Graphical programming in EICASLAB™

Via Vincenzo Vela, 27 10128 Torino - ITALY (IT)
Tel. +39 011 56 23 798 +39 011 56 23 088
Fax +39 011 43 60 679
www.eicas.it

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- Concept of graphical layout and related library
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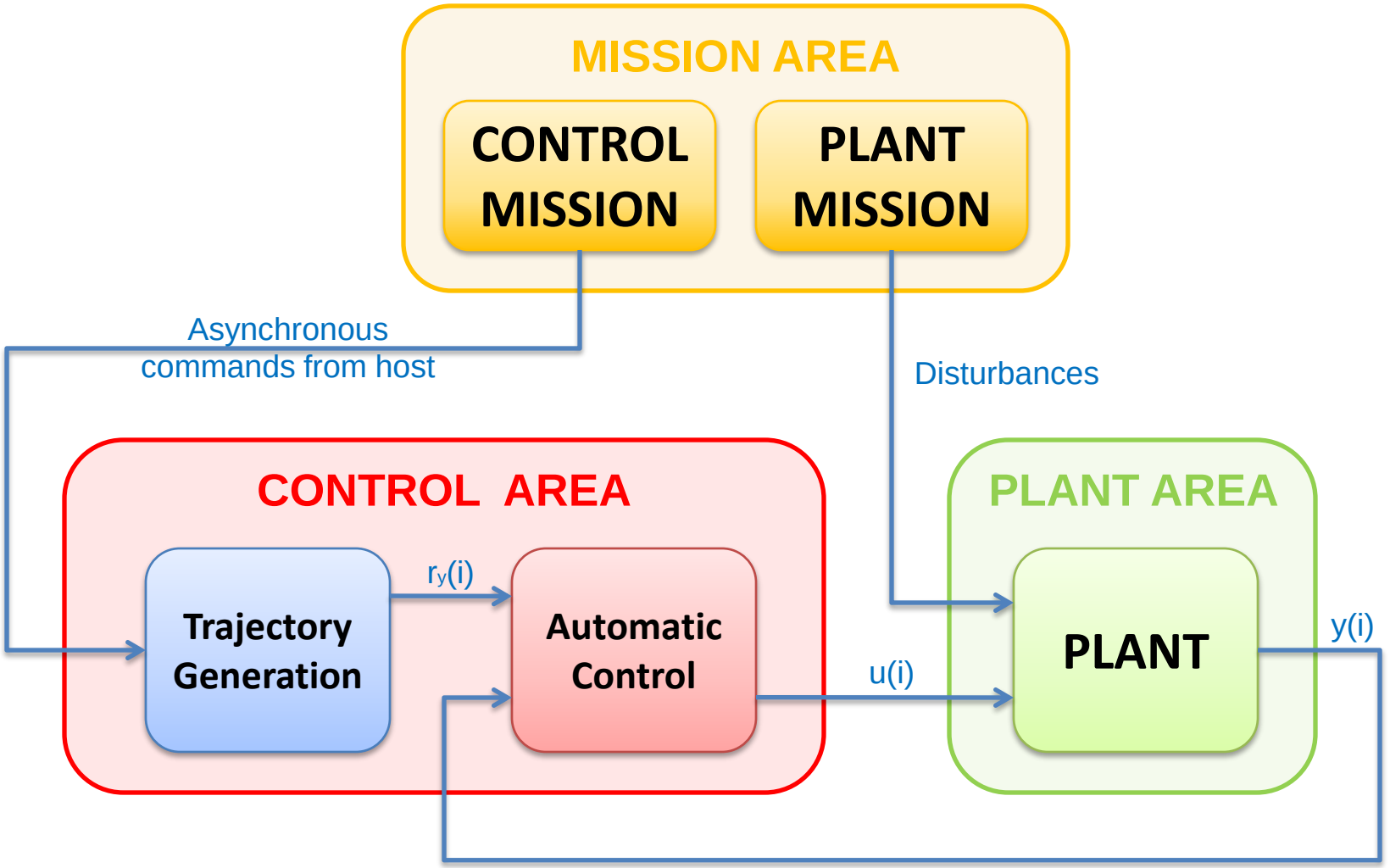

MISSION AREA
CONTROL MISSION
PLANT MISSION
Asynchronous commands from host
Disturbances
CONTROL AREA
PLANT AREA
Trajectory Generation
ry(i)
Automatic Control
u(i)
PLANT
y(i)

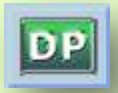
Main Areas/blocks/layouts

GRAPH
C
LIB
LIB+C
AAG

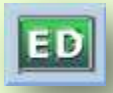
PLANT AREA

Continuous Plant

Discrete Plant



Experimental Data



Hybrid Plant

CONTROL AREA

Control

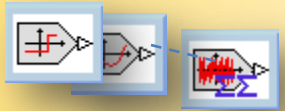
Processor

Processor Network

MISSION AREA

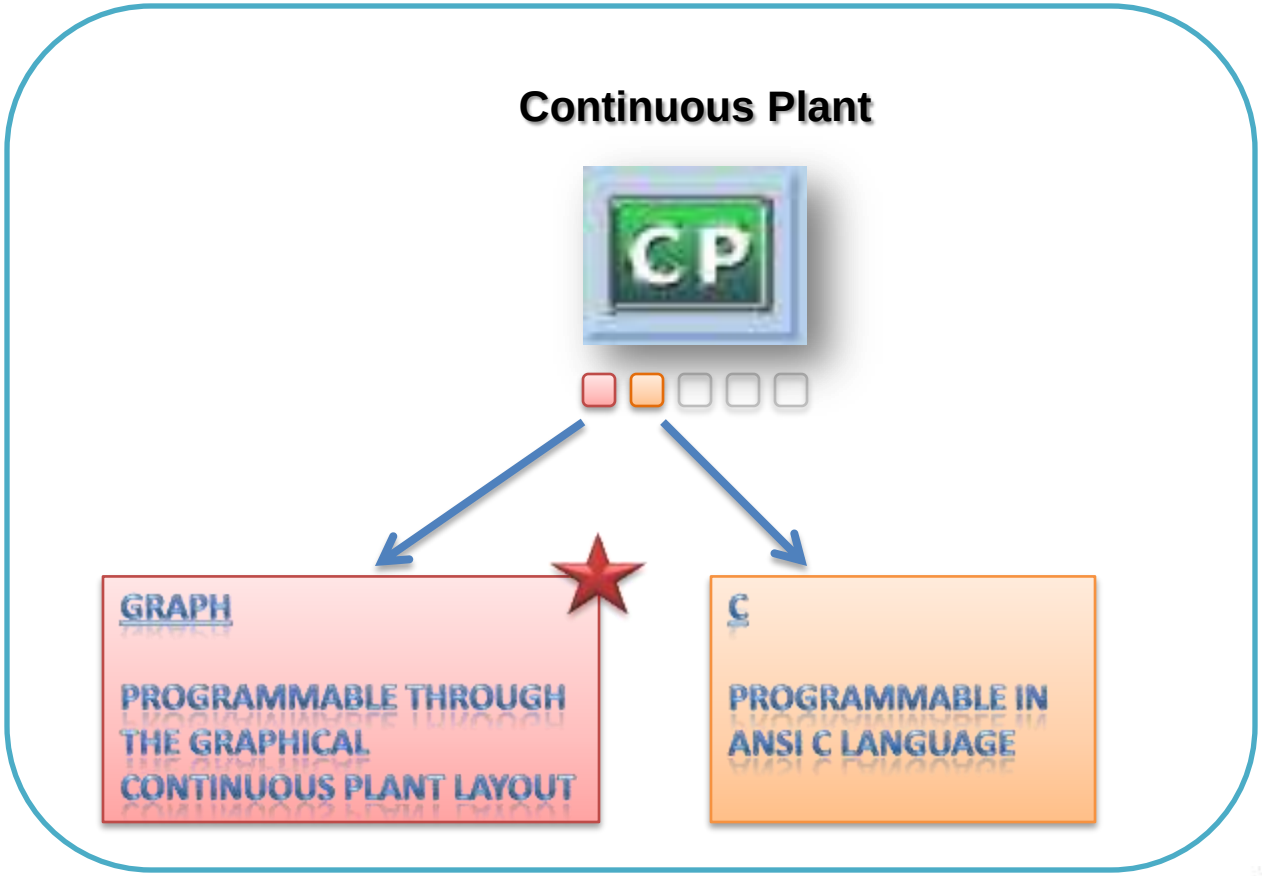
User Mission

Elementary Mission



Welcome to Innovation

Main Areas/blocks/layouts



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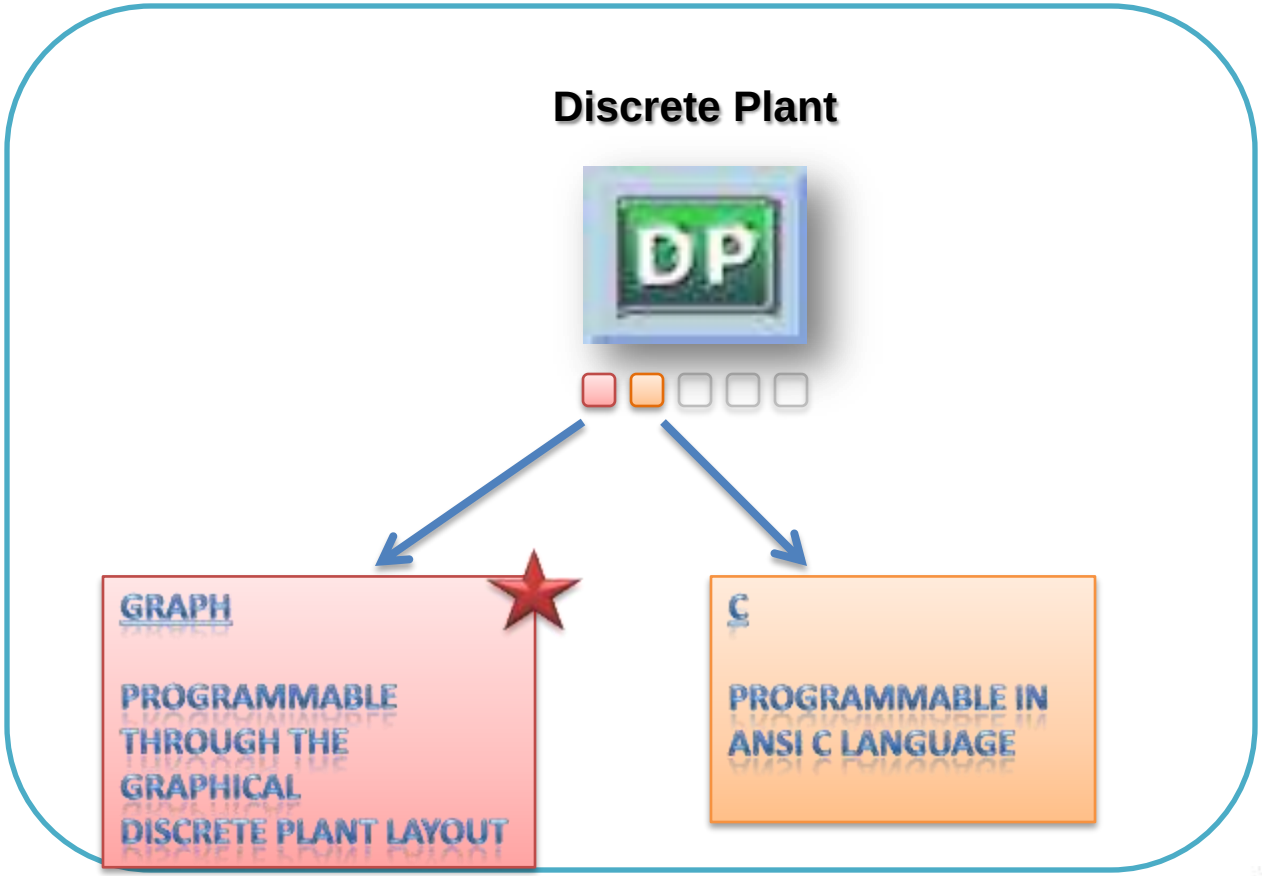

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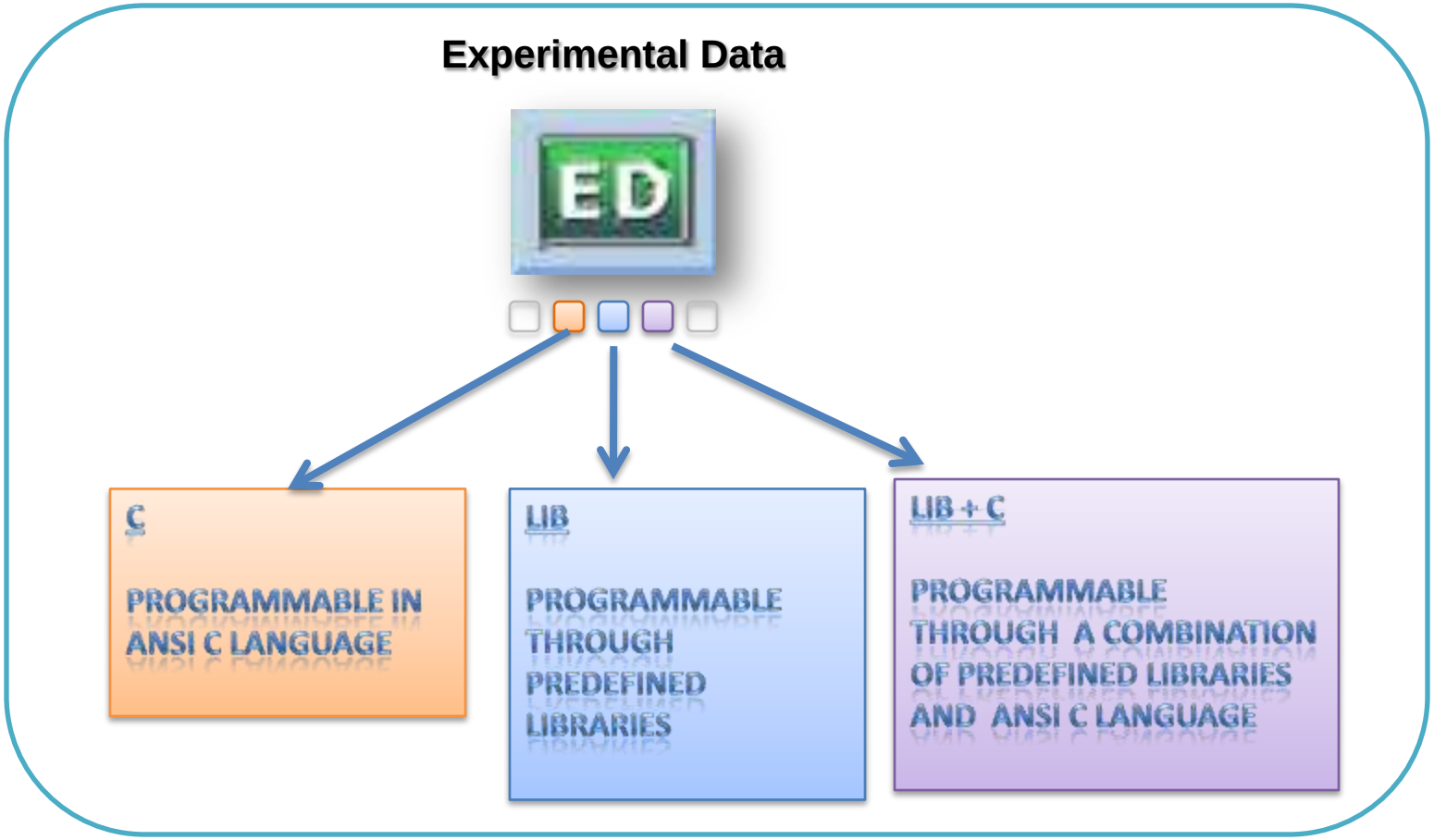

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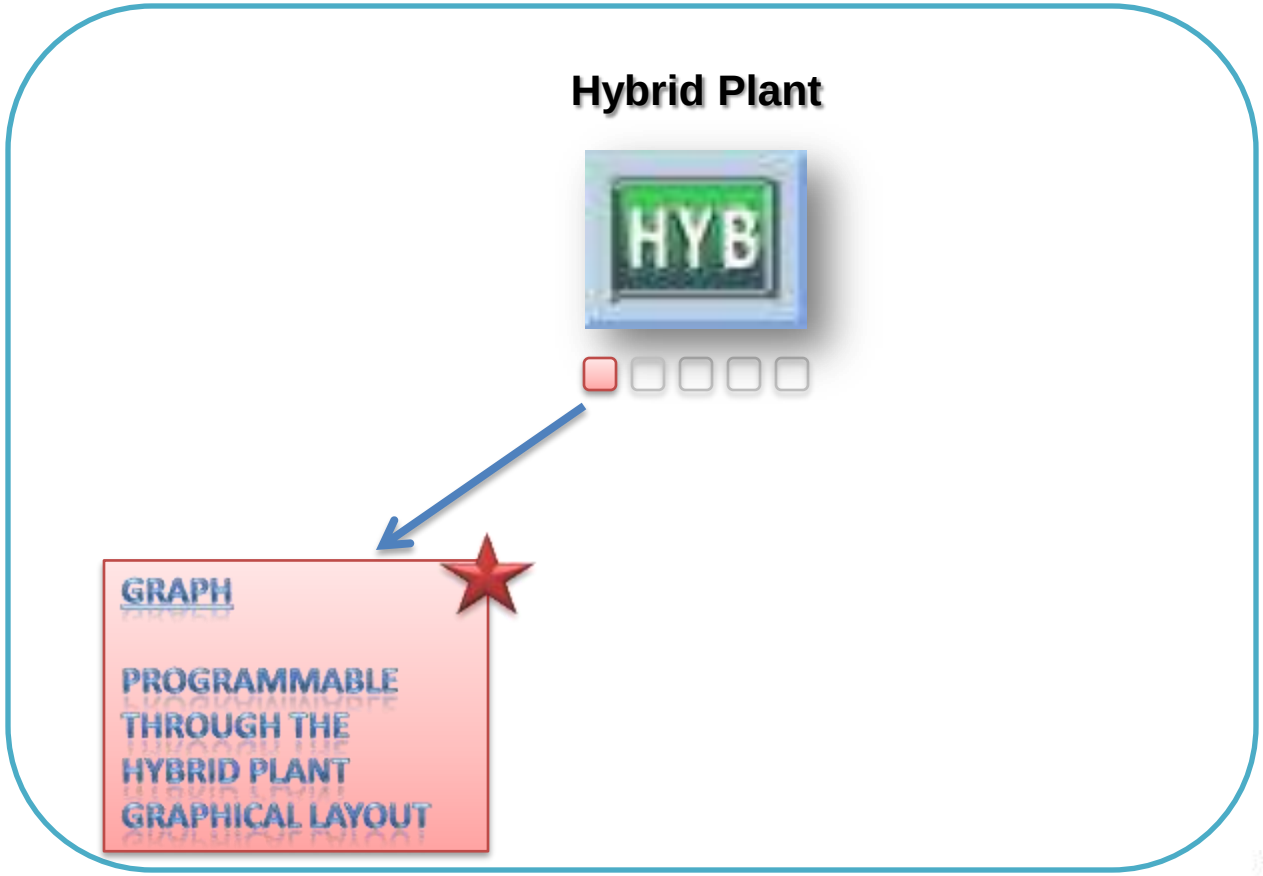

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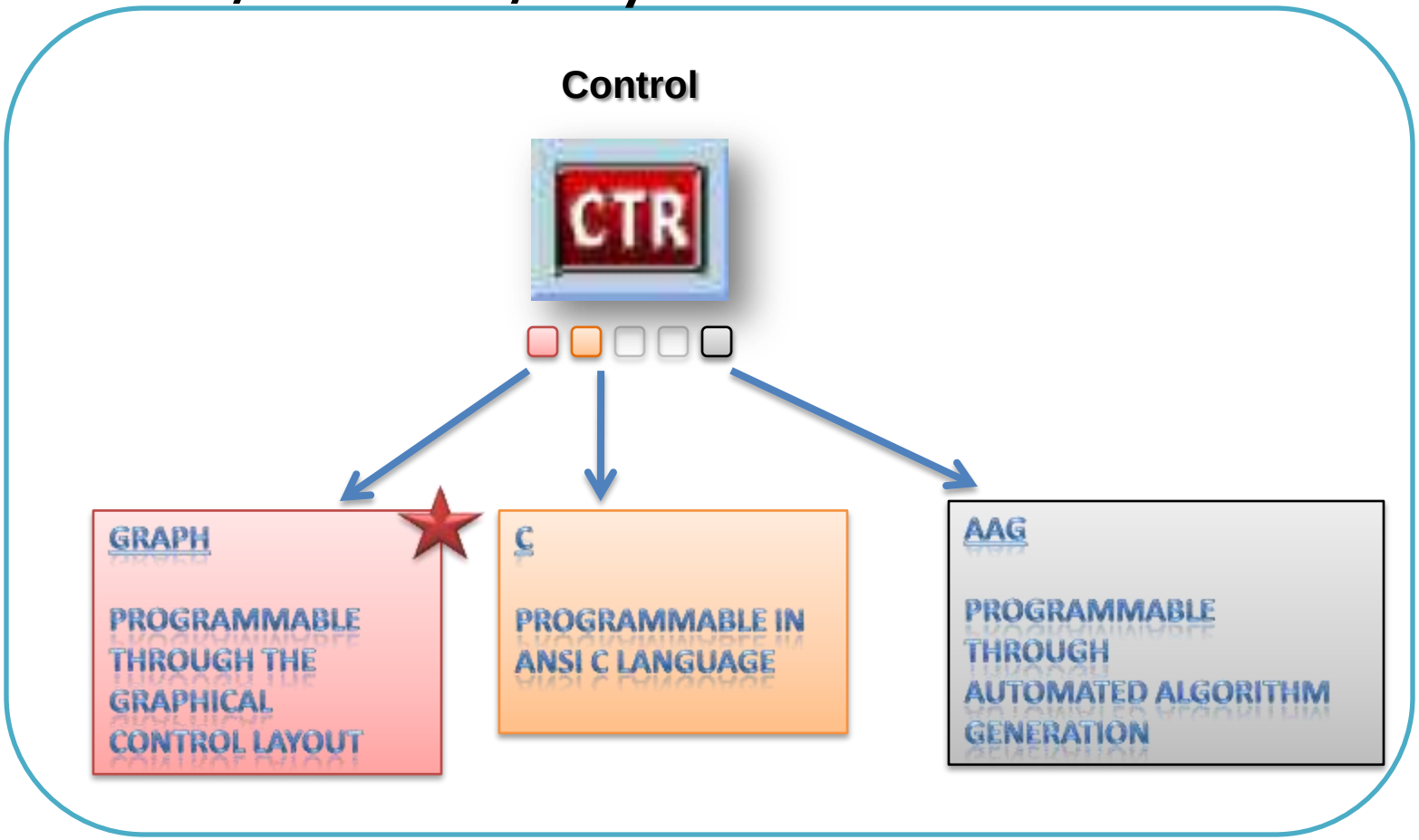

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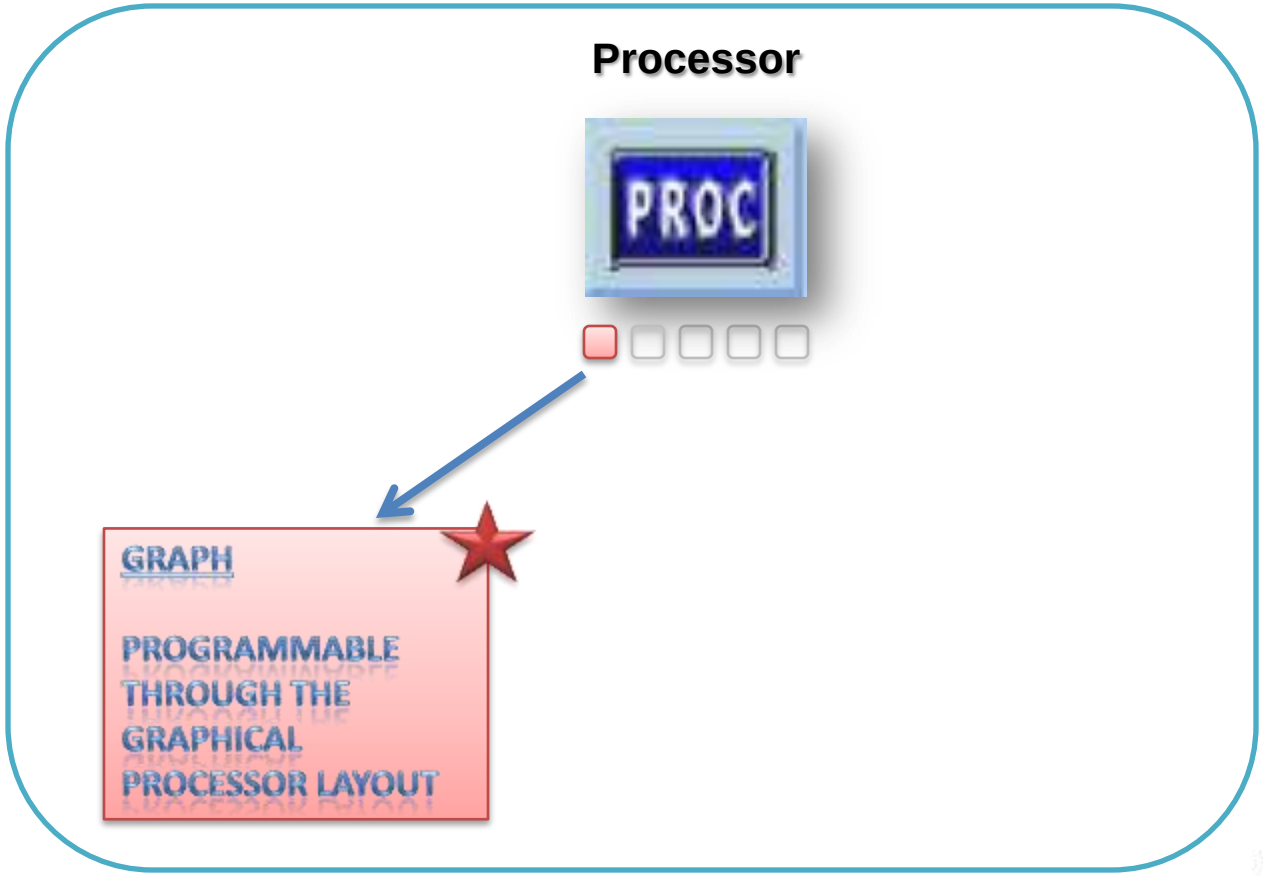

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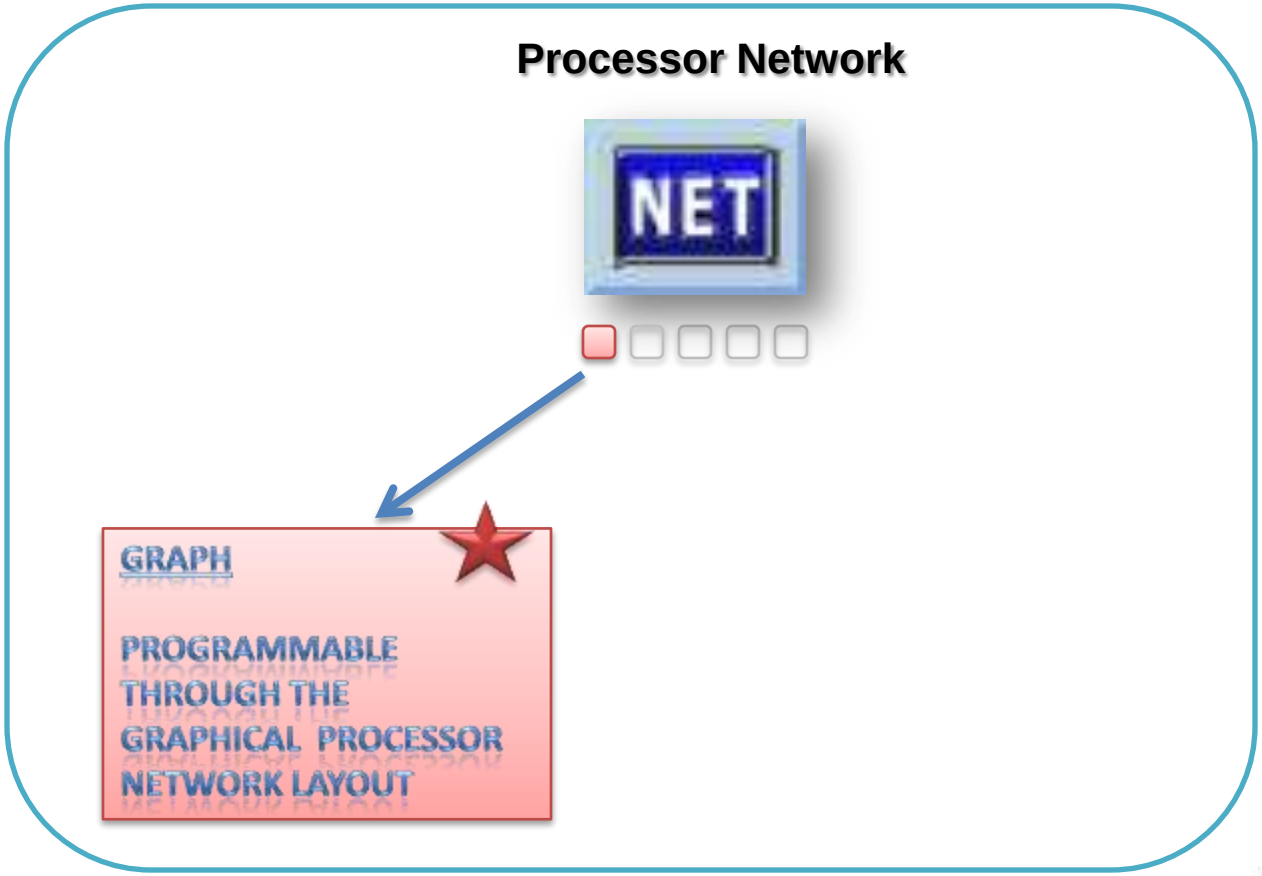

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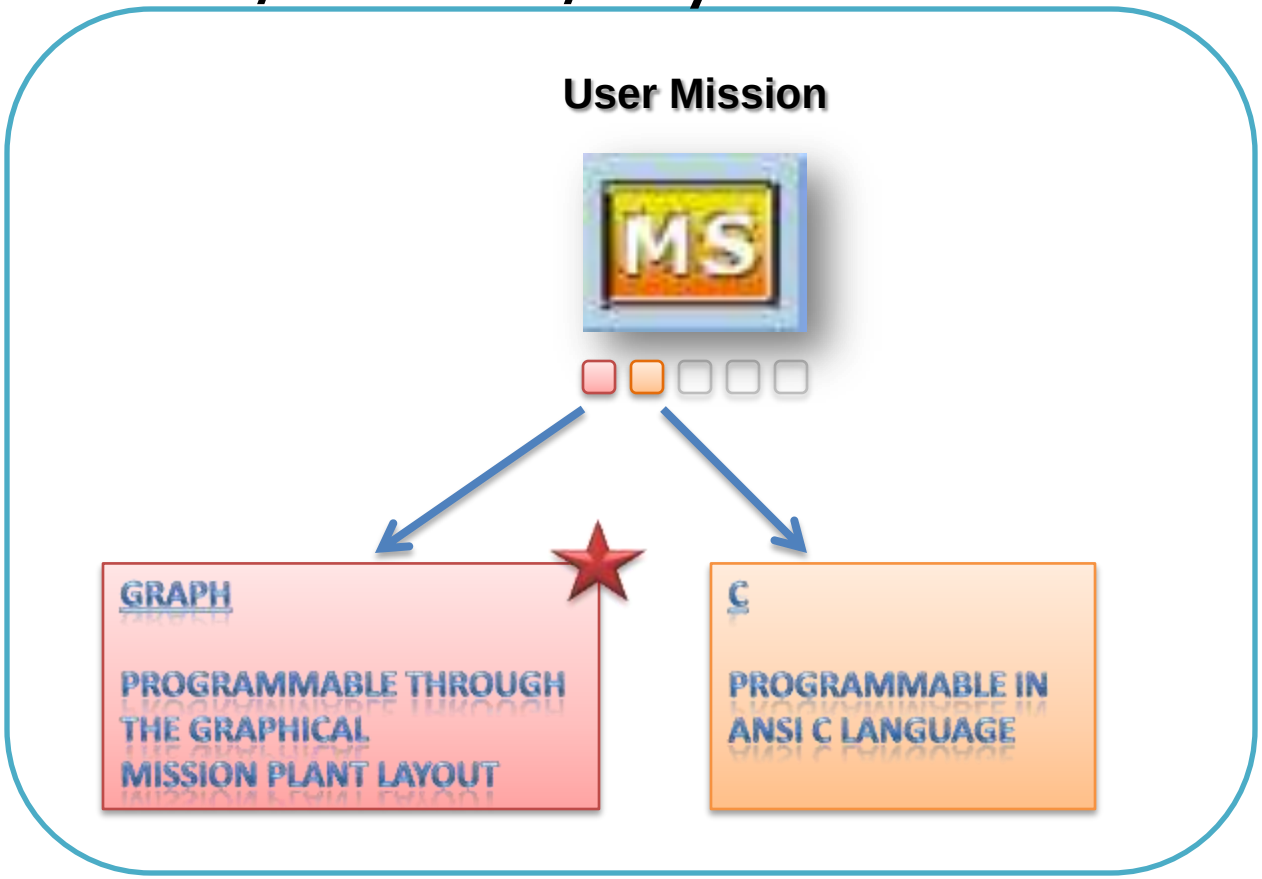

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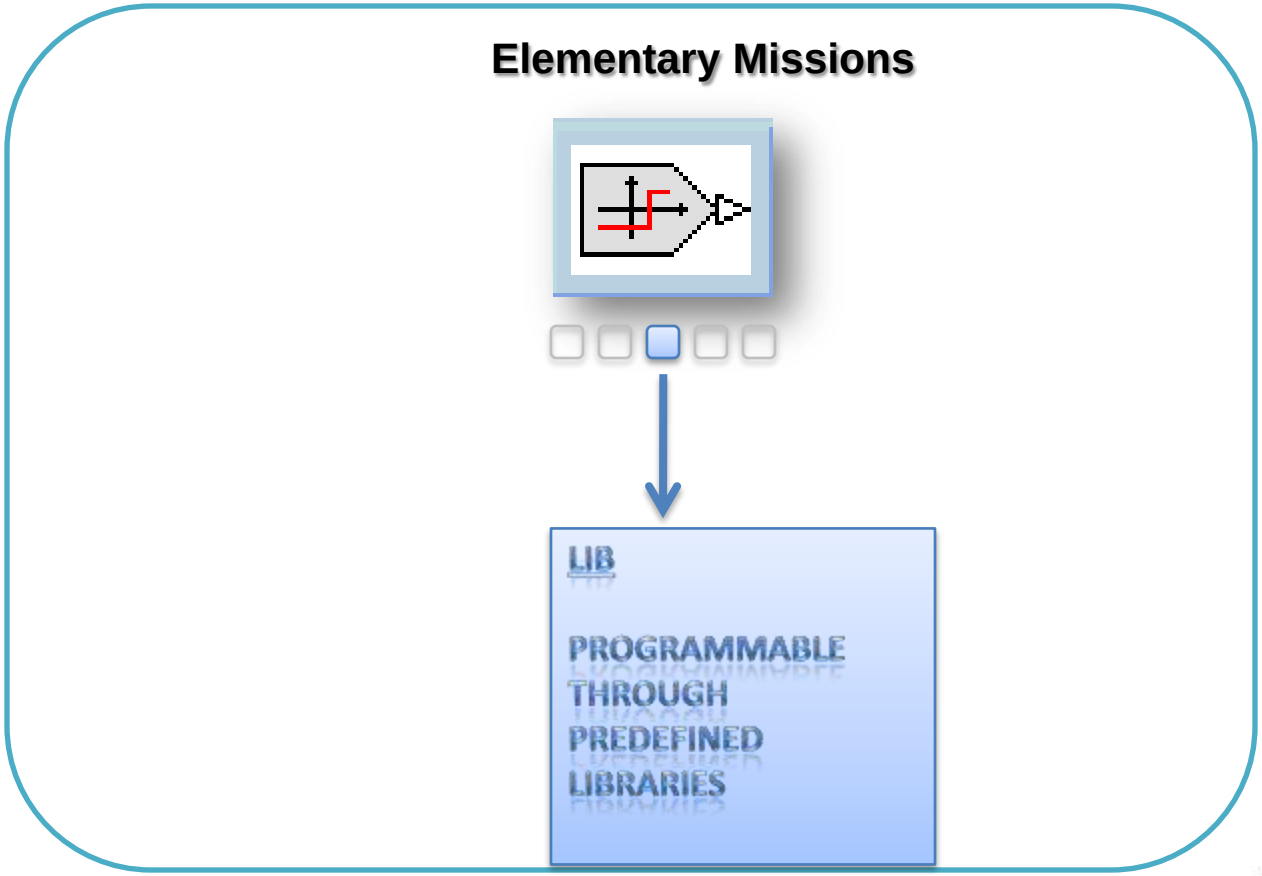

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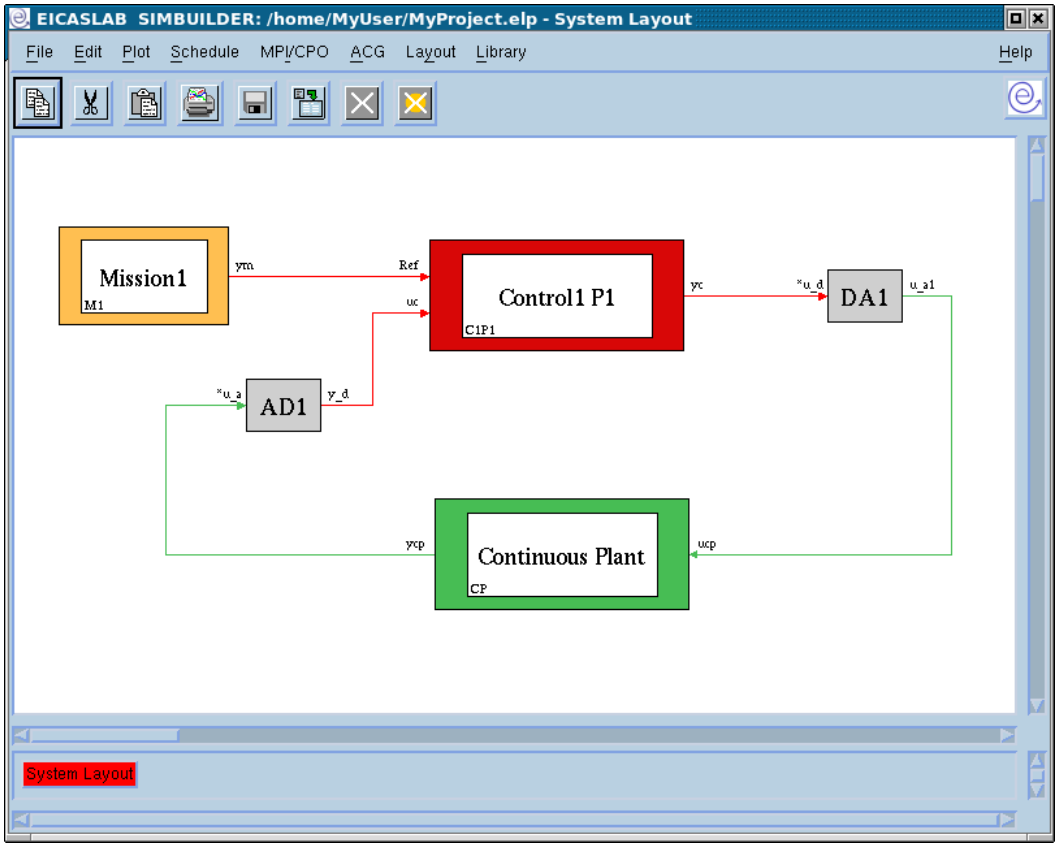
Layout architecture in EICASLAB™

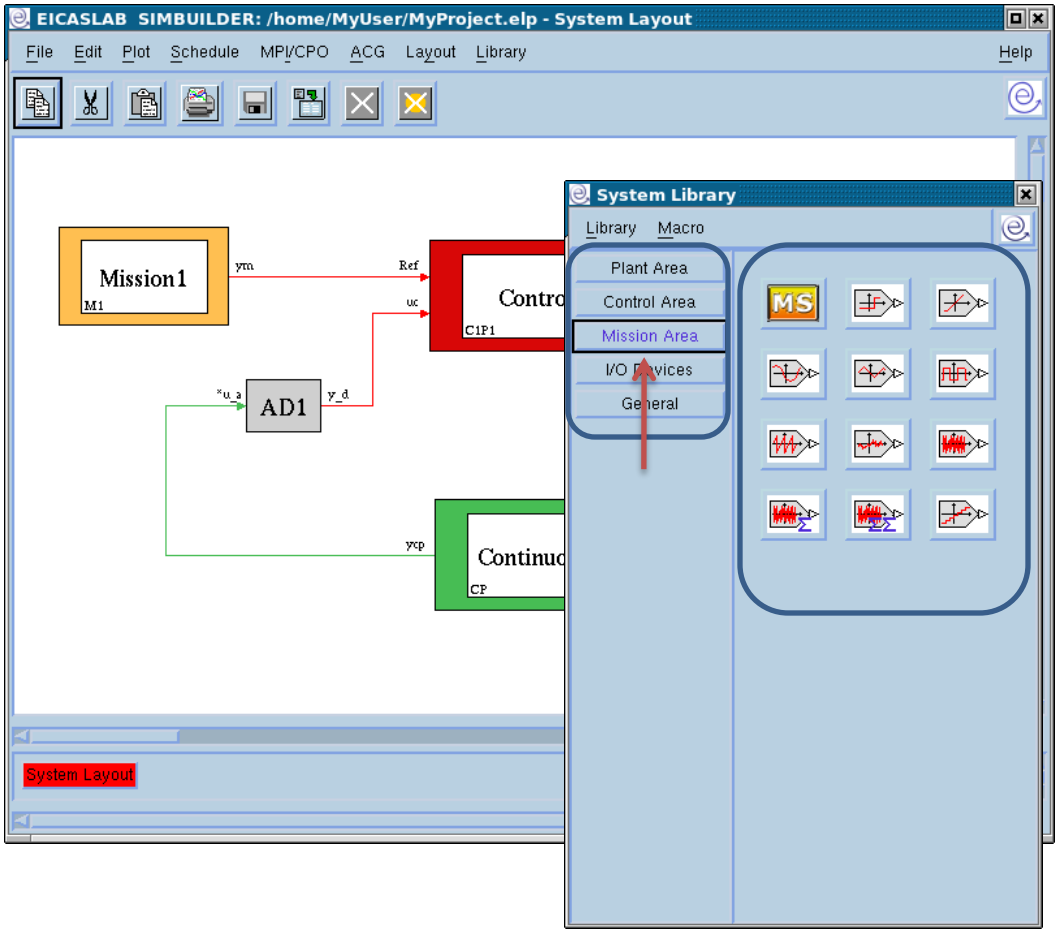


The EICASLAB projects are focused on the concept of **graphical layout**: layout is a graphical space for programming part of your system.

In EICASLAB, a set of **graphical layouts** are available, organized in a **hierarchical** way, each of them is devoted to a specific task.

A layout can contain blocks represented by other layouts.

Libraries of the layouts



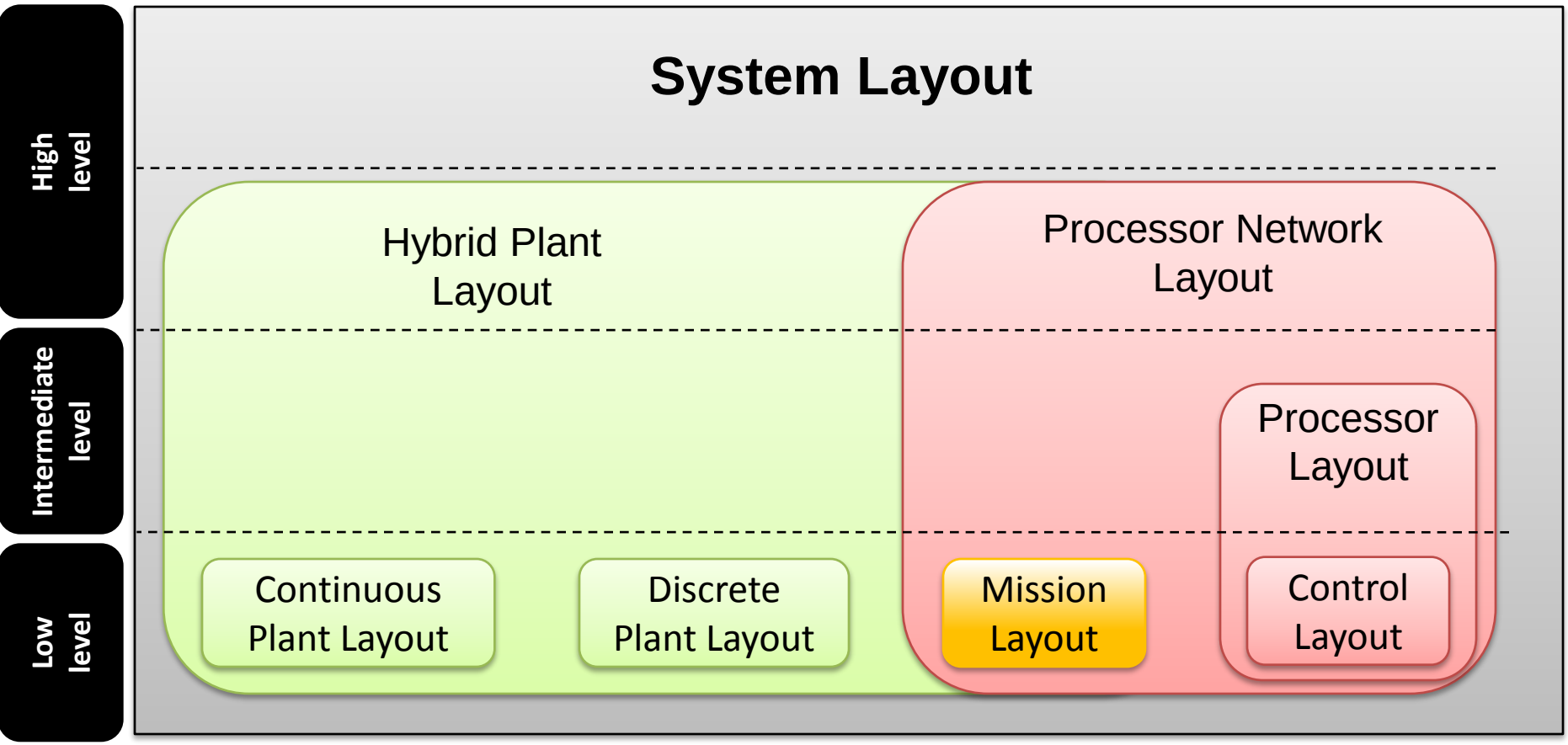
Every **layout** is equipped with a specific and oriented **library** window which contains only the blocks that can be inserted in that layout.

You can build your graphical representation by dragging & dropping the blocks available in the libraries.

The left section of the *library window* indicates the name of the available libraries of the layout.

The right section contains the *icons* representing the blocks contained in the selected library.

The Layout Hierarchical Structure



Low level graphical layouts

Name	Area	Insertable from the block library of …		
CONTINUOUS PLANT LAYOUT	**PLANT AREA**	SYSTEM LAYOUT	HYBRID PLANT LAYOUT	
DISCRETE PLANT LAYOUT	**PLANT AREA**	SYSTEM LAYOUT	HYBRID PLANT LAYOUT	
CONTROL LAYOUT	**CONTROL AREA**	SYSTEM LAYOUT	PROCESSOR NETWORK LAYOUT	PROCESSOR LAYOUT
MISSION LAYOUT	**MISSION AREA**	SYSTEM LAYOUT	HYBRID PLANT LAYOUT	PROCESSOR NETWORK LAYOUT

Intermediate graphical layout

PROCESSOR LAYOUT	**CONTROL AREA**	SYSTEM LAYOUT	PROCESSOR NETWORK LAYOUT	

High level graphical layouts

Name	Area	Insertable from the block library of …
HYBRID PLANT LAYOUT	**PLANT AREA** MISSION AREA	SYSTEM LAYOUT
PROCESSOR NETWORK LAYOUT	**CONTROL AREA** MISSION AREA	SYSTEM LAYOUT
SYSTEM LAYOUT	PLANT AREA	HYBRID PLANT LAYOUT
	MISSION AREA	
	CONTROL AREA	PROCESSOR NETWORK LAYOUT

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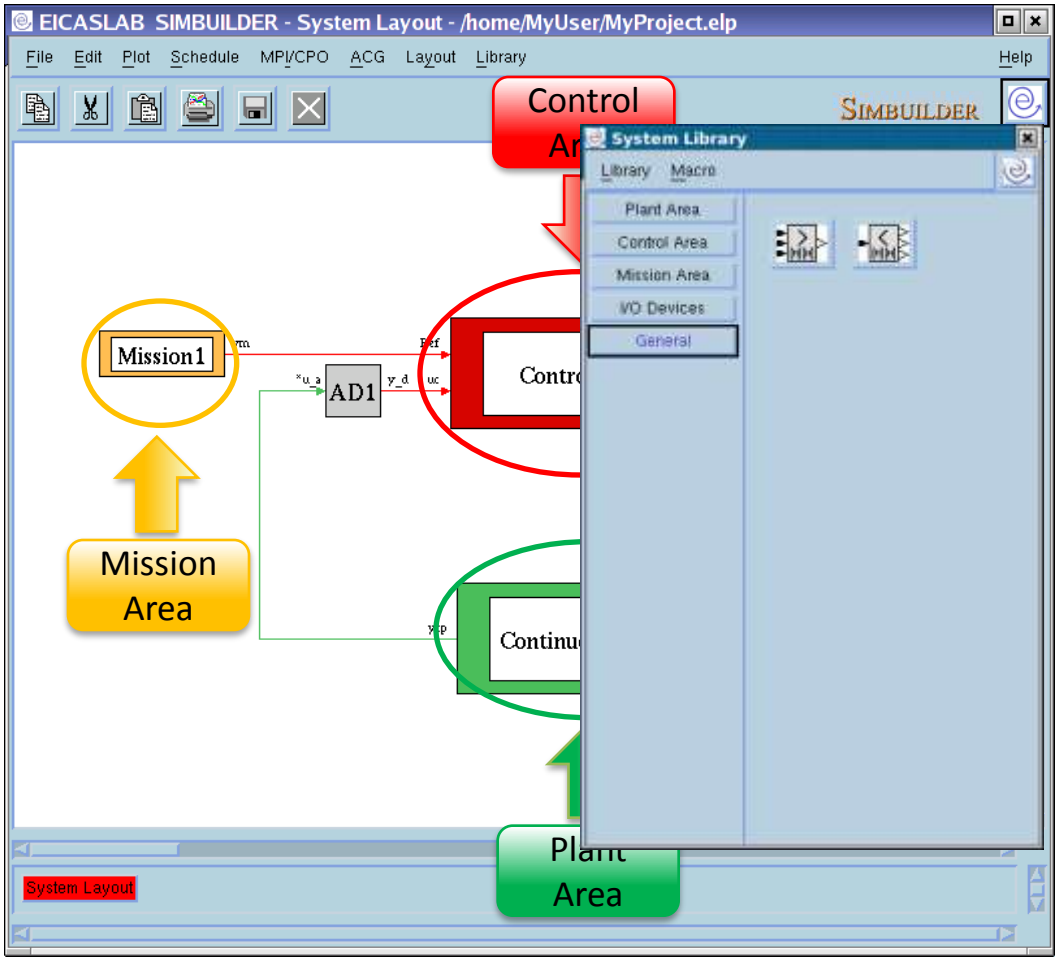
The System Layout

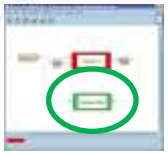


The System Layout is the highest level of the project representation and it appears when you run SIMBUILDER.

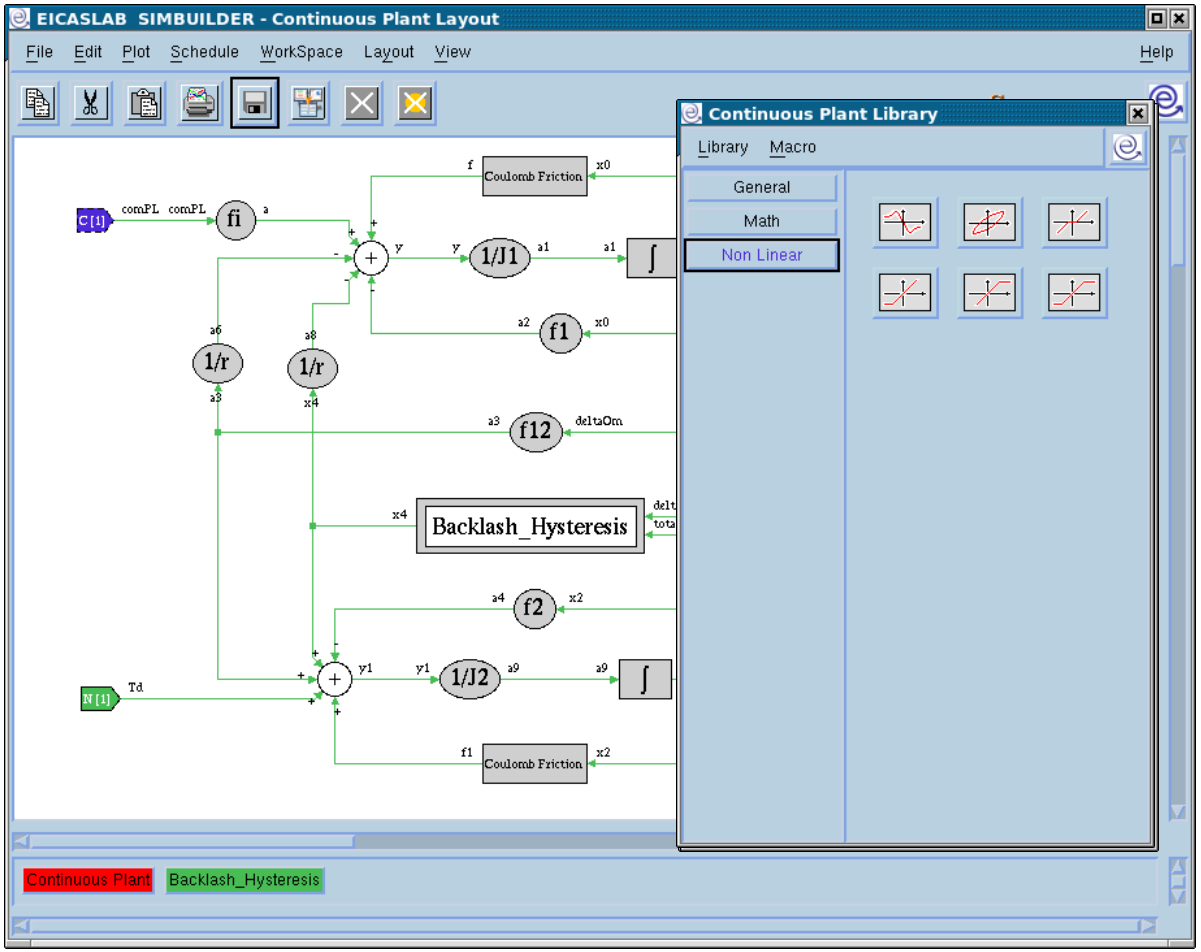
The System Layout is organised in order to contain the following three areas

- the Plant Area
- the Control Area
- the Mission Area

specifically devoted and customized to program the different parts of your project

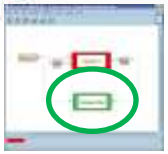


The Continuous Plant Layout

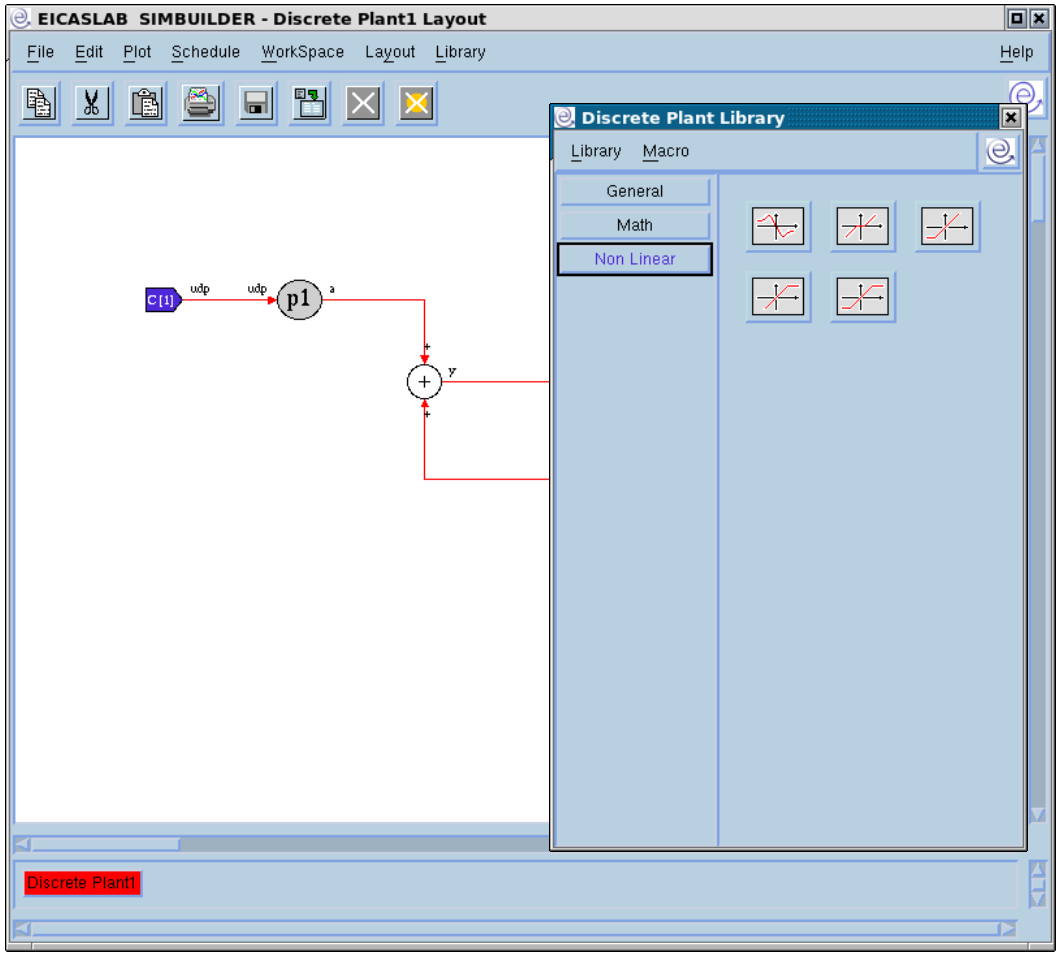


The Continuous Plant layout allows to graphically program the Continuous Plant.

You can build your plant model by using the blocks available in the Continuous Plant Library.

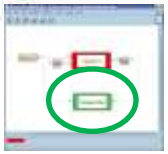


Discrete Plant Layout

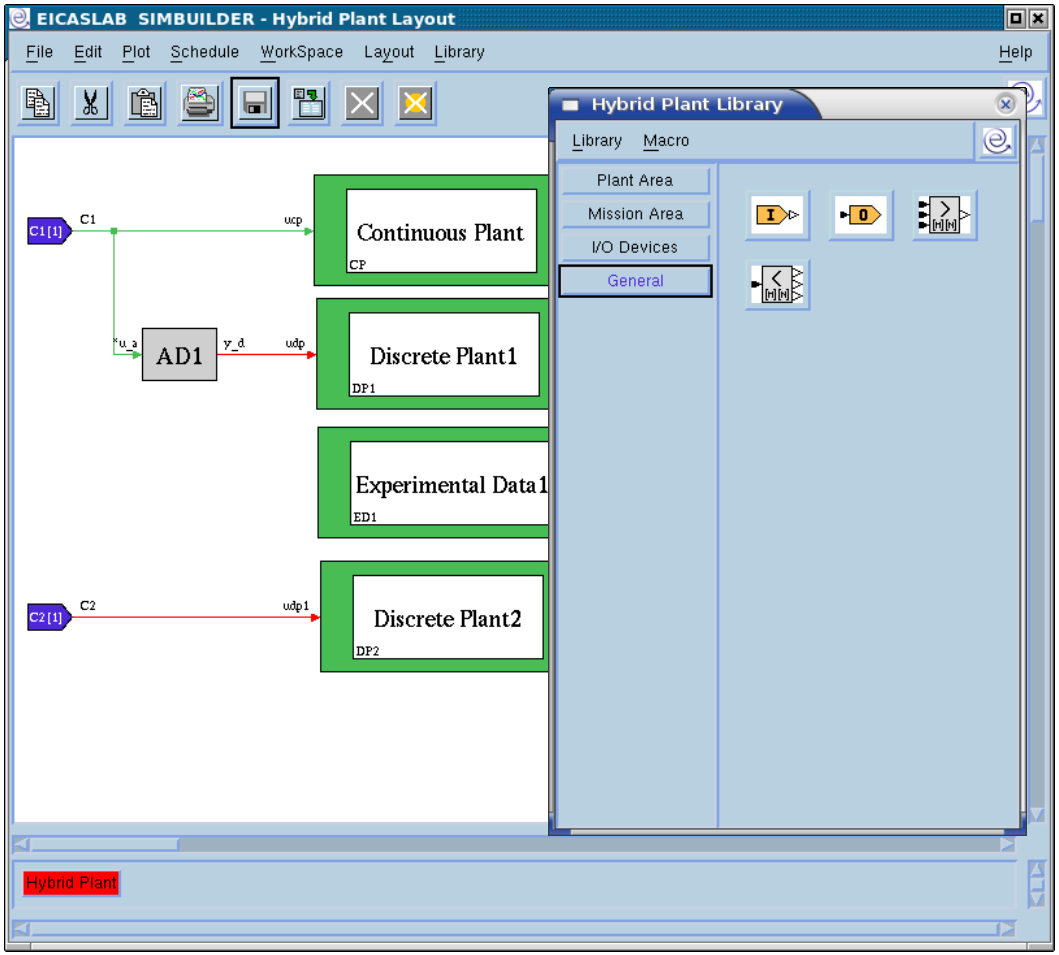


The Discrete Plant layout allows to graphically program the Discrete Plant.

You can build your plant model by using the blocks available in the Discrete Plant Library.

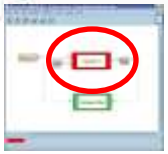


The Hybrid Plant Layout

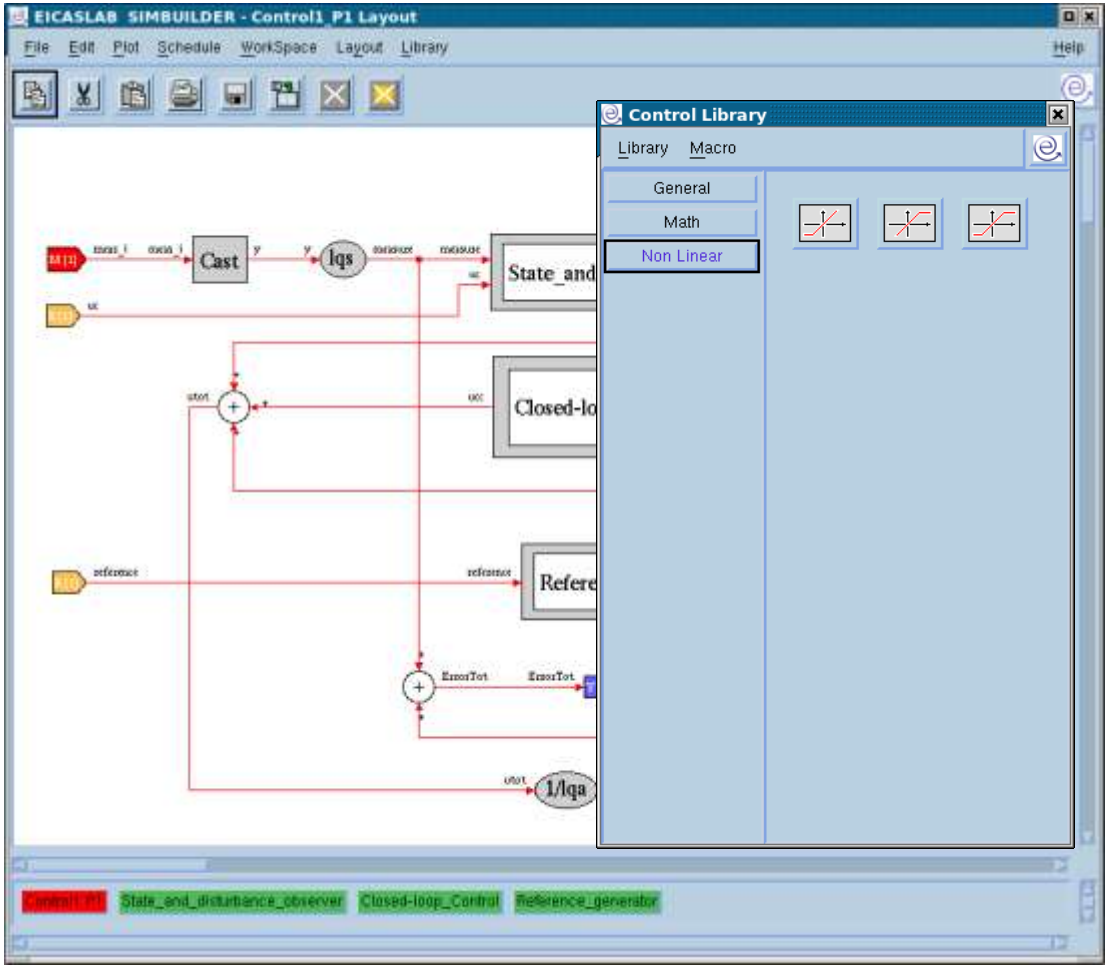


The Hybrid Plant Layout allows you to group generic Plant Area blocks (Continuous and Discrete Plants and Experimental Data) and Plant Mission blocks.

The Plant Area blocks are available in the Hybrid Plant Library.
In addition Mission Area blocks are available for modelling disturbances acting on the plant.

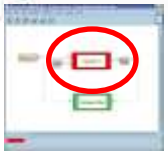


The Control Layout

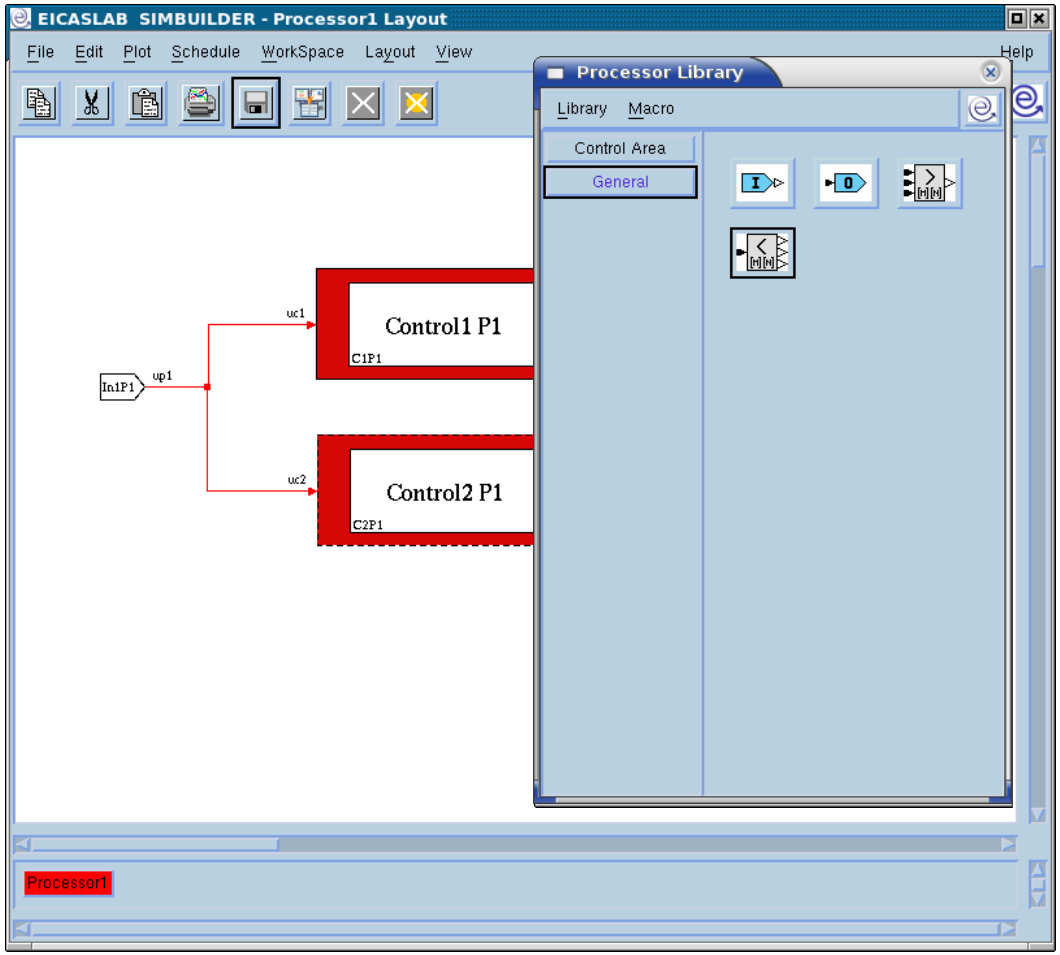


The Control layout allows to graphically program the Control.

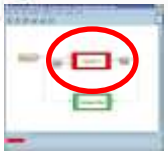
You can develop your control algorithm by using the blocks available in the Control Library.



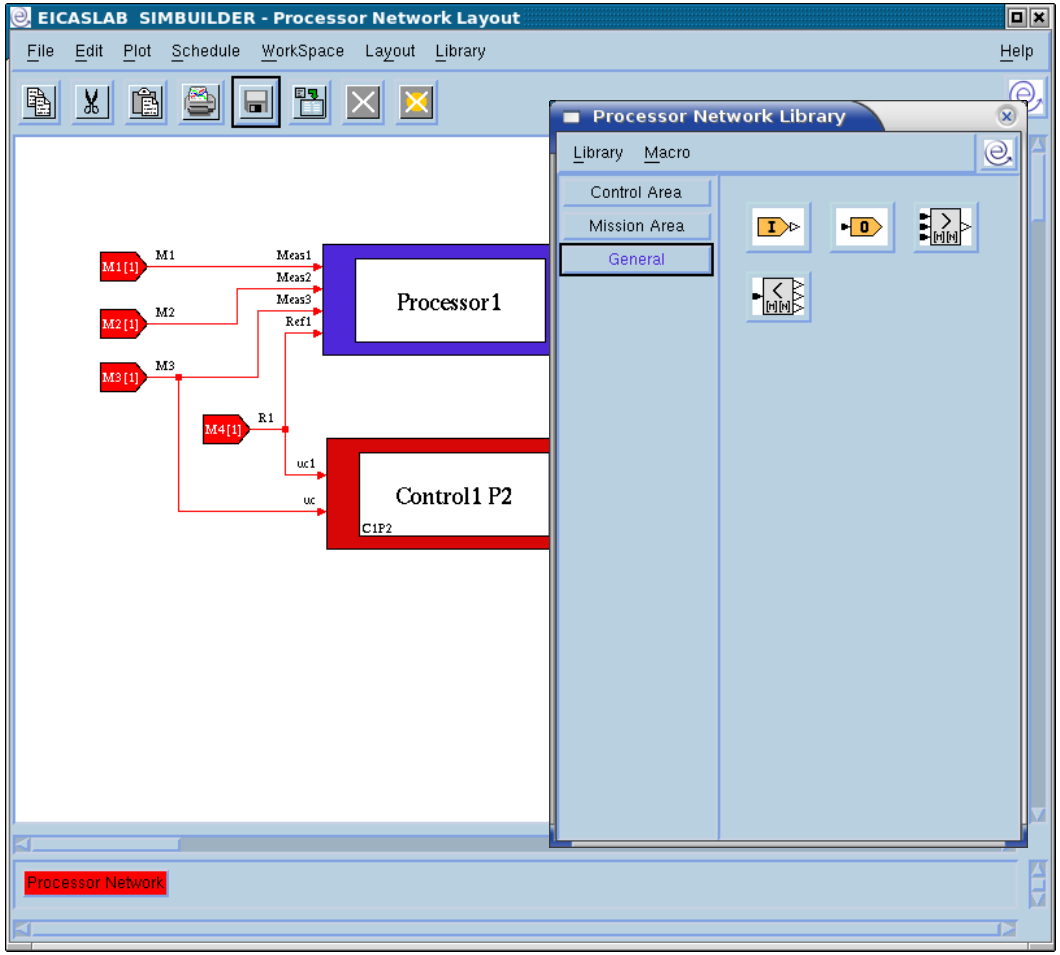
The Processor Layout



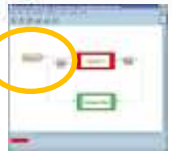
The Processor Layout can contain many Controls functions, all running on the same Processor.



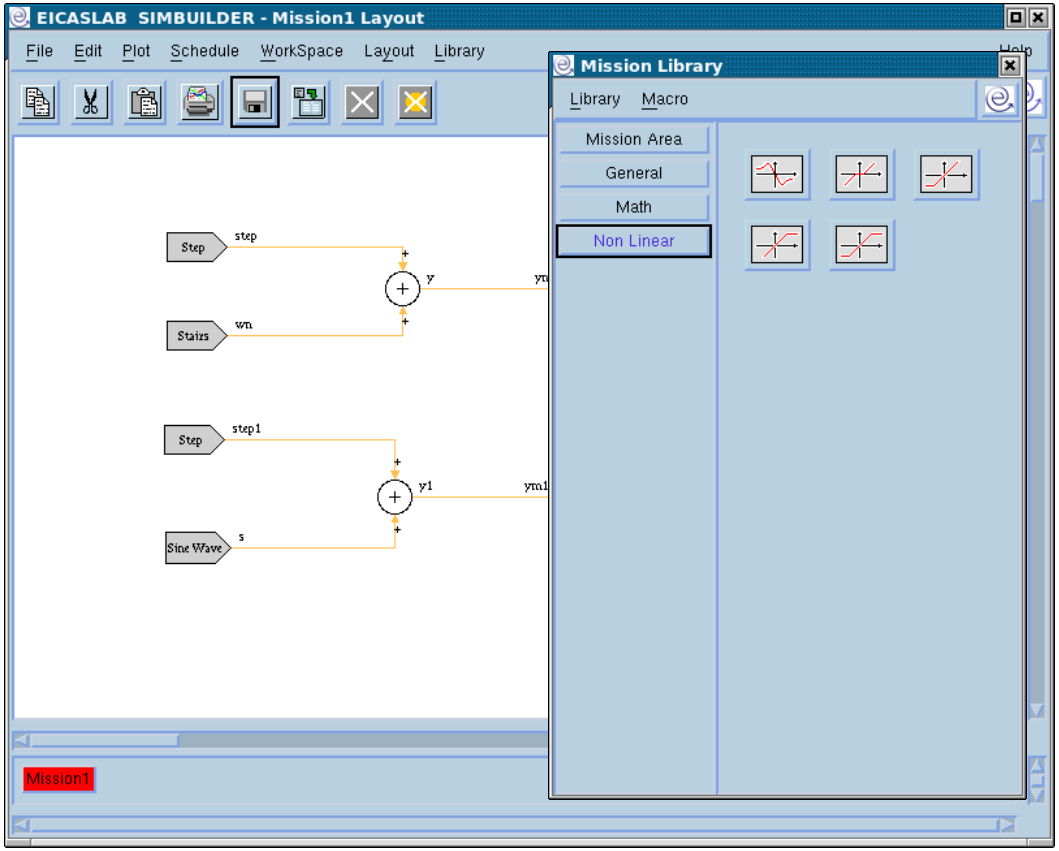
The Processor Network Layout



The Processor Network Layout allows you to group generic Control Area blocks (Control and Processors) and Control Mission blocks.



The Mission Layout

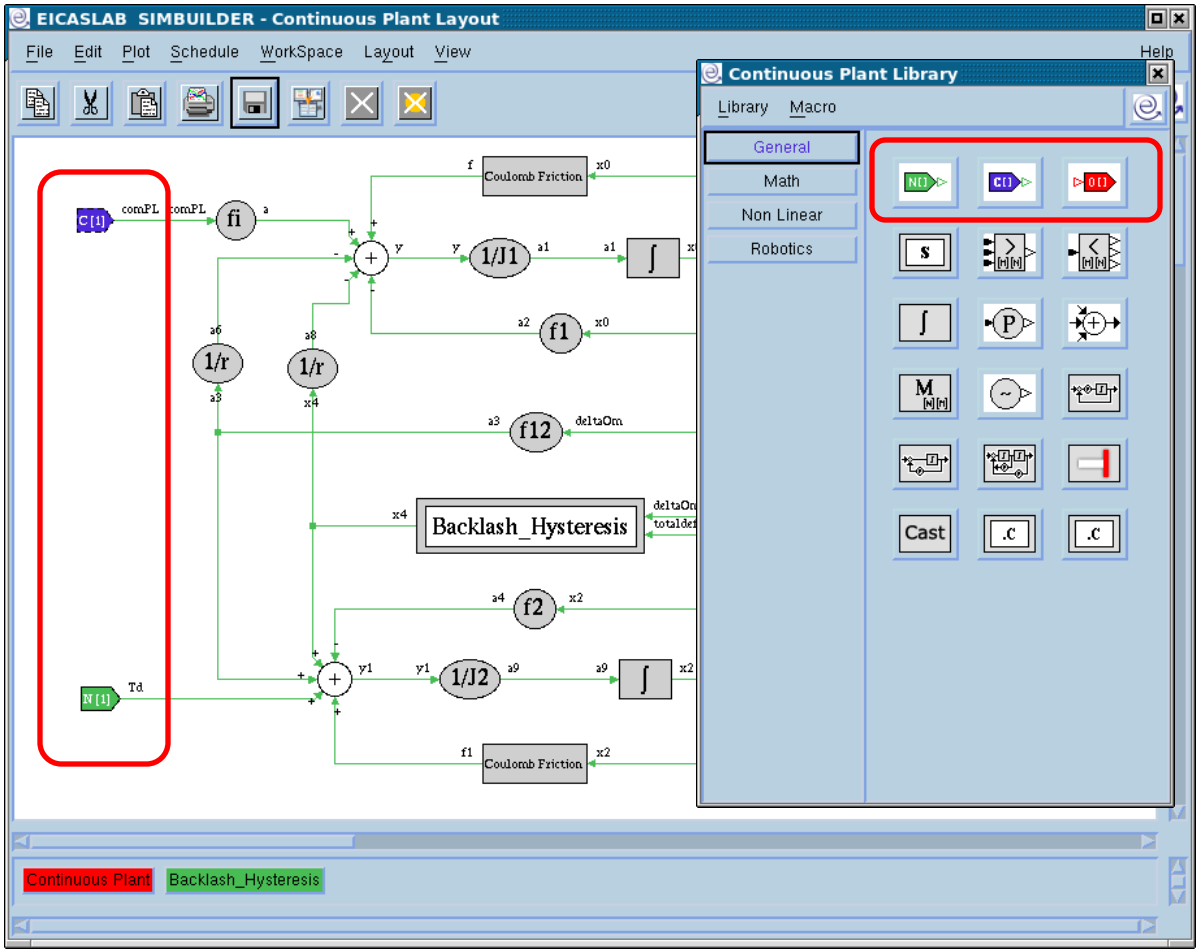


The Mission layout allows to graphically program the Mission.
You can develop your Mission by using the blocks available in the Mission Library.

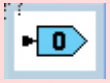
Input/output of graphically programmed blocks

In order to define the inputs and the outputs of a graphically programmed block:

insert
inside the graphical layout the input – outputs blocks.

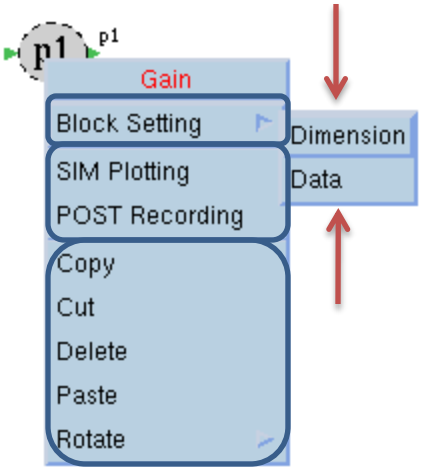


Input/output blocks in graphical layouts

Layout	Input	Output
Hybrid Plant	 Hybrid Plant Input	 Hybrid Plant Output
Processor Network	 Network Input	 Network Output
Processor	 Processor Input	 Processor Output
Control	 Control Measure Input;  Control Reference Input	 Control Data Output;  Control Command Output
Mission	 Mission Input	 Mission Output
Continuous/ Discrete Plant	 Plant Noise Input;  Plant Command Input	 Plant Output

The menu of the blocks of the low level layouts

Every block inserted in a low level layout has its own popup menu.



Block Setting menu
the **first item** of the *Block Setting* menu depends on the type of the selected block:

it can set the dimension of the block (which generally corresponds to the dimension of the input and the output), or its structure (opening a "*Structure*" window which depends on the type of block),

the **second item** of the *Block Setting* menu opens the "*Data*" window of the block.

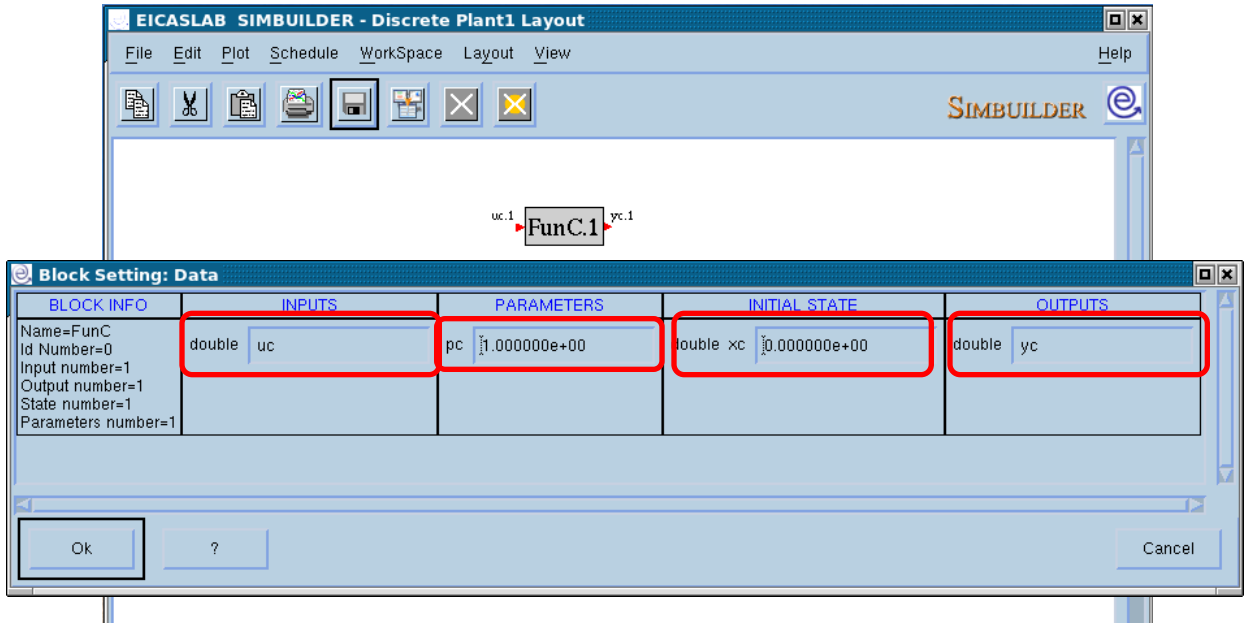
The ***SIM Plotting*** and ***POST Recording*** menus allow to select the variables to be plotted and/or recorded.

Every block has the standard ***Copy***, ***Cut***, ***Delete***, ***Paste*** and ***Rotate*** menus.

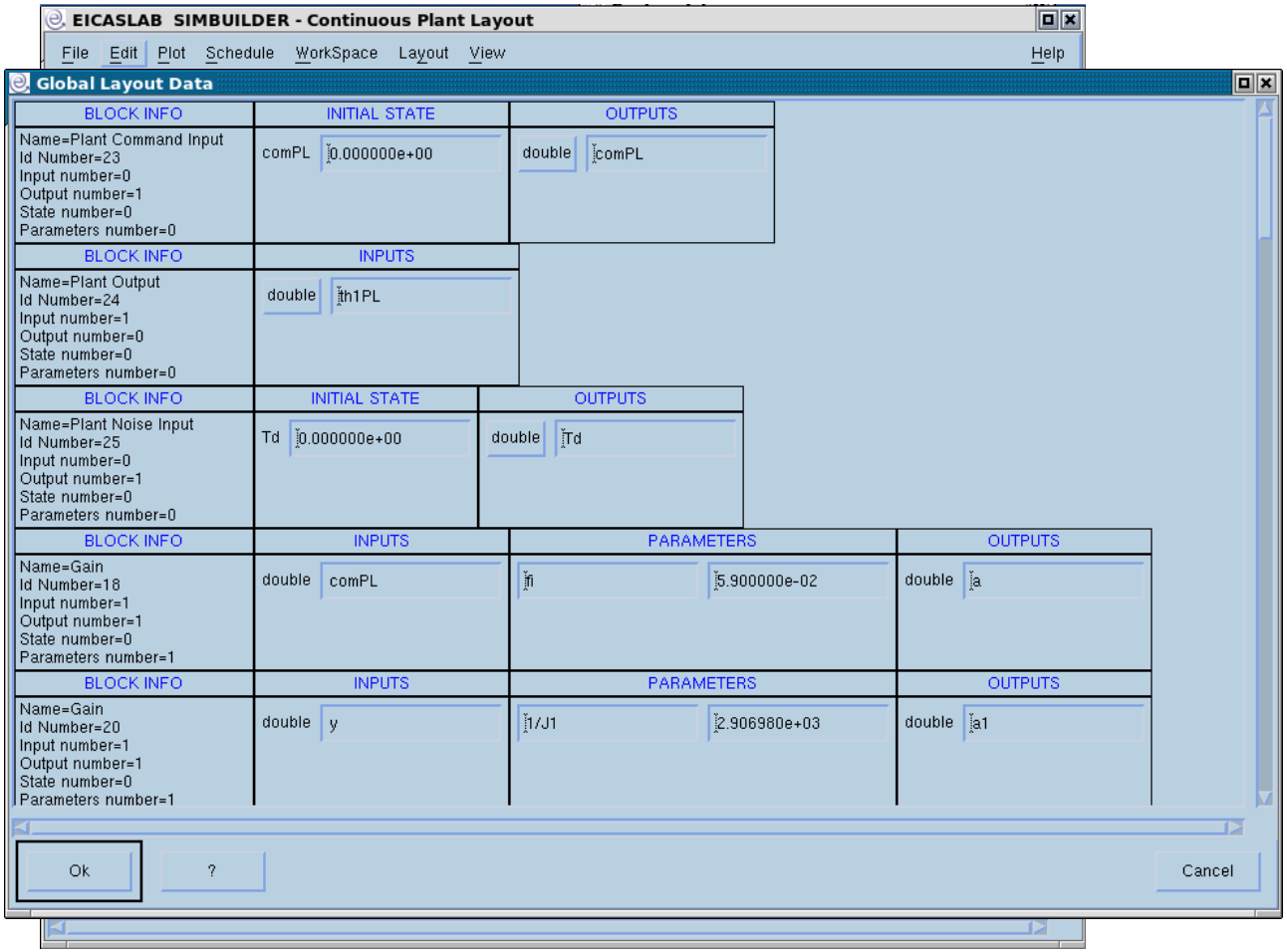
The "Data" window

Every block inserted in a low level layout has its own **"*Data*" window** which allows to view and modify (whenever possible):

- the inputs,
- the parameters,
- the states (if any) and
- the outputs of the block.

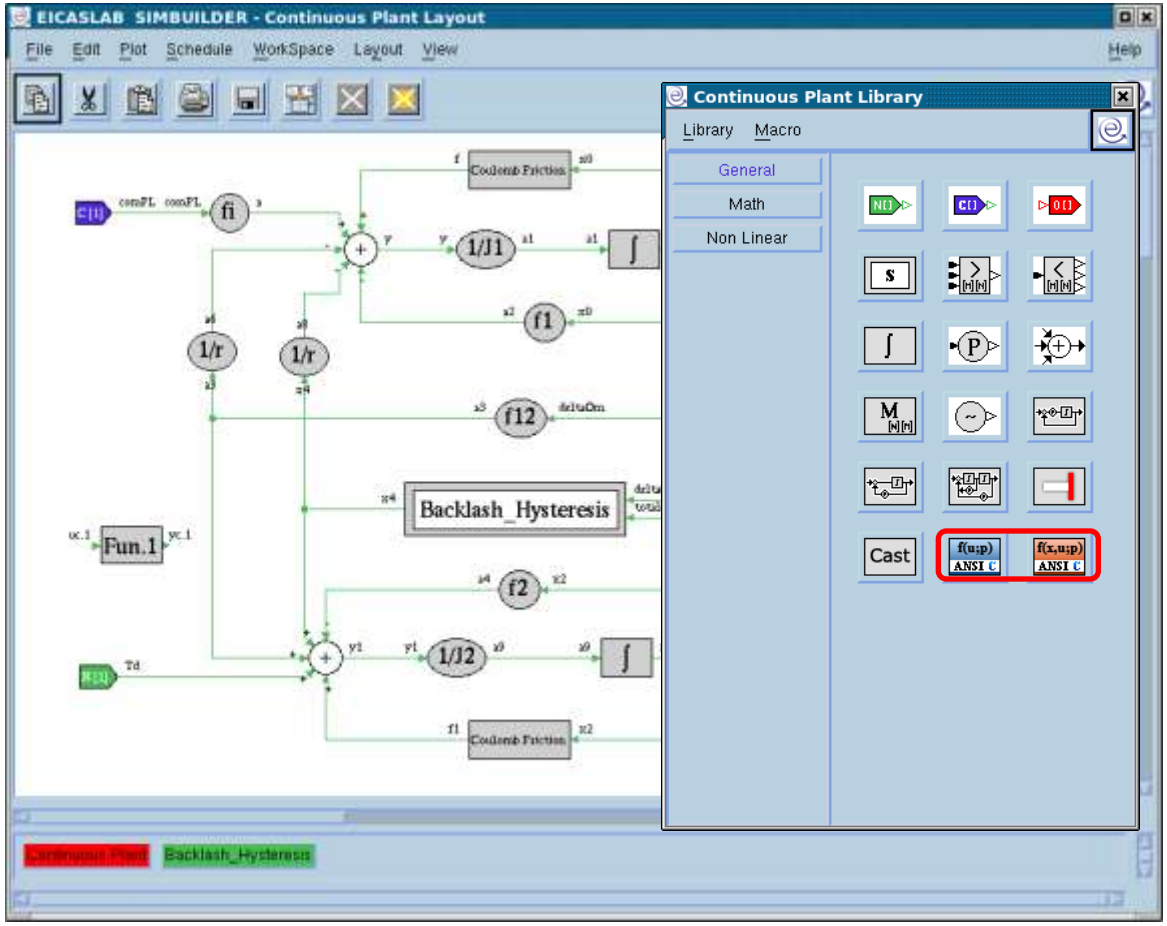


The "*Global Layout Data*" window



It is possible to view and/or modify all the data of all the blocks of a layout by means of the "*Global Layout Data*" window.

Using ANSI C blocks in a graphical layout



In the low level graphical layouts (Continuous Plant, Discrete Plants, Control and Mission Layouts), it is possible to insert special blocks programmable in ANSI C language.

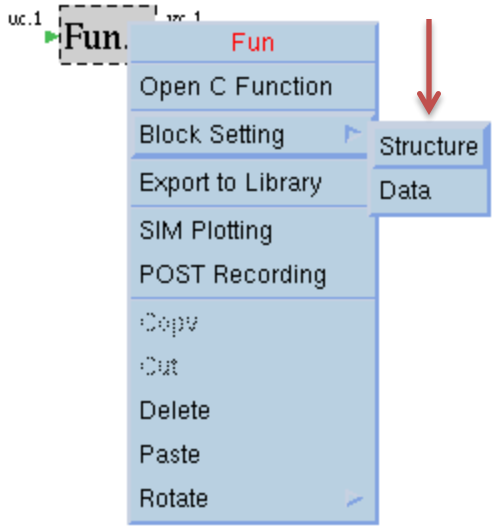
There are two types of blocks, allowing you to program in ANSI C language:

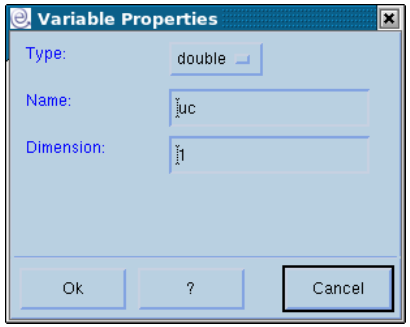
- static functions
  in this case the C block implements the function:
  y= f(u;par);

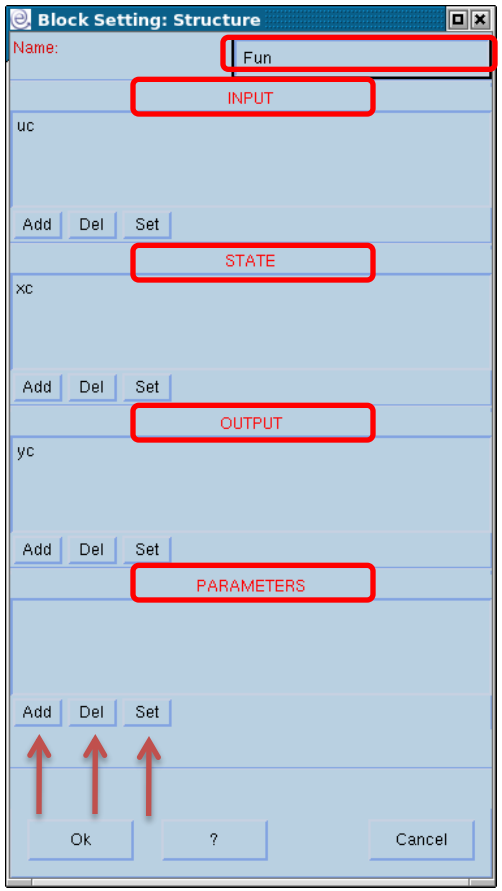
- dynamic functions
  in this case the C block implements the function:
  y= f(x,u;par);

(having indicated:
y: outputs, u inputs, x: states, par: parameters)

ANSI C Block: structure



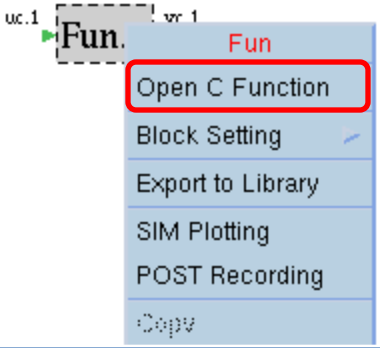




Through the "*Block Setting->Structure*" window you can define the structure of the ANSI C block in terms of:

- block name,
- block input,
- block states (if it is dynamic),
- block outputs,
- block parameters,

ANSI C Block: C files



Every C Block is associated to an ANSI C template containing pre-defined C functions.
These C functions can use all the inputs, the states (if it is dynamic), the outputs and the parameters of the C Block and the time of the simulation.

Function name	Description	Schedule
<FunctionName>_Ini	Function used for initialisation purposes	Function executed before starting the simulation
<FunctionName>_Exe	Function used to calculate the state evolution of *dynamic functions* or the output of *static functions*	called each time the block is scheduled
<FunctionName>_Out	Function used to calculate the output of *dynamic functions*	called each time the block is scheduled
<FunctionName>_Fin	Function used for final operations	Function executed at the end of the simulation

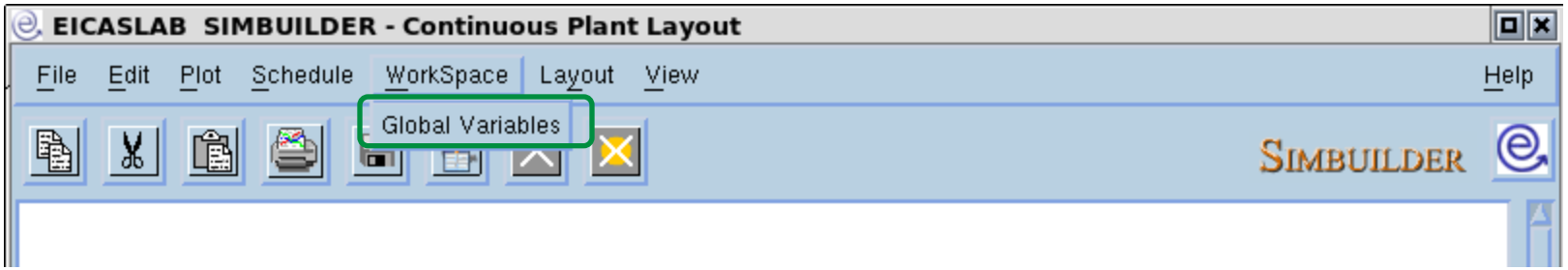
The WorkSpace

EICASLAB WorkSpaces are sets of global variables defined by the user.

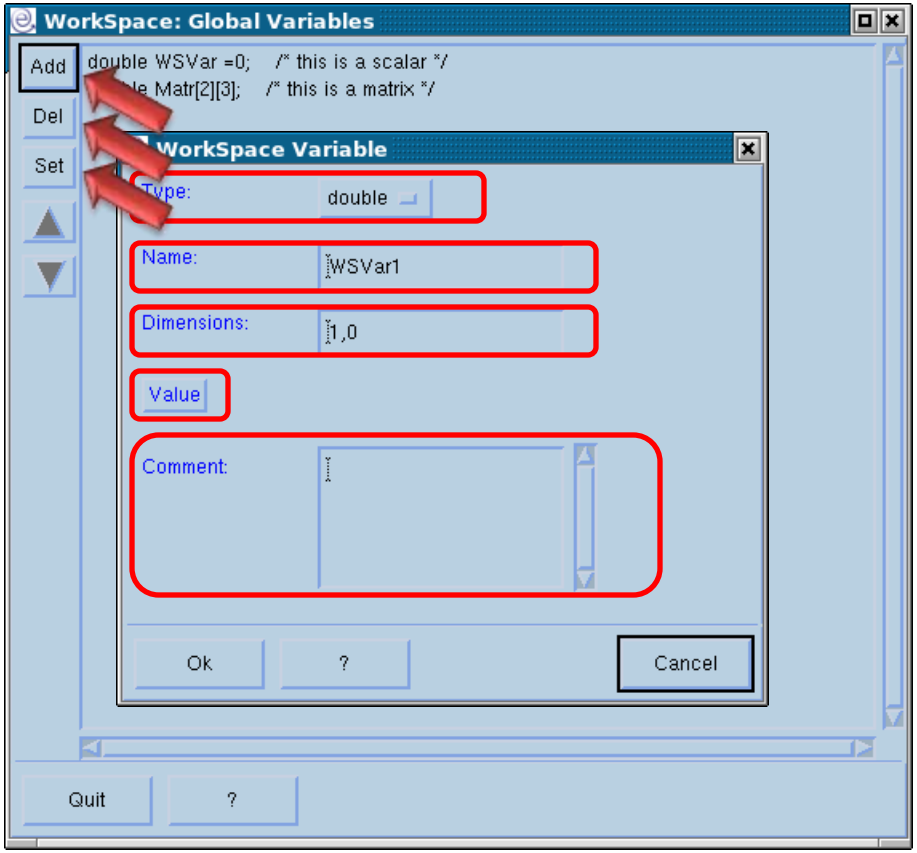
Workspaces are available, associated to:
- the Plant Area: 1 WorkSpace for all the blocks of the Plant Area,
- the Mission Area: 1 WorkSpace for all the blocks of the Mission Area,
- the Control Area: 1 WorkSpace for every processor.

The internal blocks inserted in a low level graphical layout (Continuous Plant, Discrete Plants, Control and Mission Layouts) can use the global variables of the corresponding WorkSpace.

The Workspace variables can be viewed and modified by means of the "*WorkSpace: Global Variables*" menu.



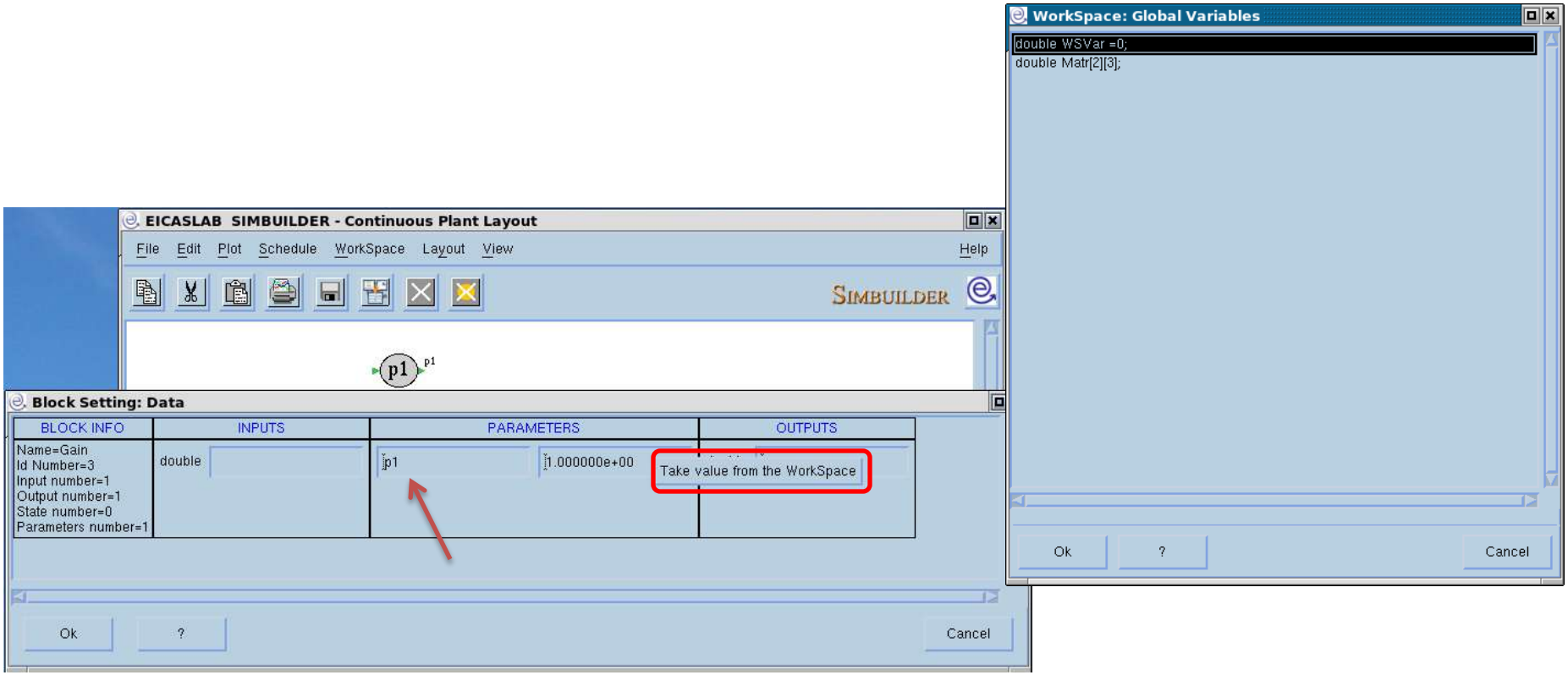
The WorkSpace variable definition



The WorkSpace contains a set of global C variables, defined by the user.

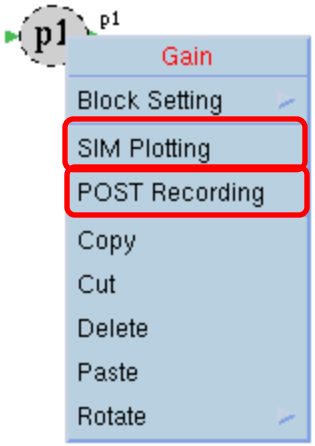
How to use WorkSpace variables in graphical blocks

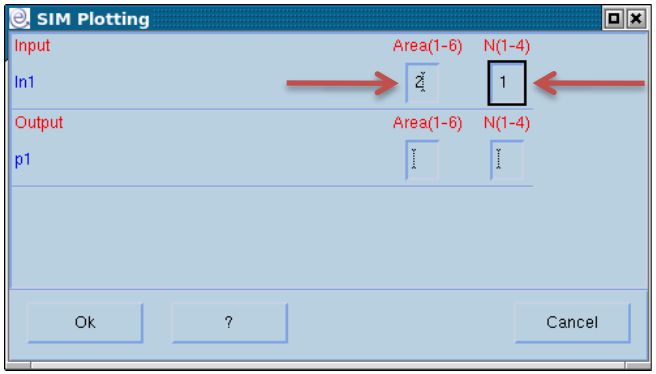
Any parameter of any block of a graphical layout can assume the value of a WorkSpace variable.



Variable selection for SIM plotting and POST recording

It is possible to select any input, any state (if any) and any output of every block inserted in a low level layout for SIM plotting and/or POST recording:

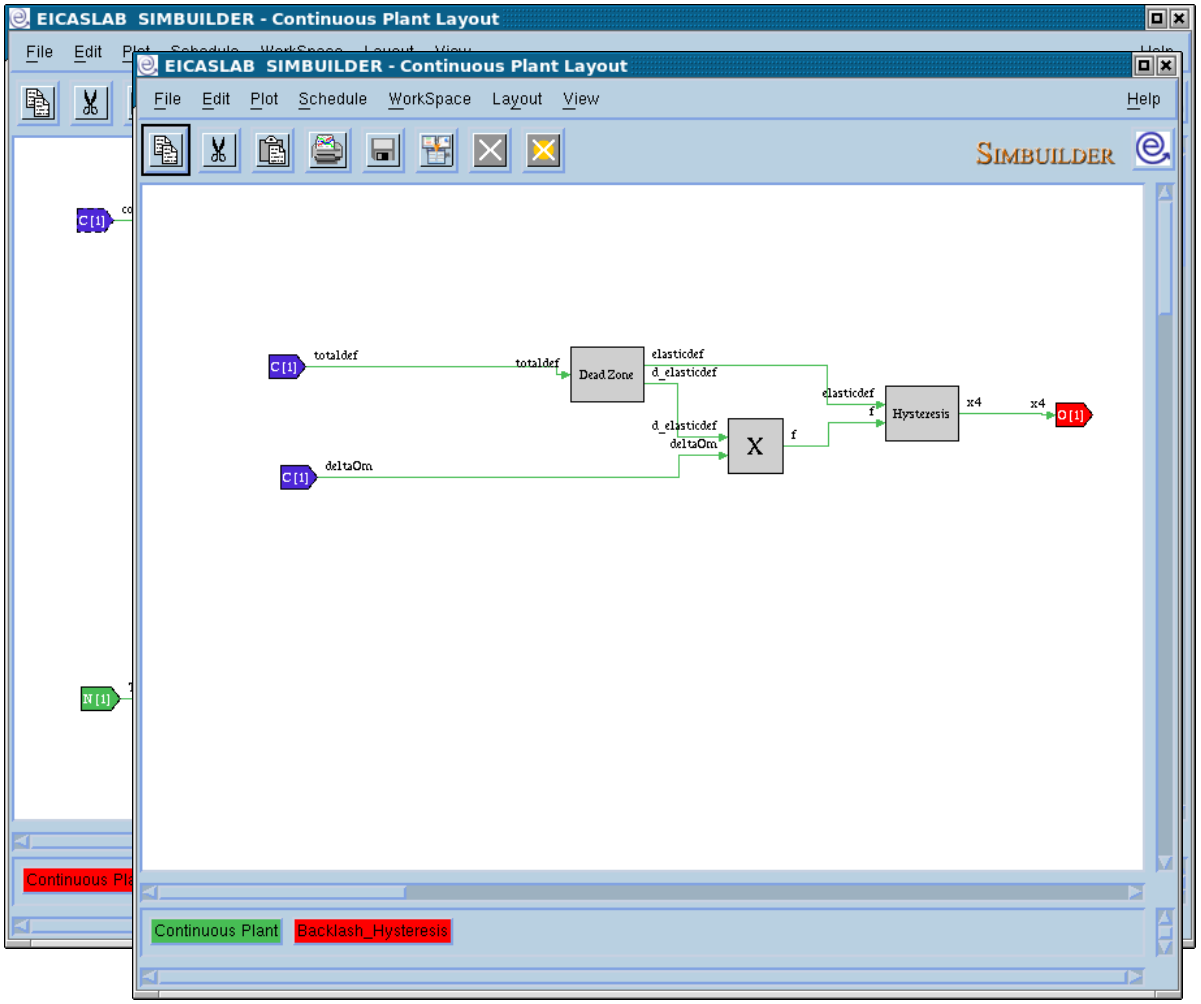




Selection of the variable for **SIM plotting**.
The SIM has six plotting areas in which you can display up to four variables: when you select a variable you indicate in which area and in which position to plot it

Selection of the variables for **POST recording**.

Subsystems



When you create your project in *Graphical mode*, you can simplify the representation of your system by collecting parts of your block diagram in a block called **Subsystem**.

Double clicking on the subsystem opens the *Subsystem* layout, where you can use all the blocks available in the related library.
You can also create other subsystems in order to build a hierarchical block diagram

Macros in graphical layout

The libraries of the low level layouts (Continuous Plant, Discrete Plants, Control and Mission Layouts) are **customizable** with user blocks called **'macros'**.

The macros are created by the user in order to complete the library according to the user needs.

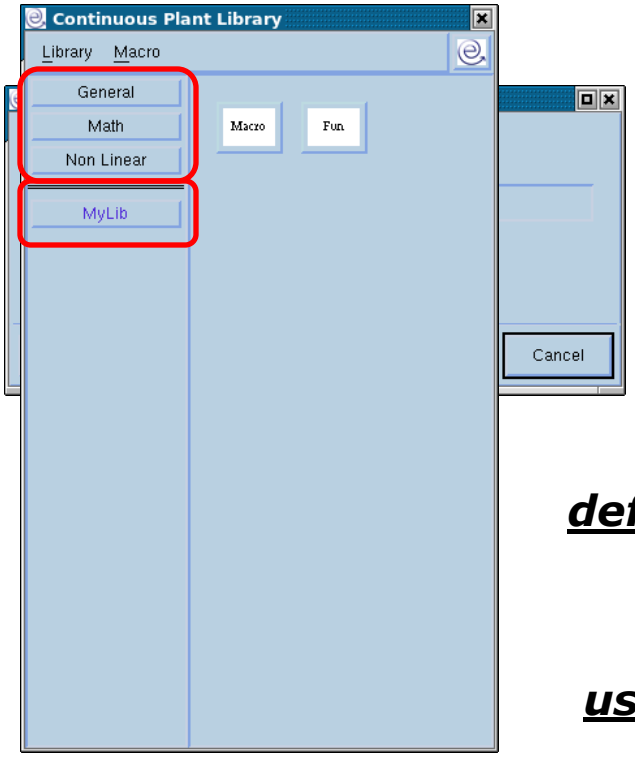
The macros can be programmed:

- **graphically** (working on the Graphical Macro layout) or
- **in ANSI C language**.

They are then available in the library window of the layout, as all the other blocks and can be used in the current project.

They can also be exported and then used in other projects.

User libraries



The macros are created in 'user libraries': before creating macros it is necessary to create user libraries.

There are then two categories of libraries:

default libraries: containing the blocks available as a default for each specific layout

user libraries: containing the user macros, they are indicated in the low part of the left section of the library windows.

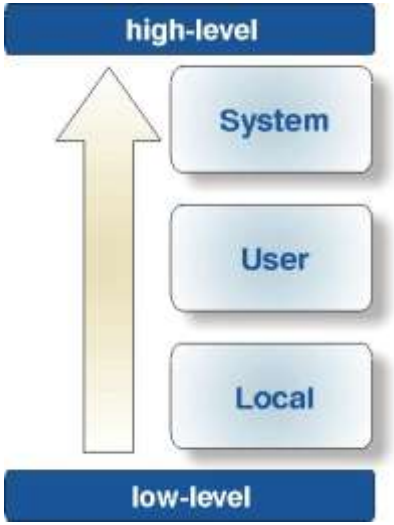
Macros level

You have at disposal three levels of macros:

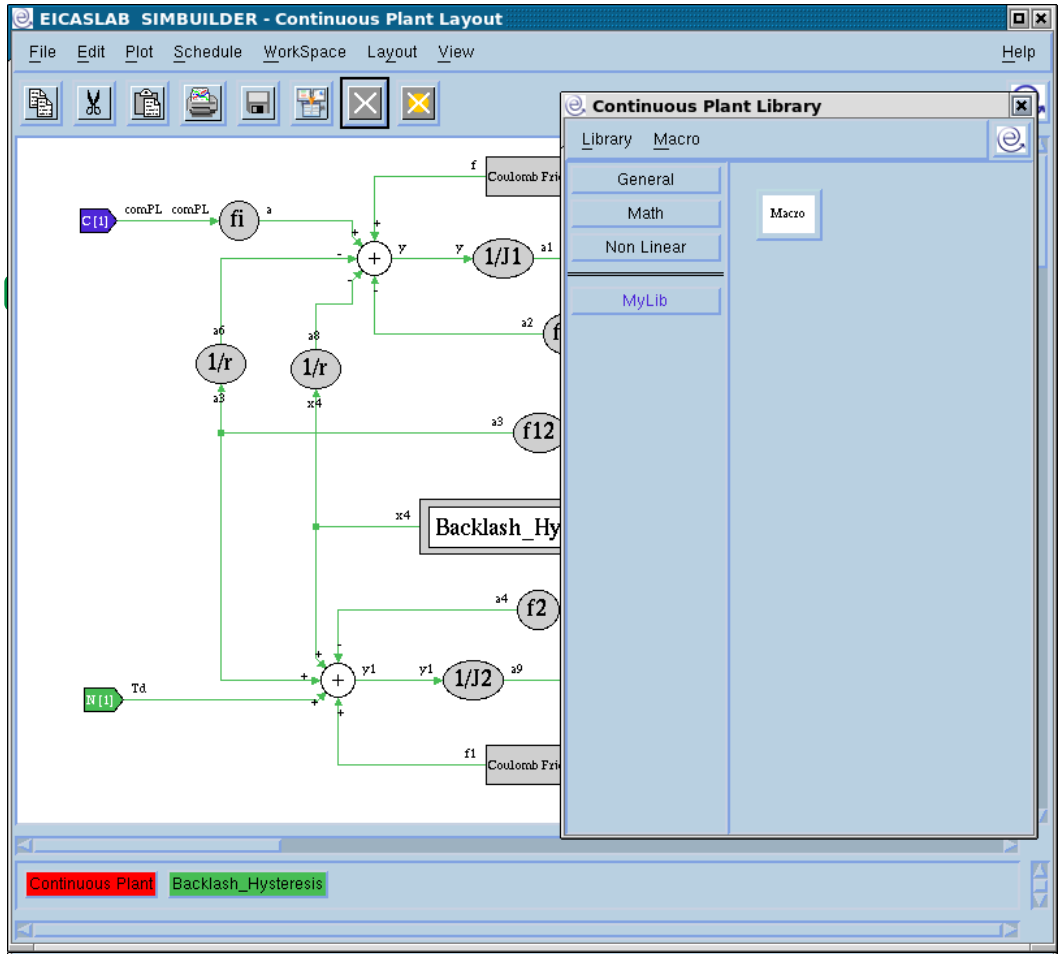
Local level macros: macros that can be used and modified only in the project in which they have been built,

User level macros: macros that can be used and modified only by the user who built them,

System level macros: macros that can be used and modified by every user that share the same EICASLAB.

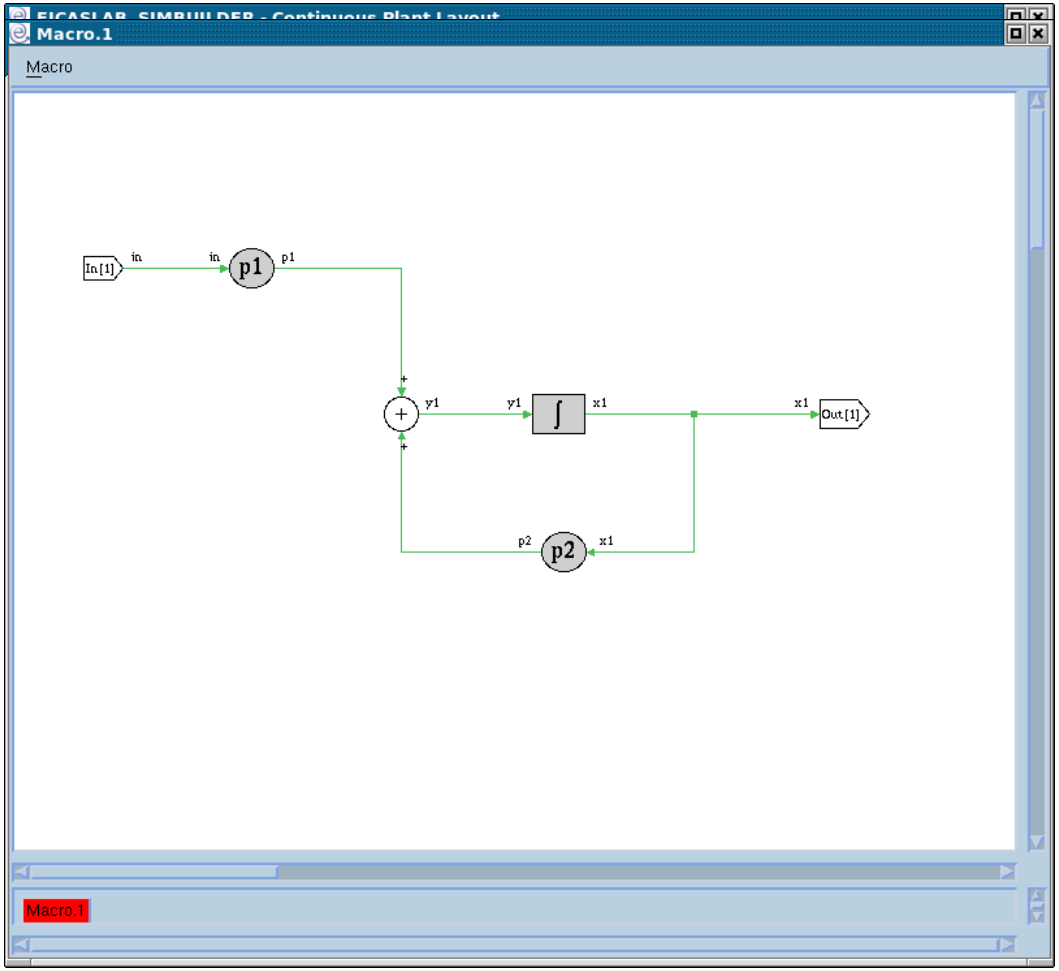


Graphical Macros: creation and editing



You create a Graphical Macro by means of a Macro Layout, which has the same library window as the block from which you edit the Macro.

Graphical Macros: instances



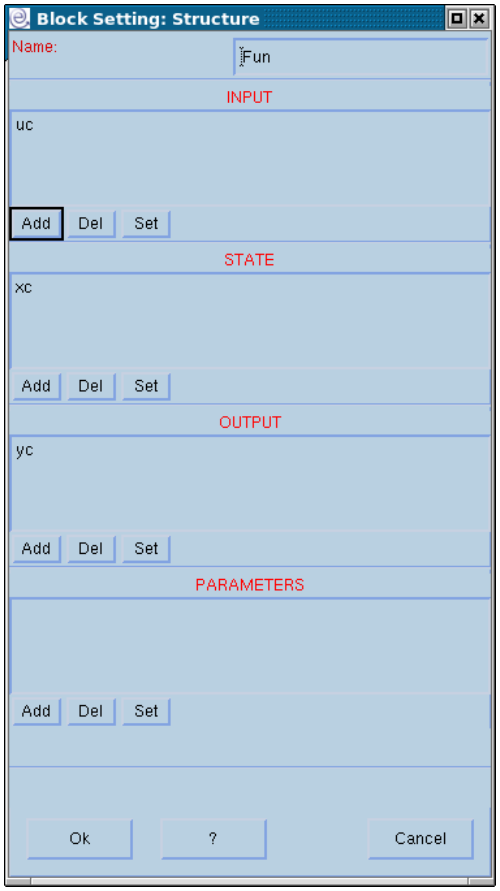
We call **instance** of a block available in a block library any occurrence of it in the graphical layout.

An instance in the graphical layout can be created by drag & dropping a block selected in the block library in the graphical layout.

You can customise the parameter values of any *instance* by double clicking on the *instance*, or by selecting the ***Open Layout*** item in the *popup menu* of the *instance*: a Graphical Macro layout representing the macro gets opened.

In the Macro layout you cannot change the structure of the *macro* but you can modify the value of the parameters.

ANSI C Macros

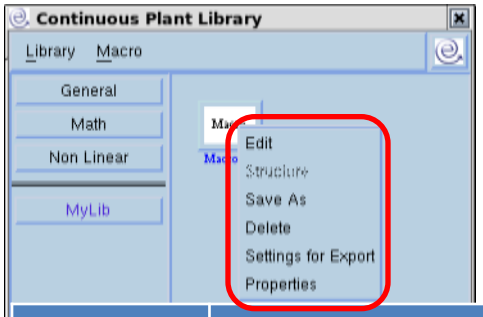


You can create an ANSI C Macro which is similar to the ANSI C blocks but is inserted in a user library and can then have many instances in the corresponding layout.

Two types of Macros are available:
- **static ANSI C Macro** (static functions)
- **dynamic ANSI C Macro** (dynamic functions).

When you create an ANSI C Macro its "*Structure*" window immediately gets opened.

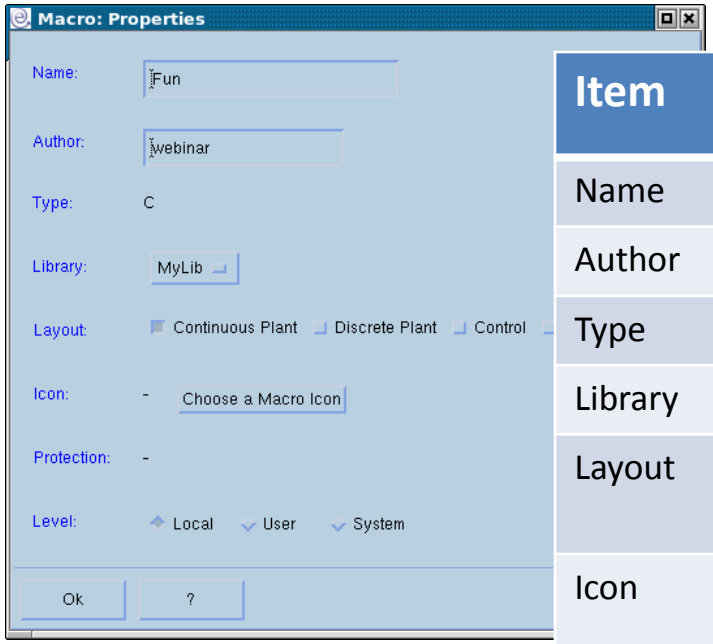
Macros popup menu



Every Macro has its popup menu.

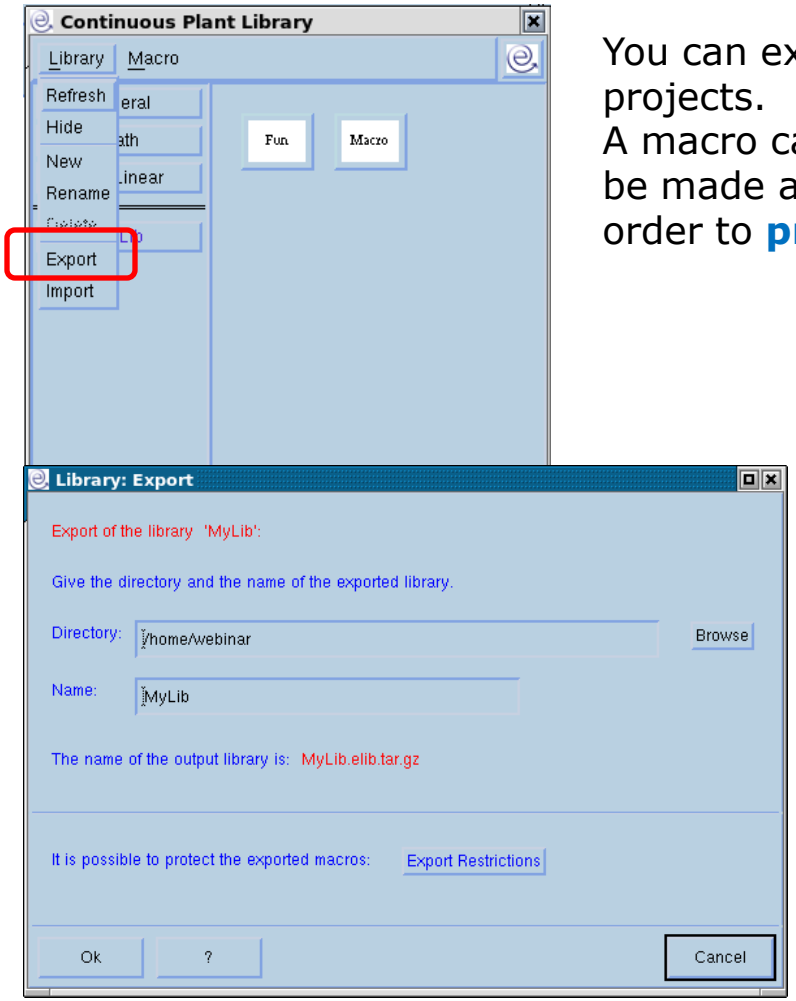
Menu name	Description	Note
Edit	Allow to modify the macro. It opens the C source file for ANSI C Macros, and the Graphical Macro layout for Graphical Macros	
Structure	Open the *"Block Setting: Structure"* window to modify the structure of the *macro*	Only for ANSI C Macro
Save As	Create a copy of the macro with a new name	
Delete	Delete the macro	
Settings for Export	It is possible to export a set of user macros to be shared with other projects. The "Settings for Export" menu allows to specify if and how an user macro has to be protected when it is exported	
Properties	Open the "*Properties*" window of the macro	

Macros: Properties window



Item	Description
Name	Name of the macro
Author	Author of the macro
Type	Indicate if it is Graphical or ANSI C (this is a not editable field)
Library	User library to which the macro belongs (which can be changed)
Layout	Indicate in which layout the macro can be used and allows to extend the use of the macro to other layouts
Icon	Each macro is represented by an icon in its user library; The icon is the image associated to a given user block of a user block library. By default the icon contains the name of the macro. It is possible to provide a user icon for the macro by means of a x*pm* file.
Protection	Indicate whether the macro is protected (imported with restrictions) or not
Level	Allows you to view and to change the current level of the macro

Macros: export



You can export macros to make them available to other EICASLAB projects.
A macro can be exported with *restrictions* in the sense that it can be made available with limited permissions in reading/writing in order to **protect your IPR** (Intellectual Property Rights).

You can export an entire user library or a set of selected macros of a user library.

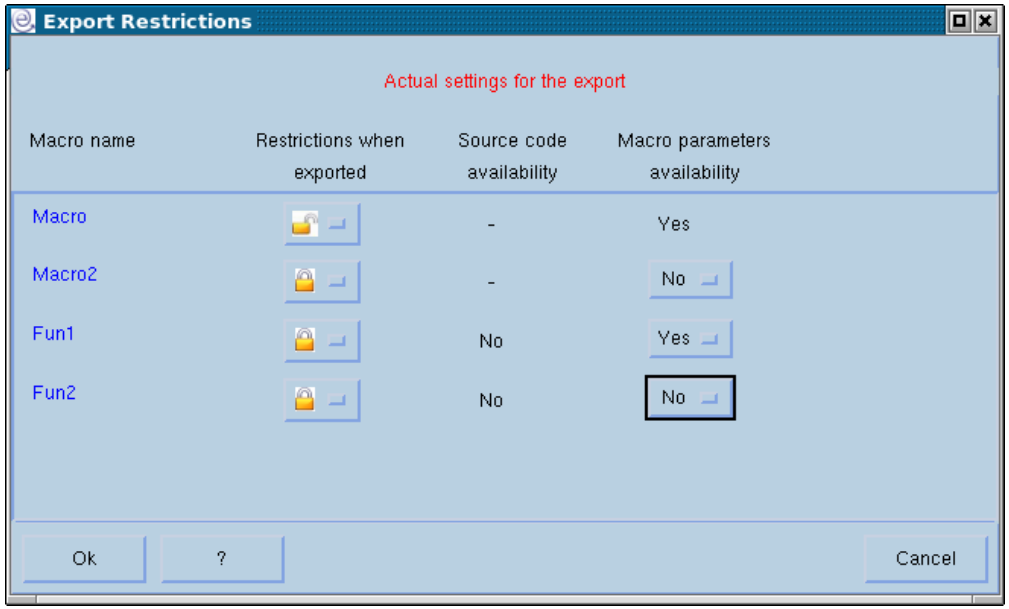
The "*Library: Export*" window allows to set:

- the name and the destination path of the library to export,
- the ***Export Restrictions*** button which opens a window containing the list of the exporting macros with their own export settings and where you can set the restrictions of the exported macros.

Macros: export restrictions

You can export the macros:

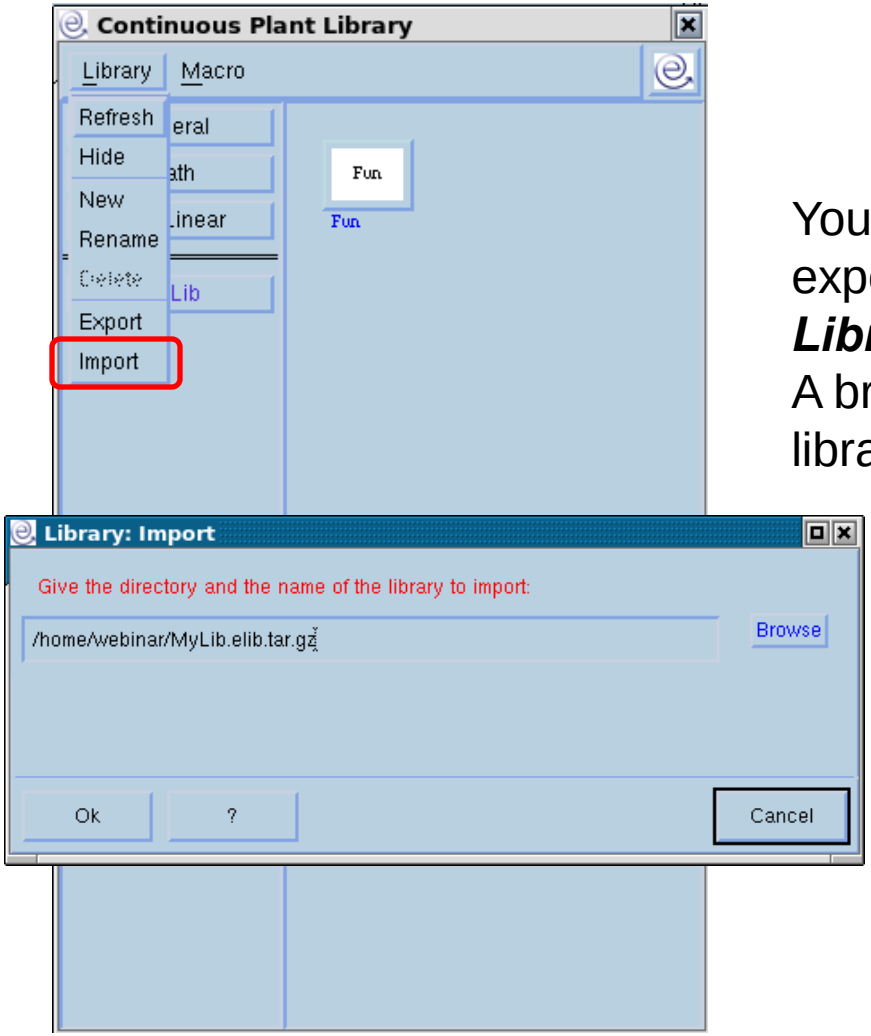
- without any restriction (open padlock)
- with restrictions (closed padlock)



AVAILABLE EXPORT RESTRICTION

- for ANSI C Macros:
  - deny access to source code
  - deny access to parameters
- for graphical macros:
  - deny access to graphical layout
  - deny modification of graphical layout structure .

Macros: import



You can import all the macros of an exported library through the ***Library → Import*** menu:
A browser appears for selecting the user library to be downloaded.

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