Modular Robot Design and LabView

A course Project at Machine Design Division

Edris Safavi,

IEI- Division of Machine Design

Linköping university

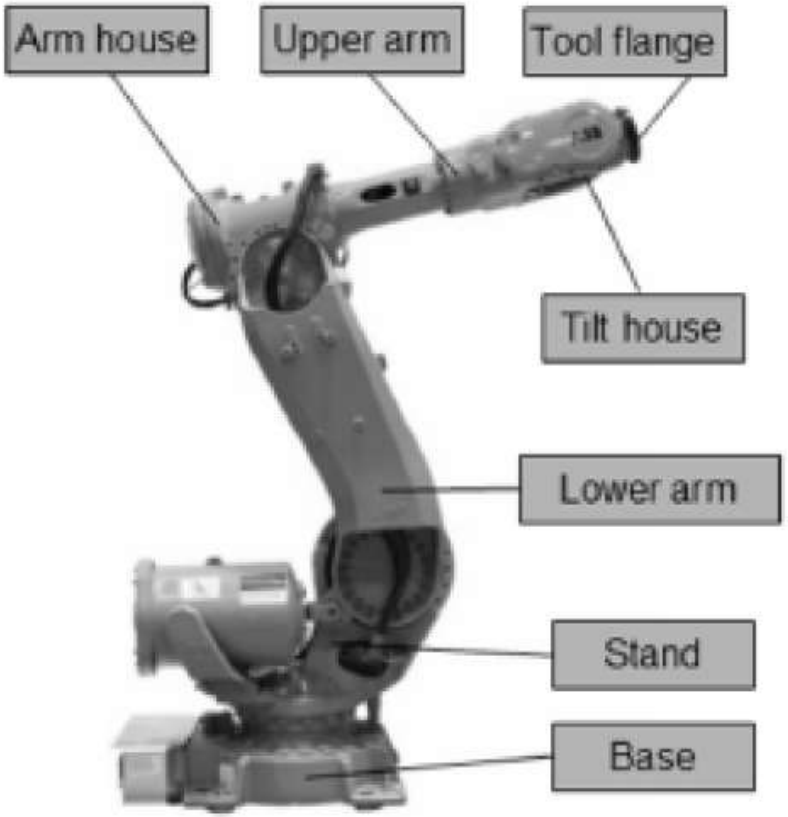
Aim

- Create a family of robots which shares maximum number of modules within the family. Generic reusable modules is the result of this design process.
- An automated design framework is to be developed which is used to verify various design concepts rapidly. Simulation based optimization is a requirement.
- Build a physical prototype of the selected robot design concept.

Modular Design

- An approach that subdivides a system into smaller parts (modules) which can be independently created and then used in different systems to drive multiple functionalities

Conventional and Modular Robots



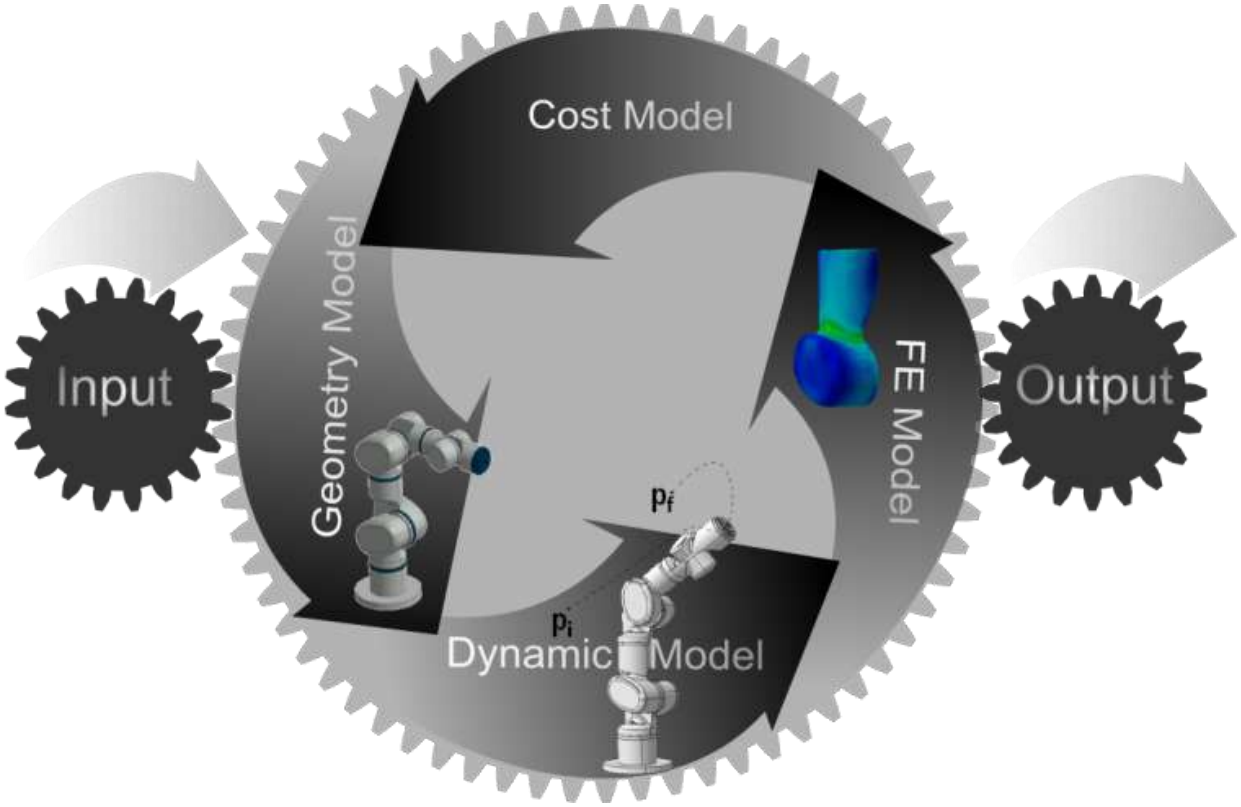
Conventional

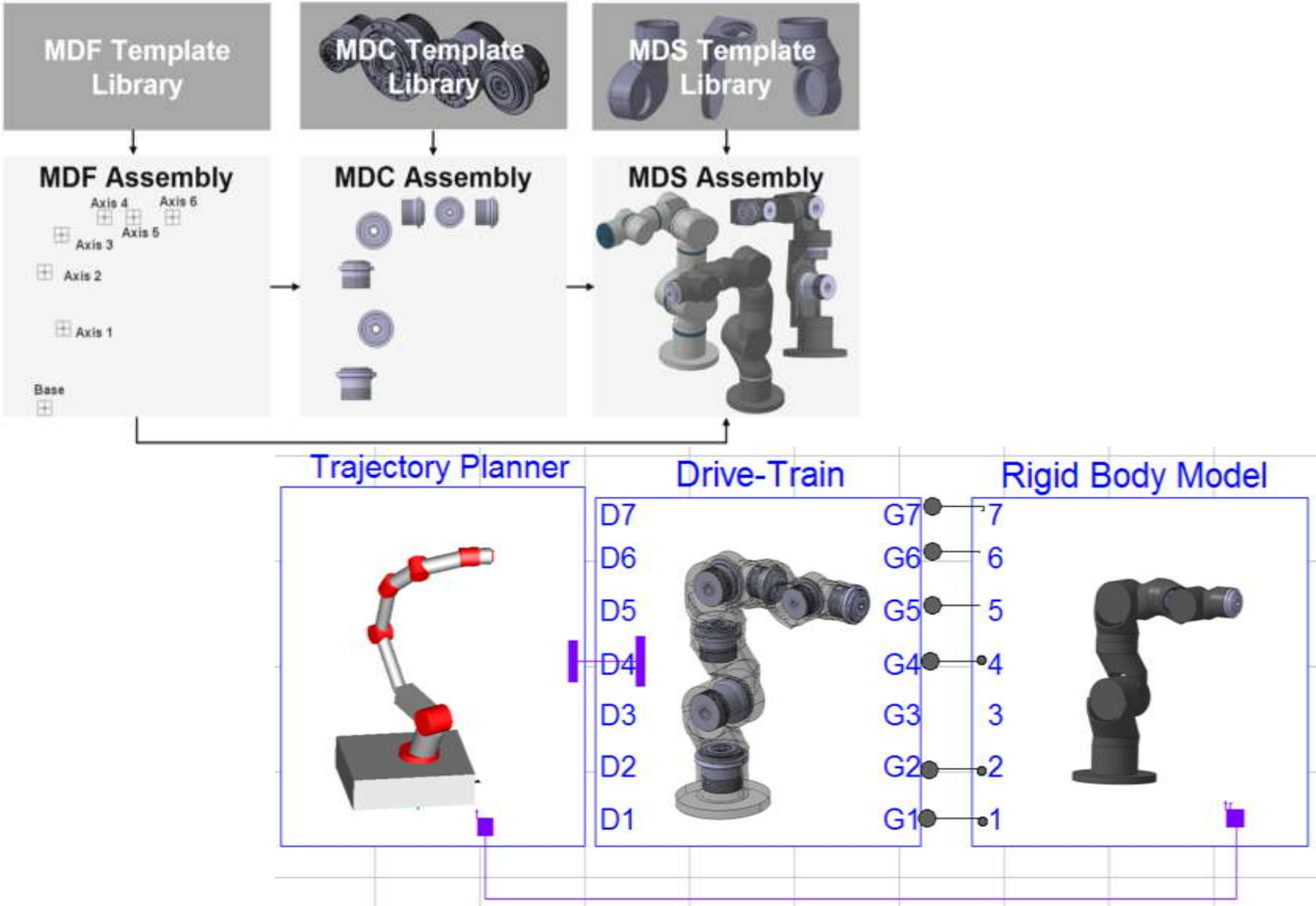
Modular

Requirements

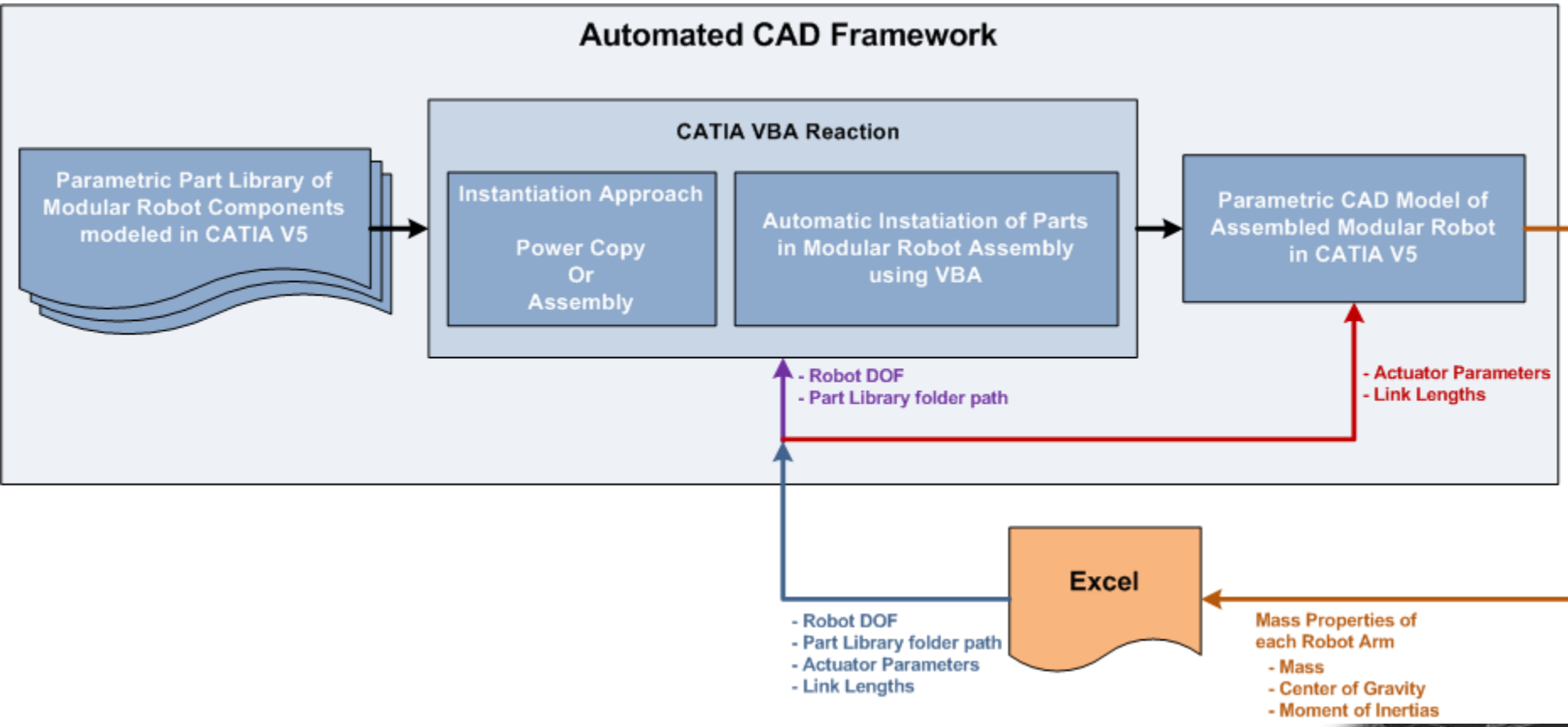
- Crating the framework to rapidly test and evaluate the new modular robot concept
- Creating both virtual 3 to 7 axis modular robot family
- Maximize number of shared modules
- Light weight
- Hidden cabling
- Rapid manufacturing and assembly
- Able to follow pre-defined trajectories
- Easy to control
- PC based control

Automated Design Framework

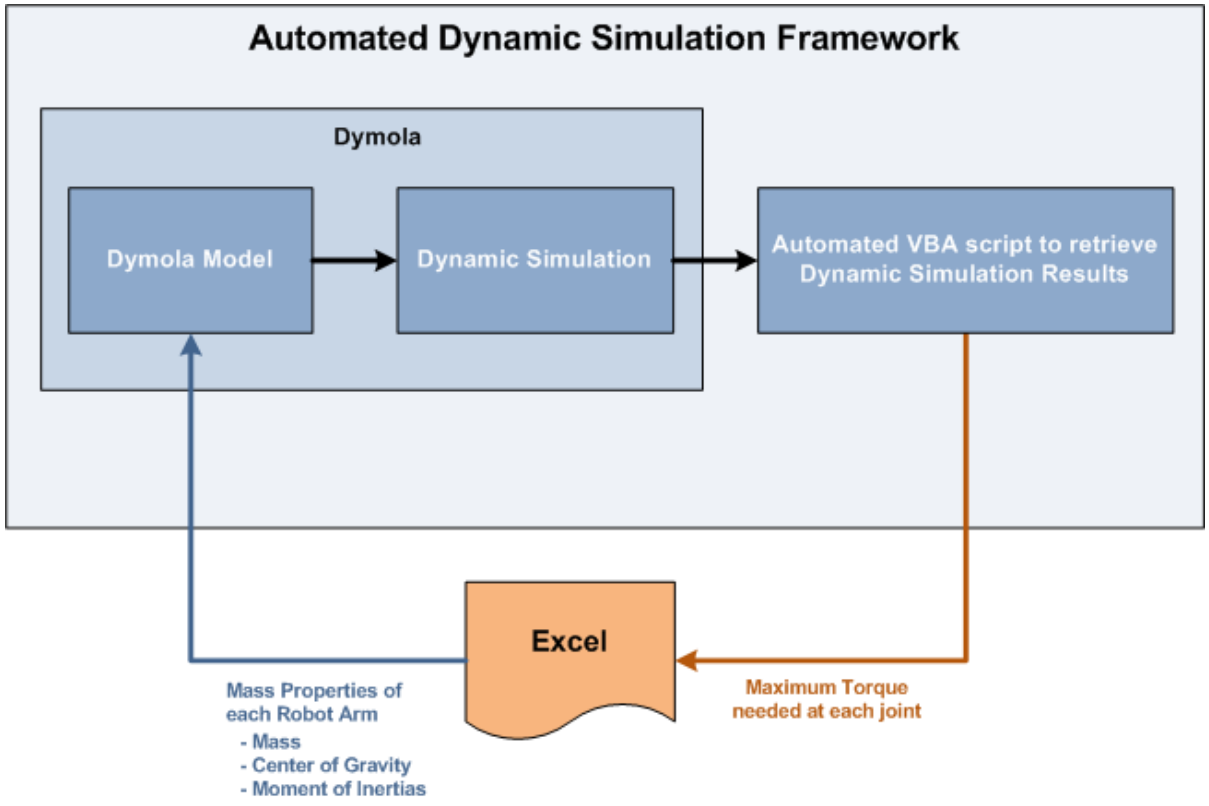



MDF Template Library
MDC Template Library
MDS Template Library
MDF Assembly
Axis 4
Axis 6
Axis 5
Axis 3
Axis 2
Axis 1
Base
MDC Assembly
MDS Assembly
Trajectory Planner
Drive-Train
Rigid Body Model
D7
D6
D5
D4
D3
D2
D1
G7
G6
G5
G4
G3
G2
G1
7
6
5
4
3
2
1

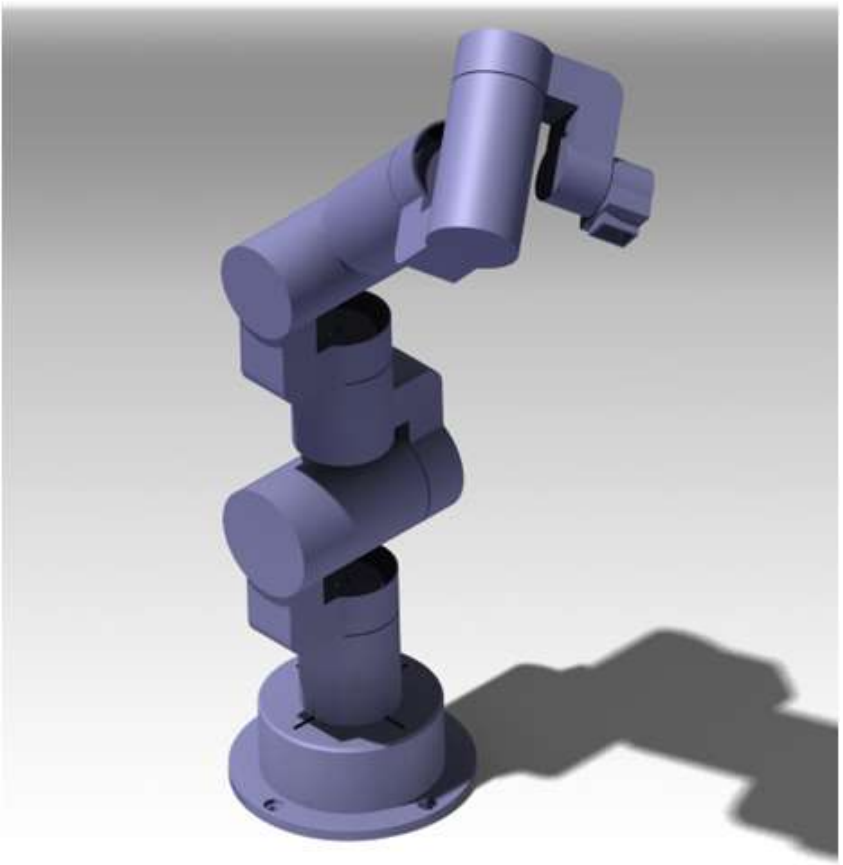
Automated CAD Framework

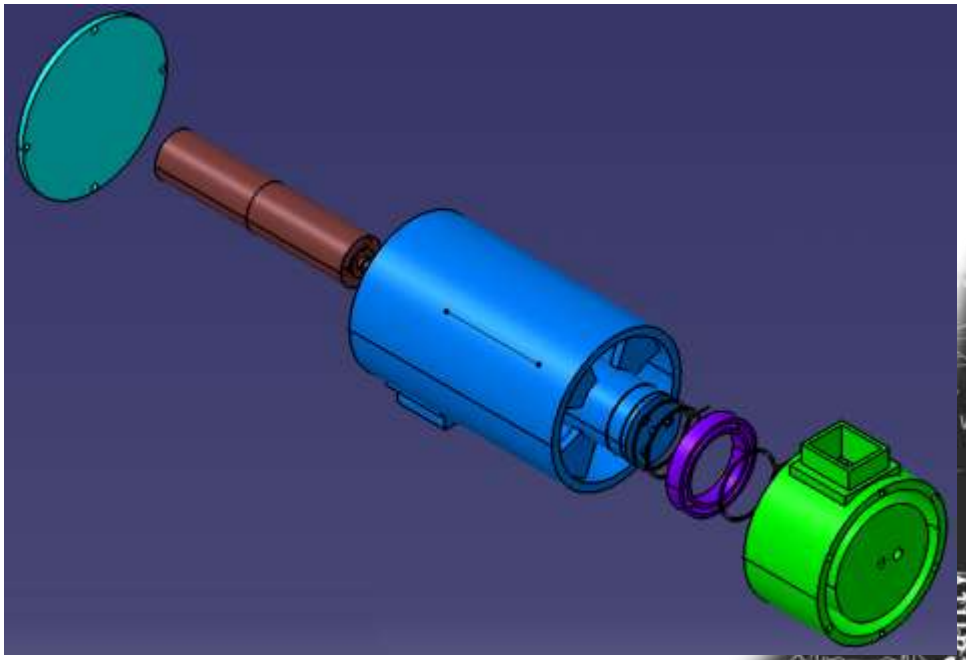


Automated Dynamic Simulation Framework

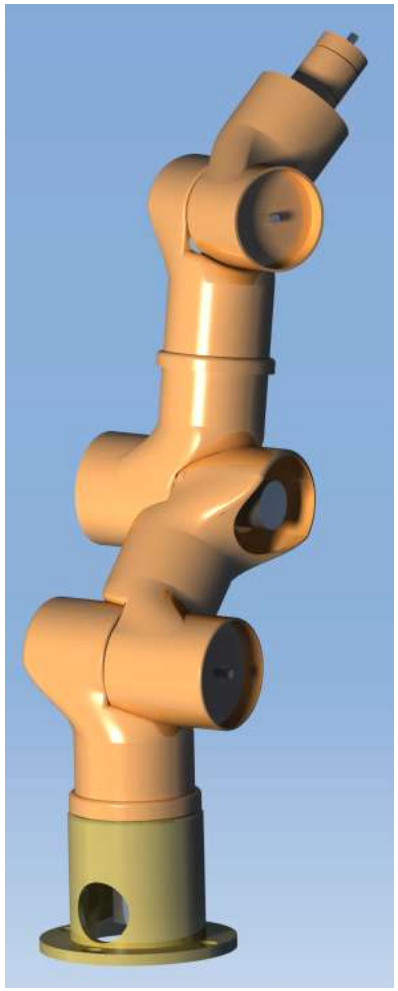


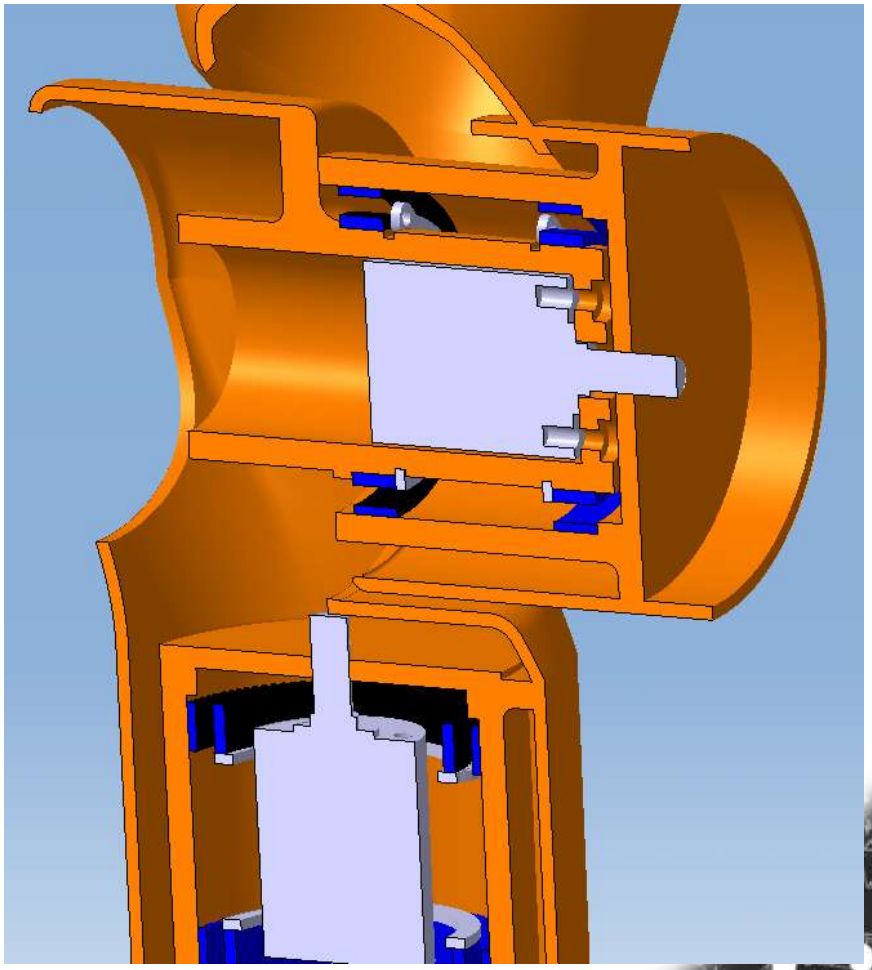
Concept 1



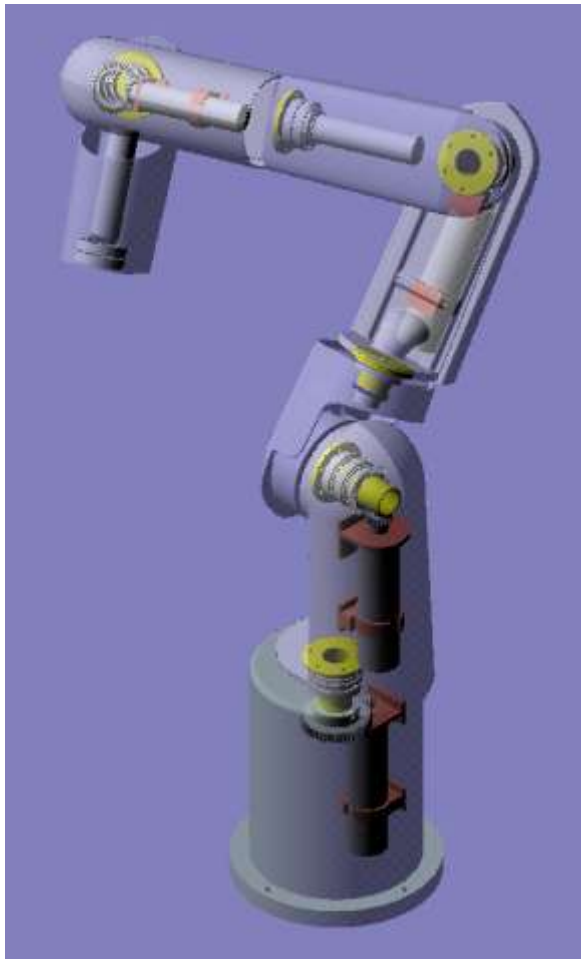


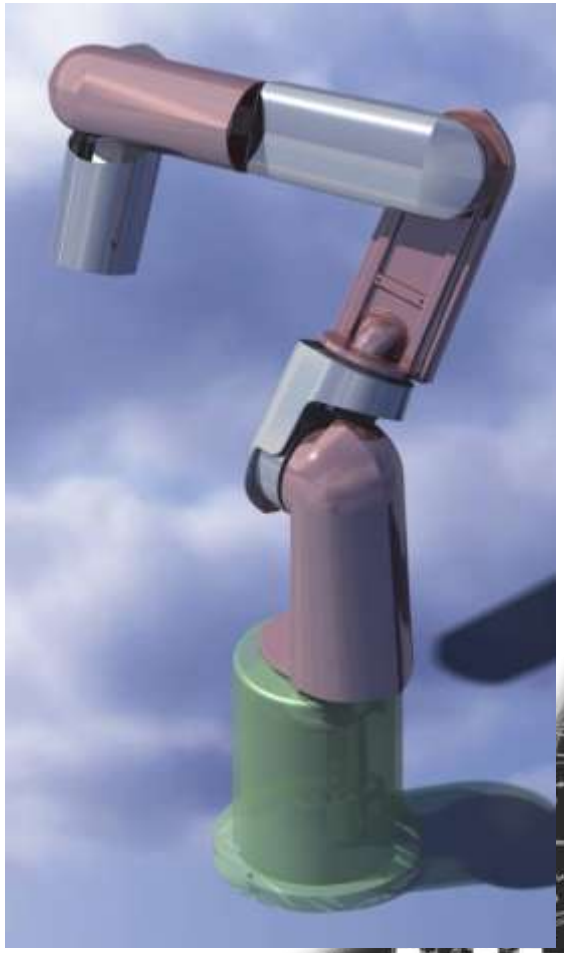
Concept 2





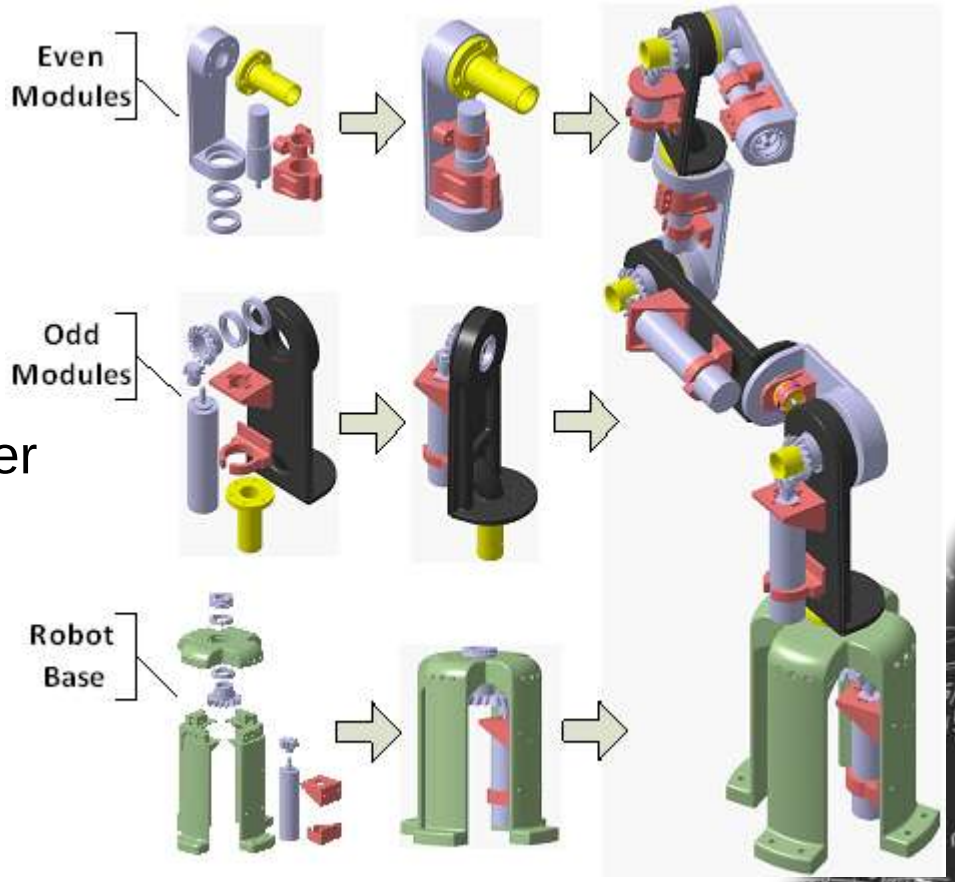
Selected Concept





Main Features of Final Concept

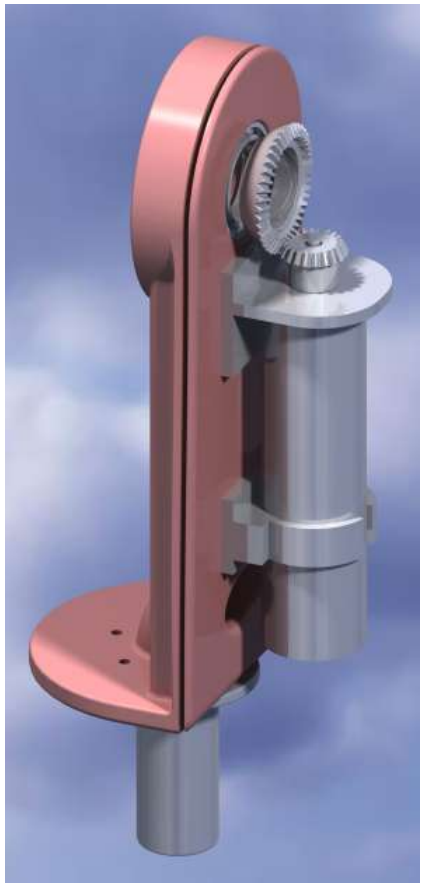
- Consists of 2 main modules
- Hollow shafts to pass cables inside the structure
- A pair of bevel gear is used to transfer actuator’s motion in roll joints
- Payload = 0.1 kg
- Weight of 7 axis robot is around 2 kg
- Reach of 7 axis robot is 670 mm



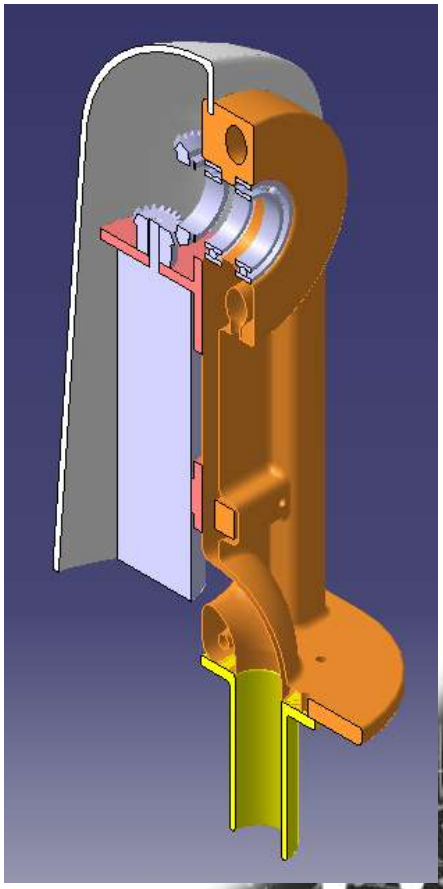
Selected Concept: Module 1 for odd arms

With cover

Without cover

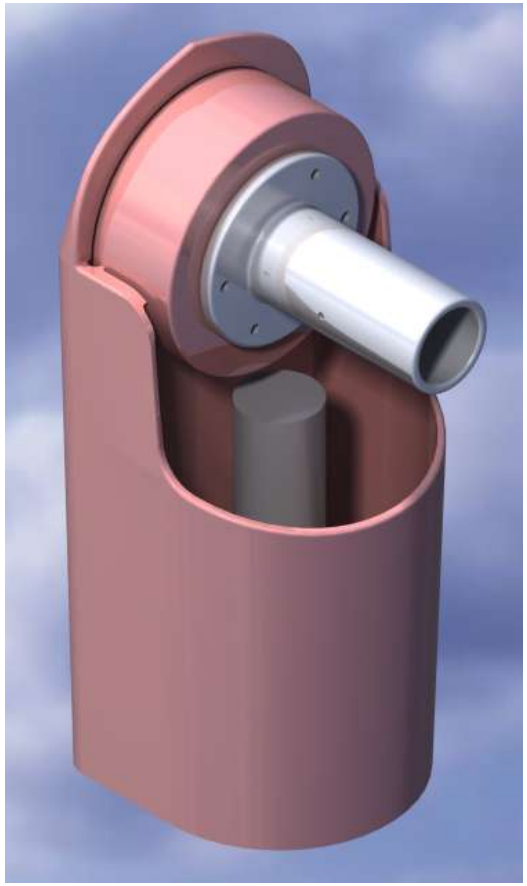


Section view

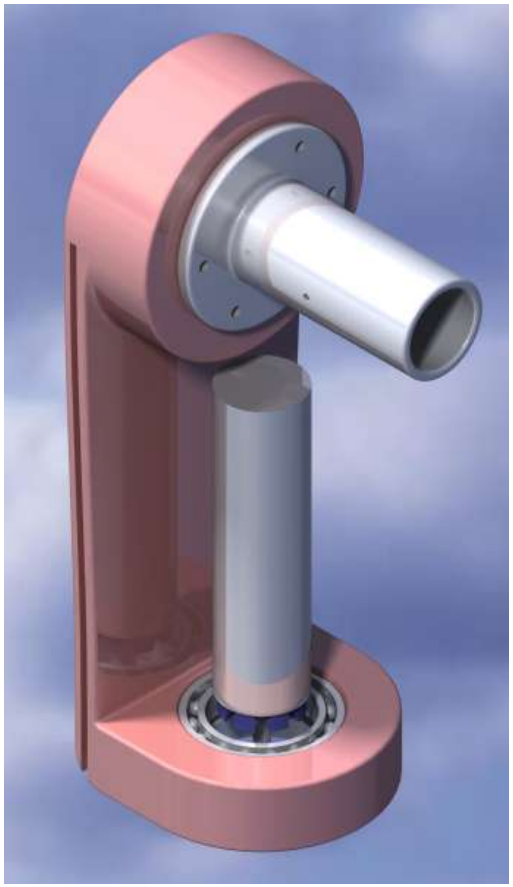


Selected Concept: Module 2 for even arms

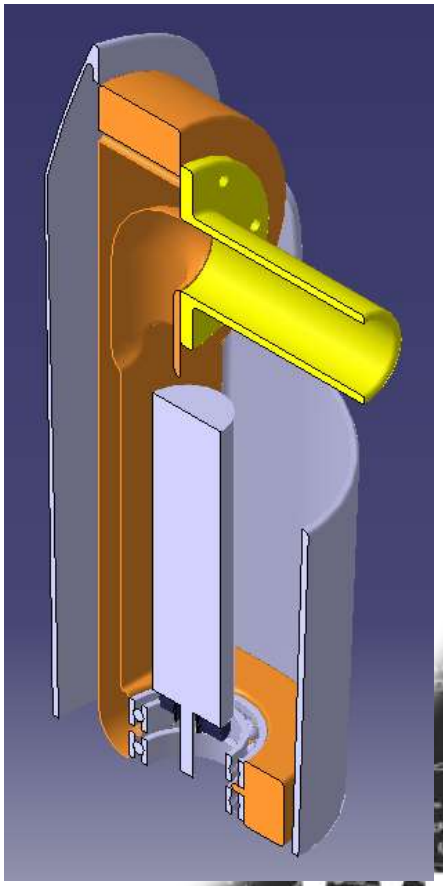
With cover



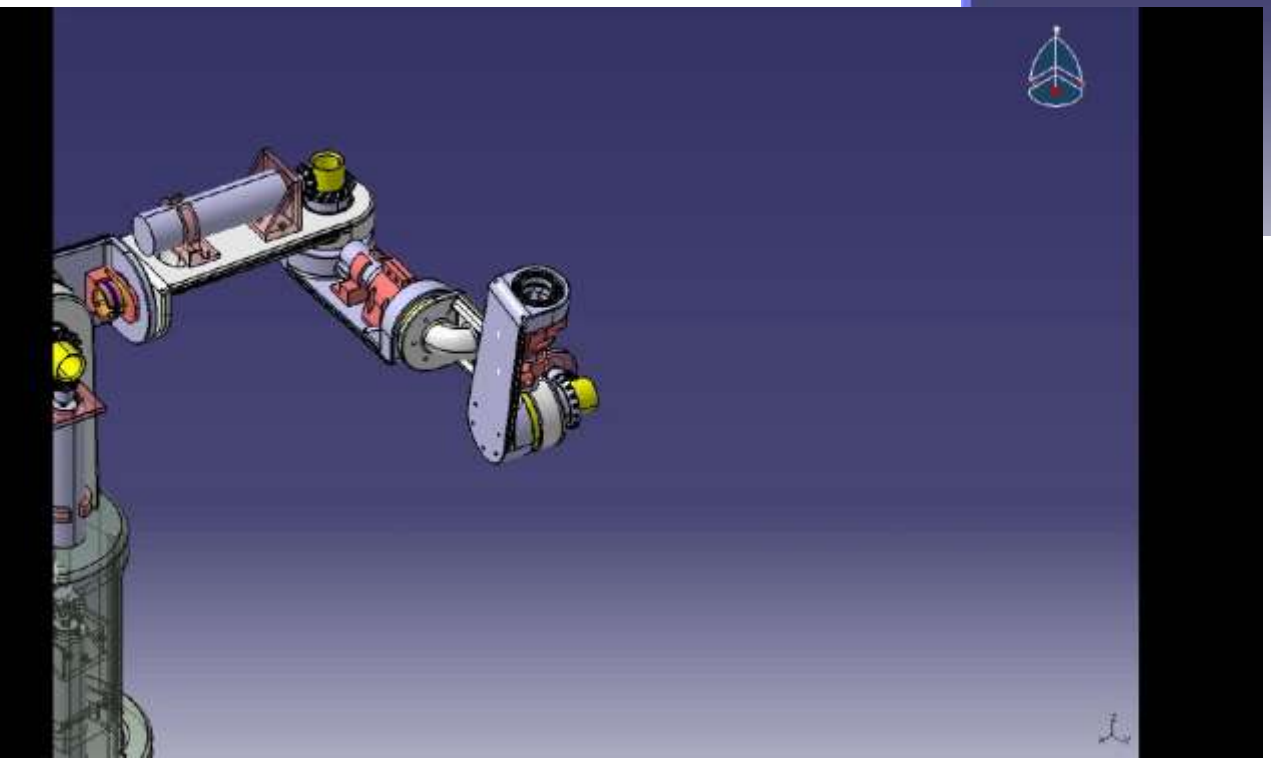
Without cover



Section view



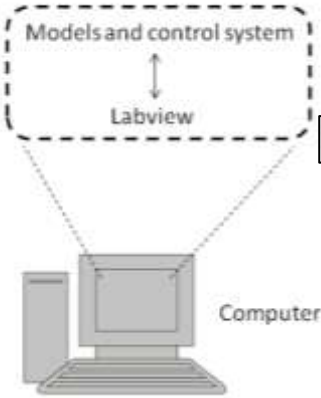
Kinematic Simulation of Final Concept



Drive System Components

- NI CompactRIO cRIO-9022
- NI CompactRIO Reconfigurable Embedded Chassis cRIO-9114
- NI 9514 Servo Drive Interface Module with Encoder Feedback
- FAULHABER Servo Amplifier Type BLD 5603-CC4P

Manufacturer Name	Motor description with Encoder details	Gearhead	Gear ratio
FAULHABER	Brushless DC-Servomotors 3242G024BX4IE3L with Encoder IE3-64 L	Planetary Gearhead 32A	68:1
FAULHABER	Brushless DC-Servomotors 3242G024BX4IE3L with Encoder IE3-64 L	Planetary Gearhead 32A	236:1
FAULHABER	Brushless DC-Servomotors 2232S024BX4IE3L with Encoder IE3-64 L	Planetary Gearhead 26A	16:1



NI cRIO-9014 Real-Time Controller

Reconfigurable FPGA Chassis

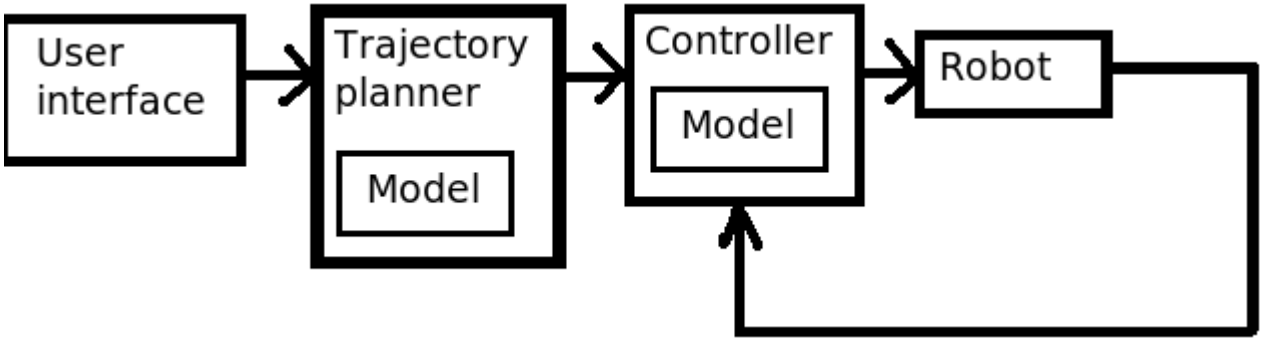
NI 9514 Servo Drive Interface

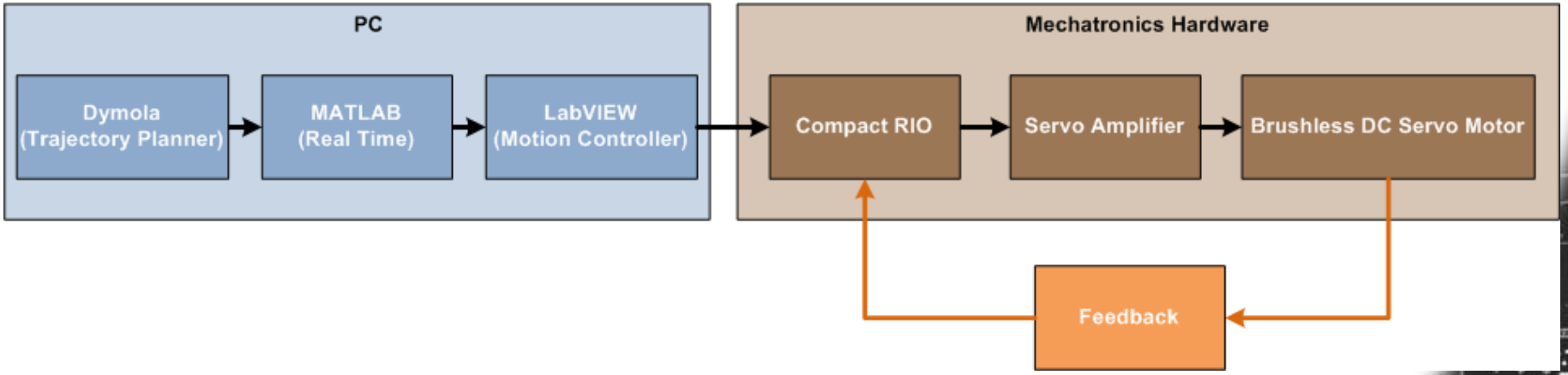
Servo Amplifiers

- **Motion Control Configuration Software**
  - Configure axes
  - Configure motion I/O
  - Configure digital I/O
  - Tune servo motors with Servo Tune
  - Included with all National Instruments motion controllers

Panel	Available Parameters
Axis Configuration	Axis type settings
	Axis resource and update period
	Encoder settings
	Stepper-specific settings
Axis Settings	Home and limit switch settings
	Software limit settings
	Trigger input settings
	Inhibit output settings
	Position breakpoint settings
Trajectory Settings	Default move settings
	Advanced move settings
Find Reference Setting	Find home settings
	Find index settings
	Find center settings
Digital I/O Settings	I/O port direction
	I/O port polarity
	Output state
Gearing Settings	Gearing mode
	Gearing enable
	Slave settings
ADC Settings	Set ADC range
Encoder Settings	Filter frequency
PWM Settings	Clock frequency
	Duty cycle
Interactive	Interactive 1D
	Interactive 2D
Calibration	Servo Tune

Mechatronics





Physical Prototype