# PHM Panel on Manufacturing Philadelphia, Sep 2018



# Al in Future Automation: The "Adaptation" Edge

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# Siemens Milestones – Across 170 Years Of History





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#### Who We Are



#### **Research and Development at Siemens**

€5.2 billion Expenditures for R&D in fiscal 2017

#### Inventions and patents securing our future



3,600

patent applications<sup>1</sup>



CKI

#### University cooperation – our knowledge edge



Corporate Technology – Our competence center for innovation and business excellence<sup>3</sup>



5,400 software developers



400 patent experts

3 Employee figures: As of September 30, 2017

1 In fiscal 2017

2 Centers of Knowledge Interchange

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## **Corporate Technology – Innovating Globally**





# A worldwide presence

is the heart of the Siemens brand – and that goes for us as well.

This presence enables us to quickly offer targeted solutions that are tailored to regional requirements.

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## Our Focus in Digitalization and Automation – Securing and Extending Technology Leadership





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# **PHM Vision – Intelligent Machines**

#### Machine Intelligence ... Intelligent Edge

• Edge: Where the action is! Control, computing, communication...



- Present paradigm: cloud computing accumulates and processes data in the data center
- The "edge computing" paradigm: Perform data processing near the source of the data at the edge of the network

# Vision: Intelligent edge implements and executes high-level task specifications without detailed programming, are self-sufficient assistants to other machines and humans

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#### **Present vs. Future Automation**





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#### **Present and Future Automation**





# **Digitalization - The Digital Twin**

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#### Ingenuity for Life Siemens Tecnomatix Plant Simulation - Simulate Digital Factory Representation in Real-Time

Optimize amount, position, sequence of production resources:

- System operation
- Plant layout
- Control Logic
- Dimensioning, etc.

Investigate system behavior with analysis tools (Sankey diagram)









# Time to market, productivity, reduce energy costs Can create corner cases, dangerous situations rarely met in practice

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# Augmented Reality / Virtual Reality Enablers for Smart Factory





#### Fully digitalized factory model representing production system

- Can additionally generate realistic data about machine, human/environment, and interaction between human/environment and machine, accidents, etc.
  - Connected through sensors/SCADA PLC/automation devices to product lifecycle management (PLM) data repository
  - Sensors (simulated by advanced physics-based models, e.g. cameras, vibration, radar, lidar, temperature, etc.)

Can create corner cases, dangerous situations rarely met in practice

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<u>https://community.plm.automation.siemens.com/t5/Tecnomatix-News/Virtual-and-</u> augmented-reality-in-the-smart-factory-**JRG:iAiREX.5**24PO/ba-p/470322

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# Bring AI in the Edge - PHM Edge Intelligence

SIEMENS Ingenuity for life

- (Deep) Perception, Reasoning, Prediction
- Business enablers:
  - Digital Twin: domain engineering knowledge captured by "digital twin" (Siemens Tecnomatix, Teamcenter, NX)
  - **Programming**: software that evolves over lifecycle of the product, its verification and validation
  - Reusable runtime stacks: software deployable on a variety of hardware platforms
- "Plumbing" (or "hidden technical debt") makes it all possible:
  - Sensors and edge devices, connectivity, networking (install/reuse)
  - **Data management**: acquisition, storage, historization of high resolution high dimensional data
  - Software: infrastructure, configuration, machine, process, preparation, monitoring, analysis and visualization management
  - Cloud services: Siemens Mindsphere





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# **PHM Edge Intelligence - Manufacturing**



#### Autonomous System Use Case:

- Processes interact; an error or failure a missing piece of inventory or stumble on the automation line can cause extremely costly slowdowns and interruptions
- Automation control intelligence / intelligent machine: predicts course; safely shutdown; rectifies; resumes
- Intelligent edge components: perceive, analyze, diagnose, correct the quality of the product immediately, automatically feeding the results back into the production process



Intelligent machines implement and execute high-level task specifications, are self-sufficient assistants to other machines and humans

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# **Additional Challenges**



#### Beyond cost and methods for edge intelligence: human aspects

#### Trusted decisions, transparency, safety, collaboration, fun!

- Trust, transparency capabilities for autonomous systems to explain their actions
- Safety From Safety Integrity Level (SIL) for failsafe operation to Machine Learning software run-time assurances - strong (run-time) verification methods



# Small or Large Manufacturing: road to autonomy, self sufficiency, is to integrate adaptation and prediction capabilities exploiting both simulation and real data

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