BE in CPPS

Business Experiments in Cyber Physical Production Systems

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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.
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 Württemberg, 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)
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)
Business Models
Training & Certification Programmes > SME-friendly digital transformation
The 5 BEinCPPS regions expanded

- 16 Glasgow
- 16 West IRL
- 11 Wales
- 18 Navarra
- 4 Rioja
- 7 IMR Ireland
- 13 South Coast
- 2 South OstroBothnia
- 17 North Denmark
- 8 Torun
- 19 Lviv

Overview selected proposals
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 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.

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.
Evolution of Digital Open Platforms

- WP2.2 Internet of Things Platforms federation

- WP2.3 Future Internet Platforms federation

- WP2.4 Smart Systems Platforms federation
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 Modelling & Simulation suite

#### the Virtual Factory (Digital Twin)

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<th>BUSINESS MODELLING and ENGINEERING TOOLS</th>
<th>EMBEDDED SYSTEMS MODELLING and SIMULATION TOOLS</th>
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<td>MSEE BSM, GRAI GRID &amp; ECOGRAI PIs</td>
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<td>PAPYRUS REQUIREM. ENGINEERING</td>
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<td>PAPYRUS BPMN 2.0</td>
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FIELD Level Architecture

**PROTOCOL INTEROPERABILITY AGENTS**
- OPC UA
- LWM2M CoaP
- MQTT
- UL20
- FIWARE IDAS

**SEMANTIC INTEROPERABILITY WRAPPERS**
- OPC UA
- JAVA Client Library
- MQTT
- LWM2M CoaP
- IOT DEVICE MANAGEMENT

**PRODUCTION RETROFITTING & UPGRADING TO CPS COMPONENTS (D2.7)**
- 4DIAC RT OPC UA
- MICRO CEP OPC UA
- TSN / WSN OPC UA
- 4DIAC RTE (FORTE)
- MICRO CEP
- TSN / WSN

**PRODUCTION EMBEDDED SYSTEMS**
(storage computation)

**PRODUCTION SENSING SYSTEMS**
(sensing actuating)

**PRODUCTION COMMUNIC. SYSTEMS**
(M2M, Internet, HMI)
FACTORY Level Architecture

USERS
- FIWARE WIRECLOUD
  - NGSI Widgets
  - AMQP Widgets

ENTERPRISE SYSTEMS
- FITMAN ENTERPRISE SERVICE BUS
  - FITMAN 3DView Dyvisual
- FITMAN EVENTS MGMT DYCEP
- HOMARD Device Mgmt
- FIWARE ORION CONTEXT BROKER
- OPENIOT MIDDLEWARE
- FIWARE WIRECLOUD
- FITMAN ENTERPRISE SERVICE BUS
- FITMAN 3DView Dyvisual
- NGSI Widgets
- AMQP Widgets

USERS and ENTERPRISE SYSTEMS MANAGEMENT

DATA and EVENTS MANAGEMENT
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

November, 10th 2016
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<th>BEinCPPS Open Call I Objectives</th>
<th>WINNERS</th>
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| 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 MO3DIlng (#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.
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 experimentationations 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 experimentationations are located in the BEinCPPS Norte industrial champion in footwear.
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.
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).
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.
Agriculture Technologies: highly personalized cabin manufacturing, manual final assembly

Through the BEinCPPS project John Deere wants to 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.
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.
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.
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.
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.