

From Machine Learning to Artificial Intelligence for Industrial Applications

Dr. Maurizio Rovaglio
Head of Digital Enterprise Business
for Process Industry – Siemens SPA – Italy

Agenda

1 Equipment Predictive Analytics (EPA)

2 EPA approach

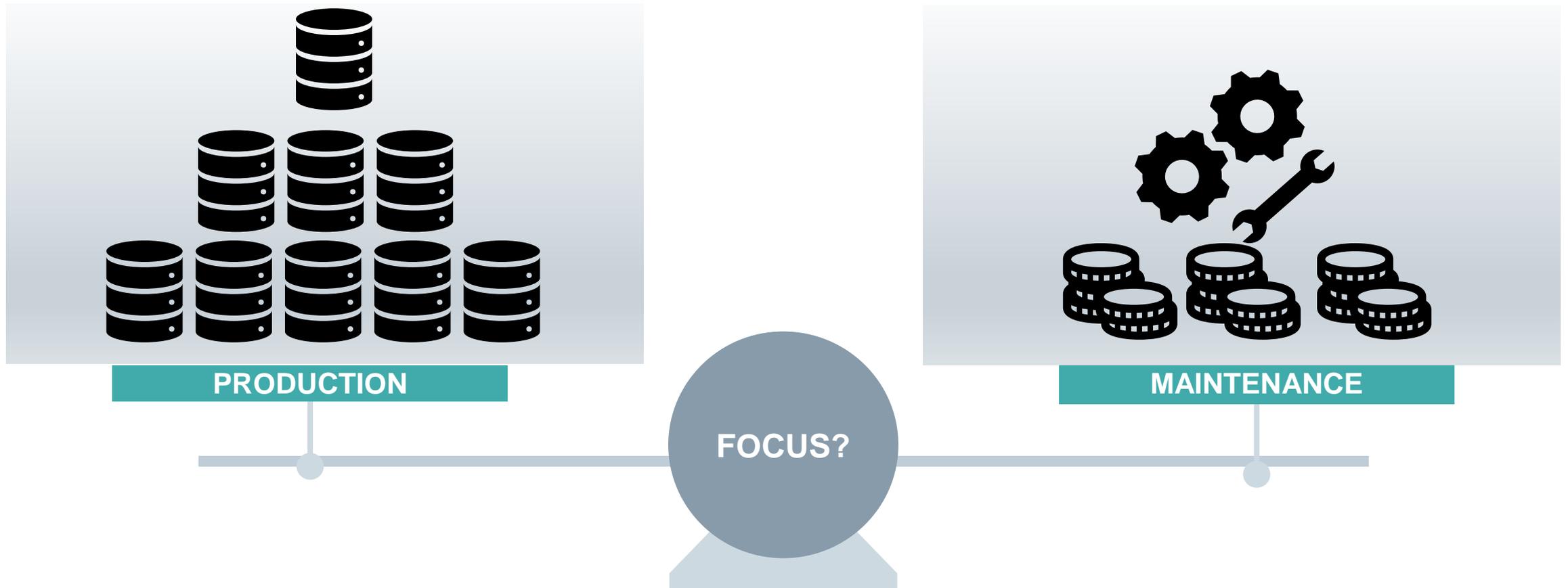
3 EPA plus AI (Case Based Reasoning / NLP)

4 Few Case Studies

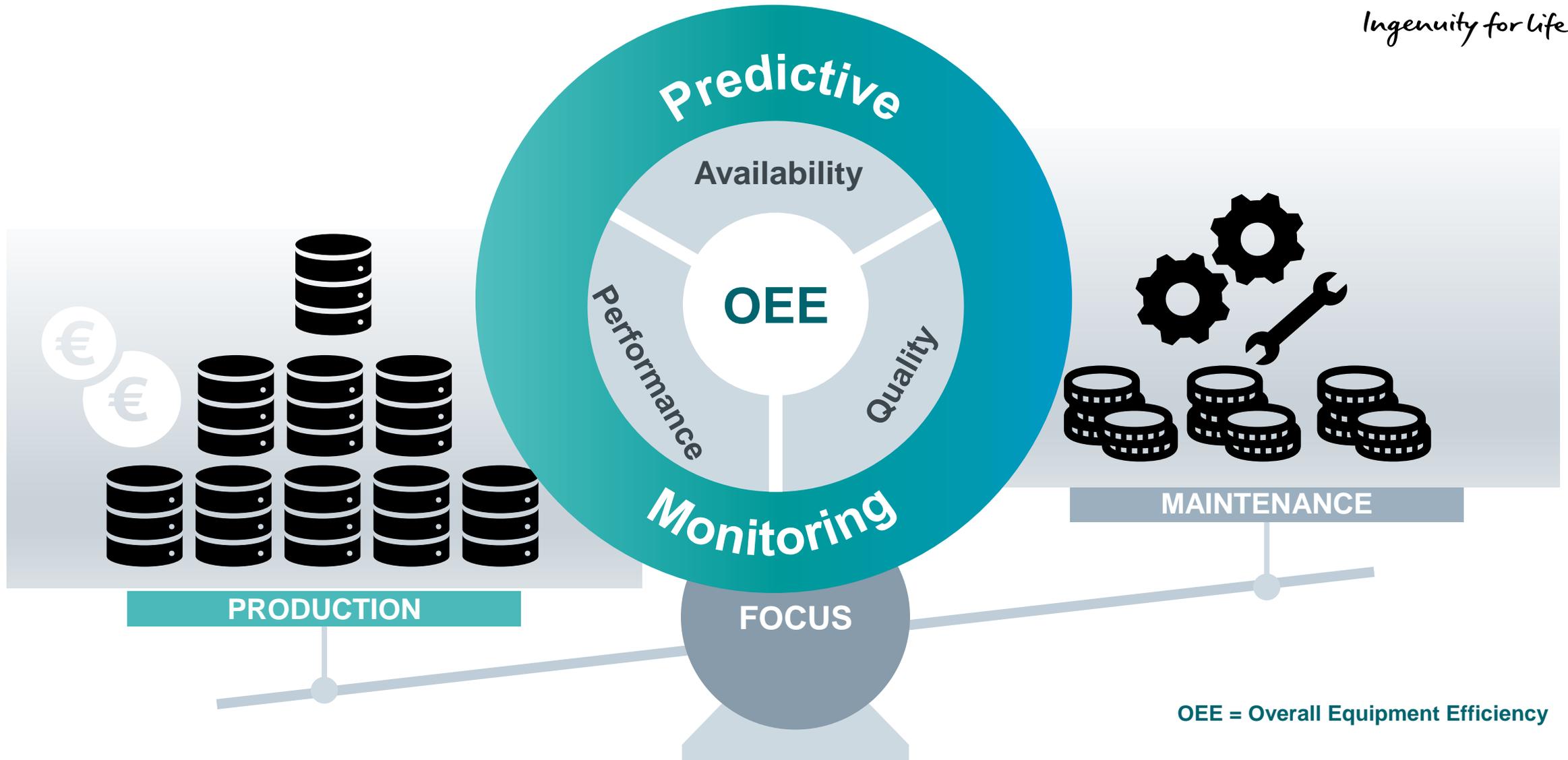
5 Short Video

6 Recap and Takeaways

Value of more production vs. value of maintenance saving

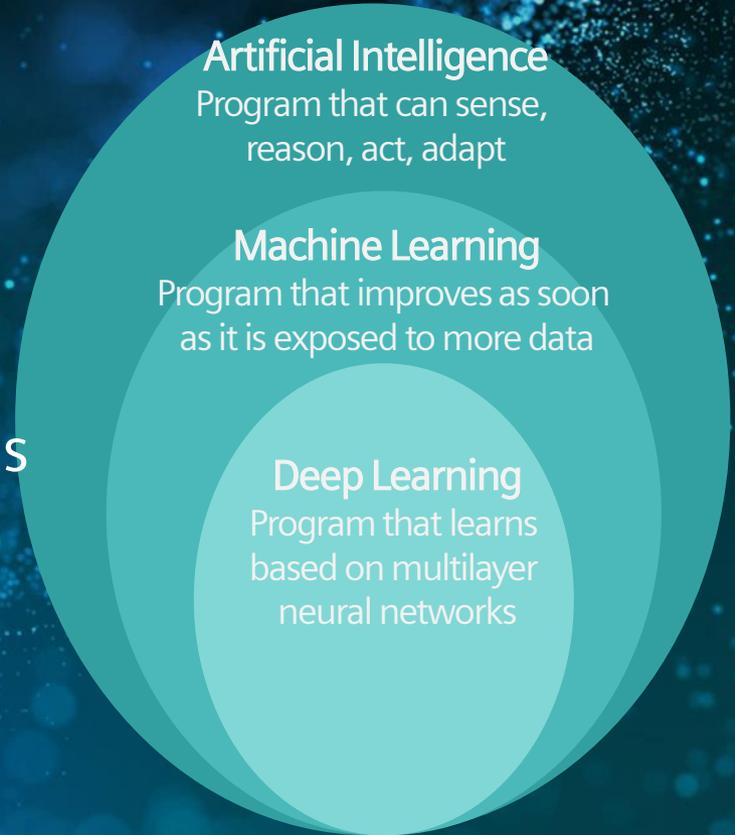


Value of more production vs. value of maintenance saving



OEE = Overall Equipment Efficiency

What is Predictive Analytics ?

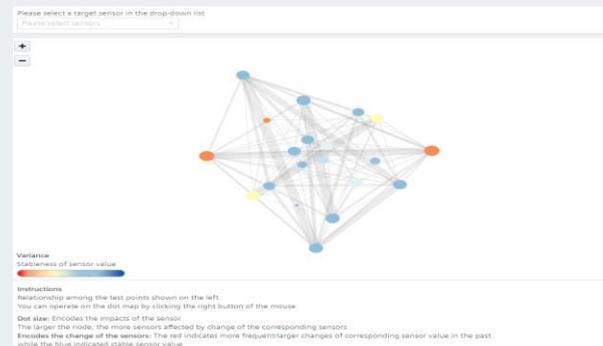


Philosophy of Equipment Predictive Analytics

Identify target sensors (most important sensors) and their correlated sensors.

Identify **correlations between the sensors** by correlations coefficients based on historical data and domain knowhow.

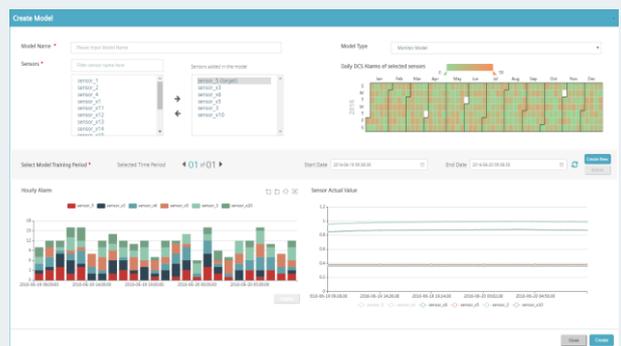
EPA first step should provides a matrix/plot of correlation coefficients.



Model training of target sensors

Training based on **normal behavior data**.

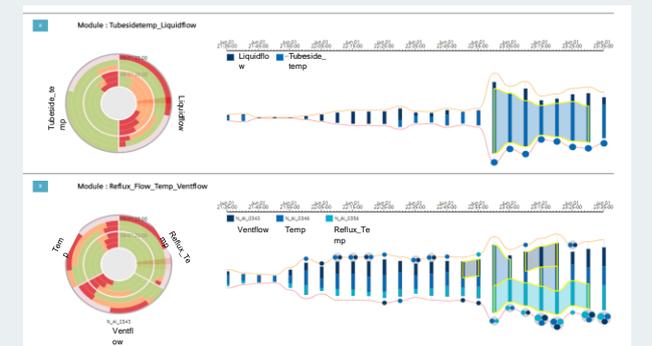
EPA should provides easy tools to retrieve plant data, select ranges and train/update the model as required.



Monitoring target sensors on dashboard

Alerts arising as soon as the **actual behaviour differs from the normal behaviour**.

Therefore EPA provides the daily and hourly alerts.

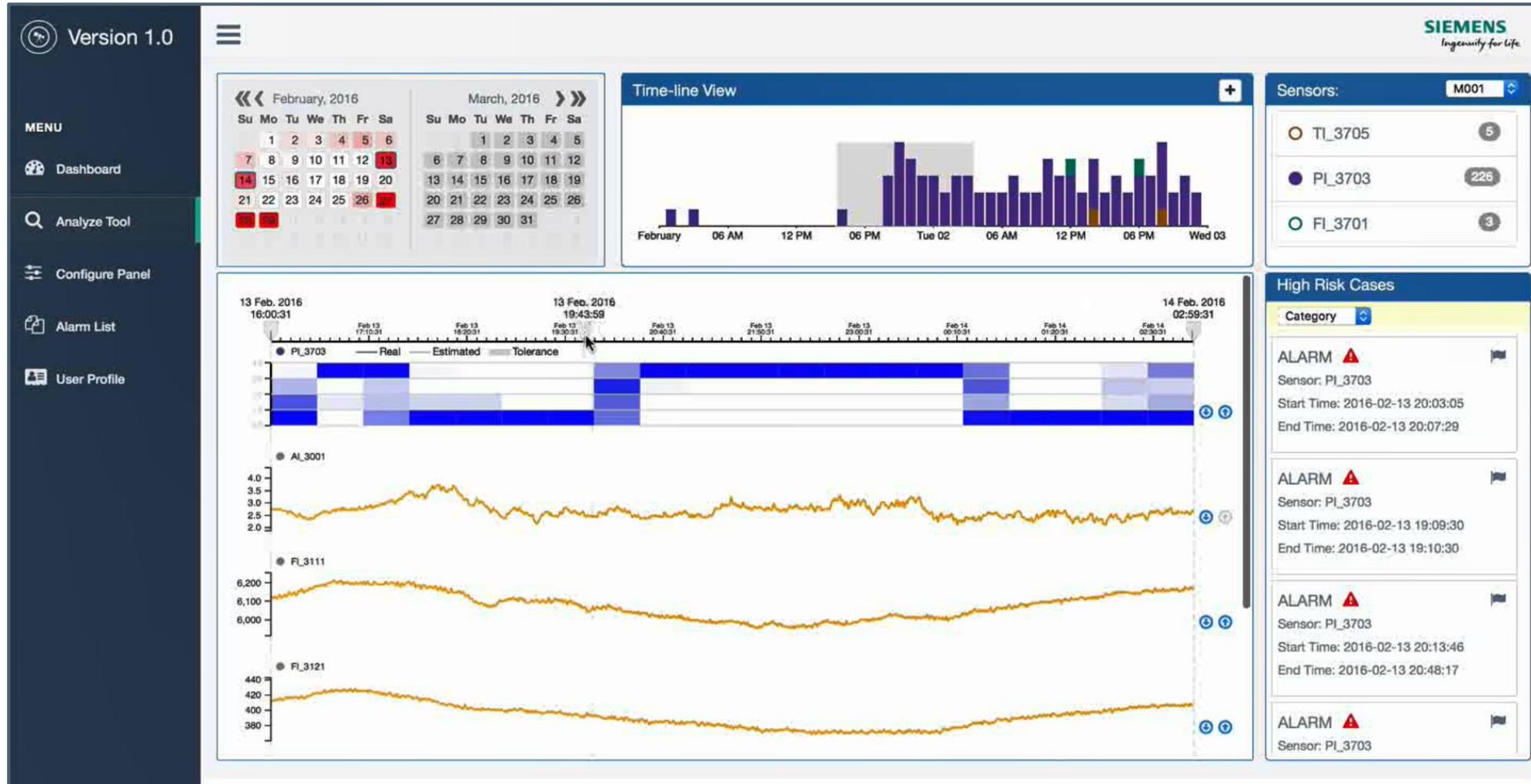


Identify Target Sensors and their Correlations

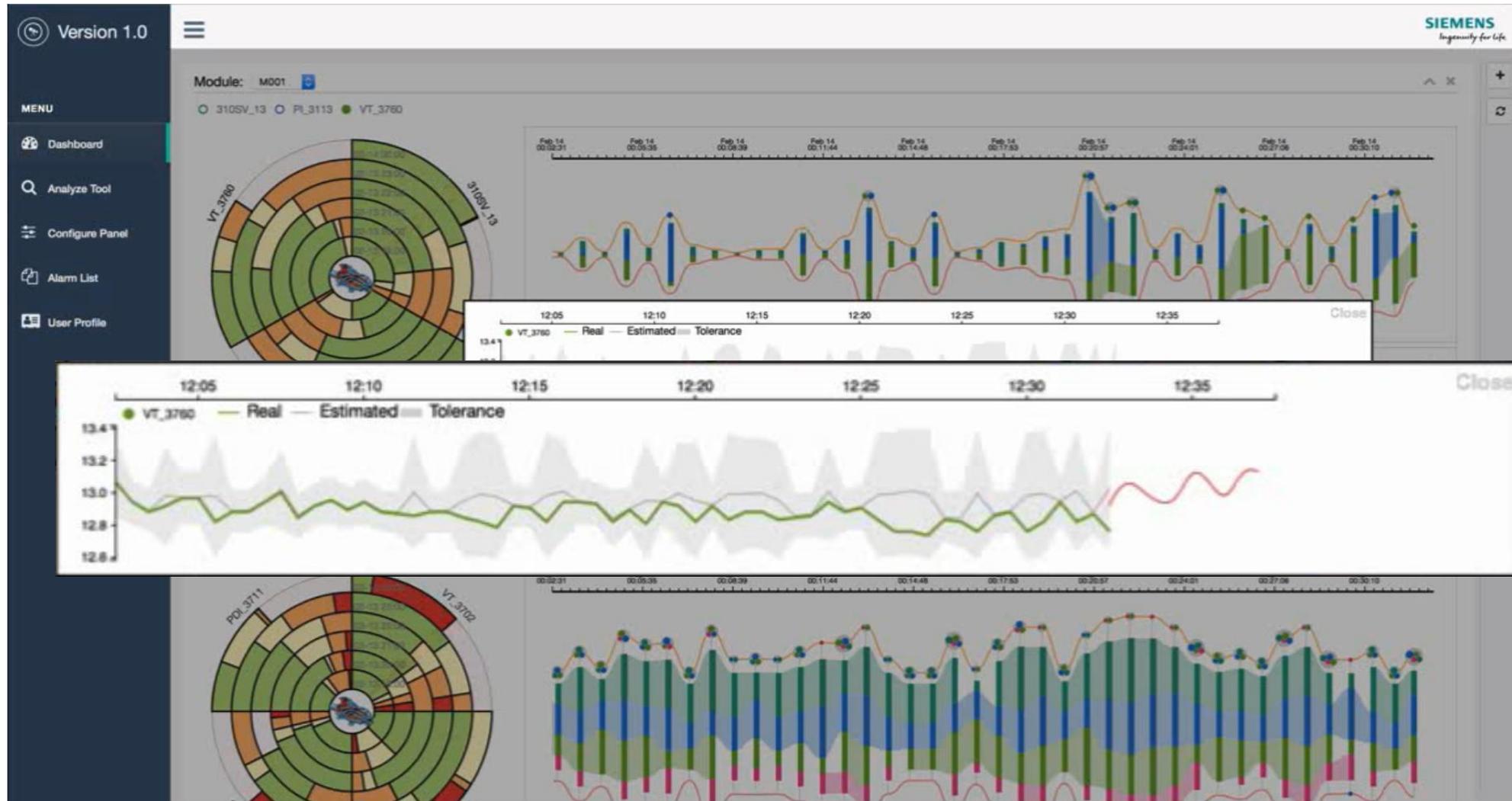
The screenshot displays a Siemens software interface for sensor analysis. On the left is a dark sidebar menu with the following items: 'Version 1.0', 'MENU', 'Dashboard', 'Analyze Tool', 'Configure Panel', 'Alarm List', and 'User Profile'. The main workspace is divided into three sections:

- Network Graph:** A large, complex graph of nodes and edges. Nodes are colored in blue, orange, green, and red. A mouse cursor is hovering over a node in the center.
- Process Diagram:** A detailed schematic of an industrial process, likely a distillation column, with various pipes, tanks, and control elements.
- Control Panel:** A panel with three columns of controls:
 - Test:** A dropdown menu set to 'Test' with expand/collapse (+/-) buttons. It contains three entries: '310SV_18' (radio button), 'PT_3706' (radio button), and 'TI_3752A' (radio button). Each entry has a red dot and an 'x' icon.
 - Correlated Sensors:** A list of sensors with radio buttons and 'x' icons: 'PT_3702', 'PT_3752', 'VT_3755', 'ZT_3751', and 'TE_3708'. A mouse cursor is hovering over the 'VT_3755' entry.
 - Chosen Time Intervals:** An empty list with an expand/collapse (+) button.

Model Training of Target Sensors

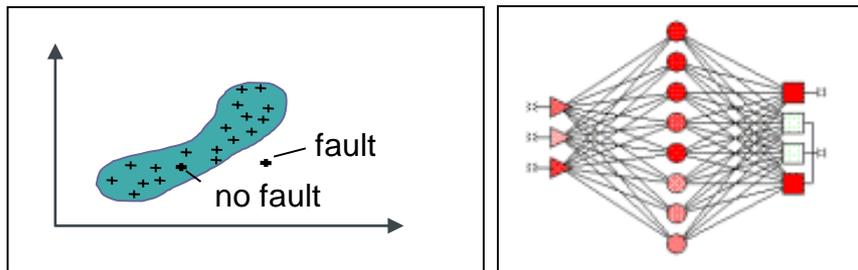


Monitoring Target Sensors



Data Driven Analytics

Knowledge Based Analytics



Effects	Anomalies												
	Insufficient Discharge Pressure	Intermittent Operation	Insufficient Capacity	No Liquid Delivery	High Bearing Temperatures	Short Bearing Life	Short Mechanical Seal Life	High Vibration	High Noise Levels	Power Demand Excessive	Motor Trips	Elevated Motor Temperature	Elevated Liquid Temperature
Bent Shaft													
Casing Distorted from Excessive Pipe Strain													
Cavitation													
Clogged Impeller													
Driver Imbalance													
Electrical Problems (Driver)													
Entrained Air (Suction or Seal Leaks)													
Hydraulic Instability													
Impeller Installed Backward (Double-Suction Only)													
Improper Mechanical Seal													
Inlet Strainer Partially Clogged													
Insufficient Flow through Pump													
Insufficient Suction Pressure (NPSH)													
Insufficient Suction Volume													
Internal Wear													



Natural Language Processing



Industry challenges

- High efficiency and “squeezing iron” by more than 100% capacity

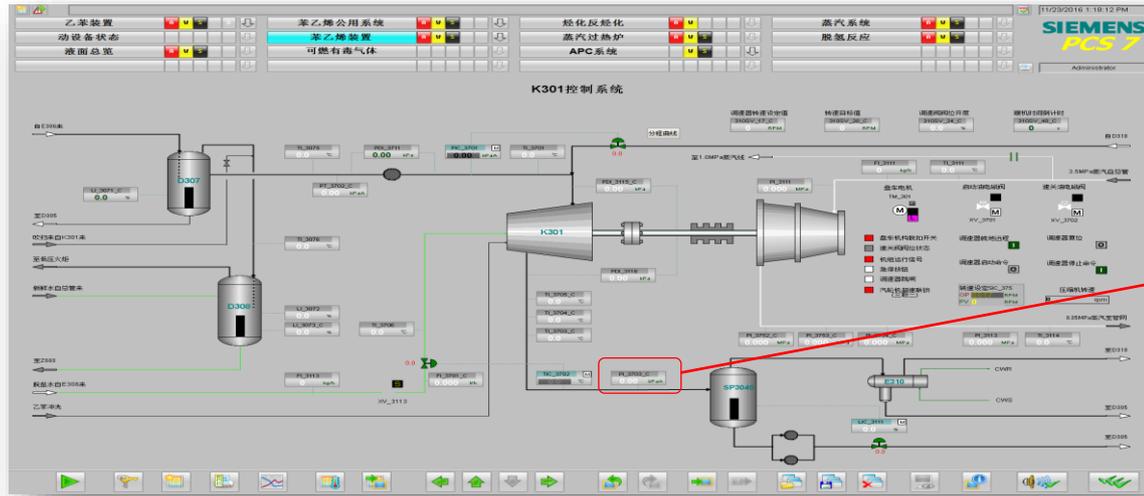
EPA solution

- Interactive machine learning tool
- Correlation calculation and EPA models for Rotating machines
- Risk pre-alert via historical-data-based model training and real-time data analysis
- NLP-based smart diagnosis for know-how/experience consolidation

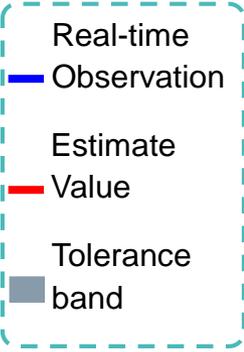
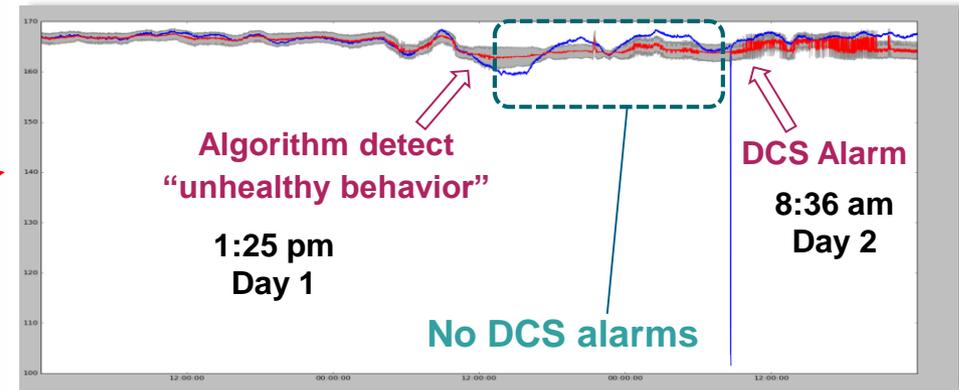
Benefits

- Increased plant uptime through avoidance of shut-downs by pre-alerting on failures.
- Higher operation efficiency through predictive monitoring.

EPA Use Case in Petrochemicals Advanced compressor monitoring



PI 3703 – Compressor output pressure

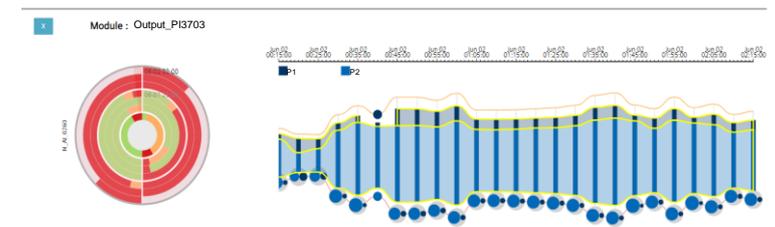
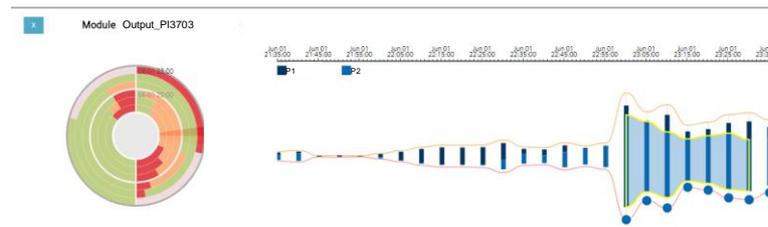
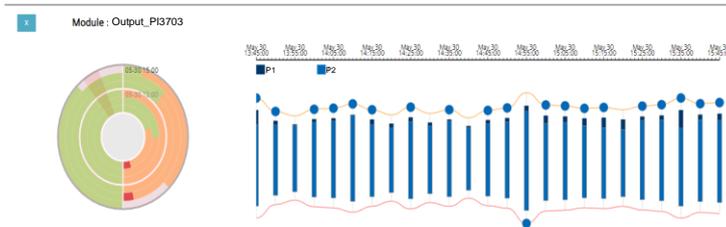


Risk detected ~18 hours earlier!

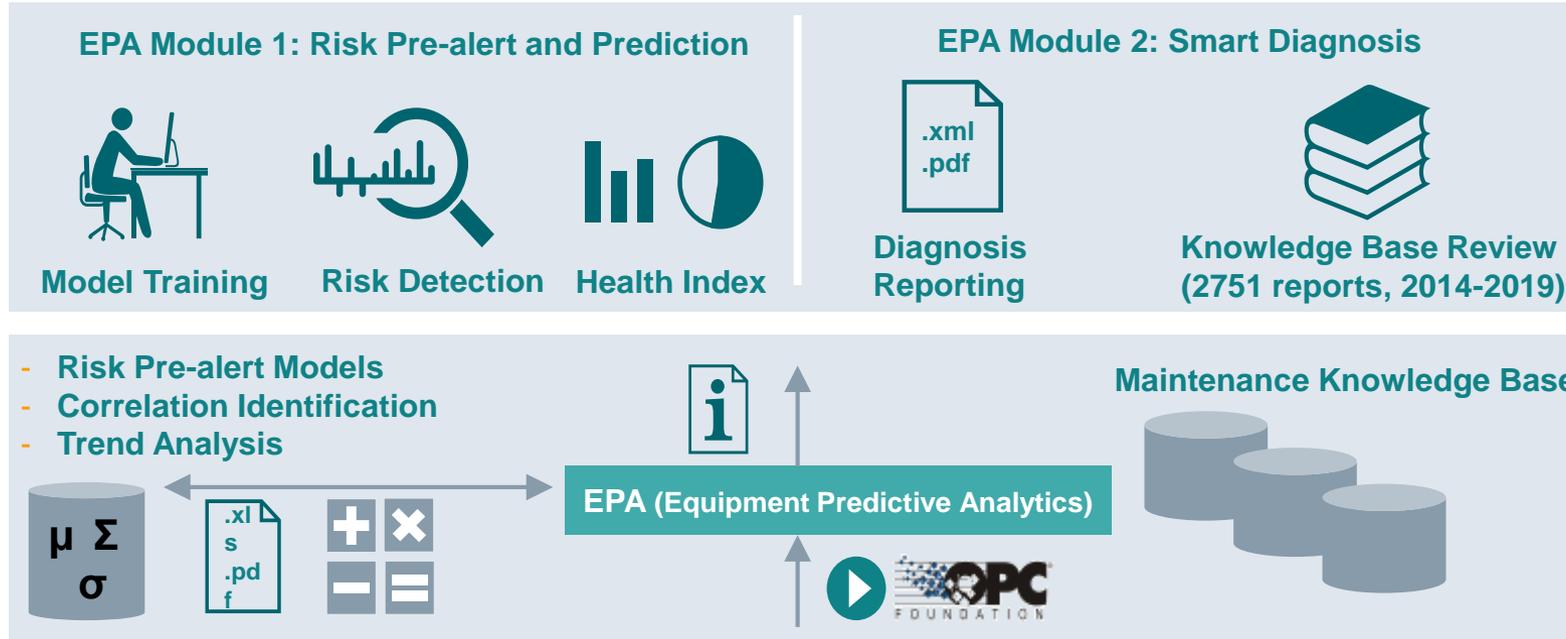
1. Almost no high risk alerts

2. Series of high risk alerts

3. Only high risk alerts



EPA reference case in Cement

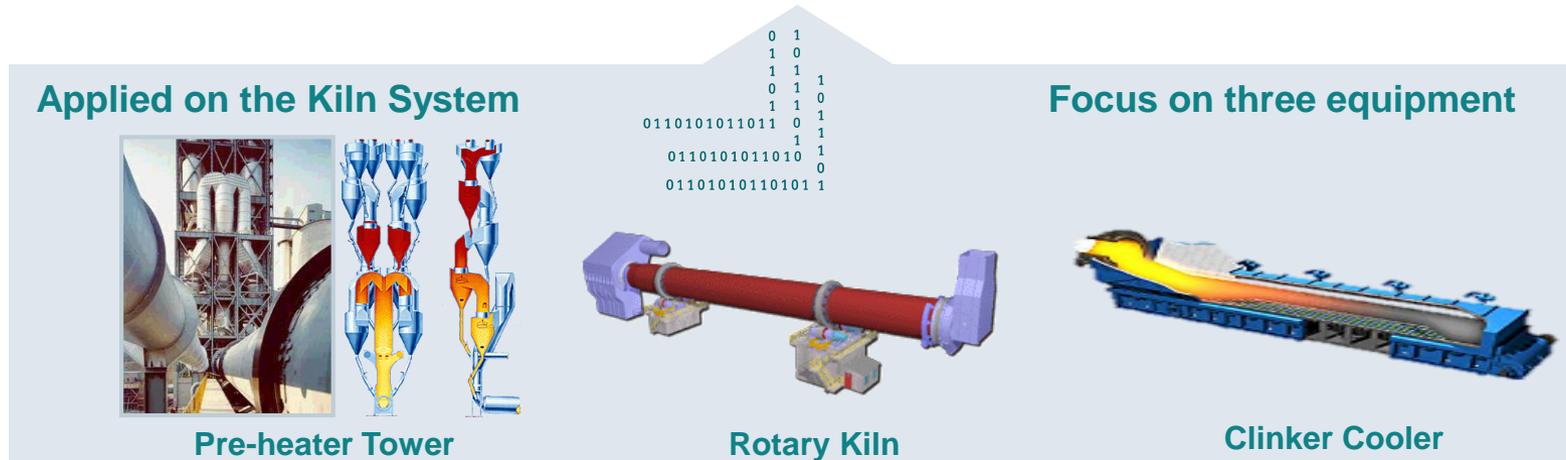


Industry Challenge:

- Crust
- Stack of materials
- Blockage

EPA Solution:

- **Risk Pre-alert and Prediction:**
Apply EPA models trained by industrial big data collected from onsite sensors
- **Smart Diagnosis:**
Apply NLP (Natural Language Processing) technology to match similar historical cases (failure/maintenance report) to support decision making

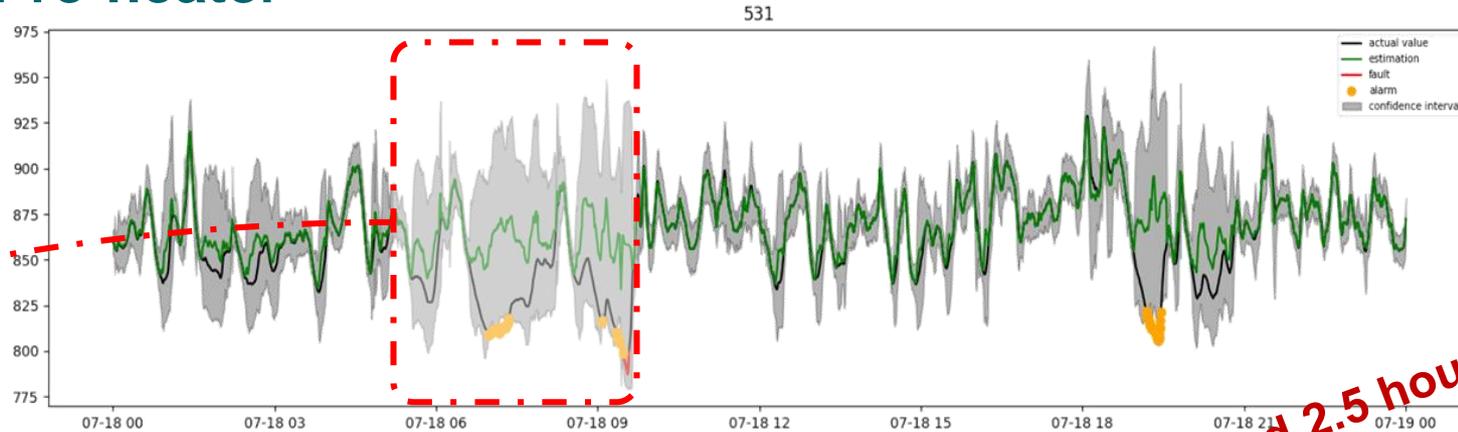


Benefits

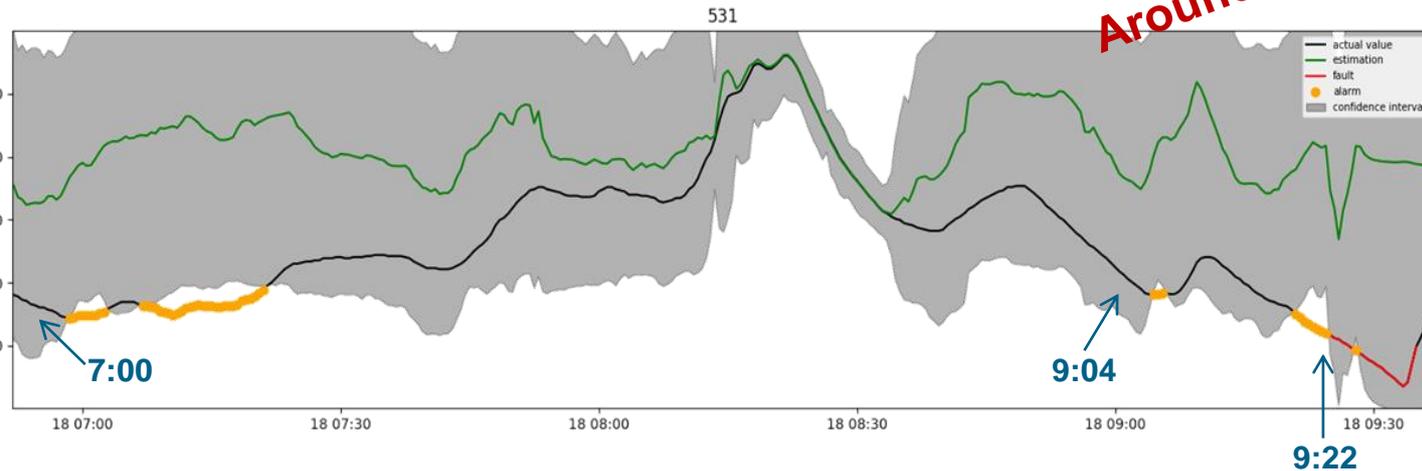
- **Increased plant uptime** through avoidance of shut-downs by pre-alerting on failures.
- **Higher operation efficiency** through predictive monitoring.

EPA Cement Use Case 1: Crust Risk in Pre-heater

2019-07-18 09:22:00



Zoom in



Around 2.5 hours earlier prediction

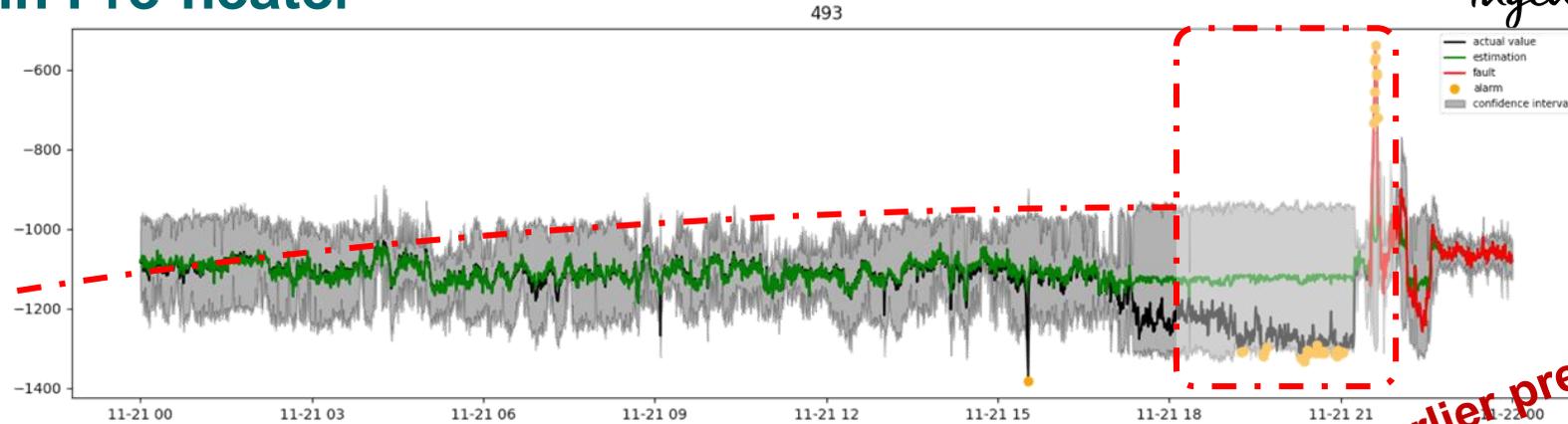
■ Tolerance band

- Target Sensor: Temperature of C5A Entrance in Pre-Heater
- **First high-risk alert in EPA at 7:00**
- **DCS alarm (lead to unplanned shut-down of kiln product) at 9:22**

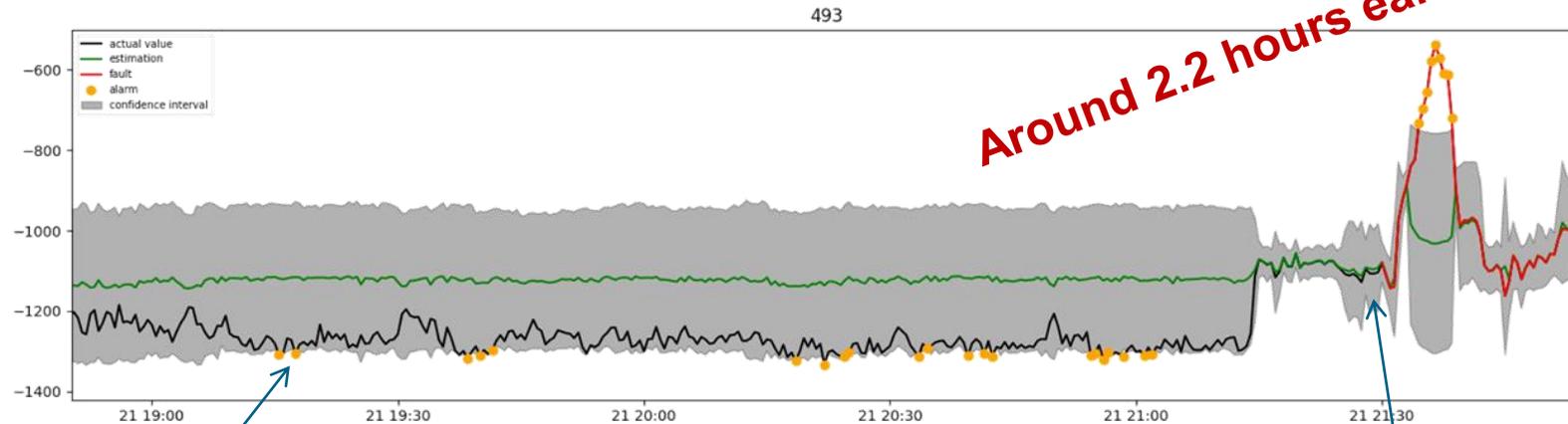
EPA Cement Use Case 2 : Material Blockage in Pre-heater

2018-11-21 21:30:00

■ Tolerance band



Zoom in



Around 2.2 hours earlier prediction

— Sensor value

— Estimated value

19:20

21:30

- Target Sensor: Pressure of C5A exit in Pre-Heater
- **First high-risk alert in EPA at 19:20**
- **DCS alarm (lead to unplanned shut-down of kiln product) at 21:30**

VIDEO

(<https://www.youtube.com/watch?v=SoXAz47hq8g&t=6s>)

SIEMENS
Ingenuity for life

The screenshot shows the Siemens SieDx dashboard interface. At the top, there is a navigation bar with various menu items: Upstream, Midstream, Refining, Chemicals, PowerGen, Fleet, ValveMonitoring, ProcessAutomationWorld, Fiber, Glass, Pharma, DR, Water, EBR. Below this, there are dropdown menus for 'Overview', 'My Views', 'My Trends', and 'Explorers'. The main content area is divided into four columns, each representing a different category of industrial assets:

- Onshore**: Aliso Viejo, Calita, Dana Point, Laguna, Mission, Newport, Playa Vista, San Juan
- Offshore**: Eagle, Jaguar, Lion, Packer, Saint, Texan, Titan, Cowboy
- Chemicals**: Berlin, Erlangen, Genoa, Hannover, Karlsruhe, Munich, Prague, Rotterdam
- Petrochemical**: Alianza, Bolivar, Colo-Colo, Flamengo, Millonarios, Olimpia, RiverPlate, Santos

Recap and Key Takeaways

- ✓ EPA approach require efforts
- ✓ EPA provides ALERTS but with no knowledge
- ✓ AI knowledge based algorithms enhance EPA use
- ✓ False positive must be addressed
- ✓ Large Improvement of operation efficiency





THANK YOU !