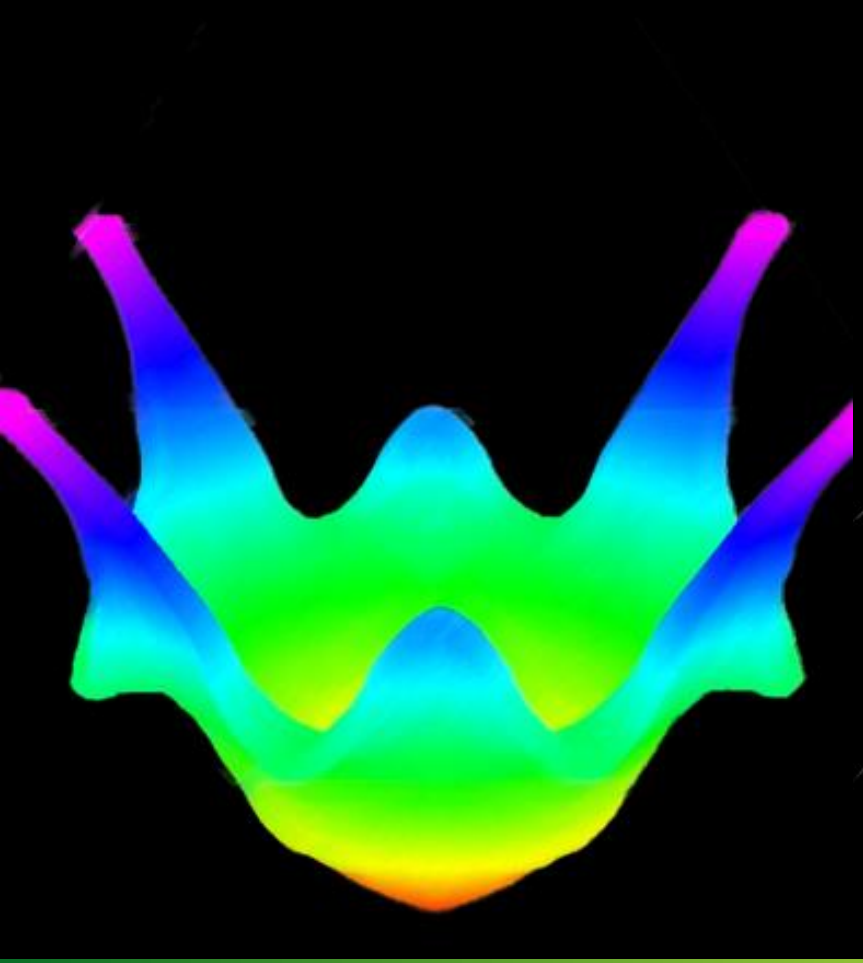
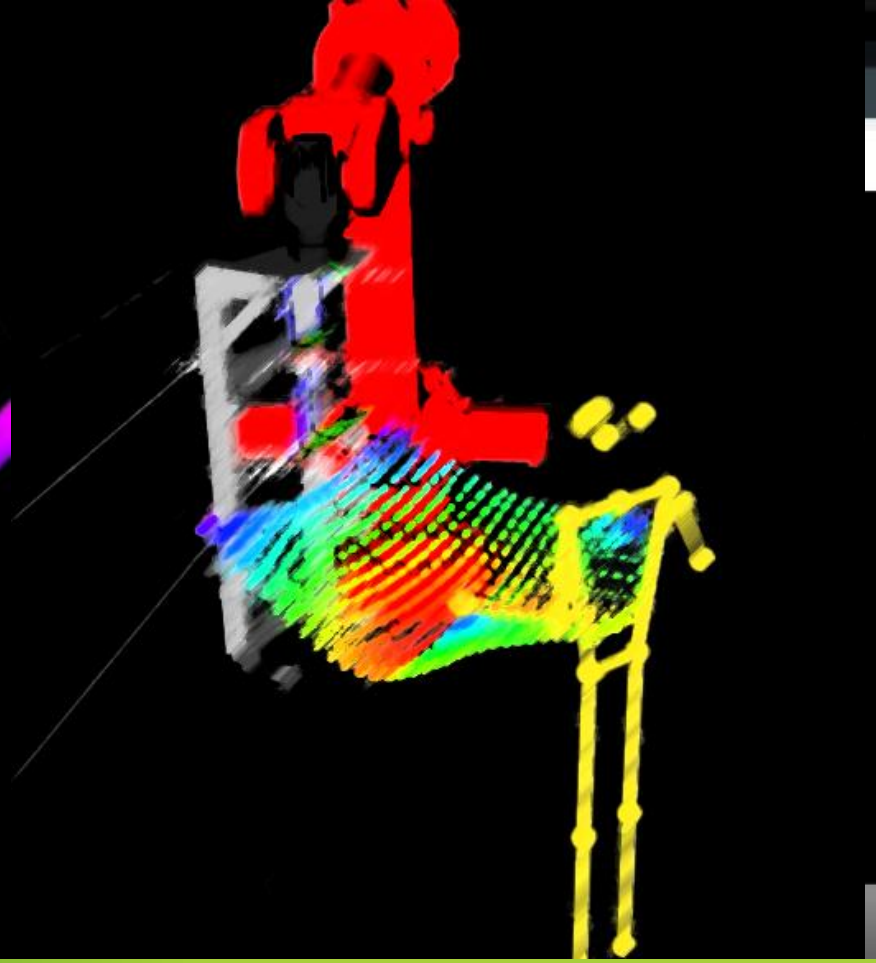
H2020-NMBP-TR-IND-2018-2020 / H2020-NMBP-FOF-2019 (869963)

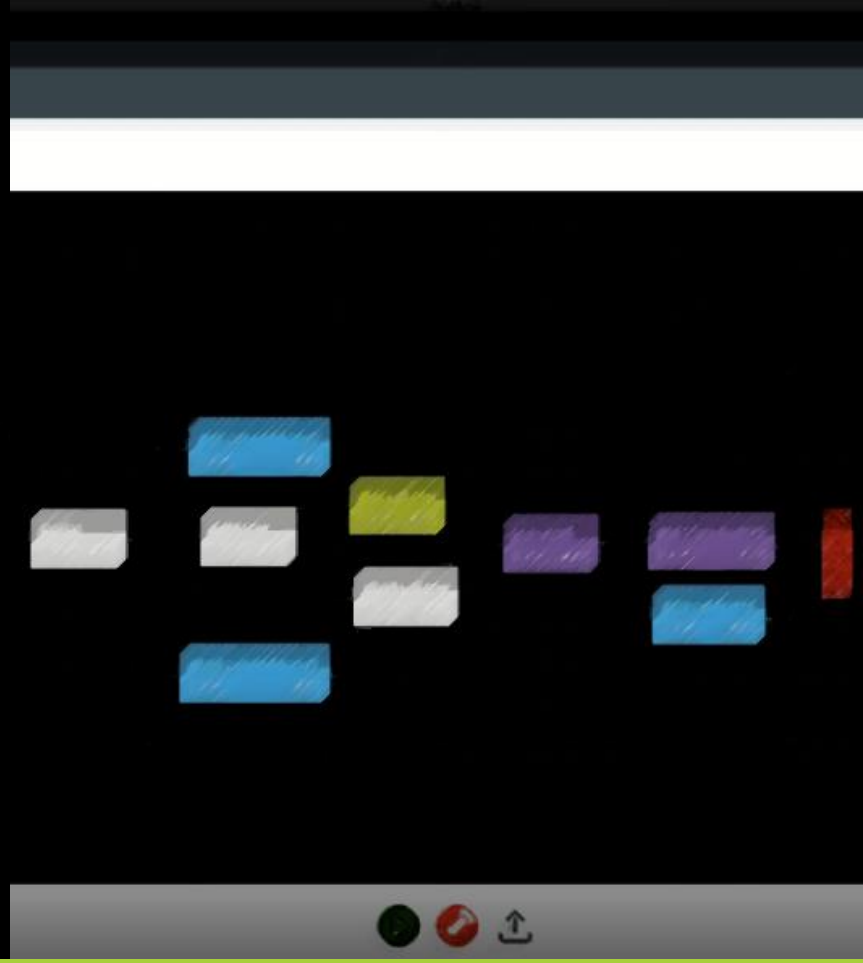
MERGING PROJECT

MANIPULATION ENHANCEMENT THROUGH ROBOTIC GUIDANCE AND INTELLIGENT NOVEL GRIPPERS

RECENT ADVANCES AND OUTLOOK IN NON-RIGID PARTS MANIPULATION, THE MERGING APPROACH







Recent advances and outlook in non-rigid parts manipulation, the MERGING approach

LMS
Laboratory for Manufacturing Systems & Automation

Presenter:
Name: **Dionisis ANDRONAS**
Role: Senior researcher and project technical manager
Contact: andronas@lms.mech.upatras.gr
Organization: Laboratory for Manufacturing Systems and Automation **(LMS)**

The MERGING project – consortium

MERGING – Manipulation Enhancement through Robotic Guidance and Intelligent Novel Grippers

- Start: November 2019
- End: October 2023

Presenter and Technical Manager
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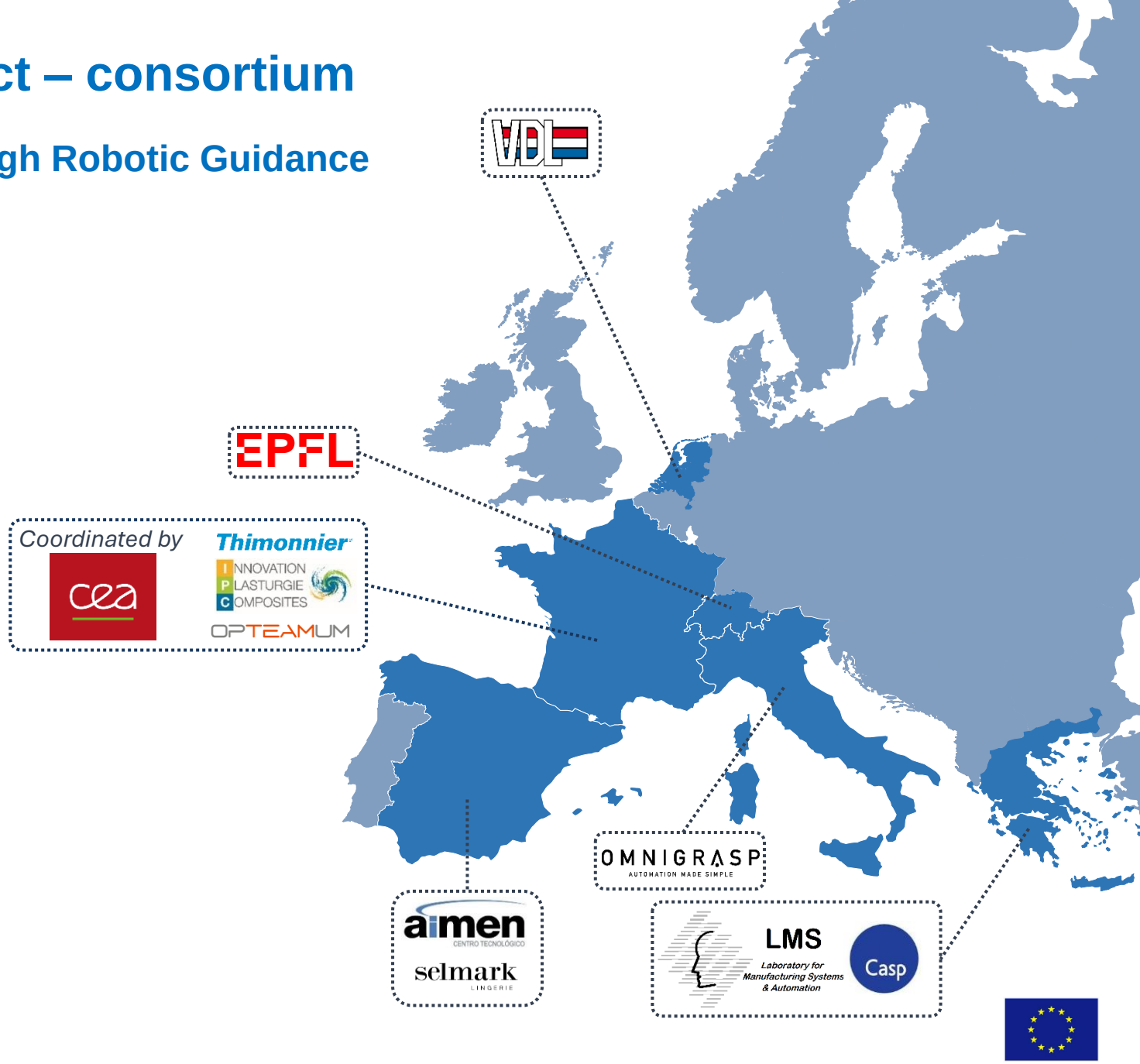
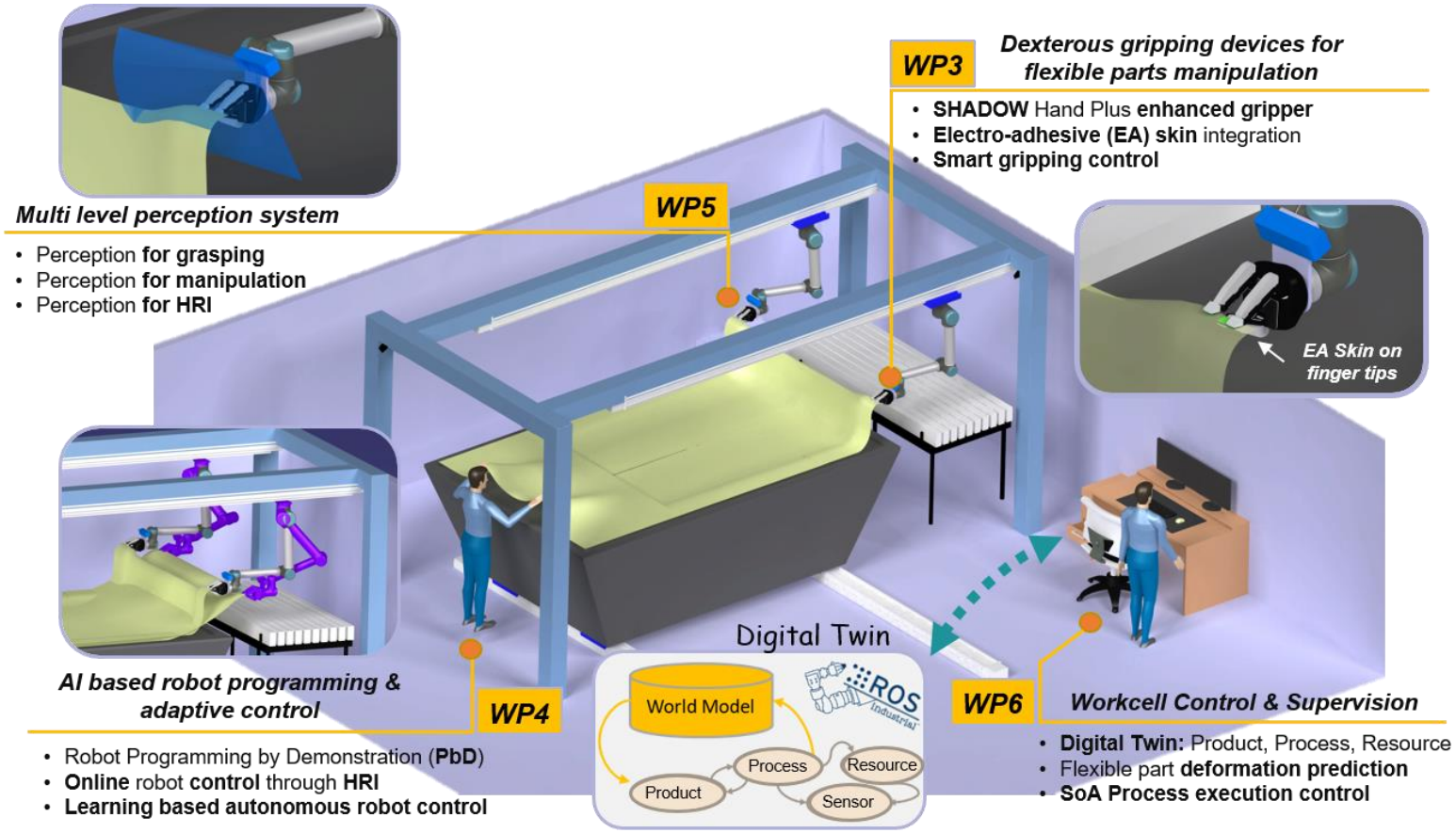


The MERGING project – objectives



Objectives

- **Objective 1:** Dexterous gripping devices for flexible part manipulation
- **Objective 2:** Multi – level perception system for environment understanding
- **Objective 3:** AI based robot programming and adaptive control
- **Objective 4:** MERGING Workcell control & Supervision

The MERGING project – industrial use cases

Food packaging industry

Thimonnier

Composites for automotive industry

VDL

Textile and garment industry

selmark LINGERIE

The MERGING project – industrial use cases

Food packaging industry

Thimonnier

Composites for automotive industry

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Textile and garment industry

selmark LINGERIE

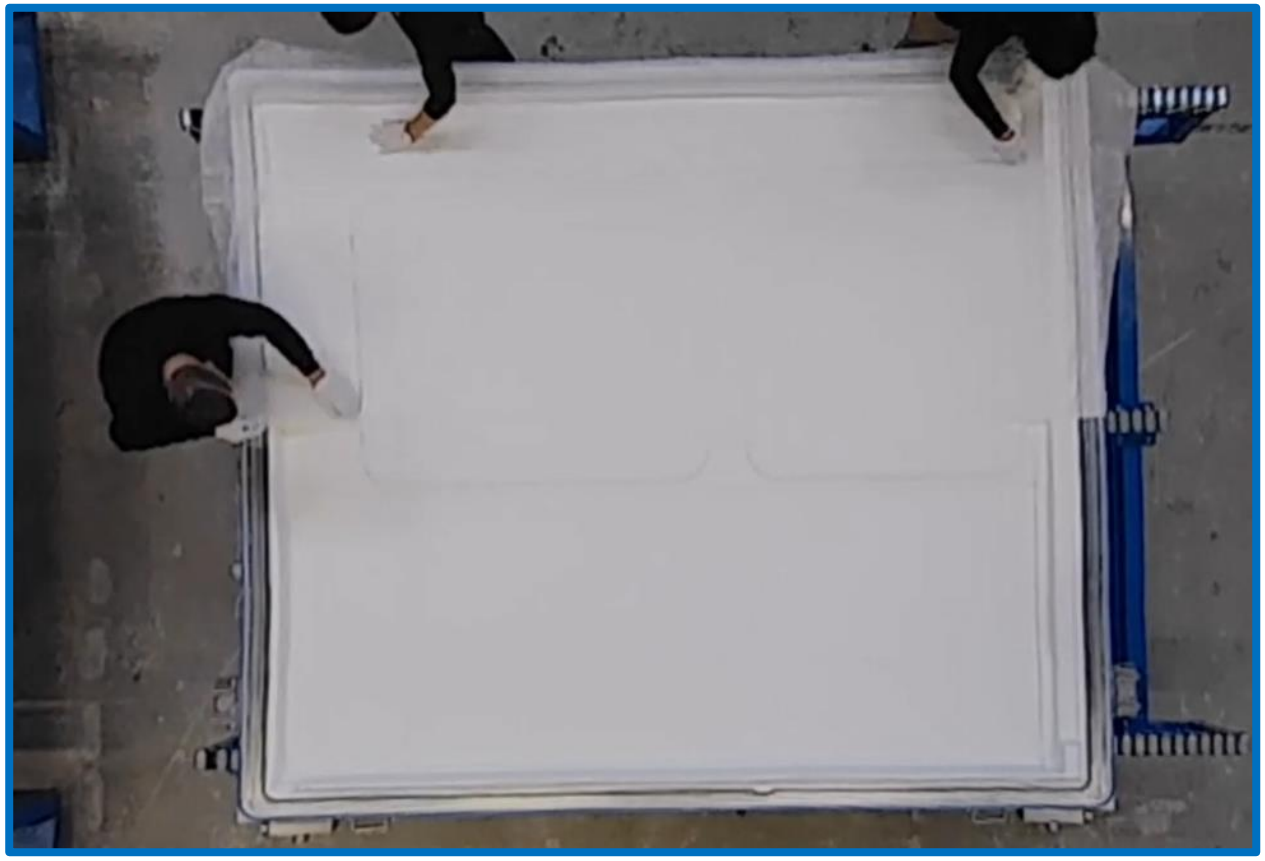
Use case and industrial challenges

Motivation:

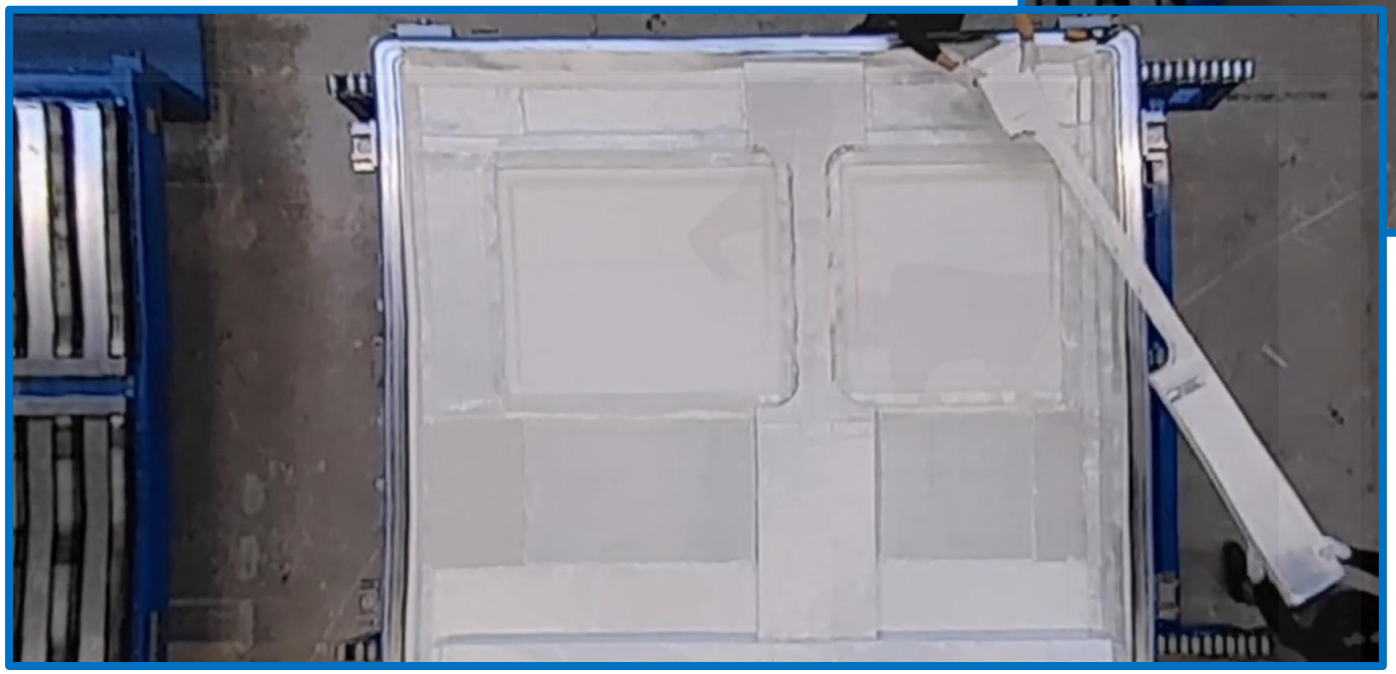
- **Ergonomics and well-being**
  - Poor accessibility at mould areas
  - High repetition of manual work
  - Exposure to chemicals
- **High demand for skilled operators**
  - Process complexity
  - Large size of composite fabrics and core materials

Challenges:

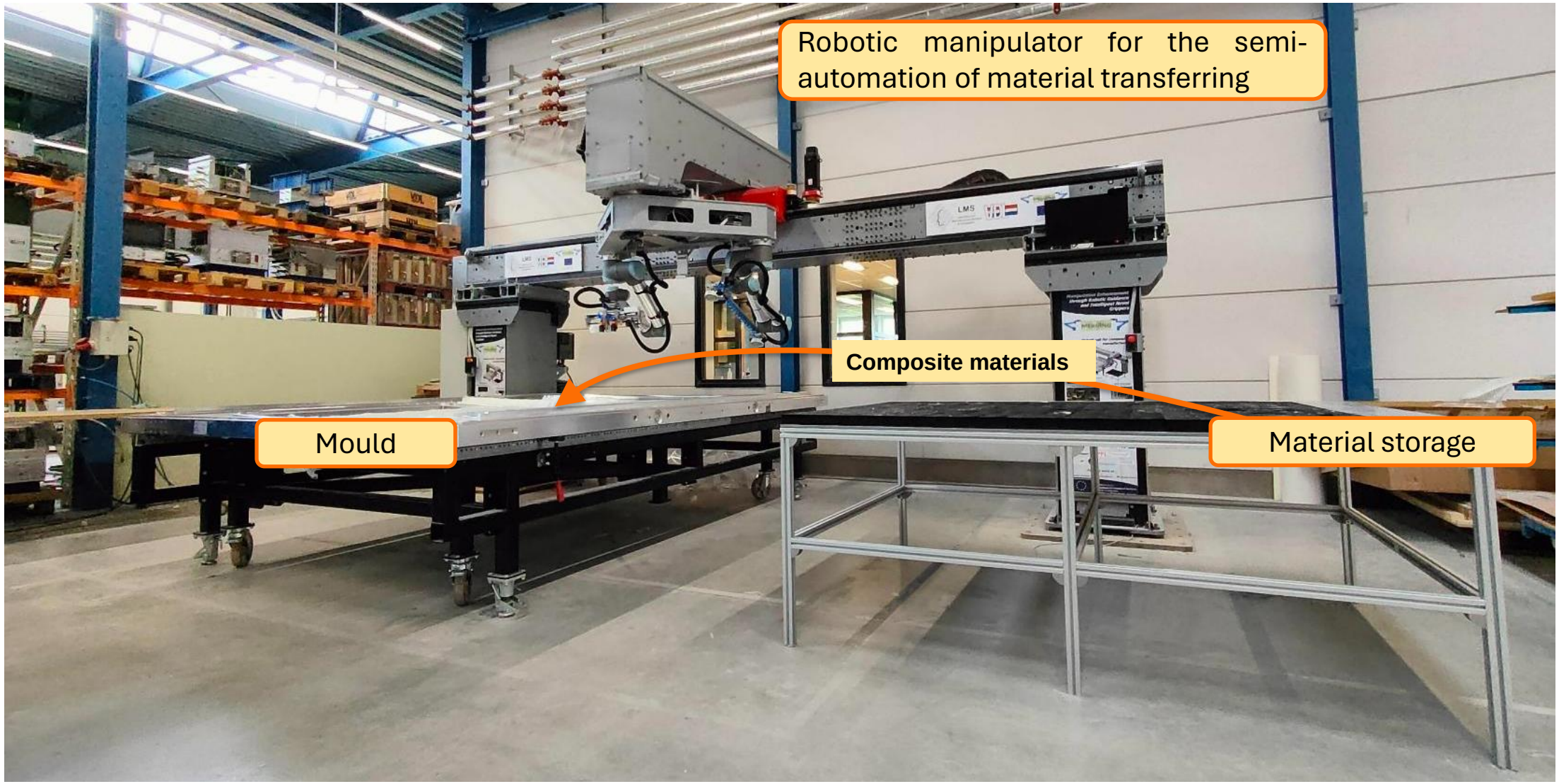
- **Deformation of on non-rigid parts**
- **Reconfiguration and teaching due to large number of components**



Use case and industrial challenges

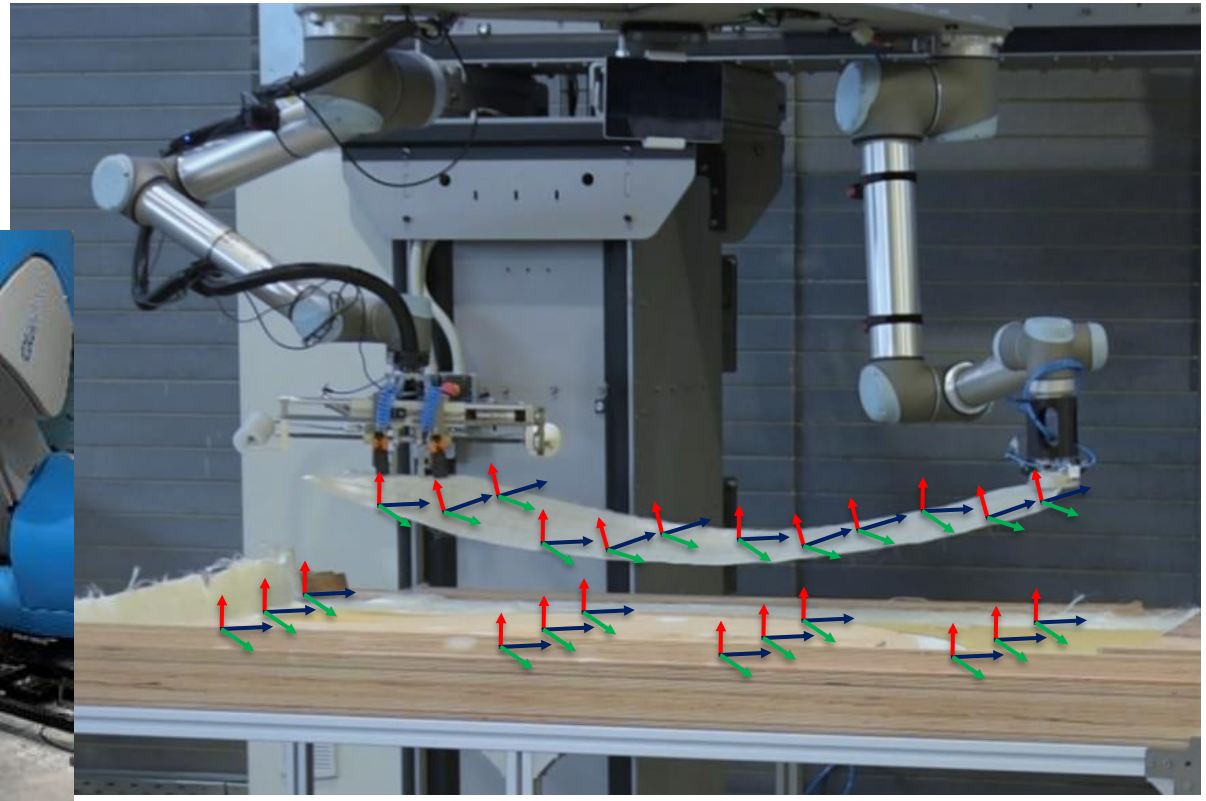


MERGING hybrid cell for semi-automated composites manufacturing

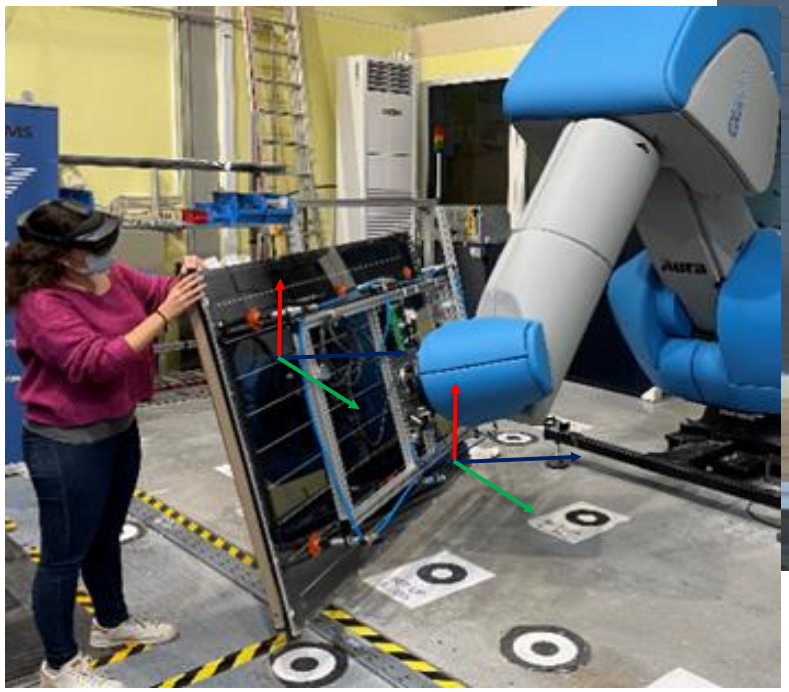


MERGING hybrid cell for semi-automated composites manufacturing

- **Non rigid assembly**

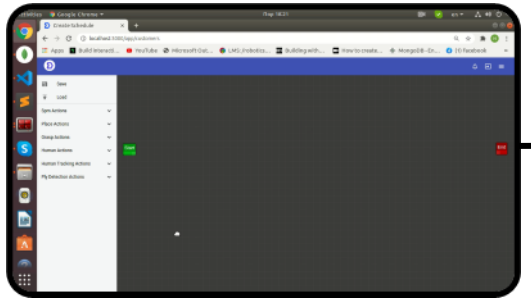


- **Rigid object handling**

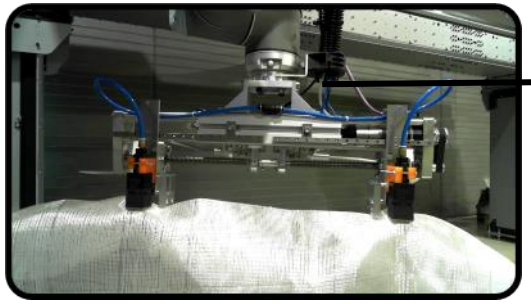


Solution and enabling technologies

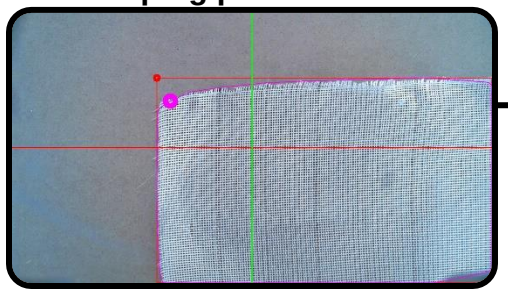
- **Intuitive scheduling & orchestration tools**



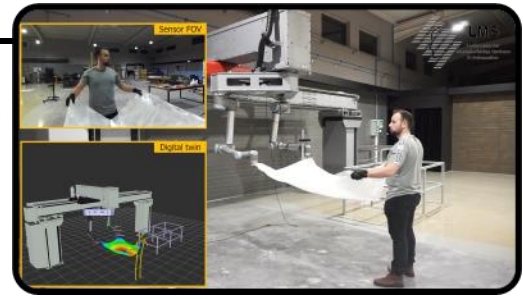
- **Multi-tool end-effector for composites layup**



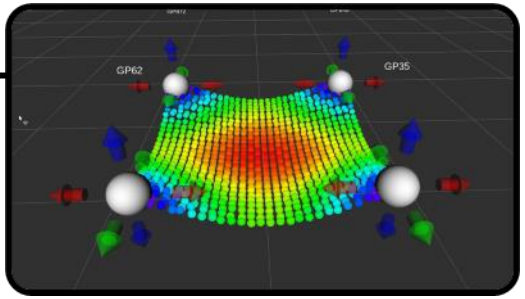
- **Grasping point detection**



- **Model-based fabric co-manipulation**

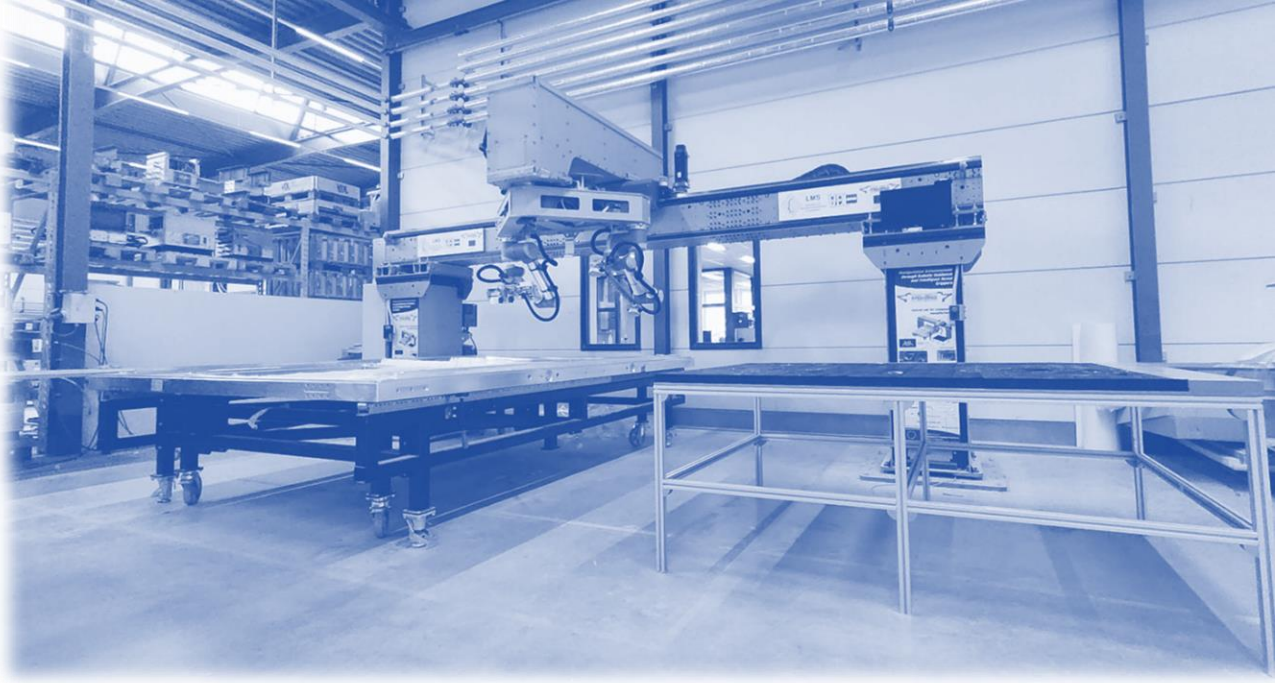


- **Deformable object reconstruction**



- **AR HMI for co-manipulation**

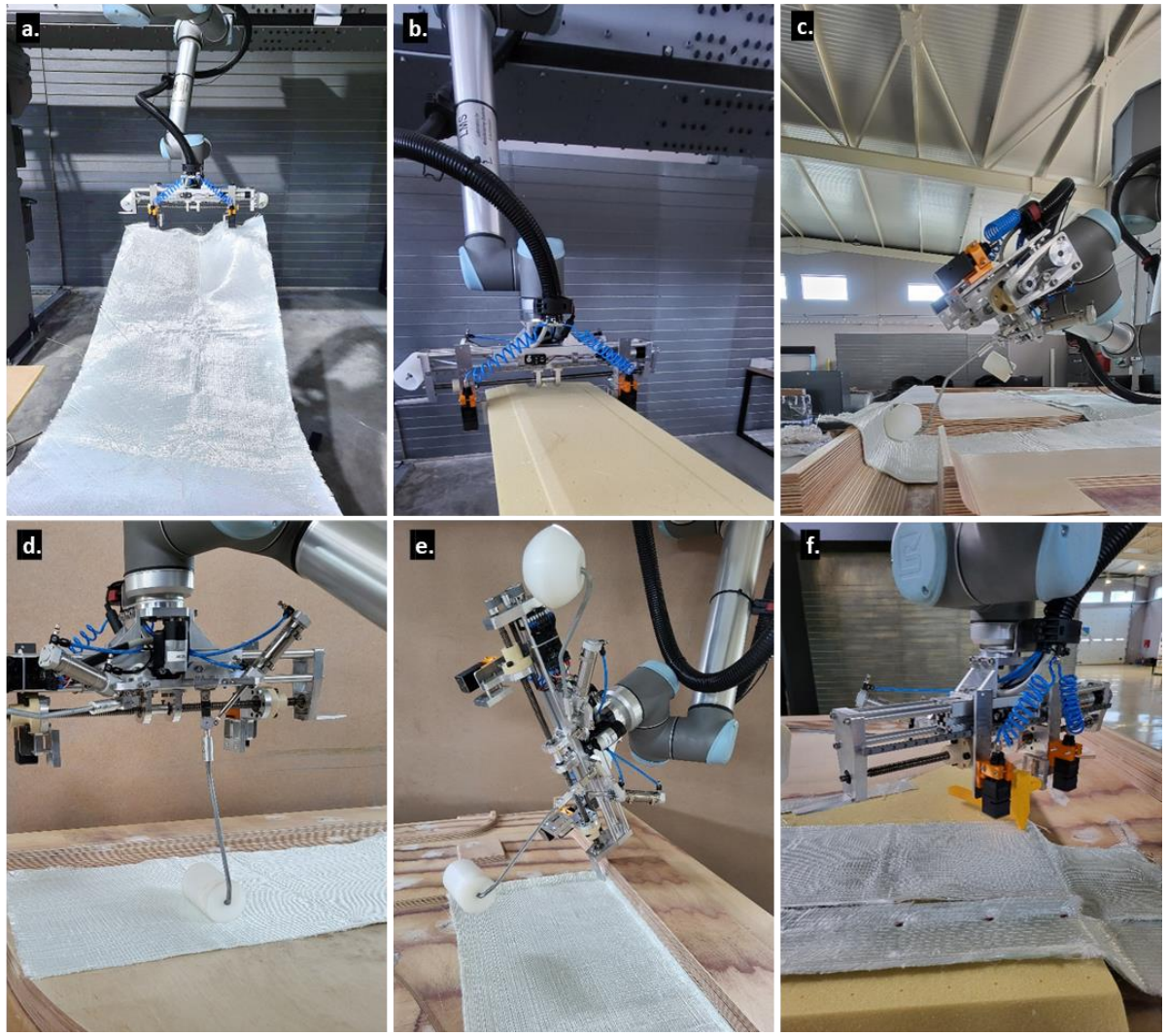
Enabling technologies

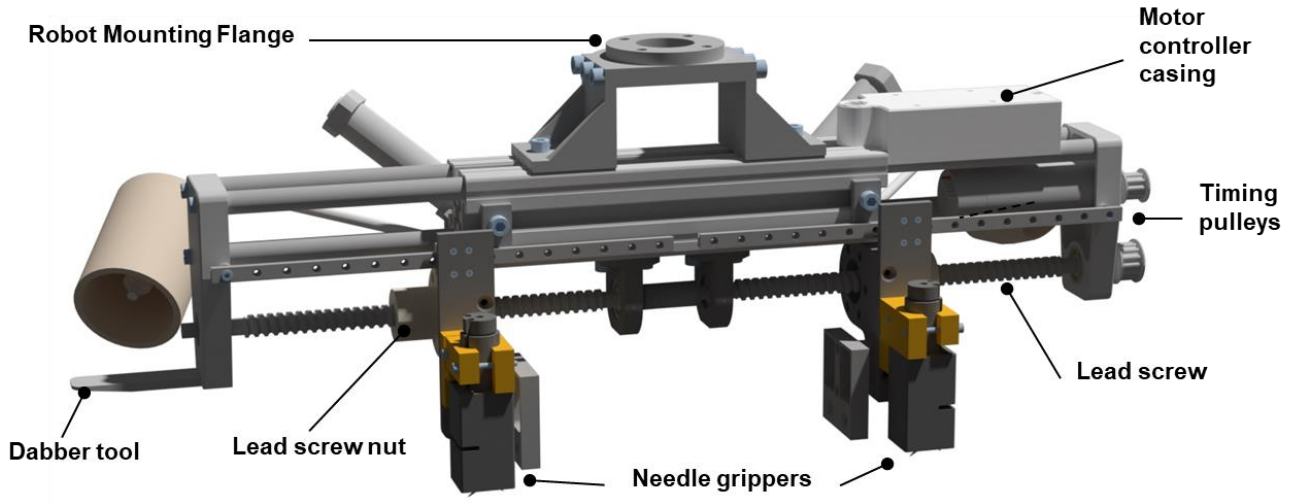


Enabling technologies

☑ Dexterity

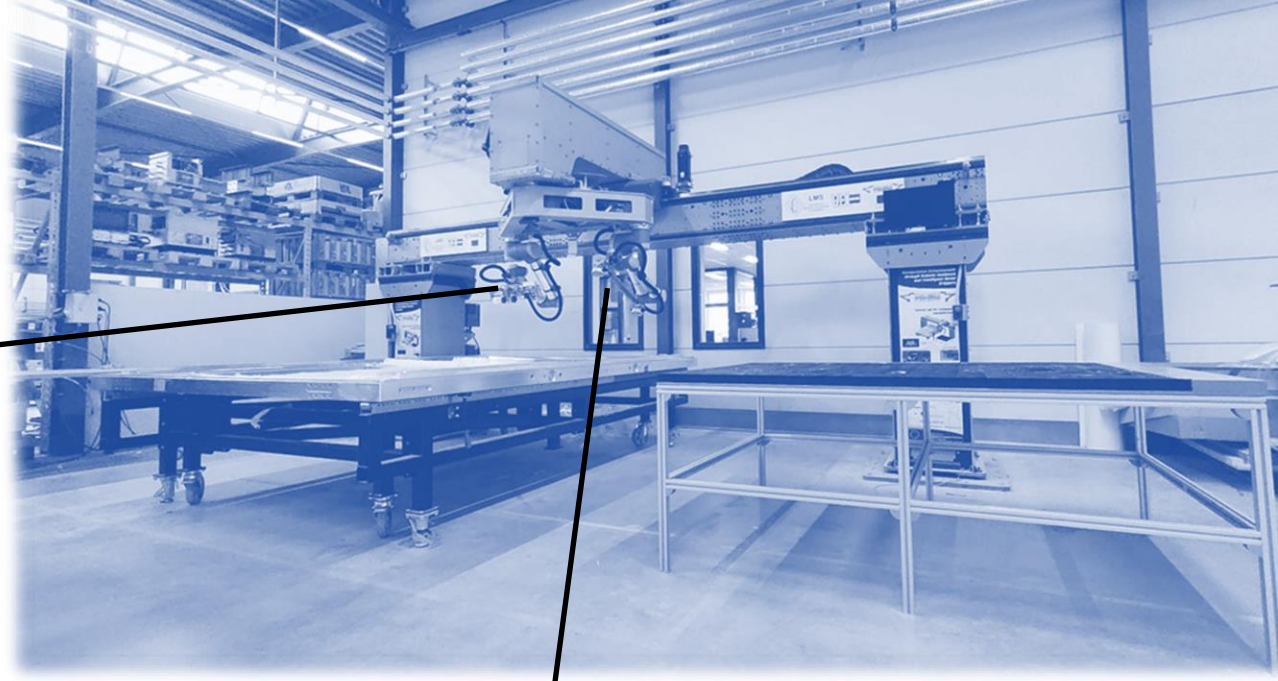
Multi-tool end-effector for composites layup



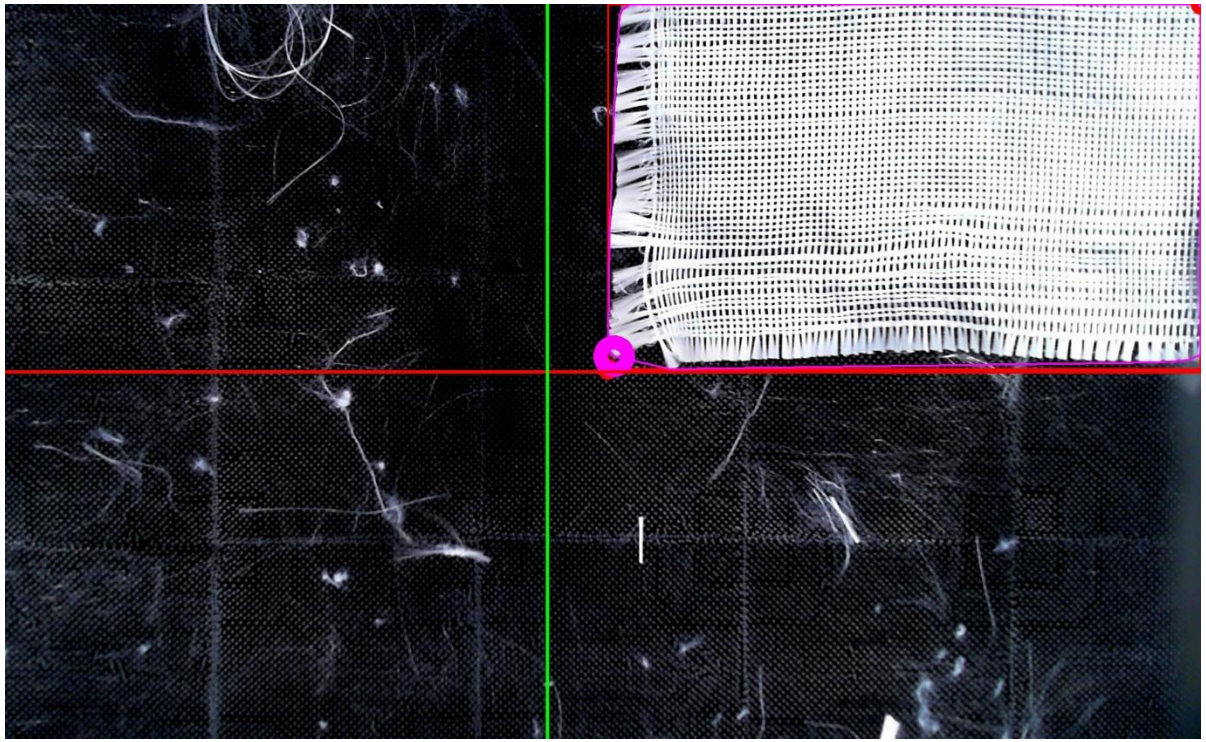


Enabling technologies

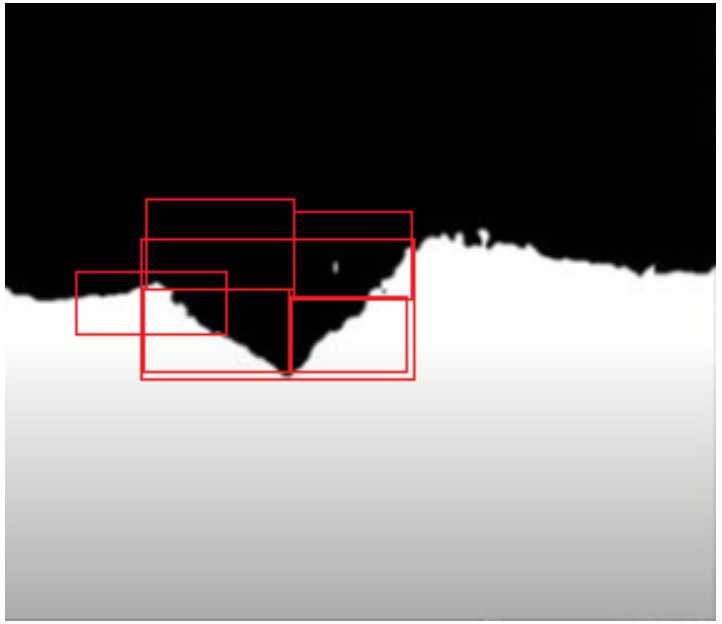
☑ Dexterity ☑ **Perception**



2D vision for grasping point detection

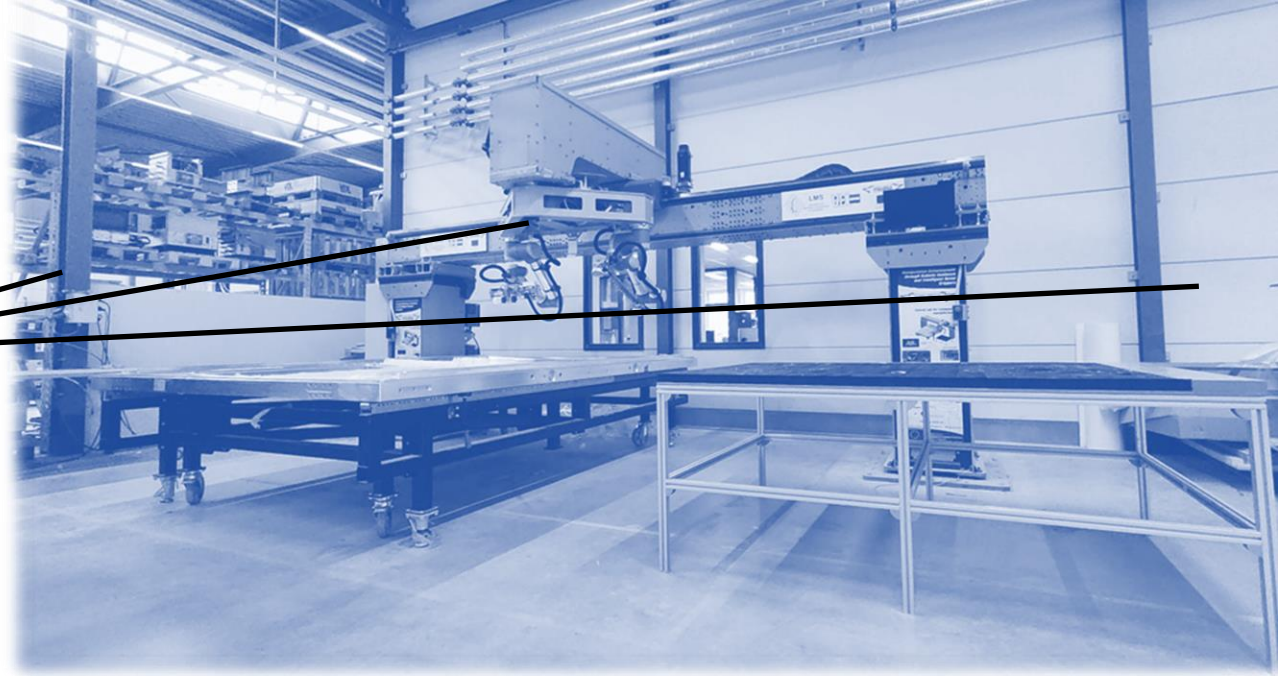


Fine positioning assurance



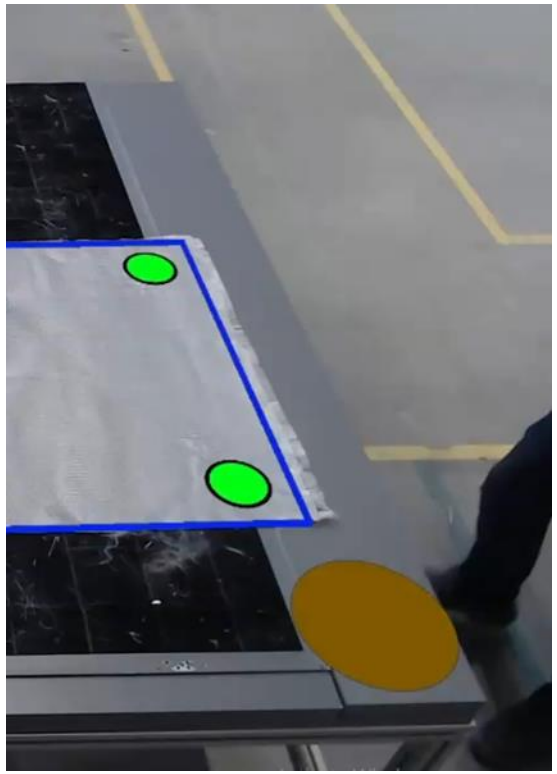
Enabling technologies

☑ Dexterity ☑ **Perception**

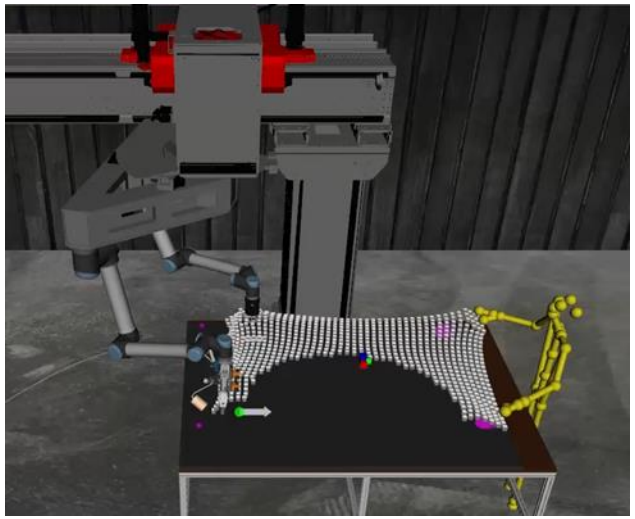


Stereo camera-based human perception

- ***For human system interaction***



- ***For human robot collaboration***

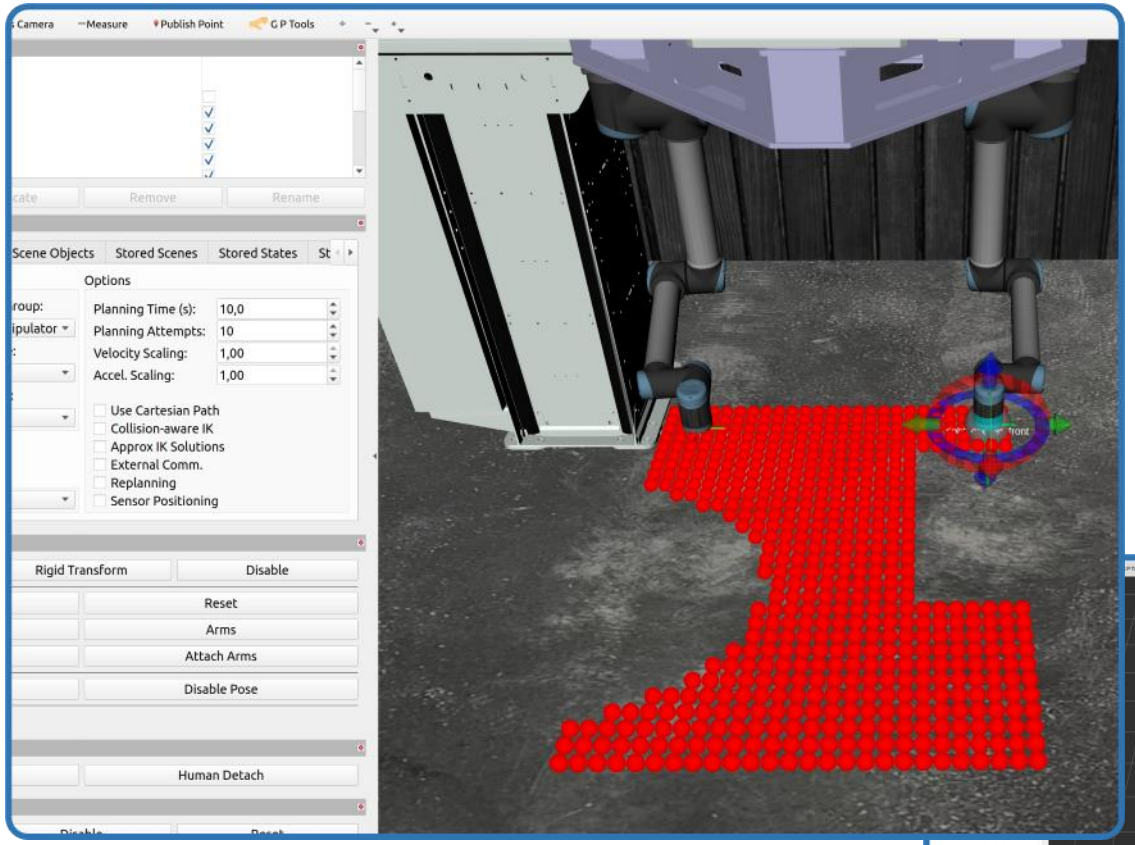


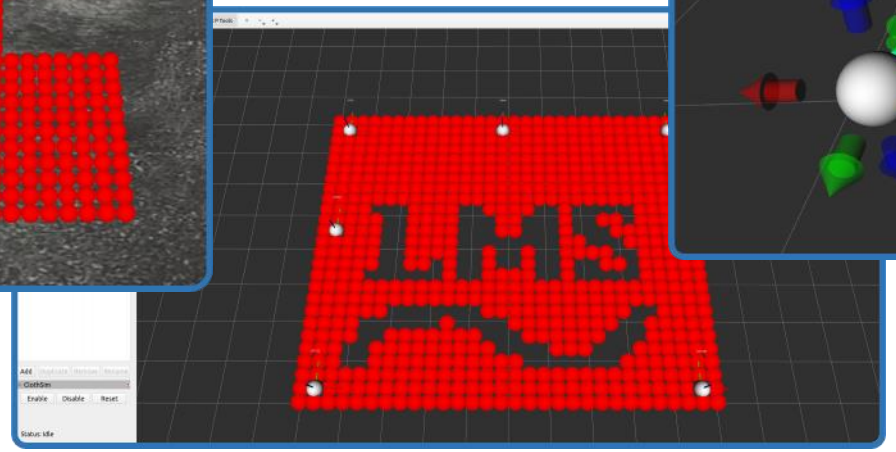
- ***For safety***

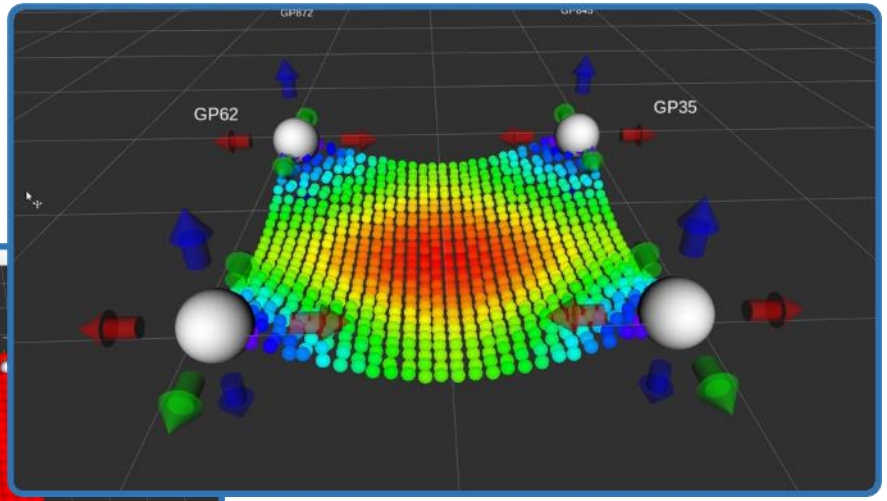
Enabling technologies

☑ Dexterity ☑ Perception ☑ **Cognition**

Simulation of non-rigid object deformation





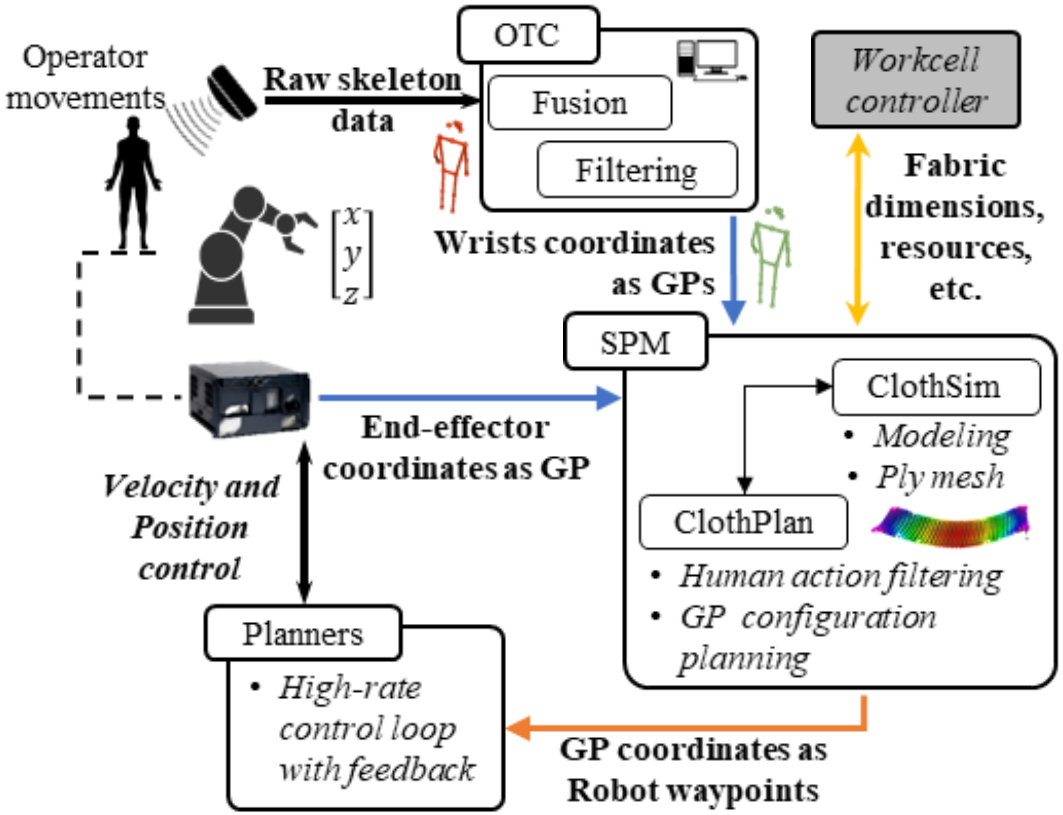


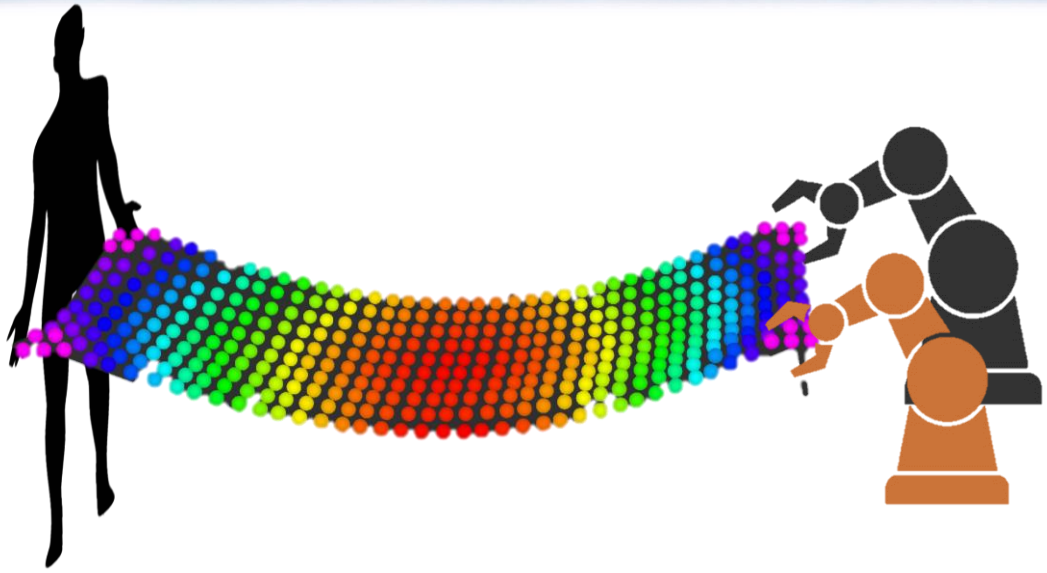
Enabling technologies

☑ Dexterity ☑ Perception ☑ Cognition

☑ **Control**

Model-based non-rigid object co-manipulation





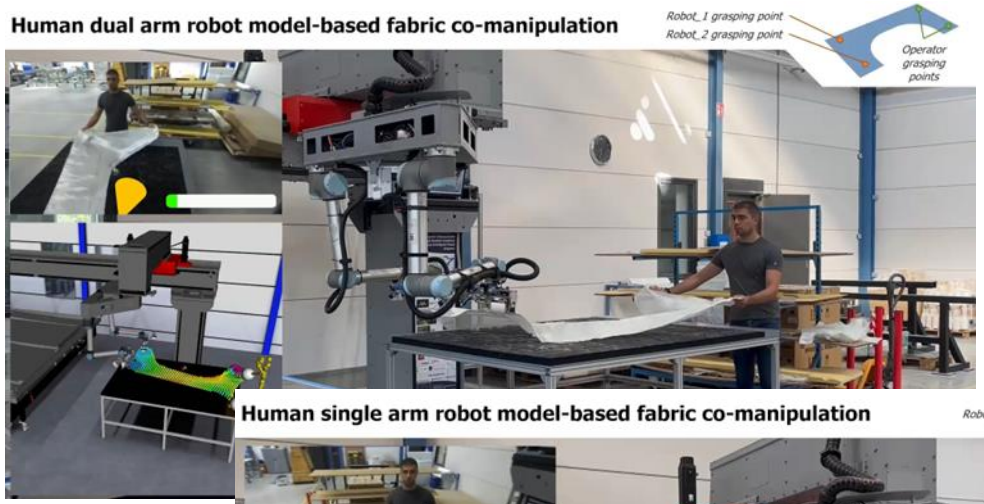
Operator Handling Commands — ***Model based robot control*** → *Supportive Robots' actions*

Enabling technologies

☑ Dexterity ☑ Perception ☑ Cognition

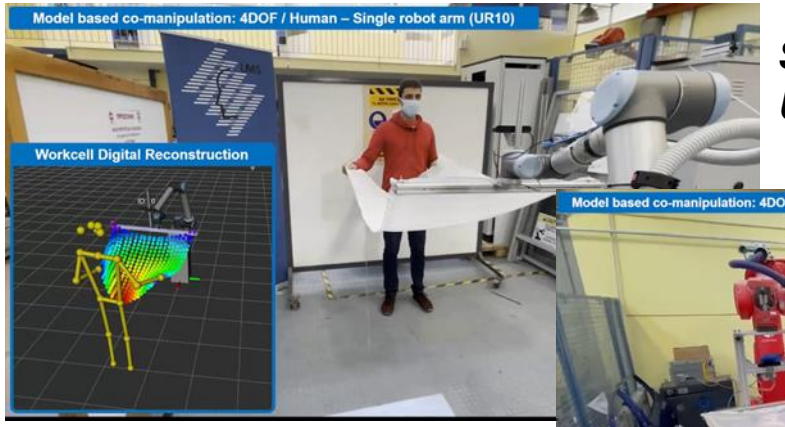
☑ **Control**

Model-based non-rigid object co-manipulation

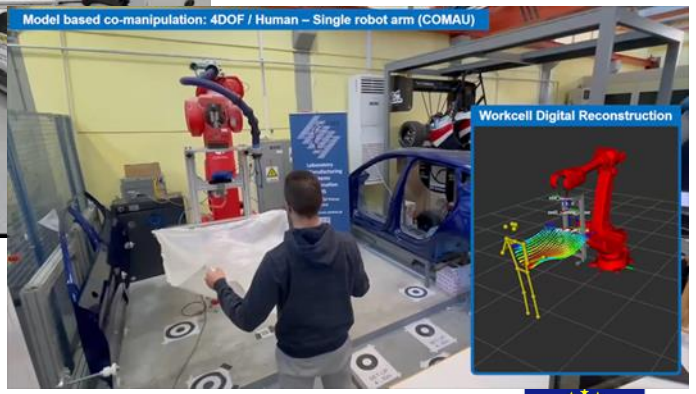


Dual arm with 7th and 8th axis

Single arm with 7th and 8th axis



Single arm UR10

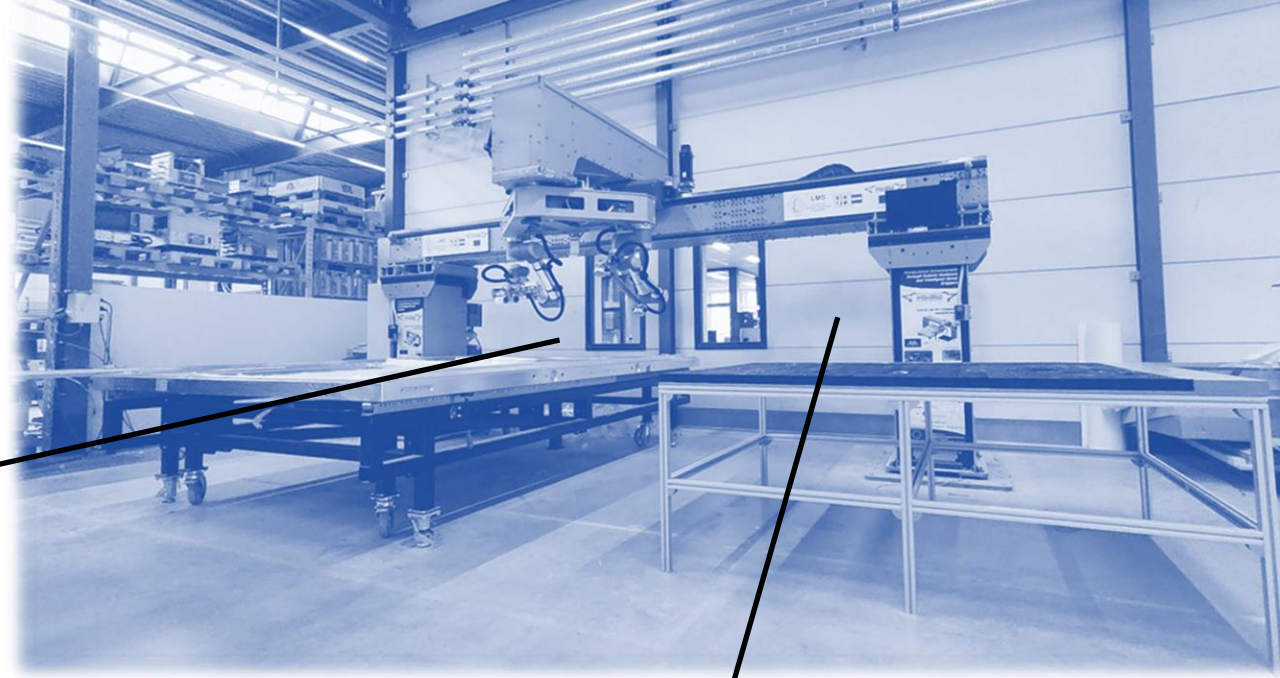


Single arm COMAU

Enabling technologies

☑ Dexterity ☑ Perception ☑ Cognition

☑ **Control**



- *Gloves-based closed-loop co-manipulation of fabrics*

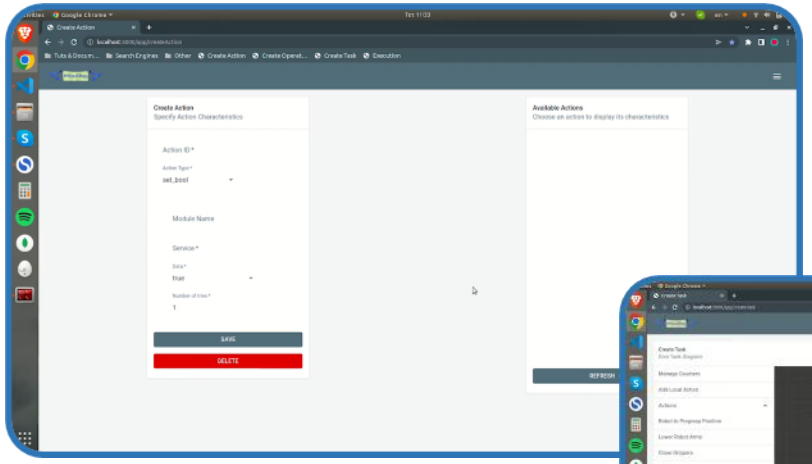
- *Co-manipulation of fragile objects*

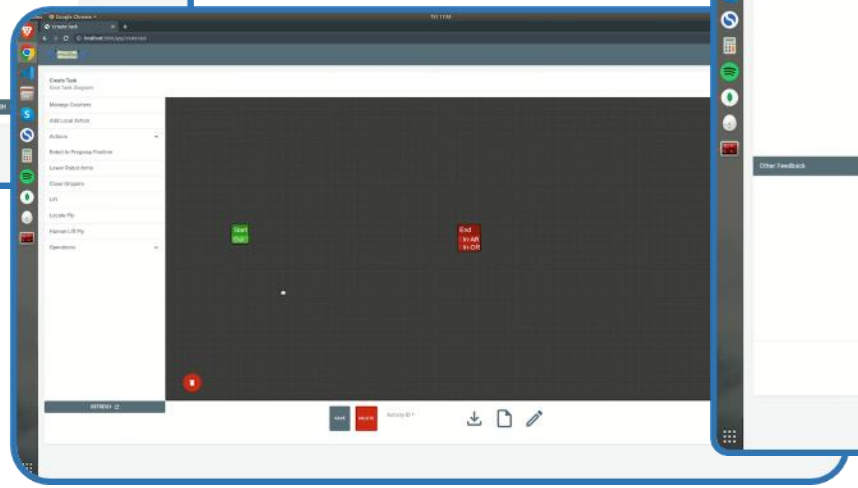
Enabling technologies

- ☑ Dexterity
- ☑ Perception
- ☑ Cognition
- ☑ Control
- ☑ **Orchestration**

Deformable object Handling Controller

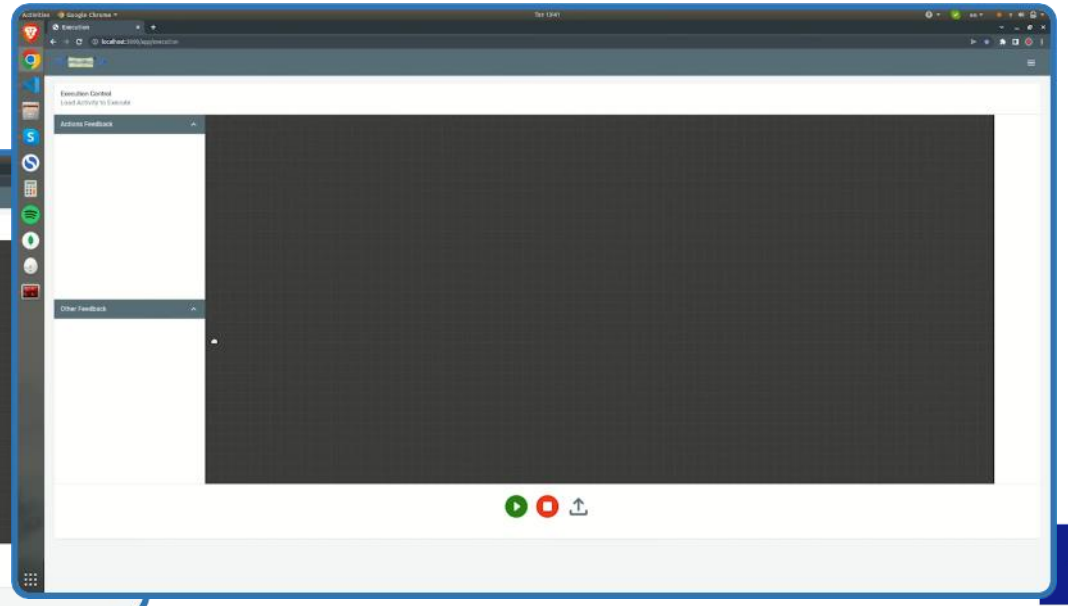
- ***Intuitive activity creation***





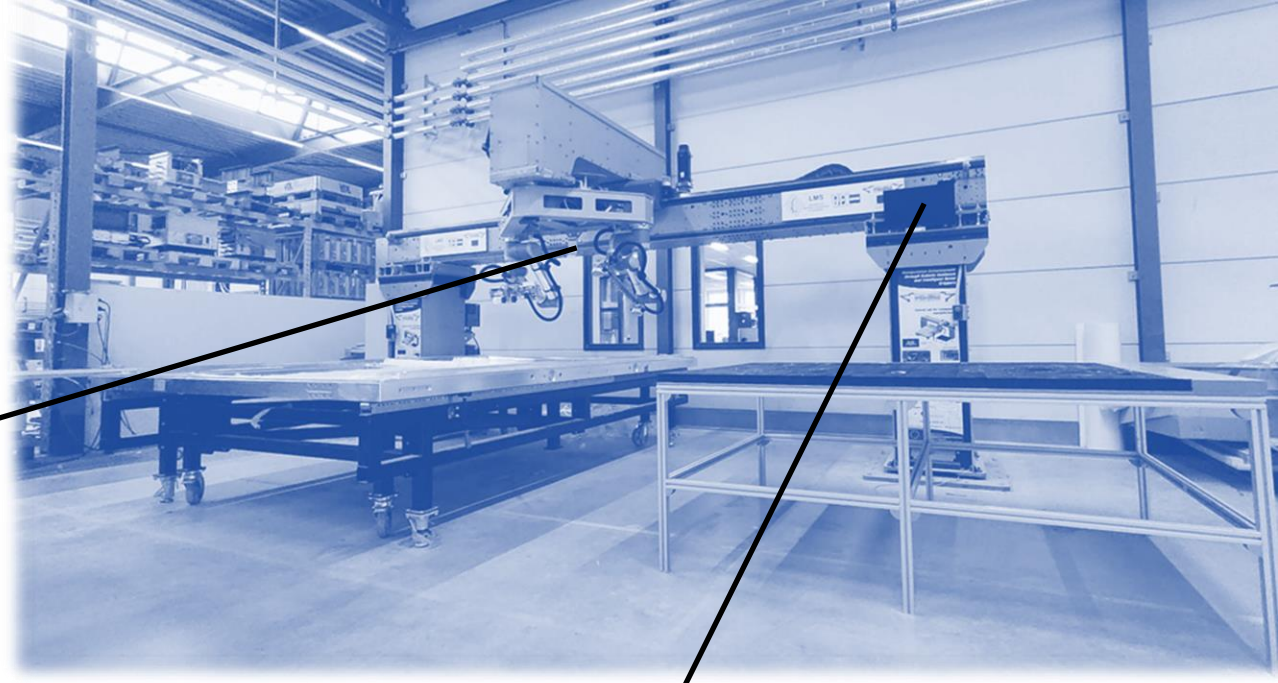
- ***Intuitive manual scheduling***

- ***Runtime execution monitoring***



Enabling technologies

- ☑ Dexterity
- ☑ Perception
- ☑ Cognition
- ☑ Control
- ☑ Orchestration
- ☑ **Interaction**



On-robot AR-based interface

Stationary AR-based interface

- ***Operator support***
- ***Handling input quality***
- ***Co-manipulation instructions***
- ***Grasping point designation***
- ***Extended reality button interaction***

Human dual arm robot model-based fabric co-manipulation

Hybrid cell for composites manufacturing

Grant agreement ID: 869963

Results

- MERGING **managed to address use case requirements** by improving
  - Ergonomics
  - Well-being
  - Efficiency

- Performance is improved by
  - Parallel execution of tasks by robot and operator
  - Rapid automated material transferring
  - Layup of hard-to-reach areas quite easily

- End-user and operators expressed
  - Substantial improvement of ergonomics
  - The manufacturing process becomes less repeatable and interesting
  - Improvement in quality and error minimization

Outlook and future directions

- Non-rigid product manufacturing still presents challenges
  - Future research should focus on improving the maturity level of solutions
  - Dexterity, perception and cognition has potential for improvement
- Machine-learning could improve, yet not replace, aforementioned results
  - Potential for cycle time improvement
  - Proactive planning of multi-agent co-manipulation
- Training is still fundamental for industrial integration
  - Operators need new skills
  - Need for training services
- Industry needs modular solutions
  - Abstracted functionalities
  - Easy to be in-house applied and maintained
  - Data secure
  - Certification

Thank you for your interest!

Interested?

Join the **MERGING Public Workshop !!!**

Thank you for your interest!

Questions and answers

Refer to our work for more details!

Modelling and model-based co-manipulation	***Keynote on non-rigid assemblies***	*Multi-tool end-effector*	*Human perception*	*Foam co-manipulation*

Funded by the European Union

Acknowledgements: This study has been funded by the European Commission under the Horizon 2020 Research and Innovation Programme (H2020-DT-FoF-12-2019) with grant agreement ID: 869963**.**

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Laboratory for Manufacturing Systems & Automation

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Organization: Laboratory for Manufacturing Systems and Automation **(LMS)**