EICASLAB™ DEMO

The Professional Software Suite
for Automatic Control Design and Forecasting

EICASLAB Demo RT-emb

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excellence and passion in automatic control design
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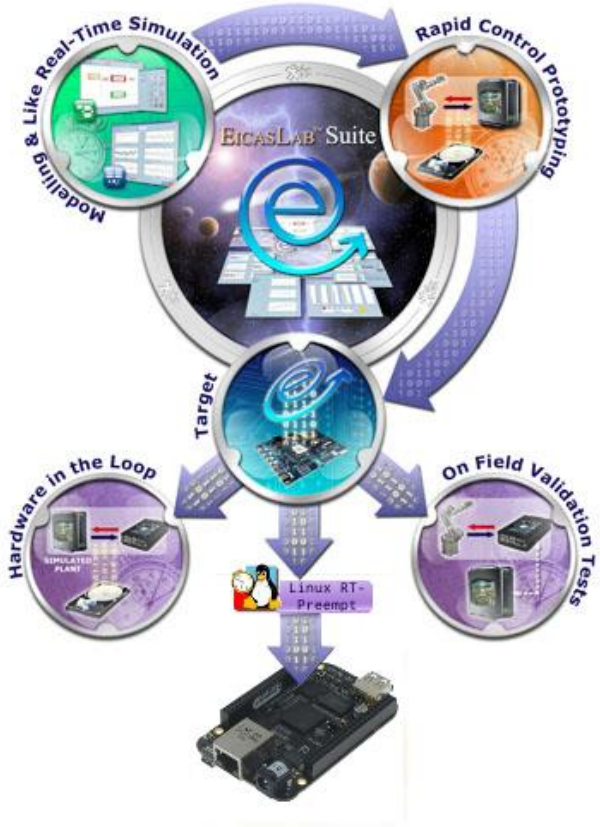
EICASLAB™ Demo RT-emb

Just 1 Software Suite

Just 1 Project

ALL the design phases



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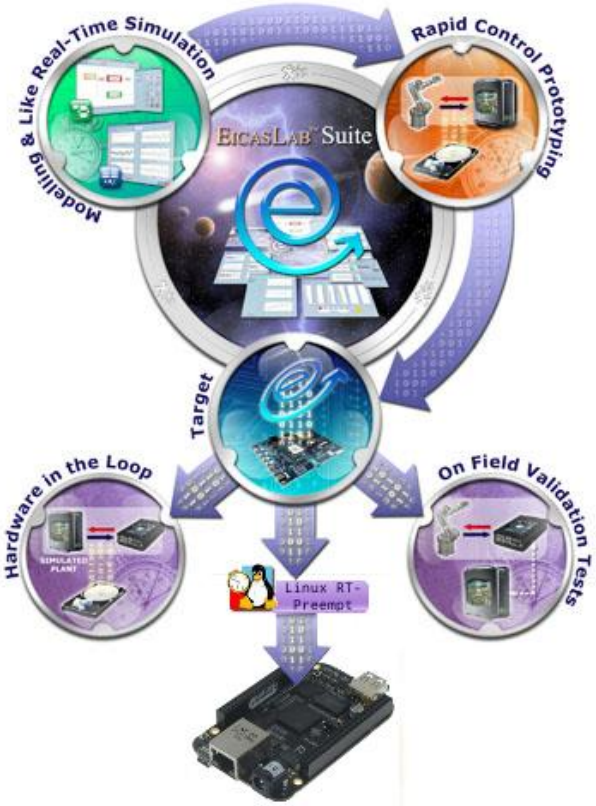
EICASLAB™ Demo RT-emb

The operative modes:

- **Modeling and Like Real-time Simulation**
- **Rapid Control Prototyping** (RCP)
  - RCP On Field sub-mode
  - Slow Motion sub-mode
- **Target**
  - Hardware-in-the-loop (HIL) sub-mode
  - Final Validation Test (FVT) sub-mode



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Summary

Slide contents:

- Overview
- Requirements
- Operative modes
  - Modelling and Like Real-time Simulation
  - Rapid Control Prototyping On Field and Slow Motion
  - Hardware-in-the-loop
  - Final Validation Test
- Further information

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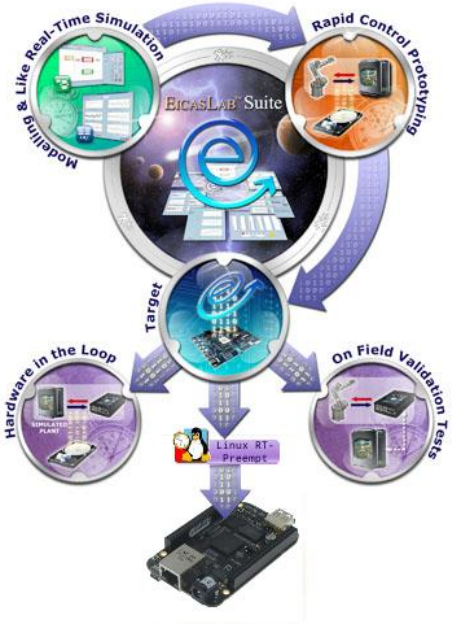
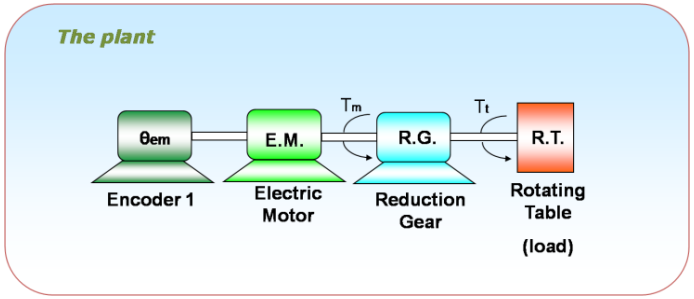
Overview

Example of a **complete control design development**, from the Simulation to the download to Final Target.



The application case is the *rotating table* of the EICASLAB DEMO.



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Overview

RT-emb = **Real-Time** on an **embedded system**

- Focus on the **real-time operative modes**: Rapid Control Prototyping (RCP), Hardware-in-the-loop (HIL) and Final Validation Test (FVT)
- Allows the user to experiment the Target mode **on a popular embedded system** (e.g. Raspberry Pi)

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Overview

The EICASLAB RCP Platform

Standard multi-core PC equipped with a Real-Time Operative System (RTOS) and the EICASLAB Suite

RCP=Rapid Control Prototyping

It is used to run EICASLAB, execute real-time tasks, to cross-compile the code for the embedded board and program it.

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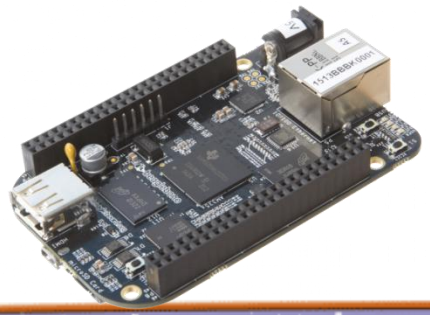
Overview

There are two versions of the RT-emb demo for different hardware devices:

- BeagleBone Black board (BBB) version ,
- Generic Linux Target version (e.g. Raspberry Pi).

Both of them do not require real plant, as RT-PC demo.



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Minimum requirements (PC)

This demo requires real-time performance, therefore it is only available in Linux version.

- Dual core CPU
- 2 GB of RAM
- 1 GB of disk space
- GNU/Linux operative system
- PREEMPT_RT kernel configuration (recommended)
- Networking interface to connect to the target (USB2.0 or Ethernet for BBB, Ethernet or WiFi for other boards)

rt.wiki.kernel.org

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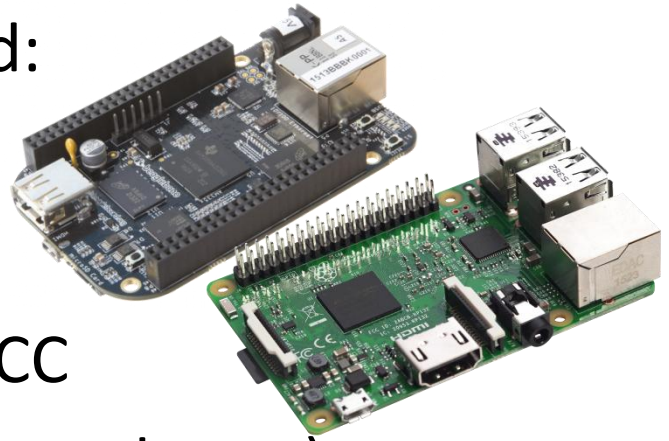
Minimum requirements (embedded)

Requirements for the embedded board:



- 512 MB of RAM
- 100 MB of storage space
- GNU/Linux operative system with GCC
- PREEMPT_RT kernel configuration (mandatory)
- Networking interface to connect to PC, SSH server

The demo was tested on **BeagleBone Black** and **Raspberry Pi 3**.

For further information and how-to: read demo user manual, or mail to support@eicaslab.com

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Minimum requirements (projects)

The EICASLAB Demo RT-PC includes **three** projects in the DEMO menu of the MASTER tool:

- the first with the pre-designed control algorithm by EicasLab Automatic Algorithm Generation (**AAG**)
- the second with an empty control where the **user** can program his own algorithm
- the third is a "**real-time plant emulator**" which is used in a second instance of the demo program during Rapid Control Prototyping and Final Validation Test trials, as explained in the following.

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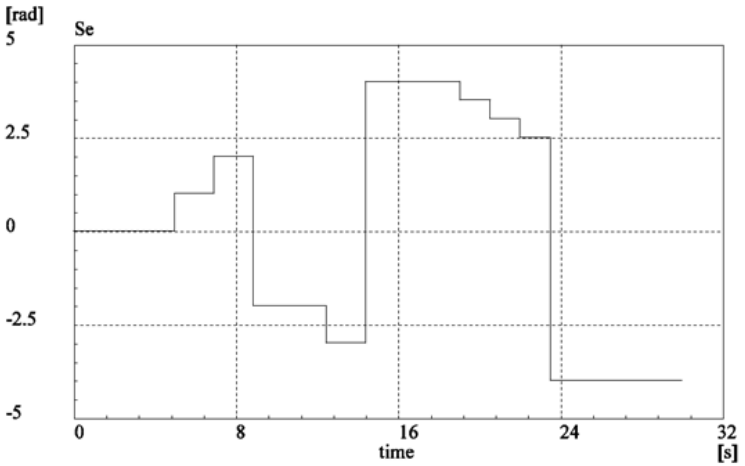
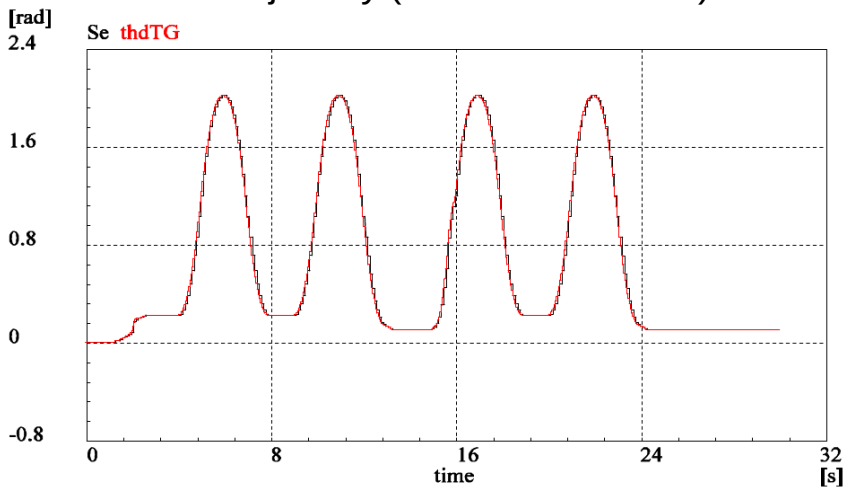
The control objective

- **Impose** the **desired trajectory** to a **rotating table**
- Actuator: electric motor acting on the rotating table
- Sensor: one **encoder** measuring motor angle



Desired angle (POINT-TO-POINT mode)

Desired trajectory (TRACKING mode)



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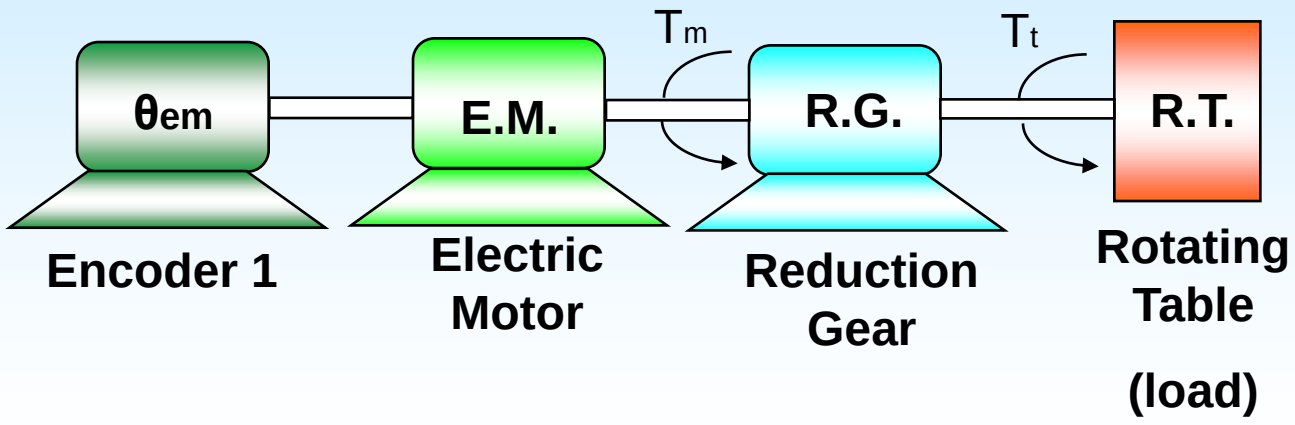
Rotating Table Physical Model

The plant



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Modelling and Like Real-time Simulation

The **Modelling and Like Real-time Simulation mode** allows the user to design and test the control algorithm and simulate the Rotating Table response to its commands.

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Modelling and Like Real-time Simulation

The main M&LRTS mode purposes are:

- to model the plant
- to run and to validate the model
- to design the control algorithm
- to run and to validate the algorithm against the simulated plant

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Modelling and Like Real-time Simulation

Who does what in Modeling and Like Real-time Simulation operative mode in RT-emb demo:

HW	**EICASLAB RCP Platform**	**Embedded board target**	**Rotating Table emulator**
SW	**run control logic** **simulate the plant**	**unused**	**unused**

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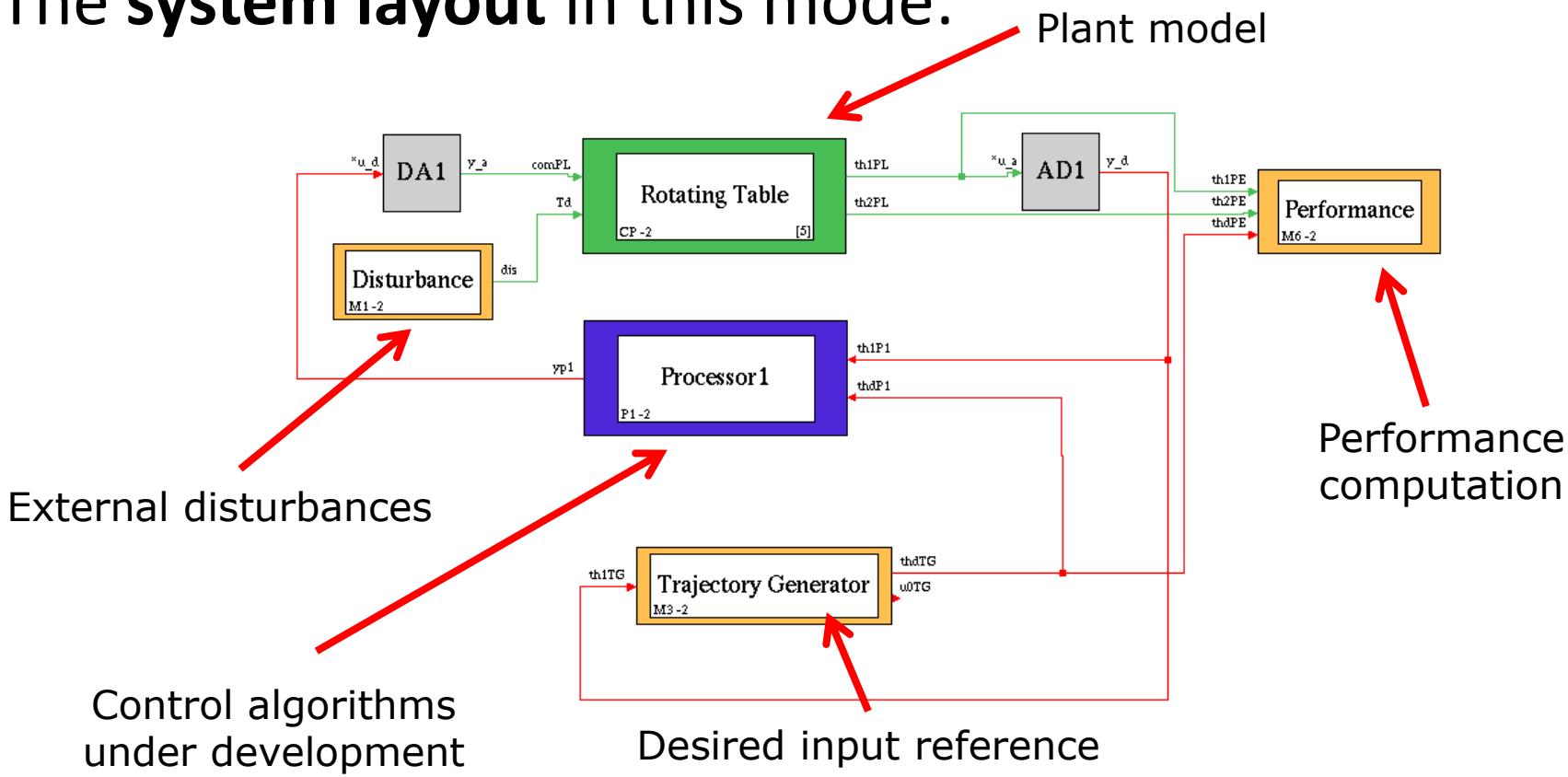
Modelling and Like Real-time Simulation

The **system layout** in this mode:



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Modelling and Like Real-time Simulation

The **SIM tool** allows the user to control the execution of simulation trials, providing diagrams, editing of run-time parameters and storage of data for post–analysis with the **POST tool**.

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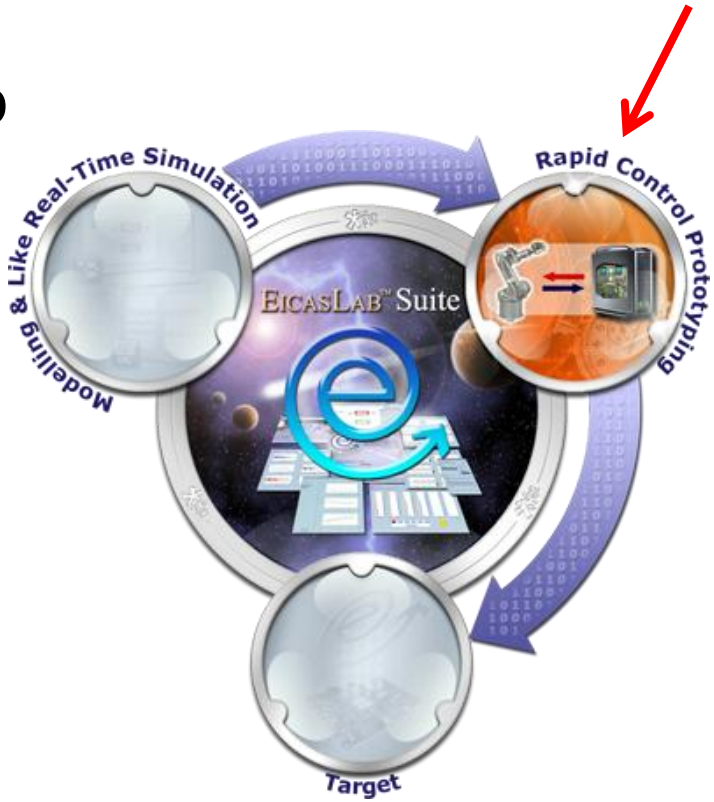
Rapid Control Prototyping

The **Rapid Control Prototyping operative mode** allows the user to test the control algorithm under development directly on the **real plant** using the advanced (and comfortable) analysis, debug and recording tools available on the EICASLAB RCP Platform.
It includes two operative sub-mode: **RCP On Field** and **Slow Motion**.



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Rapid Control Prototyping

The main RCP operative mode purposes are:

- to run and validate the algorithm against the **real** plant
- to monitor, record and tune real physical quantities and parameters
- to use debug and slow motion tools provided by the **EICASLAB RCP Platform**

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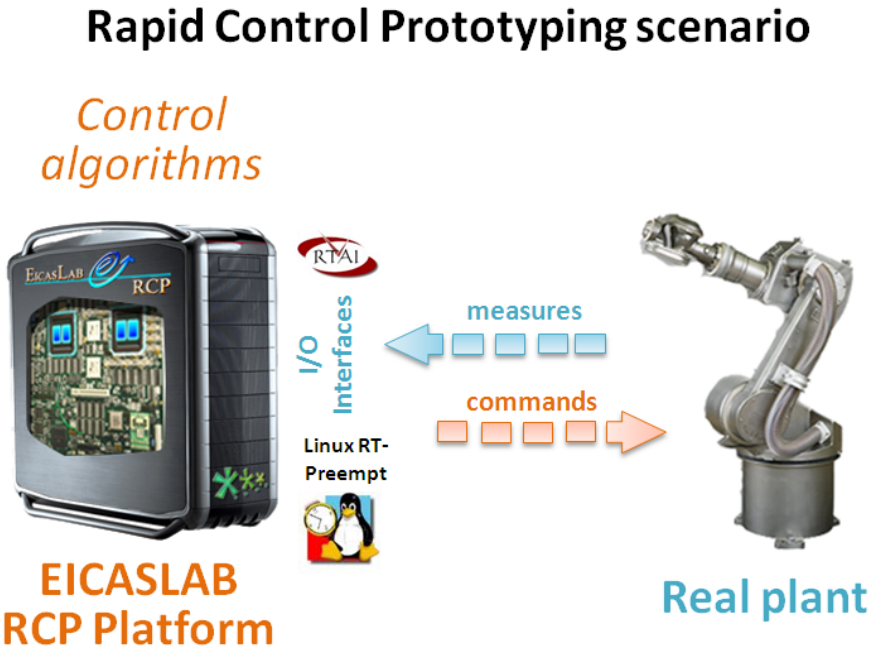
RCP On Field

In **RCP On Field** operative sub-mode, EICASLAB runs the control as a real-time application, interfacing with the **real plant** through a set of I/O interfaces, created by EICASLAB Automatic Code Generation (ACG).



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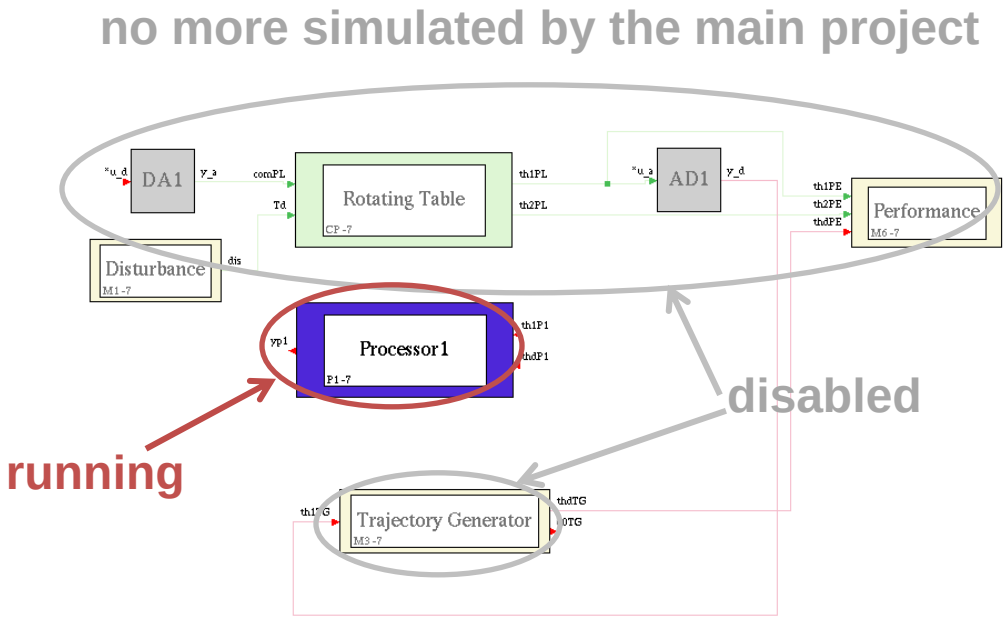
RCP On Field

The **project layout** in this sub-mode:



The System Layout of the Rotating Table project in RCP shows that all blocks except the *Processor* are **disabled**.

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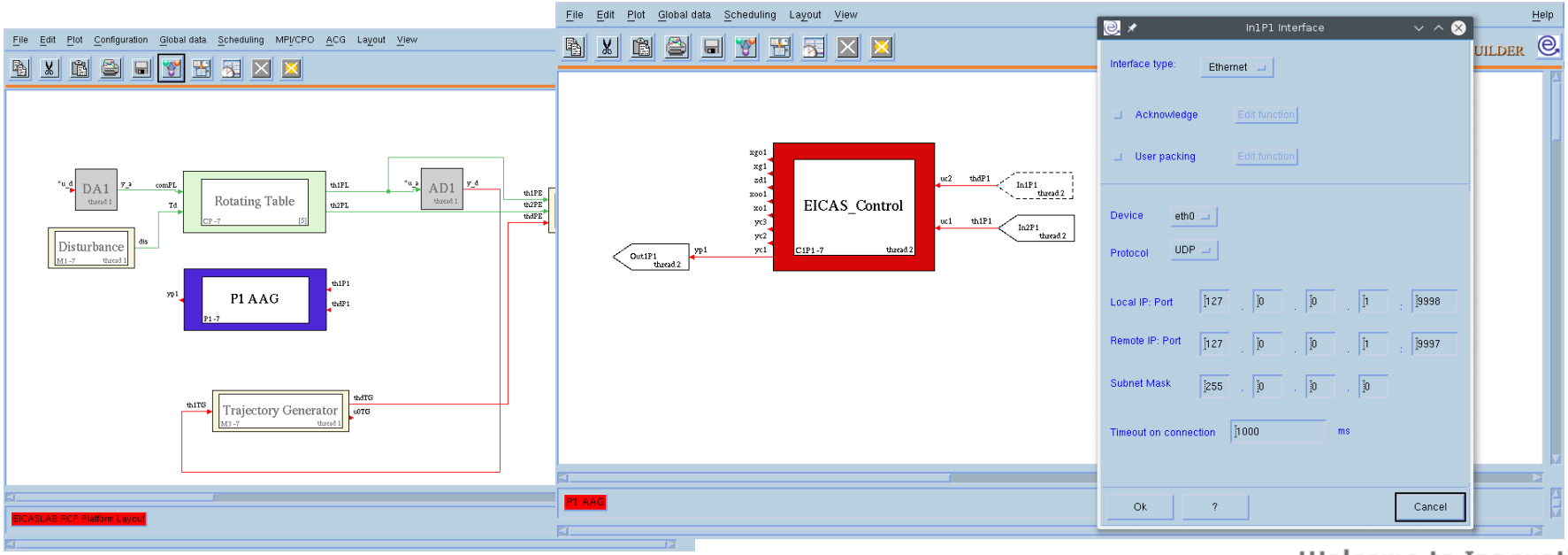
RCP On Field

In this demo, the user can explore the system layout, its pre-defined configuration and the set of parameters for the RCP trial, then generate the real-time application.



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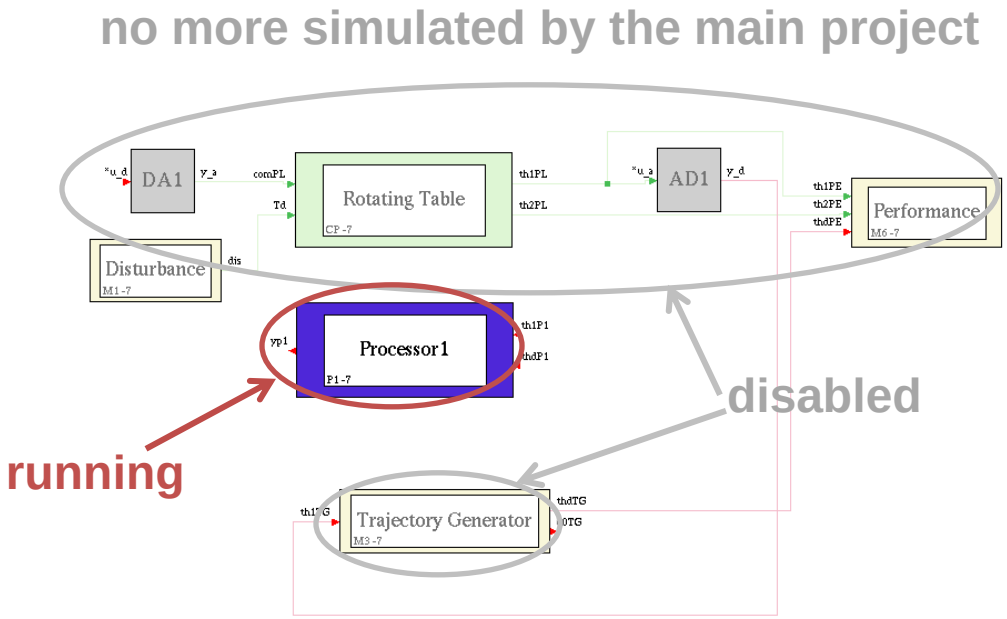
RCP On Field

The **project layout** in this sub-mode:



Since the real rotating table is not available and we must close the loop, it will be simulated by using a separate project as real-time emulator.

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RCP On Field

Who does what in RCP On Field operative sub-mode in RT-emb demo:

HW	**EICASLAB RCP Platform**	**Embedded board target**	**Rotating Table emulator**
SW	**run control logic**	**unused**	**simulated by second project**

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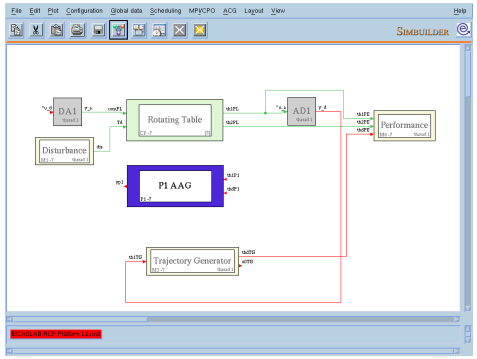
RCP On Field

The two projects in two EICASLAB instances

Linux PC

Main project in RCP



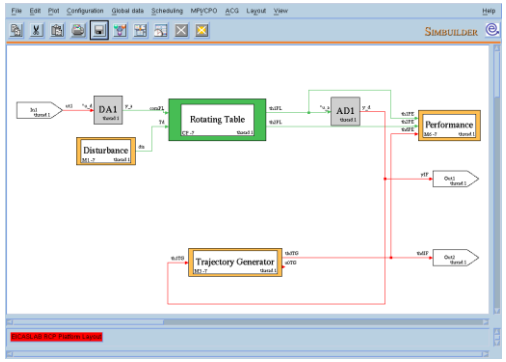
EICASLAB™ Demo #1

real-time communication on local interface

commands

measures

Plant emulator in RCP



EICASLAB™ Demo #2

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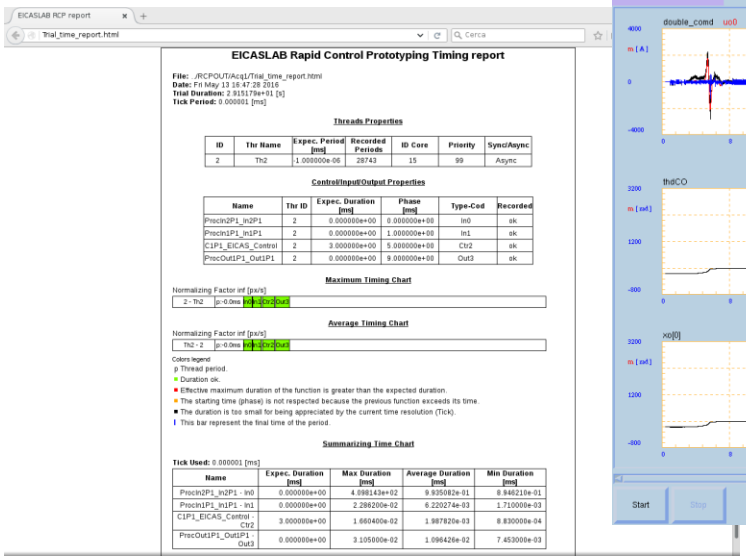
RCP On Field

The **RCP Manager tool** includes a GUI for controlling the execution of the real-time program and providing timing diagrams, performance reports and other functions.



EICASLAB Rapid Control Prototyping Timing report

File: ./RCPOUT/Acq1/Trial_time_report.html
Date: Fri May 13 16:47:28 2016
Trial Duration: 2.915179e+01 [s]
Tick Period: 0.000001 [ms]

Threads Properties

ID	Thr Name	Expec. Period [ms]	Recorded Periods	ID Core	Priority	Sync/Async
2	Th2	1.000000e-06	28743	15	99	Async

Control/Input/Output Properties

Name	Thr ID	Expec. Duration [ms]	Phase [ms]	Type-Cod	Recorded
ProcIn2P1_In2P1	2	0.000000e+00	0.000000e+00	In0	ok
ProcIn1P1_In1P1	2	0.000000e+00	1.000000e+00	In1	ok
C1P1_EICAS_Control	2	3.000000e+00	5.000000e+00	Ctr2	ok
ProcOut1P1_Out1P1	2	0.000000e+00	9.000000e+00	Out3	ok

Maximum Timing Chart

Normalizing Factor inf [px/s]

Average Timing Chart

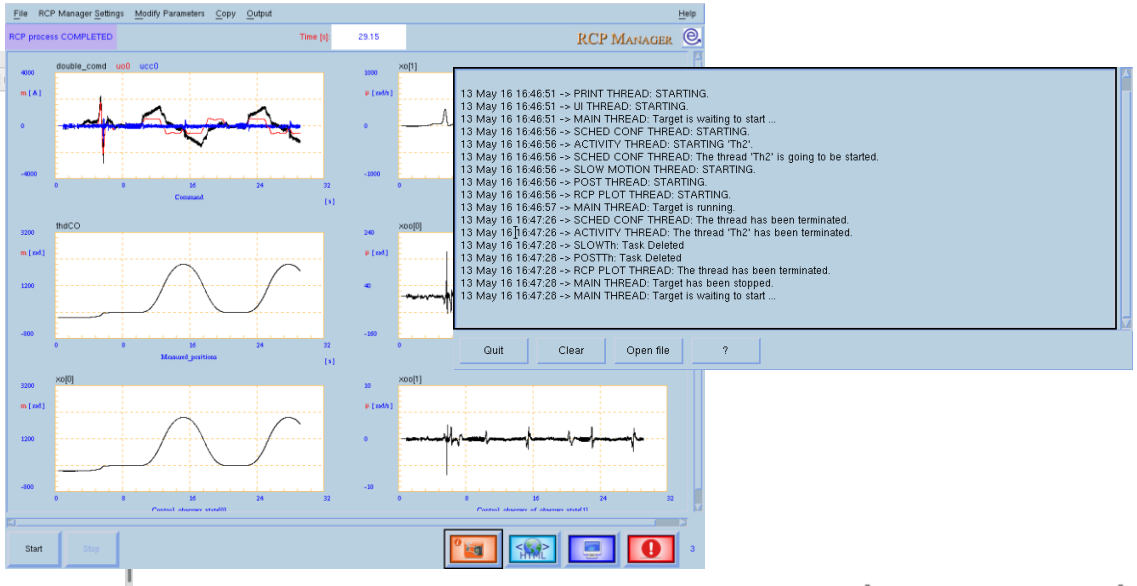
Normalizing Factor inf [px/s]

Colors legend
- Thread period.
- Duration ok.
- Effective maximum duration of the function is greater than the expected duration.
- The starting time (phase) is not respected because the previous function exceeds its time.
- The duration is too small for being appreciated by the current time resolution (Tick).
- This bar represent the final time of the period.

Summarizing Time Chart

Tick Used: 0.000001 [ms]

Name	Expec. Duration [ms]	Max Duration [ms]	Average Duration [ms]	Min Duration [ms]
ProcIn2P1_In2P1 - In0	0.000000e+00	4.098143e+02	9.935082e-01	8.946210e-01
ProcIn1P1_In1P1 - In1	0.000000e+00	2.286200e-02	6.220274e-03	1.710000e-03
C1P1_EICAS_Control - Ctr2	3.000000e+00	1.660400e-02	1.987820e-03	8.830000e-04
ProcOut1P1_Out1P1 - Out3	0.000000e+00	3.105000e-02	1.096426e-02	7.453000e-03



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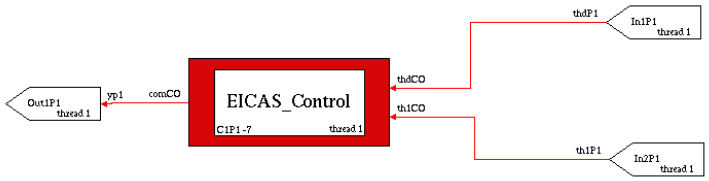
RCP On Field

RCP Manager

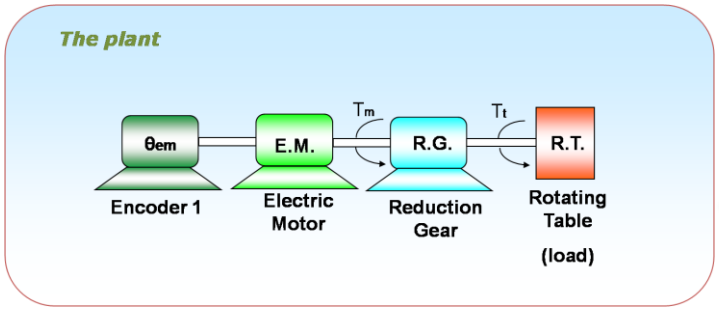
Run-time parameters and data recording

EICASLAB RCP Platform



Motor command on Eth-UDP

Plant



Position Measure on Eth-UDP

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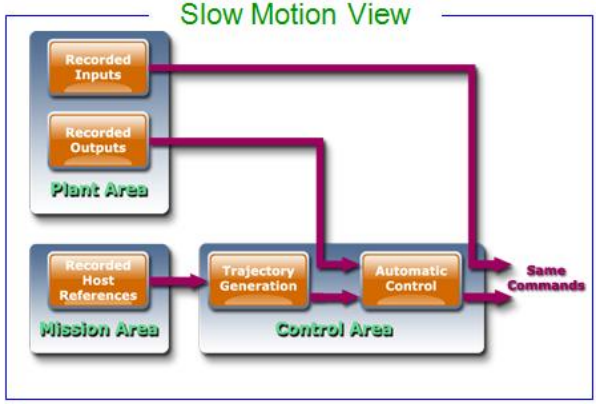
Slow Motion

The **Slow Motion operative sub-mode** is an offline **replay** of the algorithm execution, using data recorded during the previous RCP trials.

SLOW MOTION TOOL



Repeat the trial as a MOVIOLA with EICASLAB™

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Slow Motion

Who does what in Slow Motion operative sub-mode in RT-emb demo:

HW	**EICASLAB RCP Platform**	**Embedded board target**	**Rotating Table emulator**
SW	**run control logic**	**unused**	**unused**

simulated plant from recorded data

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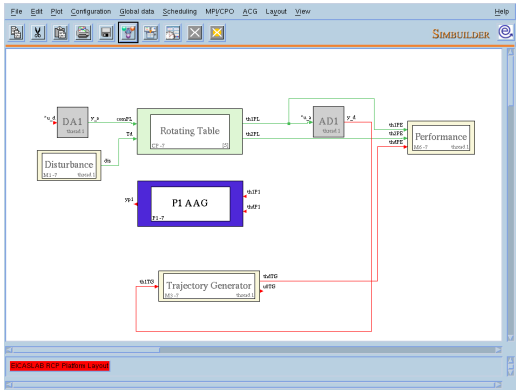
Slow Motion

The **Slow Motion tool** includes a GUI for managing the execution of the replay of trials recorded on field, providing timing diagrams and other functions.

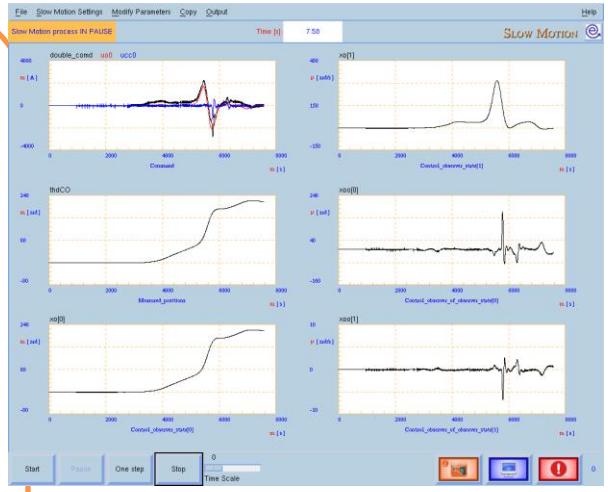
Main project in Slow Motion



Execution replay of control algorithms

measures

Previous acquisition



offline analysis, tuning

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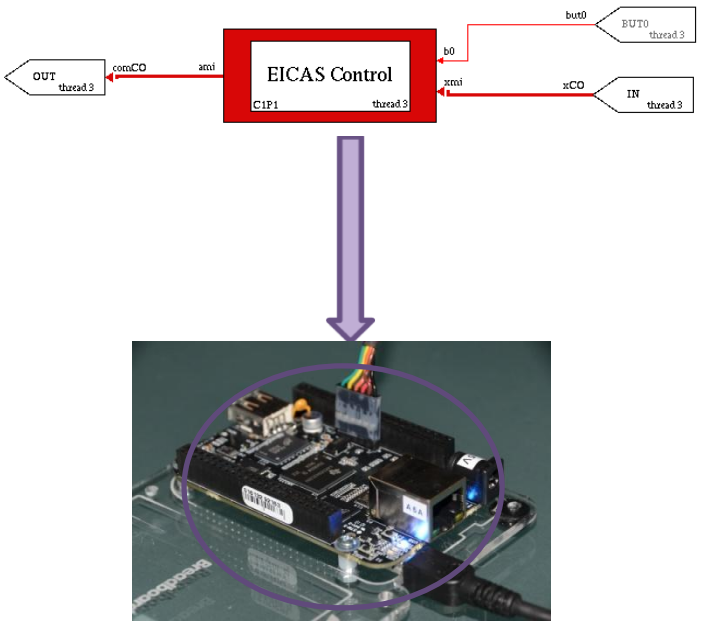
Target

The **Target operative mode** allows the user to export the control algorithm to the **final hardware device** that will execute it to control first the simulated plant in Hardware-in-the-loop and then the real plant in Final Validation Test sub-modes.



Embedded board (target)

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Target

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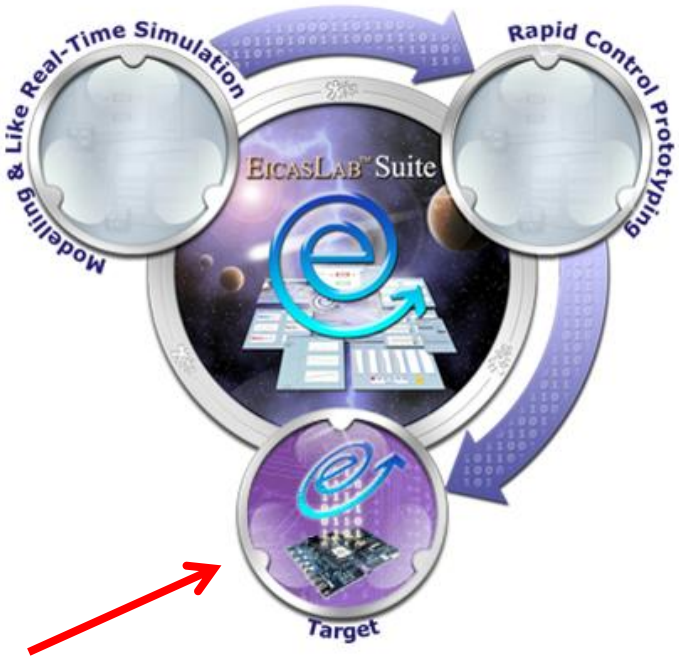

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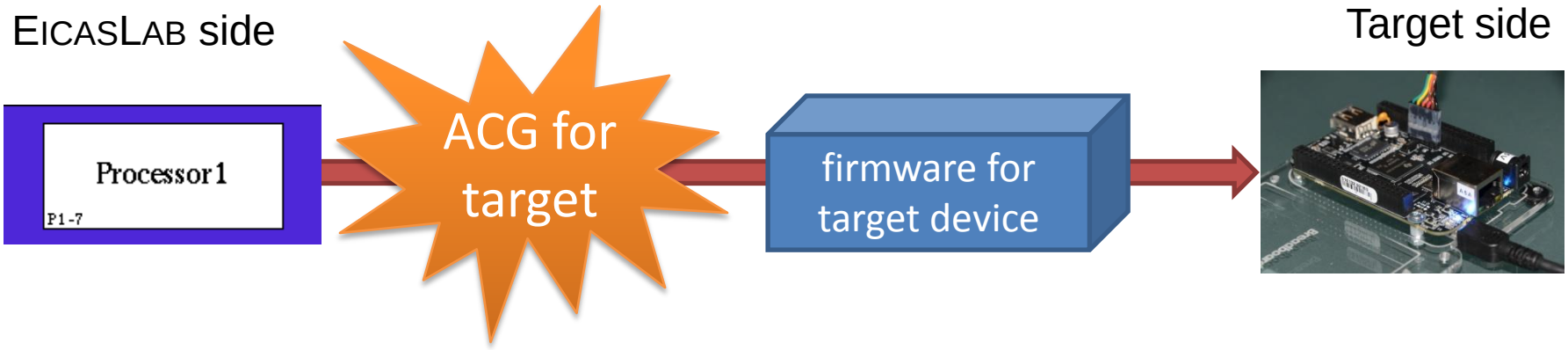
Target

EICASLAB provides the routines to generate the *Basic Software,* not only for the EICASLAB RCP Platform itself, but also for a family of devices or for a specific hardware architecture.

ACG means *Automatic Code Generation*



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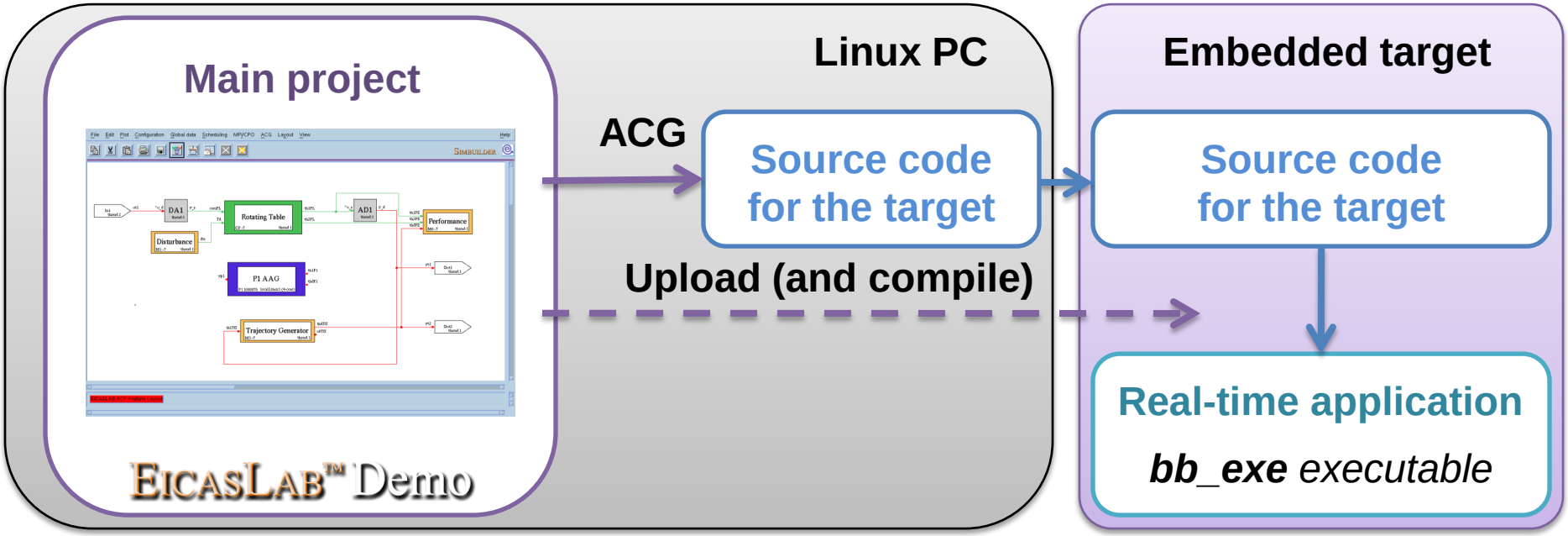
Target

This demo is designed to show EICASLAB in action on an external embedded systems: the ACG output is automatically transferred on it using SSH and compiled by GCC.



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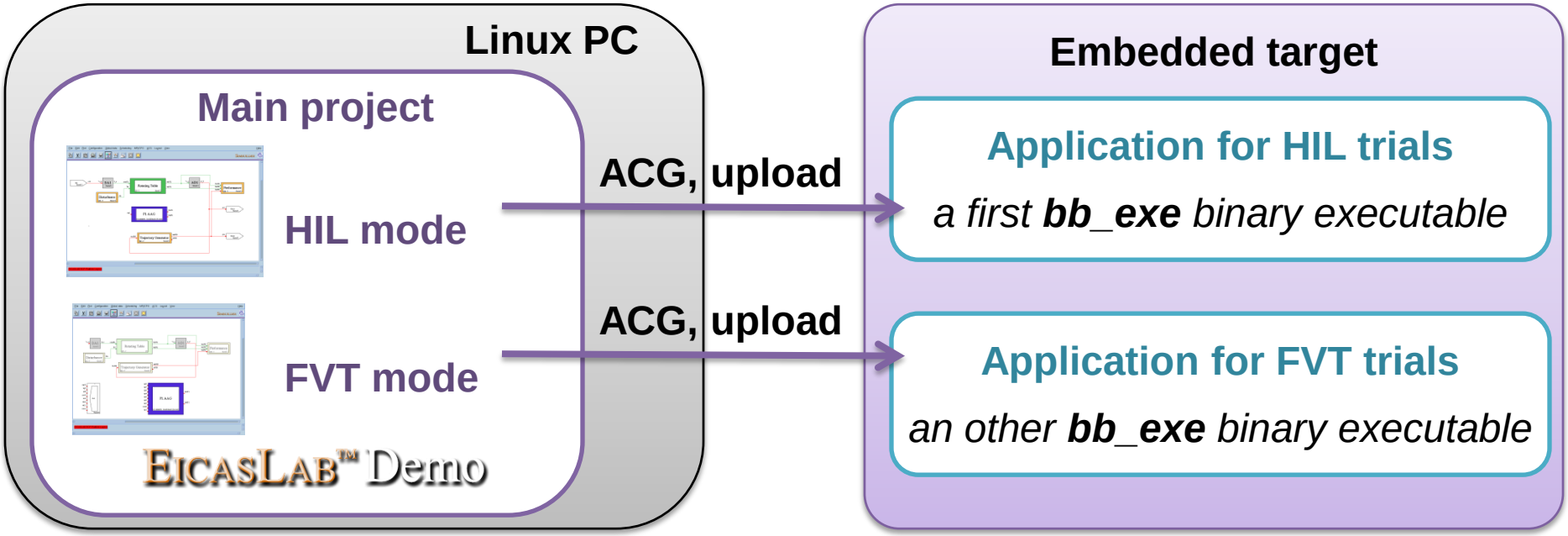
Target

This demo includes HIL and FVT operative modes, so the ACG for target is repeated twice to build two different real-time applications on the remote embedded target.



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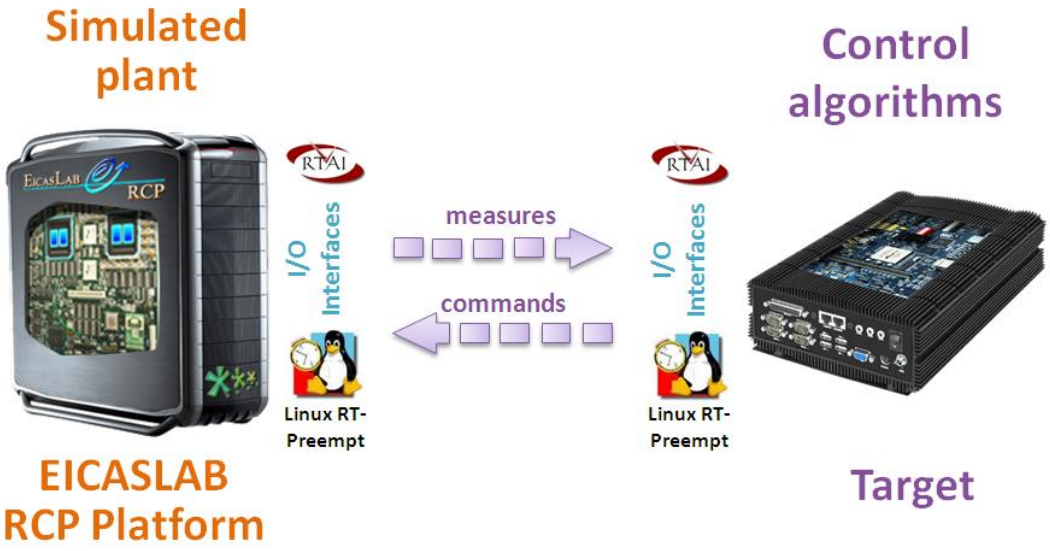
Hardware-in-the-loop

The **Hardware-in-the-loop operative sub-mode** allows to test the control algorithm **execution on the target** hardware against a **simulated plant** executed in real time on the **EICASLAB RCP Platform**.



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Hardware-in-the-loop

Who does what in Hardware-in-the-loop operative sub-mode in RT-emb demo:

HW	**EICASLAB RCP Platform**	**Embedded board target**	**Rotating Table emulator**
SW	**simulates plant**	**runs control logic**	**unused**

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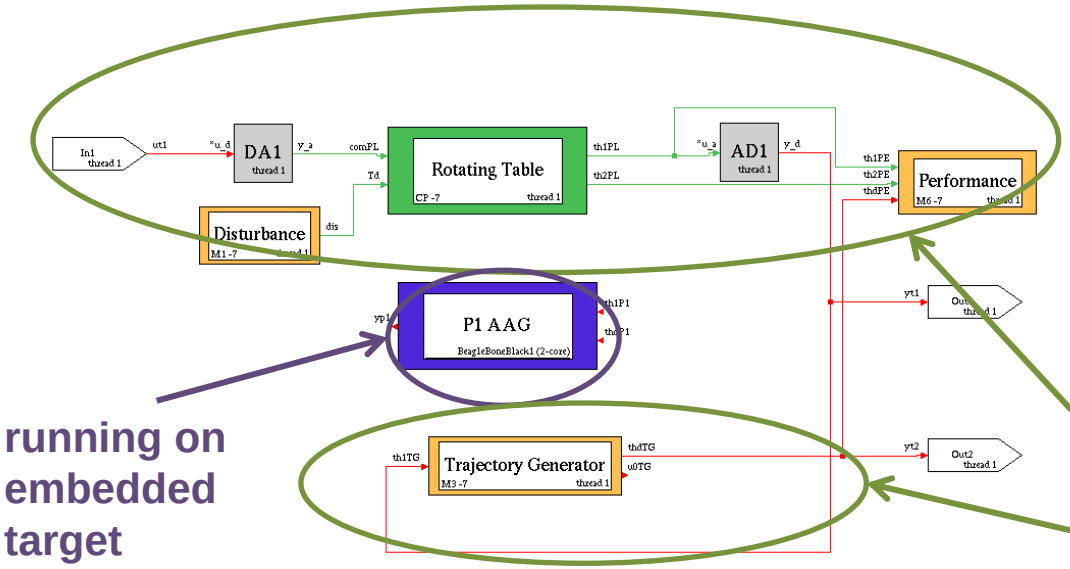
Hardware-in-the-loop

The **project layout** in HIL sub-mode:



running on embedded target

real-time simulated

The system layout shows that the *Plant Area* is enabled again: during the HIL trials it is simulated by the **EICASLAB RCP Platform**.

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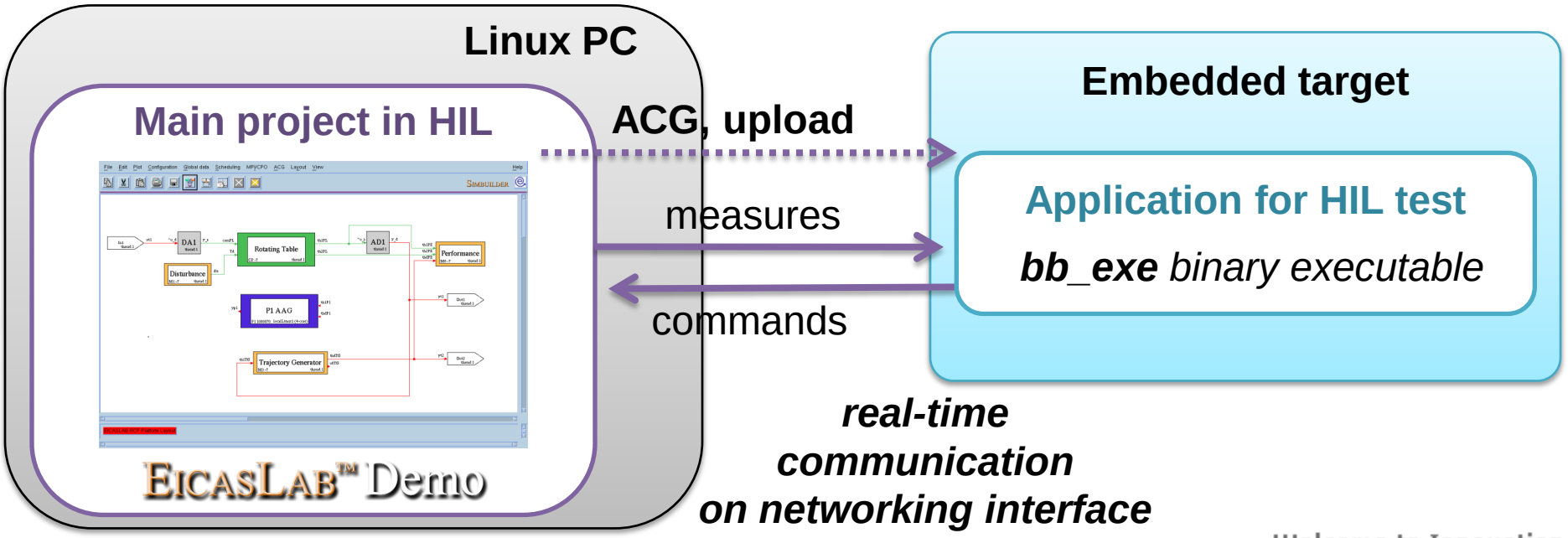
Hardware-in-the-loop

When the demo is in HIL operative sub-mode, the user can see differences with respect to RCP: the plant is enabled for simulation and the processor is assigned to target.



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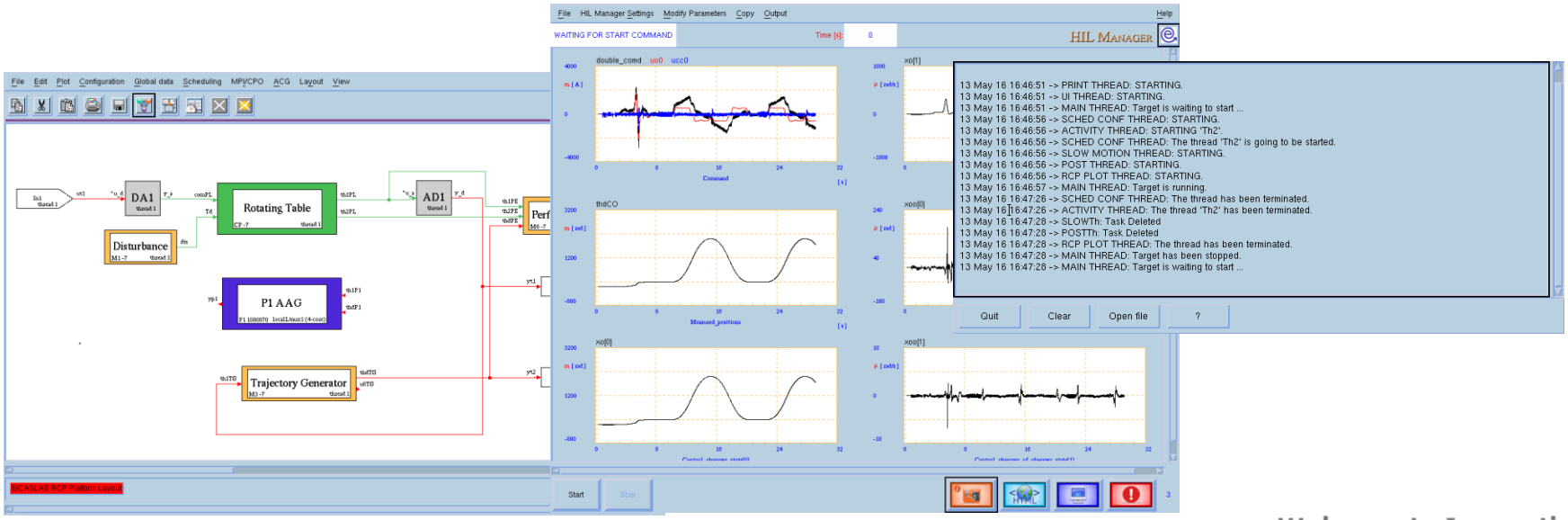
Hardware-in-the-loop

The **HIL Manager** includes a GUI for managing the execution of the real-time plant simulator program, similarly to RCP Manager for RCP operative mode.



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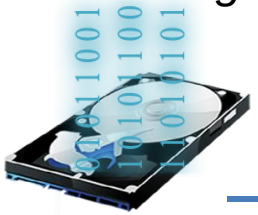
Hardware-in-the-loop

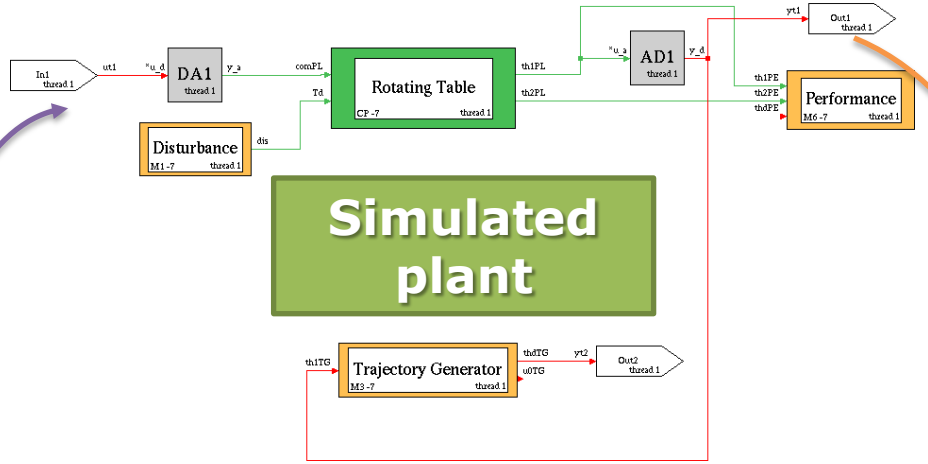
EICASLAB RCP Platform

HIL Manager

Run-time parameters plot and data recording



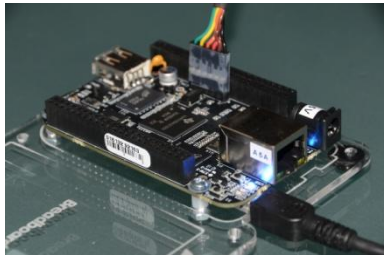
Motor command on Ethernet



Simulated plant

Simulated Measure on Eth-UDP

No real plant



Embedded target

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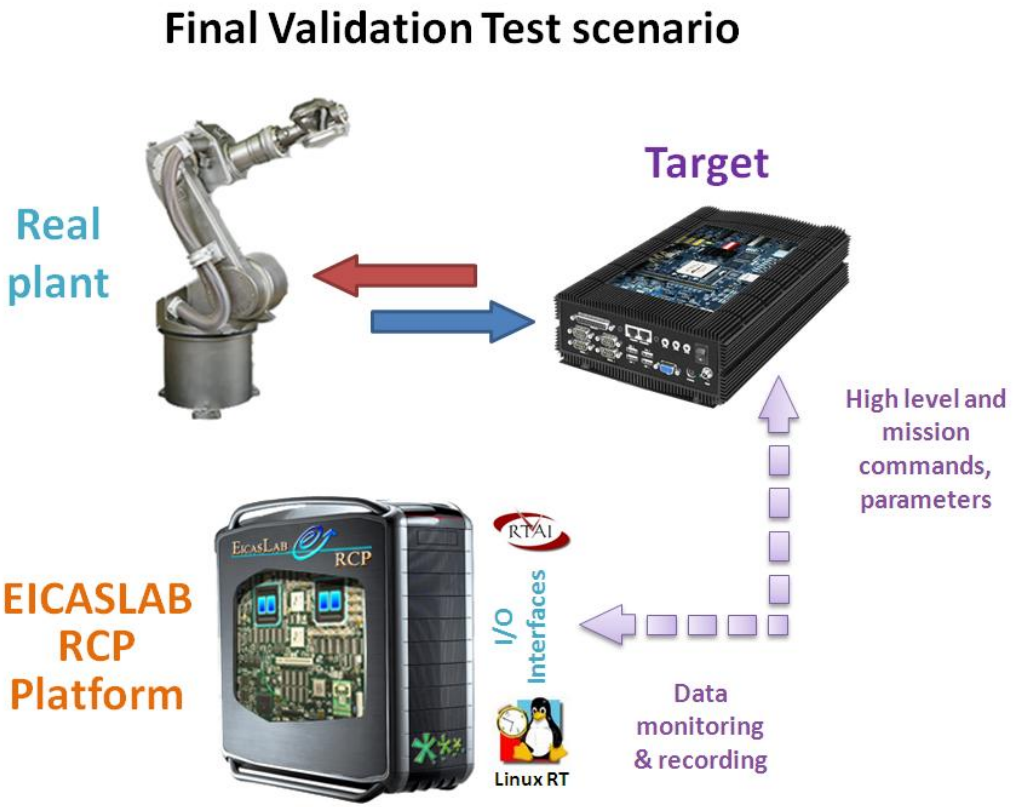
Final Validation Test

The **Final Validation Test operative sub-mode** allows the user to test the control algorithm **execution on the target** hardware controlling the **real plant**.



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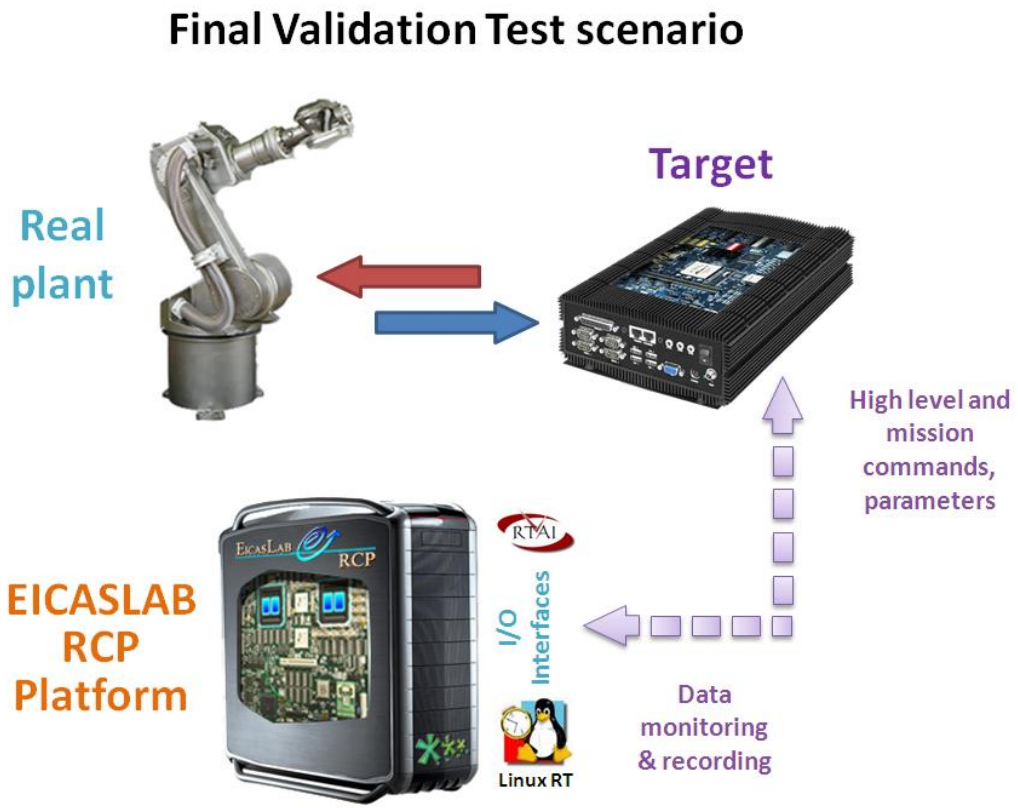
Final Validation Test

The monitoring and run-time tuning are provided exploiting the real time execution features by the **EICASLAB RCP Platform**.



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Final Validation Test

Who does what in Final Validation Test operative sub-mode in RT-emb demo:

HW	**EICASLAB RCP Platform**	**Embedded board target**	**Rotating Table emulator**
SW	**monitoring supervisor**	**runs control logic**	**simulated by second project**

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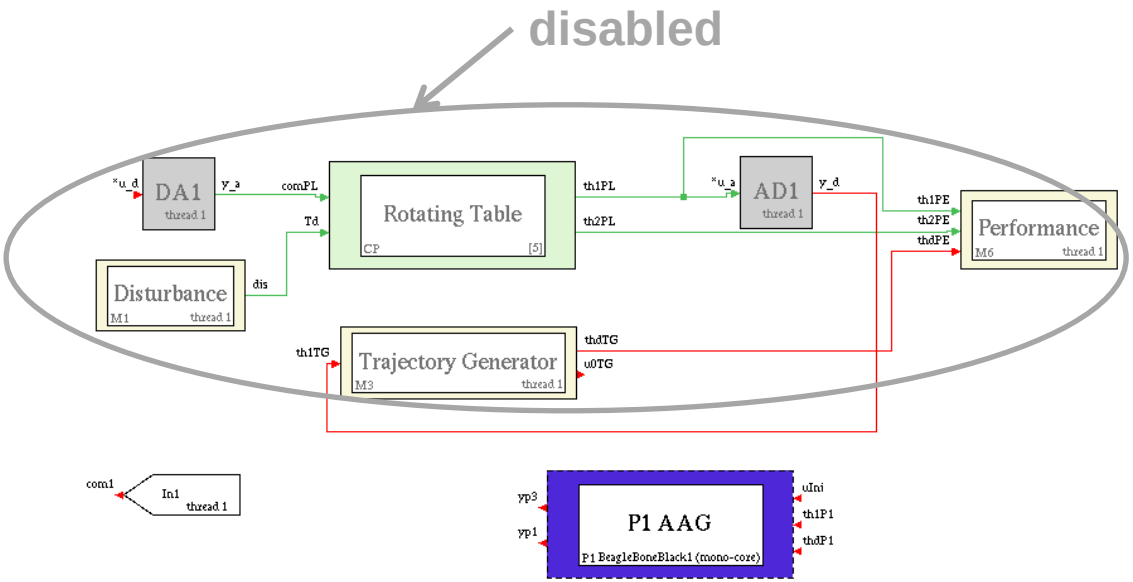
Final Validation Test

The **project layout** in this mode:



The system layout shows that the *Plant Area* is disabled again, because during the FVT trials the **real plant** is simulated using a separate project.

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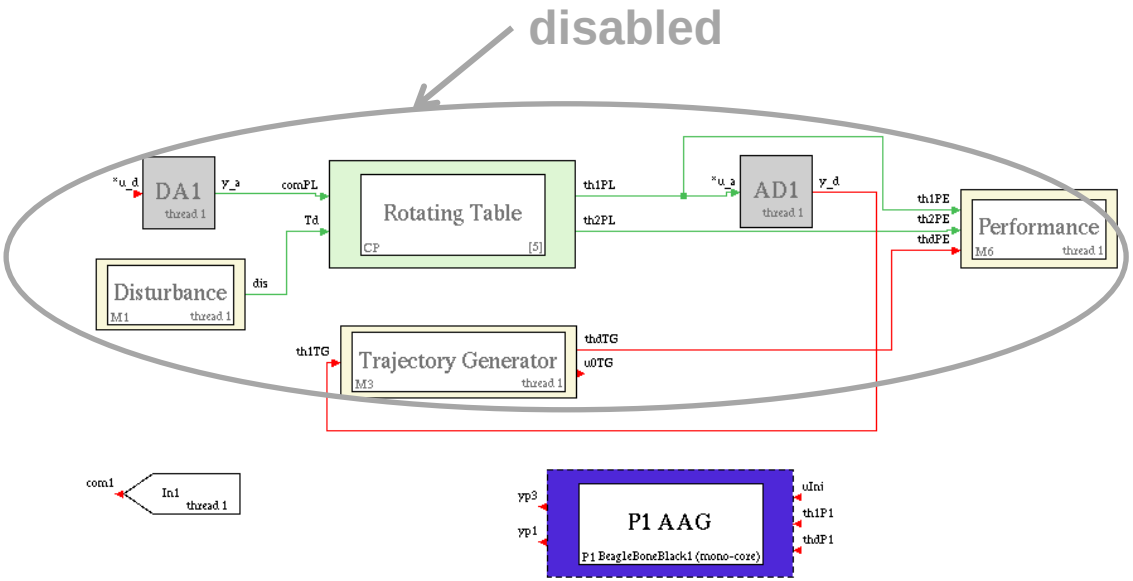
Final Validation Test

The **project layout** in this mode:



The control algorithm is executed by external **hardware target**, as in HIL trials.

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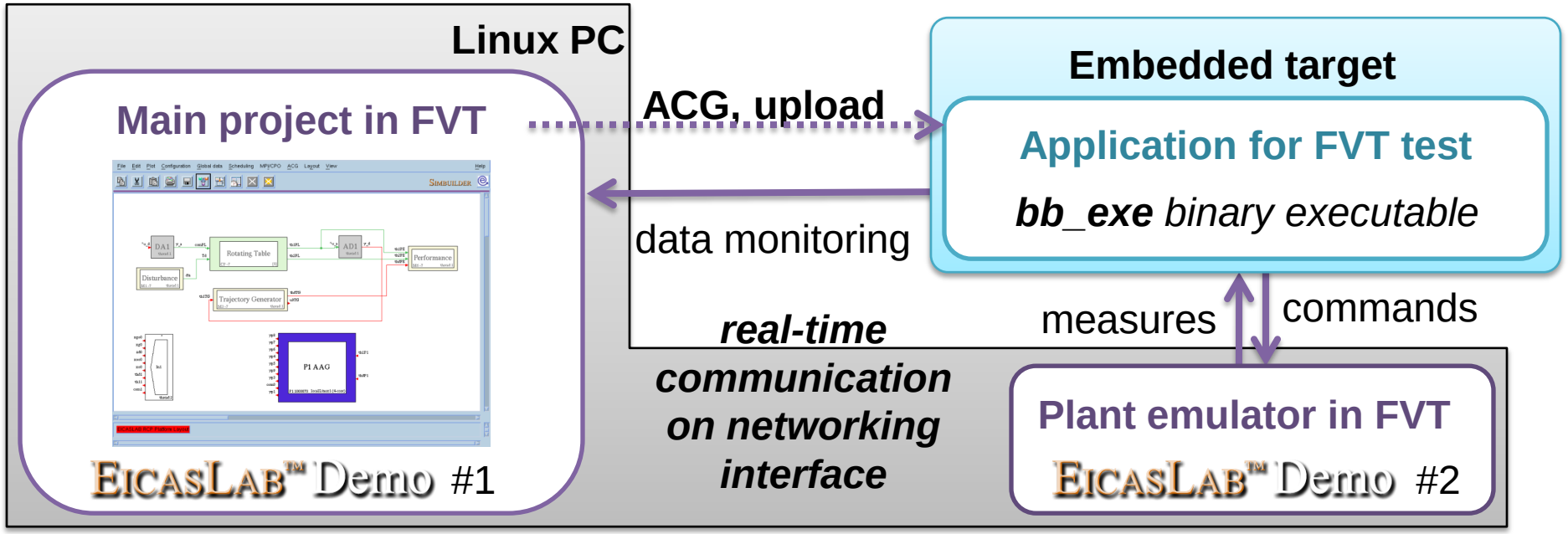
Final Validation Test

Similarly as done in RCP On Field, this demo works without real plant: the user has to run the plant emulator in a second instance of EICASLAB demo.



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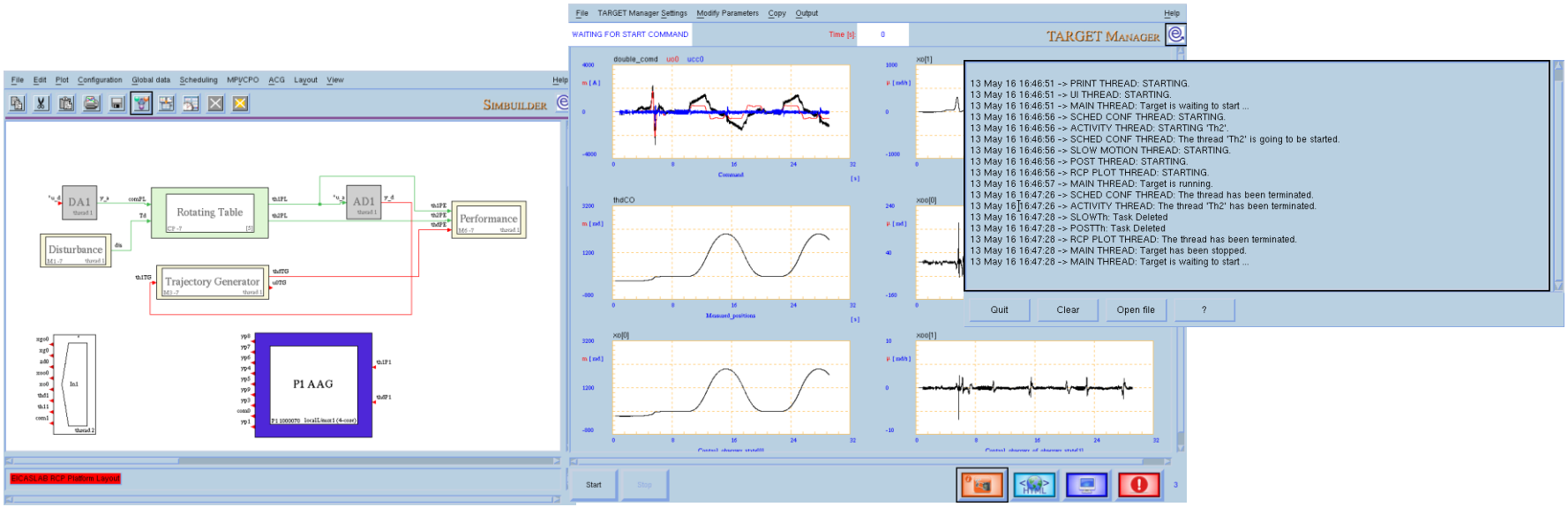
Final Validation Test

The **TARGET Manager** includes a GUI for managing the execution of the real-time FVT program, similarly to RCP Manager and HIL Manager.



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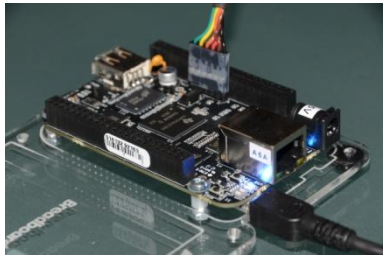
Final Validation Test

TARGET Manager ↔ **EICASLAB RCP Platform**

Run-time parameters plot and data recording

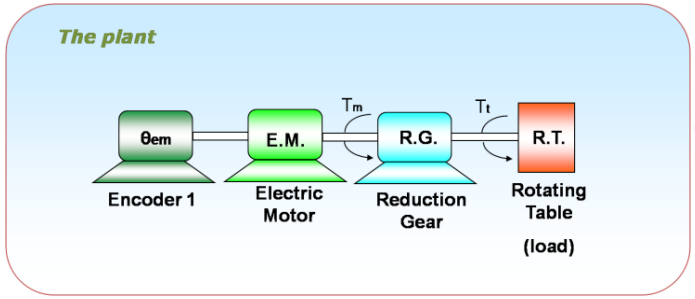
Monitoring data on Eth-UDP

Run-time parameters on Eth-UDP



Embedded target

Motor command on Eth-UDP



Real plant

Trajectory measure on Eth-UDP

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Further readings

About this demo:

- EICASLAB Demo RT-emb Webinar
- EICASLAB Demo RT-emb User Manual
- Rotating table technical note

About EICASLAB :

- EICASLAB User Manual
- Other EICASLAB Webinars

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The demo installer is downloadable from EICASLAB website (www.eicaslab.com)

For more info,
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support@eicaslab.com

DEMO
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