Novel technologies to boost the shipyard industry

Mobile Manipulator for Intralogistics Operation

Luís Rocha | Senior Researcher

iilab INDUSTRY & INNOVATION LAB
INESCTEC

ORGANIZED BY THE EU HORIZON 2020 PROJECTS:

FIBRE4YARDS SHIPYARD FOR THE FUTURE

RESURGAM

MARI4YARD MARI4ALLIANCE

30th and 31st May 2023, RTD Innovation Dock, Rotterdam

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements n° 101006860 (FIBRE4YARDS), n° 101007005 (RESURGAM), and n° 101006798 (Mari4_YARD).

35 Years
Leading R&D
in Engineering

We cover the knowledge-to-value production chain
We transfer knowledge, technologies and people
We enable science-based innovation
We offer advanced consulting and training
We create spin-offs

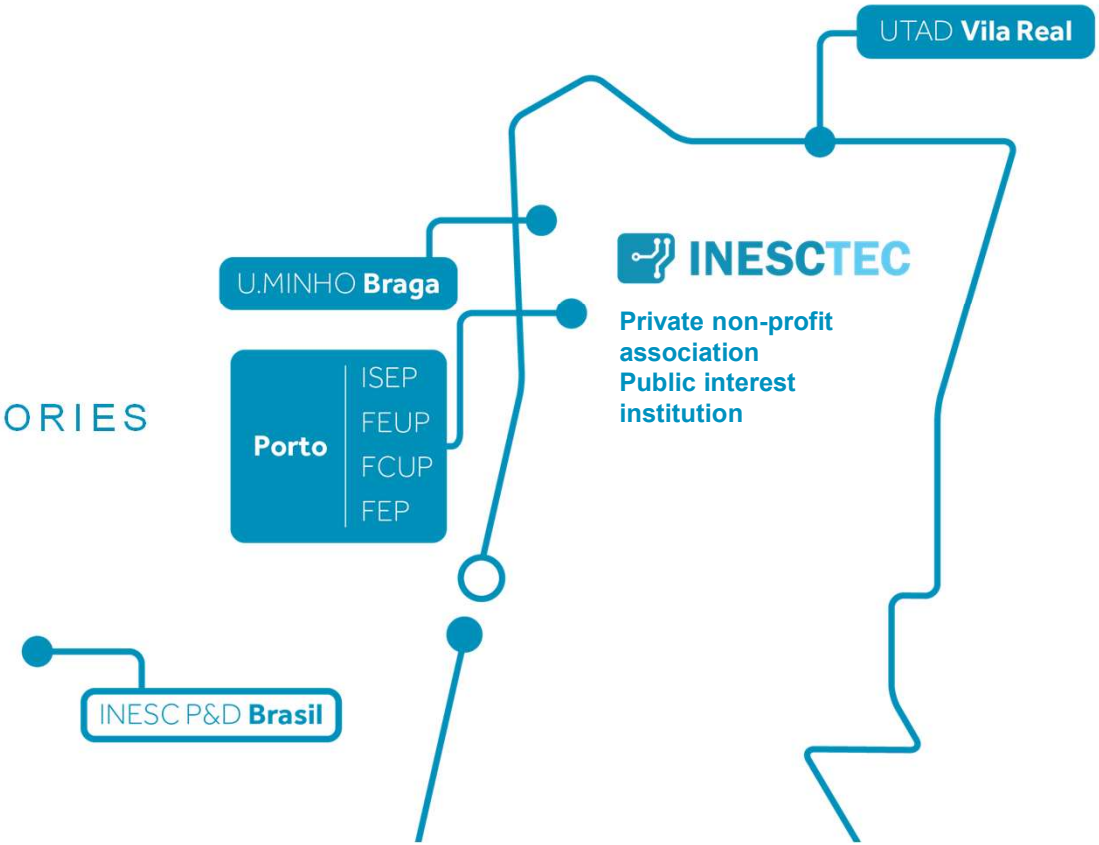
WE ARE **NETWORKED INTELLIGENT SYSTEMS**
WE ARE **POWER AND ENERGY**
WE ARE **INDUSTRIAL AND SYSTEMS ENGINEERING**
WE ARE **COMPUTER SCIENCE**
WE ARE **INESC TEC**

MULTIFACETED TEAMS
GROWING IN EXCELLENCE

6 SITES

3 CITIES

19 LABORATORIES



A mirror organisation
INESC P&D Brasil coordinates the joint work of research groups within its associates (belonging to 18 top Brazilian universities and INESC TEC).

A TALENT INCUBATOR

CHOOSING PEOPLE AS THE DRIVING FORCE

+800
INTEGRATED RESEARCHERS

+350
INTEGRATED PHDS

+25
NATIONALITIES

+200
PEOPLE GOING TO THE MARKET/YEAR

Our researchers constitute the foundations of our strategy. INESC TEC is one of the **leading Portuguese organisations in scientific employment**.

INESC TEC is also a **hub of talent**, with more than 200 professionals from 18 countries transferred to market per year.

SOME OF OUR MOST IMPORTANT CLIENTS

A RELEVANT ROLE IN THE ECOSYSTEM

AGRO-FOOD

AMORIM CORK COMPOSITES

Herculano Trailers and Machinery for Agriculture

ASSOCIATIONS

COTEC Portugal

ORDEM DOS ARQUITECTOS

AUTOMOTIVE

BOSCH

MABOR

CATERING

gertal

MINT AND OFFICIAL PRINT OFFICE

INCM

ENERGY

edp

efacec

REN

galp

EDA Electricidade dos Açores

Vestas

SIEMENS

Electricidade da Madeira

FINANCING

NATIXIS

HEALTH

centro hospitalar do Porto

INDUSTRY

KYAIA

IKEA

A.SILVA MATOS METALOMECÂNICA

Riduba

MTEX SOLUTIONS

PRECISÃO LASER

SOFTWARE

outsystems

randtech computing

Critical manufacturing

AppGeneration digitally powered

TELECOMMUNICATIONS

wavecom

eurico ferreira Portugal

SPACE

esa European Space Agency

LOCAL ADMINISTRATION

maia CÂMARA MUNICIPAL

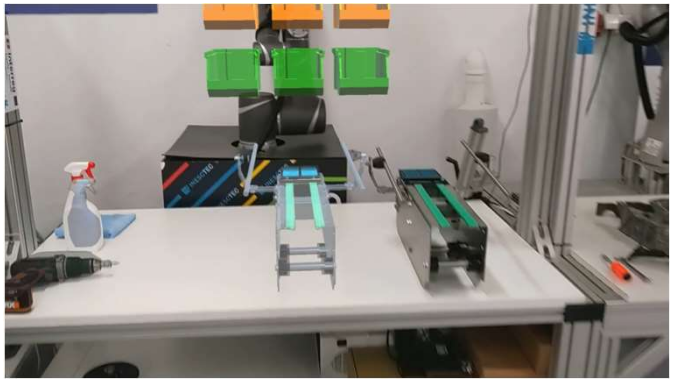
TRANSPORTATION

APDL ADMINISTRAÇÃO DOS PORTOS DO DOURO, LEIXÕES E VIANA DO CASTELO

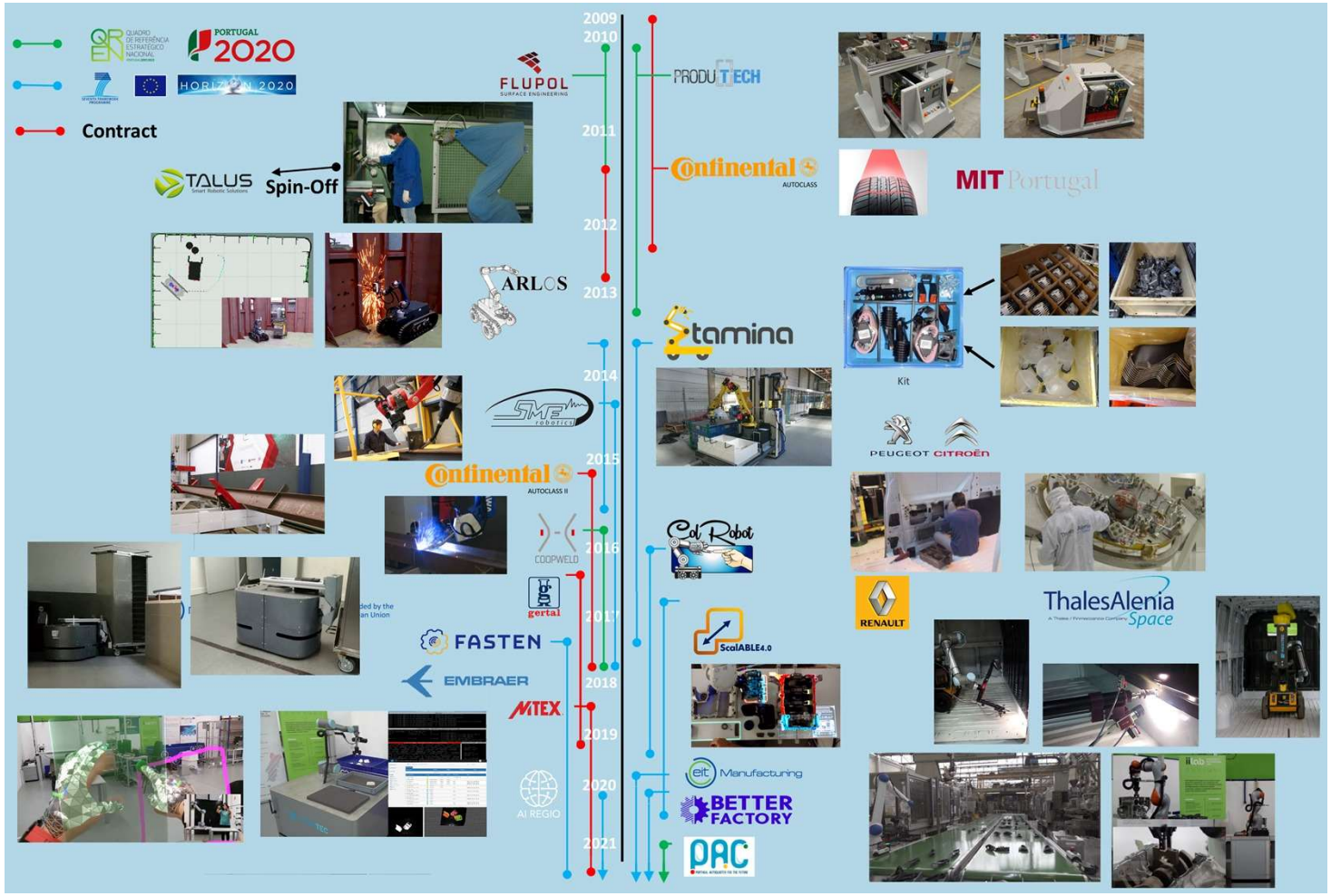
Infraestruturas de Portugal

ROBOTICS
COMPETENCES

- Localization
- Navigation
- Mobile robotics
- Distributed robotics
- Robotic manipulation
- Human-machine interaction
- Optimization
- Sensing
- Perception
- Artificial Intelligence
- Virtual and Augmented Reality
- Control



INDUSTRY
R&D PROJECTS



Mobile Manipulator for Intralogistics Operation

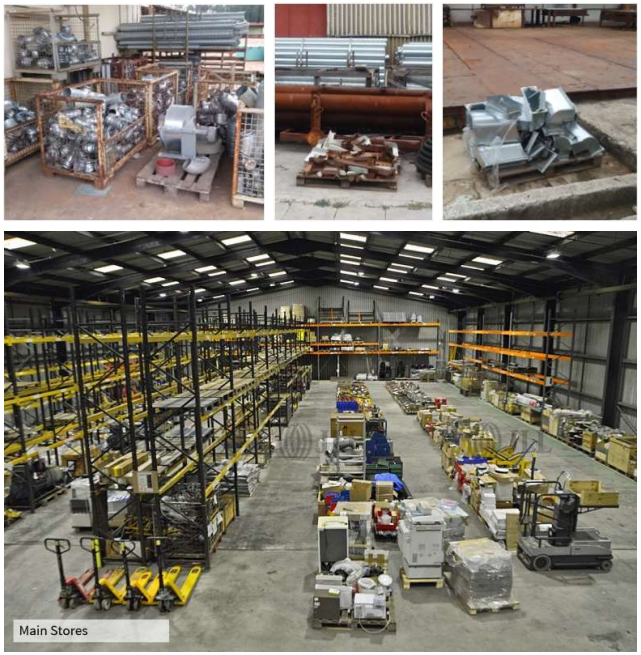
These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements n° 101006860 (FIBRE4YARDS), n° 101007005 (RESURGAM), and n° 101006798 (Mari4_YARD).

Motivation

- At today's shipyards, the transportation of raw materials and/or manufactured parts between stores and workshops, and from workshops to subassembly areas, is still heavily reliant on human operators.

- This transportation is typically performed by hand or by using self-propelled, pulled, or pushed platforms.

- During the shipbuilding process a wide range of components including structural steel, pipes, cables, valves, and outfitting are supplied, handled, and transported. These parts are normally stored in warehouses or pallets, and are placed in shelves, big containers and/or boxes.



* John Spoehr, Ryan Jang, Kosta Manning, Arvind Rajagopalan, Cecilia Moretti, Ann-Louise Hordacre, Sara Howard, Peter Yaron and Lance Worrall The Digital Shipyard, Opportunities and Challenges, March 2021, Flinders University - Australian Industrial Transformation Institute

Motivation

- From the state-of-art in mobile robotics, it is possible to find several commercial AGVs/AMRs solutions that could be used by shipbuilders to automate some of their logistic tasks*.

- These solutions, though, present limitations regarding the manipulation of the loads.
  - automate forklifts are able to directly pick pallets for transportation
  - more general AGV/AMR solutions required the addiction of a transfer system to enable the load to be automatically transferred from the place that it is stored.
  - However, they are not able to select and pick individual parts form containers or bins.

*John Spoehr, Ryan Jang, Kosta Manning, Arvind Rajagopalan, Cecilia Moretti, Ann-Louise Hordacre, Sara Howard, Peter Yaron and Lance Worrall **The Digital Shipyard, Opportunities and Challenges, March 2021, Flinders University - Australian Industrial Transformation Institute**

MARI4YARD
MARI4ALLIANCE

Challenges

- The introduction of mobile robotics into shipbuilding processes is hindered by several factors, including:

Non-standard and heavy parts

Parts with complex and highly variable geometries

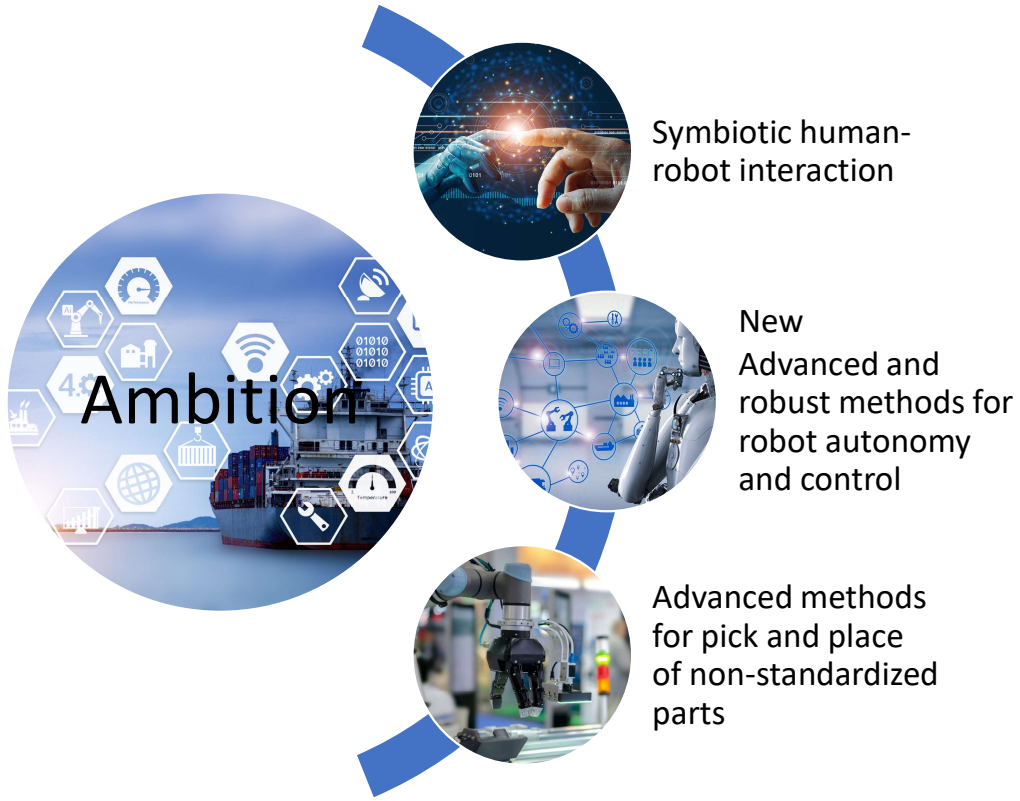
Not standard processes and tasks

Cluttered environments and enclosed spaces

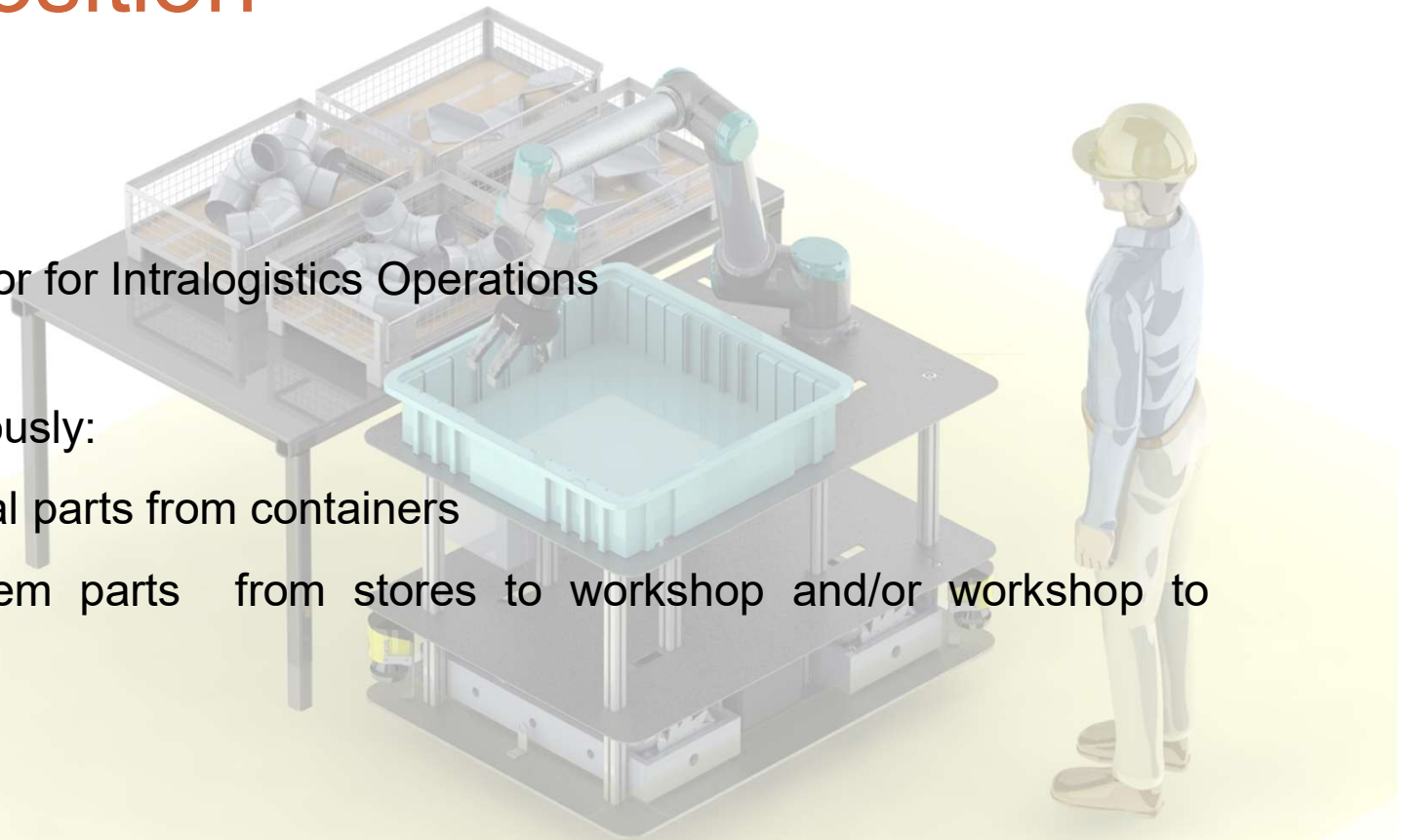
MARI4YARD
MARI4ALLIANCE

Ambition

- The effective implementation of autonomous mobile robots needs to be tailored to the specific demands of the shipbuilding industry and its processes, requiring further developments.



Value Proposition



- Mobile Manipulator for Intralogistics Operations
- Able to autonomously:
  - Pick individual parts from containers
  - Transport them parts from stores to workshop and/or workshop to building area

MARI4YARD
MARI4ALLIANCE

Value Proposition

- Technical Overview

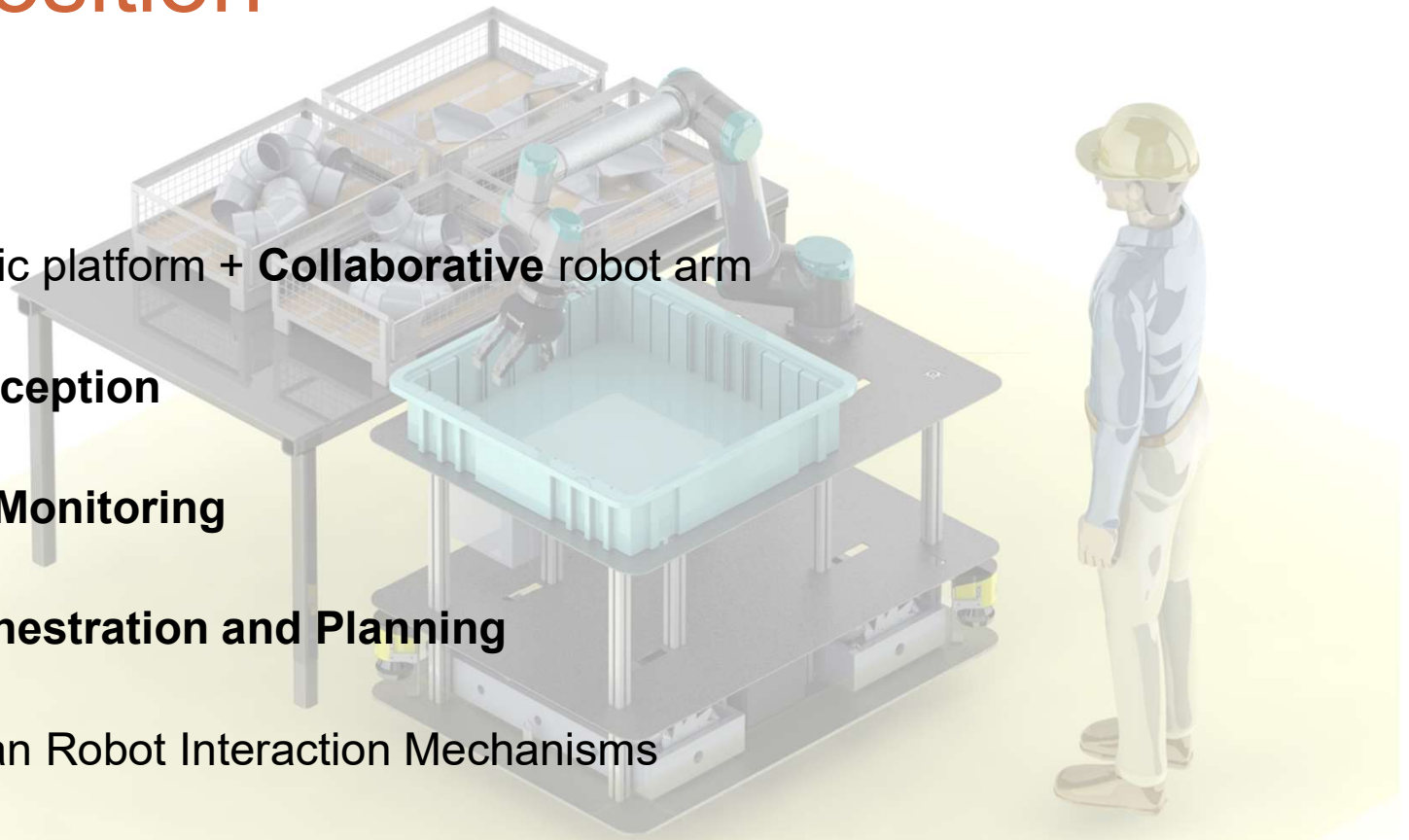
MRO → **Mobile** robotic platform + **Collaborative** robot arm

PPM → **Process Perception**

WMS → **Workspace Monitoring**

COP → **Control Orchestration and Planning**

HRIM → **HRC** – Human Robot Interaction Mechanisms



MARI4YARD
MARI4ALLIANCE

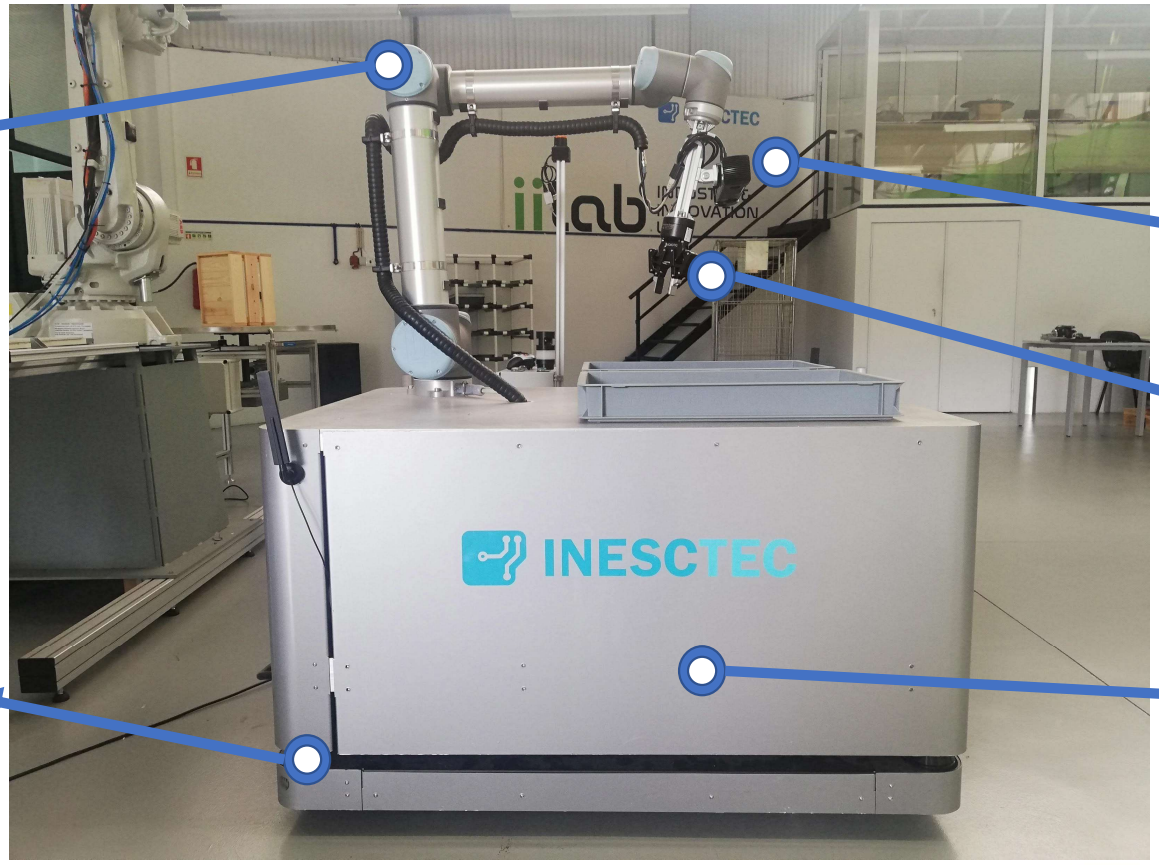
Mobile Robotic Platform

MRO

MARI4YARD
MARI4ALLIANCE

Mobile Robotic Platform

MRO



Cobot

RGB-D Sensor

2 Finger Gripper

Safety Laser Scanner

Mobile Platform Omnidirectional

MARI4YARD

MARI4ALLIANCE

Process Perception

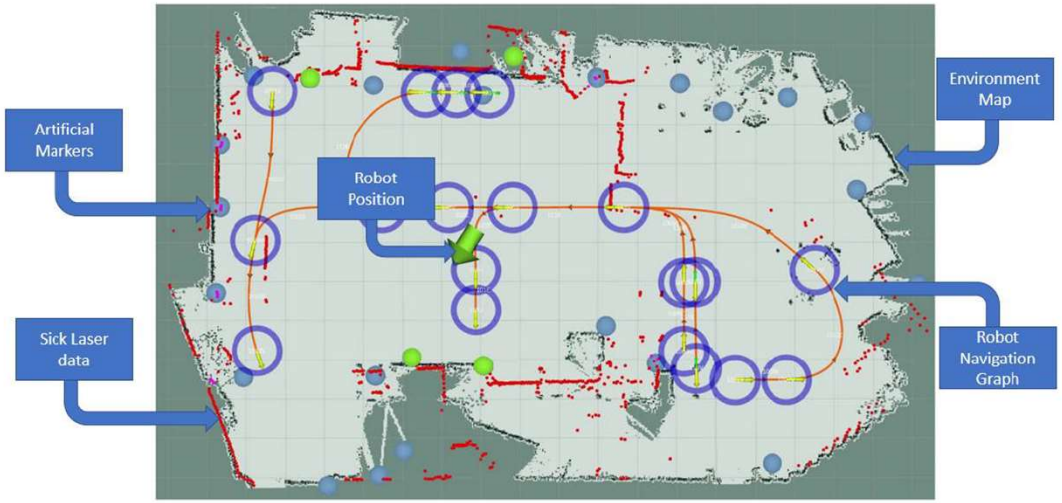
PPM

- **Main Functionalities:**

  - Multi-Robot Coordination and Autonomous Navigation

  - Uses of different types of localization systems (natural contours vs artificial markers) to allow robot navigation in unstructured environments;

  - Integration of a centralized multi-robot coordination algorithm.



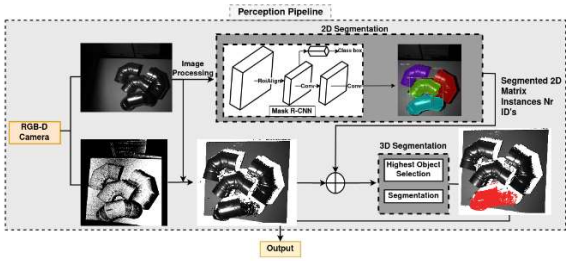
Process Perception

PPM

Main Functionalities:

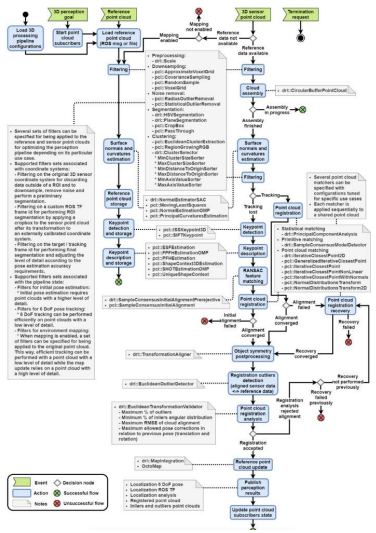
- Recognition and Grasping of Parts for Bin Picking
- Grasping planner (CAD or By Demonstration);
- Segmentation based on 2D Images and Deep Learning with mapping heuristics to 3D segmentation;
- Pose estimation based on 3D Point Cloud.

Segmentation

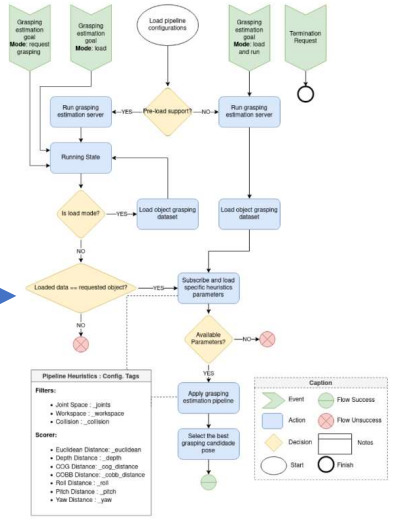


- Several metrics and heuristics are used to evaluate the estimation of the chosen grasp candidate:
(i) the effort to move robot arm to the estimated point
(ii) the collision with the workspace or another object; (iii) the joint space, excluding candidates outside this space;

Pose Estimation



Grasping Selection

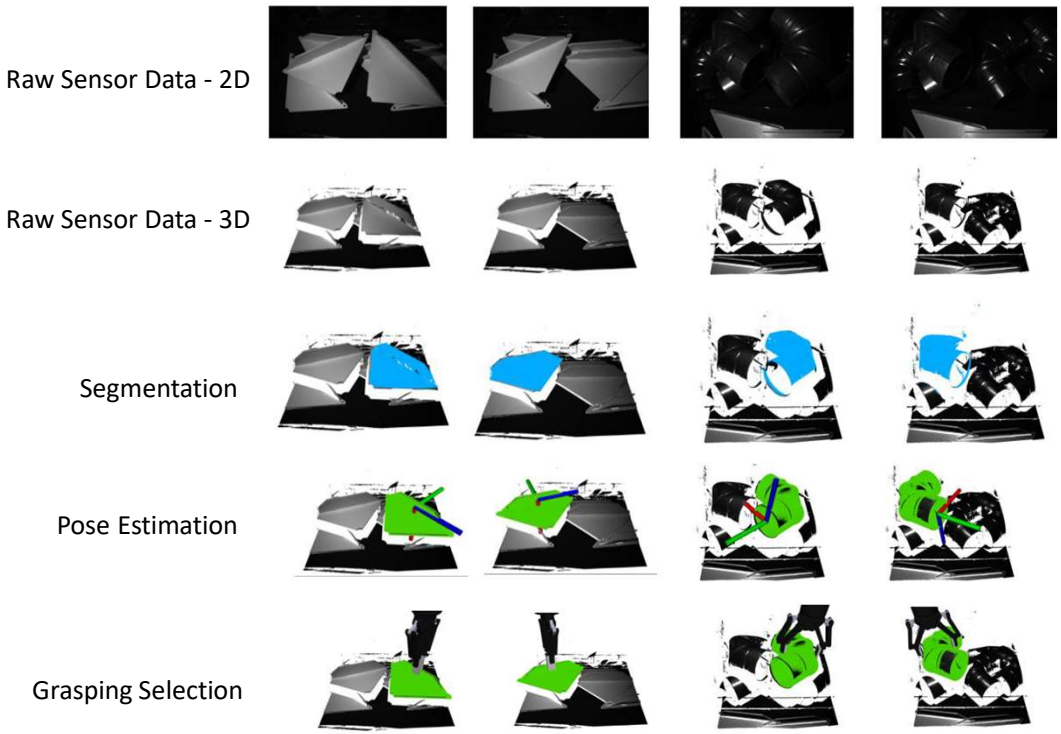


MARI4YARD
MARI4ALLIANCE

Process Perception

PPM

Perception System Results



MARI4YARD
MARI4ALLIANCE

Workspace Monitoring

WMS

- Main Functionalities:
  - Robot workspace monitoring using AR – Promote trust and confidence during Human-Robot collaboration in shared workspaces;
  - Provide intuitive process visualization and interfaces to operate the robotic system;
  - A Complement to certified safety systems that ensure "true" safety during robot autonomous operation;
  - “True Safety” using SSM trough laser scanners

INESCTEC iilab INDUSTRY & INNOVATION LAB

MARI4YARD MARI4ALLIANCE

INESC TEC

Human Robot Interaction and Safety Based on Augmented Reality

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006798

MARI4YARD MARI4ALLIANCE

Control Orchestration and Planning

COP

Skill-based Programming

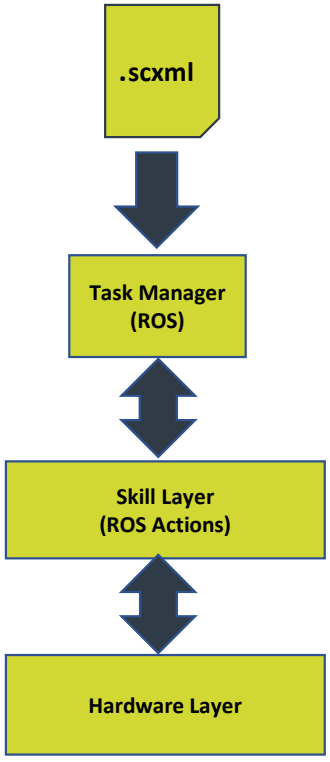
Reduce costs inherent to adapting robotic applications.

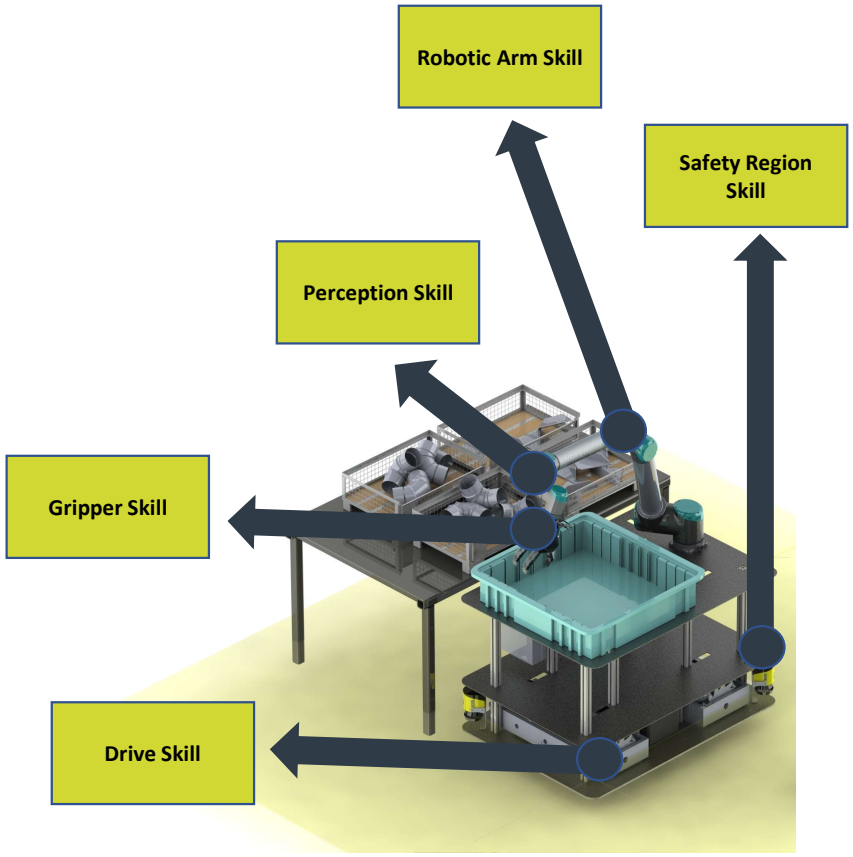
Task Orchestration

Programming robotic applications in a very intuitive and flexible way.

Vertical and Horizontal Integration

Interoperability with Manufacturing Management Systems and industrial equipment.



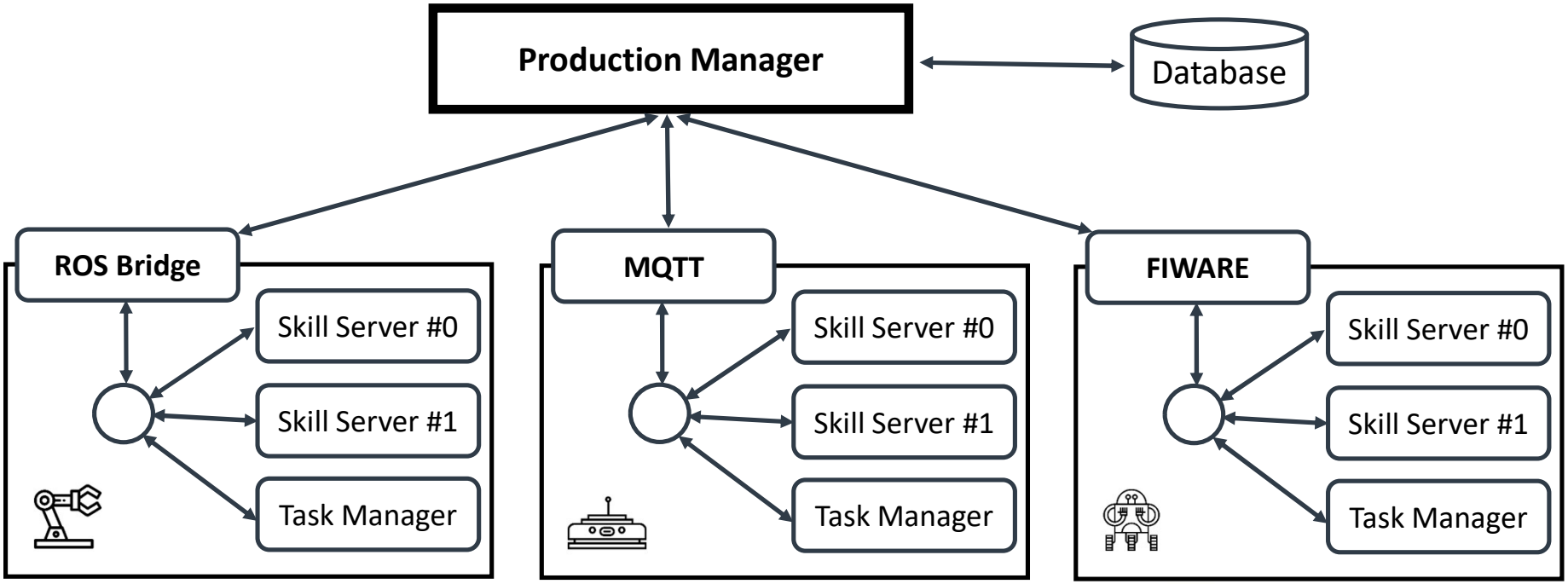


MARI4YARD
MARI4ALLIANCE

Control Orchestration and Planning

COP

Production Manager - An application that simplifies Task creation and interaction with multiple Task Manager instances.

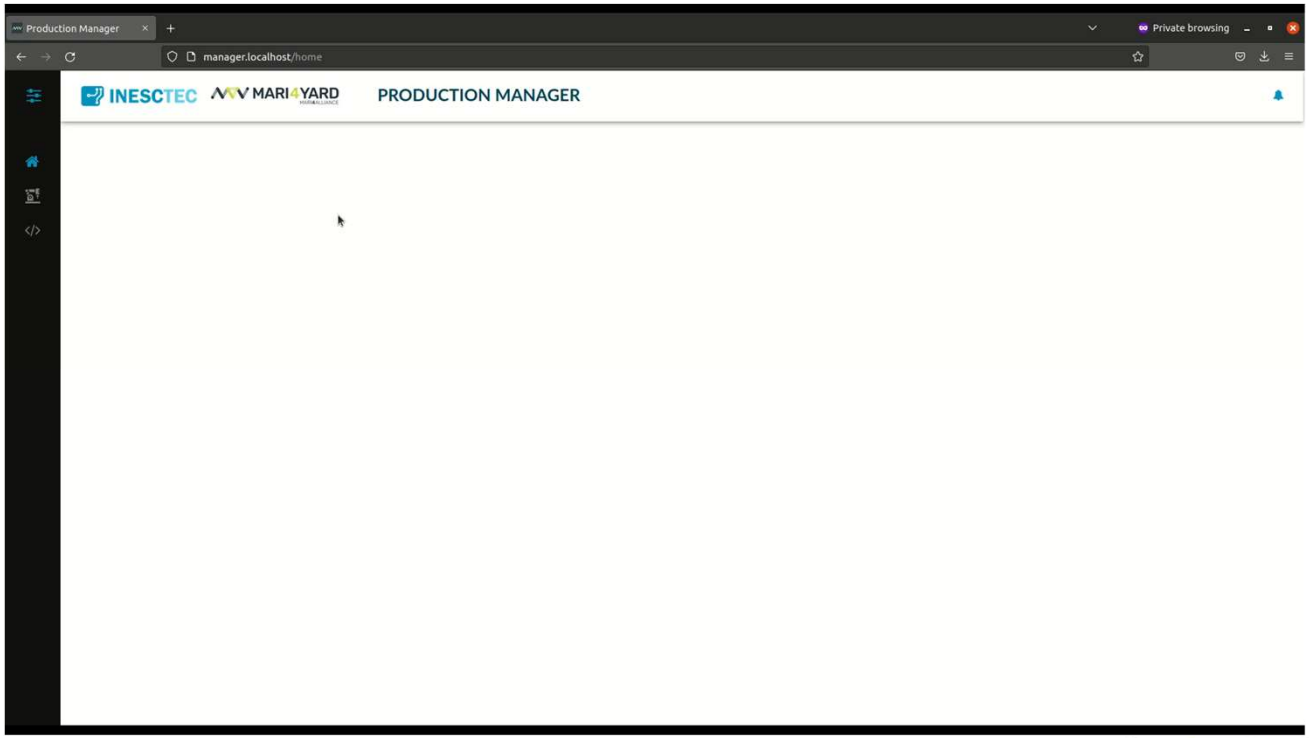


MARI4YARD
MARI4ALLIANCE

Human Robot Interaction Mechanisms

HRIM

- Robot Task Creator Using Production Manager



Human Robot Interaction Mechanisms

HRIM

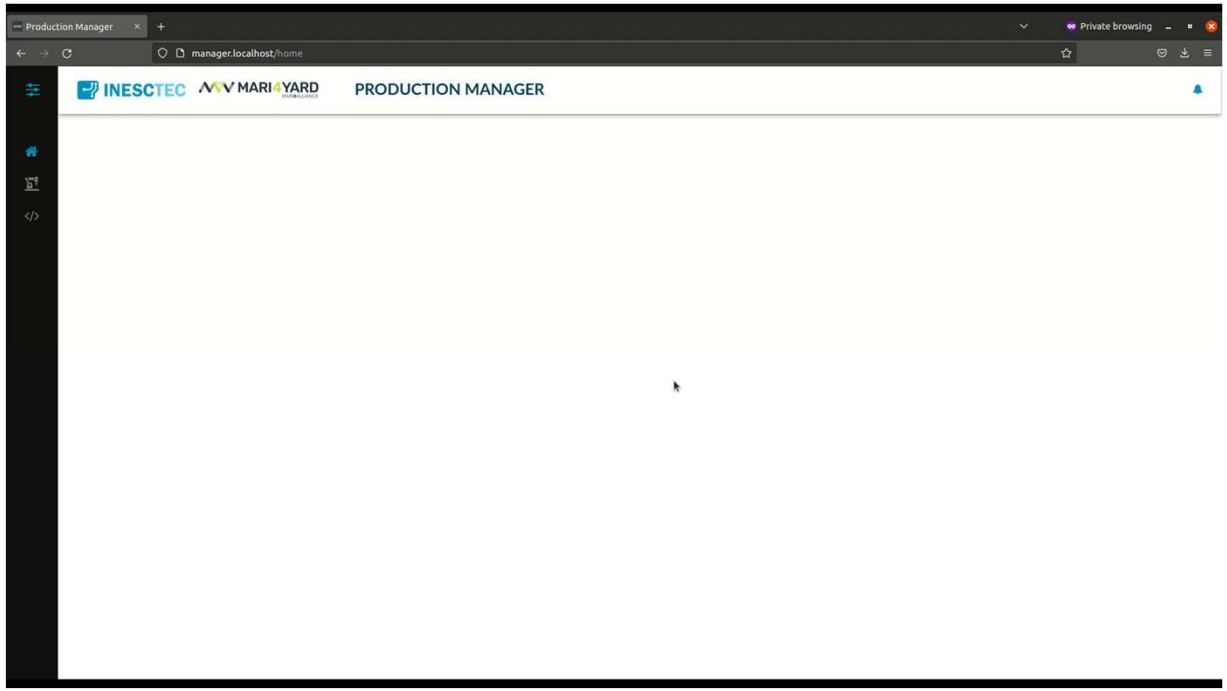
- Robot Task Creator - Using Augmented Reality Tool

MARI4YARD
MARI4ALLIANCE

Control Orchestration and Planning

HRIM

- Robot Task Assigner




MARI4YARD
MARI4ALLIANCE

Scientific Publications

- Santos, J., Rebelo, PM., Rocha, LF., Costa, P., & Veiga, G. (2021). A* Based Routing and Scheduling Modules for Multiple AGVs in an Industrial Scenario. ROBOTICS, 10(2 72), 72 (16).

- Cordeiro, A., Rocha, LF., Costa, C., & Silva, MF. (2023). Object Segmentation for Bin Picking Using Deep Learning. Lecture Notes in Networks and Systems, 590 LNNS, 53-66.

- Artur Cordeiro, Luís F. Rocha, João Pedro Souza, Carlos M. Costa, Manuel F. Silva *, Vítor Filipe, Bin picking for ship building logistics using perception and grasping systems, Robotics MDPI, 2023 Accepted for Publication.

THANKS
FOR YOUR ATTENTION

Luis Rocha | INESC TEC

luis.f.rocha@inesctec.pt

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements n° 101006860 (FIBRE4YARDS), n° 101007005 (RESURGAM), and n° 101006798 (Mari4_YARD).