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## **Digital twin for adaptation of robots' behavior in flexible robotic assembly lines**

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- Introduction
- Hybrid production paradigm
- Digital twin infrastructure
  - Resource Manager
  - Sensor manager
  - 3D Environment constructor
- Unified data model
- Automotive case study
- Conclusions
- Acknowledgments

## *Production system transition to mass customization*

### Today – Tradition production

Stationary resources – **rigid** line structure

➕ *combined with*

**Fixed control logic** of the process

↓ *Lead to*

**High cost – effort** to make changes in the line-process



### Tomorrow – Future production

Market demand for higher **product personalization**

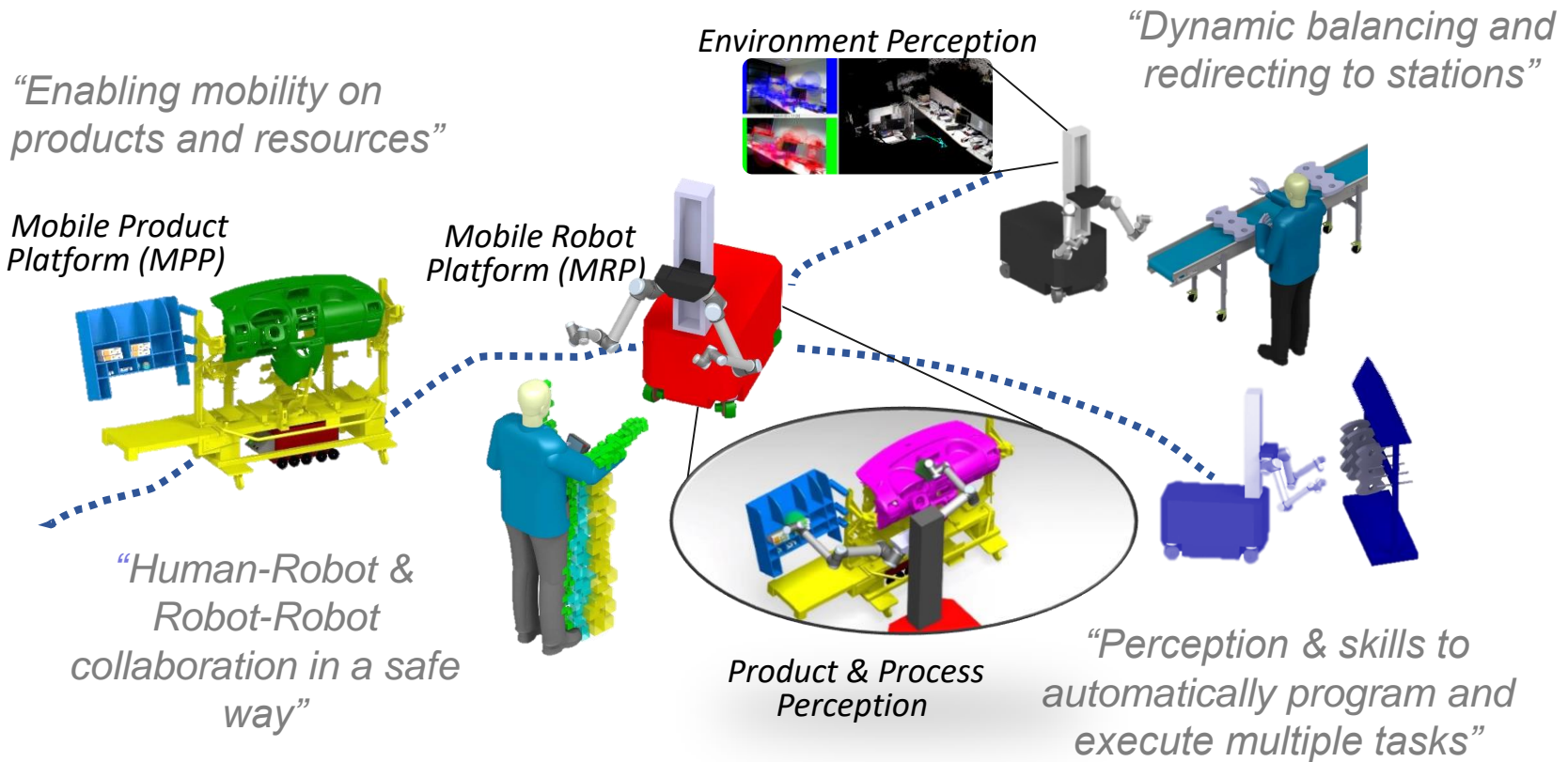
↓ *Lead to*

Need for **multi product variants**

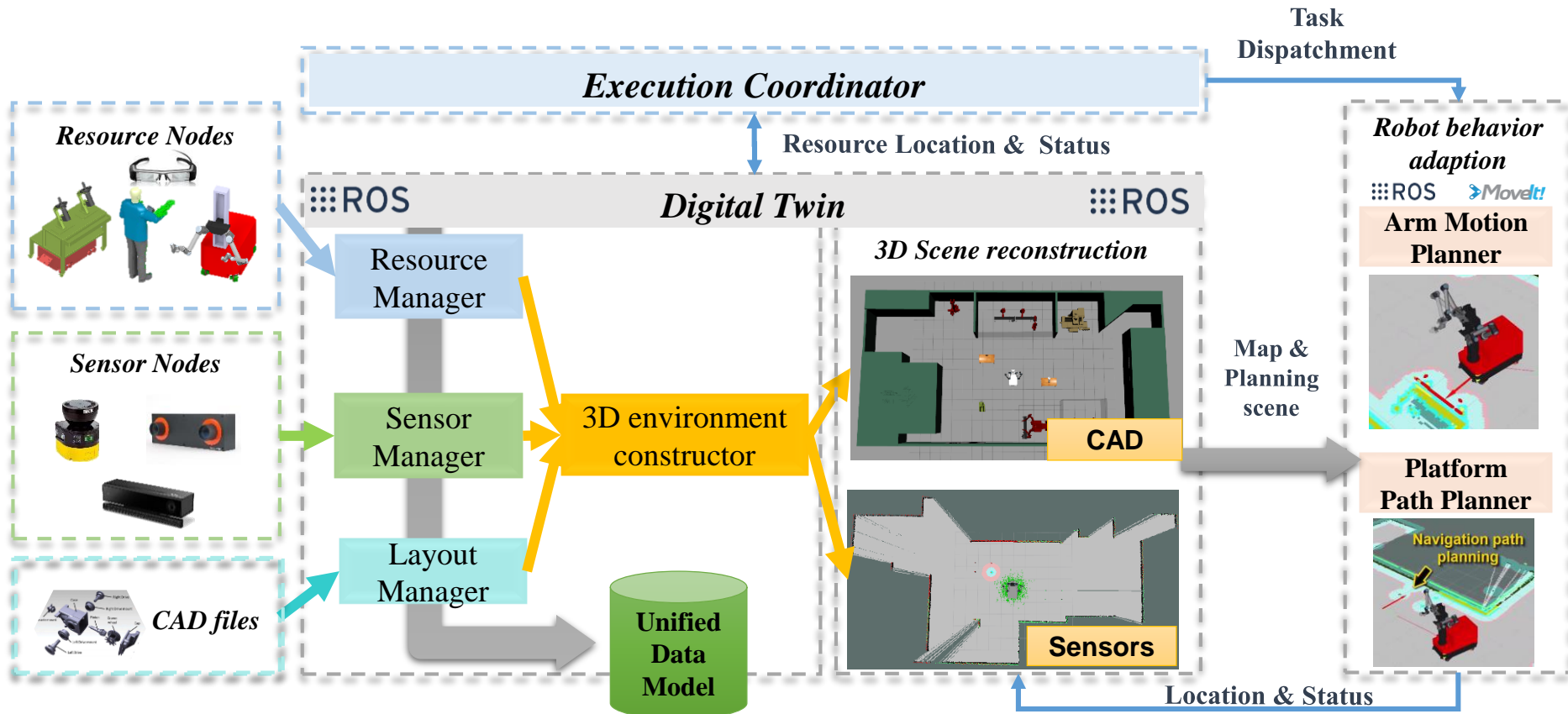
↓ *Lead to*

Need for **Flexible** and **reconfigurable** production lines



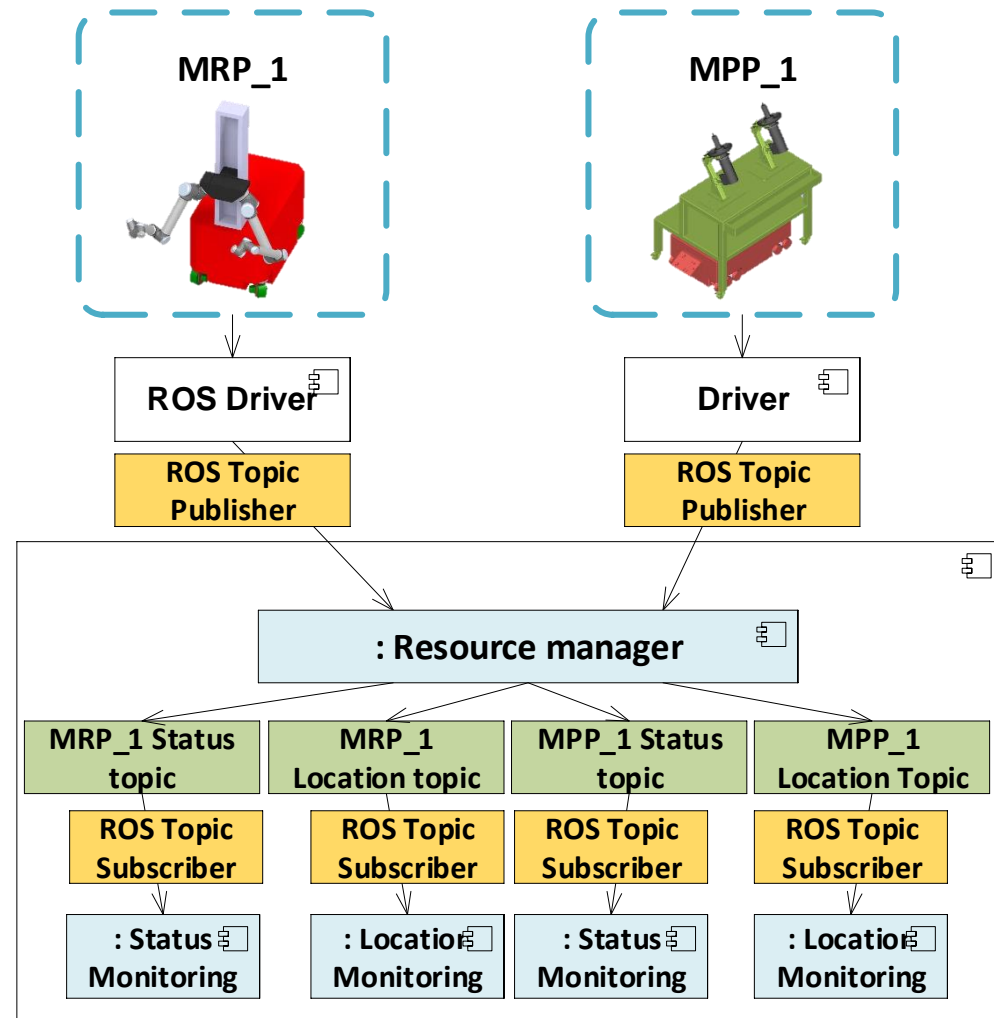


**How to enable the dynamic nature of this production paradigm ?**



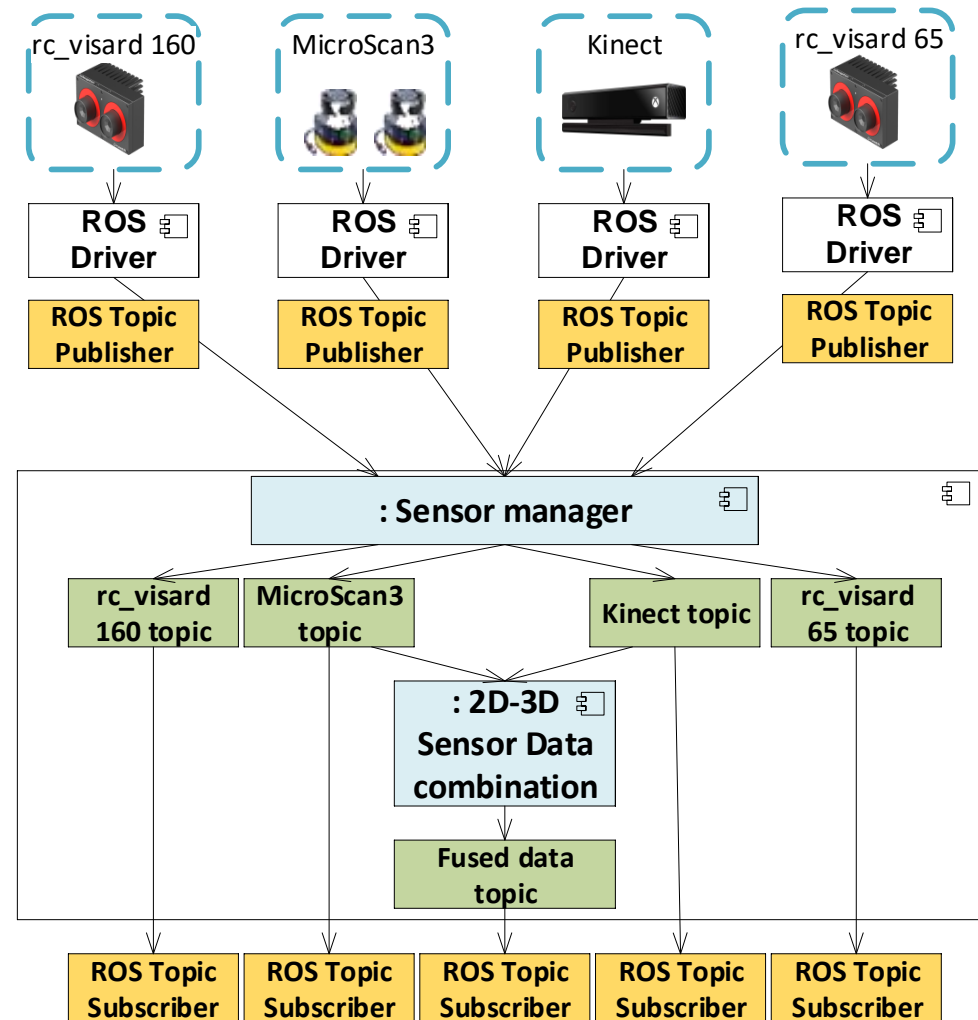
The responsibilities of resource manager are:

- The **registration** of a new resource into the production system
- The **storage** of the appropriate **attributes** based on the *unified resource model*
- **Realtime monitoring**
  - ❖ Resource location
  - ❖ Resource execution status



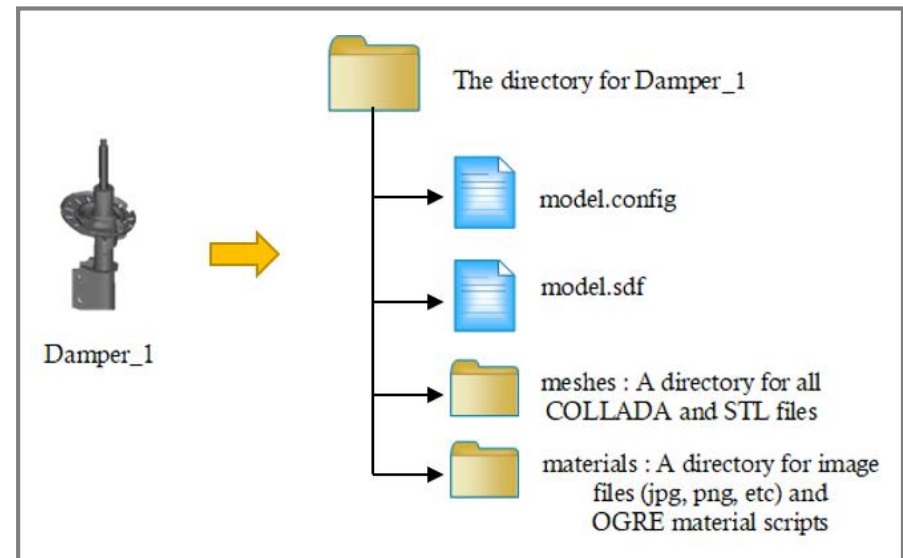
The responsibilities of sensor manager are:

- The **interfacing** with the existing's sensors' **ROS drivers**.
- The **storage** of the appropriate **configuration** files based on the *unified sensor model*
- **Sensor data combination** for merging multiple, sensor data into one topic

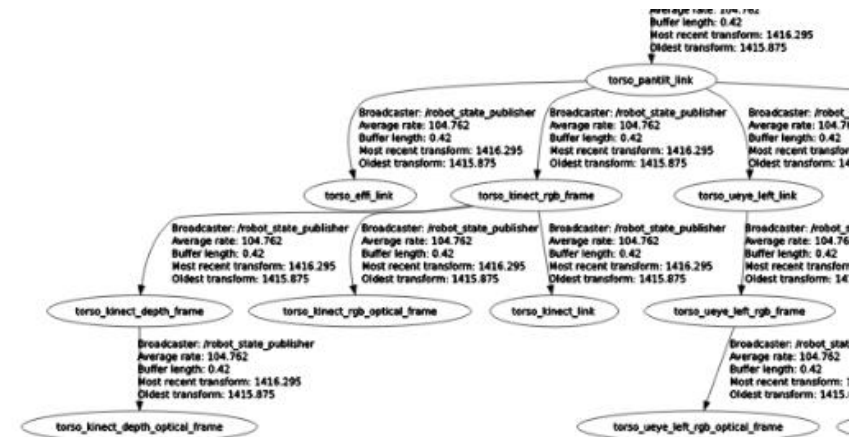
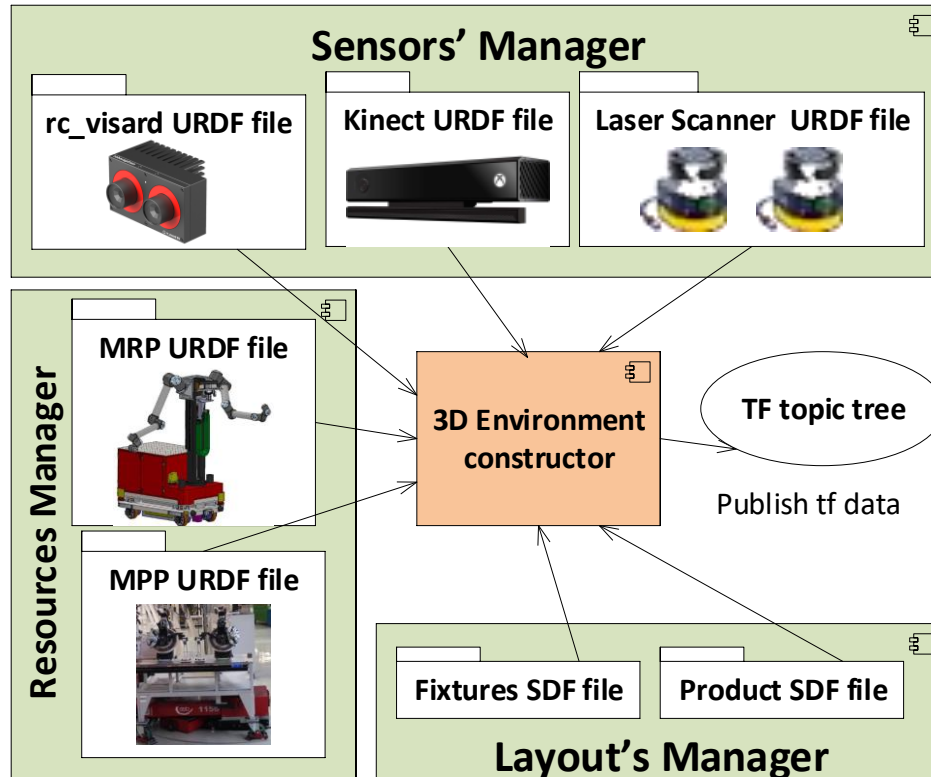


The responsibilities of layout manager are:

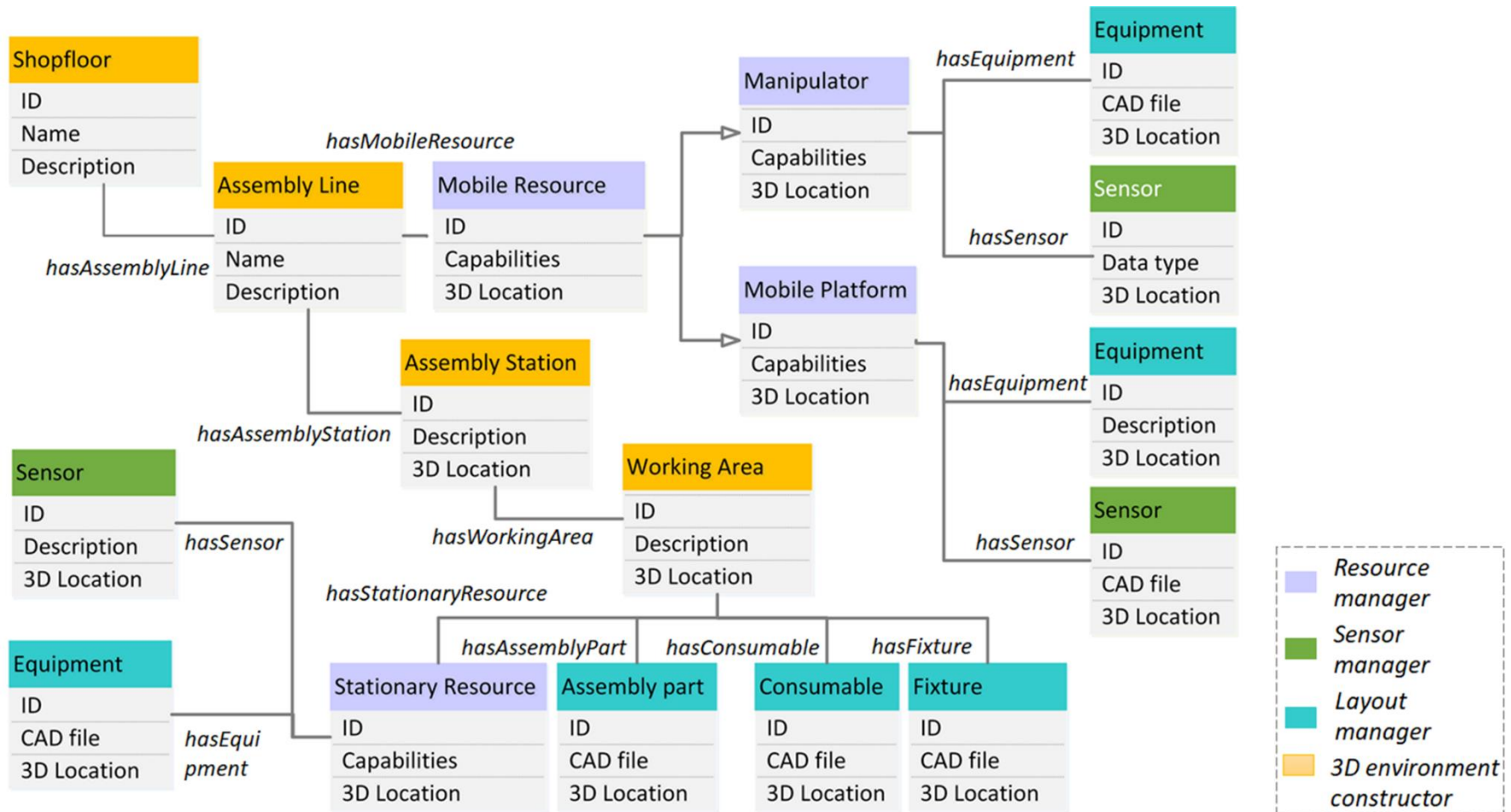
- The **storage** of the CADs files of fixtures, parts and products.
- The creation of the **.sdf files** containing the collisions and the inertia attributes
- The **relative positions** between parts and static fixtures





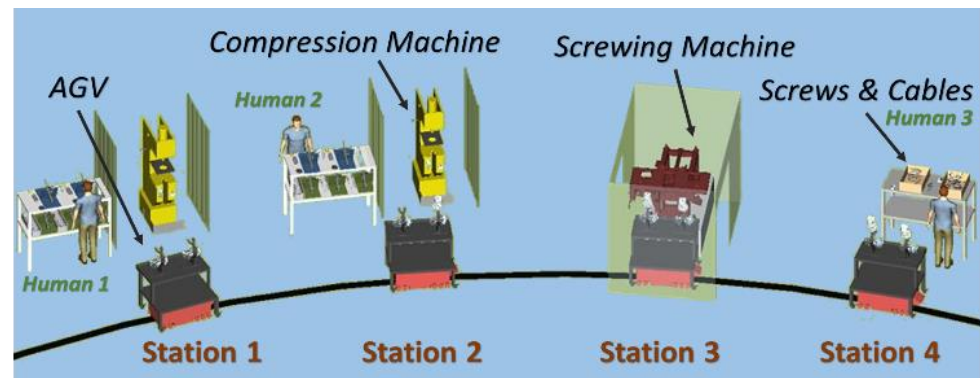


*Generated Tf tree*



- **Assembly of the front suspension** of a passenger vehicle
- Involves handling, cabling insertion and screwing operations – 4 workstations
- Manual assembly & 1 automated screwing machine
- Challenges of the current set up
  - ❖ **Ergonomy:** up to 480 dampers (6 Kg) are lifted by human operators per shift
  - ❖ **Flexibility:** the automated screwing machine cannot handle all product variants

Station	Task	Resource	Duration
S1	Pre-assembly of right damper	Human	12 secs
S1	Load damper on comp. machine	Human	5 secs
S1	Compression of right damper & Alignment / Nut insertion during the compression	Human – Comp. mach.	20 secs (human - 8 secs)
S1	Load comp. damper on AGV	Human	5 secs
S2	Pre-assembly of left damper	Human	12 secs
S2	Load damper on comp. machine	Human	5 secs
S2	Compression of right left & Alignment / Nut insertion during the compression	Human – Comp. mach.	20 secs (human - 8 secs)
S2	Load comp. damper on AGV	Human	5 secs
S3	Screwing machine connect each damper with one disk	Screwing machine	57 secs
S4	Cables / Screws Insertion	Human	50 secs

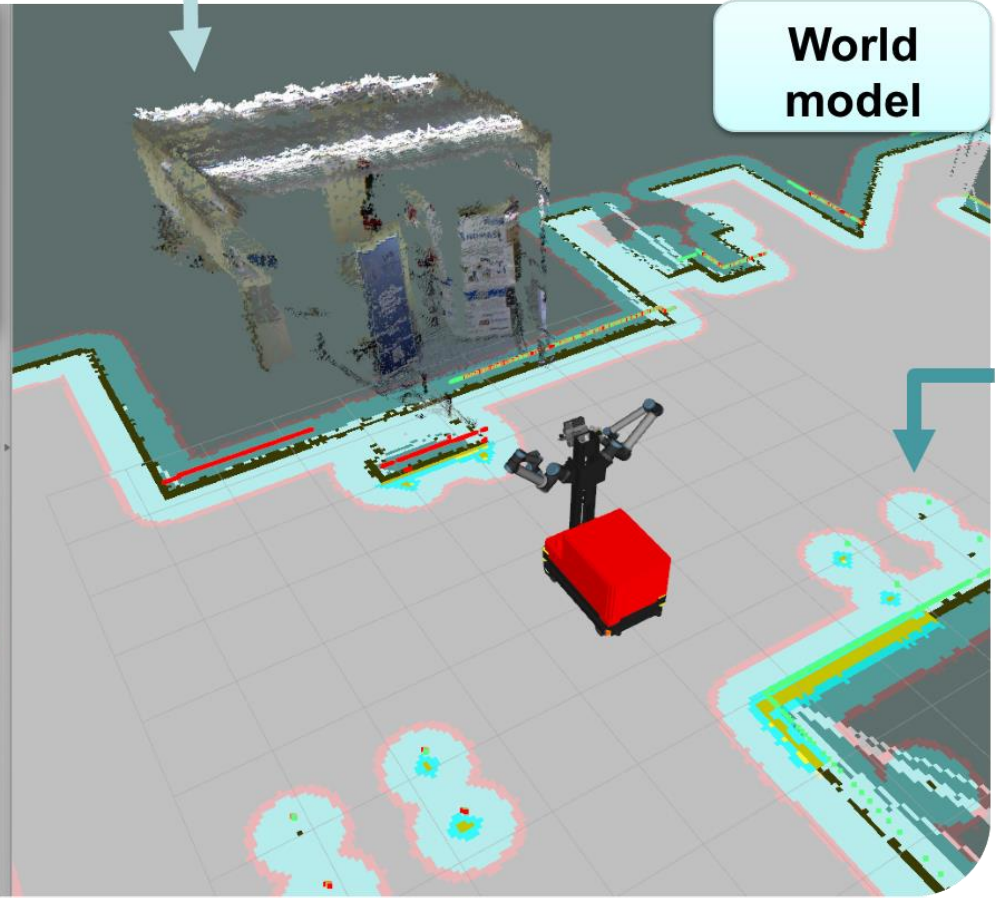
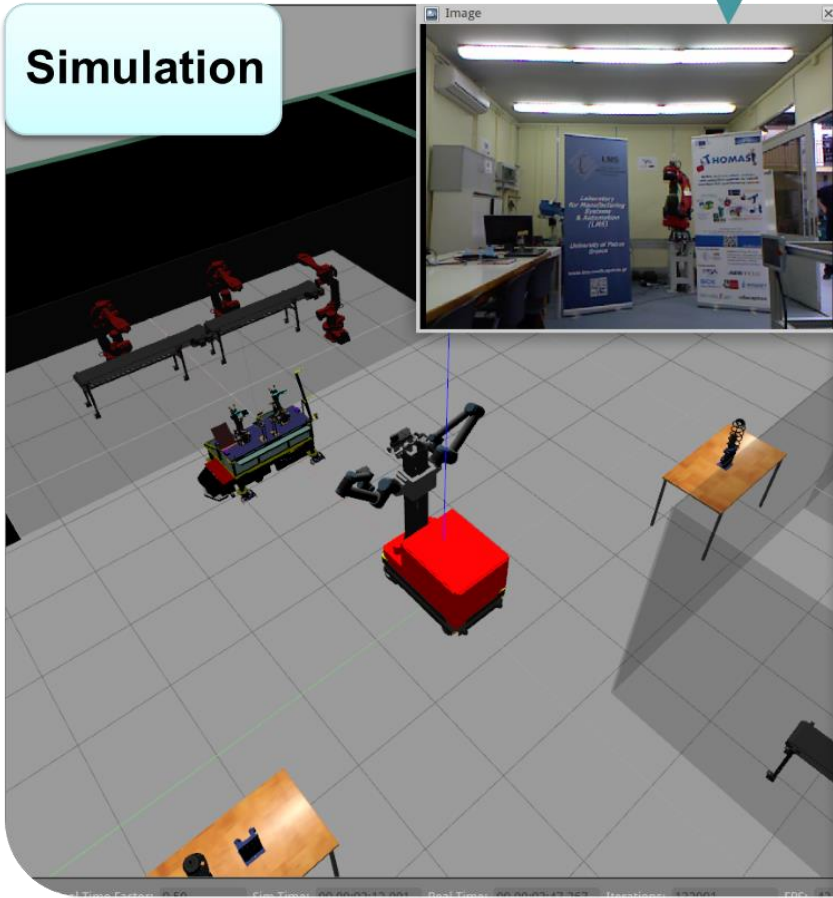


Live video view (Kinect)

3D Depth data (Kinect)

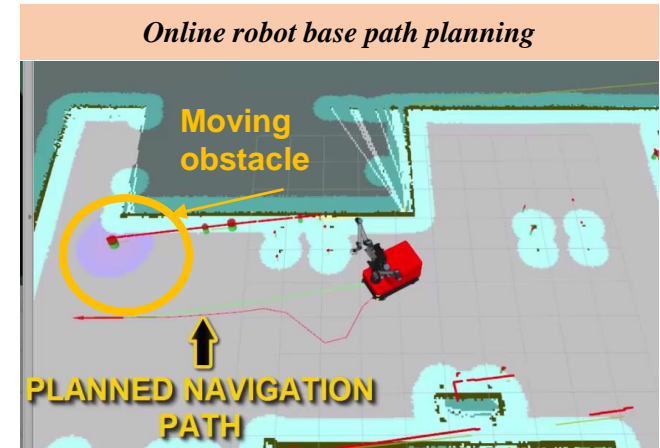
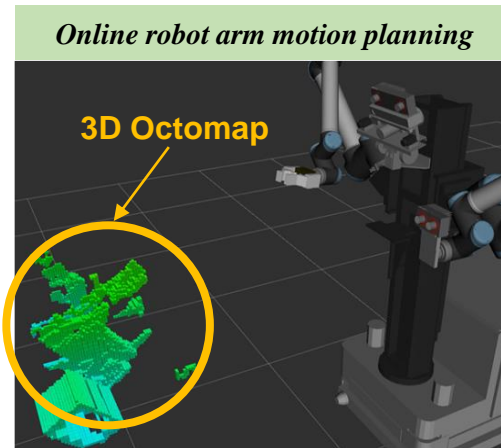
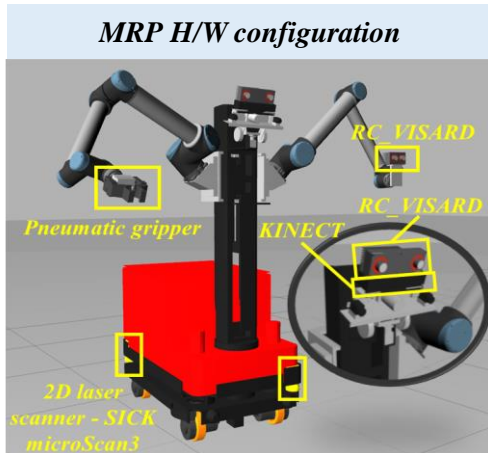
Simulation

World  
model





## Integrated software components:



The **benefits** of the proposed infrastructure for a production system

- ✓ Robustness against the real-world uncertainty
- ✓ Generic enough to be applicable in various use cases
- ✓ Fast and easy integration of new resources

## Future work

- Integration with the physical robotic set up
- Performance validation in the proposed infrastructure
- Integration with a high level decision mechanism for online task re-allocation



## THOMAS

Mobile dual arm robotic workers with embedded cognition for hybrid and dynamically reconfigurable manufacturing systems  
(Grant Agreement: 723616)

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**THANK YOU!**



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