AIKO – Tekoäly automaatiossa 15.1.2026
TwinCAT & Artificial Intelligence

BECKHOFF

TwinCAT & Artificial Intelligence

BECKHOFF

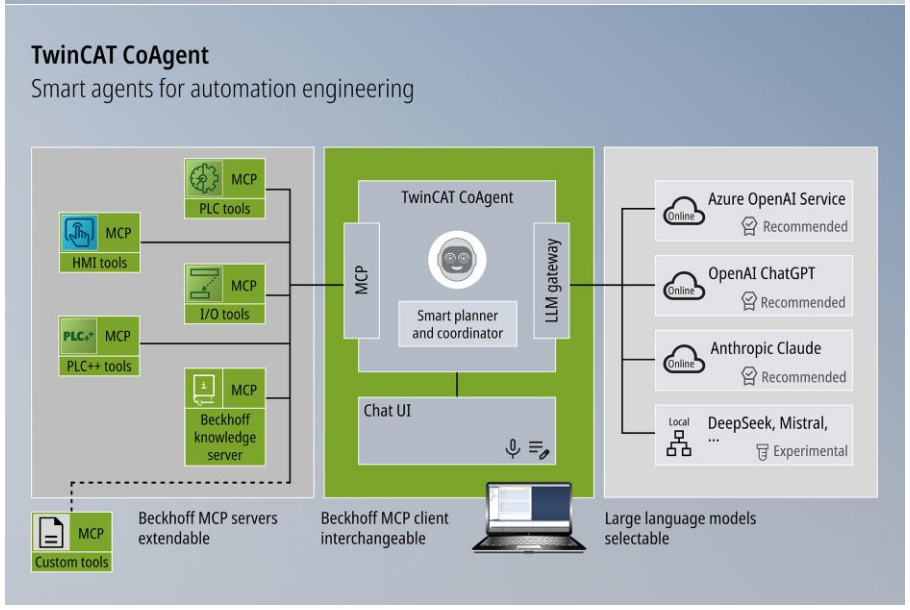
- Janne Kauppila
- Training Manager
- Beckhoff Automation Finland Oy
- Hyvinkää/Tampere

TwinCAT & Artificial Intelligence

BECKHOFF

- TwinCAT Machine Learning
  - Seamless integration of AI at the control level
  - AI models running directly on the PLC
  - Continuous workflow from data acquisition to real-time execution

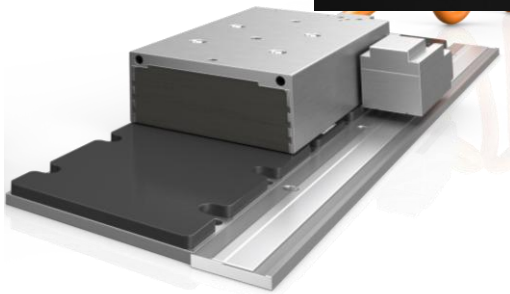
- TwinCAT CoAgent
  - AI-assistant for engineering and operation
  - Combines the latest generative AI models with specialized AI agents
  - Model Context Protocol (MCP) for open and seamless integration



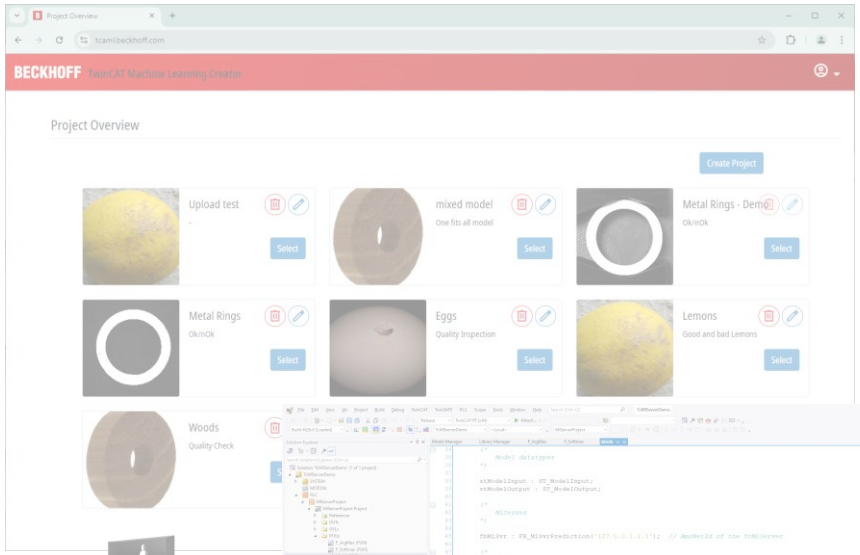
TwinCAT Machine Learning

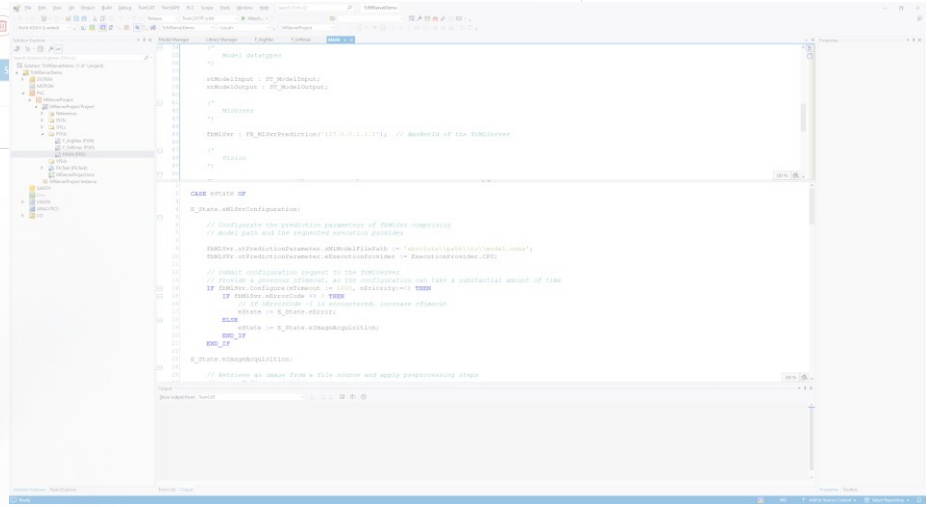
BECKHOFF

Part I: Applications



Part II: Technologies and Tools





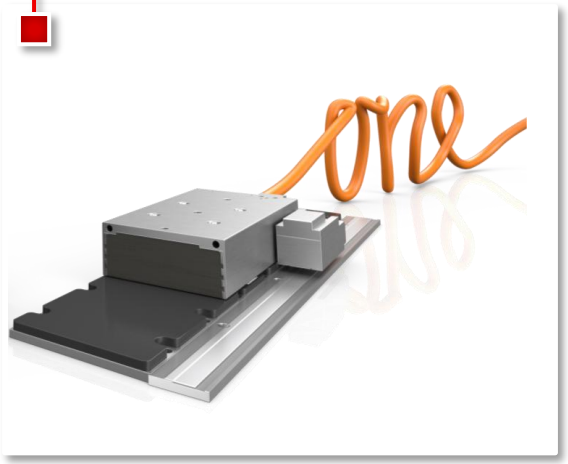
Overview on possible AI-applications in industrial Automation

BECKHOFF

Collaborative and context-aware robotics

Rejects reduction

Machine optimization

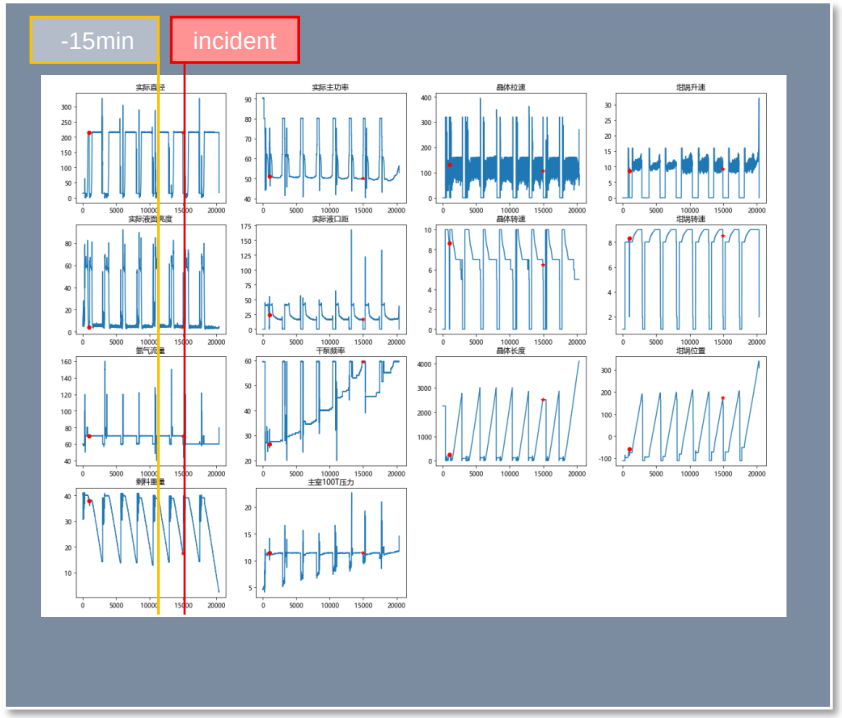


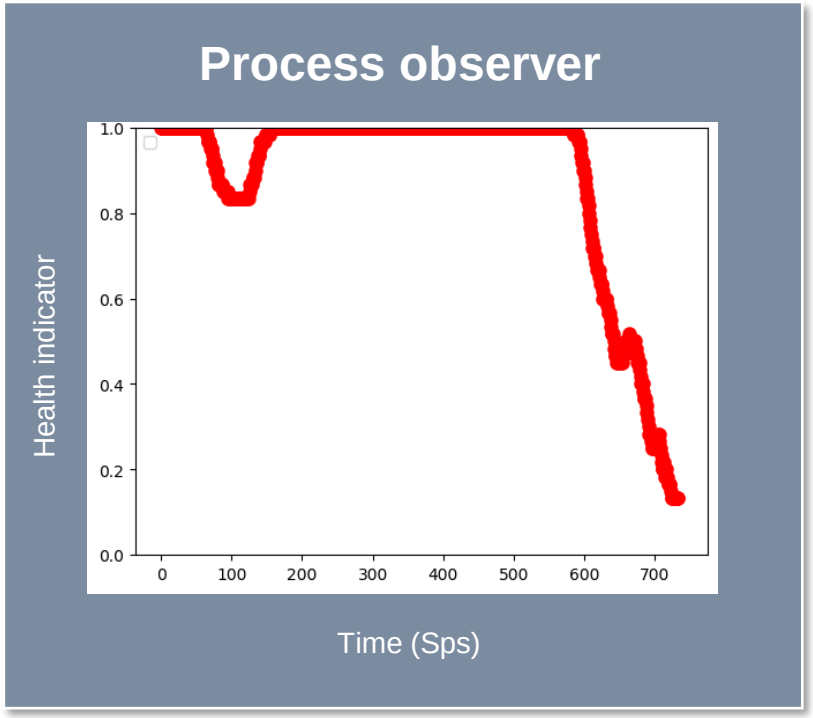
Integrated quality inspection

Predictive main-tenance

Reduction of production waste
AI model as process observer

BECKHOFF



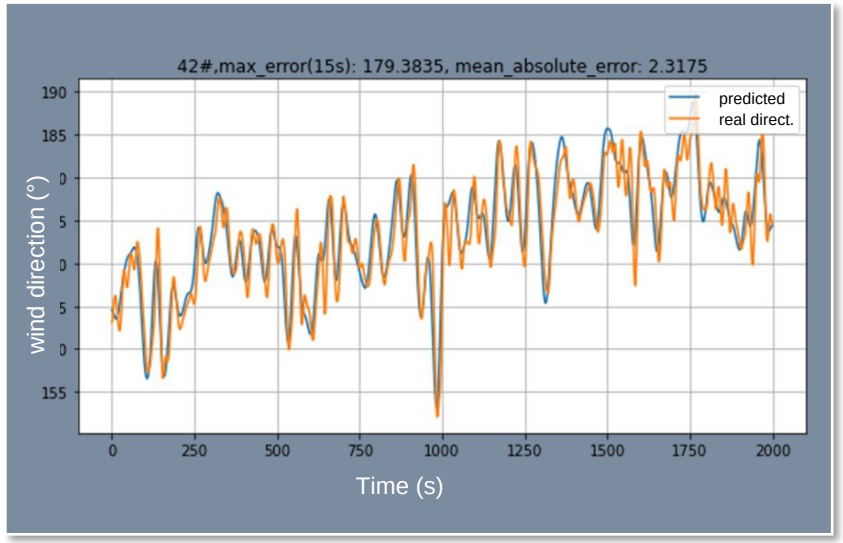


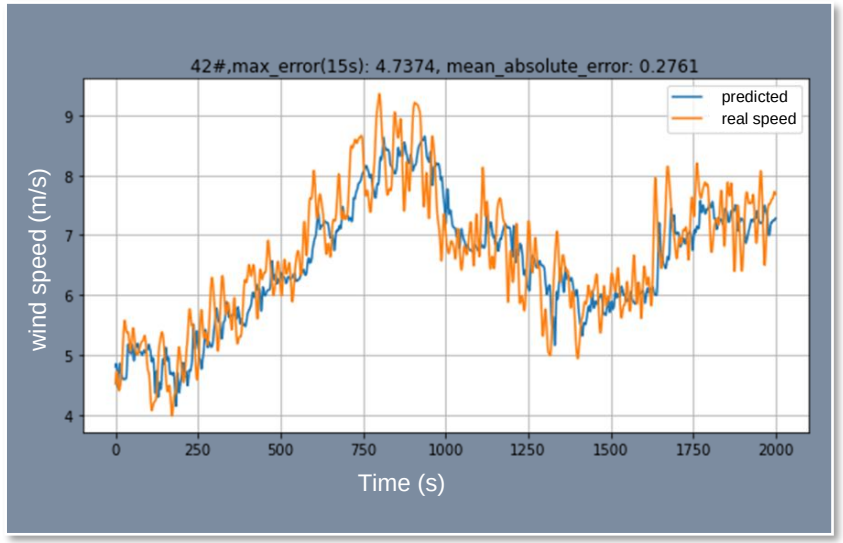
$$\begin{bmatrix} \theta_1(t) \\ \vdots \\ \theta_n(t) \end{bmatrix} \longrightarrow \longrightarrow \longrightarrow health(t+T)$$
$$T = 15\text{min}$$

- crystal growth takes more than 24h, process especially critical in the last hours
- AI model trained on historic data to predict possible process problems 15min in advance

Machine optimization
Prediction of wind speed and direction

BECKHOFF





$$[wd[t-\mathrm{N}] \quad \ldots \quad wd[t]] \longrightarrow \longrightarrow wd[t+T] \quad T = 15s$$

$$[ws[t-\mathrm{N}] \quad \ldots \quad ws[t]] \longrightarrow \longrightarrow ws[t+T] \quad T = 15s$$

- Prediction of wind speed (*ws*) and direction (*wd*) 15 seconds into the future, based on a *N* seconds time window of the past
- Goal: predictive control of pitch and yaw

Control-integrated quality inspection
Testing of packaging in the food industry

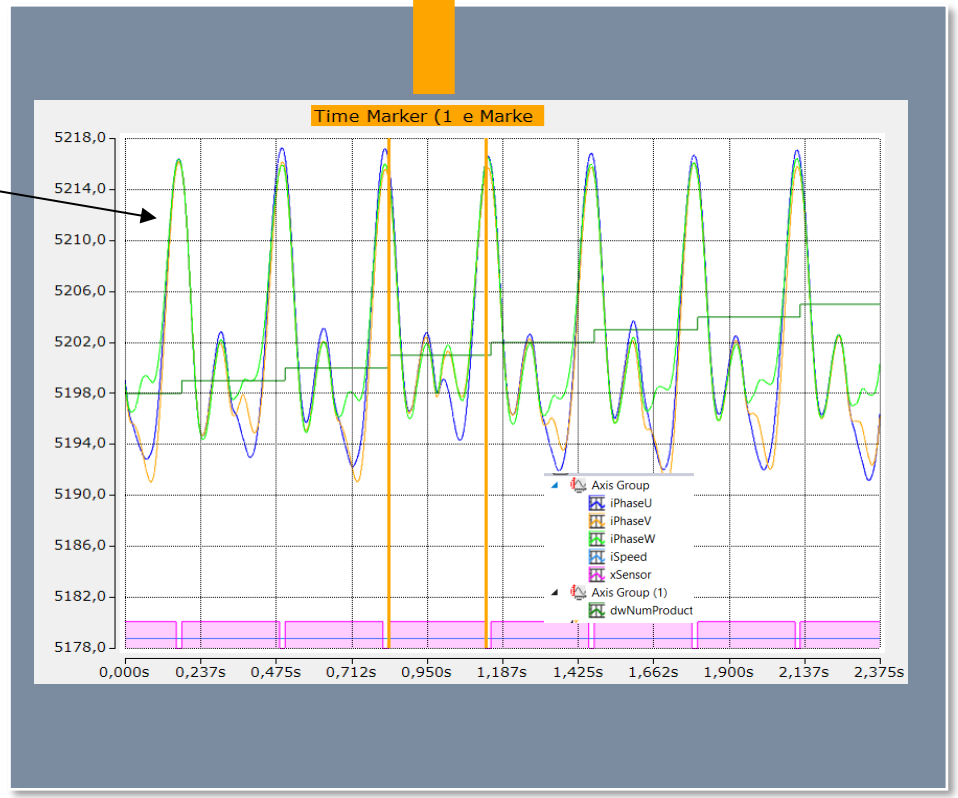
BECKHOFF

Create signal features,
e.g. mean, std, … within
time interval

$$\int_{t}^{t+T} f(\tau)\mathrm{d}\tau \rightarrow \begin{bmatrix}\theta_1 \\ \vdots \\ \theta_n\end{bmatrix}$$

OK
nOK

current feedback
of servo motor

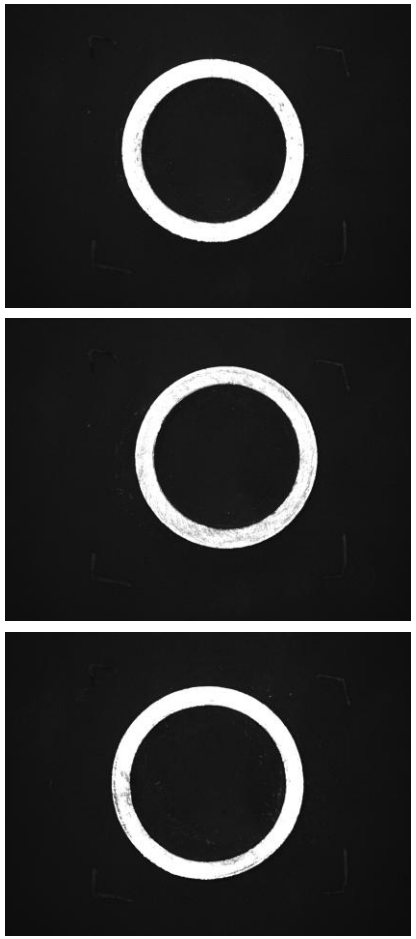


- Detect faults in the final packaging process of instant noodles based on motor currents
- Cutting and sealing process observation
- Feature generation with TwinCAT Condition Monitoring library
- Anomaly detection model trained to detect defects

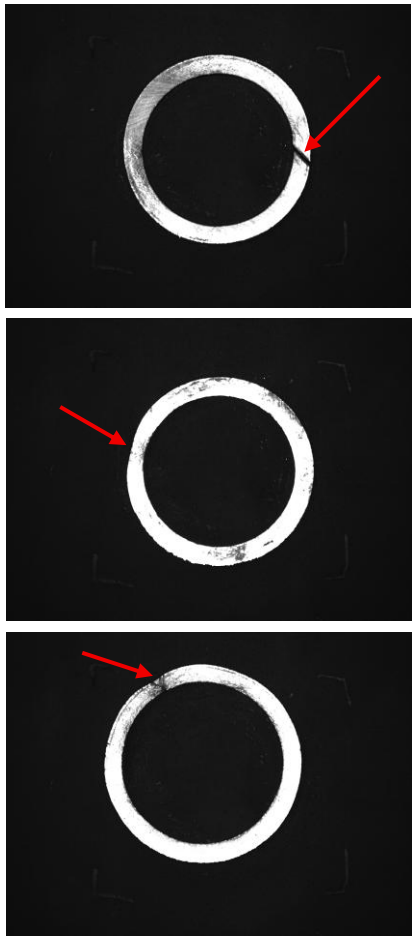
Control-integrated visual inspection
Testing of metal rings

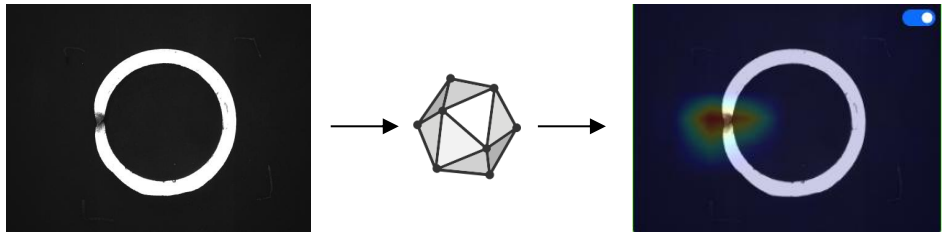
BECKHOFF

Ok

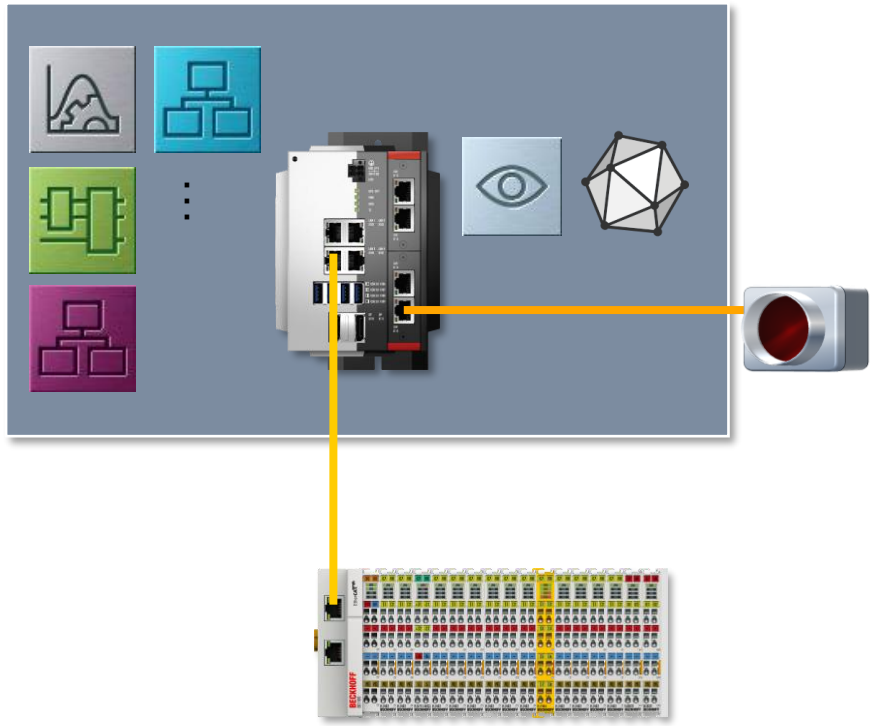


nOk





control system with vision and AI

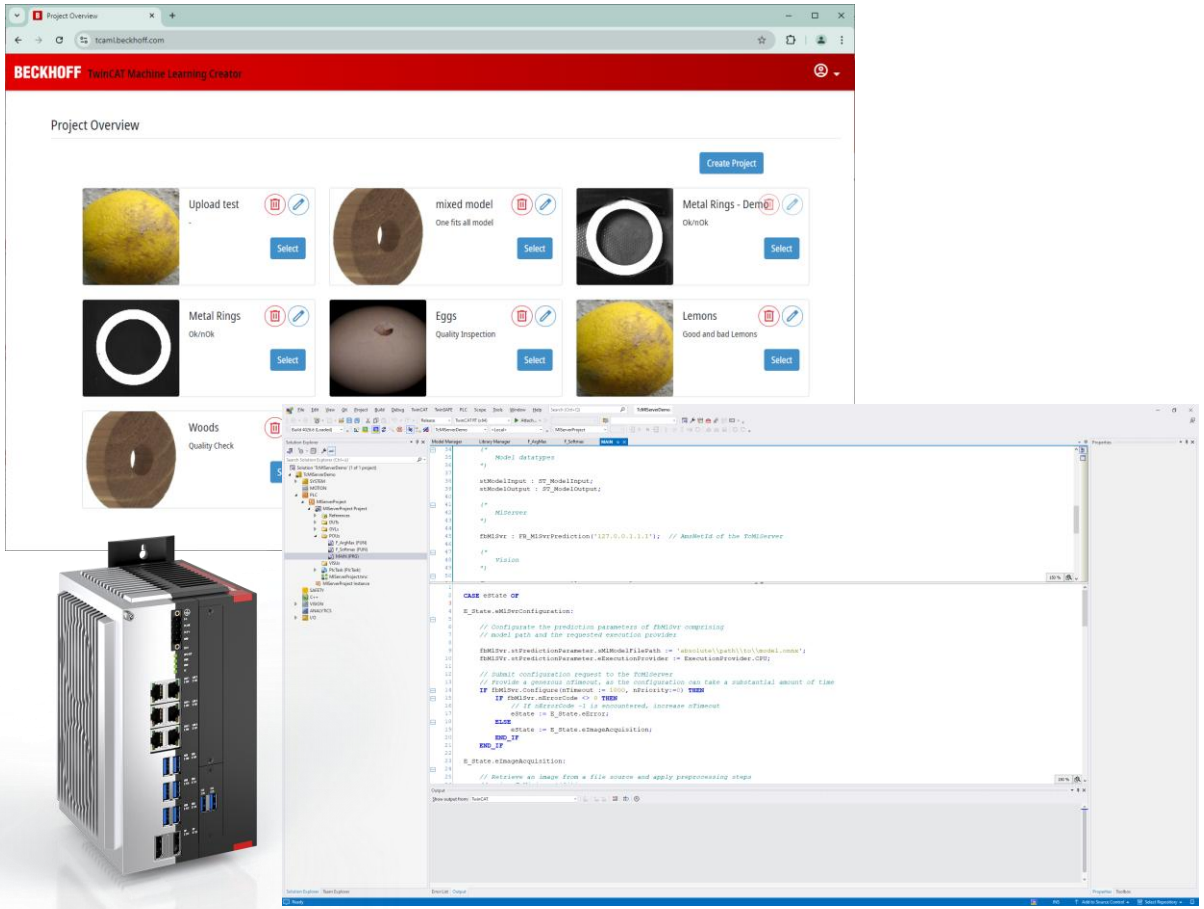


Agenda

BECKHOFF

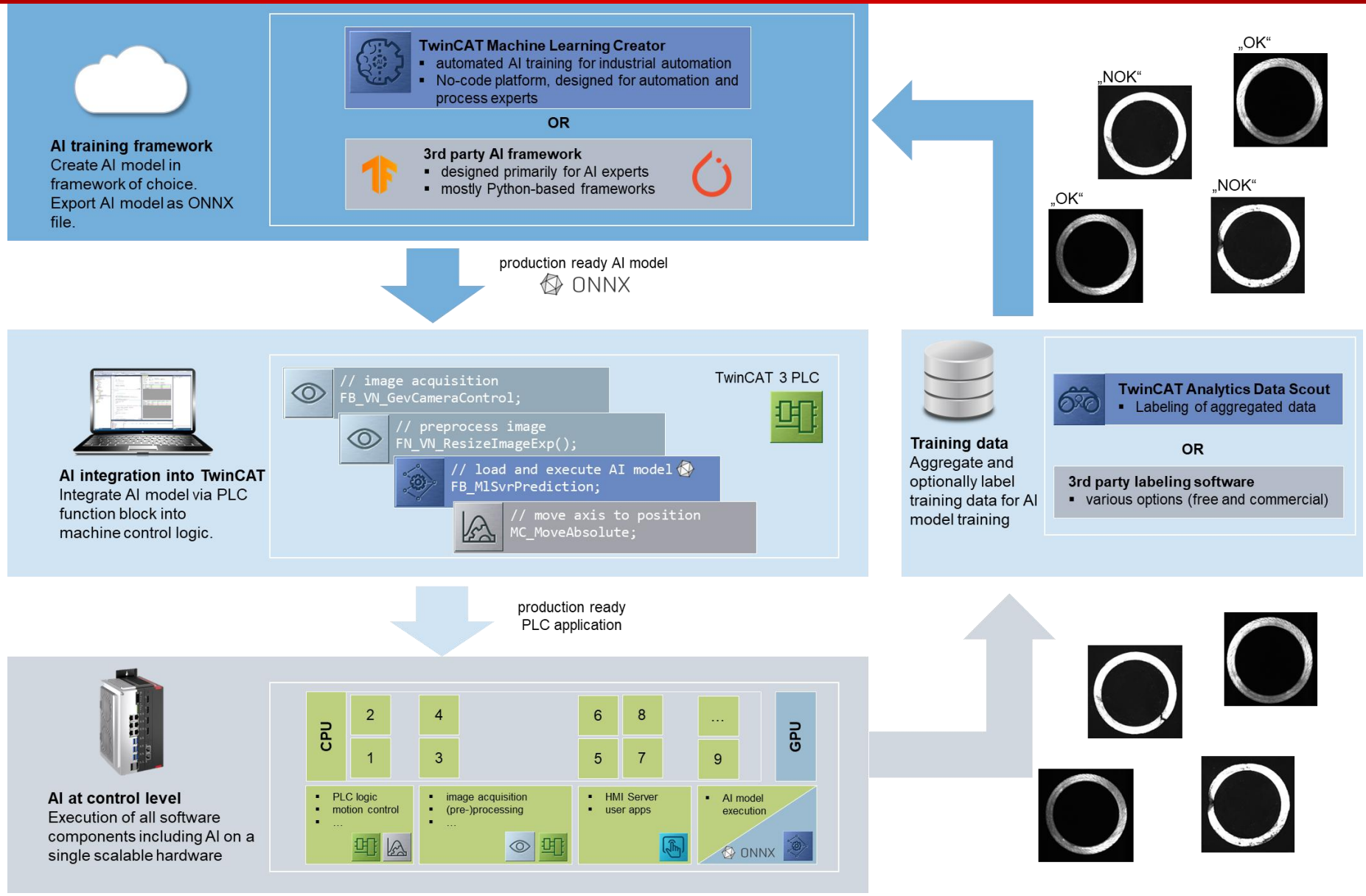
Part I: Applications

Part II: Technologies and Tools



AI Model Lifecycle: Training, Integration und Deployment

BECKHOFF



The Beckhoff AI ecosystem
Complete workflow for integrating AI at control level

BECKHOFF

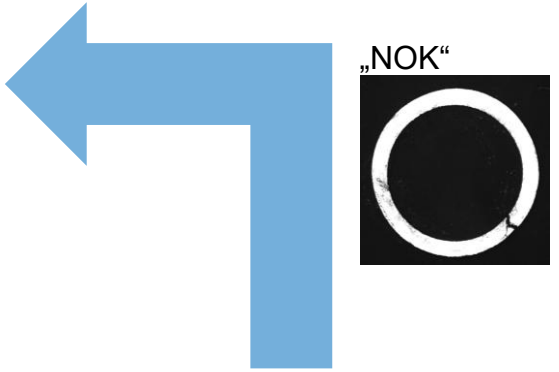
TwinCAT Machine Learning Creator
For non-AI-Experts. Automatically create latency optimized AI models.

production ready
AI model

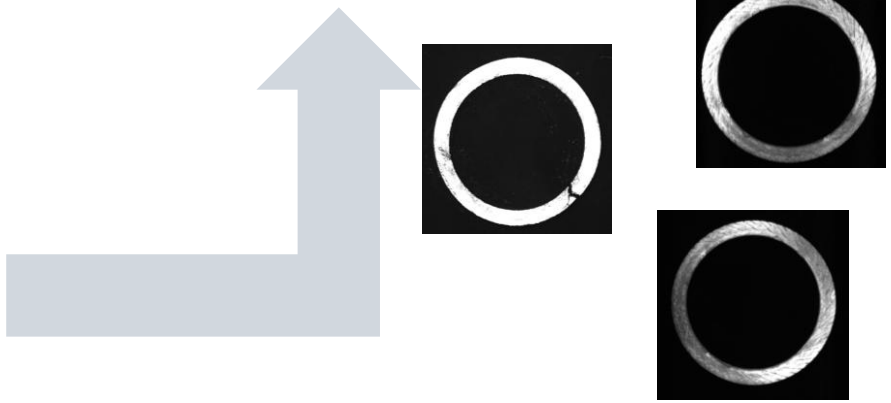
TwinCAT Vision and/or
TwinCAT Machine Learning
Integrate AI into the machine application, i.e. into the PLC code.

production ready
AI-enhanced
PLC application

Scalable IPCs
Execute AI models of different complexity at control level on CPUs or even GPUs.



Training data
Collect, clean and label data



The Beckhoff AI ecosystem
Collect, clean and label data

BECKHOFF

TwinCAT 3 Scope Server

Write images and time series to local file system

TwinCAT 3 Analytics Logger

Write images and time series to local file system or via MQTT to remote storage

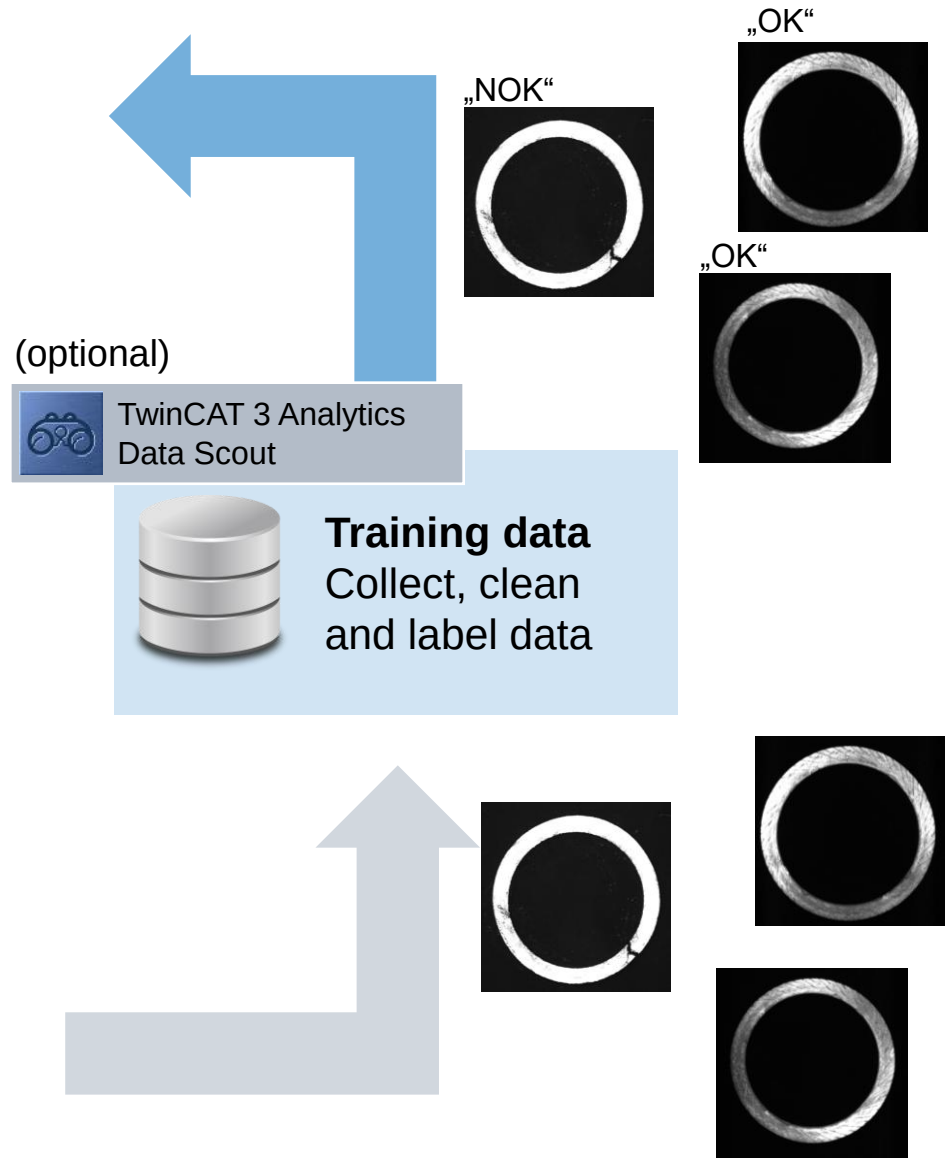
TwinCAT 3 Vision Base

Write images to local file system

TwinCAT 3 Database Server

Write time series to local or remote (no)SQL database

Scalable IPCs
Data logging realized in software modules. Logging performance depends on IPC and network capacity as well as software.



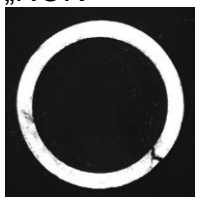
TwinCAT Machine Learning Creator
AI model training for domain experts in automation

BECKHOFF

TwinCAT Machine Learning Creator
For non-AI-Experts. Automatically create latency optimized AI models.

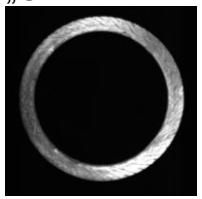
production ready
AI model

„NOK“



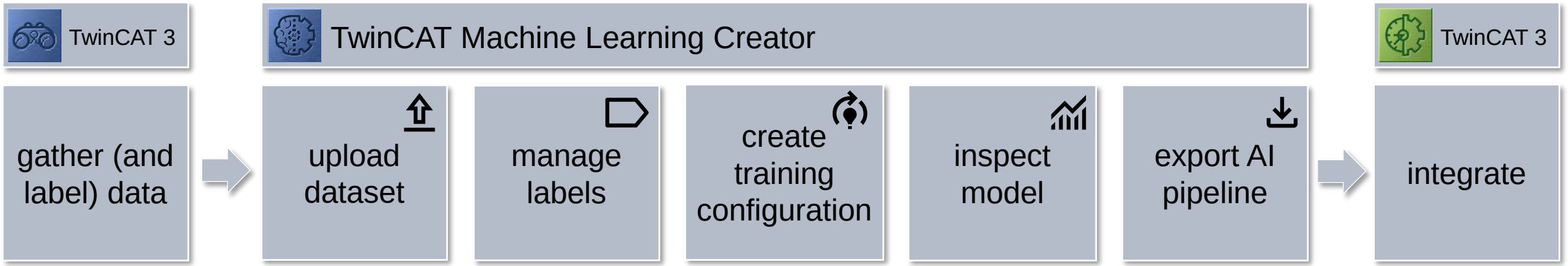
„OK“

„OK“



TwinCAT Machine Learning Creator
Workflow

BECKHOFF



TwinCAT Machine Learning Creator
Benefits

BECKHOFF

Benefits for domain experts:

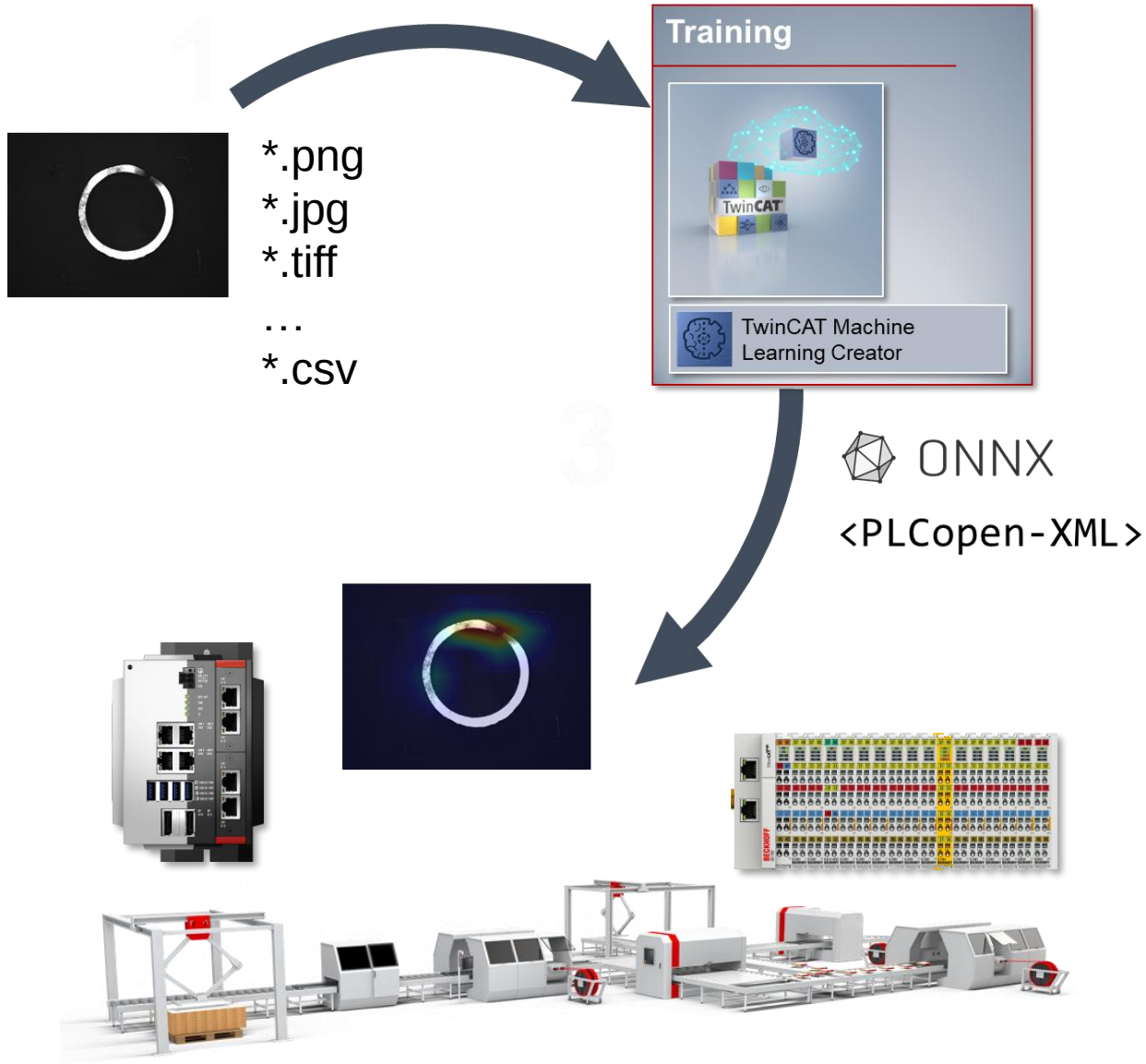
- democratization of ML: accessibility of state-of-the-art ML methods
- designed for people who are not AI experts
- standardization of ML training processes
- user-aware no-code platform

Benefits for AI experts:

- efficiency: acceleration of training processes
- inspiration: version zero generator

Industrial automation focus:

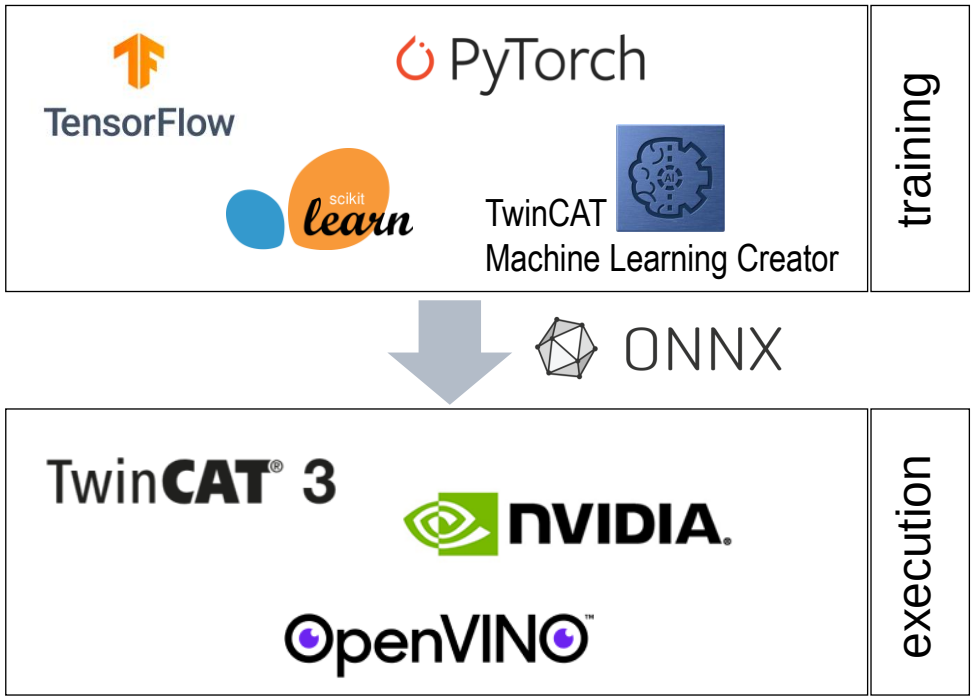
- latency optimized, hardware-aware AI models
- export PLC code for easy integration into automation system



Interoperability standard ONNX

BECKHOFF

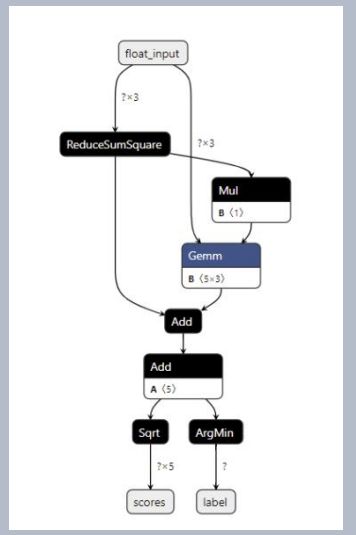
- **O**pen **N**eural **N**etwork E**x**change
- open format representing (trained) AI-models
- interoperability between AI training frameworks and AI inference engines



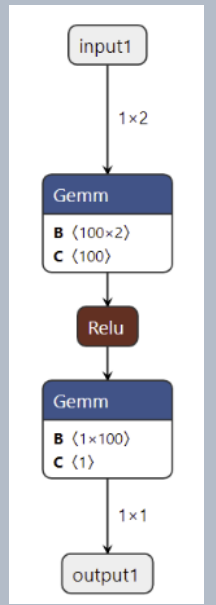
ONNX

"ONNX is an open format built to represent machine learning models. ONNX defines a common set of operators - the building blocks of machine learning and deep learning models - and a common file format to enable AI developers to use models with a variety of frameworks, tools, runtimes, and compilers."
http://onnx.ai/

k-Means



Multi-Layer-Perceptron



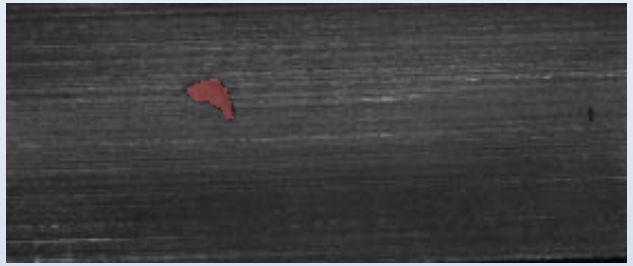
TwinCAT Machine Learning Creator Roadmap

BECKHOFF

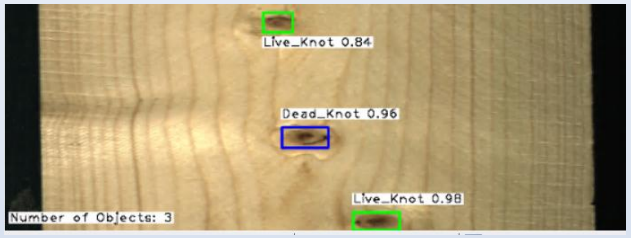
Computer Vision

Image Classification
Task: Classify the image
Beta Phase: Started
Planned Release: Q1/2026

Anomaly Detection
Task: Locate anomalies
Beta Phase: Q1/2026
Planned Release: Q3/2026

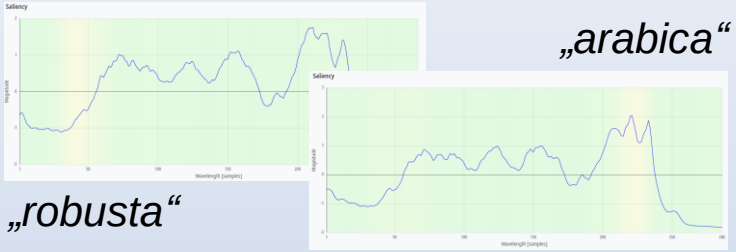


Object Detection
Task: Locate and classify objects
Beta Phase: Q3/2026
Planned Release: Q4/2026



Signals and Time Series

Signal Classification
Task: Classify signals
Beta Phase: End of 2026
Planned Release: tbd



Signal Anomaly Detection
Task: Locate anomalies
Beta Phase: tbd
Planned Release: tbd

Time Series Forecasting
Task: Forecast future values
Beta Phase: tbd
Planned Release: tbd

TwinCAT Machine Learning Creator (MLC)
Signals and Time Series

BECKHOFF

Upcoming

“With *Signals & Time Series*, the TwinCAT Machine Learning Creator becomes the universal AI tool for every machine – visual or signal-based.”

Automated AI Model Creation for Signal and Time Series Data

- Extension of the TwinCAT Machine Learning Creator
- Same easy to use workflow like with vision data

TwinCAT Machine Learning Creator (MLC)
Signals and Time Series

BECKHOFF

Customer Benefits

- Unlocks AI potential for any machine, even without camera systems
- Provides an easy and low-effort entry point into AI-enhanced automation, delivering fast value and scalable results

Typical Applications

- Anomaly detection & predictive maintenance
- Process monitoring and quality assurance (e.g., welding, pressing, packaging)
- Tool wear detection from current, vibration, or acoustic data

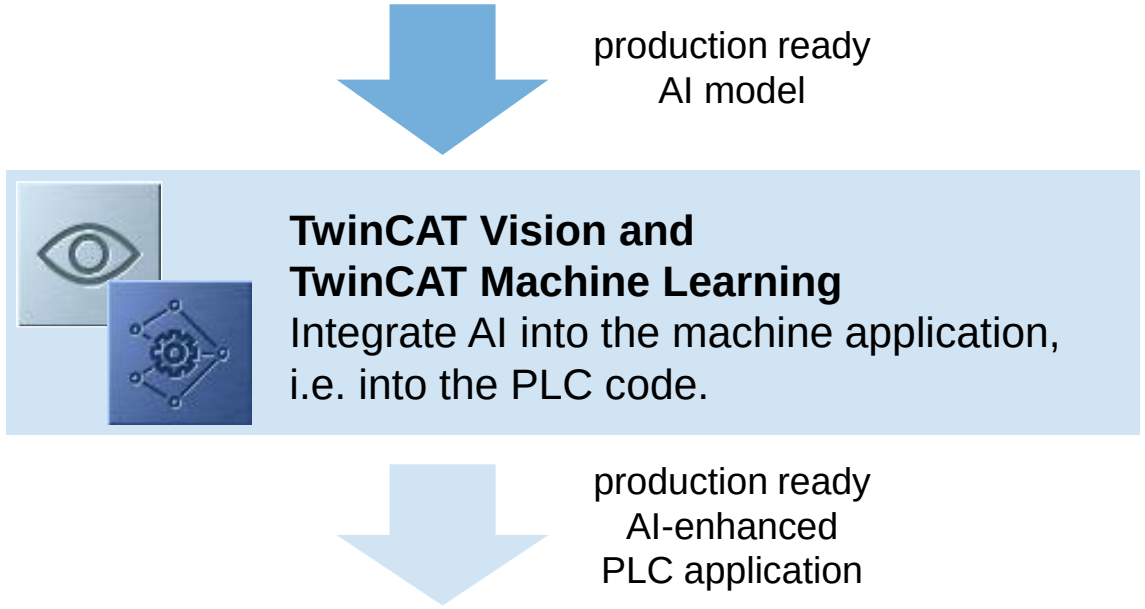
Why is the TwinCAT Machine Learning Creator a game changer?

BECKHOFF

- **democratization**
  - empowers automation engineers to create task-specific AI models
- **accuracy**
  - creates the most effective solution for a customer-specific task
- **efficiency**
  - creates solutions more than 10 x faster compared to hand-crafted AI models
- **scalability**
  - no own infrastructure needed, uses scalable AWS resources
- **standardization**
  - structured and well-documented AI model training simplifies reviewing processes

The Beckhoff AI ecosystem
AI at control level

BECKHOFF



AI at control level
Products and features

BECKHOFF

Products


TwinCAT Neural Network Inference Engine | TF3810


TwinCAT Vision Neural Network | TF7810


TwinCAT Machine Learning Inference Engine | TF3800


License bundle

small and latency critical AI models


TwinCAT Machine Learning Server | TF3820

medium to large AI models

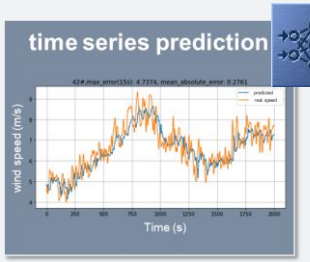
Features

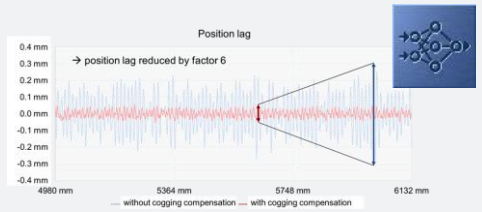
Deterministic AI	Accelerated AI-Server
deterministic execution in TwinCAT-runtime	Near-real time execution (in **separate process**)
Execution on standard x64 **CPUs**	Acceleration possible with NVIDIA **GPUs**
supports **selected AI models** and operators	supports **recent ONNX operators**
Licence-Bundle	Can also be used as a **server** in a network with several clients
Standard PLC Function block for simple integration into TwinCAT PLC	
Interoperability through ONNX support	
Update AI-model at runtime without new compile or TwinCAT Stop	

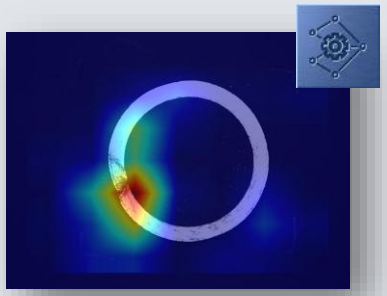
AI at control level
Products and features | exemplary allocation to applications

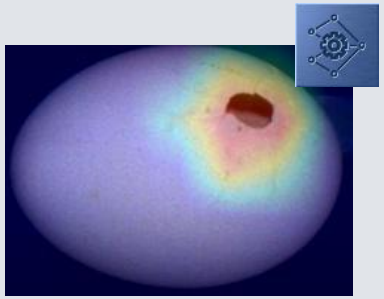
BECKHOFF

Products









Features

Deterministic AI	Accelerated AI-Server
deterministic execution in TwinCAT-runtime	Near-real time execution (in **separate process**)
Execution on standard x64 **CPUs**	Acceleration possible with NVIDIA **GPUs**
supports **selected AI models** and operators	supports **recent ONNX operators**
Licence-Bundle	Can also be used as a **server** in a network with several clients
Standard PLC Function block for simple integration into TwinCAT PLC	
Interoperability through ONNX support	
Update AI-model at runtime without new compile or TwinCAT Stop	

TF3800 | TwinCAT Machine Learning Inference Engine
Key Facts

BECKHOFF

AI models

- Classic machine learning models
- ONNX support
- Trained offline e.g. using Python, R or others

Execution details

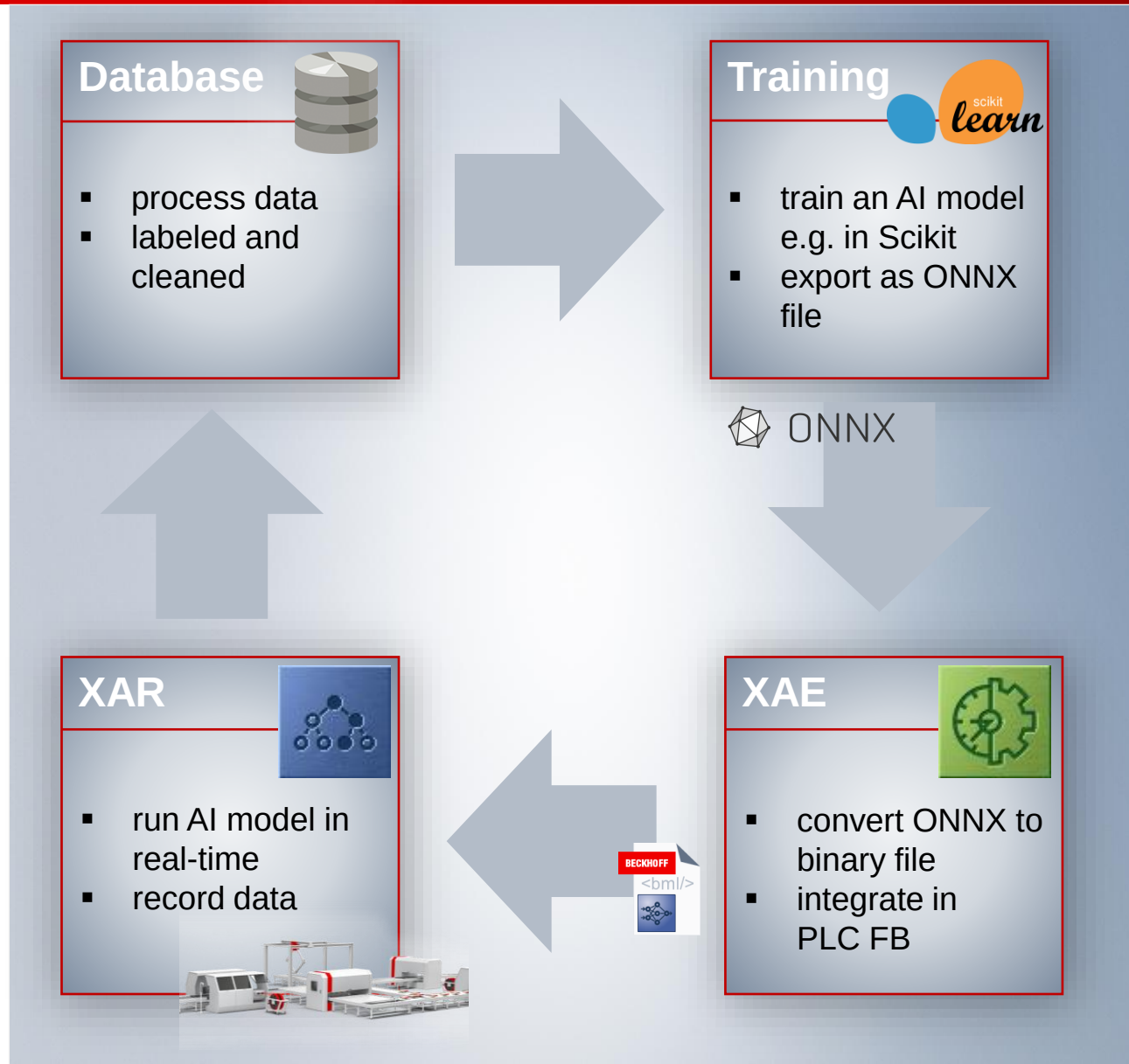
- CPU
- single core
- deterministic real-time

Interface

- FB_MllPrediction
  - Configure
  - Predict

Supported models

- SVM
- k-means
- PCA
- Random Forest
- Decision Trees
- Gradient Boosting
- XGBoost
- LightGBM
- ExtraTree(s)



Samples link to Infosys

TF3810 | TwinCAT Neural Network Inference Engine
Key Facts

BECKHOFF

AI models

- Models of type Neural Network
- ONNX support
- Trained offline e.g. using Python, R or others

Execution details

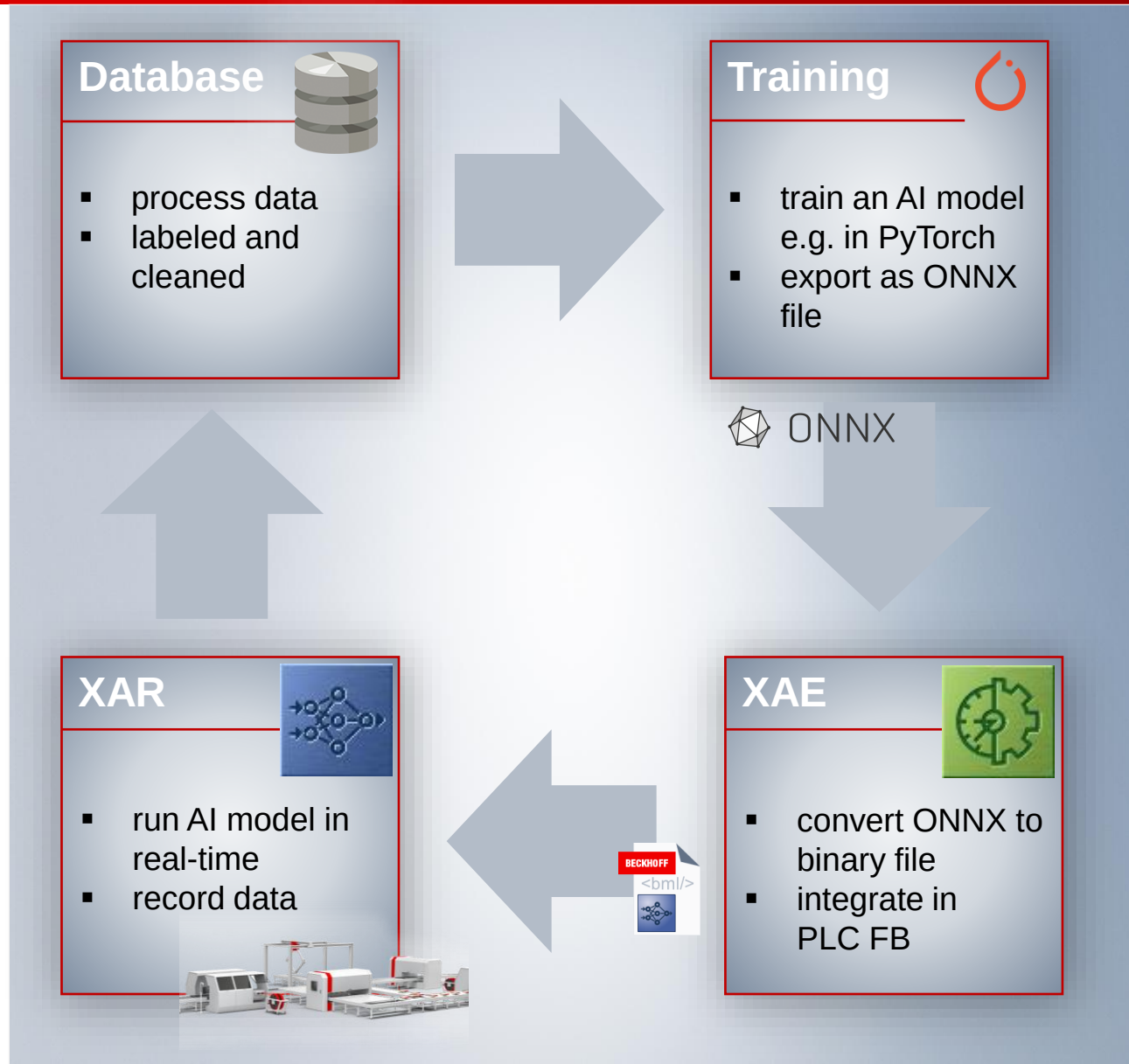
- CPU
- single and multicore (model specific)
- deterministic real-time

Interface

FB_MllPrediction*
- Configure
- Predict

Supported models
- MLP
- LSTM
- CNN

*may change in newer release



TF7810 | TwinCAT Vision Neural Networks
Key Facts

BECKHOFF

AI models

- Models of type Neural Network
- ONNX support
- Trained offline e.g. using relevant Python Frameworks or TwinCAT Machine Learning Creator

Execution details

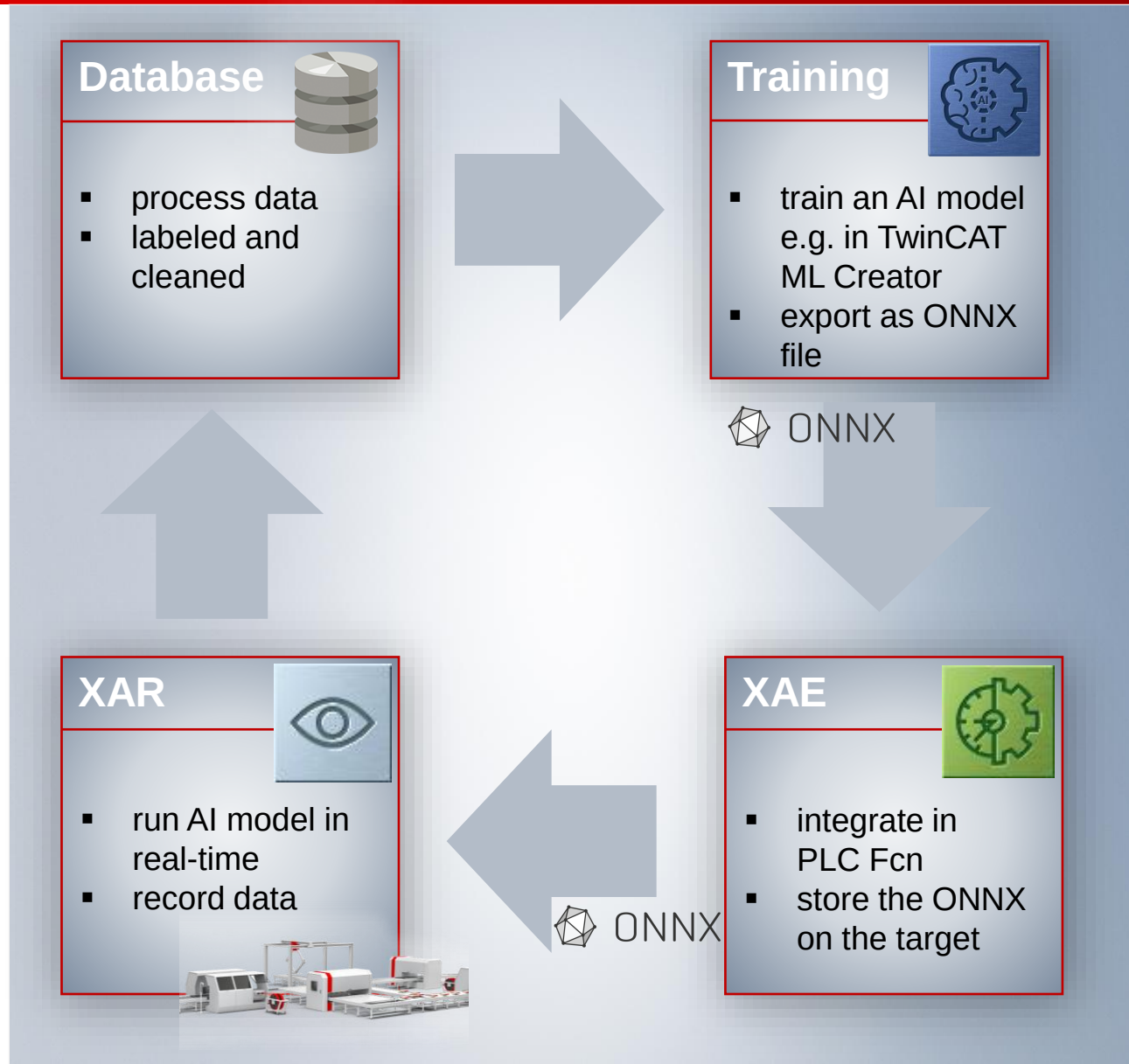
- CPU
- single and multicore (model specific)
- deterministic real-time

Interface

```
hr := F_VN_ExecuteNeuralNetwork(
    ipNN         := ipModel,
    ipSrcImage   := ipImage,
    ipDestImage := ipResult,
    hrPrev       := hr);
```

Supported models

- MLP
- CNN



TF3820 | TwinCAT Machine Learning Server
Key Facts

BECKHOFF

AI models

- Supports everything that can be represented as ONNX model
- General ONNX Opset version 21 support
- Trained offline e.g. using relevant Python Frameworks or TwinCAT Machine Learning Creator

Execution details

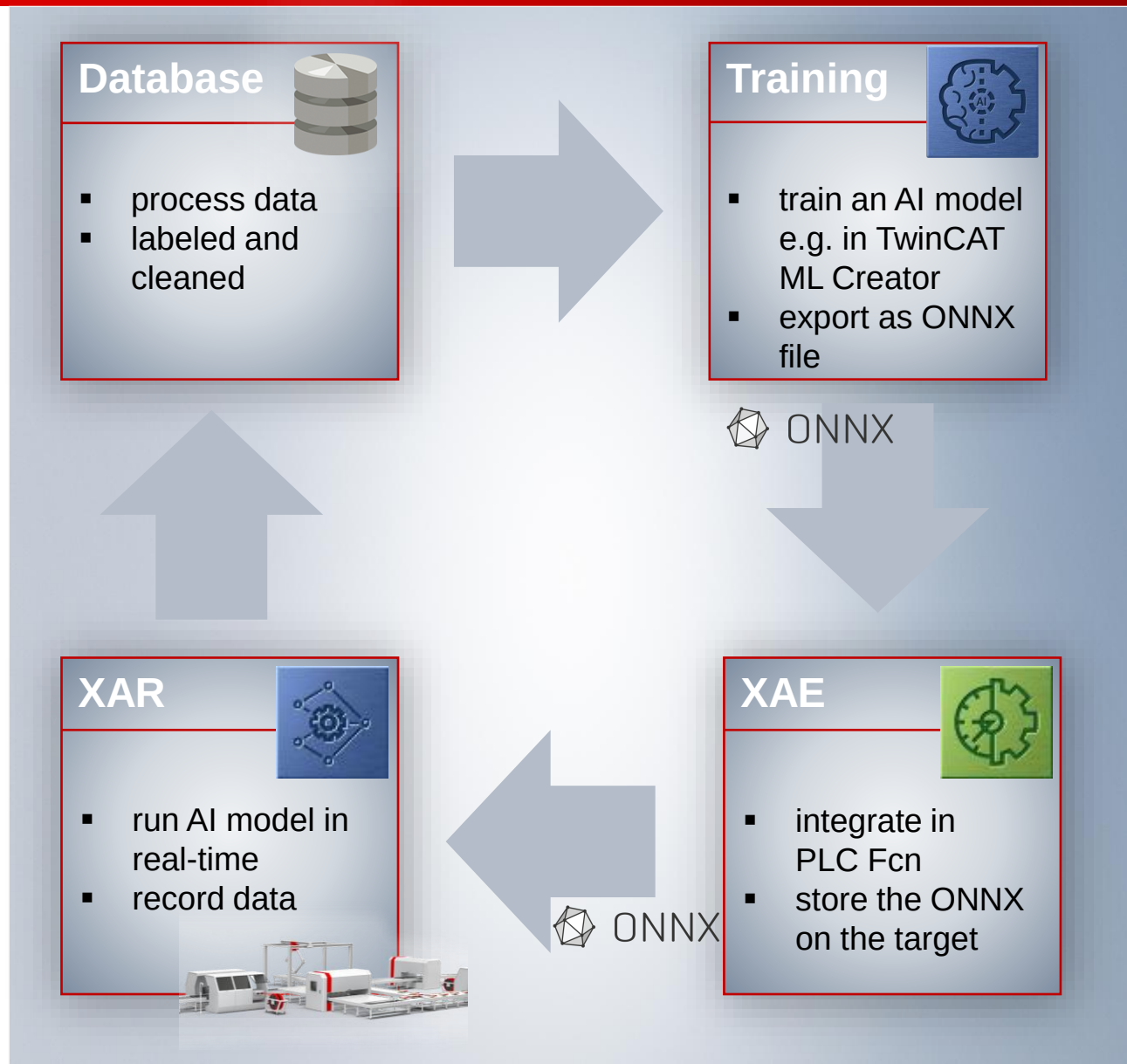
- CPU and GPU execution
- near real-time execution in a sperate user-mode process

Supported models

- all models

Interface

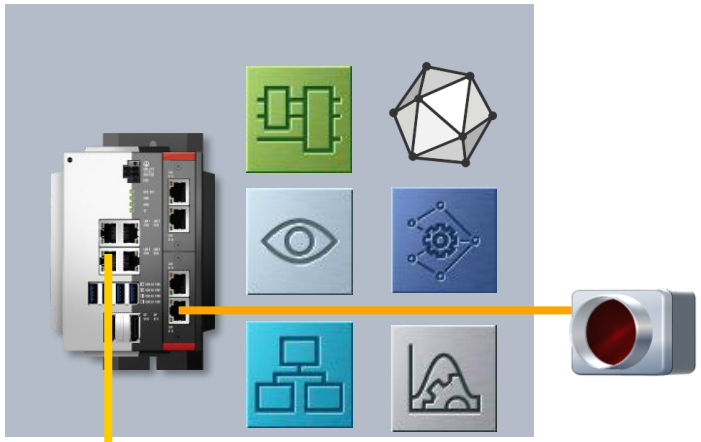
```
bDone := fbModel.Predict(
         pDataIn := ADR(ModelIn),
         nDataInpDim := SIZEOF(ModelIn),
         pDataOut    := ADR(ModelOut),
         nDataOutDim :=
SIZEOF(ModelOut),..)
```

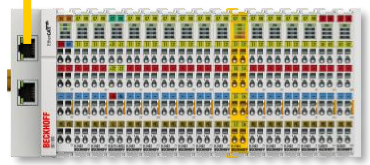


Flexible integration strategies
Fully integrated vs. modular add-on

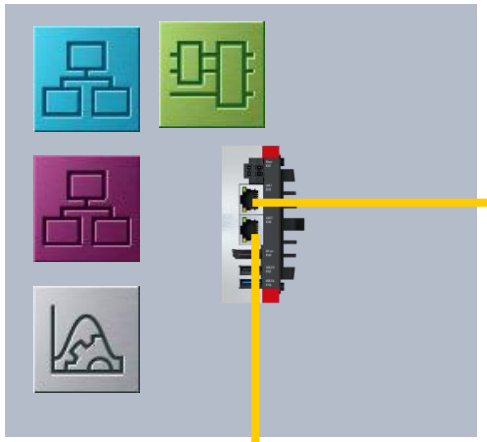
BECKHOFF

Control and AI system



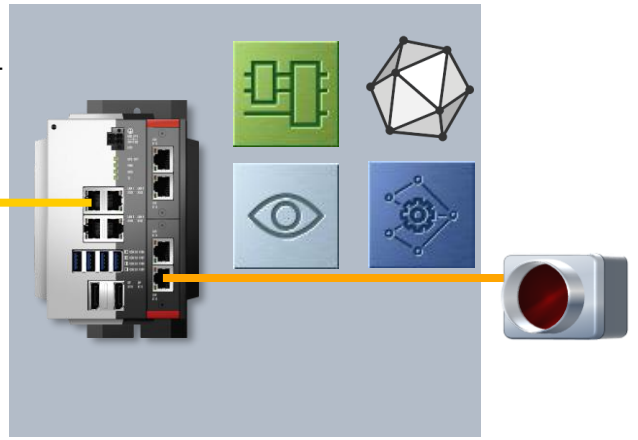


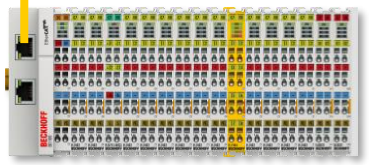
Control system

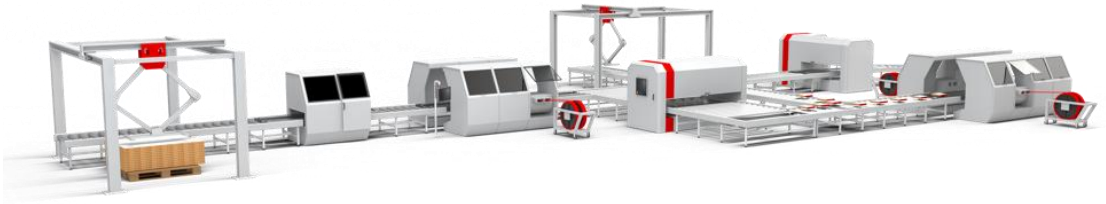


EtherCAT
Profinet
TCP/IP
ADS, …

AI add-on system

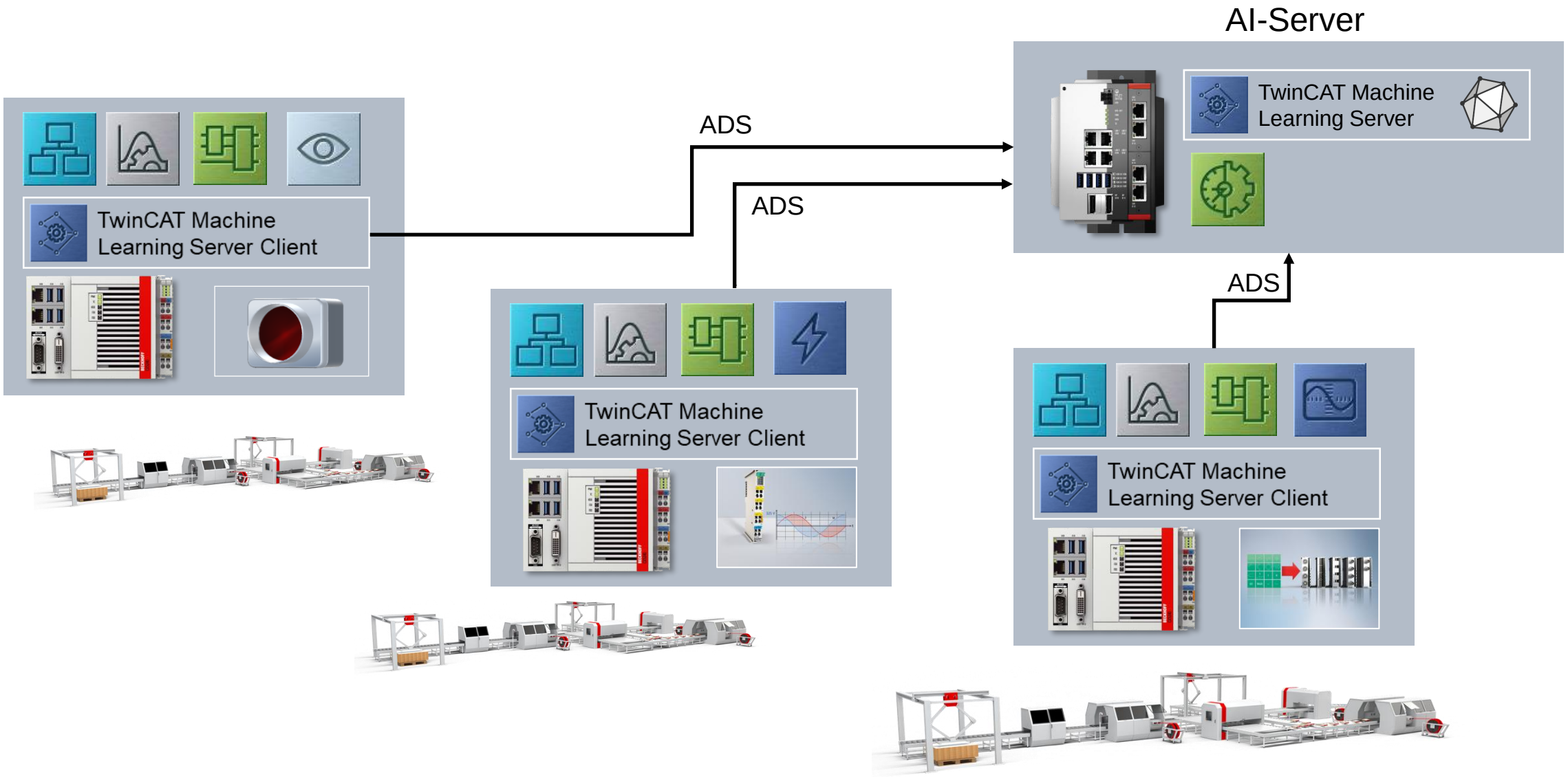






Flexible integration strategies
Mutiple clients calling mutiple AI models on a central server instance

BECKHOFF



TwinCAT CoAgent

BECKHOFF

BECKHOFF

TwinCAT CoAgent for automation engineering

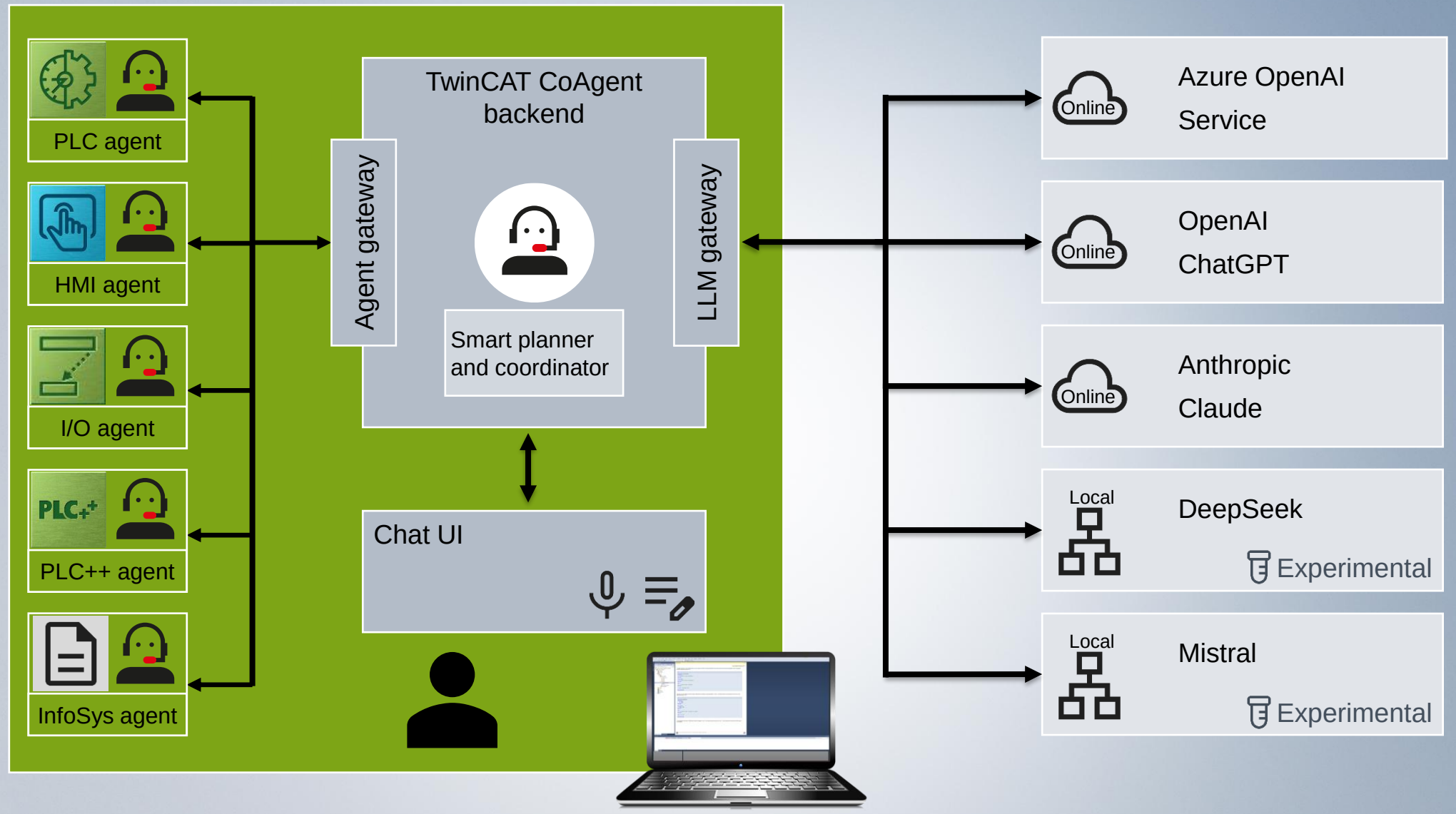
- smart AI-based agents to
  - shorten development cycles
  - improve software quality
  - increase productivity

TwinCAT CoAgent for automation runtime

- smart AI-based agent to
  - shorten downtimes
  - increase productivity
  - translate from machine to human

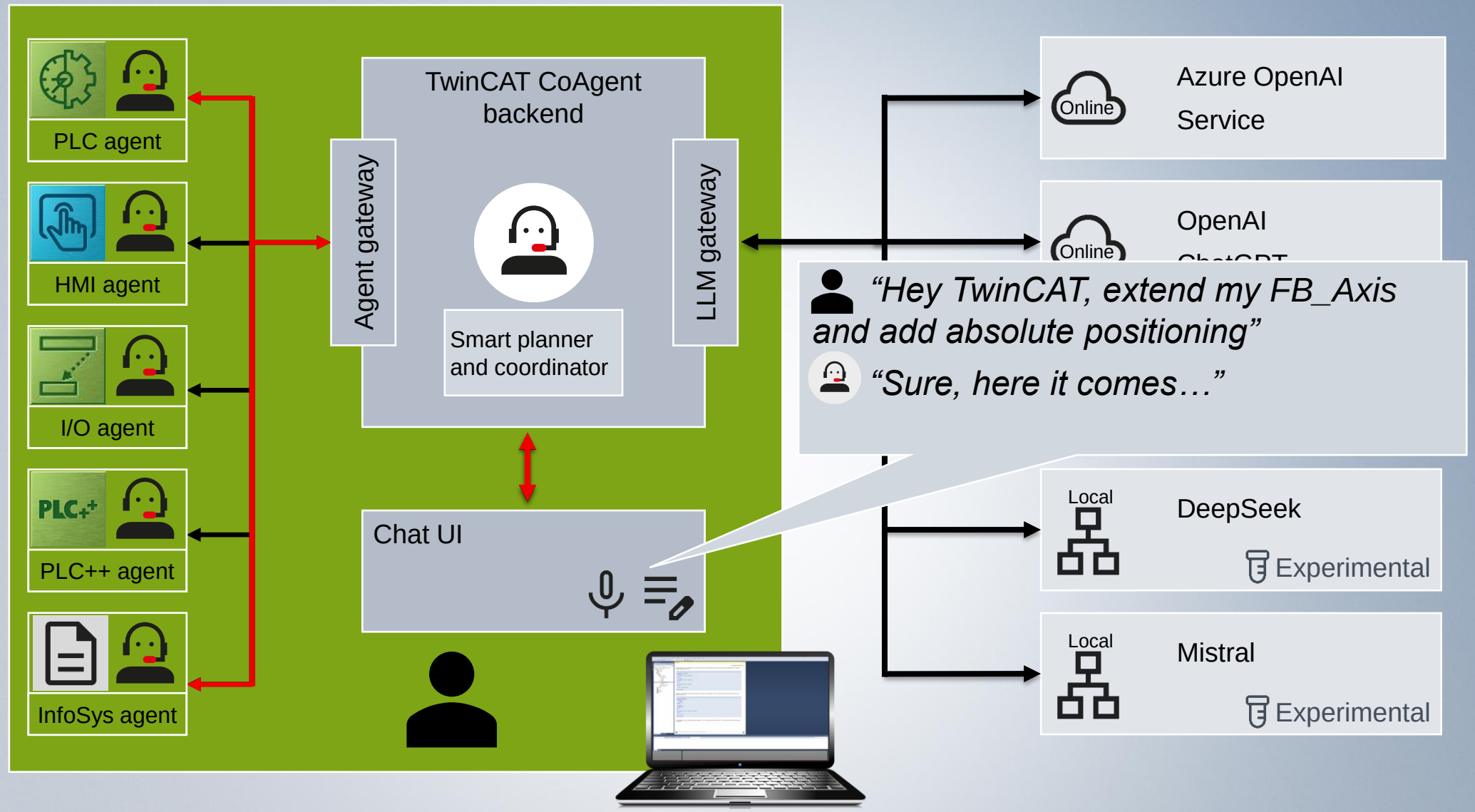
TwinCAT CoAgent | Smart agents for automation engineering

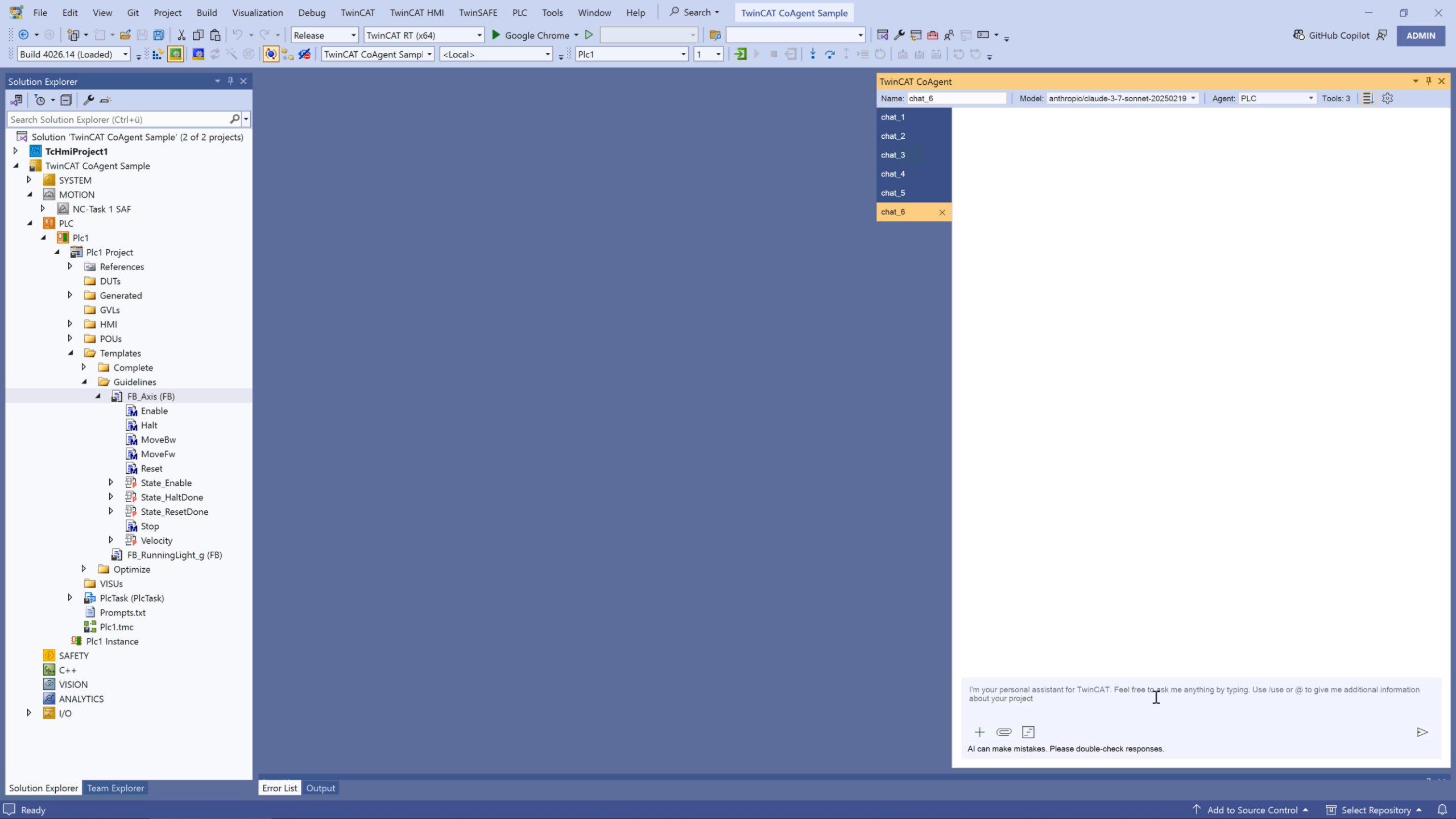
BECKHOFF



TwinCAT CoAgent | Smart agents for automation engineering

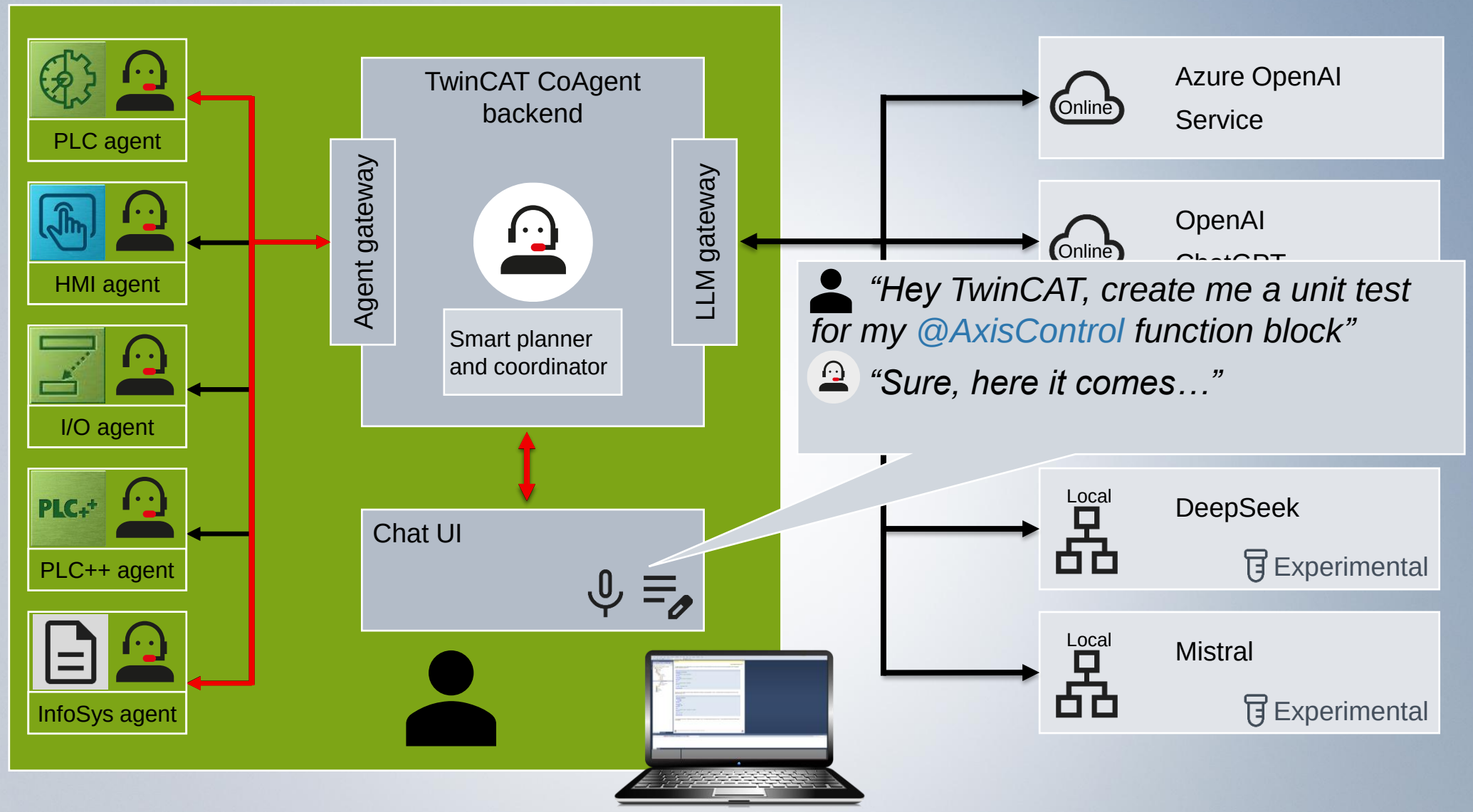
BECKHOFF

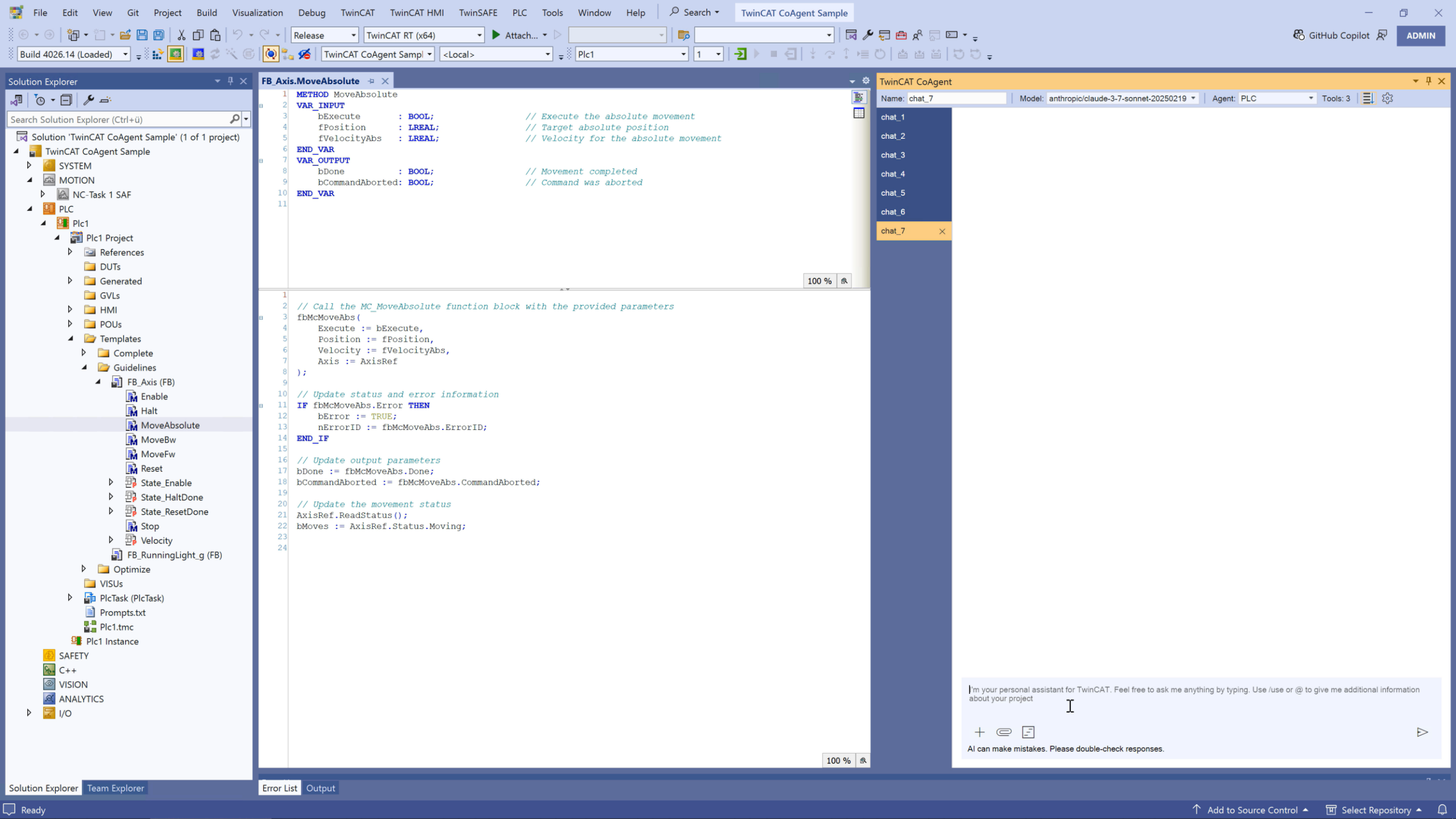



File Edit View Git Project Build Visualization Debug TwinCAT TwinCAT HMI TwinSAFE PLC Tools Window Help
Search
TwinCAT CoAgent Sample
Release
TwinCAT RT (x64)
Google Chrome
GitHub Copilot
ADMIN
Build 4026.14 (Loaded)
TwinCAT CoAgent Sampl
<Local>
Plc1
Solution Explorer
Search Solution Explorer (Ctrl+ü)
Solution 'TwinCAT CoAgent Sample' (2 of 2 projects)
TcHmiProject1
TwinCAT CoAgent Sample
SYSTEM
MOTION
NC-Task 1 SAF
PLC
Plc1
Plc1 Project
References
DUTs
Generated
GVLs
HMI
POUs
Templates
Complete
Guidelines
FB_Axis (FB)
Enable
Halt
MoveBw
MoveFw
Reset
State_Enable
State_HaltDone
State_ResetDone
Stop
Velocity
FB_RunningLight_g (FB)
Optimize
VISUs
PlcTask (PlcTask)
Prompts.txt
Plc1.tmc
Plc1 Instance
SAFETY
C++
VISION
ANALYTICS
I/O
TwinCAT CoAgent
Name: chat_6
Model: anthropic/claude-3-7-sonnet-20250219
Agent: PLC
Tools: 3
chat_1
chat_2
chat_3
chat_4
chat_5
chat_6
I'm your personal assistant for TwinCAT. Feel free to ask me anything by typing. Use /use or @ to give me additional information about your project
AI can make mistakes. Please double-check responses.
Solution Explorer
Team Explorer
Error List
Output
Ready
Add to Source Control
Select Repository

TwinCAT CoAgent | Smart agents for automation engineering

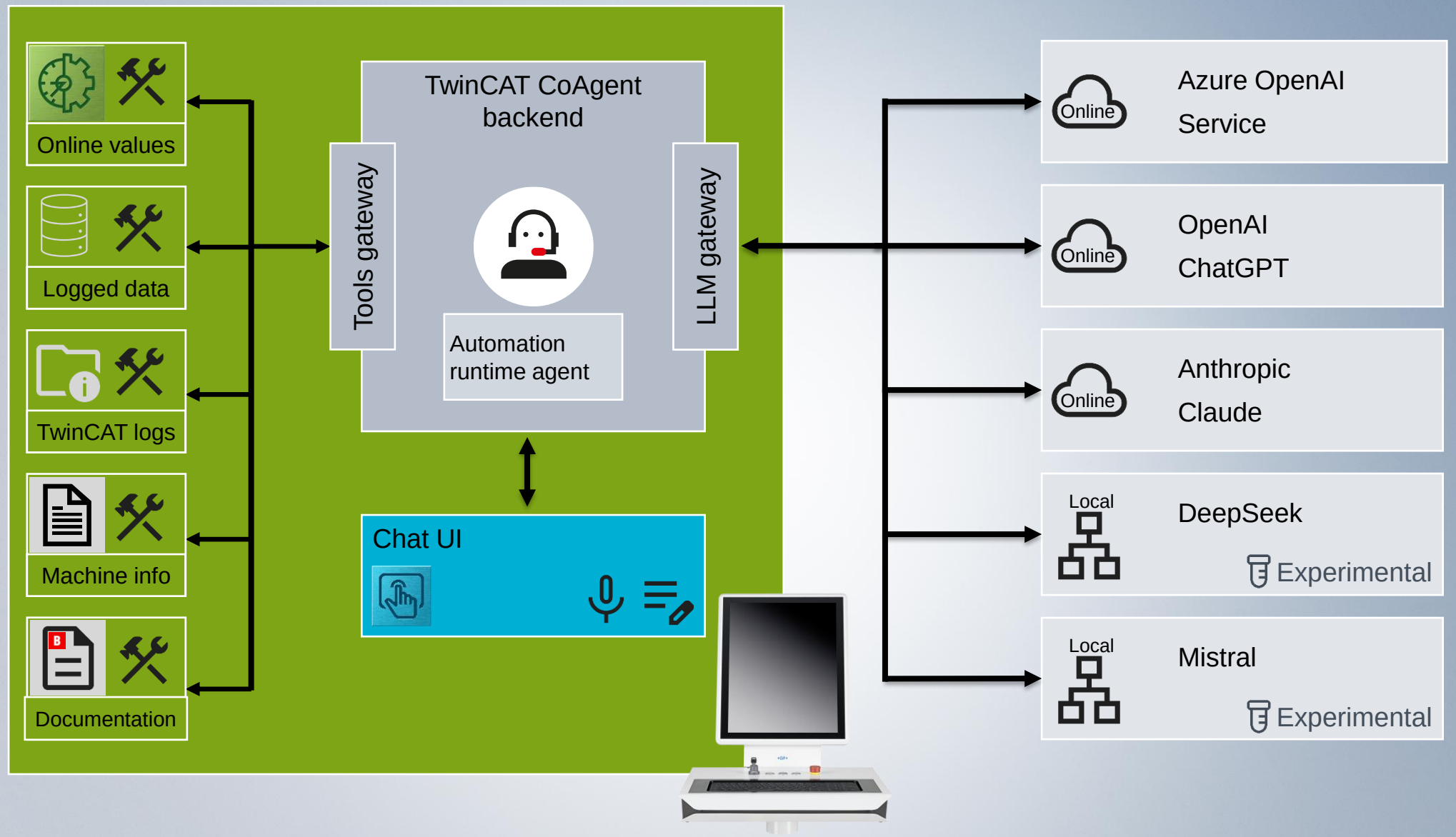
BECKHOFF




File Edit View Git Project Build Visualization Debug TwinCAT TwinCAT HMI TwinSAFE PLC Tools Window Help
Search
TwinCAT CoAgent Sample
Release
TwinCAT RT (x64)
Attach...
GitHub Copilot
ADMIN
Build 4026.14 (Loaded)
TwinCAT CoAgent Sampl
<Local>
Plc1
Solution Explorer
Search Solution Explorer (Ctrl+ü)
Solution 'TwinCAT CoAgent Sample' (1 of 1 project)
TwinCAT CoAgent Sample
SYSTEM
MOTION
NC-Task 1 SAF
PLC
Plc1
Plc1 Project
References
DUTs
Generated
GVLs
HMI
POUs
Templates
Complete
Guidelines
FB_Axis (FB)
Enable
Halt
MoveAbsolute
MoveBw
MoveFw
Reset
State_Enable
State_HaltDone
State_ResetDone
Stop
Velocity
FB_RunningLight_g (FB)
Optimize
VISUs
PlcTask (PlcTask)
Prompts.txt
Plc1.tmc
Plc1 Instance
SAFETY
C++
VISION
ANALYTICS
I/O
FB_Axis.MoveAbsolute
METHOD MoveAbsolute
VAR_INPUT
bExecute : BOOL; // Execute the absolute movement
fPosition : LREAL; // Target absolute position
fVelocityAbs : LREAL; // Velocity for the absolute movement
END_VAR
VAR_OUTPUT
bDone : BOOL; // Movement completed
bCommandAborted: BOOL; // Command was aborted
END_VAR
100 %
// Call the MC_MoveAbsolute function block with the provided parameters
fbMcMoveAbs(
Execute := bExecute,
Position := fPosition,
Velocity := fVelocityAbs,
Axis := AxisRef
);
// Update status and error information
IF fbMcMoveAbs.Error THEN
bError := TRUE;
nErrorID := fbMcMoveAbs.ErrorID;
END_IF
// Update output parameters
bDone := fbMcMoveAbs.Done;
bCommandAborted := fbMcMoveAbs.CommandAborted;
// Update the movement status
AxisRef.ReadStatus();
bMoves := AxisRef.Status.Moving;
100 %
TwinCAT CoAgent
Name: chat_7
Model: anthropic/claude-3-7-sonnet-20250219
Agent: PLC
Tools: 3
chat_1
chat_2
chat_3
chat_4
chat_5
chat_6
chat_7
I'm your personal assistant for TwinCAT. Feel free to ask me anything by typing. Use /use or @ to give me additional information about your project
AI can make mistakes. Please double-check responses.
Solution Explorer
Team Explorer
Error List
Output
Ready
Add to Source Control
Select Repository

TwinCAT CoAgent | Smart agents for automation runtimes

BECKHOFF



Overview

Station Milling

Position Z	179
Spindle Rotation	2000
Total operations	474308

Station
Quality Check

Station
Monitoring

Last production cycle time

10.46s

Station
Detection

Station
Storage

Contact

BECKHOFF

Beckhoff Automation Oy
Hakakalliontie 2
05460 Hyvinkää

Phone: +358 20 7423 800
E-mail: info@beckhoff.fi
Web: www.beckhoff.fi