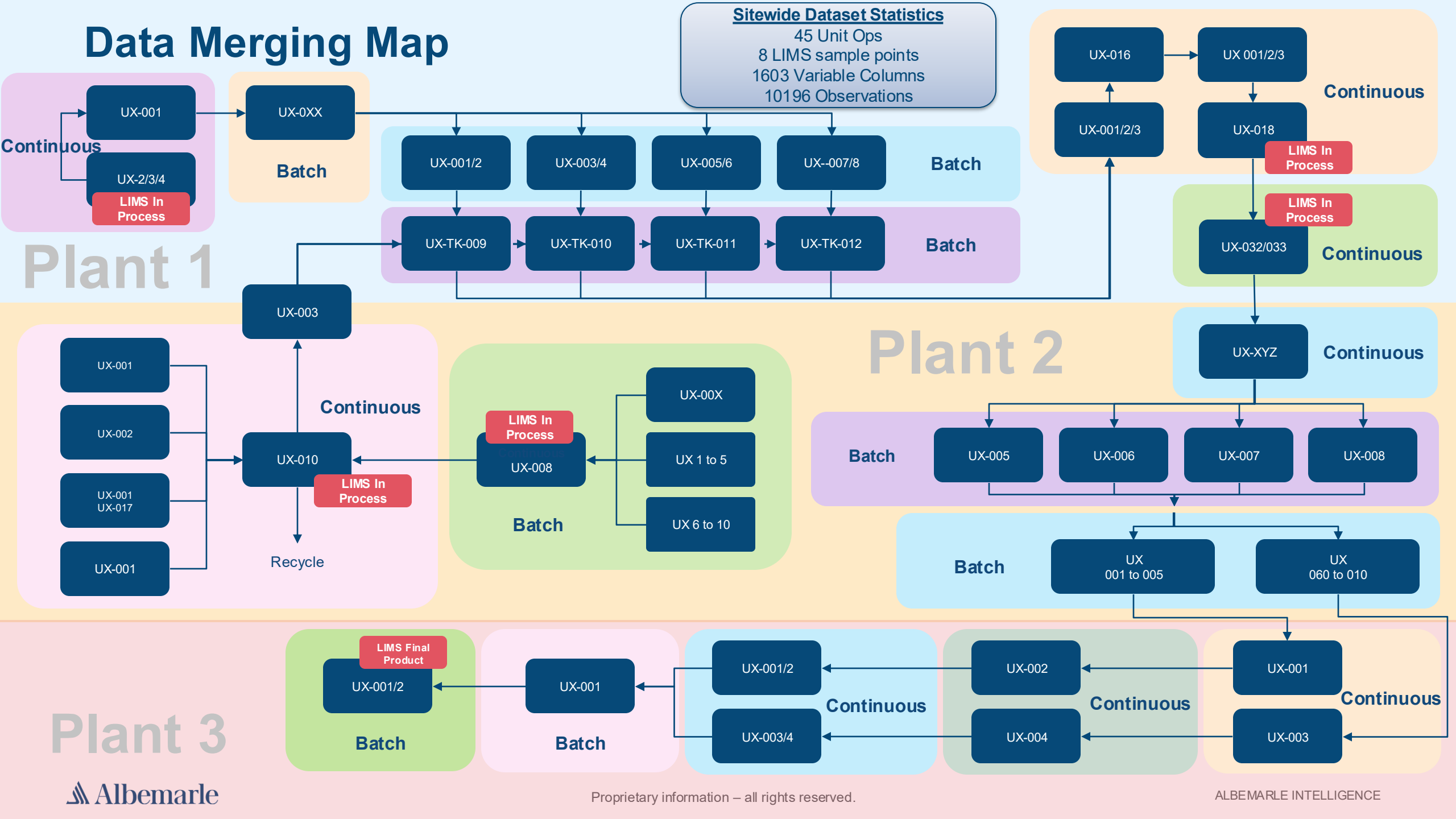
1	12/19/18 13:21:45	13691	1	606	304.1	80.0	2098	44.5	22	104	107	77	164.46	7149	6419.3	2.3	8847.334
2	12/19/18 19:31:45	13692	1	606	303.0	80.2	2048	44.5	23	101	136	77	164.01	7148	6360.6	2.3	8409.153
3	12/20/18 1:36:45	13693	1	607	303.7	81.4	2226	44.5	24	101	125	77	164.13	7149	6386.1	2.3	8478.928
4	12/20/18 7:45:45	13694	1	610	303.7	81.8	2316	44.5	25	98	132	77	164.01	7151	6327.4	2.3	8499.396
5	12/20/18 14:25:45	13695	1	610	*	109.1	2060	44.5	26	98	160	79	162.23	7150	6338.3	2.3	8611.963
6	12/21/18 7:50:45	13696	1	609	305.6	81.4	1227	45	27	108	148	80	162.42	7149	6447.5	2.3	8683.596
7	12/21/18 14:09:45	13697	1	606	304.9	82.7	2054	45	28	98	146	79	162.27	7151	6362.6	2.3	8832.448
8	12/21/18 20:24:45	13698	1	610	303.9	83.4	2061	45	29	97	144	80	162.08	7150	6406.9	2.2	7730.021
9	12/22/18 2:37:45	13699	1	610	303.2	81.2	*	45	30	97	67	80	162.21	7150	6440.3	2.2	8021.211
10	12/22/18 8:33:45	13700	1	611	303.7	80.9	2013	45	31	97	117	78	162.12	7150	6323.9	2.3	8285.421
11	12/23/18 3:43:45	13701	1	609	306.9	79.9	2140	45	32	107	67	80	162.38	7148	6525.2	2.3	7762.682
12	12/23/18 10:00:45	13702	1	606	303.7	80.9	2176	45	33	98	137	81	162.26	7149	6197.5	2.2	6291.748
13	12/23/18 16:50:45	13703	1	611	306.2	85.1	2064	45	34	96	137	82	162.29	7151	6414.4	2.2	7566.285
14	12/23/18 22:54:45	13704	1	*	311.6	81.9	2048	45	35	102	126	74	162.70	7152	6028.4	2.3	10093.03
15	12/24/18 7:31:45	13705	1	602	309.4	81.4	2090	45	36	94	286	71	162.48	7155	5982.3	2.4	11320.12
16	12/24/18 14:37:45	13706	1	545	309.5	84.2	2043	45	37	95	183	74	161.79	7157	5706.0	2.3	11832.73
17	12/24/18 20:33:45	13707	1	603	312.2	85.8	2068	45	38	99	105	79	162.27	7153	6245.2	2.2	9536.7
18	12/25/18 2:46:45	13708	1	603	309.8	82.2	2056	45	39	94	119	79	162.32	7156	5918.0	2.2	11451.3
19	12/25/18 10:40:45	13709	1	603	310.2	81.5	1877	45	40	96	244	72	162.21	7153	6043.8	3.0	11545.26
20	12/25/18 17:26:45	13710	1	602	312.4	85.1	2055	45	41	96	167	77	162.22	7154	6183.0	2.9	10347.01
21	12/26/18 0:00:45	13711	1	609	309.1	84.7	2022	45	42	96	168	80	158.78	7151	6091.4	2.8	9602.66
22	12/26/18 6:03:45	13712	1	609	309.7	83.9	2146	45	43	94	139	72	158.67	7158	5912.0	2.8	11360.13
23	12/26/18 12:55:45	13713	1	603	312.7	83.9	2022	46	44	99	173	79	162.28	7153	6170.2	2.8	9911.619
24	12/26/18 19:22:45	13714	1	605	307.8	85.4	2051	46	45	98	137	81	162.18	7150	6102.3	2.9	7056.47
25	12/27/18 1:04:45	13715	1	606	308.3	84.7	1971	46	46	100	111	81	162.26	7150	6211.3	2.9	7109.456
26	12/27/18 6:46:45	13716	1	606	308.8	83.8	2158	46	47	101	109	80	162.03	7149	6233.1	2.9	8123.546
27	12/27/18 12:44:45	13717	1	609	313.8	84.4	2019	46	48	106	112	80	161.58	7147	6333.8	2.9	8759.883
28	12/27/18 18:53:45	13718	1	603	307.8	84.7	1897	46	49	104	130	78	161.39	7149	6197.8	2.8	8932.923
29	12/28/18 0:59:45	13719	1	602	307.0	85.2	2097	46	50	104	128	79	161.53	7150	6237.0	2.9	9011.07
30	12/28/18 7:06:45	13720	1	602	309.8	85.0	2012	46	51	103	130	78	161.62	7151	6163.3	2.7	9939.628
31	12/28/18 16:17:45	13721	1	598	308.8	85.6	1937	46	52	118	288	85	161.21	7151	5904.8	2.7	9986.976
32	12/28/18 22:40:45	13722	1	597	312.8	86.3	1953	46	53	120	120	85	161.08	7151	6000.9	2.9	10469.81
33	12/29/18 5:20:45	13723	1	598	307.0	85.0	1852	46	54	117	130	83	161.17	7151	6356.3	2.7	9537.63
34	1/1/19 19:03:45	13725	3	565	307.9	86.4	2031	46	56	108	438	56	160.53	7148	6567.6	2.9	10104.2
35	1/12/19 2:10:45	13726	1	569	300.7	87.9	1967	46	57	118	166	86	160.92	7150	6329.3	2.8	7185.794
36	1/12/19 8:16:45	13727	1	577	305.3	85.4	1966	46	58	117	109	84	160.97	7151	6336.5	2.8	10049.31
37	1/12/19 15:52:45	13728	1	602	303.1	83.5	1944	46	59	117	152	82	160.99	7148	6277.2	2.8	8655.588
38	1/12/19 21:23:45	13729	1	602	306.0	84.0	1797	46	60	118	126	85	160.93	7148	6433.7	2.9	9941.989
39	1/13/19 4:11:45	13730	1	605	302.9	82.6	1735	46	61	119	156	83	160.85	7144	6283.6	2.9	8946.879
40	1/13/19 10:39:45	13731	1	602	303.4	83.6	2006	46	62	118	132	83	160.97	7147	6282.8	2.7	9694.954
41	1/13/19 17:18:45	13732	1	603	302.9	82.5	1946	46	63	116	124	80	160.97	7147	6046.4	2.8	9181.318
42	1/13/19 23:45:45	13733	1	602	304.9	83.1	2076	46	64	119	122	81	160.89	7146	6236.6	2.9	9758.116
43	1/14/19 6:23:45	13734	1	602	303.3	83.5	2041	46	65	117	140	80	160.99	7147	6148.1	2.9	9389.709
44	1/14/19 12:50:45	13735	1	602	303.7	83.9	2025	46	66	117	136	81	161.01	7147	6171.1	2.9	9540.422
45	1/14/19 19:23:45	13736	1	602	304.3	83.9	2013	46	67	118	136	82	161.03	7147	6187.4	3.0	9624.605
46	1/15/19 1:47:45	13737	1	602	305.9	83.6	2004	46	68	120	120	82	161.73	7146	6279.8	2.9	9932.086
47	1/15/19 8:09:45	13738	1	603	309.9	83.7	1977	46	69	121	121	82	161.88	7146	6287.2	2.9	9844.636
48	1/15/19 14:26:45	13739	1	602	312.1	83.6	1990	46	70	119	124	81	161.91	7147	6095.9	2.4	10440.04

Azure Databricks Lakehouse Architecture



Data Merging Map

Sitewide Dataset Statistics
45 Unit Ops
8 LIMS sample points
1603 Variable Columns
10196 Observations



Albemarle

ALBEMARLE INTELLIGENCE

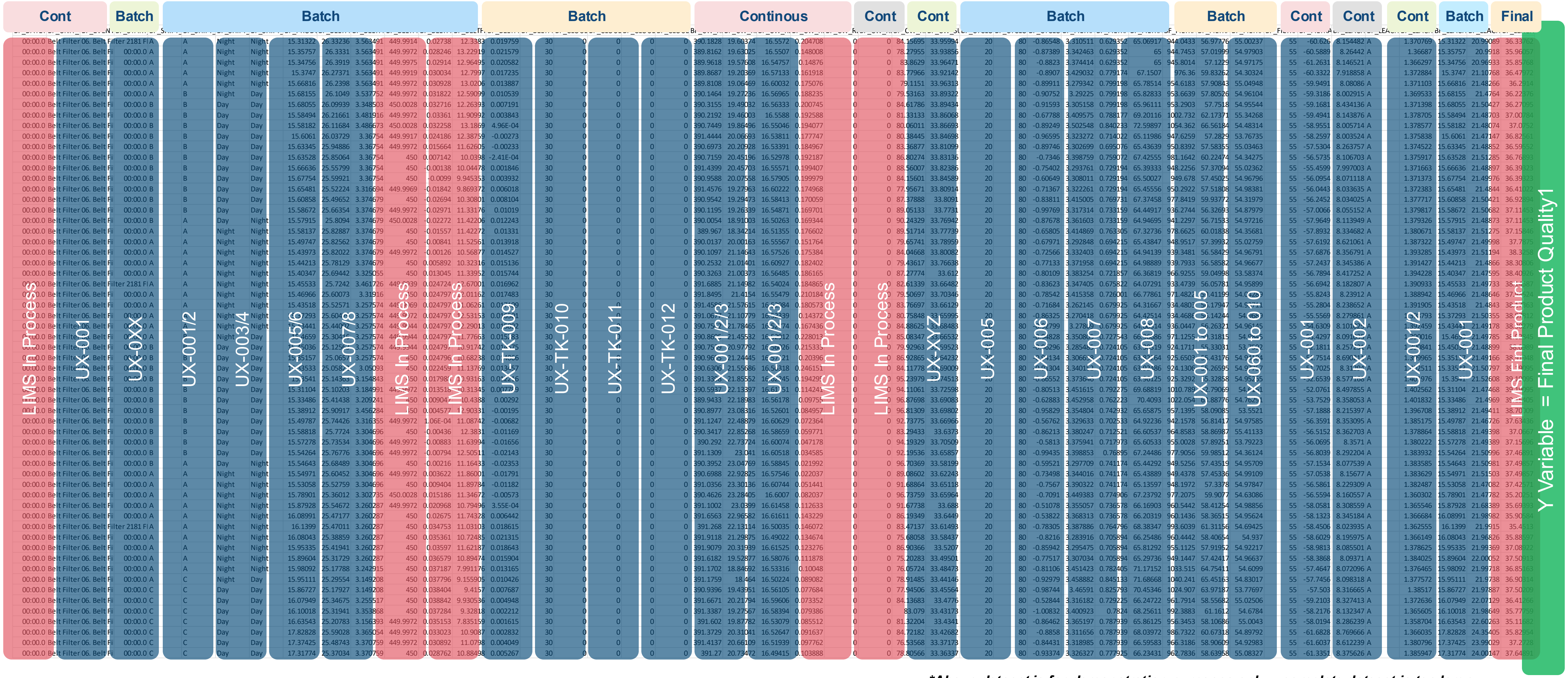
Sitewide Data Merging Map

PIAF Dataset

LIMS Dataset

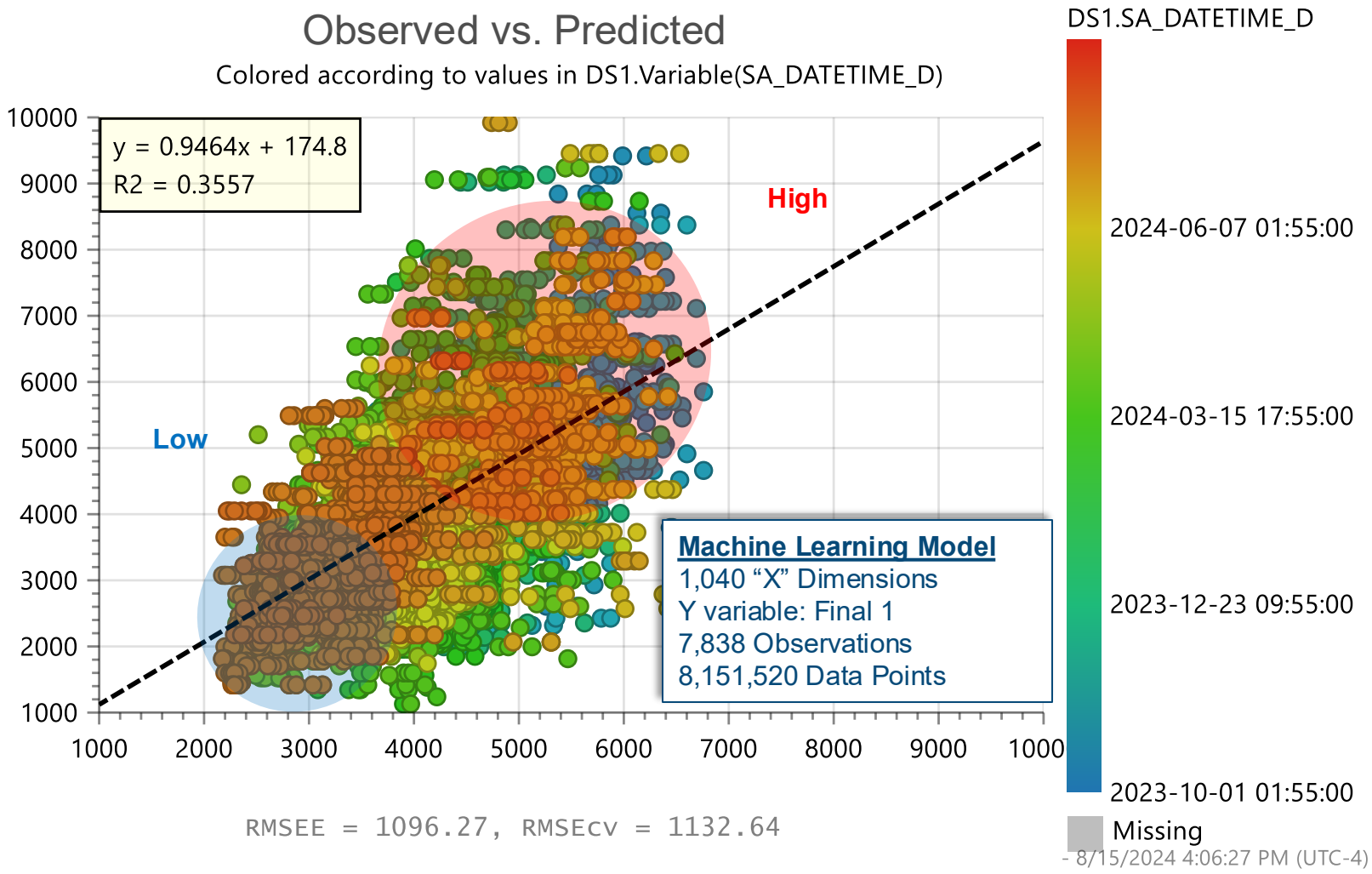
Sitewide Dataset Statistics
45 Unit Ops
8 LIMS sample points
1603 Variable Columns
10196 Observations

Each row represents the same material passing through the plant as it travels through each unit and sample point.

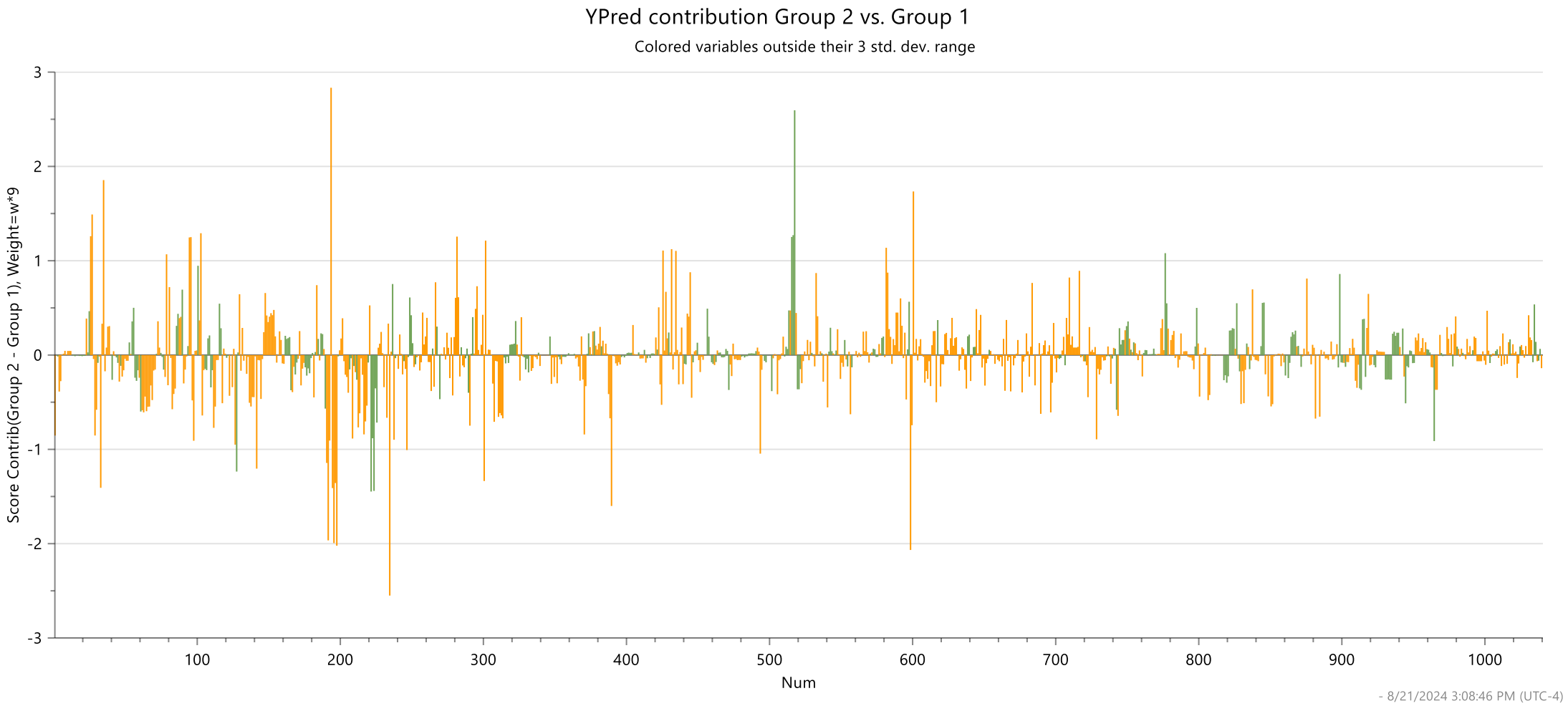


**Above dataset is for demonstration purposes only – complete dataset is too large*

Machine Learning Predictive Modeling – Quality Parameter 1



Machine Learning Predictive Modeling – Quality Parameter 1



Modern Machine Learning for Time Series – XGBoost

databricks

Feature Importance (Python)

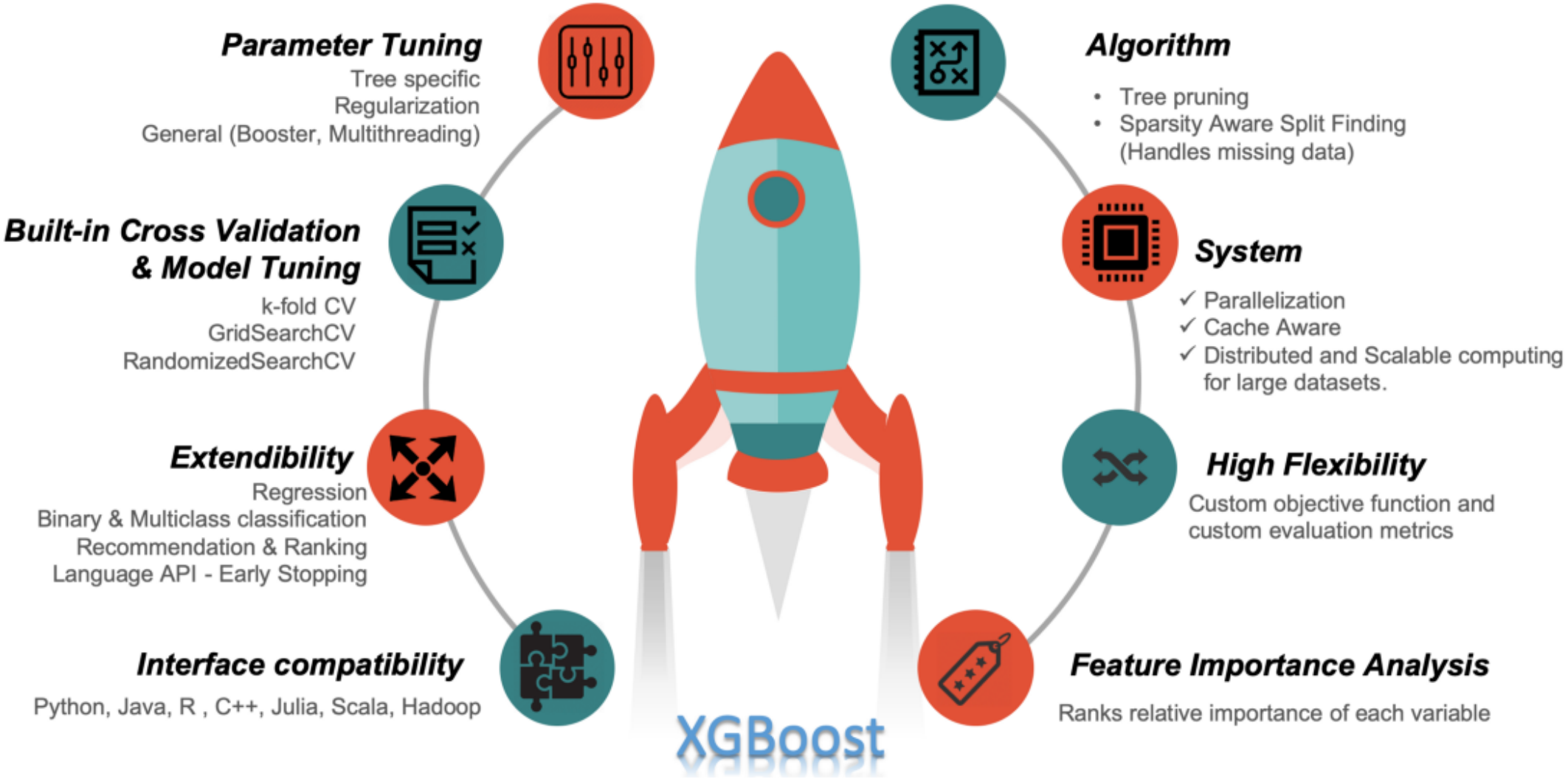
Import Notebook

1

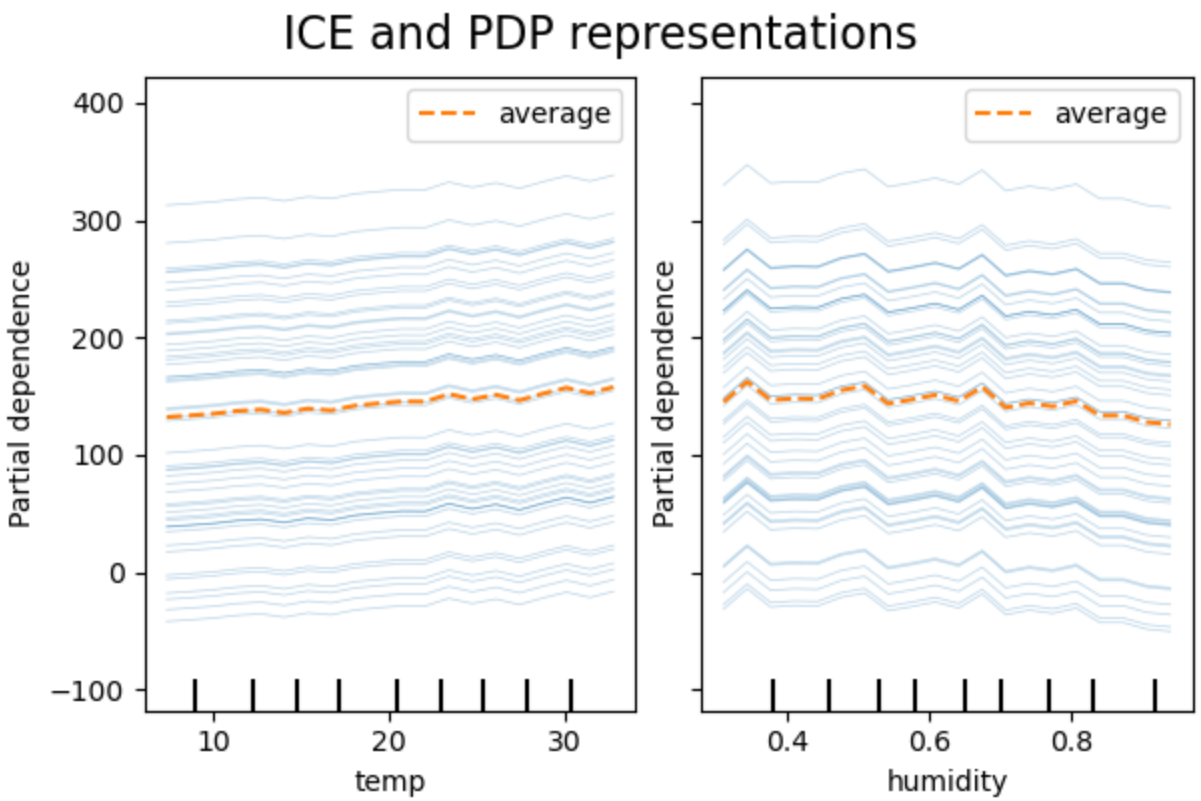
```python
from pyspark.sql import SparkSession
from pyspark.sql.functions import col
from pyspark.sql.types import NumericType
import pandas as pd
import numpy as np
!pip install networkx
import networkx as nx
import warnings
warnings.filterwarnings("ignore")
%pip install xgboost
from sklearn.ensemble import IsolationForest
from sklearn.impute import SimpleImputer
import xgboost as xgb
from sklearn.model_selection import train_test_split, cross_val_score, KFold
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import make_scorer, mean_squared_error
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import RobustScaler
```

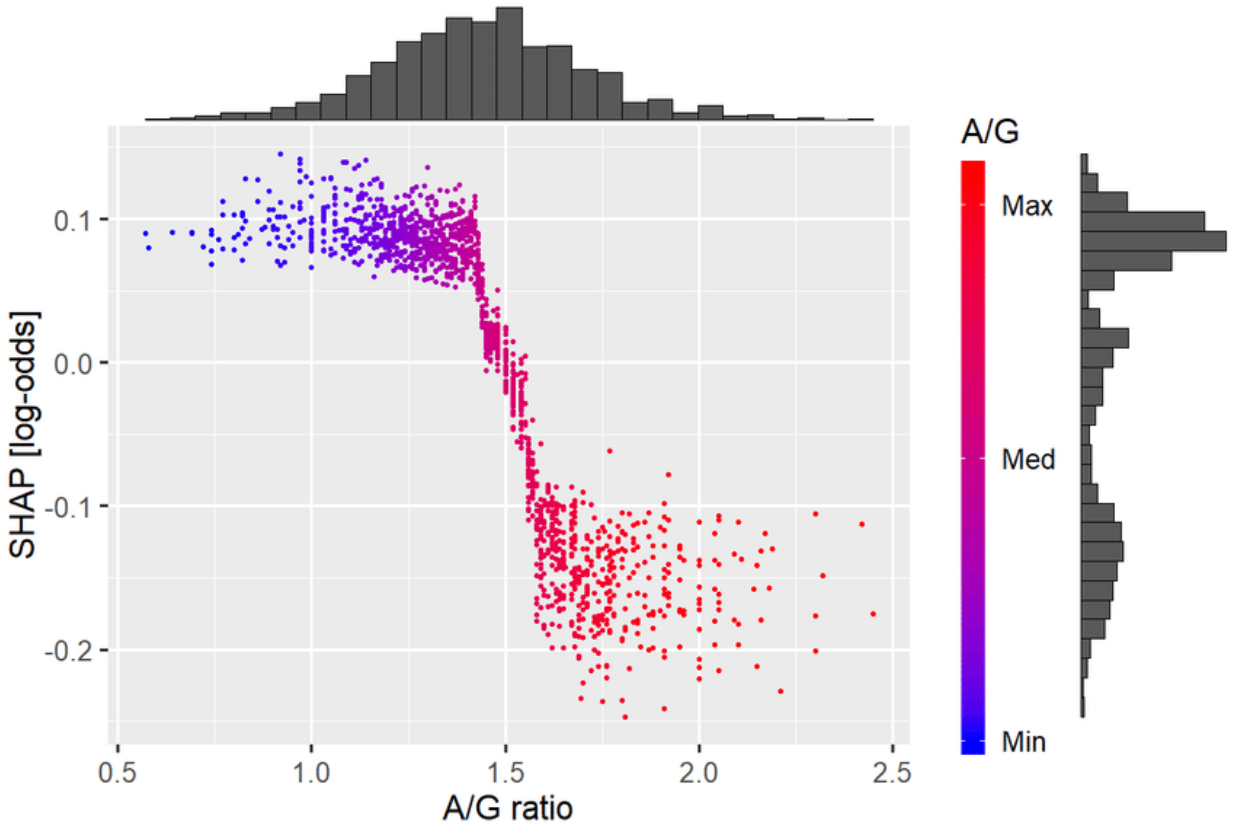
```python
# Drop rows with NaN values in the target column from the original dataframe before splitting
df_filtered_zn_clean = df_filtered_zn.dropna(subset=[target_column])

X = df_filtered_zn_clean.drop(target_column, axis=1)
y = df_filtered_zn_clean[target_column]

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

xgb_model = xgb.XGBRegressor(missing=None, random_state=42)
kf = KFold(n_splits=5, shuffle=True, random_state=42)
mse_scorer = make_scorer(mean_squared_error, greater_is_better=False)
cv_scores = cross_val_score(xgb_model, X_train, y_train, cv=kf, scoring=mse_scorer)


xgb_model.fit(X_train, y_train)
```

Modern Machine Learning for Time Series – XGBoost

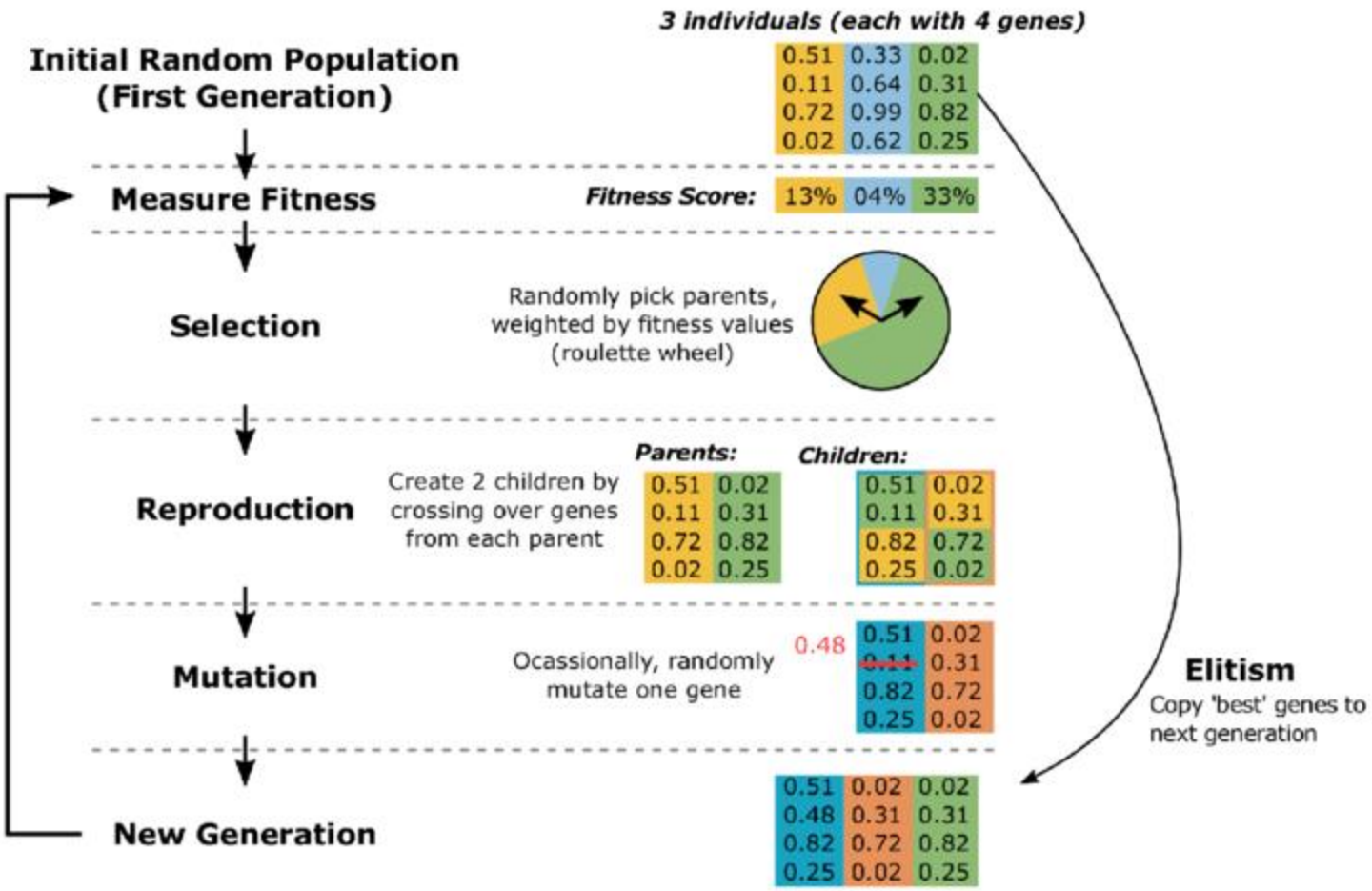


XGBoost Optimization – SHAP & Partial Dependency





Optimization – NSGA II Genetic Algorithms

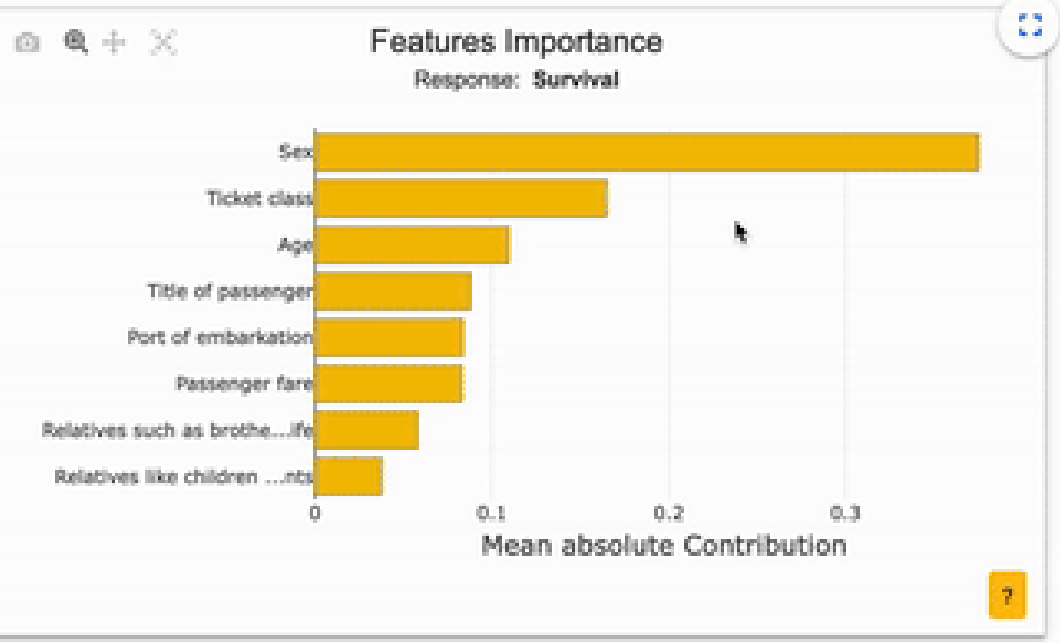


Shapash Monitor

Titanic - Binary classification

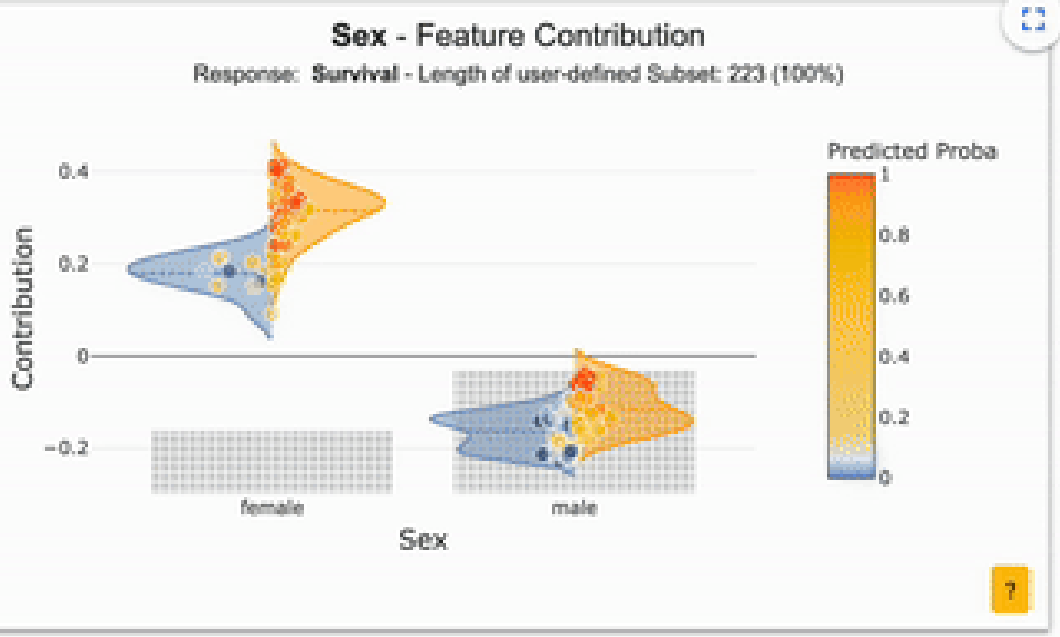
Classification

Class: Survival



Dataset | Dataset Filters | True Values Vs Predicted Values

index	_predict_	target_	Age	Embarked	Fare	Parch	Pclass	Sex
10	1	1	14	Cherbourg	30.1	0	Second class	female
14	0	0	39	Southampton	31.3	5	Third class	male
16	1	1	55	Southampton	16	0	Second class	female
21	0	0	35	Southampton	26	0	Second class	male
23	1	1	15	Queenstown	8	0	Third class	female
27	0	0	29.5	Cherbourg	7.2	0	Third class	male
35	1	0	28	Cherbourg	82.2	0	First class	male
47	0	0	29.5	Queenstown	15.5	0	Third class	male
49	1	0	29.5	Cherbourg	21.7	0	Third class	male
51	0	0	7	Southampton	39.7	1	Third class	male
54	1	1	29	Southampton	26	0	Second class	female



Select a valid single sample to display Local Explanation plot.

index

Threshold: 0

0

Features to display: 8

1 4 8

Contributions to display:

Positive Negative

Feature(s) to mask:

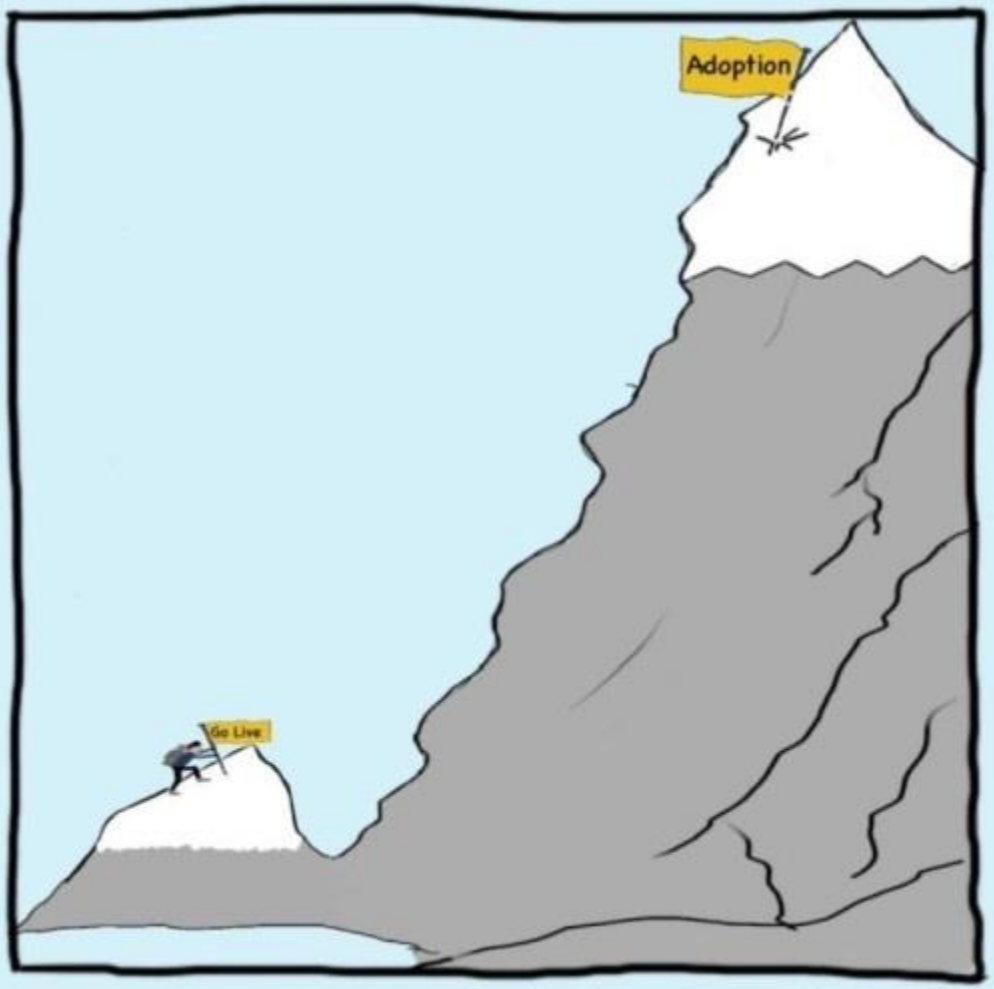
Select...


AI
TECHNOILOGY

Reason #7


Success
Doesn’t End at
Launch


GO LIVE


Adoption
Go Live

Implementation Roadmap

3 Months

Discovery & Installation

Discovery
- Resources
- Data Quality
- Infrastructure

Hardware
- Servers
- IT Security

Enterprise Software
- OSIsoft PI
- Analytics

3 Months

Prework & Training

Prework
- Business Case
- AF Hierarchy
- Process Flow Diagrams
- P&IDs

Training
- OSIsoft PI
- Analytics

3 Months

Sprints

Organize Process Data
- PI Asset Framework

Custom Process Analytics
- PI Analytics
- PI Event Frames

Automated Datasets
- Analytics Datasets
- SQL

Actionboard Configuration
- Real-Time SPC & SQC

1 Month

Process Optimization Academy & Go Live

Process Optimization Academy
- High Level Software Training
- Practice on Albemarle data
- DMAIC Six Sigma Improvement Methodology
- Improvement Brainstorming
- Change Management

Go Live
- Commissioning of Actionboards in Control Room
- New Roles & Responsibilities

3 - 6 Months

Operation AI

Improvement Projects
- Site Engineers use AI tools to drive site Improvements
- Priorities set by site Leadership
- Continuous Improvement

Actionboards
- Continuous Improvement in the Control Room
- Bringing Actionable Analytics to the Shop Floor

ALBEMARLE INTELLIGENCE

Actionboard Executive Summary

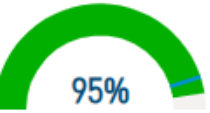
Month Selection for Gauges: Jan 2025

Actionboard: All

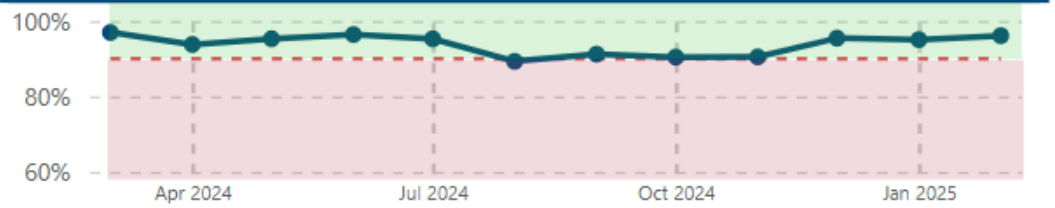
Range Selection for Charts: Last 12 Months

Phase: All

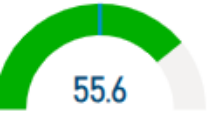
% Usage



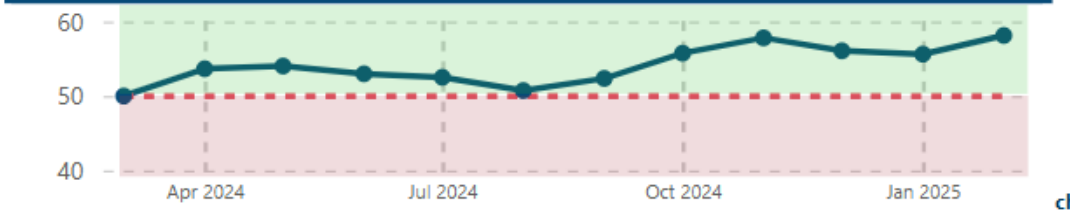
Percent of alarms that were acknowledged on the Actionboard | Target > 90%



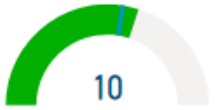
Response Quality



Avg # of characters in comments. Longer comments have more details and are more valuable | Target > 50

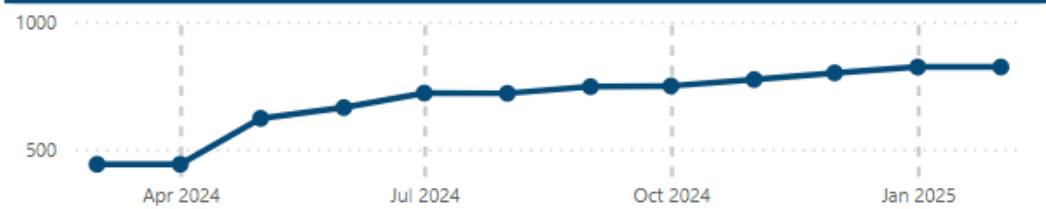


Increased Coverage Over Time

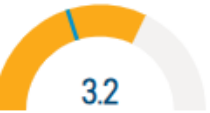


change over past month

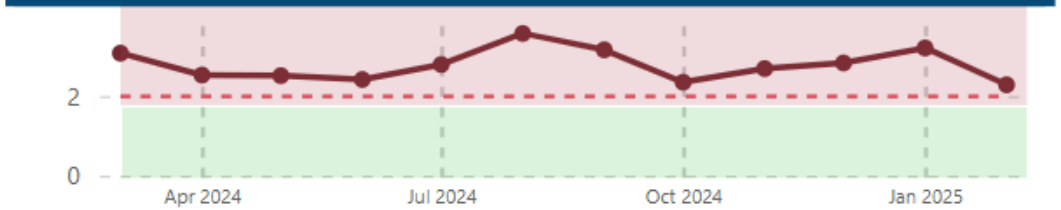
Count of charts with alarm over past month | Target > 5 additional charts per month



Response Hours

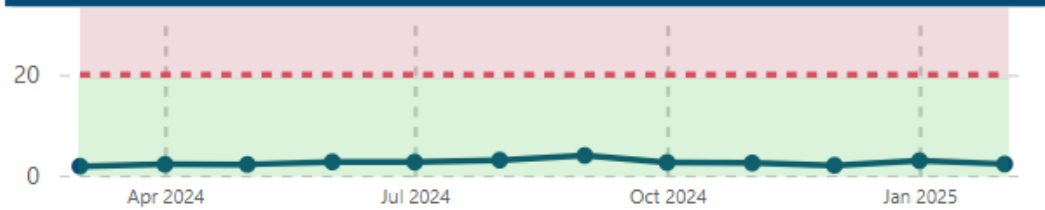


Average time from when the alarm appears on the actionboard until it has been responded to | Target < 2

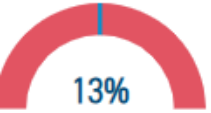


Insights per Hour

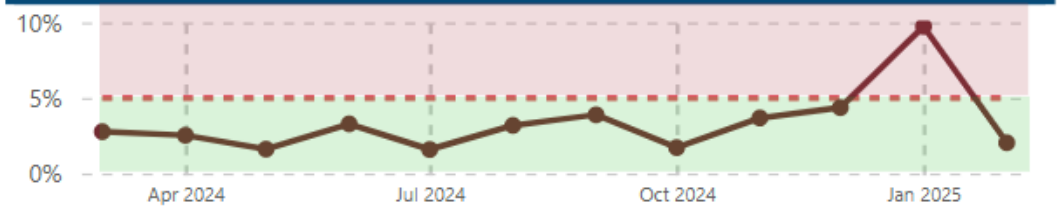
Average number of insights generated per hour | Target < 20



% Nuisances

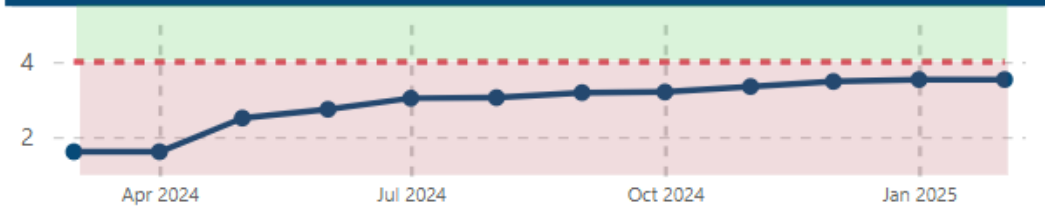


Percent of Nuisance alarms, as selected by operator | Target < 5%

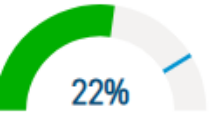


Unit Op Coverage

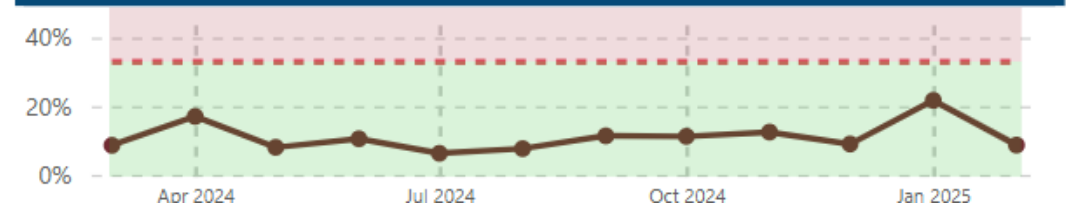
Total # of charts with alarms enabled divided by # of unit ops on the actionboards | Target > 4



% No Action

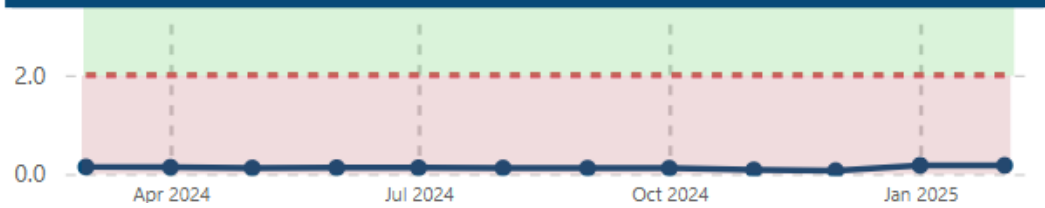


Percent of insights with no Corrective Action | Target < 33%



SPC Alarms per UnitOp

Total # of charts with SPC alarms enabled divided by # of unit ops on the actionboards | Target > 2



Reason #8


If You Build it,
They Won't
Come

Digital Transformation Framework

The key elements to modernize your business

Leadership & Vision

Having a clear vision for the digital transformation journey and effectively communicating it to all employees

Digital Skills & Training

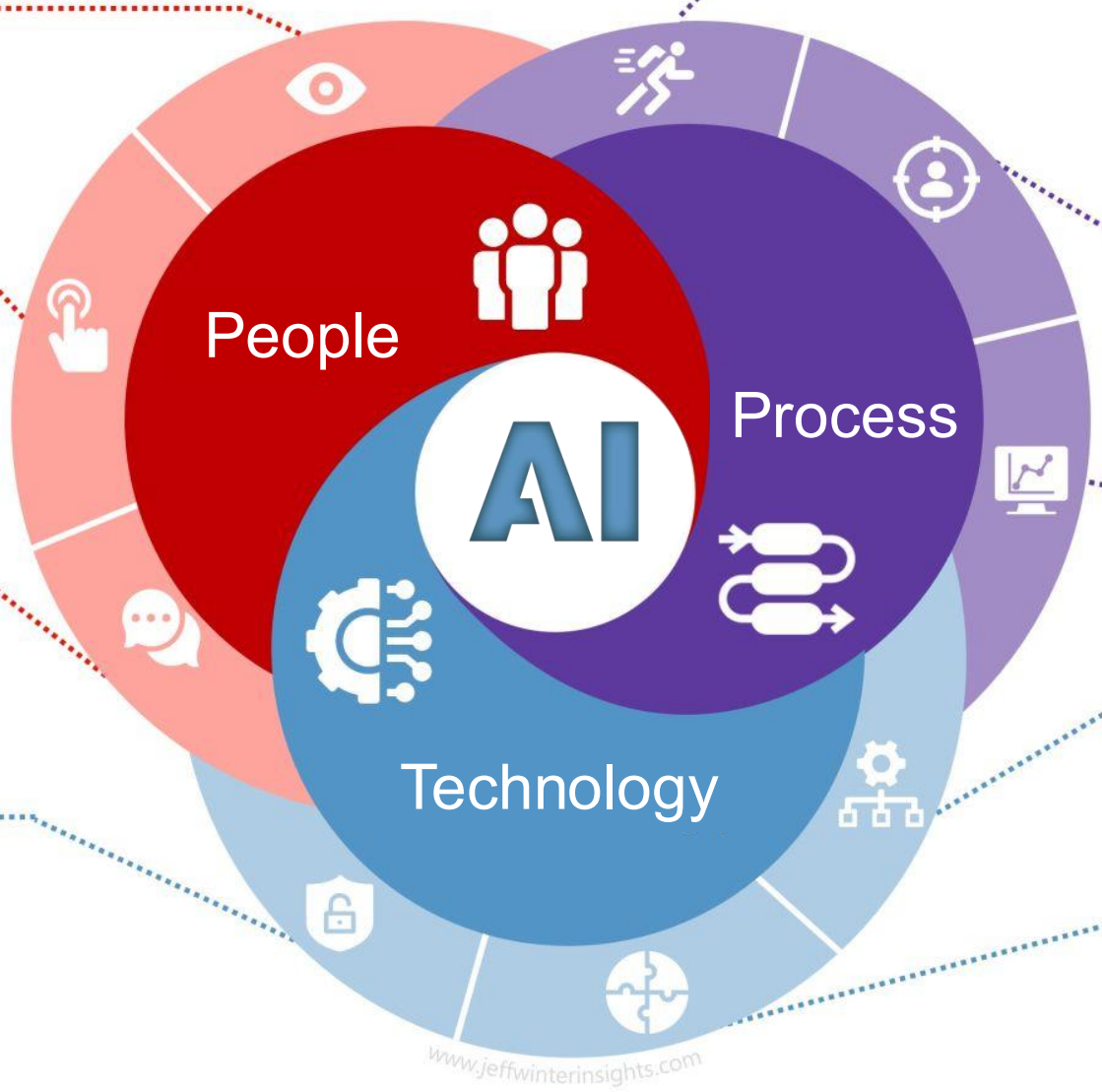
Equipping the employees with the necessary digital skills to navigate new technologies and tools

Collaboration & Communication

Fostering the right culture by breaking down silos, encouraging cross-functional teams, and facilitating knowledge sharing across the organization

Cybersecurity

Implementing strong cybersecurity measures to protect data, systems, and networks from potential attacks



Agile Methodologies

Implementing iterative and incremental approaches to project management and product development to be nimbler and more responsive to change

Customer-Centricity

Adopting a design thinking approach and continuously seeking feedback from customers

Data-Driven Decision-Making

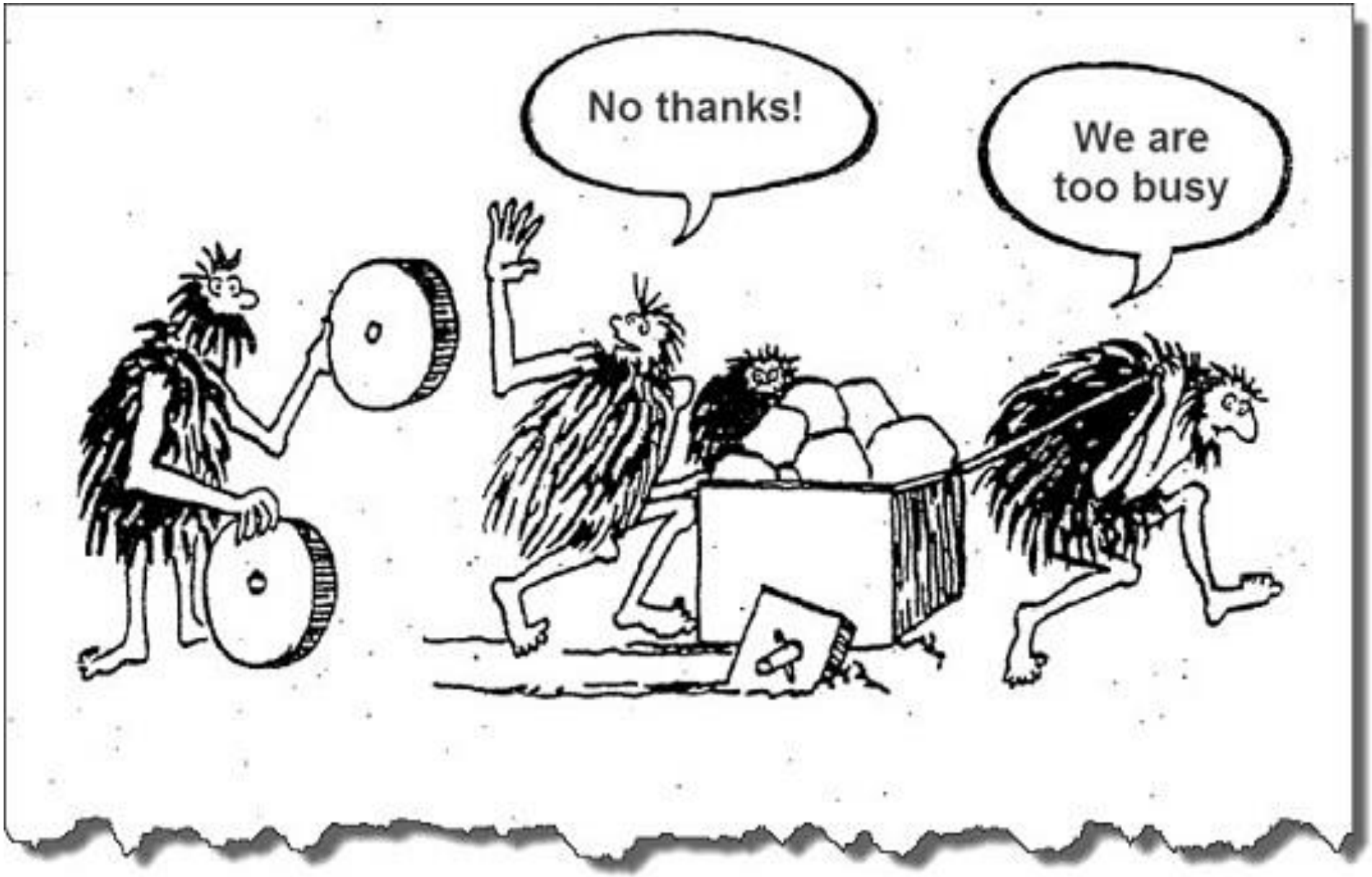
Leveraging data and analytics as an integral part of decision-making processes

Infrastructure

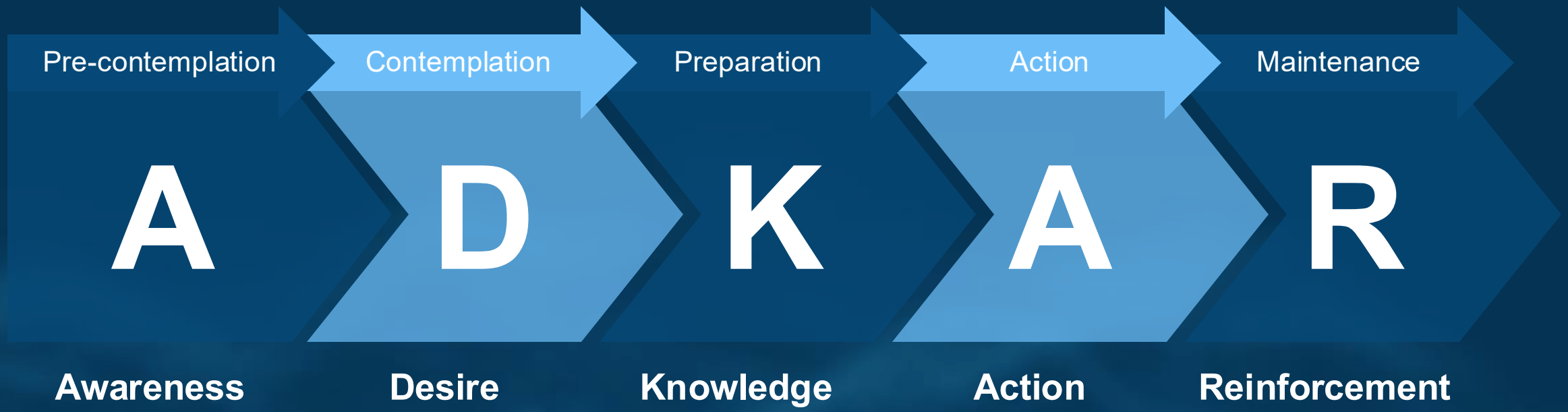
Investing in a robust and scalable digital infrastructure that can support the organization's needs

Integration

Ensuring seamless integration of different systems and platforms across business functions

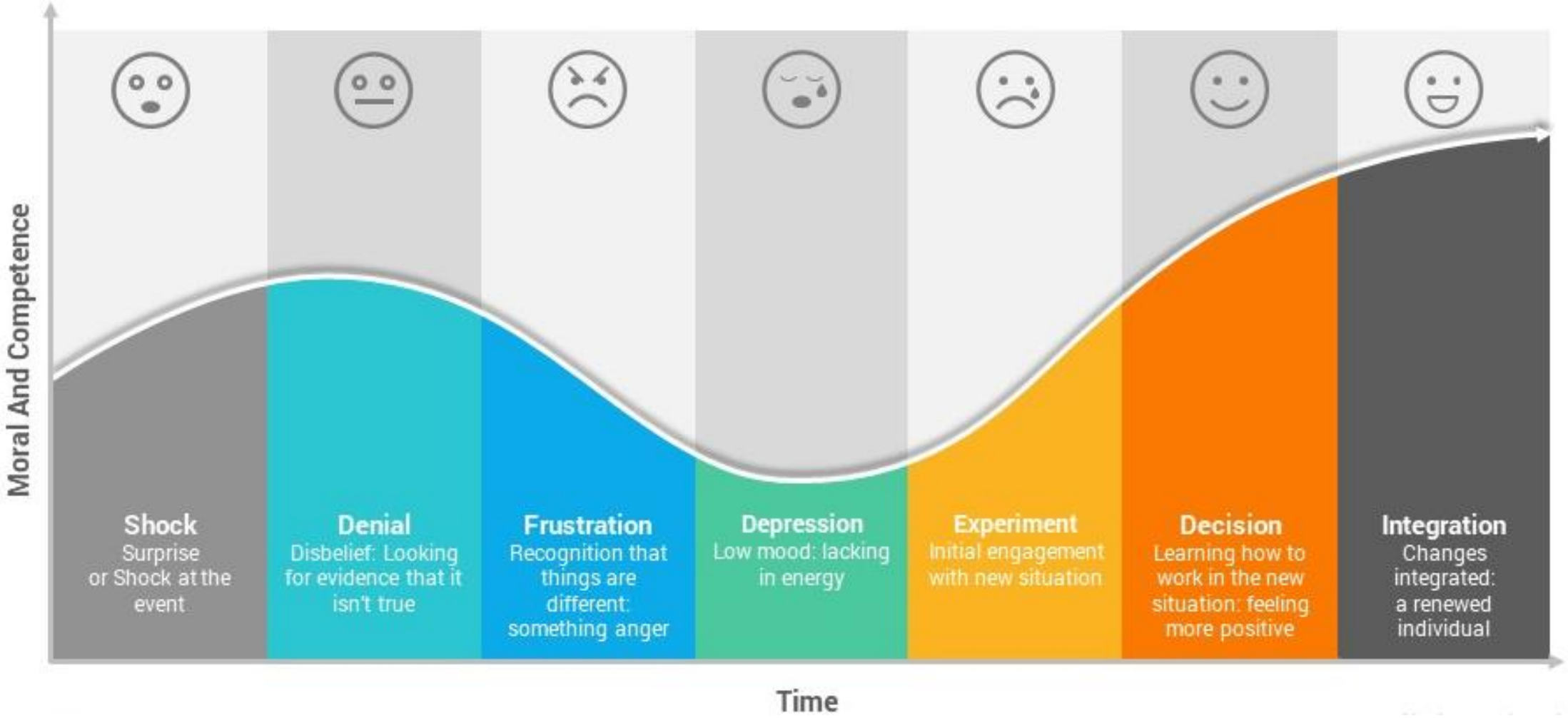


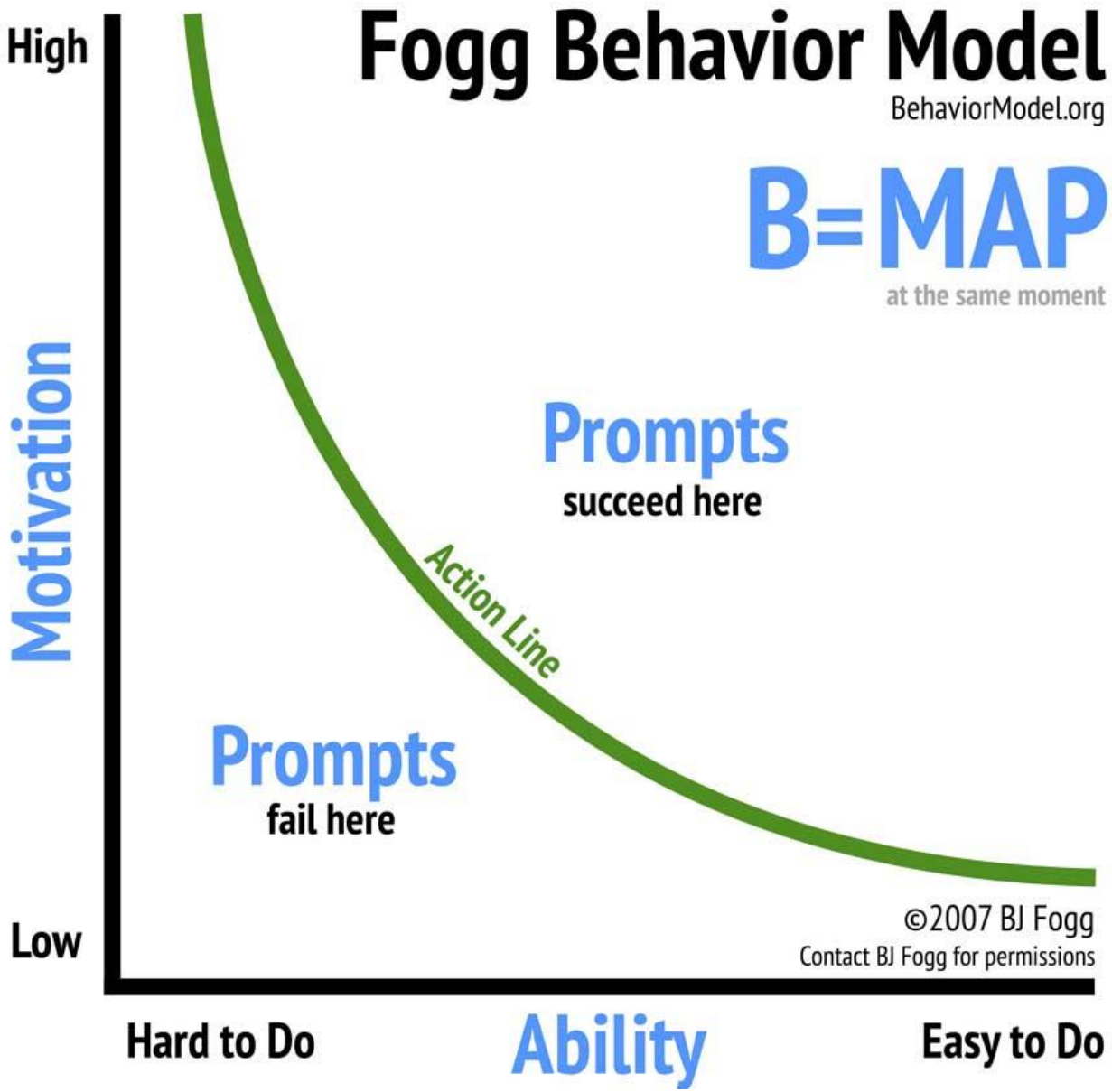
ADKAR Change Management



Kübler-Ross Change Model Curve Template

Emotional Response to Change



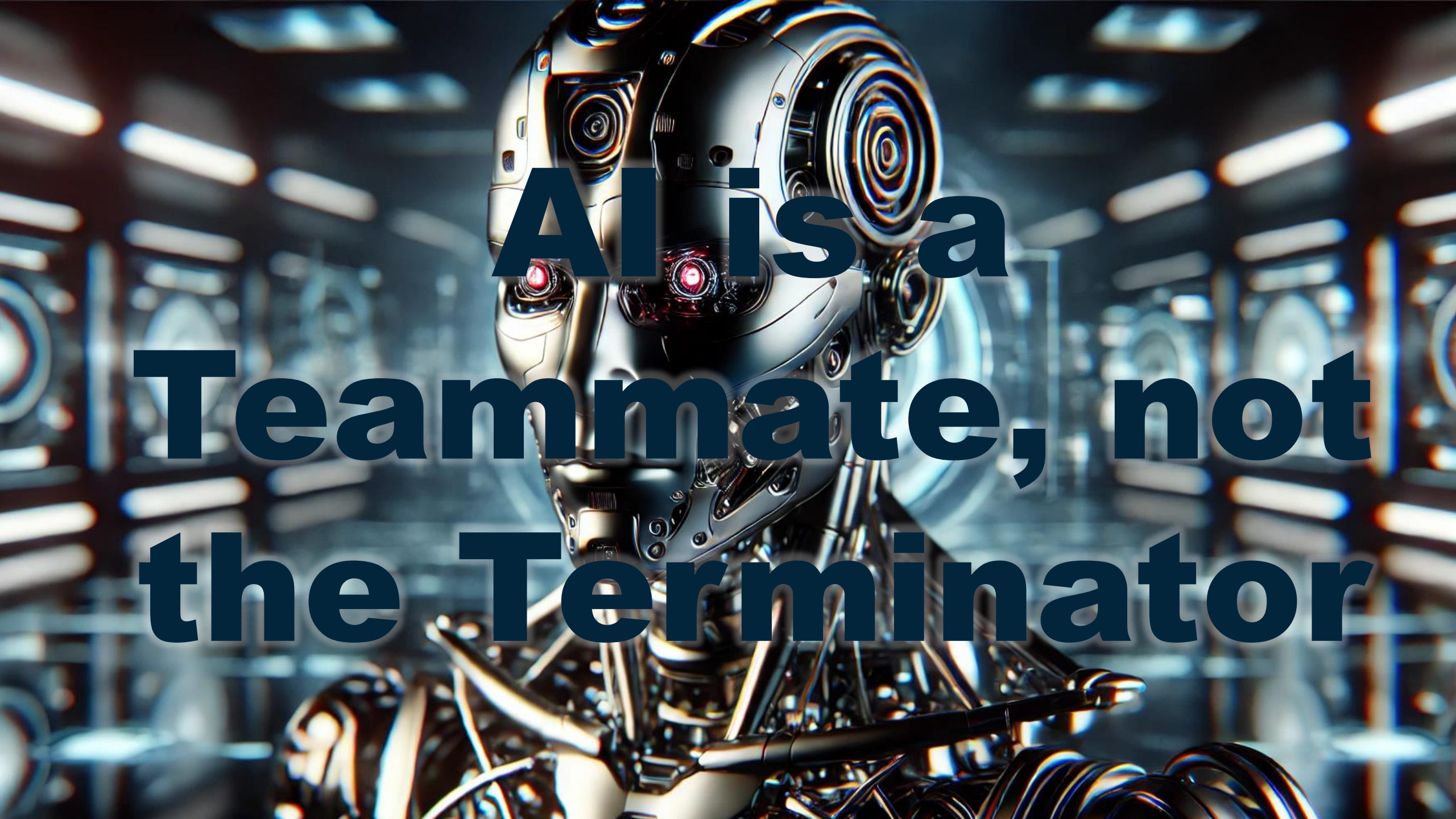


Reason #9

Culture Eats Strategy for Breakfast

ALBEMARLE INTELLIGENCE

Reason #10

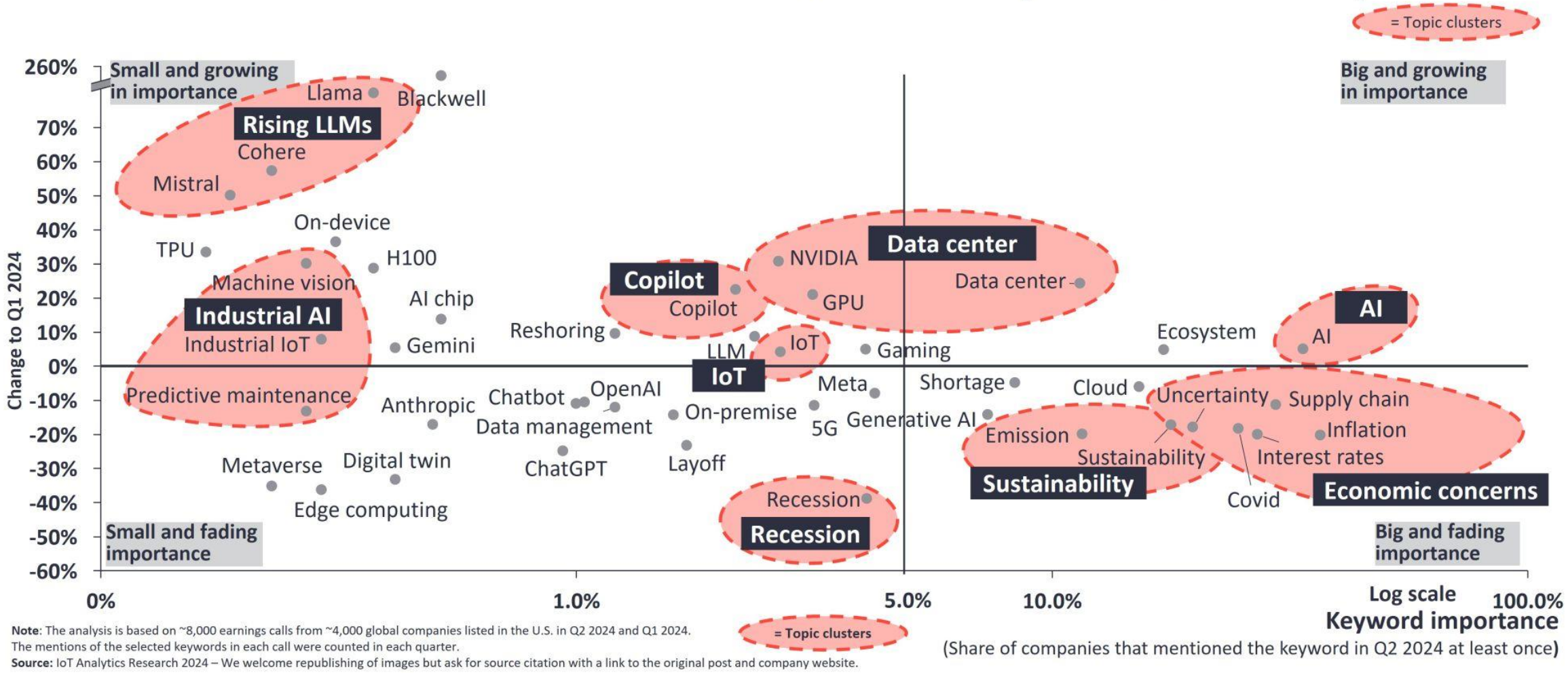

AI is a
Teammate, not
the Terminator


AI

IOT ANALYTICS

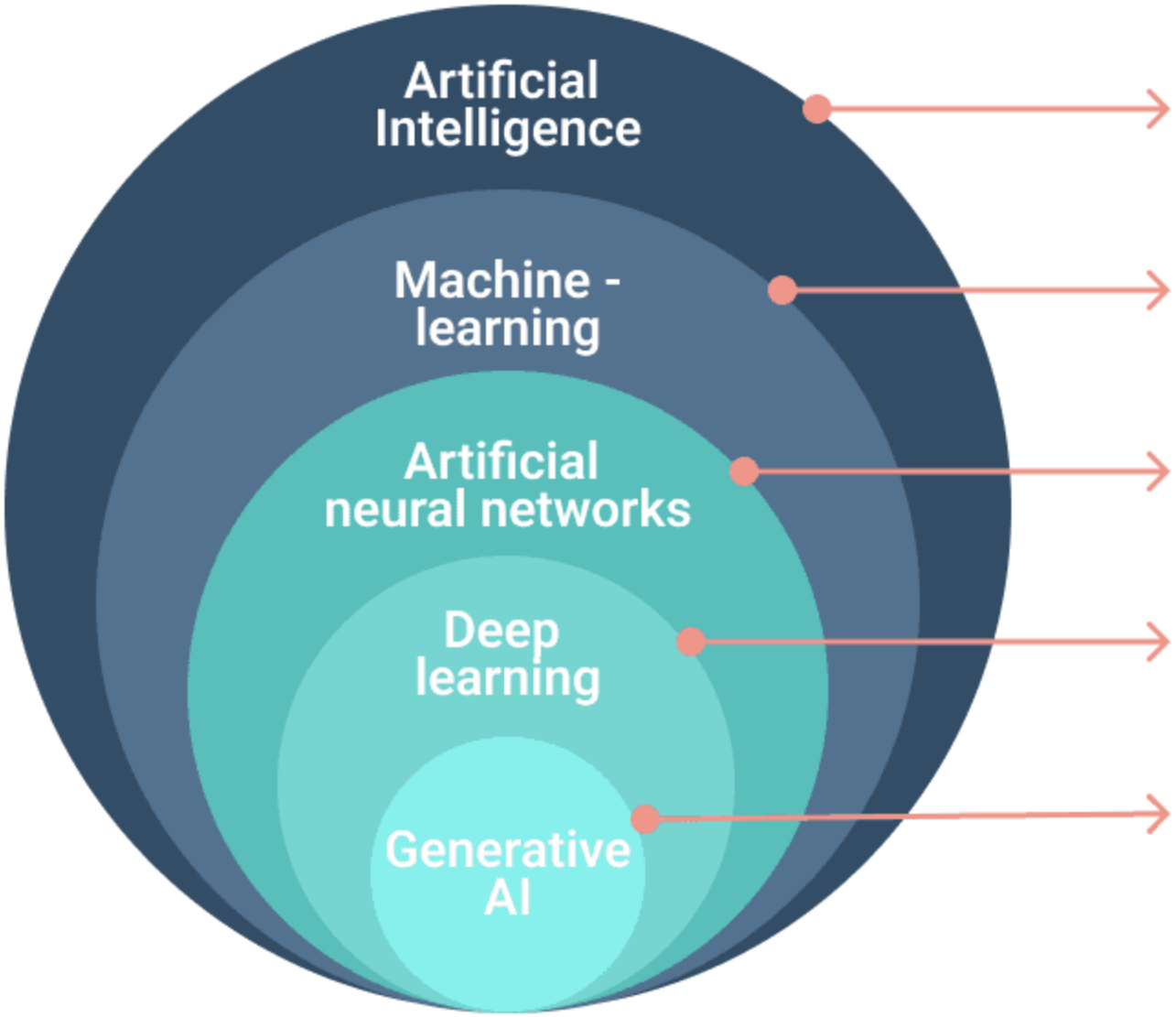
This analysis is part of the **CEO Insights** series

What CEOs talked about in Q2 2024 (vs. Q1 2024)



Note: The analysis is based on ~8,000 earnings calls from ~4,000 global companies listed in the U.S. in Q2 2024 and Q1 2024. The mentions of the selected keywords in each call were counted in each quarter.

Source: IoT Analytics Research 2024 – We welcome republishing of images but ask for source citation with a link to the original post and company website.



Artificial Intelligence (AI)

Development of machines that can perform tasks requiring human-like intelligence.

Machine-learning (ML)

Training of computers to learn and make predictions or decisions without being explicitly programmed.

Artificial neural networks (ANN)

Human brain-inspired machine-learning models.

Deep learning (DL)

Neural networks with multiple layers to extract complex patterns and make accurate predictions or decisions.

Generative AI (GenAI)

Creating models and systems that can generate new and original content.

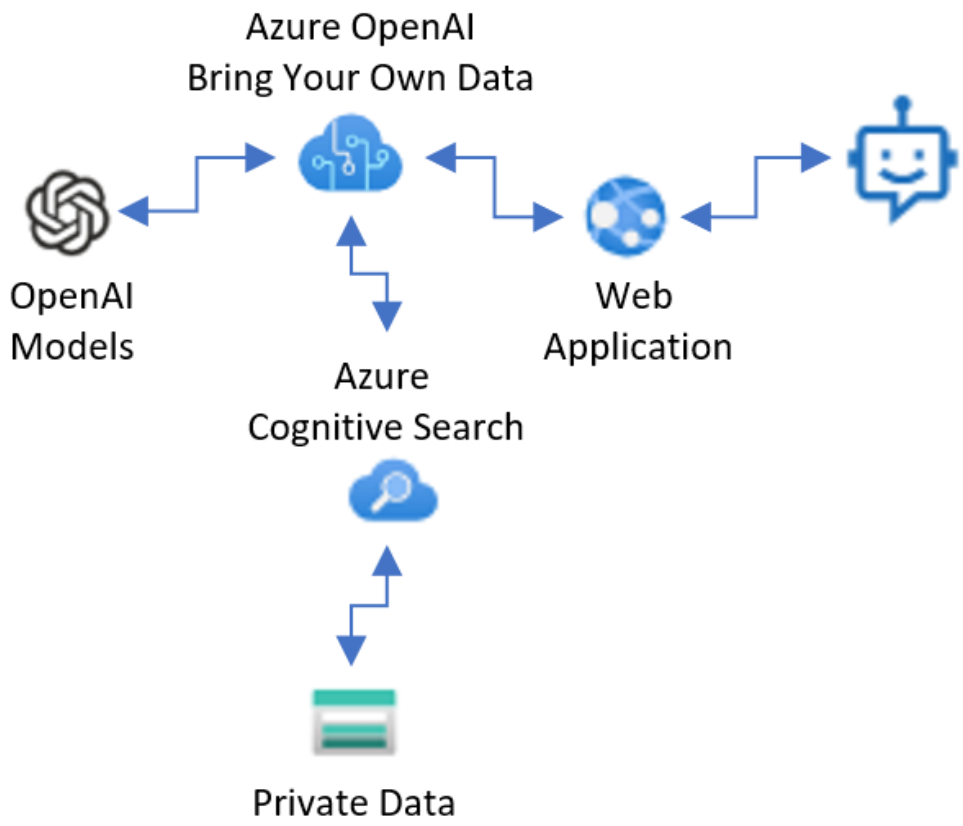
Image 2. AI subsets

OpenAI

Ensure that artificial general intelligence (AGI) benefits humanity.

Microsoft

Empower every person and organization on the planet to achieve more



Azure OpenAI Service

- GPT-4
- GPT-3
- Codex
- DALL·E (preview)
- ChatGPT (preview)

- Enterprise-grade, scalable infrastructure
- Custom AI models fine-tuned with your data and hyperparameters
- Enterprise-grade security with role-based access control and private networks
- Built-in responsible AI to detect and mitigate harmful use

GPT + Enterprise data

Chat Ask a question

Azure OpenAI + AI Search

Clear chat Developer settings

Albemarle

Chat with your data

Ask anything or try an example

Where does my raw water pump get its water from?

What modes does my BMS have on my calciner?

How does my fuel/air ratio control work for my calciner burner?

Type a new question (e.g. does Functional Control Description include Software standards?)


Hey Chat GPT,
finish this building...
Hey Chat GPT,
finish this building...
Your skills are irreplaceable.
IMPACT
Satisfying jobs in construction

Automated Information

Analytics Innovation

Actionable Insight

ALBEMARLE INTELLIGENCE

Albemarle People
Empowered by Technology
Unlocking the value of information

AUTOMATIZACIÓN DE LA INFORMACIÓN

ANALÍTICA CON INNOVACIÓN

ACCIONES INFORMADAS

ALBEMARLE INTELLIGENCE

Personal de Albemarle,
Empoderados por la Tecnología,
Liberando el Valor de la Información

自动信息

分析创新

切实可行的洞察

ALBEMARLE INTELLIGENCE

雅保人，
技术赋能，
释放信息的价值

ALBEMARLE INTELLIGENCE

ALBEMARLE PEOPLE,
empowered by technology,
unlocking the value of information.

Jonathan Alexander

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