D 3.2
Digital Transformation Pathway Cases and European demonstration Infrastructure – First Iteration

Action acronym	ConnectedFactories 2
Action Full Title	Global-leading smart manufacturing through digital platforms, cross-cutting features and skilled workforce
Grant Agreement Number	873086
Instrument	CSA: Coordination and Support Action
Project coordinator	VTT

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Deliverable Title	Digital Transformation Pathway Cases and European demonstration Infrastructure – First Iteration
Lead Beneficiary	INNOVALIA
Work package	3
Work package leader	INNOVALIA
Dissemination level[1]	PU
Type[2]	OT
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Actual submission date	[Submission date]

[1] PU: Public, CO: Confidential, only for members of the consortium (including the Commission Services)
[2] RE: Report, OT: Other; ORDP: Open Research Data Pilot

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Abbreviations and acronyms

TERMS, ABBREVIATIONS AND ACRONYMS	
KPI	Key Performance Indicator
DMP	Digital Manufacturing Platform
CSA	Coordination and Support Actions
WP	Work Package

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Executive Summary

The main intention of the catalogue 'Digital Transformation Pathway Cases and European demonstration Infrastructure' is to document the use cases and demonstrators generated by Industry 4.0 related research and innovation projects.

The catalogue includes of course use cases from the projects carried out under the call topic DT-ICT-07-2018-2019 (the same call topic to which the ConnectedFactories 2 CSA is associated), but the catalogue covers also use cases and demonstrators from other call topics within and beyond the Factories of the Future Partnership. Also, demonstrators developed by national-regional projects are included.

The collection of information and the mapping into the pathways developed by ConnectedFactories 2 builds on past work done at by EFFRA in relation to the project portfolio management of the Factories of the Future Partnership. Furthermore, it is supported by work done during the ConnectedFactories 1 CSA (Pathways, mapping framework in general with respect to digitalisation) and it builds on recent deliverables generated by ConnectedFactories 2 CSA.

The essential of the methodology of setting up the catalogue 'Digital Transformation Pathway Cases and European demonstration Infrastructure' is described in Deliverable 3.1 'Initial Scouting Collection and fine-tuned mapping methodology'. The supporting roles of other Deliverables and workshops organised by ConnectedFactories 2 with respect to the collection of information regarding uses cases and demonstrators are also described in this deliverable.

This work is related to Industry 4.0 research and innovation projects. However, due to the close relationship among the CSA ConnectedFactories 2 and the Innovation Actions projects of the same call DT-ICT-07 2018/2019, the main focus of this work was to get as much information as possible on those projects. To plan the work and to be able to monitor that the actions are having the expected effect, a series of KPIs have been proposed. These indicators are focused on monitoring the situations of the use cases related to the projects of the DMP Cluster call DT-ICT-07. KPIs focus on analysing: How many use cases each Project has, how many are presented in the **Catalogue available in the EFFRA Innovation Portal** and how many are well described and mapped according to the Pathways.

The catalogue is integrated into the EFFRA Innovation Portal, assuring a seamless integration with the processes that are in place to collect information from a broad range of projects. This is in particular relevant since almost all projects that are associated to the Factories of the Future Partnership involve the deployment and/or the development of digital technologies.

The work done by all different involved tasks of ConnectedFactories 2 will support the dissemination of information on innovation projects and encourage SMEs to access success stories and best practices. And specifically, this deliverable summarises in practical and easy way many different aspects of the work done not only as part of the WP 3, but also in the whole ConnectedFactories 2 project.

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1 Introduction

The main intention of the catalogue 'Digital Transformation Pathway Cases and European demonstration Infrastructure' is to document the use cases and demonstrators generated by Industry 4.0 related research and innovation projects.

The catalogue includes of course use cases from the projects carried out under the call topic DT-ICT-07-2018-2019 (the same call topic to which the ConnectedFactories 2 CSA is associated), but the catalogue covers also use cases and demonstrators from other call topics within and beyond the Factories of the Future Partnership. Also, demonstrators developed by national-regional projects are included.

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The essential of the methodology of setting up the catalogue 'Digital Transformation Pathway Cases and European demonstration Infrastructure' is described in Deliverable 3.1 'Initial Scouting Collection and fine-tuned mapping methodology'. The supporting roles of other Deliverables and workshops organised by ConnectedFactories 2 with respect to the collection of information regarding uses cases and demonstrators are also described in this deliverable.

The **catalogue is integrated into the EFFRA Innovation Portal**, assuring a seamless integration with the processes that are in place to collect information from a broad range of projects. This is in particular relevant since almost all projects that are associated to the Factories of the Future Partnership involve the deployment and/or the development of digital technologies.

2 Methodology/approach

2.1 Essentials

The essential of the methodology of setting up the catalogue ‘Digital Transformation Pathway Cases and European demonstration Infrastructure’ is described in Deliverable 3.1 ‘Initial Scouting Collection and fine-tuned mapping methodology’. The table of contents is included here below

Figure 1: Essentials of the methodology – table of contents of Deliverable 3.1

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2.2 Associated recent deliverables

As part of the work related to the Catalogue ‘Digital Transformation Pathway Cases and European demonstration Infrastructure’, it is needed to map the use cases according to the pathways and identify cross-cutting factors. In the meantime, the following deliverables have provided more information about the development of the overall framework within which cases and demonstrators can be mapped:

- **D1.1 ‘Structured wiki update on Business models, Legal aspects, interoperability, standardization, Cybersec and Human aspects – First iteration’**
  - This deliverable describes the evolution of the structured lists that support the structured description of projects, project results and use cases/demonstrators.
  - This deliverable describes for instance the in-depth collection of information about standards that are relevant for the DT-ICT-07-2018-2019 projects with an initial mapping of the use of these standards on project level (see section 3.3 and Figure 2 below).

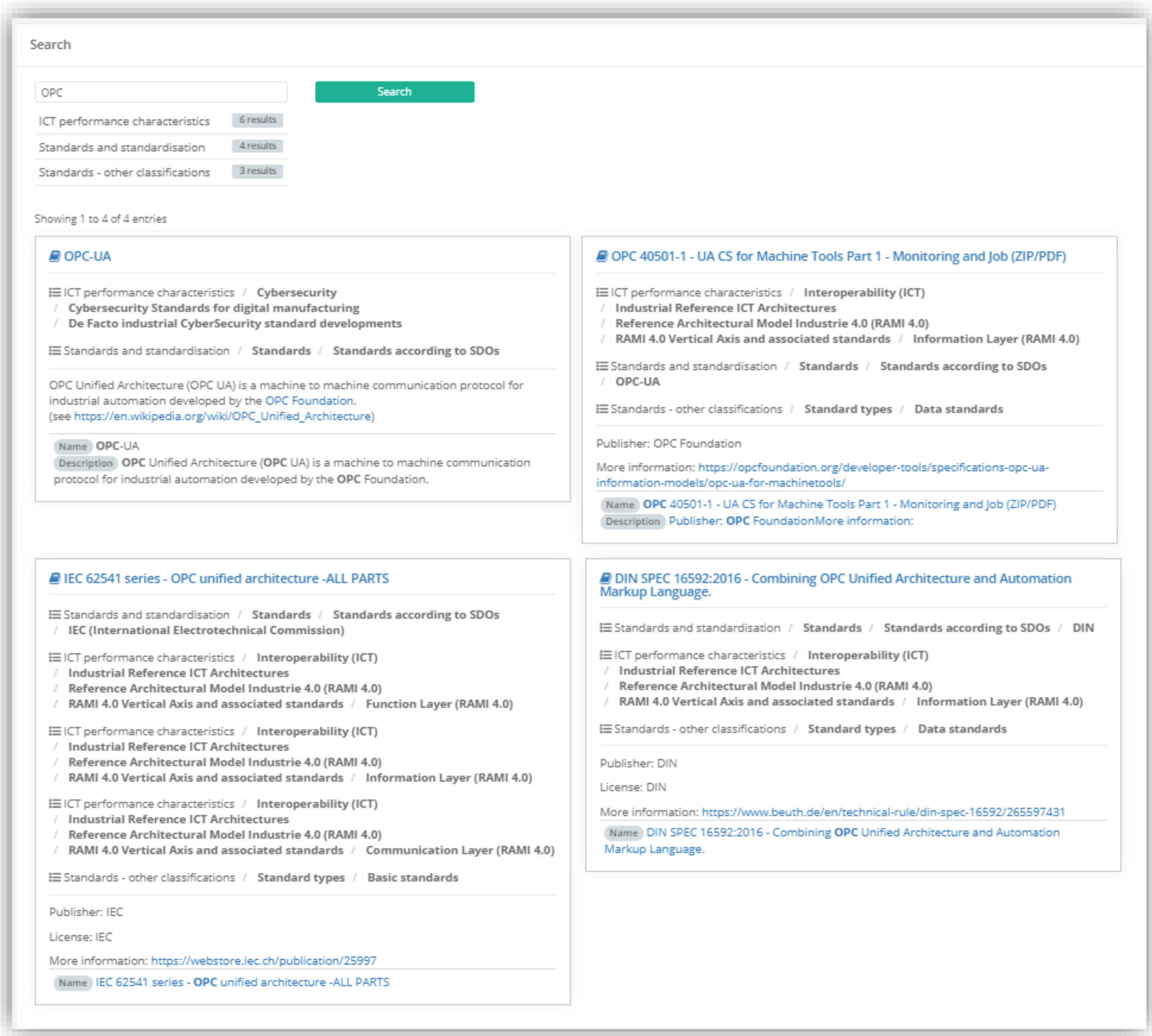

Figure 2: Screenshot of the search page of the wiki (searching for ‘OPC Unified’) showing indications of the standard type and situation of the standards within the RAMI 4.0 layers.

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- D1.2 **'Report summarizing main contributions to other WPs – First Iteration'**
  - This deliverable provides insight in cross-cutting aspects, such as cybersecurity, standards, interoperability, skills aspects, business model aspects and legal agreements and provides pointes to projects and their relation to these cross-cutting aspects.

- D2.1 **'Pathways instantiation from DT-ICT-07 domains – First Iteration'**
  - This deliverable aims to instantiate the Circular Economy pathway within the four domains of the DT-ICT-07 (i.e. (1) Agile Value Networks: lot-size one, (2) Excellence in manufacturing: zero-defect processes and products, (3) The human factor: human competences in synergy with technological progress, (4) Sustainable Value Networks: manufacturing in a circular economy) among which the DMP cluster was born.

- D2.2 **'Pathways cross-fertilisation with Digital Technologies – First Iteration'**
  - This deliverable is the first release of CF2 cross-fertilisation with new trends and roadmaps from the domain of Digital Technologies. It is concentrated on the so-called "Data Revolution", i.e., how Data Economy could affect and influence the business of Manufacturing companies and how the Manufacturing industry is ready to fully adopt the potential benefits of this revolution. It is also especially focused on AI, Cybersecurity and HPC/Cloud/Edge in line with the main technologies at the basis of next 2021-2027 Digital Europe Programme.

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3 Catalogue on EFFRA Innovation Portal

The catalogue is integrated into the EFFRA Innovation Portal, assuring a seamless integration with the processes that are in place to collect information from a broad range of projects. This is in particularly relevant since almost all projects that are associated to the Factories of the Future Partnership involve the deployment and/or the development of digital technologies. As described in Deliverable 1.1, the structured wiki within the EFFRA Innovation Portal serves also as a mapping framework for the structured description of project, project results and demonstrators.

This Catalogue will be launched on 7 June 2021, supported by an animated picture (see Deliverable 6.4). See the associated article on the Connected Factories website.

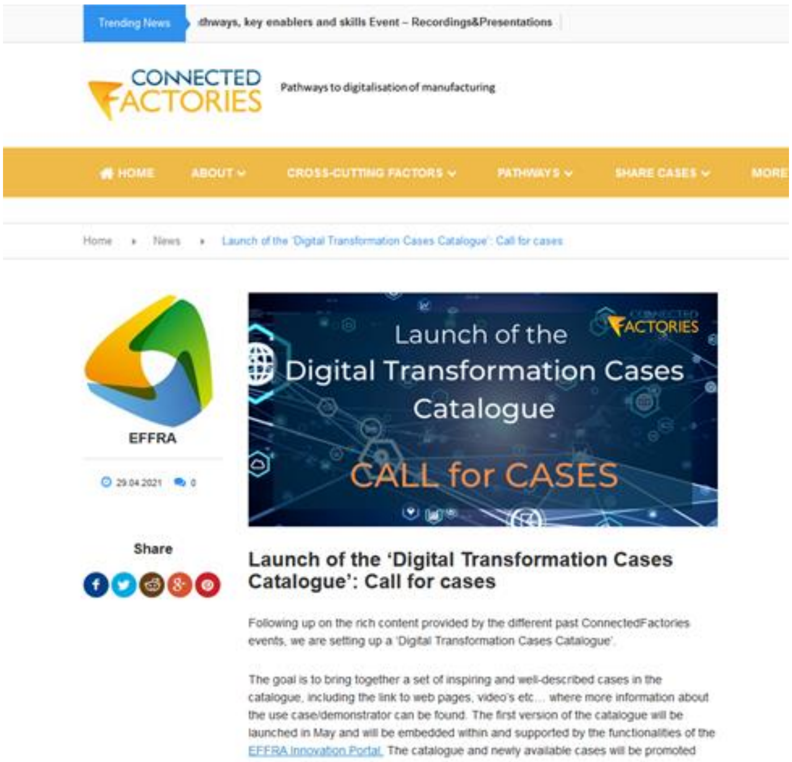

Figure 3: Launch of the Digital Transformation Cases Catalogue

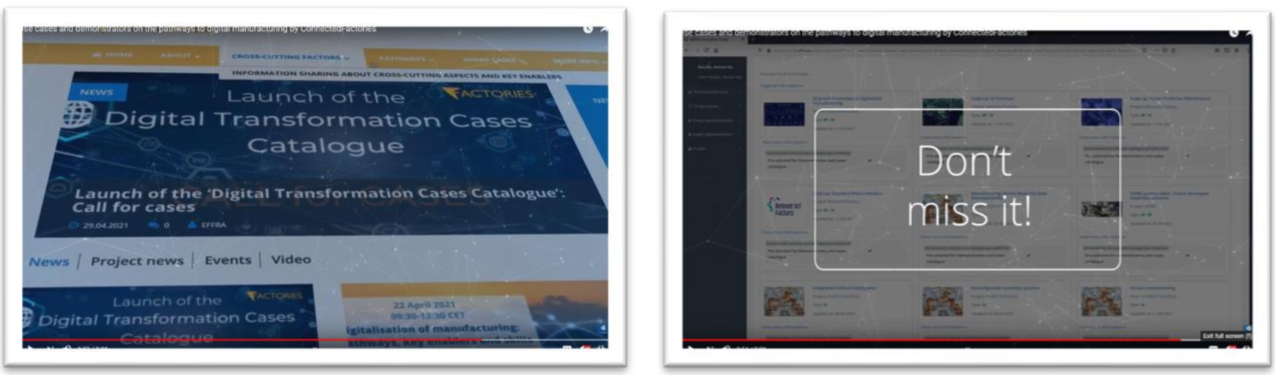

Figure 4: Screenshots from the animated picture that supports the launch of the catalogue

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Projects, results and use cases are indexed through any text field, including the structured lists. In addition, structured lists allow filtering of projects and results/demonstrators that have been explicitly assigned in structured lists (covering standards, business model aspects, pathways etc).

The EFFRA Innovation Portal, and therefore the ‘Digital Transformation Pathway Cases and European demonstration Infrastructure’ catalogue, allows specific searches on particular topics. For instance:

Demonstrators associated to the Smart Autonomous Factories Pathway:

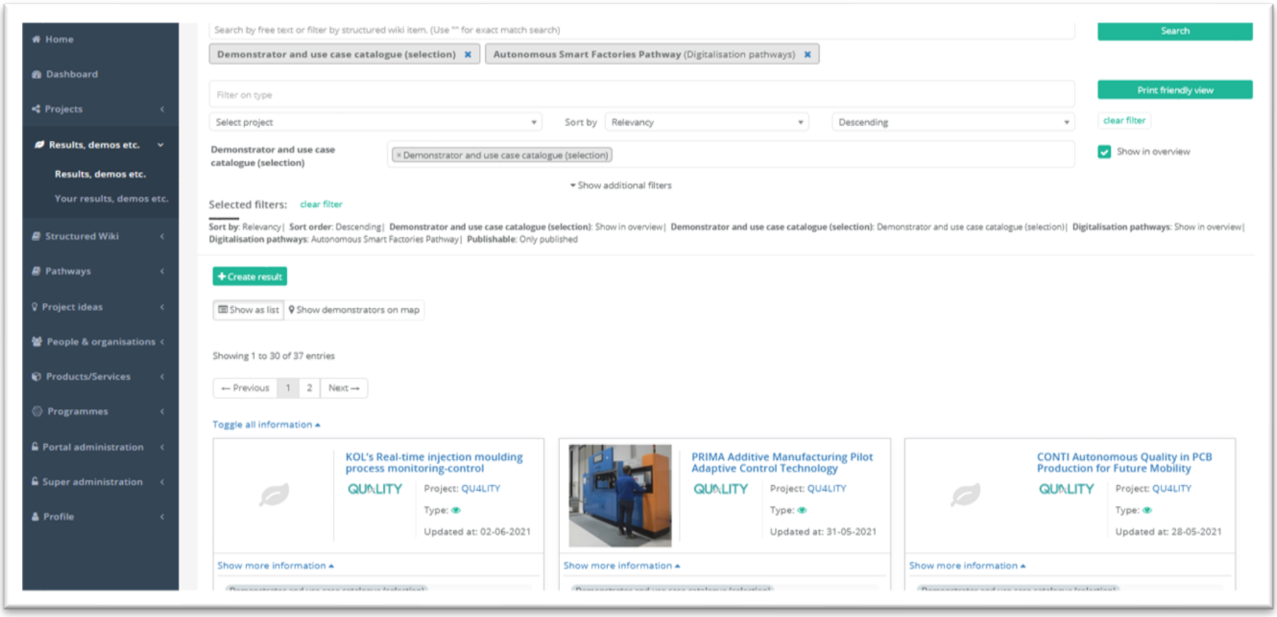

Figure 5: Filter on Catalogue - Smart Autonomous Factories Pathway (click picture to access)

Demonstrators associated to the Hyperconnected Factories Pathway:

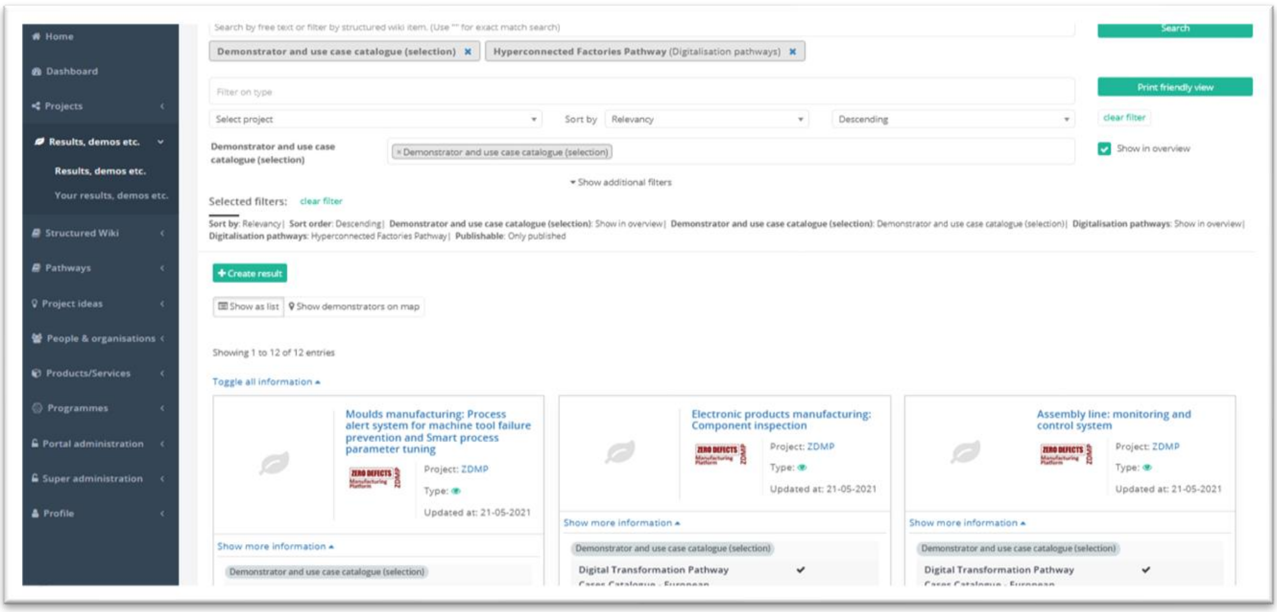

Figure 6: Filter on Catalogue – Hyperconnected Factories Pathway (click picture to access)

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Explanations on how to share information through the catalogue can be found in the video available in the link below. In addition, indications on how the Innovation Portal works, how to properly describe cases, search for information, etc. are mentioned.

- [Extracts from the presentations prior to the launch of the catalogue (from CF2 event on 22 April)]()

Below, you can find a series of screenshots of the explanations in the video. In them you can see important aspects about the Portal and the Catalogue.

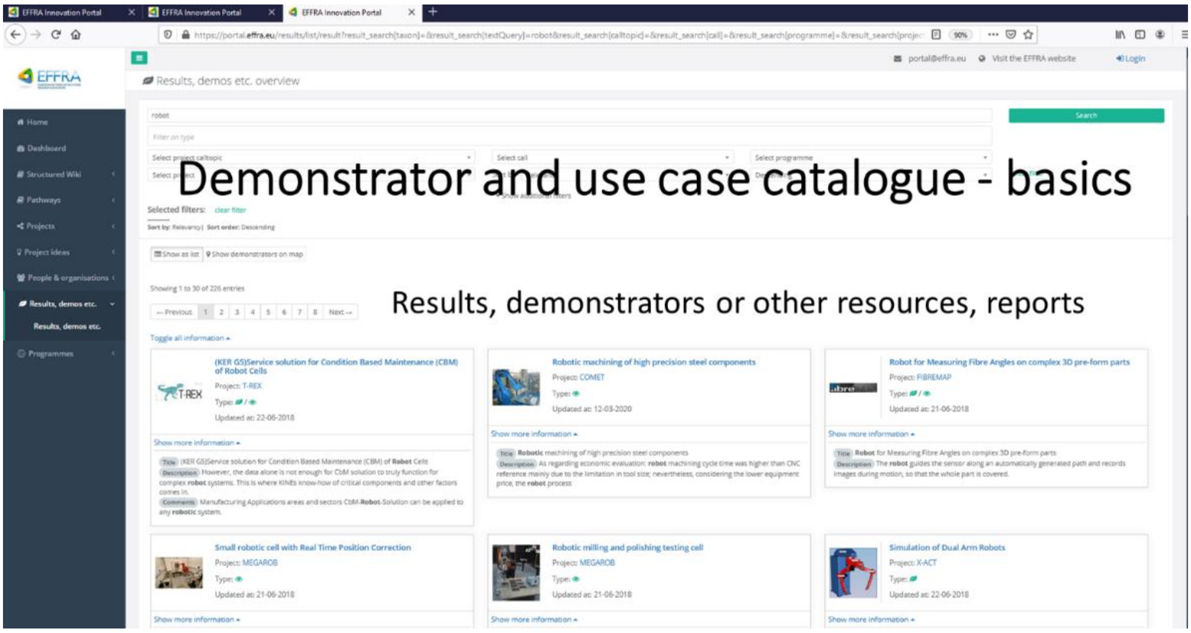

Figure 7:Demonstrator and use cases catalogue - basics

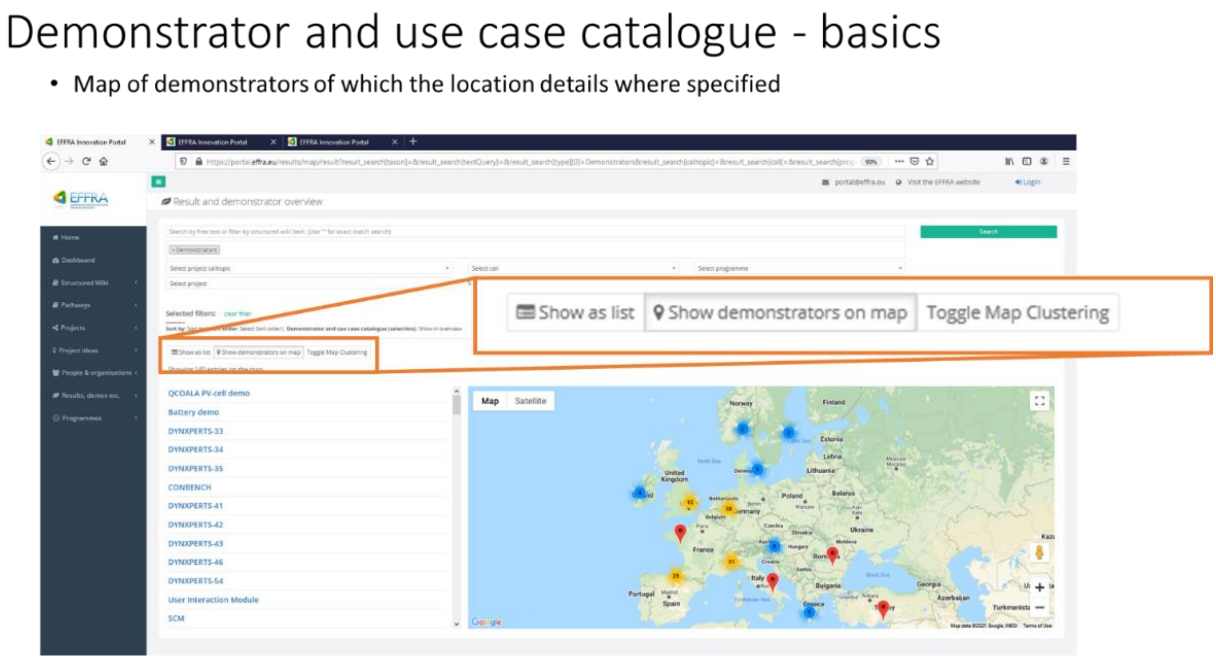

Figure 8: Map of Demonstrators and use cases

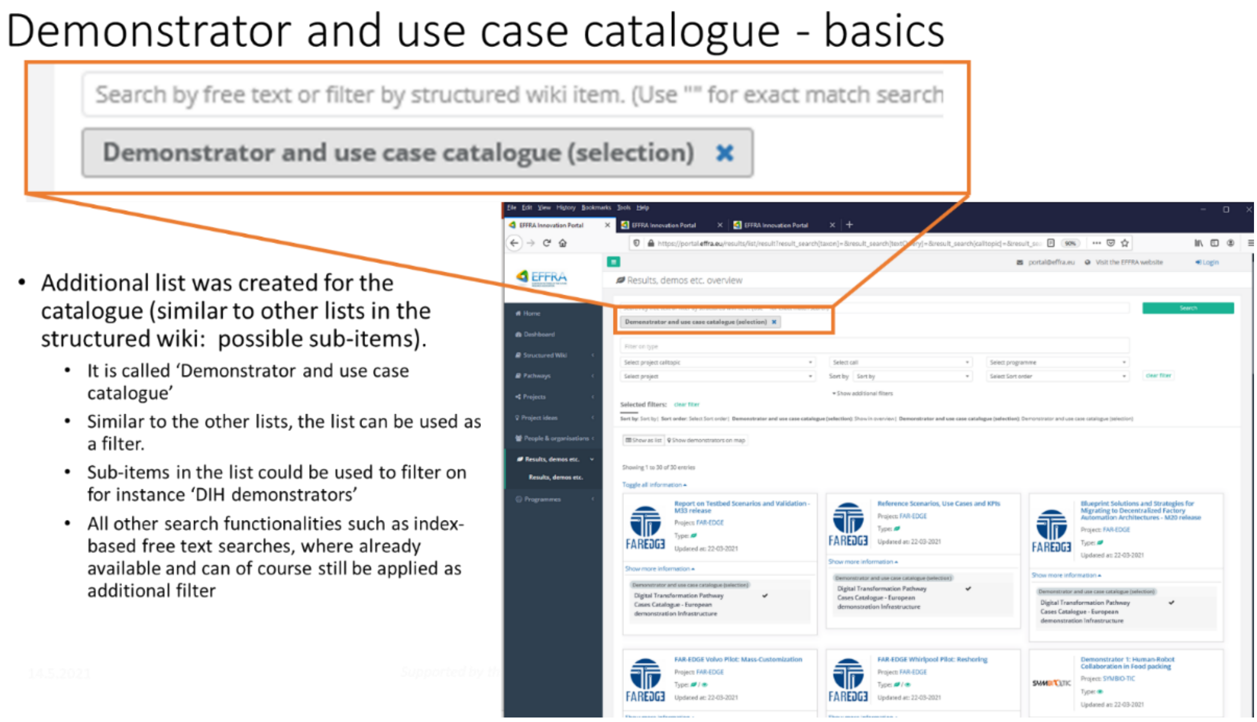

Figure 9: Catalogue filter on the EFFRA Innovation Portal

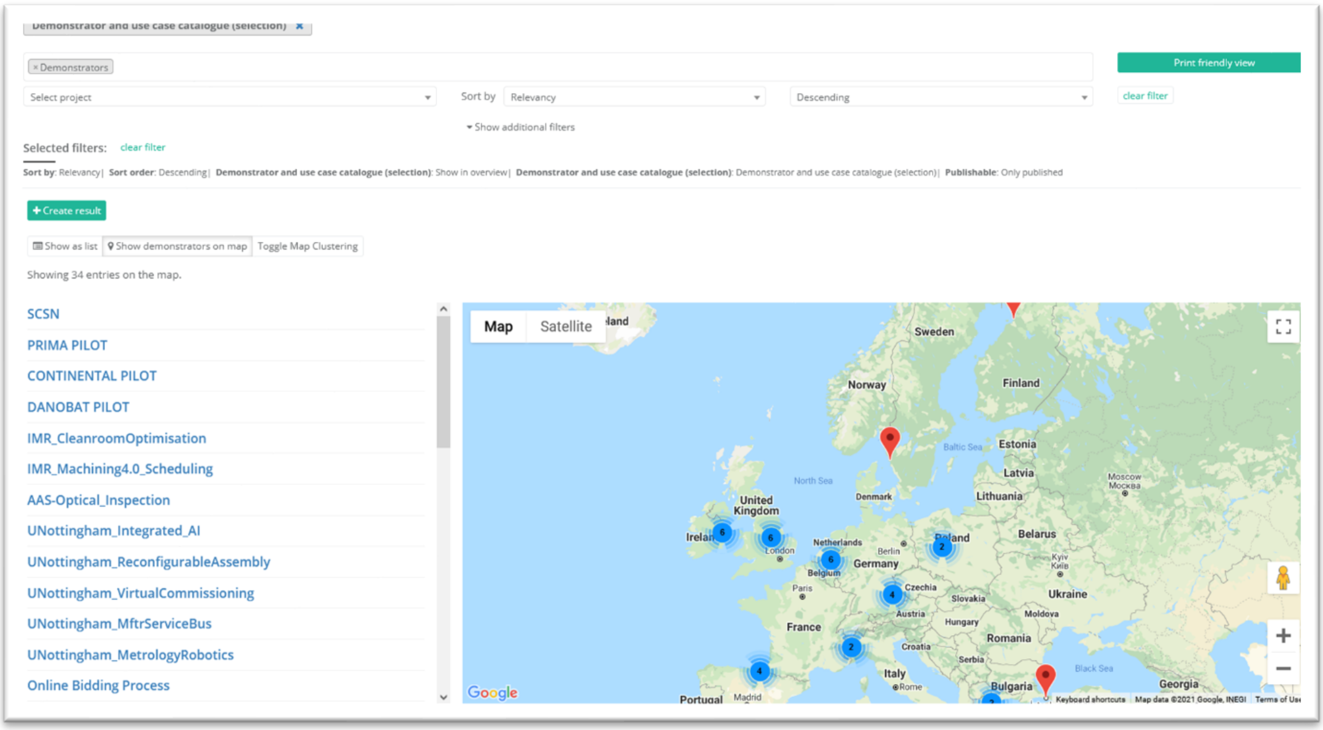

Figure 10: Geographical location of demonstrators

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4 KPIs achievements

To plan the work and to be able to monitor that the actions are having the expected effect a series of KPIs have been proposed. These indicators are focused on monitoring the situations of the use cases related to the projects of the DMP Cluster call DT-ICT-07. These KPIs focus on analysing: How many use cases each Project has, how many are presented in the Catalogue available in the EFFRA Innovation Portal and how many are well described and mapped according to the Pathways.

For this purpose, a matrix has been created with the three possible situations:

1. Initial situation at the beginning of this task **(AS WAS)**
2. The target situation, in other words the realistic situation to achieve taking into account the development stage of the projects **(TO BE)**
3. The current situation of the Catalogue at the deliverable's submission **(AS IS)**

This matrix can be seen in Figure 11 below.

		EFFRA PORTAL					
		AS WAS		TO BE		AS IS	
Project name	**Number of pilots in project**	**Pilots on portal**	**Mapped pilots on portal**	**Pilots on portal**	**Mapped pilots on portal**	**Pilots on portal**	**Mapped pilots on portal**
Wave 1 - 2018	**30**	**14**	**2**			**27**	**20-22**
ZDMP	13	0	0	10	8-10	10	10
EFPF	3	0	0	3	2-3	3	2
QU4LITY	14	14	2	14	8-10	14	8-10
Wave 2 - 2019	**17**	**0**	**0**			**5**	**0**
SHOP4CF	4	0	0	4	0-1	4	0
KYKLOS 4.0	7	0	0	7	0-1	1	0
DigiPrime	6	0	0	6	0-1	0	0

Figure 11: KPIs matrix

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5 Conclusions

To conclude it is necessary to highlight the excellent results obtained through this work. The 'Digital Transformation Pathway Cases and European demonstration Infrastructure' has become a reality and is populated with a large number of different use cases and demonstrators.

In addition, the catalogue is integrated into the EFFRA Innovation Portal, which has been fed with a wealth of information on standards, certifications and descriptions of different projects. This is in particularly relevant since almost all projects that are associated to the Factories of the Future Partnership involve the deployment and/or the development of digital technologies.

The work done by all different involved tasks of ConnectedFactories 2 will support the dissemination of information on innovation projects and encourage SMEs to access success stories and best practices. And specifically, this deliverable summarises in practical and easy way many different aspects of the work done not only as part of the WP 3, but also in the whole ConnectedFactories 2 project.

All the projects belonging to the first wave of the DT-ICT-07 have been engaged in this activity and have mapped their use cases. As for the second wave of projects from the same call, it is valuable to note that each of them is now aware of the Catalogue and the dissemination opportunities it offers. They are involved in this task and as it is a continuous work, different fine-tuning actions will be carried out, since the Catalogue and its information are continuously growing and updated along the development of the projects. There are also many national and regional initiatives involved and it has been demonstrated that the current set of pathways is capable of sustaining all these activities without the need for additional pathway configurations on top of those that are already in development.

In addition, new European Industrial priorities could benefit from the EFFRA and ConnectedFactories framework and portal, such as the need to enable the repurposing of manufacturing capabilities. It is crucial that the suitable links are established among the manufacturing stakeholders and that enabling technologies and best practices (demonstrators) can be easily identified. Future work that will also elaborate on the current interaction established with some initiatives such as the ECSEL (KDT) JU (see https://www.ecsel.eu/industry4e), the future AI and Robotics Partnership, etc... Such interactions will be crucial to define effective and pragmatic procedures to facilitate agile and efficient sharing of information and implementation of interoperability at the most suitable level.

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Annex I: Supporting events and workshops

Regarding to supporting events and workshops, the CF2 project have coordinated different activities in which the related work was shown and explained. As stated before, the main task is to collect information about the cases and populate the Catalogue on the EFFRA Innovation Portal. With respect to this, the following events/workshops have contributed:

Workshops/Webinars:

1. **Digitalisation and digital platform Webinar: 11 March 2020**
    - Agenda- here
    - Presentations - here

2. **Standards for digital manufacturing webinar: 20 October 2020**
    - Agenda- here
    - The presentations and the recordings:
        - **Industrial requirements for standards in manufacturing** by Michel Iñigo Ulloa, MONDRAGON Corporation: recording & presentation
        - **ISO 10303 in EU projects like Kyklos4.0, Arrowhead Tools, Change2Twin** by Kjell Bengtsson, Jotne: recording & presentation
        - **Standardisation and Research & Innovation** by Luc Van den Berghe, CEN-CENELEC: recording & presentation
        - **The Digital Manufacturing Platform Cluster** (DMP Cluster) **and standardization** by Olga Meyer, Fraunhofer IPA: recording & presentation
        - EFPF-**Standards as trusted glue to federate digital platforms in the digital manufacturing domain** by Karl Grün, Austrian Standard: recording & presentation
        - ZDMP-**Standardisation Activities and the Role of CEN-CENELEC Workshop Agreements** by Christian Grunewald, DIN: recording & presentation
        - **QU4LITY-Application of Reference Architecture Model** (IDS-RAM) by Giulia Giussani, IDSA11: recording & presentation
        - **The German Standardisation Roadmap Industry 4.0** by Olga Meyer, Fraunhofer IPA: recording & presentation
        - **CyberSecurity Related Standards** by Ulrich Seldeslachts, LSEC: recording & presentation

3. **Cybersecurity workshop: 20 January 2020**
    - Agenda- here
    - Presentations- here
    - Recordings - here

4. **Pathways to digitalisation of manufacturing and associated use cases: 24 March 2021**
    - Presentations - here
    - Recordings - here

5. **Digitalisation of manufacturing: pathways, key enablers and skills: 22 April 2021**
    - Agenda- here
    - Presentations- here
    - Recordings- here

DMP Cluster meetings:

1. **CF_DMP Cluster plenary online: 25 September 2020**
    - Presentations- here
2. **CF_DMP Cluster web meeting: 02/03 December 2020**
    - Presentations:
        - 2 December 2020- here
        - 3 December 2020- here
    - Recordings- here
3. **CF_DMP Cluster Plenary meeting: 22 February 2021**
    - Presentations- here
    - Recordings- here

In addition to preparing different events, ConnectedFactories2 has established different launch and follow-up meetings with those responsible of the different use cases that have been shown in the catalogue.

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Annex II: Extraction from the catalogue

This is an extraction from the EFFRA Innovation Portal (at the time of submission of this deliverable) of the use cases that have been included in the catalogue. (NP = No project is associated to use case in the portal)

List without summaries

- (NP) - AAS (Asset Administration Shell) powered Optical inspection Station demonstrator
- (NP) - BMW Group Partner Portal
- (NP) - CanvAAS: Connected Assets iNteroperability framework Via AAS
- (NP) - LNI 4.0 Testbed Edge Configuration - Business View
- (NP) - EFPF Circular Economy Pilot A Waste to Energy Scenario
- (NP) - Cleanroom Optimisation Through Machine Learning
- (NP) - Machining 4.0 scheduling platform demonstrator
- (NP) - Mobile Robot Intralogistics by IMR
- (NP) – Human-Robot Collaboration
- (NP) - Human-Robot Collaboration 2.0
- (NP) - SIEMENS: Global vehicle manufacturer uses Capital software to develop a digital thread across the entire product lifecycle
- (NP) - Smart Connected Supplier Network (SCSN)
- (NP) - Whirlpool Pilot - Qu4lity - Presentation 24 March 2021
- BEinCPPS - Baden-Württemberg Industrial Champion
- BEinCPPS - Rhône-Alpes Champion: The Smart Mold
- BEinCPPS - Lombardy Champion - Zero-Hours Quality
- BOOST 4.0 - BOOST 4.0 standardization & certification v1
- CloudiFacturing - Numerical modelling and simulation of heat treating processes
- COMPOSITION - Connectors for Inter-factory Interoperability and Logistics II
- DIGICOR - D2.5: Community Use Cases Definitions
- DYNXPERTS - Machine Tool Component 7: Wireless Monitored High Speed Spindle
- EFPF (European Factory Platform) - Online Bidding Process for Automated Negotiations
- EFPF (European Factory Platform) - Predictive Maintenance demonstrator in lot-size-1 manufacturing furniture domain
- EFPF (European Factory Platform) - Visual Detection of Personal Protection Equipment
- EFPF (European Factory Platform) - Production Environment Using Advance Digital Solutions
- EFPF (European Factory Platform) - Wastes Tracking Decentralized Application for Circular Economy
- FA3D - Future Automated Aerospace Assembly Demonstrator
- FA3D - Metrology-integrated Robotics
- FA3D - Manufacturing Service Buses for Data Interoperability
- FA3D2 - Future Automated Aerospace Assembly Demonstrator
- FA3D2 - Integrated Artificial Intelligence
- FA3D2 - Reconfigurable assembly systems
- FA3D2 - Virtual commissioning
- FACTS4WORKERS - Detailed and Refined Industrial Challenges I, II, III, and IV (1)
- FAR-EDGE - Reference Scenarios, Use Cases and KPIs
- FAR-EDGE - Blueprint Solutions and Strategies for Migrating to Decentralized Factory Automation Architectures - M20 release

- FAR-EDGE - Report on Testbed Scenarios and Validation - M33 release
- FAR-EDGE - FAR-EDGE Volvo Pilot: Mass-Customization
- FAR-EDGE - FAR-EDGE Whirlpool Pilot: Reshoring
- FLEXCELLE - Integrated Artificial Intelligence
- FLEXCELLE - Reconfigurable assembly systems
- FLEXCELLE - Virtual commissioning
- Fortissimo 2 - Advanced, cloud-based HPC simulation in the foundry business
- Fortissimo 2 - Near Real-time Analysis of Airframe Certification Test Data
- Fortissimo 2 - Cloud-based HPC processing for knowledge generation in camshaft manufacture
- HORSE - Augmented Reality software for user assistance in a manufacturing work cell
- MIDIH - MIDIH Open CPS/IOT Integrated Platform v1
- QU4LITY - AIRBUS Trade space framework for Autonomous Quality Manufacturing Systems' Design
- QU4LITY - CONTI Autonomous Quality in PCB Production for Future Mobility
- QU4LITY - Danobat Digital Machine for zero-defects at high precision cutting/grinding
- QU4LITY - Data Spaces for Additive Manufacturing Machinery in QU4LITY project
- QU4LITY - FAGOR Zero-Defects Manufacturing Digital Press Machine
- QU4LITY - GF Digital machine and part twins for zero defect manufacturing
- QU4LITY - GHI Real-time cognitive hot stamping furnace 4.0
- QU4LITY – KOL's Real-time injection moulding process monitoring-control
- QU4LITY - MONDRAGON Zero defect and Autonomous Quality in Machinery Building for Capital Goods sector
- QU4LITY - PHILIPS OneBlade shaving unit production line
- QU4LITY - PRIMA Additive Manufacturing Pilot Adaptive Control Technology
- QU4LITY - RiaStone Autonomous Quality ZDM for "Ceramic tableware Single-firing"
- QU4LITY - SIEMENS SIMATIC Products Quality Improvements
- QU4LITY - THYS Quality Management of Steering Gear based on Acoustic control
- QU4LITY - WHR Dryer Factory Holistic Quality Platform
- RebootIoTFactory - 20 proof-of-concepts of digitalised manufacturing
- RebootIoTFactory - Scale-up: AI Foreman
- RebootIoTFactory - Specific Characteristics Define Business-to-Business Supply Chains in the Manufacturing Industry
- RebootIoTFactory - Future Work with AI Foreman in Digital Factory
- RebootIoTFactory - Taking Care of Employees' Well-being and Preferences is the Key to Profitable Industry
- RebootIoTFactory - Voice assistance makes factories smarter
- RebootIoTFactory - Towards Future Factories: Automatic Quality Control
- RebootIoTFactory - Hunting Data and Putting It to Work - Piloting Data Collection for Industrial IoT
- RebootIoTFactory - Exploring the Challenges of Manufacturing with Learning Machine Vision
- RebootIoTFactory - Predictive Maintenance Supports Autonomous Shipping
- RebootIoTFactory - In Robotics Fusion Routine Tasks Blend Into Seamless Co-operation Between Robots and People
- RebootIoTFactory - RPA Making People Experts Again
- RebootIoTFactory - Scale-up: Standard Robot Interface
- RebootIoTFactory - Scale-up: Tester Predictive Maintenance
- SAFIRE - SAFIRE Electrolux pilot: Cloud-driven product optimization

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- SAFIRE - SAFIRE OAS pilot: Optimisation of production processes and preventive maintenance activities
- SAFIRE - SAFIRE ONA pilot: Adaptive Machining
- SHOP4CF - Utilisation of AR/VR communication & remote sensing Technologies for Technical Support between Remote Plants of Arçelik
- SHOP4CF - Support workers and to reduce the error rate
- SHOP4CF - Definition of the deployment scenarios
- SHOP4CF - Improve automatic data acquisition, storage, traceability with user-friendly interfaces and human safety
- SHOP4CF - Upfront challenges faced by the assembly workers and engineers
- SodaLite - Eclipse Papyrus Manufacturing: Sizing Stocks Buffers of a Line
- SYMBIO-TIC - Demonstrator 2: Human-Robot Collaboration on Aircraft Rib Assembly
- SYMBIO-TIC - Demonstrator 1: Human-Robot Collaboration in Food packing
- USE-IT-WISELY - Upgrade service for mobile rock crushers
- VIEWS - Metrology-integrated Robotics
- VIEWS - Manufacturing Service Buses for Data Interoperability
- VIEWS - VIEWS project video - Future Aerospace Assembly solutions
- ZDMP - Assembly line: AI-supported optical defects detection
- ZDMP - Assembly line: monitoring and control system
- ZDMP - Steel tubes: production monitor
- ZDMP - Stone tiles: equipment wear detection
- ZDMP - Construction supply chain: quality control at construction site and quality traceability
- ZDMP - Engine block manufacturing: Defects detection and prediction in aluminium injection and machining operations
- ZDMP - Engine block manufacturing: Defects reduction by the optimization of the machining process
- ZDMP - Moulds manufacturing: Process alert system for machine tool failure prevention and Smart process parameter tuning
- ZDMP - Moulds manufacturing: in-line 3D modelling
- ZDMP - Electronic products manufacturing: Component inspection

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List including summaries

- **(NP) - AAS (Asset Administration Shell) powered Optical inspection Station demonstrator**

What is it?

Optical inspection station is a physical demonstration build of an automated 3D printed part visual inspection cell. Is has automated material handling for part trays and individual parts, camera-based vision system, RFID and serial based part and tray tracking, standard industrial inductive presence sensors, wired cell local LAN and local computational capabilities for control, vision and analytics. While the hardware itself would not surprise anyone familiar with industrial automation environments, the software components are presenting a rather novel approach based on RAMI 4.0 AAS. The main goal of the station is to demonstrate how the AAS architecture could be implemented, what are the benefits, what still needs to be addressed.

Why it is important?

Data driven technologies are seen more and more relevant to the industrial environments with some claiming that it is leading to the 4th industrial revolution. Increasing connectivity and availability of cheap computational power and memory allows to access and process information more easily than before, enabling improvement of the existing processes and creation of new use cases. On another hand, historically installed industrial systems are often not well connected, information is spread around different systems that don't talk to each other, different communication protocols are used, and no uniform data models were implemented.

This points toward the needs of the standardised architecture that uses available technology to address the issues that current industrial systems face. One of the attempts to create such architecture is RAMI 4.0 (Reference Architectural Model Industry 4.0) and its main component AAS (Asset Administration Shell). RAMI 4.0 approach tries to aggregate and extend existing standards and change how we build, integrate, use, and maintain industrial systems in the future.

Implementation

Physical platform implementation is based on several subsystems:

- Part and tray handling system – that consists of cobot arm and tray shelving
- Part and tray serialisation system – that consists of RFID tag readers and OCR serial number reading software

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- Optical inspection system – that consists of lighting, camera, optics, PC and vision application
- DAQ system – that consists of (mostly) presence sensors, digital input/output units and industrial NUC computer
- Station base – that includes table, electrical panel, power supplies, standard button terminal and platform indicators
- Local operator GUI – touch screen monitor with graphical user interface application displayed on it

Integration of each subsystem and subsystem components is done via AAS data models and applications. Each individual inspection station component is represented by its own AAS which provides relevant information about asset as well as the control interface (where applicable). AAS application can communicate to each other via OPC-UA communication protocol.

Conclusions

There are multiple different technologies and architecture emerging as part of Industry 4.0 effort. It is important to understand how these could be applied in the real-world environments as well as what are the limitations and benefits of the different approaches. Optical Inspection Station demonstrator allows to have a glimpse at potential route of AAS implementation, benefits and challenges.

- **(NP) - BMW Group Partner Portal**

  The Partner Portal is the global platform for a cooperation which is distinguished by a common understanding of quality of product and quality of production, security of supply, innovative capacity as well as the consequent integration of our commitment to sustainability. (From https://b2b-sso.bmw.com)

- **(NP) - CanvAAS: Connected Assets iNteroperability framework Via AAS**
- **(NP) - LNI 4.0 Testbed Edge Configuration - Business View**
- **(NP) - EFPF Circular Economy Pilot A Waste to Energy Scenario**
- **(NP) - Cleanroom Optimisation Through Machine Learning**

  Objective

  - Analyse the underlying potential for energy reduction in cleanrooms.
  - The possibility of reducing current air change rate without affecting critical quality parameters were tested in four cleanrooms using fixed air change rate reduction or dynamic air change control.
  - Cleanroom and HVAC data was collected, a simulation model was developed replicating each of the four cleanrooms and its associated HVAC systems to test with different air change rates and analyse its implications.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

    - A machine learning algorithm was developed to implement the dynamic control and was integrated with the cleanroom simulation model.

- **(NP) - Machining 4.0 scheduling platform demonstrator**

What is it?

Machining 4.0 demonstrator platform is a simulated small-scale production environment. It can be seen as a machining workshop with a different material/batch sources, process machines, storage area, material logistics system and completed part feed out and operator interfaces. The main goal of the demonstrator is to provide a physical platform to explore production scheduling complexity where the issues encountered in real large scale production environments are not obvious to observe.

Why it is important?

Key concerns in machining environments are how efficiently machine time is being used, how to react to unexpected changes (like machine going offline for unplanned maintenance), how to plan production if the most efficient way depending on the (constantly changing) production goals (i.e. priority batches, machine OEE optimisation, energy use, etc…). Scheduling and optimisation are extremely difficult tasks to tackle – best known example is traveling salesman problem. Frequently, in real production environments this is done sub optimally, but this can be improved using right tools, which is demonstrated by Mach 4.0 platform.

Implementation

Physical platform implementation is based on several subsystems that include simulated machines, multiple material feeds, logistics tasks executing robot and storage area for part buffering. Even in this simple environment, scheduling of the production in the most efficient execution if difficult for human operator. In addition, sudden production environment changes can be introduced by taking machines offline using operator’s interface.

Platform accepts manually configured schedule or schedule from the automatic scheduling system. This creates an easily understood challenge and a way to compare human abilities versus specialised optimisation system capabilities.

Conclusions

Some tasks humans are good at and some they are not. Optimisation and scheduling tasks are examples of the latter. Even for the computers brute force optimisation or scheduling approach could be very difficult and require lots of computational recourses. On the other hand, there are different algorithms that can be employed depending on the problem at hand. Machining 4.0 platform demonstrator allows to experiment and demonstrate different approaches and well as scheduling problem complexity itself.

- (NP) - Mobile Robot Intralogistics by IMR

Context & Aim

The adaptive robotics team aims to advance robot capabilities as a component of a wider Industry 4.0 shift. With this in mind, we are developing a pilot flexible intralogistics line that forms part of a paradigm shift from linear assembly lines to "automated cells" served by mobile robots. In IMR our pilot demonstration comprises 4 work-stations (either automated or manually operator) that complete an assembly task.

A mobile manipulator transports the work piece between stations, while a centralized controller can then operate at a system level by reading the sensor outputs from stations and robots. Finally our long term goal is to exploit this data to optimize the current assembly operation and to predict and adapt to future changes.

Challenge

The classical fixed assembly line structure for manufacturing is an excellent solution for high volume low variability assembly operations. However, this structure is difficult to reconfigure and thus lacks flexibility as we move toward an era of mass customization envisaged by Industry 4.0.

Solution

An alternative view is to use modular assembly lines, where cells of automation or human technicians carry out specific operations. Thus, instead of parts flowing from one station to another in a predefined linear fashion, the material is transported between stations by mobile robots whose tasks are defined by a higher level planner which by measuring production flow, sensors and quality can optimize the process.

- (NP) – Human-Robot Collaboration

Context & Aim

This Industrial Research project focuses on Human-Robot Collaborative (HRC) applications and advancing their uptake within the Irish Manufacturing ecosystem.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

The aim of this project is to demystify the safety requirements surrounding collaborative robots and in doing so de-risk the adoption of collaborative systems. To achieve this, IMR developed a fully collaborative application where the operator and the robot work together in the same workspace to accomplish an industrial operation. In particular, two overarching objectives have been defined:

- To develop a collaborative application without using any external sensors or safety equipment.
- To risk assess the collaborative application to industrial standards.

Challenge

Classical industrial robots can operate at high speeds and with excellent precision but require stringent security measures and a significant factory floor footprint. An alternative paradigm is human-robot collaboration where the robot can carry out the mundane or dangerous portion of the task while the human carries out the complex part. While this presents an attractive model, the lack of clarity about safety requirements is hindering uptake in the Irish manufacturing eco-system.

Solution

To demystify the safety requirements around HRC, IMR chose to construct, from the bottom up, a fully collaborative demonstrator where humans and robots work together to assemble a medical device. The application was developed with an aim to ensure the safety of the operator without any external safety equipment relying on (a) the application design (b) the force, power, and speed limitations defined in the safety configuration of the collaborative robot. In doing so, IMR highlighted the pain points associated with this process and earn valuable experience which can then be passed on to partner organisations.

Results

The result of this project is a functional and interactive demonstrator showing a human-robot assembly task, fully risk assessed by an external partner. Additionally, IMR has developed a fully documented risk assessment procedure with intelligent strategies to mitigate risks related to close collaboration.

During the course of the project, several methods of improving the efficiency of the system have been identified. In phase 2 of the Human-Robot Collaboration project, these changes will be implemented in order to maximise the productivity of the cells.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Impact

This project provided understanding to partner organisations about the advantages and limitations of human-robot collaborative applications and the corresponding risk assessment process.

- **(NP) - Human-Robot Collaboration 2.0**

Context & Aim

Survey on collaborative robot adoption clearly indicated that safety and viability based on cost and speed are the biggest concerns over collaborative robot adoption. This project set about demystifying those concerns by understanding the principles of the standards and designing a shared human robot workspace which can be made viable without adding significant cost or installation of safety barriers based on a generic application

Challenge

Using a Physical Demonstrator, prove that in a shared workspace where the operator and robot need to coexist, the collaborative cell can compete with a fully manual cell in terms of ease of setup, low cost of additional equipment and productivity, while ensuring the safety of the operator

Solution

Phase1 of this project identified operating zones where the risks of a collision or impact went from no risk to minor risk to major risk and altered the robot and speed in each zone so that the robot impact on the human causes no injury. While the phase passed a third party risk assessment, cycle times were too long to make it viable. This phase set about reducing cycle time, while maintaining the necessary safety features, by:

- Removing or reducing any unnecessary travel and wait times or the robot
- Optimising the trajectory movements of the robot while minimising impacts or collisions
- Adding extra safety devices to slow or stop the robot when the human is working collaboratively with the robot

Results

With no additional safety devices, the cell can pass a risk assessment and become a viable option
By adding some low cost off the shelf safety devices, the cell can hit a higher output than the human equivalent for the chosen application

Based on the specification of the robot and the application, the return on investment on the robot fully installed can be as little as 2 years The experience gained concerning safety zones and speeds can are transferable to most collaborative applications

Impact

In using a standard collaborative robot and a generic application, the research dispels some of the biggest concerns in Industry around safety of collaborative cells and their ability to perform as productively as an equivalent fully manual cell. As the cell is risk assessed by an external partner this project translates the requirements of the standards into a physical demonstrator to which industry can relate and understand.

- **(NP) - SIEMENS: Global vehicle manufacturer uses Capital software to develop a digital thread across the entire product lifecycle**
- **(NP) - Smart Connected Supplier Network (SCSN)**

Smart Connected Supplier Network (SCSN) is a data standard that makes the exchange of information in the supply chain more efficient, making it easier, faster and more reliable for companies to share data.

This results in higher productivity of the supply chain through fast, secure and interoperable exchange of information between companies.

By registering your company with the SCSN network you can exchange data with all affiliated companies in your production chain, such as orders, invoices, technical product data, etc. You link your ERP system to one of the service providers, which will send your messages. then deliver to the recipient either directly or via another service provider.

- **(NP) - Whirlpool Pilot - Qu4lity - Presentation 24 March 2021**
- **BEinCPPS - Baden-Württemberg Industrial Champion**

Agriculture Technologies: highly personalized cabin manufacturing, manual final assembly

Through the BEinCPPS project John Deere wants increase efficiency by further digitizing their manufacturing processes. With BEinCPPS John Deere 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.

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Specifically at John Deere we address:

- The integration a connection of CPS to a smart manufacturing bus that allows the exchange of data with IT services.
- The integration of legacy IT systems to allow these to cooperate and communicate with new CPS systems.
- 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 - Rhône-Alpes Champion: The Smart Mold**
- **BEinCPPS - Lombardy Champion - Zero-Hours Quality**

At Whirlpool, statistical quality controls are done by the Zero Hours Quality department (ZHQ), where in-depth tests are performed on a significant sample of products as they leave the assembly line (Quality Gate). The objectives of ZHQ are to assess the average quality of the delivered product and to verify the correctness of the production process. Currently, ZHQ is implemented as a CPS where products under test are connected to a number of fixed workstations. Tests are driven by rules that are stored in a Factory database, and results are collected in the same storage facility.

The main problems with the current ZHQ implementation are physical constraints on the mobility of operators, per-station hardware costs, lack of integration with Factory and Corporate information systems, partial exploitation of data and hard-coded logic. The new-generation architecture developed in BEinCPPS leverages a lightweight Shopfloor infrastructure – based on a mix of custom-developed and commodity hardware on the product's side (CPU and Power Board) and on Android mobile applications as the human-machine interface (HMI) – and a Cloud layer for cross-plant data storage and computationally-intensive data analysis tasks. The implementation of this new-generation design leverages the three BEinCPPS Platforms – i.e., SmartSystems, IoT and Future Internet – from which a selection of hardware and software components have been deployed across the three physical levels defined by the BEinCPPS Reference Architecture: Field, Factory and Cloud.

On the Field level, Whirlpool-specific hardware (Controller and Actuator boards) and software components (the Test Executor) are interconnected by the Deterministic Ethernet implementation (TSN by TTTech) provided by BEinCPPS' SmartSystems Platform. A custom Android application on tablet devices (Test Front End) plays the HMI role. The Actuator board is custom-built on Whirlpool's specs: its role is to interface the product under test, providing physical measurements to the Controller board and allowing the Controller board to operate and monitor the high-voltage appliance power supply. The Controller is a standard PC104 board that hosts a Windows operating system. The Controller runs the Test Executor software, which is a modified version of a legacy workstation-based application. The Test Executor embeds the local logic that drives the Actuator board: as the name implies, it executes test rules and collects results. In this new version, the software does not include the HMI and operates instead as a headless Field service that is exposed as an OPC-UA Address Space, thus enabling a tight integration of the Controller/Actuator bundle with the Factory and the Cloud levels. It is worth noting that the development of the OPC-UA Address Space used for in Whirlpool experimentation was entirely done by means of the UA Modeler tool, which is a Virtual World component.

The Field level is completed by peripherals that provide the physical connection with tested appliances and HMI functionality. One of them, the Bar-Code Reader, is directly plugged into the Controller board and is used for the fast identification of the product items under test. However, the key element of the system is the tablet device which provides the user's Front End to three different applications: Test Operation, Test Results, and Rule Editor. All of them are Android applications that are developed in the scope of WP4, and are directly connected to the Cloud.

From an architectural perspective, however, the Test Front End belongs to the Field level, while the Results and Editor Front Ends are Factory level components, as their users play a different role in the ZHQ business process. In the new-generation ZHQ architecture, the Factory level is not merely a logical environment for the Result and Editor Front End mobile applications: its main role is to host the IDAS OPC UA Agent, which acts as a gateway between the Field and the Cloud levels. This component is a IoT Platform's protocol adapter belonging to the Fast Lane – i.e., the FIWARE-based channel for Field-Factory-Cloud communications. The only customization required for the Whirlpool scenario is the configuration of specific mappings between the OPC-UA Address Space and the NGSI context used to publish and subscribe to the Field data stream. Such customization was easily done by editing a configuration file, and did not require any modification to the software.

Last but not least, the Cloud level is where most of the BEinCPPS value is delivered. This software layer is entirely deployed on external computing facilities. In this first iteration, this means the Common Cloud Environment (CCE) that is provided by the BEinCPPS project. The CCE hosts several components from the FI Platform: FIWARE Orion Context Broker, FIWARE Wirecloud, FIWARE Cosmos, FITMAN DyCEP and FITMAN CAM. Orion Context Broker is the middleware that provides publish/subscribe services using the NGSI standard, while Cosmos and DyCEP are generic Big Data Processing engines that run BEinCPPS-specific data analytics. In the context of the

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Lombardy demonstrator, Wirecloud is used as a provisional HMI to monitor the Field data flow during the execution of tests on appliances.

- [BOOST 4.0 - BOOST 4.0 standardization & certification v1]

  I4.0 standards and certification

- [CloudiFacturing - Numerical modelling and simulation of heat treating processes]

  Experiment Description

  Many industries such as automotive, aerospace, civil engineering require fast and well controlled cooling to obtain the material properties and strength of thin walled aluminium profiles. This cooling process is controlled by several parameters. The main problem is that these parameters are set base on operator's experience, which makes it very difficult to perform this process completely automatic and is difficult to use. This applies especially when a new profile is being treated; the process involves a trial-and-error approach wasting time, energy and resources. Numerical modelling and simulation could help to derive operation conditions of this process and make it less dependent on the user. Creating a numerical model of whole water quench with all necessary details and containing all physical processes are the challenges to be faced. Guidelines for operational conditions of quenching machine based on various inputs, such as profile shape and temperatures, will be derived by elaborating a numerical model of quenching process, carrying out CFD simulation using HPC resources and validating reliability of simulation results by physical experiments.

- [COMPOSITION - Connectors for Inter-factory Interoperability and Logistics II]

  The present document named "D6.6 Connectors for Inter-factory Interoperability and Logistics II" is a public deliverable of the COMPOSITION project, co-funded by the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement No 723145. This deliverable presents the final results of the Task 6.3 "Connectors for Inter-Factory Interoperability and Logistics". It aims to describe and analyse the final version of COMPOSITION Marketplace's components. COMPOSITION has two main goals:

  - The integration of data along the value chain from the inside of a factory into one integrated information management system (IIMS).
  - The creation of a (semi-)automatic ecosystem that extends the local IIMS concept to a holistic and collaborative system incorporating and interlinking both the supply and the value chains.

The purpose of this deliverable is to further describe the development process related to the generation of the (semi-)automatic ecosystem. Particularly, the analysis will focus on:

- The design of the different connectors between the various marketplace components:
    - Marketplace Agents
    - Stakeholder Agents
    - Matchmaker Agent
    - Security framework
- The implementation of the connectors described above.
- A short description of every component.

The results of the analysis of all the aforementioned features have been implemented in the COMPOSITION Marketplace's components. The Agents have been developed in a full custom way to avoid constraints coming from frameworks usage. The existing technologies have been analysed as state of the art, then, due to the project needs, the COMPOSITION Marketplace has been developed without using any of these frameworks but taking inspiration from those ones.

The Agent Management Service is the core Marketplace Agent that enable Stakeholder Agents to register to the COMPOSITION Marketplace and to take part to the negotiation process. Another Marketplace Agent developed is the Matchmaker. It supports semantic matching in terms of manufacturing capabilities, in order to find the best possible supplier to fulfil a request for a service with raw materials or products involved in the supply chain. Different decision criteria for supplier selection are considered by the Matchmaker according to several qualitative and quantitative factors.

The two Stakeholder Agents, requester and supplier work together to achieve the goal of creating new supply chains by negotiating in a semi-automatic way. They receive command through the UI from the owners exploiting a set of REST APIs developed during the project and reported in this document.

The negotiation is enabled by COMPOSITION eXchange Language, a language derived from FIPA ACL standard.

This language provide high flexibility thanks to a large set of action and the description of the message content by means of custom ontologies. The Security Framework together with the Blockchain layer is strongly interlaced with the COMPOSITION ecosystem, providing all the necessary security features as authentication, authorization, message integrity and message traceability.

The COMPOSITION Marketplace brings a new and dynamic way in supply chain creation. It has shown an easy and successful way in doing negotiation in a semi-automatic manner outperforming the old mechanism based on a full manual process that usually takes much more time.

- **DIGICOR - D2.5: Community Use Cases Definitions**

  Detailed description of relevant use cases defined in collaboration with the community in addition to the three primary use cases from project partners

- **DYNXPERTS - Machine Tool Component 7: Wireless Monitored High Speed Spindle**

  A spindle has been instrumented with a generator that provides energy for a wireless communication system The wireless communication system may be used as a platform for machine tool condition and process monitoring. For this purpose a FIDIA NC has been connected to the test stand to simulate a real machine setting. The wireless communication is able to provide data that may be used for condition monitoring and is able to communicate the data over a range of about 10 m, which is well suited for the application in machine tools. The system has been realized using COTS-Components and is therefore easy to adapt to specific needs and inexpensive which suits well for the application in machine tools.

- **EFPF (European Factory Platform) - Online Bidding Process for Automated Negotiations**

  EFPF project supports a circular economy scenario, from wastes to energy. The wastes producer sells its wastes to a waste management company which pre-process them and sell them again to a bioenergy company to produce energy. A part of this energy returns back to the first company that has produced the wastes as an outcome of its production processes.

  The negotiation of offers and services regarding processed wastes is a very challenging procedure since it involves several organisations from different sectors (such as recycling companies) and needs fast decision making. All these procedures are conducted manually using phones and emails to select the offers and choose the best one based on specific criteria such as price, health and safety issues (regarding collection) etc. This procedure is inefficient and expensive. The three companies participating in the circular economy scenario need a solution that will provide automated bids and negotiations through an online system to obtain high-quality services and products at reasonable prices.

  EFPF Online Bidding Process service provides an automated matchmaking mechanism for information requests from buyers to suppliers, to execute negotiations and business transactions automatically via configured agents. It is a matchmaking application that achieves automated negotiations and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

business transactions between interested stakeholders. The matchmaker's goal is to find the best possible supplier to fulfil a request for a service or product in a fully automated way. Different decision criteria for supplier's selection, according to several qualitative and quantitative factors, are considered by the matchmaker. It also evaluates the available offers from the providers in order to suggest the best one to the supplier. Virtual agents enable the automated communication between companies as every company is represented by an agent during the communication/negotiation phase.

Partners: KLEEMANN, ELDIA, MILOIL, LINKS and CERTH

- **EFPF (European Factory Platform) - Predictive Maintenance demonstrator in lot-size-1 manufacturing furniture domain**

The Predictive Maintenance demonstrator is focused on the monitoring of the operation of an edge banding machine to detect anomalous working conditions evaluating the risk of machine breakdown and take preventive actions through machine data analysis.

This experimentation has been deployed in a real manufacturing environment in the Spanish company LAGRAMA. They produce high-quality home furniture and they are located in Vinaròs (Spain).

The operator gets live information from the UI, which is accessible from the portal. The operator can monitor information, such as the failure prediction and confidence in the prediction. Sensors readings can be monitored from the UI as well to help identify the location of a fault. Working in batches means many machine stops and, of course, affects whether a machine is running all the time continuously. Predicting when the edge banding machine may need maintenance of a part or motor is a significant advance for LAGRAMA since it can prevent any part from being damaged, decreasing productivity and consequently losses and a bad image in the face of customers for late deliveries

To predict when the edge banding machine requires some maintenance operation, machine data is captured from the machine by retrofitting sensors (temperature, electric current and air pressure) to parts of the machine.

The sensors are connected to an interface board on the Industreweb Factory Connector, which monitors the values and publishes them to the EFPF Data Broker. The Analytics component monitors these data and builds up a machine learning model. This enables the publication of a special event to the Message Broker when the machine operation values indicate some potential problem.

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This way, the Risk component, which is subscribed to the Analytics Component's output topic, can evaluate if there is a risk of a machine breakdown and, in such case, this component triggers an alert to maintenance staff in LAGRAMA.

In summary, we can conclude that the value proposition for LAGRAMA is:

- Reduction of the reaction time when some problem arises during production
- Reduction of the machine downtime due to primary failure in the machine
- Avoiding failures that may affect the quality of produced goods through the detection of abnormal machine operation.

- **EFPF (European Factory Platform) - Visual Detection of Personal Protection Equipment**

Through their wide-ranging applications in the manufacturing environments, it is increasingly evident that Artificial Intelligence techniques can increase process reliability and efficiency. Expanding the applications areas of AI in the manufacturing environments, in the EFPF project a specific use-case investigates the use of AI-based visual analytic techniques to ensure operational health and safety compliance. In this use case, a tool for automatic detection of facemasks has been implemented using AI-based visual analytic techniques. The tool orchestrates various systems in the spray booth area of the shop floor to ensure operational safety, compliance with relevant procedures as well as efficiency in the painting process.

The EFPF solution detects that the operator is wearing the correct face masks, checks that the required air temperature is available and opens the spray value automatically. At the same time, the extraction system is turned on and the safety lights indicate the status. The solution utilises a small computer that hosts the EFPF Factory Connector, which is responsible for establishing the connection between various hardware and software components. The AI visual analytic algorithms are tuned to process real-time video feeds. Advance machine learning techniques were used to train the models that are able to recognise compliance with relevant safety procedures (e.g. use of correct mask, the positioning of mask etc) or raise alarms if anomalies or non-compliance are detected. The Factory Connector also provides remote access and connection to the EFPF Data Spine so that the relevant data can be directly analysed to provide valuable intelligence.

Through this visual analytic tool, the painting process was optimised in terms of process reliability and operational safety. The tool provides another building block towards increased digitalisation in the manufacturing sector.

- **EFPF (European Factory Platform) - Production Environment Using Advance Digital Solutions**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

Many SMEs lack fundamental digitisation that can allow them to connect their machines and devices to digital networks without significant investments. Such connectivity and digitalisation can enable SMEs to unlock the value of their data and increase the efficiency of production processes. In a specific EFPF pilot scenario, capturing and processing relevant shop floor information is demonstrated through the use of federated EFPF solutions. The overall goal of this pilot scenario is to ensure that specific parameters in specific production machines and production environment are analysed in real-time to provide effective decision support. In aviation, large OEMs such as Airbus and Boing set detailed product specifications for suppliers. In some cases, certain production steps are only permitted under very specific and monitored environmental conditions. For example, aerospace paints may only be processed within a specific temperature range.

The implementation of this scenario is carried out at EFPF aerospace partners Walter Otto Müller GmbH & Co. KG (WOM) and Innovint Aircraft Interiors GmbH (IAI). WOM requires control of temperature and humidity in their manufacturing area to ensure consistent quality and environmental conditions required for component tolerances. Similarly, IAI needs to survey raw material stored in a freezer to avoid scrapping in case of too high temperature. When a high temperate is detected the vacuum forming machine needs to be controlled to take immediate actions.

In these scenarios, the goal is to secure the stability and quality of manufacturing processes by monitoring the relevant parameters and provide alarms in case defined thresholds are underrun or exceeded. Overall goals are to make sure that:

- Products are manufactured in acc. with relevant process specifications
- Rejects and waste are reduced
- Failures can be detected early, and intervention actions can be taken if necessary
- Record history data as proof for the correct functioning of the system even when unattended

The developed EFPF solution utilises small industrial computers and Ethernet-IP input-output modules linked to the relevant process sensors and actuators on the hardware side. All needed hardware was agreed upon between the partners. These are installed in electrical cabinets with supporting electrical equipment to solve a high-standard industrial level. The installation of all hardware and equipment into the cabinets has been done by the user companies WOM and IAI.

- **EFPF (European Factory Platform) - Wastes Tracking Decentralized Application for Circular Economy**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

The lack of capability to track and trace assets and transactions throughout the entire supply chain is one of the critical challenges that the companies face towards the circular economy. This lack of traceability hinders companies from quickly adapting, planning, and managing their assets effectively and optimised.

A solution is needed to help companies track and trace their assets at every supply chain stage and increase supply chain visibility without significantly increasing operational costs.

In particular, for EFPF project supports a circular scenario, from wastes to energy. The wastes producer sells its wastes to a waste management company which pre-process them and sell them again to a bioenergy company to produce energy. A part of this energy returns back to the first company that have produced the wastes as an outcome of its production processes. A track and trace mechanism for the exchanged wastes over this circular closed loop is needed.

EFPF provides a Blockchain-based mobile app available to the stakeholders of the transportation (i.e. drivers etc.) to enable a secure and trusted handshake between them. Furthermore, a web application based on blockchain enables adding permissions to drivers, vehicles etc. that participate in a transportation process, monitor the various stages of the transported waste and issue a digitally signed document related to waste's transportation and handling. Both mobile and web apps share a common blockchain back end in logging transportation information in the same blockchain instance. Smart Contracts are used as a back-end part of the two DApps (web and mobile). Identity Smart Contracts, Supply Chain Smart Contracts, Logging Smart Contracts and Notification Smart Contracts are used. The combination of the two apps (mobile and web) provides a complete solution of wastes' track and trace in a circular closed-loop and promotes full visibility of the processes.

Partners: KLEEMANN, ELDIA, MILOIL and CERTH

- **FA3D - Future Automated Aerospace Assembly Demonstrator**

The University of Nottingham's Centre for Aerospace Manufacturing (CAM) works closely with the European aerospace industry leaders to deliver translational industrially focused research in future aerospace assembly systems.

The Future Automated Aerospace Assembly Demonstrator (FA3D) platform is the testbed where newly developed innovative and ground-breaking assembly methods and solutions for cost-effective future aerospace manufacture are tested and validated.

The cell combines intelligent fixturing, automation systems, advanced process end effectors, integrated safety systems, spatially-aware RFID tracking, state-of-the-art metrology systems, and integrated informatics to deliver reconfigurable, evolvable cells capable of significant product variation, which are variability aware and which enable batch sizes of one.

The demonstrator platform allowed for aerospace companies to test and validate future information-rich assembly methods for aerostructures, using metrology data integrated with robot controllers to compensate for variability in assembly, and to achieve fixtureless assembly of aerostructures.

- **FA3D - Metrology-integrated Robotics**

  Aerospace assembly is characterised by the tight tolerances required – deviations over 0.1mm from nominal can cause significant aerodynamic effects. Simultaneously, aerospace components need to be lightweight, and are often flexible until assembled into their final structure.

  Commonly, large jigs and fixtures are used to ensure alignment in aerospace assembly, but these are costly and time consuming to create, and represent a substantial cost, particularly for low batches of aerostructures.

  FA3D utilised advanced metrology systems such as laser radar and optical coordinate measurement machines to achieve accurate measurement of parts over large volumes.

  Data from these metrology readings is directly integrated with the robotic controllers to adjust the positioning of parts to bring them back into tolerance, and hold them in place while fasteners are inserted, effectively replacing the need for fixtures.

- **FA3D - Manufacturing Service Buses for Data Interoperability**

  Large, highly integrated manufacturing systems are characterised by complex data systems that enable the manufacturing process. This is exacerbated when you need to integrate additional software platforms that analyses data (such as metrology data) to adapt manufacturing processes).

  Due to a lack of common standards, it is common for manufacturers to stick to a single vendor of digital solutions, to ensure compatibility. However, this can exclude a company from taking advantage of the latest developments (such as the laser radar used here).

FA3D uses a manufacturing systems bus concept to enable a manufacturing system to be easily reconfigurable from a logical control perspective, and to integrate multi-vendor equipment and software into a single source of data which is used throughout.

- **FA3D2 - Future Automated Aerospace Assembly Demonstrator**

The University of Nottingham's Centre for Aerospace Manufacturing (CAM) works closely with the European aerospace industry leaders to deliver translational industrially focused research in future aerospace assembly systems.

The Future Automated Aerospace Assembly Demonstrator (FA3D) platform is the testbed where newly developed innovative and ground-breaking assembly methods and solutions for cost-effective future aerospace manufacture are tested and validated.

The cell combines intelligent fixturing, automation systems, advanced process end effectors, integrated safety systems, spatially-aware RFID tracking, state-of-the-art metrology systems, and integrated informatics to deliver reconfigurable, evolvable cells capable of significant product variation, which are variability aware and which enable batch sizes of one.

The demonstrator platform allowed for aerospace companies to test and validate future information-rich assembly methods for aerostructures, using metrology data integrated with robot controllers to compensate for variability in assembly, and to achieve fixtureless assembly of aerostructures.

- **FA3D2 - Integrated Artificial Intelligence**
    - Any complex manufacturing system generates large amounts of data, and this data is often underutilised and little value is generated. Due to FA3D2's highly flexible nature, it is an extremely complex system with many sources of variability which require understanding and compensating for.
    - The integrated digital twin system of FA3D2 simplifies the gathering and contextualising of data via an OPC UA-based service bus. This data is collected and aggregated in a cloud-based environment for analysis.
    - Machine learning approached and other analytical tools are being developed to analyse the data, update virtual twins or test proposed changes in the digital twin, and then deploy these changes to the shop floor via the same digital pipeline as the virtual commissioning process.

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        - Key to this approach is integrating the skills and knowledge of the workers on the shop floor, who work in conjunction with the AI approaches to achieve hybrid decision making – the combination of human and machine intelligence.
    - **FA3D2 - Reconfigurable assembly systems**
        - Virtual commissioning radically reduces the time required to change and recommission a manufacturing system, but the scope of possible change is bounded by the physical morphology of the system. FA3D2 uses a combination of highly flexible technologies to enable a huge possible scope of system reconfiguration.
        - Key to this is a module reconfigurable flooring system that allows fixturing, robots, and other manufacturing assets to be quickly moved and accurately located. Services are run under the flooring surface to keep the floor safe and level.
        - To compliment assets attached to the flooring system, automated ground vehicles are used for moving robots and metrology devices with even more flexibility, bring them to the locations required, as they are needed.
        - Lastly, FA3D2 uses robotics in combination with configurable fixturing systems to minimise or even eliminate the need for static jigs and fixture, allowing batch sizes down to one.
        - All these systems are integrated into the digital twin, allowing the manufacturing system to rapidly meet almost any large-scale assembly challenge.
    - **FA3D2 - Virtual commissioning**

Manufacturing systems need to be increasingly flexible to cope with the demands placed on them – changing product requirements, volumes, and availability of supply all require flexibility to manage.

        - Commissioning is the process of designing, purchasing, programming, installing, and testing a manufacturing system. It is a complex and time-consuming process. Reacting to changing manufacturing requirements may require a system to be recommissioning depending on the scope of change, and the time and cost of this contributes to the difficulty of low-batch production.
        - Virtual commissioning is a method by which a manufacturing system is designed, programmed, and tested virtually with a sufficiently high degree of accuracy that the design and program code can be deployed to the physical line immediately with only a small amount of extra testing.
        - FA3D2 is a highly reconfigurable, flexible system able to produce a wide range of aerospace components, and is designed from the ground up to take advantage of virtual commissioning. This allows for the system to be being prepared for the next product or challenge while still producing the current product, reducing the downtime to completely change the system from months to days.
        - This is achieved with tightly integrated high-fidelity simulation approach, control emulators, and a management process for the deployment of virtually tested code.

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- [FACTS4WORKERS - Detailed and Refined Industrial Challenges I, II, III, and IV (1)]

  Detailed and Refined Industrial Challenges I, II, III, and IV

- [FAR-EDGE - Reference Scenarios, Use Cases and KPIs]

  Report describing reference scenarios and use cases based on the outcomes of task T2.2.

- [FAR-EDGE - Blueprint Solutions and Strategies for Migrating to Decentralized Factory Automation Architectures - M20 release]

  This deliverable documents strategies for cost-effective migration of conventional automation architectures to hybrid and decentralized ones. The strategies are based on blueprint architectures, which are variants of the project's core edge computing architecture. The deliverable reflects the results of T3.7. This is the second of three incremental releases.

- [FAR-EDGE - Report on Testbed Scenarios and Validation - M33 release]

  A comprehensive report on the testbed validation processes, including an analysis of the technical and operational aspects of all scenarios. This deliverable is the third of a series of three, built on the findings of the previous one.

- [FAR-EDGE - FAR-EDGE Volvo Pilot: Mass-Customization]

  The FAR-EDGE Mass Customization pilot scenario is implemented in a Volvo Trucks plant. It is focused on production flexibility: how the FAR-EDGE Factory Automation Platform can support dynamic, easy and fast reconfiguration of an automated line, thus enabling one-of-a-kind production.

- [FAR-EDGE - FAR-EDGE Whirlpool Pilot: Reshoring]

  The FAR-EDGE Reshoring pilot scenario is implemented in some Whirlpool plants. It is focused on the synchronization of different production systems that, while operating autonomously, still need to share a "single point of truth" for planning and coordination at the Enterprise level. To this goal, the FAR-EDGE Factory Automation Platform supports a decentralized, collaborative governance of Edge systems.

- [FLEXCELLE - Integrated Artificial Intelligence]
  - Any complex manufacturing system generates large amounts of data, and this data is often underutilised and little value is generated. Due to FA3D2's highly flexible nature, it is an extremely complex system with many sources of variability which require understanding and compensating for.

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- Machine learning approached and other analytical tools are being developed to analyse the data, update virtual twins or test proposed changes in the digital twin, and then deploy these changes to the shop floor via the same digital pipeline as the virtual commissioning process.
- Key to this approach is integrating the skills and knowledge of the workers on the shop floor, who work in conjunction with the AI approaches to achieve hybrid decision making – the combination of human and machine intelligence.

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- This is achieved with tightly integrated high-fidelity simulation approach, control emulators, and a management process for the deployment of virtually tested code.

- **Fortissimo 2 - Advanced, cloud-based HPC simulation in the foundry business**

The goal of this experiment was to reduce the scrap rate of the foundry process. A service was needed which could predict the behaviour of the current batch of metal to reduce the amount of waste. If it were possible to adjust the process in real time, the foundry could lower energy consumption and production costs. Using historical data from previous production runs was seen as the key to this problem, but this entails data analytics requiring computing resources far in excess of those available to foundries or consultants like ProService.

Noesis and ProService collaborated to develop a new adaptive process for controlling the liquid-iron stage of the foundry-casting process, based on Noesis' Optimus software and ProService ITACA technologies. The two companies worked together to create a model of the process based on historical foundry data, and provided the required expertise to deploy the solution on a Cloud-based HPC platform. Thermal analysis software is used to generate production data, which is sent to the Fortissimo Cloud-based HPC infrastructure. The correction model is updated by the HPC resources based on the production data, and then returned to the foundry system, where the correction is calculated and applied.

- **Fortissimo 2 - Near Real-time Analysis of Airframe Certification Test Data**

he development of aircraft for civil aviation is driven largely by the economics of the materials constituting the airframe. Improvements in strength and durability can reduce aircraft weight and allow regulators to increase the inspection intervals.

There is a continuous demand for better materials and a greater understanding of how these materials perform in aircraft components. However, introducing a new structural material for an airframe is costly and takes several years, so there is a significant need for better certification processes.

One of the ways of reducing the cost and lead-time of the material qualification process is to improve the predictive capability of material

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models. Improved models lead to a reduction of the amount of testing required to achieve an reduction in the overall weight of the airframe.

The approach taken in this experiment was to use KE-chain, together with Colosso's data analysis and storage framework to calibrate a new algorithm to model materials based on data from fatigue tests. An HPC environment provided by Gompute was used to provide on-demand computing resources. This resulted in an improved ability to predict crack propagation in airframe components and a reduction in the required amount of fatigue testing.

- [Fortissimo 2 - Cloud-based HPC processing for knowledge generation in camshaft manufacture]

EPC manufactures more than half a million camshafts every year. The company needs to ensure that it produces high-quality parts. Monitoring of the manufacturing process generates a massive amount of data which could be used as a basis for machine learning to improve the production process. However, current software solutions are not able to fully process the data fast enough, so the potential knowledge that may be generated from it cannot be exploited.

TRIMEK developed a metrological module of its M3 software, which enables the use of big data resources for data analysis. The new module is able to analyse scanning and measurement data and compare parts much faster than before by using cloud-based HPC. The production process is therefore more time-efficient. The time savings enables more of the produced parts to be checked in the same amount of time, increasing the overall production quality.

Reducing the processing time for data analysis allows a higher knowledge and control of the quality of the production process and of its needs, such as maintenance requirements. By using this system, the end-user receives a higher-quality product, saving time and money, leading to benefits for their own client.

- [HORSE - Augmented Reality software for user assistance in a manufacturing work cell]

Augmented Reality technologies will be used for providing two services, exploiting the wealth of the monitoring information as well as HORSE systems' intelligence:

i) To assist human agents about tasks they are executing (e.g. next tasks), with superimposed information about potential dangers that are estimated by the various safety technologies,

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ii) to assist the inspection tasks and provide status and alert information over a portable device by superimposing this information on the scene in efficient and user friendly manner. In this case the inspector will get a “snapshot” of the condition of the shopfloor actors especially concerning safety aspects for instance an upcoming mechanical failure of a robot, or an approaching risk for a worker.

Assistance provided must be as intuitive, as immersive as can be; non-obtrusive, non-invasive and provided on-demand. It is aimed that the assistance reduces the strain on the worker.

Assistances to the worker will be provided using head mounted displays (HMD) such as Google glass which provide the opportunity to be comfortably integrated into the work space with the maximum safety and targeting the best efficiency.

The selected HMD will be assessed in a manufacturing application to ensure that worker can continue to work normally while getting support by AR. The assessment will also address evaluating the way the operators appreciate the device and the technical efficiency (resolution, field of view, integration within specific tasks) of the displays. The goal of this task is a module that can be optimized for in the implementation in the several use cases.

- **MIDIH - MIDIH Open CPS/IOT Integrated Platform v1**

  This prototype represents the MIDIH CPS/IOT Open Platform ready for experimenters, constantly supported till the end of the project

- **QU4LITY - AIRBUS Trade space framework for Autonomous Quality Manufacturing Systems’ Design**

  During the early phase of an aircraft program, Industrial Architects are evaluating different industrial scenarios and trade-offs. Interesting findings, include:

  (1) Manufacturing Processes are not enough agile and not enough flexible in order to answer to the complex and competitive environment and to the incessant changesneeded concerning both the performance (need to improve the ramp-up) and the product (change of MSN) on the assembly lines;

  (2) Engineering, Manufacturing & support processes are still considered in a sequential approach. For solving part of the problems, Product Line and Co-design concepts needs to be tackled. A Model-based systems engineering (MBSE) approach where the Industrial System is seen as a System like any

other (in parallel of the Aircraft) will allow to structure and optimise the development of Industrial System and to perform trade-offs efficiently.

Model based System Engineering, Trade Space exploration and Multi Skill optimization are common capabilities in Engineering Systems; often in the context of "Design to Aircraft Performance". The Engineering process and the Digital solutions are not enough supporting Design to Manufacturing Value.

This leads to late design loops, rework and the end extra costs for Airbus and for the customers.

The use case involves multiple engineering options and sites and at least one Airbus supplier; keeping in mind the need to deploy the solution at a large scale and at a low cost for Airbus and the suppliers.

The pilot will demonstrate applicability of the approach to design an industrial system at high level (Supplier network, Factories, Machines and processes) for near Zero-Defect Manufacturing. By taking the Industrial System as a whole, Autonomous Quality control loops will be integrated at the pertinent points. Also, the easy reconfiguration of manufacturing process will be compliant with AQ concepts. AQ for ZDM will also ensure to keep the right quality level as a target. Case focus aero structure design –with composite or metallic machining and assembly process using robots or humans.

- **QU4LITY - CONTI Autonomous Quality in PCB Production for Future Mobility**

The production of automotive electronics for future mobility is based on automated lines that secure highest quality and output. For the production and assembly of respective PCBs an effective ZDM approach and availability is paramount. Key features, such as "product/component quality", "cost control" and "time-to-market" for multi-millions of products outline the situation in the automotive industry at the brink of a new economic scenario and govern the global competitiveness.

As to Equipment Data Collection and Communication, it is obvious that:

(i) Sensing and combining data from a variety of sources is essential to enable a progressive approach. Setting a standard for data formats in shop floor communication, such as "Bluetooth 4.0 for Autonomous Quality" is crucial, aiming at achieving an independent format for machine communication; (ii) Autonomous quality control loops, as well as recognition a management of unstructured data for several production lines all over Europe requires establishing an "EU-Cloud "for safe, secure and trustworthy data processing; (iii) The adoption of Big Data technology in supervisory and strategic decision-

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making actions on production lines and the full supply grid are the gateway to immediate reaction to problems.

The pilot supports the realization of a ZDM Scenario for multi-stage production lines through introduction of deep analysis and decision-making control loops, for capturing, communicating, secure storing and visualizing real-time holistic data on products, material, equipment, environment, human actions; in relation to quality control and processes. Essential KPIs, such as FPY, OEE, MTBF/MTTR, PPM and Control loop time throughout the supply network will be fully taken into account.

- **QU4LITY - Danobat Digital Machine for zero-defects at high precision cutting/grinding**

Danobat, is a benchmark manufacturer of high value-added solutions in the field of grinding. Danobat develops, in close collaboration with its customers, turnkey solutions for specific applications in the following sectors: aerospace, railway, automotive, energy, oil and gas, and metal forming. Machine condition monitoring and data analytics are the foundation of Danobat and Ideko ?s approach for ZDM at machining level.

Danobat desings, develops and provides grinding and turning machines, as well as turn key complete manufacturing lines for high added value parts in the above mentioned sectors. The new digital factory environment has driven new developments and technological offer in the areas of Smart HMI, Danobat Data System and the Control System for integral automation of manufacturing lines.

The pilot of Danobat ZDM grinding machine will use grinding machine operational data to relate machine-use with evolution of machine components condition. The analytics and the applied control loops on ZDM grinding machine will be based on combination continuous data and test conditions.

- **QU4LITY - Data Spaces for Additive Manufacturing Machinery in QU4LITY project**
- **QU4LITY - FAGOR Zero-Defects Manufacturing Digital Press Machine**

FAGOR has a long experience in delivering manufacturing lines (machine-tools & the whole automation solution) as well as providing the building blocks of such lines (press machines). Press machine is the product par excellence of FAGOR. A press machine is composed by 2 rigid platforms (head and base), a bed, a ram, a mechanism and other surrounding components that guarantee the full automation and process control (temperature, pressure, etc.).

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The pilot proposed in QU4LITY project is framed within the process of continuous improvement of FAGOR R&D strategy. The development of this project will allow FAGOR to offer to its customers a more accuracy, competitive and productive press machines that can take part in a production line. All the improvements performed at press machine level will directly improve the production line where it is integrated with. The development of this project will facilitate the increase of the level of sales. The technological development together with the quality, constitute the great bet of FAGOR to achieve its objective of customer satisfaction.

The objective of this project is to reach zero defects manufacturing process collecting press machine critical parameters and identifying exactly the process developed in the manufacturing of pieces. Traditional zero defects approaches propose the analysis of such parameters isolated from the rest of the process where the machine is integrated. Whereas these approaches try to maximize the efficiency of the process by maximizing the efficiency of the parts, it fails to maximize the efficiency of the overall system. Such process has a great complexity from the point of view of the acquisition, measurement and transmission of the parameters and variables. In addition to that, the integration of the data from other parts of the system at machine level should be valuable.

- **QU4LITY - GF Digital machine and part twins for zero defect manufacturing**

Current barriers to high accuracy in manufacturing in multi-technology and automated cells are related to limitations in data aggregation to either machining processes or machine health scopes. Zero defect manufacturing in these systems will be therefore possible by taking into account in the planning stage how the machine mechanics evolve towards states where deviations are more likely to occur, where failures might damage the part or the machine, or where uncertainties are introduced by maintenance, repairing or any other uncontrolled factor in the chain.

The pilot will address the challenge by setting up a first digital system for detecting, diagnosing, and fully compensating deviations on accuracy, productivity and sustainability of a machining cell based on the aggregation of information from milling and EDM machinery health, process performance and geometrical part characterisation, using AQ control loops and a common data space for making possible a realistic information integration from different types of hardware & software coexisting at different end-users factories, and targeting fully automated, zero defect manufacturing.

- **QU4LITY - GHI Real-time cognitive hot stamping furnace 4.0**

Since 1937, GHI been designing and manufacturing industrial furnaces for melting, heat treating and heating any type of metal. GHI Furnace uses cutting-edge technology, which enables us to identify anomalies, provide support for in-use improvement, and plan predictive maintenance activities. The aim is to minimise unexpected downtime and to maximize the potential of our installations.

GHI provides to worldwide customers (1) Turnkey plants. GHI has developed an extensive range of turnkey plants in response to the growing demand for integral solutions. Industrial furnaces (2) Industrial furnaces for melting, heat treating and heating any type of metal. (3) Auxiliary equipment. GHI supply is rounded off by a wide range of auxiliary equipment for providing an integral solution to customer requirements. (4) Smart SAT 4.0. Through our after-sales service, we maintain a relationship with customers throughout the service life of equipment. GHI is a global leader and has engineered and delivered the largest rotary furnace in the world.

GHI has delivered 8000 installation's products and services to 1250 companies, in 48 different countries, and sectors around the world, among them aluminium production, automotive, aeronautical, railway, steelworks, renewable energies, zinc, etc. Customers include ALCOA, BEFESA, ThyssenKrupp, CIE Automotive, FAGOR, NEMAK, ARCELOR MITTAL, CAF, GM, GESTAMP, DAIMLER, VW, RENAULT, SCHAEFFLER, AIRBUS, EADS, SKF among many others.
One of the challenges of the automotive industry in recent years is to meet the demand to reduce fuel consumption, assuming a reduction in CO_2 emissions into the atmosphere. On the other hand, automotive sector has always been looking for increase the safety of the occupants of the vehicle in the event of a collision.

In order to obtain this double objective, a series of steps have been taken aimed at optimizing the structure of the vehicle, using other materials than conventional low-carbon steel for the manufacture of the vehicle structure or implementing advanced manufacturing techniques such as the technique of hot stamping. By means of this technique, parts with the required safety characteristics are obtained, even owning a weight reduction with respect to traditional methods of cold stamping.
Hot stamping is a current process for the manufacture of structural parts in the automotive sector. Hot stamping is a process by which a sheet is subjected to a load between two dies, while the entrance temperature of the sheet is bigger than the austenitization temperature of about 900-950 °C. This process takes advantage of the high ductility of the piece due to its high initial temperature and then proceeds to a rapid cooling to achieve the martensitic hardening of the piece.

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- **QU4LITY – KOL's Real-time injection moulding process monitoring-control**

Kolektor (KOL) is known as the world's largest manufacturer of commutators, the second largest European manufacturer of slip rings and the second largest European manufacturer of plastic-bonded magnetic products. Injection moulding is enabling technology for production of all these parts. The scope of this pilot project will be a production line where Kolektor produces one type of products. The aim of this pilot is to detect, possibly predict, and remove the cause of the process failure as soon as possible, ideally in real-time.

In the process of real-time process monitoring, we are planning to:
(i) Collect moulding process parameters;
(ii) Monitor environmental parameters;
(iii) Inspect moulding tool and moulded parts;
(iv) Introduce AQ control loops at the operational level.

Based on the collected data and by applying control loops, advanced analytics and artificial intelligence methods we will better understand the moulding process and will be able to detect anomalies and failures as soon as possible. Because of the geometry of a moulding tool and number of cavities, it is not possible to inspect all cavities at once. Therefore, we are planning to use robots to perform complex moves required for inspection. We would like to study if it is possible to automate the removal of root cause of the bad parts being produced (like cleaning the cavity with dry ice).

- **QU4LITY - MONDRAGON Zero defect and Autonomous Quality in Machinery Building for Capital Goods sector**

The goal of MONDRAGON Corporation roadmap for the coming years, as a global business group, is to change the structure of the businesses, leading their evolutions towards higher added value and developing new activities in leading sectors. Machinery Building for Capital Goods is a main industrial division within the Corporation providing high quality –high performance solutions based on smart technology in a wide variety of sectors (automotive, aerospace, energy, railway, oil &gas, capital goods, white goods, etc.). Danobat Group, Fagor Arrasate, and other leading corporate brands represent a benchmark in machines, solutions and advanced services in the area of Machine Tools.

Given the strategic importance of the Machine Tools industry, and in the context of QU4LITY, MONDRAGON proposes two process pilots in the Machinery Building for Capital Goods scenario; two realities that can be complementary in many customers' value chains:

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Use Case MONDR1:

Multi stage zero defect manufacturing rayway axes production line: Manufacturing Processes with Cutting/Grinding Machinery, leaded by DANOBAT (DAN). The objective of MONDR1 pilot is to reach zero defects in the production line of axles that includes several stages: machining (gridnging and turning), finishing stages, as well as in-process and final inspection and verification operations. During this multi-stage process, several deviations or process variability may cause geometry and quality defects that cause both extensive rework operations and part scrap.

The technologies and the control loops provided by QU4LITY will make it possible to achieve observability of the product, process and resource states, throughout the system stages.

Use Case MONDR2:

Zero-Defects Manufacturing digital Hot Stamping process: Manufacturing Processes with Hot Stamping Machinery, leaded by FAGOR. The objective of this MONDR2 pilot is to reach zero defects in the hot stamping cooling temperatures, transfer speed, loss of temperature in the transfer or settings of press and identifying exactly the process developed in the manufacturing of the parts.

- **QU4LITY - PHILIPS OneBlade shaving unit production line**

PHILIPS has recently developed a new male grooming device called OneBlade. The OneBlade is undergoing a phased worldwide introduction, started in 2016. PHILIPS is currently developing new production lines with increased capacity to meet the increased market demand. To remain competitive, there is a clear need to improve PHILIPS productivity by improving three main metrics: Time to market, Production costs and Product/component quality. An increase of component quality will have a positive effect on production costs and time to market.

- **QU4LITY - PRIMA Additive Manufacturing Pilot Adaptive Control Technology**

Prima Industrie is a world leader manufacturer of laser machines for metal components. Prima has recently started with a new activity in Additive Manufacturing systems, investing in both technologies of metal powder bed and direct energy deposition. The scope of this use case is to enhance process monitoring and control for producing metal components and make Additive process more productive and robust.

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The next generation of manufacturing systems will be based on advanced processes, where additive manufacturing (AM) leads the technology trend. If AM has done a first quantum leap shifting from prototyping to production, the second relevant leap is now directed to make series production a reality. Next Generation of AM systems go towards a cost-effective solution by embracing a more robust process and higher process quality. To reach this aim, it is important to improve monitoring and control aspects towards process reliability and ZDM in terms of part dimension, surface roughness, part quality. Improving the real time monitoring and closed loop control can lead to reduce development time, enhance part quality and reduce waste and cost of production.

In this pilot, additive manufacturing machines for powder bed and direct deposition will be considered to enhance process control for producing metal components. Traditional solutions and new concepts of machines will be considered to test new edge devices for process control, towards a ZDM result, and to work on data management and analytics to implement the whole manufacturing process by a platform and control loop approach. In laser-based additive manufacturing, production time has a great influence on the economic efficiency of the production process. To increase the productivity but also reliability of such processes, a zero-defect AM strategy is targeted. Starting from modular devices for real time detection of the process, it will be possible to collect data, deploy new parameters to adapt the machine control to the actual task and communicate data at management level, where not only the single machine is considered; approach will consider both new systems and new concepts of machines in parallel with AQ control loops.

- **QU4LITY - RiaStone Autonomous Quality ZDM for �Ceramic tableware Single-firing�**

RiaStone (RST) is part of “Visabeira Industria” a sub-holding of the “Visabeira Group” conglomerate. RST manufactures the IKEA worldwide supply of “Dinera”, “Fargrik” and “Flitighet” tableware families, being these products fabricated through an innovative Industrial ceramics production process: tableware automated single firing. RST needs to improve its Overall Production Effectiveness (OPE) KPI; from ~92%, to the improvement goal of reaching OPE 99%. This requires new approaches to production, promoting better and innovative defect management and production control methods, consistent with the integration of ZDM processes, namely in-line inspection technologies, and integration of tools for autonomous, automatic, smart system decision making.

In order to achieve the required improvement goals, RST will apply a systems-level strategy consisting in the integration of new inline inspections systems and QA control loops into the current production line. In parallel new in-line automation components will be implemented that will automatically remove detected defective parts from the production lines; enabling the introduction of recycling and re-using of raw materials into the production line for a new defect-free production cycle.

- **QU4LITY - SIEMENS SIMATIC Products Quality Improvements**

At Amberg, Siemens' Digital Factory Division is manufacturing its SIMATIC products. Core of the manufacturing process is the production of the circuit boards, which are later on assembled with the housing parts to form the final product.
The overall objective is the introduction of AQ control loops for testing improvement and thus for overall production efficiency, while at the same time further raising the quality rate of finished products. This shall be achieved by implementing a closed control loop approach via the deep analysis of process data and the implementation of digital twins for products and production. Data from control loops throughout the manufacturing lines are to be collected and analysed via data mining and machine learning techniques, allowing to systematically identifying faulty products and the respective failure causes, providing the base for the intended improvements. By means of quality forecasting and simulation, (production) control decisions shall be derived at an early stage if quality deviations occur, thus avoiding further added value in ok products.

- **QU4LITY - THYS Quality Management of Steering Gear based on Acoustic control**

The current context of the automotive sector leads to continuous improvement. For all customers, the quality of THSYS products passes by an acoustic comfort. Therefore, a large part of THYS production requires acoustic control.

Today, to make an acoustic control on our steering gears, a workstation uses accelerometers to measure the noise caused by the mechanical linkages and is able to determine if the product respect the acoustic limits. In case of defect, there is a need to identify which component from the assembly is responsible of the acoustic defect, so, that after a specific treatment and analysis of the signal, component as the root cause can be isolated.

- **QU4LITY - WHR Dryer Factory Holistic Quality Platform**

Whirlpool is opening a green field plant in Lodz/Poland. The white good that will be produced there is Dryer. Digitalizing the Factory, we want to reach a holistic approach to ZDM considering the full product lifecycle: from Product Design to Customer Service, cycling back to Product Design.

The pilot will leverage the outcomes of a previous research project (NMBP FP7 GRACE) and will integrate the QU4LITYdigital enablers and platforms (through the APIs) and the AQ control loops. The main innovation will be represented by the introduction in production of MPFQ model fused with AQ control loops: Functional Integration and Correlation between Material, Quality, Process and Appliance Functions.

This innovative way to control quality and model data inherent to quality will be the fundamental approach that will lead to the vision of holistic Quality system.

In addition, it will be deployed AQ reference implementations to address unresolved problems in the vertical integration of data management (from data gathering to visualization and decision-making), enabling a holistic vision to be achieved.

The production process to build a Clothes Dryer comprises many stages; combination of automatic equipment and manual operation and all along the production process several Quality Stations are installed to perform gauge, to detect defective parts, filter them out or repair them. The main stages of the production process (Drum Line, Heat Pump, Side Fabrication, Main Assembly, Functional Test, ZHQ Area and Reliability Test) will be equipped with a Quality Gate, i.e. station to perform gauges and pass/fail test on product as well as Process monitoring means (OEE, SPC, Andon).

All these data sources will be integrated in the experiment, providing a comprehensive view of the production process.

- **RebootIoTFactory - 20 proof-of-concepts of digitalised manufacturing**

  The main operational focus in Reboot has been in a creation of a Phase I PoC Portfolio, resulting in 20 entries during the first eighteen months. All of them originated from company needs and utilised by our factory members Nokia, ABB, GE Healthcare, KONGSBERG and Ponsse. In addition, there have been several innovation spill-overs where factories learned and implemented good practices from each other or from research.

  - **Prospect to project** enables better sales prediction to improve production planning, procurement and budgeting. It utilizes several kinds of business data such as CRM reports, sales history and market predictions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 873086.

- **Supply chain transparency** improves response times of supply chain in terms of production planning and material flow. Shorter overall production time gives benefit in the market.
- **Extranet development PoC & B2B extranet data transfer PoC** reduce manual non-value-adding work and increase information transparency in procurement processes at both factory and its supply chain.
- **Digital twin technical development** replaces physical sensors with virtual ones in end products, cutting the sensor maintenance costs in very demanding environments such as marine thruster systems.
- **Tester predictive maintenance** lowers the cost of electronics tester maintenance, improves production efficiency and lowers waste as testing is more reliable and anomalies can be spotted via data analytics. **SCALE-UP**
- **Robotic process automation** saves human daily working time by utilizing software robots in low value routine work related to IT-systems such as ERP and excel sheets.
- **Value of service enabled by digital solution** improves means to communicate the customer value of product digital twin to the potential customer. This gives manufacturer confidence when investing to digital service development.
- **Factory acceptance test** automates the data collection and reduces manual work in product final testing. It also creates a possibility for external classification agencies to give approvals remotely.
- **Mobile robots in material handling** reduce manual non-value-adding work and increase productivity in intralogistics. Components are transferred automatically/by-order from supermarket to assembly line with mobile robots.
- **Automatic component quality control** with machine vision increases capacity of assembly cells as inspection is quicker. It is also more reliable and less demanding in terms of human work.
- **Standard robot interface** increases the utilization rate of cobots, which are usually statically installed to a single workstation. New technology allows cobots to attach to and detach from individual workstations and to utilize task-specific grippers, significantly shortening the ROI related to cobot investments. **SCALE-UP**
- **Automatic error handling** reduces the downtime of robots that have entered in an error state through self-diagnostics based on machine learning from video data. Automatic error recognition also facilitates the development of self-recovery functionality.
- **AI foreman** PoCs produce automated production personnel allocation proposals based on multiple data sources to support faster day-to-day decision-making regarding production planning and resourcing. **SCALE-UP**
- **VR to achieve more understandable instructions** facilitates training of new employees and/or new products on manual assembly work and can also serve as competence development / maintenance tool for senior workers.
- **Wearables in industry** such as smart watches present new ways to inform employees about forthcoming tasks or alerts in production. Notifications can be tailored to each stakeholder group.

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- **Well-being at work** increases understanding on what affects well-being of employees and how it could be improved. Studies show that productivity goes hand in hand with employee wellness.
- **Gamification at factory floor** improves work motivation and employee satisfaction. Work instructions or routine reporting can have game-like features such as rewarding trophies or visuals with 3D game engines.
- **Legislation** brings understanding on what conditions data privacy legislation (such as the GDPR & the Act on the Protection of Privacy in Working Life) sets for personal data gathering and processing within factory employees, as well as for automatic decision making through artificial intelligence.

- **RebootIoTFactory - Scale-up: AI Foreman**

One of the most important tasks for a foreman is to ensure that the team has as little obstacles as possible disturbing their work. This applies also to “AI foreman”, a concept developed in the Reboot IoT project. AI foreman is supposed to assist the human foreman. It complements human skills with its own strengths, resulting in improved overall performance.

People working in factories these days spend way too much time in managing and scheduling orders. Furthermore, capabilities to react in sudden changes are not on a good enough level. Inventory management might fail if the storage runs out of a critical component, a worker with the needed skill profile might call in sick, a parallel project might reserve the needed factory equipment for a longer time than originally anticipated, and so on. Typically resourcing and scheduling is performed once a week or once a day, but because of the aforementioned incidents it is rarely realized in production as originally planned.

Together with VTT, University of Oulu, Gambit Labs, Parta Games, and FixUI, ABB is developing a system to assist order management and scheduling. This system, also called the AI foreman, has real-time knowledge of the factory’s state. It can also perform forecasts and notify of potential future incidents. It helps to speed up order management and improves the factory’s performance.

AI foreman can take into account the employees’ skill domains and levels. A future version will also start to gather and utilize employees’ own preferences in its reasoning. Light surveys can be conducted to collect feedback of various work phases. This can be used to plan an employee’s day so that it consists of pleasant and sensible tasks.

The same collected information can also be used for adopting new skills and career development. Diverse tasks often improve wellbeing and enjoying the work. In addition to the employee, also the factory as a whole benefits from multidisciplinary know-how because it helps resourcing and dynamic reaction to changes.

Gamification is in a central role in the project. When an employee completes a task enough times within the target schedule, she levels up and the AI foreman can use this information in its future planning. ABB's factory has in the spring of 2019 had more orders than ever before, which has caused some challenges to make the deadlines. If the AI foreman had already been deployed, scheduling might have been easier to accomplish.

- [RebootIoTFactory - Specific Characteristics Define Business-to-Business Supply Chains in the Manufacturing Industry]

Digitalization has enabled consumer product supply chains take significant leaps during the past two decades. Information flows from one player to the next and the customer can observe the parcel's journey almost in real time, using a computer or even a smartphone. Companies present in the ecosystem can estimate the supply, demand, and delivery times of products with high accuracy.

In a business to business (B2B) environment the situation is different. Consumer products are typically standardized and volumes high. In contrast, in B2B supply chains the products are tailored and volumes low. Products are often unique and targeted to a specific need. Also the purchasing process differs: you can buy a consumer product by clicking a couple of buttons on a webshop. Purchasing between companies takes longer and is more complex, often including for example tenders.

Balancing supply and demand

One central objective of the Reboot IoT Factory project's second phase is to estimate demand in a B2B supply network. As in the consumer market, also in B2B supply and demand need to be balanced. In a business like this, where the product varies a lot, estimations take for example the order backlog, ongoing sales processes, and tenders as input.

Predicting demand is challenging, but it has to be done in order to evaluate future product configurations. Product configurations, in turn, have impact on the kinds of components and materials that need to be ordered by the manufacturer. And all this needs to get done in time so that the ordered products will be shipped according to the agreed schedule. In theory this problem would go away if everything imaginable was stored in the warehouse. In practice, however, this is not a realistic option.

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Inventory management is a central process to be optimized in many if not all business domains. In B2B it is even more relevant than in consumer market. This is because the products vary so much, as mentioned above, and this would require maintaining even bigger an inventory. Naturally, B2B is not homogeneous and even within the Reboot IoT project there are different companies in this respect. For example Ponsse forestry machines are somewhat standard compared for example with KONGSBERG propulsion systems, where almost each product is unique. This is why it is enough for Ponsse to update its forecasts relatively rarely. The electronics contract manufacturer Scanfil, in contrast, needs new updates on a weekly basis.

Joint processes and information management in the core

There is still a long way to go until B2B supply networks are fully automated. Various players in the network typically have their own IT systems and interfaces between those are only partly implemented. That is why it is central to concentrate not only on technical integrations, but also on defining joint operating models and processes. The ecosystem needs to function on common rules and share enough information to guarantee that the products get shipped in time and as ordered.

There are roughly three main streams in a supply network: information flow, material flow, and money flow. The information flow is extremely important and has impact in the other two. Detailed and up-to-date information is crucial for the products to be manufactured and shipped as agreed. This is a basis for the money to flow from one company to another and profitable business to be made.

- **RebootIoTFactory - Future Work with AI Foreman in Digital Factory**

How the new technologies can be used to improve well-being and productivity of employees? Milla Immonen from VTT, Mikko Jukkanen from ABB and Anna Rohunen from the University of Oulu have been working on the Reboot IoT Factory Grand Challenge 3: Labor at Digital Work Environment. We had the chance to discuss with them how to develop a factory towards a digital working environment.

The big picture of developing the digital working environment consists of commitment of executives, rapid testing of new technologies and involving the workers on the factory floor. Gathering data about human resources requires empathy and legal control as well as appropriate tools.

How to Measure Stress?

The starting point of the work was tracking the well-being and performance of the employees at a factory – gathering data of the stress of factory floor work and limitations and preferences of the workers. The topic is sensitive, and it is important to explore thoroughly how to handle it with workers and their representatives.

"We have discussed the implementations of data collecting. Not big volume, just basics like how current algorithms can help measuring preferences. This begins with research", explains Mikko Jukkanen from ABB factory.

"In the beginning we thought a lot of how the load of different work tasks could be measured. There are different kinds of workload: e.g. physical and cognitive. Together with the factory we have been building a concept of the worker information that could be used in work allocation to enhance the wellbeing and satisfaction of the workers", Milla Immonen from VTT explains.

Mikko adds that other factors affecting the work have been mapped as well: the data of employee well-being, personal strengths and preferences completes the picture, and makes it possible to create a digital twin of an employee. The concept of employee digital twin is something VTT has created and it is in testing phase.

As Mikko says, "These measurements help taking care of well-being and tailoring the work for each worker. Creating a virtual pool of workers' skills and combining the information to the order backlog helps making decisions and enhancing the production process."

Listening the Factory Floor

The topic faces challenges in getting the factory workers receptive of the idea. The purpose is not to watch behind their backs but to support their performance and wellbeing. This requires a lot of background research especially in questions of privacy and confidentiality.

Anna Rohunen is a data expert who advices researchers in legal questions concentrating on privacy protection: "Collecting and using personal information is often considered sensitive in the context of employment. Privacy legislation regulates the data usage to guarantee the employees' rights. We need to carefully make sure that the system is compliant with the legislative requirements", she highlights.

It is very important to listen the workers and they have done exactly that by interviewing them. The pilot services have involved volunteers to test them

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and the workers got a chance to keep track of their own data and shape their own job.

”We have piloted gamification in production. The service tracks the production and records skill data to a matrix that collects the expertise of each worker. Each employee can then access and visualize their own personal data through GUI of the MES system. There have been promising results: we got good feedback from the volunteers and some of them continued to use the service,” Mikko talks about ABB’s pilot.

Another challenge is the attitude towards data collection. “When presenting the new solutions to the employees the focus needs to be on the positive effects and telling openly what data is collected. The solution is supposed to enhance well-being, safety, and satisfaction at work. The common fear is being constantly monitored and watched”, adds Milla.

Future vision: AI Foreman

Using AI in the production will increase in the future. AI Foreman is a solution developed by VTT that carries out work management with AI. Humanising AI is a future vision that these projects are aiming at. It is important to make digital environment and AI humane and user centred.

“The legal obligations are challenging and it is not yet completely clear how to interpret them in our context. References are still scarce in this field”, reminds Anna when speaking of AI-based data processing at work environment.

Mikko depicts a future vision: “AI foreman distributes tasks based on a worker’s digital twin. When a worker checks in the AI foreman greets and guides them. The worker’s preferences and skills have been mapped and the information is combined to the orders. The system monitors the day’s progress and how the goals are met. The AI basically takes care of resourcing and that everything goes well.”

Read more about Grand Challenge 3: Labor at digital work environment

- **RebootIoTFactory - Taking Care of Employees� Well-being and Preferences is the Key to Profitable Industry**

Reboot IoT Factory concentrates mainly on automation, simulations, robotics, and other highly technical means for streamlining industry. While doing this, however, it does not forget the human worker: one essential objective is to apply various methods for helping people to cope at their work.

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Factory workers' average age is increasing in many industry domains. This poses all kinds of challenges for carrying out the tasks at work. It is important to try and make the work easier for the older employees. At the same time job profiles are made more attractive also for younger generations.

Taking care of job wellbeing means long-term optimization

Often the productivity of a factory is measured in a short-term fashion, attempting to maximize for example the amount of products manufactured during one work shift. Such approach can easily overlook for example ergonomics. This can later on manifest as dissatisfaction at work and sick leaves. As a long-term rule of thumb one can state: the better the work wellbeing, the less sick leaves and the more production.

Technology has an important role in advancing work wellbeing. Automating routine work helps to allocate time in tasks that are cognitively and socially more meaningful. As an example: when the team leader spends less time with filling excel sheets and reading pdf reports, she can direct his attention to organizing work and interacting with the team members. Reboot IoT's AI Foreman concept aims at exactly this.

On the factory floor the worker benefits from technology for example via automated work rotation so that the same muscle groups are not burdened for too long at a time. Worker's "digital twin" tells what tasks he has performed earlier, what is his skill profile, and what are the limitations. The system can also recommend micro breaks and stretching the muscles. Collecting, utilizing, and storing data like this has to be done so that the personal privacy of the worker is carefully respected.

Acknowledging personal preferences in addition to the skill profile

One interesting approach in improving work wellbeing has to do with making use of the worker's preferences in organizing tasks and work rotation. This will be piloted during the second phase of the Reboot project. Versatile and diverse tasks make the work more meaningful, in particular if the worker can influence on how his own workday is organized.

- **RebootIoTFactory - Voice assistance makes factories smarter**

Voice assistants, such as Amazon Alexa and Google Assistant, are being used daily by hundreds of millions of people at home, in the car, or on the go. Even though speech is natural and effortless way of interacting with devices and services, voice control is not yet widely used in factory environment. As part of the Reboot IoT Factory challenge, Nokia and Creoir wanted to bring

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voice control into Nokia Conscious Factory to validate the voice user interface in a factory environment.

Creoir Oy is a technology and product development company specialized in speech technologies and voice-enabled products and services. Creoir Offline Voice Solution SDK (Software Development Kit) enables a flexible and effortless way of bringing Automatic Speech Recognition (ASR) and Natural Language Understanding (NLU) to devices that need to work in challenging noise conditions.

Hands-free at the Factory

The operators and workers at the factory have typically many concurrent tasks at hand. The challenge is that operators need to interrupt the current tasks and free their hands to access instructions and manufacturing data, or to control computers and machines.

Security and reliability are extremely important in any factory. Therefore, it is not possible to use major cloud-based voice platform providers like Amazon or Google. Also, to reach robust speech recognition performance, attention needs to be paid to noise reduction and voice processing.

Smart Factory Voice Assistant

The solution in the PoC project was to create a Smart Factory Voice Assistant, which enables a hands-free voice user interface to access Nokia factory data. Creoir Offline Voice Solution SDK was used to create custom wake-word and needed voice commands to access the Nokia factory system. Special voice processing and noise reduction algorithms were deployed to guarantee far-field voice control even from a distance of five (5) meters.

The Smart Factory Assistant is a stand-alone product with an integrated speaker and two microphones. All speech processing is done on-device, and MQTT (Message Queuing Telemetry Transport) interface is used to access the Nokia factory back-end.

The deployment in the project was straightforward; at the beginning of the project MQTT topics based on intents were agreed upon between Creoir and Nokia. Creoir was responsible for speech to meaning conversion and the Nokia team implemented the needed action code at the Nokia back-end.

The noise conditions were recorded on-site, and these recordings were used in the configuration and parametrization of the noise processing algorithms.

Benefits and Next Steps

Smart Factory Voice Assistant is now in use at the Nokia Conscious Factory control corner to provide an easy way of getting quality data of the ongoing production. The plan is to extend use cases to support operators during the assembly process on the factory floor. Also, voice control for mobile robots is being investigated.

There are also many other opportunities for voice control in a factory environment. Feel free to contact Creoir if you would like to learn more about adding voice to your factory!

"Speech is the most natural way of interacting between people. At Nokia, we wanted to find out how we could use voice control for machines in a factory environment. Working with Creoir was a good experience for us – their expertise in speech technologies and embedded products was essential to achieve the targets of the PoC project. We are looking forward to continue co-operation in the future" – Jouni Herronen, Technology Program Manager, Nokia.

This project was part of the Grand Challenge 4. Read more: GC 4: Digital Production

Find out more about Creoir Oy here.

- **RebootIoTFactory - Towards Future Factories: Automatic Quality Control**

Reboot IoT Factory works to re-imagine the automation levels of existing processes in the factories. Developing and using AI, intelligent algorithms, software robotics and robotics process automation the project helps the factories develop new intelligent ways for production. Automatic quality control is a field with promising applications of automatized visual inspection.

We talked with **Ilpo Tanskanen** and **Markus Broman** from ABB Porvoo and **Vili Kellokumpu** from VTT about the theme automatic quality control and more precisely, about visual inspection. The field is moving towards automatization with machine vision, learning systems and neural networks. Visual inspection is also a handy way to acquire measured information, data, and quality control.

"Opportunities created by developing digitalisation help the factories take robotics and automation to the next level. Reboot IoT Factory is a sure way to achieve this goal", say Markus and Ilpo. "The project offers different

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approach to innovations: the participant SMEs create solutions for the factories and productize them. The researchers bring in the scientific approach. The way of working is different than we have used to in corporate life. In business it is usual to run rapid tests and set mind towards future needs. Now we have a large knowledge and research base and testing laboratories that we can use. We get help to our projects and achieve better understanding along with the better results."

Factory as an Innovation Platform

Factories' roles as innovation platforms make it possible to successfully merge different approaches to develop new solutions. The co-operation was fruitful. The first Proof of Concept developed with ABB Porvoo was about visual inspection and was completed in co-operation with VTT. It dealt with quality control of a surface of the product and finding aberrations. The purpose of this PoC was to find the right equipment for this task.

Before the Reboot IoT Factory project, 5 pairs of human eyes carried out the quality control procedure and the factory was eager to find another, automatized solution. The focus was on researching the methods, not building any device. The Reboot IoT Factory made it possible to work with a world class expert.

The expert, Vili Kellokumpu, worked with the technical solutions of PoCs together with the companies. His area of expertise are optical measurements, machine vision and imaging.

Vision: A Self-Correcting System in Quality Control

In the future, a self-correcting system lets the computer know how to develop production. The first step, finding the errors is already working. The technology for correcting the aberrations automatically is existing, but it has not been possible yet to utilise it in producing plastic objects.

Markus and Ilpo are enthusiastic about the project:

"Strategic PoCs can offer these future solutions. We will continue automatization and digitalisation in ABB Porvoo and invest in skills. Reboot IoT Factory work has been a great window to the future. We feel that sharing knowledge serves strategic thinking and the technological knowledge increases in this kind of co-working."

Increasing automatization and digitalisation is an indisputable trend of industry. Vili clarifies that automatised visual inspection can use wavelengths invisible to human eye making it more precise.

“Neural-networks have made a breakthrough in image analysis and when suitable imaging techniques are applied the quality of the image is so good that you can spot the problems in quality of the product inspected.”

Collecting production data and utilising it is the future. Machine learning and AI complete the vision.

Responding the Factory’s Needs Ideal for All

The theme, automatic quality control and the PoCs related to it came from the factory. It is reasonable to start with them as the other operators are often more agile and the factory moves slowly.

The beginning of the PoC work started with samples. A prototype was created after that in the lab. The PoC was first demonstrated in a small scale. Rapid testing and productizing finalised the work. The results were good.

“Results on a larger scale include delivering important knowledge based on scientific research, but also actual products. Technical development of machine vision made this possible”, Vili explains.

Markus and Ilpo unwrap the current challenges: “Objects with shiny surfaces and 3D objects. The solution for them must be tailored as there are no such equipment in the market that would be ready and suitable for our needs of quality control of surfaces. Now we know which technology can be applied and which not. The process was smooth: rapid testing, minimum investment and scientific validation were the cornerstones.**”**

The work continues with the second PoC. The financial investment is on totally different level now when it is clear what methods to use. The situation is ideal for the factory and the company developing the solution. The product development moves ahead based on the needs of the factory. That is exceptional in corporate life.

This project was part of Reboot IoT Factory’s Grand Challege 2: Robotics Fusion

Text: Veera Kiurujoki, Design Inspis Oy

Picture: Design Inspis Oy

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 873086.

- [RebootIoTFactory - Hunting Data and Putting It to Work � Piloting Data Collection for Industrial IoT]

Collecting data forms the groundwork for developed IoT solutions. We had the chance to discuss about data collection pilot with Jouni Vuorensivu and Janne Ouni (in the picture above) from Remion Oy. They have been working with ABB Porvoo Wiring Accessories on Remion created system that enhances the productivity of the factory with data utilisation.

Remion Oy is Tampere-based company specialised in industrial internet services, such as data collection, analytics and visualization using state-of-the-art technologies. The experienced company employs 23 people.

Piloting Big Data Collection

ABB Porvoo was looking for data collecting solutions and asked Remion to join the project. The solution was to collect, analyse and transfer production cell operation data into the cloud for further utilisation.

“Our PoC was a pilot concept, which aimed at building up experience of data collection. The main questions were what kind of information can be collected from the production cells and what can be developed of that data,” Janne explains.

Remion’s project with ABB Porvoo focused on big data collection. It was carried out with the service called Regatta®. It is Remion’s industrial IoT solution – a modular system offering different components based on the client’s needs. The ABB Porvoo project was to collect data for quality, predictive maintenance and production metrics and it was targeted to measure Cpk (quality) and OEE (production).

The service was tailored to meet the factory’s needs: the first module collected data, another processed it and the third module visualised the collected information.

Various Utilisations – from Maintenance to Visualising Trends

The pilot was built around injection molding machines that produce plastic electrification products for the building industry.

”We wanted to follow up the efficiency of the whole production cell – the OEE statistic. The traditional challenge with quality control is that the errors have been sorted manually, it is laborious and naturally less precise,” Jouni describes the project.

With the IoT solution, ABB Porvoo aims at higher OEE statistic and more precise follow up and control.

The data could be utilised in so many ways and different situations: in maintenance, quality control, catching errors and homogenising the products. Data helps minimising stops and interruptions; it helps monitoring the production. The users can react to alarms right away and fix the problems. The managers can follow the revenue and general efficiency of the plant or a machine on time. The data can also be integrated to other systems.

Putting the data on visual form makes it easy to analyse, browse values, and follow trends.

The Work Continues

The co-operation went smoothly according to Jouni: ”Working with ABB Porvoo was easy, everybody there were enthusiastic about the project and its goals. The challenges we faced were mostly concerning schedules. Although we had to solve the information security and privacy issues: we decided to keep the data collecting and transferring networks separate with manual transition for now.”

Remion has been discussing about expanding the system inside ABB Porvoo and will continue the work there. In the future they can utilise the factory’s own platforms to which the solutions can be integrated.

“We are in the early stages of updating and adding to the digitalization of our production equipment at the Porvoo factory, and the pilot project with Remion was a big leap in the right direction for us. The work that was done has been a great learning experience in how data from industrial equipment can be collected and processed, and this experience will aid us in configuration and scale-up of more comprehensive production data systems in the future.

Working with Remion was pleasant right from the start of the project. They are clearly experts within the industrial data area, but also very competent in project management and working flexibly within the constraints set by the client.” – Jesse Wickström, Production Development Specialist, ABB Oy WA

This project was part of the Grand Challenge 4. Read more: GC 4: Digital Production

Find out more about Remion Oy

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 873086.

- **RebootIoTFactory - Exploring the Challenges of Manufacturing with Learning Machine Vision**

Learning-based Machine Vision Tackled the Challenge

The challenge of ABB consisted of inspection of a one specific product on the automatic assembly line. They needed a system to make sure the product is assembled correctly. To make it easier, the factory already had a camera on the assembly line's final inspection station. That camera collected the testing material needed to pilot the deep learning algorithm. Algorithms based on neuro-networks are one of the most recent trends on the field, but already familiar to Mika Saarinen:

”The development process was amazingly easy. This is a technical challenge we have been trying to solve with traditional rule-based algorithms for years, but it is not going to happen that way. The novelty of algorithms based on deep neuro-networks is that we can now solve problems that were previously very difficult.”

The solution's Proof of Concept (PoC) is ready, waiting only for the paperwork to be completed until it can be utilised in production.

The project was called Cognex Vidi Deep Learning Machine Vision PoC. We tested learning machine vision instead of traditional machine vision in one automation cell. The co-operation with AP Vision went well and the results are promising. The learning machine vision was able to perform the inspection in this cell more reliably than previously used rule-based application. Programming the system was faster and easier than it was with the old method. We are considering expanding the utilisation of the new technology into new implementations after this project is completed. -Mikko Jukkanen, ABB

Seamless Co-operation

Reboot IoT Factory has been establishing ecosystem that creates easy co-operation among researchers, SMEs and factories. The companies have fresh networks, and chances to introduce their products and technology to the new audiences.

The project work has fitted seamlessly to AP Vision's everyday business and there have been fruitful consequences. The company got another case, a chance to work with GE Healthcare Finland in a project that aimed to implement Cognex's neuro-network AI camera into inspecting the coupling cables' solders of an oxygen measurement sensor. This solution is ready and currently being used in production.

- **RebootIoTFactory - Predictive Maintenance Supports Autonomous Shipping**

Increasing the level of automation is a major trend in shipping, with advanced navigation systems and collision avoidance algorithms currently getting most of the headlines. To achieve business benefits and lifetime cost savings, however, it is equally important to ensure reliable operation of ship machinery and propulsion systems. Traditionally, maintenance of these ship systems has been very reliant on manning, reactive maintenance practices and scheduled overhauls. This approach has proved to be sufficient, as the crew has been constantly available to handle repairs and other maintenance tasks on-board. In the future, this may not be the case anymore, as the shift towards remote operated and autonomous vessels proceeds. This will potentially reduce manning and alter the crew tasks – whether they are located on-board the ship or in a remote control centre.

Predictive maintenance is considered in the Reboot IoT Factory project as a key approach to mitigate the risk of failures as well as to improve the efficiency of industrial operations and the utilization of assets. Until recently, however, the research in the maritime sector on the implementation and use of predictive maintenance technologies, instead of continuous manning, has been quite rare. Thus, a pre-study on how to better understand the safety, legal, liability and insurance requirements, as well as the initial business considerations of using predictive maintenance in shipping was conducted in a collaboration between VTT, Åbo Akademi University and Kongsberg Maritime.

New predictive maintenance technologies need to be applied safely. This will require changes in the safety regulations, as well as in development and testing practices.

The maritime safety regulations are set by various actors, such as national flag state authorities, classification societies and the International Maritime Organization (IMO). The international and national regulations mostly do not set exact limits for the number of crew members on board, but some changes in the legal framework might be needed, as the idea of autonomous operation is not considered at all in the current regulations. The needed changes in international conventions are currently being studied, but the changes are expected to be very slow. Classification societies have taken an active role and have published some high-level guidelines to support the development of autonomous and remote operated ships. These guidelines are still quite high-level and do not cover many of the technical systems in detail. In practice, the first applications will likely be operated within the national waters of a single country. In such cases, the national authority plays a major role in approving the new technology and in issuing permits for testing activities. A step-wise approach, starting with small vessels operating in a small sea area, can be adopted to mitigate risks in new technology deployment.

The liability and insurance aspects are also just starting to develop, and they are internationally somewhat less harmonized than the safety regulations. The main questions revolve around the changing role of human and understanding who should be liable when an autonomous system makes mistakes. Currently, the liable party is usually the ship–owner, but in the future, this may not be quite as clear. Insuring the new technologies would need to start from consideration whether the predictive maintenance is predictable enough to be insured – in the first cases, this might be a challenge as there is no data available from previous installations.

Predictive maintenance is emerging in shipping, with the potential to improve efficiency, generate significant cost savings and create entirely novel business opportunities.

The potential business benefits of predictive maintenance in shipping can be significant. In addition to the reduction of the lifetime operating cost and extending the life of equipment and assets, predictive maintenance solutions can create totally novel opportunities for business activities. Moreover, better predictability of operations will enable more accurate decision-making. In the long term, the development may also lead to changes in the roles of different stakeholders in the maritime business ecosystem and expansion of the industry boundaries by enabling new, agile service providers to enter the market. As next steps in the Reboot IoT Factory project, the potential business models for deploying predictive maintenance solutions will be studied in more detail.

Experts involved in the study:

- VTT: Eetu Heikkilä, Minna Räikkönen, Pasi Valkokari
- Åbo Akademi University: Henry Schwartz
- Kongsberg Maritime: Joni Keski-Rahkonen, Ari Vehanen, Mikko Mattila

- **RebootIoTFactory - In Robotics Fusion Routine Tasks Blend Into Seamless Co-operation Between Robots and People**

One central goal of the Reboot IoT Factory project's second phase is to transform routine factory tasks from people to robots. There is a noble societal objective underlying this: to keep factories and industry in Finland.

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Finland is a country of high labor costs. Automating tasks suitable for robots makes it possible to redirect humans' activities into cognitively higher-level tasks. This, in turn, helps keeping the Finnish industry competitive.

Robotics fusion combines several activities

The first phase of Reboot IoT succeeded in automating many activities. Now, during the second phase, the focus is on combining them. The used term is *robotics fusion*. Robotics fusion means not only connecting the activities of robots, but also advancing the co-operation between robots and people. Robotics fusion presupposes developing both software and hardware. The results are very concrete and demonstrable in real settings.

Central areas for this work are for example machine vision, mobile robotics, and actions performed by a robot arm. Machine vision can be applied for example in monitoring how cogwheels wear out. This information can act as input for a digital twin. The twin, in turn, can perform estimations on future repair needs. Mobile robot Reetu transports components to appropriate locations in a factory. A robot arm can select proper parts and deliver them forward, in the right position.

People play central role in robotics fusion

Robotics fusion combines above-mentioned areas: a robotics arm can be attached to a mobile robot and machine vision can be applied in selecting the right parts. These days Reetu can even operate an elevator and dock itself with other carts. Furthermore, the fusion is also focused on the collaboration between people and robots. Traditionally, mainly due to security reasons, robots have been operating in separated fenced areas. Now Reboot IoT has started the first pilots where people and robots work together in shared spaces.

Error anticipation and recovery are specific themes in robotics fusion. If a robot makes a lot of mistakes and always needs help from humans to recover, the whole point of automation goes down the drain. That is why it makes sense to invest in the robot's fault tolerance and self-recovery capabilities. This is of particular importance in keeping the shared workspaces safe.

Expert: Markku Hentula, VTT

Text: Santtu Toivonen

- **RebootIoTFactory - RPA Making People Experts Again**

Festum Software is a Finnish company that creates Robotic Process Automation solutions for companies. That means automatization of repetitive and monotonous tasks carried out by human workers. Software robots are not replacing people but letting them be the experts and concentrate on the work that requires thinking and intelligent decision making. Jorma Messo, Business Manager of Festum, tells us how to utilise RPA solutions in different processes with manufacturers.

Festum started to develop robots together with Scanfil, a global contract manufacturer and systems supplier. During the first development process they found out that Scanfil's real need was automatizing purchasing**.** Purchasing needed to be faster and easier, and it contains tasks that could be taught to a software robot. The process included finding repetitive tasks, teaching the robot how to use the systems and perform the tasks. The selected Kofax RPA technology was based on Low Code technology and enabled fast implementation of the robot without traditional coding.

“Before Reboot IoT Factory, we had only little experiences in RPA mainly from the small-scale research we had done. Festum offered useful models how to build an environment in which RPA could be managed as part of the processes. They mapped and evaluated the potential targets for automation, formed and maintained the specifications and tailored the software”, says **Sami Tervo** from Scanfil.

“The project was ideal”, Jorma explains. “The work was open-minded and goal-oriented, and the technology used challenges interestingly the traditional solutions. Building trust was easy and working remotely went smoothly. Scanfil was very engaged in the project. Our company also got attention from new audiences.”

“We have only had good experiences: the standard office work is partly delegated to a robot and people have time to concentrate on more demanding tasks. The co-operation with Festum has worked well. Their experts have found solutions even to some more unusual cases”, Sami adds.

A Software Robot Goes Through Data

Festum was part of another development project as well: they worked with Nokia Oulu Factory to pilot RPA solution to material simulation. Manually performed simulation is a slow and demanding process. The amount of data is massive and there are several systems to go through. This task is strenuous to a human worker. The software robot was implemented in gathering the information and human expert comes along when it is time to analyse the data.

"Festum built the software based on existing model – how a human performs the simulation", Jorma clarifies.

Daily material simulation creates visibility to material availability to production. This simulation is a manual process and requires high manual effort to complete. Together with Festum we have been piloting how Robotic Process Automation could be used to automate this process.

Collaboration with Festum has been working very well despite the covid situation and thus doing work mainly in remote mode. – Mika Kaivola, Nokia

Robotics from the Human Standpoint

When developing new solutions that involve robotics it is important to properly introduce the solutions to the people working in the factory. The robot is not going to replace humans. It helps to diminish the rush and unnecessary tasks. The benefits are clear: RPA helps to predict things; it enhances quality and helps controlling the processes. Humans have time and better resources to complete the analysis.

Anywhere there are repetitive tasks there are implementations for robotics. As Jorma says: "The technology is not the challenge anymore – at the start, a change in mindset to upgrade outdated work processes might be. There are right tools for every environment. RPA solutions are perfectly possible for the smaller companies as well as for the big manufacturers. The only thing that matters is data volume and the nature of tasks.

The next step of the developing industry is machine learning. Robots are connecting different technologies, industries, processes, and people. There is an exhilarating atmosphere in the field. These projects have taught us a lot of manufacturing. This is a very diverse and interesting field."

Read more about Festum Software.

- **RebootIoTFactory - Scale-up: Standard Robot Interface**

Standard Robot Interface is a device, which makes it possible to use one robot with multiple production cells. Robots, especially cobots are expensive, and utilization rate of those should be high. Standard Robot Interface connects the hardware interfaces (mechanical, electric and pneumatic connectors), as well as software interfaces so that it is easy to move a robot from one task to another thus improving its utilization rate.

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Standard Robot Interface has first been tested at GE Healthcare factory in Helsinki. Based on the first tests in real factory environment, new features such as automatic gripper finger change system has been developed. Roboco (https://roboco.fi/) has made an implementation of Standard Robot Interface, specification and usage tests have done at GE Healthcare (http://www.gehealthcare.fi/), and research work has mainly been done at VTT (https://www.vttresearch.com/en). Standard Robot Interface has gained a lot of interest in Reboot IoT Factory project, and and there is plans to try it at ABB Vaasa factory.

- **RebootIoTFactory - Scale-up: Tester Predictive Maintenance**

Scale-up Proof-of-concepts are the finest the Reboot has to offer. They are the proof-of-concepts that are so successful that they are taken to another factory already during the project.

Tester Predictive Maintenance proof-of-concept arose from the need of detecting when a tester is breaking down and not the products it is testing. Research was done towards how the testing data from the tester could be analysed in a way that it would indicate the wear and tear of the testing equipment. The first implementation was done at Nokia factory for electronics needs. The proof-of concept were a success and the algorithms could be applied to find the testing equipment failure. As data is gathered more the more efficient the analysis become.

Often the simplest solution to a problem is also the most effective. In order to discover such solution one has to take a step back and look for new points of view. To think outside of the box, as the saying goes. This is what happened at Nokia in Oulu, in Reboot IoT Factory's TesterWatch project. As the outcome a novel way to test the functioning of base station products was invented.

Before shipping to customers, the proper functioning of base station products is ensured with test devices. Parallel identical test devices are used for scaling up the operations. If one tester gives systematically different readings than its peers, the problem is likely in that particular tester, not in the product which is being tested. For example the connectors used to attach test devices with products start to wear down over time. This causes contact failures and the test results start to fluctuate. Anomalies result in sending a real time alarm to the maintenance team. This way quality engineers can immediately engage in repair activities. Before TesterWatch they run reports in mornings and based on those performed the needed actions.

The algorithm itself and the solution based on it are straightforward. They were born in a brainstorming session among the project team followed by

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statistical analysis. The analysis and number crunching was completely agnostic to base station technology. Exactly this is the out of the box approach. The solution most likely would not have been invented if the project team had consisted only of the base station factory's own workforce.

The approach can be extended to other industry domains. Reboot IoT consortium has introduced it in GE's factory in Vallila, Helsinki where predictivity ability has been researched and implemented. Naturally also Nokia is going to implement it in its other factories. In Oulu it is already used in production 24/7.

TesterWatch is a prime example of digitalization project which delivers new process innovations rather than tangible gadgets. Testing base station products is now more reliable than it was before. Time and money get saved.

Even though the current version of TesterWatch is quite simple, it can be developed towards machine learning and AI. The aim is to enable predictive maintenance. Today's maintenance team is called when something has already happened. In the future they can be paged before things go wrong. The system can for example keep log of test devices' functioning and propose changing some parts to a particular device once it reaches certain age.

TesterWatch can also be attached with a broader digital system of a factory.

- **SAFIRE - SAFIRE Electrolux pilot: Cloud-driven product optimization**

  Within the SAFIRE Project Electrolux seeks to address the use-case where products connected to a cloud-based system can be optimized through a reconfiguration process (Cloud-driven product optimization).

- **SAFIRE - SAFIRE OAS pilot: Optimisation of production processes and preventive maintenance activities**

  The objective of the OAS manufacturing case study is to demonstrate the use of the SAFIRE solution to optimize production processes and preventive maintenance activities through reconfiguration of such processes based on big-data analysis in the cloud.

- **SAFIRE - SAFIRE ONA pilot: Adaptive Machining**
- **SHOP4CF - Utilisation of AR/VR communication & remote sensing Technologies for Technical Support between Remote Plants of Ar�elik**

  Challenge

Arçelik has eight different Washing Machine plants that are located in different countries. We will focus on Romania and Cay?rova/Istanbul Washing Machine plants with this use-case. Technical support for production lines and collaboration of design teams at remote factories require the existence of experts in many different engineering branches. This causes additional costs and delays in providing the technical support, which can even lead to halts in manufacturing lines. Currently, there is no other option except phone calls, e-mails and factory visits to investigate the technical problems and to receive the detailed feedback about the reported problem and root cause. It causes delays in the project deadlines, the downtime on the production lines, time-consuming and extra cost, huge efforts between teams.

Use case

A central team of engineering experts will remotely support the local factories through augmented reality (AR) and virtual reality (VR) communication tools. The experts will be able to remotely advise and inspect the local problems by means of video teleconference, augmented by sensor readings, instructions and notes. Local engineers would be able to be guided by experts located at the main headquarters which will enable the efficient use of expert human resources to solve technical problems, reduce the efforts (site visiting, equipment transport and travel needs) and reduce the error-rate caused by humans.

SHOP4CF scope:

- AR or/and VR remote support (live)
- Remote sensor readings

- **SHOP4CF - Support workers and to reduce the error rate**

Challenge

Robert Bosch España Fábrica Madrid S.A. is the mass-scale manufacturer for automotive sensors, which process is fully automated and is running 24/7 non-stop. However, the plant is also manufacturing Electronic Control Units, where small series of spare parts are supplied to car makers and aftermarket. Since the batches are small and it only requires a few hours in one month, even in some cases, in one year, hence it is neither possible nor economically viable to automate the production line for those automotive spare parts. Although they are small in quantity, they are complex in reference designs that usually BOSCH need to produce more than 1500 different reference designs. Therefore, BOSCH have workstations target for such small-scale

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production in the shopfloor supervised by experienced workers. It's not hard to understand such production is prone to errors.

Use case

BOSCH expects to support collaboration and monitor the process, speed up task allocation, exception handling, reduce labour effort (lifting and transferring products) and quality checking operations, thus changing this area into a truly collaborative workspace.

This will be achieved by redesigning and optimising production process, to take full advantage of several new technologies – end-to-end production monitoring and execution including:

- collaborative robots capable of handling and reliably manipulating Printed Circuit Boards (PCBs) and boxes containing electronic components;
- AGVs capable of transferring components and processed goods between the working cells without interrupting the workers' tasks;
- Augmented Reality to support non-expert workers in proper placement of the electronic components over the PCB;
- Additional technologies like RFID or computer vision to facilitate tracking and quality assurance integration of this production process with the existing management software, including SAP used in the plant.

Currently the worker has to read carefully the instructions and understand the whole assembly sequence and actions required. Then they have to perform the assembly sequence keeping in line with the instructions. After the assembly is completed, the worker has to manually check if the assembled PCB corresponds to the result on the instructions.

Additionally, the transport of finished PCBs (depending on the final product to be manufactured) has to be done between floors. This introduces a big amount of non-added value worker time for performing manually these transfers. Additionally, in crisis situation, like the COVID pandemic, the personnel is reduced, and it needs to even more focus on added value activities instead of transporting items.

The objective of the SHOP4CF pilot is to release the worker from the cognitive load, and ensure the correctness and quality of the assembled PCB, as well as take over the transporting of assembled PCBs.

SHOP4CF scope:

- Show instructions for the human worker with AR
- Check that the components assembled are the correct ones

- Check that the components were assembled on the correct position

- **SHOP4CF - Definition of the deployment scenarios**

This report includes the description of the revised and extended experiments, the objectives of the pilots related to the SHOP4CF project, the detailed scenarios, as well as the components to be used. These will be the basis of the subsequent actions towards their implementation

- **SHOP4CF - Improve automatic data acquisition, storage, traceability with user-friendly interfaces and human safety**

Challenge

Improve automatic data acquisition, storage, traceability with user-friendly interfaces and human safety. Simple tools for the set-up of robotized human-centric cells for production lines in different manufacturing scenarios:

- **Pilot 1:** Manufacturing of a healthcare component for diagnostic imaging
- **Pilot 2:** Robot training for part sorting.
- **Pilot 3:** Frame manufacturing AR assistance.

Use case

- **Pilot 1:** Manufacturing of a healthcare component for diagnostic imaging The pilot will deal with the set-up of a manufacturing cell for a transmission component of a diagnostic image machine. Due to the importance of the product the designed pilot will need to address quality monitoring and data integration in existing IT infrastructures to ensure medial certification processes. Moreover, due to the complexity of the assembly, collaboration of the robot with the operator in the same workspace is foreseen, sharing tasks in the same part assembly. Additional components for improving the acceptance of the robotic solution and flexible safety will be evaluated and deployed, along with VR training of the operator.
- **Pilot 2:** This use case relates to sorting contact pads, parts of electrical switches. For the autonomous assembly of those switches, the contacts must be stored and placed in a well-defined position. However, the specifications of such pads change quite frequently, and long time is spent by system integrators for teaching a new part. The objective of the SHOP4CF solution is to enable the robot training by means of a specialized glove, to place the parts in front of the camera and enable the automated CAD generation.
- **Pilot 3:** In this use case, a robotic arm is used to manufacture 3D printed parts out of aluminum wire deposited on an aluminum substrate. Prior to the task, a human worker must calibrate the robotic arm, by pointing the frame of where the manufacturing should take place on the substrate. Without real-time instructions, it is difficult for inexperienced workers to

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follow-up on the actions they need to perform for the robot calibration. Additionally, they need to be able to inspect the frame that was identified by the robotic arm after the calibration, as improper calibration could result in faulty manufacturing, even out of the bounds of the substrate. The objective of the SHOP4CF pilot is to assist the human worker in calibrating and inspecting the frame manufacturing by means of AR technology.

Health device gearbox assembly

SHOP4CF scope:

- Collaborative assembly or gearbox
- Some parts assembled by the robot – some parts assembled by the worker
- AR to indicate worker instructions / tasks
- Final quality checks of assembled part
- Communication with MES

Robot training for part shorting

SHOP4CF scope:

- Robot teaching using a specialized glove.
- Optimize the positioning during the robot teaching for the automated CAD model generation
- Part optimal sorting and positioning using Reinforcement Learning
- Provide/monitor information and data from the components (e.g. percentage of scanning of a part)

Frame manufacturing AR assistance

SHOP4CF scope:

- Use a projector to display task instructions to the worker and for the frame generation and inspection of the frame created.

- **SHOP4CF - Upfront challenges faced by the assembly workers and engineers**

Challenge

Volkswagen Wrzesnia factory situated in Poland has been established for the manufacturing of VW Crafter since 2016. The plant is equipped with a modern paintshop, assembly section customised cars section, pilot production and supplier park, with a production capacity of 100k cars per year. The challenge for assembly workers resides in the fact that, although the crafter car only has 69 base versions, there can be as many as 99 million+ variations in customised design.

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Use case

The first pilot takes place in the KTL area. Car bodies, placed on skids, dive into a pool of chemicals, and through the use of electric current paint attaches to the car body. As skids are dipped into the pool many times, disturbances in their conductive properties may occur, which affect the correct completion of the KTL task, e.g., wrong thickness of the paint attached.

SHOP4CF pilot is focused on predicting and managing maintenance tasks of the skids, before faulty results on produced car bodies appear.

SHOP4CF scope:

- Optimize the schedule and management of the workers who take care of the maintenance tasks
- Reduce ad-hoc maintenance needs.
- Provide more information to operators, technicians and maintenance, hence enabling more informed decision-making

- **SodaLite - Eclipse Papyrus Manufacturing: Sizing Stocks Buffers of a Line**

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Keywords: Multi-Model Assembly Line, Malfunctions, Buffer Stock, Cyclo-Static DataFlow.

Introduction

As part of the SodaLite1 project, we consider an assembly line consisting of machines and inter-machine buffer stocks. Machines are subject to hazards and a line can be to produce different variants / versions of a product (i.e. a model assembly line mixed) that may have different processing times from one version to another. All this introduces an asynchronism between the different parts of the line and justifies the use of these zones buffers even for a perfectly balanced line (i.e. the time of treatment of a variant is the same for all machines). Buffer stocks then have the task of decoupling different machines in order to provide a smoothing effect on the treatment times and to prevent the total apparent failure time of the line is an accumulation of the duration of failures of all its machines.

The purpose of this work is to determine the minimum capacities of these buffer stocks as that the line reaches a target production rate. This sizing

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problem has been proven NP-difficult. In order to solve it, we had two ways to take into account the uncertainties of production and sequencing of the different variants.

The first is to do a study stochastic or worse-case, in which case the laws of probability of failures are to be integrated and the sequencing worst case is to be identified. This approach has been ruled out for reasons of increased complexity and duration reduced project. Moreover, the worse-case results that would have come out of it would not have been considered as acceptable by the participating company.

The other more pragmatic approach, which has been adopted, was to be in agreement with the technique used by companies for the validation of their lines, namely, the simulation of the line for a long production time considered as sufficient and representative of the different situations that may arise during the life of the line. This ensures for the resolution technique that we offer as much coverage of problematic cases than the validation approach itself.

- **SYMBIO-TIC - Demonstrator 2: Human-Robot Collaboration on Aircraft Rib Assembly**

  Automatization with a collaborative robot of a manual process to install BUA's and TIE's in the ribs of the aircraft wings. In the new process, a robot sets the position of the BUA's and TIE's. The robot's precision is independent from its wear and mechanical properties, since there is a vision system guiding it and correcting in 6DoF the positioning errors.

- **SYMBIO-TIC - Demonstrator 1: Human-Robot Collaboration in Food packing**

  Food Packaging and commissioning today is mostly done manually. That is due to the fact that style and sizes of packagages is often changed. A robot is used in order to automize the handling processe. This gives a possibility of high flexibility in handling operations and constant output. The collaborative task is here that the operator can interfear fast if something in the process is going wrong. This can happen often, because the tollerances of packages in the box are high. The customer wants to reduce labour for monotous tasks. He hardly can find motivated labour for this task.

- **USE-IT-WISELY - Upgrade service for mobile rock crushers**

  Tools and business models for collaborative collection and management of system data

  The expected lifetime of mobile rock crushers is 20-30 years. During this time, they may have undergone several undocumented modifications. The

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demonstrator presented a new upgrade service based on in-situ 3D scanning of machine condition and augmented reality applications for upgrade design in collacoration with customers and end users.

Results

- Tools and processes for collection of system geometry data in the field based on photogrammetric scanning
- Visualisation of upgrade designs based on Augmented and Virtual Reality
- Modular noise encapsulation upgrade
- Business model scenario for upgrade delivery

Benefits, impact, opportunities

- Enhanced system data through fast and low-cost on-site scanning
- Improved communication through in-situ visualisation of design solutions
- Streamlined upgrade delivery process reduce costs and saves time.
- New business opportunities with modular system upgrades – increased demand expected within next 3-5 years

- **VIEWS - Metrology-integrated Robotics**

Aerospace assembly is characterised by the tight tolerances required – deviations over 0.1mm from nominal can cause significant aerodynamic effects. Simultaneously, aerospace components need to be lightweight, and are often flexible until assembled into their final structure.

Commonly, large jigs and fixtures are used to ensure alignment in aerospace assembly, but these are costly and time consuming to create, and represent a substantial cost, particularly for low batches of aerostructures.

FA3D utilised advanced metrology systems such as laser radar and optical coordinate measurement machines to achieve accurate measurement of parts over large volumes.

Data from these metrology readings is directly integrated with the robotic controllers to adjust the positioning of parts to bring them back into tolerance, and hold them in place while fasteners are inserted, effectively replacing the need for fixtures.

- **VIEWS - Manufacturing Service Buses for Data Interoperability**

Large, highly integrated manufacturing systems are characterised by complex data systems that enable the manufacturing process. This is exacerbated when you need to integrate additional software platforms that analyses data (such as metrology data) to adapt manufacturing processes).

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Due to a lack of common standards, it is common for manufacturers to stick to a single vendor of digital solutions, to ensure compatibility. However, this can exclude a company from taking advantage of the latest developments (such as the laser radar used here).

FA3D uses a manufacturing systems bus concept to enable a manufacturing system to be easily reconfigurable from a logical control perspective, and to integrate multi-vendor equipment and software into a single source of data which is used throughout.

- **VIEWS - VIEWS project video - Future Aerospace Assembly solutions**
- **ZDMP - Assembly line: AI-supported optical defects detection**

The CONT industrial partner supplies automotive components for different car producers. To ensure the highest quality of products it uses automatic and manual final tests. The automatic test presumes comparison of images taken by one or more cameras, placed in the check stations along the assembly line, with images of expected product. If the product fails during the automatic test it is sent to the operator that performs manual test, while comparing the product image with reference image. In order, to reduce the number of quality incidents (e.g. related to false positives) during automatic test, ZDMP platform offers a set of services utilizing Artificial Intelligence to learn defects types and acceptance limits, improve testing programs though analysis of false positives resulting in improvements of base models for optical check.

- **ZDMP - Assembly line: monitoring and control system**

Two industrial partners are involved in this use-case: MASS producing equipment for process automation and CONT producing components for car industry and using MASS equipment within the assembly line. The goal of the use-case is to reduce the quality incidents, equipment breakdown time, time for automatic change (switching the line from producing one product to another) and to increase line productivity based on fast reaction and preventive actions using the ZDMP platform. The ZDMP platform has the driver providing the interface between the equipment and the server side and provides a set of services, namely: (i) product version control and changeover, (ii) automatic call for maintenance, (iii) power management, (iv) cycle time monitoring, (v) automatic material ordering, (vi) data archive control and (vii) visual management and reporting.

- **ZDMP - Steel tubes: production monitor**

Two industrial partners are involved in this use-case: PTM – the steel tube machine tool manufacturer and FLEX – steel tubes producer that is using PTM machines. The current method that is applied for quality control relies on the

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operator evaluating tubes for defects. If defect is detected, the operator has to stop the production process and adjust production parameters, as defects are tending to propagate to the next tube being produced. This use-case has the goal of reducing the load on the operator through automation of quality checking tasks and producing the warning, if defect is detected. In this way, the risk of human errors is reduced through the introduction of the defects detection tools.

- **ZDMP - Stone tiles: equipment wear detection**

  Another use-case addresses a very specific area of stone slabs ant tiles production. The industrial partners involved are: CEI – the manufacturer of the stone cutting machines and ALONG – producer of stone slabs and tiles. The process of stone slabs and tiles production includes several steps: (i) raw stone is cut and divided in multiply stone slabs, (ii) polishing of the stone slabs, and (iii) then the tiles moulds are used to cut the stone slabs. After every stage a quality check is performed to identify possible material defects, such as voids, natural cracks, etc, as well as production defects. The use-case has multiply goals, including: amount reduction of defected parts due to equipment failures, automation of the quality check procedure reducing the manual checks and correspondingly the load on operator considering both natural defects and production defects detection.

- **ZDMP - Construction supply chain: quality control at construction site and quality traceability**

  This use-case involves 3 industrial partners: FLEX – the steel tubes producer, ALONG – the stone slabs produces and CONS – the construction company. FLEX and ALONG are suppliers hired by the Works Contractor and approved by the Works Supervisor (CONS) to provide, respectively, steel tubes for the formwork and stone slabs for the infrastructure being built. The supply delays sometimes can significantly affect the working schedule causing the productivity loss. In this regard, the goal is to avoid the delays that are considered as defects in this case. Thus, it is important that all the parties have an early access to information about potential delays and about the quality of supplies to act quickly and, if needed, to reschedule activities.

- **ZDMP - Engine block manufacturing: Defects detection and prediction in aluminium injection and machining operations**

  The use cases address the engine block manufacturing process, in terms of detecting and predicting defects in aluminium injection and machining operations. Two industrial partners are involved in this use-case – the Martinrea Honsel (MRHS), located in Madrid, specialized in manufacturing of aluminium cylinder blocks and FORD Valencia Engine Plant finishing the rough

Cylinder Blocks received from MRHS to produce engines. The main types of defects occurring are categorized into two groups: porosity and leakage. The goal is to improve the quality through the scrap output reduction, but also to provide the quality predictions.

- **ZDMP - Engine block manufacturing: Defects reduction by the optimization of the machining process**

  The machines of ETXE industrial partner are installed on the FORD plant as a part of cylinder block production line. The raw process data are collected about the equipment state, as well as about the production process itself (e.g. type of cylinder blocks being produced at the moment). These data are utilized in order to detect anomalies/abnormalities and to develop a mitigation plan to return to the efficient production state. In mitigation plan development the ETXE equipment supplier has one of the leading roles. The ZDMP platform, in this case, has the goal to assist in the fulfilment of this task, through knowledge generation and automation of abnormalities detection.

- **ZDMP - Moulds manufacturing: Process alert system for machine tool failure prevention and Smart process parameter tuning**

  These use-cases come from the machine tools domain encompassing three industrial partners: (i) HSD – the electro spindle manufacturer, (ii) FIDIA – the manufacturer of high-speed milling systems and flexible manufacturing systems using the HSD spindles in their products, and (iii) FORM – enterprise for maintenance and modification of the of the large plastic injection moulds utilizing machines from FIDIA. The goal is to collect the equipment and machining process data to detect the abnormalities in the production process and inform the operator on the FORM side. In the case, if the quality control detects a scrap part the machine tools user (FORM) can ask FIDIA for to identify the cause of the defect, while FIDIA, in its turn, can acquire help from the HSD, if the problem is with the electro spindle. Another goal is to be able to adjust the parameters of the production process to achieve the optimal quality results.

- **ZDMP - Moulds manufacturing: in-line 3D modelling**

  This use case includes two industrial partners, FORM – producer of moulds for plastic injections and FIDIA machine producer. To protect the machines it is important to avoid collisions, for instance, between the machine and the workpiece. FIDIA industrial partner also supplies the anti-collision software based on 3D models in .stl format. The 3D models are generated from the data acquired by scanning of the working surface, including machines, tools, target workpieces and other objects within the working area. ZDMP platform

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has the aim to simplify the whole process of 3D models generation from communication to data cleaning and processing.

- **ZDMP - Electronic products manufacturing: Component inspection**

The use case includes two industrial partners, ALFA the company which focus is on X-Ray material inspection and CONT plant located in Timisoara that produces instrument clusters and displays for car manufacturers. The use-case presumes the introduction if the X-Ray machine for material and components quality check in order to identify deviations from specifications. One of the production lines of the CONT plant will be utilized for the use case. Moreover, additional functionality will be provided through ZDMP platform to store the inspection samples, as well as statistical analysis of current measurements with historical data/samples.

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