NOVEMBER 2019

Industrial AI and Autonomous Manufacturing

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The world is changing at unprecedented speed

Technology influences the future of how we…

…power

>$4 tn of renewable investment

…produce

+300% industrial IoT[1] devices installed

…work

+300% robot sales

…live

+1 bn people in cities

…move

~30% CAGR[2] for EV[3] sales

Source: BNEF 2018, Gartner 2018, IFR 2018, UN World Urbanization Prospects 2018, BNEF Electric Vehicle Outlook 2018
[1]Internet of Things; [2]Compound annual growth rate; [3]Electric Vehicles
Note: trends development 2018 – 2030; installed IoT devices 2018 – 2025

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Outline

Facts about ABB

Future Automation

Autonomous Industries

Industrial AI

Conclusions

ABB is evolving to be more focused and agile

Divesting Power Grids to Hitachi

Power Grids

The new ABB – focusing in Electrification, Automation and Robotization

Electrification

Industrial Automation

Motion

Robotics & Discrete Automation

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ABB has a rich history of pioneering technological innovations

With significant contributions to the industrial revolutions

2nd Industrial revolution
(19th century)

+ Electrification
+ Motion

3rd Industrial revolution
(20th century)

+ Industrial automation
+ Robotics

4th Industrial revolution
(21st century)

+ Digitalization
+ ABB Ability™

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Why ABB Future Labs?

The need for a longer term perspective

"We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten."

Bill Gates, Microsoft Co-founder and former CEO

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Radical innovation

Examples and experience

Laser printer (Xerox)

Developed from 1967 – 1971

Internal competition to fight management wariness

Multi-billion dollar business

µC-controlled robot (ASEA)

Developed from 1971 – 1973

Revolutionized programming of robots

Kicked-off new business

Digital camera (Kodak)

Developed from 1973 – 1975

Managers never **cannibalized** photo paper business

Kodak filed bankruptcy (2012)

Azipod (ABB)

Developed from 1987 - 1990

Continuous development of new tech needed for ~10 a

Patience created success

Thinking radical is necessary to tap into business opportunities outside of everyday customer challenges

Disruptive technologies entering the stage

Exploring the fuzzy front-end for digital industries

AI

Apply machine learning techniques in industrial apps

Merge AI and automation to implement Industrial AI

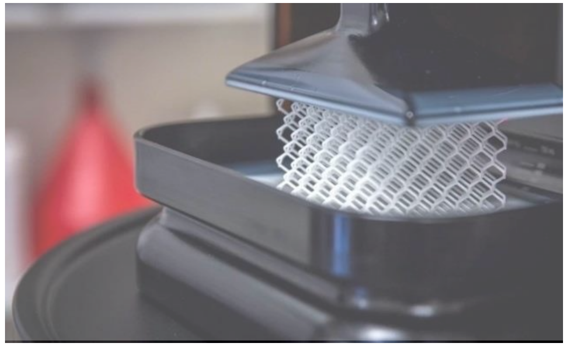
Explore AI in autonomous industries

5G

Use cases on partner hardware: Ericsson, Huawei

Exploring use case: NB-IoT, low latency networks

Drive industry requirements



Additive manufacturing

Understand materials, assembly, and system view

Build network: designers, printers, materials

Establish new ways of local manufacturing and inventory management

Quantum computing

Understand maturity and identify use cases

Evaluation of partners and execute feasibility study

Be ready to move fast once reaching maturity

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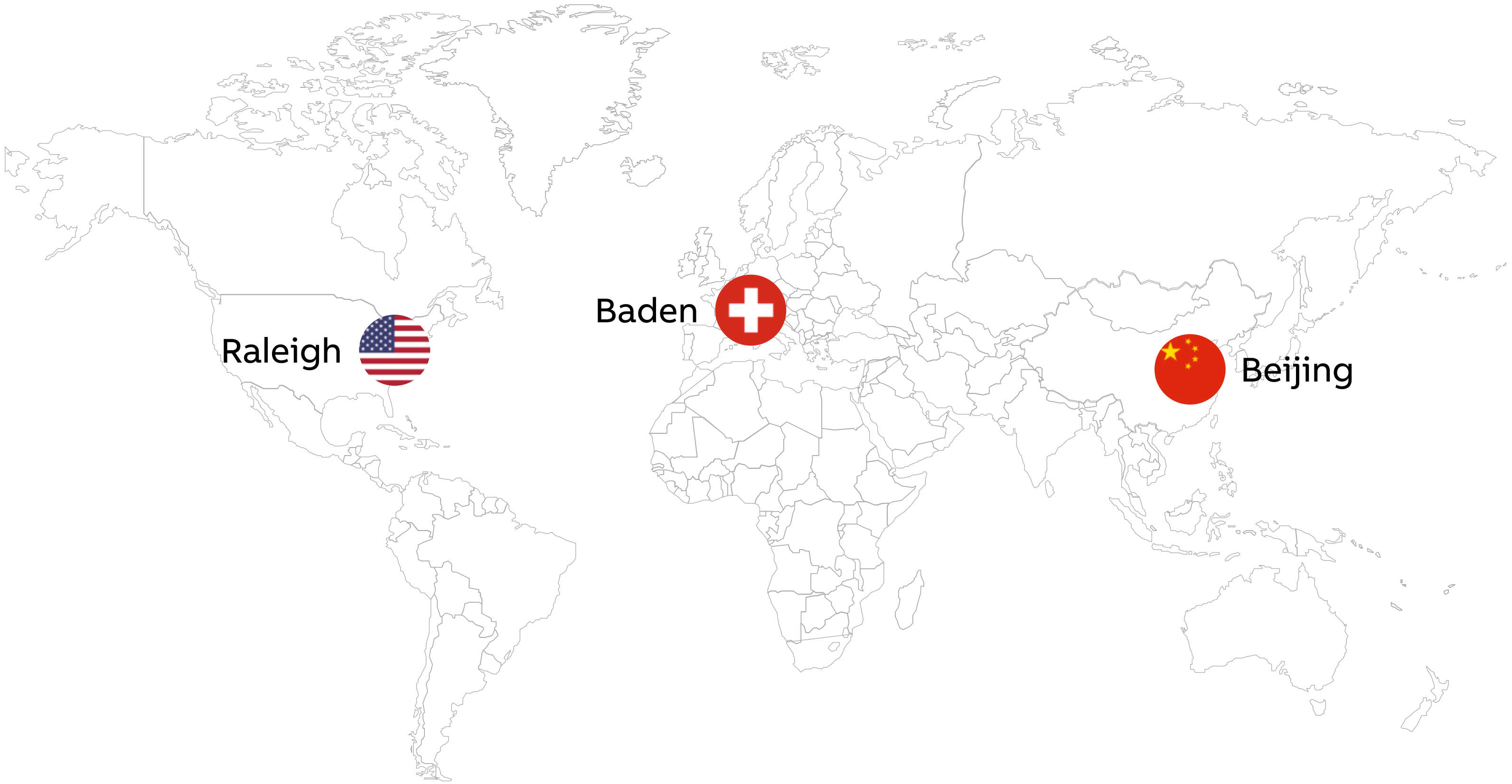
Locations



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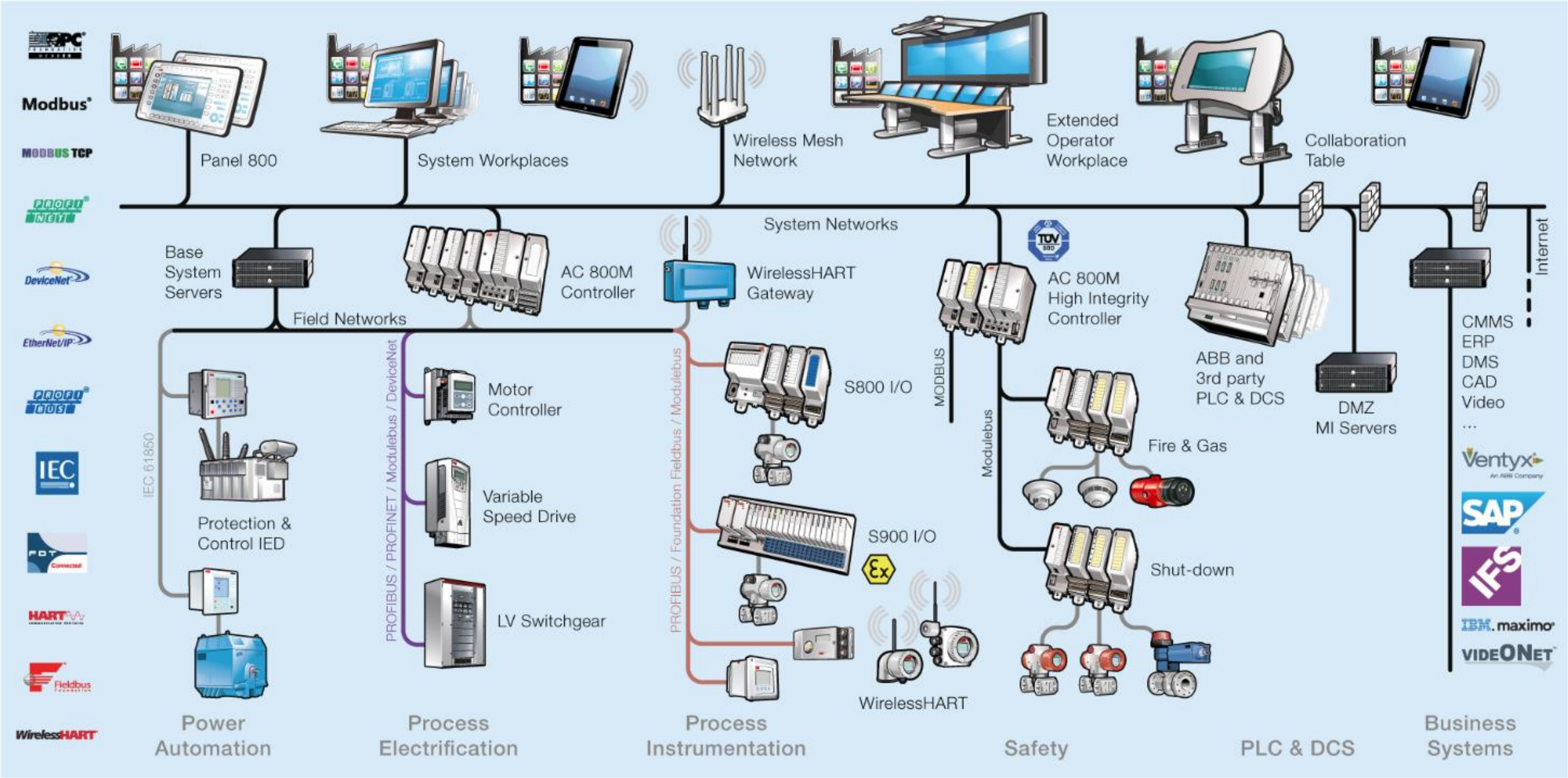
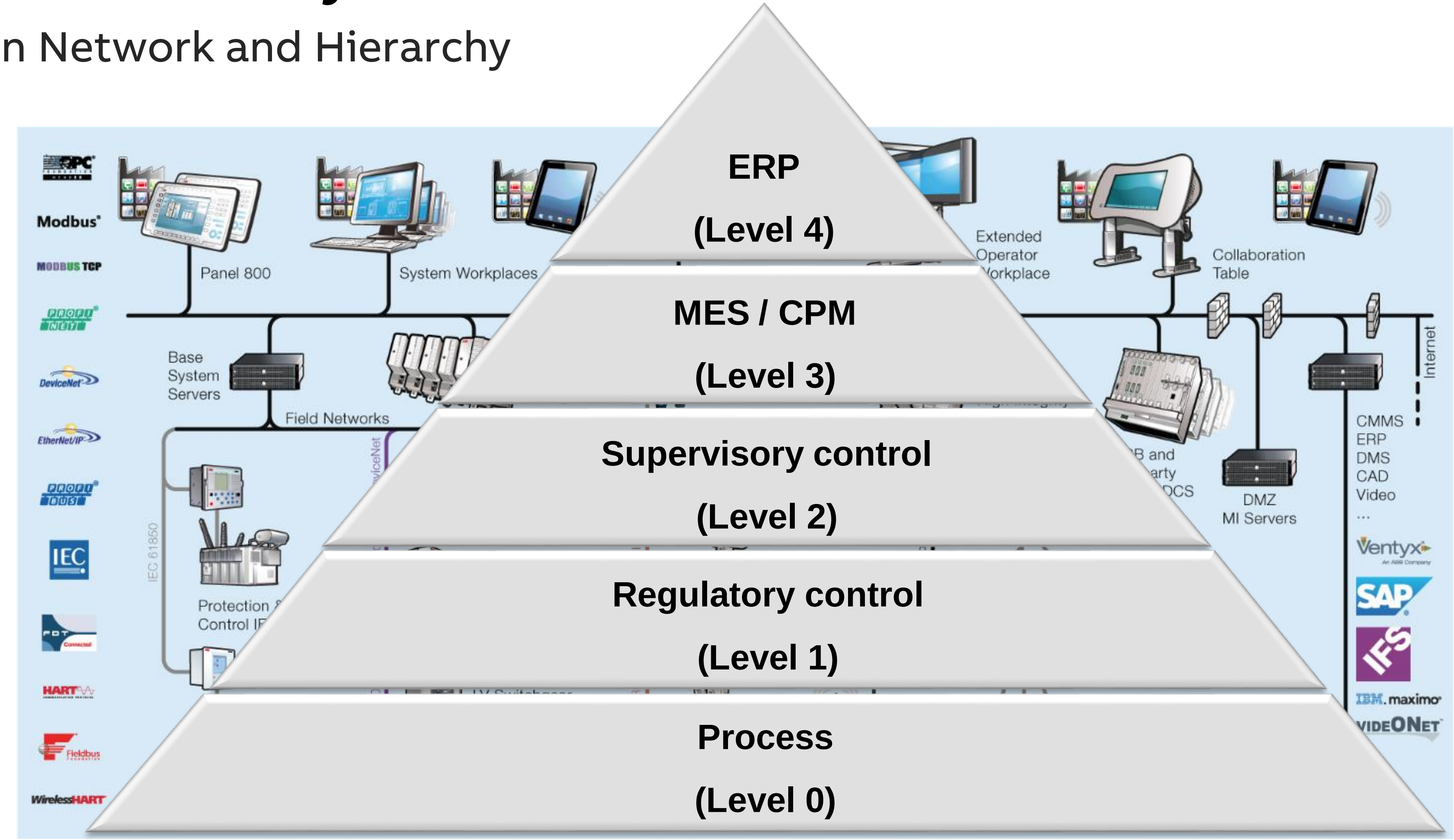
Today's automation systems

Automation Network and Hierarchy



Today’s automation systems

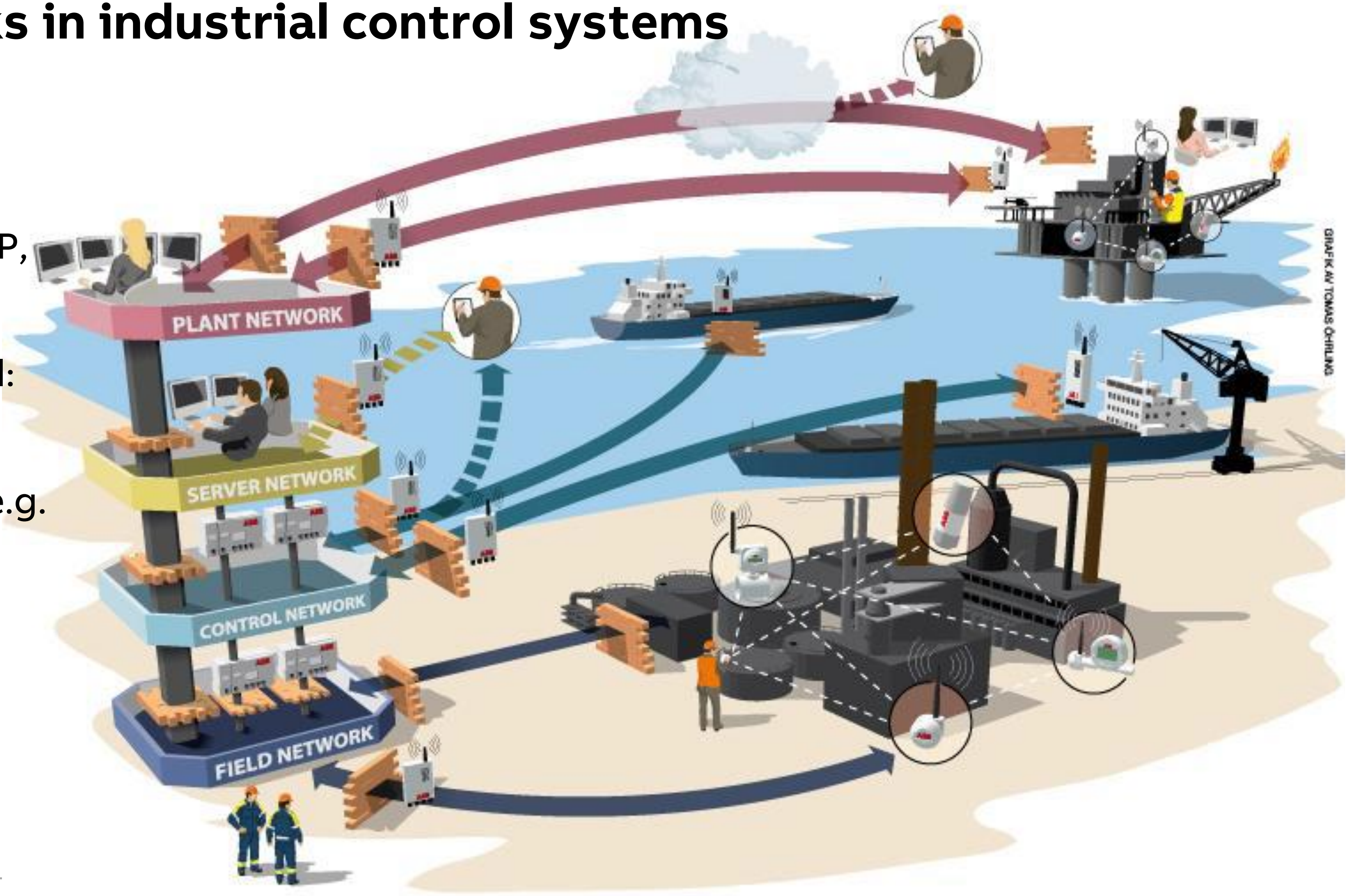
Automation Network and Hierarchy



Communication networks in industrial control systems

The traditional pyramid view

- Plant Network/enterprise level: ERP, Power Management, IT/IS, etc.
- Server Network/management level: MES, Operation Center, etc.
- Control Network/operation level: e.g. DCS, PLC, SCADA, etc.
- Field Network/device Level: field buses, I/O, sensor/actuator, etc.



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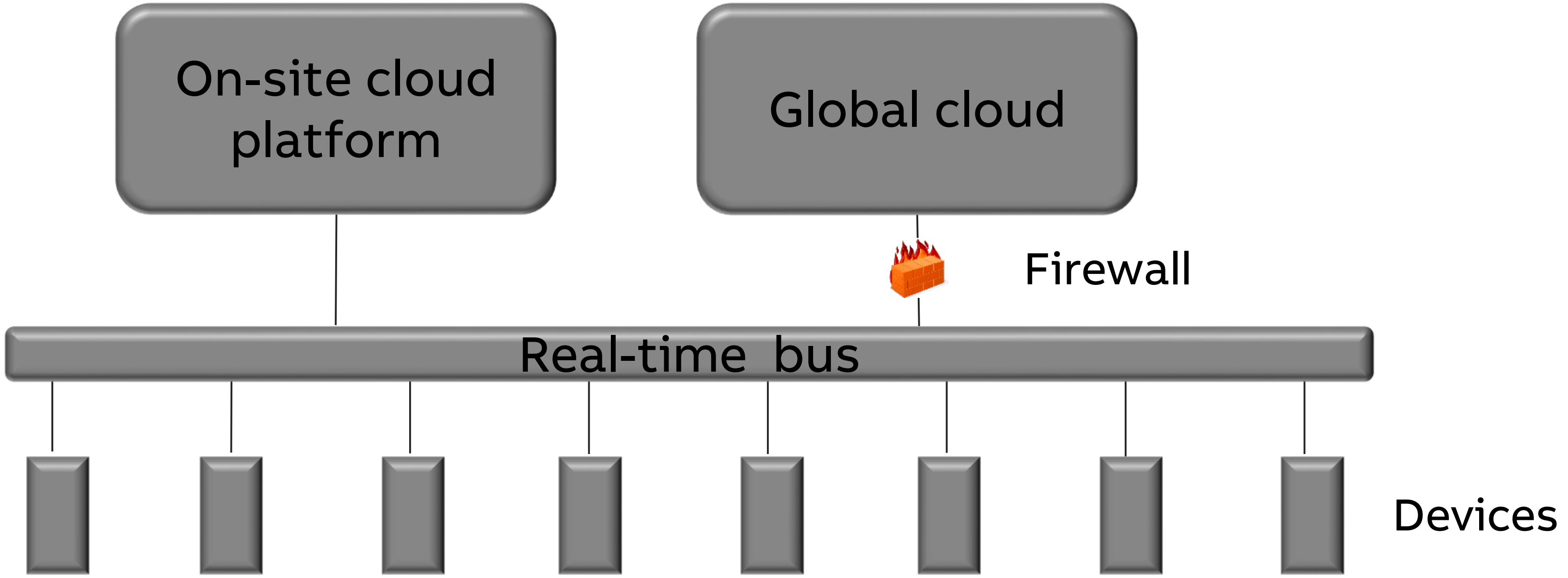
Future automation system architecture

Trade-off between edge and cloud



A Vision for the Connected Factory of the Future

Digitalization along the product life cycle – not only operation

Digital Design

Global collaborative design enable car-makers to shorten the design-cycle while become more agile responding to regional differences

Digital Commissioning

Virtual Reality enable shorter commissioning times and global utilization of domain competence.

Digital Maintenance

As connected objects, robots and process equipment will allow for fleet visualization and predictive maintenance

ABB uses digital tools throughout the complete value chain from design to maintenance

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ABB Ability™: brings industry leading digital solutions to our customers

210+ ABB Ability™ solutions

ABB Ability™

Utilities solutions

Industry solutions

Transportation & Infrastructure solutions

Platform
(common technologies for device, edge, and cloud)

Microsoft | Hewlett Packard Enterprise | IBM

What Delivers customer value (safety, uptime, speed, yield…) with AI based solutions

How Provides ABB with efficiency and scale through AI

Our customers own their data and IP

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What do we mean by an Autonomous System?

Definition

A system that can fulfil its purpose by adapting to changing circumstances without requiring external intervention

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Remote Control and Autonomous Systems

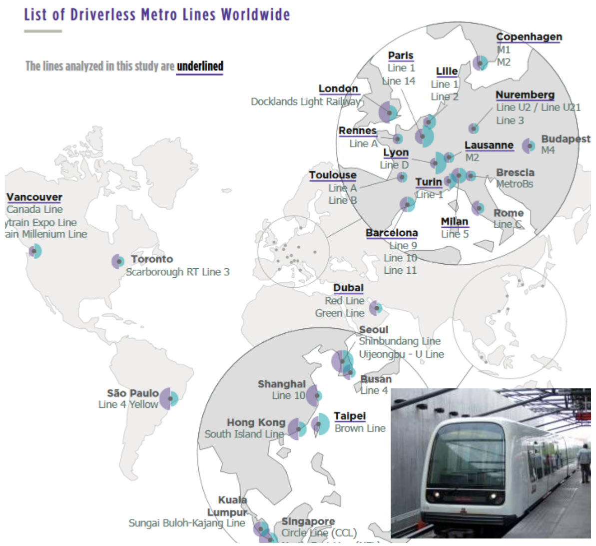
Examples from other Industries

Airplanes/Drones

General Atomics MQ-9

IAI Heron

Driverless metros



Sources: Wavestone research and analysis, UN data, UITP

Warehouse robots

Amazon Robotics
(formerly Kiva Systems)

Cars

Google's self-driving car

Autonomous Systems are appearing in various industries

Moving towards autonomous industries

Increasing the level of autonomy

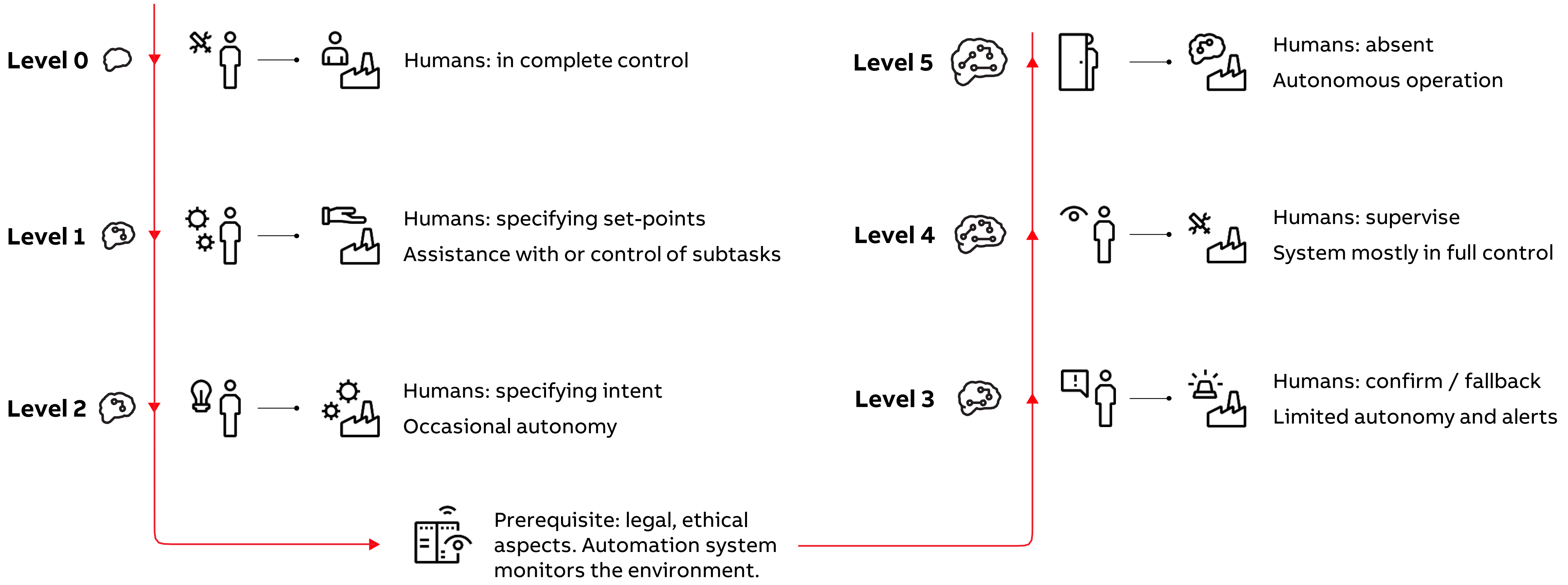


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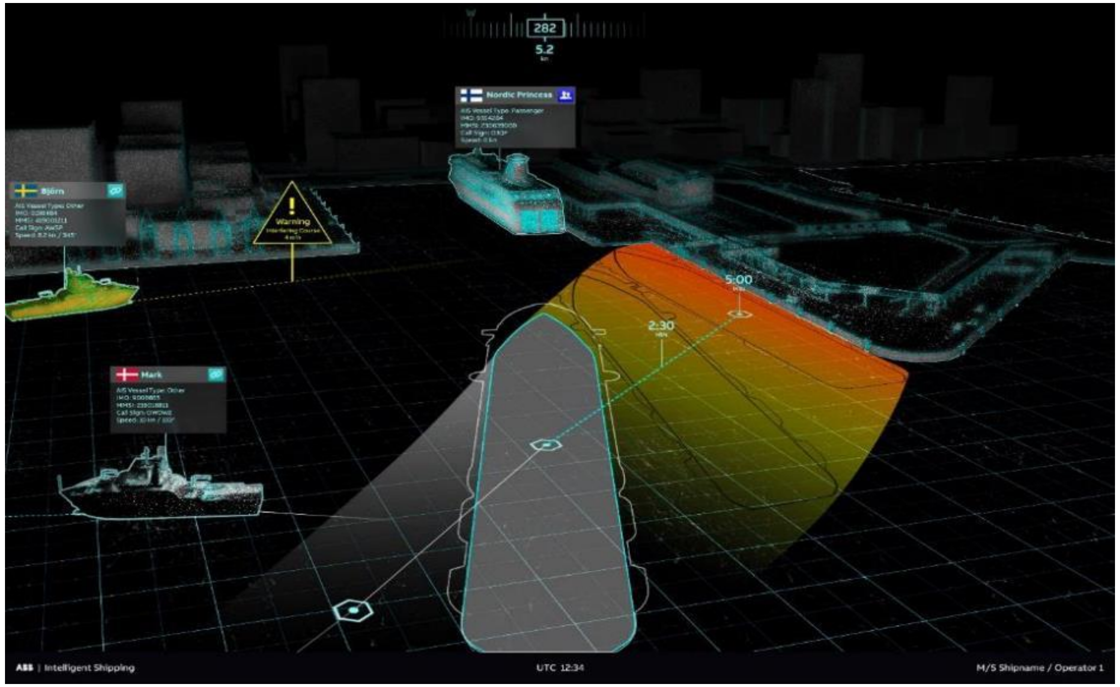
ABB Application Examples – Mining & Marine

First applications with clear customer benefits in terms of safety and productivity



Path via remote operation towards full autonomy

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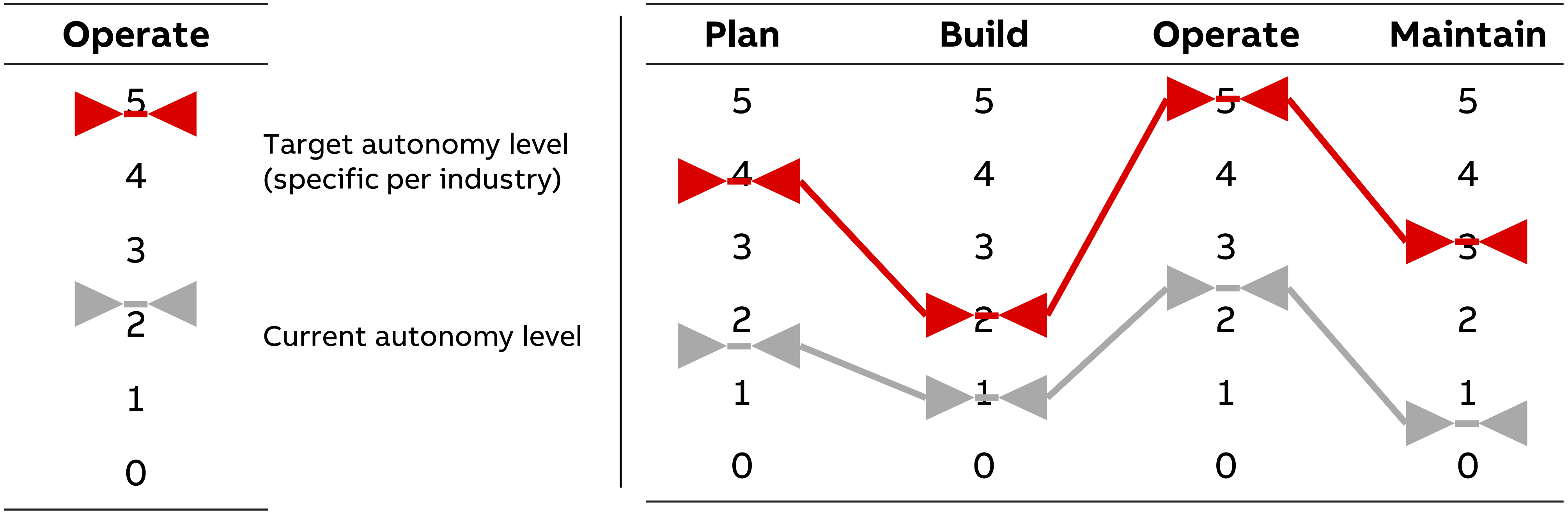
Autonomous Industrial Systems

Autonomy levels across the lifecycle

Automotive | **Industrial**

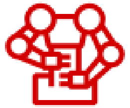


Industrial autonomy across all lifecycle stages – desirable level depends on the use case

The transition to autonomous systems in industry

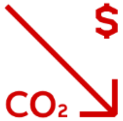
Value proposition of autonomy

Handle increasing complexity of Industrie 4.0 systems



Lot size one production

Higher productivity / yield and increased quality



Lower cost and energy consumption

Improved worker health & amplify human potential

Bring out and accelerate new innovations

Enable new business models and value propositions

Opportunities currently not imagined at all

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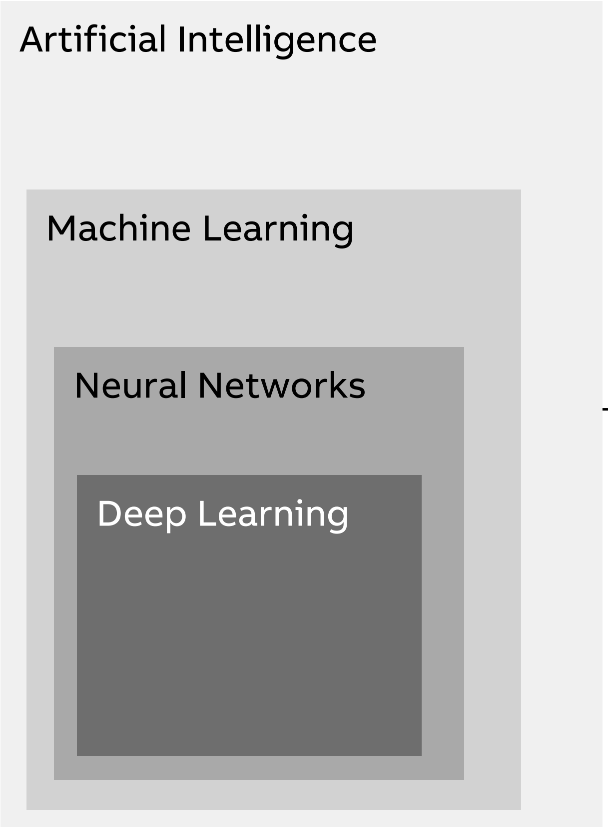
AI Key Technologies

From Automation to Autonomy



Knowledge & Inference

Emulate expert decisions and expert behavior

Pre-Requisites: Capturing expert knowledge, Contextual-knowledge

Feature Extraction

Extract informative and relevant data from the initial data set, before developing your predictive model

Pre-Requisites: Signal Processing, process knowledge

Planning & Scheduling

Find a good or optimal sequence of actions to reach a predefined goal

Pre-Requisites: Modelling of planning problem

Natural Language Processing

Interpret & process human natural languages for computer-human interaction

Pre-Requisites: Signal processing, semantics and language models (eg. BERT)

Learning Probabilities

Derive probability distributions from data for predictions & risk analysis

Pre-Requisites: Prior experiences, informative data

Machine Perception

Deduce real world aspects by using sensor input information

Pre-Requisites: Data models, good quality sensing, dealing with uncertainty

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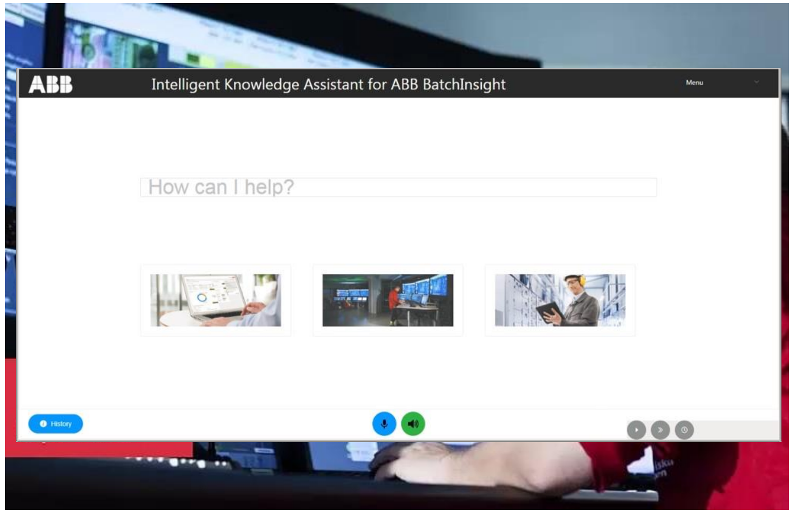
AI Applications at ABB

From perception to decision making

From NLP based process assistant…



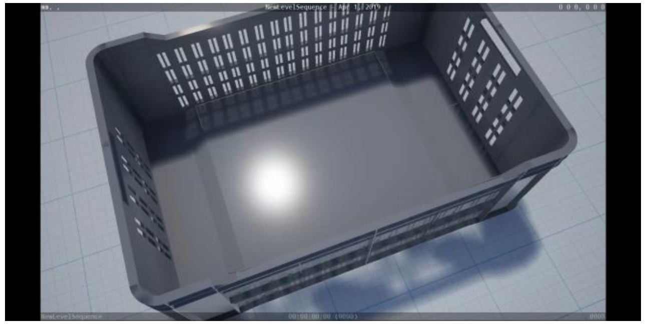
via lifetime estimation for bearings..

to graph search for ports

Industrial AI addressing the complexity in industrial reality

Combining domain knowledge with data

Know (foresight)



Domain knowledge

First principles models and simulation

– Described, but not yet observed

Safety, control and optimization

– Engineered well-defined solutions

+

Observe (hindsight)

Machine Learning

Data driven models

– Observed, but not a priori described

Industrial AI

– Complex scenarios

=

Combined approach

Build on what is known

Safely avoid known dangers

Explore the unknown through data analysis and simulation to increase flexibility

Industrial AI needs a combination of domain and data expertise to be successful

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Demo at both CIIF’19 & Huawei Connect 2019 in Shanghai

Waste separation using vision, ML and 2 robots

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Conclusions

Digitalization is inevitable

- Digitalization impacts complete value chain of future factories
- 5G promises increased reliability and low latency, instead main concern is business model
- First applications of Autonomous Systems in autonomous transport/vehicles (cars, metros and for ABB e.g. mining, cranes, ships and logistics)
- ABB is now looking at autonomy also for industrial plants
- AI and Machine Learning are key enabling technologies for Autonomous Systems
- Industrial AI will need combination of modelling and data based learning

Value proposition always most important consideration

ABB is writing the future of industrial autonomy

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