OpenSystems media

Predictive Maintenance

Speaker:

Dan Isaacs, Director Connected Systems, Xilinx

Moderator:

Brandon Lewis, OpenSystems Media

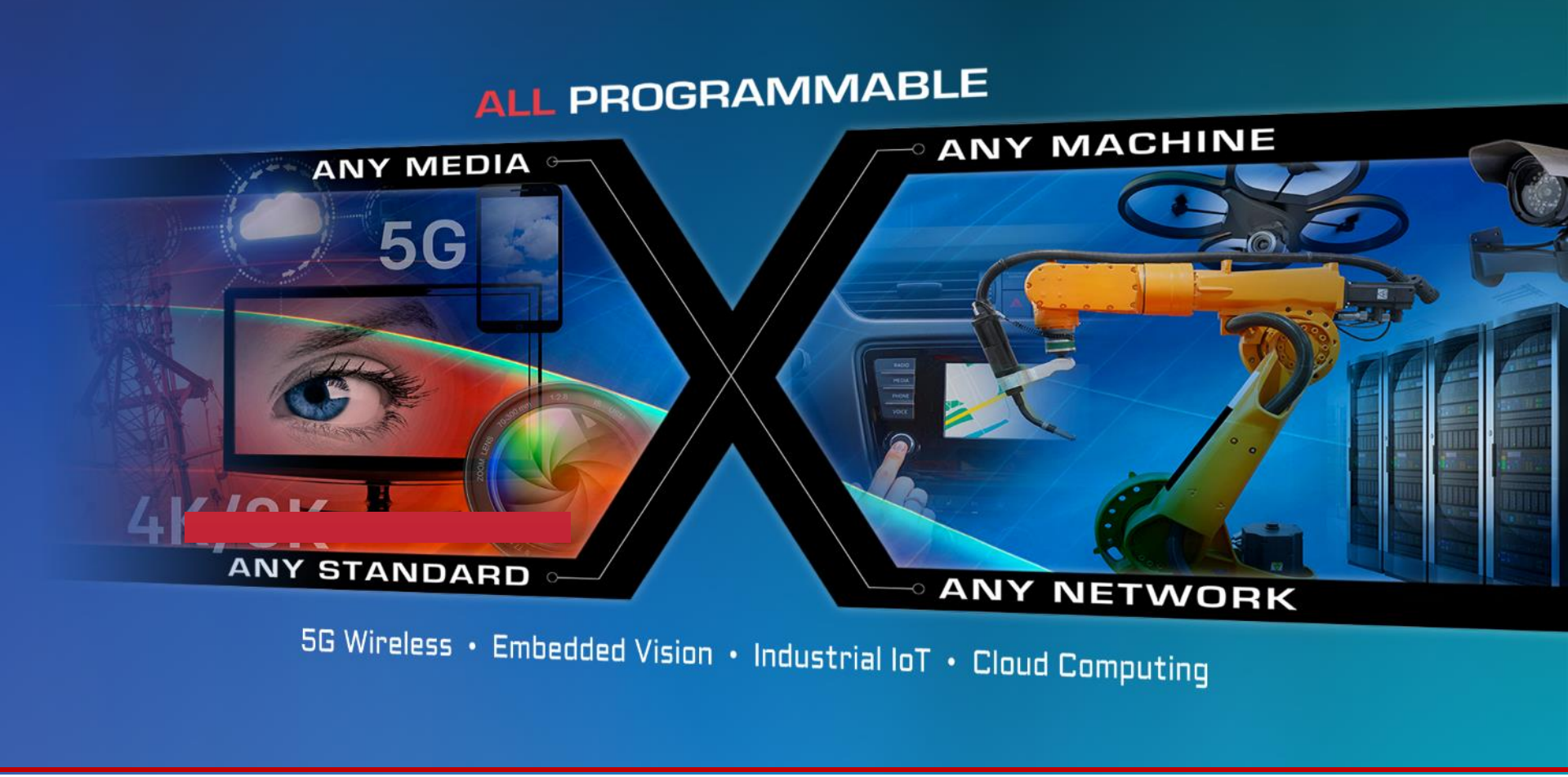
kontron

NATIONAL INSTRUMENTS

WIND

Agenda

- Housekeeping
- Presentation
- Questions and Answers
- Wrap-up



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Predictive Maintenance for Smart Factories

aingura IIoT

Dan Isaacs: Director Connected Systems

Analytics Platform

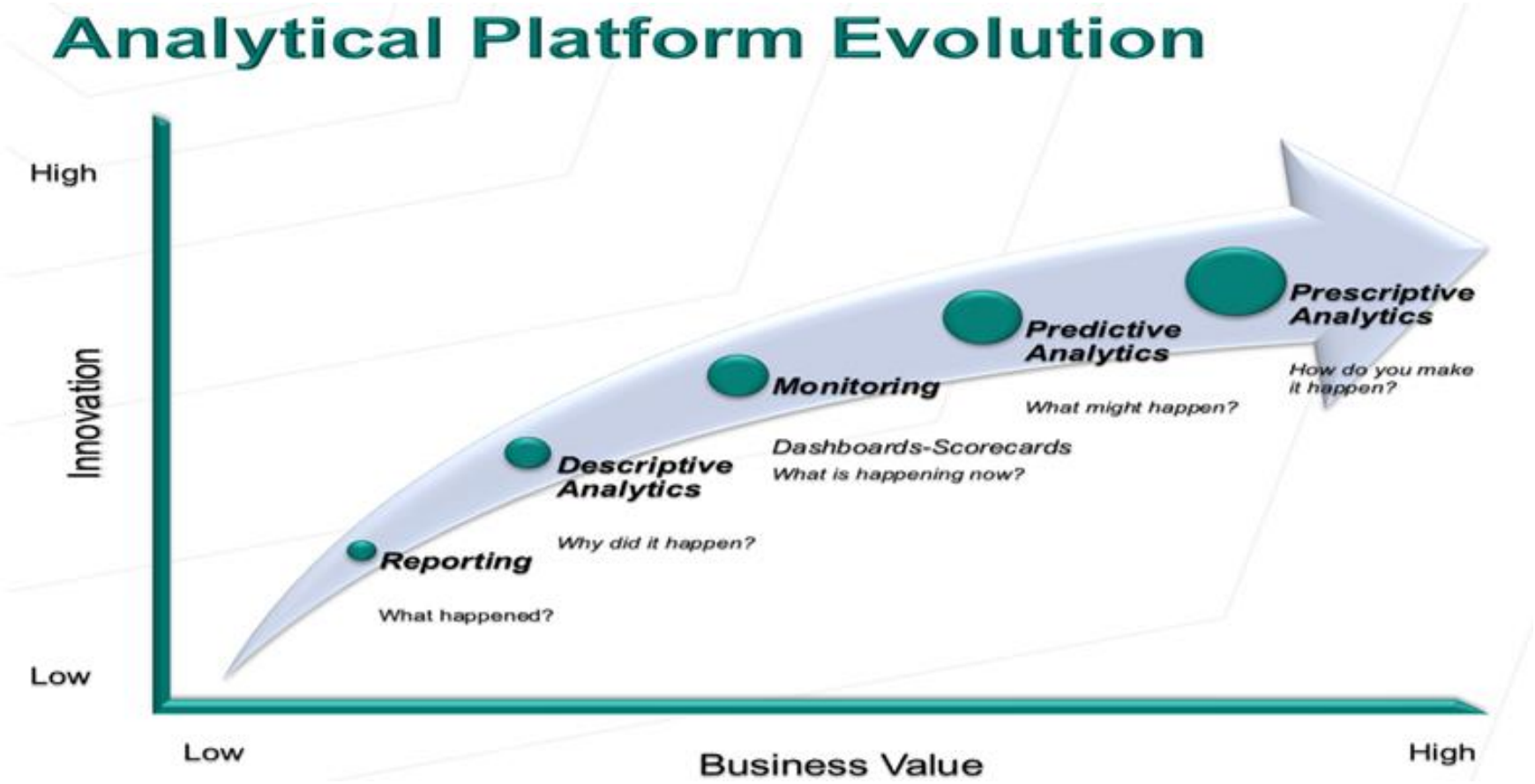
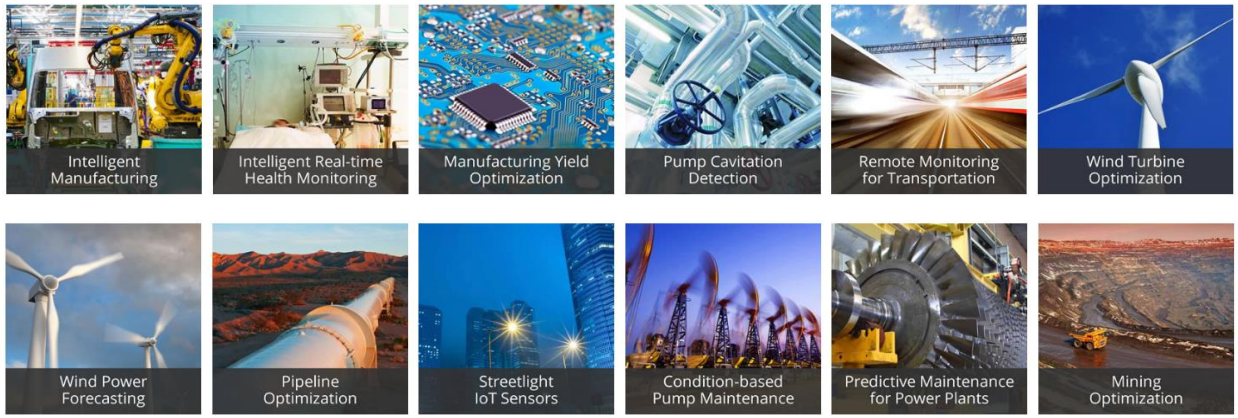


Image source: http://asi-solutions.com/2016/12/evolution-of-analytics-where-does-your-company-stand/

Machine Learning In Industrial IoT

Predictive Maintenance	Anomaly Detection	Optimal Efficiency	Autonomous Operation	Security and Safety
No Unplanned Downtime	*Highest Quality*	*Peak Productivity*	*Lowest Manufacturing Cost*	*Secure Networking Protected Environment*



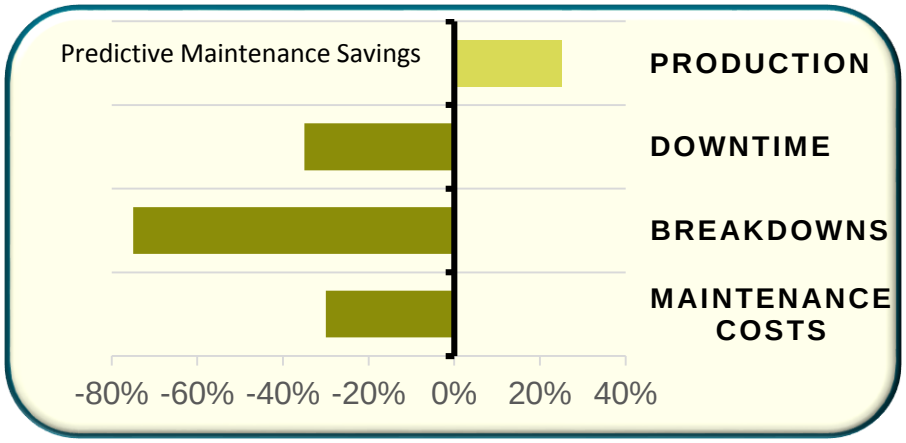
Machine Learning provides increased intelligence to the Industrial Internet of Things

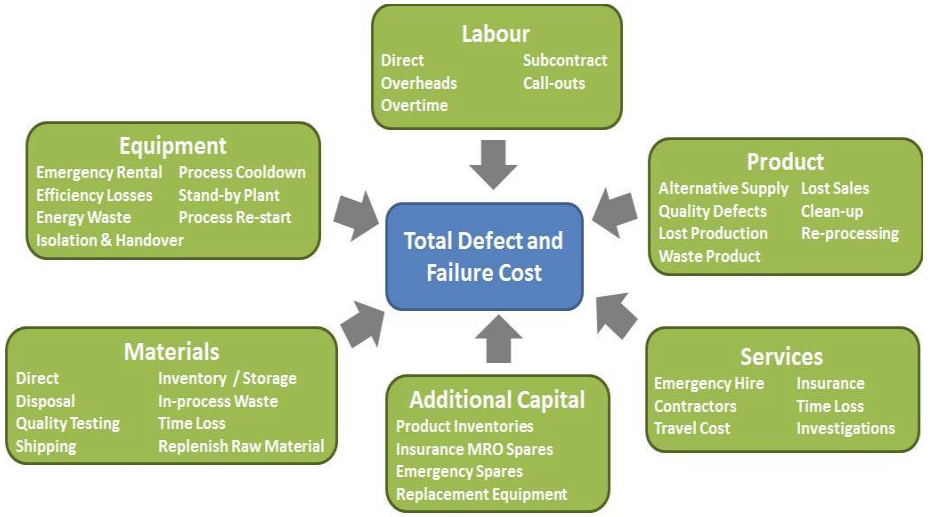
Image source: https://www.foghorn.io

Savings Potential –> Total Cost of Failure

Predictive Maintenance can provide significant savings

- **30 - 40 % over reactive maintenance and,**
- **8 - 12 % over preventive maintenance programs.**





Source: Mike Sandalini, "Defect and Failure True Costing"

Significant Savings Potential

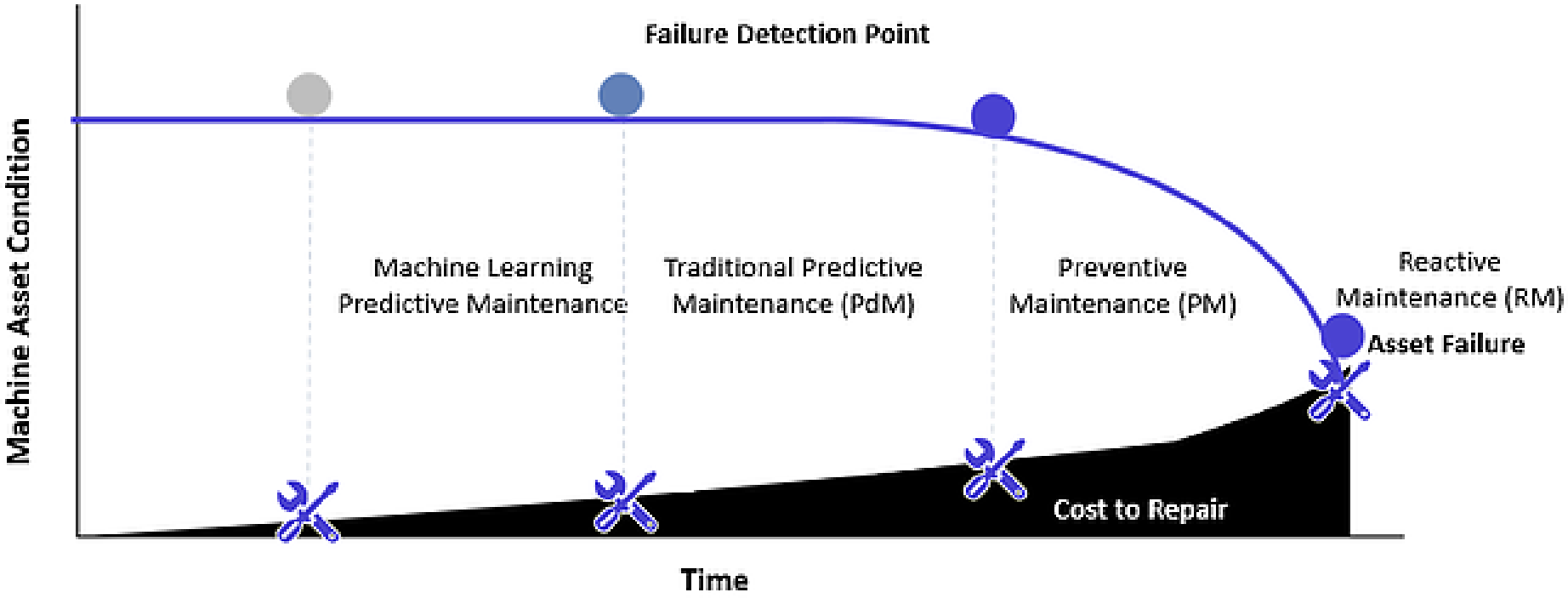


Image source: presenso

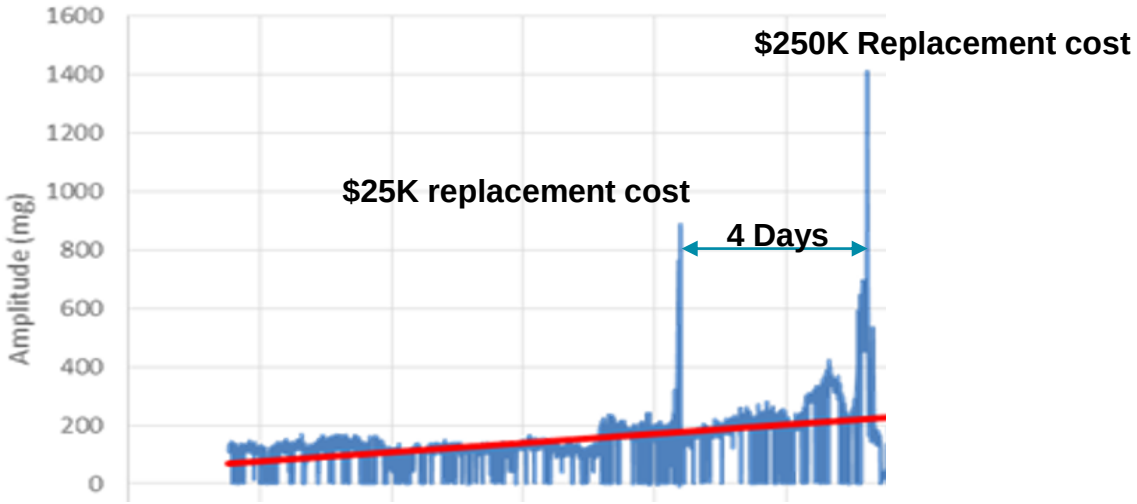
Predictive Maintenance market expected growth: $1,404.3 Million in 2016 to $4,904.0 Million by 2021, Compound Annual Growth Rate (CAGR) of 28.4%*

*Source: https://www.linkedin.com/pulse/20140814090436-13439787-the-business-case-for-predictive-plant-maintenance

Predictive Maintenance - Automotive Machine Tools Market

– **Early failure prediction can help reduce unplanned downtime reduction**
  Costs $50K+ per hour in high-productivity markets like automotive

– **Component failures signals can be measured and detected at early stage**
  Helps to avoid damage of other related/connected components



– **Machine learning-based monitoring systems can identify system inefficiencies**
  A single line in production CN codes with slightly different parameters 2% loss in cycle time
  Detection using machine learning techniques identified process anomalies.

Predictive Maintenance – Machine Learning for Early Prediction

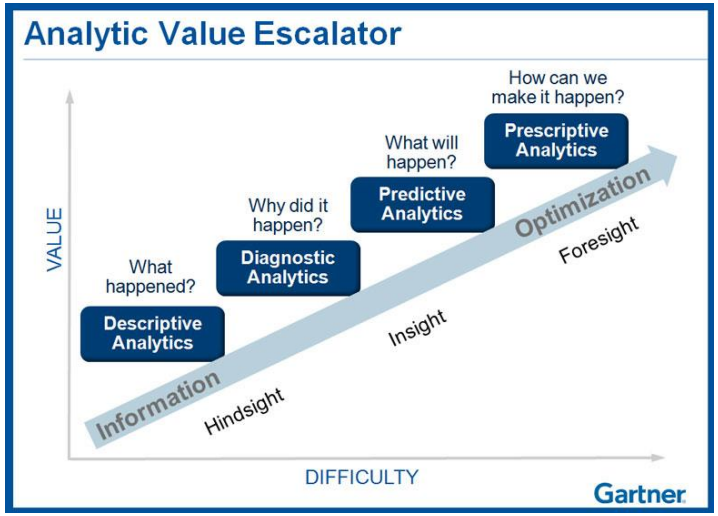
– **New machine learning-based solutions for efficient manufacturing:**

Machine learning-based tools used to increase detection rate and reduce occurrence value of High Risk Priority Numbers (RPN) for critical parts identified by machine tool's FMEA. This helps to reduce RPN increasing machine availability

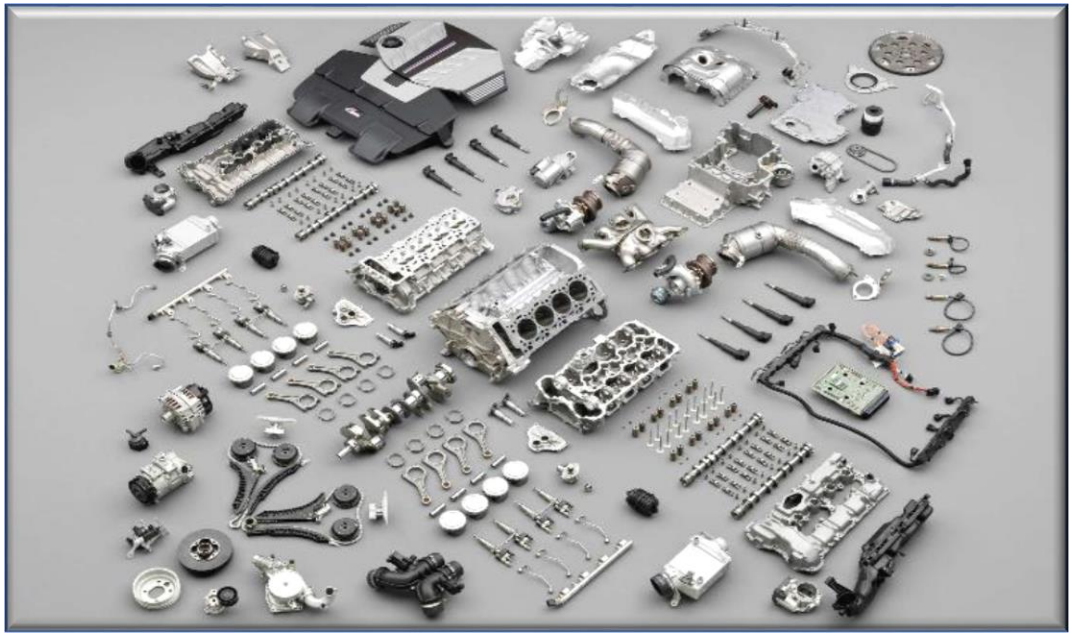
– **Support early failure prediction**

Cross-multivariable/multicomponent degradation monitoring supported through real-time machine learning solutions. These solutions can run diagnostics tasks that can evolve to prognostic detection to reduce random failure

Note: 85% of failures are considered random lack of understanding the failure mechanism(s).

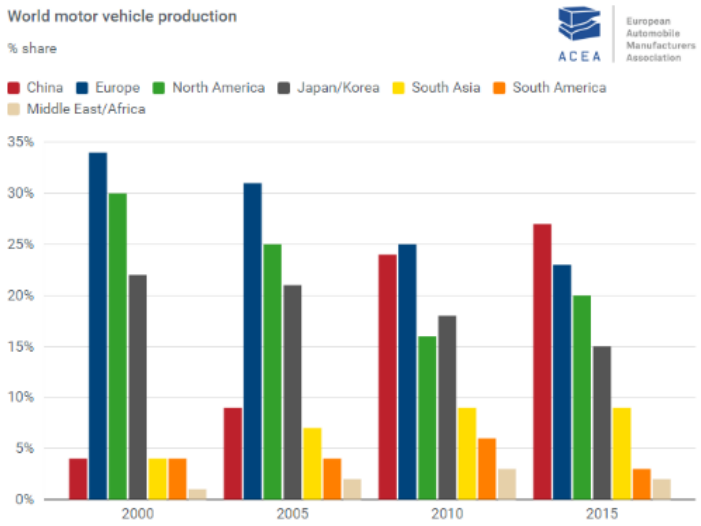


Market Opportunity



Automotive:

- 91.5 million motor vehicles were produced globally in 2015.
- ~ 250,000 motor vehicles produced per day.
- High-productivity machining of powertrain: >1,000 systems/day



Predictive Maintenance Potential

- Increase system availability through 8% reduction in unexpected downtimes.

Aingura IIoT Powered by Xilinx

Smart Factory Machine Learning Testbed

industrial internet CONSORTIUM

HOME COMMITTEES INDUSTRIES RESOURCE HUB MEMBERSHIP MEMBERS AREA

SMART FACTORY MACHINE LEARNING FOR PREDICTIVE MAINTENANCE

SMART FACTORY MACHINE LEARNING FOR PM • TESTBEDS

Testbed in Action

CASE STUDY: VALUE OF PREDICTIVE MAINTENANCE

This case study exemplifies where Predictive Maintenance with Machine Learning would

FAST FACTS

MEMBER PARTICIPANTS:

aingura IIoT IIoT, Xilinx

SUPPORTING COMPANIES INCLUDE:

Titanium Industrial Security, K… …ystem View, iVeia Infineon, GlobalSign, aicas

MARKET SEGMENT:

Industrial Manufacturing

GOALS:

- Evaluate & validate Machine learning techniques for Predictive Maintenance on high volume production machinery to deliver optimized system operation.
- Achieve increased uptime & improved energy efficiency utilizing Machine learning techniques for advanced detection of system anomalies and fault conditions prior to failure.

Industrial Internet Consortium Launches Smart Factory Machine Learning Testbed

NEEDHAM, Mass.--(Business Wire)--The Industrial Internet Consortium® (IIC™), the world's leading organization transforming business and society by accelerating the adoption of the Industrial Internet of Things (IIoT), today announced the Smart Factory Machine Learning Testbed

Sep 18, 2017 17:08 UTC

Solution Overview

Deployment Scenarios (OT) → ***Convergence (OT-IT)*** → ***Result (Actionable Insight)***

Factory

Production Line

Manufacturing Cell

Machine

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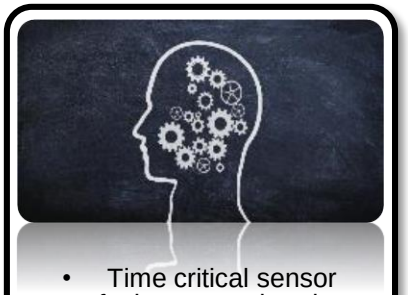
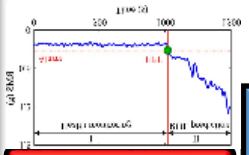
010110111
111000010

Data



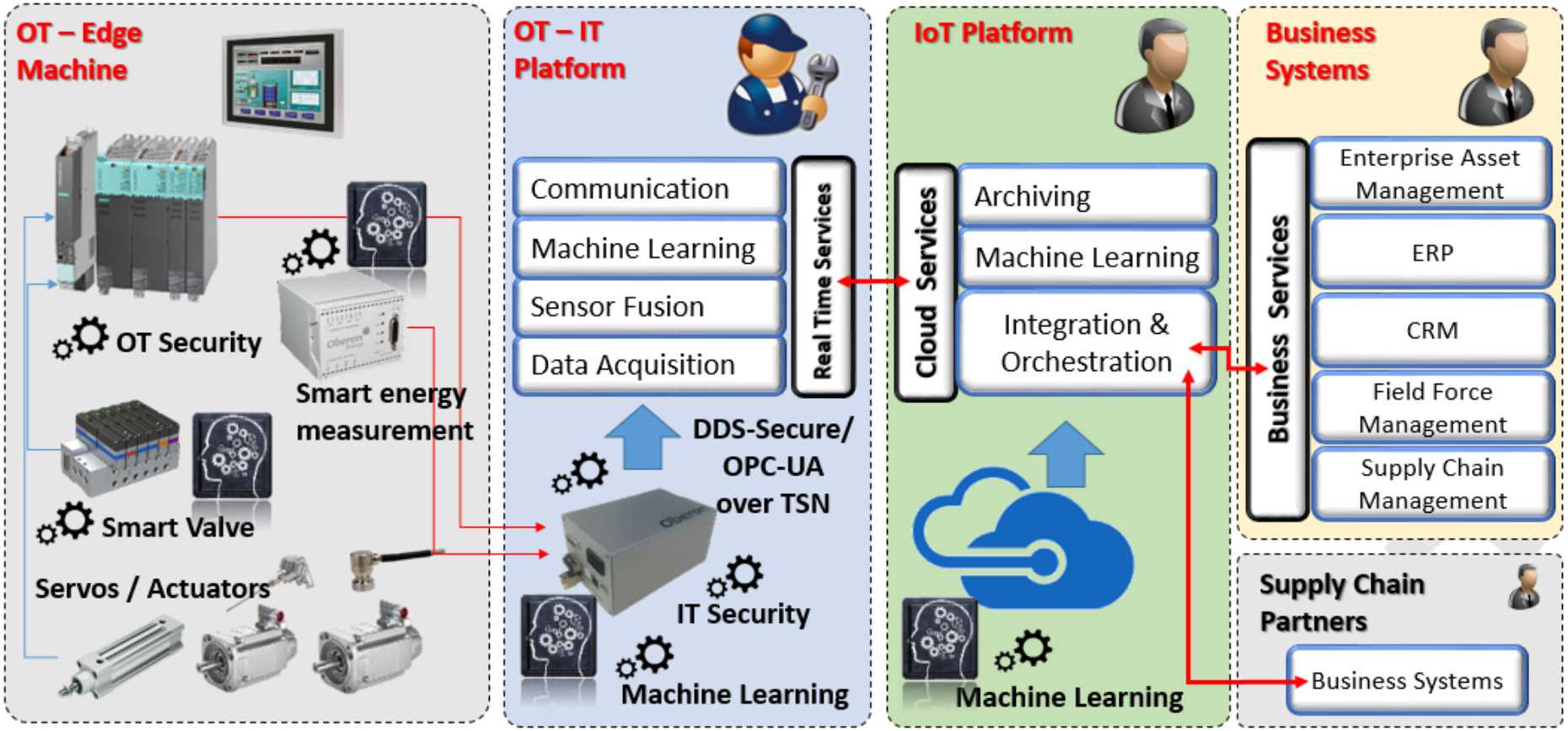
- Time critical sensor fusion to synchronize data from different domains
- Feature (variables) subset selection to:
  - optimize data transmission and
  - improve algorithms performance.
- Machine Learning algorithms to:
  - leverage knowledge discovery and
  - failure prediction



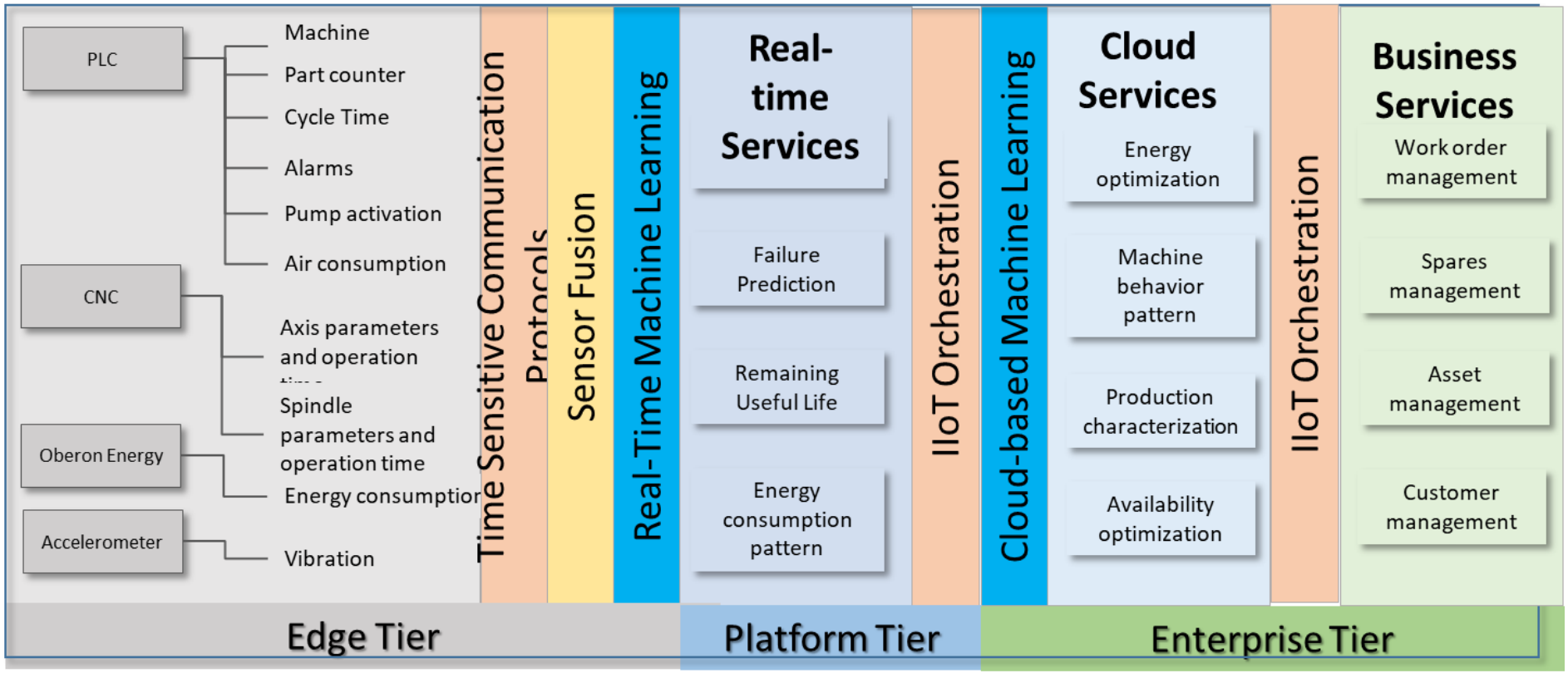
Information

- Machine Tool System
  - Component degradation pattern analysis
  - Machine behavior pattern
- Manufacturing cell
  - M2M interaction
  - Energy consumption patterns
- Production line
  - Energy optimization
  - Production line characterization
- Factory Production plant
  - Overall data aggregation
  - Availability optimization

Solution Overview



Solution – Service Stack Example



Testbed Usage Scenarios

Predictive Maintenance & Machine Learning

Machine-tool System

Identify Degradation
Behavior Pattern Measurement

Manufacturing Cell

Automation Interaction Behavior
M2M Energy Consumption Patterns

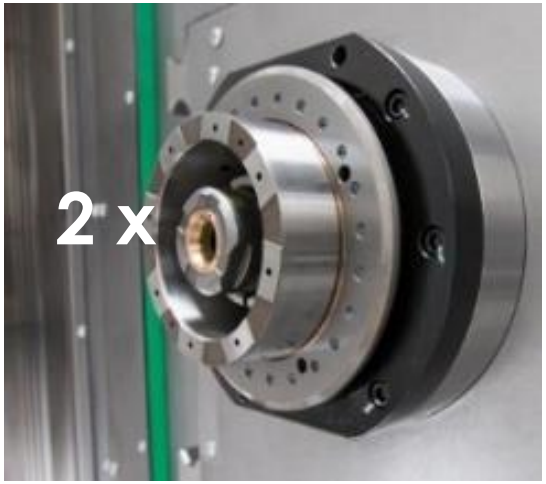
Production Line

Energy Consumption Behavior
Production Line Characterization

Factory Production

Overall Data Aggregation
Availability Optimization

Machine Tool – Spindle Critical Component



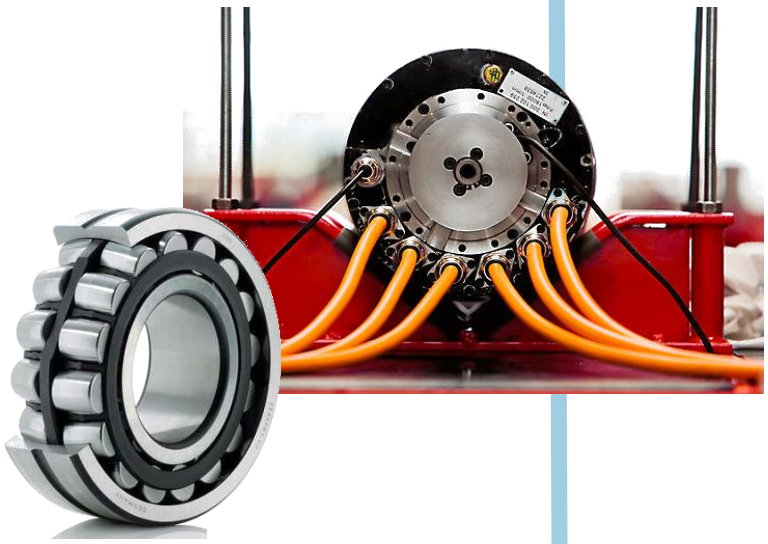
- **Machine-tool for powertrain manufacturing**
  - Cycle time 60 seconds
  - Utilization over 95%
- **Spindle head – Key critical component**
  - Power 10 kW
  - Primary function: Material removal
- **Failure cost :**
  - Costs USD 30,000 up to 250,000
  - Repair time: 5 working shifts
  - Impact: 200 direct jobs

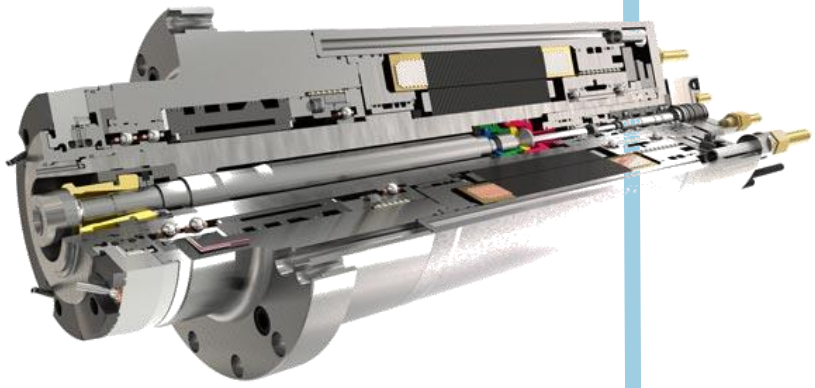
Clustering Analysis

- **Understand Cluster Evolution:**
  - Cluster shapes (how the identified machining characteristics change over time) and
  - Number of clusters (identify new machining characteristics).

- **Real-time operation:**
  - Focus on upgrading CPS embedded electronics
  - Enable the algorithm acceleration with using the Zynq Programmable SOC / FPGA

Spindle Machine Tool





Unsupervised machine learning algorithms embedded in cyber-physical systems

- Key enablers for working towards **highly precise diagnosis tools**

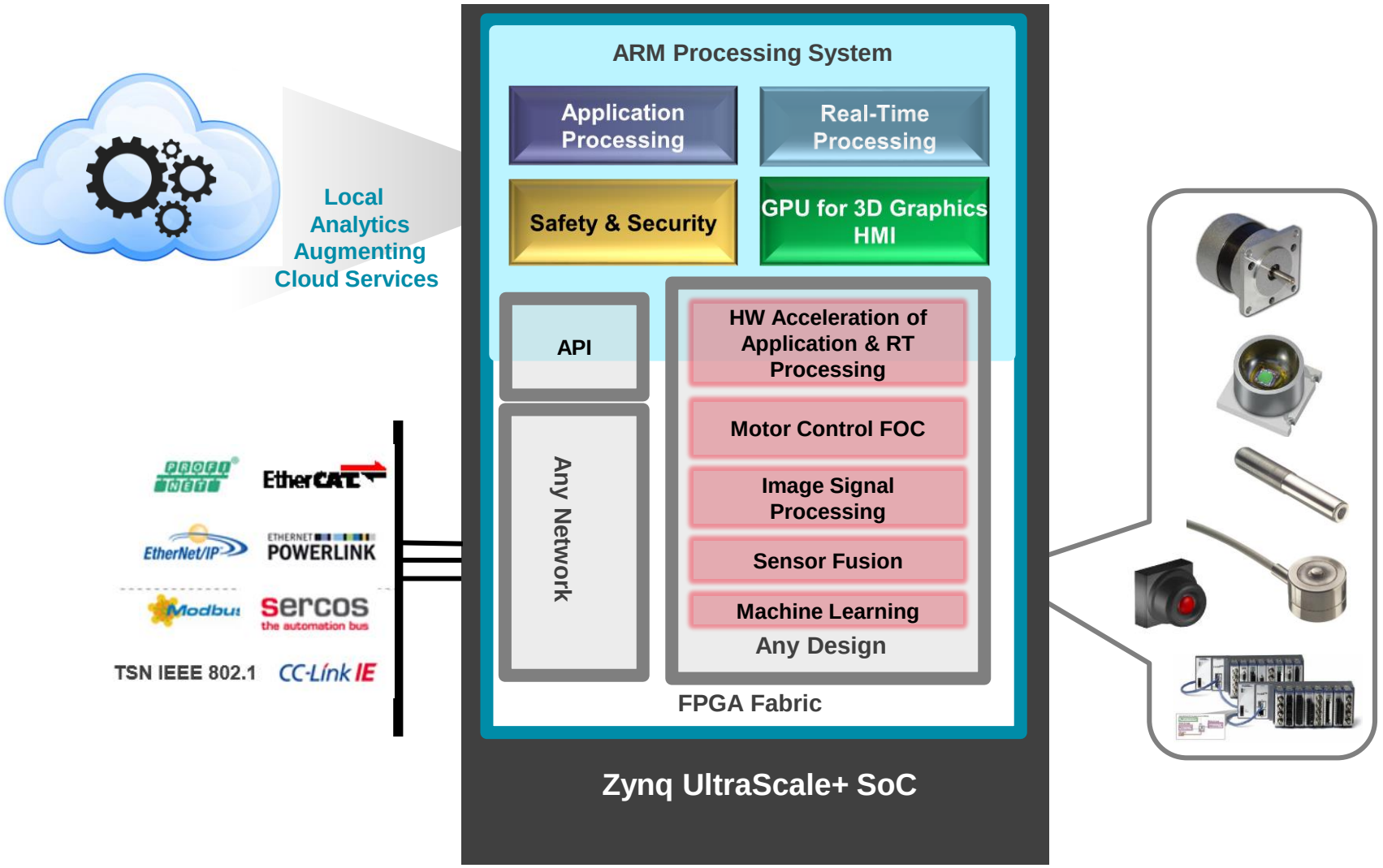
Knowledge discovery applications

- **First step** towards in-process diagnosis
- Applicable to prognosis tools which would be highly beneficial for new detection-based **predictive maintenance applications**.

Edge Tier

- **Intelligent Gateway:**
  - Zynq Programmable SOC (Xilinx)
    - Integrated ARM Processing System with Programmable Logic
  - Tasks:
    - Sensor fusion:
      - Data acquisition from sensors, PLC and CNC.
      - Fuse data from multiple sensor domains
      - To impute data when different sampling rates
    - Feature subset selection:
      - Perform multivariate variable selection
    - Pre-processing
      - Filtering , FFT, etc
    - Processing
      - Perform on-line machine learning analytics

IIoT Programmable SoC Platform



Enabling Secure, Safe, Synchronized, Autonomous Operation

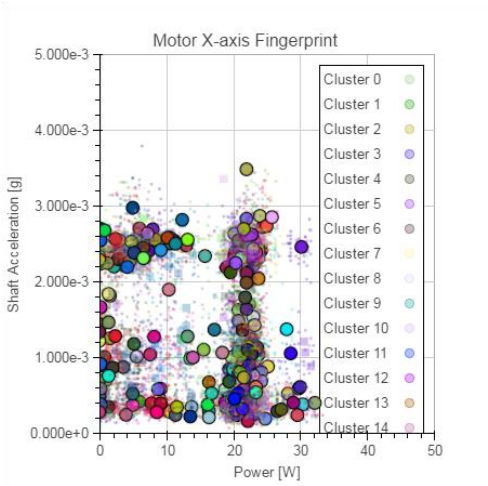
Algorithm Acceleration with Zynq Programmable SOCs

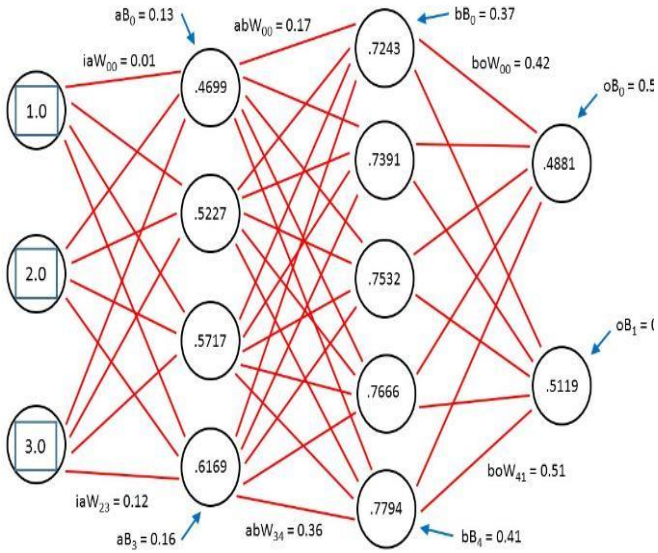
	Running function in SW	Running on FPGA	Running on optimized FPGA
Average Time (in ms)	5057.37	4208.65	257.65
Speed increase over SW	N/A	16.78%	94.91%

Clustering Analysis at the Edge

- **Understand Cluster evolution:**
  - Cluster shapes (how the identified machining characteristics change over time) and
  - number of clusters (identify new machining characteristics).
- **Real-time operation:**
  - Focus on upgraded CPS embedded electronics
  - Enable the algorithm acceleration implemented on Zynq Programmable SOC

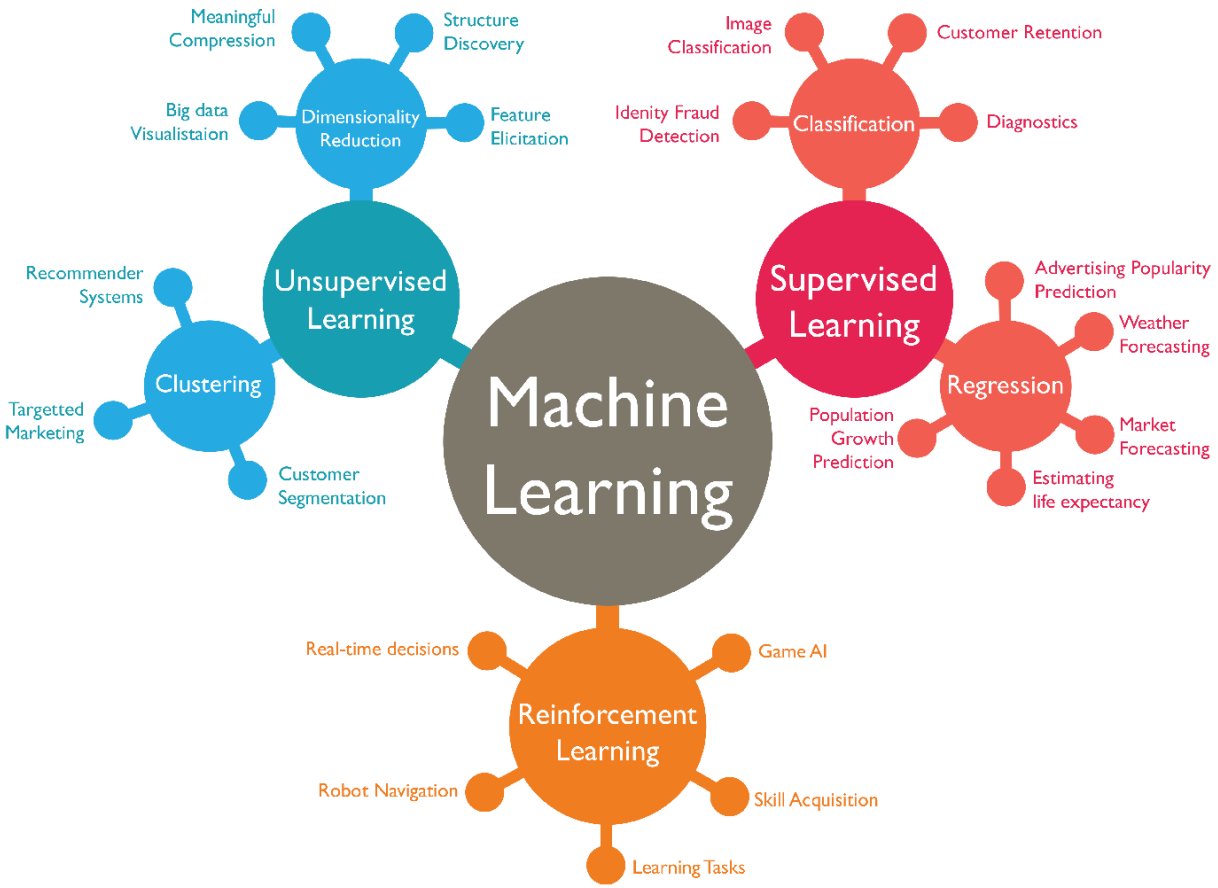
Analysis





- **Different approaches for data analysis**
  - Visual Analytics
  - Traditional statistical tools
  - Artificial intelligence-based tools
    - Automatic learning
    - Deep Learning
    - Evolution of neural networks
- **Method is transparent**
  - Reduce adverse effects of noise
  - Illogical relationships
  - Control over system variations

Machine Learning Types Applied

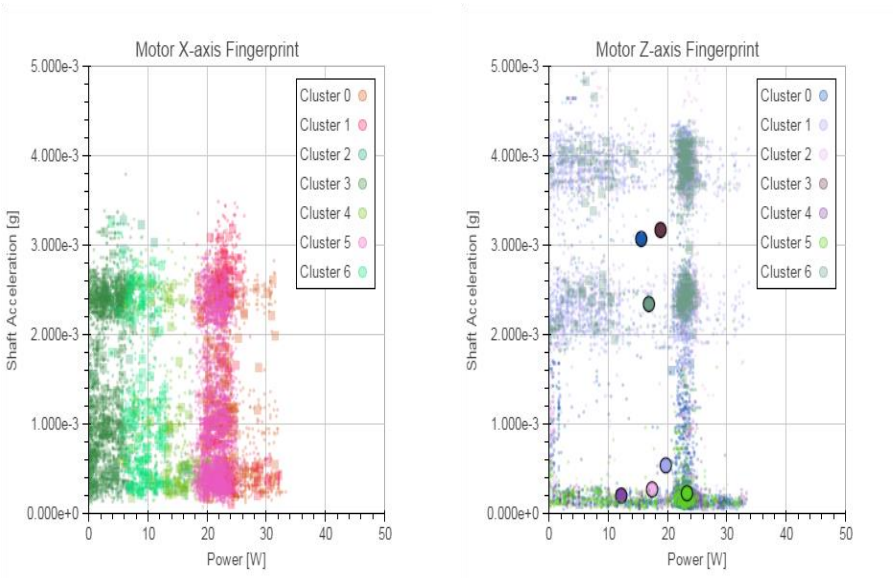


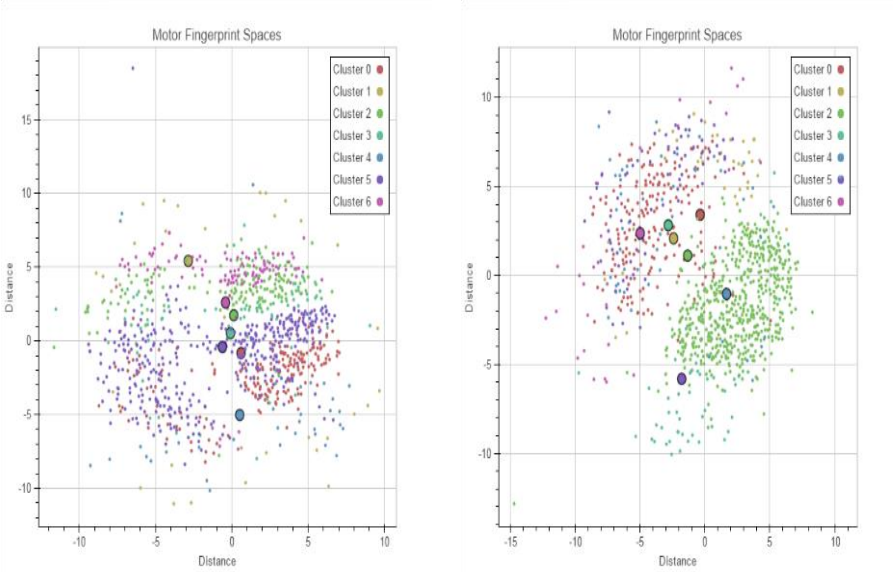
Goal: Identify structural patterns in the data

- Classify
- Predict
- Extract new knowledge

- **Three types**
  - Exploratory analysis
  - Descriptive modeling
  - Predictive modeling

Performance Analysis on Spindle Machine Tool





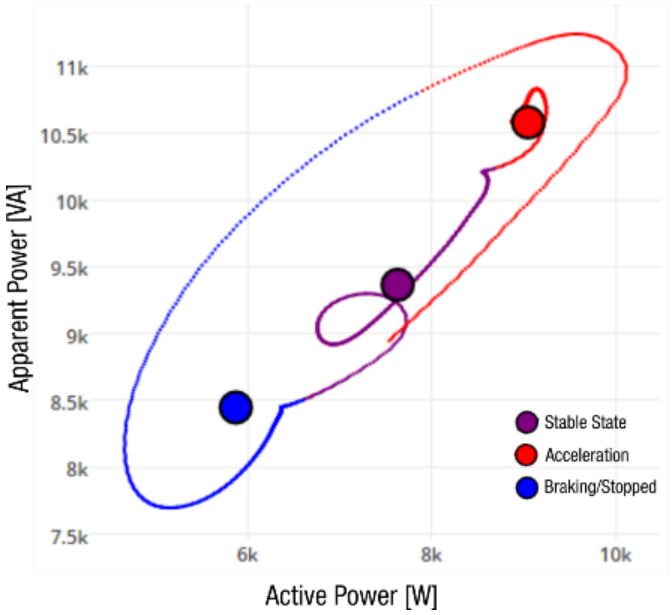
Exploratory analysis

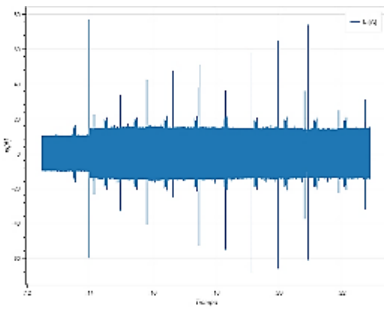
- Explore in the data without clear idea
- For small amounts of data, conventional visualization methods
- For large amounts of data, dimensional reduction

Example

Real Application on machine tool
Performance analysis of 3 servomotors
13 variables per servo

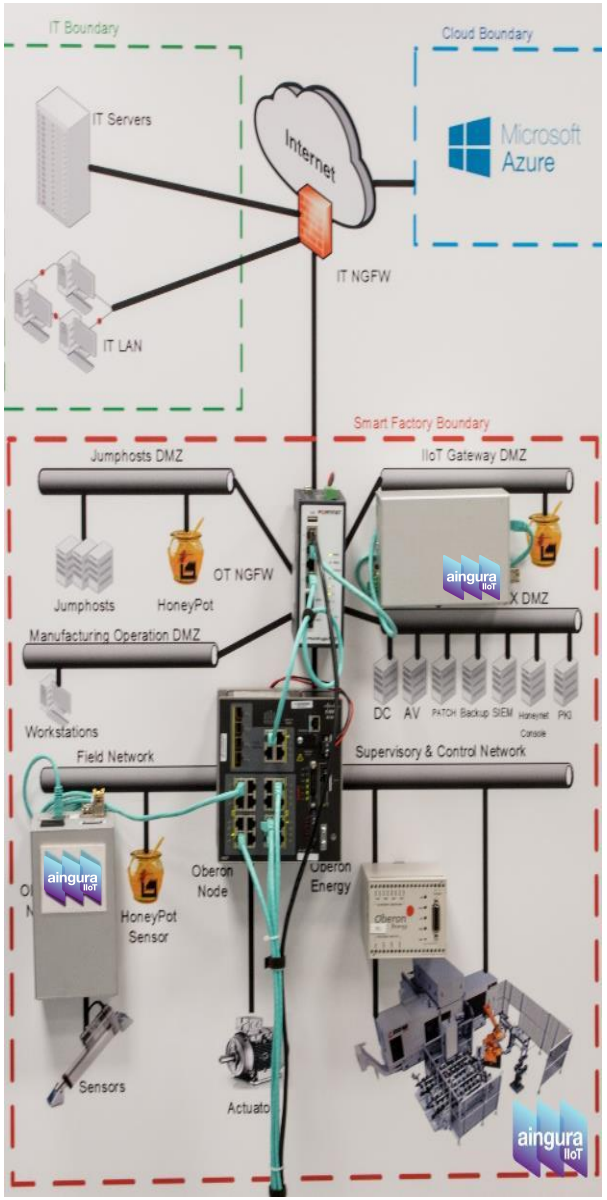
Platform Tier





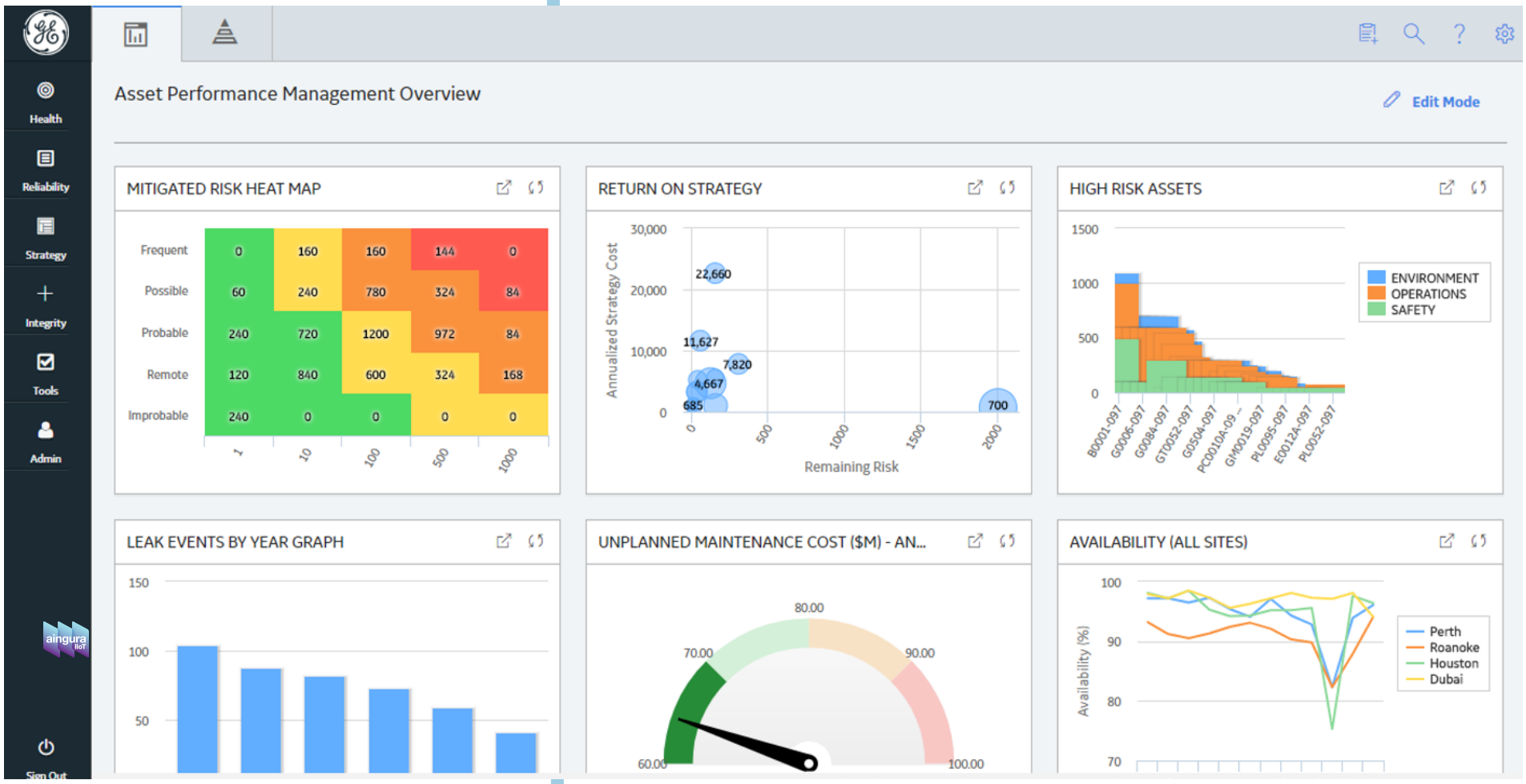
- **Remaining useful life:**
  - Machine Learning
    - Data stream analysis
    - Dynamic probabilistic clustering
  - There are not enough bad cases
    - Extremely unbalanced data → Novelty Detection
    - ML algorithm is measuring abnormal changes of the behavior pattern.
  - Detects early degradation that can affect the expected useful life.
    - Degradation can affect the expected service time.
    - It take data coming from the second stage to monitor anomalies.
    - Added value: early degradation measured using a multivariate approach.

Cloud Tier - Analytics Examples

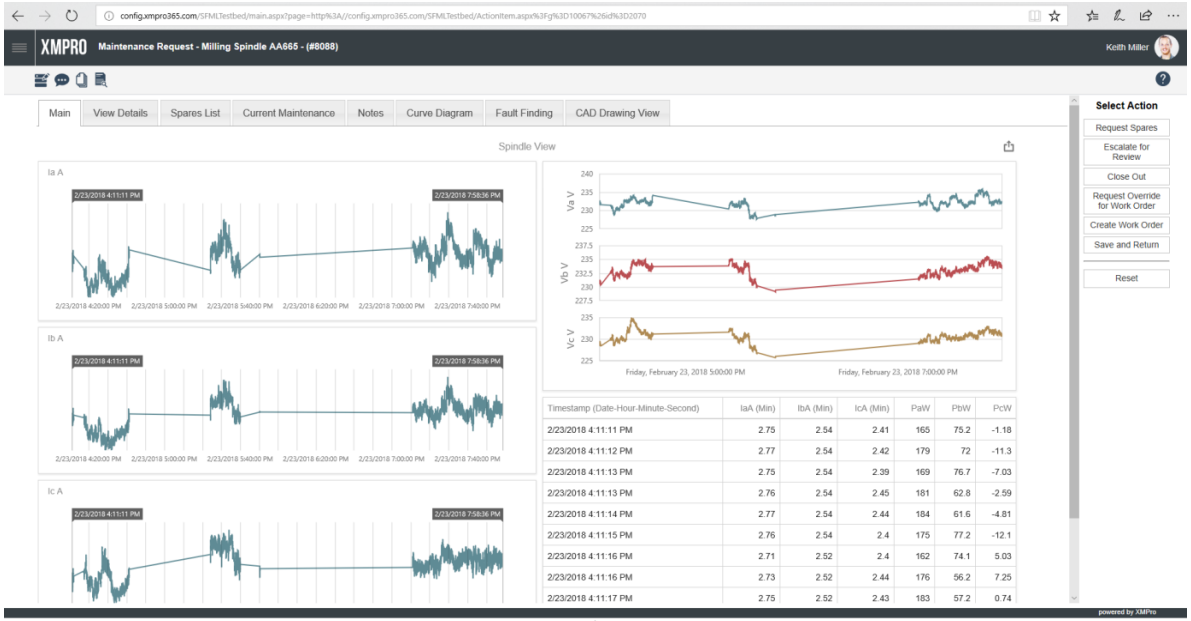


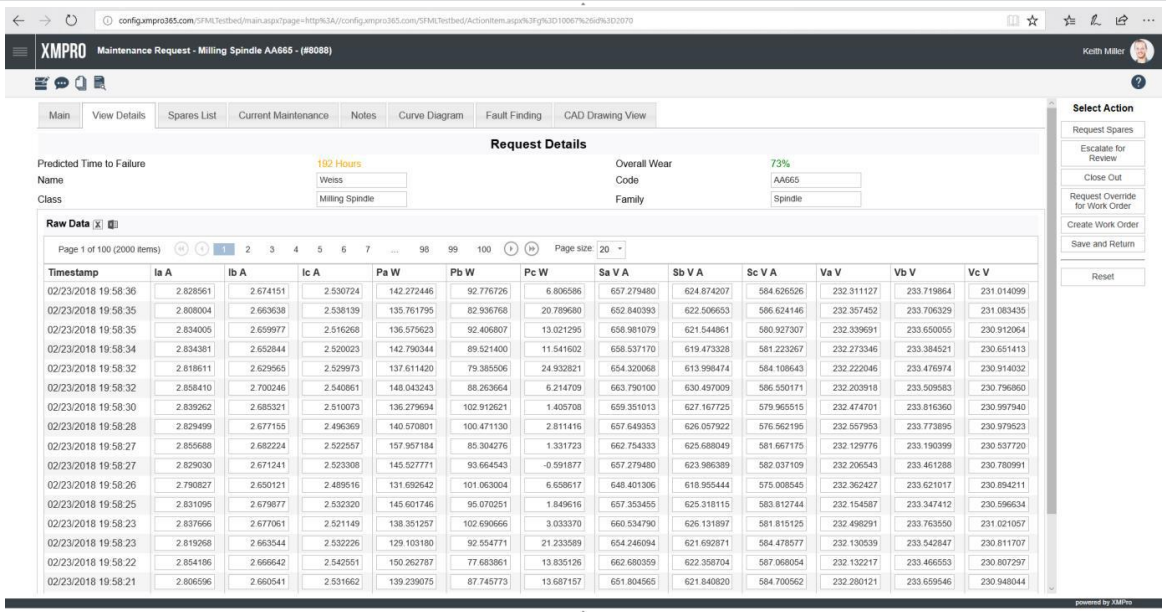
- **Microsoft-Azure**
  - MQTT-based communication
  - USD 10 per 52 MB/h
  - Analytics & Business oriented
  - Transmission speed dependent
- **GE Digital – Predix/APM**
  - Communication based on OPC-UA
  - Industry-oriented
  - KPI developed for maintenance
- **Ability to integrate**
  - ERP, MES and other business services

GE Predix APM Dashboard



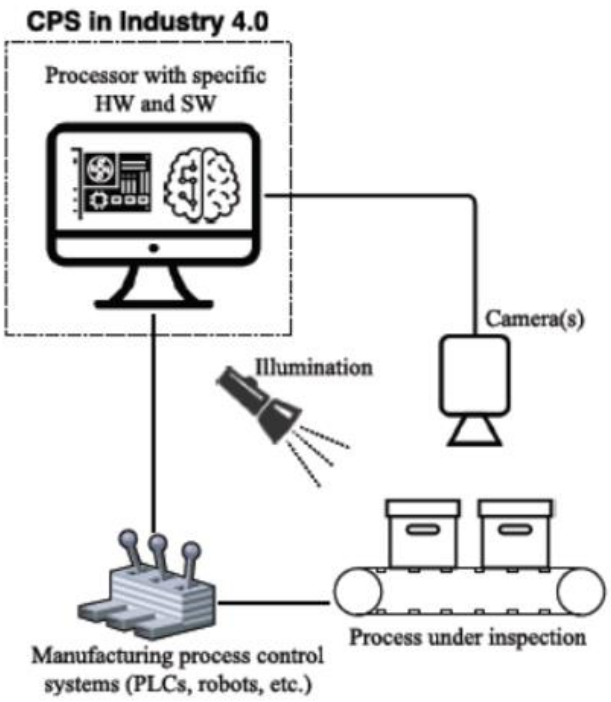
Visualization – Analysis - Business Services





Machine Learning Performed - Real Time

Visual Inspection System Solution (AVI)

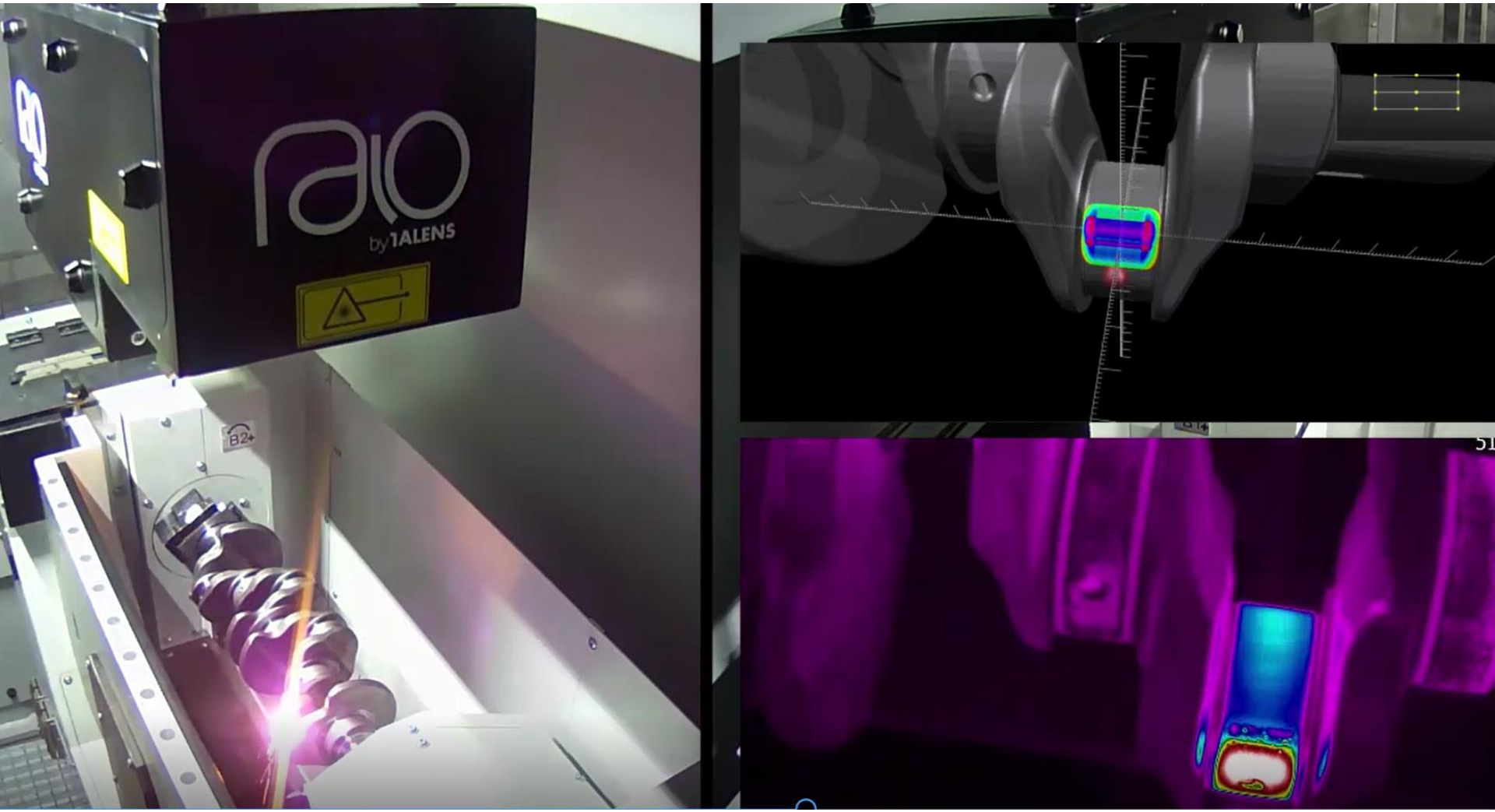


Opportunity of ML in Industry 4.0: *Analysis of data from monitored manufacturing activities while they are being carried out*

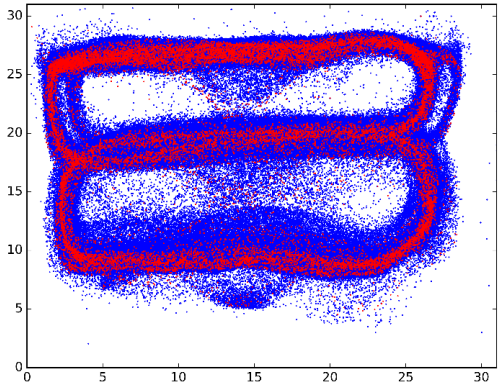
- **Identification of patterns** for detecting unwanted situations
- **In-process quality control**

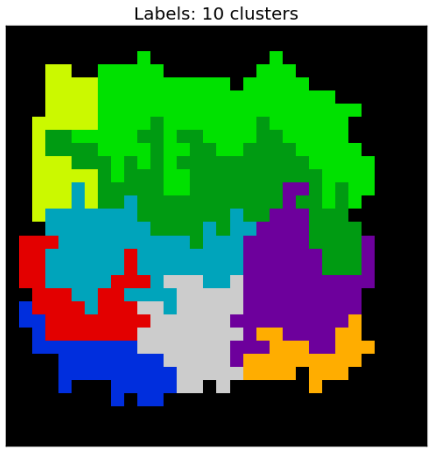
Traditional visual inspection *vs* **Automated visual inspection** (AVI) (Golnabi and Asadpour, 2007)

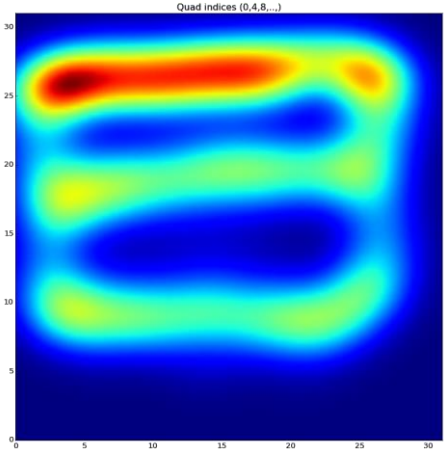
Talenz – Laser Hardening



Analysis







- **Data partitioning**
  - Depending on distribution (soft) or distance to a center (hard)
  - Density estimation
- **Example**
  - Laser tempering process
  - Laser Spot Position Analysis
- **Acquisition**
  - High-speed thermography1,000 fps
- **Spot positioning**
  - Failure Identified

Analytics applied to Laser Hardening Process

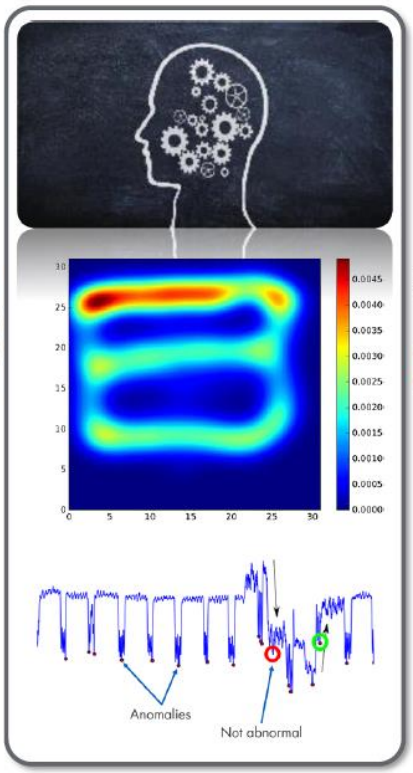
aingura IIoT

Laser Heat Treatment Process

Industrial Process

Data

Plethora IIoT Solution



Information

Actionable Insights

Cloud

Edge

Minds + Machines

Expertise from Edge to Cloud

- Data streams Machine Learning Analytics
  - Supervised and unsupervised learning
- Novelty detection
  - Feature subset selection
- Sensor fusion
  - High performance computing
- Zynq Programmable SOC processing
- Communication protocols
- Time sensitive networks
  - Cyber-Security

Industrial IoT Solutions for Operational Excellence

aingura IIoT

- **Aingura IIoT:**
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- **Xilinx:**
  - **Dan Isaacs: dani@xilinx.com**

OpenSystems media

Audience Q & A

Dan Isaacs,
Director Connected Systems,
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kontron

NATIONAL INSTRUMENTS

WIND

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Thanks for joining us

Event archive available at:

http://ecast.opensystemsmedia.com/

E-mail us at: jgilmore@opensystemsmedia.com