Novel technologies to boost the shipyard industry

Enabling collaborative robotics in shipbuilding

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FIBRE4YARDS · RESURGAM · MARI4YARD

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Introduction

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Overview of the European Shipbuilding and Maritime Supply Chain Industry

- The EU shipbuilding, ship maintenance, repair and conversion (**SMRC**) **industry** consists of around **300** specialized **shipyards**.
- **Over 80%** of these shipyards are small to medium-sized enterprises (**SMEs**).
- **SMEs** predominantly build and maintain ships up to **150 m** in length. These include **cruise ships**, **ferries**, **offshore vessels**, **seismic vessels**, **fishing vessels**, **port operating vessels**, **river vessels**, **mega yachts**, and **expeditionary ships**.
- These types of ships account for more than **90% of the vessels delivered in Europe**.
- These shipyards excel with their **highly skilled labor force** and extensive manufacturing knowledge.
- The industry plays a **vital role** in the European maritime **supply chain**, which includes more than **22,000 enterprises**.
- This **supply chain** generates a **turnover of 60 billion euros**, **55%** of which is made in domestic markets.

Introduction - Challenges

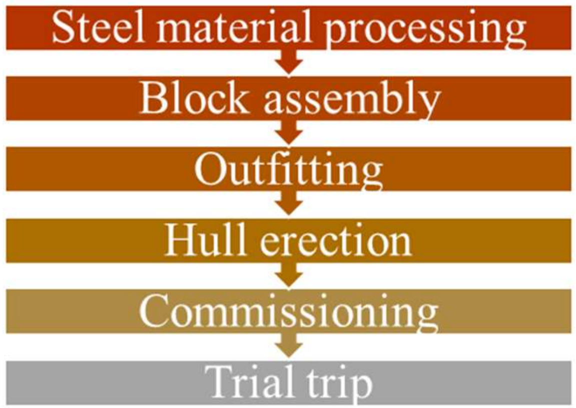
Shipbuilding:

- **Traditional** mechanical **manufacturing process**
- Requires enough **building space** and **resources**, due to large and **complex components**.
- **Highly customizable** and mostly not mass produced

Challenges in Block assembly (Maximum building time):

- High **customization**/ Different variants
- **Lack** of **3D-CAD** models
- **Confined spaces**
- **Uncontrolled** external conditions

Block assembly



Introduction – HRC contribution

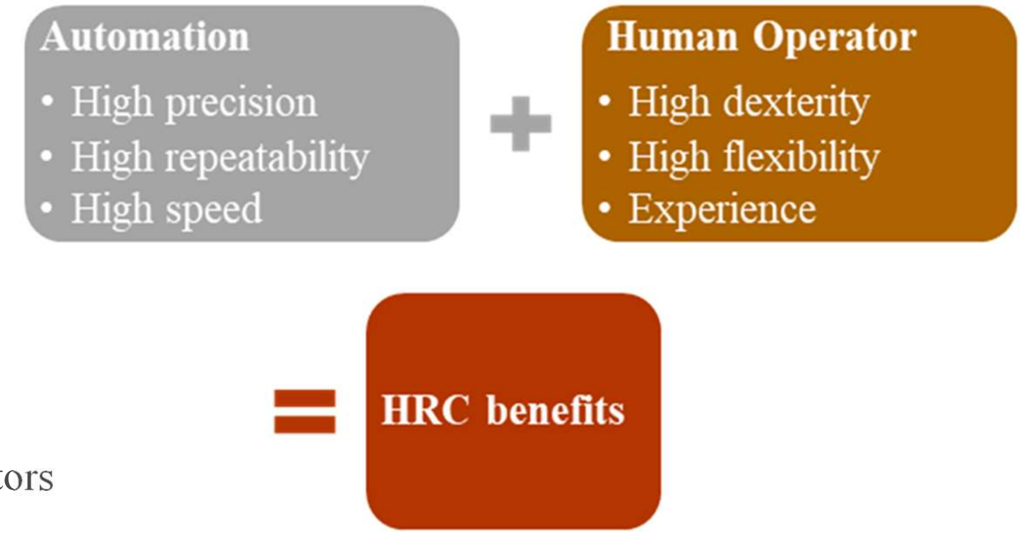
Why human – robot collaboration?

- **Full automation** is **not ideal** due to building **space requirements** and external **conditions** can be **unpredictable** and demand **human intervention**.
- **Manual** labor
- Transport of **heavy parts** causes ergonomic concerns (robot work as weight carrying assistant)
- **Repeatable** movements (parts' manipulation, welding etc.)
- **Waste** of resources (multiple operators)
- **Dangerous** environment and conditions

Introduction – HRC benefits

Benefits from human – robot collaboration?

- **Robots offer:**
  - High precision
  - High repeatability
  - High speed
- **Humans offer:**
  - High dexterity
  - High flexibility
  - Experience
- **Combination** of advantages of robots and human operators



Approach to solution

A **portfolio of tools** designed for **non-expert users:**

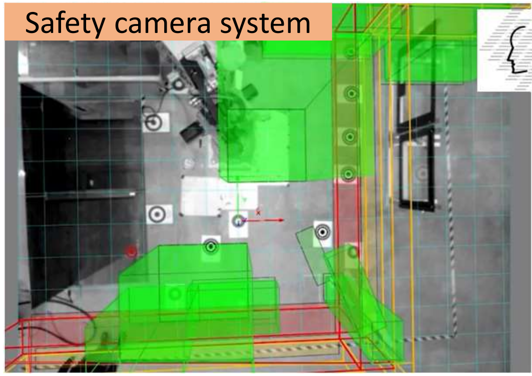
- **Tool-oriented** solutions for non-expert users (each tool can be either stand alone or coexist along with other tools)
- **Modular** architecture (easily applicable to different systems, adjustable different scenarios etc,)
- **Human - centric** design (human safety, ergonomic approach, user friendly interfaces etc.)

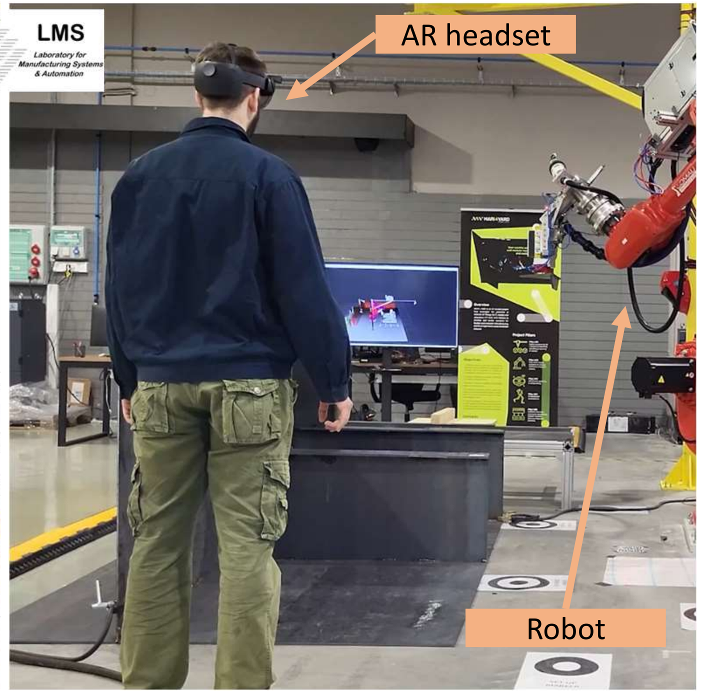
Challenge	Approach
Fully automated solutions not feasible	Inclusion of human factor, HRC is needed
One-off parts – not expert operators	Easy-to-use, seamless tools
High flexibility/ Low repeatability	Cost-effective automated and manual tools, applied based on the use case needs
Lack of CADs and documentation	General flexible architecture and dynamic robot programming

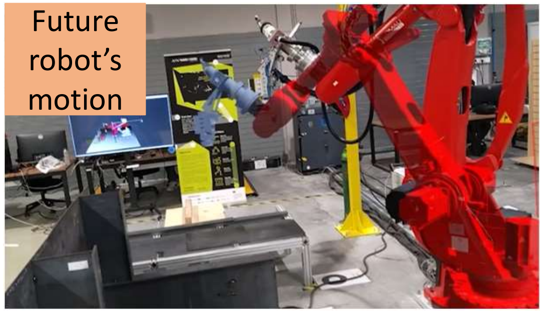
Key Technologies and Applications studied in Mari4_YARD

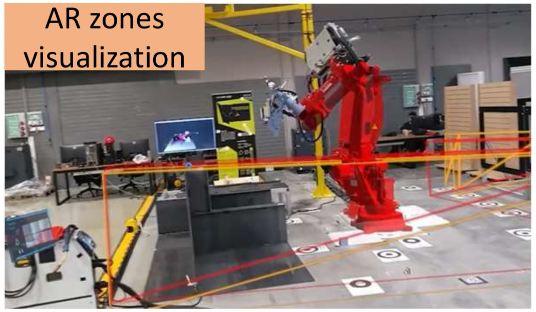
Human Robot Interaction – Operator Support using AR

- **Robot trajectory visualization** in AR environment
- **Visualization** of tasks & safety **zones**
- Safety sound **notifications**





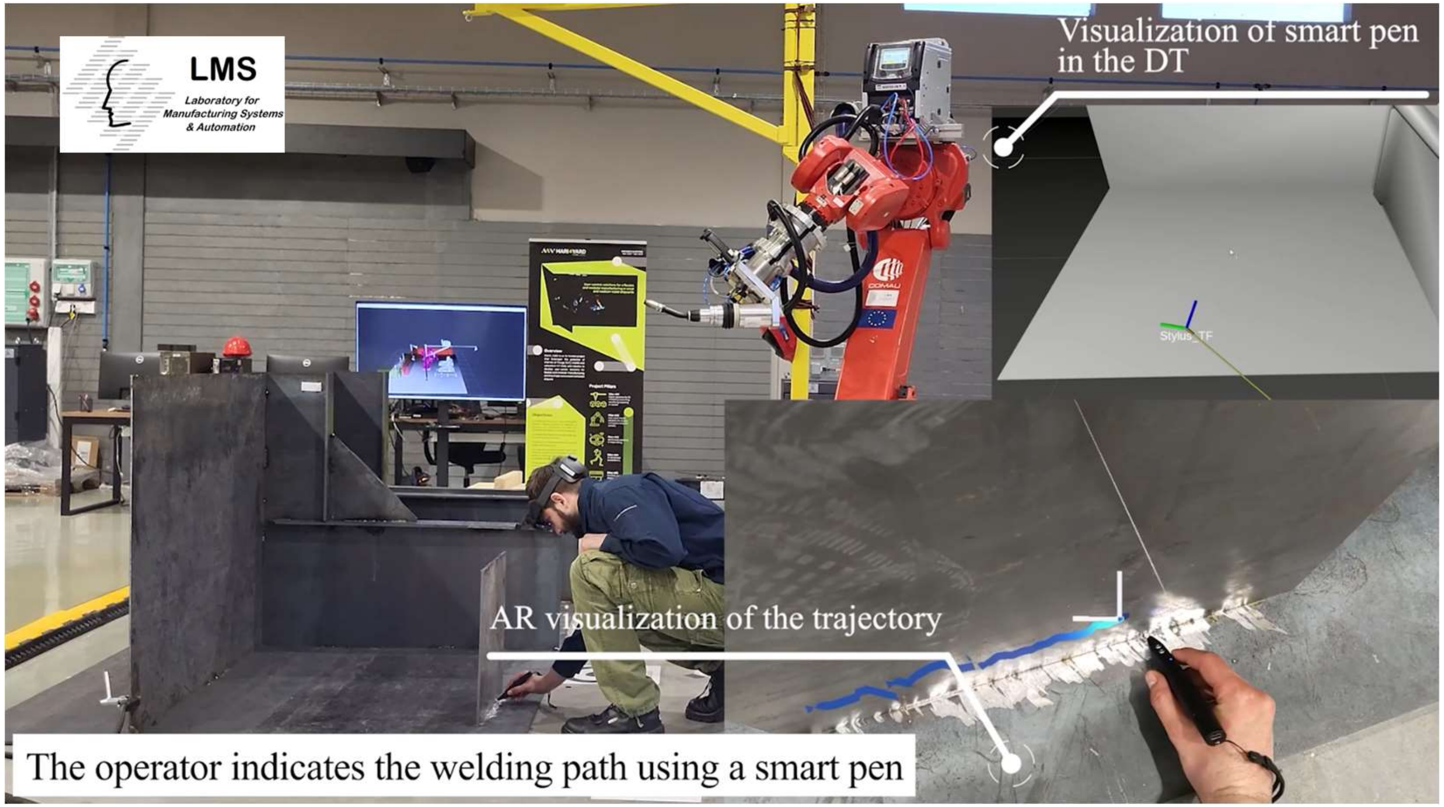




Key Technologies and Applications studied in Mari4_YARD

Human Robot Interaction – Robot programming

- **Smart pen** & **AR** glasses-based robot **path teaching** for robotic welding
- **Simulation** to validate if **taught path is feasibility** for the robot to execute



Key Technologies and Applications studied in Mari4_YARD

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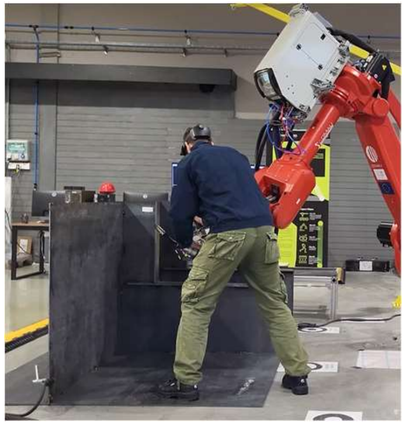
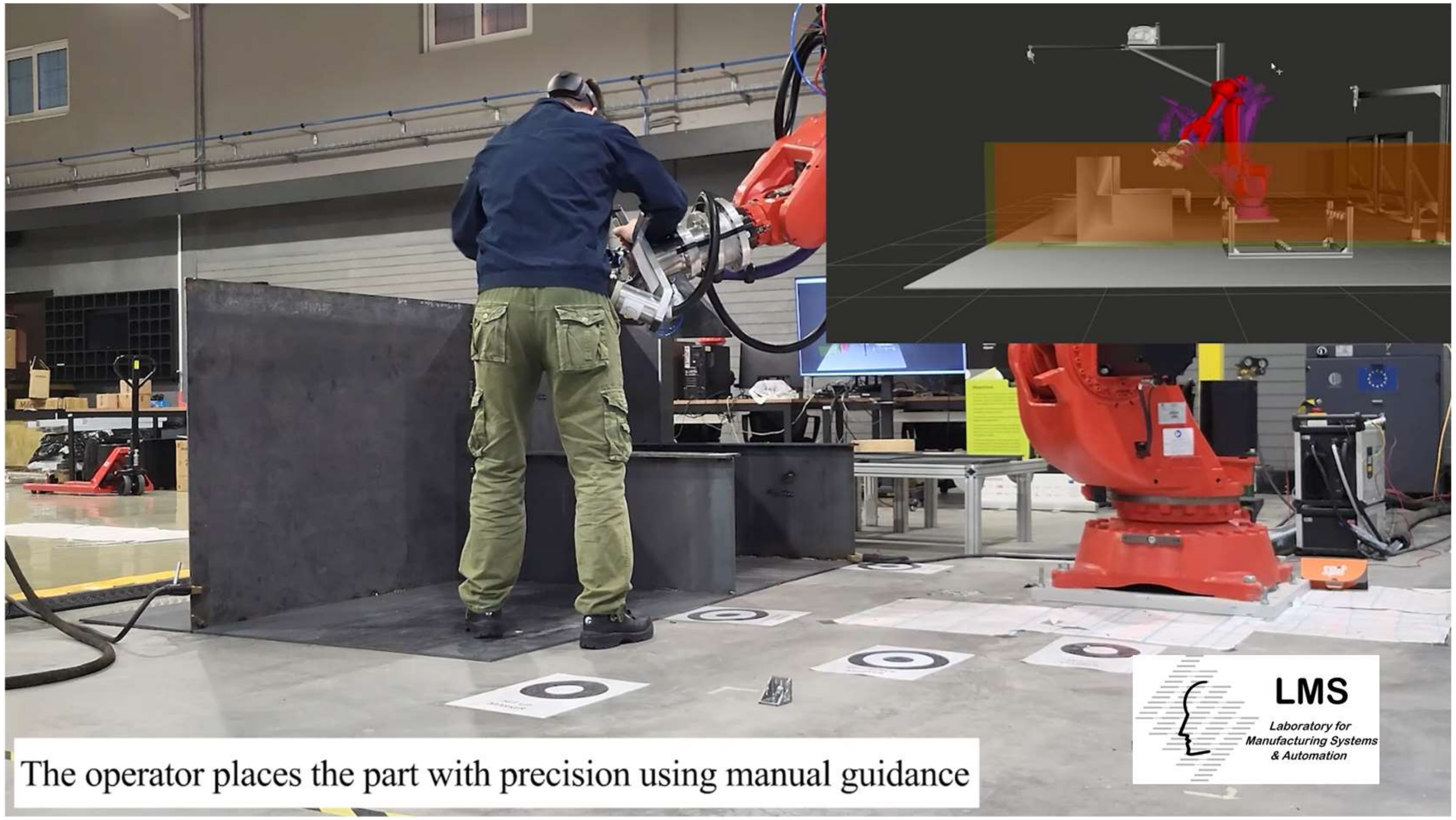
Human Robot Interaction – Robot programming

- **Force/Torque** based **control** of robot
- Operator manipulates **robot's** end-effector in the **desired pose**

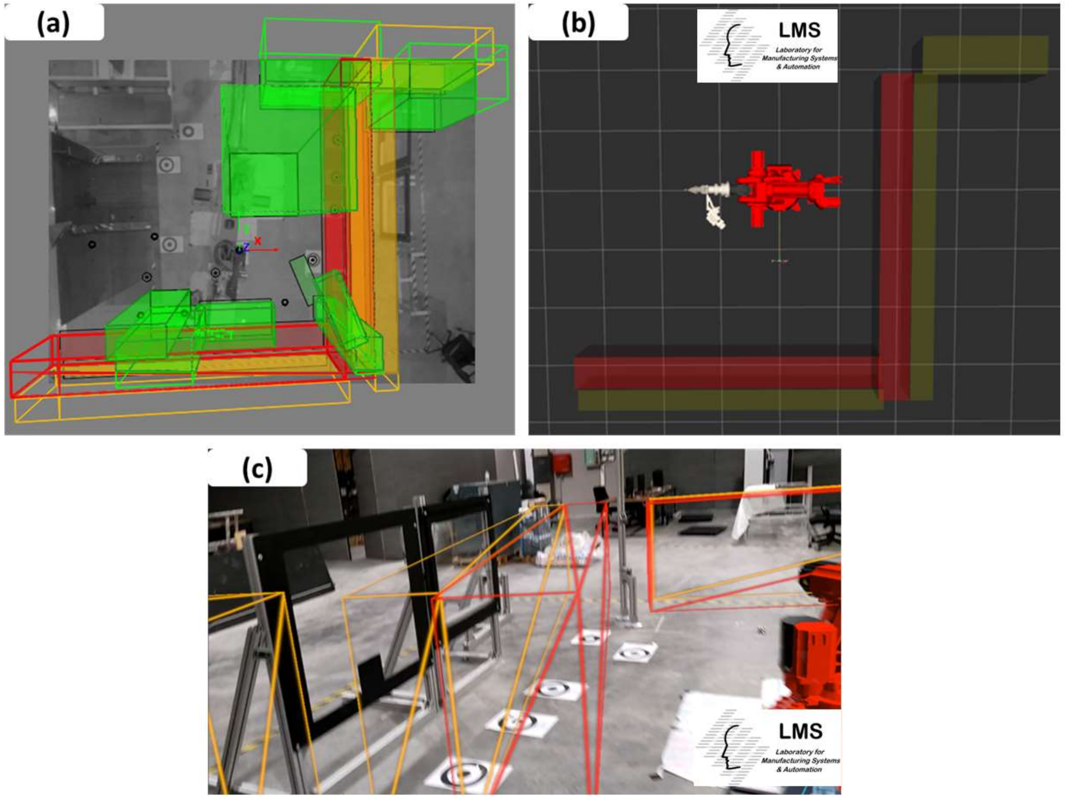




Key Technologies and Applications studied in Mari4_YARD

Multilayer Safety System

- Division of workspace in **safety zones**
- **Detection** of operator's **intrusion** to safety zones
- Robot **safety dynamics** activation
- **Certified** industrial safety **devices**, 3D scanners etc.

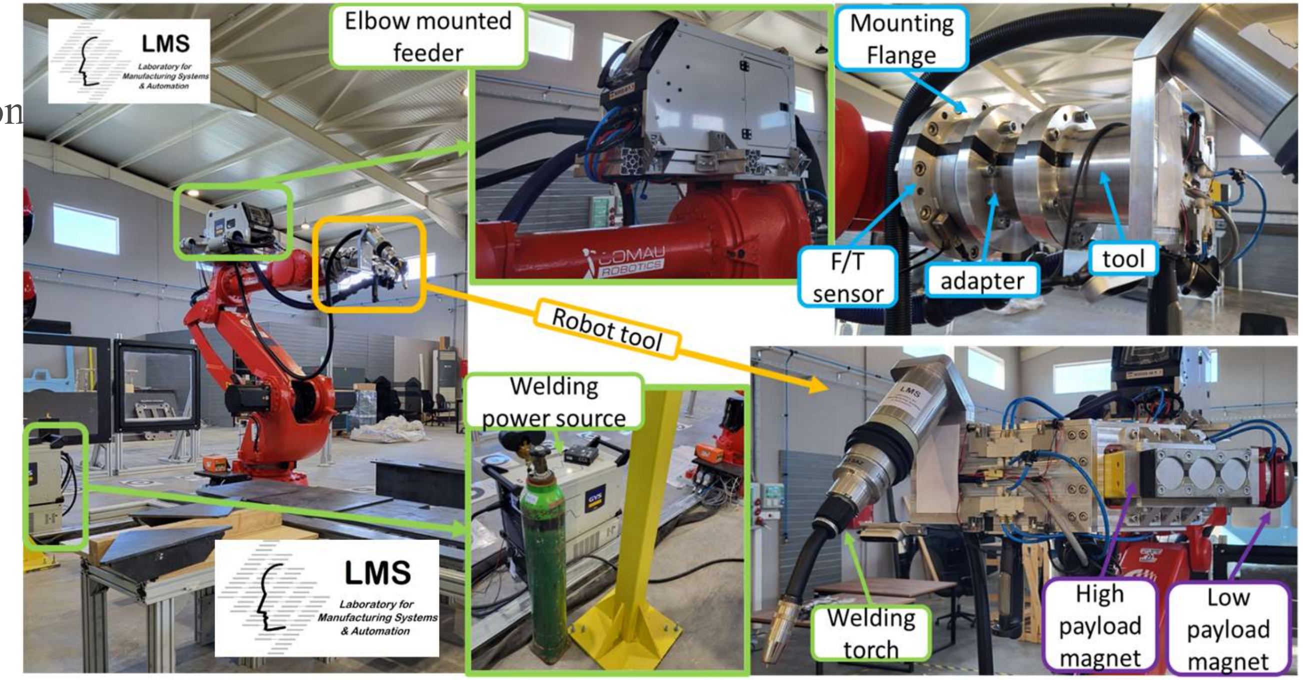


(a) SafetyEye Zones Configuration (b) ROS (RVIZ) zone Visualization (c) Hololens2 AR Visualization

Key Technologies and Applications studied in Mari4_YARD

High Payload Collaborative Robot (HPCR)

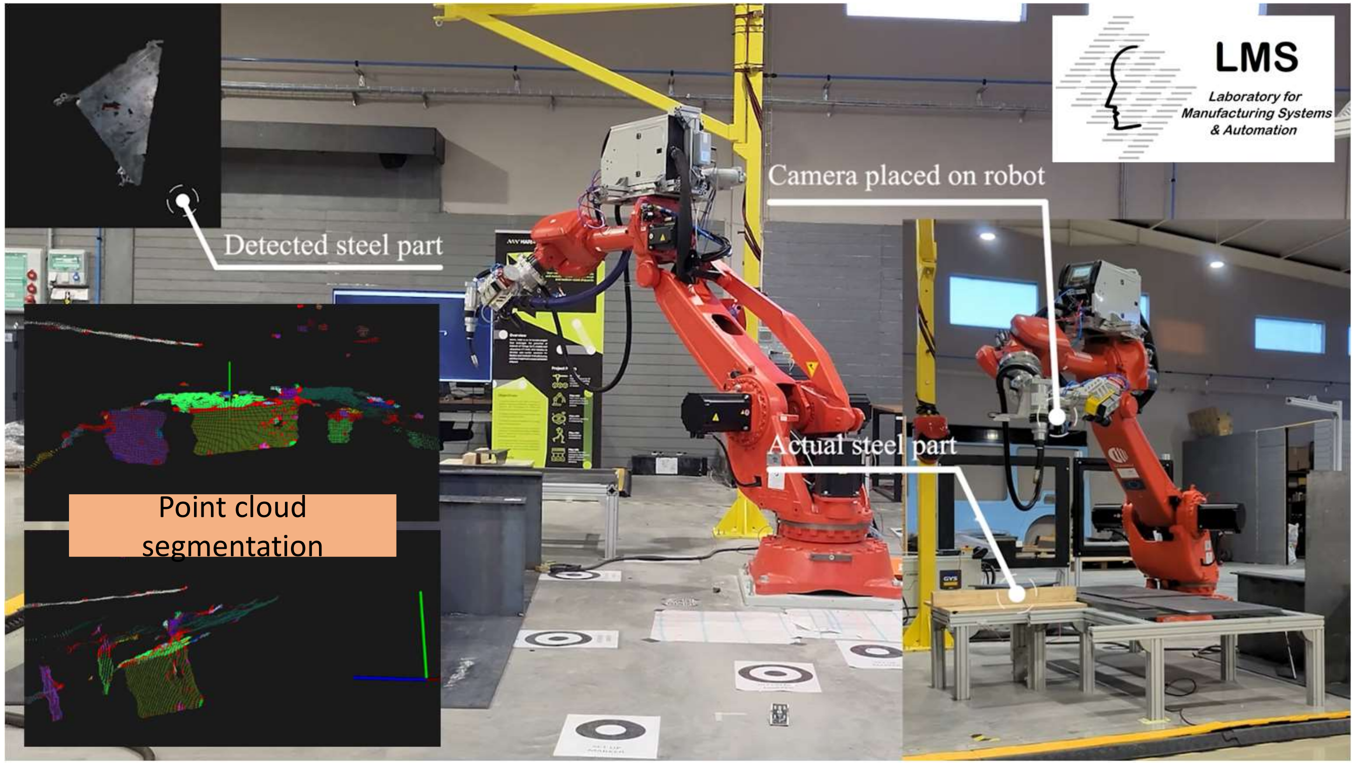
- **Manipulation** of **heavy parts** – workpiece holding device
- Robot s**afety dynamics** adjustments based on safety system inputs
- Robot autonomy based on **digital twins** for collisions avoidance during motion programming
- Not fixed robot programs



Key Technologies and Applications studied in Mari4_YARD

Process perception module for bin picking operations

- **CAD independent** part detection
- Center of gravity identification
- **Grasping point identification** to command the robot grasp the part



Use case – heavy parts manipulation and welding

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Scenario Description

- The robot uses an **AI** system to **detect sheets** to be picked
- The robot **picks** and **manipulates** the heavy sheets and roughly positions them in place
- The **operator guides** the robot to the **final position**
- The **operator tack welds** the sheet to free up the robot
- The **operator teaches** the welding seam using the **smart pen**
- The **robot fully welds** the sheet in place

Use case – heavy parts manipulation and welding

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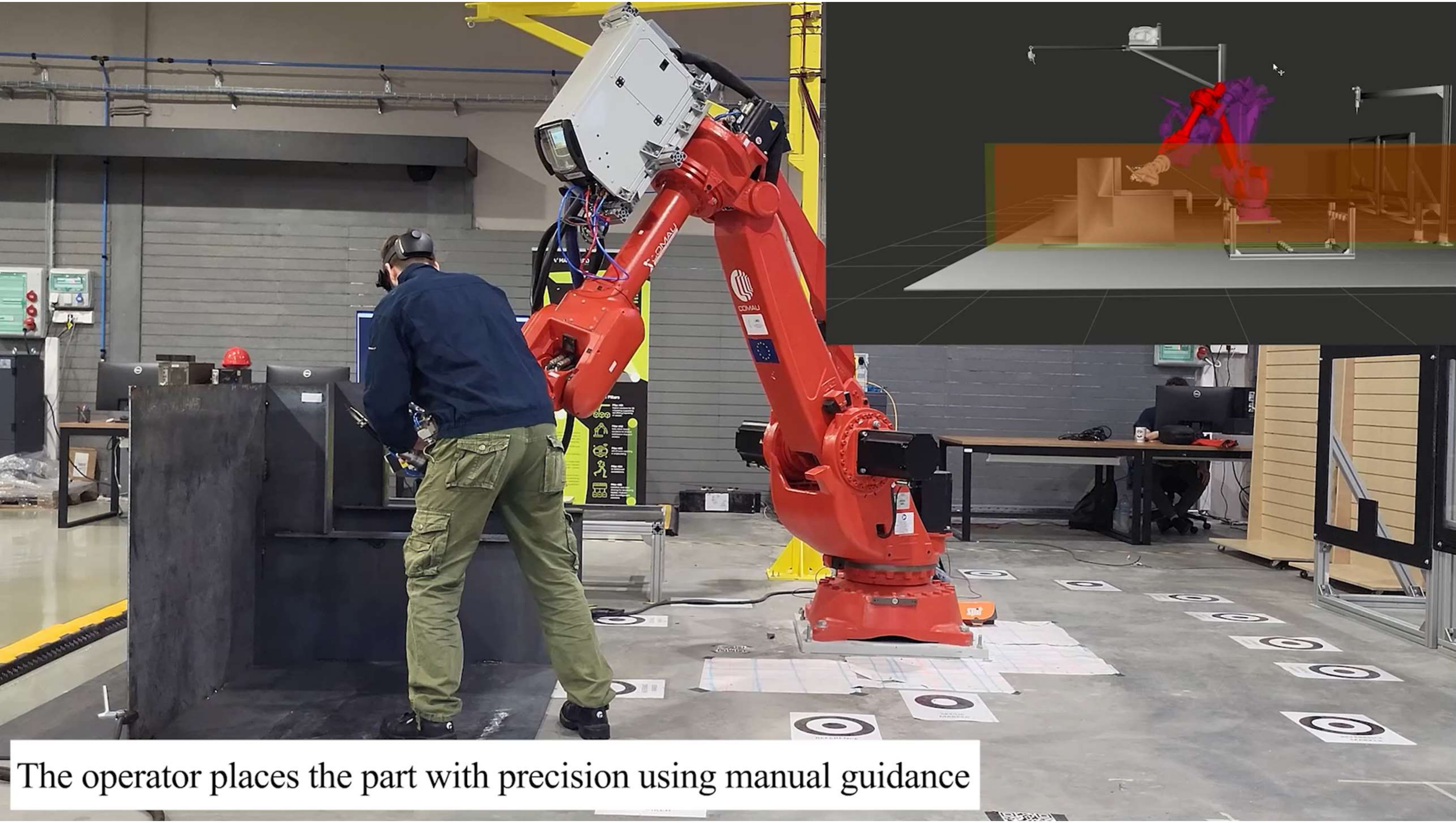
Integrated Technologies

- **Human Robot Interaction**
  - Operator **awareness** for **safety** status and zones
  - Operator **manual guidance** for parts positioning (direct interaction)
  - Operator **path teaching** using AR and a smart pen for welding trajectories (indirect interaction)
- **Process perception module for bin picking operations**
  - **Parts detection** and grasping point identification from the “bins”
- **Multilayer Safety System**
  - Safety **sensors** divide workspace in **hazardous/ warning/ non-hazardous zones** and command robot the appropriate **safety functions**
- **High Payload Collaborative Robot**
  - Capable of performing **welding** and **heavy parts**’ **manipulation** operations
  - Complies with the standards for **Speed and Separation Monitoring** (SSM)



The operator places the part with precision using manual guidance

Use case – heavy parts manipulation and welding

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Target KPIs

- **Ergonomics improvement** in handling of parts
  - **Weights** are neither carried nor held
  - Unergonomic **poses** for **welding** are avoided
- **Maximum weight** to be manipulated by the operator
  - Maximum weight is reduced to just the tools
- Cycle **time**
  - Reduced as exhaustions is reduced
  - **Robot** can perform more stable **welding w/o interruptions**
- Number of **operators required** in the production station
  - **One operator** for HRC **instead of two-three** for the heavy parts manipulation

THANKS
FOR YOUR ATTENTION

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