

# *Welcome!*

## **Enabling Quality By Design, with AI-Driven Quality Operations**

**October 15, 2021**



Inspiring collaboration. Leading innovation. Making a difference.

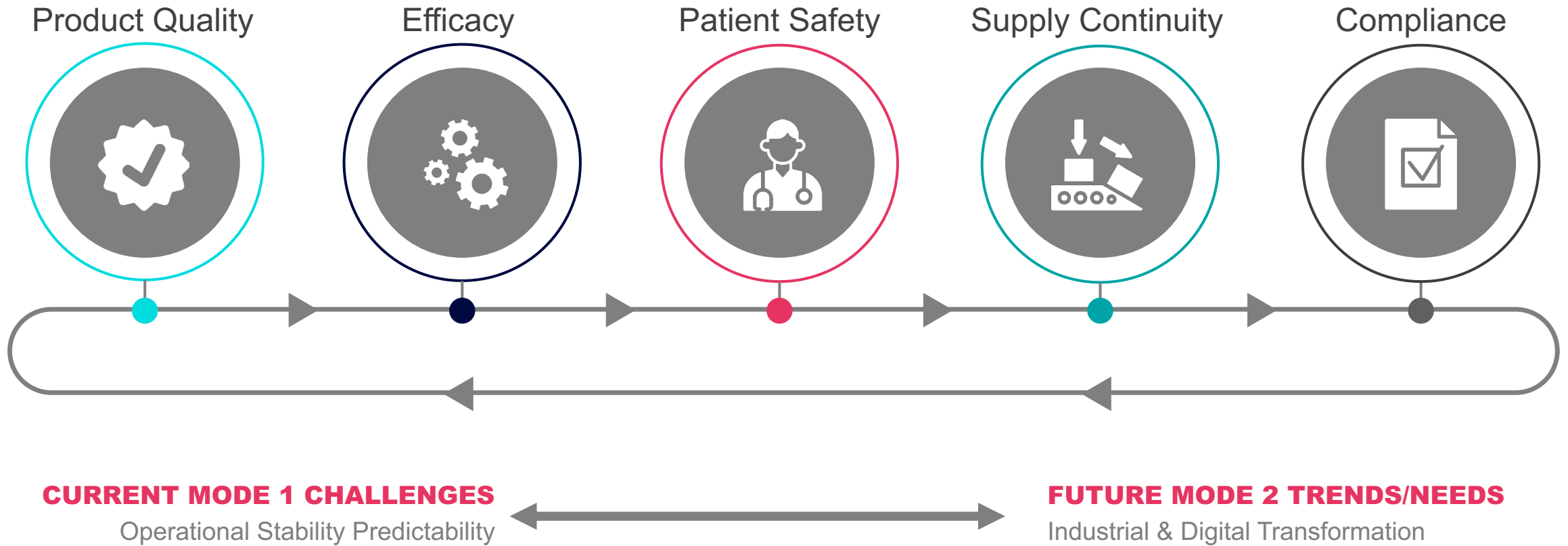
# Honeywell



**Steve McCarthy**  
*VP, Digital Innovation*

# QUALITY IMPERATIVES REMAIN THE SAME

*The Bi-modal Challenge*



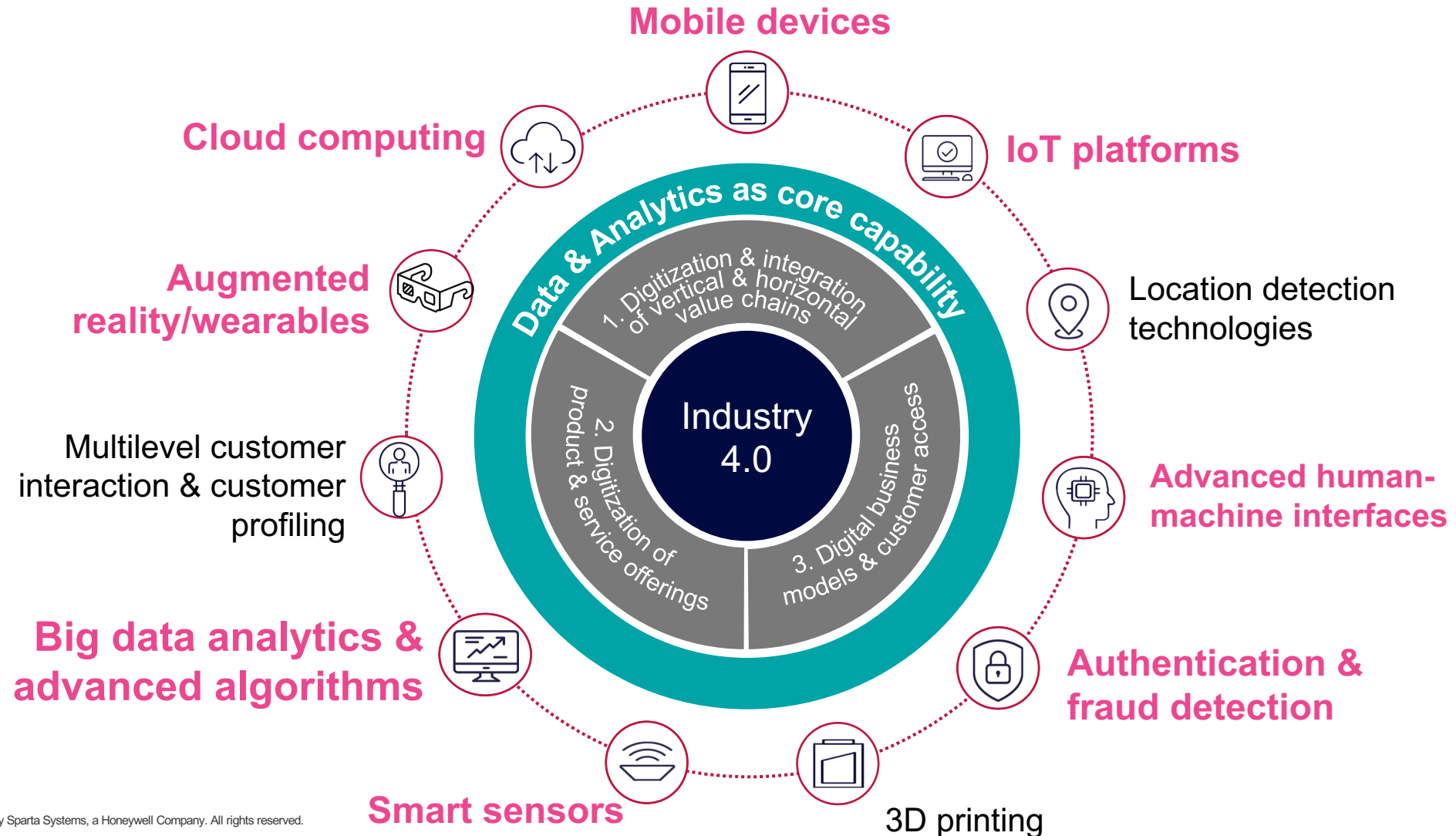
# THE CHANGING LANDSCAPE FOR LIFE SCIENCE – MODE 2

*Increased Complexity and Rapid Change is Driving Digital Transformation*



# DIGITAL IS MORE THAN CLOUD

Ind4.0 Framework & Contributing Digital Technologies



Source: PWC

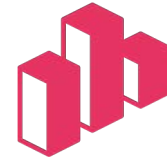
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# A FEW AI DEFINITIONS...

*Its purpose and intent*



**Artificial Intelligence**



**Predictive Analytics**



**Natural Language Processing**



**Multivariate Analysis**

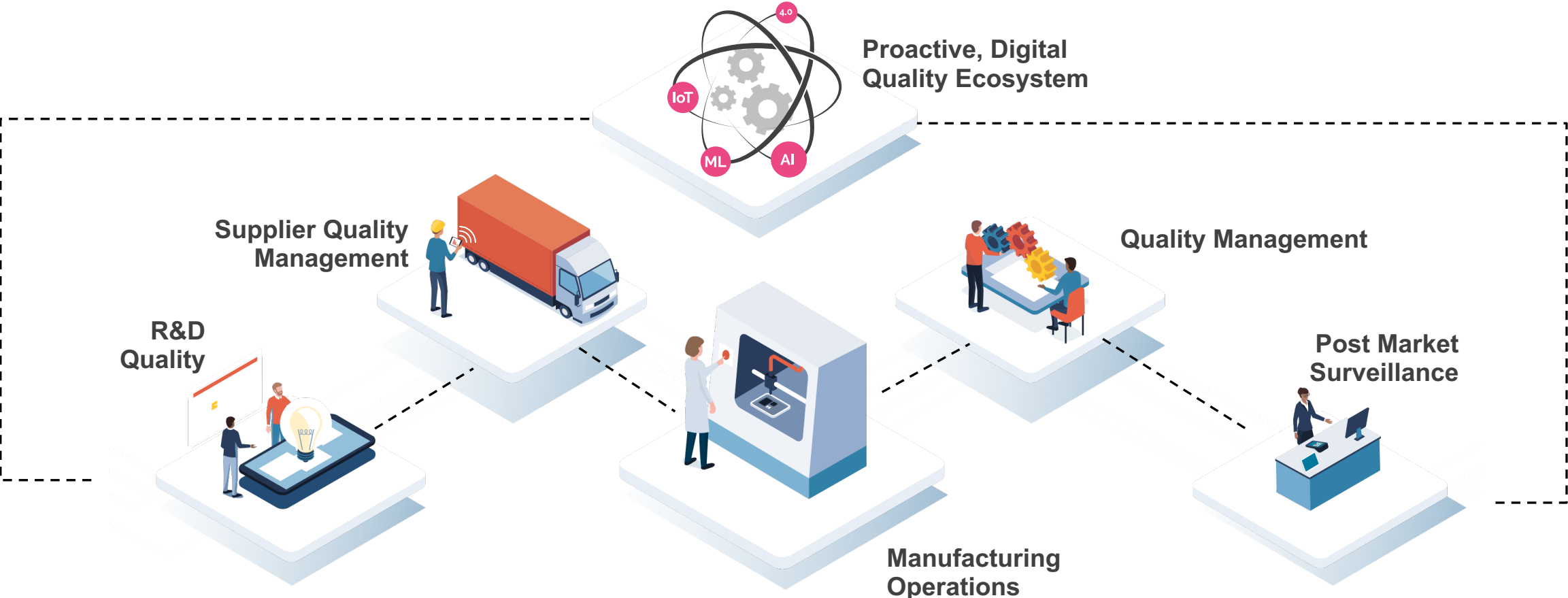


**Machine Learning**



# POWERING THE DIGITAL PLANT, LAB AND VALUE NETWORK OF NOW!

*And the future is here!*

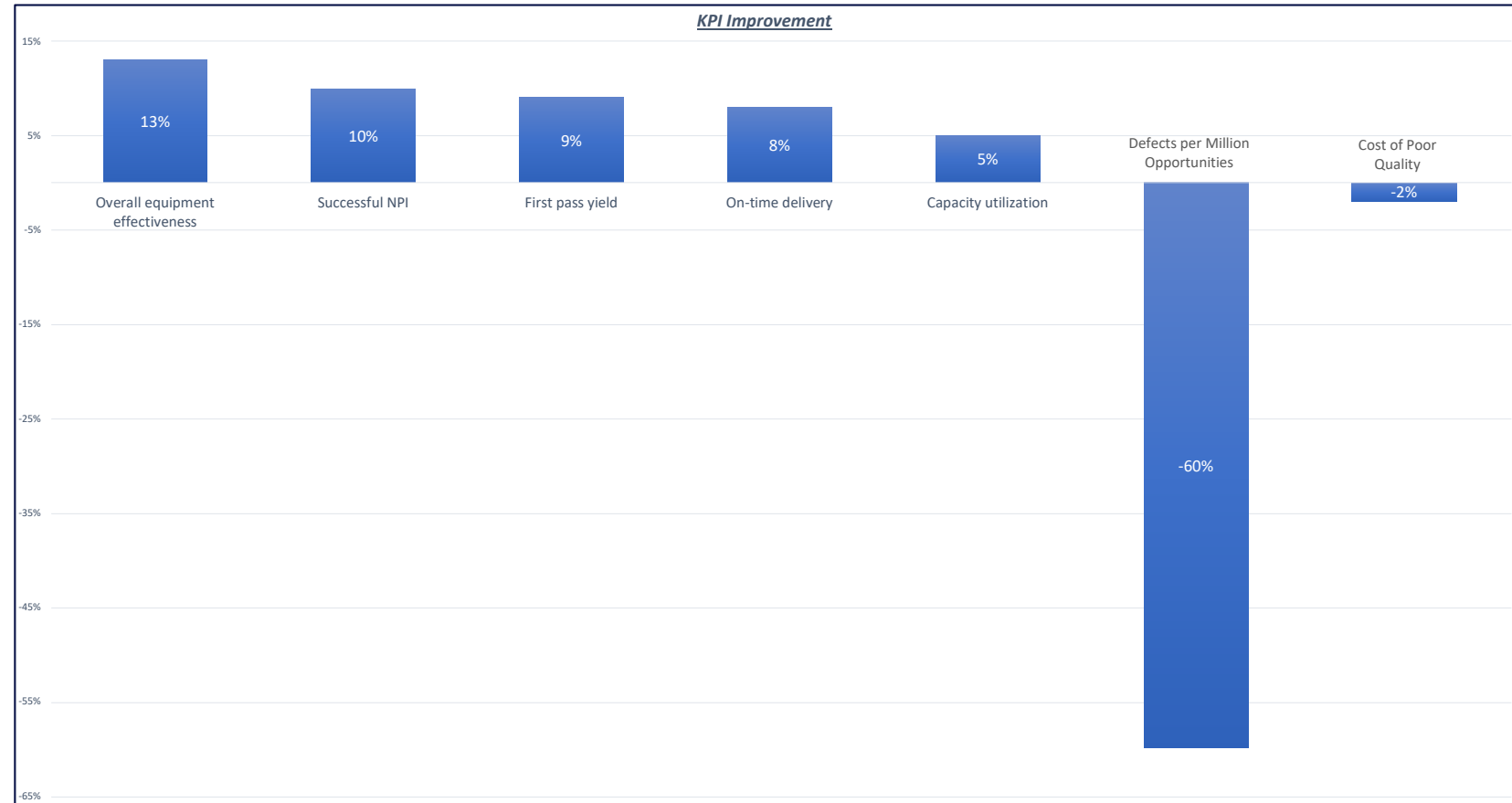


# DELIVER IMPROVED BUSINESS OUTCOMES

Measurable KPI improvement, not just QMS process cycle time reduction

## Key digital quality and smart manufacturing capabilities:

- Robust digital EQMS
- Real-time visibility of quality metrics
- Access to plant data
- Ability to detect and prioritize risks



Source: LNS Research



# TRADITIONAL APPROACH TO **QUALITY BY DESIGN**

*An enormous investment for the industry*

## Critical Process Parameters

Variables that can impact CQAs and must be monitored to enable early & accurate detection of deviations outside acceptable limits.



CPP

## Quality Target Product Profile

A summary of a product's quality characteristics that are essential to ensure the finished product meets the required standard of quality.



QTPP

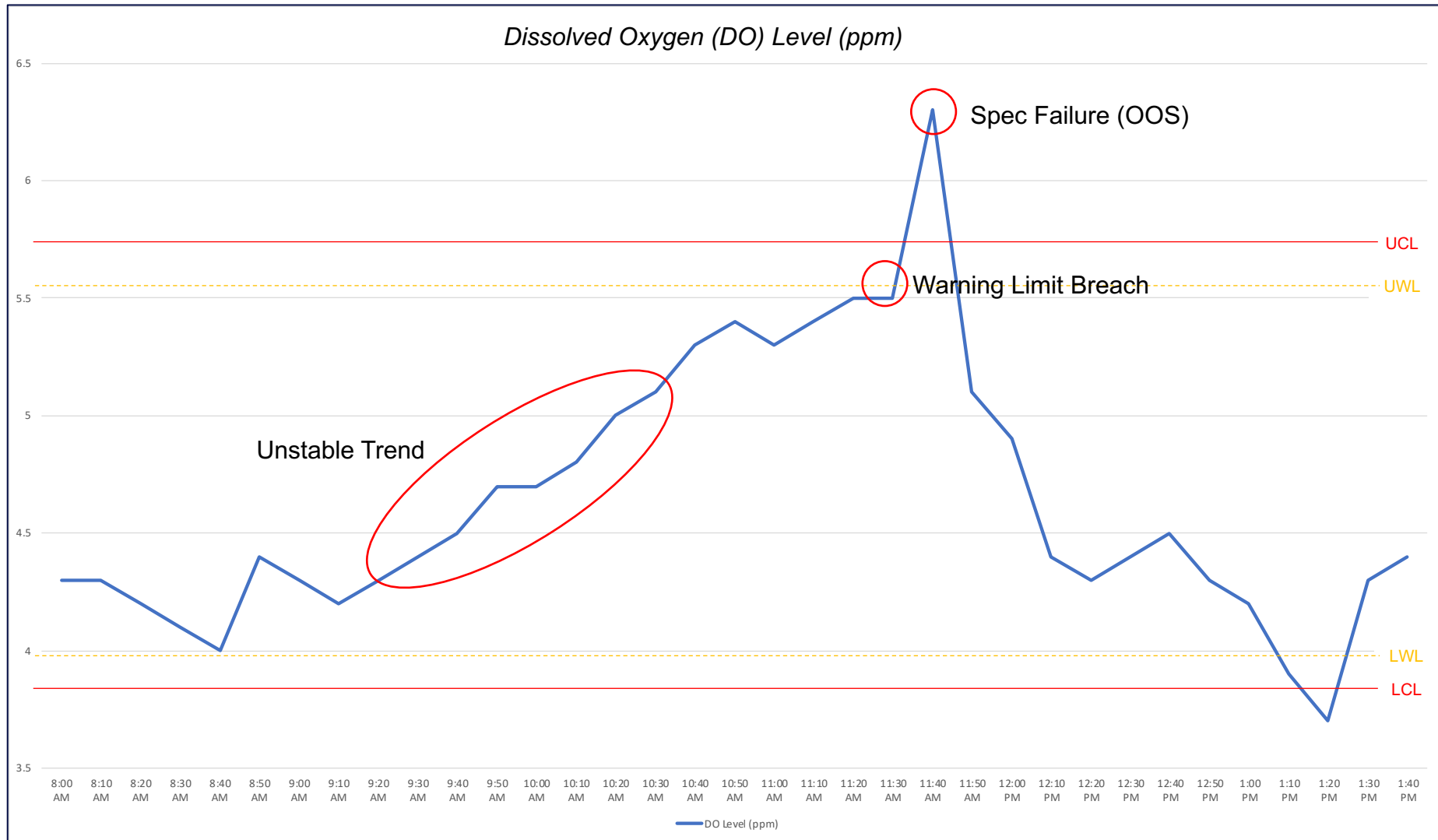


CQA

## Critical Quality Attributes

Any physical, chemical, biological, or microbiological characteristic that must be within a limit/range to ensure product quality.

# TRADITIONAL CONTROL CHART ANALYSIS - REACTIVE



# MAXIMIZE THE ROI OF QBD

## *The Challenge*

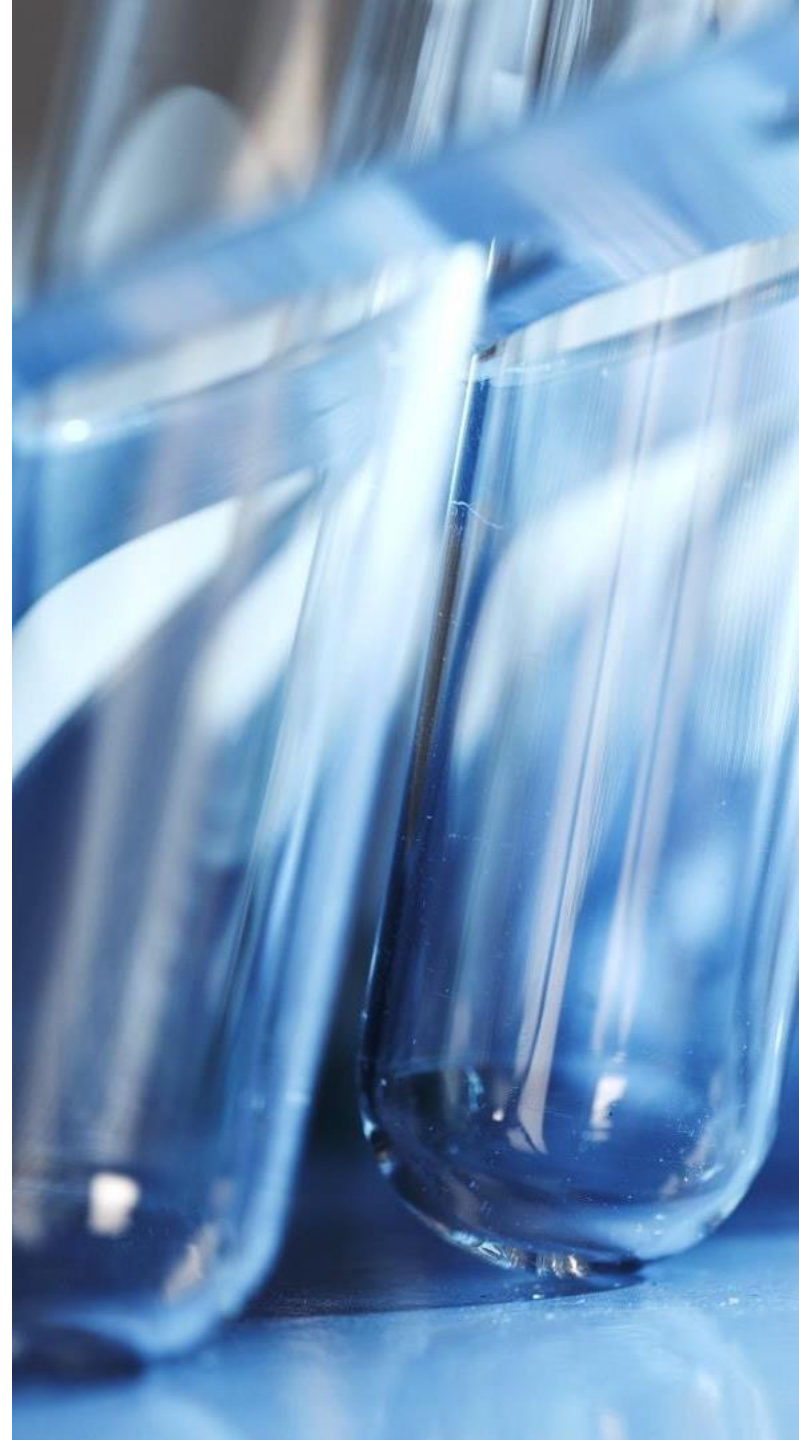
- Value returned from **investment in Quality By Design (QBD)** is suboptimal
- Lack of real time **Critical Process Parameter (CPP)** alerts for early detection and corrective action guidance
- **Manufacturing anomalies** delay product release for hundreds of hours
- Product review & release process is **time consuming and inefficient**



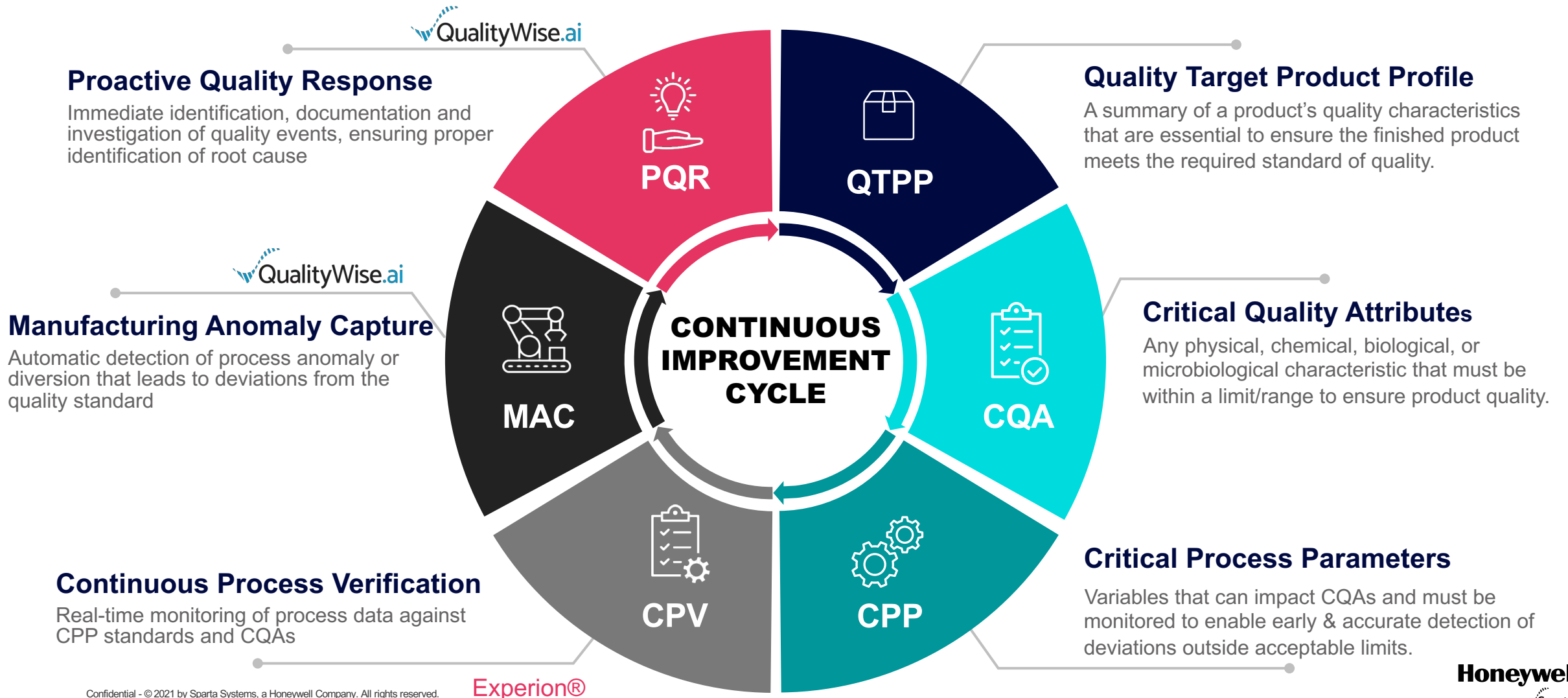
# MAXIMIZE THE ROI OF QBD

## *The Solution*

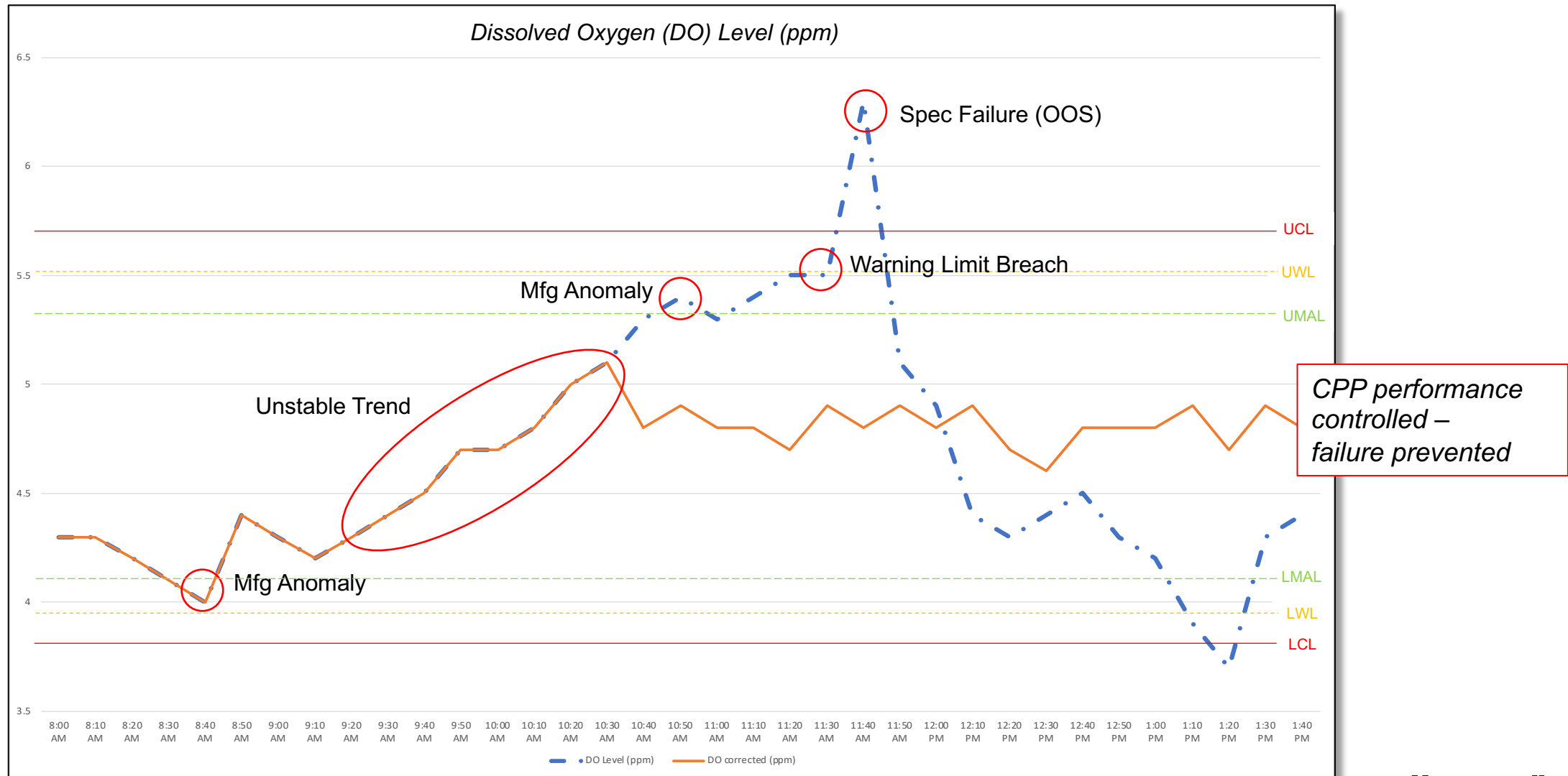
- **Connected Quality Management** and Manufacturing Automation Systems
- **Real-time** CPP alerts
- Process context quality alerts **reduces investigation**
- Real-time automation data and **AI-enabled multivariate analysis** enables CPV
- Integrated product disposition enables **review by exception and real-time release**



# AI-ENABLED QUALITY BY DESIGN

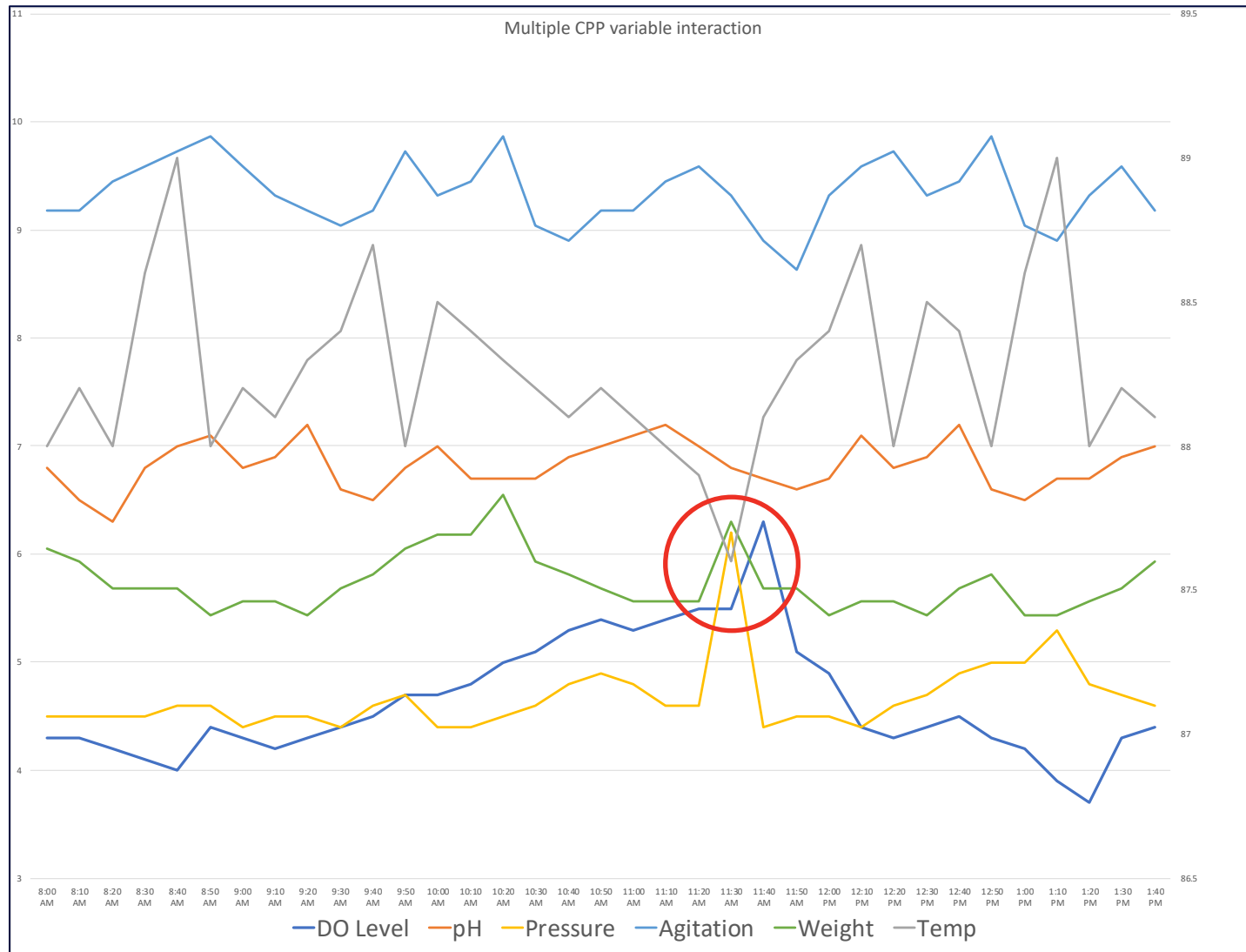


# PROACTIVE QUALITY RESPONSE – REAL-TIME ANALYSIS





# MULTIVARIATE ANALYSIS OF MANY CPPS



- Complete set of bioreactor CPPs can include **200+ variables**
- Resulting interactions translates to almost **2,000 features sets**
- Average **human can only interpret 2-4** interactions at a time
- **AI** allows control to golden batch conditions and **detection of unexpected anomalies**

# AI UNLEASHES THE POWER OF CPV

*A growing portfolio of AI and IIoT innovation*



# QUALITYWISE.AI AUTO-CATEGORIZATION

*AI aimed at a single record or data set*

- Based on historical data - AI, ML & multivariate analysis suggests most likely categories of critical data elements with statistical probability
- Records auto-populate on users' acceptance of that suggestion, augmenting human decision making

### AI Suggestions

Accept Refresh

**Mfg. Anomaly Type**

Value	Probability ↓
<input checked="" type="checkbox"/> Low Aeration Level	81%
<input type="checkbox"/> Low Agitation Speed	10%
<input type="checkbox"/> High pH	3%
<input type="checkbox"/> Low Pressure	3%
<input type="checkbox"/> High Temperature	3%

**Severity**

Value	Probability ↓
<input checked="" type="checkbox"/> Major (S4)	41%
<input type="checkbox"/> Serious (S3)	23%
<input type="checkbox"/> Critical (S5)	16%
<input type="checkbox"/> Minor (S2)	16%
<input type="checkbox"/> Negligible (S1)	4%

VALUE



Timely  
action



Consistent  
categorization



Improve Anomaly  
Identification



Improve  
Prioritization

# QUALITYWISE.AI INSIGHTS

AI aimed across multiple records or data sets

- AI rapidly identifies patterns, trends and occurrences of quality events across entire historical quality data-set
- Auto-correlation of related and similar records & data sets clearly identified with statistical relationship

The screenshot displays a quality event record for 'DEV-03166'. The header includes a 'Quality Event' icon and the ID 'DEV-03166'. Below this, a table provides key details: Short Description ('Potential unlabelled Bottle packed as finished product'), Type ('Deviation'), Originating Site ('Houston, TX'), Due Date ('4/30/2021'), Assigned To ('Katie Dowling'), and Risk level (indicated by a red square). A progress bar shows the current stage as 'Investigation, RCA and Action Planning'. The 'RECORD WORKFLOW' section includes an 'Audit Trail' link and a 'Submit for Approval' button. The 'STATUS' is 'Investigation, RCA and Action Planning'. The 'Insights' tab is active, showing a 'Recurring Deviations' section with a 'Refresh' button and a 'Download' button. A summary states: 'The following records were found to contain similar characteristics, where 81% of records contain Originating Site = Site 2 (Created Date: Jan 1, 2020 to Dec 1, 2022)'. Below this is a table of related records.

Record Name	Object	R	Short Description	Deviation Sub...	Department	Originating Site
DEV-00529	Quality Event		3 East Coast additional bottle labels found at reconciliation	Equipment/Instrume...	Quality Control	Site 2
DEV-02040	Quality Event		9 missing bottle labels found at line 3	Process	Quality Control	Site 2
DEV-04698	Quality Event		Bottle label reversed - Bottle Label upside-down	Process	Manufacturing	Site 2
DEV-01184	Quality Event		During the weekly Safety Observation Report walkabout an un...	Documentation	Engineering	Site 2
DEV-02891	Quality Event		East Coast damaged bottle in finished goods Line 3	Packaging	Facilities	Site 3
DEV-05517	Quality Event		East Coast sent potential unlabeled bottle packed as finished ...	Packaging	Engineering;Facilities	Site 1
DEV-03096	Quality Event		East Coast sent unlabeled bottle packed off in finished goods	Labeling	Quality Control	Site 1
DEV-02463	Quality Event		Failed AQL on Packaging Line 03 for creased labelled bottles.	Reconciliation	Quality Control	Site 2
DEV-05468	Quality Event		Failed end of run challenge on bottle labeler in Packaging Line...	Out of Specification	Quality Control	Site 2
DEV-04512	Quality Event		Line 6- Torn bottle label found in the AQL	Component	Quality Control	Site 2
DEV-01144	Quality Event		On Line 5 (CAM Line), 3 unlabelled bottles were processed in ...	Equipment/Instrume...	Engineering;Quality ...	Site 2

VALUE



Best next  
action



Faster  
investigation



Superior  
trending

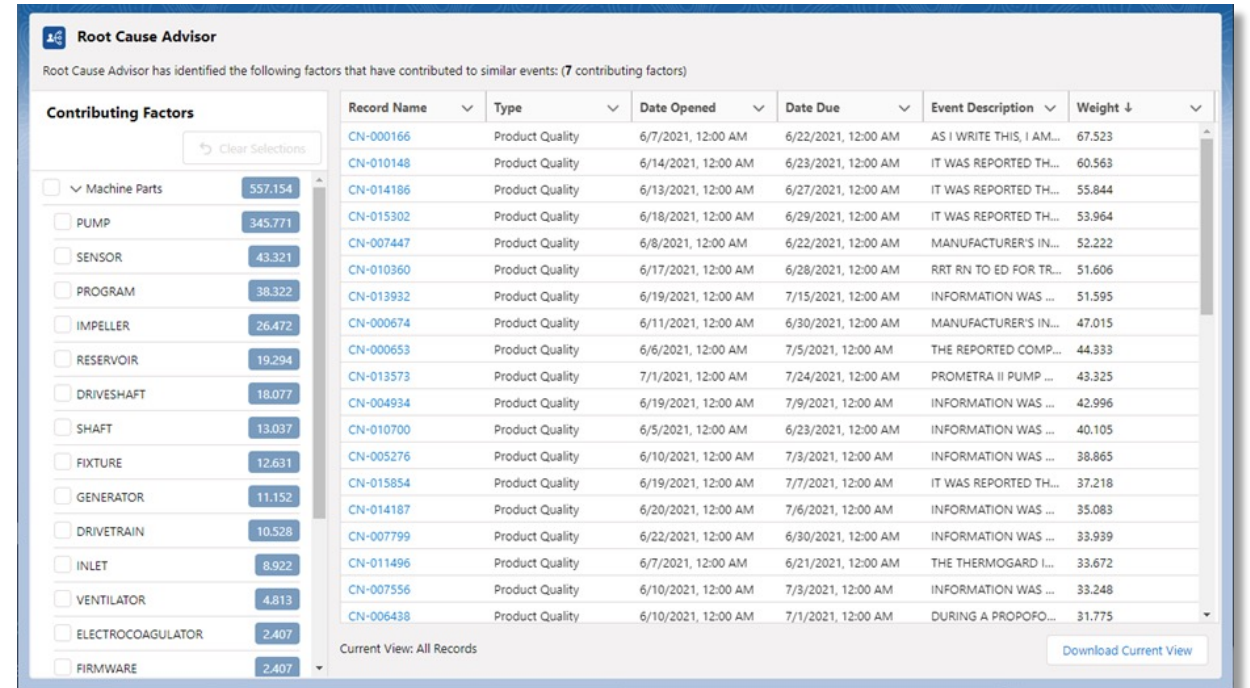


Avoid  
redundancy

# QUALITYWISE.AI ROOT CAUSE ADVISOR

*Helps find true root cause, faster*

- Correlates same / similar records & data; narrows scope to similar events and provides investigator curated list of most likely factors to investigate
- Extracts contributing factors and identifies common factors and ranks factor relevance based on overall contextual relevance



Root Cause Advisor has identified the following factors that have contributed to similar events: (7 contributing factors)

Contributing Factors	
<input type="checkbox"/> Machine Parts	557,154
<input type="checkbox"/> PUMP	345,771
<input type="checkbox"/> SENSOR	43,321
<input type="checkbox"/> PROGRAM	38,322
<input type="checkbox"/> IMPELLER	26,472
<input type="checkbox"/> RESERVOIR	19,294
<input type="checkbox"/> DRIVESHAFT	18,077
<input type="checkbox"/> SHAFT	13,037
<input type="checkbox"/> FIXTURE	12,631
<input type="checkbox"/> GENERATOR	11,152
<input type="checkbox"/> DRIVETRAIN	10,528
<input type="checkbox"/> INLET	8,922
<input type="checkbox"/> VENTILATOR	4,813
<input type="checkbox"/> ELECTROCOAGULATOR	2,407
<input type="checkbox"/> FIRMWARE	2,407

Record Name	Type	Date Opened	Date Due	Event Description	Weight
CN-000166	Product Quality	6/7/2021, 12:00 AM	6/22/2021, 12:00 AM	AS I WRITE THIS, I AM...	67.523
CN-010148	Product Quality	6/14/2021, 12:00 AM	6/23/2021, 12:00 AM	IT WAS REPORTED TH...	60.563
CN-014186	Product Quality	6/13/2021, 12:00 AM	6/27/2021, 12:00 AM	IT WAS REPORTED TH...	55.844
CN-015302	Product Quality	6/18/2021, 12:00 AM	6/29/2021, 12:00 AM	IT WAS REPORTED TH...	53.964
CN-007447	Product Quality	6/8/2021, 12:00 AM	6/22/2021, 12:00 AM	MANUFACTURER'S IN...	52.222
CN-010360	Product Quality	6/17/2021, 12:00 AM	6/28/2021, 12:00 AM	RRT RN TO ED FOR TR...	51.606
CN-013932	Product Quality	6/19/2021, 12:00 AM	7/15/2021, 12:00 AM	INFORMATION WAS ...	51.595
CN-000674	Product Quality	6/11/2021, 12:00 AM	6/30/2021, 12:00 AM	MANUFACTURER'S IN...	47.015
CN-000653	Product Quality	6/6/2021, 12:00 AM	7/5/2021, 12:00 AM	THE REPORTED COMP...	44.333
CN-013573	Product Quality	7/1/2021, 12:00 AM	7/24/2021, 12:00 AM	PROMETRA II PUMP ...	43.325
CN-004934	Product Quality	6/19/2021, 12:00 AM	7/9/2021, 12:00 AM	INFORMATION WAS ...	42.996
CN-010700	Product Quality	6/5/2021, 12:00 AM	6/23/2021, 12:00 AM	INFORMATION WAS ...	40.105
CN-005276	Product Quality	6/10/2021, 12:00 AM	7/3/2021, 12:00 AM	INFORMATION WAS ...	38.865
CN-015854	Product Quality	6/19/2021, 12:00 AM	7/7/2021, 12:00 AM	IT WAS REPORTED TH...	37.218
CN-014187	Product Quality	6/20/2021, 12:00 AM	7/6/2021, 12:00 AM	INFORMATION WAS ...	35.083
CN-007799	Product Quality	6/22/2021, 12:00 AM	6/30/2021, 12:00 AM	INFORMATION WAS ...	33.939
CN-011496	Product Quality	6/7/2021, 12:00 AM	6/21/2021, 12:00 AM	THE THERMOGARD I...	33.672
CN-007556	Product Quality	6/10/2021, 12:00 AM	7/3/2021, 12:00 AM	INFORMATION WAS ...	33.248
CN-006438	Product Quality	6/10/2021, 12:00 AM	7/1/2021, 12:00 AM	DURING A PROPOFO...	31.775

Current View: All Records [Download Current View](#)

VALUE



Faster investigation



Increased accuracy



Superior visibility

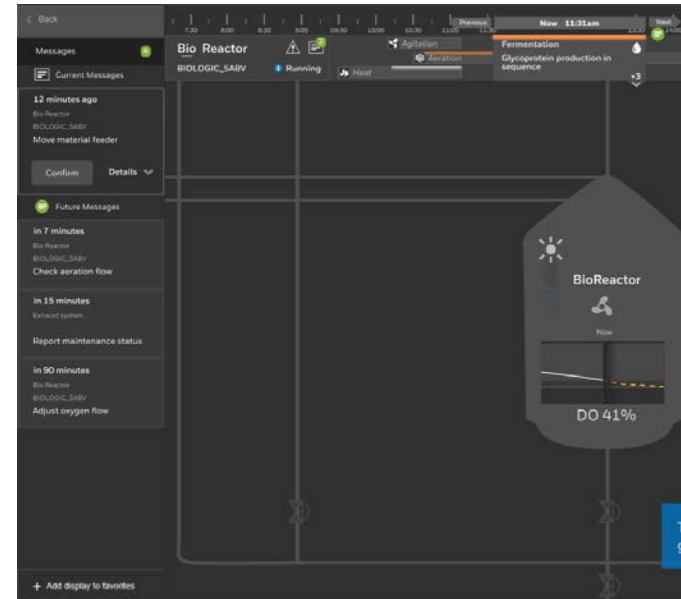


Identifies unknown factors

# QUALITYWISE.AI MANUFACTURING ANOMALY CAPTURE

*Identifies anomalies before they become failures*

- AI automatically identifies manufacturing anomalies before they become specification failures or even breaches of warning limit
- Assists in verifying implemented CAPA are effective and monitors for effectiveness in real-time



The screenshot shows a 'Quality Event' details page for 'DEV-05564'. The event is categorized as a 'Manufacturing Anomaly' originating from 'Munich Germany'. The 'Short Description' is 'Fermentor oxygen levels dropping below acceptable limits'. The event is assigned to 'Katie' with a due date of '7/22/2021'. The 'Details' section includes the date of observation (6/22/2021), department (Manufacturing), and a description: 'Oxygen levels dropped during glycoprotein production. DO (%) 40, Temperature (°C) 30, Agitation (rpm) 225, Medium Aeration (vvm) 1.8'. Immediate actions listed include: 'Batch is within tolerable limits and can be released', 'Keep batch on track and improve yield', 'Operator to increase aeration to 2.1 vvm and keep agitation at 225 rpm', and 'Initiate further investigation on why oxygen has dropped despite operator increasing agitator speed'.

VALUE



Real-time monitoring



IIoT integration



Quality insights



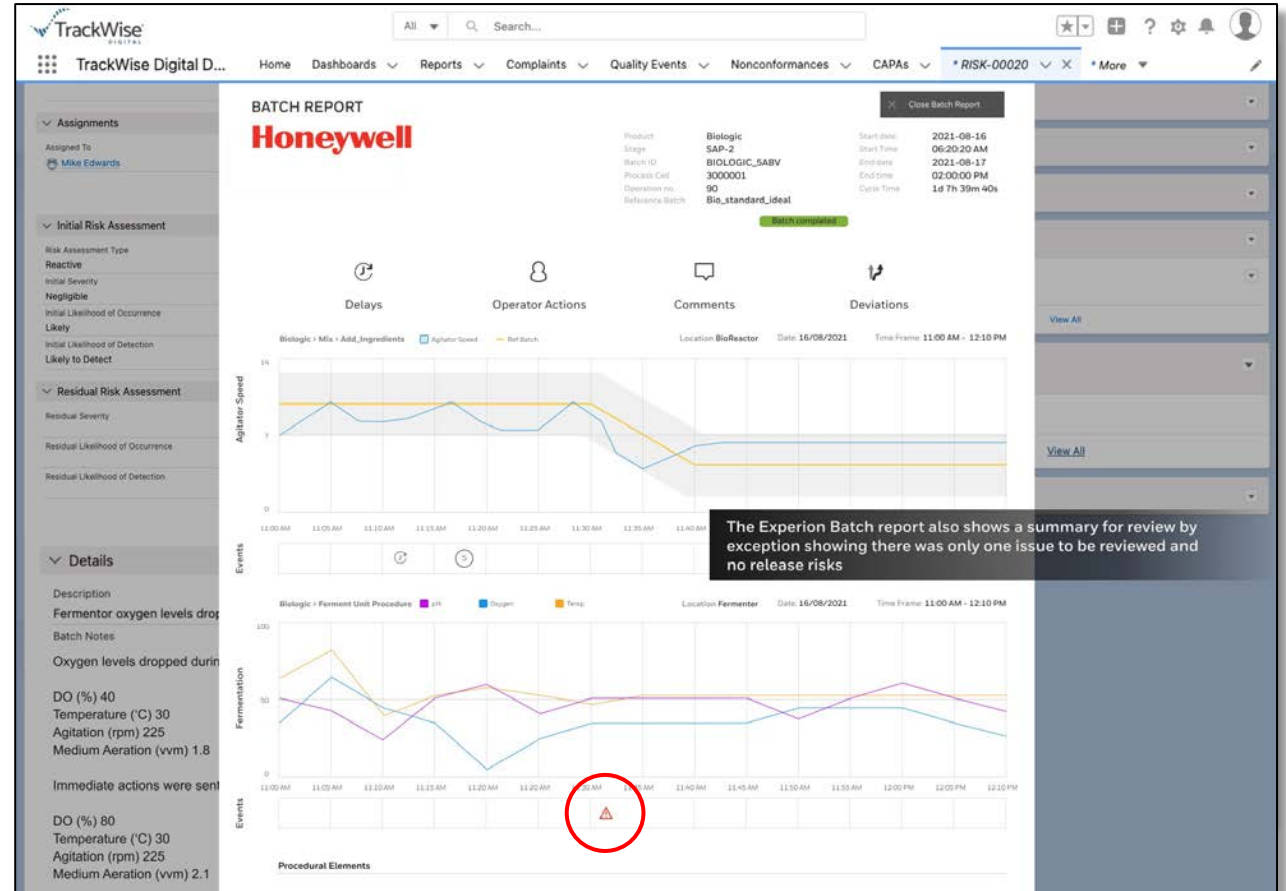
Improved effectiveness



# QUALITYWISE.AI REVIEW BY EXCEPTION

*A paradigm shift to batch and real-time release*

- AI provides recommendations based on analytics from transactional manufacturing data
- Clearly highlights manufacturing anomalies and processes outside of control limits to optimize batch record review



## VALUE



Reduce cost  
& waste



Accelerate product  
disposition



Improve  
decision-making



Speed time  
to market

# VOI – “ISLANDS OF AUTOMATION”


Silos of data

 **Filtration  
Module**




 **Fill and Finish  
Module**



 **Bio-Reactor  
Module**

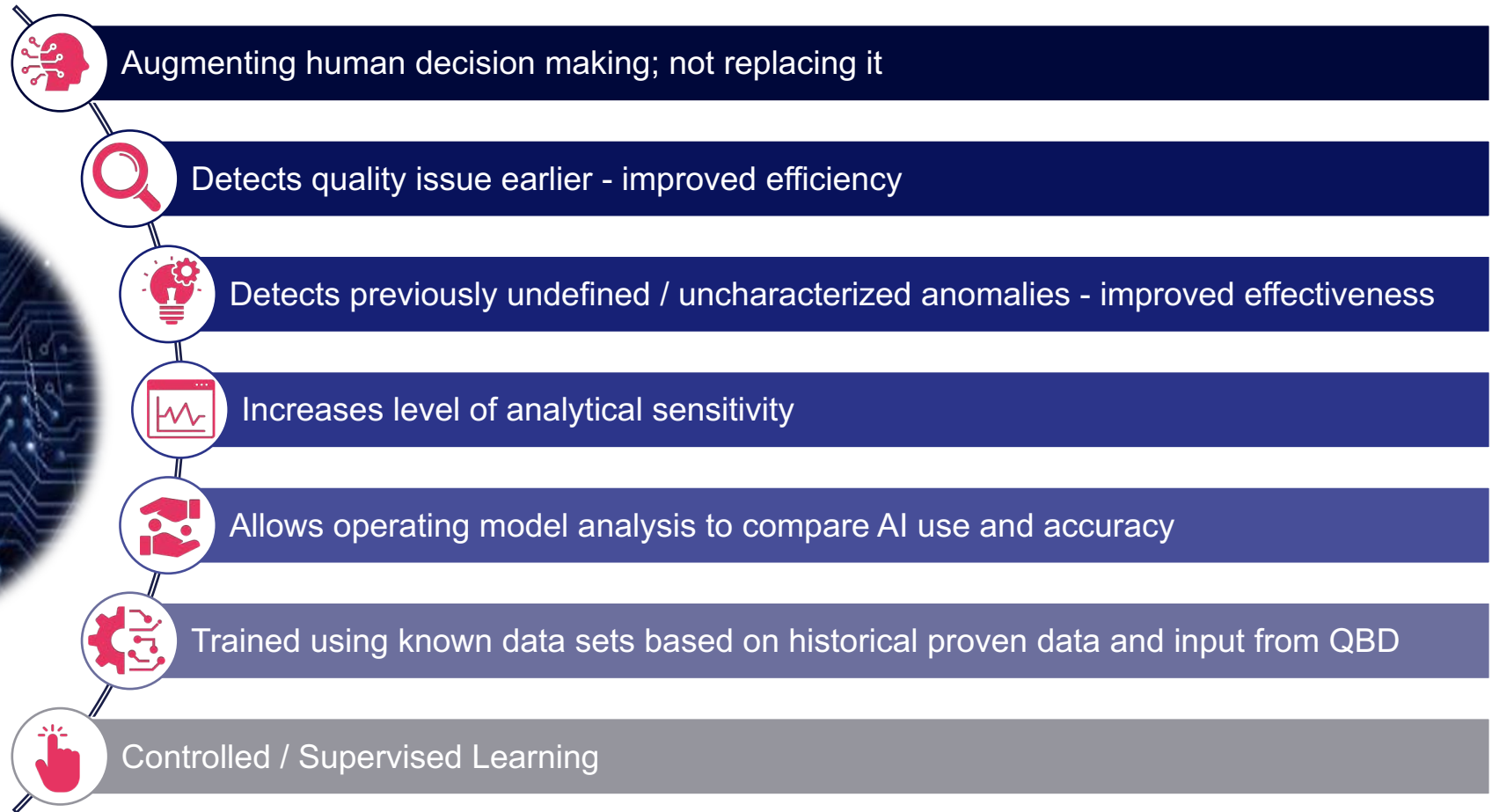


 **Chromatography  
Module**



# WOULD YOU TRUST AN AI-SUGGESTED ANOMALY?

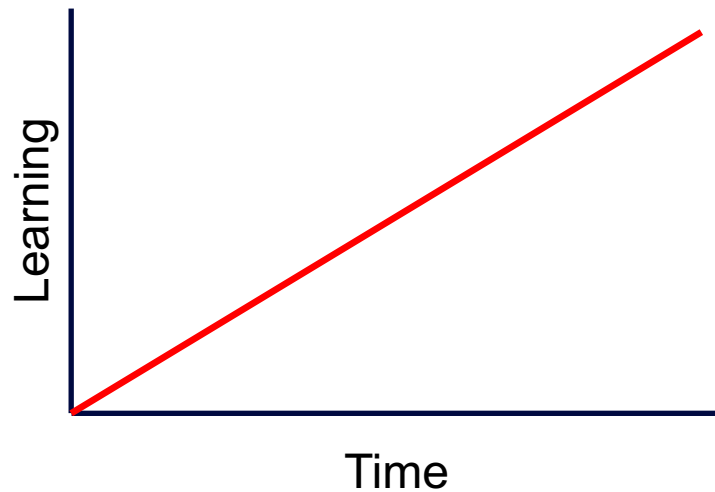
*Culture is key to a paradigm shift*



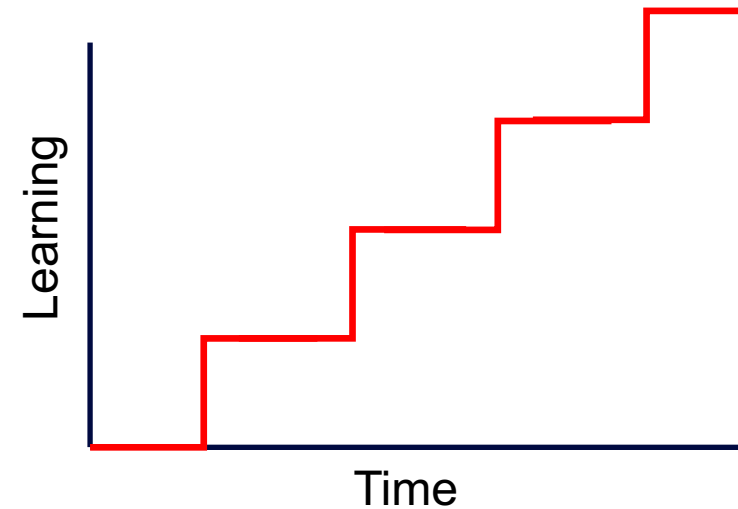
# MACHINE LEARNING REQUIRES MACHINE TEACHING

*Train AI algorithms with your data under your control*

Automatic /  
Unsupervised  
Learning



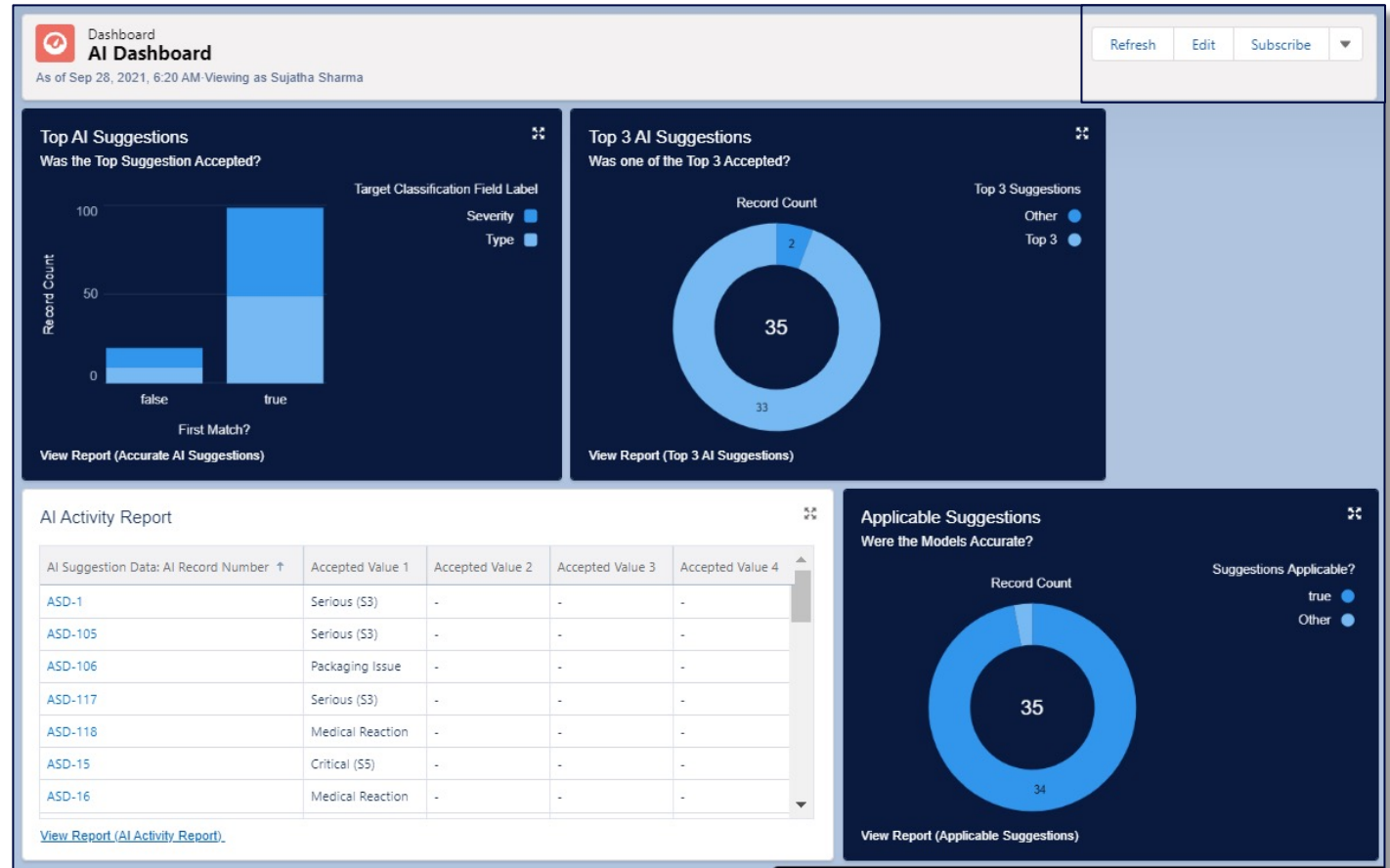
Controlled /  
Supervised  
Learning



# COMPARE HUMAN TO AI PERFORMANCE

*Back-office analytics for visibility and confidence*

- AI does more than just imitate human decision making
- Understand how AI interacts with your business at the operating model level
- Compare AI accuracy vs human acceptance



# FDA POSITION ON CPV

*FDA Warning Letters Indicate Lack Of Adoption Of CPV*



**Warning letter trends highlight lack of process validation life cycle approaches**



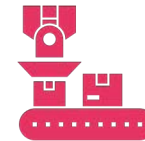
**FDA indicates lack of awareness / slow adoption of CPV by industry**



**2020 warning letter trends indicate evident gap in understanding and adoption**



**Deficient / nonexistent CPV programs contributed to FDA warning letters**



**Manufacturing quality issues linked to process validation - biggest reason for US drug shortage**

Source: <https://www.pharmaceuticalonline.com/doc/put-your-continued-process-verification-cpv-data-to-work-0>

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Systems



# IN SUMMARY



Quality Imperatives remain the same, but industry is changing as innovation accelerates



Digital transformation brings opportunity to positively disrupt the discipline of quality



QbD brings enormous value but at significant cost and ROI is limited



QbD should be dynamic; AI enables continuous improvement of CPPs



AI helps detect relevance, correlation & sensitivity, monitoring data real-time



We can detect anomalies sooner and detect anomalies not previously defined / characterized

***AI-enabled CPV & Proactive Quality Response optimizes the power of QbD***

# *Thank you!*



**Steve McCarthy**  
*VP, Digital Innovation*



XAVIER HEALTH

Inspiring collaboration. Leading innovation. Making a difference.

# Thank you for participating today!

## Join us for more from the AI community!

- **Xavier AI Summit**

- Workshop - Virtual Sprints: Nov. 4 & 5, 2021
- Main Sessions - Virtual Sprints: Nov. 9, 10 & 12, 2021

- **Xavier AI Working Teams**

- AI in Operations (AIO)
- Good Machine Learning Practices (GMLP)
- AI at the Point of Care (AI@POC)

- **Xavier AI Blog**

- [xavierhealth.org/artificial-intelligence-blog](https://xavierhealth.org/artificial-intelligence-blog)

And join us on



[xavierhealth.org/ai-experts-network](https://xavierhealth.org/ai-experts-network)