CINI4.0 Conference Day

16/06/2022, Gent

PLCnext : an open source IIOT-ready PLC

Hugo Van Rillaer
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PLCnext Technology

Designed by PHOENIX CONTACT

PLCnext Control

PLCnext Engineer

PLCnext Store

PLCnext Community

Brief overview

PLCnext Control

OPC UA

Redundancy

Functional Safety

Edge Computing

Artificial Intelligence

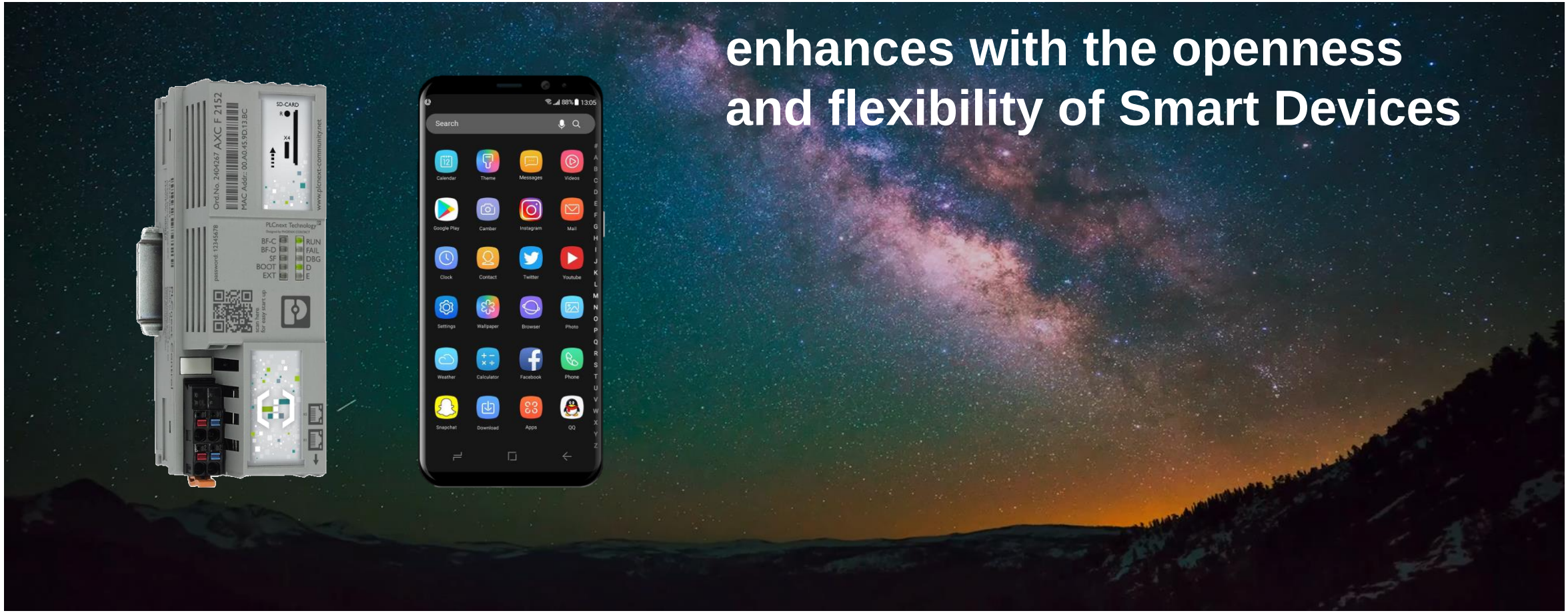
Security

PLCnext Engineer

PLCnext Store

PLCnext Community

The reliability and robustness of the classical PLC world



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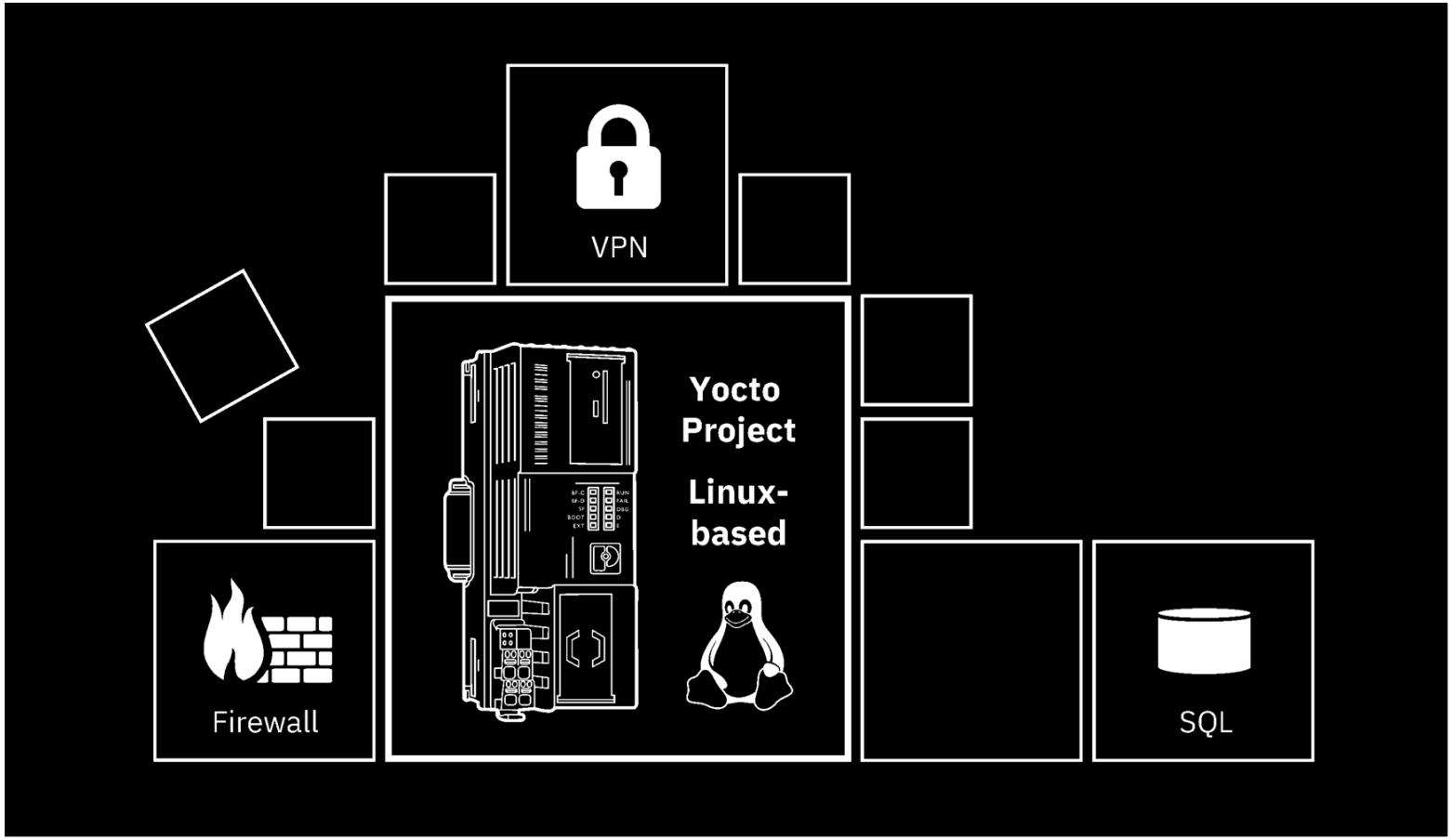
Flexibility of Linux plus the Reliability of a PLC



PLCnext Runtime System is based on Linux…

- Open Linux Operating System

…but as performant as a “classic” PLC!

- Easy task management
- Precise synchronization in realtime
- Cycle-consistent data exchange
- No Linux knowledge needed

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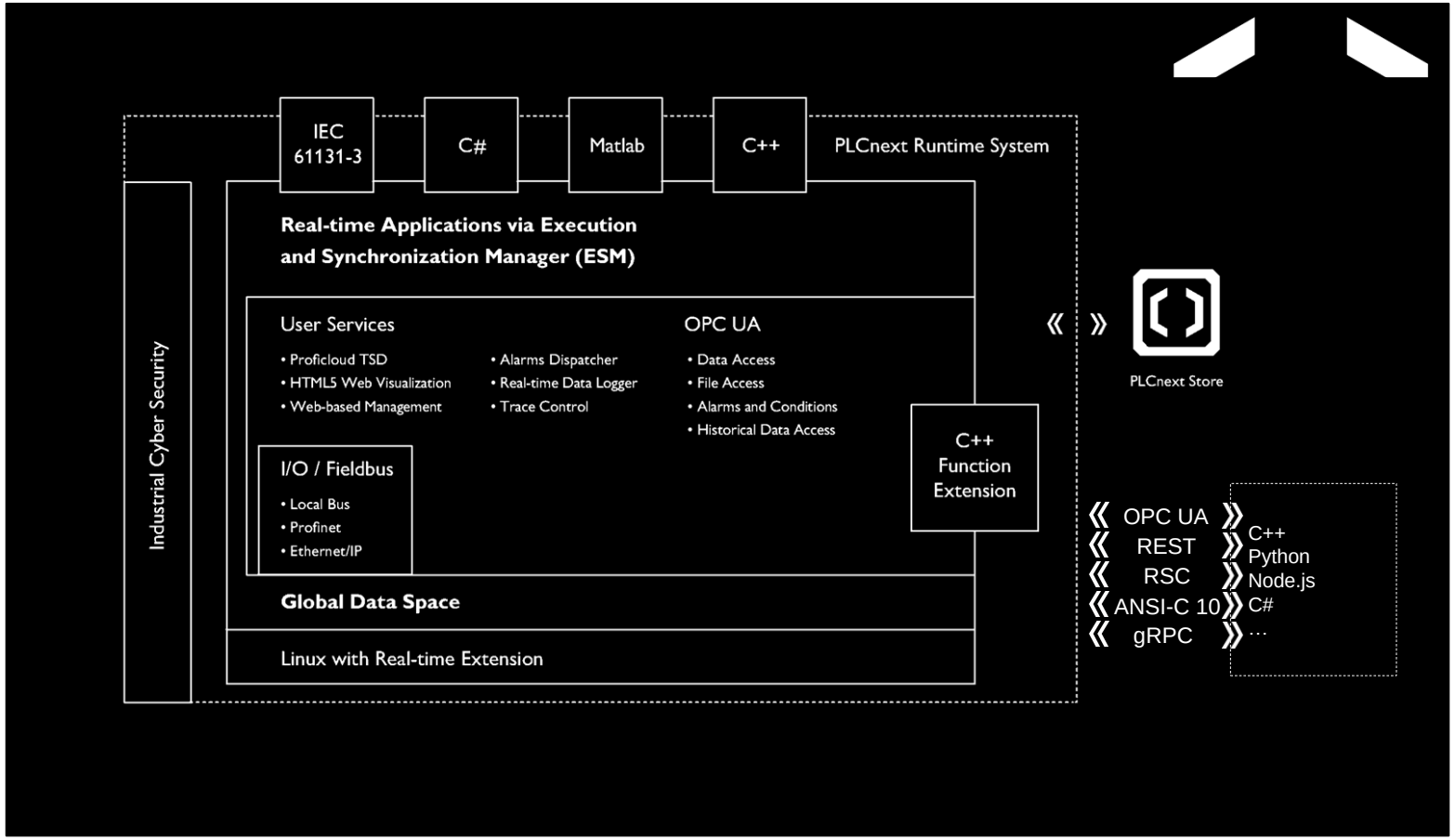
PLCnext Runtime System Architecture



- Reduced deployment time through the integration of source software
- Connectivity, security & real-time capability are already implemented
- Future-proof, flexible and secure thanks to continuous updates
- Integration of IEC61131-3, high-level languages and open-source software possible
- Apps from PLCnext Store easy to implement

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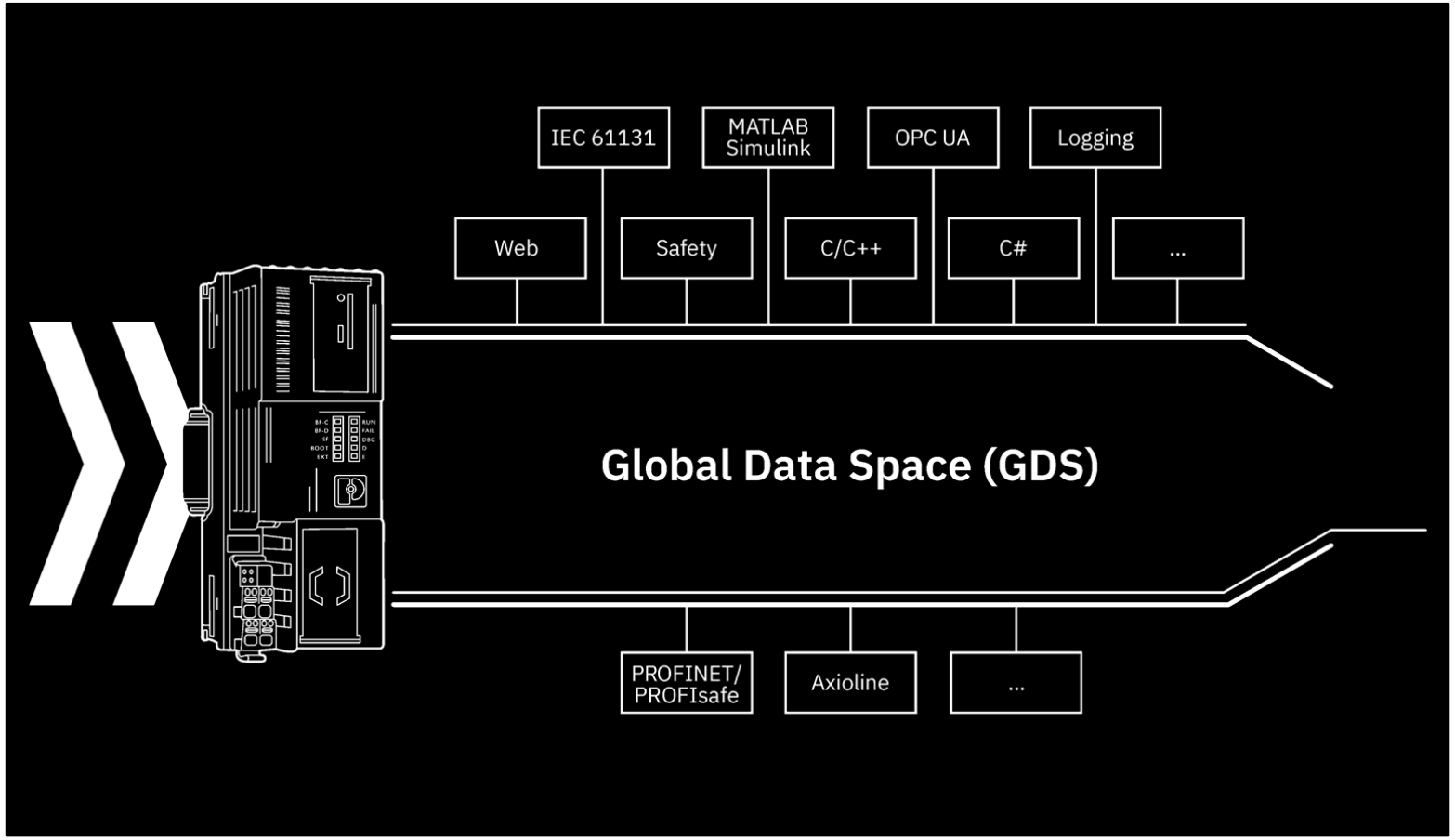
enhanced performance – Data Consistency

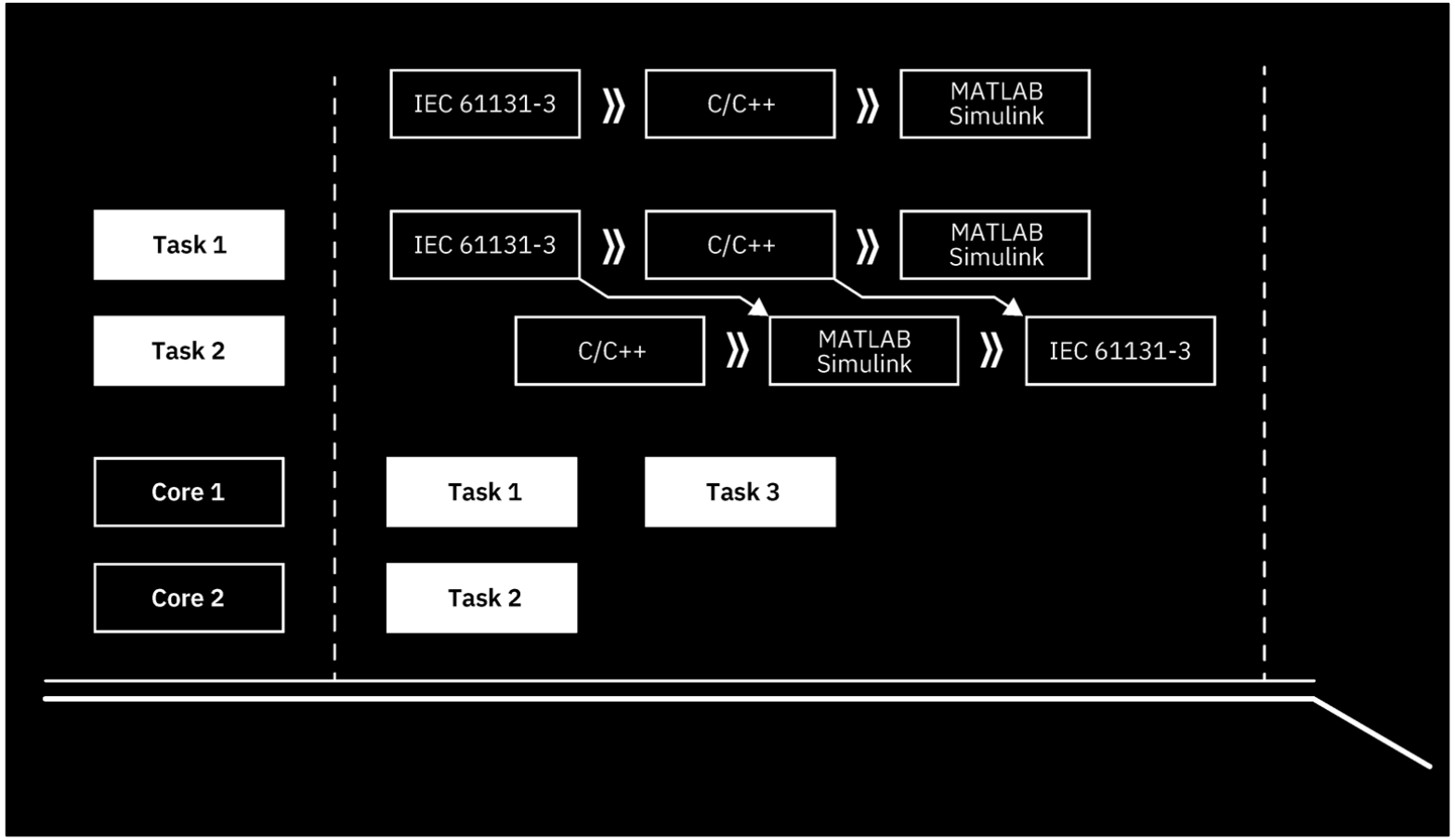
Global Data Space



Fast and consistent data exchange between user programs, fieldbuses, and system programs.
Access via Data Logger, HMI, and OPC UA. Security aspects for user management.

enhanced performance – PLC-typical Real-time Performance

Execution & Synchronization Manager



The patent-applied-for task handling of PLCnext Technology lets program routines of different origin run like classical IEC 61131 PLC code. Your high-level language programs become automatically deterministic.

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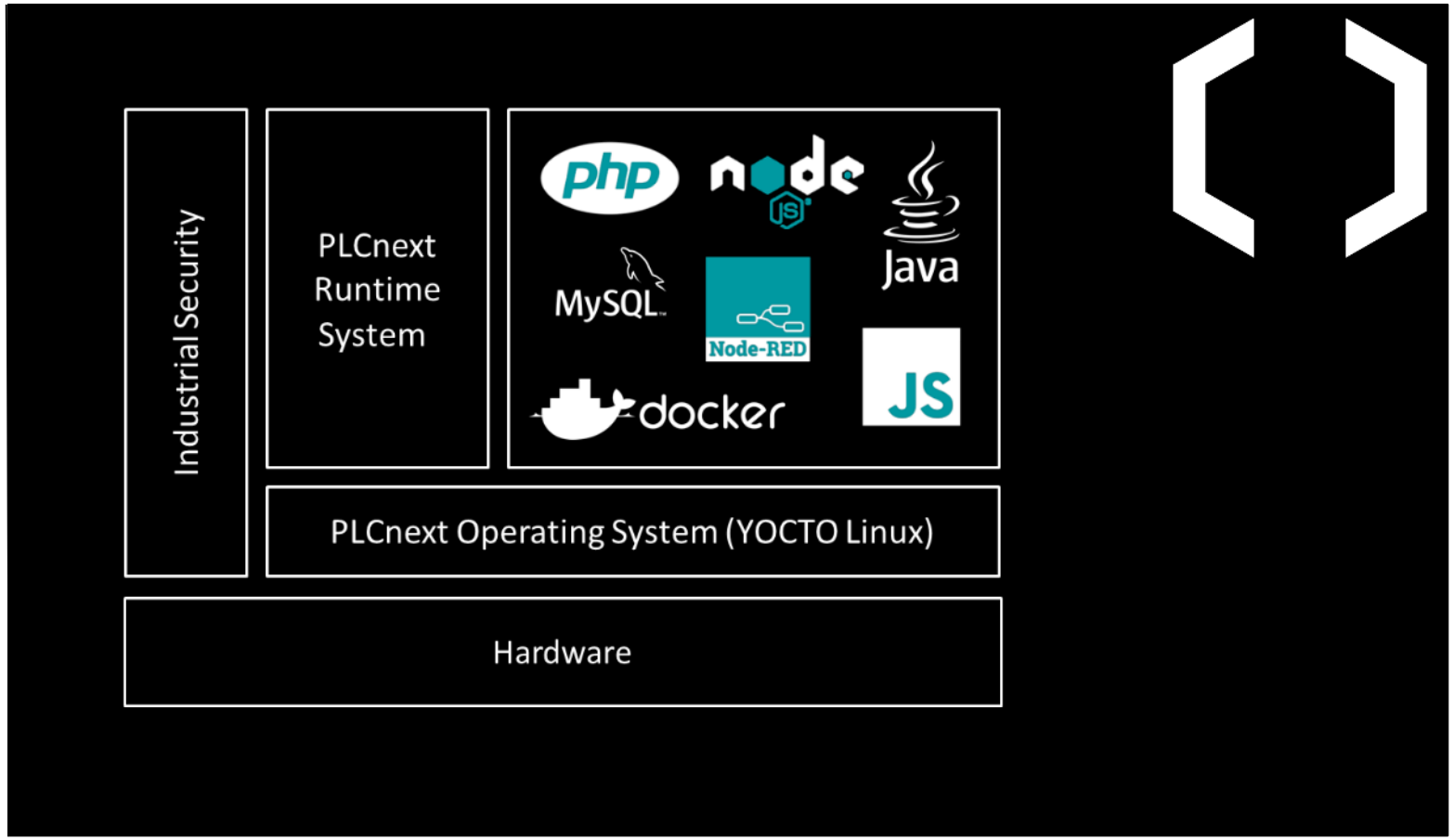
PLCnext Runtime System



- Reduced deployment time through the integration of open-source software
- Connectivity, security & real-time capability are already implemented
- Future-proof, flexible and secure thanks to continuous updates
- Integration of IEC61131-3 and high-level languages like C/C++, C#, Matlab, Java, Python, Go or Rust possible
- Apps from PLCnext Store easy to implement

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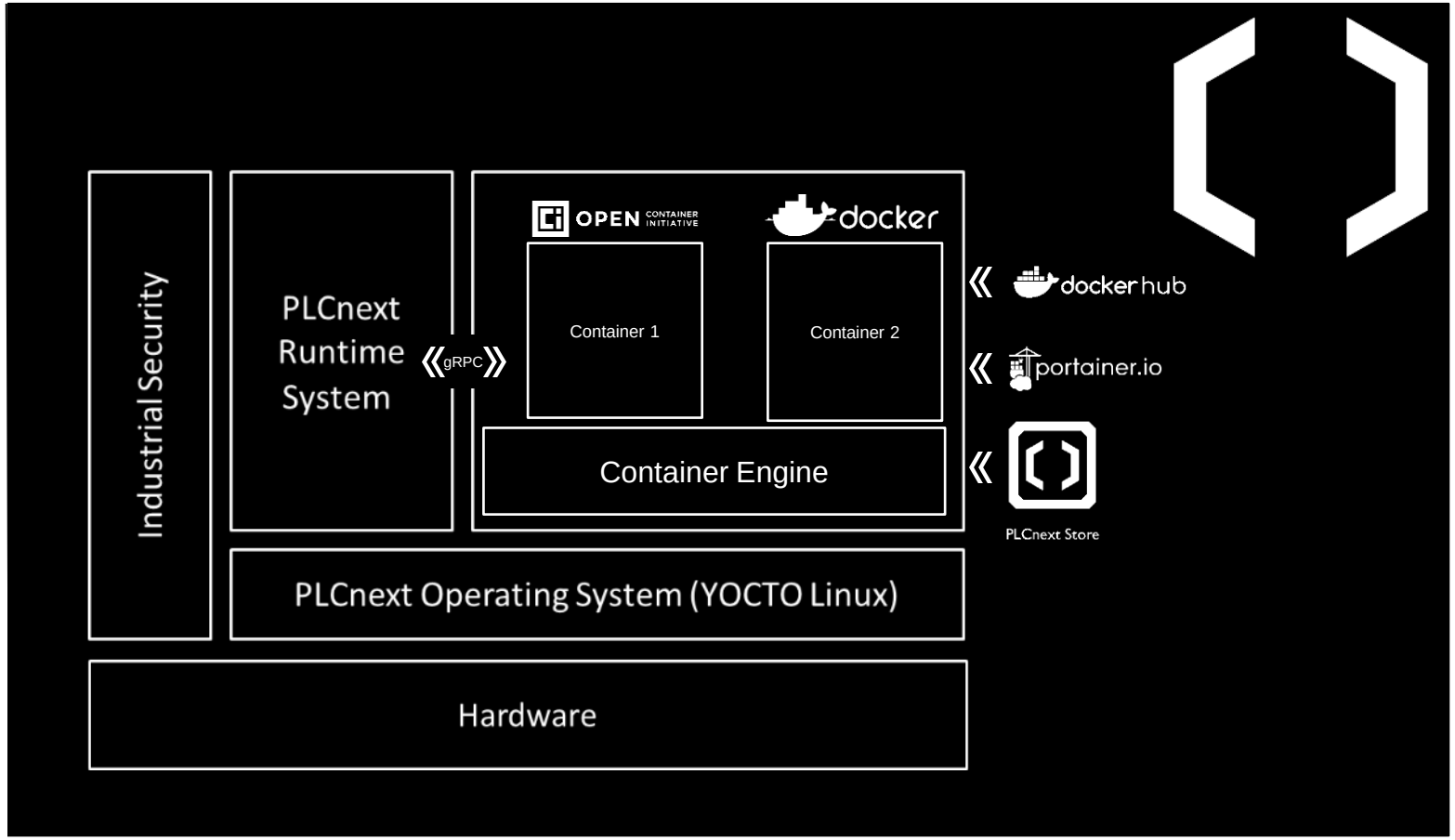
PLCnext Runtime System and Container



- Docker images from Docker hub can be used
- Portainer.io can be used for container management
- Apps in Docker format from PLCnext Store easy to implement
- (OCI) Open Container Initiative compatible
- gRPC (Remote Procedure Call (RPC) one API (IP/ Socket Communication) for many programming languages (Python, Java, Node.js, …)
- Podman as Container Engine preinstalled
- Kubernetes, Docker Engine or balenaEngine can optionally be used

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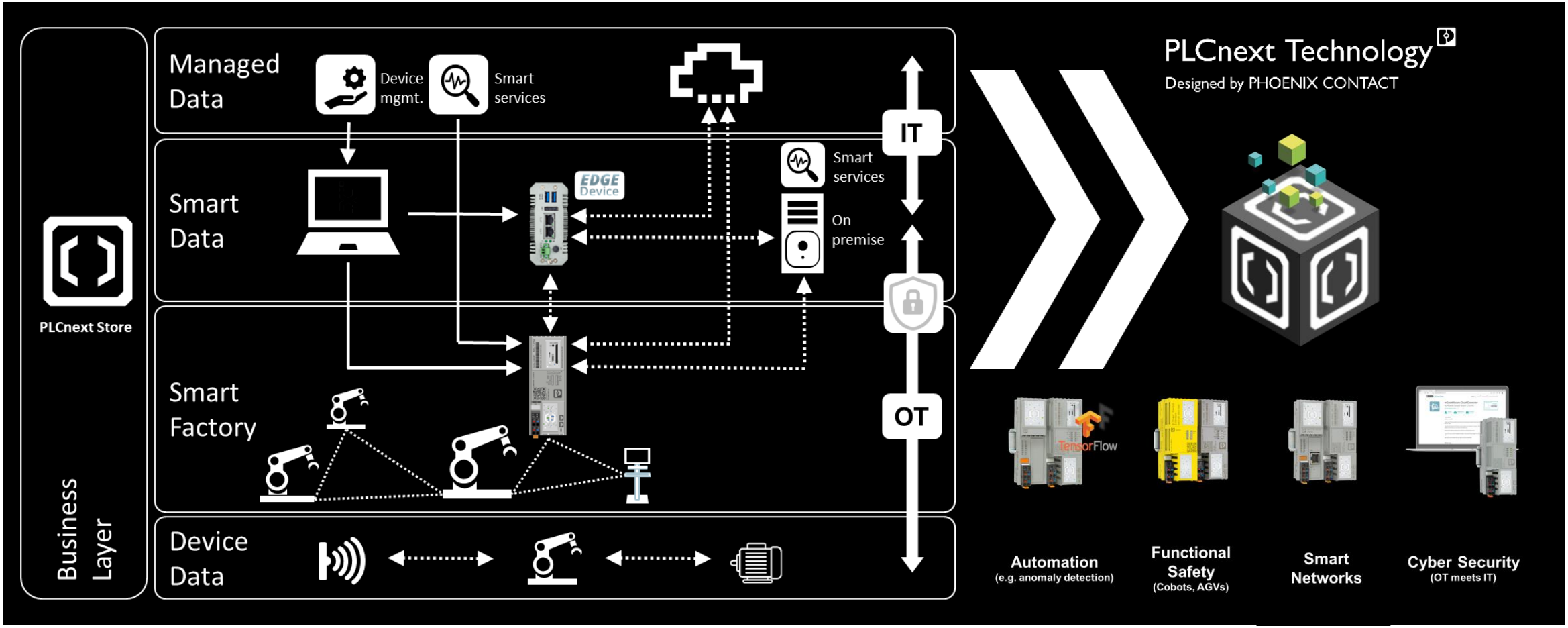
Scalable solutions based on Apps in an open Ecosystem



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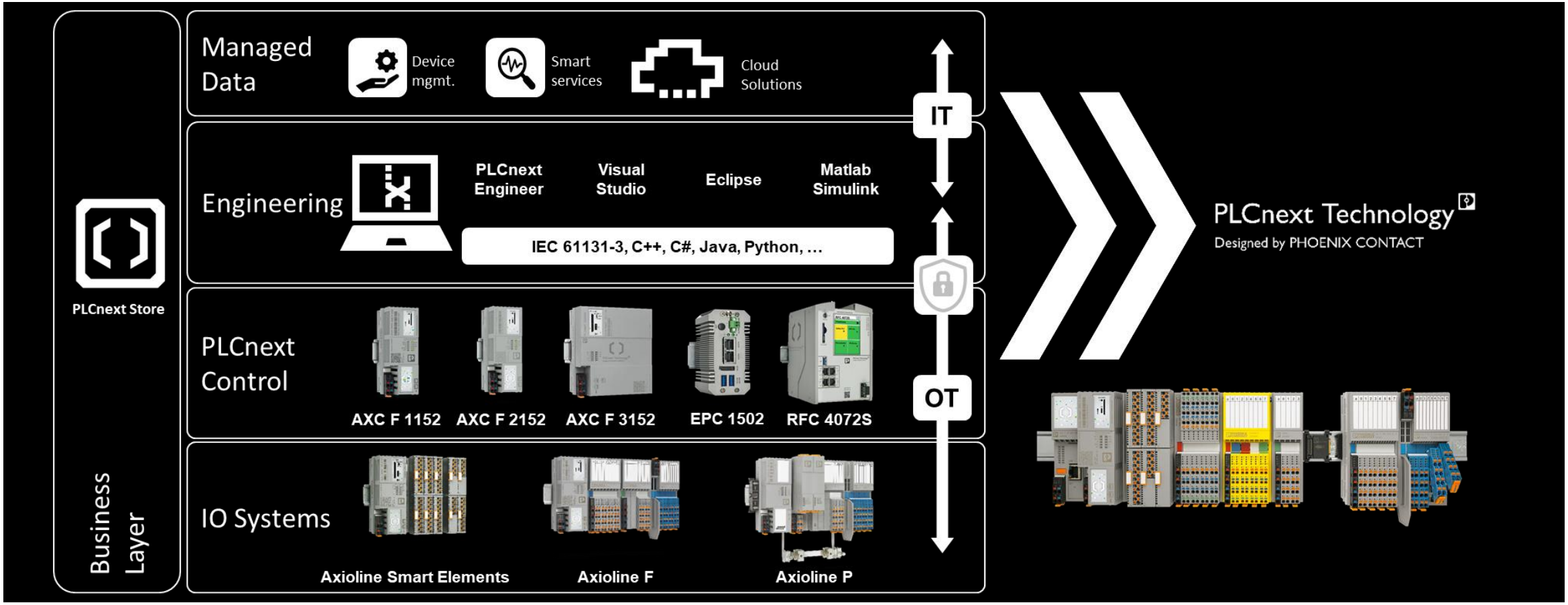
Scalable Solutions based on open Ecosystems



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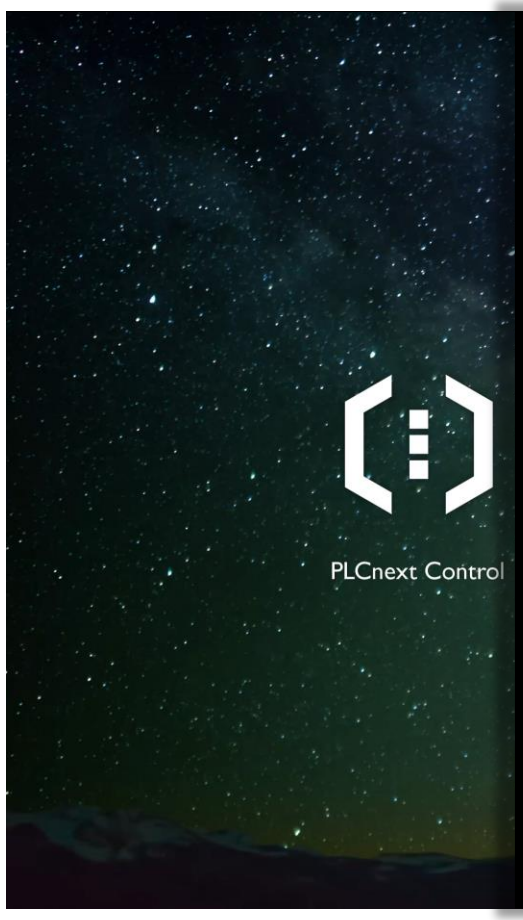

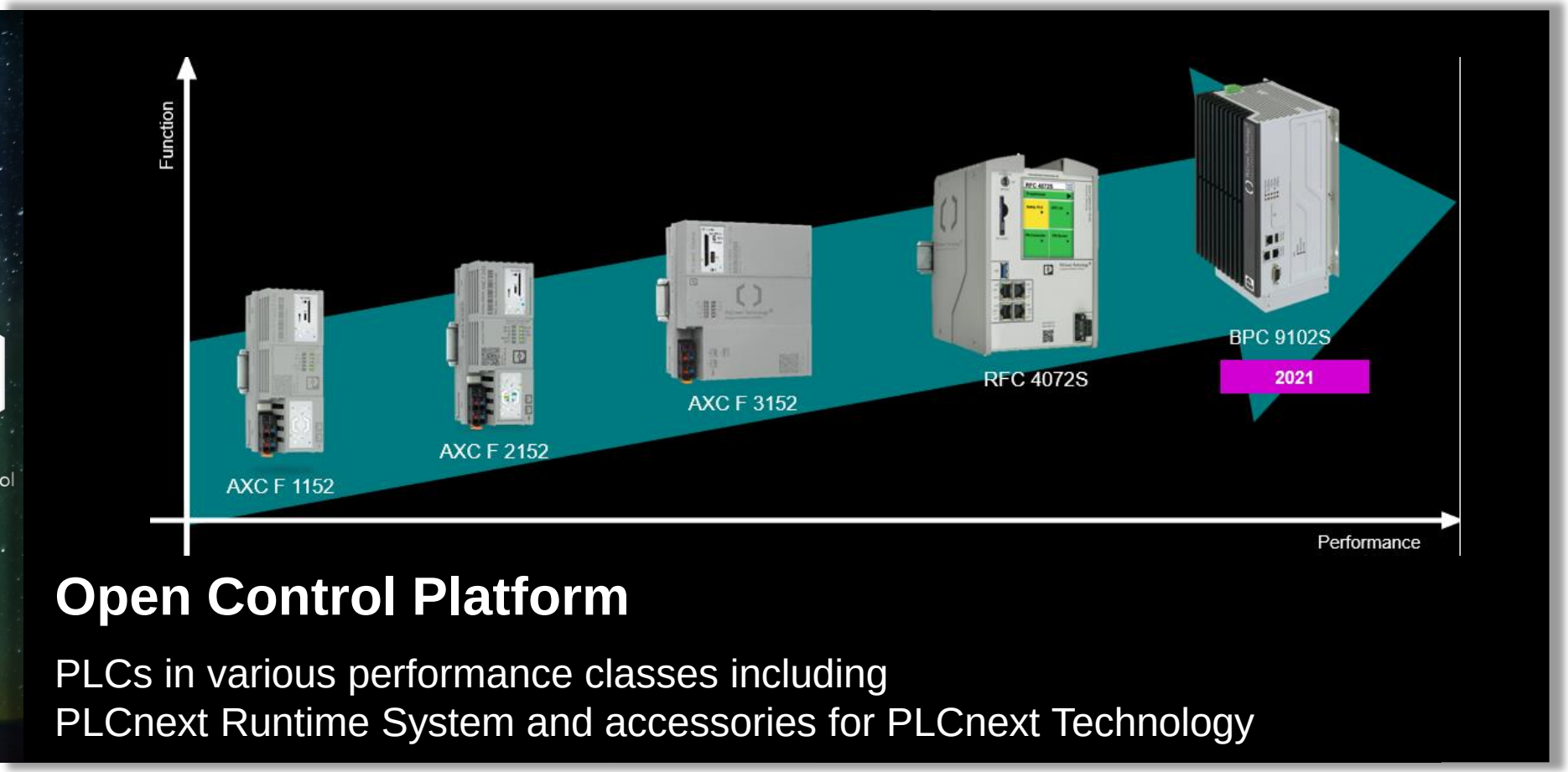

Open Control Platform

PLCs in various performance classes including
PLCnext Runtime System and accessories for PLCnext Technology

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PLCnext Control AXC F 2152

Core

ARM Cortex-A9 (2x 800 MHz)

Random Access Memory

512 Mbytes RAM

Temperature

-25°C-60°C

control tasks (IEC 61131)

32

Min. cycle time (IEC 61131)

1 ms

Security

TPM integrated

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PLCnext Technology
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PLCnext Control AXC F 3152

Core

Intel ATOM x5-E3930 dual-core

Random Access Memory

2 GB DDR4 dual-channel RAM

Temperature

-25°C-60°C

control tasks (IEC 61131)

32

Min. cycle time (IEC 61131)

500 µs

Security

TPM integrated

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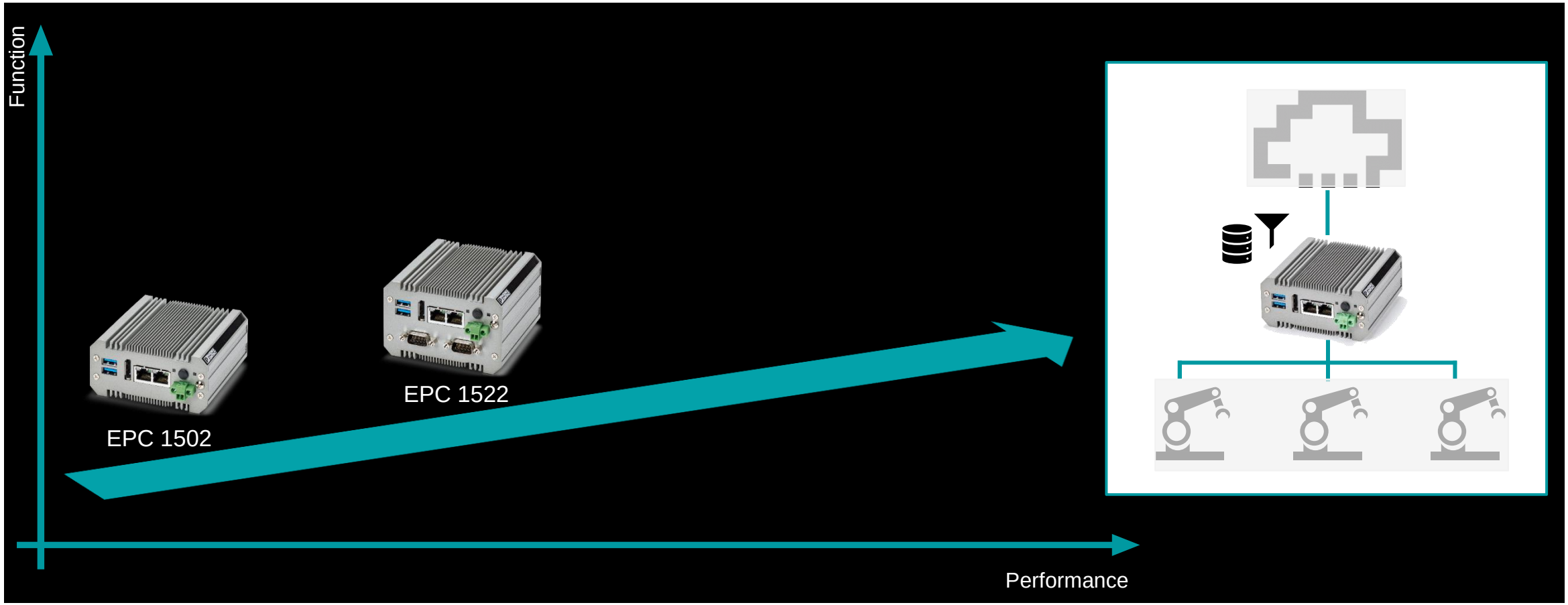
PLCnext Control for Edge Computing



PLCnext Technology
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Product Features – EPC 1502

Core

Intel Celeron N3350 (Dual Core)

RAM

2 GB RAM

Temperature

0°C-50°C

Storage

32 GB eMMC

Approvals

UL, CE

Features

PLCnext RT Edge Functions

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Product Features – EPC 1522

Core

Intel Celeron N3350 (Dual Core)

RAM

4 GB RAM

Temperature

0°C-50°C

Storage

32 GB eMMC + 128 GB m.2 SSD

Approvals

UL, CE

Features

PLCnext RT Edge Functions +Serial Interface

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PLCnext Control RFC 4072S

Core

Intel i5 6300U 2 x 2,4 GHz processor

control tasks (IEC 61131)

32

Random Access Memory

4 GB DDR 4 dual channel RAM

Min. cycle time (IEC 61131)

500 µs

Temperature

0°C up to 55°C with fan

Security

TPM integrated

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PLCnext Technology
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PLCnext Control RFC 4072R

CPU

Intel i5 6300U 2 x 2,4 GHz processor

Random Access Memory

4 GB DDR 4 dual channel RAM

ETH-MAC interface

2 x 1 Gbit, 1 x 100 Mbit switched

Synchronization interface

SFP based

Power supply

Dual interface

Temperature

0°C - 55°C

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PLCnext Control BPC 9102S

CPU

Octa-Core Intel Core™ i7-10700TE

Random Access Memory

16 GB, DDR4 RAM

Temperature

-20°C - 60°C
without FAN

control tasks (IEC 61131)

128

Min. cycle time

500 µs

Integrated Safety PLC

1x ARM A8
1x ARM A9

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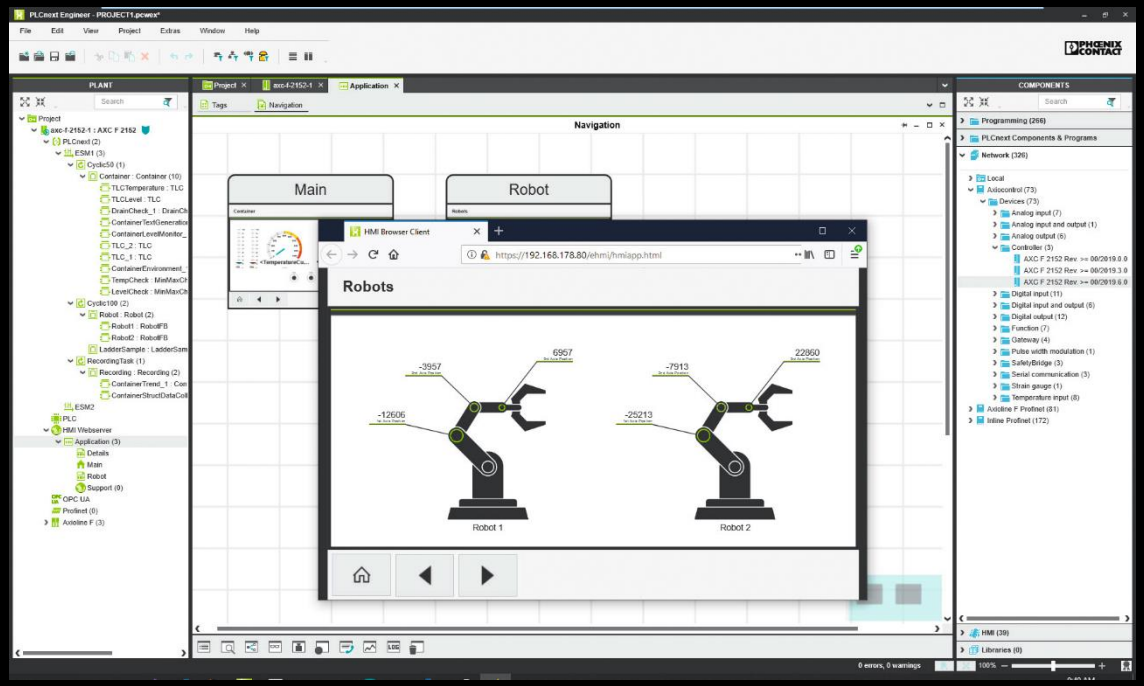
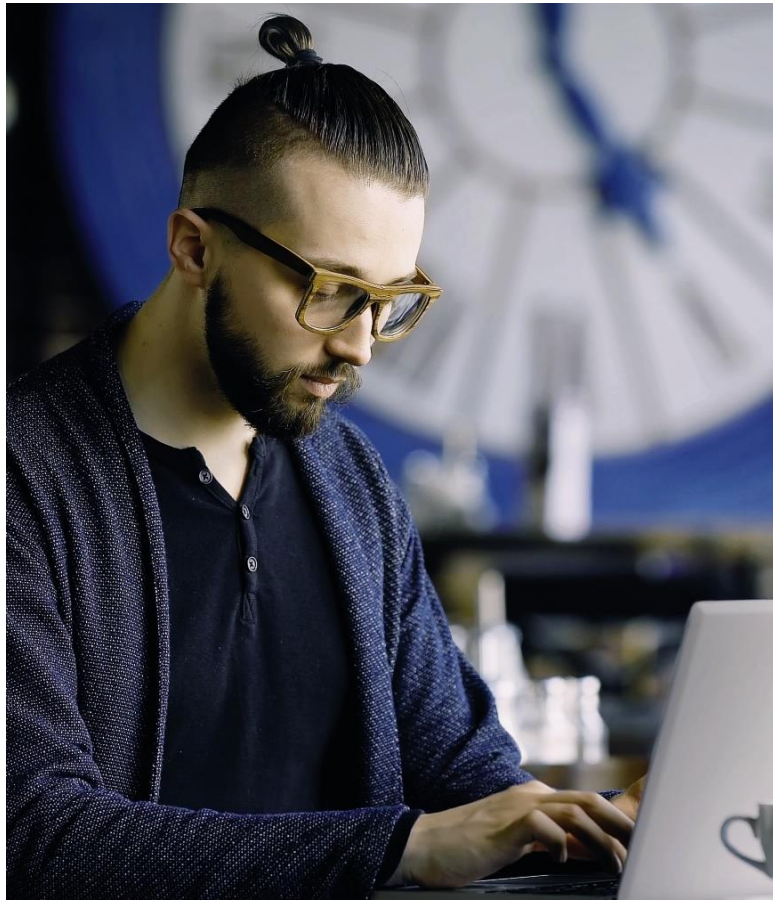
IEC 61131-3 Programming with PLCnext Engineer



Use the innovative and easy to use features of PLCnext Engineer.



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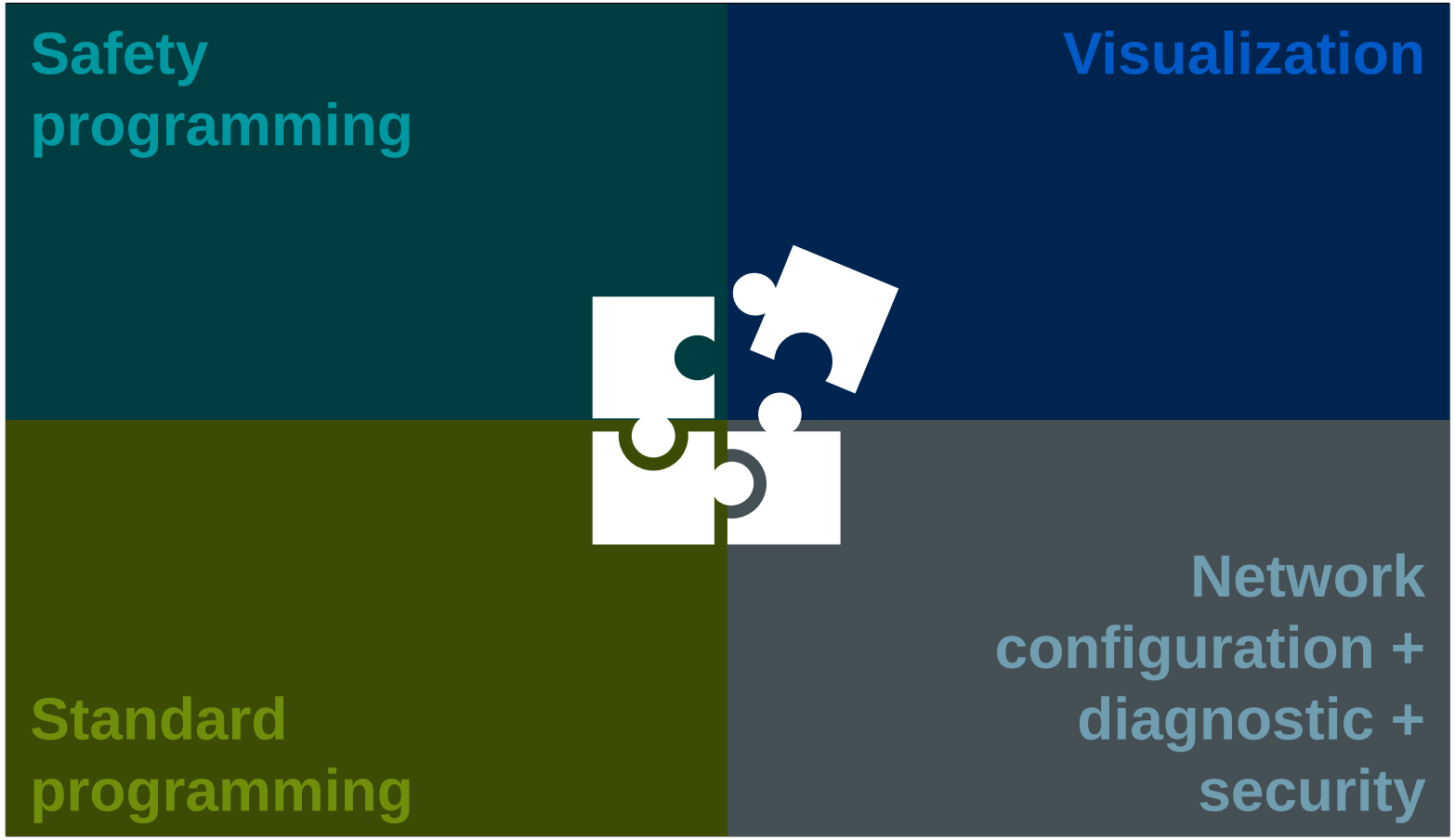
Complete Integrated System



Speed up your
application development

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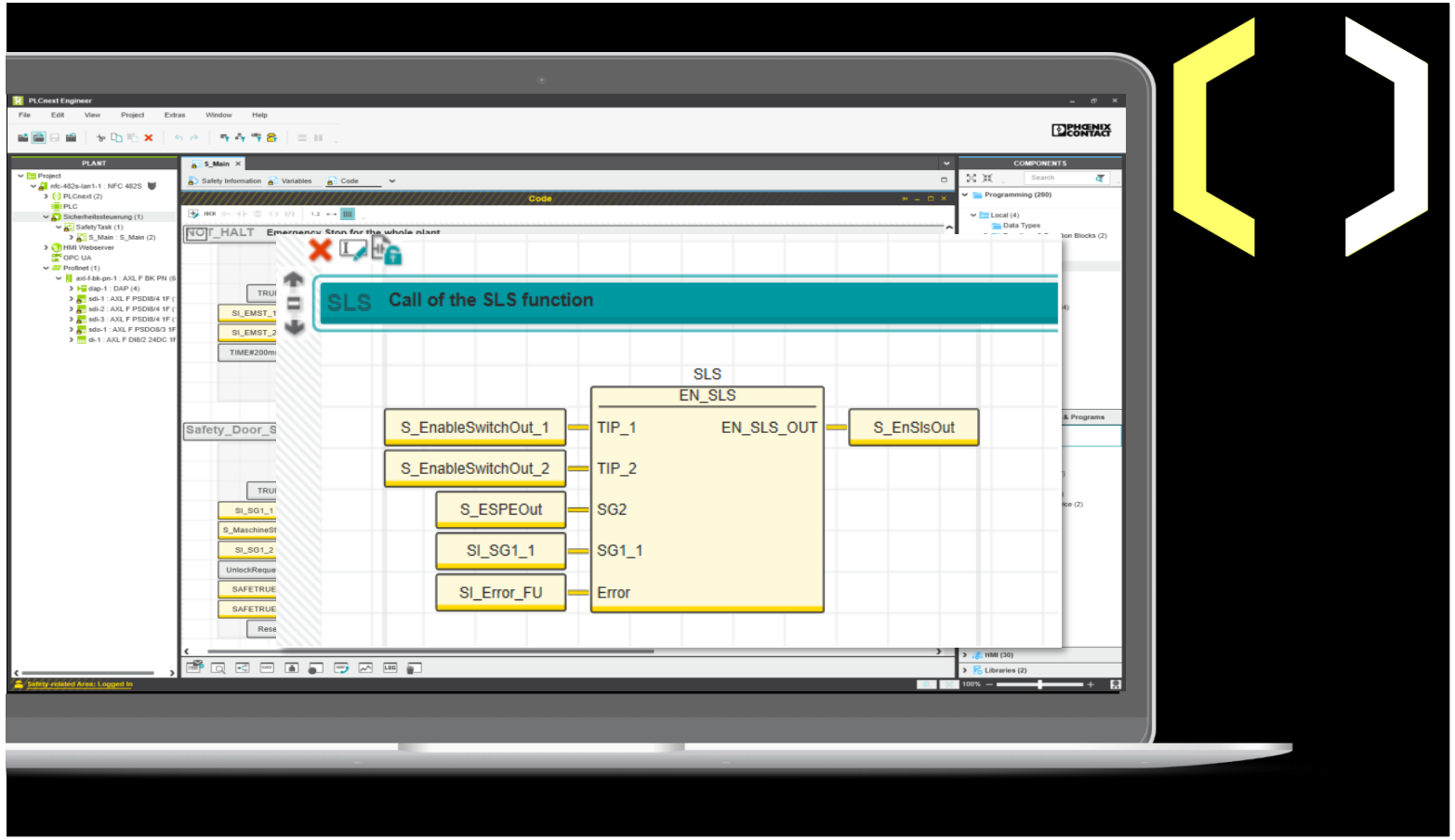
PLCnext Engineer



Fully integrated Safety programming

- Individual safety functions can be protected by a verification function
- Background signal path analysis
- Background safe semantic analysis
- Diversely-redundant code generator

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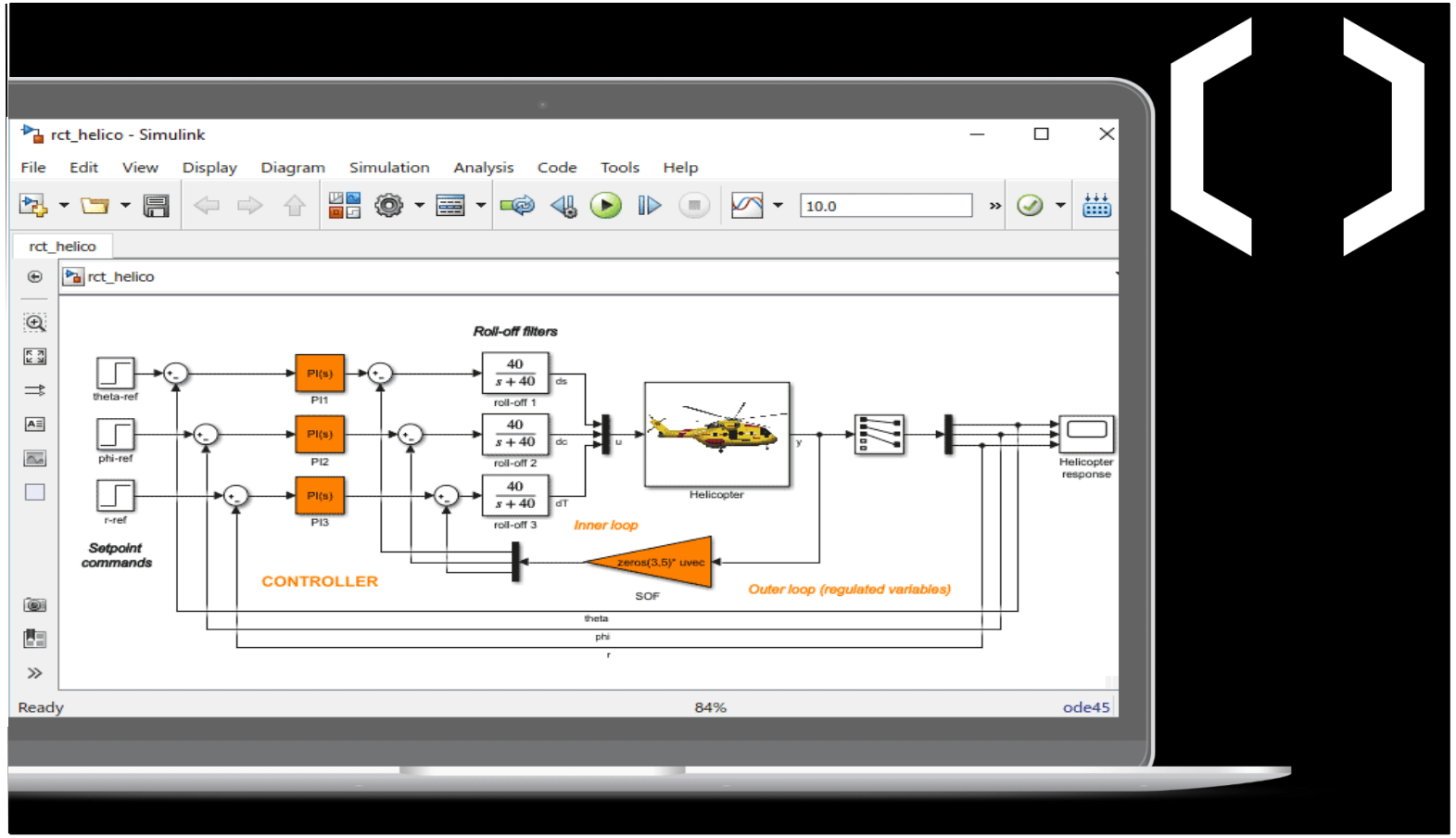
enhanced convenience

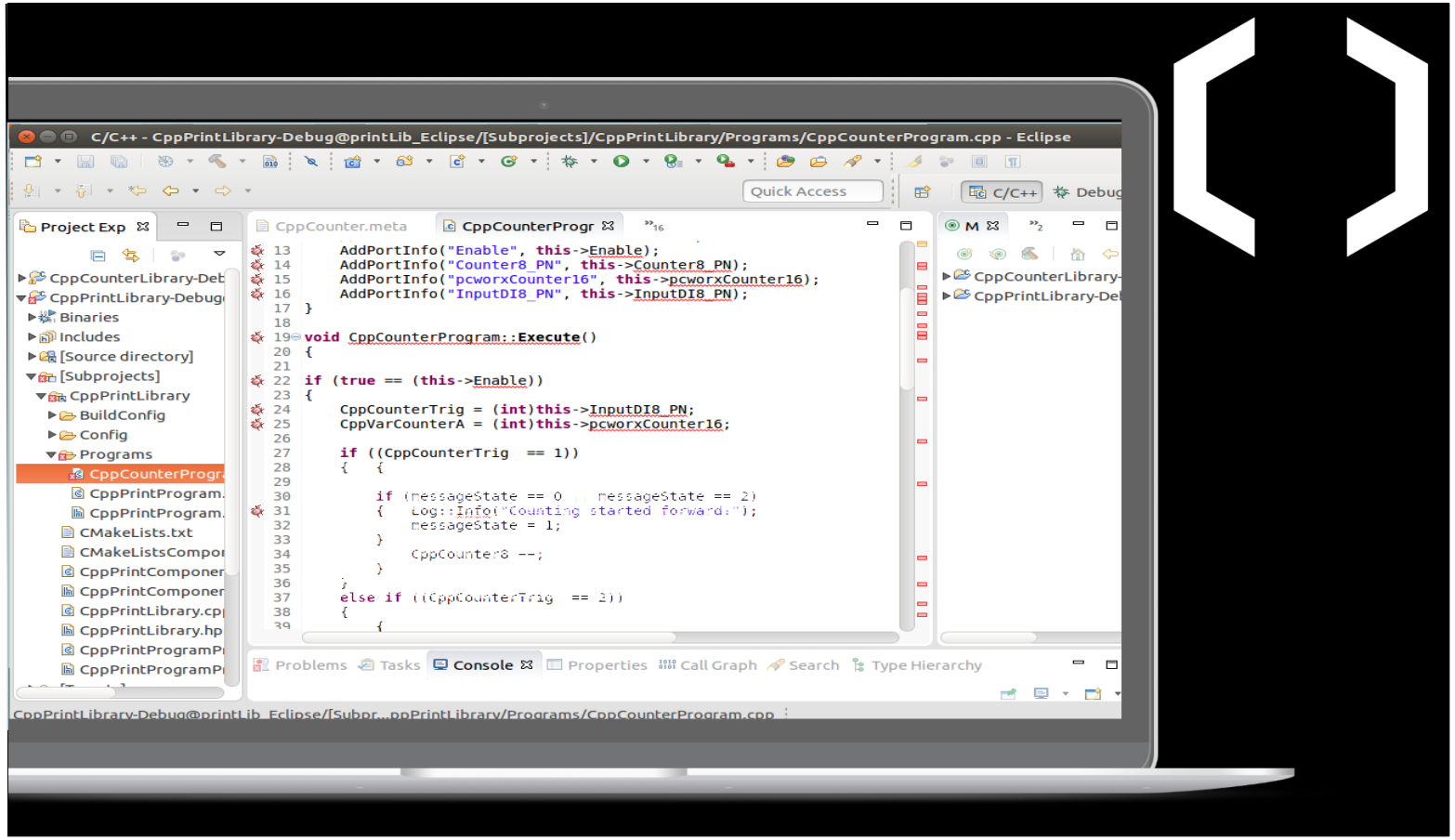
MATLAB Simulink



Seamless integration of model-based design & development with MATLAB Simulink.

enhanced convenience

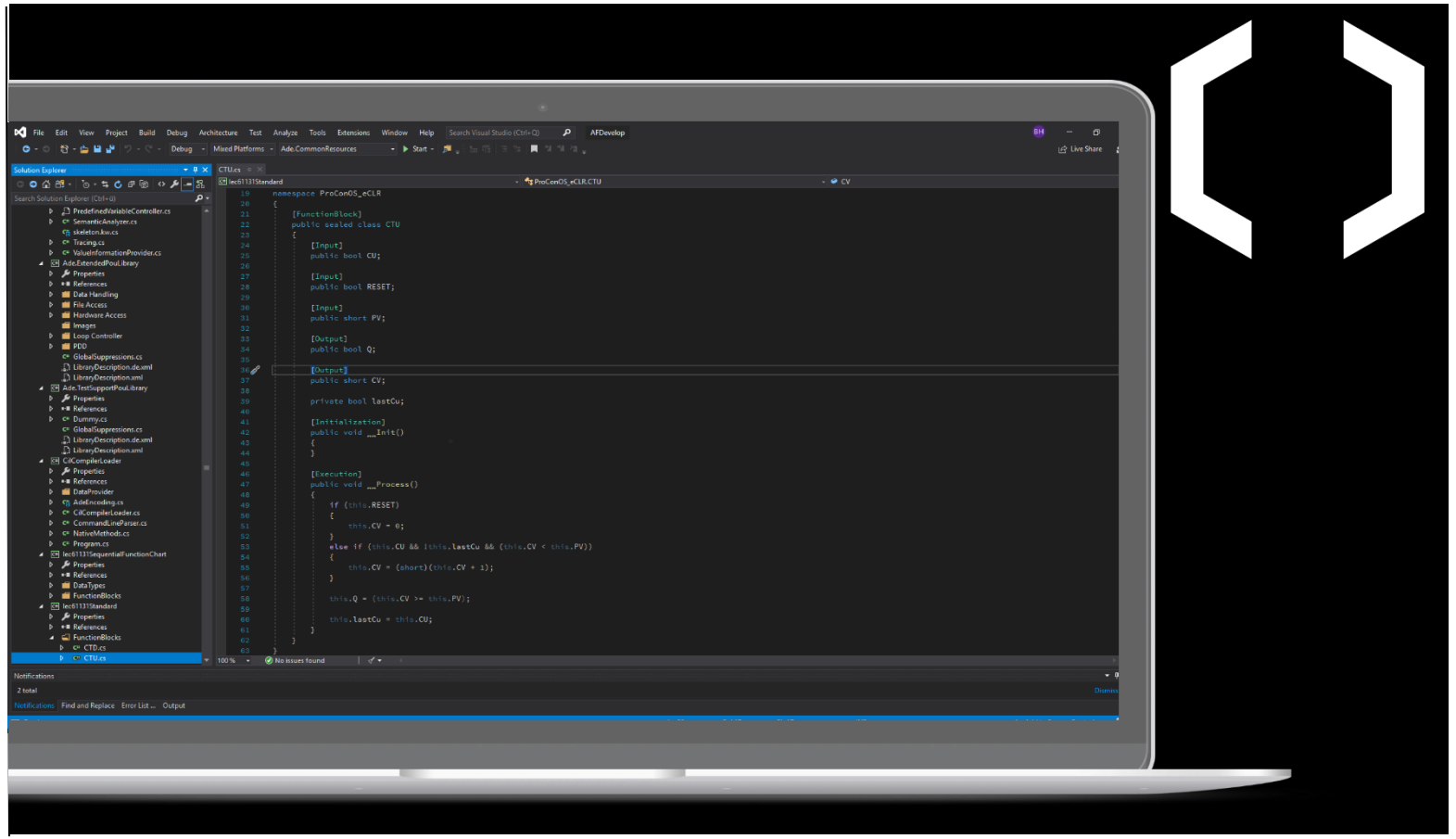
Programming – C/C++



eclipse

- C/C++ acc. to standard
- Easy interface to the PLCnext Runtime System
- Support of remote debugging
- Use the tool you are familiar with

Programming – C#



Visual Studio

- Development and integration of function blocks with C#
- Dedicated plug-in for Visual Studio.
- Execute C# function blocks in real-time with the eCLR runtime system.

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Join and get involved

PLCnext Community

More about PLCnext Technology

plcnextcommunity.com

Upload or download apps

plcnextstore.com

Ask a question in the forum

phoe.co/PLCnextForum

Use or share open source code

github.com/plcnext

Get in touch on LinkedIn

phoe.co/PLCnextLinkedin

#PLCnext
#IamPLCnext

Join and get involved
#IamPLCnext

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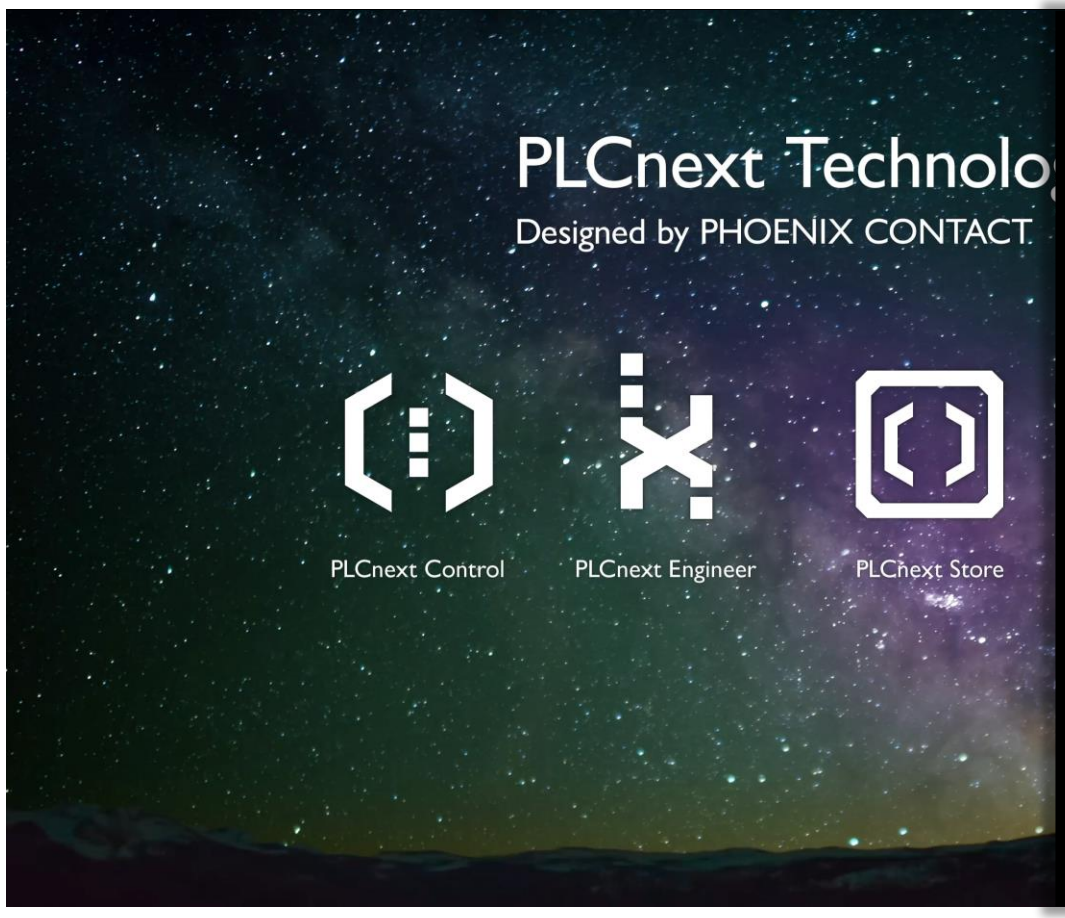
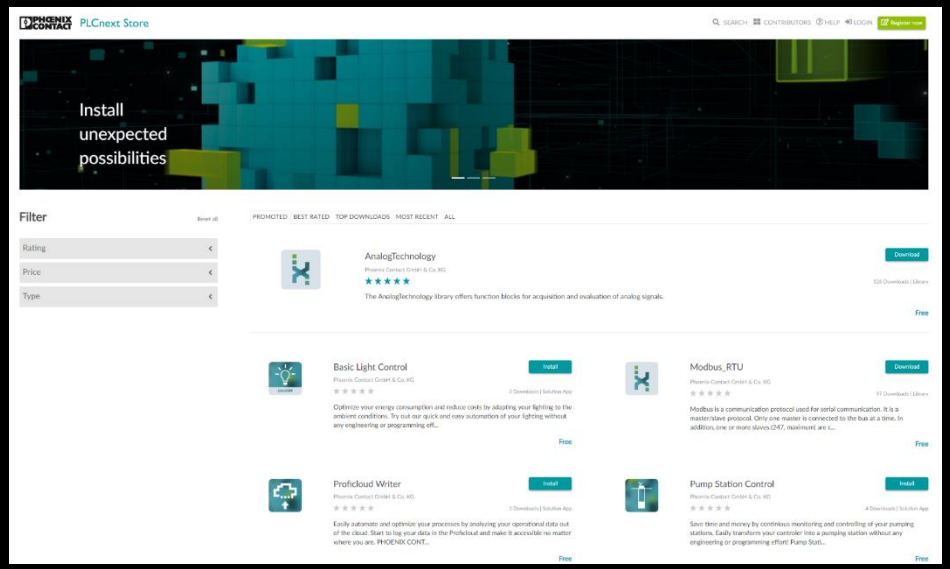
PLCnext Technology





Software Store for Automation

Apps for functional extension of
PLCnext Control and PLCnext

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Install extraordinary possibilities

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App Types

	Solution App	PLCnext Engineer 61131 Libraries	Runtime	Function Extension
Description	Automation solution consisting of different components with web pages for parametrization	Works as a part of a PLC program	Runtime or framework for further programing tools / languages	Combinable apps to create a solution
User Skill Level				
Example	Tank and Well Control, Pump Station Control, Proficloud Writer	Analog Technology, CANbus, ComSerial, Modbus TCP, IOL_Basic	Codesys, Python, Java or IEC 61499 …	MQTT, Protocol 1, 2, 3 Cloud Connector, …
Remark	Ready to use, without programming	PLCnext Engineer needed	Ready to use for programming	Combination of Apps

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New industry experts joined the Community

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PLCnext Community – Global Exchange & Collaboration

More about PLCnext Technology
plcnextcommunity.com

Upload or download apps
plcnextstore.com

Ask a question in the forum
phoe.co/PLCnextForum

Watch and learn with tutorials
phoe.co/PLCnextTutorials

Use or share open source code
github.com/plcnext

Share your experiences on Instagram
@plcnext

Get in touch on LinkedIn
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PLCnext Community

Join and get involved
#IamPLCnext

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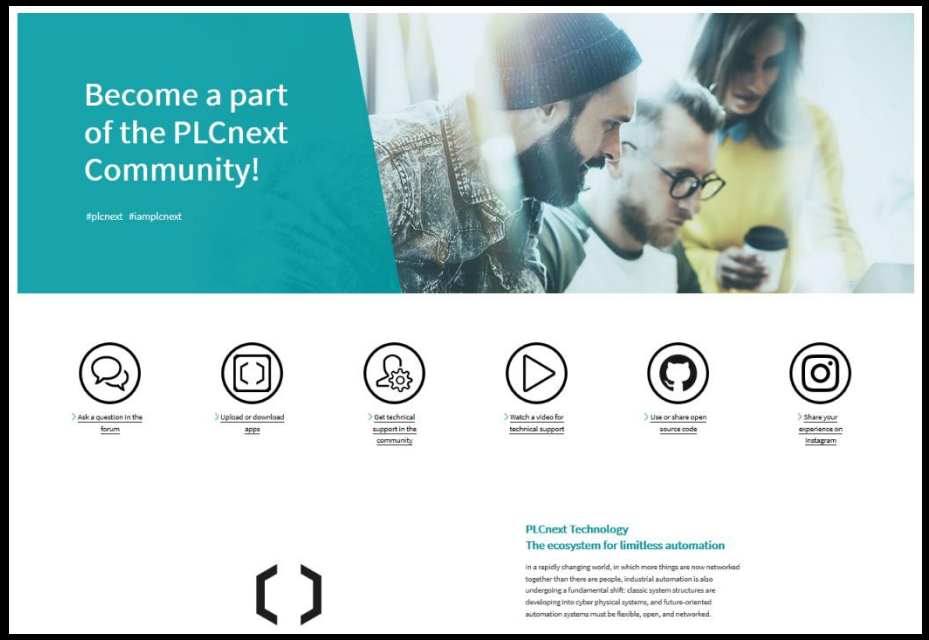

User Collaboration & Resources

Information, support, and helpful resources about PLCnext Technology including FAQs, forums, tutorials and a GitHub presence

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PLCnext Technology Ecosystem

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enhanced development

Connected coworking

enhanced convenience

Using your favorite programming tool

enhanced freedom

Flexible integration of open source software and apps

enhanced connectivity

Open interfaces and cloud integration

enhanced performance

Real-time execution across different programming languages

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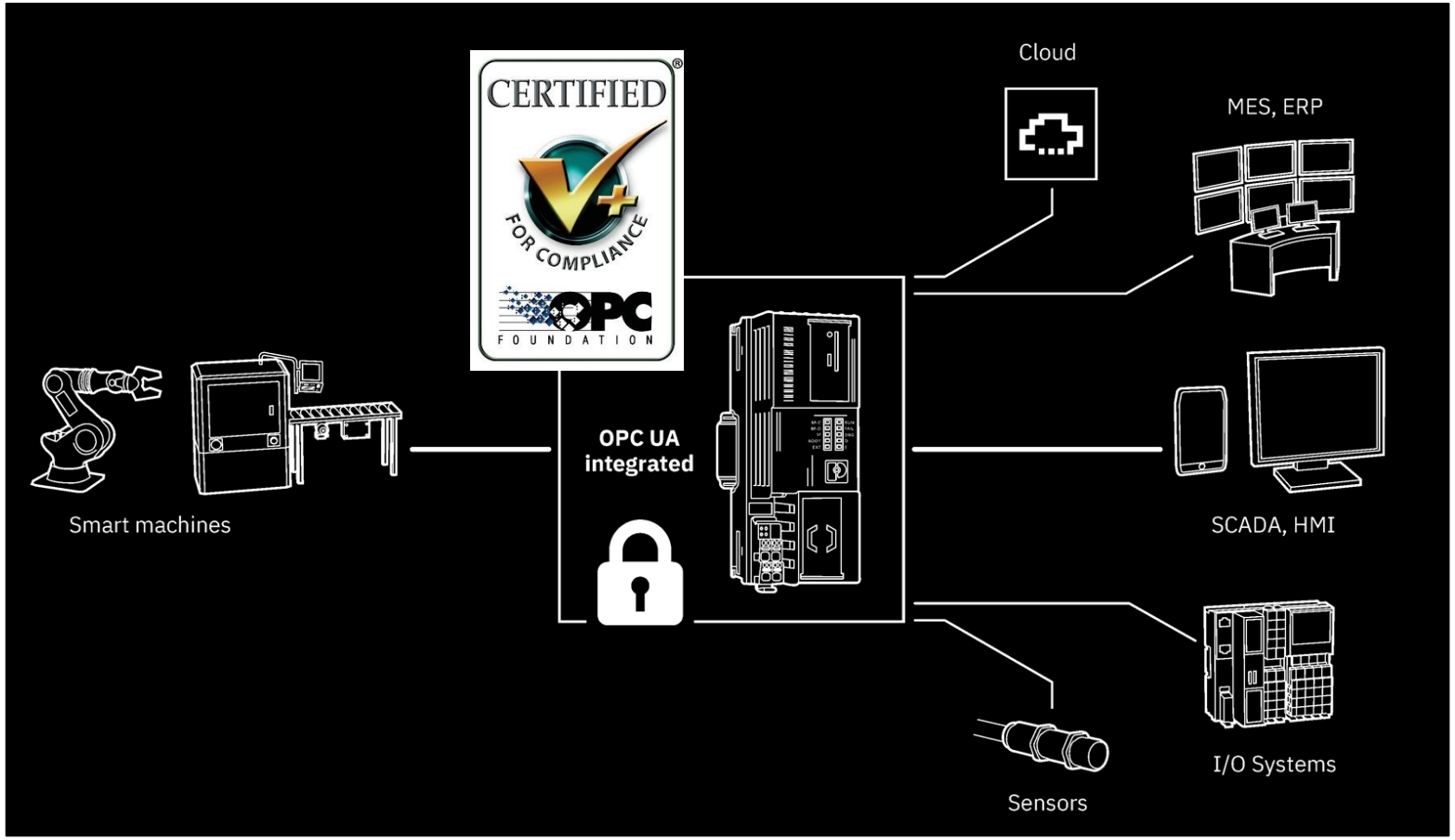
Integrated OPC UA Server



OPC UA

Data Access, Alarms and Conditions, Programs, Historical Access, Global Discovery Server

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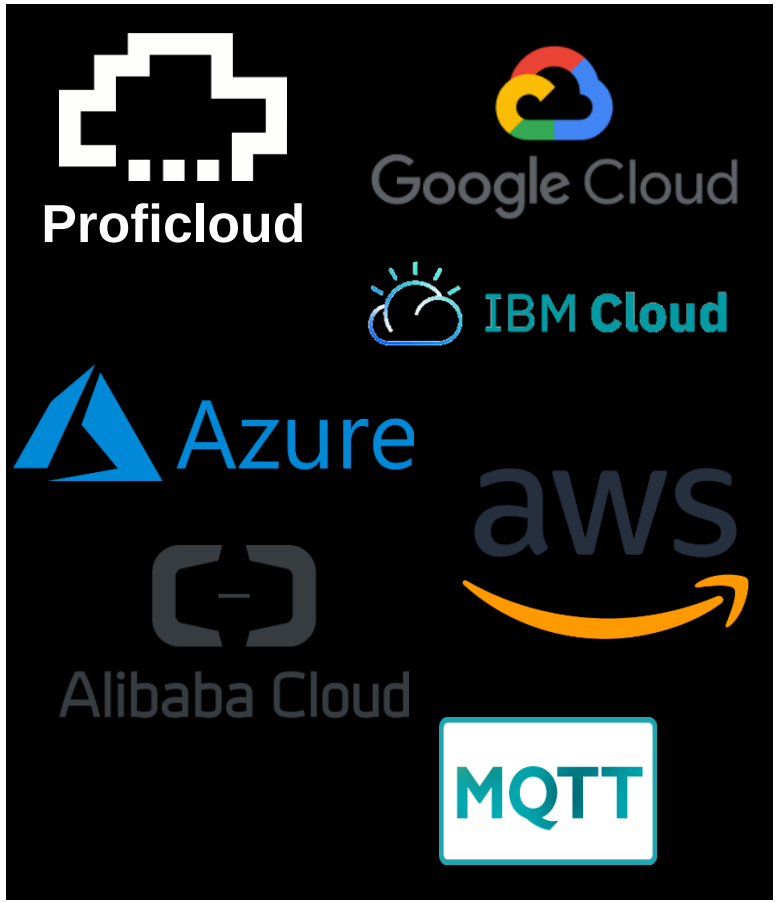
PROFICLOUD, Public Cloud, Private Cloud – any Cloud!

Implement new IoT-based business models through direct connection to cloud-based services and databases.

Benefit from the seamless integration of Phoenix Contact´s PROFICLOUD and the any cloud strategy where the PLCnext Store delivers cloud connectors for every cloud. PLCnext Technology supports any customer cloud implementation – public, private, hybrid - including AWS, IBM, Azure and Alibaba.



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List of Communication Interfaces and API's (incl. App extensions)

Fieldbus protocol

- Profinet (Profidrive via App)
- Interbus
- Modbus TCP and RTU via App
- Ethernet IP (Adapter)
- CANbus (CANopen, J1939 and NMEA) via App
- DALI via App
- HART via App
- IO-Link via App
- Profibus

General Communication Interface

- MQTT via App
- OPC UA (Server)
- OPC UA (Client) via App
- DHCP via App
- SMTP via App
- SNTP via App
- SNMP via App
- DNS via App
- DNP3 via App
- IEC60870-5-101 and -104 protocol via App

API

- gRPC
- REST
- ANSI-C
- RSC

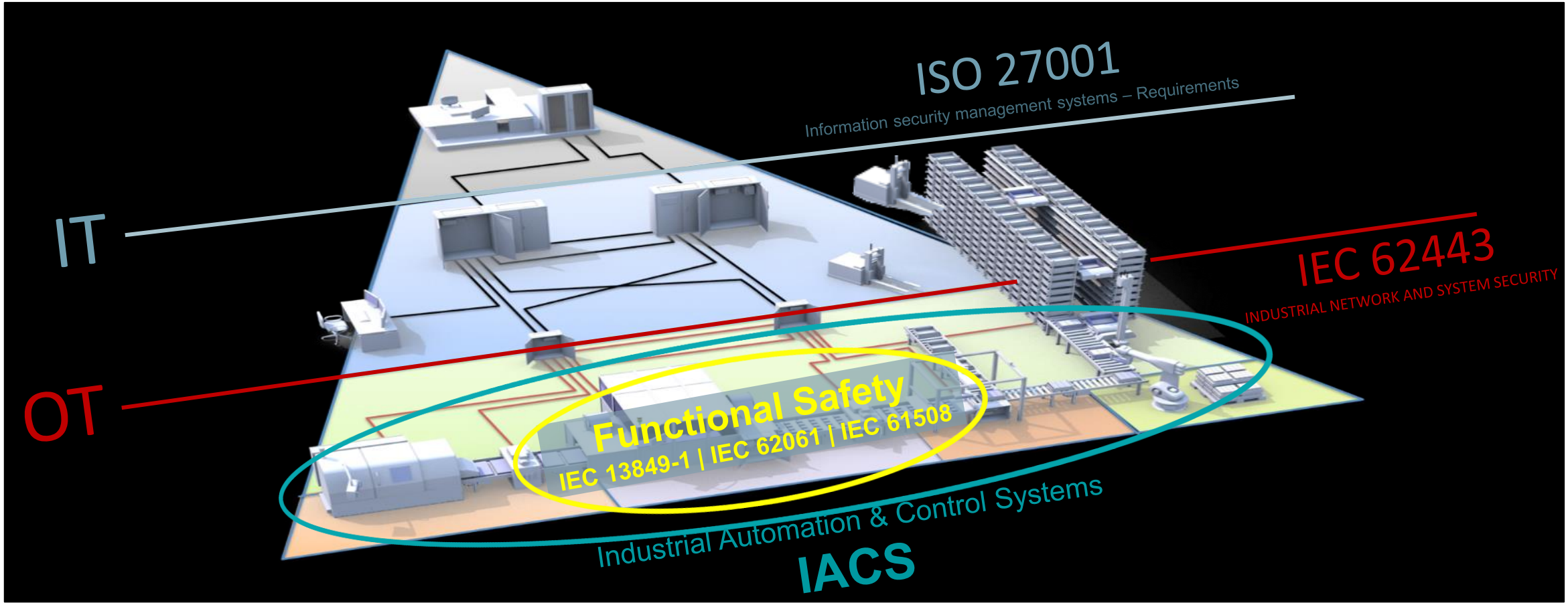
Inside APP only*

- BacNet IP
- Enocean (EVC/ESP3)
- KNX IP
- IEC61850 MMS & GOOSE
- EtherCAT

*"Inside App only" means the Interface can only be use inside an additional runtime app

Terminology, Roles, and Tasks in Security Processes

The “Automation Pyramid”



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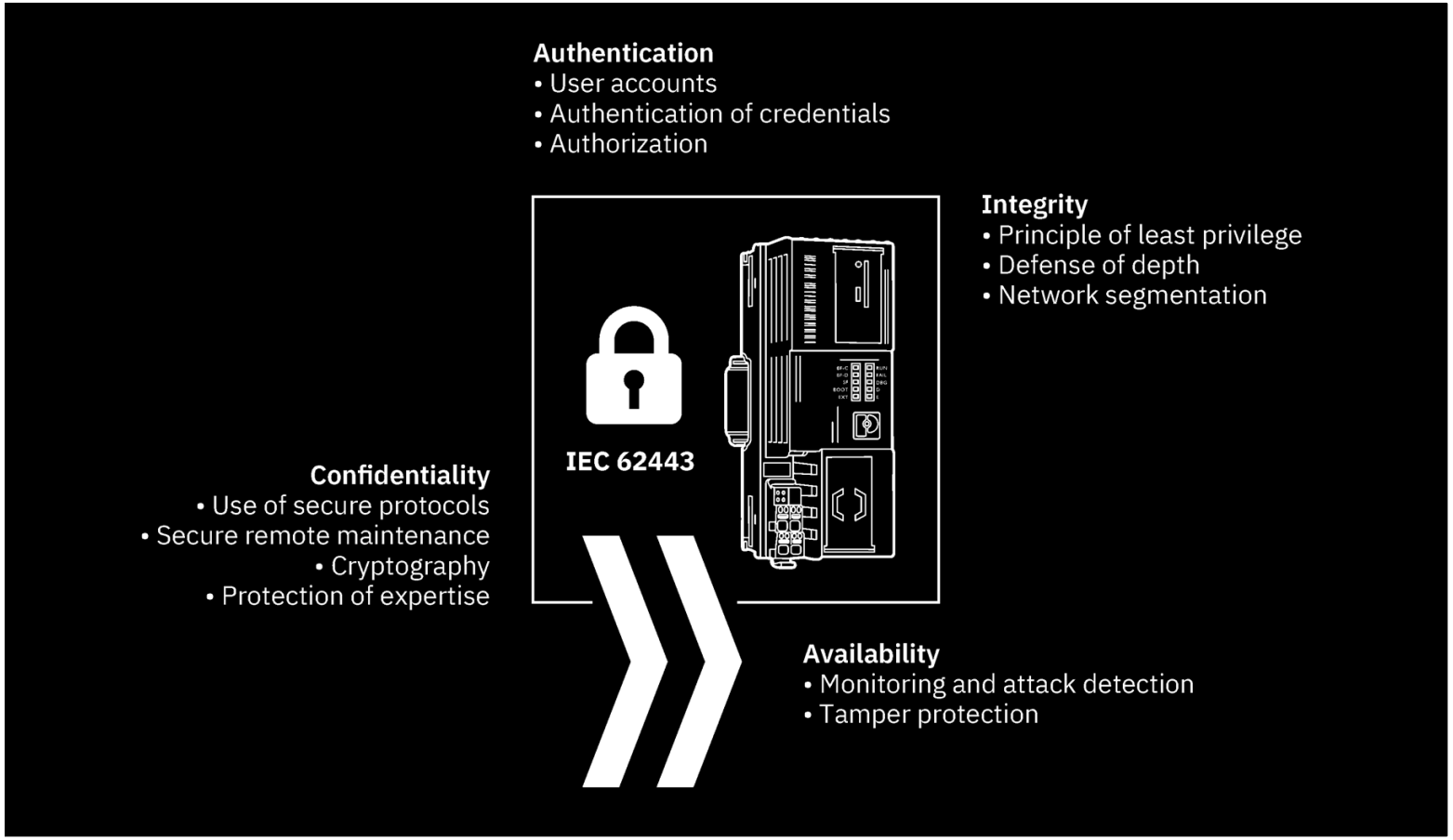
IEC 62443: IT-Security for Industrial Automation Control Systems



IEC 62443

Industrial Automation Basis Standard

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IEC 62443: IT-Security for Industrial Automation Control Systems

CERTIFICATE
No. Q4B 029429 0007 Rev. 00

Holder of Certificate: PHOENIX CONTACT GmbH & Co. KG
Flachsmarktstr. 8
32825 Blomberg
GERMANY

Factory(ies): PHOENIX CONTACT Electronics GmbH
Industry Management and Automation
Business Unit Control Systems
Dringenauer Strasse 30, 31812 Bad Pyrmont, GERMANY

PHOENIX CONTACT Software GmbH
Langenbruch 6, 32657 Lemgo, GERMANY

Certification Mark:

Scope of Certificate: Secure Product Development Lifecycle

Applied Standard(s): IEC 62443-4-1:2018
PPP 15002A:2018 *(IEC 62443-4-1 Full Process Profile)*

The Certification Body of TÜV SÜD Product Service GmbH certifies that the company mentioned above has established and is maintaining a management system which meets the requirements of the listed standards. The results are documented in a report. See also notes overleaf.

Report No.: 18CR01S007

Valid until: 2021-07-29

Date, 2018-08-01 (Andreas Bärwald)

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ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

CERTIFICATE
No. IITS2 029429 0027 Rev. 00

Holder of Certificate: PHOENIX CONTACT GmbH & Co. KG
Flachsmarktstr. 8
32825 Blomberg
GERMANY

Certification Mark:

Product: IACS components

Model(s): PLCnext Control
(Configuration: Security Profil active)
AXC F 1152, AXC F 2152, AXC F 3152

Tested according to: IEC 62443-4-1:2018
IEC 62443-4-2:2019
PPP 15003B:2021 (IEC 62443-4-1: Full ML3 Process Profile)

The secure development lifecycle and the resulting product(s) were assessed on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition, the certification holder must not transfer the certificate to third parties. See http://www.tuvsud.com/ps-cert for details.

Test report no.: 21CR03S047
Valid until: 2024-10-20

Date, 2021-11-19 (Nadia Patricia Stefan)

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ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

IEC 62443

Industrial Automation
Basis Standard

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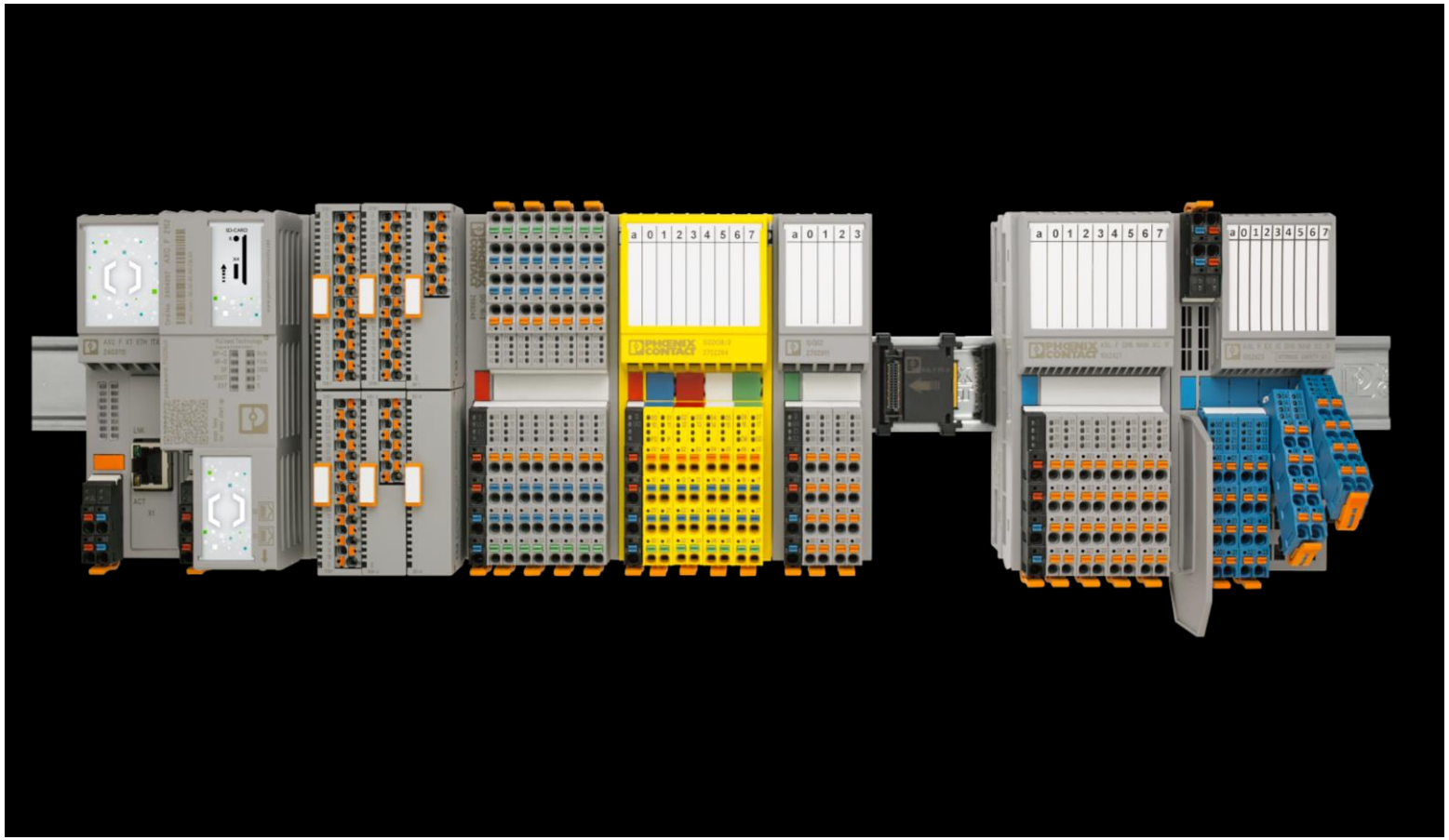
PLCnext Control extension possibilities



- Modular expandability of the controller through left-side expansion modules on the PCI express interface via a corresponding bus socket
- Unlimited expansion possibilities with Axioline IO

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Countless possibilities in hardware variance

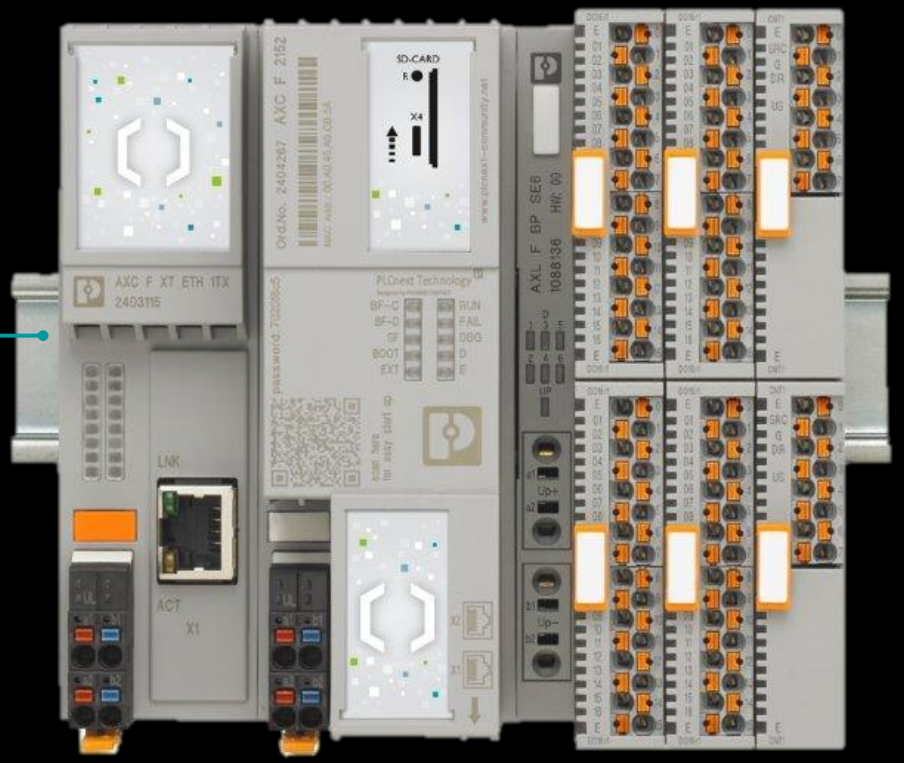
PLCnext Control

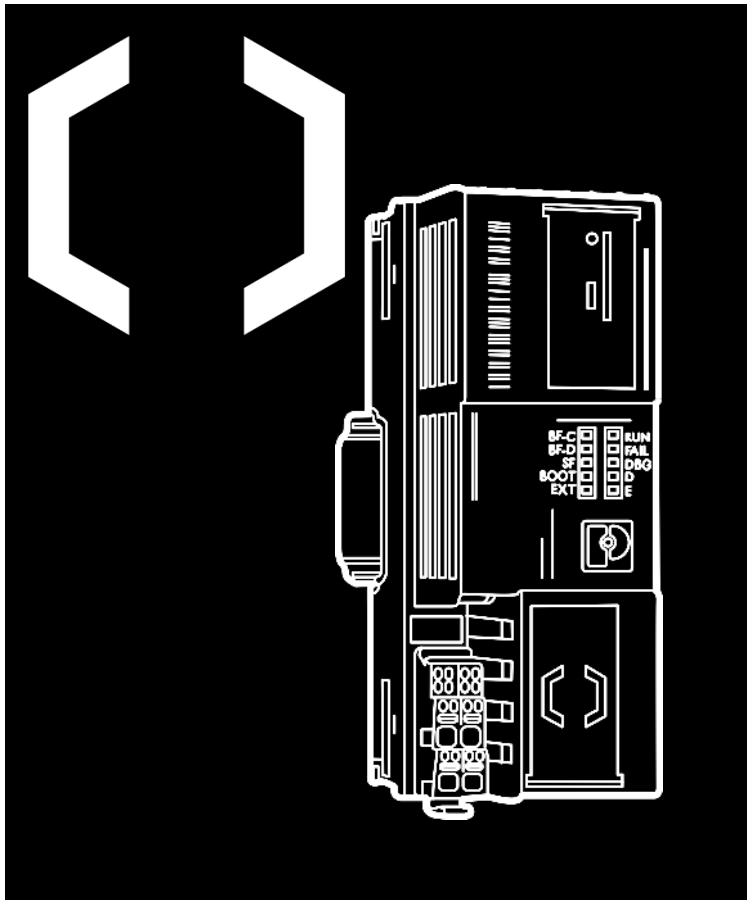
PLCnext Technology
Designed by PHOENIX CONTACT

new

PLCnext Control Extension

Control functionality can be easily extended with left-handed modules





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Automate smart and economically

Ready for automation

All necessary functionalities
incl. Safety and IO-Link

DI	SDI	AI	IO-Link	INC
DO	SDO	AO	RS485	CNT

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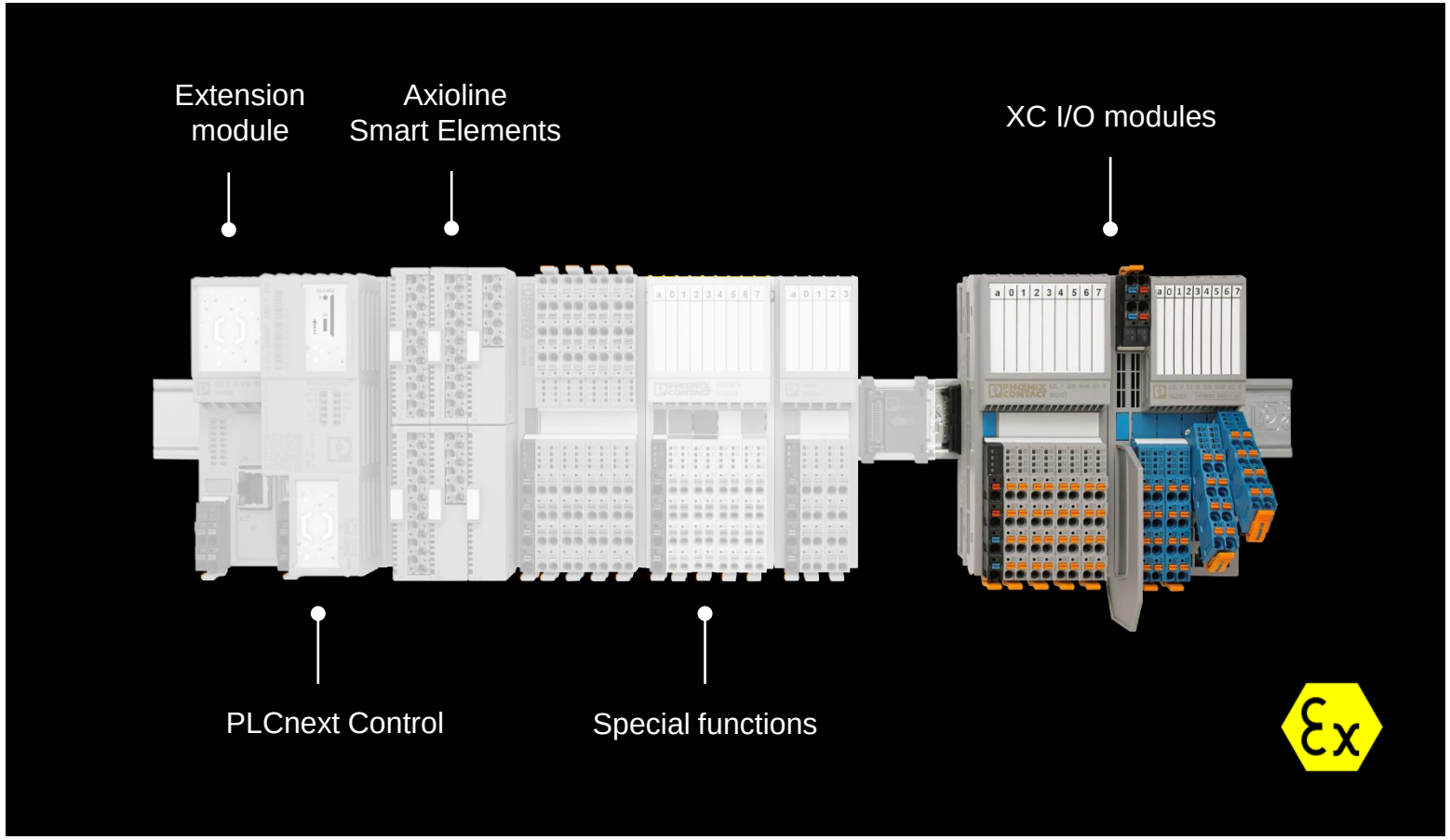
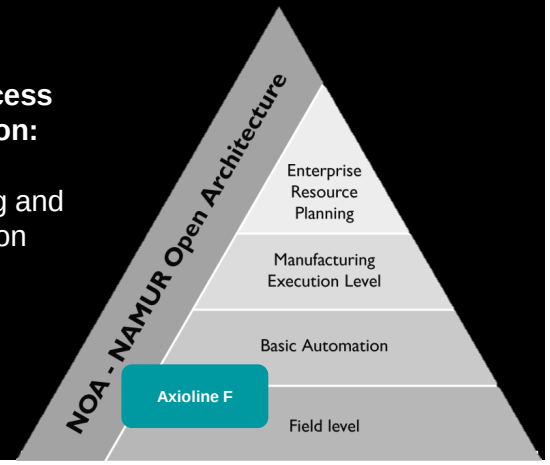
Axioline F – Monitoring and Optimization



- Extreme condition temperature range
- IECEX/ATEX zone 2 certification
- Intrinsically safe
- HART communication
- NAMUR functionality

Side process automation:
Focus on monitoring and optimization



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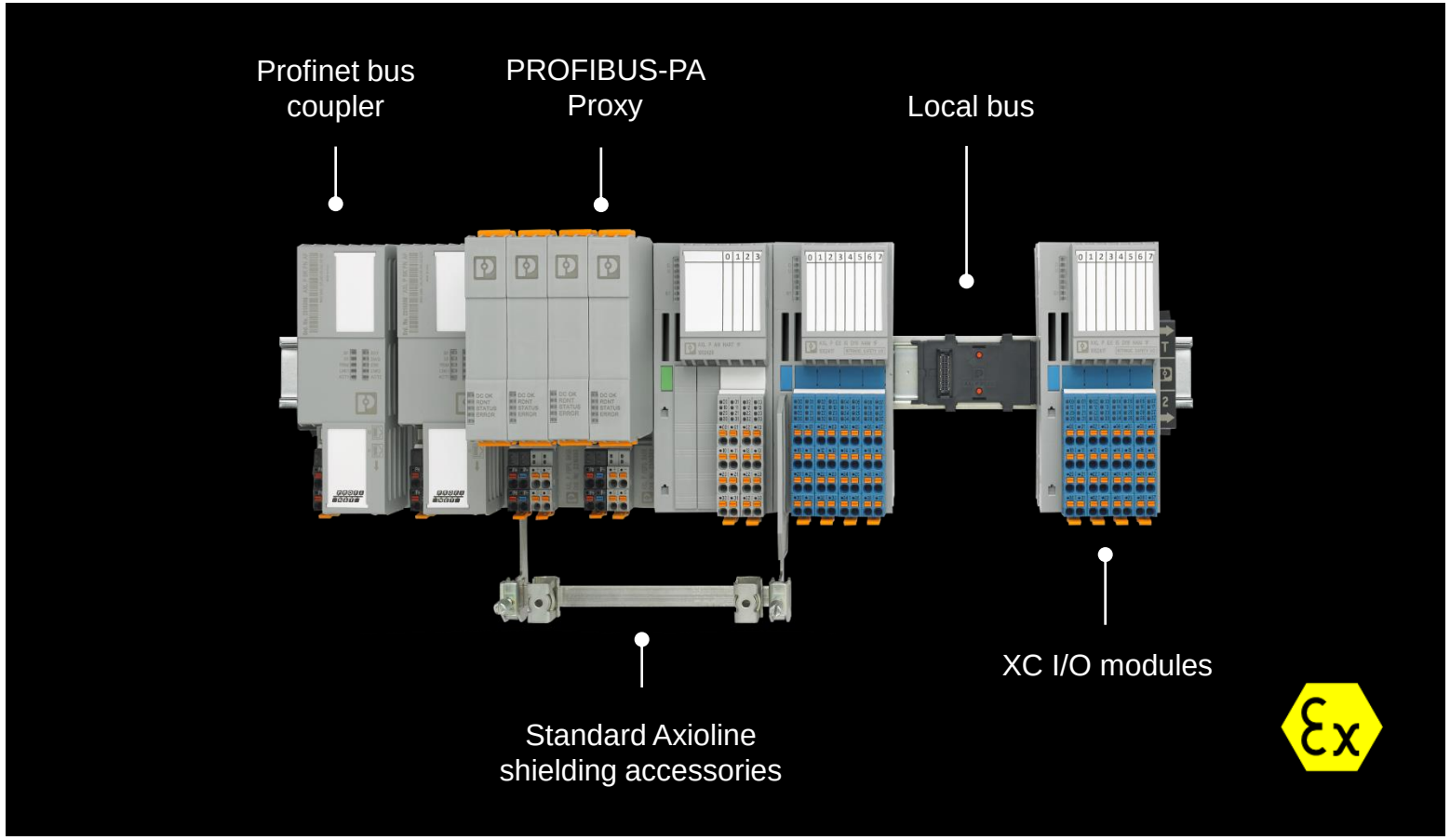
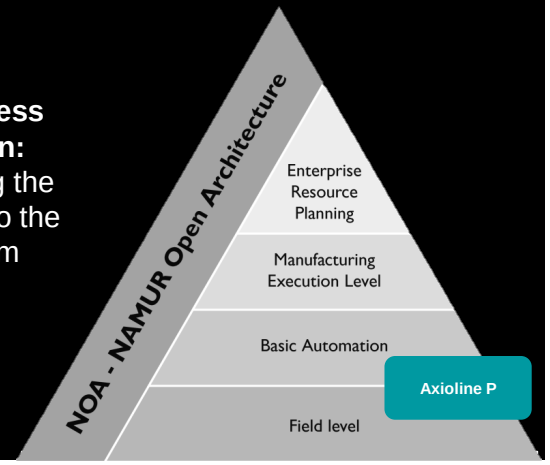
Axioline P – high availability with hot-swap



- PROFINET S2 redundancy
- Hot-swap
- Installation in zone 2
- Connection to zone 0/1
- HART communication
- NAMUR functionality

Core process automation: Connecting the field level to the control room



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Portfolio PLCnext Control Extensions

Ethernet

AXC F XT ETH

INTERBUS Master

AXC F XT IB

PCIe Switch functionality

AXC F XT EXP

PROFIBUS Master

AXC F XT PB

Safety PLC

AXC F XT SPLC 1000

Machine Learning

AXC F XT ML 1000

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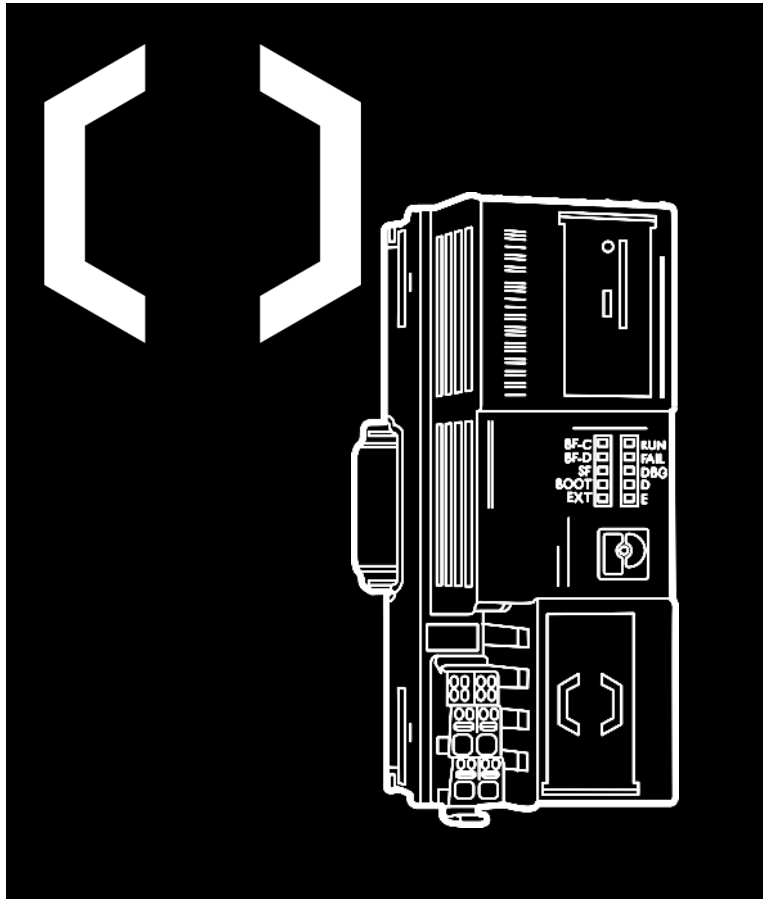
PLCnext Extension AXC F XT ML 1000

- Additional Machine Learning accelerator
- Google Edge TPU ML accelerator
- 4 trillion operations per second (TOPS)
- Tensorflow Lite or AutoML
- Approvals
  - UL (Hazloc), CUL
- Temperature range: -20°C up to 55°C
- Due to 64Bit architecture available with AXC F 3152



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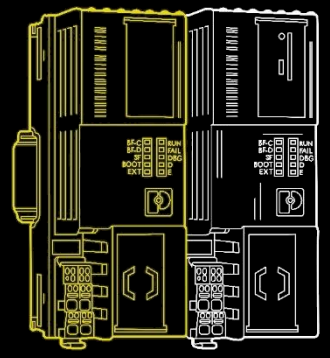
The open ecosystem for limitless automation

Safety

with PLCnext Control



PLCnext Control

Discover flexible automation

PLCnext Control Extension SPLC 1000

PLCnext Extension AXC F XT SPLC 1000

Core

2 x Cortex M4

# of Profisafe devices

32

Temperature

-25°C - 60°C

Width

45mm

Approvals

UL, CUL, etc

C Functions

C

Reloadable

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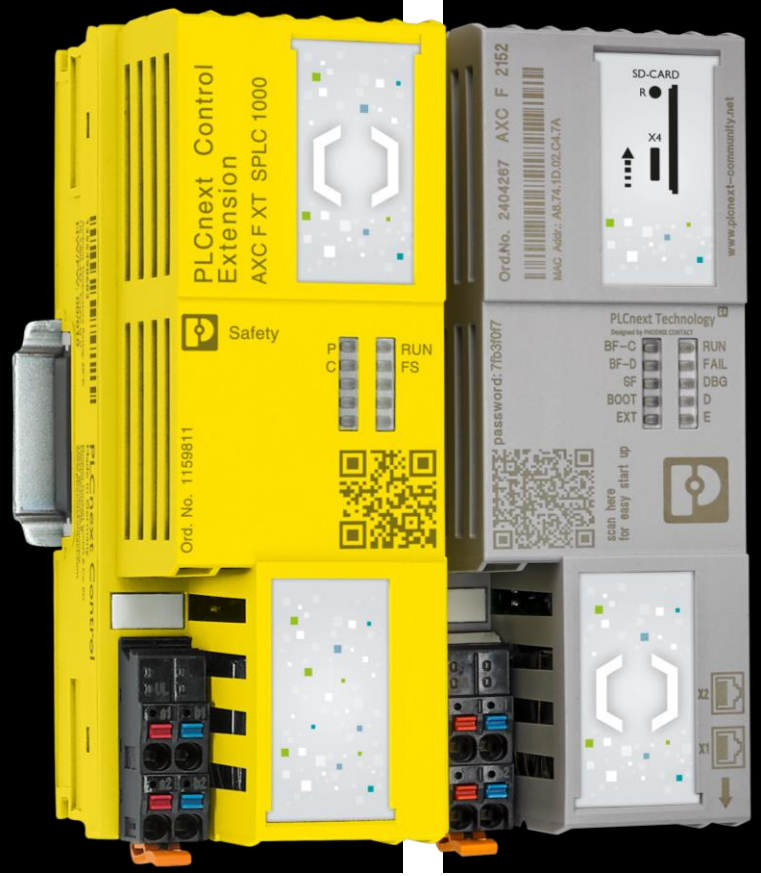
PLCnext Safety Extension AXC F XT SPLC 1000

- Scalable PLCnext Safety Control
- Reloadable C-Functions, e.g.
  - Complex safety algorithm
  - Safety Machine Learning
  - Automatic certification
- Adaptable Safety Communication, e.g.
  - OPC UA Safety (M2M)
  - PROFIsafe (M2D)
  - Vendor specific
- Approvals
  - SIL3, PLe
  - UL (Hazloc), CUL
  - IEC Ex, ATEX



- Scalable PLCnext Control
- Open ecosystem for limitless automation
- IEC 61131-3, C, C++, C#, Matlab
- OPC UA, MQTT, ...
- Open communication standards
- Security by design
- Built-in cloud connectivity

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PLCnext Technology
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AXC F XT SPLC 1000 – Modular Safety PLC

- Decentralized Small Safe PLC
- Connectable to PLCnext Controls as extension Modul
- Supported Safety Protocols:
  - PROFIsafe V2.61 (32 instances)
- Connectable to higher-layer SPLC as F-Device and via new OPC UA Safety Protocol

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PLCnext Control RFC 4072R for Profinet S2 Redundancy

CPU

Intel i5 6300U 2 x 2,4 GHz processor

Random Access Memory

4 GB DDR 4 dual channel RAM

ETH-MAC interface

3 ETH-MAC interfaces (2 x 1 Gbit, 1 x 100 Mbit switched)

Synchronization interface

minimal switch-over time 5ms

Power supply

Dual interface

Temperature

0°C - 55°C

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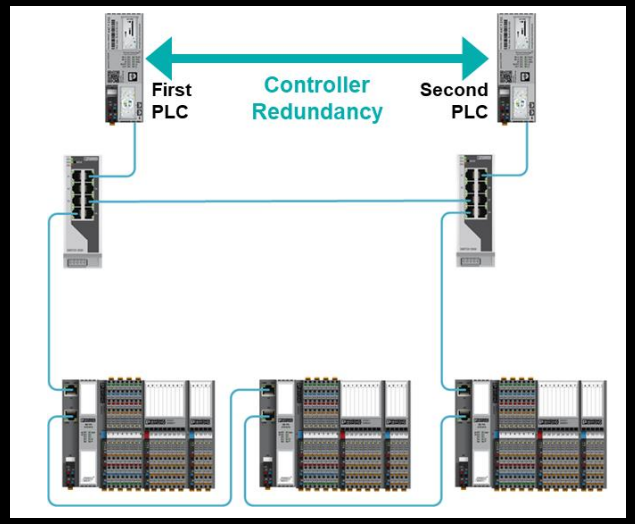
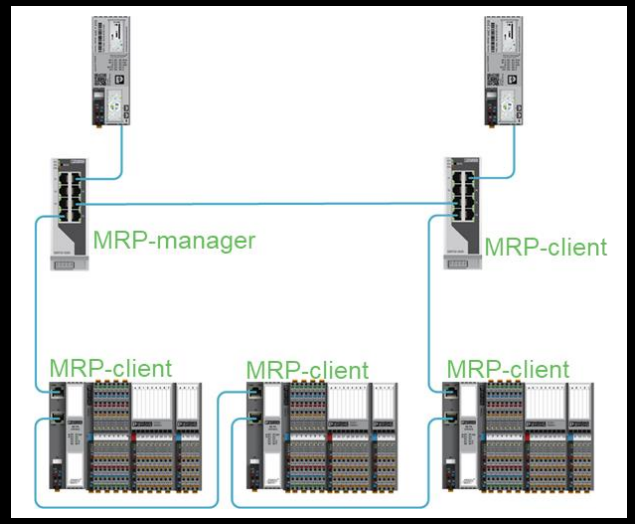
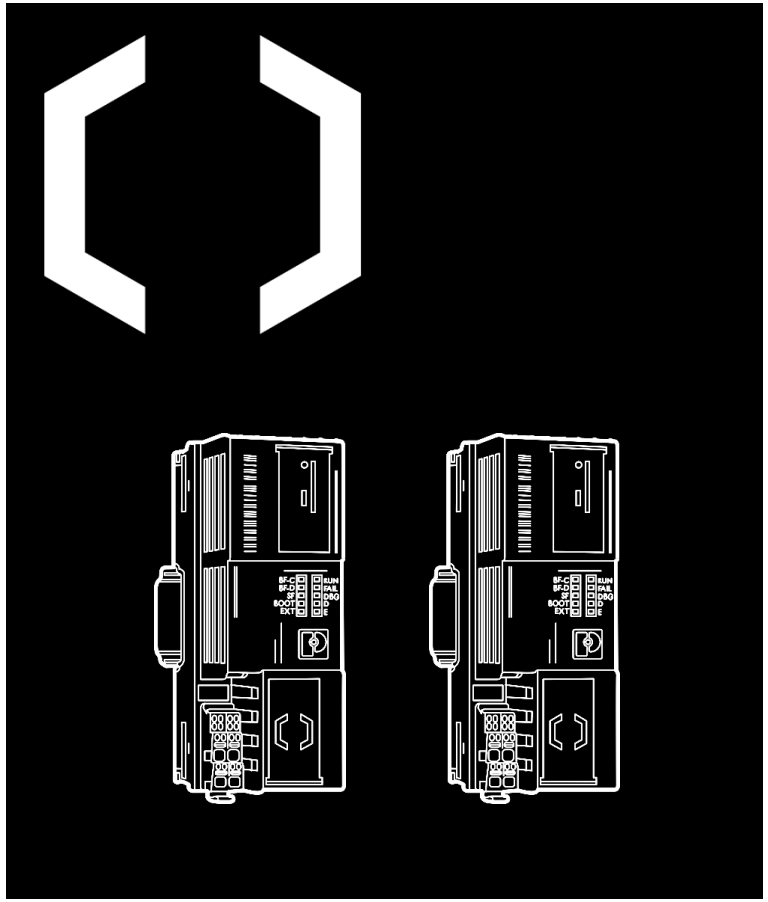
Software Redundancy for 2152 and 3152 with software function blocks



- Both Profinet IO-controllers are connected to all Profinet IO-devices at the same time.
- One has the role of the Primary the other Backup
- This communication is done via an UDP/IP based protocol.
- Typical system switch-over time:
  Minimum 300ms



- Media Redundancy Protocol (MRP) according to IEC62439:
- One Switch has the role of the MRP-manager.All other devices in the ring structure must support the MRP-client function.
- Typical switch-over time 200ms.



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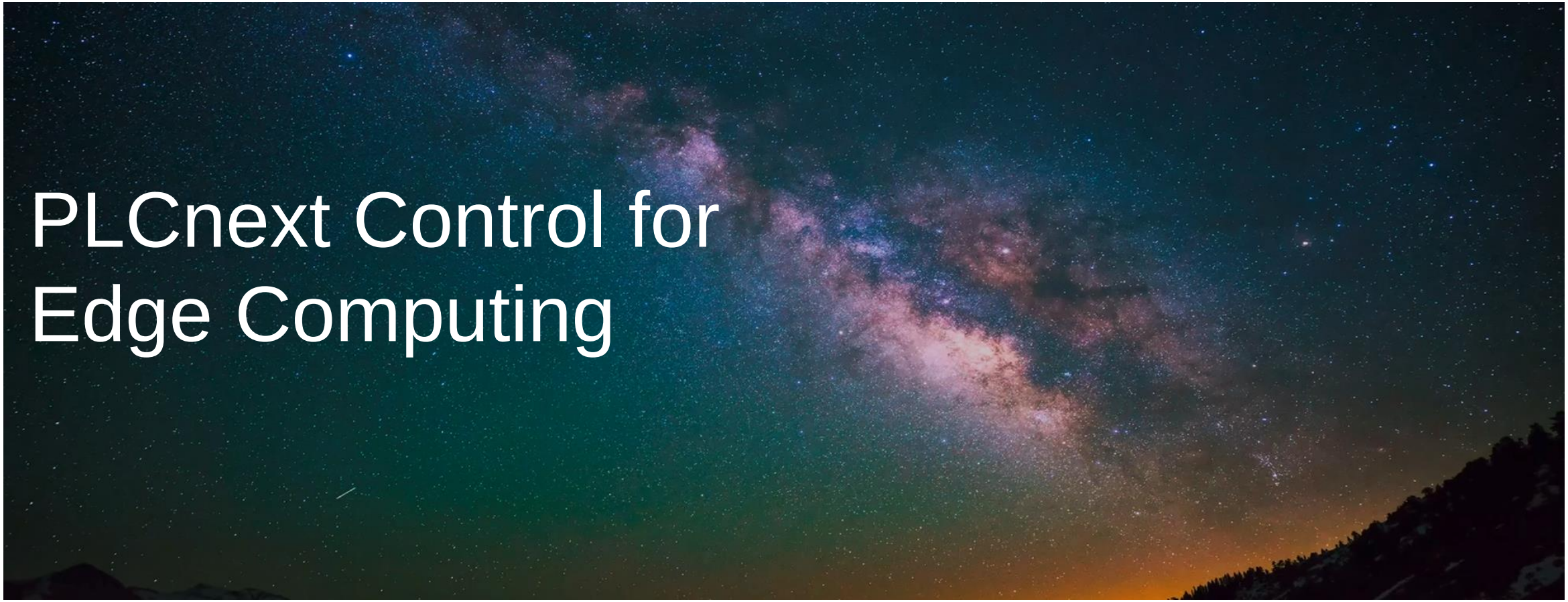
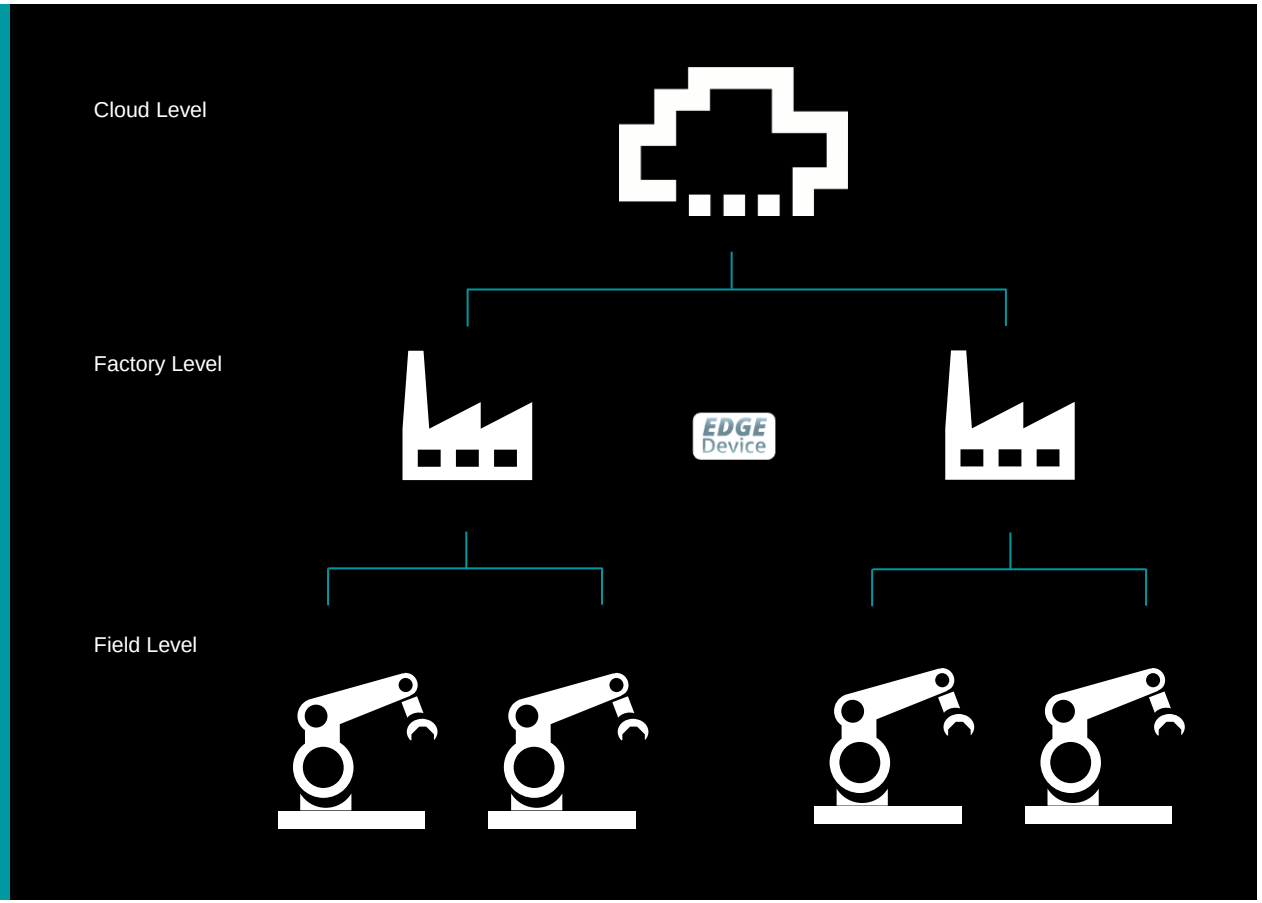

PLCnext Control for
Edge Computing

Edge Computing

- Cloud computing has revolutionized how people store and use their data, but…
- Latency, bandwidth, security or a lack of offline access can be problematic
- To solve this problem, users need robust, secure and intelligent on-premise infrastructure for edge computing
- When data is physically located closer to the user who connect to it, information can be shared quickly, securely and without latency



Edge functions within PLCnext Control

Cloud Connection

AI, Machine Learning, Deep Learning

Mobile WIFI Access

Smart Services

OPC UA Client / Server

OPC UA Aggregation Sever

Edge Management

Data Sever

Certificate Server

PLCnext Technology
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Edge functions within PLCnext Control

PLCnext Runtime System

Security

Cloud Connection

Smart Configuration

PLCnext Engineer

PLCnext Store

Data Server

Node-RED Programming

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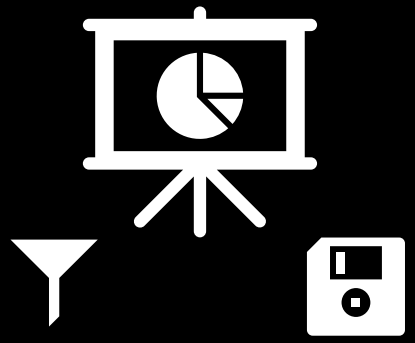
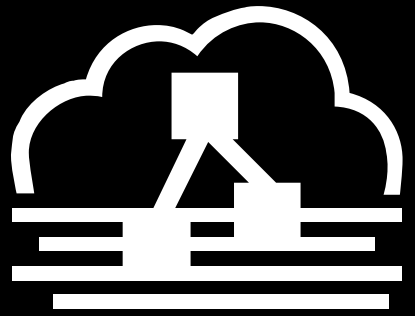
Edge Computing - Use cases

Data collection from sensors, actuators and PLCs.
Usage of typical protocols like OPC UA, Profinet, Modbus TCP & RTU and much more.



Data storage, processing and dashboards.
A wide range of rules and statistics can be used with Influx DB. Visualization is supported with Influx DB Chronograf.



Sending data to superordinated- and Cloudsystems.
Integrated cloud connection and support of a wide range of communication e.g. via Node Red

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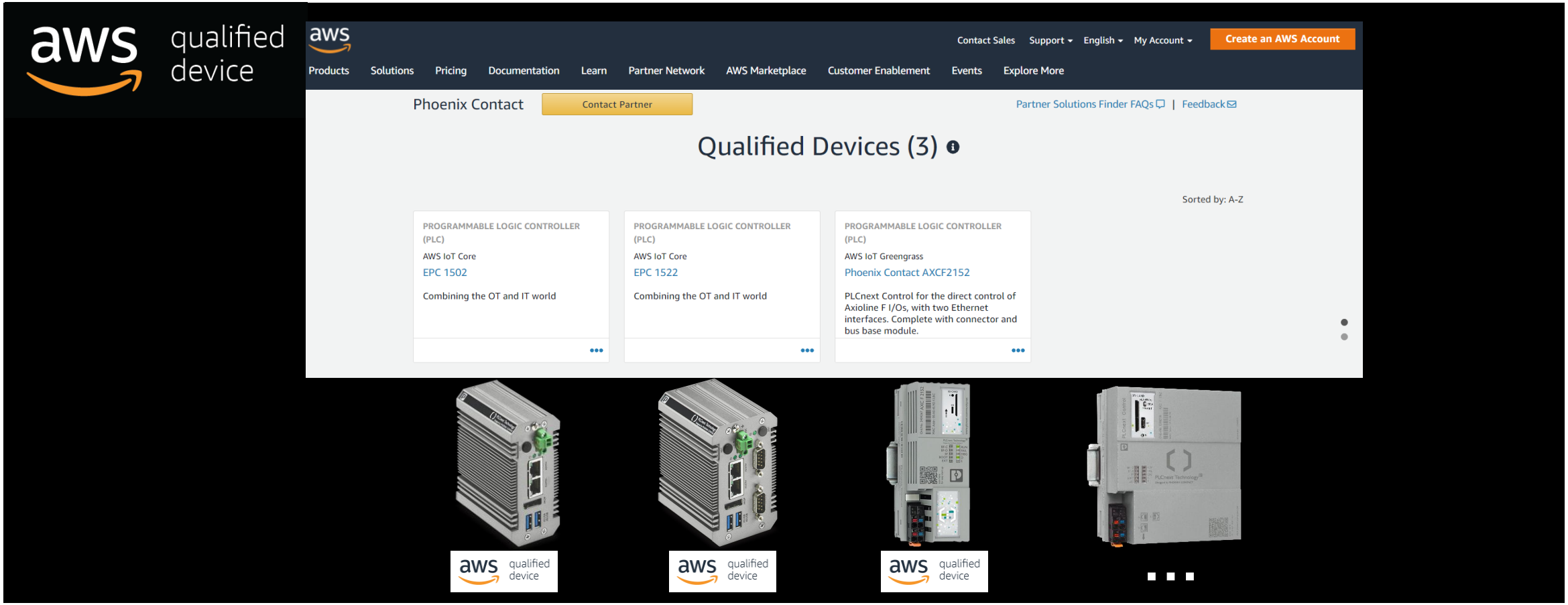
enhanced connectivity – Intelligent Networking

PLCnext Control – AWS Qualified



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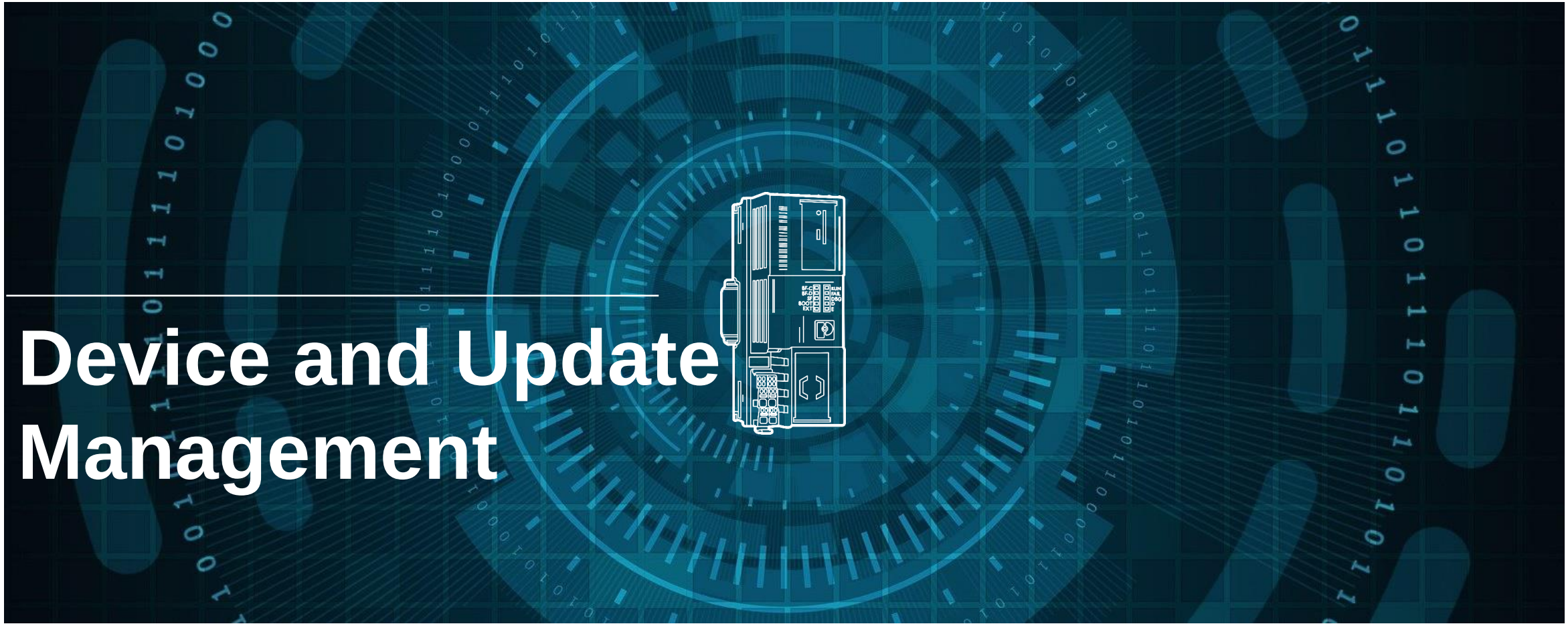
Device and Update Management with Edge Computing



Benefits of a Device and Update Management

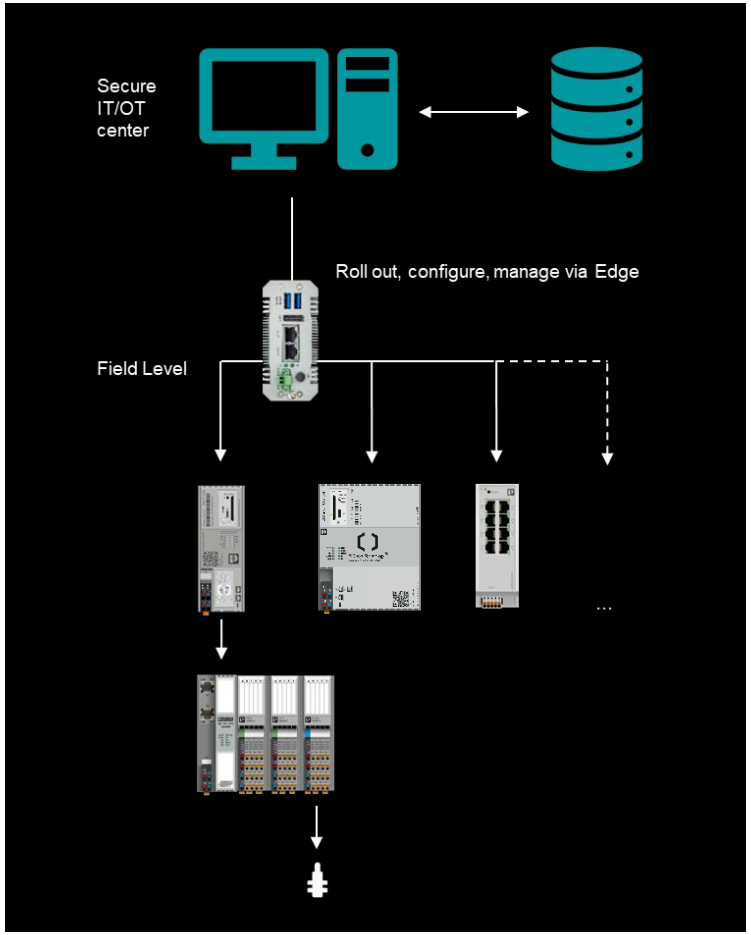
Security risks due to outdated firmware are closed at an early stage

Firmware/patches from the manufacturer are provided automatically -> Easy automation of updates

Fewer compatibility problems thanks to specifically released software versions

Reduce support effort and decrease downtime -> central rollout control

The DaUM makes it easy to inventory hardware and FW data. -> SW/FW status of all devices at a glance



Process steps of Device and Update Management

Take inventory

Inventory
Record status and parameterization of devices
Add new devices
Remove old devices

Identify tasks

Update and patch cycles
Current security vulnerabilities
New software features
Parameter changes
Identifying device problems

Provide

Installation of the updates
Report on progress and errors
Evaluation and optimization of the rollout process

Evaluate and plan

Perform risk analysis
Determine update priority
Planning the rollout

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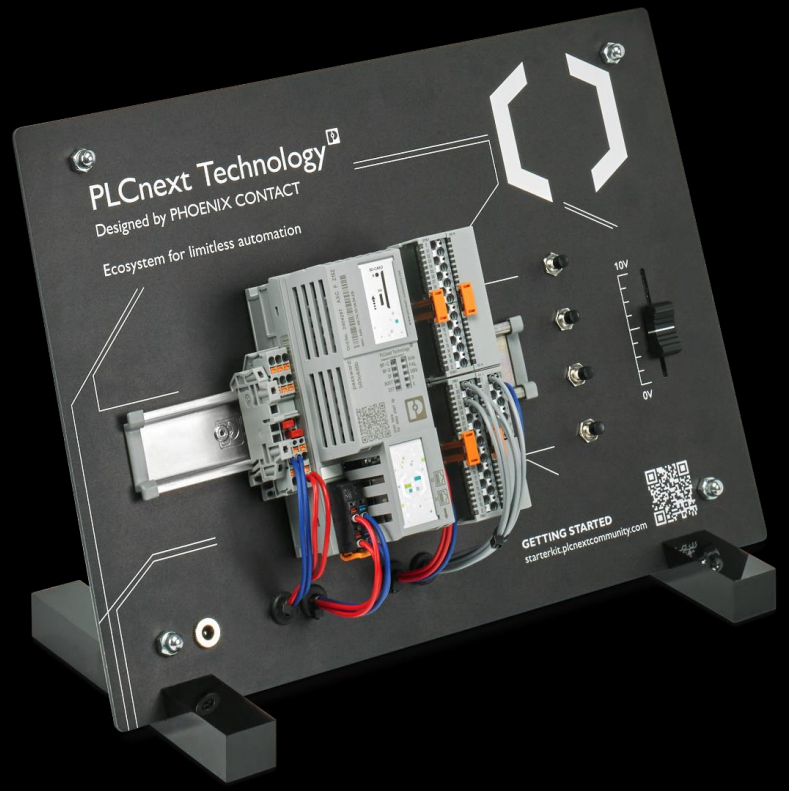
Start now and become a part of PLCnext Technology



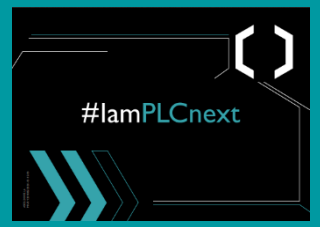
Getting started

Online

Hardware

PLCnext Control &
Axioline Smart Element

starterkit.plcnextcommunity.com



www.plcnexttechnology.be/nl/starterkit
359,-€

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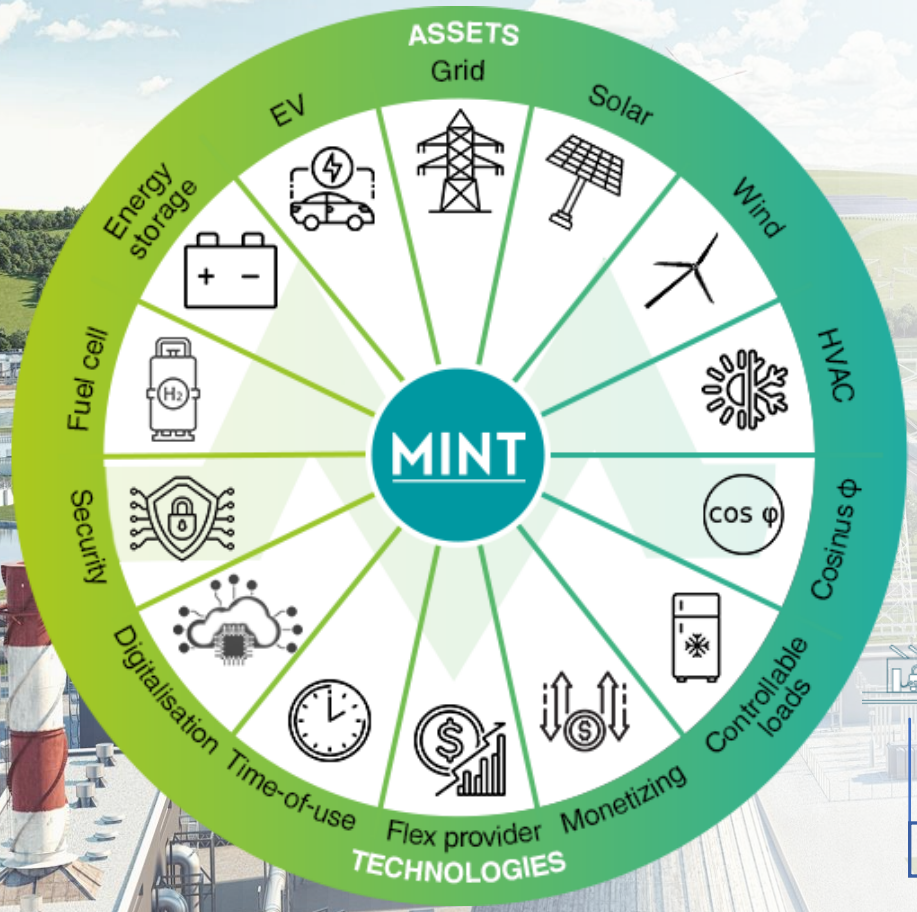
The All Electric Society:



Energy Yield Forecasting
Photovoltaic
Wind
Power To X

Spot Market Pricing

Smart Power Grids

Energy Scenarios and Modelling

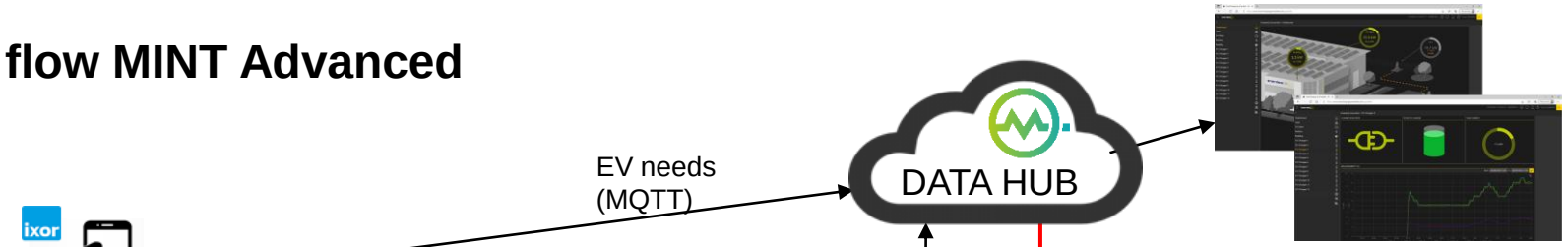
EV-Power Electonics for Ecars

Electrical Storage
Batteries
Power Devices

Energy Conversion
Thermal Fluid Conversion

Load Management for unpredictive use/loads

Data flow MINT Advanced



EV needs (MQTT)

Measurements (MQTT)

Optimized charging regime (MQTT, every 15 min.)

OPTIMIZER

EV charging system

Control

Empro @ POCC

Measurement

Battery Mgt System

Control

PV system INV / Meteo

Control

MINT onsite controller

MINT AI-enhanced Energy Management

MPC Solver

AI trainer

Weather forecast

Building/ EV needs forecast

PV yield forecast

Improve system overtime based on AI

DSO/TSO RTU

Energy-provider / Flex providers

Q- control
OPTION

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CINI4.0 Conference Day

16/06/2022, Gent

PLCnext : an open source IIOT-ready PLC

Hugo Van Rillaer
hvanrillaer@phoenixcontact.be

Questions ? Demo ? -> Phoenix Contact