

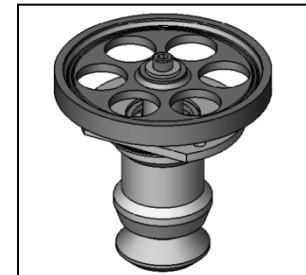
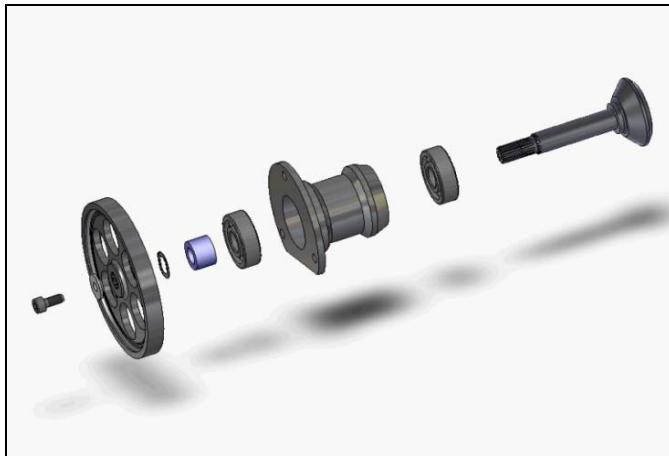
D1 Smart Dual arm assembling



Gian Paolo Gerio

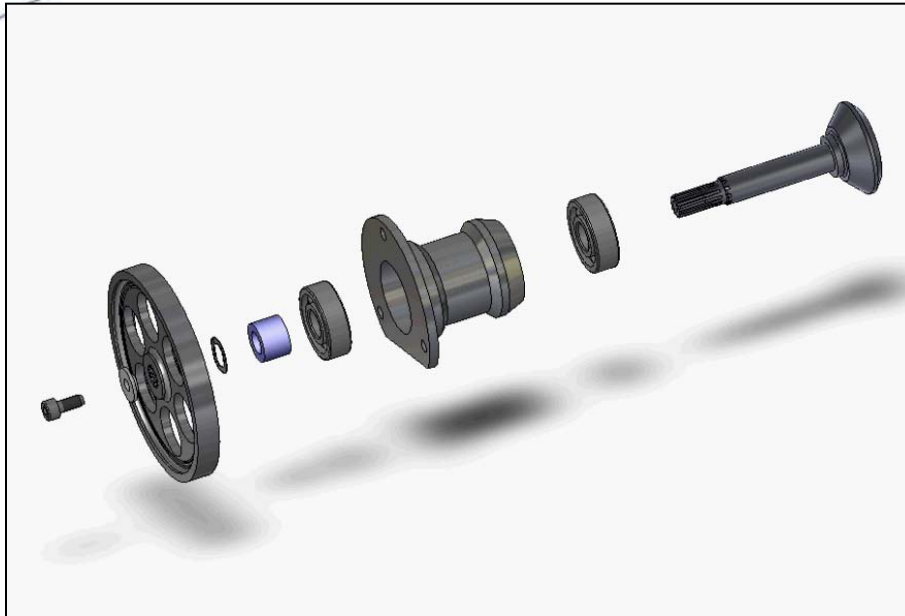
Workpiece - Gearbox

Property	Rough Specification
Type	Gear box
Size (w x d x h)	100x100x150
Shape	Approximately triangular
Visual appearance	Worked Metal (lucid and opaque)
Handled by	Robot / worker / both
CAD data	Available

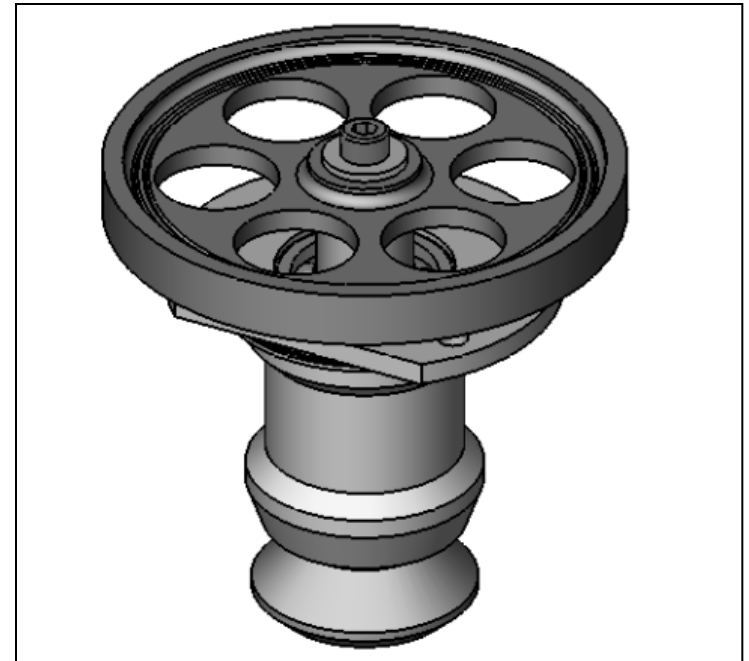


D1: Selection of work pieces

This is work piece chosen for the test and research.



Components of the part



Complete part

Machinery – Smart Dual Arm



Smart Dual Arm



C5G Open

Smart Dual Arm overview

The Smart Dual Arm is an innovative robot with the following characteristics:

- **2 anthropomorphous arms** with 6 axes
- **1 positioner arm for the TORSO** (1 axis)
- A total of **13 axes** managed by the **same C5G** controller unit
- **10 kg payload** for arm (tot. 20 kg)
- **Cooperative motion** (spatial synchronization) among the two Arms and Torso
- **Syncmove** (timing synchronization) among the two Arms and Torso
- **Hollow wrist arms** for optimized outfitting.



Open Concept

Open approach adds to Robot Control Unit further power of an External Personal Computer for programming *automated robotic cells* and integration with *external sensors* to simplify the implementation of *complex manufacturing applications*



Vision Algorithm:

- Look & Move
- Visual servoing

Interaction Algorithm:

- Force control
- Impedance control

CAD Planning:

- Surface movements
- Complex Interferences

For universities and research centers
Open architecture permits to develop
new innovative motion strategies

C5G Open is suitable for some industrial application that need additional sensors integrated in the system. For this purpose used hardware parts have to be compliant with the industrial regulations and software architectures has to be more easy to use.

Hardware: B&R LPC (Linux APC) permits to run C5G Open on a industrial hardware platform

Software: Ubuntu distribution patched by B&R is fully compliant with B&R PowerLink Interface Card with a communication rate @ 400us

eORL: C5G Open works in Cartesian frame also and can manage multi ARM configuration, details of communication are hidden to the user

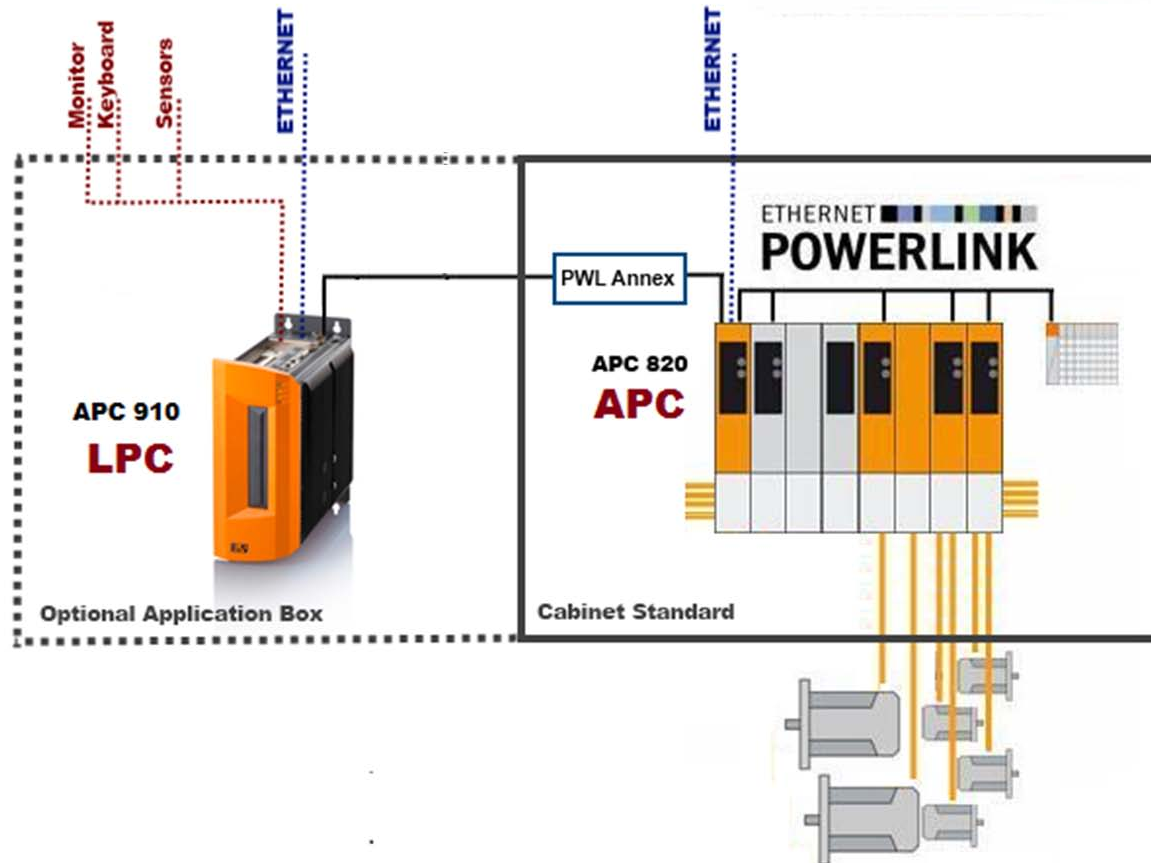
Graphic viewer: 3D visualizing of the robot movements on PC monitor

ROS Industrial interface: integration of Comau Robot with all the ROS modules developed in an academic or industrial scope

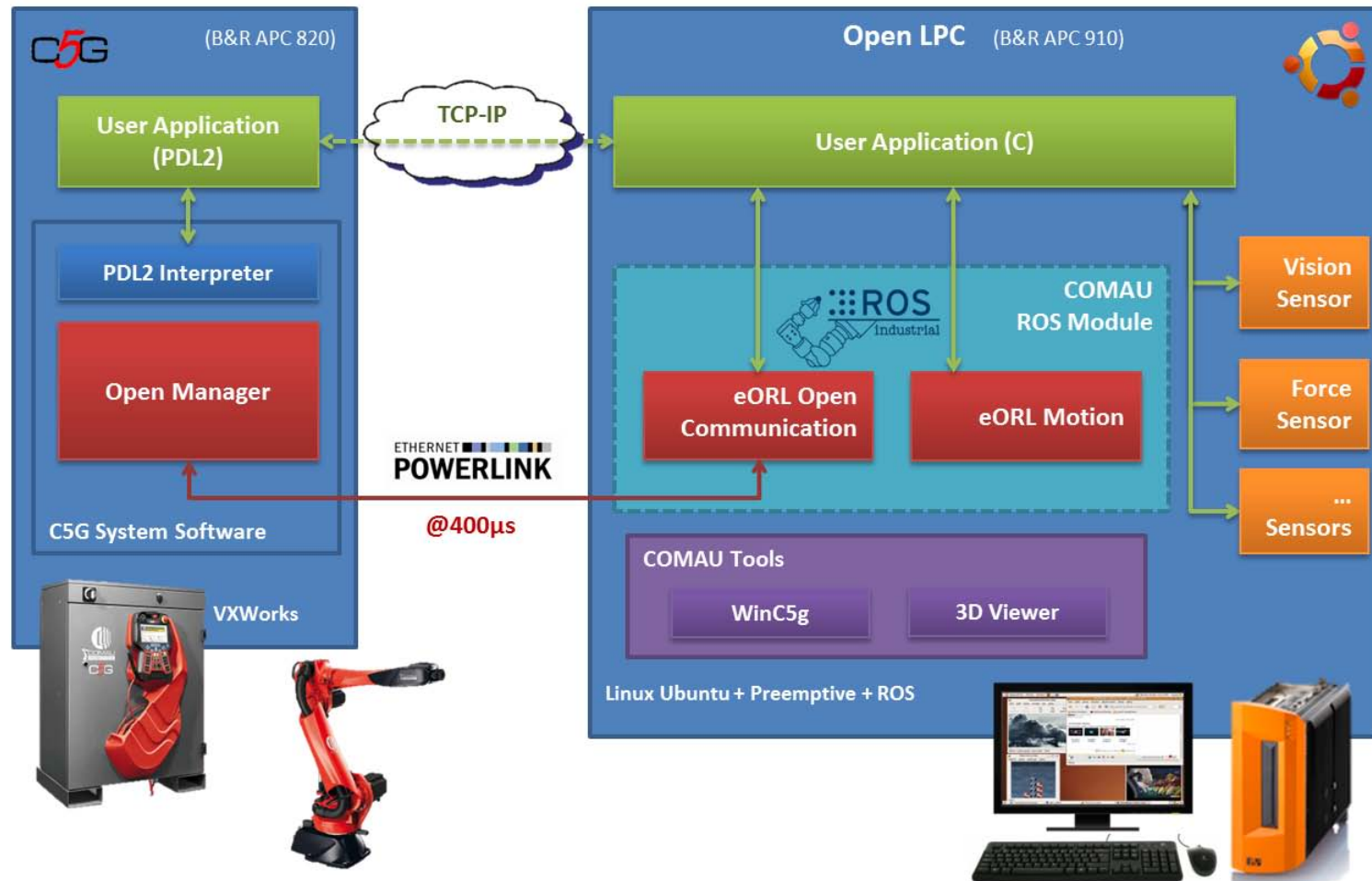
Control Function: Managing motion control algorithms inside C5G Open software the references of position, velocity or current provided by PC are checked before driving the robot

Simulator function: C5G Open can work also like a simulator testing PC application and working cycle of robot in a more safe condition

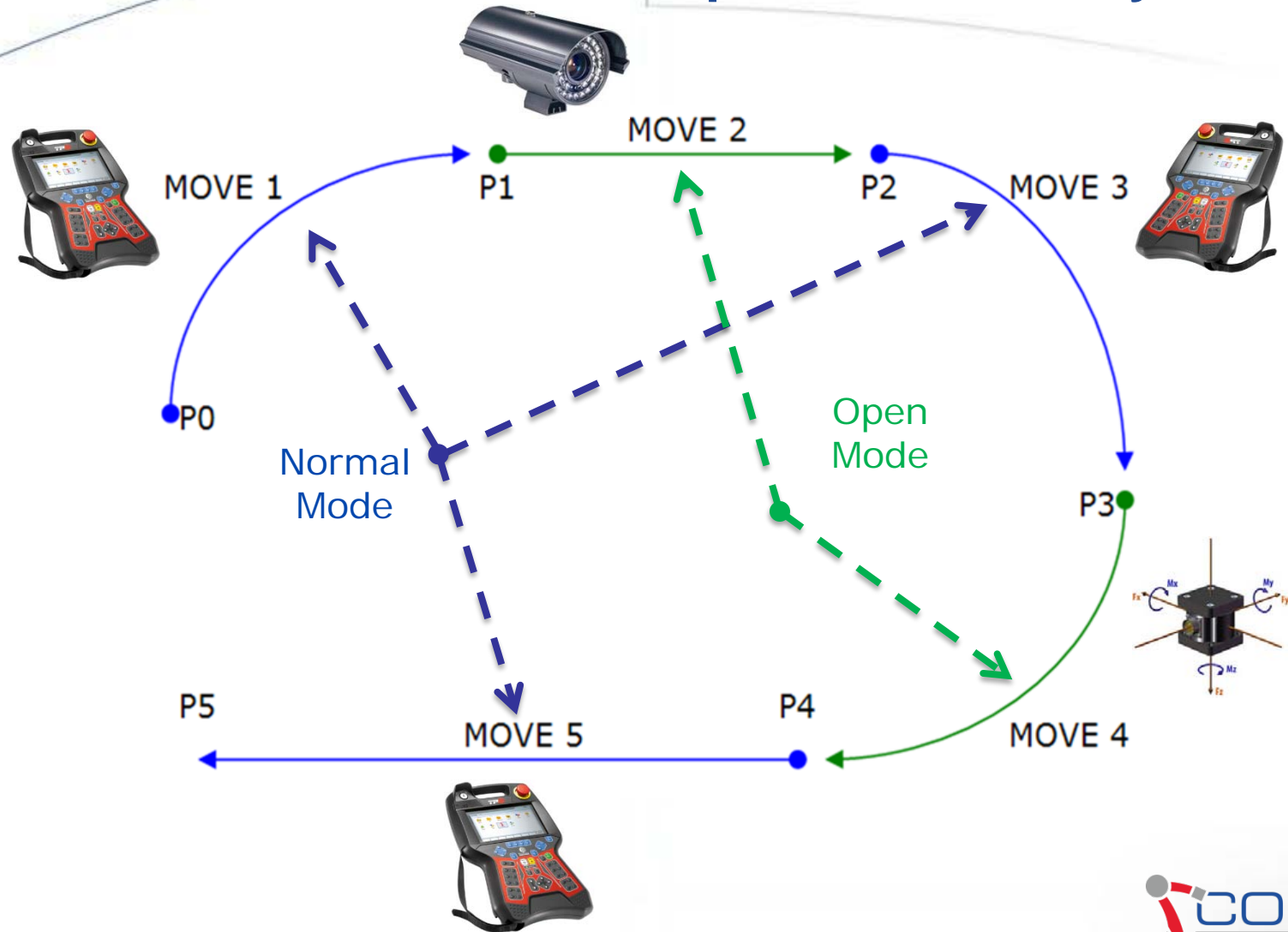
Hardware Architecture



C5G Open controller, Software Architecture

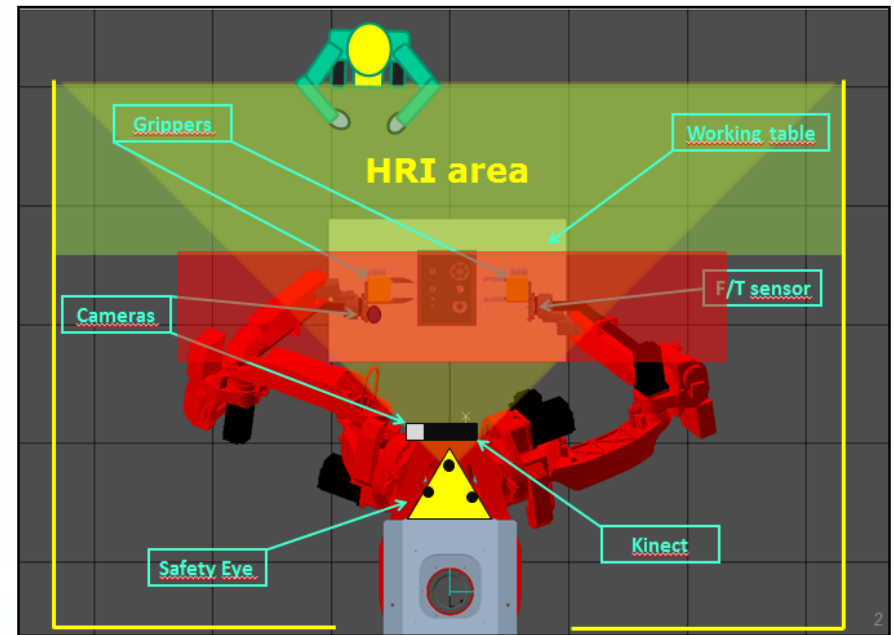
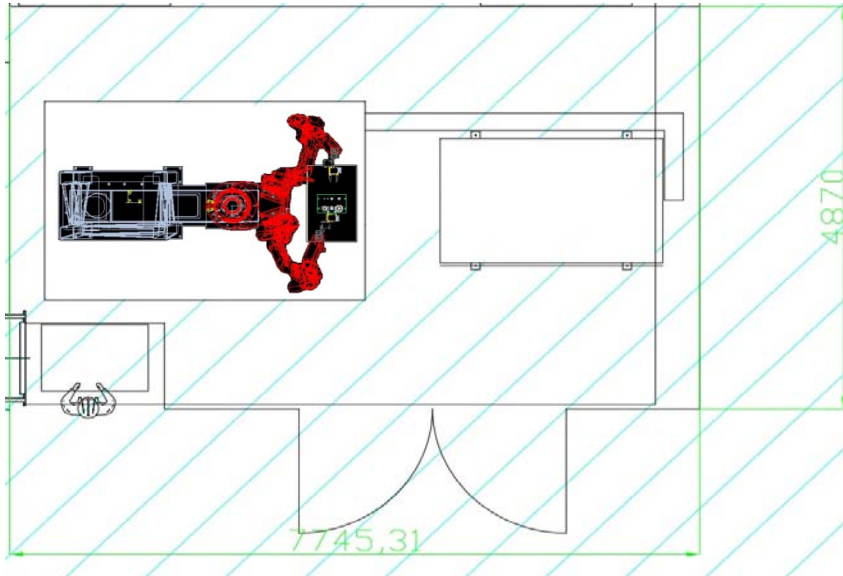


Open Functionality



Demonstrator Set-Up for mechanical assembly of GEARBOX

- Demonstrator setup, layout (3D)
 - Interfaces, Sensors Tools
 - Work pieces
 - Environment



Demonstrator D[1]: Selection of work pieces

- Work pieces: gear box



Kind of Workpiece -related uncertainty	Range of Unknowns	Detection of uncertainties	How to resolve?
Mechanical tolerance	<0.1 mm		Robustness programming – F/T control
Presence of oxide, dirt or dust on surface			Preliminary cleaning

Demonstrator D[1]: Processes considered in work-system

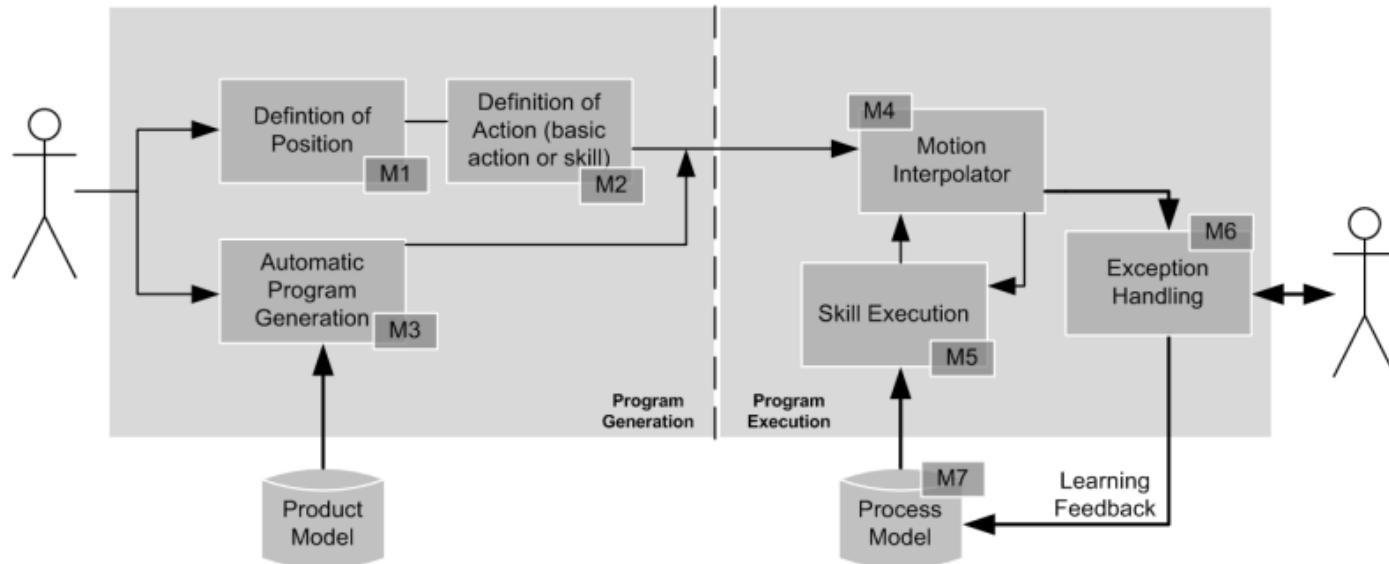
- Assembling process considered (first steps)



Kind of process -related uncertainty	Range of Unknowns	Detection of uncertainties	How to resolve?
Pieces from 1 to 6: uncertainty on 'minimal' repositioning	● 1-10 mm	● The grasping tasks fails	● Compensation with fingers grasping (dedicated shape)
Piece from 1 to 6 : Uncertainty on 'maximal' repositioning	● 10-200 mm	● The grasping tasks fails	● Vision system
Piece 7: uncertainty on assembling	● 1-2 mm	● The assembling Tasks fails	● Force/torque sensor

D1: Workflow along life-cycle – overview

- Workflow of complete demonstrator process

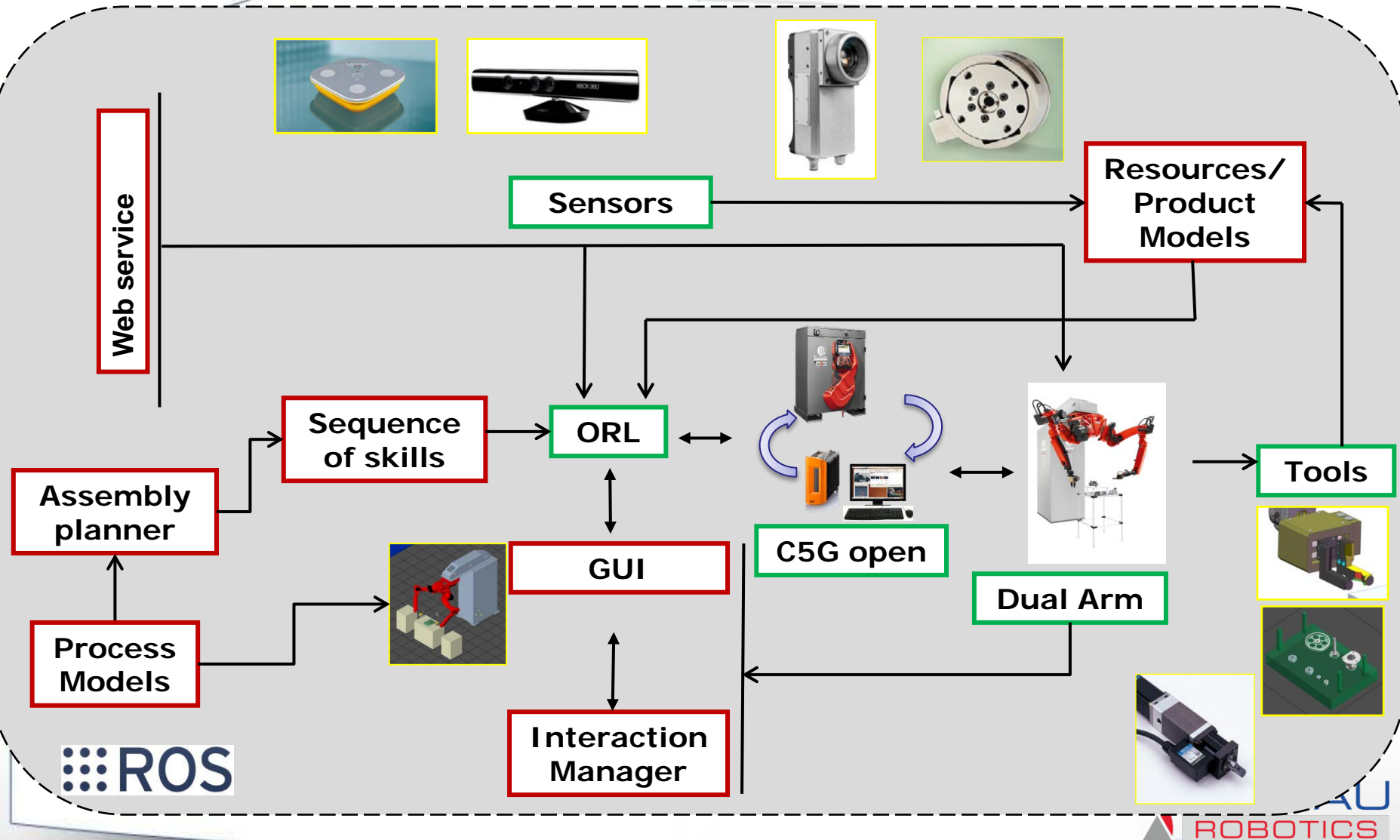


- M1: Automatic Program Generation with CAD information fulfilling restrictions in the assembly sequence
- M2: Definition of positions using manual guidance
- M3: Definition of actions, skills (fitting parts on center axis, gripping out of box, etc.) or motions
- M4: Motion interpolator for two-arm robot
- M5: Skill execution
- M6: Exception handling
- M7: Learning of assembly problems owing to varying tolerances

Tools and Sensors

Device	Task	Interface	Note
Automatic Screwdriver	Screwing and unscrewing	Digital I/O	
Tool changer	Changeover	Pneumatic	
Grippers	Grasping and assembling	Profibus	With customized fingers
F/T sensor	Force control	Powerlink	SW: interaction control
Cameras	Vision detection	Powerlink	SW: Open CV libraries
Safety eyes and kinect	Fenceless approach and HRI	Phisycal I/O	

D1 System architecture



- **Students**

- Sharing works/tutorial
- Supporting themselves

- **Researchers**

- Sharing works/tutorial
- Promote and advertise their activities

COMAU Open Community

- **Integrators and Companies**

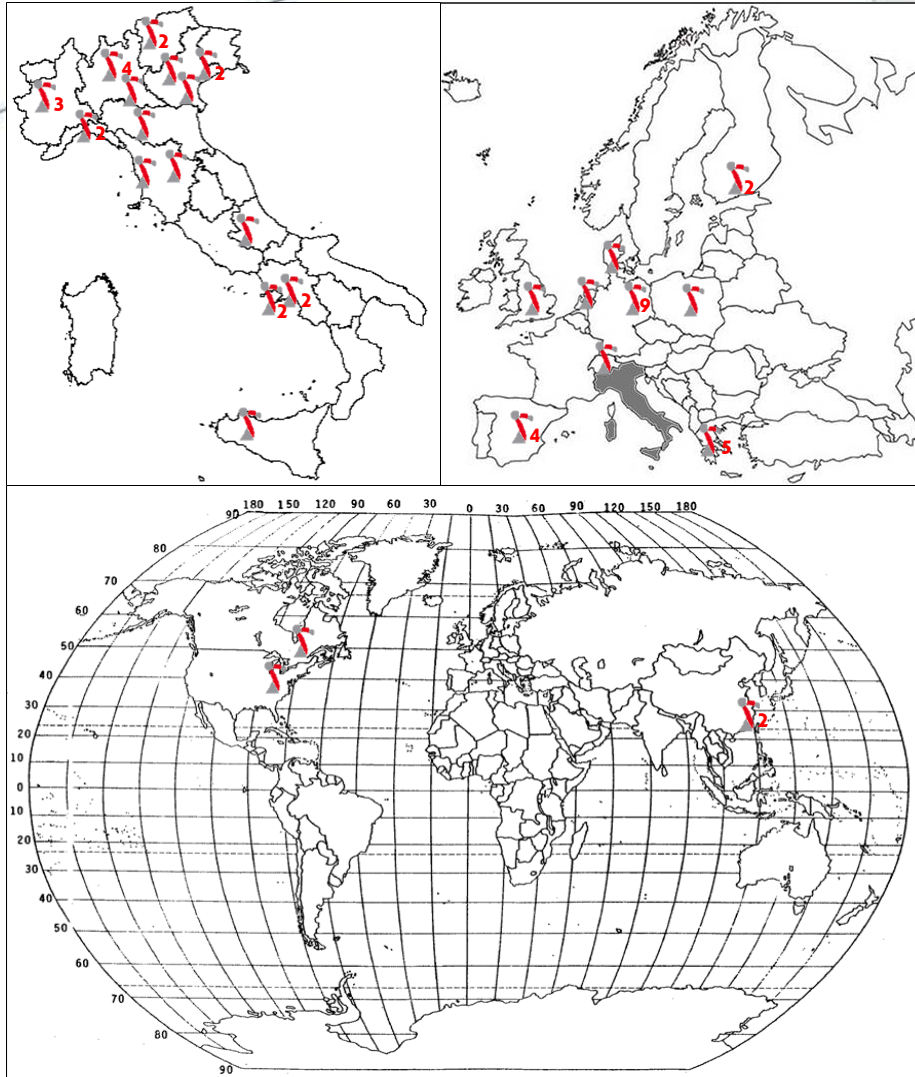
- Looking for support
- Finding new ideas
- Making self advertisement
- Finding partners, consultants and know-how

- **COMAU**

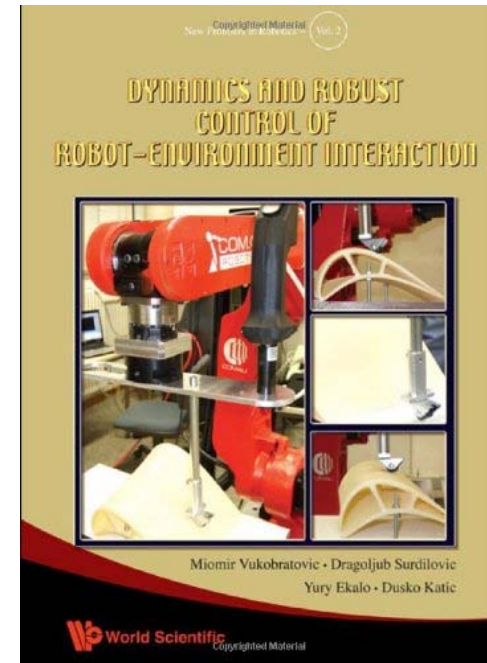
- Experiences
- Good advertisement
- Support for technical assistance

4 Everyone

Sharing is caring!



As example: Control of Robot-Environment interaction



(By Fraunhofer Institut)



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