FactoryTalk® Analytics™ LogixAI®

Rockwell Automation

expanding **human possibility**®

Agenda

1 Process Optimization through Analytics

2 Introduction to FactoryTalk® Analytics™ LogixAI®

3 FactoryTalk® Analytics™ LogixAI® Workflow

4 Considerations for Success

5 Edge Application Management

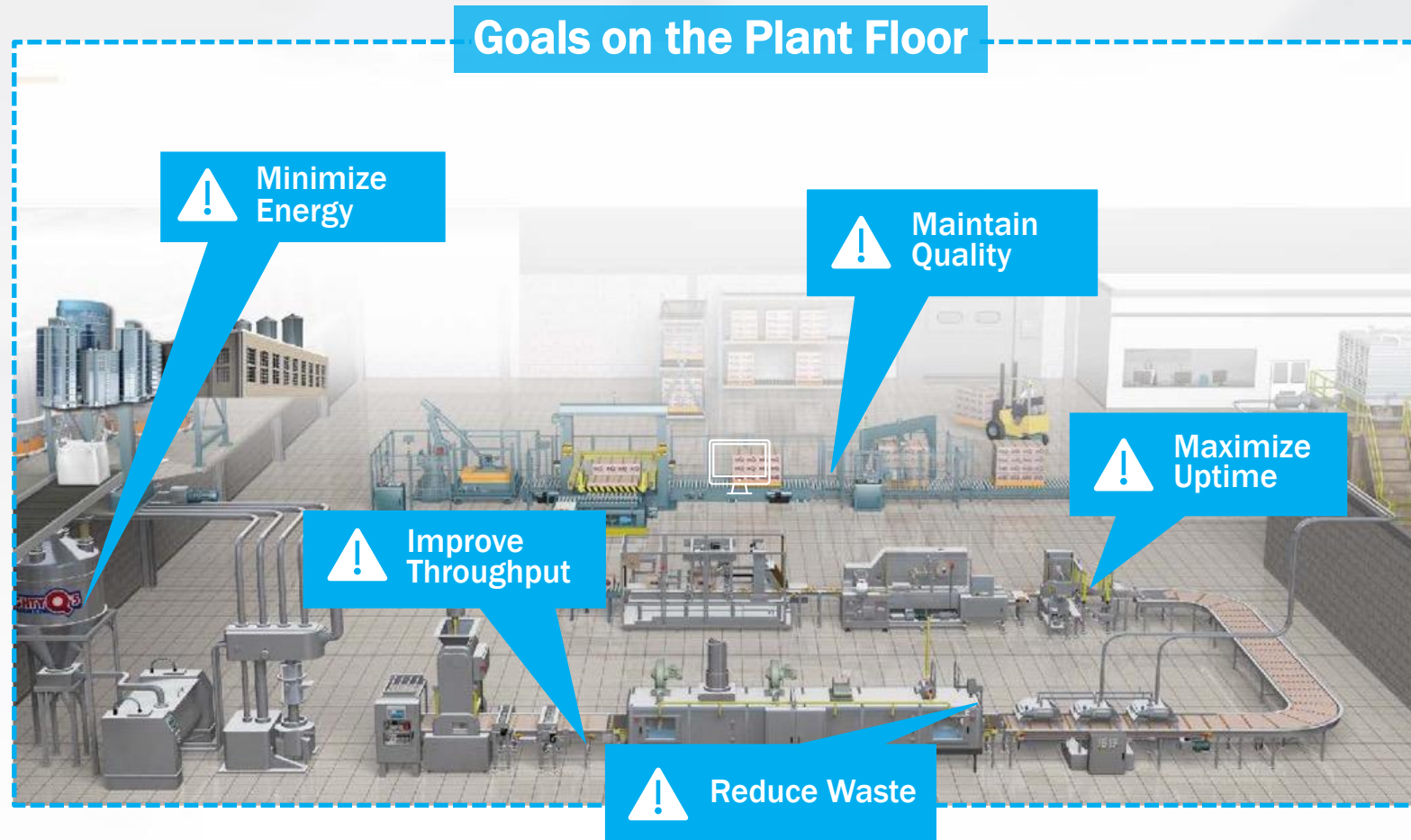**6** Success Stories

7 What's New and What's Coming

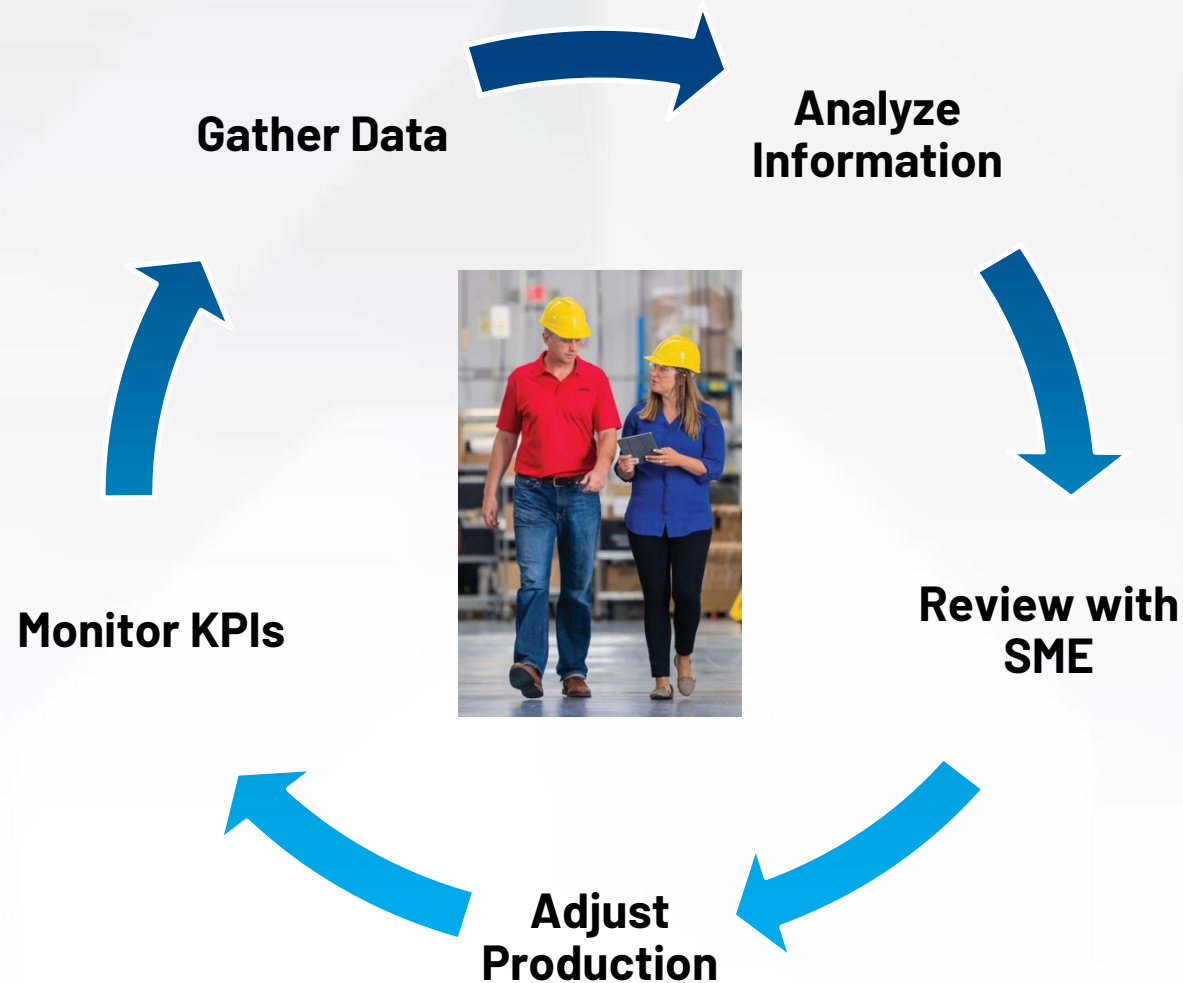**6** Key Takeaways

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Operational reality on the plant floor

Plant and process engineers must drive continuous improvement to optimize operations

The traditional approach

Manual processes and trial and error approaches limit progress

Gather Data

Analyze Information

Review with SME

Adjust Production

Monitor KPIs

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Challenges with the traditional approach to optimization

Time Consuming

- Manual analysis
- Large data volume
- Lack of data context
- Missing data relationships
- Written procedures

Expertise Required

- High process variability
- Competing priorities for few process experts

Introduces Risk

- Trial and error approach
- Delayed results
- Potential impacts to production and uptime

Reproducibility

- Not repeatable, reusable
- Difficulty to maintain and update over time
- Hard to monitor and manage across sites

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The impact of data and analytics on decision-making

Gartner

"

47% of organizations believe that the decisions they face will be more complex, increasing demand for connected, continuous and contextual Data & Analytics and explainable decision processes..

Source: Top Trends in Data and Analytics, 2022 *Gartner, Published 11 March 2022 - ID G00763301*
Top 5 Priorities That Manufacturing CEOs Expect From Their CIOs, Gartner, 19 October 2021 - ID G00759716

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The analytics landscape

	DESCRIPTIVE	DIAGNOSTIC	PREDICTIVE	PRESCRIPTIVE
ENTERPRISE	Which facility performed the best?	Why is Site A throughput behind plan?	I predict that Site A will be behind the plan soon.	What action should I take to avoid Site A from falling behind plan?
SYSTEM	Is Line 1 running ok?	Why is Line 1 quality poor?	I predict that Line 1 quality is moving out of tolerance.	What action should the operator take to avoid poor quality?
DEVICE	Am I running ok?	Why did a fault happen?	I predict a fault will happen soon.	What action should be taken to avoid the fault?

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What is a soft sensor?

QC Lab

ANALYSIS

Addressing Process Variation with Soft Sensors

- Data is available sooner and faster
- Data is available in real-time, enabling direct quality control
- The model identifies what changes the results
- May reduce lab frequency requirements (costs)

Software model that **predicts** process values based on **real-time process data**

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FT Analytics™ LogixAI®
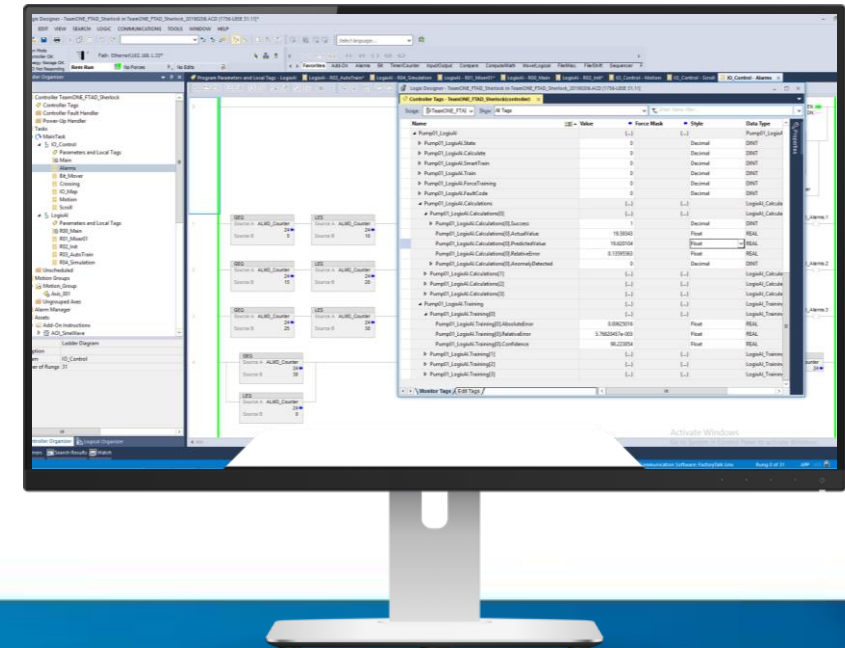
Soft Sensor

Maximize asset performance with continuous monitoring, real time data analysis and prediction of a single target outcome

Edge Based

Execute a physics-based model that makes a logical prediction of an operational parameter's value with calculation times that are valuable at the control layer (250 msec)

OT Focused

Empower OT personnel with out-of-the-box, no-code machine learning (ML) that integrates directly with ControlLogix®

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FactoryTalk® Analytics™ LogixAI®

Empower OT personnel with out-of-the-box, no-code machine learning at the edge

Compute Module

The module runs in the chassis and communicates with ControlLogix® via the backplane

Industrial Edge Computer

The containerized app runs on an industrial edge PC and communicates with ControlLogix® via Ethernet

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FactoryTalk® Analytics™ LogixAI® use cases

Automotive & Tire

Predict: Tire splice location

Value: Decreased out-of-tolerance events

Boiler

Predict: Steam pressure

Value: Reduce operator interaction and energy use
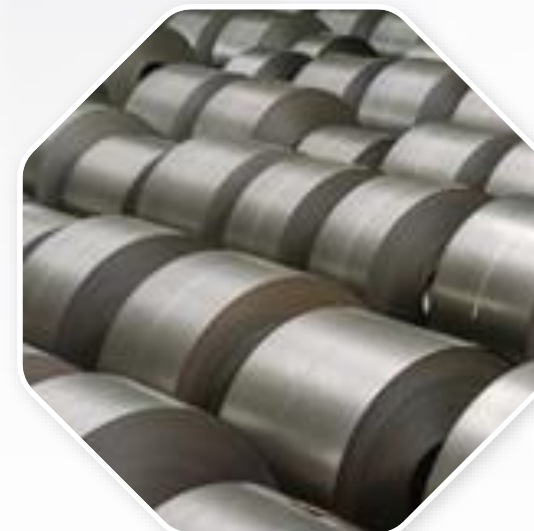
Filling/Packaging

Predict: Fill weight of product in the container

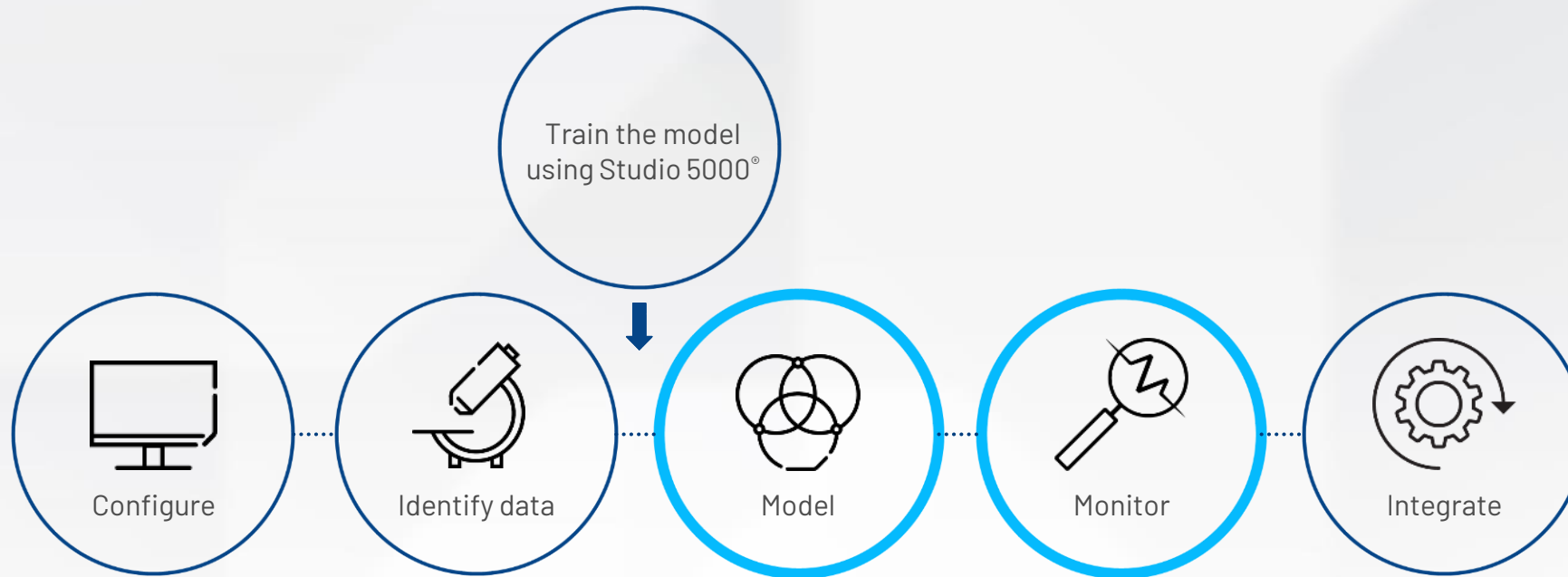**Value:** Reduce product giveaway

Rolled Products

Predict: Positioning for cuts perforation

Value: Increased product consistency and throughput

FactoryTalk® Analytics™ LogixAI®

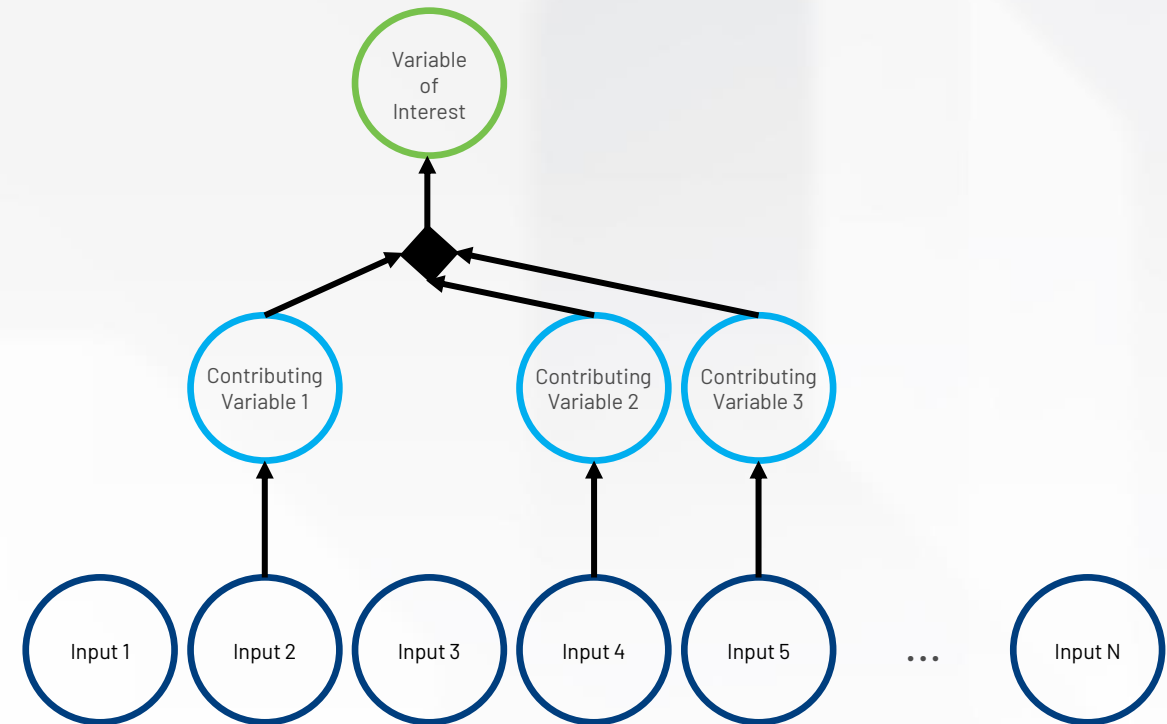Descriptive | Diagnostic | **Predictive** | Prescriptive

Train the model using Studio 5000®

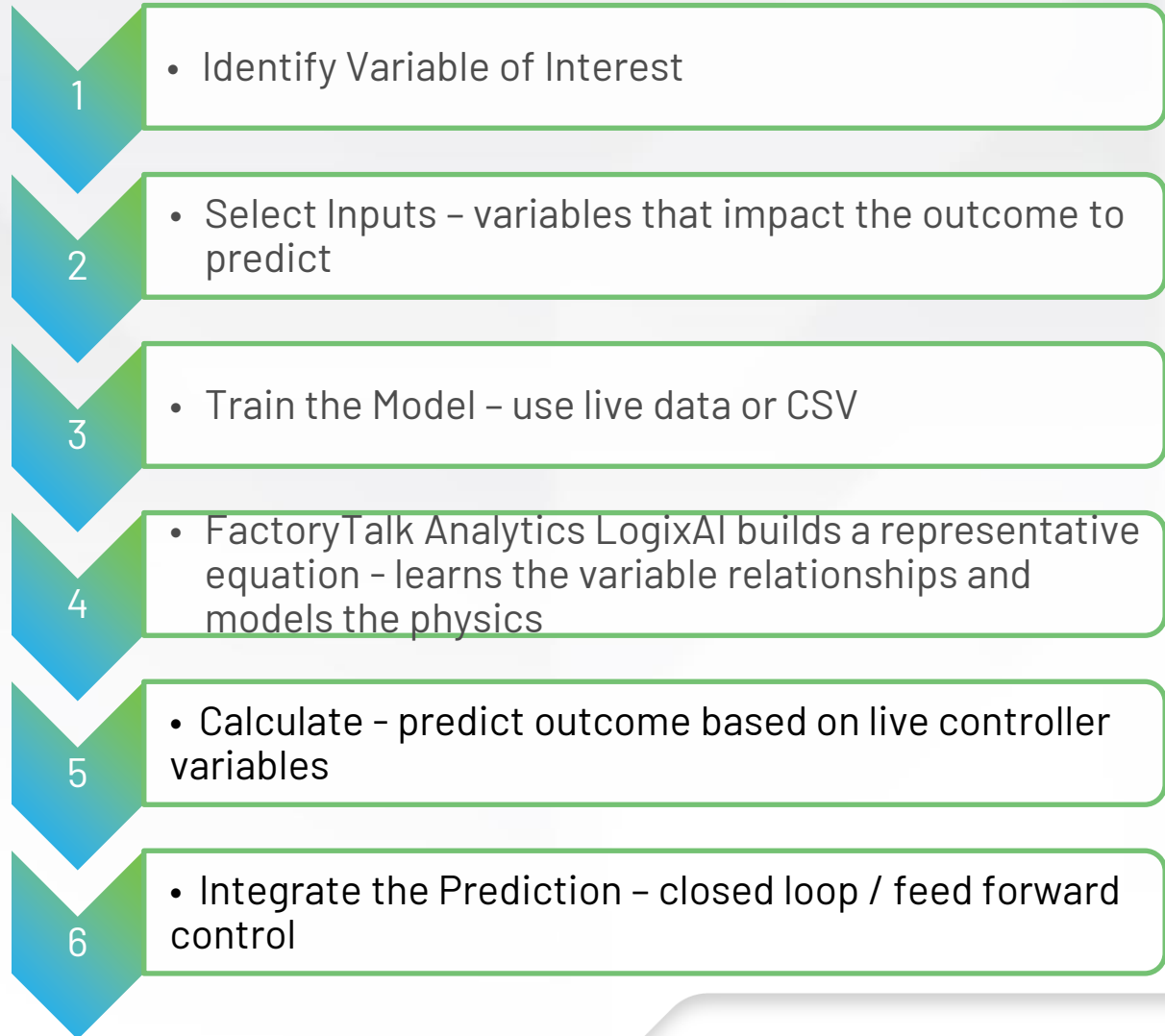Configure   Identify data   Model   Monitor   Integrate

EMPOWER CONTROLS ENGINEERS WITHOUT DATA SCIENCE SKILL SET

Automated Machine Learning Modeling for ControlLogix® Tags as Primary Data Source

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How FactoryTalk® Analytics™ LogixAI® works

Understanding the workflow

1 • Identify Variable of Interest

2 • Select Inputs – variables that impact the outcome to predict

3 • Train the Model – use live data or CSV

4 • FactoryTalk Analytics LogixAI builds a representative equation - learns the variable relationships and models the physics

5 • Calculate - predict outcome based on live controller variables

6 • Integrate the Prediction – closed loop / feed forward control

Variable of Interest

Contributing Variable 1 Contributing Variable 2 Contributing Variable 3

Input 1 Input 2 Input 3 Input 4 Input 5 ... Input N

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Model view in FactoryTalk® Analytics™ LogixAI®

Get your Prediction Started Using One of the Following Methods

Create a Prediction Model

- Create a prediction model
- Export your prediction model to an L5X
- Import your prediction model L5X into the controller program
- Train and calculate

[CREATE NEW] [IMPORT EXISTING]

Create an Experimental Model

- Import an existing dataset
- Train outside of production
- Integrate your experiment as a Prediction Model to use in production

[CONDUCT EXPERIMENT]

Prediction Models   Experiments

● Controller Slot 0 | Mixer_01_Power2
1. Import UDT to Controller | 2. Train Model | 3. Start Calculating

Enabled   Save L5X   Export Model   Information   Delete

⚠ Controller Slot 0 | CQI_Sensor2
1. Import UDT to Controller | 2. Train Model | 3. Start Calculating

Enabled   Save L5X   Export Model   Information   Delete

● Controller Slot 0 | CQI_Sensor
1. Import UDT to Controller | 2. Train Model | 3. Start Calculating | Review Steps

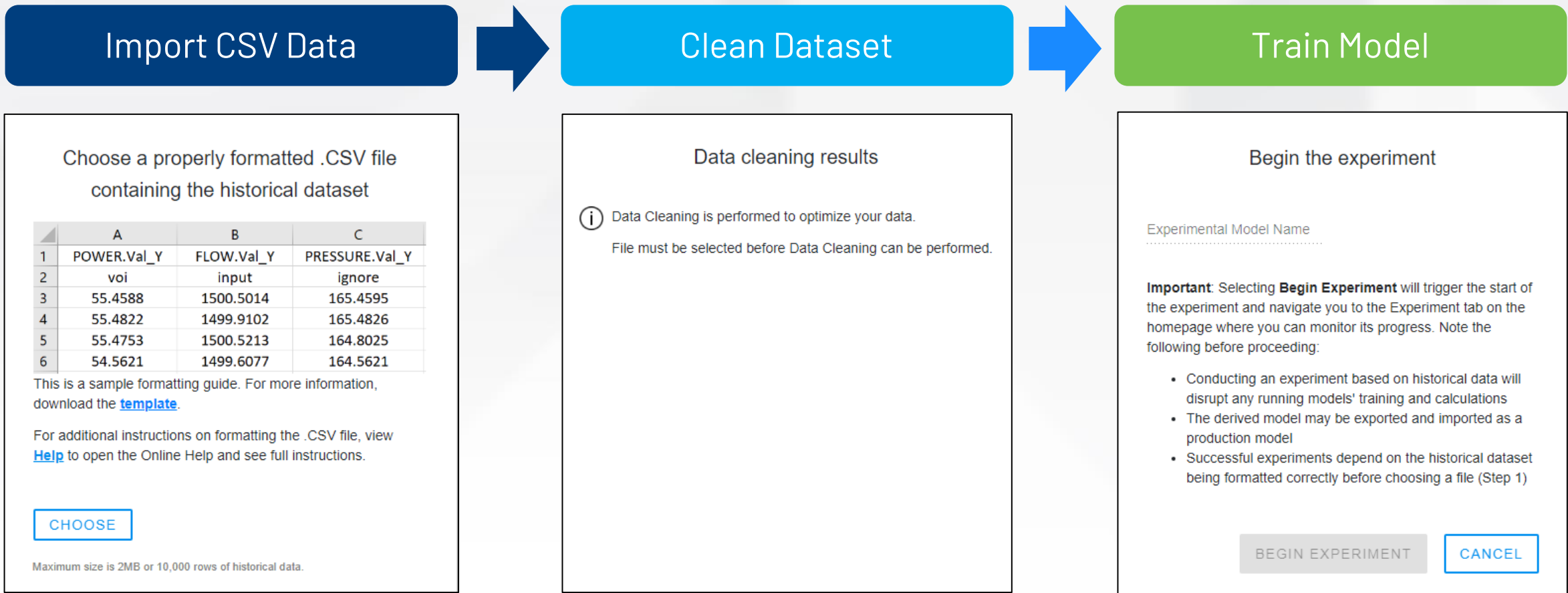Enabled   Save L5X   Export Model   Information   Delete

Experimental data training

Train using historical data via a CSV input to qualify a given use case

Import CSV Data	→	Clean Dataset	→	Train Model

Import CSV Data

Choose a properly formatted .CSV file containing the historical dataset

	A	B	C
1	POWER.Val_Y	FLOW.Val_Y	PRESSURE.Val_Y
2	voi	input	ignore
3	55.4588	1500.5014	165.4595
4	55.4822	1499.9102	165.4826
5	55.4753	1500.5213	164.8025
6	54.5621	1499.6077	164.5621

This is a sample formatting guide. For more information, download the **template**.

For additional instructions on formatting the .CSV file, view **Help** to open the Online Help and see full instructions.

CHOOSE

Maximum size is 2MB or 10,000 rows of historical data.

Clean Dataset

Data cleaning results

ⓘ Data Cleaning is performed to optimize your data.

File must be selected before Data Cleaning can be performed.

Train Model

Begin the experiment

Experimental Model Name

Important: Selecting **Begin Experiment** will trigger the start of the experiment and navigate you to the Experiment tab on the homepage where you can monitor its progress. Note the following before proceeding:

- Conducting an experiment based on historical data will disrupt any running models' training and calculations
- The derived model may be exported and imported as a production model
- Successful experiments depend on the historical dataset being formatted correctly before choosing a file (Step 1)

BEGIN EXPERIMENT   CANCEL

FactoryTalk® Analytics™ LogixAI® contributing variables

Experimental Data Training

Variable Summary				
Variable Type	Name	Contribution Status ❼	Lower Bound	Upper Bound
Variable of Interest	Vol		40.5	88.0440011
Input	Input11	Contributing	47.7540009	75.5920010999999
Input	Input2	Contributing	134.135993699999'	164.053998899999
Input	Input7	Contributing	185.940005400000'	232.8369978
Input	Input1	Not Contributing	104.3279982	131.802
Input	Input10	Not Contributing	81	99
Input	Input3	Not Contributing	48.9149982	73.4469967

View which input variables were selected as contributing to the variable of interest

Model verification

Experimental Data Training

	A	B	C	D	E	F	G	H	I	J	K
	Sample	Oven01_LineSpeed	Val_AmbientTemperature	Oven01_Temp	Oven01_GasValve	Actual	Predicted		Confidences	R2	MAE
1	1	0	80.65724	324.9994	32.50008	32.50008	32.5003025114445		('experiment', '100.0')	0.999999123402755	0.00813087389881
2	2	5	81.05362	325.0007	35.50002	35.50002	35.5004703024916				
3	3	10	80.29159	324.9876	38.50003	38.50003	38.4991973846764				
4	4	15	80.71627	324.838	41.4987	41.4987	41.4842668291045				
5	5	20	81.10652	324.9994	44.50003	44.50003	44.5004533907657				
6	6	25	80.3536	324.9994	47.50003	47.50003	47.500491110596				
7	7	30	80.77459	324.991	50.50002	50.50002	50.4996883702567				
8	8	35	81.15834	324.9938	53.50002	53.50002	53.5000062434769				
9	9	40	80.41527	324.9374	56.49964	56.49964	56.4944008735967				
10	10	45	80.83215	324.8649	59.49896	59.49896	59.4871846217248				
11	11	50	80.04128	324.9994	62.50003	62.50003	62.5006797097475				
12	12	50	80.47652	275.0024	57.50002	57.50002	57.4982407691065				
13	13	45	80.88889	275.0009	54.50002	54.50002	54.498052967103				
14	14	40	80.10407	275.0009	51.50002	51.50002	51.4980152472727				
15	15	35	80.53732	275.023	48.50025	48.50025	48.5001887381268				
16	16	30	80.94474	275.0065	45.50016	45.50016	45.4985001143919				
17	17	25	80.16676	275.3106	42.50311	42.50311	42.5288890537981				
18	18	20	80.59757	275.1015	39.50089	39.50089	39.5079298790308				
19	19	15	80.99967	275.1311	36.50115	36.50115	36.5108537807507				
20	20	10	80.22929	275.038	33.50035	33.50035	33.5015009607069				

View a side-by-side comparison between the actual and predicted values

Model Confidences

Predicted Variable of Interest measurement

Actual value of the Variable of Interest

Live data training

Train and predict using controller data

Import UDT

1. Connect and import controller data (tags)

2. Configure the model prediction

3. Train the model

4. Calculate prediction

FT Analytics™ LogixAI®

Rockwell Software
Studio 5000™

Rockwell Automation
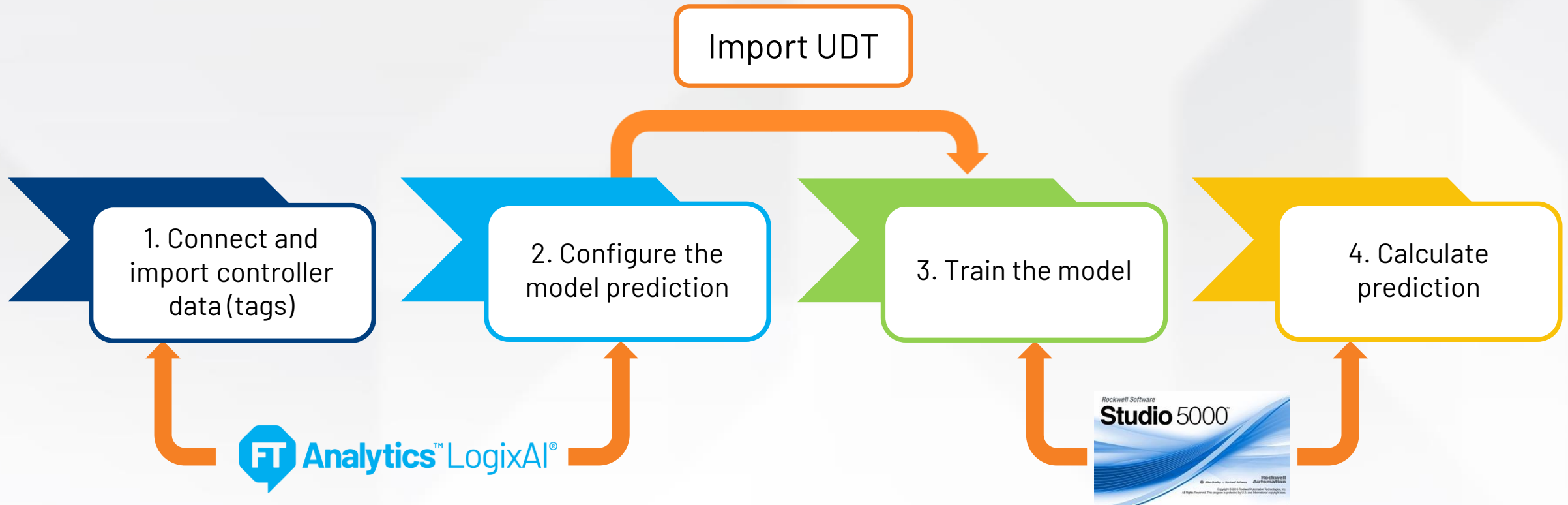
1. Connect and import controller data

Live Data Training

Variable of Interest
- Select the value you want to predict
- Define lower and upper bounds

Input Variables
- Select the variables you think might influence the variable of interest
- Define lower and upper bounds

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2. Review the model definition

Live Data Training

Review the model definition and accuracy

1

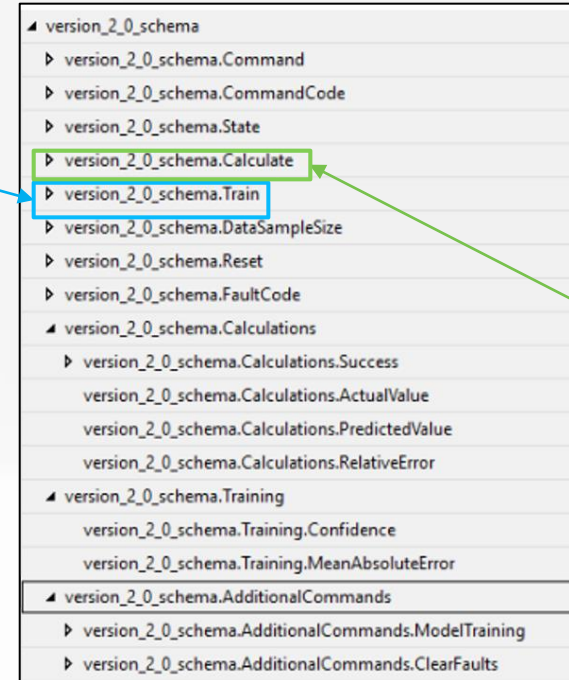Configure the minimum number of training samples required

2

Export the UDT file

3

3. Import the model definition (UDT)

Live Data Training
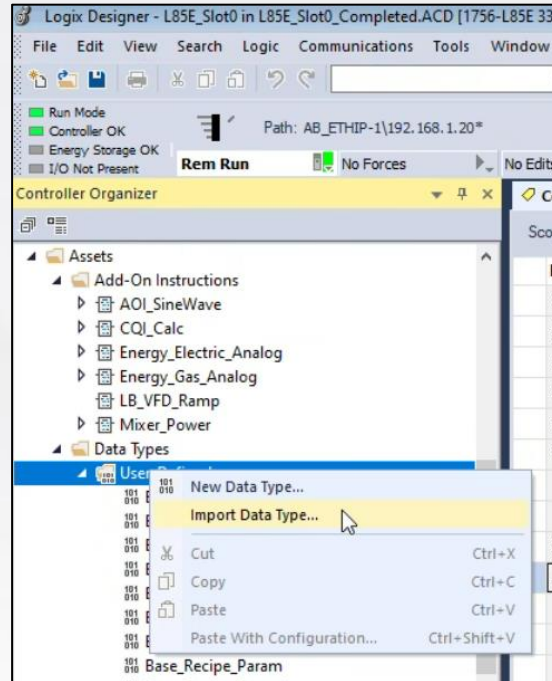
Training Variable
- 0 – off
- 1 – Default: new model training
- 2 – Static: uses the existing model and improves it

Calculate Variable
- 0 – Off
- 1 – Calculate a new prediction

Import UDT

- Import the prediction UDT and controller tag into FactoryTalk® Analytics™ LogixAI® Designer
- Close the communication loop between the controller and FactoryTalk Analytics LogixAI

Train Model

- The algorithm identifies and calculates relationships between each parameter
- Once complete, the confidence level will be displayed

Calculate Prediction

- FactoryTalk Analytics LogixAI analyzes the input parameters and calculates the predicted value of the variable of interest

Human machine interface interaction

FactoryTalk® Analytics™ LogixAI® HMI Faceplates – Train, Calculate, View Results
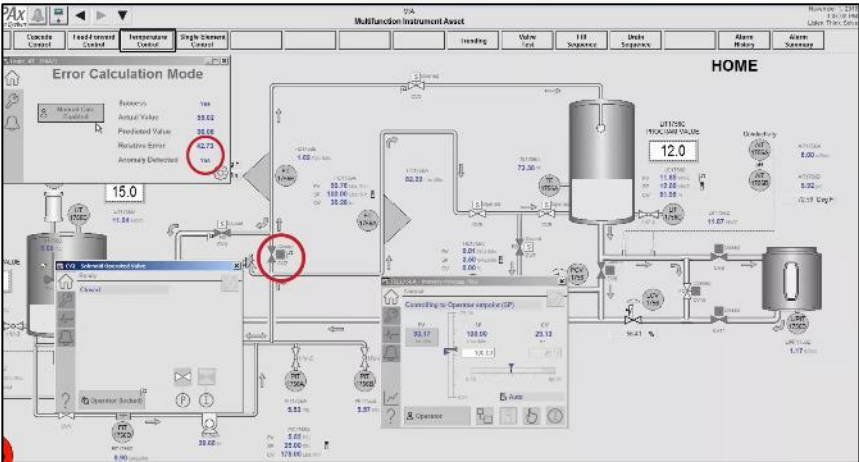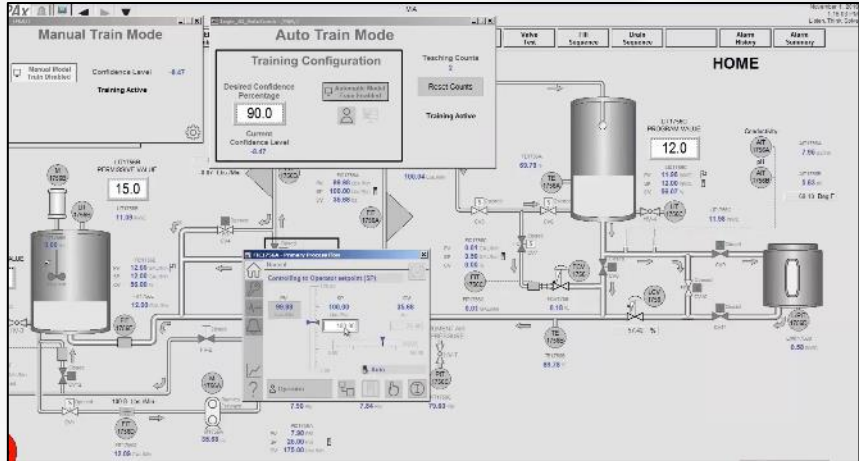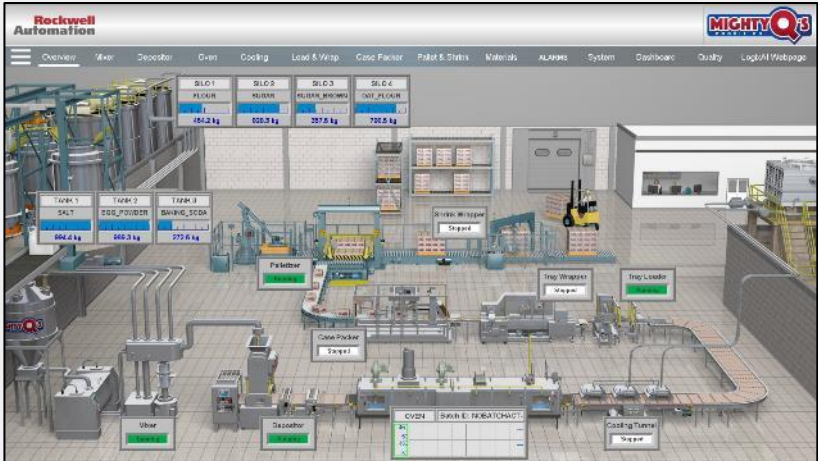
Is my application a good fit for FactoryTalk® Analytics™ LogixAI®?

Use Case Evaluation

- Where do you have a focus on increasing throughput, reducing waste or improving productivity?
- Does this challenge have a significant payback if addressed?

Application Fit

- Is my problem localized to one machine, equipment or process?
- Does my operation obey "first principles unit operations"?
- Can my problem be indicated by one key process variable?
- Do I know which process variables might contribute to my challenge?

Technical Preparedness

- Can all relevant data be localized to one ControlLogix® 5570 or 5580 controller?
- Can I write to setpoints that would address my challenge?
- Can I get regular feedback about my variable of interest?
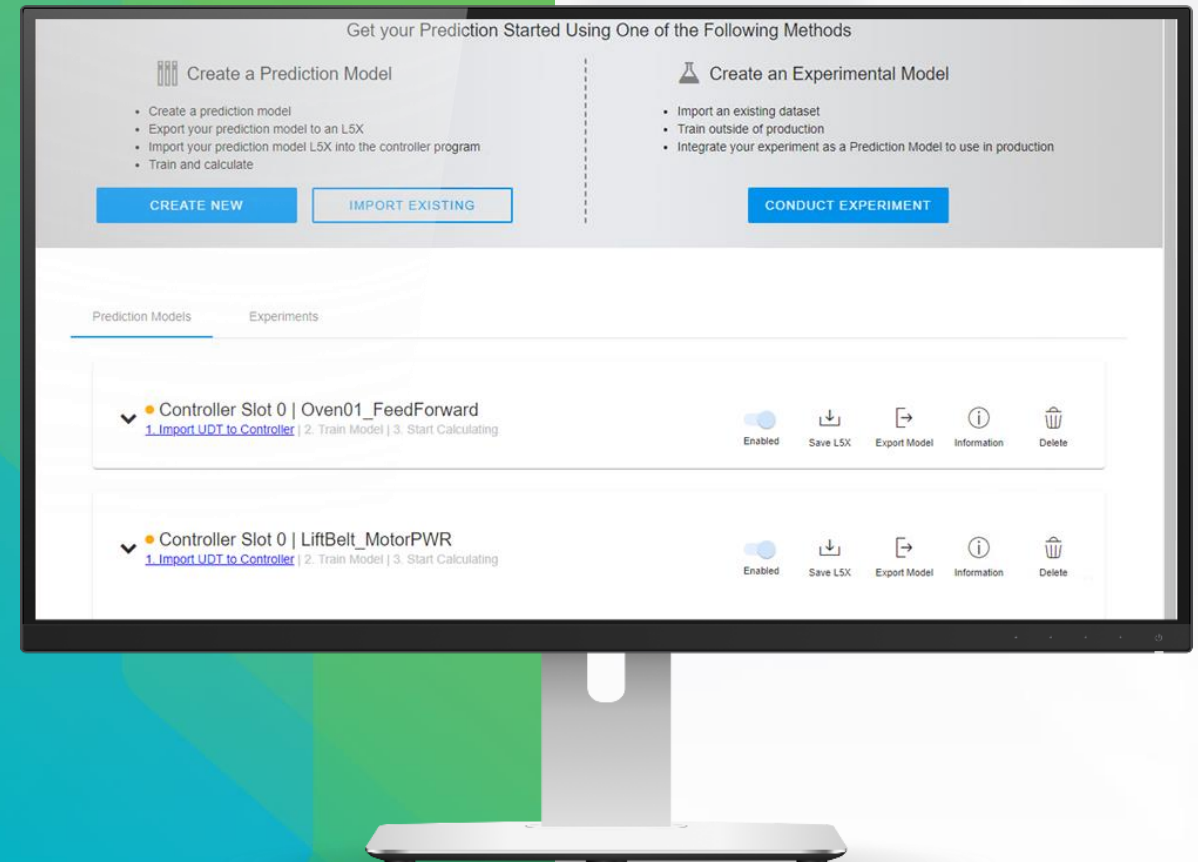
FT Edge™ Manager

Intelligent edge management solution for managing your evolving needs and use cases

Enterprise-level security and open architecture are built-in
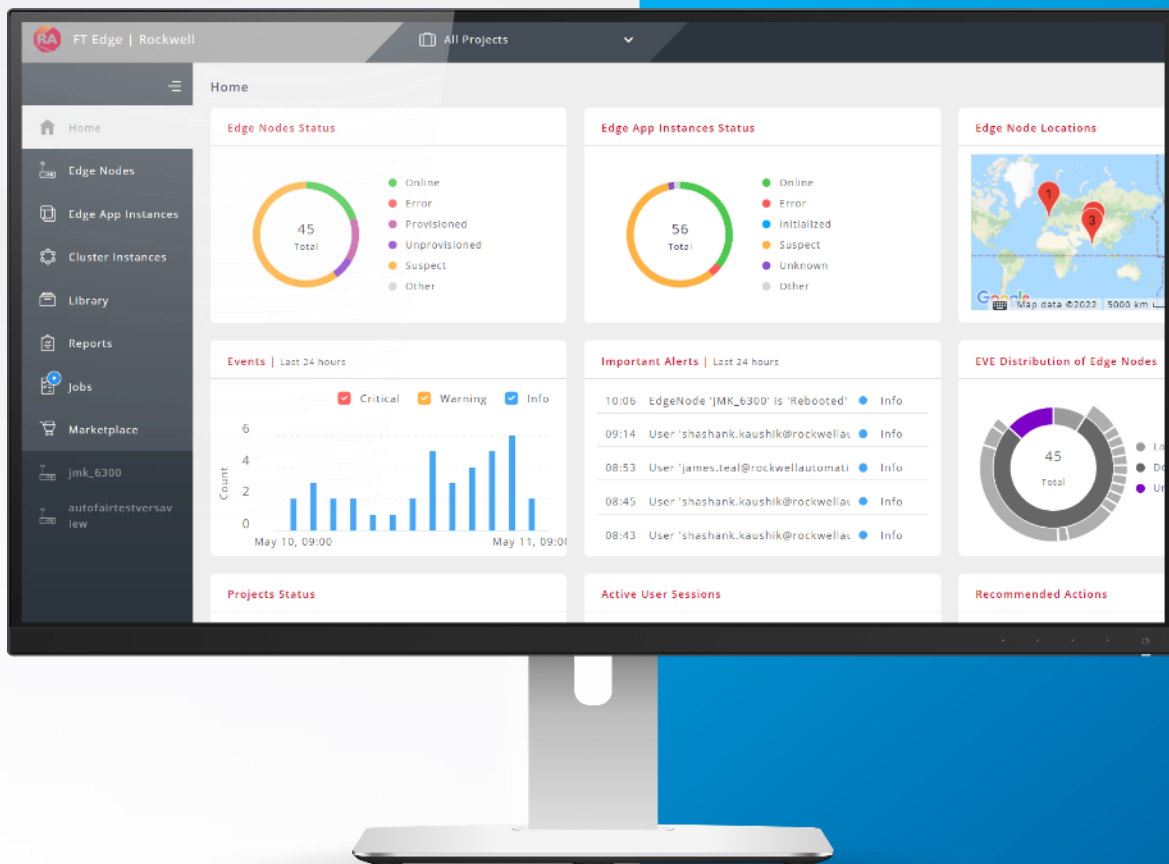
Onboard and provision edge devices

- Provision edge devices with a single step
- Visualize the status of edge devices from any cloud location
- Drill down to any single device

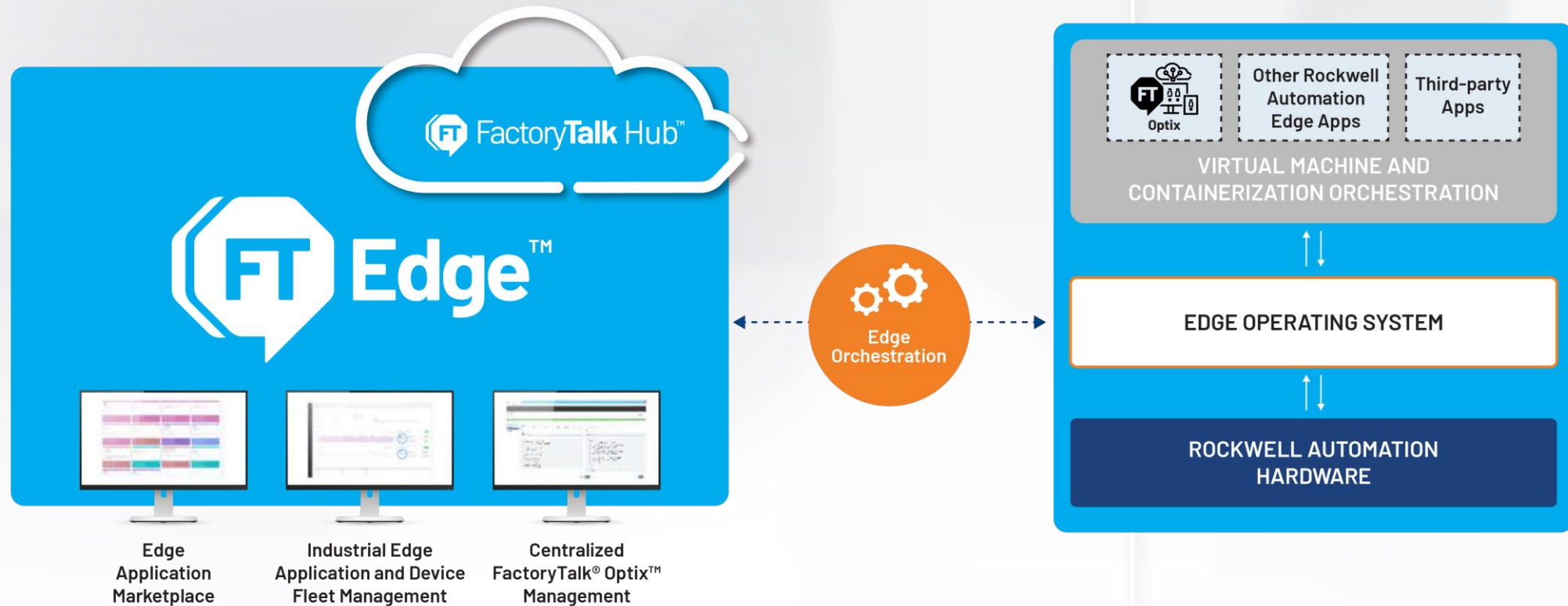**Manage a fleet** of edge devices and apps

- Curate public or private apps (bring your own or partner apps)
- Deploy containerized/VM/Cluster-aware apps
- Share applications with your organization

Drive more secure IT/OT convergence

- Deliver IT best practices to manage applications with OT-specific security

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FactoryTalk® Edge™ Manager

SaaS for edge management, orchestration and application deployment

FactoryTalk Hub™

FT Edge™

Edge Orchestration

Edge Application Marketplace

Industrial Edge Application and Device Fleet Management

Centralized FactoryTalk® Optix™ Management

FT Optix

Other Rockwell Automation Edge Apps

Third-party Apps

VIRTUAL MACHINE AND CONTAINERIZATION ORCHESTRATION

EDGE OPERATING SYSTEM

ROCKWELL AUTOMATION HARDWARE

Rockwell Automation

Cloud

Edge

Control

FT Edge™ Manager

Analytics™ GuardianAI™

Analytics™ LogixAI®

Analytics™ LogixAI®

Analytics™ LogixAI®

Analytics™ LogixAI®

**PowerFlex®
755**

**PowerFlex®
6000T**

**PowerFlex®
755T**

Pump

Fan

Blower

Temp | Vibration | Pressure | Counts | Flow | Current

Production Assets

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DESIGN

Rockwell Automation **Industry Solutions**
RapidLaunch

OPERATE

Rockwell Automation **Industry Solutions**
Batch Performance Analytics

Rockwell Automation **Industry Solutions**
Asset Intelligence

Energy Manager™

PlantPAx® Analytics

DataMosaix™

Historian SE

Analytics™ LogixAI®

Analytics™ Pavilion8™

Edge™ Manager

MAINTAIN

PlantPAx®
Provisioning and
Management

Analytics™ GuardianAI™

PlantPAx®   Rockwell Automation **Industry Solutions**
RapidLaunch

FactoryTalk Hub™

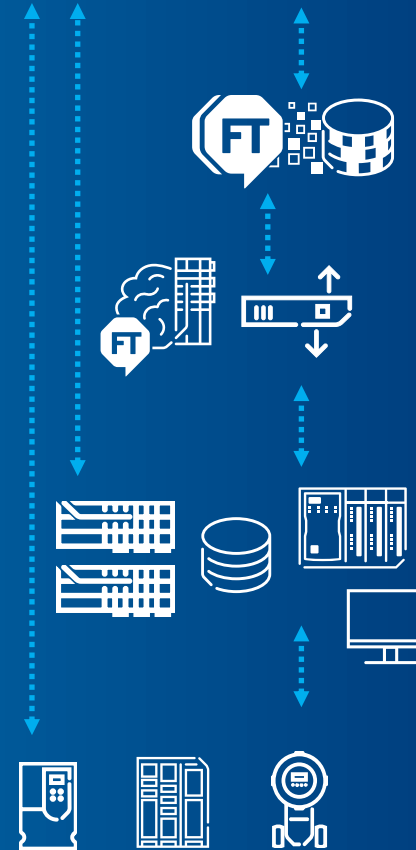**Design Hub**™   **Operations** Hub™   **Maintenance** Hub™

INDUSTRY SOLUTIONS

DATA PLATFORM

EDGE MANAGEMENT & AI

CONTROL

Minimize giveaway with perfect fill

OBJECTIVE

During the packaging process, a filling machine is used to insert 500 grams of viscous product into its container.

The filling machine runs at high-speed and, over time, loses accuracy.

It has a strict lower limit setpoint to confirm legal requirements are met. As a result, inaccuracies result in over filling containers or "giving away" the product.

Frequent adjustments by operators are required to keep the fill level as close to the target as possible.

APPROACH

FactoryTalk® Analytics™ LogixAI® was implemented in the form of a soft sensor to predict product fill level.

The machine learning model was deployed at the edge where it both trains using real process data and then runs during operation to make high speed predictions of the fill level based on current operating conditions.

The predictions were integrated with the automation system in a closed loop to improve control of the fill level.

RESULTS

- Reduced variability in container fill levels

- Minimized product giveaway by approximately 50%, saving 2 grams per container

- Decreased manual intervention required by operators

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Closed loop optimization increases profitability

Objective

The term "splice" is used to describe the length of overlapping material where the ends of the rubber bond to form a tire.

Splice length is a key process indicator. Short splices reduce product quality but long splices waste raw material.

Often, operators need to make manual adjustments to the process to achieve consistent, in-tolerance splice lengths.

When out of tolerance events occur, it causes machine downtime which cuts into production and results in wasted product.

Approach

FactoryTalk® Analytics™ LogixAI® was deployed as a soft sensor for closed loop optimization.

It analyzed previous batches to build a machine learning model that could predict whether splices would be in or out of tolerance.

Predictions were integrated with ControlLogix® to consistently make automated adjustments through an innovative closed-loop learning approach that proactively corrects out of tolerance splices.

Results

- Increased productivity of overall factory machine cycle time by 1.2%

- Reduced >900 hours per year of system downtime due to tolerance

- 80 additional tires per machine per day resulting in higher profitability

- Reduced out-of-tolerance events.

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FactoryTalk® Analytics™ LogixAI® 2.0

New and Improved Algorithm

- Improved model consistency and stability
- Enhanced ability to handle unbalanced data.
- Increased and configuration data input, recommended 10n^2 (n: number of inputs)

Additional Model Quality Indicators

- $ConfidenceLevel = \begin{cases} 100 \cdot r^2, & r^2 > 0 \\ 0, & otherwise \end{cases}$ $Modified\ R\ Squared\ Value$

- Mean Absolute Error - Magnitude of difference between the prediction of an observation and the true value of that observation.

- $MAE = \frac{1}{n}\sum_{i=1}^{n}\left|y_{actual} - y_{predicted}\right|$

Data Pre-Process for CSV Experiments Workflow

- Automated data cleaning
- Empty columns, linear correlation, missing data points, duplicate variables, constant value columns

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FactoryTalk® Analytics™ LogixAI® 3.0

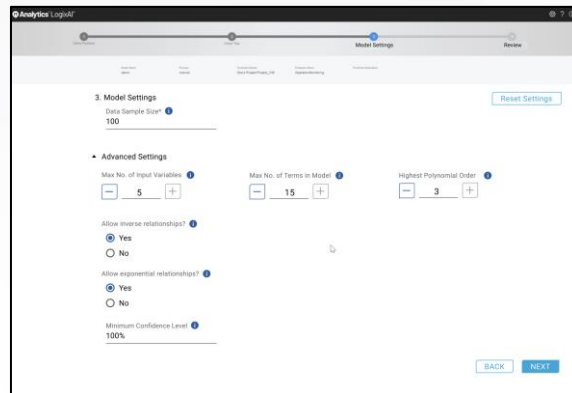Flexible software offering with additional model control

Training Control

Help prevent overtraining

- Confidence threshold

Leverage a simplified model

- Control number of terms
- Inverse relationships
- Exponential relationships

Containerized Application

Enable flexible deployment

- Compute module, edge PC or VM
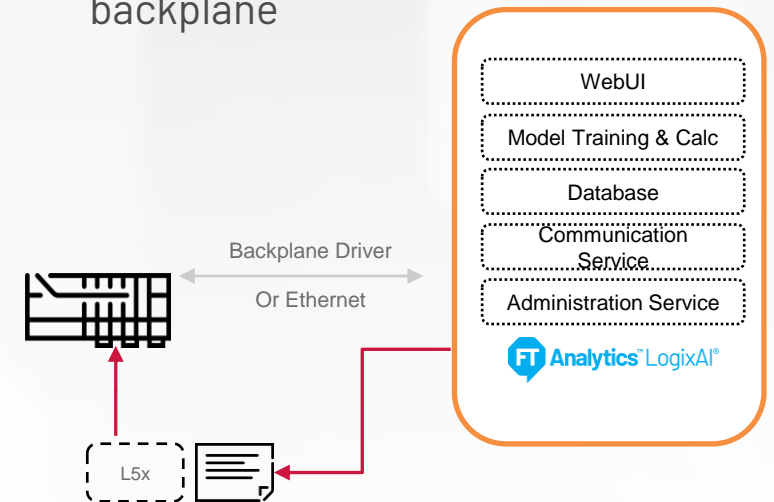- Removing dependency on single appliance

Edge PC   1756-CMS1D1

Ethernet IP Communication

Controller connection via Ethernet

- No longer fixed to ControlLogix® backplane

WebUI

Model Training & Calc

Database

Communication Service

Administration Service

Backplane Driver

Or Ethernet

L5x

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Key takeaways

1 Empower OT personnel with **machine learning at edge** designed to solve operations use cases

2 Predict hard to measure manufacturing parameters and replace manual testing with **soft sensors**

3 **Improve production efficiency** by reducing waste, increasing throughput, and raising product quality

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THANK YOU

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expanding **human possibility**®

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