

# Building a Modular Robot **User-Interface**

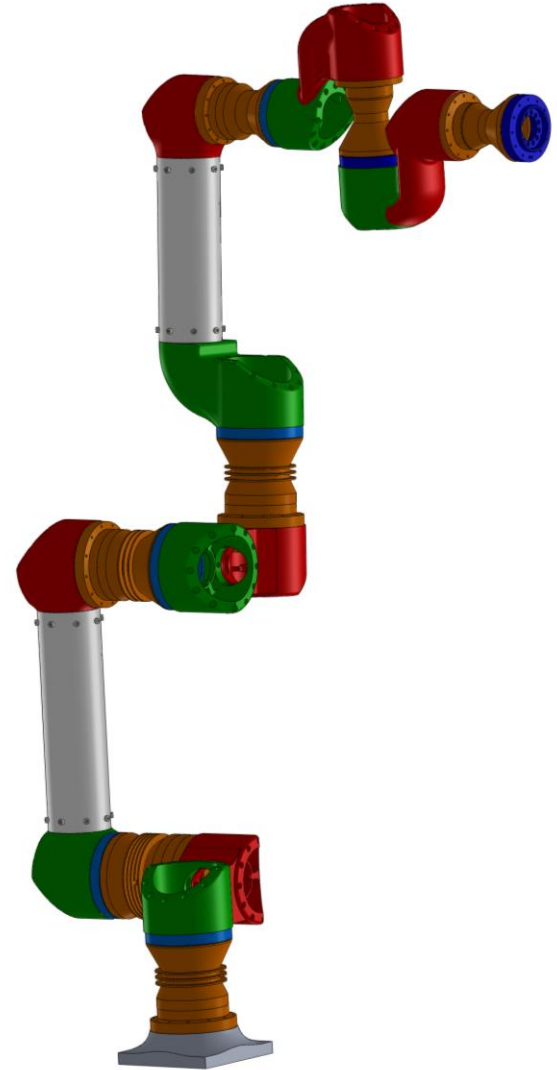
Leonardo Lerchenfeld & Emanuel Buchholz

Situation:

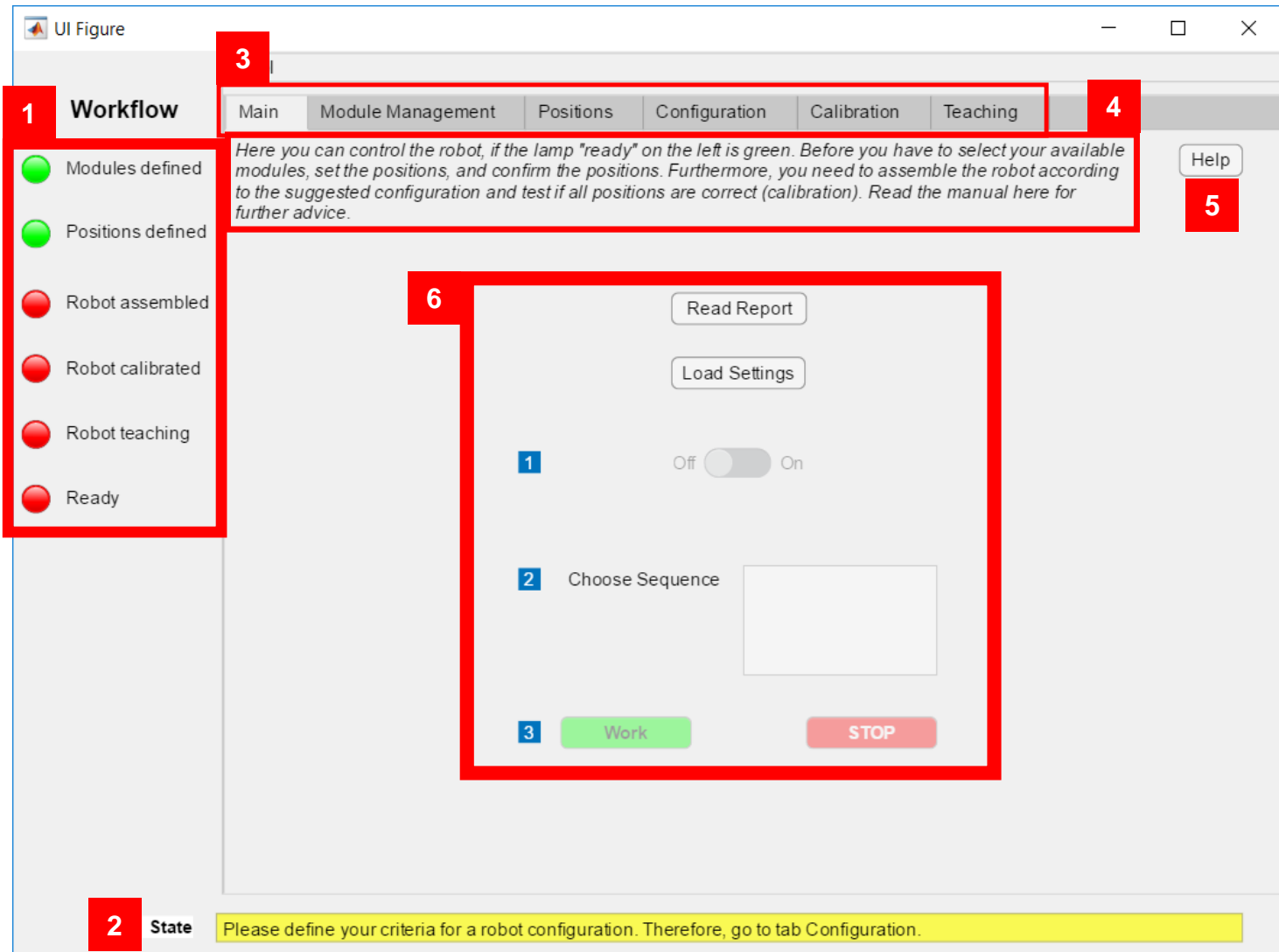
- Flexible productions
- Small companies
- Use without expert knowledge

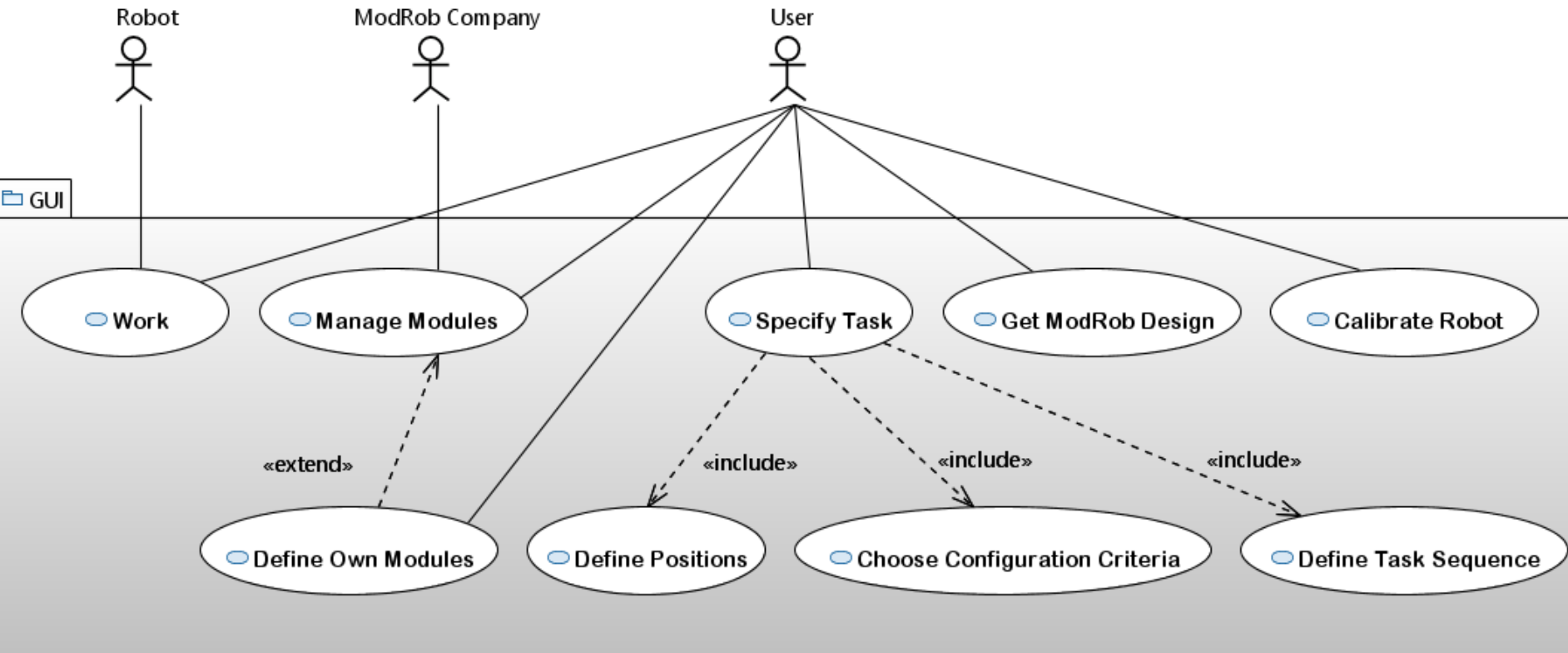
Interface:

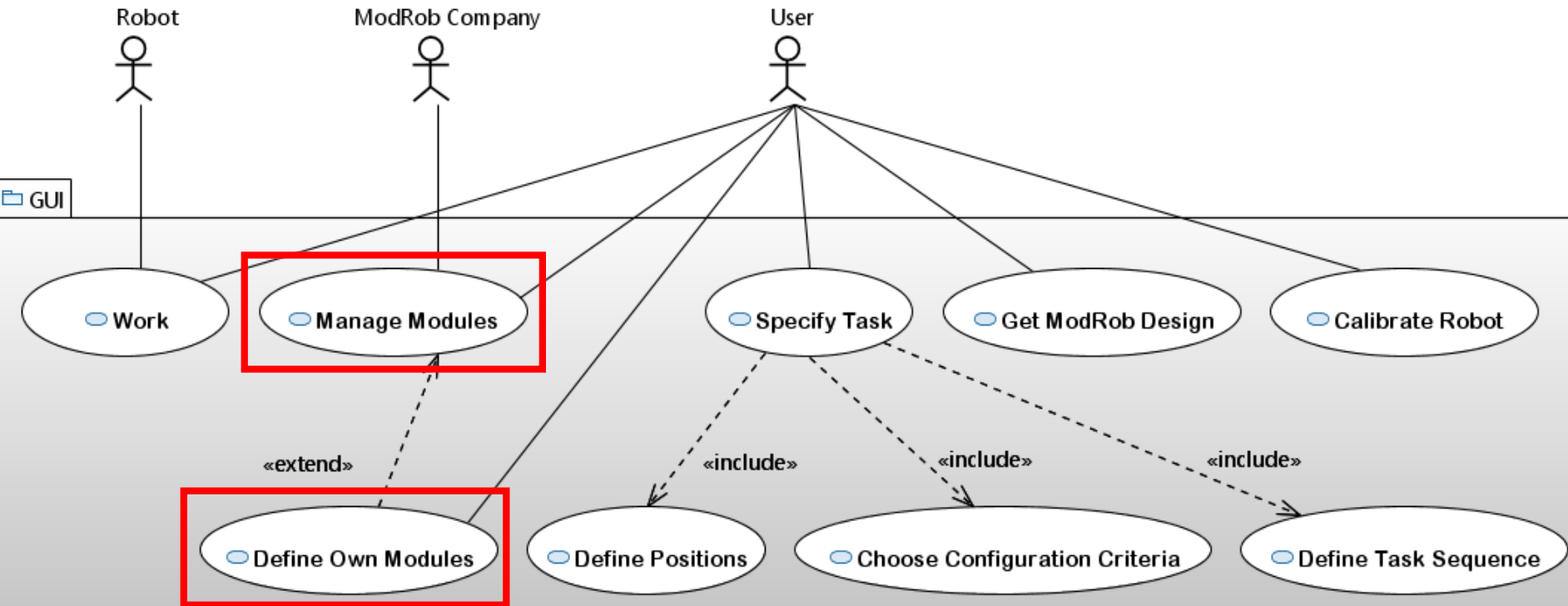
- Structured
- Clear
- Intuitive

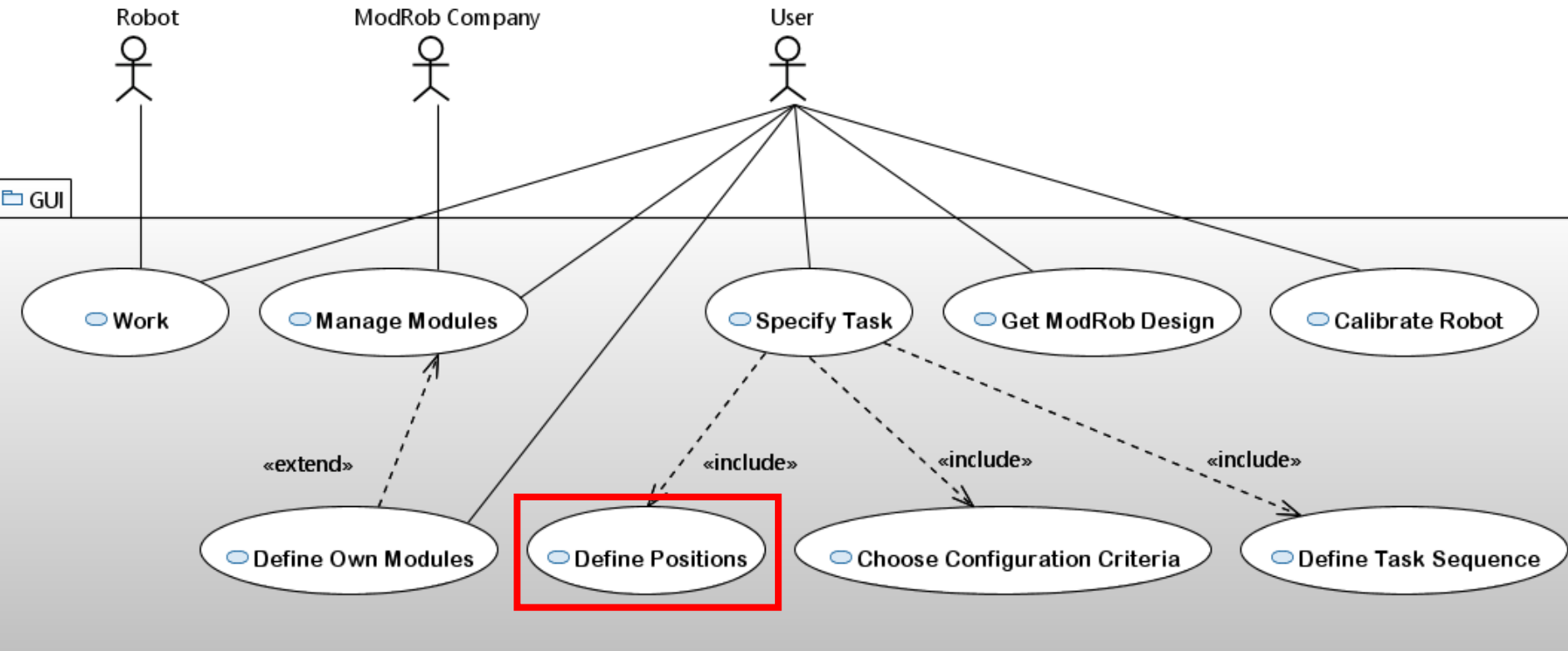


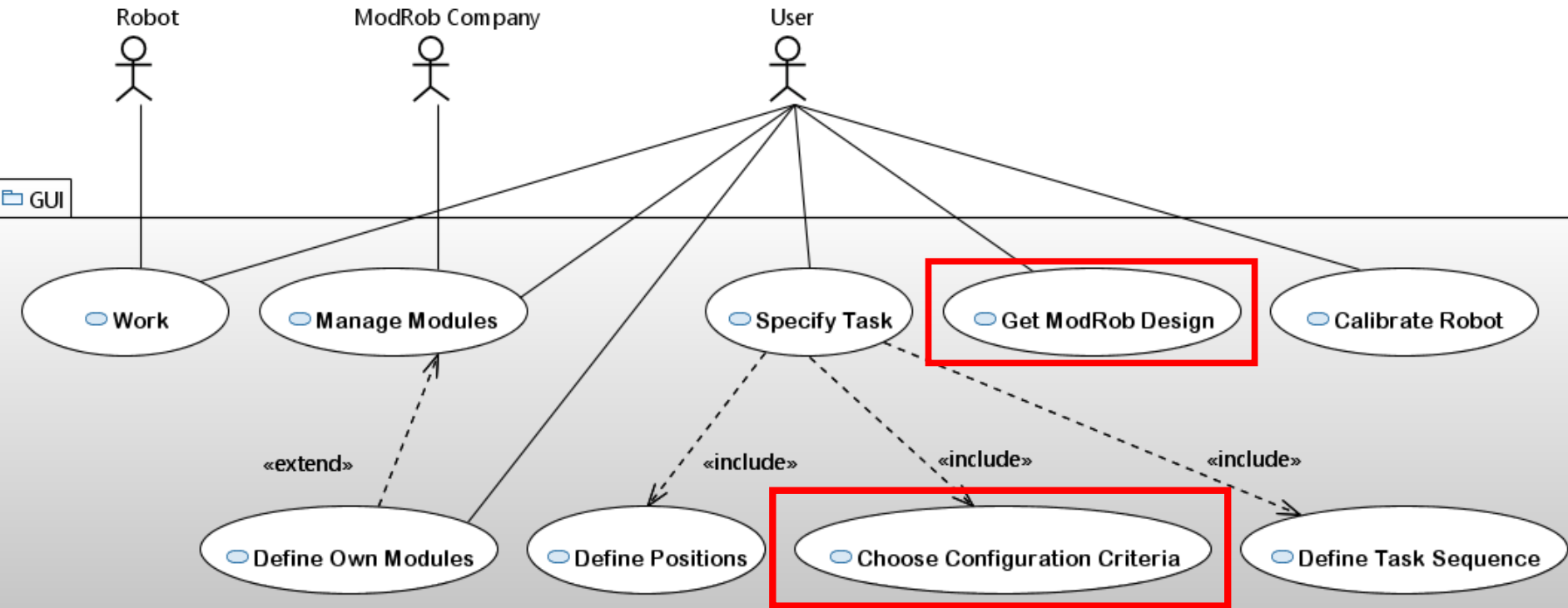
1. General Design of GUI
2. Use-Cases
3. Scenario Analysis
4. Expert Teaching
5. Evaluation
6. Programming Language
7. Further Improvements
8. Conclusions



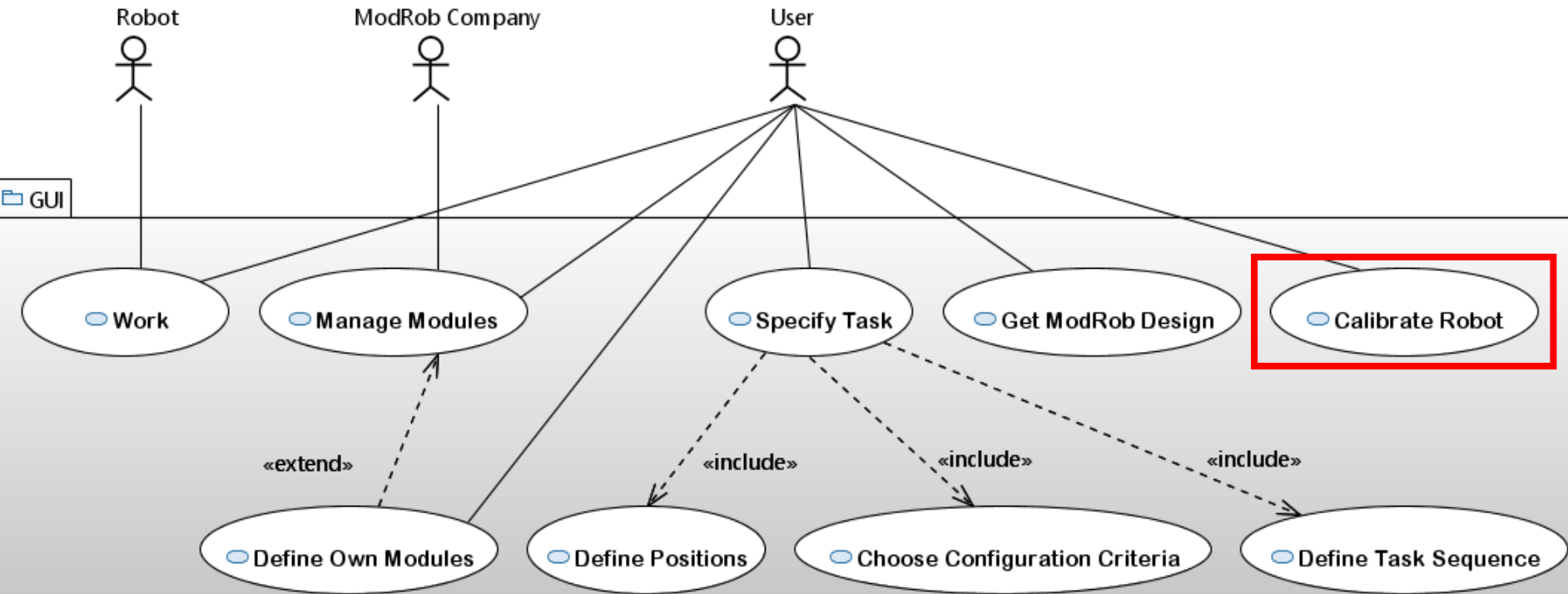


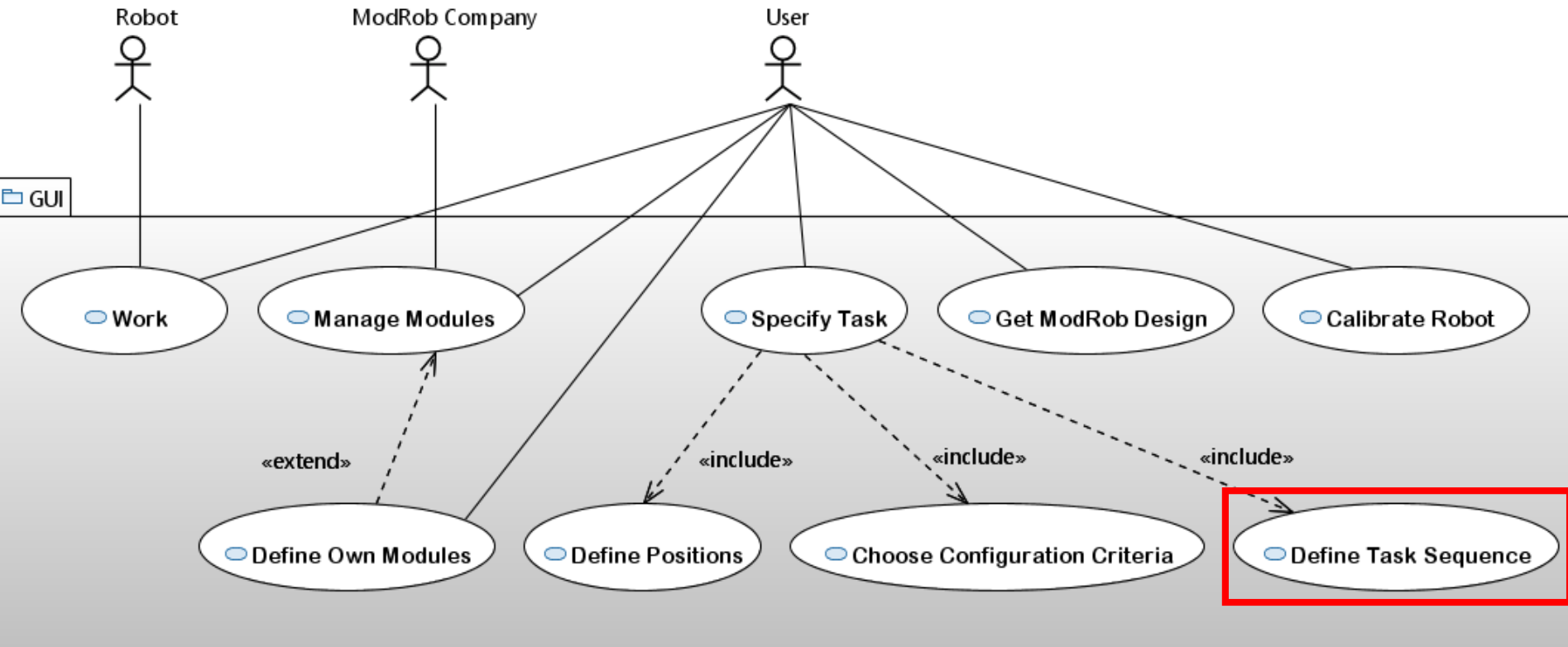


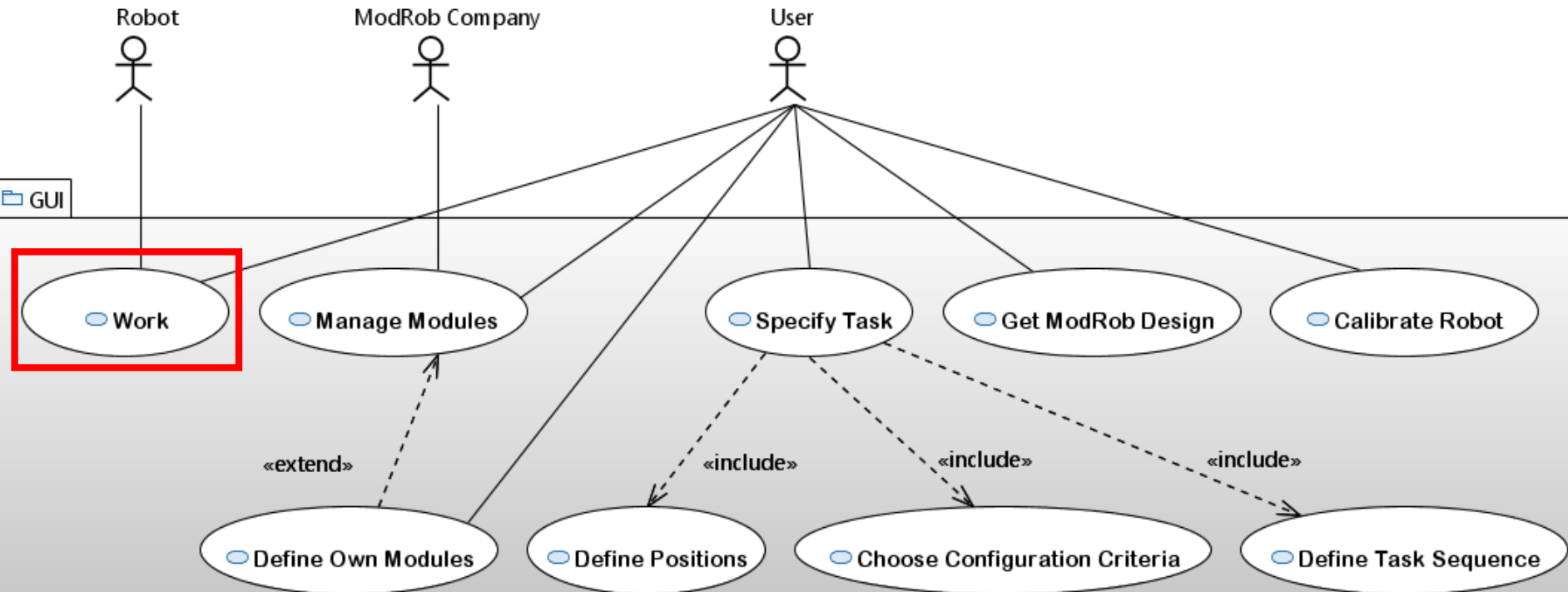


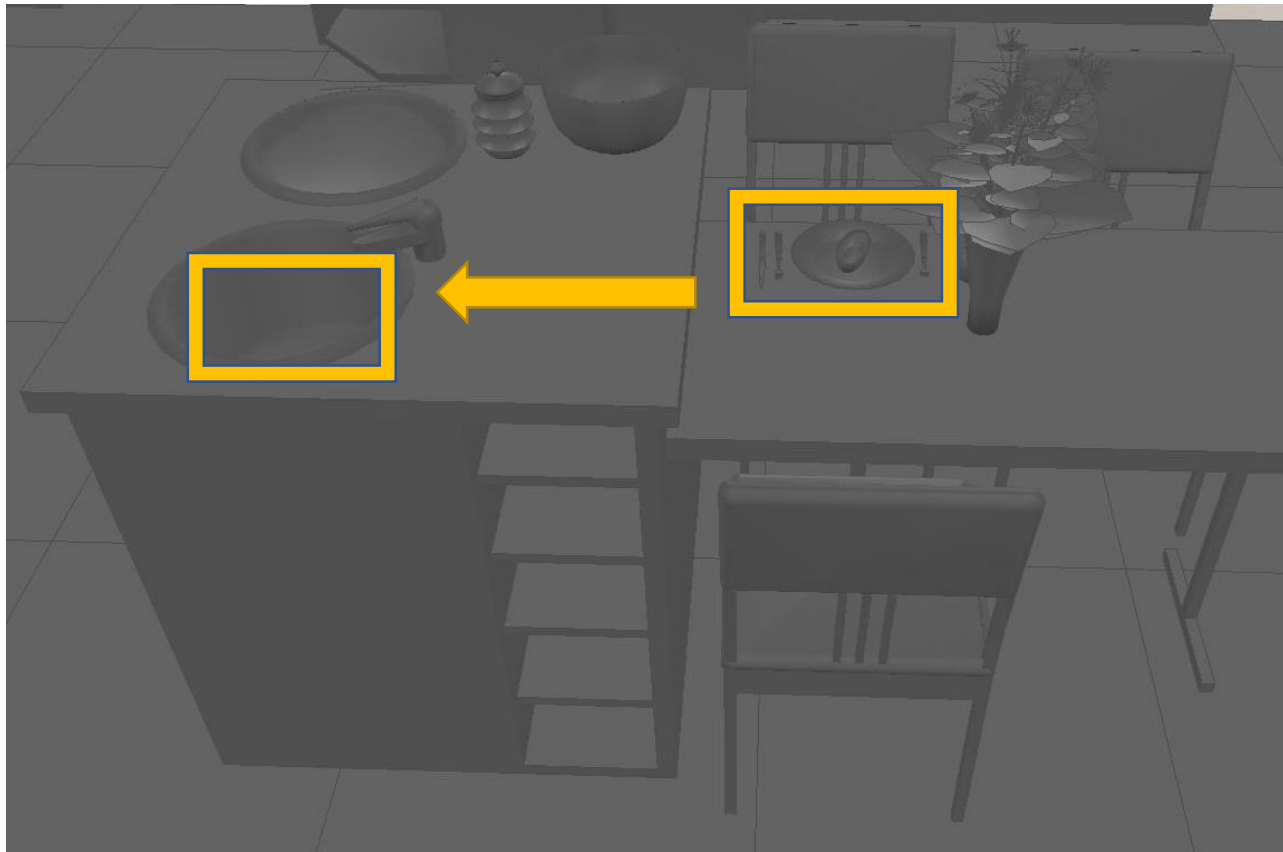










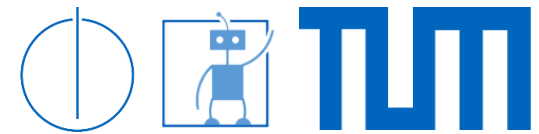


Task: move the dishes from the table to the sink

Description:

- Available joints: XL, L (3), S, XS (2)
- Available links: L\_90\_compact\_LL (2), L\_360\_400\_LL, L\_90L\_400\_LS, L\_wrist3, L\_wrist2
- Own module: endeffector (suitable for dishes)
- Positions: table and sink
- Criteria for robot: Payload: 0.5kg, Monetary: very economic, Task Time: very fast, Assembly: rather keep configuration

# Module Management



Main **Module Management** Positions Configuration Calibration Teaching

Catalog Own Modules

Name  **1** STL  **2**

Link Joint Endeffector Base  **3**

**KinPar**  $\delta_{out}$   rad

a  m  $\alpha$   rad p  m n  m  $\delta_{in}$   rad

**4**

---

**DynPar** **5**

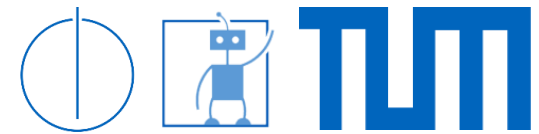
<input type="text" value="0.3"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	rc <input type="text" value="0.05"/> m
<input type="text" value="0"/>	<input type="text" value="0.3"/>	<input type="text" value="0"/>	<input type="text" value="0.05"/> m
<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0.3"/>	<input type="text" value="0.1"/> m

Inertial Tensor I in kg\*m<sup>2</sup>

select or type Actions       **6**

m  kg InputConnectorSize  **7**

# Module Management



Main **Module Management** Positions Configuration Calibration Teaching

Add New Module

Catalog Own Modules

Buyable Modules

- MXL
- ML
- MS
- MXS
- L\_180\_600\_LL
- L\_180\_600\_LS
- L\_180\_600\_SS
- L\_180\_400\_LL
- L\_180\_400\_LS
- L\_180\_400\_SS
- L\_90L\_600\_LL
- L\_90L\_600\_LS
- L\_90L\_600\_SS
- L\_90L\_400\_LL
- L\_90L\_400\_LS**
- L\_90L\_400\_SS
- L\_90S\_600\_LL
- L\_90S\_600\_LS
- L\_90S\_600\_SS

1 **Add to Available Modules** 1

User-defined Modules

SoftGripper

Load User-defined Modules

Remove

Add to Available Modules 3

Available Modules #

B0	1
EE0	1
MXL	1
ML	3
MS	1
MXS	2
L_90_compact...	2
L_360_400_LL	1
L_90L_400_LS	1
L_wrist_2	1
L_wrist_3	1
<b>SoftGripper</b>	1

Remove Reset

2 **Apply** 2

V-REP

Manual

1

Choose Endeffektor

SoftGripper.STL

Explore

1

Choose Obstacles

Kitchen\_WorkCell.stl

Explore

Start Vrep

2

Cartesian Coordinates

X

0

mm

Euler Angles

Roll

0

grad

Rot. around X

Y

0

mm

Yaw

0

grad

Rot. around Y

Z

0

mm

Pitch

0

grad

Rot. around Z

3

confirm

Name

Position Type

Base

Start

End

Confirmed Positions

Add

Remove

Remove

Reset Positions Tab

4

Apply



Main

Module Management

**Positions**

Configuration

Calibration

Teaching



V-REP
Manual

1 Choose Endeffektor  Explore

1 Choose Obstacles  Explore

---

Start Vrep

2

Cartesian Coordinates
Euler Angles

X  mm
Roll  grad Rot around X

Y  mm
Yaw  grad Rot around Y

Z  mm
Pitch  grad Rot around Z

3 confirm 3

---

Name

Position Type

End

Confirmed Positions

Base: Euler(grad):[0 0 0] Cart.(mm)[420 -1200 60]  
Start Euler(grad):[-90 0 -120] Cart.(mm)[600 -580 500]

Add

Remove

Remove

---

Reset Positions Tab

4 Apply 4

Energy Consumption

do not care

Task Time

very fast

Payload

0.5

Kg

Assembly

rather keep configuration

Monetary

very economic

1

Calculate Configuration

1

2

Choose Configuration

Option\_1

Option\_2

2

4

Stop Calculating

Robot Composition

Base

Joint 1

Link 1

Joint 2

Joint 4

Link 3

Joint 3

Link 2

Link 4

Joint 5

Link 5

Joint 6

Joint 8

Link 7

Joint 7

Link 6

Link 8

Joint 9

Link 9

End Effector

B0

ML

L\_90\_compact\_I

MXL

ML

L\_90\_compact\_I

ML

L\_360\_400\_LL

L\_90L\_400\_LS

MS

L\_wrist\_3

MXS

NotDefined

NotDefined

MXS

L\_wrist\_2

NotDefined

NotDefined

NotDefined

SoftGripper

Energy Consumption

medium

Task Time

fast

Max. Payload in Kg

1

Assembly

1

Modules have to be changed

Monetary

Buy

0

New Modules

Assembly Instruction

5

3

Finished Assembly

3

# Connect a Joint to a Link

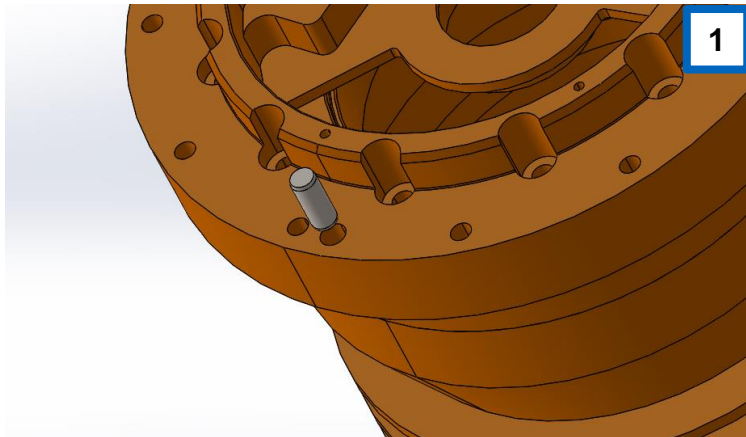
Main   Module Management   Positions   **Configuration**   Calibration   Teaching

## Required Tools:

- Cross-tip screwdriver

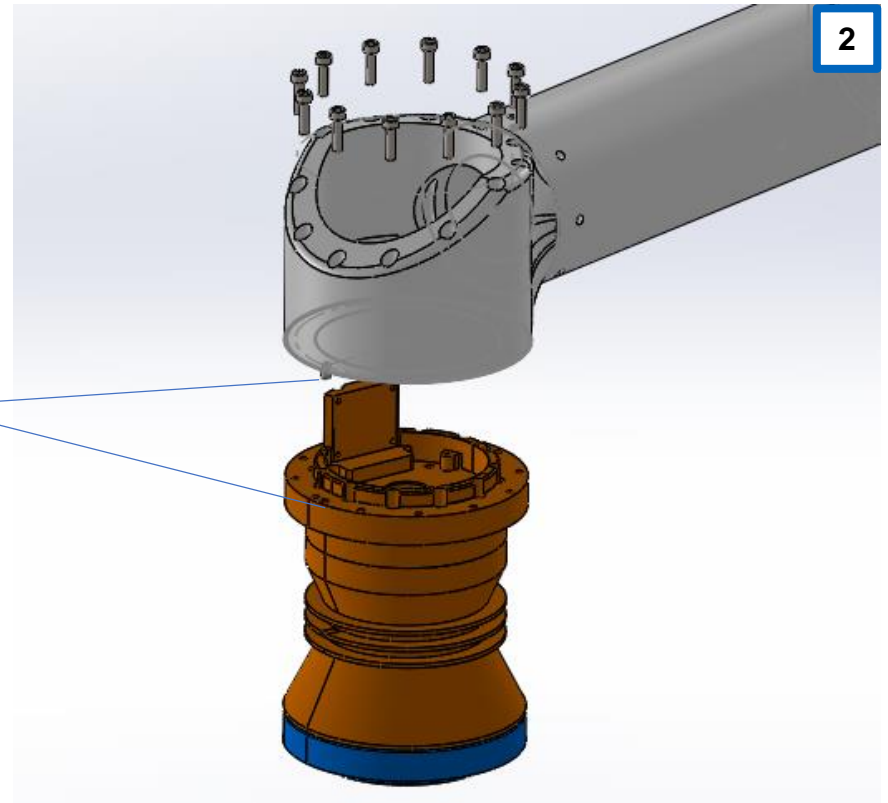
## Step 1:

Orient motor to link such that the adjust pin fits into both parts



## Step 2:

Insert the 12 screws



1

Connect

1

Automatic Move

STOP

Disconnect

---

Task Space

Joint Space

Select Joint

1

2

3

4

Joint Speed

0.31

rad/s

2

Set & Control

2

---

Positions to calibrate

Start

End

Calibrated Positions (This tab)

3

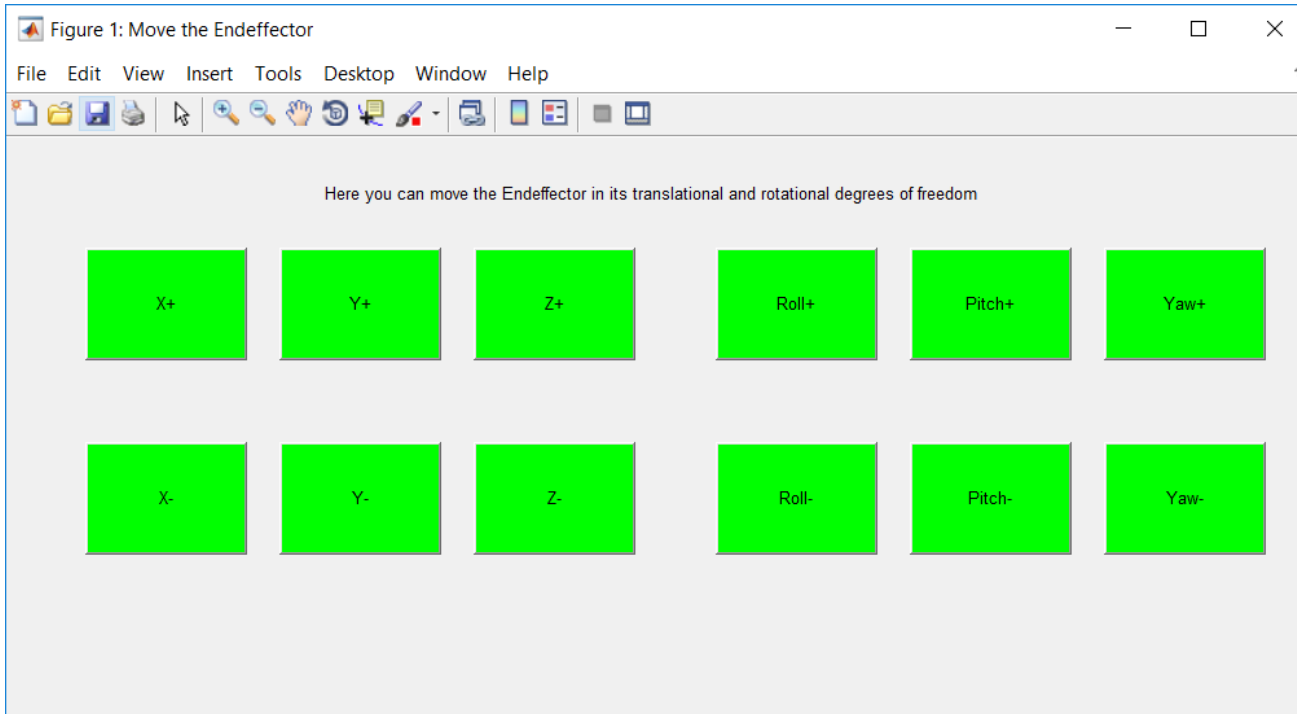
Confirm Calibrated Position

Remove Calibrated Position

---

4

Apply



1

Connect

1

Automatic Move

STOP

Disconnect

Task Space

Joint Space

Select Joint

1

2

3

4

Joint Speed

0.3

rad/s

2

Set & Control

2

Positions to calibrate

End

3

Confirm Calibrated Position

3

Calibrated Positions (This tab)

Start: Position[0.5051 -0.3354 0.6185]

Remove Calibrated Position

4

Apply

4

Type of Movement  
PTP  
LINE  
CIRC

Available Postions  
Start  
End

Gravity Compensation  
On  
Off

Name  
Homing

Available Actions  
Pick  
Place

Wait Time  
0  
seconds

Available Signals  
Robert

Desired Value  
0

1

Add Position

1

Add Action

Add Delay

Add Signal

Sequence

PTP\_Start  
Act\_Pick  
PTP\_End  
Act\_Place

STOP

☐ Expert Mode 0  
Remove  
Reset

2

Follow Sequence

2

Velocity

0.25 m/s

Sequence Name

HomersKitchen

3

Confirm Sequence

3

Defined Sequences

HomersKitchen

Load Sequences  
Remove

4

Apply

4



Read Report

Load Settings

**1****1**

Off ☐ On

**2****2**

Choose Sequence

HomersKitchen

**3****3**

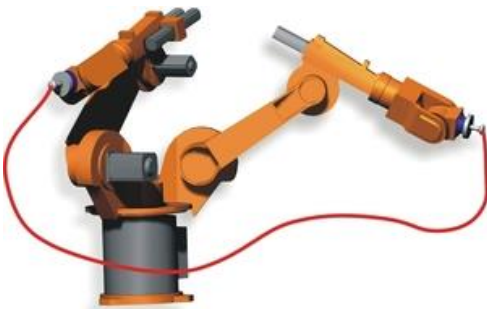
Work

STOP

Homer does not need to move  
and the table will be cleaned



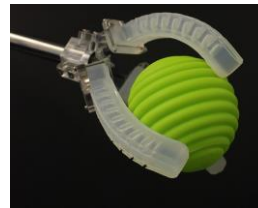
Main	Module Management	Positions	Configuration	Calibration	Teaching
<b>1</b> Type of Movement PTP <b>LINE</b> CIRC	Available Postions Start End	<b>2</b> Gravity Compensation On <input type="checkbox"/> Off <input checked="" type="checkbox"/> Name Driller	<b>3</b> Available Actions Pick <b>Place</b>	<b>4</b> Wait Time 0 seconds	<b>5</b> Available Signals Robert <b>Drill</b> ROBERTa Desired Value drilled Out <input type="checkbox"/> In <input checked="" type="checkbox"/>
<b>1</b> Add Position		Add Action		Add Delay	Add Signal



1



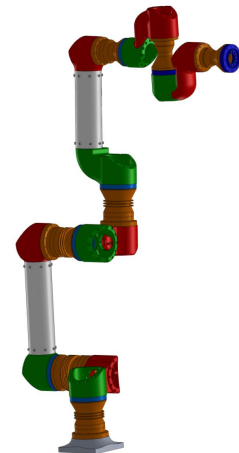
2



3



4



5

## Tests

High-Level

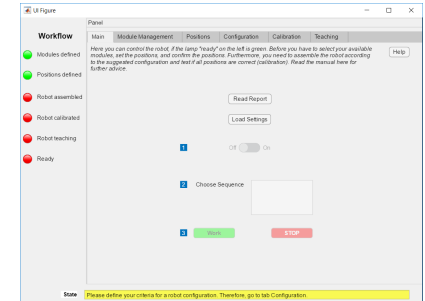
Mid-Level

Low-Level

=

Tab

Button





Define first task  
Define another task

Connection to Robot and Algorithm



Requirements are fulfilled

User-friendliness tested by DLR employee





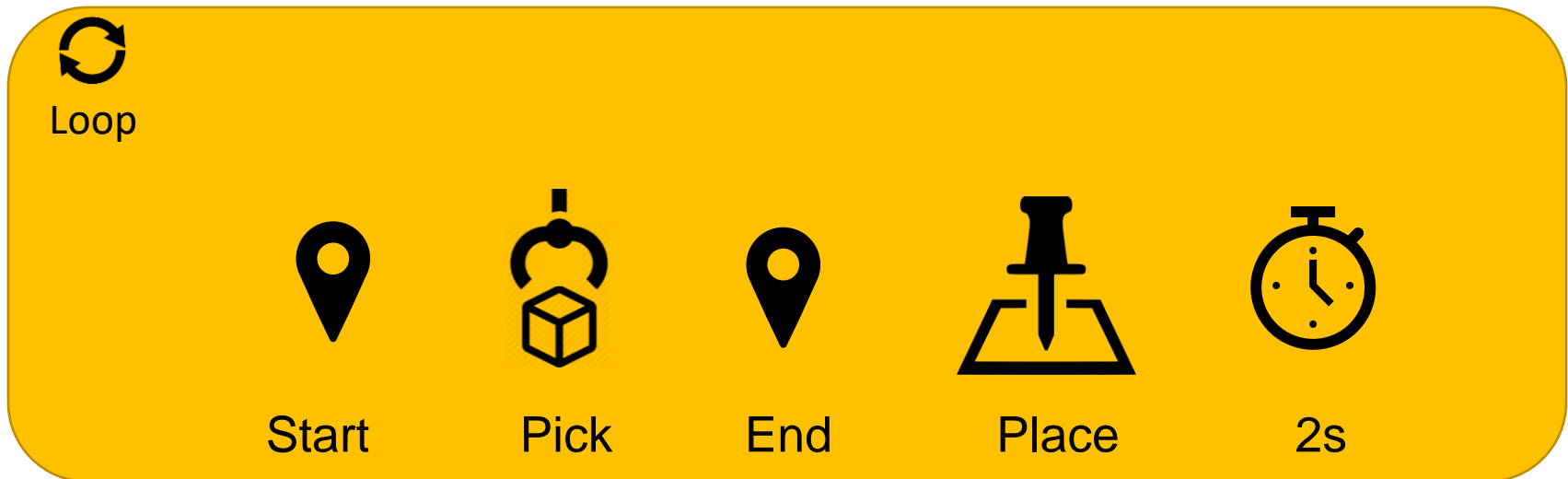
+	-
Academic license	Expensive commercial license
<b>Modular Robot Toolbox</b> in MATLAB	
<b>Simulink Real-Time</b>	Requires Windows
<b>V-REP API</b> for MATLAB	
<b>Appdesigner</b> for graphical user-interface	Recommended for small apps Only basic graphical support

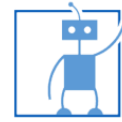


## WEB-BASED

+	-
No licenses required	
Runs on <b>every platform</b> & device	
Advanced <b>graphical</b> support	
	Migrating Modular Robot Toolbox to other programming language is complicated
	Requires API to Simulink Real-time
	Requires API to V-REP

- Highlight current tab
- Teaching: Icons and Drag & Drop





## Requirements:

- + fulfilled all use-cases
- + intuitive guidance through entire menu
- + detailed instructions
- + handles errors
- + provide additional functionalities for expert users

## Outlook: Web-based GUI

- Can be used by every platform and every device
- Supports much more graphics





Thank you for your attention!  
**DEMO!**

Leonardo Lerchenfeld & Emanuel Buchholz

## Slide

- 12: Homer Simpsons - [123RF.com](http://123RF.com)
- 22: Emergency STOP - [reichelt.de](http://reichelt.de)
- 24: Homer Simpsons - [YouTube.com](http://YouTube.com)
- 25: Trajectory - [uni-hannover.de](http://uni-hannover.de)
- 25: Gravity Compensation Mode - [YouTube.com](http://YouTube.com)
- 25: Soft Gripper - [robohub.org](http://robohub.org)
- 25: Drill - [diybook.de](http://diybook.de)
- 28: MATLAB - [hochschule-biberach.de](http://hochschule-biberach.de)
- 29: WEB - [mariokart8.eu](http://mariokart8.eu)
- 30: Pick - [iconfinder.com](http://iconfinder.com)
- 30: Place - [onlinewebfonts.com](http://onlinewebfonts.com)