BE in CPPS

Business Experiments in Cyber Physical Production Systems

Sergio Gusmeroli
sergio.gusmeroli@polimi.it

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CPPS-driven Products, Processes, Business

BE in CPPS

Smart Products > **Intelligent** Processes > **Digital** Business

Develop faster, develop better.
CPS production solutions.

Become a **CPS Manufacturing SME.**

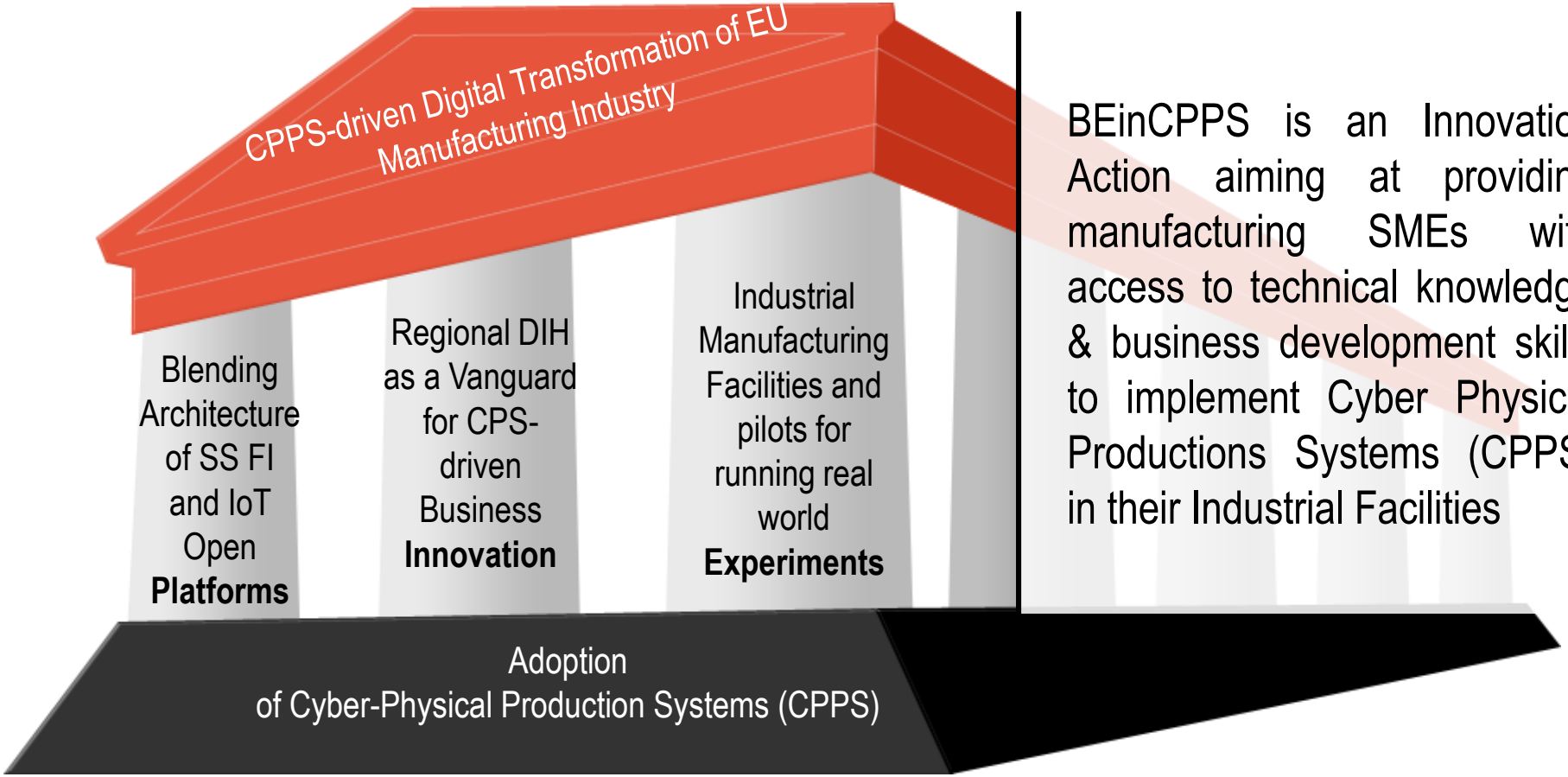
The BEinCPPS I4MS European Project

Factories of the Future obj. 9: ICT Innovation for Manufacturing SMEs;
Budget: EUR 8,000,000; **Open Calls for DIH & SMEs: EUR 2,250,000**;
Start Date: November 1st 2015 – End Date: October 31st 2018
A Consortium of 23 partners performing CPPS experiments in 5 regions (Lombardia, Euskadi, Baden Württenberg, Norte, Rhône Alpes)

- **Phase I**: 5 Big Industrial Champions & value chain
- **Phase II**: Open Call for additional platform / app providers (800k for IT SMEs)
- **Phase III**: pan-EU Open Call for replications of champions (1.2M for Manufactur. SMEs)

Lombardia: Whirlpool, ENGINEERING, HOLONIX, AFIL Lombardia
Euskadi: innovalia ASSOCIATION, MAIER, MTC MAIER TECHNOLOGY CENTRE, TRIMEK METROLOGICAL ENGINEERING
Baden Württemberg: Fraunhofer IPA, JOHN DEERE, DFKI
Norte: inesc, KYAIA, ctcp centro tecnológico do calçado de portugal
Rhône Alpes: cea, Georges PERNOUD Le Groupe, Nissatech innovation centre, fortiss
FINCONS GROUP, ITI INSTITUTO TECNOLÓGICO DE INFORMÁTICA, hop ubiquitous, TTTech Ensuring Reliable Networks

Mission and Goals



BEinCPPS is an Innovation Action aiming at providing manufacturing SMEs with access to technical knowledge & business development skills to implement Cyber Physical Productions Systems (CPPS) in their Industrial Facilities

Regional **DIH** > A PPP for implementing Industrial Modernization (DIH I4MS Open Call)

Open **Platforms** > Fast Development of CPPS applications (Open Call I)

Industrial Manufacturing **Pilots** > Lead by Example, replication and extension (Open Call II)

Basic Idea: 5 (+11) Regional DIHs

2.000.000 €
30+
Experiments

Business Models
Training & Certification Programmes

> **SME-friendly** digital transformation

The 5 BEinCPPS regions expanded

Overview selected proposals

IoT/CPS

Robotics

HPC/Cloud-Based

Laser

November, 10th 2016

Mentoring/Coaching: Main Deliverables

a) A feasibility and readiness analysis report to become Regional Manufacturing DIHs in the field of CPS/IOT. (D1 M3);

b) A set of at least three awareness and training workshops and seminars in the regions with the participation of all the relevant stakeholders (D2 M5);

c) A final fully integrated social, business and technical sustainability plan for the establishment in the region of a CPS/IOT oriented RMDIH (D3 M6).

Introduction: How to implement a Digital Readiness Assessment?

At the company level

Industry 4.0 Readiness Self-assessment

An **on-line tool** to perform a quick **self-assessment** of the company **readiness** and to identify a migration strategy towards Industry 4.0.

Digital Readiness Assessment Maturity Model

An **in-depth** assessment of the current **digital readiness maturity level** along the main **manufacturing processes.**

At the regional level

Industry 4.0 Readiness Index

An Index to assess how **Regions** are prepared for **the Industry 4.0 revolution** and to evaluate their positioning with respect to EU Member States they belong to.

Evolution of Digital Open Platforms

- WP2.2 Internet of Things Platforms federation

OPENIoT homard OMA Resources Dashboard → IoT OPEN PLATFORMS

IoT European Platforms Initiative

- WP2.3 Future Internet Platforms federation

FIWARE For Industry ITMAN → FIWARE FOUNDATION

- WP2.4 Smart Systems Platforms federation

CPSE Labs CRYSTAL → SAE SmartAnythingEverywhere

Evolution of BEinCPPS architecture

CLOUD LEVEL

Ten Classes in Industrial IT Applications addressed (developed in the 5 ecosystems & Open Call I & Open Call II)

FACTORY LEVEL

Event-Service Interoperability infrastructure for Real-Digital World Integration with Legacy Systems at Enterprise Level

FIELD LEVEL

Retrofitting existing Factory Automation systems to CPPS: Embedded Intelligence; Smart Communication; Real World Sensing

CPPS MODELS

CPS-driven **Business Modelling**

CPS-driven **System Modelling**

CPPS Modelling & Simulation suite the Virtual Factory (Digital Twin)

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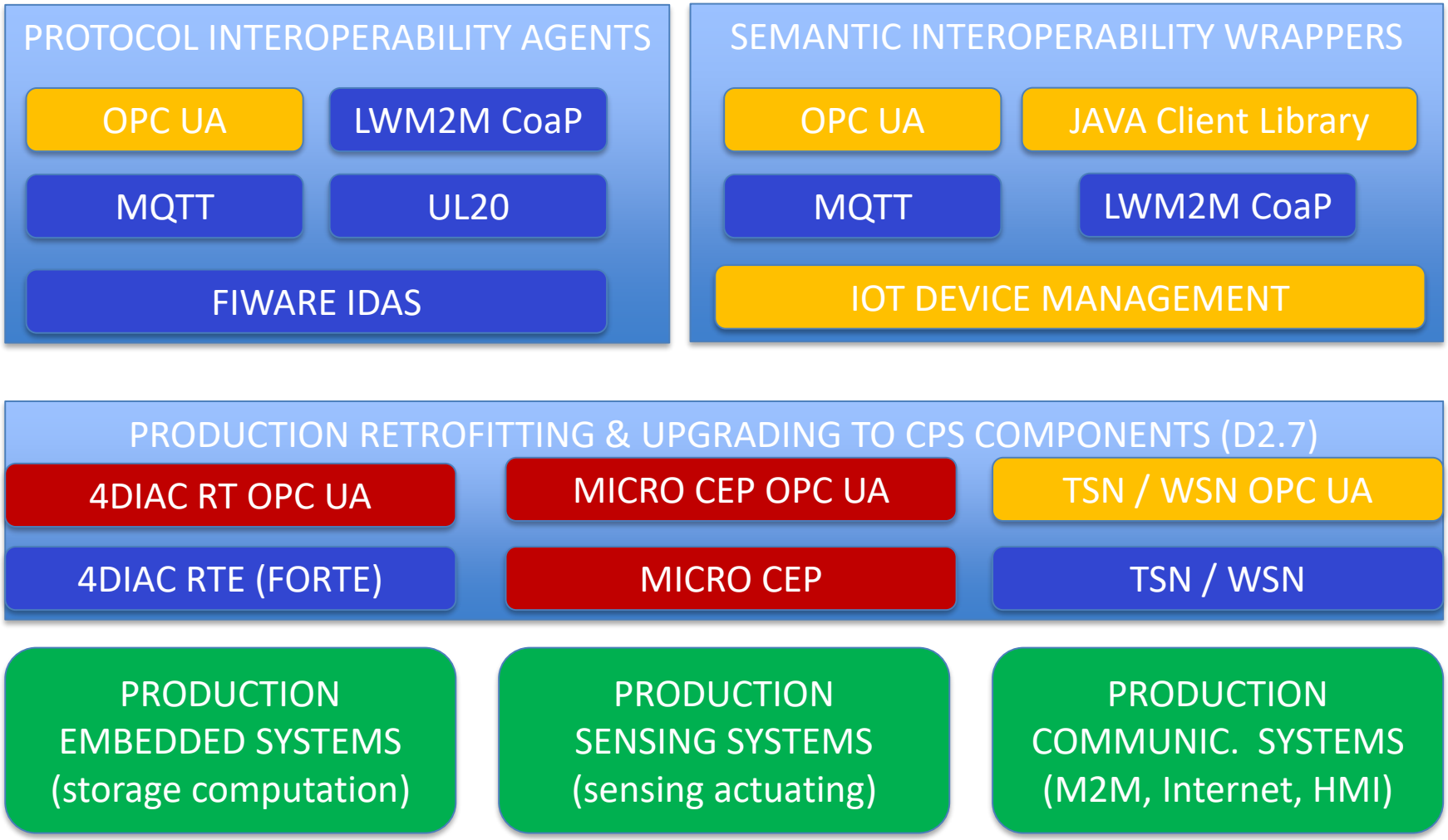
BUSINESS MODELLING and ENGINEERING TOOLS

- MSEE BSM GRAI GRID & ECOGRAI PIs
- MSEE BSM EXTENDED ACTIGRAM
- PAPYRUS REQUIREM. ENGINEERING
- PAPYRUS BPMN 2.0

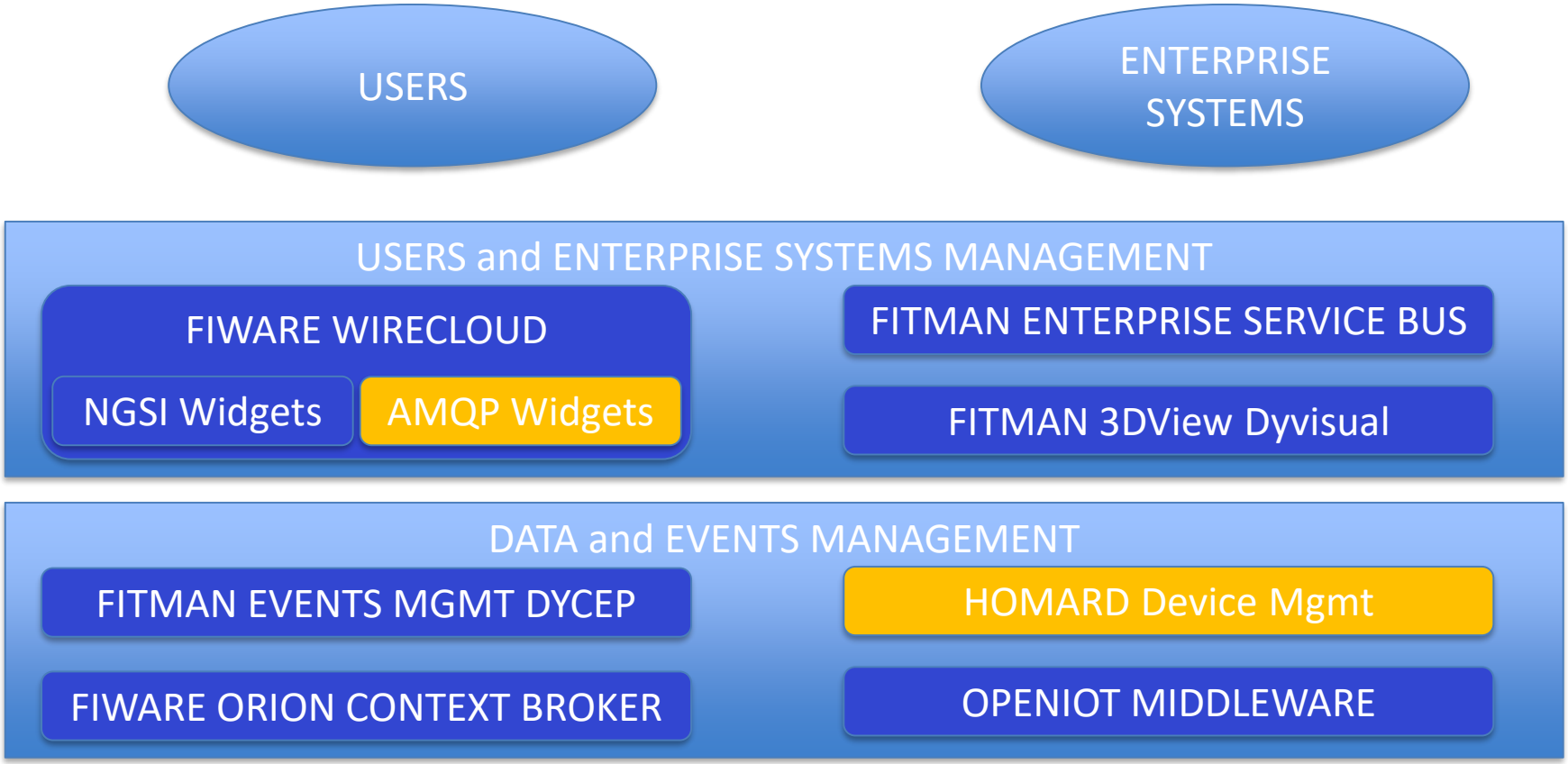
EMBEDDED SYSTEMS MODELLING and SIMULATION TOOLS

- 4DIAC DISTRIBUTED SYSTEMS
- UaMODELLER OPC UA DATA
- DAEDALUS
- CRYSTAL IoS

FIELD Level Architecture



FACTORY Level Architecture



CLOUD Level Architecture

BEinCPPS APPLICATIONS and DECISION SUPPORT SERVICES

- 1 Data Analytics for Production Systems Opt. & Maintenance
- 2 Production System Design and Ramp-up Process
- 3 Energy & Waste Management in Production Systems
- 4 Zero Defect Manufacturing & Quality Assurance
- 5 Factory raw & finite goods Storage & Logistics
- 6 Smart Workplaces, Training & Human Machine Interaction
- 7 Product Lifecycle & End of Life Management
- 8 Sensors Data Acquisition and Decisional Support

CPPS DATA ANALYTICS SUITE

- FIWARE COSMOS SUITE
- D2LAB SUITE
- Open API / Interfaces

CPPS MONITORING SUITE

- HOMARD IOT MGMT
- iLIKE THINGS LIFECYCLE
- Open API / Interfaces

CPPS COLLABORATION SUITE

- FITMAN ASSETS MGMT
- VIRTUAL OBEYA
- Open API / Interfaces

Open Call I: Winners

BEinCPPS Open Call I Objectives	WINNERS
1 Big Data for maintenance, optimization	1 CPPLEAN (#7 SPAIN) Own Experimental Facility 2 PMEinCPPS (21 PORTUGAL) NORTE Experimental Facility
2 Production Process Ramp-up	3 SmartPlantOne (#2 ITALY) EUSKADI Experimental Facility
3 Energy Efficient Manufacturing	4 E3ARM (#13 ITALY) Own Experimental Facility
6 Workplace, Training and HMI	5 KM Smart Glasses (#12 CZECH) BW Experimental Facility 6 ARWoS (#16 GERMANY) BW Experimental Facility
8 Sensors data acquisition and Mgmt	7 MStoCPPS (#14 GREECE) Own Experimental Facility 8 MO3Dlling (#10 SPAIN) RA Experimental Facility 9 PressNozz (#19 SPAIN) RA Experimental Facility 10 3D-RTM (#1 SPAIN) RA Experimental Facility

Open Call II: Equipment Experiments

BeinCPPS Call-2 (Nov 2nd – Dec 15th) targets the development of equipment assessment experiments by Manufacturing SMEs.

The objective is to carry out **innovative experiments in CPPS-based manufacturing facilities** provided by the applicants themselves and **based on HW/SW components of the BEinCPPS reference architecture**.

The open call aims at addressing **different industrial sectors or business cases** with respect to the 5 BEinCPPS Industrial Champions.

The presence in the proposing small consortium of a Manufacturing SME providing the experimentation facilities is mandatory.

Open Call II: Equipment Experiments I

1. **CPS-based Product Lifecycle and End-of-Life Management**. The Cyber and the Physical components of a **CPPS artefact (Product)** are characterised by quite different lifecycles, especially in the End of Life phase where the huge investments in CPPS could be partially recovered. Applicants are expected to propose their own experiments in this domain as well as providing the availability of the relevant CPPS manufacturing facility. Current BEinCPPS experimentations are located in the Rhone Alpes industrial champion in the moulds industry.
2. **CPS-based Factory Logistics Management**. CPPS play a fundamental role in the factory internal logistics: innovative experiments need to be developed specifically for planning, scheduling and monitoring **raw materials and finite products** inside the production system. Applicants are expected to propose their own experiments in this domain as well as providing the availability of the relevant CPPS manufacturing facility. Current BEinCPPS experimentations are located in the BEinCPPS Norte industrial champion in footwear

Open Call II: Equipment Experiments II

3. **CPS-based Zero Defect Manufacturing**. Innovative product quality assessment experiments are now enabled by CPS-based intelligent **metrology and quality assessment** systems. Applicants are expected to propose their own experiments in this domain as well as providing the availability of the relevant CPPS manufacturing facility. Current BEinCPPS experimentations are located in the Lombardia in the white goods industry.
4. **CPS Predictive maintenance.** The adoption of CPS in manufacturing systems is generating huge amounts of data which require specific analytics techniques and tools. Equipment **condition monitoring, diagnosis and predictive maintenance** experiments are therefore enabled by this huge availability of shop floor data. Applicants are expected to propose their own experiments in this domain as well as providing the availability of the relevant CPPS manufacturing facility. This aspect is not covered by any BEinCPPS experimental facility.
5. **CPS Modelling and simulation.** During the whole lifecycle of a CPS-based production system, since its design-engineering till to its renovation-dismantling, there is a need for **advanced modelling and simulation** environments to generate the so-called digital twin and to simulate several different what-if scenarios. Applicants are expected to propose their own experiments in this domain as well as providing the availability of the relevant CPPS manufacturing facility. This aspect is not covered by any BEinCPPS experimental facility.

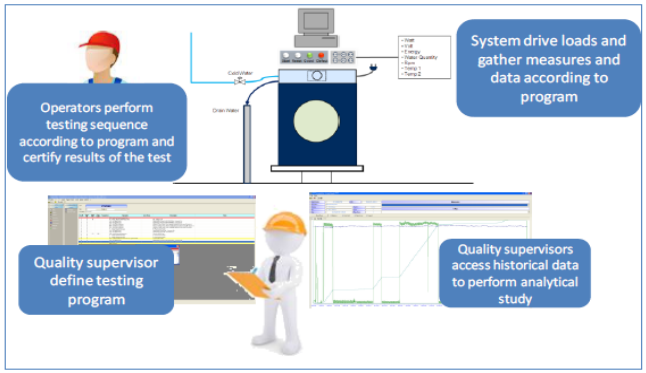
BEinCPPS Industrial Champions: Whirlpool Lombardia

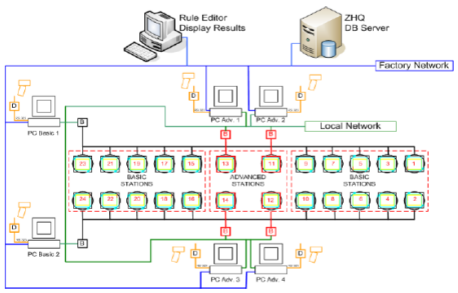
Washing Machines: Statistical Zero Defect Quality Control system

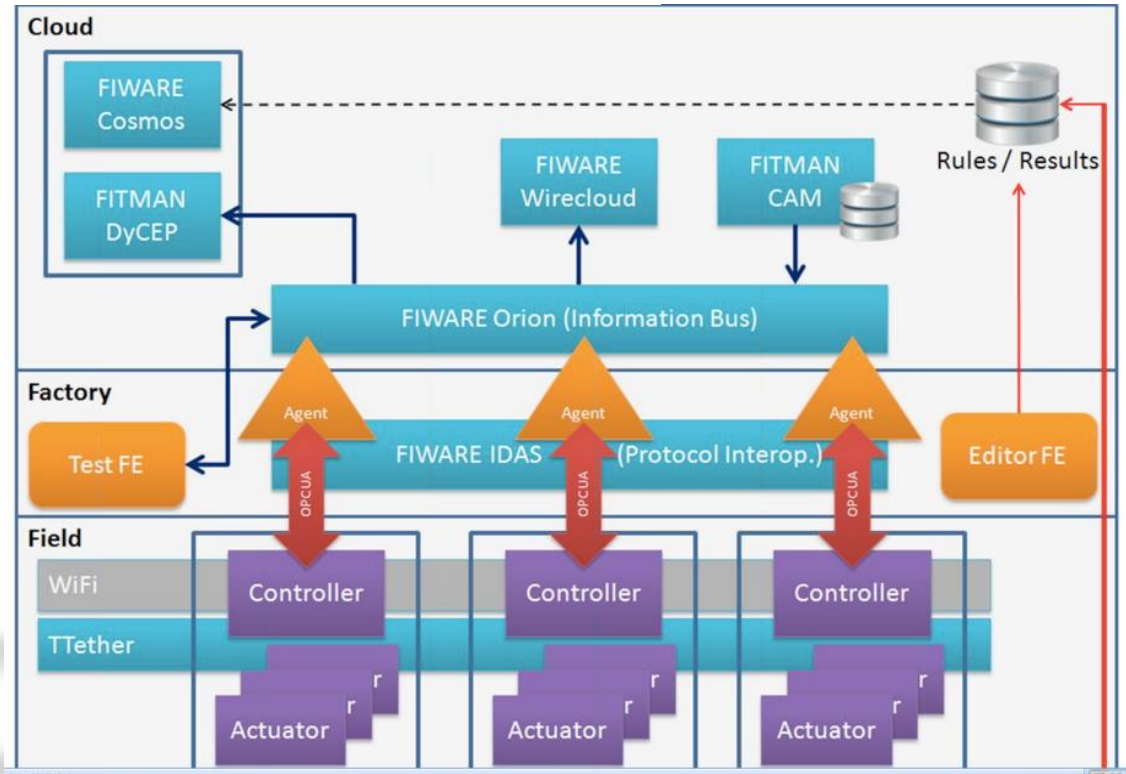
In ZHQ department, Statistical Quality Control simulates the first usage of Whirlpool products at the customer's premises. Quality operators connect the appliances to be tested to the testing stations, which activate a test program automatically enacting product standard functioning cycle and measure states and performance data of the appliance. ZHQ IT system guides the quality operators during visual inspection of the appliance and gathering of test results. Test results data are stored in a central repository, supporting Quality Managers.

The ZHQ system provides four basic functions:

1. **Programmability**: sequence of tests can be programmed by quality managers using a programming tool (Rule Editor) .
2. **Guided operations**: operators are instructed in real time to perform sequence of tasks to check and measure products (Rule Editor).
3. **Automatic I/O**: the product under test is interfaced both in input (actuators) and output (sensors) to change state and gather data (Box Handler) .
4. **Data management**: data are stored and available for immediate or historical analysis (Display Result).







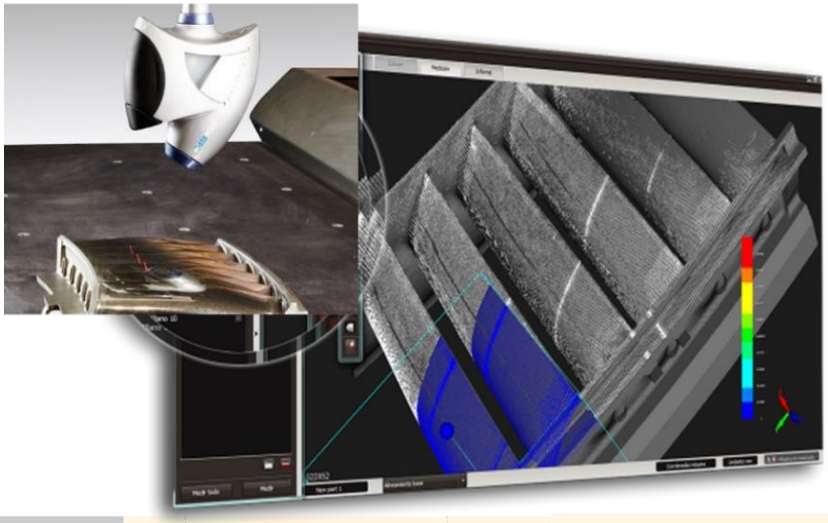
BEinCPPS Industrial Champions: Maier Euskadi

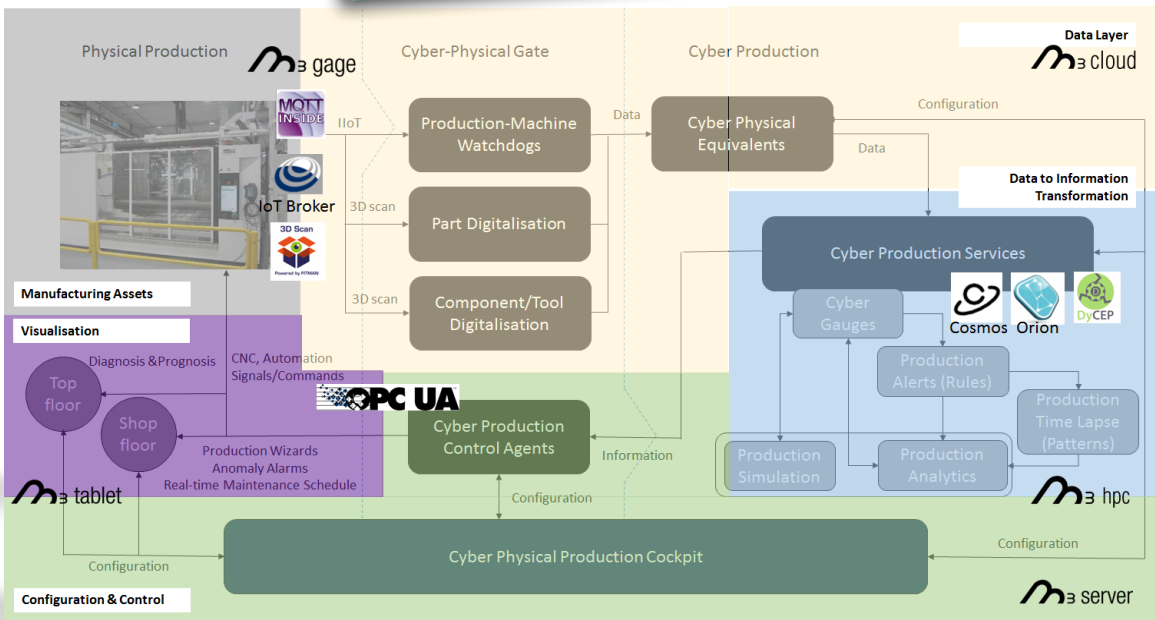
Plastic Components Industry: Manufacturing Process for Automotive Parts

The Euskadi Digital Innovation Hub has deployed the experimental facilities to experiment new technologies in the checking fixtures, used as a tool for **quality control in automotive part manufacturing**. The aim is to implement a **cyber-physical gauging system** based on 3D digitalisation technologies and 3D point cloud analytics to reduce the complexity of checking fixtures

The BEinCPPS platform will allow a more efficient synchronisation and operation of the physical and cyber production operations. Inside the Measuring machines, the metrology software platform provides highly efficient and flexible **virtual part management** solutions for storage of massive 3D point cloud information and high performance exchange of virtual part information.

The software in combination with 3D optical scanner can be used to develop precise and accurate **point cloud images** that can then be converted to different 3D design and modelling software.





BEinCPPS Industrial Champions: John Deere Baden-Württemberg

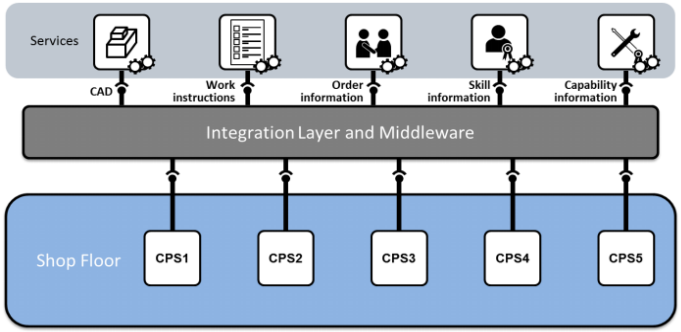
Agriculture Technologies: highly personalized cabin manufacturing, manual final assembly

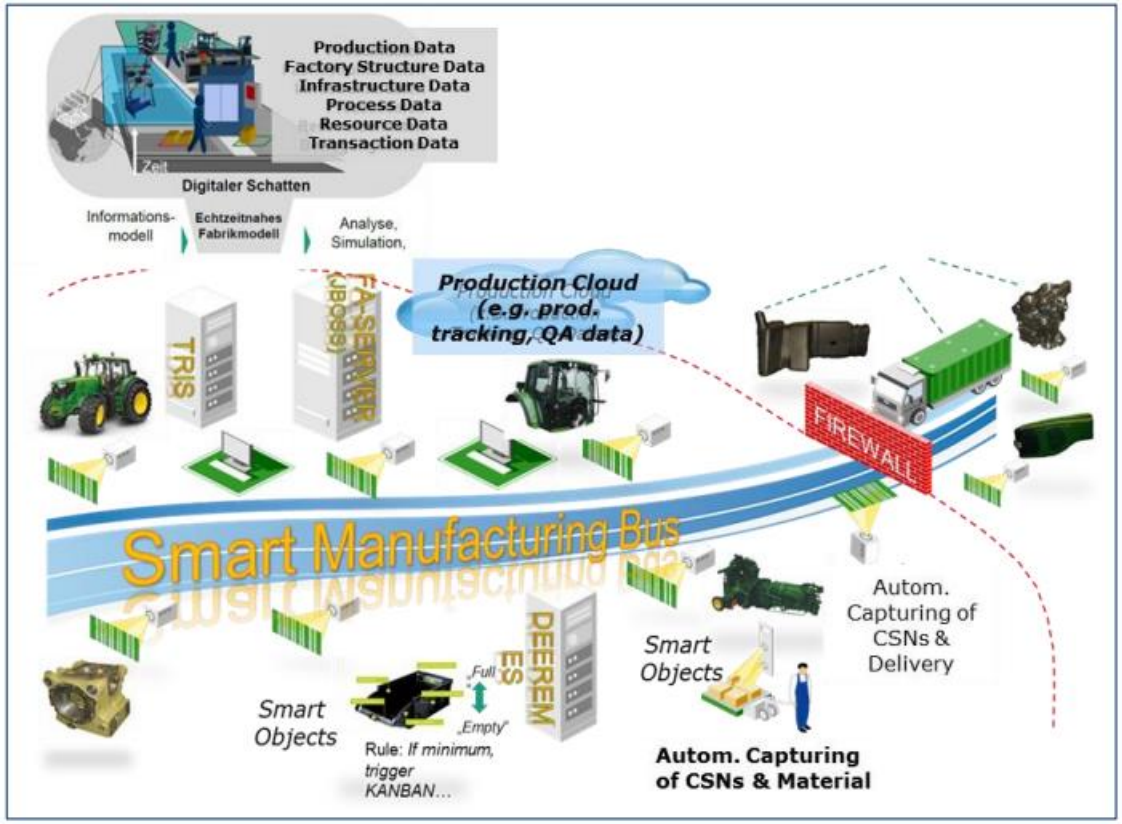
Through the BEinCPPS project John Deer wants increase efficiency by further digitizing their manufacturing processes. With BEinCPPS John Deere will focus on a better **integration of workers** in the value adding process by promoting flexibility to allow for easier customization of manufactured parts.

This will be achieved by providing workers with automatically generated order and worker specific instructions produced by information generated on the enterprise resource planning level.

Specifically at John Deere we will address:

1. The integration a connection of CPS to a smart manufacturing bus that will allow the exchange of data with IT services.
2. The integration of legacy IT systems to allow these to cooperate and communicate with new CPS systems.
3. Reduction of manual labor and quality of worker guidance improved through the integration data produced at the ERP level (design department and order management) to the shop floor level.





BEinCPPS Industrial Champions: KYAIA Portugal Norte

Footwear Manufacturing: High Speed Shoe Factory automation and control

KYAIA aims to improve its **production flexibility** to allow it to respond to customer orders and customization requests in a quick and agile way. This will be achieved by automating multiple systems related to production logistics and the companies ERP system. This automation will involve the connection of relevant sub-systems across all levels of production from machine processes up to production and logistics networks.

Specifically at KYAIA we will address:

- The integration of main factory elements (Internal logic system, working posts with related software based management systems) and the company ERP to allow autonomous cooperation among elements.
- Big data storage and usage that may be produced by the logic systems.
- The adoption of publish-subscribe broker that will mediate the flow of data between the PLC devices and planning, scheduling and control applications.
- The adoption of an event processor component able to analyze real time data generated by the PLC´s and to detect patterns that can result in new relevant production information that can aid in the development of a predicative maintenance system.

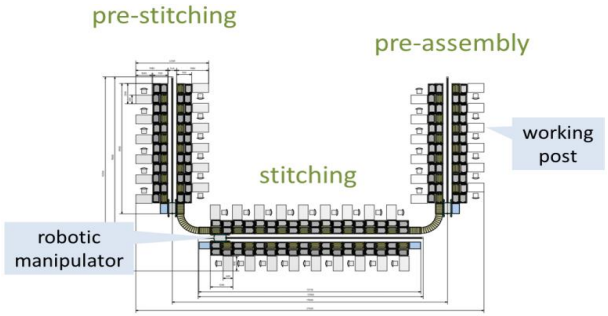
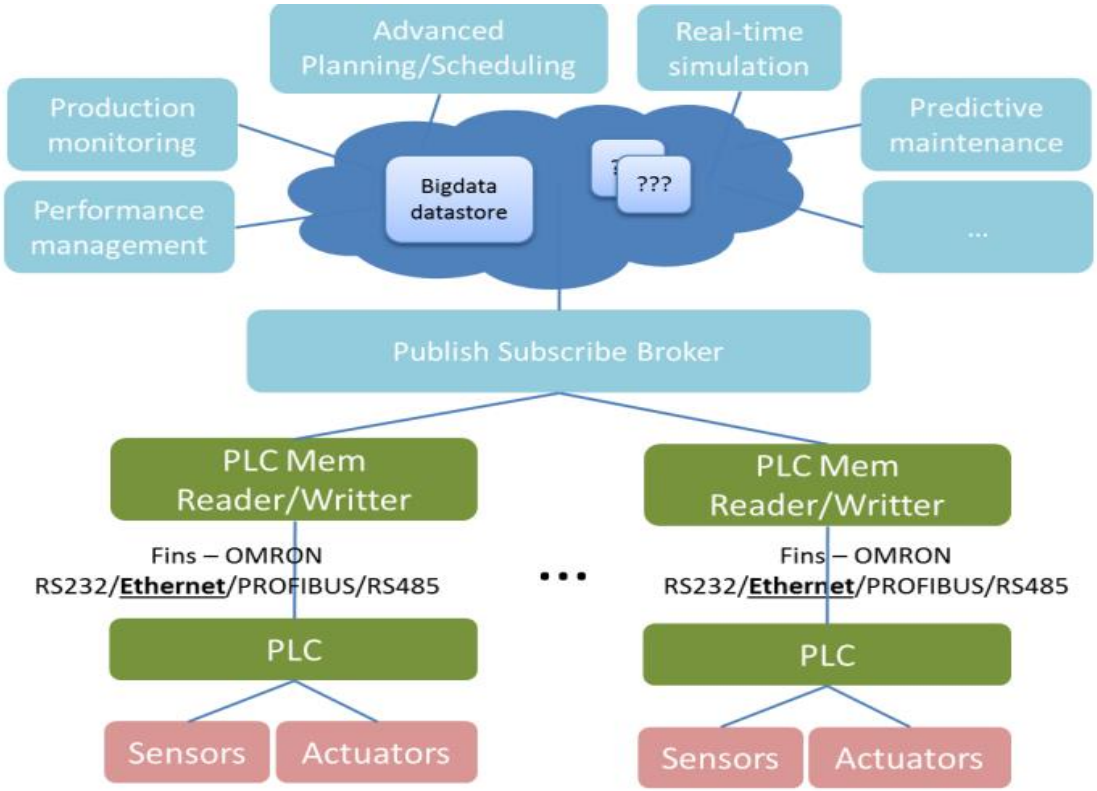


Figure 5- Stitching System: overview.

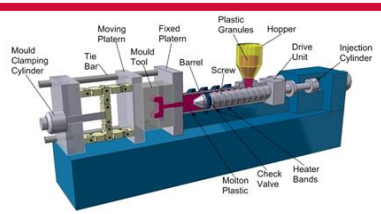


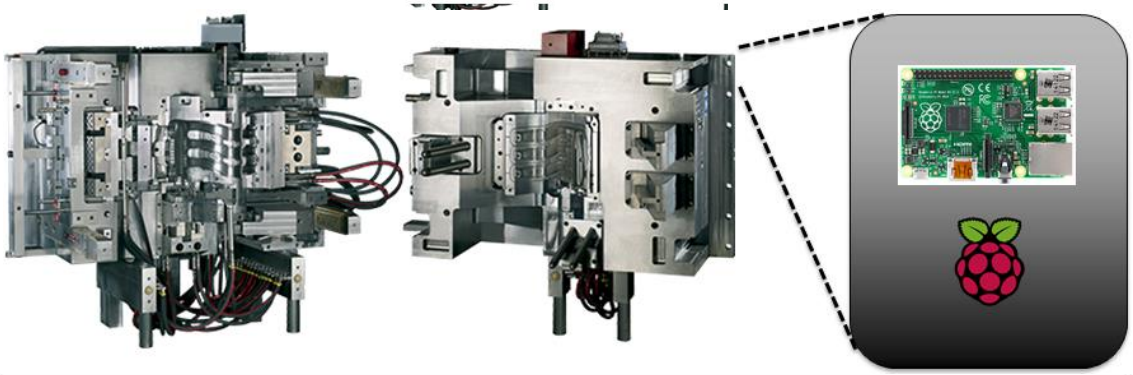
BEinCPPS Industrial Champions: Georges PERNOUD Rhône Alpes

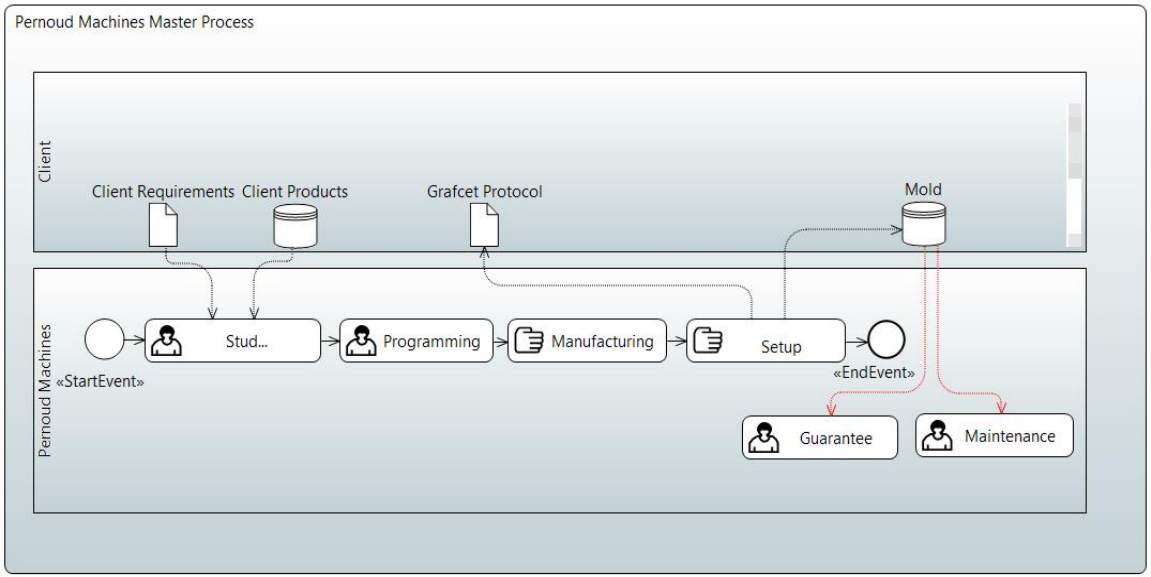
Moulds Manufacturer: high precision intelligent moulding

The objective for Pernoud Company is to add intelligence on plastic injection **steel molds** to transform this mechanical system in a CPS one, with an expectation of improving quality and reducing costs and delays of the part produced. To reach this goal we need a feedback from the mold to know what happened during the production. So to access to this information we need to instrument the mold with different embedded devices on it but also to directly have a look on that information any time it could be needed. Our first experiment is focusing on:

- Data acquisition with thermocouple: Monitoring environment conditions using a smart system and thermocouple sensors.
- Driving electrical actuators: The movement of the mold can be performed by electrical actuator. Those actuators will achieve flexibility levels not possible with standard hydraulic actuators.
- Cloud data monitoring: to store the data acquired during the utilization of the smart tool, the smart system is linked to a cloud and this cloud will allow an access to the entire life cycle of the tool from anywhere and at any time.







BEinCPPS Industrial Facilities: Smart Factory Kaiserslautern

Smart Factory KL 3 production lines

The first production line produces liquid soap which is processed, coloured, bottled and labelled according to the user's individual needs. Therefore the equipment is divided into a continuous batch process part being responsible for the production of the liquids, and a discrete bottling line for filling and handling the soap bottles. Each bottle has a product memory, which locally stores product and production information, being the first implementation of an intelligent product.

The **second production line** assembles consumer electronic products, such as handy flashlights, using service-oriented architecture principles for a decentralized CPS-based control of the manufacturing process. Moreover, approaches for orchestrating of services features by CPS components into meaningful production processes are demonstrated.

A **third production line** follows the "Plug&Produce" principle, to demonstrate the hot plugging of production modules from several distinct industrial partners. The independent modules are thereby fulfilling vendor independent standards defined by DFKI, which are based on widely accepted communication protocols. The production line includes also a technology-assisted manual workstation.

BEinCPPS Industrial Facilities: FoF Lab Milano (in 2017)

POLIMI FoF Lab at Bovisa Campus

The Milano FoFLab is currently under construction at Bovisa Campus of Politecnico di Milano. FoFLab will address the following processes:

- **Product LifeCycle** (from Customer to Design, from Design to Virtual Manufacturing, from Design to Recycle, Track&Tracing, Product life history).
- **Plant and Production Process Efficiency and Flexibility** (Production system flexibility: Semantic (re)configuration of production system, Mix flexibility), The production system as a product (Production system commissioning strategies, Production system lifecycle) and the Smart Factory enabling technologies (e.g. CPS – CPPS).
- **Sustainability and Energy and Resource Efficiency**.

The processes implemented include:

- Flow control (bar-code, RFId).
- Processing operations emulation or real.
- Final product assembly using robot.
- Quality control using optical camera.
- Intelligent handling system.
- MES software for production, orders monitoring.
- Energy consumption measurement and monitoring.