Adaptive Automation in Assembly
For BLUE collar workers satisfaction in Evolvable context

A4BLUE

This project has received funding from European Union’s Horizon 2020 research and innovation programme under grant agreement n° 723828

Project results
ICAM - Toulouse 20/09/2019
A4BLUE objectives

Put together workers and AUTOMATION mechanisms to take advantage of each others strengths

Put together workers and context-aware ADAPTATIVE ASSISTANCE TOOLS

TO

Increase worker SATISFACTION and workability
Increase productivity and overall PERFORMANCE

Long term socio-economic sustainability
**A4BLUE key outputs**

### Methods & Tools for Sustainability
- Methodology for the definition of the optimal level of automation
- Methodology for usability and satisfaction assessment
- Socio Economic assessment framework

### New or enhanced automation mechanisms
- New: deburring robot and automated tool trolley
- Enhanced: smart torque wrench, dual arm and logistic robot

### A4BLUE Reference architecture and implementation
- New interaction mechanisms: verbal and non verbal
- A4BLUE adaptive framework
- Assistance tools: Context aware on the job training and guidance, decision support system and collaborative knowledge management
A4BLUE involves 4 use case scenarios ...

<table>
<thead>
<tr>
<th>INDUSTRIAL PILOTS</th>
<th>LAB PILOTS</th>
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<tbody>
<tr>
<td><strong>AIRBUS</strong></td>
<td><strong>IK4-TEKNIKER</strong></td>
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<tr>
<td>Complex, manual hydraulic system assembly.</td>
<td>Collaborative assembly in a fenceless environment.</td>
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<tr>
<td><strong>TOULOUSE, FRANCE</strong></td>
<td><strong>EIBAR, SPAIN</strong></td>
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<tr>
<td>WHAT To optimise hydraulic system assembly through the usage of smart tools and Virtual/Augmented Reality.</td>
<td>WHAT To introduce active safety measures supporting Human-Robot collaboration; to support personalized ergonomic adaptation; to provide natural Human-Automation multi-channel interaction; to provide decision support dashboards for quality and maintenance.</td>
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<tr>
<td>WHY To evaluate the impact of an adopted AR HMI in terms of performance and error rate for different skilled groups of people and to enable full quality assurance approach and operators performance thanks to traceability.</td>
<td>WHY To evaluate trust, usability and worker satisfaction in terms of safety, interaction, ergonomics, assistance.</td>
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</table>

| **CESA** | **RWTH AACHEN UNIVERSITY** |
| | **AACHEN, GERMANY** |
| **MADRID, SPAIN** | |
| WHAT To incorporate a robot to assist the worker in the deburring operation; To incorporate AR based guidance based on operator’s profile as well supporting knowledge sharing. | WHAT To incorporate AR based guidance based on operator’s profile and to provide the tools required for the assembly by means of an automated tool trolley. |
| WHY To increase the quality, efficiency and ergonomics of the deburring process; To reduce operators training time through AR; to reduce time for reviewing documentation; to increase confidence, participation, and internal communication among the personnel. | WHY To improve worker satisfaction, to reduce training time, to improve process efficiency; to improve ergonomics; to validate a tool to determine the optimal degree of automation. |
AUGMENTED WORKPLACE
A4BLUE collaboration dimensions

#1: Worker + Collaborative industrial robot

#2: Worker + Collaborative mobile robot

#3: Worker + context aware adaptive automation

#4: Worker + multi-modal interactions

#5: Worker + AR based on-the-job guidance

#6: Worker + Decision support tools

#7: Worker + Worker

Workers

Decision Support

Industrial robots

Mobile robots

Augmented Reality

HMI

Automations
Worker + Collaborative industrial robot

Deburring robot

- Industrial robot collaborating with process operations to perform the MOST EXHAUSTING phases of the deburring process

Initial situation

- Long, exhausting, repetitive, non added-value manual task
- High physical demands: risk of breathing metal chips, bad ergonomics conditions (i.e. moving heavy parts)
- Results are highly dependent on the operator’s expertise
Worker + Collaborative industrial robot

**Resulting benefits**

- **Improved efficiency**: increases productivity while maintaining quality (i.e. 100 min reduction of manual work)
- Reduced **process variability**
- **Improved working conditions**: increases ergonomic and safety conditions and reduces physical demands
- **Opens up job opportunities**: the level of required expertise is lowered
- **Increased worker satisfaction**

**Identified actions**

- **New added value competences** required → scheduled training in robot programming for the operators
Worker + Collaborative mobile robot

Automated tool trolley
• Provides on demand tooling

Logistic robot
• Transports parts from/to the warehouse

Resulting benefits
• **Improved efficiency**: reduction of displacements
• Reduced **physical demands**
• **Opens up job opportunities** to people with some kind or physical or sensorial limitations
Worker + context aware adaptive automation

Adaptation to process variability

- Automatic configuration of the process parameter

Resulting benefits

- Increased quality

Adaptation to human variability

- Ergonomic positioning based on workers ‘characteristics

Resulting benefits

- Reduced physical demands
- Increases safety
- Opens up job opportunities
Worker + multimodal interaction

Multimodal interaction with Tool Trolley
- Voice commands for long range steering
- Gesture commands for short range navigation
- Follow-me function for ergonomic improvements
- AR-supported navigation and trajectory visibility

Multimodal interaction with robots and MES
- Voice commands: natural speaking
- Gesture commands

Resulting benefits
- **Improved efficiency**: reduction of displacements
- Reduced **physical demands**
- **Opens up job opportunities** to people with some kind or physical or sensorial limitations
Worker + AR based on-the-job guidance

On the job guidance

- Context aware information: based on the operation being performed and the profile of the worker

Resulting benefits

- **Improved traceability**: completion of all the steps is registered.
- Reduces **training duration**
- **Opens up job opportunities** to less experienced workers,
Definition of the optimal level of automation

- Based on the optimization of process costs and worker satisfaction

Resulting benefits

- Considers socio economical aspects
Best practices management

- Knowledge sharing between workers
- Takes advantage of expert workers knowledge
- Different GUIs supported: web based and AR based
- Context aware information: based on the operation being performed

Resulting benefits

- **Improved efficiency**: increased productivity due to reduced time to solve issues during the process
- **Supports** less experienced workers, reduces training time
Future Vision
**A4BLUE main breakthroughs**

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<tr>
<td>Digital Technologies will bring us toward the Autonomous and Hyper-connected Factories</td>
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<td>Human Factors will remain crucial for the next generation factories</td>
</tr>
<tr>
<td>Humans and Digital Technologies experts need to join forces</td>
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<td>Clear Skill pathways and Assistance technologies will help us on becoming augmented worker (operator 4.0)</td>
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<tr>
<td>Exploit proactive and open collaboration among all the involved stakeholders (Multi-Actor approach is needed!!)</td>
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THANK YOU