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

A4BLUE

SPS ICP Drives Italia

Continuous adaptation of work environments with changing levels of automation in evolving production systems

Parma, 24-05-2017

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Adaptive **A**utomation in **A**ssembly For **BLUE** collar workers satisfaction in **E**volvable context

Project ID: 723828

Topic: FOF-04-2016 - Continuous adaptation of work environments with changing levels of automation in evolving production systems

From: 01-10-2016

To: 30-09-2019

Consortium

Research Centre (Coordinator)

IK4 TEKNIKER
Research Alliance

Universities

RWTH AACHEN UNIVERSITY

Cranfield University

LEs

AIRBUS

CESA
COMPAÑIA ESPAÑOLA DE SISTEMAS AERONAUTICOS S.A.

ENGINEERING

SMEs

CiaoTech

illogic
digital creativity lab

KOMAT
INGENIERIA Y SERVICIOS DE AUTOMATIZACION Y ROBOTICA

A4BLUE **aims**

1) to **develop** and **evaluate** a new generation of **sustainable**, **adaptive** **workplaces** dealing with **evolving requirements** of manufacturing processes (i.e. short & long term changes);

2) to introduce **automation mechanisms** that are suitable for **flexible** and **efficient task execution** in **interaction** with human workers and by optimising **human variability** through **personalised** and **context aware assistance** capabilities as well as **advanced human-machine interfaces**.

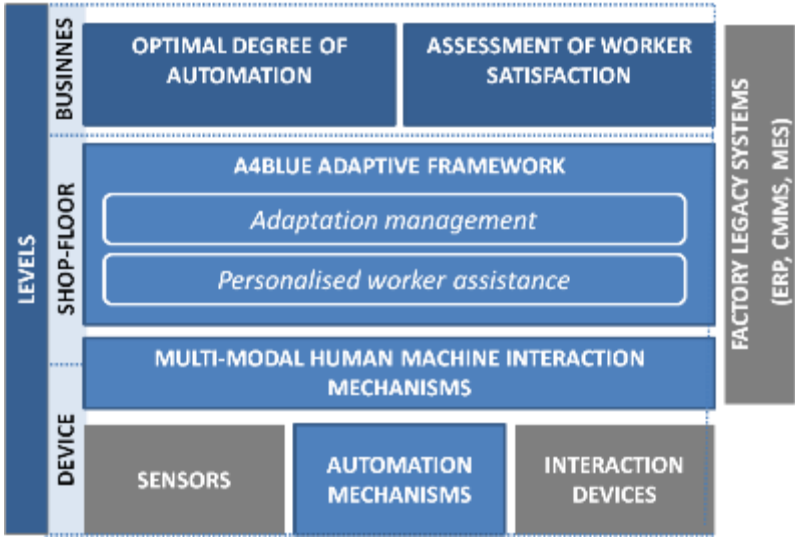
Specific objectives

To support this objective the key features are:

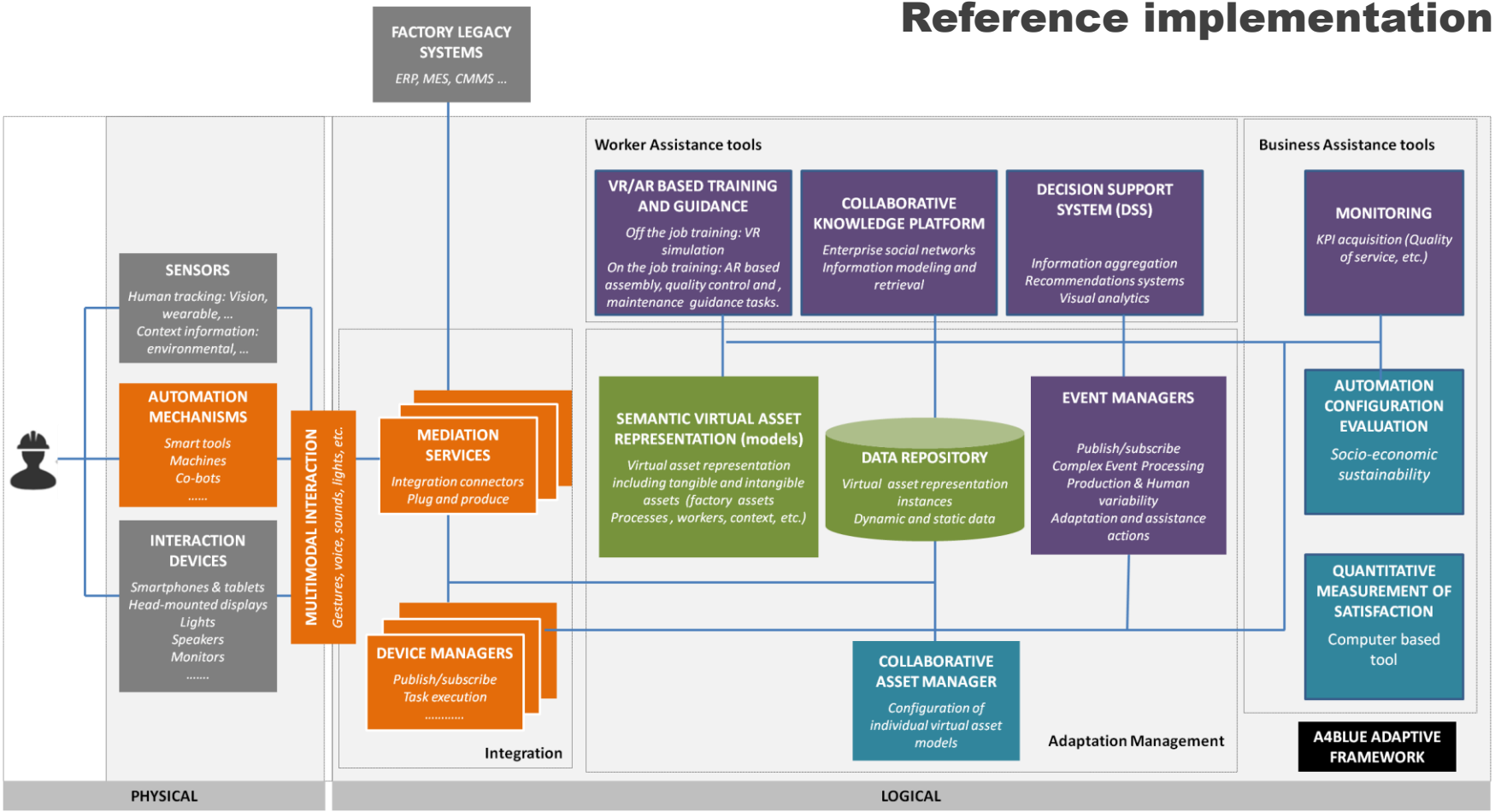
1) **Adaptability**: by providing an **open, secure, configurable, scalable and interoperable adaptation management and assistance system** (A4BLUE adaptive framework) that allows effortless integration of heterogeneous hardware and software components and is able to adjust the behaviour of workplace parts according to changes;

2) **Interaction**: by providing a set of **safe**, **easy to use, intuitive and personalised and context aware multimodal human-automation interaction mechanisms** ;

3) **Sustainability**: by providing methods and tools **to determine the optimal degree of automation of the new assembly processes** that combine and balance social and economic criteria to **maximize long term worker satisfaction and overall performance.**

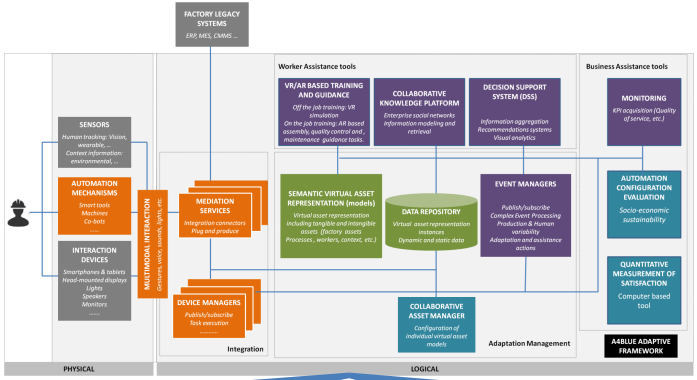


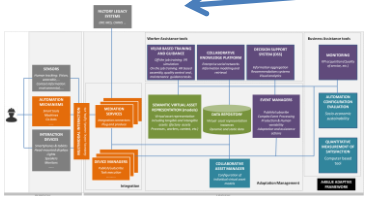
Reference implementation

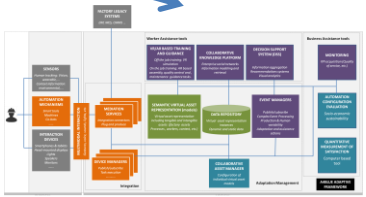


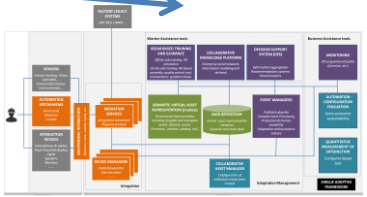
Validation: use case applications

Reference implementation









Industrial use case scenarios (AIRBUS, CESA)

Lab use case scenarios (IK4-TEKNIKER, RWTH)

Use case applications

Use cases

Real scenarios

AIRBUS

aeronautics

SC1: : Towards the next generation hydraulic system assembly through Automation and Virtual/Augmented Reality

SC1.1: Hydraulic system assembly

CESA
COMPAÑÍA ESPAÑOLA DE SISTEMAS AERONÁUTICOS S.A.

aeronautics

SC2: Assembly and auxiliary operation of the main landing gear actuator

SC2.1: Deburring Auxiliary

SC2.2: Main Landing gear assembly

Lab scenarios

aeronautics

IK4 TEKNIKER
Research Alliance

SC3: Collaborative assembly of latch valve

SC3.1: Collaborative assembly

SC3.2: Logistics (auxiliary)

automotive

RWTH AACHEN UNIVERSITY

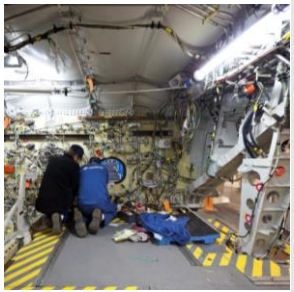
SC4: Assembly and auxiliary operation in automotive final assembly

SC4.1: Wing and bonnet assembly

SC4.2: Mobile tooling supply (auxiliary)

INDUSTRIAL SCENARIO #1 – AIRBUS: towards a next generation hydraulic system assembly through automation and virtual/augmented reality

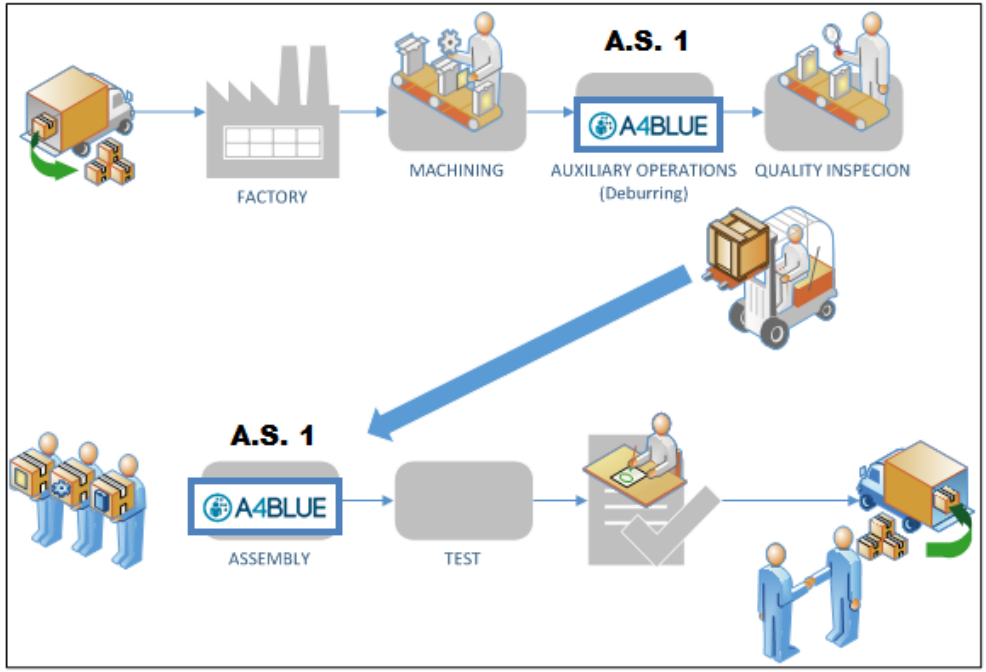
[Airbus future factory]

Central box overview	Parts involved in the assembly			
Hydraulic assembly view 	Clamp blocks (88)		Fittings	
	Clamp		Flexible pipes (4)	
	Pipes (118)			

BC#1 AIRBUS: Challenges

Challenges	Scope	Description
CH1.1 Adapted on the job guidance	Human, process & context variability	A4BLUE should provide **on the job guidance** adapted to both the specific worker and operation involved. Both the way the information is displayed to the workers and the **AR device** to display such information should be considered.
CH1.2 Adaptation of the tools involved in the assembly process	Process variability	A4BLUE should support the **automatic adaptation of the parameters** of the tools involved in the assembly process considering both the operation being performed and the related standard operating instructions.
CH1.3 Decision support	Process variability	A4BLUE should support the Quality Inspector to secure a **full quality assurance approach** by making available in-real time the information collected from the smart tools (not available in the current process) during the assembly; avoiding to manually control the executed task, ease the error detection and then correction, measure the realization time to ensure time and quality delivery

INDUSTRIAL SCENARIO #2 – CESA: Assembly and auxiliary operation of the main landing gear retraction actuator



[Deburring process video]

BC#2 CESA: Challenges

SC2.1 Deburring (auxiliary)

Challenges	Scope	Description
CH2.1 **Including automation mechanisms in manual deburring process**	Process variability	A4BLUE should increase **productivity** and reduce deburring operation time. The operator can use this time in a more effective way. A4Blue solution should **reduce dependence on manual work to increase quality**.
CH2.2 **Safety and ergonomics**	Safety and worker satisfaction	Deburring operation is a repetitive and boring task, which can be very long, so to provide a solution that can support the operator in the performance of the task can be very beneficial to him and should **improve ergonomics conditions of operators**. A4BLUE should **improve safety conditions**, Reducing the risk which the operator is exposed during the operation (contact with deburring tools, particles from the part…).

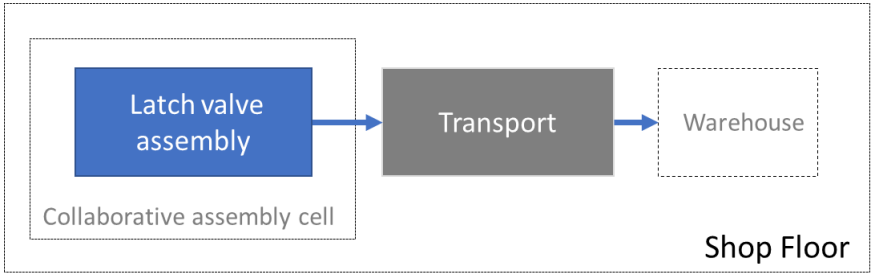
SC2.2 Main landing gear assembly

Challenges	Scope	Description
CH2.3 **Information and documentation fragmentation**	Process variability	A4BLUE should provide the operator a one stop solution that provide all the information to perform the specific on going operation.
CH2.4 **Training**	Human & Process variability	A4BLUE should involve on the Job trainig capabilities, based on AR solutions and involving multi modal interaction mechanisms to support the adaptability of the training and the provision of technical Instructions.
CH2.5 **Knowledge management**	Human & Process variability	A4BLUE should provide collaborative knowledge management capabilities.

LAB SCENARIO #3 – IK4-TEKNIKER: collaborative assembly of latch valve

Video

Collaborative assembly of a latch valve in a fenceless environment, including **auxiliary activities** as initial preparation activities, final inspection and transport of the finalised part to the warehouse.



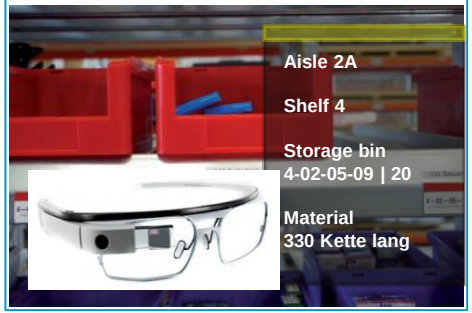
BC#3 - IK4-TEKNIKER: Challenges

Challenges	Scope	A4BLUE support
CH3.1 **Adaptation to worker's profile**	Human variability	A4BLUE: a) should launch parametric programs that consider the **anthropometric characteristics** of the operator that is performing the collaborative assembly with the robot (i.e. the one that is logged in) so the position of the sub-assembly varies on worker's profile. b) should include **multimodal interaction** (verbal and not verbal) to support different workers' capabilities or preferences.
CH3.2 **Adaptation of the robot behaviour based on safety related criteria**	Context variability	A4BLUE should involve **enhanced active safety mechanisms** to adapt robot behaviour (e.g. robot speed) to different context situations as for example detection of animate/inanimate obstacles, prediction of the intention of animated obstacles.
CH3.3 **Adaptation of on the job guidance**	Context & human variability	A4BLUE should provide **on the job guidance** adapted to both the specific worker and operation involved.
CH3.4 **Integration with legacy systems**	Process variability	A4BLUE will be able to **collect information/events from the factory level** MES (i.e. operator log in/logout; order start/end; bad/good register; downtime register, etc.). Furthermore, the latest version of the technical instruction should be available.
CH3.5 **Integration of auxiliary activities (i.e. maintenance, quality)**	Process variability	A4BLUE should notify relevant stakeholders of relevant information to accomplish their assigned task (e.g. provide information and notifications to quality supervisor or maintenance technician if defects or failures are detected).
CH3.6 **Adaptation to new trends**	Process variability	The **mobile robot** should be integrated with the A4BLUE adaptation manager to provide relevant information on is status and location and should receive commands from A4BLUE to navigate to the appropriate location to perform its assigned activities (i.e. collect parts from the collaborative work cell and transport them to the warehouse).

UC RWTH: Selected Use Case Scenarios

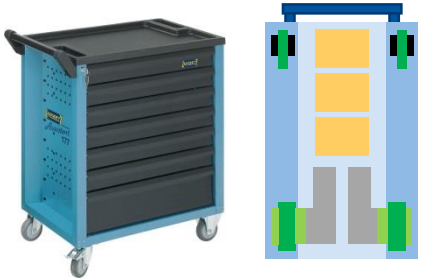
1 AR/AV Solutions

- Use of AR/ AV to provide assembly instructions to the worker

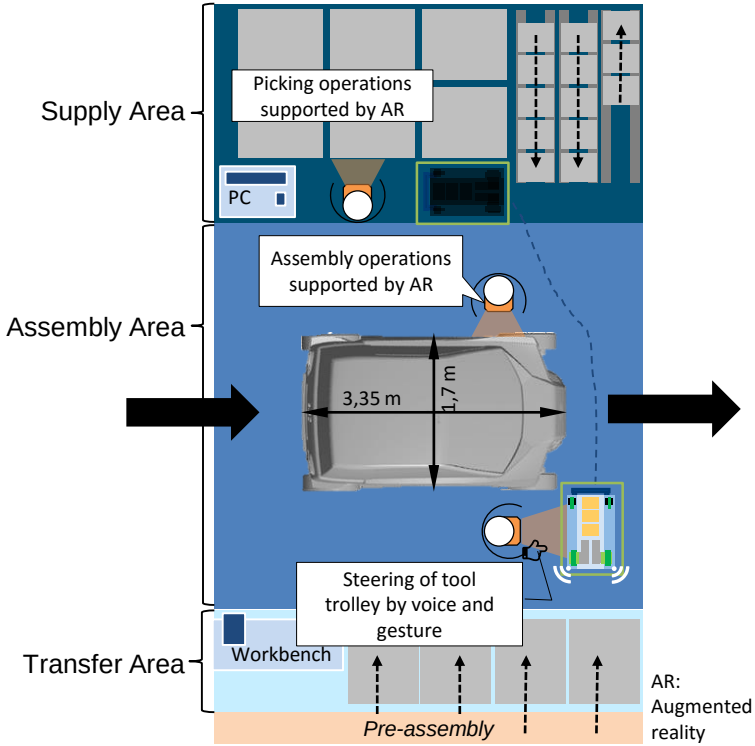


2 Automated tool trolley

- Adaption of autonomously driving tool trolley in terms of gesture/ voice steering



Video



BC#4 – RWTH: Challenges

SC4.1 Wing and bonnet assembly (AR)

Challenges	Scope
CH4.1 Adaptation to worker's experience	Human variability/ worker satisfaction
CH4.2 Training of inexperienced workers	Human variability
CH4.3 Picking individual variant parts	Process variability/ worker satisfaction
CH4.4 Picking joining parts	Process variability
CH4.5 Adjusting wing to correct gap size	Process complexity
CH4.6 Integration of auxiliary activities (i.e. maintenance, quality, quality assurance)	Process variability
CH4.7 Determining the optimal level automation	Automation

SC4.2 Mobile tooling supply (auxiliary)

Challenges	Scope
CH4.8 Minimizing non-valuable ways	Process efficiency
CH4.9 Improving ergonomics	Worker satisfaction, ergonomics
CH4.10 Enhancing area efficiency	Process efficiency
CH4.11 Error prevention	Worker satisfaction
CH4.12 Transparent decision on adaptive automation	Automation/ Worker satisfaction

Project benefits | Sectors

Impact

- **20%** increase in adaptability, e.g. product customisation capability
- **10%** quality increase in human and automation performance, e.g. quality or productivity
- Wide adoption of the new developments in advanced manufacturing systems
- The A4BLUE solution will be instantiated and validated in two real industrial scenarios (**AIRBUS** and **CESA**) and in two lab scenarios (**IK4-TEKNIKER** and **RWTH Aachen**)

Sectors


Aerospace


Transport

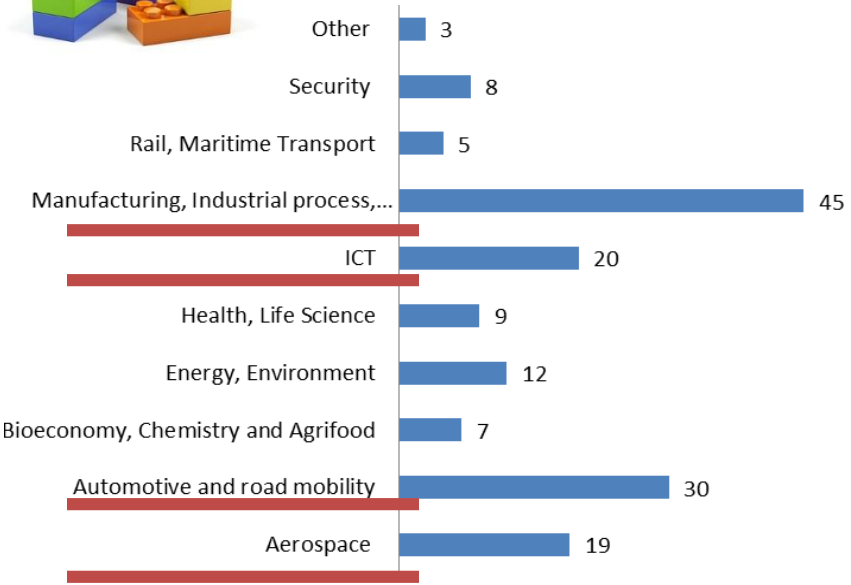

Wind power


Capital goods

Industry 4.0

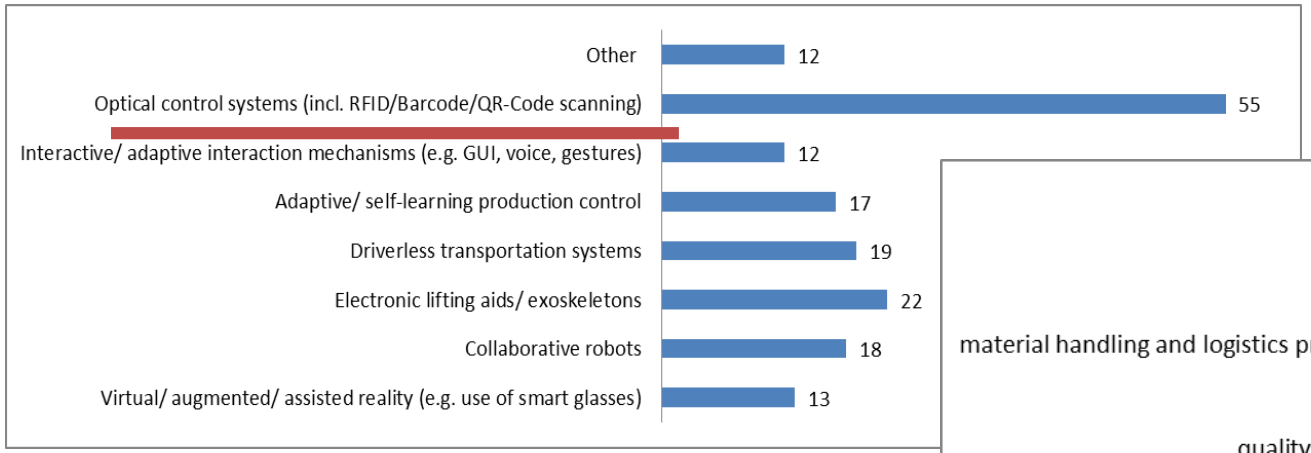
Stakeholder analysis

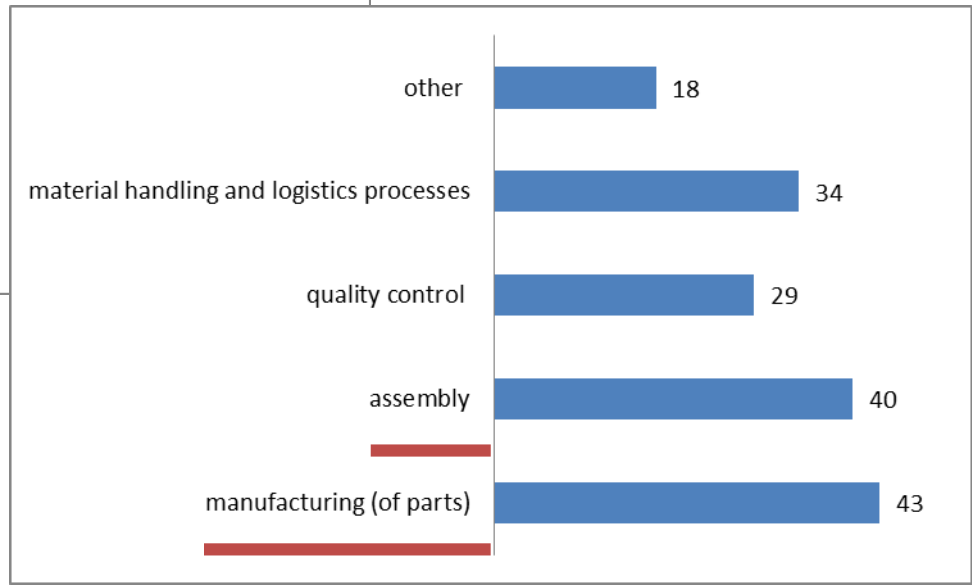
- 91 responses collected, by LE and SME (67% both)



Data analysis – AS IS situation

- Low-medium level of automation (74% both)



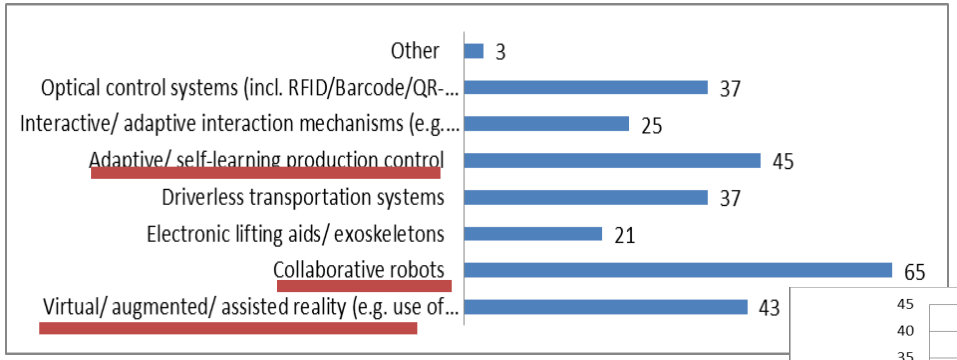


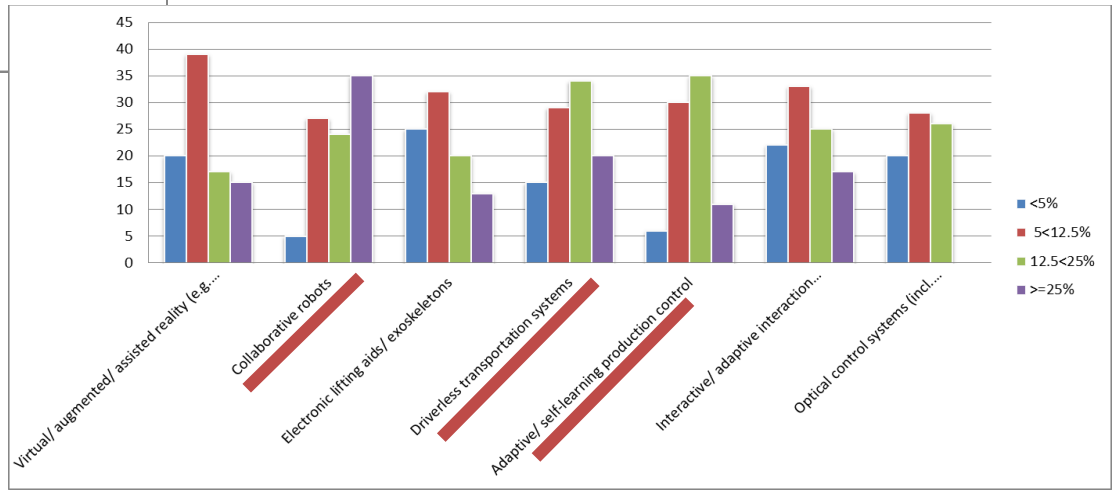
Data analysis – AS IS situation

- Main limitations vs key facilitators

Data analysis – Responders point of views

- Adaptive automation solutions – TO BE scenario





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THANK YOU