Integrated factory digital twin designer on RAMP 1.0

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EXECUTIVE SUMMARY

This document is the first release of the User Manual of the Advanced Plant Model and its Digital Twin Designer, integrated in the RAMP Marketplace. This information was taken from Better Factory Deliverable D1.2 "Integrated factory digital twin designer on RAMP 1.0".

The Advanced Plant Model (APM) is a system developed by INESC TEC that aims to provide a real-time digital representation of the ongoing state of a given shop floor, in the form of semantic and geometric information. It includes representations of workers, industrial and mobile robots, work-stations, manufacturing lines, racks, boxes, palettes, kits and parts, consolidated by a production schedule generated by a Manufacturing Execution System (MES). Human operators and robotic manipulators can exploit this information when participating in manufacturing operations on the shop floor.

The Digital Twin Designer, described in this document, is the element inside the APM system that provides the means to enable the User to build a digital representation of manufacturing areas, including their major objects such as logistic racks, robotic manipulators and equipment is general, among others. CAD models representing the objects available in the manufacturing area, may be selected, entered into the system in order to reach a digital model of the three-dimensional environment.

This document provides a User Manual of the Digital twin Designer, describing the main application features of the Tool and a set of training material, oriented to the User and letting him/she experience the main functions implemented by the Tool.

1 Introduction

1.1 Scope and objectives

The document aims the "Integration of the APM in the RAMP Marketplace and a guide how to use it".

The Advanced Plant Model (APM) is a system developed by INESC TEC that aims to provide a real-time digital representation of the ongoing state of a given shop floor, in the form of semantic and geometric information. It includes representations of workers, industrial and mobile robots, work-stations, manufacturing lines, racks, boxes, palettes, kits and parts, consolidated by a production schedule generated by a Manufacturing Execution System (MES). Human operators and robotic manipulators can exploit this information when participating in manufacturing operations on the shop floor.

1.2 Document organization

Besides this introduction, the document is organized in the following chapters:

- Chapter 2 "The Advanced Plant Model and the Digital Twin Designer" supplies an overall description of the APM and of the Digital Twin Designer, identifying their relationship;
- Chapter 3 "Methodology" specifies the methodology one should follow to create a digital model on the Digital Twin Designer;
- Chapter 4 "User Manual" aims to describe all the relevant functional and graphical elements in the Digital Twin Design that enable Users to create digital models;
- Chapter 5 "How to" provides a series of "how to" cases aiming to provide Users working examples on the usage of the Digital Twin Designer.

Acronym	Term		
APM	Advanced Plant Model, name of the software-based system that includes the Digital Twin Designer		
MES	Manufacturing Execution System		
OSPS	Open Scalable Production System, architecture framework specifying the relationship of a set of software elements aiming to manage a scalable production system		
PLY	Polygon File Format, data format for CAD models		
RAMP	Robotics and Automation Market Place		
STEP	STandard for the Exchange of Product model data, ISO 10303, data format for CAD models		
STL	Standard Triangle Language, data format for CAD models		
URDF	Unified Robot Description Format, data format for CAD models		

1.3 Acronyms

2 The Advanced Plant Model and the Digital Twin Designer

The Advanced Plant Model (APM) is an autonomous software-based system that aims to manage a near real-time digital representation of the ongoing state of a given manufacturing area with the main purpose of controlling and monitoring the operations carried out by a fleet of fixed and/or mobile robotic manipulators that carry on logistic and assembly operations.

The model maintained by the APM comprehends the three-dimensional information about the geometry of major objects present in the shop floor, such as Racks, Boxes, Palettes and Kits in the case of a logistic area and WorkStations, Conveyors, Equipment and Manufacturing Lines in the case of an assembly line. The CAD models of the parts that are manipulated and/or assembled are also included in the Model, together with the corresponding grasping poses.

Robotic Manipulators are modelled in terms of three-dimensional geometry but also in terms of their capabilities to operate on the shop floor and to execute logistic and assembly tasks. In particular, the robotic programs are also kept in the Advanced Plant Model and downloaded to the robots when needed.

The third aspect that links together the two above ones, is the production schedule. Instances of production schedules may be retrieved from a Manufacturing Execution System, specifying the operations to be achieved, their sequence and the assignment of production resources (human operators, robots, other equipment). The Advanced Plant Model integrates the robotic programs in the production plan and interacts with them in order to instruct them to execute the assigned manufacturing/logistic tasks and to monitor their execution. During the execution of a task by a robot, the Advanced Plant Model provides information to the robot, stating the location and geometry of all the objects that will be used in the context of that task, fulfilling the main purpose of the system which is to provide information about the 'world' to the robot fleet.

The communication model between the APM, the robot fleet and the MES is specified by the OSPS framework (Open Scalable Production System). Communication between these elements is achieved through the exchange of messages and via a publish-subscribe mechanism.

The Digital Twin Designer is the identification of the element, inside the APM, that enables Users to build the digital representation of a physical area (logistic, assembly, ...) by creating 3D models of objects, such as racks and workstations, and to provide a 3D visualization of the Model for other purposes not initially envisioned by the Advanced Plant Model.

This document addresses the Digital Twin Designer and its integration in the RAMP Platform.

3 Methodology

The Digital Twin Designer assumes that the User knows very well the layout of the physical area that he/she intends to represent in a digital form as well as the functional and geometric characteristics of the physical objects located in the physical area. These objects may be racks, palettes, conveyors, workstations, production lines, robotic manipulators and equipment in general. The very first step for the User to start using the Tool is to get acquainted with the physical reality of the targeted area.

Subsequently, the User should:

- Build a Catalogue comprehending the geometry of each type of physical objects he/she needs to insert in the final Model. CAD models should be retrieved from external sources (either from public repositories available in the Internet, from the company's own CAD/CAM system or from the equipment manufacturers). Section 4.4 addresses this step.
- Create a Map that specifies the layout of the target physical area. Create the 'physical area' object by specifying its dimension, scale and map. Section 4.5.1 addresses this step.
- Start populating the Map with instances of objects, by selecting objects on the Catalogue and implanting them on the image representing the Map. Section 4.5.2 addresses this step.
- 4. Validate the locations where objects were implanted, by looking at the entire model in a three-dimensional window. Section 4.5.3 addresses this step.

Initial training is essential for the user to know concretely what he/she can do with the Tool and how to do it. Section 5 addresses this need.

4 User Manual

This section describes the main features of the Digital Twin Designer (the Tool), taking the perspective of the final User. Thus, the section aims to be the User Manual of the tool. A set of screen shots support this manual so that the User sees always the concrete elements that interact with him/her in the context of each main feature being explained. In the text, the term Interface is used to designate the User Interface of the Tool.

4.1 The Login process

Usage of the tool requires the User to go through an authentication process, through which the User has to supply a username and corresponding password. As the Tool is integrated with the RAMP Platform, but continues to be an autonomous system, running in an independent way, this authentication process is done by the RAMP Platform by following the OAuth2 protocol (<u>https://oauth.net/2/</u>), the industry-standard protocol for authorization. The following steps guide the User:

1. The Tool shows the screen below, User presses the "RAMP...." button.

APM Advanced Plant Model	v4.6.12 3	3-September-2021	•0 Sign In
		APM - Advanced Plant Model	
		To continue, log in to APM.	
		O GitHub - Software Repositories	
	R	AHP - Robotics and Automation MarketPlace	
		or	
	Email	<u>D</u>	
	Passwo	brd 🖏	
		Log In	
		Copyright @ ##E30 1EC 2014-2021. All Rights Reserved.	

Figure 1 – Login process: 1st step

- 2. In the first access to the Tool, a screen is presented asking the User to authorize the Tool to access his/her account on the RAMP Platform.
- 3. Subsequently, the RAMP platform presents the screen below (left), asking the User to enter his/her user name and password.
- 4. Another window is shown by the RAMP platform (below, on the right), asking the User to authorize the RAMP to access his/her account.

RAMP	
Login	Do you authorize moocramp to access your protected resources?
Email address: man@test.com	Authorize
Password:	Deny
🔘 14MS 🖉	🔿 I4MS 🛩
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No 767642 and No 824964	This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No 767642 and No 824964
6 2019 RAMP Preasy policy	© 2019 RAMP Privacy policy

Figure 2 – Login process: 2nd (left) and 3rd (right) steps

In the end (if the User provided all the right information), the login process is completed and control is given to the Tool. The Tool's interface is shown (Figure 3), allowing the User to start using the Digital Twin Designer.

4.2 Organization of the user interface

After a successful login process, the Tool presents its user interface as shown below.

		Identification and	l access to training, la	anguage selection and	login/logout
	M Advanced Plant Model	4.6.12 3-September-2021		Training E	N.▼ Demoname ▼
Administration	/ 🕋 APM / 📃 Impla	antation / Set Objects		IILAB	
Catalogue >	Grid Hide	Zoom 1.00 - +	Pan < > < ^	1 pixel : 0.010 meters	Selected
Implantation 💙					Manufacturin Area
Physical Areas		Identificat	ion		71100
Set Map		of selecte	ed		
Set Objects		feature			
Racks L. boxes & Parts					
Equipments					
Conveyors					
Workstations					
Production Lines					
Robot fleet					
Runtime 🕽					
Mai	n features	Main workir	ng and display area		

Figure 3 – User Interface: main working areas

The Interface is organized in four areas:

- The top area identifies the Tool (name and version) and allows the User to access a training area (see chapter 5 "How to"), to change the language used by the Tool (at present stage English and Portuguese are the supported languages) and to exit the Tool.
- The left area provides access to the several application features (Administration, Catalogue, Implantation and Runtime) that are then presented in the central area of the Interface.
- The central area is the area where most information is presented and where the value-added interactivity with the User takes place.
- Between the top and central areas, on the left, a "breadcrumb" is displayed identifying the feature of the application that is active and its navigation hierarchy ('APM / Implantation / Set Objects' in the above picture). On the right side, a drop-down list lets the User select the physical area (e.g. a logistic or assembly area) he/she is working on. This is VERY important. By opening this drop-down list, all the known physical areas are shown, letting the User select the one which he/she will start to work with ("IILAB" in the picture above). After this selection, the implantation and Runtime features are dependent on the selected physical area.

4.3 The Administration area

This application feature identifies which Users have already entered into the Tool (successfully concluded the login process). As the Tool is integrated with the RAMP Platform, any User is the RAMP Platform is associated with an organization. By default, all the users associated with a company can use the Too.

As show in the picture below, the Tool knows two users ('Demoname' and 'Providername'), that are associated with the 'test.com' organization. Be selecting one user (e.g. ('Demoname'), the Interface allows one to update the picture that will visually identify the User in the Interface. The remaining options, 'Edit Profile' ... have no effect when the Tool is integrated in the RAMP Platform.

APM Adva	APM Advanced Plant Model v4.6.12 3-September-2021 Training EN+ Demonarre *							
Administration 💙	/ 🕋 APM / 📃 Administration / 🕍 Users /	Details						
L Users								
Catalogue >	test.com							
Implantation 💙	Demoname Demolastname							
Physical Areas	Providername Providerlastname							
Set Map		Demoname Demolastname						
Set Objects		test.com						
Racks		✓ Edit Profile						
L. boxes & Parts								
Equipments								
Conveyors								
Workstations								
Production Lines								
Robot fleet								
Runtime 🔪								

Figure 4 – Administration feature

4.4 The Catalogue

The Catalogue is the application feature responsible for keeping a list of all the known 3D models. Depending on the final aim of the User, each major object present in a physical area (e.g. a workstation) should have a correspondent 3D model. The Catalogue is the feature letting the User create, change or remove the models associated with each type of object. The purpose of the Catalogue is to enable the user to build models of a given physical area by 'instantiating' and implanting the object models on the digital representation of the physical area.

Presently, the application supports the following types of objects: Racks/Large Boxes/Small Boxes/Kits for modelling logistic areas, Workstations/Conveyors/Equipments/Production Lines for modelling assembly areas and Parts/FinalProducts for modelling the elements processed in a physical area. Robots are related with the modelling of robotic equipment.

4.4.1 Listing the objects

By selecting an object type on the left area of the Interface (see picture below where 'Equipments' is selected), a list of all known models is shown, presenting the name and the geometrical dimension of the object's volume.

	APM Advanced Plant Model v4.6.12 3-September-2021 Training EN - Demonarme						
Administration >	/ 🕋 APM / 📃 Catalogue / 🧮 Equipments		IILAB		*		
Catalogue❤					+ New equipment		
Racks	Equipment 1	Width 11	Depth 🔰	Height \downarrow	Actions		
Large boxes	Stand_ex_1	1000	3000	800	8		
Conveyors	inspection station	350	700	1300	& 1		
Parts	injection machine	4000	1250	1800	8		
Workstations							
Production Lines							
Robots							
Final Products							
Implantation >							
Runtime 🕽							

On top of the list, a button '+ New ..." enables the creation of a new object type (described later in this chapter).



The two buttons on the right (picture above) allows one to remove a model or to visualize and edit its 3D model. Activating this button, causes the Interface to access the 3D model of the selected object (see picture below). User is now able to see the details of the model by using the mouse in the image:

- Pressing the left button and dragging the mouse allows one to orbit around the object's image;
- Rolling the central button allows one to zoom in or zoom out the image;
- Pressing the right button and dragging the mouse allows one to pan the object's image.

INESCIEC INC.	PM Advanced Plant Model v4.6.12 3-September-2021	Training	EN▼	Demoname	•
Administration	/ MAPM / Runtime / Physical Object Type (View/Edit)				•
<u></u>	Equipment Type : Stand_ex_1				^
Catalogue❤					71
Racks		Open Controls			
Large boxes	£				
Equipments					
Conveyors					
Parts					
Workstations					
Production Lines					
Robots					
Final Products					
Implantation >					
Runtime >					
Kullune /					

Figure 6 - Catalogue: Access to the 3D Model of an object type

4.4.2 Adjusting the CAD model to the object's bounding volume

By clicking on the top right button 'Open Controls', an interface is opened (see picture below), letting the User change the position of the 3D CAD model on the object's bounding volume. Please note the following:

- Each and every object created in the Catalogue has a bounding volume with the external dimensions provided by the User during model creation (with, depth and height).
- Optionally, a CAD model may be associated with an object. The following formats are supported: STEP, STL, PLY, URDF. After assigning a CAD model to an object, its position within the bounding box can be adjusted if needed.

The adjustment of the CAD model is accomplished by moving its geometry within the bounding volume:

- The 'red axis', 'green axis' and 'blue axis' slider widgets on the 'large displacement' zone, causes the geometry to move in the three X, Y, Z dimensions;
- The widgets below with the very same names but under the 'fine-tune displacement' zone, also allows one to adjust the position of the 3D geometry within its bounding volume but with greater precision.
- The 'Rotation' widgets allow the CAD image to rotate around its X, Y, Z axis.



Figure 7 – Catalogue: Access to the 3D model of an object

The following picture shows the same object but the CAD model is completely separated from the bounding volume of the object. This situation must be avoided because the bounding volume is the concept that will enable the User to locate an instance of the object in the proper place within the model of a physical area.

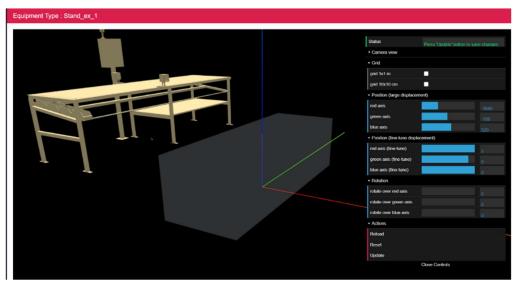


Figure 8 - Catalogue: separation between the CAD model and the bounding volume of an object

4.4.3 Creating a new object type

As shown on Figure 5, on top of the list identifying the different models of a selected object category, a button '+ New ..." is present, enabling the User to create a new object type.

For all the object categories, the creation of a new object model, comprises the following steps:

1. Identification of the new object model, by supplying an identifier and the dimensions of the object's bounding volume, that is, the dimensions of the volume that encompasses the physical elements of the object.

/ \ll APM / \equiv Catalogue / \equiv Equipments /	IILAB						
Identifier:							
unique identifier for the new object		۱. ۱.					
External width (mm): External height (mm):							
2000	500	1000					
3D CAD model:							
Format: Upload:							
step - Select File							
Save changes							

Figure 9 - Catalogue: Identification of new object

2. The upload of the CAD model that corresponds to the new object. The CAD model is retrieved from the User's computer and may be a STEP, STL, PLY or URDF file or set of files. This step is optional but recommended. As show below, the button 'Select File' triggers the selection of the files. A new field is then presented, to enable the user to specify the scale conversion (from meters to millimetres).

/	IILAB 🗸							
ldentifier:	Identifier:							
unique identifier for the new object		<u>ا</u>						
External width (mm):	External depth (mm):	External height (mm):						
2000	500	1000						
3D CAD model:								
Format: Upload:								
step 👻 Select File	attached file: agv_conveyor.stp							
Convertion to mm (1000):								
1								
Save changes								

Figure 10 - Catalogue: Upload of CAD model

- 3. The identification of the internal geometry of the new object. This step is mandatory for logistic racks and Large boxes (logistic pallets). In both cases, the Tool requests the Users to specify the number of levels (rack) or layers (pallet) in the object and their physical dimensions. Additionally, information about the following characteristics are requested to the User:
 - In a logistic rack The physical dimensions and positioning of each level. Levels may be horizontally and/or vertical displaced and each level can also be subdivided into cells. Once instantiated (see chapter 4.5) logistic racks can support on each compartment small boxes containing physical elements (parts).
 - In a logistic pallet The physical dimension of each layer and the number of cells planned to hold one physical element (part).

Step 1 Step 2			Front view	Side view	
Identifier:	# Functional levels:	# Cells per level:		external width	•
Enter the type name of the rack	2 🗸	1 🗸			
External width (mm):	Level width (mm):				external
1000	900				height
External depth (mm):	Level thickness (mm):				\$ thickness
1000	50				
External height (mm):					vertical offset
1000			4	level width	Unser
3D CAD model:		l			
Format: Upload:					
step 👻 Sel	ect File				
Save changes					

The following pictures shows the interfaces used to capture this information from the User.

Figure 11 - Catalogue: Internal geometry of a Rack (part 1)

Step 1 Step 2		Front view Side view
Level 2 : vertical offset (mm):	Level 2 : horizontal offset (mm):	external width
0	0	
Level 1 : vertical offset (mm):	Level 1 : horizontal offset (mm):	external
		‡ thickness
		vertical offset
3D CAD model:		
Format: Upload: Step Select File Save changes		

Figure 12 - Catalogue: Internal geometry of a Rack (part 2)

Identifier:			Front view Top view		
unique identifier of new	large box				< external width
Level height (mm):	# Levels:	# Rows:	# Columns:		internal width #Columns
10 -	2 -	2 🗸	2	-	
External width (mm):		Internal width (mm):			‡ Level height
1000		900			+internal height +# Levels
External depth (mm):		Internal depth (mm):			*#Levels
1000		900			External height-
External height (mm):		Internal height (mm):			
1000		900			
3D CAD model:					- ÷
Format:	Upload:				
step -	Select File				
Save changes					

Figure 13 - Catalogue: Internal geometry of a Pallet

4.5 Implantation

The implantation feature aims to enable the User to build the digital representation (model) of a given physical area, be it a logistics area, assembly line or any other manufacturing area. The main elements used to build the model are the Catalogue and a Map of the area. The Catalogue contains the models of the objects that may be used in the creation of the model. The Map of the area constitutes the instrument that will enable the User to 'implant' objects and their proper locations. Naturally, the Map must represent the layout of the area one is targeting to model.

The creation of a given physical area model comprises the following steps:

- 1. Specification of a Map to represent the physical area to model
- 2. Implantation of object instances in the Map
- 3. Checking and validating the entire model by visualizing it in 3D

4.5.1 Specifying the Map

The Map is the first instrument to use in order to build the digital representation of a given physical area. The Map must have a dimension and may have a 2D image that graphically identifies the objects that are presented in the physical area.

By default, if a 2D image is not supplied, the Tool represents the map in the screen as a grid, as shown in the picture below.

	M Advanced Plar	nt Model v4.6	.12 3-Septem	ber-2021				Tr	aining EN -	Demoname	-
Administration	/ 🕋 APM /	n 📃 Implanta	tion / 📃 Sel	Objects			III	AB			•
Catalogue >	Grid	now de	Zoom 1	.00 – +	Pan <	> ~ ^	1 pixel :	0.010 meters			Í
Implantation ¥											H
Physical Areas											Н
Set Map											\perp
Set Objects											Н
Racks											Н
L. boxes & Parts											+
Equipments											Н
Conveyors											Н
Workstations											T
Production Lines											
Robot fleet											
Runtime 🕽											
	4										•

Figure 14 – Implantation, 'Set Objects' screen

The specification of the 2D image, reflecting the layout of the area, must me provided on the first step in the creation of the model, by doing the following steps:

1. On the Implantation area, select the 'Physical Areas' feature. All the physical areas created so far are listed in the central area of the Interface.

	APM Advanced Plant Model v4.6.12 3-September-2021 Training EN+ De									
Administration	/ 🕋 APM / 📃 Implantation /	Physical Areas	IILAB	•						
					+ New Physical Area					
Catalogue 🕽										
Implantation V	Physical Area 👫	Type Of Area	Reference Robot	Physical Area Map	Actions					
Physical Areas	IILAB	V Type V warehouse	IILAB_virtualRefRobot		Ê					
Set Map										
Set Objects										
Racks										
L. boxes & Parts										
Equipments										
Conveyors										
Workstations										
Production Lines										
Robot fleet										

Figure 15 – Implantation, 'Physical Areas' screen

2. Pressing the button 'New Physical Area' (top right zone of picture above), opens the screen shown below. User is requested to name the area, to supply the physical dimension of the area and to optionally provide a 2D image, making an upload of the image from his/her own computer.

Identifier	Туре
unique name for the new physical area	▼ warehouse
Physical area width (m)	Physical area height (m)
20	10
Мар	
Select File	
Save changes	

Figure 16 – Implantation: Initial creation of a physical real

The following picture, shows the Map that corresponds to the area 'assembly_area_1', for which a 2D image was supplied as map. When supplying the Map, the User has to identify the scale of the image (how many meters are represented by each pixel in the image map).

Catalogue > Implantation Physical Areas Set Map Set Objects Racks L boxes & Parts Equipments Conveyors Workstations Production Lines	assembly_area_1
Implantation Physical Areas Set Map Set Objects Racks L. boxes & Parts Equipments Conveyors Workstations Production Lines	
Physical Areas Set Map Set Objects Racks Laboxes & Parts Equipments Conveyors Norkstations Production Laboxed Areas	
set Map set Objects tacks boxes & boxes & arts open set of the set o	
et Objects acks . boxes & arts quipments onveyors forkstations roduction ines	
acks boxes & arts quipments onveyors forkstations roduction ines	
boxes & arts quipments onveyors forkstations roduction ines.	
arts	
onveyors /orkstations roduction ines	
ionveyors forkstations roduction ines	
/orkstations	
ines in the second s	
obot fleet	

Figure 17 – Implantation: 'Set Map' screen

In the case the map image has not the same orientation as the screen used to visualize the map (left picture on the following Figure), User can specify a horizontal line in the map by selecting two points in the image. This is done by selecting the 'Set horizontal line' button, available on the top of the image. See the first picture below, showing a non-horizontally aligned image and the picture on the right that shows the very same image but aligned horizontally, after the selection of two points in the image (the image shown on the second image below was generated by a mobile robot, that has navigated around in the physical area and analysed by laser scanning the area in order to detect opaque zones).

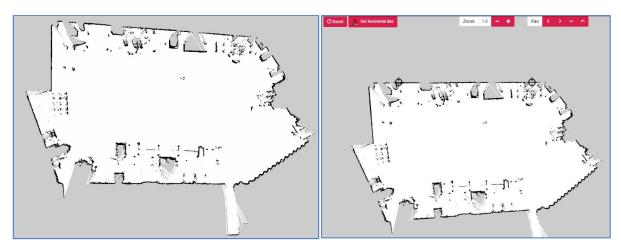


Figure 18 – Implantation: Map non-horizontally aligned (on the left) and horizontally aligned (on the right)

The visualization of the map may be adjusted by clicking the 'Zoom' and 'Pan' red buttons available on the top of the image.

The 'Reset' button resets the horizontal alignment of the image.

4.5.2 Implanting objects in the Map

The implantation of objects in the Map is done on the 'Set Objects' screen (see picture below).

	APM Advanced P	lant Model v4.6	3.12 3-Septen	nber-2021				Tr	aining EN+	Demoname	2 1
Administration	/ 🕋 APM	/ \equiv Implanta	ation / \equiv Se	t Objects				LAB			•
Catalogue >	Grid	Show Hide	Zoom	.00 - +	Pan 🤇	> ~ ^	1 pixel :	0.010 meters			*
Physical Areas											
Set Map	_										
Set Objects											
Racks											
L. boxes & Parts											-
Equipments											
Conveyors											
Workstations Production Lines											
Robot fleet											
Runtime 🕽											
	(,					+

Figure 19 – Implantation: 'Set Objects' screen

After zooming and moving the image to a proper representation of the area, the procedure is very simple. The mouse right hand button must be pressed and the Catalogue is presented, letting the User the object he/she intends to deploy (picture below).

Add rack	•
Add largebox	\mathbf{F}
Add equipment	\rightarrow
Add conveyor	\mathbf{F}
Add workstation	$\left \right\rangle$
Add Production Line	$\left \right $
Add parking station	\mathbf{F}

Figure 20 – Implantation: selecting an object from the Catalogue

By selecting object types from the Catalogue, the Tool is creating the correspondent instances and placing them on the location where the right hand button was pressed. A rectangle with red arrows represents the external volume of the object instance. Following picture shows three objects implanted in the map. In this scope, one can move each object instance by pressing and holding the left mouse button, and dragging it until the object reaches the intended location.

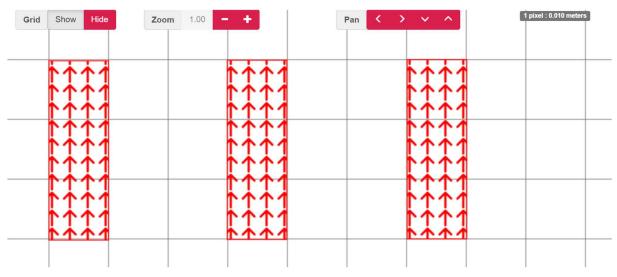


Figure 21 – Implantation: Populating the map with objects

When selecting an object by pressing the mouse right hand button, a pop-up is shown, presenting actions that can be performed on the selected object (e.g. cloning the object, renaming the object, rotating it or removing it from the map).

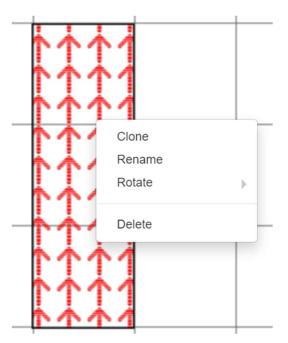


Figure 22 – Implantation: selecting an object to act on it

It is also possible to select several objects and align vertically/horizontally their representations, to rotate them and to remove all of them from the map (see next picture).

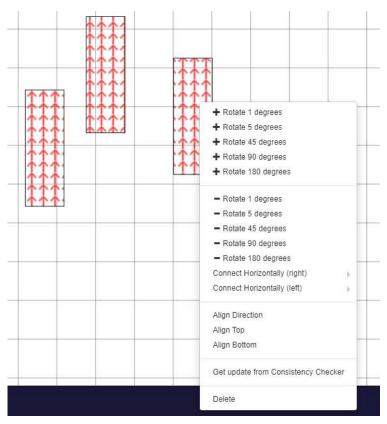


Figure 23 – Implantation: Selecting several objects in order to act on them

4.5.3 Validating the Model

The visual validation of the Model (the digital representation of a given physical area) is done by looking at the threedimensional model that one has built so far. This is achieved in the 'World Model' feature as shown below.



Figure 24 – World Model World Model screen

The Interface allows the User to navigate in the 3D model, by zooming in and out, and orbiting around the objects. The mouse is used in the same way as used to visualize the 3D Model of a single object:

- Pressing the left button and dragging the mouse allows one to orbit around the object's image;
- Rolling the central button allows one to zoom in or zoom out the image;
- Pressing the right button and dragging the mouse allows one to pan the object's image.

5 How to

This section provides eight cases oriented to helping the User to accomplish typical actions on the construction of a Model through the Digital Twin Designer (mentioned in the text as "The Tool"):

- How to create a physical area
- How to implant objects on a physical area
- How to create a physical area with a map
- How to add a new rack to the catalog
- How to add a new rack to the catalog with STEP
- How to add a new equipment to the catalog
- How to add a new workstation to the catalog
- How to add a new production line to the catalog

These cases are directly provided by the Tool itself on the training area, which also gives the User access to examples of CAD models that are required to go through these cases.

5.1 How to create a physical area

The Tool lets you model a given manufacturing area. The first thing you should do is to create a "Physical Area" in the Tool:

1. Go to "Implantation / Physical Areas"

APM Adva	ved Plant Model v4.6.12 3-September-2021 Trainin									
Administration >	/ APM / E Implantation / Physical Areas	APM / Emplantation / Physical Areas								
Catalogue >							+ New Physical Area			
Implantation V	Physical Area 1	Type Of Area	Reference Robot	Physical Area Map			Actions			
Physical Areas	PhysicalArea-Default	Type 👻 warehouse					â			
Fleet Setup										
Set Map										
Set Objects										
Racks										
L. boxes & Parts										
S. boxes & Parts										
Equipments										
Conveyors										
Kits		и. 								

2. Press "New Physical Area" button (top right in the above screen)

APM Adva	APM Advanced Plant Model v4.6.12 3-September-2021 Training EN+ Rui Correia D •											
Administration 🕻	/ APM / Emplantation / Physical Areas / Add physical area	PhysicalArea-Default										
	Identifier	Туре										
Catalogue >	IILAB	• warehouse										
Implantation *	Physical area width (m)	Physical area height (m)										
Physical Areas	10	10										
Fleet Setup	Мар											
Set Map	Select File											
Set Objects	Save changes											
Racks												
L. boxes & Parts												
S. boxes & Parts												

- Supply an identifier (e.g. IILAB)
- Specify the type (warehouse or assembly line)
- Specify the width and height (meters) of the physical area
- Press "Save changes"

• Confirm the creation of the physical area (press the combo box on the top right).

APM Advan	ced Plant Model v4.6.12 3-September-2021				Training EN	I∓ Rui Correia D ▼
Administration >	/ I APM / E Implantation / Physical Areas		PhysicalArea-Default	-		
Catalogue 🕽						PhysicalArea-Default IILAB
Implantation ❤	Physical Area 🚺	Type Of Area	Reference Robot	Physical Area Map		Actions
Physical Areas	IILAB 🗸	Type 👻 warehouse	IILAB_virtualRefRobot			<u>ii</u>
Fleet Setup	PhysicalArea-Default	Type - warehouse				
Set Map	PhysicalArea-Delauli	varenouse				
Set Objects						i i
Racks						
L. boxes & Parts						

• Select it so that you start modelling this new physical area.

APM Advan	ced Plant Model v4.6.12 3-September-2021				Training EN-	Rui Correia D 🔻
Administration >	/ APM / EImplantation / Physical Areas			IILAB		
Catalogue 🕽						+ New Physical Area
Implantation	Physical Area 1	Type Of Area	Reference Robot	Physical Area Map		Actions
Physical Areas	IILAB 🗸	Type - warehouse	IILAB_virtualRefRobot			
Fleet Setup Set Map	PhysicalArea-Default	Type - warehouse				â
Set Objects						
Racks						
L. boxes & Parts						

- In case this is the first physical area you create, please remove the physical area with the name 'PhysicalArea-Default'.
- Go to "Implantation / Set Objects". This is the place where you will implant objects on the Physical Area.

APM Adva	kvanced Plant Model v4.6.12 3.September 2021 Training EN+ Rai Correa											ui Correia D 🖣	Ł	
Administration >	/ 🕋 APM / 📃 Implantatio	on / 📃 Set Objects							IILAB 🗸				•	
Catalogue 🔪	Grid Show Hide	Zoom 1.00	+		Pan <	> ~	^	10	ixel : 0.010 meters					^
Implantation ❤														
Physical Areas														
Fleet Setup														
Set Map														
Set Objects														
Racks														
L. boxes & Parts														
S. boxee & Parte														
Equipments														
Conveyors														
Kits														
Workstations														
Final Products														
Production Lines														
Robot fleet														
Workers														
Runtime 🗲														
	4		1 1											

The grid is configured to show 1 x 1 meters of area.

You can zoom in or zoom out by pressing the Zoom button.

You can move in the area by pressing the fours Pan buttons.

5.2 How to implant objects on a physical area

The Model of a given Physical Area is built by selecting objects defined on the Catalog and adding them to the Physical Area.

1. Go to "Implantation / Set Objects" (make sure you have selected your Physical Area in the top right combo box)

Administration 🕽	/ $rightarrow$ APM / \equiv Implantation .	/ 📃 Set Objects						IILAB		
Catalogue 🕽	Grid Show Hide	Zoom 1.00	+	Pan <	> ~	^	1p	ixel : 0.010 meters		
nplantation										
nysical Areas										
leet Setup										
et Map	_			 						
Set Objects										
Racks boxes & Parts										
. boxes & Parts										
quipments										
Conveyors				 						
lits										
Vorkstations										
inal Products										
Production Lines										
Robot fleet Norkers	_			 						
Runtime 🕽										

2. Press the right button in the mouse, you'll get options that let you select an object from the Catalogue

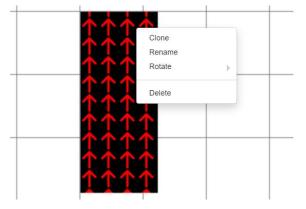


3. Select one of the objects (e.g. rack / PSA 2870x1225), a red rectangle will appear in the working space

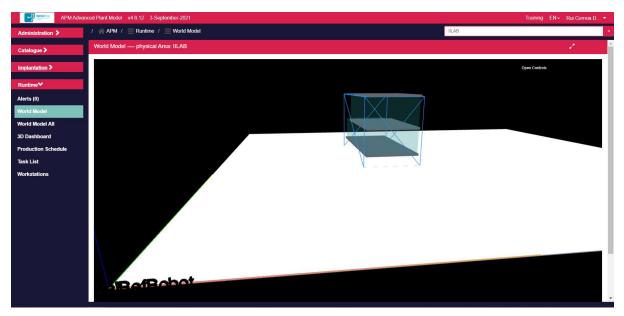
nistration 🕽	/ 😤 APM / 📃 Implar	ntation / E Set Objects					IILAB		
ogue 🕽	Grid Show Hide	Zoom 1	00 - +		Pan <	> ~ ^	1 pixel : 0.010 meter	3	
intation♥									
cal Areas									
Setup									
ар	_			****					
bjects				***					
				<u> </u>					
es & Parts es & Parts				1111					
nents				****					
iyors				<u> </u>					
tations									
Products									
ction Lines									
fieet									
rs									
ne 🕽									

4. You can now select the object and move it in the working area

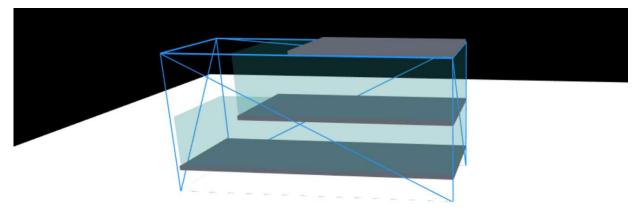
5. You can clone, rename, rotate and delete the object by selecting it and press the right button in the mouse



6. Go to "Runtime / World Model", a 3D visualization of the Model created so far is shown



- 7. You can zoom in and out by using the mouse wheel
- 8. You can change the viewing perspective by selecting the left button in the mouse and moving the mouse around
- 9. You can also press the right button in the mouse and move the mouse



5.3 How to create a physical area with a map

The APM lets you model a given manufacturing area. The first thing you should do is to create a "Physical Area" in the APM. You should supply a 2D image of the target area.

1. Go to "Implantation / Physical Areas"

APM Advan	iced Plant Model v4.6.12 3-September-2021				Training I	EN - Rui Correia I	D *
Administration >	/ APM / \equiv Implantation / \equiv Physical Areas			IILAB			-
Catalogue >						+ New Physic	al Area
Implantation ~	Physical Area 👖	Type Of Area	Reference Robot	Physical Area Map		Actions	
Physical Areas	IILAB 🗸	Type - warehouse	IILAB_virtualRefRobot			â	
Fleet Setup							
Set Map							
Set Objects							
Racks							
L. boxes & Parts							
S. boxes & Parts							

- 2. Press "New Physical Area" button (top right in the above screen)
- Supply an identifier (e.g. IILAB)
- Specify the type (warehouse or assembly line)
- Press "Map / Select file" button
- Supply a file containing the map for the physical area
- Identify the scale of the map: how many meters correspond to a pixel

APM Adv	anced Plant Model v4.6.12 3-September-2021				Training	EN-	Rui Correia D	
Administration >	/ APM / EImplantation / Physical Areas / Add physical	al area		IILAB			_	-
Catalogue >	Identifier		Туре					
Catalogue 🖉	IILAB_with_map		 warehouse 					
Implantation *	Physical area width (m)		Physical area height (m)					
Physical Areas	10		10					
Fleet Setup	Мар							
Set Map	io _k a a ca							
Set Objects								
Racks	nti az nitan an							
L. boxes & Parts	Select File							
S. boxes & Parts	Resolution (meters / pixel)							
Equipments	0.00455							_
Conveyors	Origin (relative to left bottom corner)							
Kits	X (pixeis)	Y (pixeis)		Yaw (pixeis)				
Workstations	0	0		0				_
Final Products	Save changes							
Production Lines								
Robot fleet								
Workers								
Runtime >								

- Press "Save changes"
- Confirm the creation of the physical area (press the combo box on the top right).

APM Adv	anced Plant Model v4.6.12 3-September-2021				Training EN∓ Rui Correia D ▼
Administration >	/ \ll APM / \equiv Implantation / \equiv Physical	Areas		IILAB	•
Catalogue >					+ New Physical Area
	Physical Area 👫	Type Of Area	Reference Robot	Physical Area Map	Actions
Physical Areas	IILAB	✓ Type → warehouse	IILAB_virtualRefRobot		Î
Fleet Setup Set Map	IILAB_with_map	✓ Type → warehouse	IILAB_with_map_virtualRefRobot		â
Set Objects					
Racks					
L. boxes & Parts					
S. boxes & Parts					
Equipments					

• Select it so that you start modelling this new physical area.

APM Advan	iced Plant Model v4.6.12 3-September-2021					Training	EN - Rui Correia D
Administration >	/ # APM / \equiv Implantation / \equiv Physical Areas				IILAB_with_map		2020) - P
Catalogue >					11/83	1 1111	+ New Physical Area
Implantation ~	Physical Area 💵	Type Of Area	Reference Robot	Physical Area Map		h	Actions
Physical Areas	IILAB 🗸	Type 👻 warehouse	IILAB_virtualRefRobot		\sim	Y	
Fleet Setup Set Map	IILA8_with_map	Type + warehouse	IILAB_with_map_virtualRefRobot				
Set Objects							
Racks							

• Go to "Implantation / Set Objects". This is the place where you will implant objects on the Physical Area.

APM Advan	ced Plant Model v4.6.12 3-Septemb	er-2021			Training EN≁ Rui Correia D ▼
Administration >	/ MAPM / EImplantation /	Set Objects		IILAB_with_map	*
Catalogue 🕽	Grid Show Hide	Zoom 0.40 - +	Pan < > ~ ^	1 pixel : 0.011 meters	
Implantation ~		I con en el la con en la con en la			
Physical Areas					
Fleet Setup					
Set Map					
Set Objects					
Racks					
L. boxes & Parts					
S. boxes & Parts					
Equipments					
Conveyors		The second s			
Kits		A second se			
Workstations		Q			
Final Products			- P		
Production Lines Robot fleet					
Robot fleet Workers					
Runtime >					

The grid is configured to show 1 x 1 meters of area.

You can zoom in or zoom out by pressing the Zoom button.

You can move in the area by pressing the fours Pan buttons.

5.4 How to add a new rack to the catalog

The Catalogue contains the 3D model of all the objects that may be used to build the Model of a given Physical Area.

The Catalogue supports the following types of objects: Kits, Racks, Large boxes, Small boxes, Equipments, Conveyors, Parts, Workstations, Production Lines, Robots and Final Products.

Let's add a new Rack to the Catalogue.

1. Go to "Catalog / Racks"

APM Advances	d Plant Model v4.6.12 3-September-2021					Training EN+ Rui Correia
ainistration 🕽	/ # APM /			I III	\B_with_map	
ilogue♥						•
	Rack II	Width 11	Depth 👪	Height 11	# Levels #	Actions
	PSA.AUL1	1391	2501	1598	3	
boxes	embraer 1000X1000	1000	1000	1500	2	
nents	embraer 1000X1000 type 2	1000	1000	1500	2	
rona	embraer 1000X1000 type 3	1000	1000	1500	2	
	rack_step_ex_1	1100	700	1200	6	@ =
lations	flowmat automated warehouse	2800	700	2000	4	
ction Lines	flowmat operator workstation	900	610	1200	2	
roducts	flowmat table	420	1300	1200	2	
cturing Tasks	EMB 845x800	845	800	3000	2	
ntation >	EMB 845X800	845	600	3000	2	
ne 🕽	MakProfile 1115x870 4x3 levels	1115	870	1570	5	
	MakProfile 371x870 4x1 levels	371.66	870	1570	5	
	Table 800x600x750	800	600	2000	2	8
	Table 400x600x750 cell on left	400	600	2000	2	8 1
	Table 400x600x750 cell on right	400	600	2000	2	(6)
	rack	2800	700	2000	4	6 0 1
	Table 600x800x750	600	800	2000	2	(10)
	Hannover 550 X 360	550	360	500	3	8
	PSA 2870x1225	1225	2870	1425	3	8 8
	PSA 2870x1410	1410	2870	1425	3	80 ±
	EMB 768×900	757.5	900	3000	2	

2. Press the top right button "New rack" and fill the fields according to the picture (Front view)

	dvanced Plant Model v4.6.12 3-S	eptember-202	1						Trainin	g EN. .	Rui Correia D.	
Administration >	/ 🕋 APM / 📃 Catalogue /	Racks	$d\equiv$ Add rack type					IILAB_with_map				
Catalogue❤	Step 1 Step 2						Front view	Side view				
Kits	Identifier:		# Functional lev	els:	# Cells per level:		•	external width	•			
Racks	Rack 1000 x 2000 3 layers		3	•	2	•				Ī		
Large boxes	External width (mm):		Level width (mm):					externa			
Small boxes	1000		900						height			
Equipments	External depth (mm):		Level thickness	(mm):					thicknes	s		
Conveyors	2000		50									
Parts	External height (mm):								vertica offset			
Workstations	1800						4	level width	•			
Production Lines Robots										**		
Final Products	3D CAD model: Format:	Upload:										
Manufacturing Tasks	step		elect File									
Implantation >												
	Save changes											
Runtime 🕽												

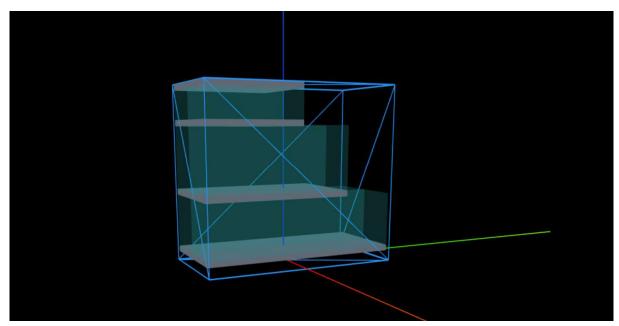
3. Select "Step 2" in the form and fill the fields according to the picture (Side view)

8

	dvanced Plant Model v4.6.12 3-September-2021				Training	EN∓	Rui Correia D	. •
Administration 🕻	/ \ref{APM} / \equiv Catalogue / \equiv Racks / \equiv Add	rack type		IILAB_with_map				*
Catalogue❤	Step 1 Step 2		Front view	Side view				
Kits	Level 3 : vertical offset (mm):	Level 3 : horizontal offset (mm):	4	external width	•	-		
Racks	1400	1000						
Large boxes	Level 2 : vertical offset (mm):	Level 2 : horizontal offset (mm):			external			
Small boxes	700	500			height			
Equipments	Level 1 : vertical offset (mm):	Level 1 : horizontal offset (mm):			thickness			
Conveyors	100	0						
Parts					vertical			
Workstations			4	level width	1.000000			
Production Lines			1					
Robots	3D CAD model:						Ľ.	
Final Products	Format: Upload:							
Manufacturing Tasks	step Select File							
Implantation >								
Runtime >	Save changes							

- 4. Press the "Save changes" button
- 5. In the list of Racks, press the

icon and check if the defined Rack has the right form.



5.5 How to add a new rack to the catalog with STEP

The Catalogue contains the 3D model of all the objects that may be used to build the Model of a given Physical Area.

The Catalogue supports the following types of objects: Kits, Racks, Large boxes, Small boxes, Equipments, Conveyors, Parts, Workstations, Production Lines, Robots and Final Products.

Let's add a new Rack to the Catalogue by using a STEP model.

1. Go to "Catalogue / Racks"

ministration >	/ ☆ APM / ☱ Catalogue / ☱ Racks			11	AB_with_map	
talogue*						+1
•	Rack II	Width 11	Depth 1	Height IT	# Levels If	Actions
ks.	PSA-AUL1	1391	2501	1598	3	
e boxes Il boxes	embraer 1000X1000	1000	1000	1500	2	
ments	embraer 1000X1000 type 2	1000	1000	1500	2	
ryors	embraer 1000X1000 type 3	1000	1000	1500	2	
	100	1100	700	1200	6	
stations	rack_step_ex_1					
action Lines	flowmat automated warehouse	2800	700	2000	4	
8	flowmat operator workstation	900	610	1200	2	8
Products	flowmat table	420	1300	1200	2	80 B
ifacturing Tasks	EMB 845x800	845	800	3000	2	
antation 🕽	iilab 800x600x750	845	600	3000	2	8
ime 🗲	MakProfile 1116x870 4x3 levels	1115	870	1570	5	a
	MakProfile 371x870 4x1 levels	371.66	870	1570	5	a
	Table 800x600x750	800	600	2000	2	(6)
	Table 400x600x750 cell on left	400	600	2000	2	8
	Table 400x600x750 cell on right	400	600	2000	2	8
	rack	2800	700	2000	4	(6)
	Table 600x800x750	600	800	2000	2	
	Hannover 560 X 360	550	360	500	3	
	PSA 2870x1225	1225	2870	1425	3	S B
	PSA 2870x1410	1410	2870	1425	3	
	EMB 758x900	757.5	900	3000	2	

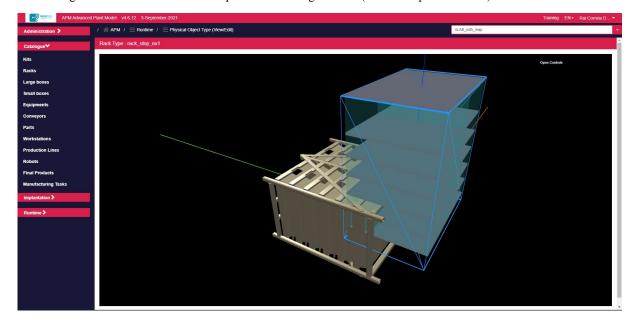
- 2. Press the top right button "New rack"
- (1) Set the field: "Identifier field" (DON't use blank spaces)
- (2) Set the fields: "Functional Levels" and "Cells per level"
- (3) Set the fields: "External width", "External depth" and "External height"
- (4) Set the fields: "Level width" and "Level thickness"
- (5) Press the "3D CAD model / Select file" button
- (6) Set the "Convertion to mm" field

	dvanced Plant Model v4.6.12 3-September-2021		Training EN -	Rui Correia D 🔻
Administration >	/ 🕋 APM / 📃 Catalogue / 📃 Racks / 📃 Add rack type	IILAB_with_map		*
Catalogue❤	Step 1 Step 2 Fr	ront view Side view		
Kits	Identifier: # Functional levels: # Cells per level;	external width		
Racks	rack_step_ex_1 6 2 • 2 2			
Large boxes	External width (mm):		external	
Small boxes			height	
Equipments	External depth (mm):		thickness	
Conveyors	700 3 10 4			
Parts	External height (mm):		vertical	
Workstations	1200 3	evel width		
Production Lines				
Robots	3D CAD model:			
Final Products	Format: Upload:			
Manufacturing Tasks	step Steel File attached file: rack_ex_1(original).step 5			
Implantation >	Convertion to mm (1000):			
Runtime >	1 6			
	Save changes			

3. Select "**Step 2**" in the form and adjust the vertical offset of each level (In the **Step 1** were defined 6 levels). Then press the "**Save changes**" button and wait. When the upload is concluded the navigation will be redirected to the list of Racks in the catalogue.

	Advanced Plant Model v4.6.12 3-September-2021				Training EN+	Rui Correia	a D 🔻
Administration >	/ \ll APM / \equiv Catalogue / \equiv Racks / \equiv	Add rack type		IILAB_with_map			*
Catalogue♥	Step 1 Step 2		Front view	Side view			
Kits	Level 6 : vertical offset (mm):	Level 6 : horizontal offset (mm):		external width		-	
Racks	920	0					
Large boxes	Level 5 : vertical offset (mm):	Level 5 : horizontal offset (mm):			external		
Small boxes	750	0			height		
Equipments	Level 4 : vertical offset (mm):	Level 4 : horizontal offset (mm):			thickness		
Conveyors	590	0					
Parts					vertical		
Workstations	Level 3 : vertical offset (mm): 420	Level 3 : horizontal offset (mm):	-	level width	- Onset		
Production Lines	420	0		level main		+	
Robots	Level 2 : vertical offset (mm):	Level 2 : horizontal offset (mm):	*			- 294	
Final Products	260	0					
Manufacturing Tasks	Level 1 : vertical offset (mm):	Level 1 : horizontal offset (mm):					
Implantation >	100	0					
Runtime >	3D CAD model:						
	Format: Upload:						
	step - Select File	attached file: rack_ex_1(original).step					
	Convertion to mm (1000):						
	1						
	Save changes						

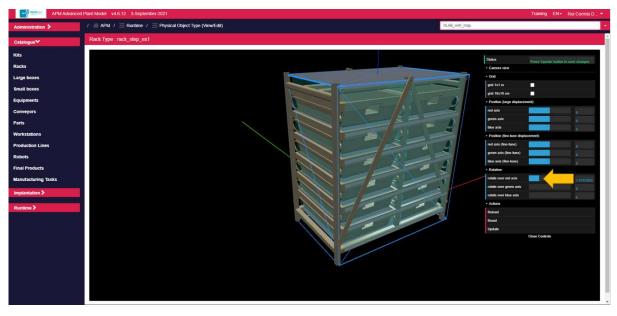
4. In the list of Racks, press the icon and check if the defined Rack has the right form. It may be necessary to align the CAD model with the respective Bounding Volume (like in the picture below).



- 5. To align the CAD model with the respective Bounding Volume, press the top right button "**Open Controls**". The following menu comprising four categories will expand:
 - Status: gives feedback about the user's actions.
 - **Position**: adjusts the CAD model position.
 - Rotation: adjusts the CAD model orientation.
 - Actions: allows to undo, reset and update the configuration.
 - $\circ~$ Undo : loads the last saved configuration.
 - $\circ~$ Reset : sets to zero the configuration.
 - Update: saves the current configuration.

Status The configuration is up to date				
Camera view				
- Grid				
grid 1x1 m				
grid 10x10 cm				
 Position (large displacent 	nent)			
red axis				
green axis				
blue axis				
 Position (fine-tune displated) 	icement)			
red axis (fine-tune)				
green axis (fine-tune)				
blue axis (fine-tune)				
- Rotation				
rotate over red axis				
rotate over green axis				
rotate over blue axis				
- Actions				
Reload				
Reset				
Update				
	Close Controls			

a. Adjust CAD model **orientation** using the **Rotation sliders**. Each slider performs the rotation over a specific axis (red, green, or blue).



b. Adjust CAD model **location** using the **Position sliders**. Each slider performs a translation over a specific axis (red, green, or blue).

APM Advanced	Plant Model v4.6.12 3-September-2021		Training EN+ Rui Correia D *
Administration >	/ 🐖 APM / 📃 Runtime / 🚍 Physical Object Type (View/Edit)	IILAB_with_map	
Catalogue♥	Rack Type : rack_slap_ex1		
Kits		Status	the second s
Racks		Camera view	Pseus Update' bullon to save changes
Large boxes		• Grid	
Small boxes		grid txt m	•
Equipments		grid 10x10 cm	
- 31 - 21	and a second sec	Position (Jarge disp red axis	(accment)
Conveyors		green axis	
Parts		the aris	
Workstations		- Position (line-tune	displacement)
Production Lines		red axis (fine-hane)	
Robots		green axis (line-hun blue axis (line-hune)	
Final Products		Rotation	
Manufacturing Tasks		rotate over red axis	1.57079633
		rotate over green a	
Implantation >		rotate over blue asi	
Runtime >		+ Actions Reload	-
		Reload	
		Update	
			Close Controls

c. Once the CAD model is aligned with the Bounding Volume, press Update button to save the configuration. A message is presented "The configuration is up to date" confirming the action.

Status	The configuration is up to date			
Camera view				
✓ Grid				
grid 1x1 m				
grid 10x10 cm				
 Position (large displace) 	nent)			
red axis	0			
green axis	0			
blue axis	0			
 Position (fine-tune displa 	acement)			
red axis (fine-tune)	19			
green axis (fine-tune)	0			
blue axis (fine-tune)	0			
- Rotation				
rotate over red axis	1.57079632			
rotate over green axis	0			
rotate over blue axis	0			
- Actions				
Reload				
Reset				
Update				
	Close Controls			

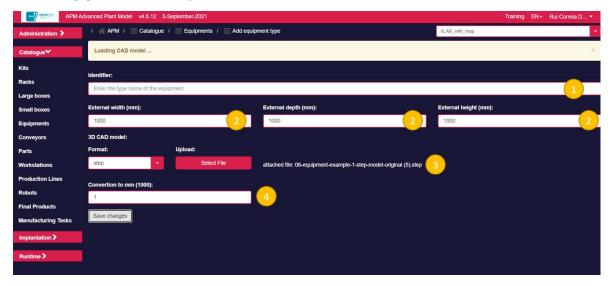
5.6 How to add a new equipment to the catalog

The Catalogue contains the 3D model of all the objects that may be used to build the Model of a given Physical Area.

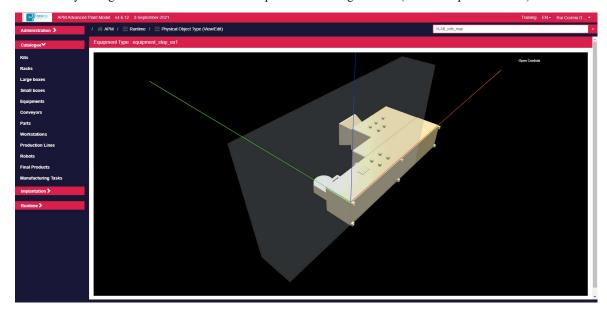
The Catalogue supports the following types of objects: Kits, Racks, Large boxes, Small boxes, Equipments, Conveyors, Parts, Workstations, Production Lines, Robots and Final Products.

Let's add a new Equipment to the Catalogue by using a STEP model.

- 1. Go to "Catalogue / Equipments"
- 2. Press the top right button "New equipment"
 - (1) Set the field "Identifier field" (DON't use blank spaces)
 - (2) Set the fields: "External width", "External depth" and "External height"
 - You may optionally associate a STEP model with the Equipment (DON't use spaces in the Identifier field)
 - (3) Press the "3D CAD model / Select file" button
 - (4) Set the "Convertion to mm" field
- 3. Press the "**Save changes**" button and wait. When the upload is concluded the navigation will be redirected to the list of Equipments in the catalogue.



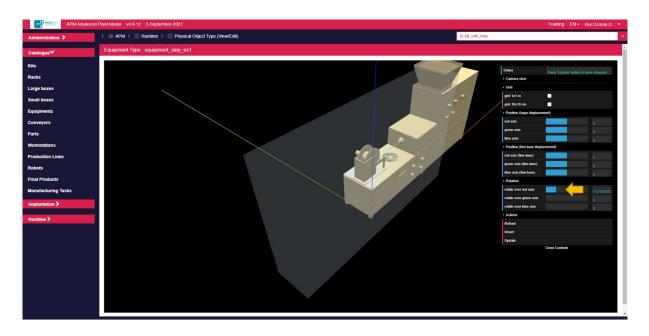
4. In the list of Equipments, press the icon and check if the defined Equipment has the right form. It may be necessary to align the CAD model with the respective Bounding Volume (like in the picture below).



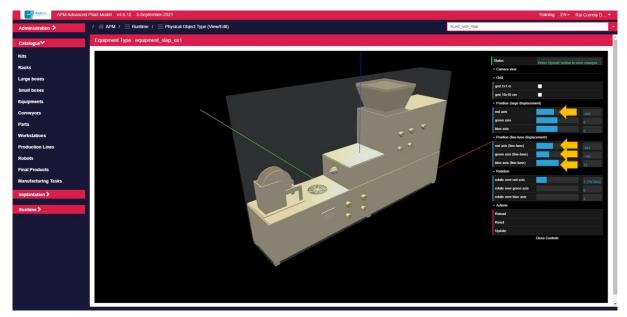
- 5. To align the CAD model with the respective Bounding Volume, press the top right button "**Open Controls**". The following menu comprising four categories will expand:
 - Status: gives feedback about the user's actions.
 - **Position**: adjusts the CAD model position.
 - Rotation: adjusts the CAD model orientation.
 - Actions: allows to undo, reset and update the configuration.
 - $\circ~$ Undo : loads the last saved configuration.
 - $\circ~$ Reset : sets to zero the configuration.
 - Update: saves the current configuration.

Status	The configuration is up to dat	e	
Camera view			
- Grid			
grid 1x1 m			
grid 10x10 cm			
 Position (large displacement 	ent)		
red axis			
green axis			
blue axis			
 Position (fine-tune displac 	ement)		
red axis (fine-tune)			
green axis (fine-tune)			
blue axis (fine-tune)			
- Rotation			
rotate over red axis			
rotate over green axis			
rotate over blue axis			
- Actions			
Reload			
Reset			
Update			
	Close Controls		

a. Adjust CAD model **orientation** using the **Rotation sliders**. Each slider performs the rotation over a specific axis (red, green, or blue).



b. Adjust CAD model **location** using the **Position sliders**. Each slider performs a translation over a specific axis (red, green, or blue).



c. Once the CAD model is aligned with the Bounding Volume, press **Update** button to save the configuration. A message is presented "The configuration is up to date" confirming the action.

Status	he configuration is up to date
Camera view	
+ Grid	
grid 1x1 m	
grid 10x10 cm	
 Position (large displacement)
red axis	-800
green axis	0
blue axis	0
 Position (fine-tune displacent 	nent)
red axis (fine-tune)	-841
green axis (fine-tune)	-142
blue axis (fine-tune)	13
- Rotation	
rotate over red axis	1.5707963;
rotate over green axis	
rotate over blue axis	
✓ Actions	
Reload	
Reset	
Update	(<u> </u>
Cl	ose Controls

5.7 How to add a new workstation to the catalogue

The Catalogue contains the 3D model of all the objects that may be used to build the Model of a given Physical Area.

The Catalogue supports the following types of objects: Kits, Racks, Large boxes, Small boxes, Equipments, Conveyors, Parts, Workstations, Production Lines, Robots and Final Products.

Let's add a new Workstation to the Catalogue.

- 1. Go to "Catalogue / Workstations"
- 2. Press the top right button "**New workstation**" set the description fields (a workstation may have an inbound buffer and an outbound buffer which correspondent to the inbound / outbound spaces that may store temporarily the work in progress)
 - (1) Set the field "Identifier field" (DON't use blank spaces)
 - (2) Set the fields: "External width", "External depth" and "External height"
 - (3) Set the fields: "Inbound buffer depth" and "Outbound buffer depth"
 - You may optionally associate a STEP model with the workstation (DON't use spaces in the Identifier field)
 - (4) Press the "3D CAD model / Select file" button
 - (5) Set the "Convertion to mm" field
- 3. Press the "**Save changes**" button and wait. When the upload is concluded the navigation will be redirected to the list of Workstations in the catalogue.

APM A	dvanced Plant Model v4.6.12 3-	September-2021			Training	EN + Rui Correla D +
Administration >	/ 🕋 APM / 📃 Catalogue	$i \equiv$ Workstations $i \equiv$ Add wor	kstation type		IILAB_with_map	+
Catalogue❤	Loading CAD model					×
Kits	Identifier:					
Racks Large boxes	workstation_step_ex1					1
Small boxes	External depth (mm):		Inbound buffer capacity:		Outbound buffer capacity:	
Equipments	3250	2	1		1	
Conveyors	External width (mm):		Inbound buffer depth:	~	Outbound buffer depth:	~
Parts	900	2	1000	3	1000	3
Workstations	External height (mm):					
Production Lines	850	2				
Robots	3D CAD model:					
Final Products	Format:	Upload:			z. .	
Manufacturing Tasks	step	Select File	attached file: 07-workstation-example-1-step-model-original ((2).step	4	
Implantation >	Convertion to mm (1000):					
Runtime >	1					
	Save changes					

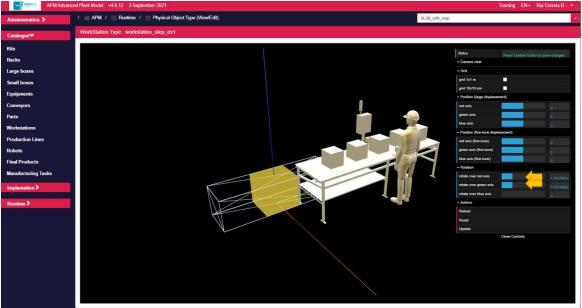
4. In the list of Workstations, press the icon and check if the defined Workstation has the right form. It may be necessary to align the CAD model with the respective Bounding Volume (like in the picture below).

APM Advance	ed Plant Model v4.6.12 3-September-2021	Training EN+ Rui Correia D +
Administration >	/ 🔗 APM / 📃 Runtime / 📃 Physical Object Type (View/Edit)	AB_with_map
Catalogue❤	WorkStation Type : workstation_step_ex1	
Kits		Open Controls
Racks		Open Computs
Large boxes		
Small boxes		
Equipments	a start	
Conveyors		
Parts		
Workstations		
Production Lines		
Robots		
Final Products		
Manufacturing Tasks		
Implantation >		
Runtime >		

- 5. To align the CAD model with the respective Bounding Volume, press the top right button "**Open Controls**". The following menu comprising four categories will expand:
 - Status: gives feedback about the user's actions.
 - **Position**: adjusts the CAD model position.
 - Rotation: adjusts the CAD model orientation.
 - Actions: allows to undo, reset and update the configuration.
 - $\circ~$ Undo : loads the last saved configuration.
 - $\circ~$ Reset : sets to zero the configuration.
 - Update: saves the current configuration.

Status	The configuration is up to da	ate		
Camera view				
→ Grid				
grid 1x1 m				
grid 10x10 cm				
 Position (large displace) 	ment)			
red axis				
green axis				
blue axis				
 Position (fine-tune display 	acement)			
red axis (fine-tune)				
green axis (fine-tune)				
blue axis (fine-tune)				
- Rotation				
rotate over red axis				
rotate over green axis				
rotate over blue axis				
- Actions				
Reload				
Reset				
Update				
	Close Controls			

a. Adjust CAD model **orientation** using the **Rotation sliders**. Each slider performs the rotation over a specific axis (red, green, or blue).



b. Adjust CAD model **location** using the **Position sliders**. Each slider performs a translation over a specific axis (red, green, or blue).



c. Once the CAD model is aligned with the Bounding Volume press Update button to save the configuration. A message is presented "The configuration is up to date" confirming the action.

Status The configu	ration is up to date
Camera view	
+ Grid	
grid 1x1 m	
grid 10x10 cm	
 Position (large displacement) 	
red axis	
gmen axis	
blue axis	
 Position (fine-tune displacement) 	
red axis (fine-tune)	-2675
green axis (fine-tune)	-1040
blue axis (fine-tune)	
Rotation	
rotate over red axis	1.5701963
rotate over green axis	1 5707063.
rotate over blue axis	
Actions	
Reload	
Reset	
Update	
Close Contro	ls 👘

5.8 How to add a new production line to the catalogue

The Catalogue contains the 3D model of all the objects that may be used to build the Model of a given Physical Area.

The Catalogue supports the following types of objects: Kits, Racks, Large boxes, Small boxes, Equipments, Conveyors, Parts, Workstations, Production Lines, Robots and Final Products.

Let's add a new Production Line to the Catalogue.

- 1. Go to "Implantation / Production Lines"
- 2. Press the top right button "**New production line**" and set the description fields (a production line comprises several workstation in line; you have to create the model for the workstation before)
- 3. You may optionally associate a STEP model with the production line (DON't use spaces in the Identifier field)
- Press the "Save changes" button

APM.	Advanced Plant Model v4.6.12 3-September-2021			Training EN -	Rui Correia D 🔻
Administration >	/ APM / Ecatalogue / Production Lines / Add production line type		IILAB		
Catalogue❤	Identifier:	# Number of workstations:		# workstation type:	
Kits	Enter the type name of the production line	2		▼ WS 780x5260	
Racks	Save changes				
Large boxes					
Small boxes					
Equipments					
Conveyors					
Parts					
Workstations					
Production Lines					
Robots					
Final Products					
Manufacturing Tasks					
Implantation >					
Runtime 🕽					

4. In the list of Racks, press the icon and check if the defined Rack has the right form (if specified a STEP model for the workstation, you will you see it in the 3D visualization in a future version of the software).

