

# Task Planning in Flexible Manufacturing

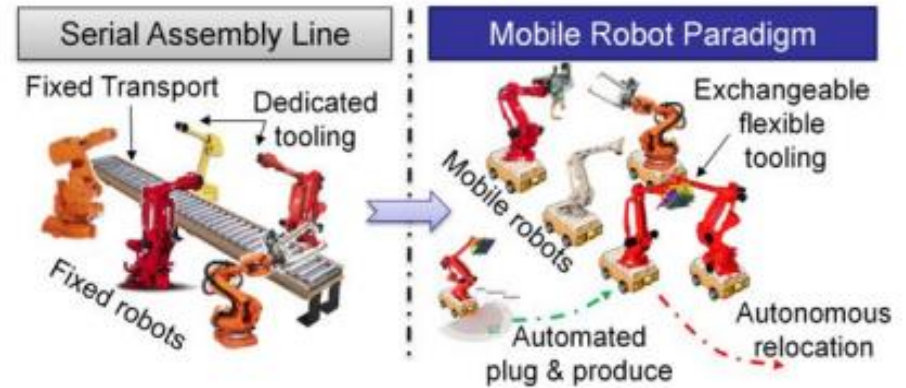
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**LMS – University of Patras**



# CHALLENGES

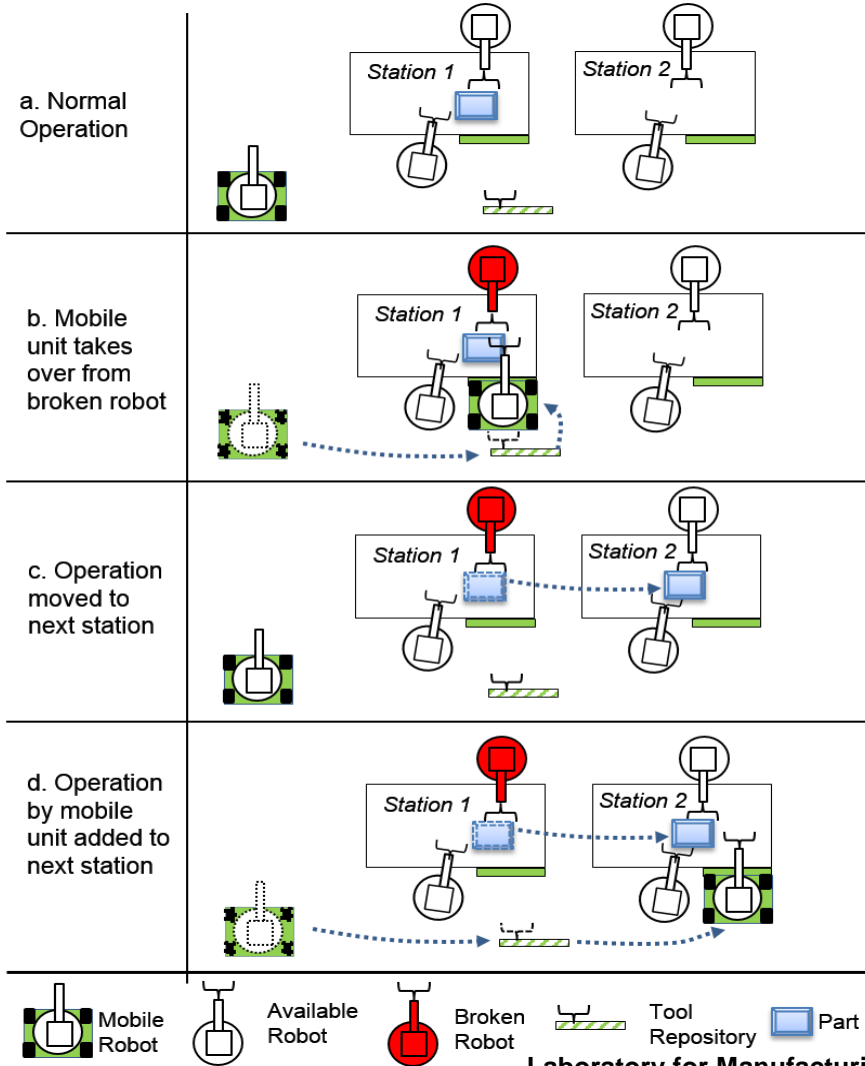
## Current Practise and limitations

- Fixed sequence of operations with manual and automated tasks, repeated in each cycle,
- Single supervisor responsible for planning and monitoring the system's operation
- Increase in product variants and related cost introduce the need for higher reconfigurability
- In case of failure of a single component, the entire line stops
- Introducing a new model requires extensive manual re-programming



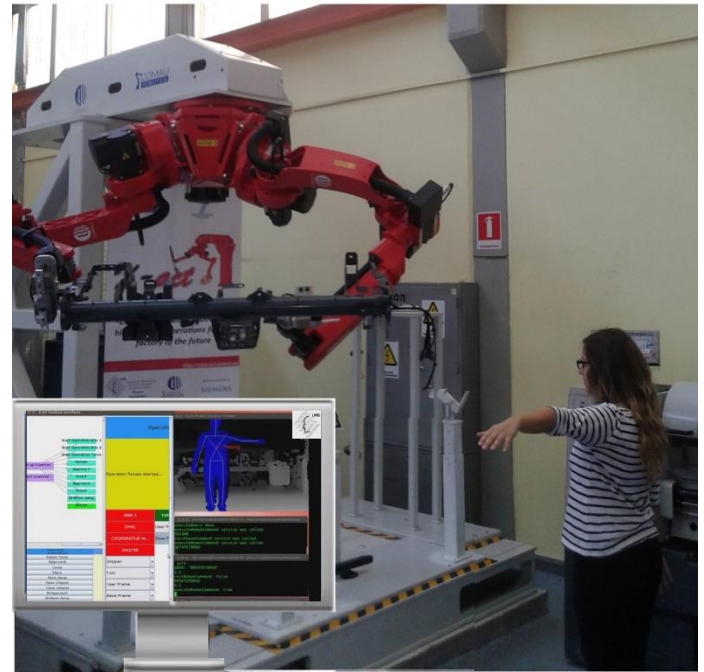
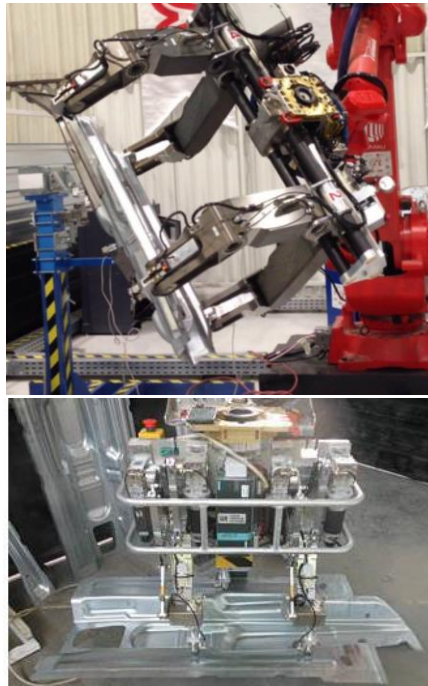


# RECONFIGURATION ALTERNATIVES



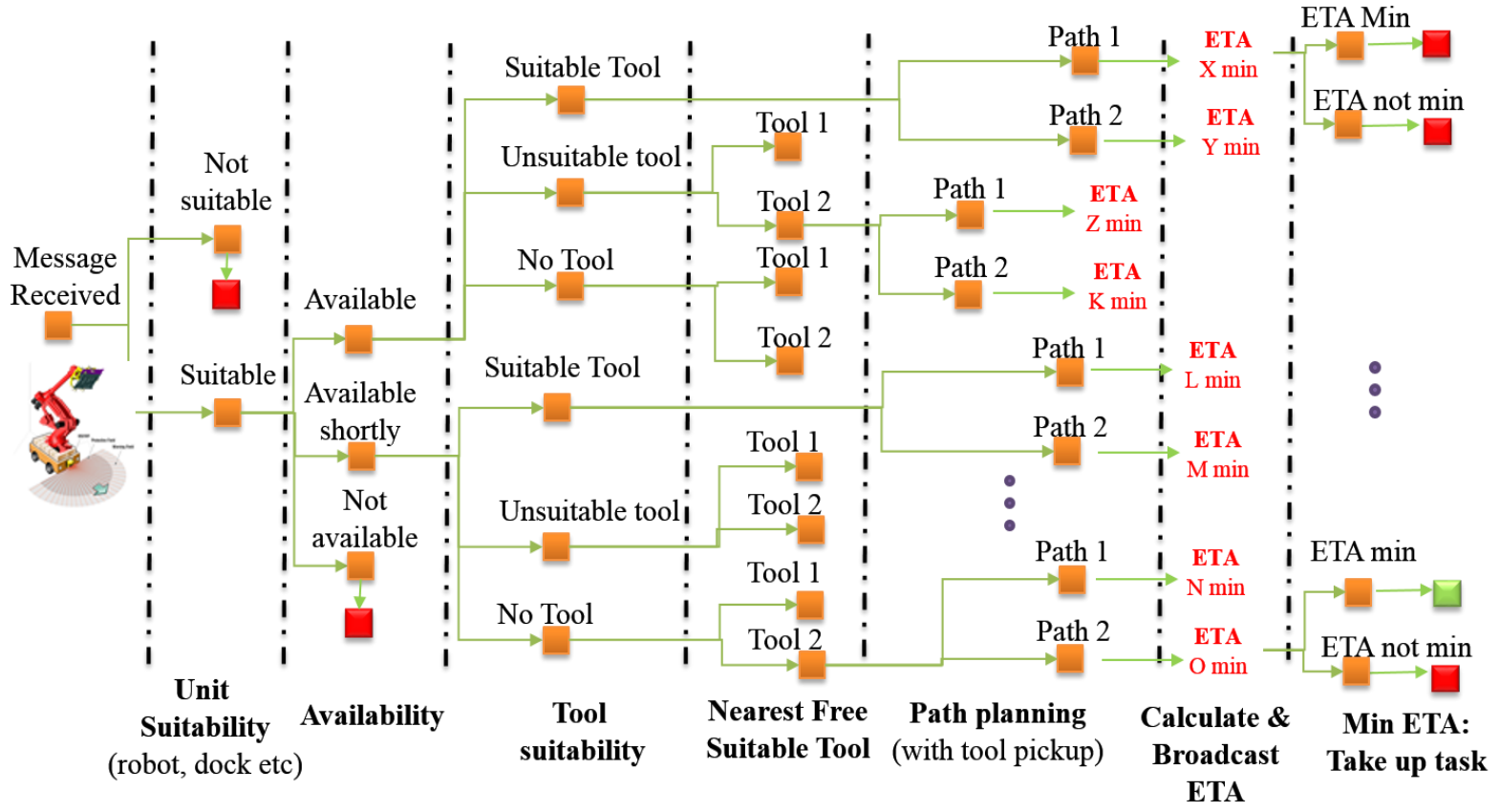


# FLEXIBLE RESOURCES





# EXAMPLE OF ALTERNATIVE ACTIONS



■ End Decision Making    
 ■ Decision Making Required    
 ■ Task assigned to unit

$$\hat{C}_{ij} = \frac{C_{ij} - C_j^{\min}}{C_j^{\max} - C_j^{\min}}$$

$$\hat{C}_{ij} = \frac{C_j^{\max} - C_{ij}}{C_j^{\max} - C_j^{\min}}$$

$$RU = \frac{\sum_{i=1}^r RU_i}{r}$$

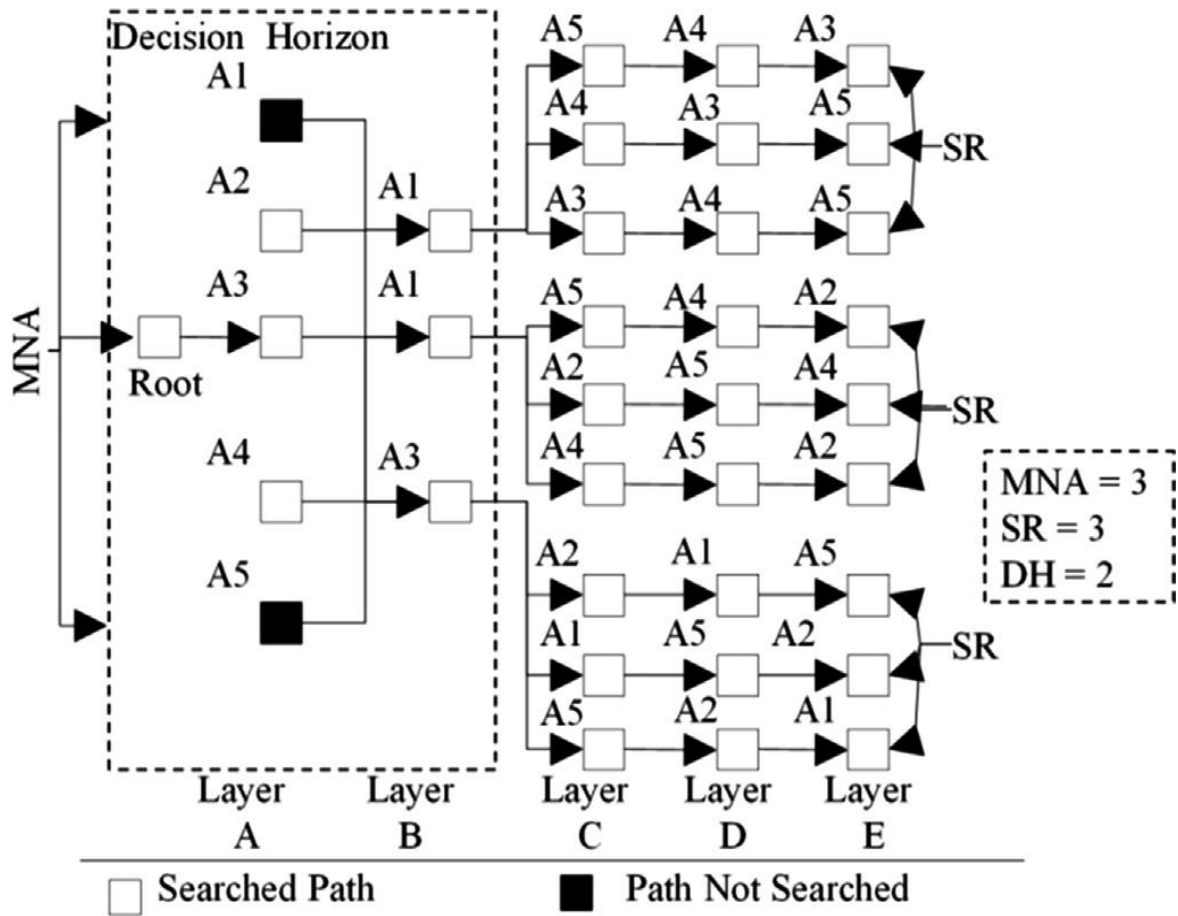
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# SMART SEARCH LOGIC



# SOFTWARE IMPLEMENTATION

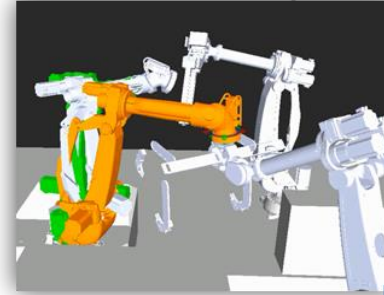
## ONTOLOGY GRAPH & MODEL



## 3D Models

### URDF Model

- Geometry
- Kinematics
- Dynamic constraints



### Offline programming

- Motion program
- I/O, Messages

### Motion planning algorithms

- Motion planning request
  - Collision free Paths calculation

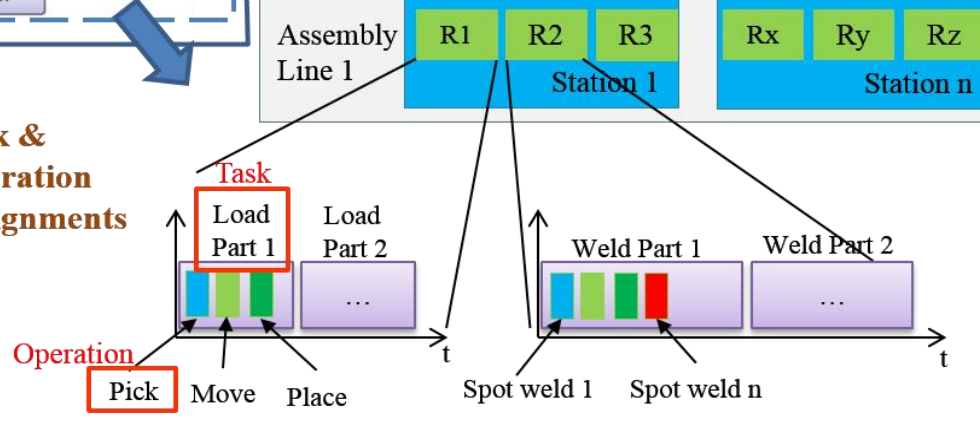
VIRTUAL



PHYSICAL

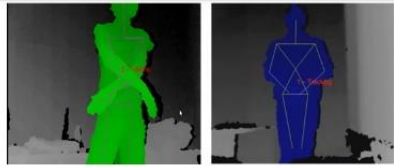
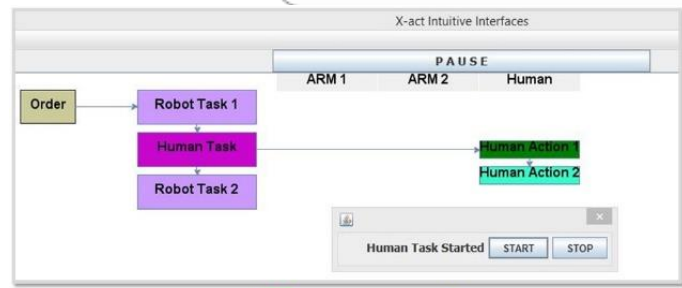
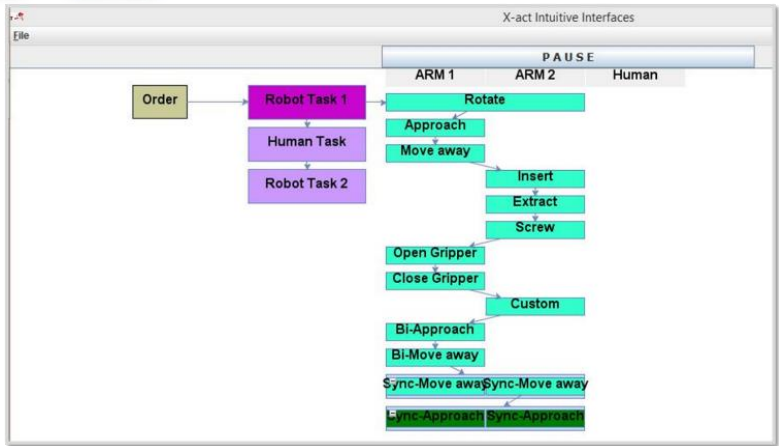


## Task & Operation Assignments

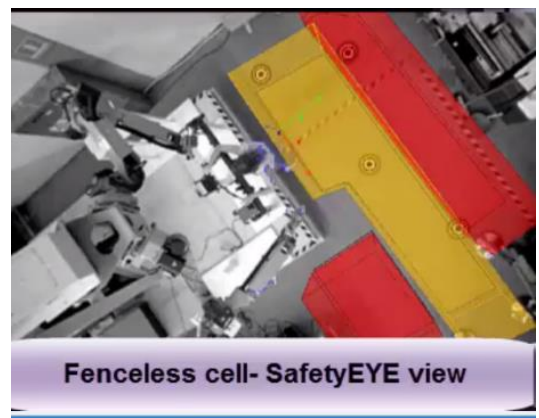
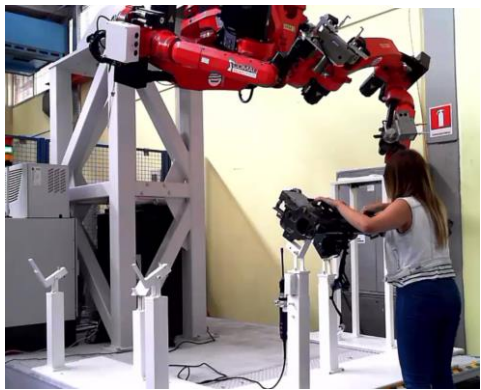
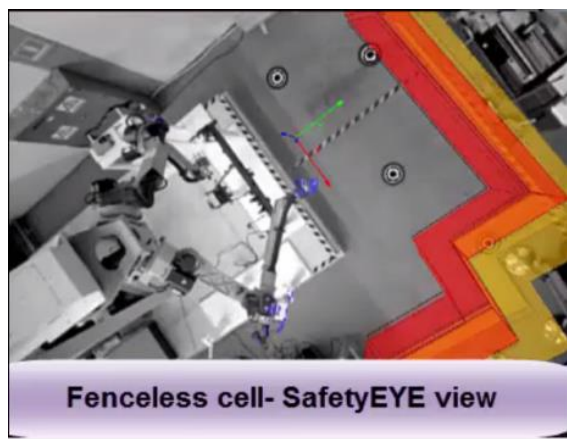




# TASK EXECUTION AND MONITORING – HRC case



Start gesture      Stop gesture



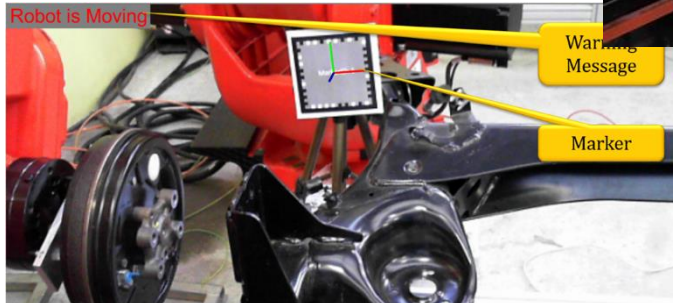
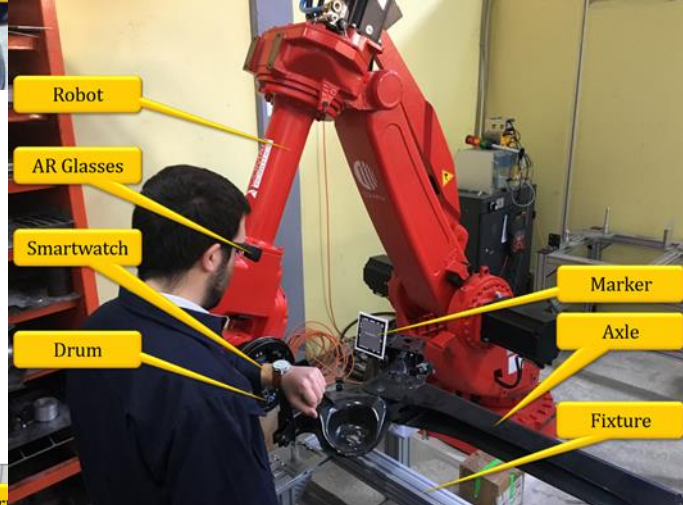
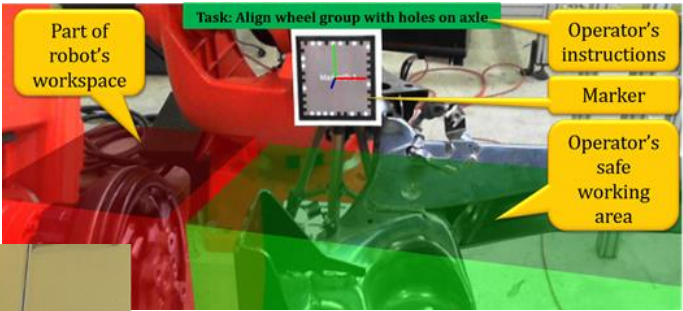
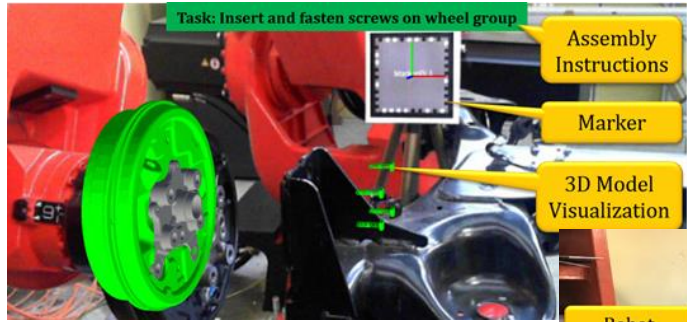
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# THE ROBOT – OPERATOR CONNECTED



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# REFERENCES



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# WorkShop Work Flow

## Robots 4.0

- Adaptive Grippers
- Dexterous Manipulators and Human Manipulation
- Multi-Modal/Arms “drum-circle”

## Manufacturing 4.0

- Human Robot Collaboration
- Cognitive Manufacturing
- Cooperative Manufacturing

## Flexibility 4.0

- Service Oriented Approach in Flexible Manufacturing
- Task Planning in Flexible Manufacturing**
- Open Dynamic Manufacturing Operating System in Flexible Manufacturing





# THANK YOU FOR YOUR ATTENTION!

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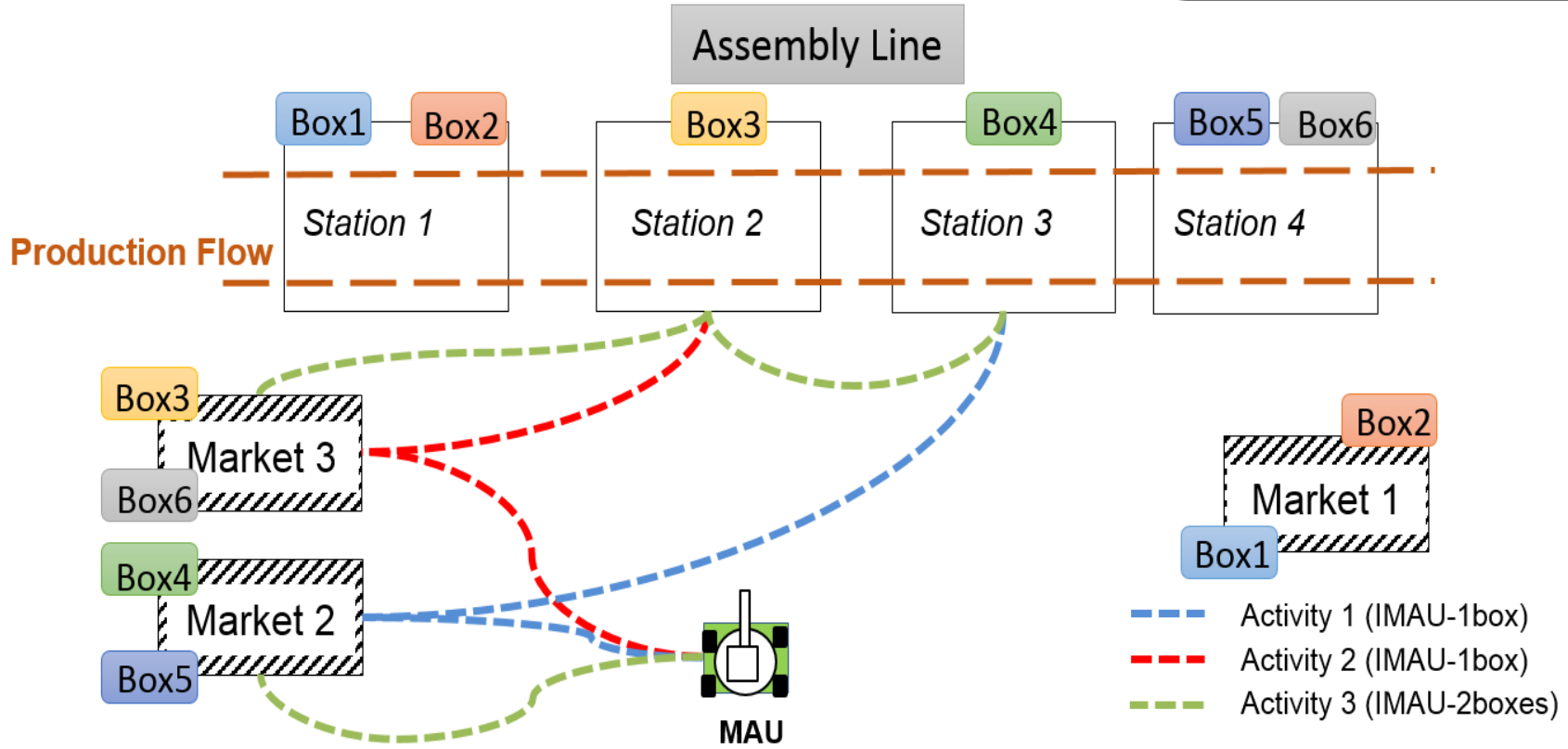
# OUTLINE

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1. Challenges for flexible assembly lines
2. Artificial intelligence for reconfiguration of assembly system
3. Modelling – implementation
4. Human robot cooperation case
5. Conclusion

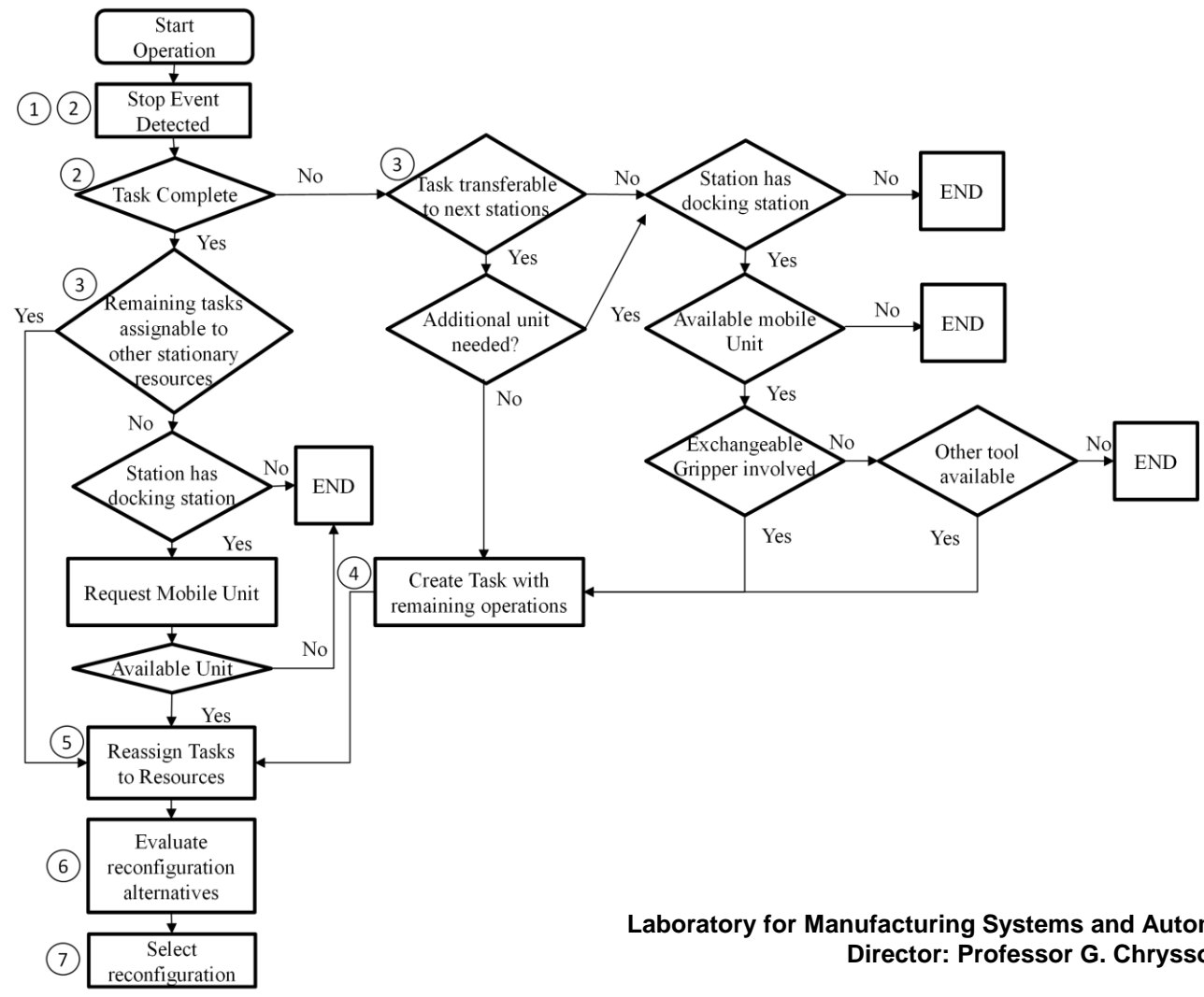


# MATERIAL SUPPLY CASE





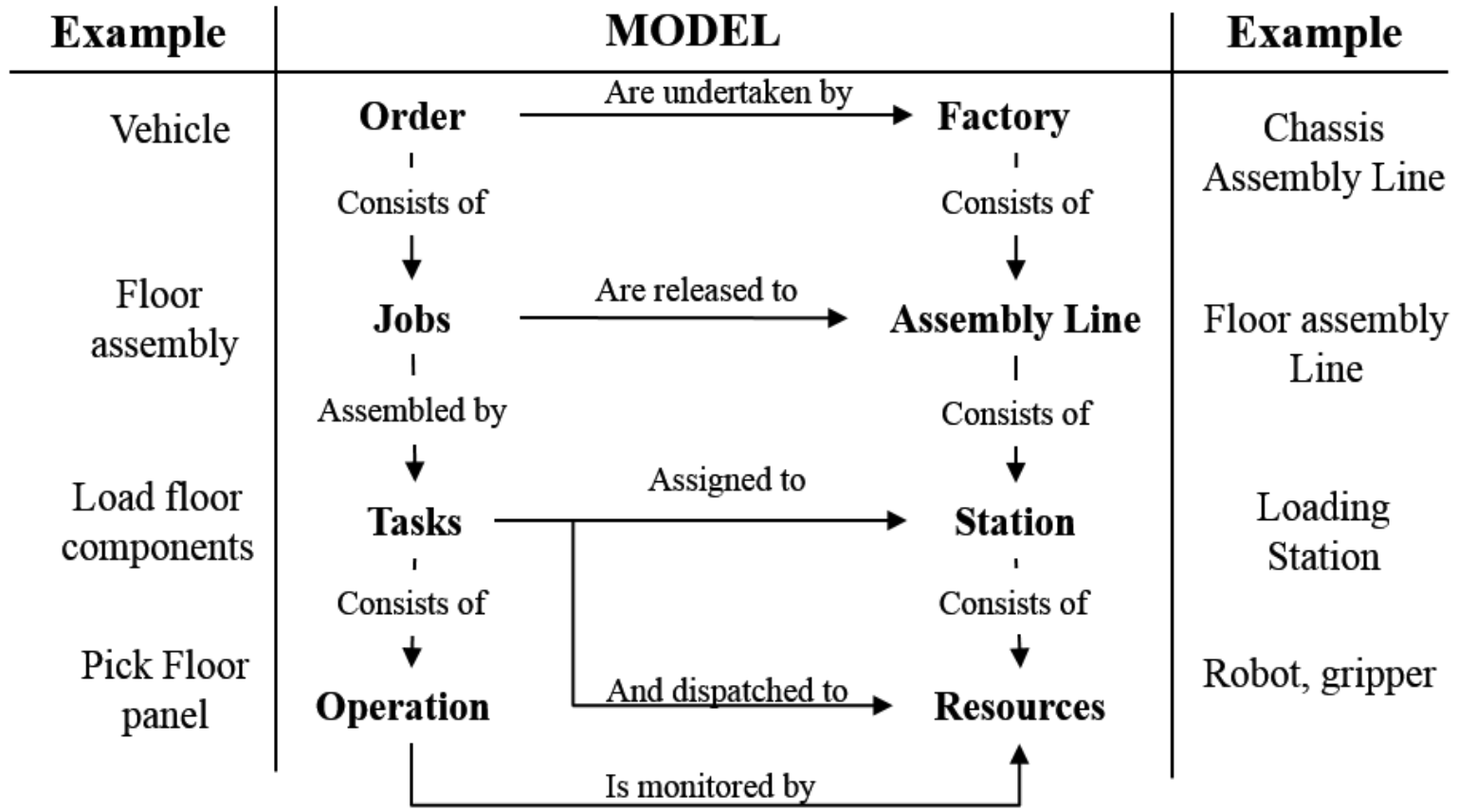
# LOGIC FOR SYSTEM RECONFIGURATION







# HIERARCHICAL MODEL

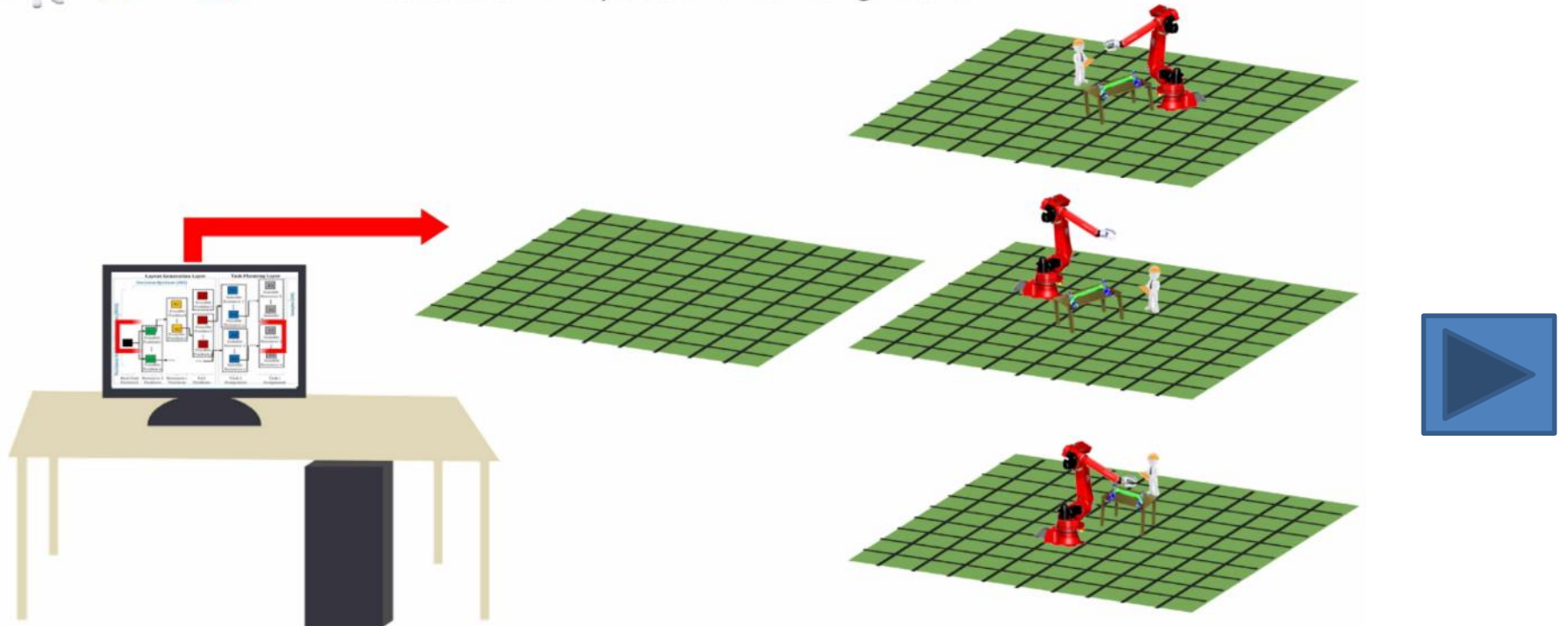




# HUMAN ROBOT COOPERATIVE WORKPLACE



Human-Robot cooperative tasks planner  
Generation of layouts and task assignments





# CONCLUSIONS



- Plug and produce flexible resources (e.g. mobile robots) facilitate reconfiguration
- Reconfiguration scenarios - system to smoothly absorb the technical disturbances without disturbing the production flow
- Control software - algorithms for alternative reconfiguration plans to be derived
- Systematic and automatic generation of the reconfiguration alternatives
- Task breakdown to be automated - dynamically generate the workload
- “Real time” communication among resources
- Ontologies - semantics technologies combined with reasoning techniques.

