MONSOON
MOdel based coNtrol framework for Site-wide OptimizatiON of data-intensive processes

MONSOON project: Boosting the development and deployment of data enabled predictive control solutions for process industries

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Towards Industry 4.0: Digital Technologies in Process Industry

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Outline

- Project Overview
- MONSOON Vision
- Use Cases
- First Achievements

PROJECT OVERVIEW

INTRODUCTION TO MONSOON

Context and main challenges

- Process industries characterized by **intense use of raw resources and energy**, where even small optimizations can lead to high absolute savings both in terms of economic and environmental costs
- Deployment of **model-based predictive functions** not always feasible at a sustainable cost or with sufficient reliability
- **Change** in global competition and resources availability calls for a drastic re-design of production processes and sites

MONSOON at a glance

- MONSOON is a **36-months** **R**esearch and **I**nnovation **A**ction (**RIA**) funded by the EC (H2020 **SPIRE-02-2016**)
- **Scope**: Plant-wide monitoring and control of data-intensive processes
- **Aim**: improve **process efficiency** and **reduce usage** of **resources** as well as **GHG emissions**, thus strengthening the global position of EU process industry
- **Total cost**: about 5.5 M€

Consortium Overview

Coordinator

ISMB Istituto Superiore Mario Boella

Fraunhofer FIT

TECHNICKÁ UNIVERZITA V KOŠICIACH

CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

RioTinto

Capgemini

probayes

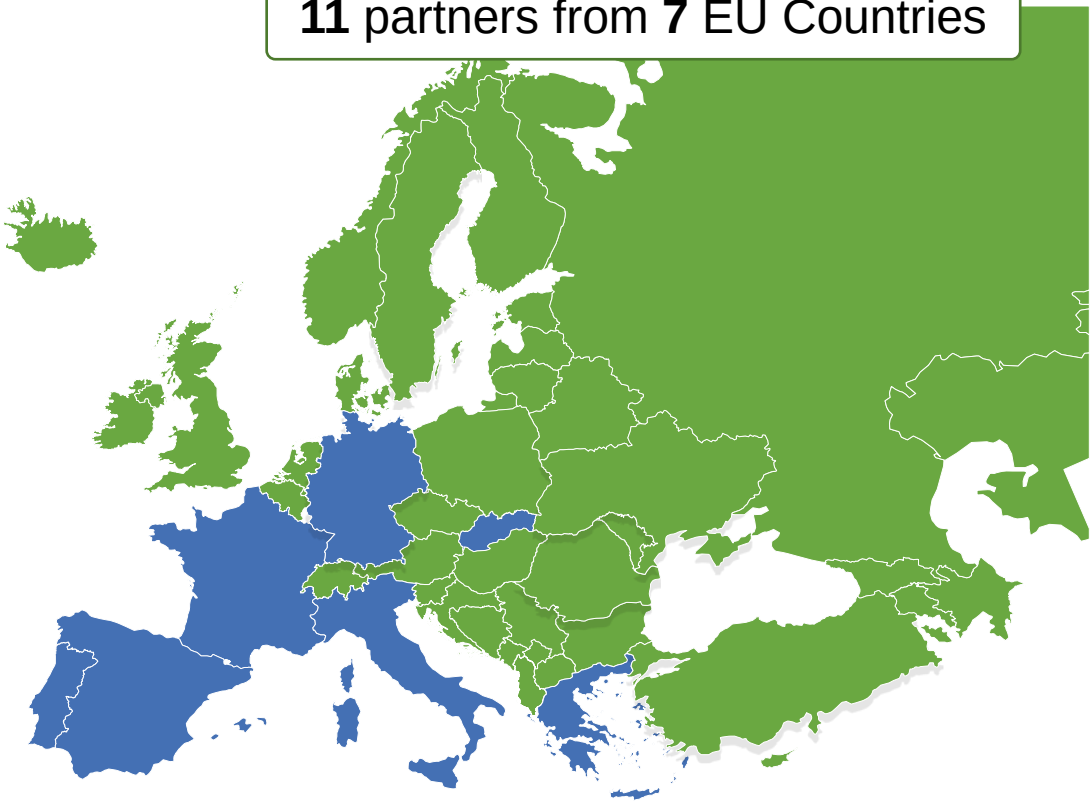
GLN Molding the Future

KUNSTSTOFF INSTITUT LÜDENSCHEID

UNE NormalizaciónEspañola

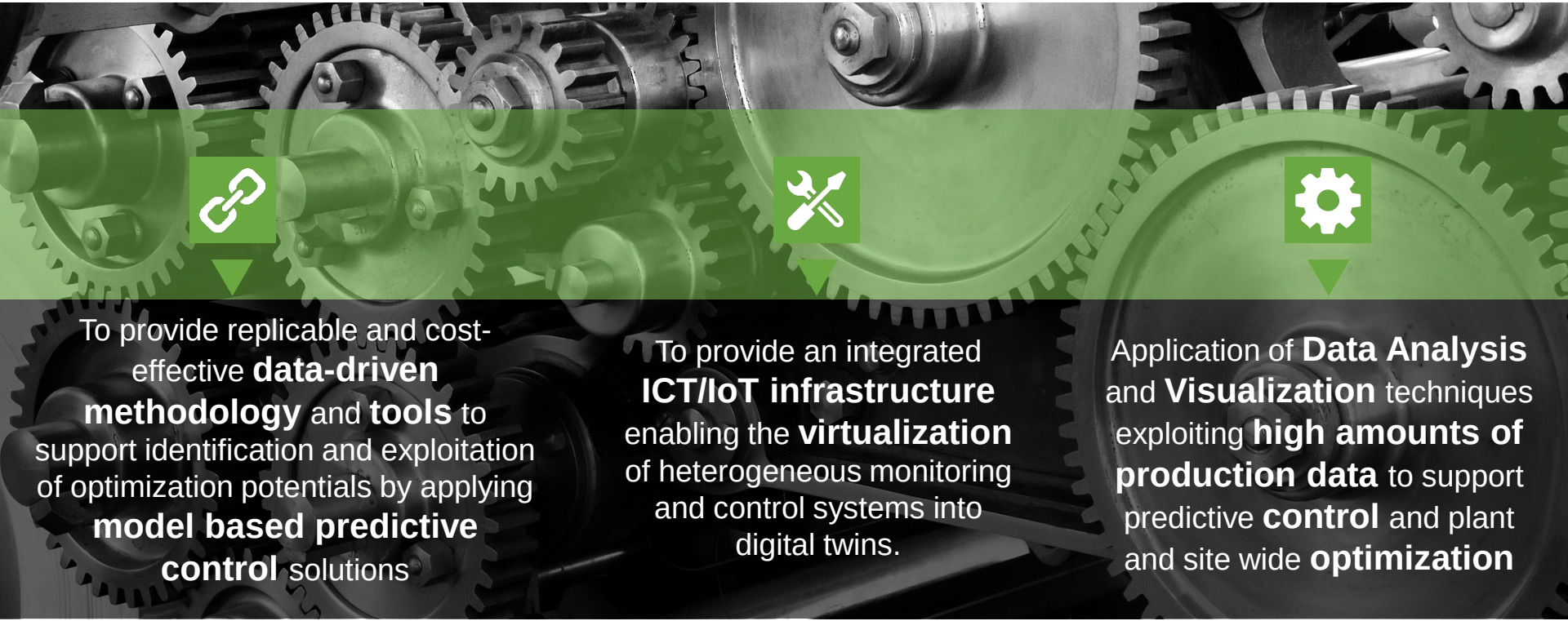
LIFE CYCLE ENGINEERING we support your sustainable business

11 partners from **7** EU Countries



MONSOON VISION

MONSOON Objectives



To provide replicable and cost-effective **data-driven methodology** and **tools** to support identification and exploitation of optimization potentials by applying **model based predictive control** solutions

To provide an integrated **ICT/IoT infrastructure** enabling the **virtualization** of heterogeneous monitoring and control systems into digital twins.

Application of **Data Analysis** and **Visualization** techniques exploiting **high amounts of production data** to support predictive **control** and plant and site wide **optimization**

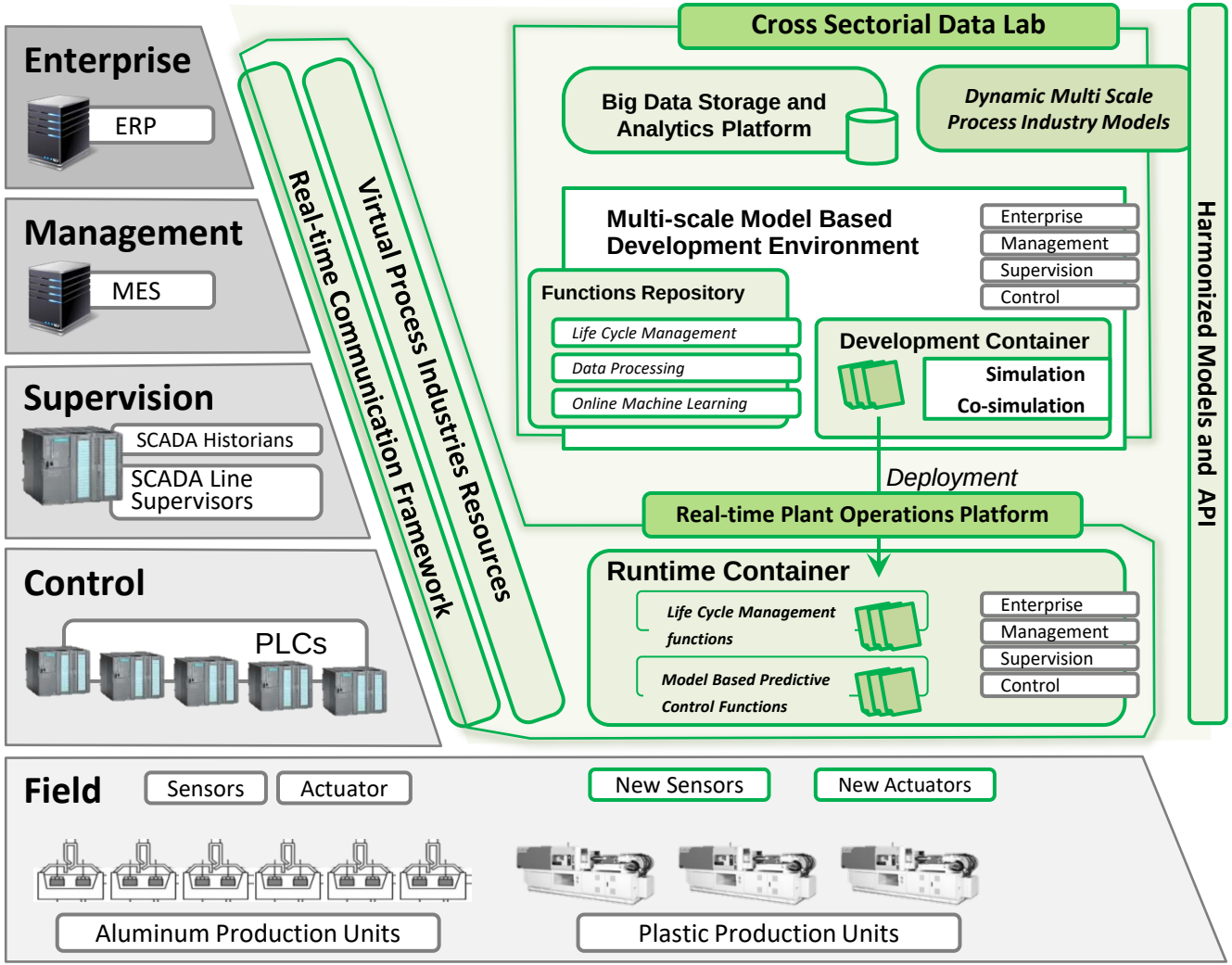
MONSOON Objectives

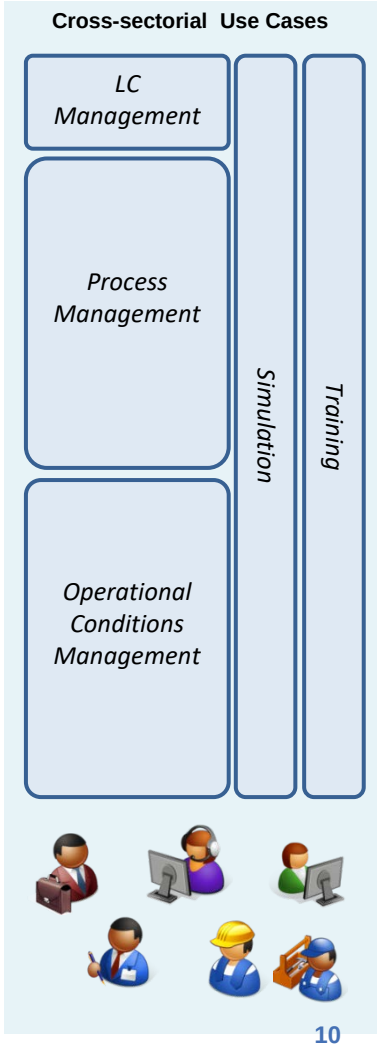
A novel **model based development environment** – **Cross-Sectorial Data Lab** – to facilitate design, development, integration, deployment and testing of **predictive control algorithms**

Symmetric plant and site-wide **Online Life Cycle Management Tools** (also entailing **circularity** aspects) **integrated** with the monitoring and control infrastructure

Demonstration and Evaluation of the proposed solution in the **Aluminium** and **Plastic Industry**

The MONSOON Reference Architecture

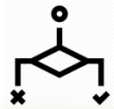




MONSOON enabled Vision

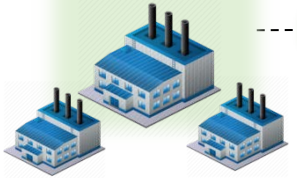
MONSOON Data Lab

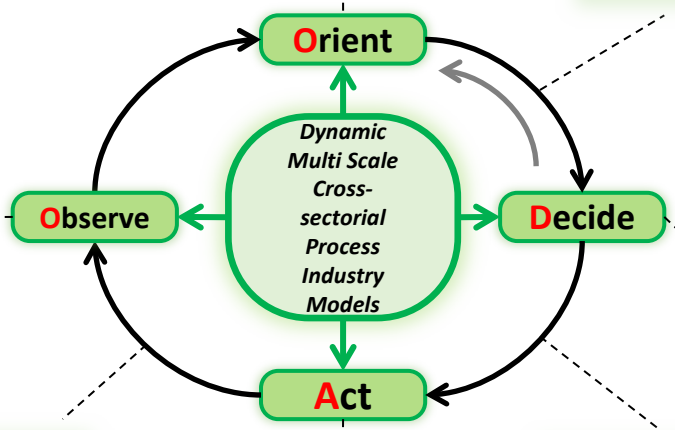
Cross-sectorial collaboration to **develop** data-driven Model Based **Predictive Functions**



Hybrid off-line and on-line **evaluation** of model based Predictive Functions (development, iterative fine-tuning, etc.)

Scalable Real-time **Monitoring** of Data-Intensive Processes from Multiple Production Sites





Impact prediction, Feasibility **Assessment**

Impact **Evaluation**, LC **Assessment**

Multi Scale Distributed Controls **Runtime** in the Factory

Rapid **Prototyping** and **Deployment** of Model Based Predictive Functions

Cross-sectorial Use Cases

- *LC Management*
- *Process Management*
- *Operational Conditions Management*
- *Simulation*
- *Training*

MONSOON Application Domains

Aluminium

Primary Production

Dunkerque plant (FR)

Highest-producing primary aluminium plant in the EU-28 area (consumption 3.7 TWh of electricity - equivalent to a 1 million people city)

Plastics

Injection moulding

Maceira-Leiria plant (PT) – GLN

Injection moulding machines

ALUMINIUM USE CASE

Green Anode Production

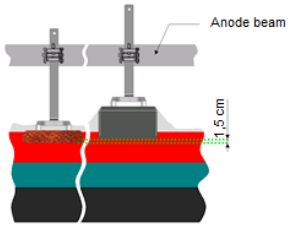
- **Prediction of Anode Quality**
  - **detect bad anodes** with high level of confidence and avoid forwarding them to the electrolysis area
  - **predict** non conformant production (global or individual anomalies) and **trigger** relevant actions to correct the problem

Anode non-quality can lead to non-homogeneous and reactive anodes

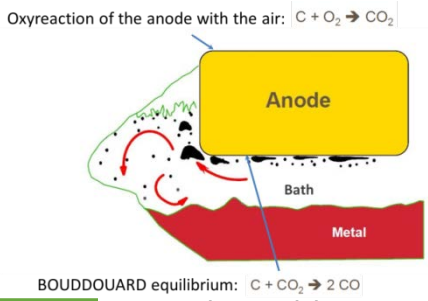
- *Dusting in pots*
- *Reduced lifecycle on pots (more frequent anode change)*
- *Incidents on pots like mushrooms (spikes), flatness defect (deformation)*
- *CO_2 emissions due to the anode overconsumption*

Mushrooms or spikes

Anode flatness defect



Net carbon and anode consumption



Anode reactivity

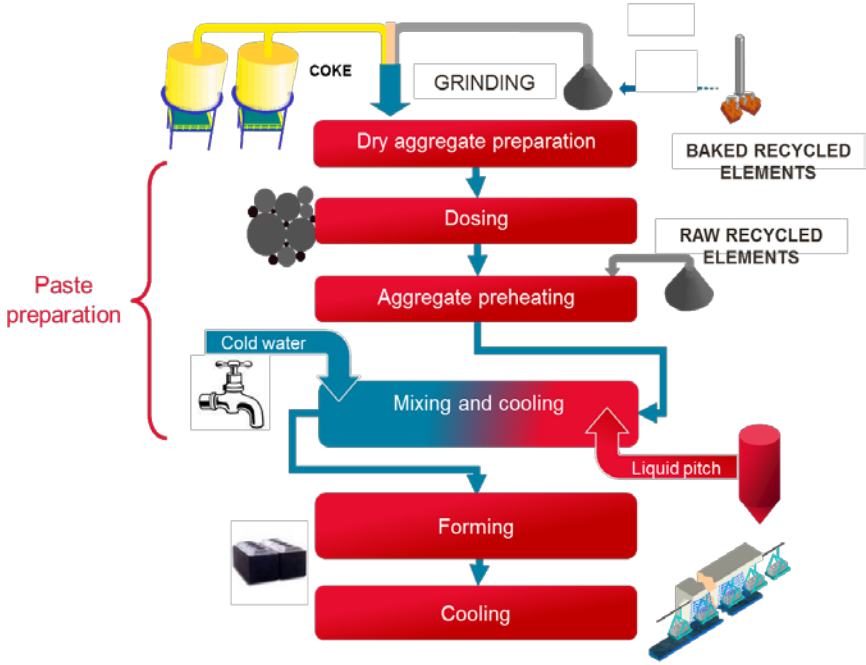
Green Anode Production

- **Predictive Maintenance**
  - **prediction** of paste plant stoppages and equipment deviation
  - Identification of **correlation** between equipment deviations and stoppagies and decrease of anode quality to **trigger** relevant actions and predictive maintenance operations

Monitoring of equipment most impacting on anode production

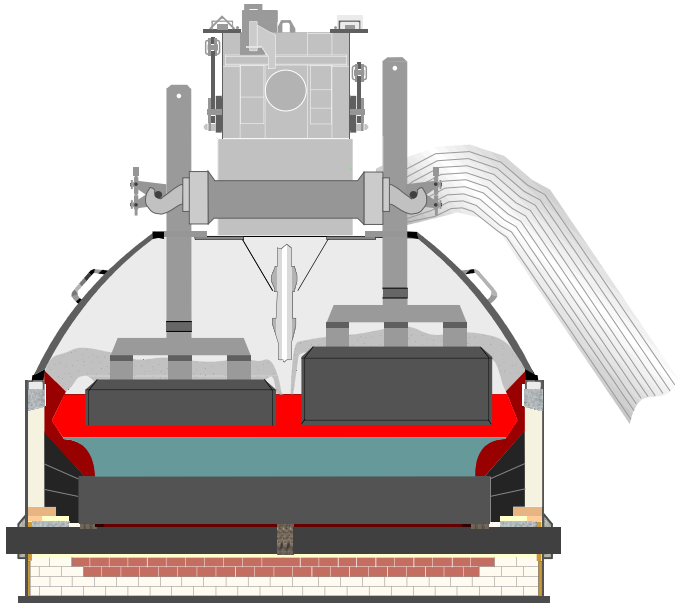
- ***Paste mixer**: machine to prepare the paste*
- ***Paste cooler**: machine to cool down the paste before the forming step*

Results could be used as a basis for the predictive quality enhancements



Electrolysis Area

- **Predict in real-time the liquid heights (bath and metal)**
- **Predict in real-time the thermal balance**



These two variables have a great impact on the pot performances that are the optimized energy consumption and current efficiency.

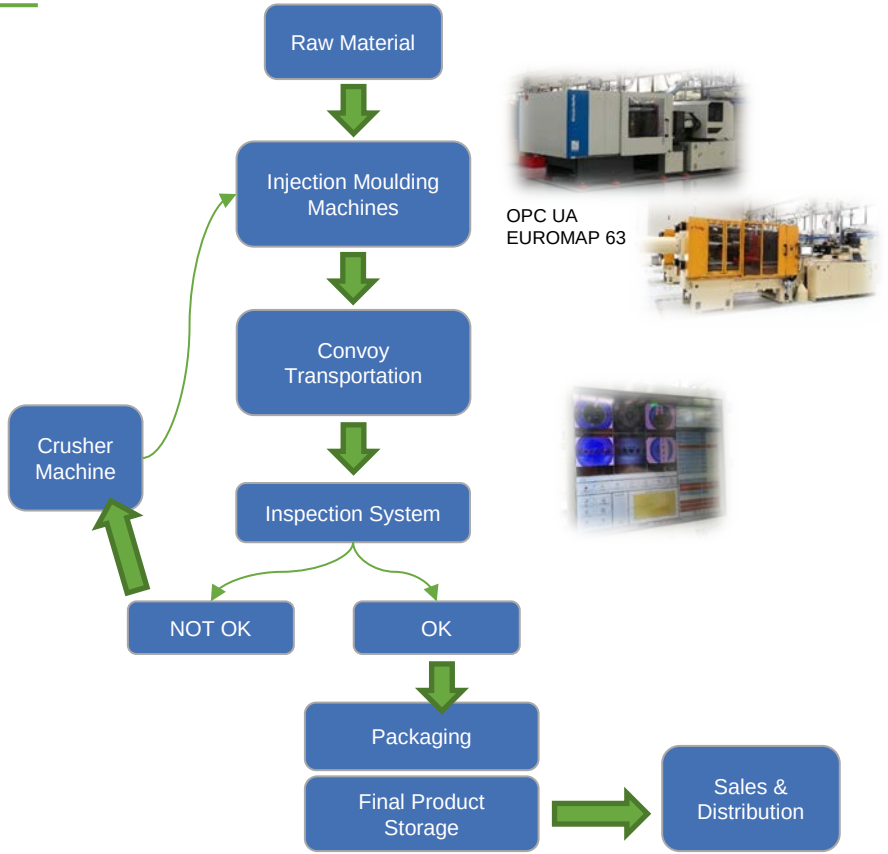
Objectives:

- *Give* **indications** *on the appropriate operations to be done on the pot (adjustments of the bath volume, volume of metal to be tapped…)*
- *Give* **optimal parameter settings** *based on process expertise*
- *Anticipate process deviations via* **predictive alerts** *and* **take countermeasures** *(e.g. adjust parameters settings) to improve pot stability.*

PLASTIC USE CASE

Injection Moulding – Coffee capsules

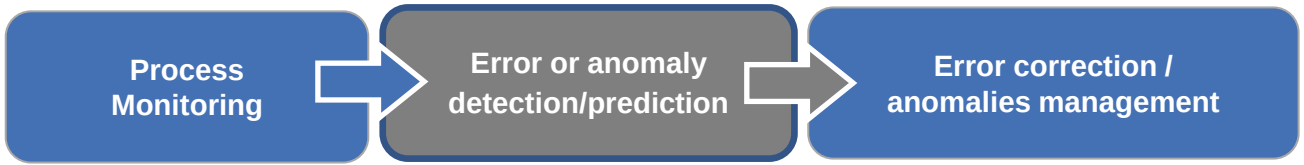
- *Polypropylene coffee cups and respective lid - being produced*
  - in large quantities (400.000 units produced per machine/day)
  - with a fixed product flow and small variations
  - with a high production rate
  - using 32 cavity moulds, 6,5 – 7 sec cycle



Injection Moulding

- *Objectives*
  - *to **reduce production stoppages** and*
  - ***decrease** the **waste** of raw material (mainly caused by height deviation from nominal values in produced capsules)*

- Considered steps
  - **Exploit** the data coming from the injection moulding machines, possible additional sensors and from the ***inspection system*** (*properly updated to collect information useful for predictions*)
  - **predict** equipment/process **deviations** that impact the quality of manufactured capsules
  - **predict capsules quality** as binary classification (high/low quality)
  - **trigger** relevant actions to correct the problems

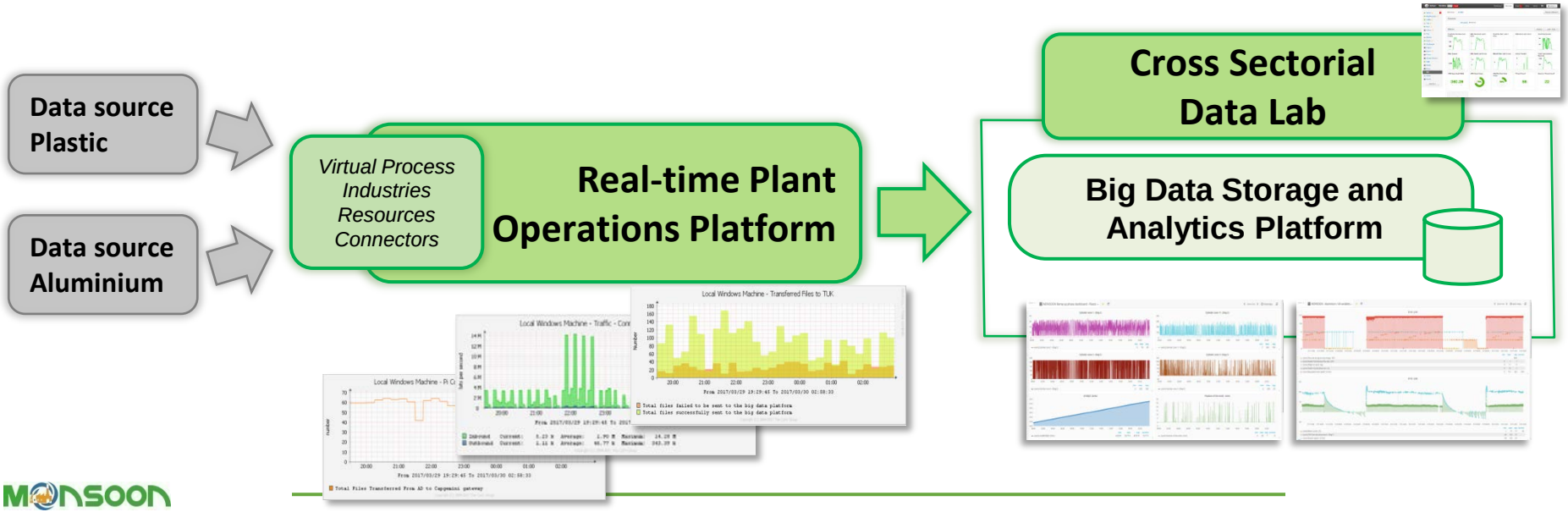


FIRST ACHIEVEMENTS

Ramp up phase

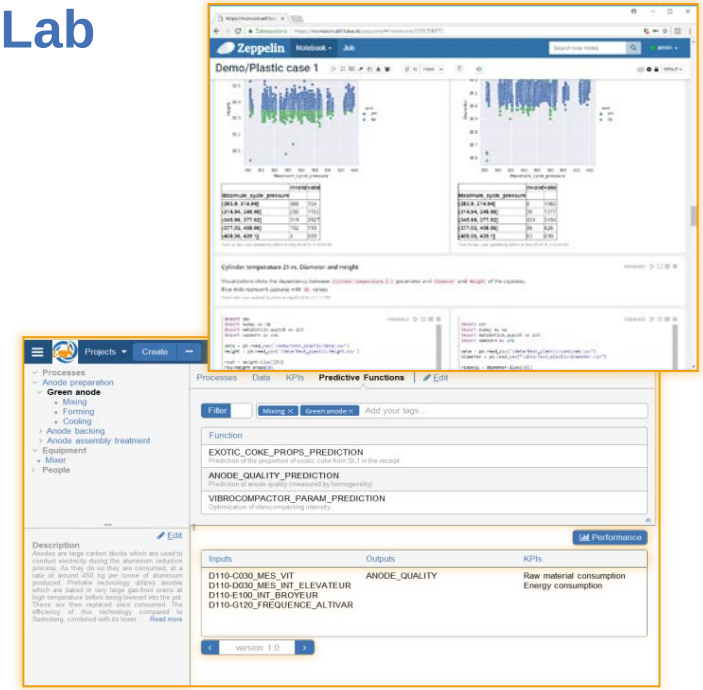
****** Data driven approach ******

- MONSOON **Data Collection** and **Monitoring infrastructure** installed in real environment, also supporting interoperability between heterogeneous plant systems, sensors and actuators
- Initial **Cross Sectorial Data Lab** – big data storage and analytics platform and GUIs presenting observed data



Cross Sectorial Data Lab

- First release of the **Big Data Storage and Analytics Platform**, adopting and extending **open source solutions**
  - KairosDB (time series query engine), Cassandra (distributed database) and Grafana
  - Python tools for **data analytics** (SciKit learn, Xgboost, LIME, …)
  - Apache Zeppelin – **collaborative development environment** customized and extended for Docker environment, i.e. scripts edited in Zeppelin are running in Docker container connected to Big Data storage
- **Semantic Framework** to simplify communication between the domain experts and data scientists across different domains.



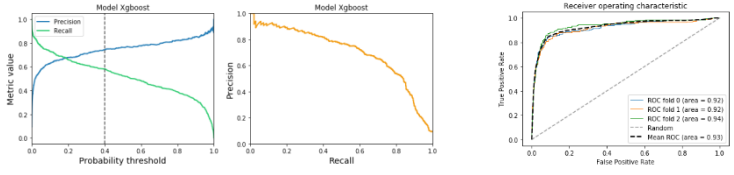
- 1x server 16 logical CPU cores, 84 GB operating memory, 450 GB local drive mapped to the host physical drive
- 7.6 TB network attached drive
- 1x 1Gbps virtual network interface (VNIS)

Online and deep machine learning solutions

Anode quality

- A machine learning **model** classifies 30 minutes periods of anode production as **high** or **low quality**, using only **process data** (51 variables)

*- Identification (with the help of process experts) of possible new **causes** of abnormal anode quality and relevant **actions** to correct/mitigate the issues*



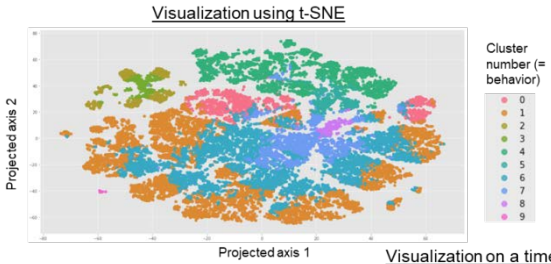
The model has been deployed and connected to real data flow

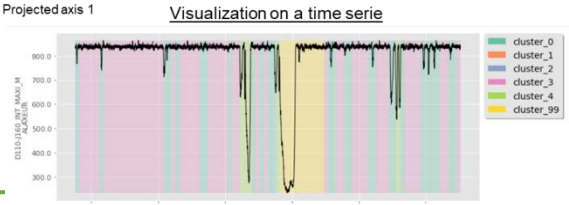
Anomalies in the paste plant

- Unsupervised machine learning techniques (**clustering**) have been used to identify the different **behaviours** of the paste plant equipment

- Preliminary analysis for BUSS mixer proved to be valuable

Insights about several BUSS mixer behaviours

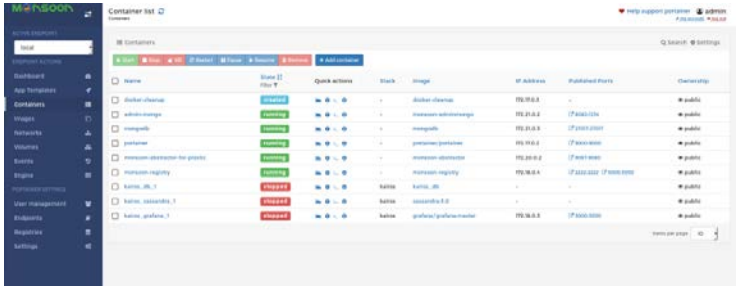




Enabling easier and faster deployment to the field

- **Runtime Container** – ICT infrastructure (*based on Docker technology*) supporting more easily and quickly deployment to the real environment of **predictive control functions** and **LifeCycle (LC) calculations** designed, developed and tested in the **Cross-Sectorial Data Lab** (MONSOON model based development environment)

  - **Executes** at **runtime** model based predictive control functions and LC online calculations
  - Ensures proper deployment, execution and **access** to relevant **industry resources**, **data** from sensors, actuators and sub-systems
  - **Manages** the **life cycle** of predictive control functions and LC online calculations
  - Provides **data visualization solutions** and **dashboards** embedded on the Plant Platform, also displaying predictive alerts



additional results are still to come!!

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DIGITIZED OPERATIONS for SUSTAINABLE PROCESS INDUSTRIES

FREE ATTENDANCE
REGISTRATION REQUIRED!!

DECHEMA - Frankfurt am Main, Germany

18 October 2018, 9:30 – 20:00

Participation of A.SPIRE, EFFRA and
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Sustainable Process Industry through Resource and Energy Efficiency