TECNOMATIX SIEMENS

Tecnomatix Plant Simulation 9 Step-by-Step Help

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Getting to Know Tecnomatix Plant Simulation

Getting to know Tecnomatix Plant Simulation introduces you to the basic concepts that simulation is based on and to the basics of working with *Plant Simulation*.

Simulation and Modeling Concepts

Simulation concepts and modeling concepts introduce you to the theoretical background of simulation as such and show you what to keep in mind before you start modeling.

In general, operations research processes are intended to allow you to make the right decisions, qualitatively as well as quantitatively. They formulate optimization models, containing all relevant factors, such as destination function, conditions and destination description. These processes require large amounts of processing power the more detailed the model is. Besides, the results and acceptance of operations research processes often are not satisfactory.

In addition to linear optimization models nowadays simulation is increasingly used for making the right decisions. It offers good solutions for complex problems but does not automatically create the actual optimum. This is justified by the comparatively low amount of mathematical expenditure to obtain that result.

As processes to be analyzed become more complicated and complex and as more factors have to included, the more important simulation becomes with its analysis of real processes. These processes cannot be covered by mathematical solution processes or optimization processes or they may be realized only by using a large amount of resources.

The aim of simulation is to arrive at objective decisions by dynamic analysis, to enable managers to safely plan and, in the end, to reduce cost.

Thus, if real systems and plants are too expensive for conducting experiments and the time to conduct trials is too limited and too expensive, modeling, simulation and animation are excellent tools for analyzing and optimizing time dynamic processes.

What is Simulation?

VDI (Verein Deutscher Ingenieure, Association of German Engineers) guideline 3633 defines simulation as the emulation of a system, including its dynamic processes, in a model one can experiment with. It aims at achieving results that can be transferred to a real world installation. In addition, simulation defines the preparation, execution and evaluation of carefully directed experiments within a simulation model.

As a rule, you will execute a simulation study like this:

- You first check out the real-world installation you want to model and gather the data you need for creating your simulation model.
- You then abstract this real-world installation and create your simulation model according to the aims of the simulation studies.
- After this, you run experiments, i.e., execute simulation runs, within the simulation model. This will produce a number of results, such as how often machines fail, how often they are blocked, which set-up times accrue for the individual types of station, which utilization the machines have, etc.
- The next step will be to interpret the data the simulation runs produce.
- Finally, management will use the results as a base for its decisions about optimizing the real installation.

Developing your simulation model is a cyclical and evolutionary process. You will start out with a first draft of your model and then refine and modify it to make use of the intermediary results the simulation runs provide. Eventually, after several cycles, you will arrive at your final model.

As a simulation expert, you must never loose sight of these questions:

- What do you want to accomplish with the simulation study?
- What are you examining?
- Which conclusions do you draw from the results of the simulation study?
- How do you transfer the results of the simulation study to the real-world installation?

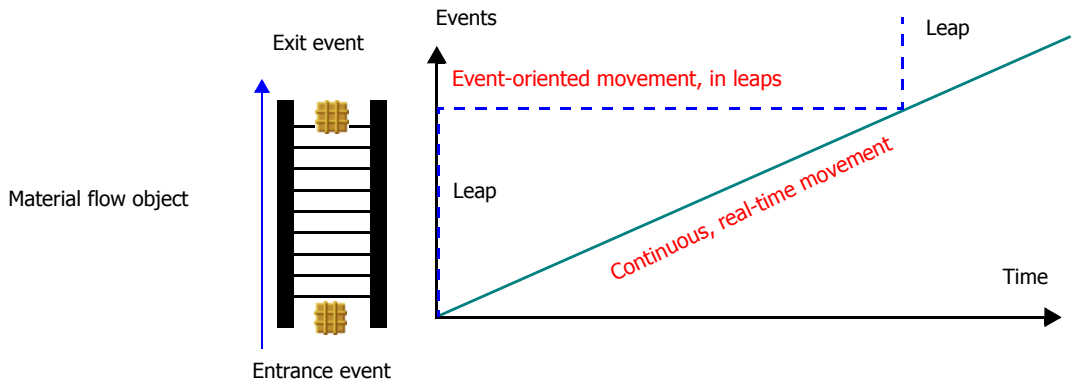
Time-Oriented Simulation and Event-Oriented Simulation

Plant Simulation is a discrete, event-oriented simulation program, i.e., it only inspects those points in time, at which events take place within the simulation model.

In reality, on the other hand, time passes continually. When watching a part move along a conveyor system, you will detect no leaps in time. The curve for the distance covered, and the time it takes to cover it, is continuous, it is a straight line.

A discrete, event-oriented simulation program on the other hand only takes points in time (events) into consideration that are of importance to the further course of the simulation. Such events may, for example, be a part entering a station or leaving it or of it moving on to another machine. Any movements in between are of little interest to the simulation as such. It is only important that the entrance and the exit events are displayed correctly. When a part enters a material flow object, *Plant Simulation* calculates the time until it exits that object and enters an exit event into the list of scheduled events of the *EventController* for this point in time.

Thus, the simulation time that the *EventController* displays, leaps from event to event. This happens as soon as an event is processed.



Why Employ Simulation?

As a rule, you will employ simulation when you have to:

- **Plan a new facility.** Here simulation helps you to:
  - Detect and eliminate problems that otherwise would require cost- and time-consuming correction measures during production ramp-up.
  - Determine and optimize the times, such as processing time, failure time, recovery time, etc., and the throughput of the plant.
  - Determine the size of buffers and the number of machines your intended throughput requires. When a single machine costs hundreds of thousands of dollars, it certainly helps to know if you need one or more machines of one type.
  - Determine the limits of performance of the machines and of the plant as a whole.
  - Investigate how failures affect the throughput and the utilization of the machines.
  - Determine how many workers and staff members are required for the intended throughput.
  - Gain knowledge about the behavior of the facility.
  - Determine suitable control strategies of the machines and of the way the machines interact.
  - Evaluate different alternatives by running a number of simulation experiments.
  - Minimize the investment cost for production lines without jeopardizing required output
- **Optimize an existing facility.** Here simulation helps you to:
  - Optimize the performance of existing production systems by implementing measures that have been verified in a simulation environment prior to implementation
  - Optimize the control strategies you devised.

  - Optimize the sequence of orders that have to be fulfilled to make as few tool changes necessary as possible.
  - Test the daily proceedings to make sure that everything works smoothly.
- **Put the plan you formulated into practise.** Here simulation helps you to:
  - Develop a template for creating the control strategies.
  - Test different scenarios during the warm-up phase of the facility.
  - Train the operators of the machines in the different states, which machines and the facility can be in.

In general, you will reap these benefits from employing simulation:

- Enhance the productivity of existing production facilities.
- Reduce investment in planning new production facilities.
- Cut inventory and throughput time.
- Optimize system dimensions, including buffer sizes.
- Reduce investment risks by early proof of concept.
- Maximize use of manufacturing resources.
- Improve line design and schedule.

Implement a Simulation Project

As you remember, developing your simulation model is a cyclical and evolutionary process. You will start out with a first draft of your model and then refine and modify it to make use of the intermediary results the simulation runs provide. Eventually, after several cycles, you will arrive at your final model.

- Before you start implementing your simulation project, you will, more or less, proceed like this. You will: **Describe the project.**

  Determine the goals, so that the purpose of the simulation project becomes clear. Why are you examining a problem? Which questions do you want answered? Put the definition of the project in writing and consult it repeatedly during the course of the project, as the purpose of the simulation study determines the efforts to be made.

- **Plan the project.**

  Create a concept of your model, with its initial values, its model elements, variables, logic of proceeding and a preliminary description of the simulation experiments. Which parameters do you have to change, which data do you have to collect and how do you interpret this data? Make a list of all functional units that the installation you are modeling will contain. Think about which functional units have identical or similar functionality. Combine them and derive a list of application objects you and your colleagues have to create. Consider re-using existing objects. Specify and plan the remaining objects on paper. Define and describe the interfaces for material and information flow. Outline *reset* and *init Methods*.

- **Find out about the data you need and how to acquire it.**

  Ensure early on that the data you need to run the simulation experiments is going to be available. Frequently a lot of time and effort is involved to acquire the data. Make sure that you have the name of a person who responsible for acquiring the data from your client, which may, for example, be another department of your company.

- **Build the simulation model.**

  Build a first version of the simulation model in its simplest, most basic form. Build the application objects you need and test them one by one. After you are sure that all objects work the way they are supposed to do, put together the overall model. Document the model in a clearly arranged manner, as six months or a year from the time you modeled you might not remember how you accomplished a certain task or why you solved a specific problem the way you did.

- **Verify the simulation model and check its validity.**

  After you are finished building the simulation model, you have to verify it, i.e., check if the components you modeled perform the tasks you programmed them to do. Test each and every object you created. Check for the correct functioning and for concurrence with the specifications. Test the objects in combination with other objects and then in the overall model. Make sure that all parameters are set to the correct values. Once you have verified the model, check it for its validity: Make sure the functionality of the model is as expected and conforms to the functionality of the planned or real installation and see if the results are plausible and credible. Make an estimate of the most important results and compare them with the results of the simulation. Introduce your model to a production or planning expert and discuss the results, the proceedings and your modeling approach with him.

- **Execute simulation experiments and collect the results.**

  Execute simulation experiments according to your final trial plans to arrive at the desired data. Plan a number of simulation runs and prepare for the variation of parameters and models to get reliable results.

- **Analyze the results of the experiments.**

  Analyze and interpret the results of the simulation experiments. Conduct a sensitivity analysis of the most important parameters, data and results.

- **Author the final documentation of the entire simulation project.**

  Once you are finished with the simulation project, update the notes you made while modeling to create the final documentation of the entire simulation project. This will help you, when you have to update or extend your simulation model or any of its components. Executing simulation experiments is a cyclical and evolutionary process. You will modify and improve your initial simulation model a number of times as you incorporate new insights from previous simulation runs. Thus you will arrive at your final simulation model after several cycles after continuously changing your initial draft of your simulation model.

Getting to Know the Program

You can familiarize yourself with *Plant Simulation* in a number of ways. You can:

- *Visit Training Classes*
- *Work Through the Tutorial*
- *Consult the Step-by-Step Help*

Visit Training Classes

Tecnomatix and its partners offer a complete training program with courses that build on each other.

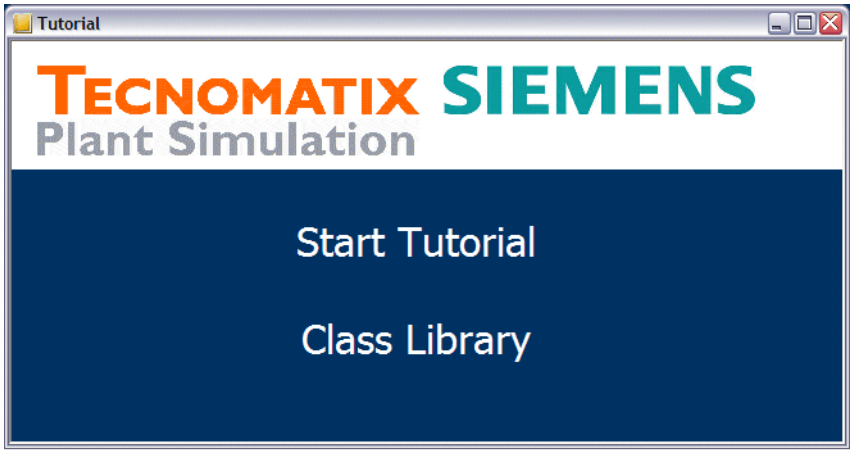
- The course *Plant Simulation* **Basics** introduces you to *Plant Simulation* and to the basic functionalities of the different *Plant Simulation* licenses.You learn to build and to run a simulation model in *Plant Simulation* with a sample model, which demonstrates the functionality of the objects.
- The course *Plant Simulation* **Strategies** introduces you to the syntax and the structure of the programming language SimTalk. You learn to program your own control strategies for managing the behavior of the objects.
- The course **Acquiring Data** introduces objects and methods for acquiring data. You learn to use the statistical objects and to create strategies, to further process the extracted data in tables and to use external programs and *Plant Simulation* interfaces.
- The course **Optional Products** introduces you to the *Plant Simulation* add-ins you can purchase to solve specific modeling tasks.
- The course *Plant Simulation* **Effective Modeling** introduces you to a number of tools to optimize your simulation models and your simulation runs. You learn to model services and to work with debugging tools.

Work Through the Tutorial

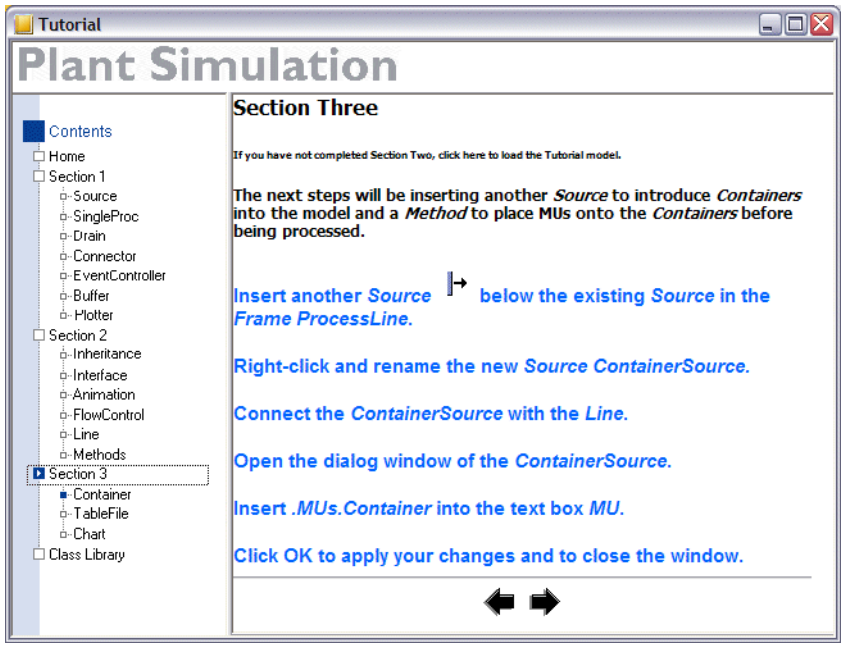
To get acquainted with *Plant Simulation* you also can move along at your own pace by working through the lessons of the *Tutorial*. It shows how to build a simulation model for a testing line for TVs and VCRs.

To open the tutorial:

- Start *Plant Simulation*.
- Click Start Tutorial on the *Start Page*.
- Click Start Tutorial again.



- To open the associated simulation models, click Section Two or Section Three and click the link.



View the Sample Models

To get acquainted with *Plant Simulation* and the *3D Viewer*, you also can view the sample models on the *Plant Simulation* Program DVD. These models demonstrate how to approach a number of problems and will give you ideas how to solve your modeling tasks.

View the Documentation that Comes with the Object Libraries

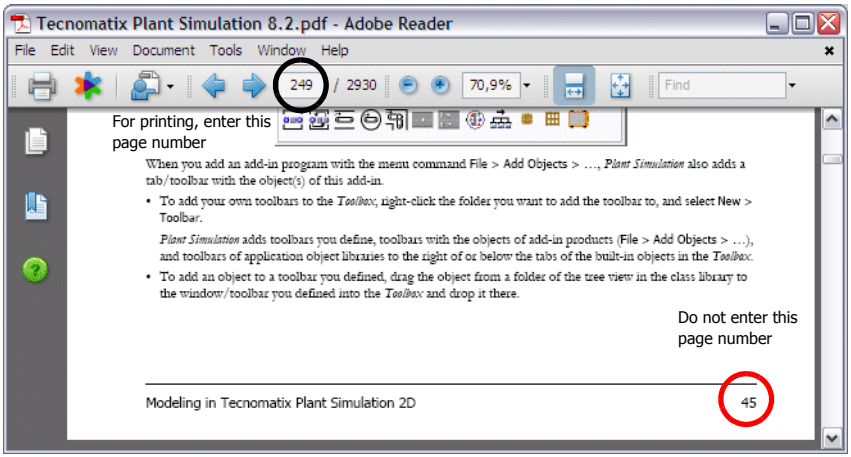
To get acquainted with *Plant Simulation*, you also can view the pdf documents describing the application object libraries on the *Plant Simulation* Program DVD. You might find that one of these libraries might already cover the intentions of your modeling task.

Note: You have to purchase an extra license for some of the application object libraries.

Consult the Step-by-Step Help

To get acquainted with *Plant Simulation*, you also can consult the *Tecnomatix Plant Simulation* step-by-step help and the online help that are part of the program. The former will cover most of your modeling tasks and provide you with information on how to solve them. Start *Plant Simulation*, go to the Help menu and select Contents. Double-click the book Step-by-Step Help and select the topic you need information about.

If you prefer to read the documentation as a book in consecutive order, consult the printed materials that are part of your program package. You can also locate the pdf file of the manuals on the DVD and view it online or print it in its entirety or only sections of it.



Note: When you print a topic of the pdf file, do not enter the page number on the bottom of the page you are viewing, but the page number the Adobe Reader shows on the top of the display pane.

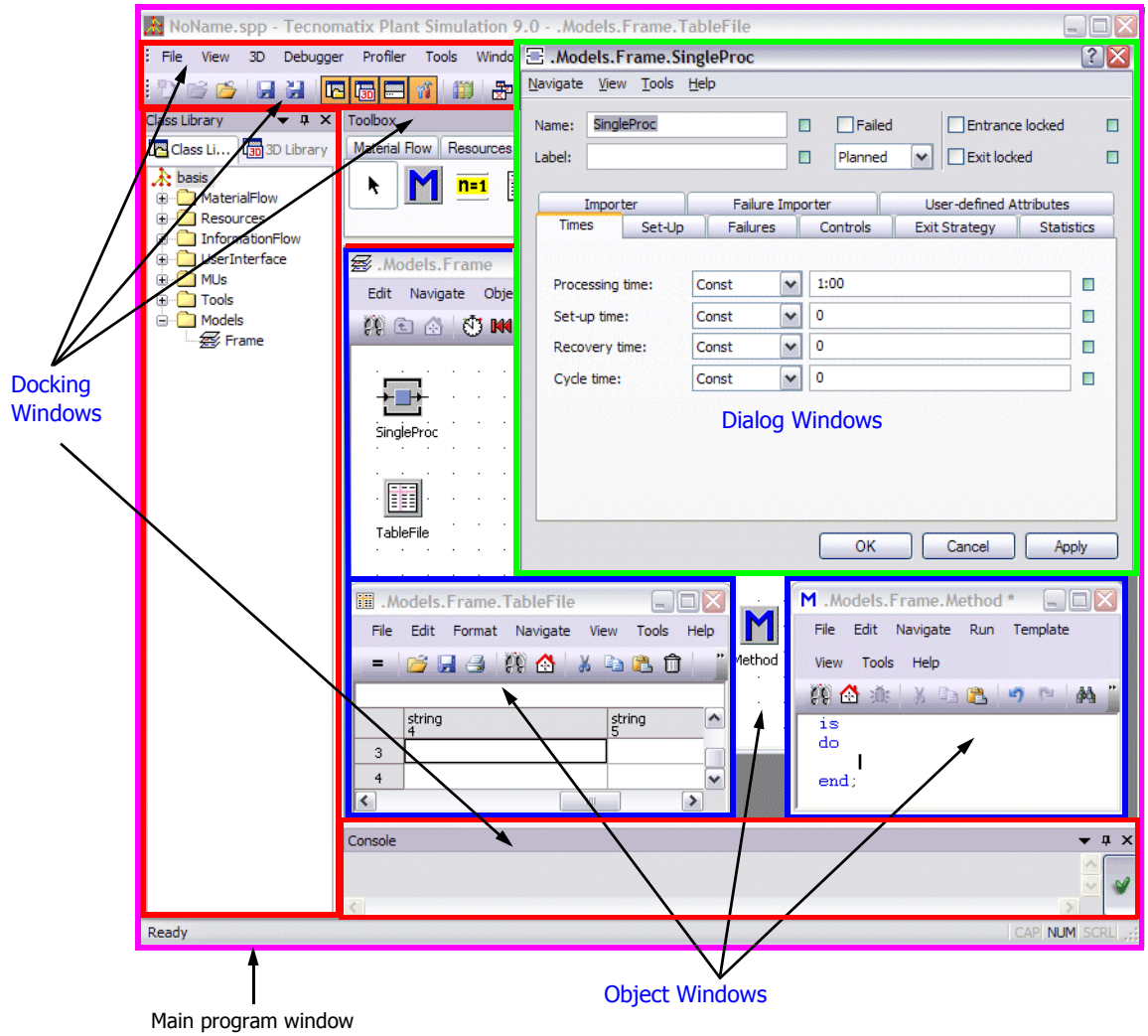
Working with the Program, Basics

Basics of working with *Plant Simulation* provides information about:

- *Working with Window Types*
- *Finding Objects and Text*
- *Selecting Settings*

Working with Window Types

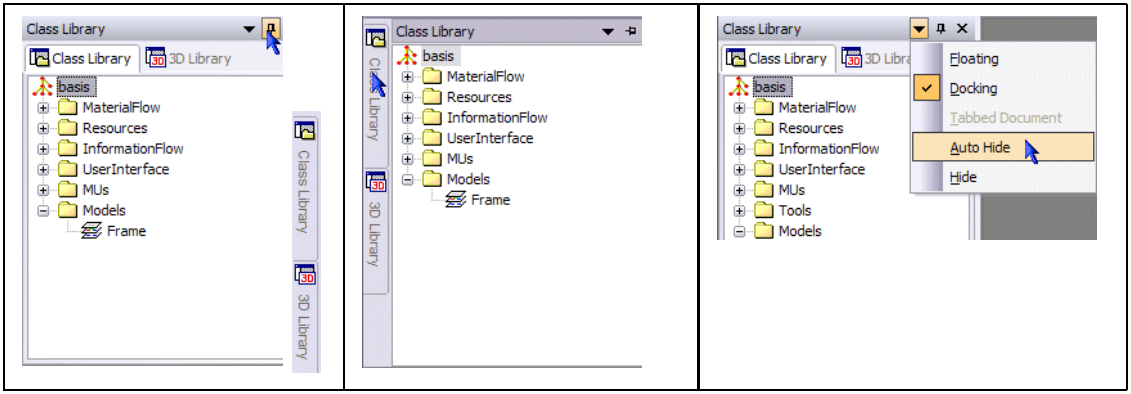
Plant Simulation is a multiple-document interface application. It shows its windows in the common parent window.



The *program* window has a magenta border in the online version of the picture above.

Note: The different window types open in a certain order within the program window. At times it may happen that the window you want to work with opens in the background, instead of the foreground, where you would expect it to be. If this is the case, move the windows in the foreground aside to access the window into which you want to enter data.

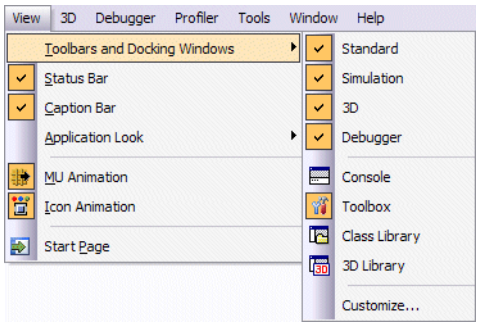
Instead of closing and reopening the *Class Library*, the *3D Library*, the *Toolbox*, and the *Console*, you can hide them: Click to auto hide the window. When you then click in another window, *Plant Simulation* hides the window until you move the mouse over the name of the window again. To deactivate auto hide, click .



For further information compare *Working in the Program Window* in the Reference section of the *Online Help*.

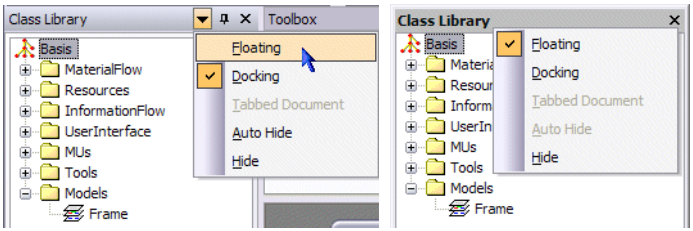
Docking Windows

Plant Simulation docking windows are the *Class Library*, the *3D Library*, the *Menu Bar*, the *Standard Toolbar*, the *Simulation Toolbar*, the *3D Toolbar*, the *Debugger Toolbar*, the *Toolbox*, and the *Console*.

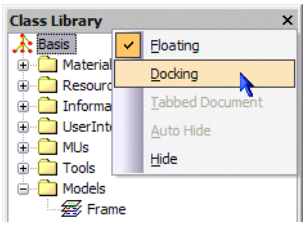


Docking windows have a red border in the online version of the picture below *Working with Window Types*. *Docking windows* always open in the foreground, on top of any other windows, i.e., they also are on top of any open dialog windows.

- To undock a docking window, click the Window Position button in the title bar of the window and select Floating.

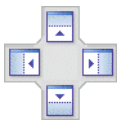


- To redock a floating window again, right-click the title bar of the window and select Docking.

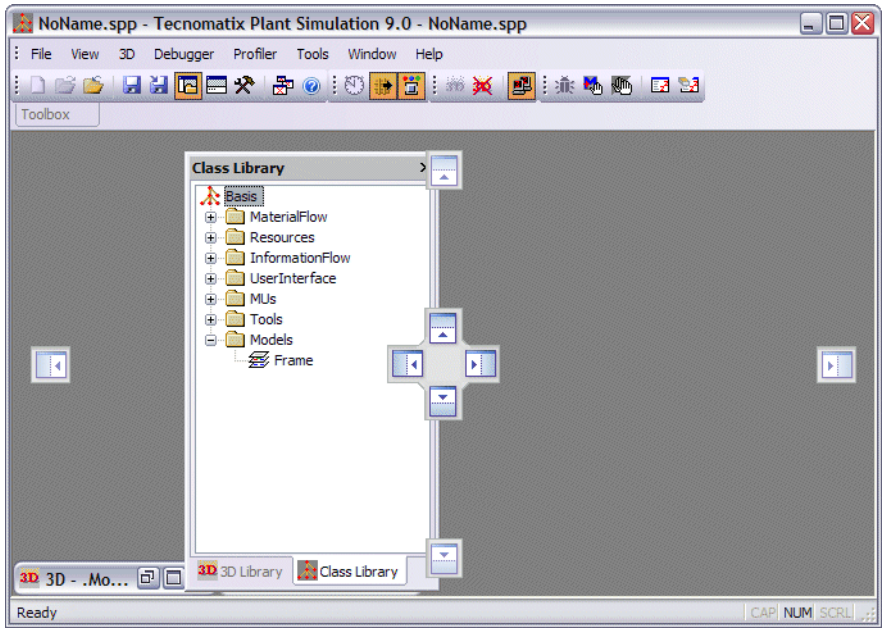


Or

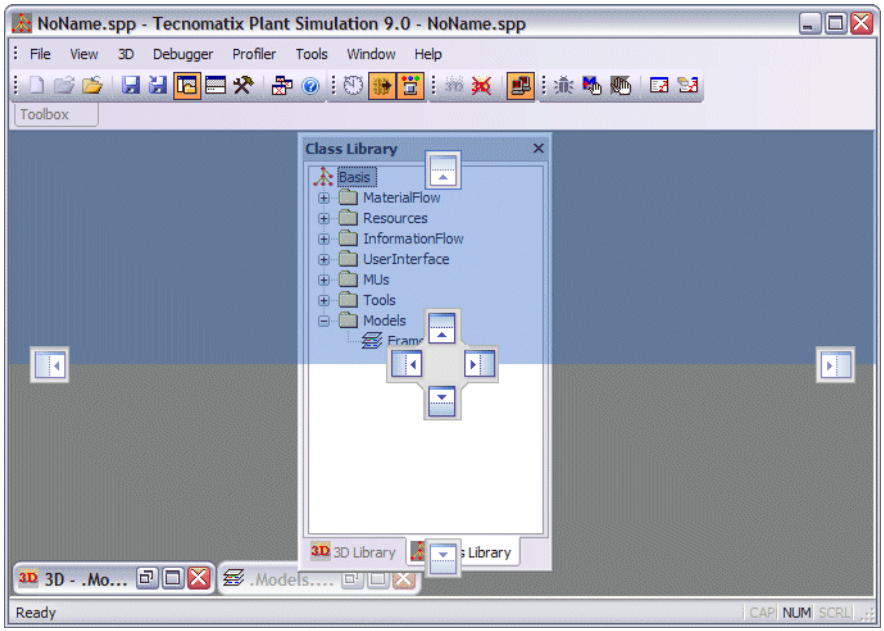
Click the title bar of the docking window and hold down the mouse button. *Plant Simulation* shows a docking guide in the middle of the window pointing to the top, the bottom, the right, and the left edge of the program window. Drag the mouse onto the respective docking arrow where you want to dock the window. *Plant Simulation* highlights that area, i.e. the destination, in blue. Release the mouse button when the docking position is correct. *Plant Simulation* then **docks** the window to the respective **docking (child) window**.



Plant Simulation also shows individual docking guides at the four sides of the **parent window**, i.e. of the *Tecnomatix Plant Simulation* program window.



Drag the mouse onto the respective docking arrow where you want to dock the window. *Plant Simulation* highlights that area, i.e. the destination, in blue. Release the mouse button when the docking position is correct. *Plant Simulation* then **docks** the window to the respective edge of the **parent window**, i.e. the *Tecnomatix Plant Simulation* program window.



- To dock a toolbar to any of the sides of the program window, drag the move handle on a toolbar, or drag the title bar on a floating window to another location. When you drag the window to the edge of the program window or to a location beside another docked window, it docks there.

  Note: When you move a docked window, this might affect the location and size of other windows in the same row within the program window.

- To prevent a floating window from docking when you drag it, hold down Ctrl, and move the window to a position of your choice.
- To make a docked window a floating window, double-click the move handle or hold down Ctrl, and drag the window.
- To dock a floating window again, double-click its title bar or drag the window to one of the sides of the program window or to a location beside another docked window, it docks there.
- To close a floating window, click Close on the title bar.
- To show or hide a docking window, right-click the Menu Bar in the program window and select the name of the toolbar you want to show or hide. A displayed toolbar shows a check mark to its left. Or

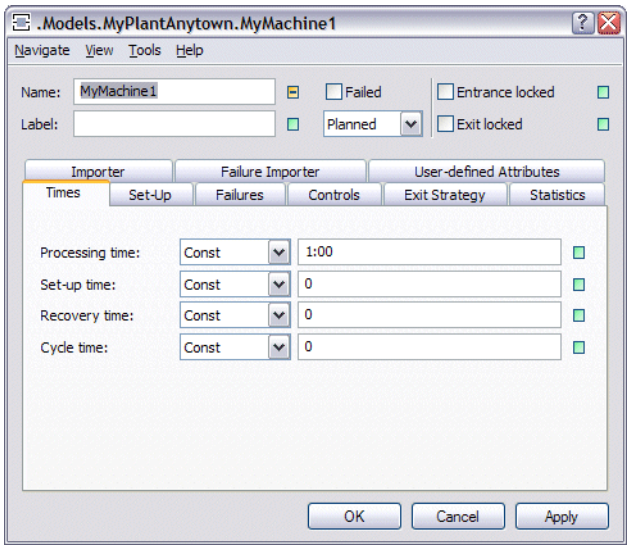
  Select Tools > Customize, click Toolbars and select the check box with the name of the toolbar.

- To show or hide the *Class Library*, click on the Standard toolbar .
- To show or hide the *Toolbox*, click on the Standard toolbar.

- To show or hide the *Console*, click on the Standard toolbar.
- To customize the menu bar, the toolbars or keyboard shortcuts, click the menu bar or the toolbar with the right mouse button and click the menu command Customize on the context menu.

Dialog Windows

Plant Simulation dialog windows are the *dialog* windows of the *Plant Simulation material flow objects*, the *mobile objects*, the *resource objects*, the *information flow objects*, and the *user interface objects*.



Dialog windows have a green border in the online version of the picture below *Working with Window Types*.

A *dialog* window always opens in the front as it expects that you select or enter something. You cannot minimize or maximize it.

You can drag a *dialog* window outside of the program window and move it around on the entire screen.

To hide or show all open dialog windows at once, click on the Standard toolbar.

Object Windows

Plant Simulation object windows are the *object* windows of the *Frame*, the *Method*, the *Debugger*, the *QueueFile and StackFile*, the *CardFile*, the *TableFile*, the *Icon Editor*, and the *Plant Simulation 3D Viewer*.

Object windows always open in the background. *Object* windows have a blue border in the online version of the picture below *Working with Window Types*.

To bring an open object window to the foreground, click the Window Menu and select the name of the window.

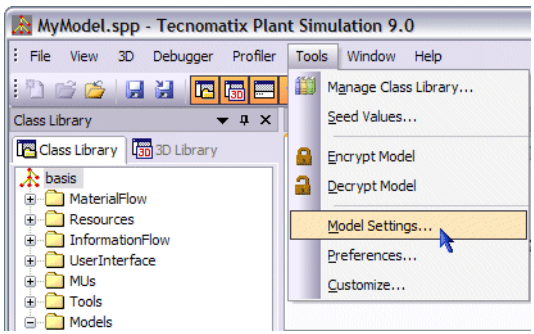
Note: You can use the method *openDialogBox* to open the windows of the *StackFile*, *QueueFile*, *CardFile*, *TableFile* and *TimeSequence* with the same properties as a dialog window in the foreground!

You can minimize and maximize an *Object* window and move it around within the program window. When you maximize an *object* window, *Plant Simulation* adds the button combination Minimize, Maximize, Close that is otherwise located in the title bar of the window, to the *Menu Bar*.

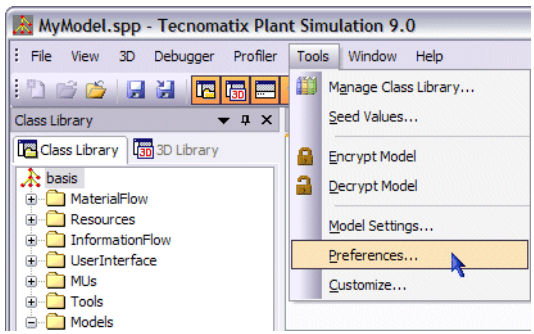
Selecting Settings

Before you start working with *Plant Simulation*, you might want to change some of the default settings that affect your simulation model.

- To select settings, which apply to the active model, select Tools > Model Settings. *Plant Simulation* saves theses settings in the mode file.



- To select settings, which apply to new models, select Tools > Preferences. On the tabs General, Modeling, User Interface and Editor you can select general settings, which are independent of the simulation model. On the tabs Simulation and Units you can select model-specific settings, which apply to new models.



You will:

- *Select General Options*
- *Select Modeling Options for the Frame*

- *Select Options for Units and for Displaying the Time*

Select General Options

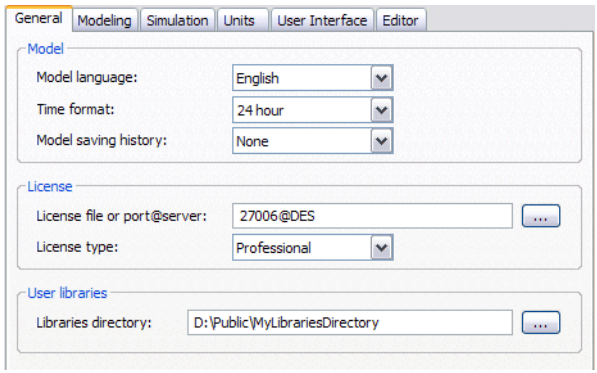
Select the language *Plant Simulation* uses when it creates a new simulation model. This language determines the names of folders and objects, such as *MaterialFlow* or *Materialfluss*, *SingleProc* or *Einzelstation*, etc.

Note: The language of the operating system of your computer determines the language of the *Plant Simulation* user interface.

The language determines:

- The name of the elements of the drop-down lists, such as the names of the distributions (Uniform or Gleich).
- The return value of the attributes that correspond to the entries of the drop-down lists, such as *SingleProc.proc-Time.Type*.
- The contents of the window Show Attributes and Methods.
- The names the feature Auto Complete within the *Method* editor suggests.

Select if you want to use the **24 hour** time format or the **12 hour** time format on the tab General.



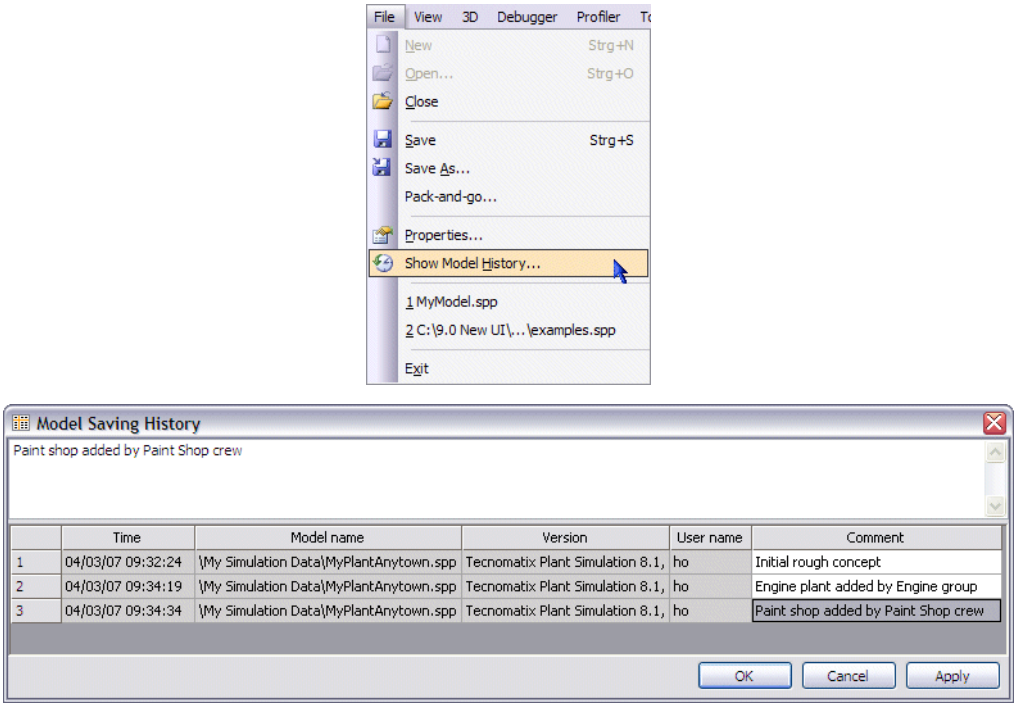
Select which kind of comment *Plant Simulation* adds to your model file, each time you save it:

- Without comment adds no comment to the model (.spp) file.
- With comment opens a comment window, each time when you save the model. Enter your comment here.
- When you select Without comment or With comment *Plant Simulation* adds a row to the dialog Model Saving History each time you save the model.

  When the model crashes, *Plant Simulation* adds a description of the problem to the model history window instead of a comment. This helps our software engineers detect what caused the crash.
- None does not save the history of saving your model.

  To view the comment you entered:

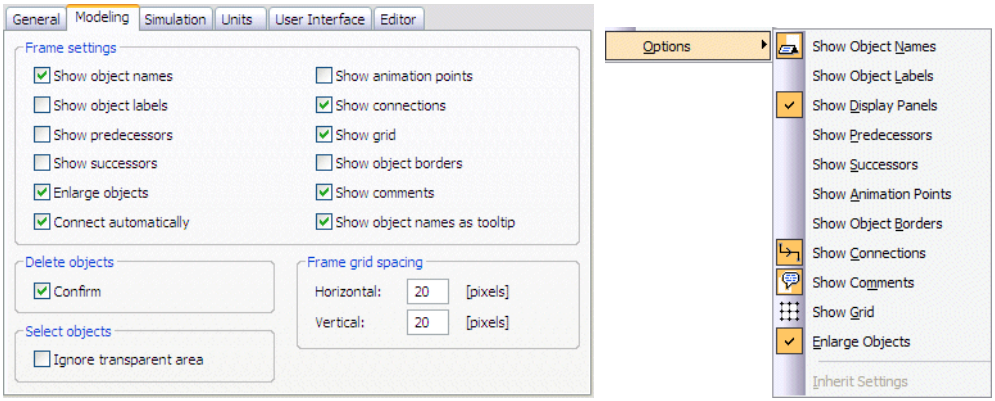
  Select File > Show Model History in the program window.



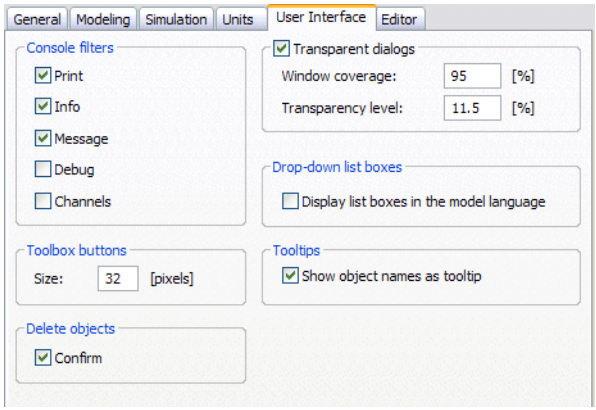
Select Modeling Options for the Frame

Select which items the *Frame* shows on the tab Modeling. Which features you want to show or hide largely depends on your modeling situation. The more items you choose to show in the *Frame* the more cluttered its display gets. We recommend to experiment with the different settings.

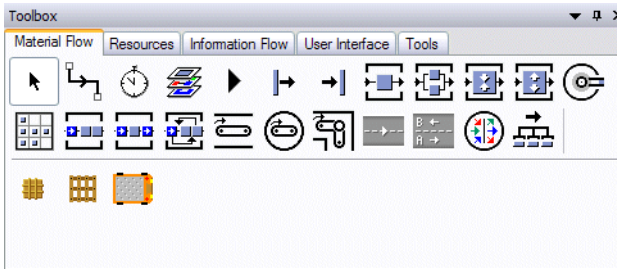
Note: You can override these settings for each individual *Frame* under View > Options.

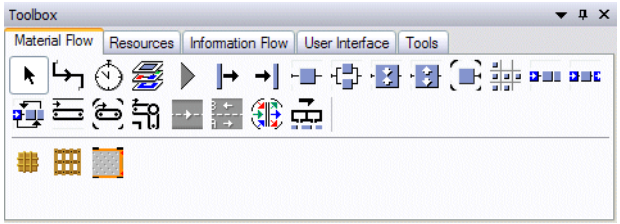


If it annoys you that *Plant Simulation* opens a dialog prompting you to confirm, when you delete objects, clear the check box Confirm.



If the icons of your objects are small, you can enter a smaller Size for the *Toolbox* buttons. The smaller the icons, the more icons the toolbox can display without having to scroll. Compare the settings 32 pixels and 24 pixels.

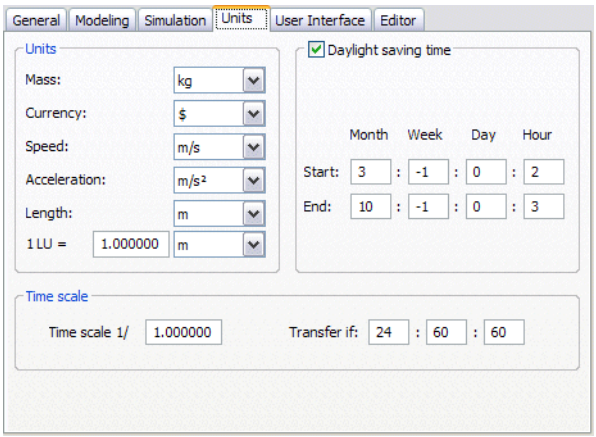




If you want to use another spacing for the grid in the *Frame*, enter a larger or a smaller number for the Frame grid.

Select Options for Units and for Displaying the Time

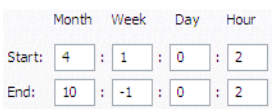
As daylight saving time is widely used internationally, you will also use it in your simulation model.



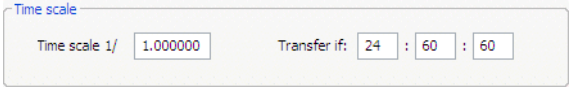
Note: To select units and time settings, which only apply to the active model, select Tools > Model Settings > Units.

To select units and time settings, which apply to all new models, select Tools > Preferences > Units.

- Select the check box Daylight saving time.
- If the facility you are modeling is located in the **European Union**, you do not have to change the default settings. Here summer time starts at 2 o'clock in the morning Greenwich Mean Time (GMT) on the last Sunday in March. It ends at 3 o'clock in the morning on the last Sunday in October. In the EU, all time zones change at the same moment.
- If the facility you are modeling is located in the **United States of America**, you have to change the settings. For most of the US daylight saving time starts at 2 o'clock in the morning on the second Sunday of March. It ends at 2 a.m. on the first Sunday of November. In the U.S., each time zone switches at a different hour.



If your specific modeling needs require it, you can also change the display of the Time scale. Enter a number between `0` and `86400`. Enter an integer greater than 1 into the text boxes Transfer if.



You might, for example, divide a minute into 100 units, instead of in 60 seconds, or you might want to read 1:50 as 1.5 hours instead of 1 minute and 50 seconds.

Note: You can only change the display of the time scale, not the time scale itself.

A time statement consists of four numbers, separated by colons, normally in the format days:hours:minutes:seconds. *Plant Simulation* stores the value itself in seconds and converts it at output time for the **display**.

Plant Simulation converts times according to the values you enter into the text boxes Time scale and Transfer if.

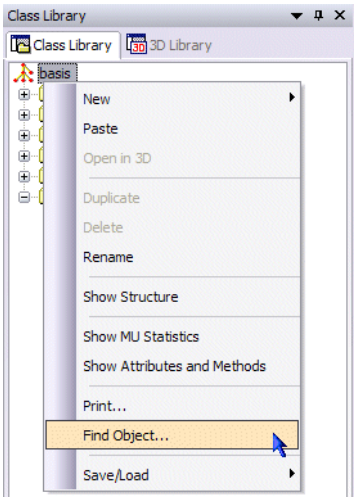
The following examples illustrate what to enter to achieve different displays of the time:

- If you want to use the standard time format, 24 hours to the day, 60 minutes to the hour, 60 seconds to the minute, use the default setting Time Scale 1/1.0 Transfer if 24:60:60.
- If you want to simulate a longer period of time and want to display the time in the format years:months:days:hours, enter Time Scale 1/`3600` Transfer if `12:30:24`, as an hour has 3600 seconds, a year has 12 months, a month has 30 days, and a day has 24 hours.
- If you want to divide a minute into 100 subunits instead of 60 seconds, enter Time Scale 1/`0.6` Transfer if `24:60:100`.

Finding Objects and Text

To find the name of an object, the name of a condition or any text you entered as source code into a method in your simulation model:

1. Click the right mouse button anywhere in the *Class Library* and select Find Object on the context menu.



2. Select what you want to find from the left drop-down list:

   Find the Name of an Object

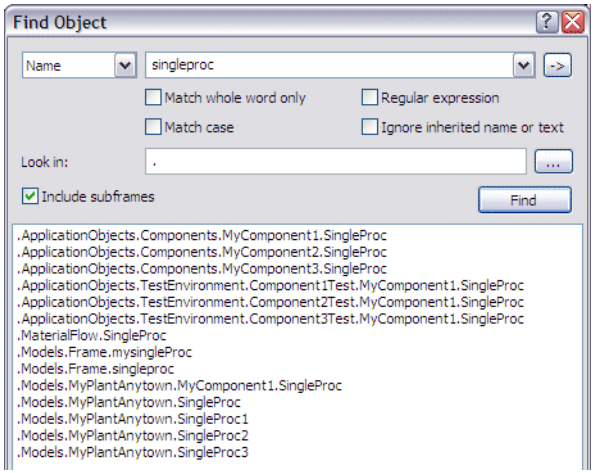
   Find a Condition of an Object

   Find any Source Code

Find the Name of an Object

To find the name of an object you inserted into your simulation model:

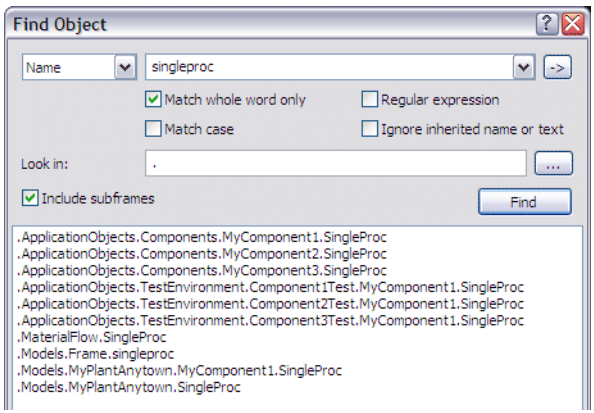
1. Select Name from the left drop-down list.
2. Type in the name of the object you want to find into the right drop-down list. We entered `singleproc`.
3. When you do not select the check box Match whole word only, *Plant Simulation* finds all words that contain the word you entered. In our example it finds all word containing the word *SingleProc*, such as *SingleProc*, *SingleProc1*, *SingleProc11*, *mySingleProc*, etc.



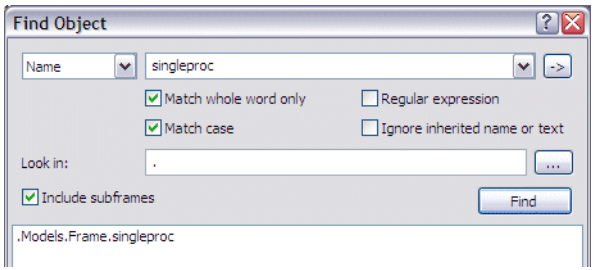
4. Type in the name of the folder or the *Frame* into the text box Look in, where *Plant Simulation* is going to start searching for the expression you entered into the text box.

   You can also click ... and select a folder or a *Frame* in the dialog Select Object.

   To search on the highest level of the structure, accept the default setting that *Plant Simulation* enters, namely the period (.).
5. Select Include subframes to also search all *Frames* located in the *Frame* in which the item you are searching for is located.
6. Click Find, to start searching.
7. Double-click the name of the object in the results field, to open its dialog. You can then change any settings.
8. When you select Match whole word only, *Plant Simulation* only finds entire words that exactly match the word you entered. In our example it only finds the word *singleproc*.



9. When you select Match whole word only, and also select Match case, *Plant Simulation* only finds words that exactly match the word you entered, including upper and lower casing. In our example it only finds the word *singleProc*.



10. When you select Regular expression, *Plant Simulation* also finds the regular expression you select. Click -> and select any of the items displayed in the window Regular Expression. *Plant Simulation* enters the special characters designating that expression into the right drop-down list.

Select	to enter and to find
Any single character	.
Beginning of line	^
End of Line	$
Beginning of word	\<
End of word	\>
Group	\(\)
Zero or one matches	?
Zero or more matches	*
One or more matches	+
Any one character in the set	[]
Any one character not in the set	[^]
Or	|

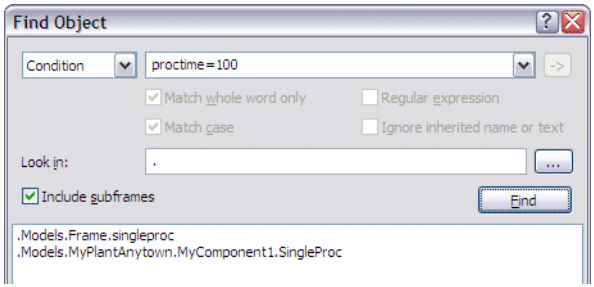
Searching with regular expressions allows you to use wild cards in the string you are searching for.

- To find all strings that contain a sequence of the character `a`, followed by any character, and the character `b`, enter `a.b` into the text box.
- To find all objects whose name starts with an upper case S, enter `^[S]`.
- To find all objects whose name does not end with an e, enter `[^e]$`.
- To find all objects whose name contains an upper case L, followed by any character, followed by proc, enter `L.*proc` into the text box.

Find a Condition of an Object

To find a condition of an object you inserted into your simulation model:

1. Select Condition from the left drop-down list.
2. Enter any SimTalk expression whose *attributes* or *methods* are identical to the expression you enter in the drop-down combo box. You might, for example, enter the name of an attribute or a method and the expression you are looking for, such as `Proctime = 100`, or `OpenCtrl = void`, etc.

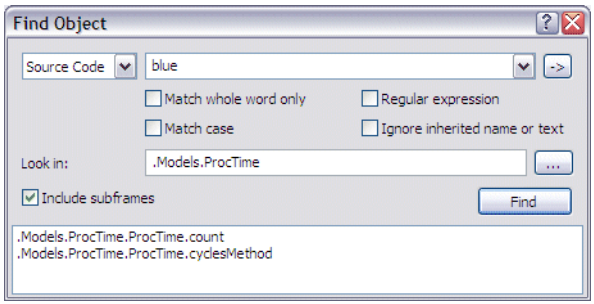


3. Repeat steps 4 to 7 described under *Find the Name of an Object*.

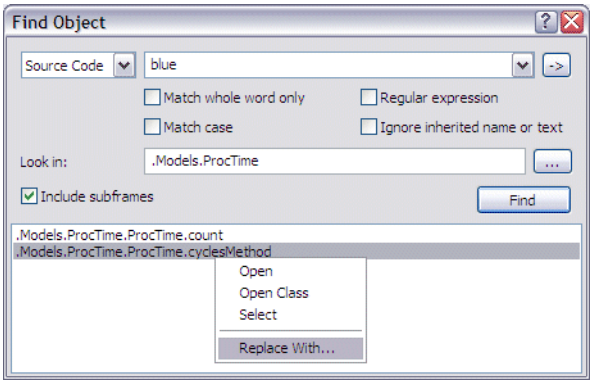
Find any Source Code

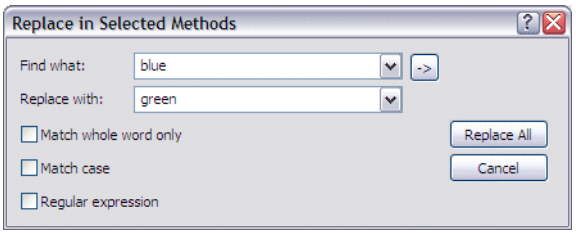
To find any text, which you entered as source code into any *Method* object you inserted into your simulation model:

1. Select Source Code from the left drop-down list.



2. Repeat steps 4 to 10 described under *Find the Name of an Object*.
3. When you select Ignore inherited name or text *Plant Simulation* then only finds the original source code you entered into a *Method* object, and not the source code in derived or duplicated objects.
4. To replace the found source code with other source code, right-click one or several *Methods* in the results list and select the command Replace With. Then, enter the replacing source code into the dialog which opens.


Find Object
Source Code
blue
->
Match whole word only
Regular expression
Match case
Ignore inherited name or text
Look in:
.Models.ProcTime
...
Include subframes
Find
.Models.ProcTime.ProcTime.count
.Models.ProcTime.ProcTime.cyclesMethod
Open
Open Class
Select
Replace With...


Replace in Selected Methods
Find what:
blue
->
Replace with:
green
Match whole word only
Match case
Regular expression
Replace All
Cancel

Modeling in Tecnomatix Plant Simulation 2D

Modeling in *Plant Simulation* **2D** introduces you to the most important tasks you will face when you create your simulation model in *Plant Simulation* 2D. If you start a new simulation project from scratch, and at one point in time or another, you might also have to create a corresponding 3D model at the same time or in the future, you have to keep a number of criteria in mind to facilitate this.

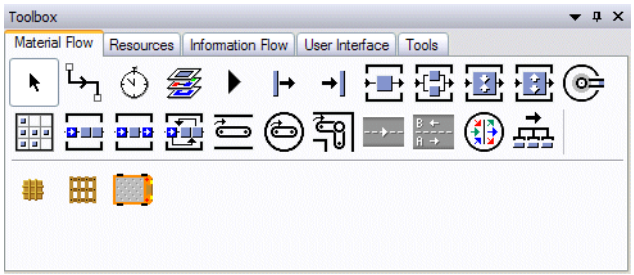
Go to Packing a Model and Sending it to Somebody Else

Creating a Simulation Model

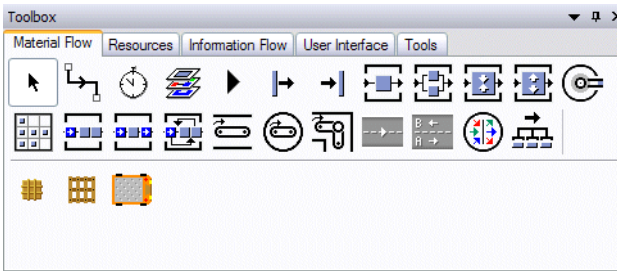
You will create your simulation model by inserting instances of the built-in objects and of objects you yourself or a colleague designed, the so-called user-defined or application objects, from the *Class Library* into the object *Frame* in the folder Models. By modeling application objects you can develop libraries that meet the modeling requirements of your company. The most important built-in objects are: the *Frame*, the active and the passive material flow objects, the movable objects, the *Method* object, lists and tables, and the *EventController*.

- The *Frame* is the object in which you create your simulation model. You will rename this *Frame* and then insert the objects that represent the stations in your installation, into it.
- To run the simulation you will insert an *EventController* that starts, stops and resets the simulation run. You can re-use each and every simulation model you created as an application object in other simulation models.

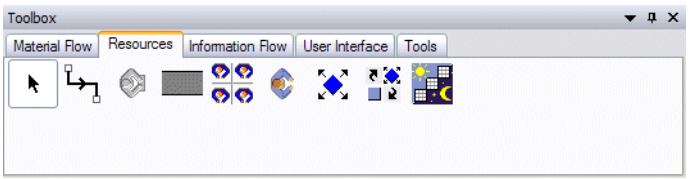
  By inserting *Frames* into *Frames* you create a randomly nested **hierarchy** of models. This way you can build and structure simulation models that exactly match the installation you are simulating, and break down complex tasks into manageable chunks.
- You can derive or duplicate each object and re-use it as often as required, which introduces an important time-saving key feature of *Plant Simulation*: **inheritance**: A derived object, i.e., a child object, retains a controllable link to the template object, i.e., the parent object. In many cases the immense advantage of inheritance regarding productivity and the low number of errors only becomes clear at a later point in time, when you actively work with your simulation models. Naturally you can also turn inheritance for individual features off, by clicking the inheritance button, so that it looks like this .
- The **active material flow objects** transport and/or actively process mobile objects, i.e., parts, within the simulation models.



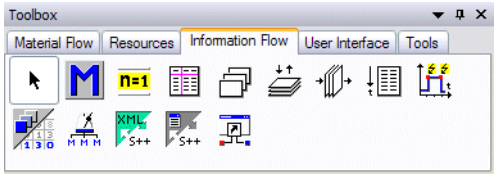
- The **passive material flow objects** do not actively process parts. They store parts and represent tracks on which the processed parts are moved.
- The **mobile objects** (MUs) represent the parts that are created in, stored in, transported in, processed in and removed from your simulation model.



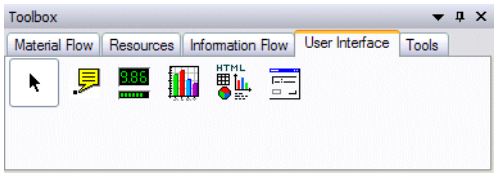
- The **resource objects** are intended for modeling how and when *Workers* move from the *WorkerPool* to the *Workplaces* at the stations.



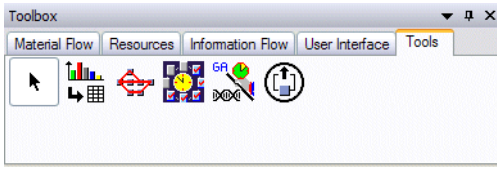
- Employing objects of type *Method* you can program the actions that you need to take place when the conditions you program become true. For this we integrated a powerful programming language into *Plant Simulation*. The *Methods* are either activated as controls by the material flow objects or by other *Method* objects. The *Method* also provides a *Debugger* to locate errors and allow you to correct faulty code.
- **Lists and tables** ensure the random exchange of information between all objects. The powerful processing of information in *Plant Simulation* is the result of a variety of functions, data types and operators.



- The objects *Chart* and *HTML Report* allow you to graphically display the statistical values that the material flow objects collect during the simulation runs.



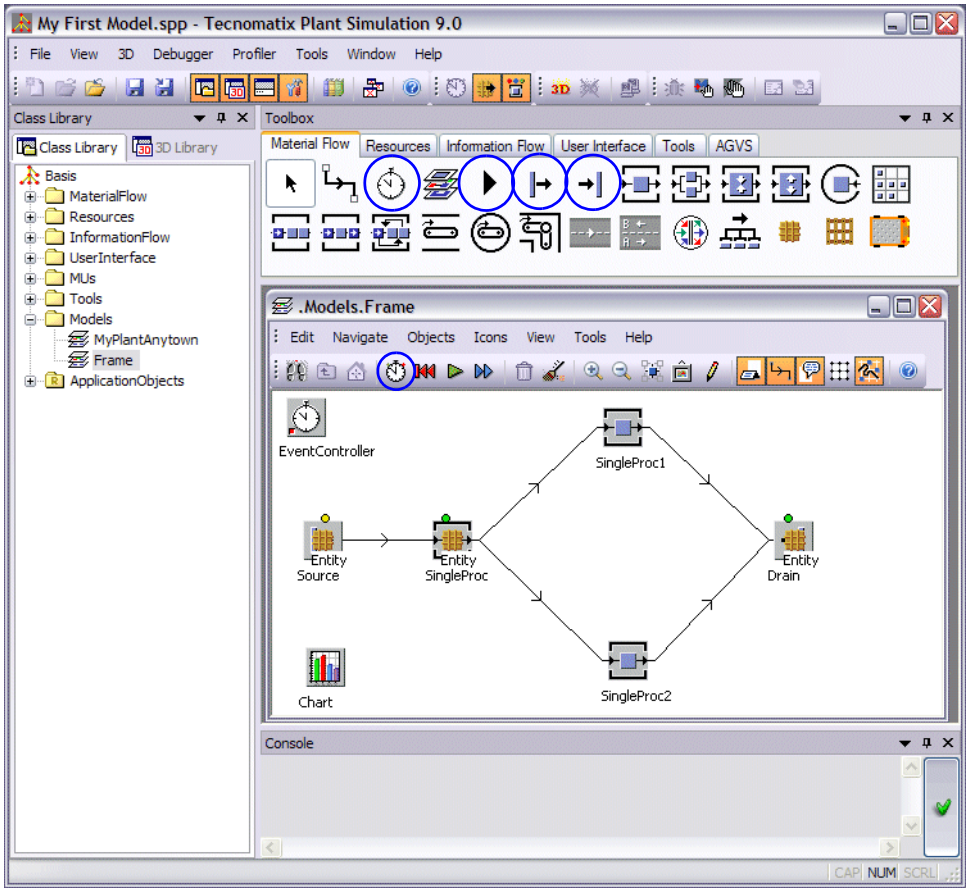
- With the object *Dialog* you can create a dialog window similar to the built-in dialog windows that *Plant Simulation* provides. This way you can provide a simple user interface for complex simulation models other users work with. You can also prevent another user from manipulating a *Frame*. To accomplish this, insert a *Method* object as an Open control into the *Frame*. Double-clicking the *Frame* will then not open it any longer, but call the control method in which you might, for example, program it to open a dialog, where the user can then select the settings.
- With the objects *BottleneckAnalyzer* and *SankeyDiagram* you can analyze and evaluate the results the simulation runs provided. Use the *ExperimentManager* to define how *Plant Simulation* executes the simulation experiments.



- Naturally you can also exchange data with other programs and processes using the interfaces we provide. For integration purposes with other software it is important that data can be exchanged not only at the beginning and the end of the simulation run but also during the simulation run.

Creating a Simple Simulation Model

Creating a simple simulation model demonstrates how easy it is to quickly create a simple simulation model. We will build a simple production line with a *Source* object, several *SingleProcs* and a *Drain*.



The *Source* produces the parts that the stations, symbolized by the *SingleProcs*, are going to process. The *Drain* removes the parts, symbolized by the *Entities*, from the production line after the *SingleProcs* have processed them. The *Source* can represent the receiving department, while the *Drain* can represent the shipping department. We also insert a *Chart* that visualizes the results of our simulation run in different ways.

You will:

- *Insert Objects into the Frame*
- *Connect Objects in the Frame*
- *Run the Simulation*

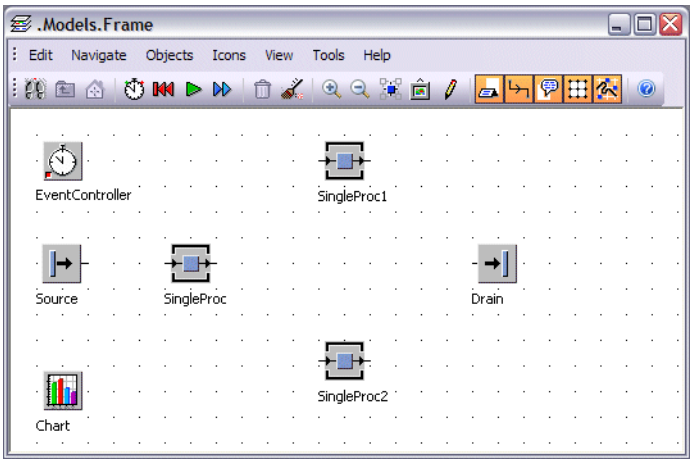
- *View the Results of the Simulation Run*

Insert Objects into the Frame

Proceed as follows to insert the objects, which symbolize the machines and stations in your installation, into the *Frame* that symbolizes the installation or plant you are modeling:

- Start *Plant Simulation* and open a new model: Click Create New Model on the Start Page, select File > New or click on the Standard toolbar.

  This opens the *Class Library* with the built-in objects *Plant Simulation* provides, the *Toolbox* and an empty *Frame*—in the folder Models—for creating your simulation model.
- To insert an object into the *Frame*, do one of the following:
  - Use drag-and-drop to insert objects from the **class library** into the *Frame*.
  - Click the icon of the object you would like to insert in the **toolbox**, move the mouse pointer, which then turns into crosshairs (+), to the location in the *Frame* into which you would like to insert it and click the left mouse button once.
- Insert the objects, so that your model matches the screenshot.
  - Click the folder or the tab Material Flow and insert a *Source*, three *SingleProcs*, and a *Drain*.
  - Click the folder or the tab User Interface and insert a *Chart*.



- To move an object in the *Frame*, do one of the following:
  - Click the object once with the left mouse button, hold the button down, move the icon to the desired location, and release the mouse button.
  - To move the selected object one pixel at a time in the direction of the key, press one of the arrow keys.
  - To move the selected object one grid unit at a time, hold down the Shift key, and press one of the arrow keys.

- To align all objects to grid points in the *Frame* window, select all objects by dragging a marquee over them and select Icons > Align to Grid.
- To delete an object, press the Del key on the keyboard or right-click it and select Delete.

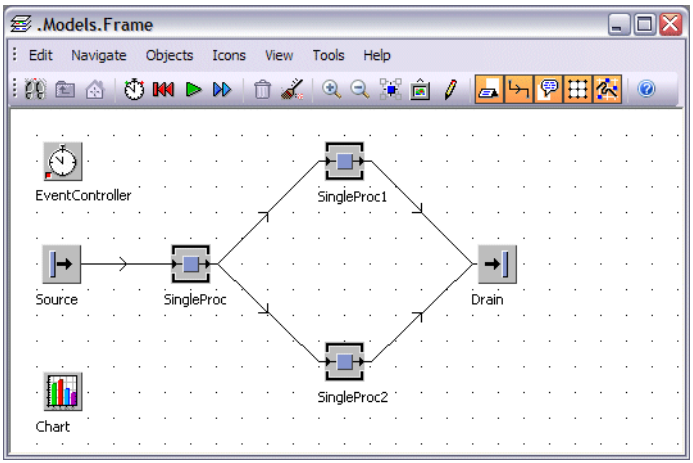
Connect Objects in the Frame

Once you have inserted the objects, you have to connect them, so that *Plant Simulation* can pass the parts from object to object through the installation.

- Click the *Connector* in the *Toolbox* to activate connect mode. The mouse pointer turns into crosshairs (+), when it is located over an object to which you can attach a *Connector*.
- Click on the *Source* and then on the *SingleProc* to the right of it. This establishes the connection between the two objects, symbolized by a line. The arrow in the middle shows the direction of the connection.
- Repeat this for the other objects.

Note: To connect several objects one after the other without having to return to the *Toolbox* each time you established a connection, hold down Ctrl, while you establish the connection.

Your model should now match the screenshot.



Run the Simulation

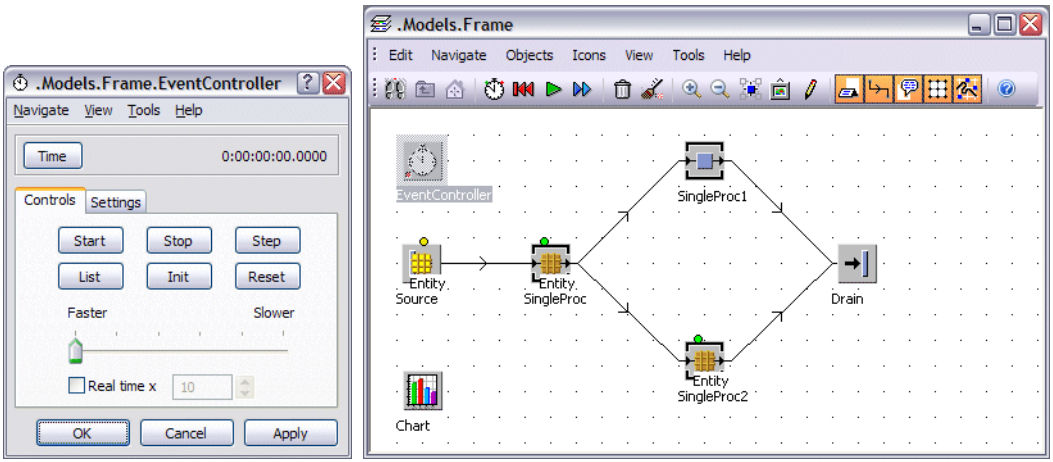
To run the simulation, click or on the toolbar of the *Frame*, to insert an *EventController* into the model.

- Double-click the *EventController* to open its dialog window.
- Click the Start button to start the simulation, click Stop to stop it.
- Click Step to process one simulation event at a time and to proceed through your model step by step.

- Drag the slider to set the speed of the simulation. The slower the simulation is running the better you will be able to watch how the parts move through the model.

Now change different components of the model and check the impact of these changes. You might:

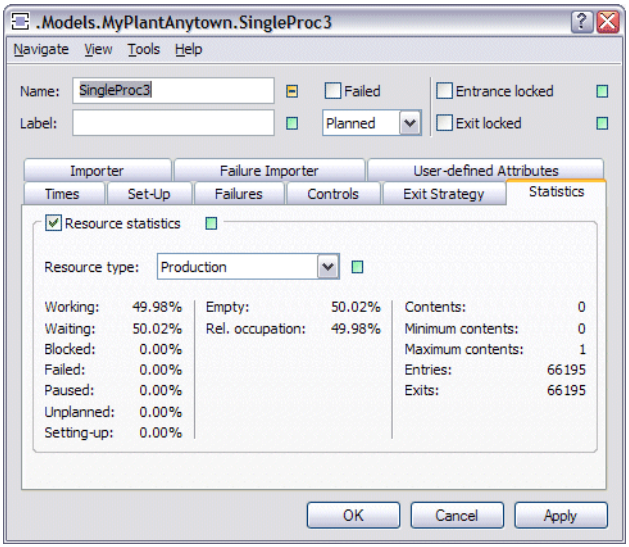
- Manually pause *SingleProc1* for a while, re-start the simulation, remove the pause and continue the simulation.
- Change the processing time of *SingleProc1* or *SingleProc2*.
- Select a different Exit strategy for the *SingleProc* to see how it distributes the parts to the succeeding machines.
- Change the type of MU the *Source* produces: Double-click the *Source* and click MU. Select the Container in the dialog Select Object.



View the Results of the Simulation Run

Once the simulation run is finished, you will be eager to check its results. You can view the statistics of each individual object in its dialog window and you can visualize the statistics of as many objects as you like in a chart.

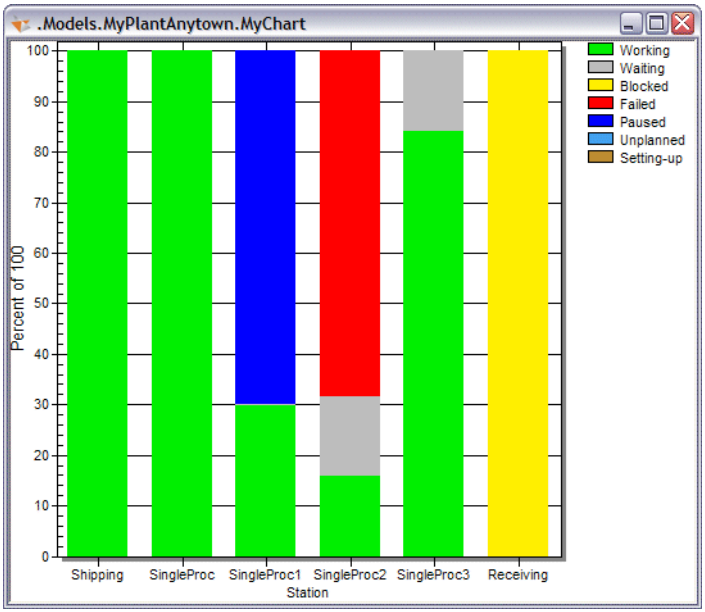
- To view the values resulting from the simulation runs for the individual stations, click the tab Statistics in the dialog of the respective object. There, the object shows the most important data.



- To view the statistics, which the object collected, in the statistics report, select the object and press F6. This opens a report showing the most important statistics value in meaningful overview.
- To present the results of our simulation run to management, we will use the object *Chart* . Drag the objects whose data you would like to show over the icon of the *Chart* and drop them there or right-click the *Chart* and select Statistics Wizard. Then, select the objects there.

  Right-click the *Chart* and select Show.

  If you want to, you can play around with the settings to show the values in different ways.



About Classes

Imagine that, for example, you have to find the optimum type of store for a production plant. First, you have to come up with different types or stores that might work for the specific installation, such as fully automated high bay warehouse, manually operated shelving system, etc. To be able to compare the different types of stores, you are going to build several simulation models, execute simulation runs and suggest the type of store with the best cost/gain relation.

Your simulation models are going to be variants of a single basic model, i.e., you are going to use the same production installation and are going to modify the store.

When creating the model variants you are going to build the basic model first. In conventional systems you would then copy this basic model until you arrive at the number of variants you need. In *Plant Simulation*, on the other hand, you will inherit this basic model, which we call the parent model, and arrive at child models. The main difference between a copied and an inherited model is that a child model recognizes which parent it is derived from while a copied model knows nothing about its origin.

Now you are going to insert the different types of stores into the model variants you created. If you now find a modeling error while modeling the basic model or if a specification changed, a conventional system requires changing all copies, which is time-consuming and error prone.

In *Plant Simulation*, on the other hand, you make the change once in the parent model. It then immediately propagates all of your changes to all of its children, provided you did not change the setting in the child model. This saves a considerable amount of time and the hassle of manually updating a number of sub-models.

Classes, Subclasses and Instances

When creating your simulation model, keep in mind:

- A **class** is the template for an *instance*, which you insert into a *Frame*. All objects in the *Class Library*, those we built-in as well as those you yourself define, are *class* objects. You can add more detail to these classes and thus create new classes that inherit properties from the master classes.

  By changing a property in the class object, you change that property for all objects you derived from this class. This is much less error-prone than having to change the same property for each and every individual object over and over again.

  - A *class* passes all of its properties on to an instance you derive from it.
  - A *class* passes those of its properties on to a *subclass* you derive from it, for which you do not deactivate inheritance. Remember that a button that looks like this ▫ means that inheritance is active.

  Note: Inheritance only works from *class* to *subclass/instance*, not the other way around!

- A **subclass** is an object in the *Class Library*, which inherits some, but not all, of its properties from another *class*. By deactivating inheritance for certain dialog items, you can define properties that only apply to this subclass. An example of subclasses could be several lines that only differ in their length.

  To **create a subclass** from a class, right-click the class in the *Class Library* and select Derive. When you open the dialog of the derived object, you will notice that inheritance is active for all dialog items, denoted by button that looks like this ▫.

  Instead, you can hold down Ctrl and Shift, and click the object you wish to derive an instance from with the left mouse button. Then, hold down the mouse button, drag the object to the location of your choice, for example into another folder in the *Class Library*, and release both keys and the mouse button.

- To **create a copy** from a class, right-click the class in the *Class Library* and select Duplicate. When you open the dialog of the duplicated object, you will notice that inheritance is deactivated for all dialog items, denoted by button that looks like this ▫.

  Instead, you can hold down Ctrl, and click the object you wish to duplicate with the left mouse button. Then, hold down the mouse button, drag the copy to the location of your choice in the *Class Library*, and release Ctrl and the mouse button.

- An **instance** is an object, which you insert into your simulation model from the *Class Library* or the *Toolbox* by dragging a class object to a *Frame* and dropping it there.

The objects use class relations and origin relations to inherit their properties from other objects:

- The object inherits all of its basic properties from its **class** object. This includes settings it has by default, build-in *Methods*, basic functionalities, etc. The *class* is the object in the *Class Library* you instantiated the selected object from.
- The object inherits its settings from the **originating** object, provided you did not change them locally within the object. The *origin* of the selected object is the object you derived it from.

Making full use of the potentials of inheritance saves a considerable amount of time and effort during modeling.

Replacing and Merging Objects with Drag and Drop

While creating your simulation model you can:

- **Replace** an instance with a class by holding down Alt while dragging the class object on the instance and dropping it there. This way you can, for example, replace a *SingleProc* with an *Assembly* station. *Plant Simulation* preserves all connected *Connectors*, but deletes all MUs on the object. *Plant Simulation* also lets you copy the attribute values of the previous instance into the new instance. When you select to not do this, the new instance is in the same state as an instance you inserted from the *Class Library*, i.e., all built-in attributes are inherited and all user-defined attributes and sensors, which you defined in the previous instance, will be discarded.
- **Merge** objects by holding the Alt key and the left mouse button down. Then click the replacing object, drag it over the object to be replaced, and drop it there.

Using Inheritance

Inheritance allows one class or object to incorporate data or behavior of another.

Inheritance has a number of applications:

- **Specialization** of existing classes or objects. In specialization, the new class or object has data or behavior aspects, which are not part of the inherited class.
- **Extension** to provide additional data or behavior features. In contrast to the case of specialization, with extension the new data or behaviors could have been provided in the inherited class because they are generally applicable to all instances of the class.
- **Code re-use** to allow a new class to re-use code, in our case any of the settings you selected, which already exists in another class.

The toggle button to the right of a dialog item activates or deactivates inheritance

for that item in the dialogs of the *Plant Simulation* objects.

- A button that looks like this means that inheritance is active. Then the object inherits, i.e., uses, the value from the parent object from which you derived it. When you modify the value of the parent object, *Plant Simulation* also modifies the value of the child object.

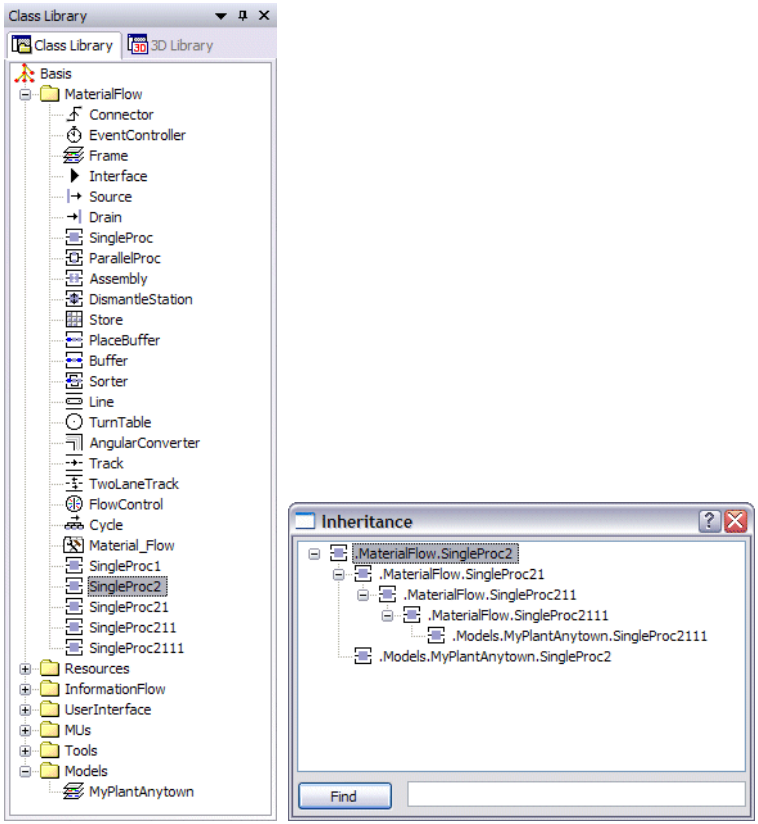
  Let us illustrate this with an example. We derive the *SingleProc* in the *Class Library* and insert it from the *Class Library* into the *Frame Model1*. Then, we derive *Model2* from *Model1*. The origin of the *SingleProc* in *Model2* is the *SingleProc* in *Model1*. When we now change the value of an attribute that inherits its value in the *SingleProc* in *Model1*, the *SingleProc* in *Model2* also applies this value.
- A that looks like this button means that inheritance is not active. The values you enter only apply to the current object.

Note: The object might display the current value only after you click Apply.

Show Inheritance Relations in the Class Library

The objects can use **class** and origin **relations** to inherit some, or all of their properties from other objects. To get an overview over which object inherits from which other object, right-click the object you are interested in in the

Class Library and select Show Inheritance. The dialog Inheritance shows the paths of all objects that are derived from the selected object and thus inherit some or all of its properties from it.



Show the Origin of an Object in the Class Library

The objects can use class and **origin relations** to inherit some, or all of their properties from other objects.

To select the object in the *Class Library* that the selected object was instantiated from, right-click the object you are interested in in the *Class Library* and select Show Origin.

You can repeat this to move up in the hierarchy until *Plant Simulation* does not select another object. Then you have reached the object the selected object was derived from originally, i.e., its origin.

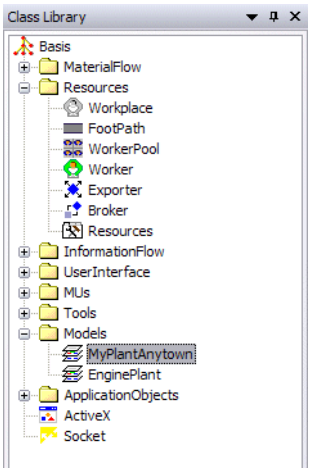
Working with Classes in the Class Library

The Class Library shows the built-in objects in a hierarchical structure in folders and subfolders. By default the *Class Library* contains a folder with *MaterialFlow* objects, with *Resource* objects, with *InformationFlow* objects, with *MUs*, with

UserInterface objects, for *Models* and for *Tools*. When you start modeling, you will derive child objects from the built-in class objects or from class objects you, or a co-worker, built from scratch.

Plant Simulation initially opens the frame *Frame* for creating your simulation model, and any other *Frames* you add later on, in the *Models* folder. The folders in the tree window share a number of properties with the other objects. Among others you can apply a number of control *Methods*, for example the *Rename* control, etc.

When you add an add-in program, the *Class Library* also shows its objects—either loose or in a folder of its own—on the topmost level of the structure below Basis. Note that Basis designates the *Class Library* itself, compare *basis*.



Configure the Class Library

You can configure the Class Library to best suit your needs. You can do this for new simulation models which you create and for any of your existing models. This results in a lean *Class Library* and an uncluttered *Toolbox*, preserving precious screen space. You can:

- *Add Basic Objects to the Class Library or Remove Them from It*. Naturally you can also add or delete objects at a later point in time.
- *Add a Library or a Tool to or Remove it from the Class Library*.
- *Add a Library, which You Yourself Developed*.
- *Update a Library*.

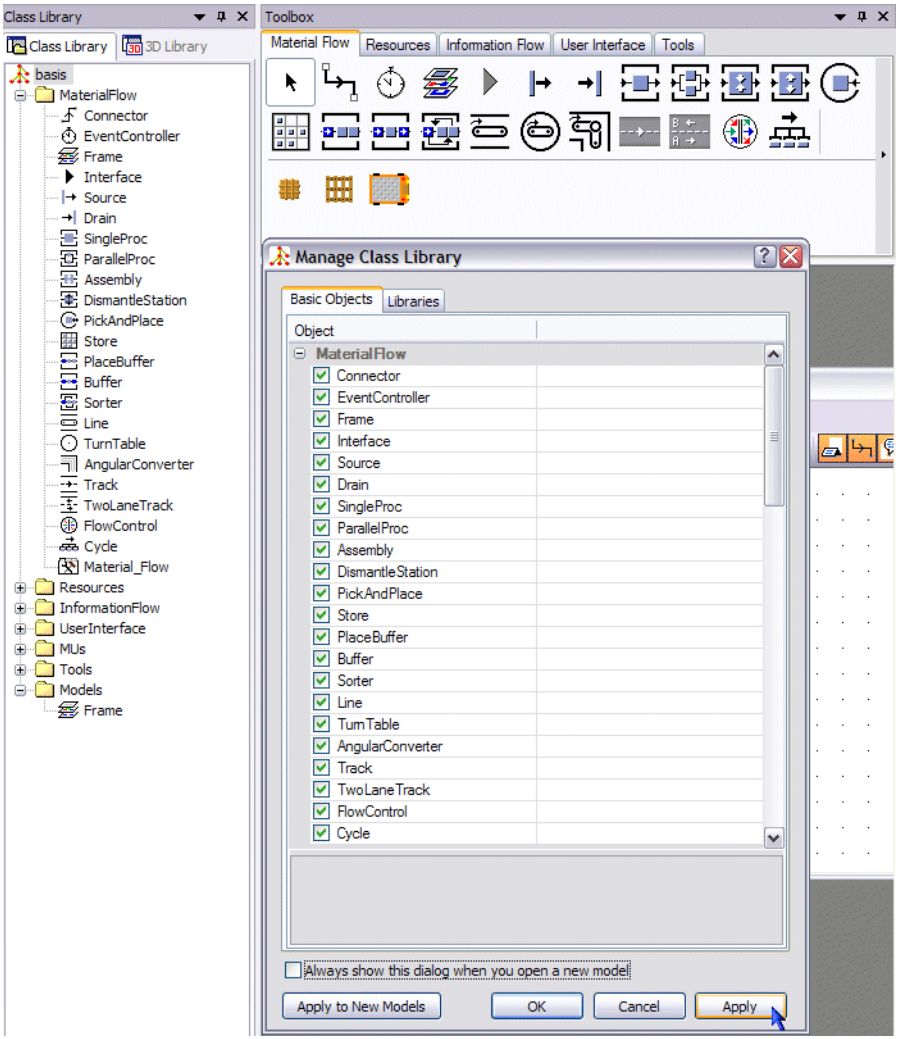
When you select the command File > New for the first time, *Plant Simulation* opens the dialog Manage Class Library by default.

Add Basic Objects to the Class Library or Remove Them from It

To add the **built-in objects**, which are part of your program package, to the *Class Library* and to the *Toolbox*:

- Select the objects, which you need for creating the current and future simulation models.

Deselect the objects, which you do not need.

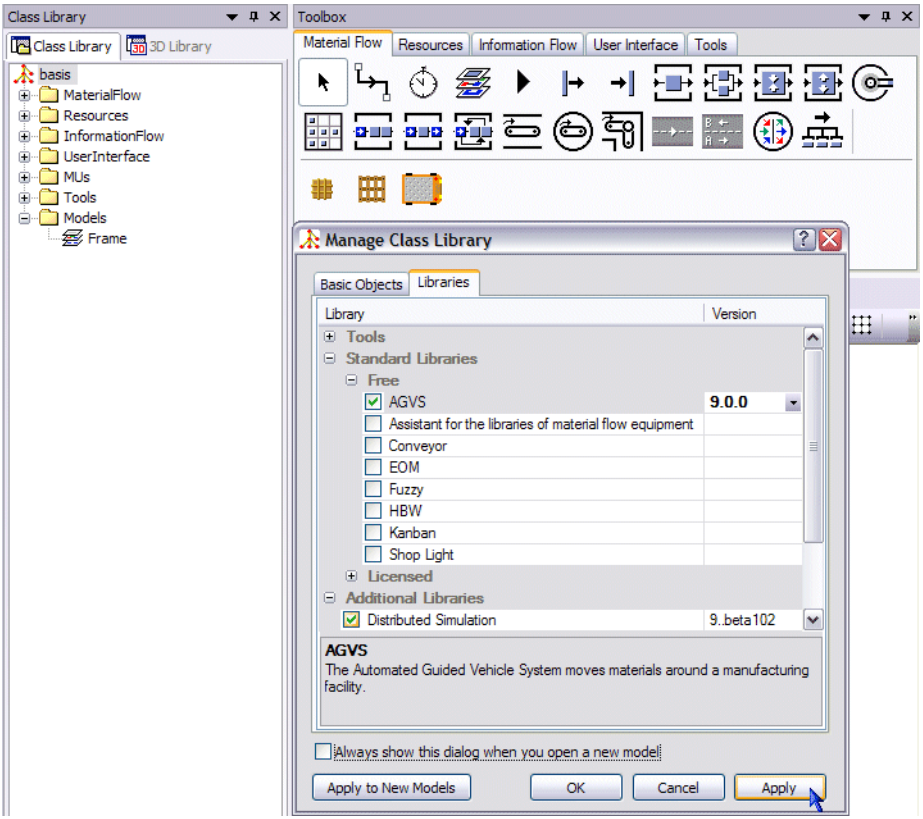


- Click Apply to add the selected objects to the *Class Library* and to the *Toolbox* or to remove them from it.
- If you want *Plant Simulation* to always show this dialog, when you open a new model, select the check box Always show this dialog when you open a new model. Then you can configure each simulation model to your liking. If you want to use the same settings for all new simulation models, clear the check box.
- If you want *Plant Simulation* to apply the settings you selected in the dialog to all new models, which you create hereafter, click Apply to New Models.

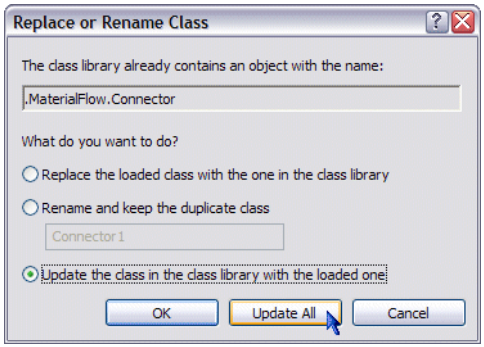
Add a Library or a Tool to or Remove it from the Class Library

To add any of the **built-in tools or libraries**, which are part of your program package, to the *Class Library* and to the *Toolbox*:

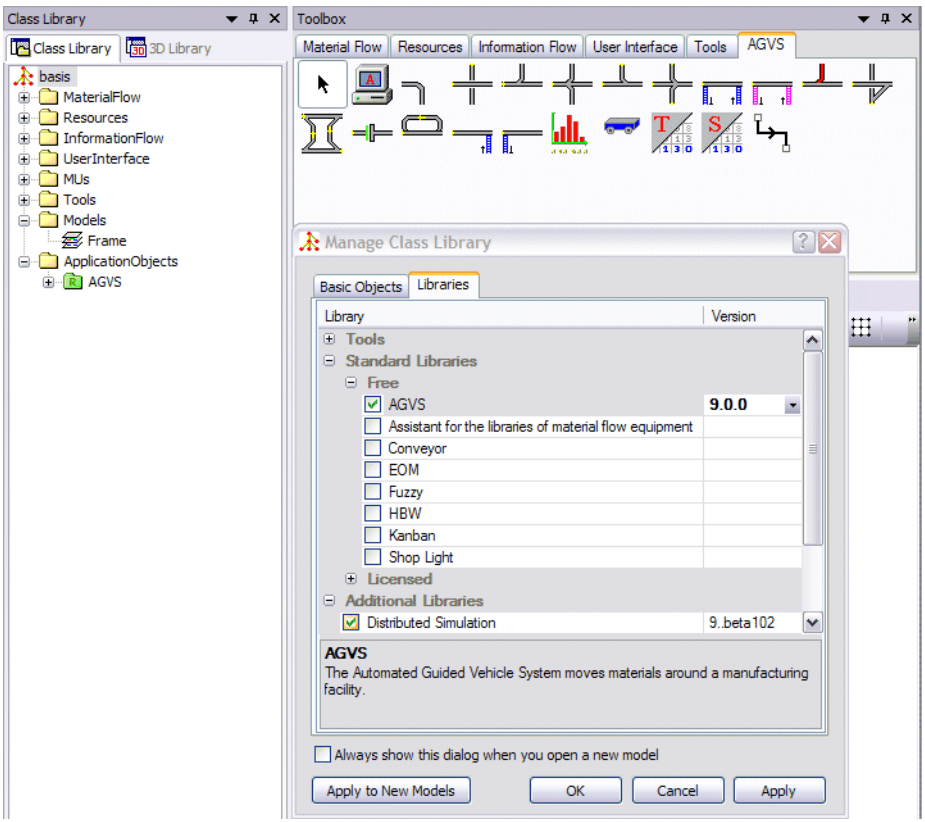
- Select one or several tools and libraries, which you need for creating the current and future simulation models. Deselect the tools or libraries, which you do not need.



- Click Apply to add the selected objects to the *Class Library* and to the *Toolbox* or to remove them from it.
- As we want to update the class in the class library with the loaded class, we select that radio button in the dialog Replace or Rename Class.



Plant Simulation adds the folder AGVS within the folder Application Objects to the *Class Library* and the *Toolbar* AGVS to the Toolbox.

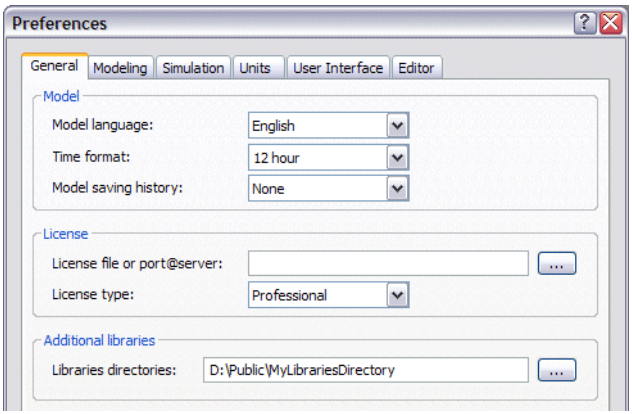


Add a Library, which You Yourself Developed

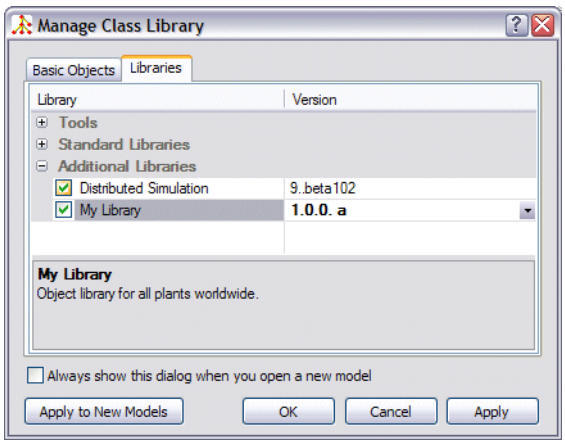
To add one of the **libraries**, which you yourself developed to the *Class Library* and to the *Toolbox*:

- First you have to tell *Plant Simulation* where to look for the library, which you are going to add. This location may be a folder on a local computer or on a network drive.

  Select Tools > Preferences. Click ... to the right of Libraries directories and select the path. Click OK.



- The dialog Manage Class Library shows the library, `My Library` in our example, on the tab Libraries under Additional Libraries.

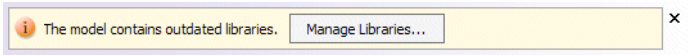


- Click OK to add My Library to the *Class Library* and to the *Toolbox*.

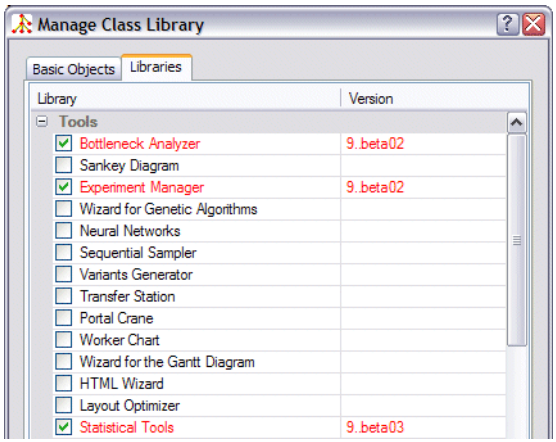
Update a Library

You can also update an outdated library on your computer with a newer version with the *library manager*. Let's say you have to update a model, which you haven't worked with for a while and which contains a library. If the *library*

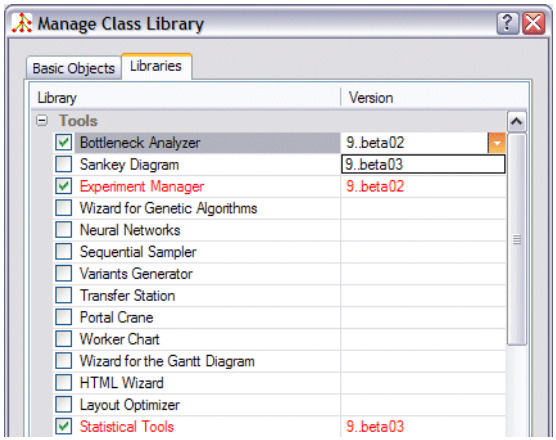
manager finds a newer version of the used library in the directory, which you entered under Tools > Preferences > Libraries directories, the *Caption Bar* shows this message:



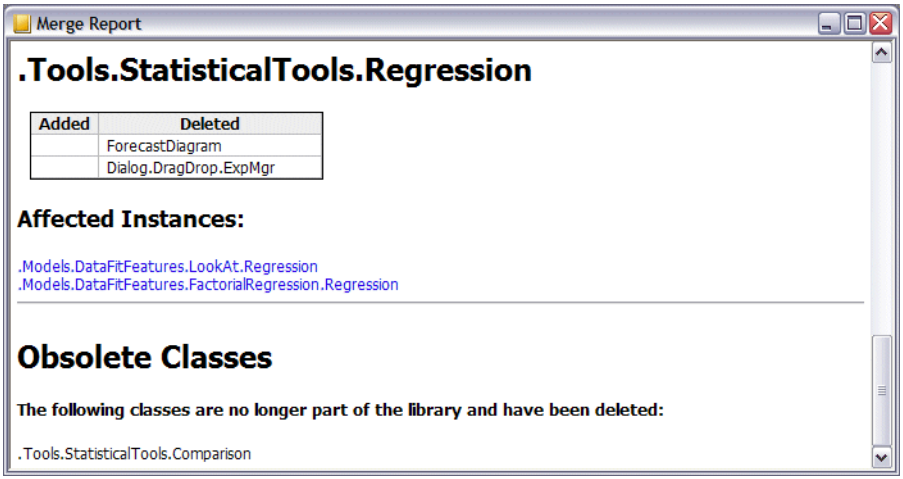
- Click Manage Libraries. The dialog shows libraries in red for which a newer version is available.



- Click in the cell below version to show the version number of the newest version and select it if you want to update the *Class Library*. Click OK.



Plant Simulation shows a Merge Report with detailed information about added and deleted objects, about the instances of the objects which were affected by the changes and which classes were deleted.



- Click OK, when you're done configuring the *Class Library*.

Create a Folder Structure for Your Simulation Model

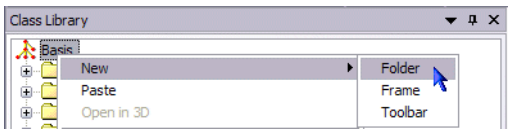
Before you start modeling, we recommend to think about the structure in the *Class Library* of your simulation model, as a clear structure will facilitate locating the objects.

To get an idea about structuring, you might want to take a look at the application object libraries that were installed, when you set up *Plant Simulation*. By default these are located in C:\Program Files\Plant Simulation\Libraries.

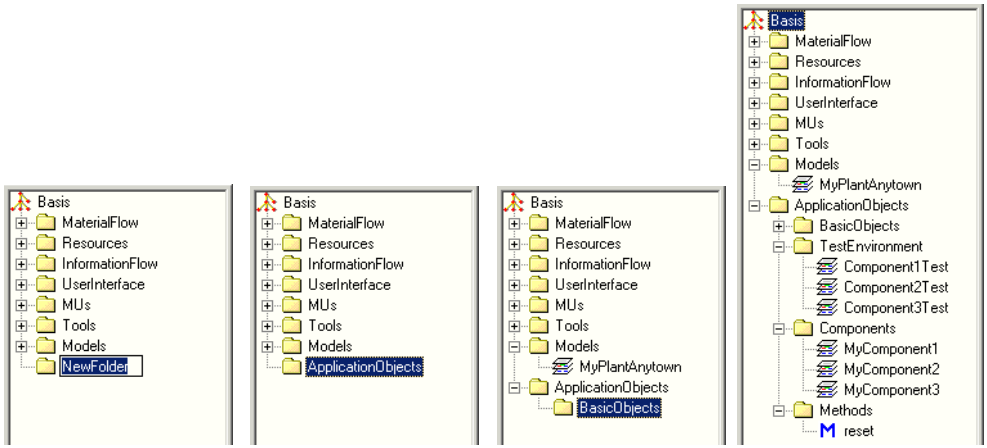
When you start modeling, we recommend to create new folders for the objects you use in your model, rather than store the objects within the built-in folders. Otherwise the risk of changing the built-in objects inadvertently might have confusing and unpredictable effects. This also facilitates saving your application object libraries as an object file, which you can then load into any existing simulation model.

To create a new folder:

- Right-click Basis in the *Class Library* if you want to insert the new folder on the same level as the built-in folders.
- Right-click any folder in the *Class Library* if you want to insert the new folder into that folder.
- Select New > Folder.



- Rename the folder: Click NewFolder once and type in a meaningful name. In our application object libraries we use `ApplicationObjects`.



We also recommend to create a subfolder for the basic, built-in objects that your simulation model uses, within the folder ApplicationObjects. In our application object libraries we named this subfolder `BasicObjects`. This facilitates that your application object libraries are independent of the language of the model that the user selects and of the naming conventions of the built-in objects you use in your model. In addition, this simplifies loading the application object library into other models, as this mechanism makes merging objects superfluous.

Set the Root Folder for Your Simulation Model

To prevent *Plant Simulation* from wasting RAM, you might, for example, not want to insert a *Method* that has a large number of instances into a large number of *Frames*. Instead, you can directly call this *Method* in which you programmed an action that many object use, from the *Class Library*. In this case, you can use the anonymous identifier *rootFolder* to avoid long paths.

When you use *rootFolder* in a *Method*, the *rootfolder* is a folder in the *Class Library* for which you have set the attribute *RootFolder* to `true`. Then, *Plant Simulation* searches for that folder, starting with the class of the *Method*, upwards in the hierarchy of objects.

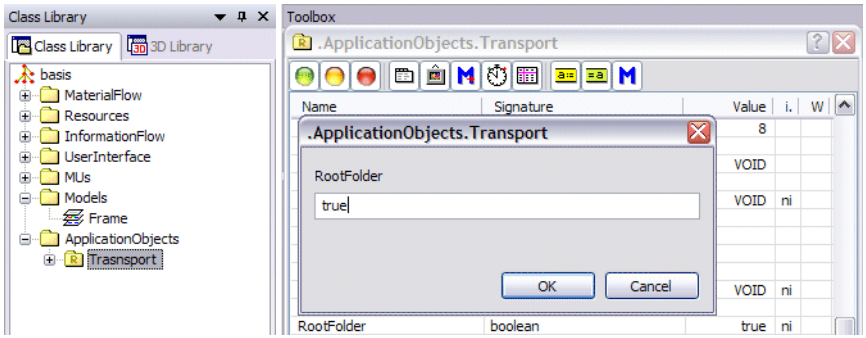
In your application object library, you will, as a rule, set the top folder that contains all your application objects as the rootfolder. This allows you to access any of the application objects you created, to access any of the dialogs you, or your colleagues designed, and so on.

To set the root folder:

- Use the attribute *RootFolder*. You might, for example, enter into a *Method*:

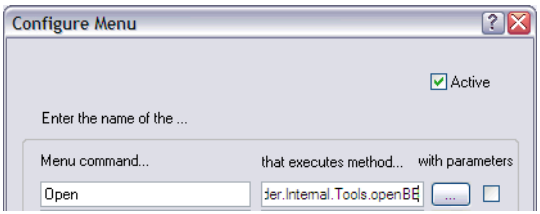
  ```
  .ApplicationObjects.RootFolder := true;
  ```

  Or
- Right-click the folder you would like to use as the root folder in the *Class Library*. Select Show Attributes and Methods, and click in the window. Press r on the keyboard and scroll down to RootFolder. Double-click it, type `true` into the dialog that opens and click OK. *Plant Simulation* adds an upper-case R to the icon of the folder .



This example from our application object library *Transport* illustrates one of the usages of the root folder.

We designated the folder Transport as the RootFolder. We inserted all objects that a large number of other objects use into the *Frame* Internal > Tools. An example is the method *openBB* that opens a context menu for the objects and that provides the command Open. This allows us to access *openBB* from this one central location by entering `rootfolder.Internal.Tools.openBB` under View > User-defined Context Menu > Configure of the *Frames* for which we want to provide a context menu.



You can also use the anonymous identifier *rootFolder* within *Methods* in which you programmed controls. Here *Plant Simulation* looks for the folder for which you set the attribute *RootFolder*, starting with the class of the *Frame* into which you inserted the object in which you programmed the control.

Create Your Own Classes

To create your own **customized classes**, you can either derive one of the built-in classes in the *Class Library* and modify its features, or you can built a class of your own from scratch, for example in a *Frame* in the *Class Library*.

To create a **class** that shares all of its features with the parent class:

- Do not change anything in the class object you want to derive an instance from. Then, right-click that object in its folder in the *Class Library* and select Derive. This adds the derived class to the bottom of that folder, below the icon for the toolbar and adds a number to its name, for example *SingleProc1*. Then, rename the new class.

  Or

- Hold down Ctrl and Shift, and click the object with the left mouse button. While holding the mouse button down, drag the object into another folder in the *Class Library*, and release both keys and the mouse button. Be aware that the class object keeps its previous name, when you proceed like this. Then, you can rename the new class.

To create a **subclass** that shares some, but not all, of its features with the parent class:

- Deactivate inheritance in the class object for the features you want to modify in each of the instances separately. Remember that a button that looks like this denotes that. The features with active inheritance will be passed on unchanged to the instances of the class object.
- Right-click the class in its folder in the *Class Library* that has the features you would like to use and select Derive. This adds the derived class to the bottom of the folder, below the icon for the toolbar and adds a number to its name, for example *SingleProc1*. Then, rename the new class.

  Or
- Hold down Ctrl and Shift, and click the object with the left mouse button. While holding the mouse button down, drag the object into another folder in the *Class Library*, and release both keys and the mouse button. Be aware that here the class object keeps its previous name. Then, you can rename the new class.

To create a **class of its own**, which originally shares the settings of the original class, but does not keep an inheritance relation with it:

- Right-click the class in its folder in the *Class Library* that has the features you would like to use and select Duplicate. This copies the selected object or model and creates a new class from it, severing all inheritance relations. Changes you make to the original class object are not passed on to the copy you create. Or
- Hold down Ctrl, and click the object you wish to duplicate with the left mouse button. While holding the mouse button down, drag the copy to another folder in the *Class Library*, and release Ctrl and the mouse button.

Work with Folders, Frames and Objects in the Class Library

To **move a folder in** the **tree window**:

- Select the folder you want to move in the tree window by clicking it with the left mouse button.
- Drag it to the folder above which you want to place it in the structure and drop it there.

To **move a folder**, a *Frame* or an object **into another folder** in the tree window:

- Click the folder, *Frame* or object you want to move into another folder with the left mouse button to select it.
- Hold down the Shift key, drag the object to the destination folder and drop it there.

  The move pointer looks like this .

To **copy a folder**, a *Frame* or an object into another folder in the tree window:

- Click the folder, *Frame* or object you want to copy into another folder with the left mouse button to select it.
- Hold down the Ctrl key, drag the object to the destination folder and drop it there.

  The copy pointer looks like this .

To **merge folders**, hold down Alt and drag the replacing folder in the *Class Library* onto the folder to be replaced and drop it there. *Plant Simulation* then forms the superset of both folders and merges those classes, which are present in both folders.

To **merge objects**, hold down Alt and drag the replacing object in the *Class Library* onto the object to be replaced and drop it there.

To **arrange the order** in which *Plant Simulation* shows objects **within a folder in the tree window**, for example sort them by function or by name:

- Click the object with the left mouse button to select it.
- Hold the mouse button down, drag the object to the location of your choice in the folder and drop it there.

To add icons of objects to the toolbar in the tree window:

- Click the object with the left mouse button to select it.
- Drag the object to the object <name of the toolbar> located at the bottom of the respective folder and drop it there.

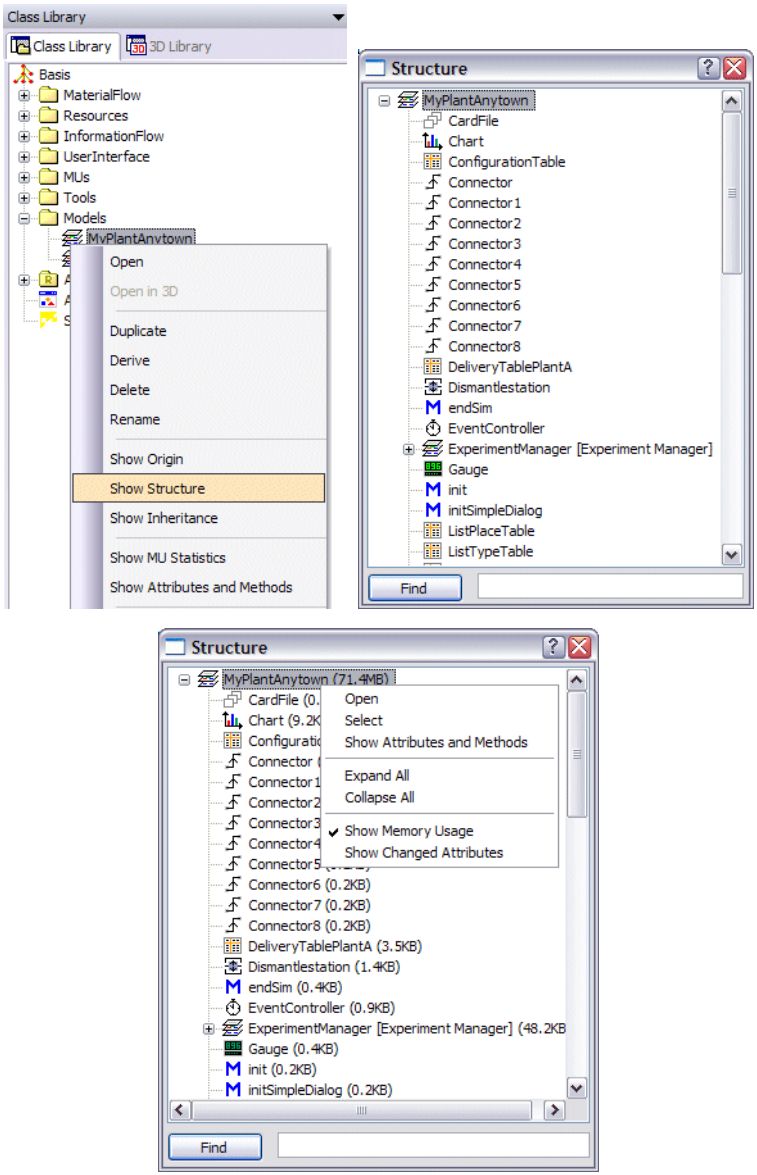
To **rename an object**, do one of the following:

- Double-click it, and enter another name into the text box Name.
- Press F2 and enter another name.
- Select Rename on the context menu and enter another name.
- To rename an open object, press F4 and enter another name into the dialog Rename.

Show the Contents of a Frame in the Class Library

Plant Simulation does not show objects you insert into any *Frame* in the *Models* folder, as it only shows classes of objects in the *Class Library*, not instances of those classes.

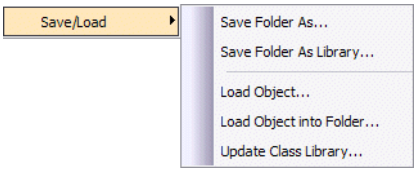
To view the hierarchical structure of objects within a *Frame*, right-click the *Frame* in the *Class Library* and select Show Structure on the context menu.



Saving a Folder or an Object and Loading it into Another Model

You can load an application object, which may be a single object or an entire simulation model you created in a *Frame*, into other simulation models or share it with your co-workers.

As compared to an object file a **library** is a **collection of objects** for which you enter a **version**, which you **maintain over time** and which you share with your colleagues. The version number enables you to either update your simulation models with a newer version of the library or to stay with the present dated version.



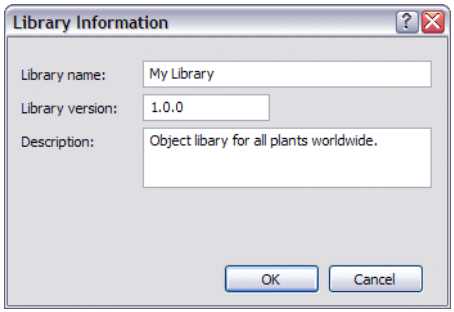
You can:

- *Save a Folder as a Library*
- *Save an Object or a Folder as an Object*
- *Load an Object or a Folder into Your Simulation Model*
- *Load an Object or a Folder into Another Folder*

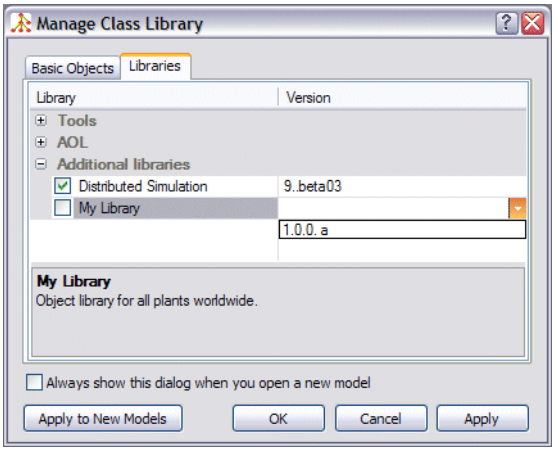
Save a Folder as a Library

To save a folder as a *Plant Simulation* library (.lib), right-click it in the *Class Library* and select Save/Load > Save Folder As Library.

This opens the dialog Library Information.

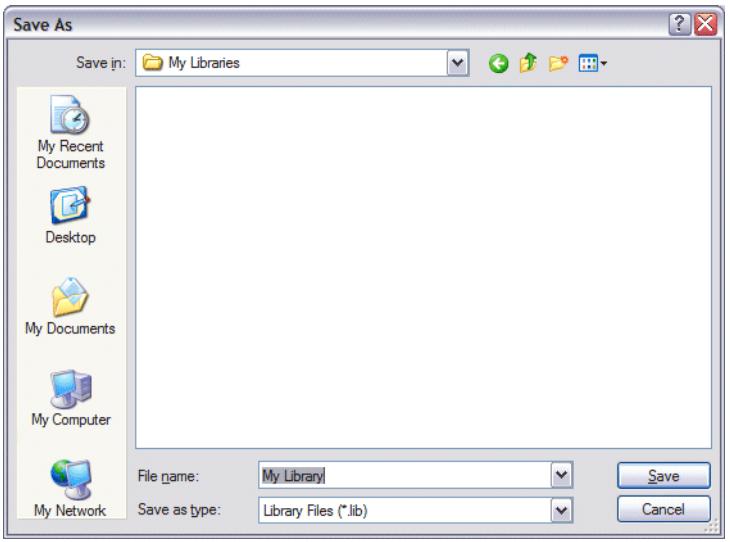


- Type in the name of the library. You can type in any text.
- Type in the version of the library. You can enter any number of number and letters separated by periods.
- Type in a meaningful description of the library. The dialog Manage Class Library then shows this description.



- Click OK.

Type the file name of the library into the dialog Save As and specify a location of your choice.

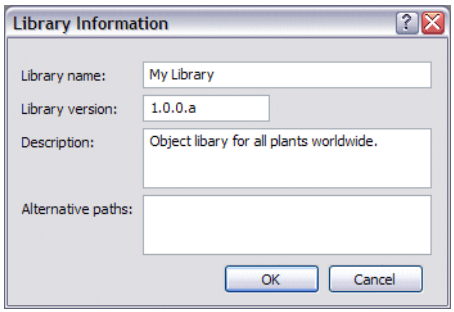


Plant Simulation saves the folder and all objects it contains as a library. The *Class Library* shows a library with a green folder icon ApplicationOb.

You can then load this application object library into other simulation models and share it with your co-workers.

To do so, click on the Standard toolbar in the program window or select File > Manage Class Library.

You can edit the information you typed in when you created the library by clicking the library with the right mouse button in the *Class Library* and by selecting Edit Library Information.



In addition, you can type in one or more alternative paths for your library. As a rule, you will not enter an alternative path.

Plant Simulation identifies a library by its absolute path to the library folder in the *Class Library*. When you type in an alternative path, this absolute path will also be assigned to this library. This may be helpful for two reasons:

1. When you rename the library folder in a new version of your library or when you move the library into another folder, the absolute path of the library changes. *Plant Simulation* will from then on treat the library as another library. If you do not want this, you can type in the previous path to the library as an alternative path. This way you can update a model, for which the library is still located under the previous path, with the new library. For this model, the library remains at its previous location in the *Class Library*.
2. You can use alternative paths to assign several names in different languages to the library folder. We, for example, also assigned the German path `.Tools.EngpassAnalyse` language to the library .Tools.BottleneckAnalyzer. For this reason *Plant Simulation* considers both folders as the same library and can thus update both folders with the same library file.

Note: When you type in the name of a language between $ signs in front of the alternative path, for example `$German$` or `$Japanese$`, *Plant Simulation* will automatically use this path, when you load this library into a model with this language, i.e. when the model did not already contain this library. The alternative path for the *BottleneckAnalyzer* is `$German$.Tools.EngpassAnalyse` for example.

Note: You can type in any number of alternative paths. Separate alternative paths with a line break.

Save an Object or a Folder as an Object

To save an application object as an *Plant Simulation* object file (.obj), right-click it in the *Class Library* and select Save Object As.

Enter a name into the dialog Save As and specify a location of your choice. *Plant Simulation* saves the object, and all objects, which that object uses, together with their folders and paths.

To save a folder, which may contain an entire application object library, as an *Plant Simulation* object file (.obj), right-click it and select Save Folder As.

Enter a name into the dialog Save As and specify a location of your choice. *Plant Simulation* saves the folder and all objects it contains.

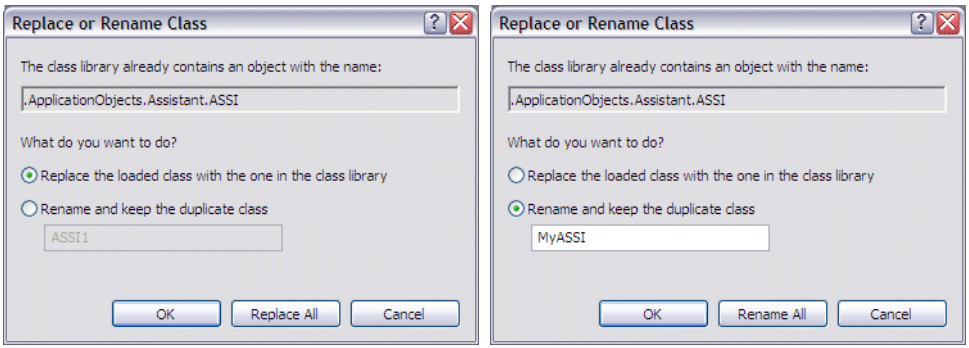
Load an Object or a Folder into Your Simulation Model

To load an object or a *Frame/folder* into your open or into another simulation model, right-click any folder and select Load Object. *Plant Simulation* loads the object with all of its existing paths and the folders, sub-folder and classes the object inherit values from into the *Class Library* at the Basis level.

To preserve the existing objects in your simulation model, and to discard duplicate objects that are contained in the model you load, you will use Load Object, and then select to Replace the loaded class with the one in the class library.

To port a lower version of a simulation model or of an application object library to a higher version with modified and improved classes, you will use Update Class Library.

- Right-click any folder in the Class Library and select Load Object on the context menu.
- Select the object in the dialog Open.
- If an object or a *Frame* with the same name as the object to be loaded already exists in your simulation model, *Plant Simulation* opens the dialog Replace or Rename Class.



- To Replace the loaded class with the one in the class library, select the radio button. Then, *Plant Simulation* does not load the new object, but replaces it with the existing object and merges all inheritance hierarchies into one.
- To replace all duplicate objects, click Replace All.
- To Rename and keep the duplicate class, select this.
- Enter a new name for the duplicate object into the text box.

  Note: When the object to be replaced is a *Frame*, select Tools > Replacement Mode in the *Frame*. Then, select if you want to Merge the contents of the new *Frame* with the existing one or if you want to Exchange the existing *Frame* with the new *Frame*.

  Repeat this until all duplicate objects are renamed or replaced.

  If you are unsure if both classes are identical, we recommend that you enter a new name and compare the classes. You can still replace the objects at a later point in time:

- Hold down the Alt key, click the replacing object and drag it over the object to be replaced while holding the left mouse button down.
- When replacing and merging is possible, a dialog opens where you can confirm that you want to replace the object or not replace it.

Instead of using Load Object, you can also drag an *obj* file from the Windows Explorer to the *Class Library*, and drop it there.

Load an Object or a Folder into Another Folder

To load an object or a *Frame* that you saved as an object file (.obj), into the folder in the *Class Library*, which you select, right-click the folder and select Load Object into Folder. *Plant Simulation* loads the object, with its complete structure of objects, which this object uses and which are used by it, into this new folder.

Note: As a rule, you will create a new folder before you load the object or the folder.

You will use Load Object into Folder, when you do not want to replace any of the existing objects and their hierarchical structure in your simulation model with the object/objects you are going to load.

The tools in the Tools folder in the *Class Library*, such as the *BottleneckAnalyzer*, use this technique and provide their own parameterized BasicObjects that are independent of the object classes in the built-in folders.

Update the Class Library

To update an application object library, you and your coworkers are working on, with the most up-to-date classes you developed or to port a lower version of a simulation model or of an application object library to a higher version with modified and improved classes:

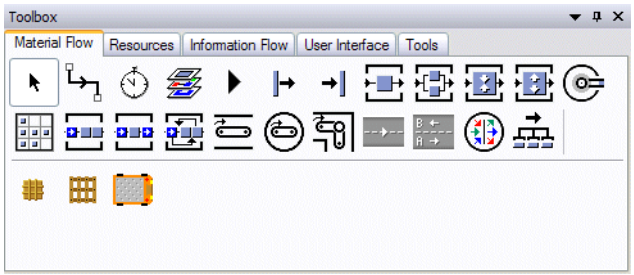
- Save the object as an object file (.obj): Right-click it and select Save Object As.
- Right-click any folder in the *Class Library* and select Save/Load > Update Class Library. This loads the object into the *Class Library* at the Basis level.

When loading the object file, *Plant Simulation* supposes that the classes in the file it is loading are the most recent ones, and replaces any existing classes with the same name in your model file. Note that this replaces the old class with the new class, but attaches any instances of the old class to the new class, and thus preserves the settings you made in these instances. This applies for classes that are located in the hierarchy directly below the newly saved class.

For classes that were saved through an inheritance relation, and that are located outside of this hierarchy below a class, *Plant Simulation* opens a dialog, where you have to select to replace any duplicate classes or to rename them.

Working with Objects in the Toolbox

The *Toolbox* is a container for the different *Plant Simulation* toolbars that hold the objects of the *Class Library*. By default, the *Toolbox* shows the built-in objects on the toolbars Material Flow, Resources, Information Flow, User Interface, and Tools. You find the toolbars for the objects at the very bottom of their folders next to the icon .



When you add an add-in program with the menu command File > Manage Class Library, *Plant Simulation* also adds a tab/toolbar with the object(s) of this add-in.

- To add your own toolbars to the *Toolbox*, right-click the folder you want to add the toolbar to and select New > Toolbar.

  Plant Simulation adds toolbars you define, toolbars with the objects of add-in products (File > Manage Class Library), and toolbars of application object libraries to the right of or below the tabs of the built-in objects in the *Toolbox*.

- To add an object to a toolbar you defined, drag the object from a folder of the tree view in the *Class Library* to the window/toolbar you defined into the *Toolbox* and drop it there.

  Note: After you inserted an object from the *Toolbox* into a *Frame*, *Plant Simulation* automatically switches back to the tool Select in the toolbars of the *Toolbox*.

- To change the name *Plant Simulation* shows on the toolbar, go to the folder that contains the objects in the tree view, select the icon at the very bottom of the folder, press the F2 key and enter a term of your choice into the text box Label. If you do not enter a label, *Plant Simulation* shows Toolbar, i.e., the name of the toolbar in the *Toolbox*.
- To change the size of the icons of the objects in the *Toolbox*, select Tools > Preferences > Modeling > Toolbox buttons in the program window.
- To open the class of the object, right-click it and select Show Class.

You will:

- *Add Objects to the Toolbox or Delete Them from It*
- *Copy Objects from Toolbar to Toolbar*
- *Insert an Object from the Toolbox*

Add Objects to the Toolbox or Delete Them from It

You can add an object to and remove an object from the *Toolbox* and change the order of the icons:

- To add an object to a toolbar, drag it from its folder in the *Class Library* to the toolbar of your choice and drop it there.

Note: When you derive an object from another object in the *Class Library*, modify the icon of the new object, and add it to the toolbar, you might have to resize the window before *Plant Simulation* displays the new icon.

- To remove a button/object from the toolbar, right-click it and select Delete from Toolbar.
- To change the order in which the icons of the objects are displayed on the toolbar, click the button you would like to move and drag it to a different location on the toolbar.

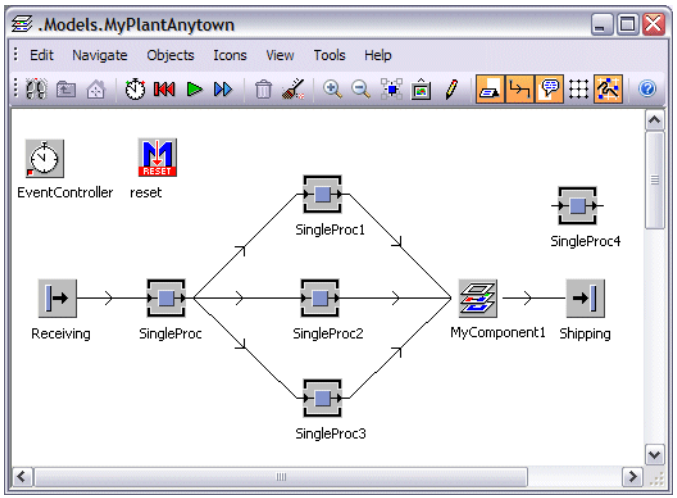
Copy Objects from Toolbar to Toolbar

To adapt simulation models that you created in previous versions of *Plant Simulation*, you can use this technique to copy objects from one toolbar of the *Toolbox* to another. This is especially handy for *Toolboxes* that contain a large number of objects:

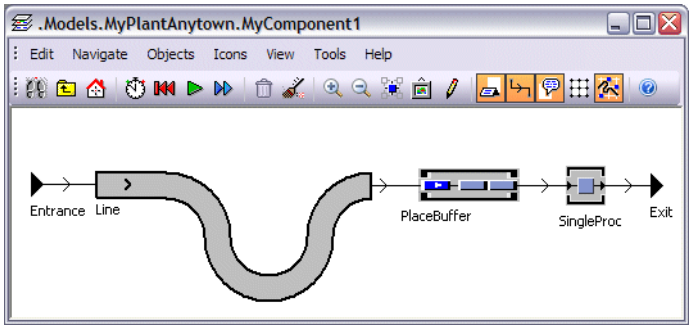
- First, select the toolbar containing the object you would like to add to another tab.
- Right-click the folder whose tab you would like to add the object to in the tree window and select Show Structure. This opens the window Structure. Expand the folder here.
- Hold down the Ctrl key and click the object you would like to copy on its toolbar in the *Toolbox*. This selects the object in the tree window.
- Drag the object from the tree window to the icon of the toolbar in the dialog Structure.

Modeling Hierarchically

Modeling hierarchically is the concept of inserting components, which you modeled in a *Frame*, into other *Frames*. This way you can model, and test, the individual components of your simulation model detached from the *Frame* which holds your complete simulation model.

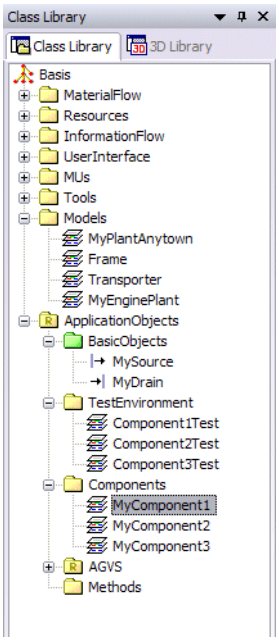


You can combine any number of components in the *Frame* in which you build your overall model. In our example we modeled a component in the *Frame* MyComponent1 and inserted it into *Frame* MyPlantAnytown, which holds our complete simulation model.



- To move up in the hierarchy of *Frames*, closing the active *Frame*, and opening the *Frame* one level up in the structure, click . In our example, clicking Up One Level closes MyComponent1 and selects it in MyPlantAnytown.
- To open the window of the *Frame* from which the current *Frame* was derived, click . In our example, clicking Open Origin opens the *Frame* MyComponent1 in the folder ApplicationObjects > Components in the *Class Library*.

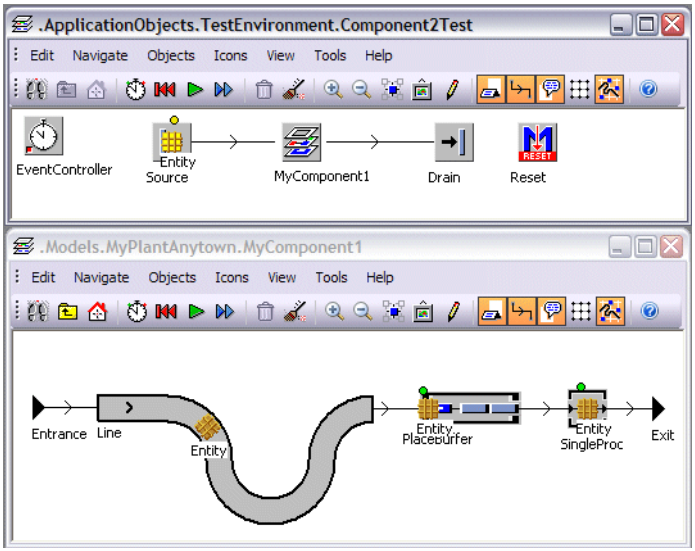
You can thus model the components, such as large machines or entire departments, to match their counterpart in your real-life facility as closely as possible. You can also insert these components several times. You can use these components in exactly the same way as you use any of the other user-defined or built-in objects. You can create icons for them and insert them into your model just as you would any of the material flow objects. In addition it allows you to clearly structure your simulation model.



Another advantage of modeling hierarchically is the fact that you can distribute developing the simulation model among several colleagues, even among several sites. You can then integrate the components into the complete model at any point in time.

Test a Component You Modeled

Modeling hierachically allows you to test the components detached from your complete simulation model, thus ensuring that they work as intended, before integrating them. For this you can create a testing environment with the desired level of detail. Insert the component into the test *Frame*, insert a *Source* and a *Drain*, connect all objects and run the simulation.



Working with the Frame

As a rule you will create your simulation models in the *Frame* that we placed in the folder Models in the *Class Library*. Naturally, you can also insert additional *Frames* into this folder and model there.

To rename this *Frame*, so that it matches the name of the installation you are modeling, do one of the following:

- Right-click it in the *Class Library* and select Rename.
- Select it in the *Class Library* and press F2.
- In the *Frame* window itself, select Tools > Rename or press F4.

To build your simulation model, you will insert any of the built-in objects or any objects you yourself design, and connect these objects, which represent your stations, with the *Connector*.

To run the simulation you will insert an *EventController* that starts, stops and resets the simulation run. You can use each and every simulation model as an application object to create additional simulation models.

By placing *Frames* within *Frames* you can build hierarchically structured models. This way you can build and structure simulation models that exactly match the real world systems you want to simulate. It also enables you to break down complex tasks into manageable chunks and distribute a laborious task to several co-workers.

You will:

- *Select Options in the Frame*
- *Model with Objects from the Class Library*
- *Work with Folders, Frames and Objects in the Class Library*
- *Work with Objects in the Frame Window*

- *Connect Objects with the Connector*
- *Model Transitions between Frames*
- *Add a Graphic and a Color to the Background or the Icon of the Frame*
- *Draw Vector Graphics or Text onto the Background of the Frame*
- *Create Your Own Menu/Context Menu in the Frame*

Select Options in the Frame

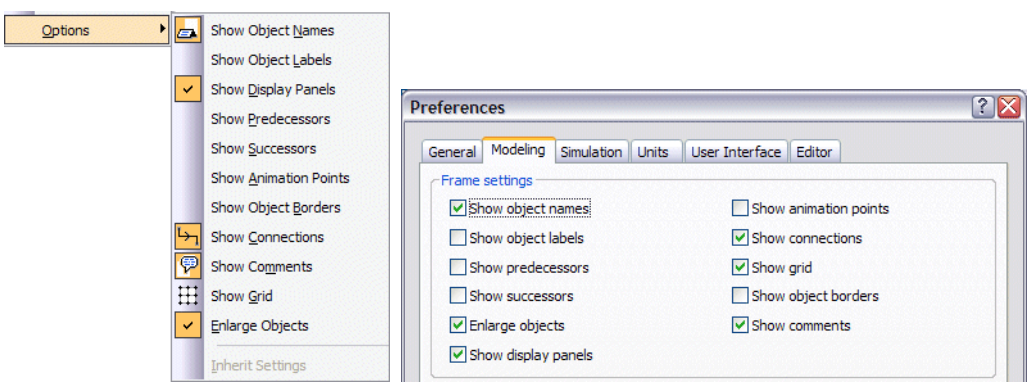
You can select general options for modeling under Tools > Model Settings/Preferences in the program window. You can also select options for each *Frame* individually, which only apply to that *Frame*:

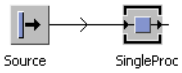
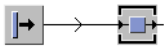
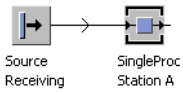
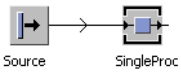
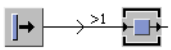
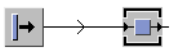
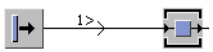
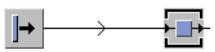
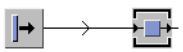
- By clicking the buttons on the toolbar of the *Frame*.

To	Click
Hide or show the names of objects in the *Frame*.	
Hide or show *Connectors* in the *Frame*.	
Hide or show *Comment* objects in the *Frame*.	
Hide or show the grid in the *Frame*.	
Deactivate or activate Modify Structure, allowing you to insert objects into the *Frame* or manipulate them.	

- By selecting View > Options on the menu bar of the *Frame*.

  Initially, any *Frame* you insert into your model uses the settings you selected under Tools > Preferences in the program window. Select any of the commands to activate or deactivate them for the selected *Frame*. To restore the built-in settings, and deactivate any of your changes, select Inherit Settings.



Option	On	Off
Show Object Names		
Show Object Labels		
Show Predecessors		
Show Successors		
Show Comments	My comment	
Show Connections		

Model with Objects from the Class Library

To create a simulation model, you will insert instances of the class objects from the *Class Library* folders into your model. This, as a rule, will be the *Frame* that is located in the folder Models in the *Class Library*.

You can modify and expand the structure of the *Class Library* to meet the requirements of your simulation project. You might, for example, add additional folders to save your simulation models, the test runs and the different components of your model to.

Note: You can rename any object in the *Class Library*. Be aware though that your simulation model may not run correctly any more when you rename an object that you entered as entrance or exit control into another object or MUs *Plant Simulation* entered in a *Source* object under Attributes > MU Selection > MU. In these cases the path statements will be wrong after renaming objects.

You can:

- *Insert an Object from the Class Library*
- *Insert an Object from the Toolbox*

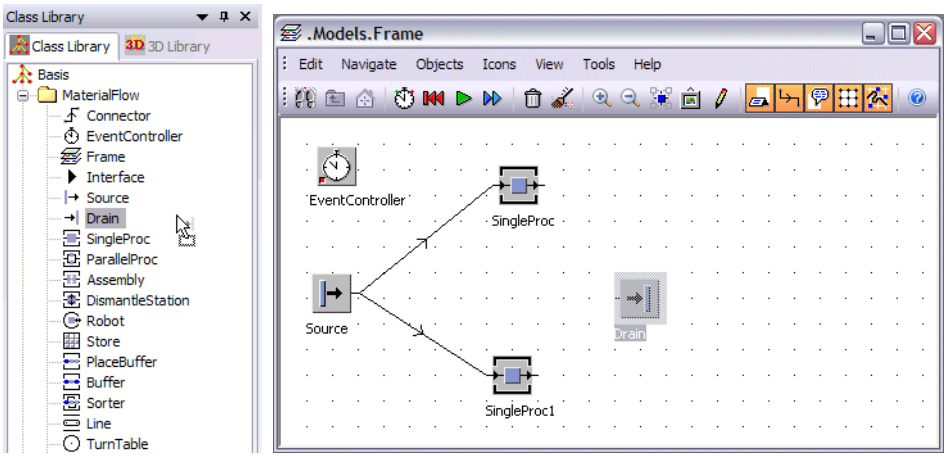
Insert an Object from the Class Library

In the structure, navigate to the folder and then to the object you would like to insert. Note that the objects are grouped according to their functions and to the frequency you use them.

To insert an instance of the class object into the *Frame*:

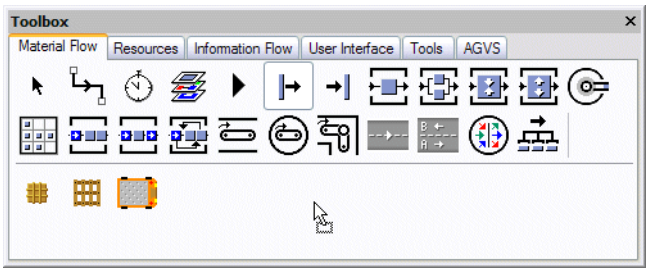
- Click the object of your choice with the left mouse button to select it. The insert cursor looks like this .

- While holding the mouse button down, drag the object to the target position in the *Frame* window and drop it.



Insert an Object from the Toolbox

You can insert objects from the *Toolbox* that contains the objects grouped on tabs/toolbars. You might, for example, insert one of the built-in material flow objects from the toolbar Material Flow.



- Click the toolbar, i.e., the tab, which contains the object you would like to insert.
- Move the mouse to the icon of the object.
- Click the object with the left mouse button to select it. The insert cursor looks like this .
- Drag the mouse to the target position in the *Frame* window and click the mouse button once.
- To insert several instances of the same object class, hold down the Shift or the Ctrl key while you click the mouse button in the *Frame* window. This way you do not have to return to the *Toolbox* each time after inserting an object.
- To go to the class of an object, press the Ctrl key and click the object in the *Toolbox*. Note that *Plant Simulation* highlights the class object in the tree window in the *Class Library*. Double-click that object in the tree window to edit class properties or hold down the Ctrl+Alt keys and click the object in the *Toolbox*. Note that this does not work, when the object is already selected.

Add a Graphic and a Color to the Background or the Icon of the Frame

To add a graphic to the background of a *Frame*, do one of the following:

- Drag a .gif, .bmp, .ppm, .ppm raw, .dxf or .dwg file from the Windows Explorer, the Internet Browser, the icon library etc. over the background of the *Frame* and drop it there.

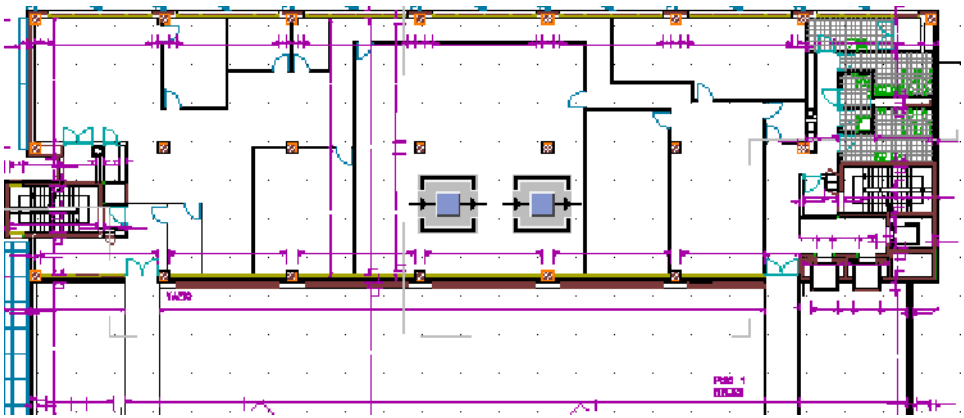
  This new graphic will then replace the icon named *background* of the *Frame*. If you have not assigned a background icon, *Plant Simulation* automatically creates a *background* icon. Note that *Plant Simulation* does not automatically scale the size of the background icon to the size of the *Frame*!

- Drag a layout drawing you created in Autodesk over the background of the *Frame* and drop it there.

  You can use this layout drawing as the actual background of the *Frame* and insert the *Plant Simulation* objects on top of it. This is feasible when your simulation model is not too complex.

  Note: If you are modeling a complex installation, this might not be practicable, as it might lead to a very cluttered layout. Then, you might want the layout drawing to be one of the icons of the *Frame*, and have the MUs move through the installation on the animation lines you define in the class of that *Frame*.

  Be aware that these dxf or dwg files are vector based, whereas *Plant Simulation* uses pixel based graphics. This means that you have to think about how to transfer one size to the other.



To make the background graphic transparent, so that the background color of the *Frame* shines through:

- Open the *Icon Editor* (View > Edit Frame Icons).
- Click Next Icon to navigate to the icon called *background*.
- Click the eyedropper and click in the background of the icon. This makes that color the active drawing color, which we want to replace.
- Select Edit > Replace Color.
- Select the transparency color in the *Color Palette* that replaces the active drawing color.

  If the transparency color is not part of the color palette, double-click any field in the *Color Palette* that contains a color you do not need, and enter `0`, `128`, `128` into the dialog Color. Then, click Add to Custom Colors, and OK.

  - Select Icon > Transparent.
  - Click Apply Changes to make the dxf file transparent.
- Open the *Icon Editor* (View > Edit Frame Icons), select File > Open and then select the type of file and the actual file you would like to open.
- Draw an icon for the *Frame* and name it *background*. *Plant Simulation* uses this graphic as the new background graphic.

To define a color of your choice for the background of the *Frame*:

- Select View > Background > Select Color. If you do not like the white frame around the icons of objects you inserted into the *Frame*, select the icon with the number 0 in the *Icon Editor* and select Icon > Transparent.

Draw Vector Graphics or Text onto the Background of the Frame

To draw vector graphics on the **background** or in the **foreground** of the *Frame*, you can use the features of the Vector Graphics Toolbar. As opposed to the pixel-based graphics *Plant Simulation* uses by default, you can scale vector graphics or text without loss of quality.

- Click on the Standard toolbar to activate vector graphics mode and to show the *Vector Graphics* toolbar in the *Frame*. The shape of the cursor changes to .

  Note: As long as vector graphics mode is active, you cannot manipulate any objects in the *Frame*. To deactivate it, and to return to normal mode, click the button, so that it looks like this .

- Select the shape you would like to draw:

To	Click
Draw a line.	
Draw the outline of an ellipse.	
Draw a filled ellipse.	
Draw the outline of a rectangle.	
Draw a filled rectangle.	
Enter text that appears in the *Frame*.	

  To force a line break when entering text, enter `\n` and continue typing.

- Drag the mouse into the *Frame* window, click the left mouse button once and drag the mouse until the shape has the form you need.
- To change the properties of the shape/text you drew, double-click it and edit its settings in the dialog Graphic Settings.
- To change the form of the shape or to move it, select it, click one of the handles and drag the mouse.

The move mouse pointer looks like this .

The change shape mouse pointer looks like this .

- To move a vector graphics object one pixel at a time, press the respective arrow key.

  To move a vector graphics object one grid unit at a time, hold down Shift press the respective arrow key.
- To enlarge a vector graphics object by one pixel, hold down Ctrl and press the respective arrow key.
- To enlarge a vector graphics object by one grid unit, hold down Ctrl and Shift and press the respective arrow key.
- To place an object onto a different layer, click and enter the number of the layer into the text box Layer.

  The layers serve two purposes: They allow you to define the drawing order of the element you placed onto a layer.
  - When you enter a negative number, `-1` for example, *Plant Simulation* draws the shape you created onto the **foreground** of the *Frame*.
  - When you enter a positive number *Plant Simulation* draws the shape onto the **background** of the *Frame*.

  They allow you to delete all objects on a certain layer: Click and enter the number of the layer you would like to delete into the text box Layer.
- To delete all objects on all layers, click .
- To group any number of objects, hold down Shift and click each object with the left mouse button, or drag a marquee over them, and click .
- To ungroup a group, select it, and click .
- To delete the selected shape, press Del or click .
- To delete all objects on a certain layer, click .

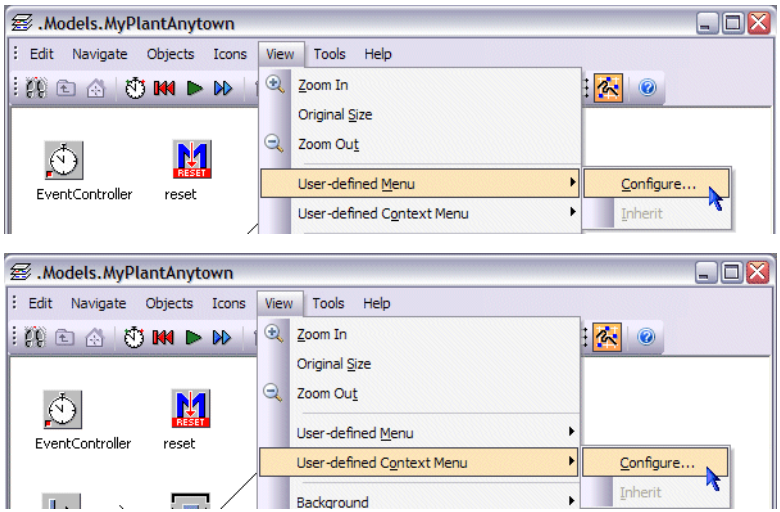
  Enter the number of the layer you would like to delete into the text box Layer.

To draw vector objects, you can also use the methods *drawEllipse*, *drawLine*, *drawRectangle* and *drawText*. To delete the vector objects you can use the methods *eraseLayer* and *eraseAllLayers*.

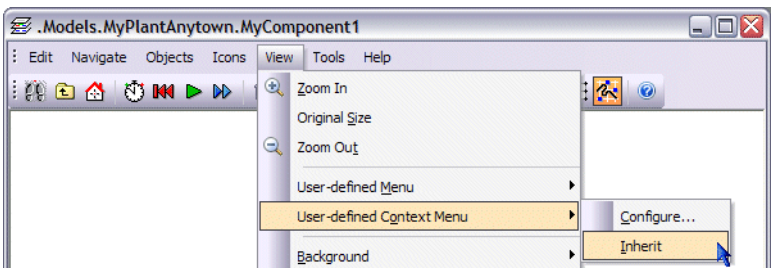
Create Your Own Menu/Context Menu in the Frame

To create a user-defined menu or a user-defined context menu with your own, frequently used, menu commands:

- Select View > User-defined Menu > Configure or select View > User-defined Context Menu > Configure.



Note: To create a user-defined menu in a *Frame*, which you inserted into another *Frame*, deactivate the menu command Inherit, so that it does not show a check mark to the left.

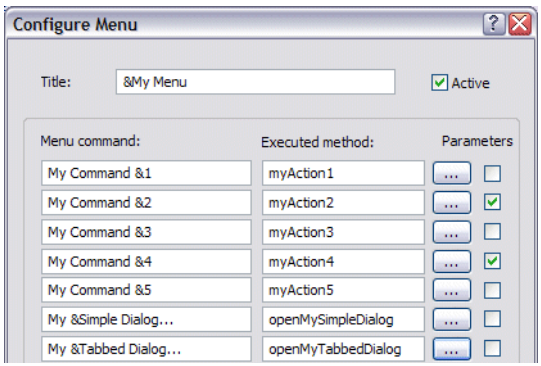
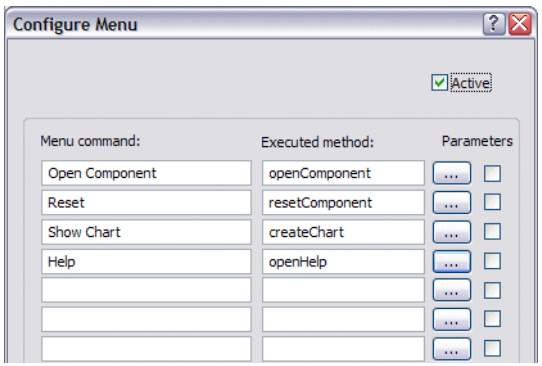


- Enter the Title of the *User-defined Menu* with which *Plant Simulation* shows the menu next to the built-in menu bar of the *Frame*.
- To show the *User-defined Menu* below the built-in menu bar of the *Frame*, for which you defined it, select Active.
- Enter the name of the menu command that *Plant Simulation* shows on the *User-defined Menu* in the *Frame*. Enter an & (ampersand) in front of a letter to make this letter the access key. You can select this menu command by holding down the Alt key and by pressing that letter. The built-in *Plant Simulation* access keys take precedence over any access keys you define!
- Enter the *Methods*, which the menu commands execute into the text boxes below that executes this method.

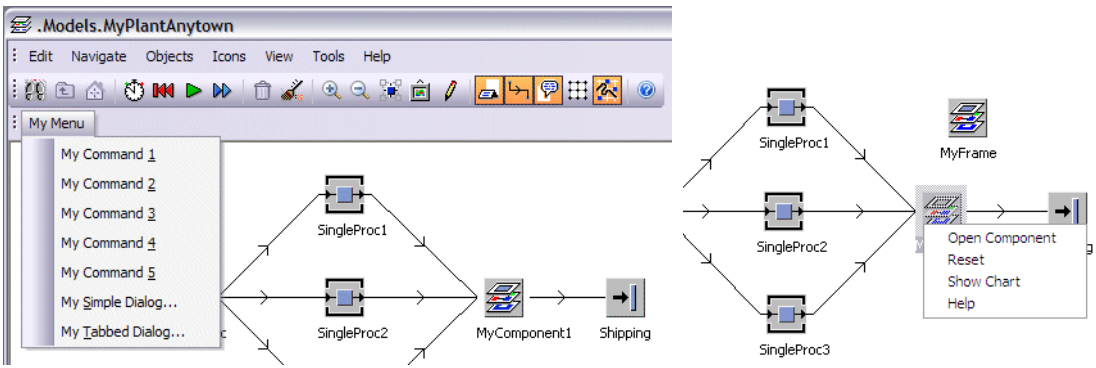
- Select with arguments, if the method passes arguments, clear it if it passes no arguments. As soon as the user clicks the corresponding menu command in the *Frame*, *Plant Simulation* passes the selected objects as arguments to the *Method* to be called.

  This only works, when the *Method* defines an argument of type *list[object]*. The sequence of the objects in the list is not defined.

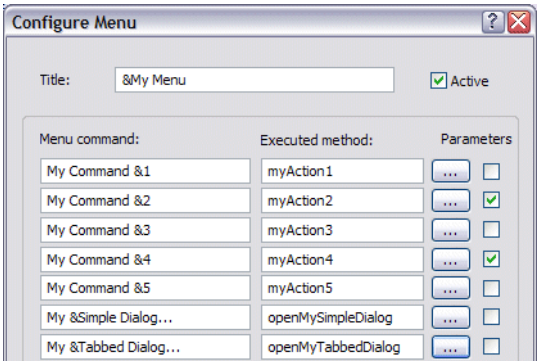
  Note: The commands on the user-defined context menu only apply to the selected object(s) within the *Frame* for which you defined the context menu.

User-defined menu of a Frame	User-defined context menu of a Frame
	

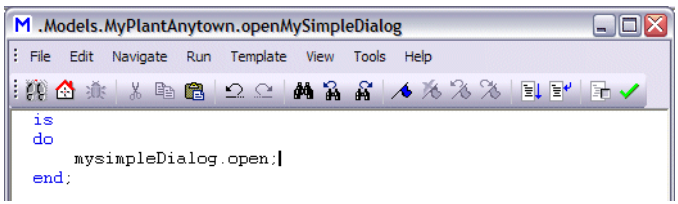
- To create the user-defined menu or the user-defined context menu, click OK.



- To open a user-defined dialog from the user-defined menu:
  - Enter the name of the menu command, which opens the user-defined dialog, into the text box below menu command.
  - Click ... to enter the path to and the name of the *Method* M, which tells *Plant Simulation* to open the dialog, into the text box below executed method.

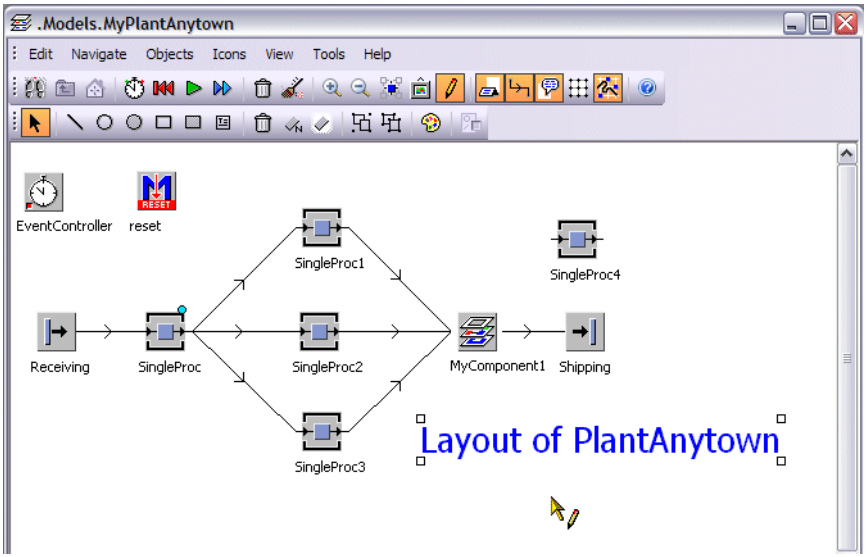


- Create a method with the name you entered above and enter `<name_of_your_user_defined_dialog>.open`.



Work with Objects in the Frame Window

Use these techniques to manipulate the objects, *Plant Simulation* objects as well as vector graphics you drew and inserted into the *Frame*.



- To open the object or the *Frame* window, double-click the object or a *Frame* in the model *Frame*, *PlantAnytown* in our sample model.
- To insert an object in the *Frame*, select the object in the *Class Library* or the *Toolbox*, drag it over the *Frame* window and drop it there.
- To show or hide the grid in the *Frame* window, click . Showing the grid makes it easier to insert an object at exactly the position you need it to be at.
- To select an object, click it with the left mouse button. You can then move it in the *Frame* by dragging the mouse.
- To nudge the selected object one pixel at a time in a direction, press the arrow keys on the keyboard. To move the selected object one grid unit at a time, press Shift+an arrow key.
- To deselect a selected object, click another object or click anywhere in the *Frame*.
- To select more than one object in a *Frame* at a time, hold down Shift, and click the objects you wish to mark or drag a marquee over the objects: Hold the left mouse button down, and drag the mouse over the objects, making sure the marquee encloses all of them, and then release the mouse button. You can also combine both methods.

  To select all objects in the *Frame* window, you can use the method *selectContents*.
- To connect objects, use the *Connector*. The *Connector* displays handles after you select it. Click a handle to change its shape, i.e., to make the *Connector* longer or shorter or to move the anchor point up or down.
- To show or hide connections between objects you established with the *Connector*, click .
- To show objects that are not connected to another object, click .
- To zoom the contents of the *Frame* in, click .

- To zoom the selected icons in the *Frame* to the greatest possible zoom factor, drag a marquee over the icons with the right mouse button and release the mouse button. To return to the original size of the icon, select View > Original Size.
- To zoom the contents of the *Frame* out, click .
- To show or hide the names of the objects you inserted into the *Frame*, click .
- To prevent another user from modifying the structure of the model, click .
- To edit the icons of the *Frame*, and to add animation structures to it, click .
- To model transitions between *Frames* use the *Interface*. When you connect *Frames*, which have several *Interfaces*, with objects, *Plant Simulation* opens the dialog Select Interface. Select the *Interface* the *Connector* attaches to and click OK.
- To change the size of the icon of an object you inserted in a *Frame*, hold down Ctrl and Shift. Then, click anywhere on the border of the icon and drag the mouse until the size of the icon meets your needs. To return to the original size of the icon, select Icon > Original Size.

  Note: This does not work for a rotated icon.
- To open the *Frame* you double-click and to close the *Frame* it is contained in, press the Shift key and double-click a *Frame* located within a *Frame*.
- To move down in the hierarchy of *Frames*, closing the active *Frame*, and opening the next *Frame* one level down in the structure, select Down one Level on the context menu.
- To move up in the hierarchy of *Frames*, closing the active *Frame*, and opening the next *Frame* one level up in the structure, click in the toolbar.
- To open the window of the *Frame* from which the current *Frame* was derived, click Open Origin .
- To close the active *Frame* and open its location, click Open Location in a *Frame*.
- To assign the different states a *Frame* can be in, you can use the attributes *StateBlocked*, *StateEntryShut*, *StateResourceMissing*, *StateSetup* and *StateWorking*. The *Frame* then shows the state it is in in the LED area along the top of the icon.

A	means that the object is
red dot	failed.
blue dot	paused.
green dot	working.
yellow dot	blocked.
brown dot	setting-up.
gray dot	waiting for a resource (*Exporter*).

A	means that the object is
light blue dot	recovering.

- To manipulate any of the vector graphics, which you inserted into the *Frame*, click on the Standard toolbar, double-click the shape and edit the Graphic Settings.
- To open help for the selected object, press F1.

Note: The menus Objects and Icons are active only after you select an object in the *Frame* window.

Connect Objects with the Connector

The objects you insert into your simulation model represent stations in a production process. Each material flow object in your model has entrance points which receive parts, and exit points from where the parts move on to the succeeding objects in the sequence of stations.

In real installations the relation between the different stations is obvious by the way in which the machines are arranged on the shop floor. *Plant Simulation*, on the other hand, handles this somewhat differently.

To clarify to which other object parts are to be moved when exiting an object, you have to establish connections between these objects.

- To connect the stations that represent the flow of materials:

  Click the *Connector* in the *Toolbox* to activate connect mode. The mouse pointer turns into crosshairs (+). When you connect objects in the *Frame*, *Plant Simulation* attaches the connecting line to the front end of the cursor , allowing you to actually see the connection before setting it.

  To connect object *A* and object *B*, first click object *A* and then object *B*.

  Note: *Plant Simulation* only shows the connection, when you select View > Options > Show Connections.

- **To connect several objects one after the other** without having to return to the *Toolbox* each time you established a connection, **hold down** Ctrl, while you establish the connection.
- To automatically connect the objects while you insert them, place the objects right next to each other, when you insert them.

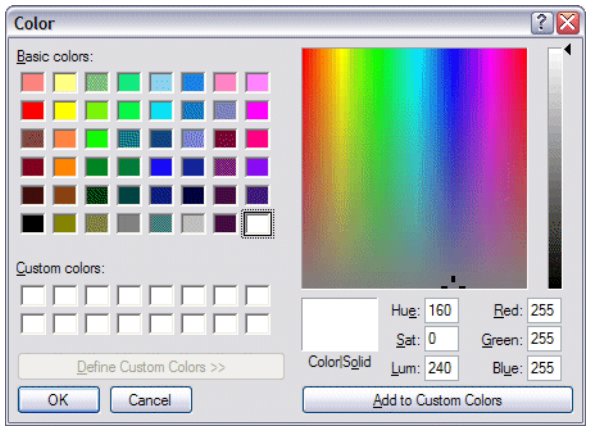
  Note: This only works, when Tools > Preferences > Modeling > Connect automatically is active. In addition the position of the exit of the one and the entrance of the other object are to be no more than 3 pixels apart.

- To tell *Plant Simulation* where and how to place the *Connector* in the *Frame*, hold down Shift, Ctrl, or Alt while you establish the connection:
  - *Connector*, no key: *Plant Simulation* aligns the connection to the grid, i.e., to the grid points next to the location where you click the mouse button.
  - *Connector*+Ctrl: *Plant Simulation* stays in connect mode, so you can connect several objects one after the other without having to return to the *Toolbox* each time you established a connection.
  - *Connector*+Shift: *Plant Simulation* inserts the connection at a right angle, regardless of where you click.

  - *Connector*+Alt: *Plant Simulation* sets anchor points of the connection at the location where you click. Note that this is similar to the freehand drawing feature.
- To create a **non-straight connection**, set one or more anchor points: First, click object *A*, proceed to point 1 and click once, then proceed to point 2, click once, and finally move to object *B* and click the mouse button once to establish the connection.
- To create a **right-angled connection**, hold down Shift and click the left mouse button to set the anchor point.
- To move an anchor point, click on it, hold the mouse button down, and drag the handle to the desired location. *Plant Simulation* also moves the *Connector*.
- To check if all connections between the objects really have been established, select View > Unconnected Objects. *Plant Simulation* selects all objects with unconnected entrance and exit points.
- To make the connecting line thicker, enter higher number into the text box Weight.

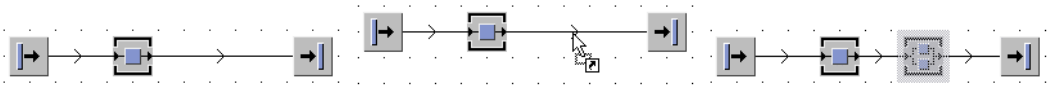
  To make the connecting line thinner, enter lower number into the text box Weight.
- To select another color than the default black, in the dialog Color, click the field next to Color.

  To define a color, move the mouse in the color matrix over the area that is similar to the color you want. Set the attributes of the color with the scrollbar on the right hand side. Click Add to Custom Colors. This adds the color to one of the fields under Custom colors. Click OK.

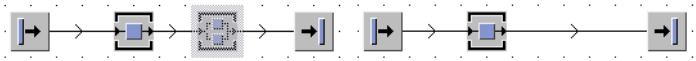


- To **exchange the successor** of a *Connector*, select the end point of the *Connector* and drag it to another object.

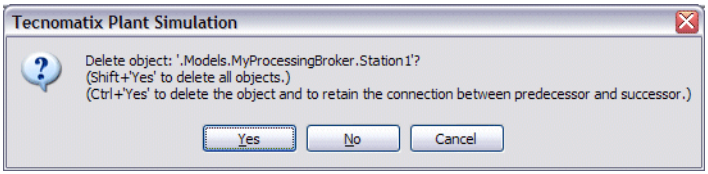
  To **exchange the predecessor** of a *Connector*, select the starting point of the *Connector* and drag it to another object
- To **place an object**, which you insert from the *Class Library* into a *Frame*, **in between two already connected objects**, drag that object onto that spot of the *Connector* and drop it there. In this process *Plant Simulation* exchanges the successor of the original *Connector*.



- To **automatically connect predecessor and successor when deleting an object** located between other connected objects, hold down the Ctrl key while you delete the object with the context menu command Delete.

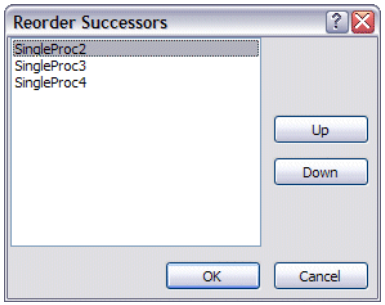


When you work with the Del key, select the object you want to delete, and press Del. When the dialog opens, hold down Ctrl and click Yes.



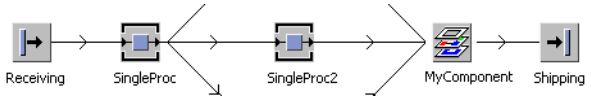
Note: This does not work when an object has more than one predecessor and successor. If the object has a successor, *Plant Simulation* exchanges the successor of all preceding *Connectors*. If the object has a predecessor, *Plant Simulation* exchanges the predecessor of all succeeding *Connectors*.

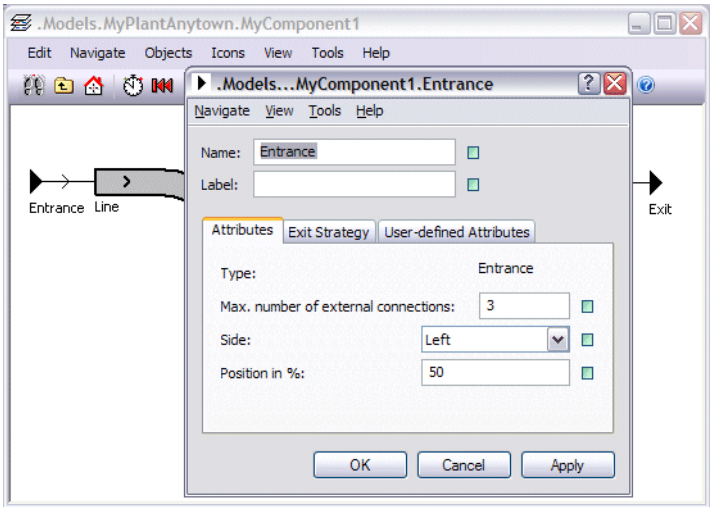
- To **reorder the sequence of the succeeding objects**, i.e. the sequence of the *Connectors*, click the object with the right mouse button and select Reorder Successors.



Model Transitions between Frames

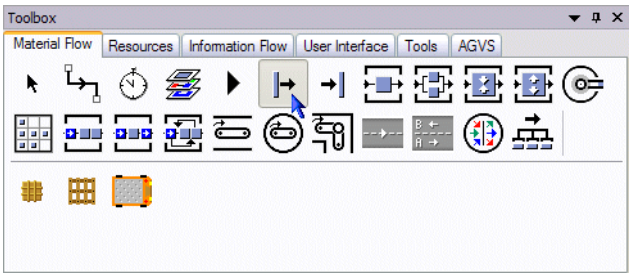
One of the main advantages of *Plant Simulation* is that you can model hierarchically, i.e., you can model components of your overall installation in a *Frame*, make sure that these components work by themselves and then insert them into your overall simulation model.





In this case, you will have to connect the component (*Frame*) to the material flow objects or *Frames* that precede and succeed it in the sequence of stations with the object *Interface* . The transitions are the places where MUs move from one *Frame* to another or from a material flow object to a *Frame* and vice versa. *Plant Simulation* shows if the *Interface* you inserted into a *Frame* is connected to another object with a *Connector* or not connected .

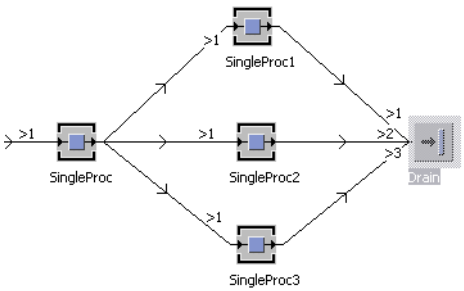
You can insert the *Interface* into your simulation model from the folder MaterialFlow in the *Class Library* or from the tab Material Flow in the *Toolbox*.



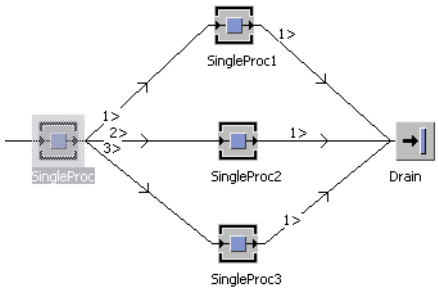
To model transitions, click the folder or the toolbar Material Flow and insert as many objects of type *Interface* anywhere in the *Frame*.

- Select the side of the icon of the *Frame* at which the *Interface* is to be located: on the Top, on the Right hand side, on the Bottom, or on the Left hand side of the *Frame*.
- Enter the maximum number of external connections the *Interface* may have. Depending on the type, any number of *Interfaces* may have more than one predecessor or successor.

  The **predecessor** is the object that is connected to the selected object with a *Connector* and that is located in front of it in the sequence of stations in the simulation model.



The **successor** is the object that is connected to the selected object with a *Connector* and that is located after it in the sequence of stations in the simulation model.

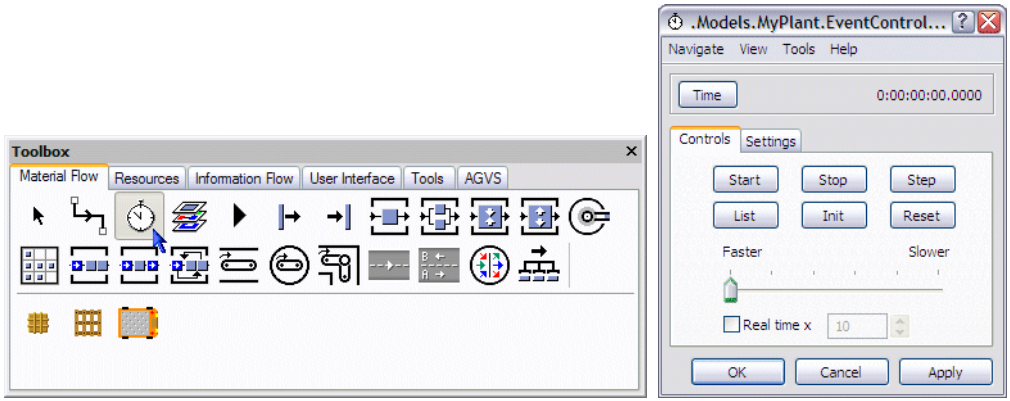


- Enter the position of the *Interface* on the side of the *Frame* it is inserted into in percent into the text box Position in %. Enter a value between 0 and 100 percent. *Plant Simulation* uses the value you enter, when you activate Tools > Preferences > Modeling > Connect automatically. Connecting objects automatically only works when the exit of *FrameA* and the entrance of *FrameB* are not more three pixels apart.
- An *Interface* object you insert into a *Frame* and connect with a *Connector* shows its Type in the dialog: either *Entrance* or *Exit*.

Controlling the Simulation with the EventController

The *EventController* coordinates and synchronizes the different events taking place during a simulation run. When an MU enters a processing station, for example a *SingleProc*, *Plant Simulation* computes the time it takes to process it and enters that event and that time into the List of Scheduled Events of the *EventController*.

You can insert the *EventController* into your simulation model from the folder MaterialFlow in the *Class Library*, from the tab Material Flow in the *Toolbox*. You can also click or on the toolbar of the *Frame*.



- *Plant Simulation* shows the current simulation time of the simulation run in the box next to Time. Click Time to change the display of the time between the:
  - **Relative time**: *Plant Simulation* resets the relative time to zero, when it starts the simulation run. This is the default.
  - **Current time plus simulation time**: *Plant Simulation* adds the simulation time to the time and date at which it started the simulation run.

  Let us assume today is March 13, 12 o'clock noon and the simulation is to run for two days:
  - For the setting **relative time** *Plant Simulation shows* 2:00:00:0000, i.e., two days.
  - For the setting **current time plus simulation time** *Plant Simulation shows* 15.03.2003 12:00:00.00, i.e., March 15, 12 o'clock noon, after the simulation run is finished.
- To initialize your simulation model, click Init. *Plant Simulation* executes all *Methods* named *Init*. *Methods* being executed when you click Init will be processed first.

  Plant Simulation initializes the simulation model before it executes the next scheduled event.

  Note: *Plant Simulation* automatically executes *init Methods* when you start the simulation for the first time or when you stopped the simulation and clicked Reset and you did not click Init before you started the simulation.
- To reset your simulation model, do one of the following:
  - Click Reset.
  - Click ⏮ in the *Frame*.

  Plant Simulation calls all *Methods* named *Reset* in your simulation model. It deletes all unprocessed events, resets the simulation time to 0, resets the statistics, and clears any pause and any failure of paused or failed machines.

  When you click Reset while the simulation is running, *Plant Simulation* will first finish processing the active event and then reset the simulation model.
- To start the simulation, do one of the following:
  - Click Start.

- Click in the *Frame*.
- Double-click the icon of the *EventController* while holding the Shift key down.

If this is the first simulation run or you clicked Reset before, *Plant Simulation* executes all *Methods* named *Init* located in your simulation model.

Note: To start the simulation without animating objects and MUs, click in the *Frame*.

- To stop the simulation after the active simulation event has been processed, do one of the following:
  - Click Stop.
  - Click in the *Frame*.
  - Double-click the icon of the *EventController* while holding the Shift key down.
- To process one simulation event at a time and to proceed through your model step by step, click Step.
- To open the *Dialog of the Event Debugger*, click List.

  The List of Scheduled Events shows all currently scheduled events in ascending order, allowing you to detect, which events are scheduled at what point in time.
  - The column Breakpoint shows an S, for a breakpoint you inserted, by double-clicking a cell in the row.
  - The column Type shows the type of event, for example Out, Pause, PauseEnd, etc.
  - The column Time shows the point in time the event is going to be executed.
  - The column Receiver shows the receiving object, i.e., the object that receives the breakpoint.
  - The column Sender shows the sending object, i.e., the object that sends the breakpoint.
- To increase the speed of the simulation, drag the slider to the left or press the left arrow key. To decrease the speed of the simulation, drag it to the right or press the right arrow key.

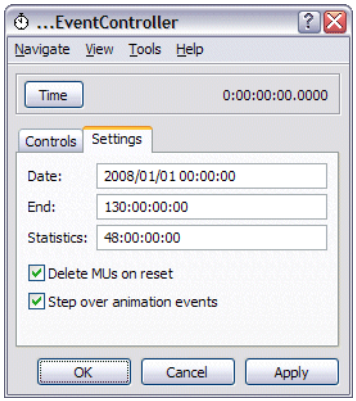
  Decreasing the speed enables you to better follow the movements of MUs, as *Plant Simulation* shows their icons for a longer time on the same station.

You will:

- *Select Settings for the Simulation*
- *Working with the Event Debugger*

Select Settings for the Simulation

When your modeling needs require it, you can select settings for controlling the simulation run on the tab Settings of the *EventController*.

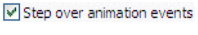


- *Plant Simulation* shows the current simulation time of the simulation run in the box next to Time.

  Click Time to change the display of the time between the:

  - **Relative time**: *Plant Simulation* resets the relative time to zero, when it starts the simulation run. This is the default.
  - **Current time plus simulation time**: *Plant Simulation* adds the simulation time to the time and date at which it started the simulation run.

  Let us assume today is March 13, 12 o'clock noon and the simulation is to run for two days:

  - For the setting **relative time** *Plant Simulation shows* 2:00:00:0000, i.e., two days.
  - For the setting **current time plus simulation time** *Plant Simulation shows* 15.03.2003 12:00:00.00, i.e., March 15, 12 o'clock noon, after the simulation run is finished.
- Enter the Date and the time the absolute time during the simulation is based on.
- Enter the time when the simulation run will be finished. Enter a relative time, i.e., the period of time the simulation runs. *Plant Simulation* compares this period with the simulation time and stops the simulation run when both are identical. Let us assume it is March 13, 12 o'clock noon and the simulation is to run for two days. Enter `2:00:00:00` into the text box End. If you do not want to write this out in full, you can also just type `2:::` and click Apply to have *Plant Simulation* translate this to the full format `2:00:00:00.0000`.
- Enter the time the *EventController* resets the statistics. *Plant Simulation* starts collecting statistical data for all material flow objects anew from this time on.
- To subtract the simulation time from the active **absolute** time during the simulation run, select Backwards. The **absolute** time, which the *EventController* shows then appears to be running backwards. The simulation itself still uses positive times.
- To delete all MUs from all *Frames*, when you reset the simulation model by clicking the Reset button or by calling the method *reset*, select Delete MUs on reset.
- To step over animation events and to stop at the next event relevant to the simulation, select Step over animation events  and click Step on the tab Controls.

- To pause the simulation until the time span between two events has elapsed in real time, select Real time.

  Note: Normally *Plant Simulation* does not take the time span in between events into account, as it is a discrete event simulation system.

  Enter the scaling factor for real time mode. The scaling factor sets the time that elapses between two events in real time.

  The duration of an event in real time is the simulation time divided by the scaling factor you entered. The resulting duration is an integer.

Working with the Event Debugger

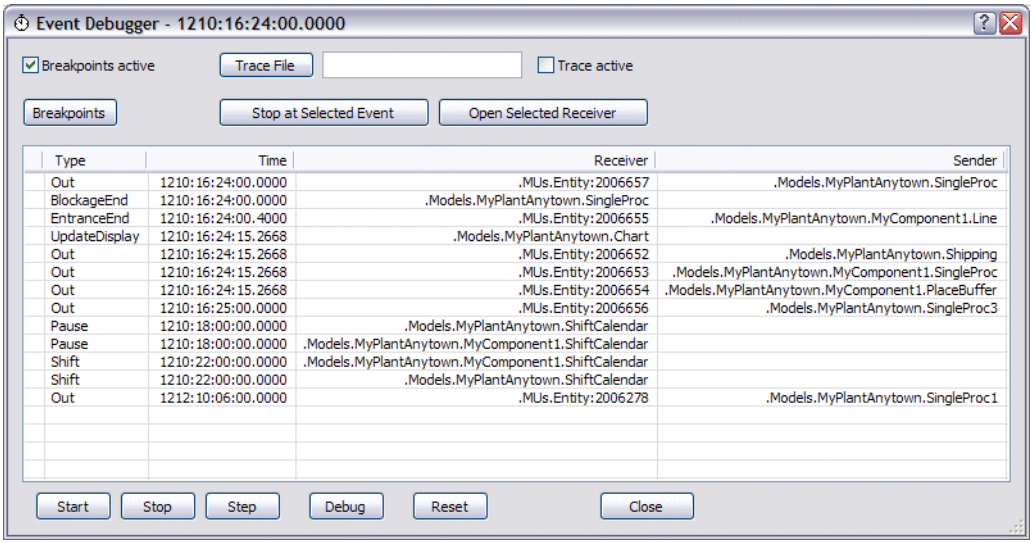
The EventDebugger is a tool that lets you accurately control the execution of simulation events, when you click Continue or Step. As opposed to clicking Stop on the tab Controls, you can, for example, enter a condition when the *Event Debugger* is to Stop the simulation. Then, you can follow the execution of the events in the *Event Debugger*.

The following examples demonstrate a number of typical usages for the *Event Debugger*.

To open the *Event Debugger*, to define breakpoints and to step through the scheduled events:

- Open the *EventController*.
- Click the List button on the tab Controls. The event list contains the types of scheduled events, which the objects in your simulation model entered and which the *EventController* has to process. It is sorted ascending by time, tells the type of event, the scheduled processing time, and lists receiver and sender.

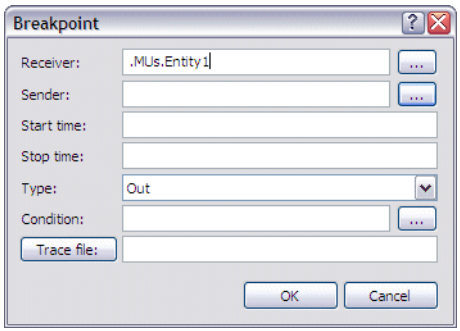
  Double-click a cell in the row where you would like to insert a single breakpoint. Then, the *Event Debugger* stops the simulation run immediately before the *EventController* processes that event. Double-click the row again to delete the breakpoint.
- Select the check box Breakpoints active.
- Click Breakpoints to open the list of the breakpoints you defined.
- Click Insert in the dialog Breakpoint to add an additional breakpoint.



- You can also use an event from the list in the *EventController* to define breakpoints. Select the event in the list and click Stop at Selected Event. This adds this event to the list of defined event breakpoints. You can also edit the selected event.
- To process a single event and stop the simulation again, click Step.
- To proceed with the simulation until the *EventController* reaches the next breakpoint, click Start.

Example 1

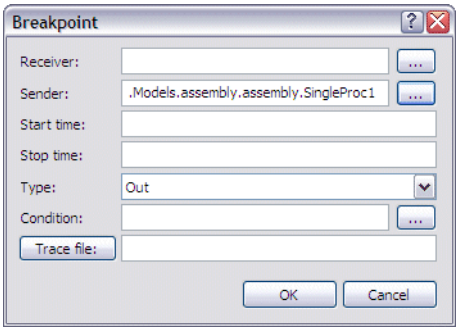
In this example we watch all exit events for the *Entity* with the ID 1, meaning that we track the course the *Entity* takes through the installation.



If you would like to create a breakpoint for each *Entity*, delete the ID of the MU.

Example 2

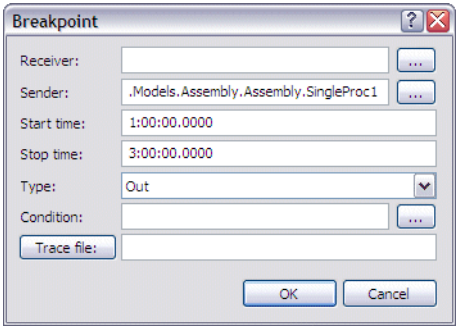
In this example all MUs exiting *SingleProc1* define a breakpoint.



This time we do not enter a Receiver, as we want the *EventController* to insert a breakpoint for each exiting MU. The Sender is *SingleProc1*.

Example 3

In this example only MUs of a certain class located on *SingleProc1* insert a breakpoint during a certain time span.

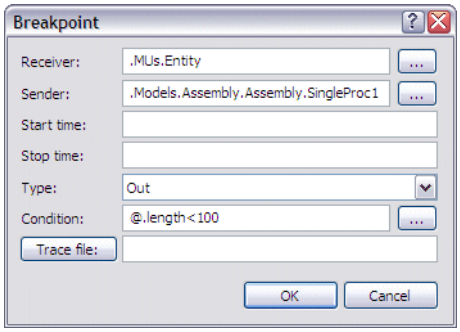


Plant Simulation inserts a breakpoint when an MU of the class `.MUs.Entity` located on *SingleProc1* creates an Out event between 1 hour and 3 hours.

At times you only want to insert breakpoints when certain conditions are met. Enter these conditions into the text box next to Condition. A condition may be a certain value or certain states of the simulation model or properties, i.e attributes, of mobile parts. You can also enter methods, returning a boolean value as a result, which will then be evaluated.

Example 4

In this example we use a property of the MU as a condition for a breakpoint.



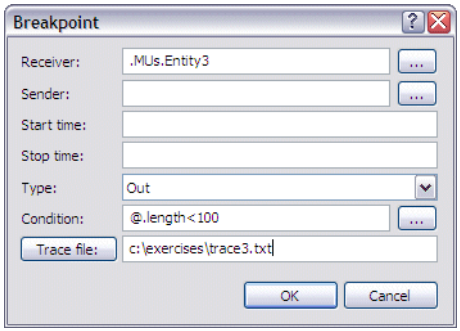
Plant Simulation inserts a breakpoint, when an MU of the class `.MUs.Entity`, which is less than 100 meters long, causes an Out event on *SingleProc1*. Note that the unit depends on the settings you selected under Tools > Model Settings/Preferences > Units > Length.

If you would like *Plant Simulation* to create a trace file that tracks all events, enter a name into the text box Trace File in the dialog Event Debugger and select the check box Trace active.

If you would to only create a trace file for a certain event, enter a file name into the text box Trace File in the dialog Breakpoint.

Example 5

In this example we track the course the *Entity* with the ID 9 takes through a simulation model and write the stations to a trace file.



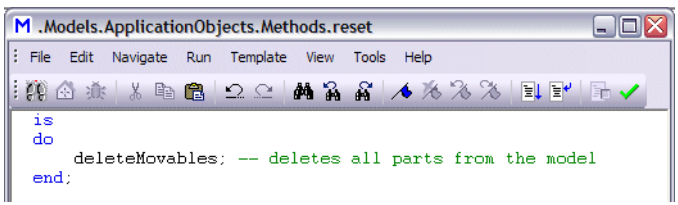
With the settings shown in the dialog above, *Plant Simulation* inserts a breakpoint for each Out event of the *Entity* with the ID 3 and writes this event to the file `c:\Exercises\trace3.txt`. Note that this only works when you selected the check box Trace active in the dialog Event Debugger. When you clear the check box Breakpoints active, *Plant Simulation* writes the trace file without stopping your simulation using a breakpoint.

In the examples above we only used Out events. You can, of course, also use any of the available types of events, compare the List of Scheduled Events.

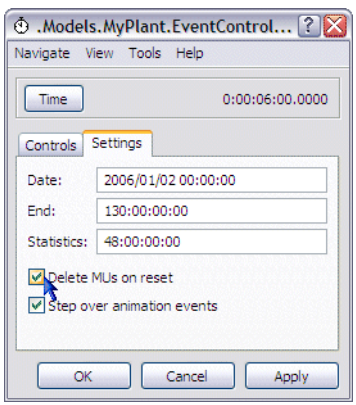
Delete Mobile Objects with the Mouse or When Resetting the Model

To delete one, several or all MUs, do one of the following:

- Select a single MU you would like to delete and press Del.
- To delete all MUs in all *Frames*, click on the toolbar of the *Frame* into which you inserted the *EventController*.
- To delete all MUs in the active *Frame*, click on the toolbar of that *Frame*.
- To delete all mobile objects, when you reset the simulation model by clicking the Reset button or by calling the method *reset*, you can enter `deleteMovables` into a method, which you name `Reset` and which you insert into your simulation model.



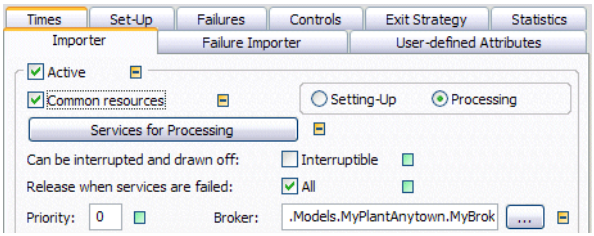
- To delete all mobile objects when you reset your simulation model, select the check box Delete MUs on reset in the *EventController*.



Work with Drag-and-Drop

Drag-and-drop has a number of applications in *Plant Simulation*. You can use it to:

- Insert an object from the *Class Library* into the *Frame* that contains your simulation model.
- Insert an object, such as a *Broker*, a *ShiftCalendar*, a *control method*, a *table*, etc. into the text boxes the dialogs of the objects provide. When you use drag-and-drop, *Plant Simulation* enters the **absolute path** to the object.



Note: If you would like to use an **object reference** instead of the absolute path, type an asterisk in front of the path. For the example above you would type `*.Models.MyPlantAnytown.Broker`.

Note: If you do not want to use the absolute path, but the **relative path**, click ... and select the object you would like to use in the dialog Select Object.

- Duplicate i.e., to copy the selected object or model and create a new class: Hold down the Ctrl key, drag the object to another location in the *Class Library*, and release Ctrl.

Modeling the Flow of Materials, Basics

Below we introduce you to the basics of modeling the flow of materials in your simulation model. You will learn:

- How to create or introduce parts into your model with the object *Source*.
- How to select and enter for how long a station processes the parts that move onto it.
- How to set a station up to process another type of part.
- How to transfer the parts from processing station to processing station.
- How to model failures and failure times of the processing stations.
- How to remove the processed parts from your model with the object *Drain*.

Active and Passive Objects

Mobile and stationary material flow objects are the basic elements you use when you create a simulation model.

- The **mobile material flow objects** *Entity*, *Container* and *Transporter* represent the physical or logical parts moving through the model, i.e., your installation. These mobile objects (MUs) require active and passive material flow objects to process and transport them.
- The *Source* creates mobile objects at the beginning of the flow of materials through your installation. The *Drain* removes the MUs from the installation after the material flow objects have processed them.
- The **active material flow objects** *Source*, *Drain*, *SingleProc*, *ParallelProc*, *Assembly*, *DismantleStation*, *Line*, *Sorter*, *PlaceBuffer*, and *Buffer* receive MUs, and process them for a certain time. They then attempt to **actively transfer the MUs** to the next object along material flow connections, symbolized by the *Connector*, **employing the push-block principle**. They represent work stations in a factory, such as a lathe or a drilling station, etc. They only differ in the number of MUs they can process at one time, a single one or several, and in the way they process them, in series or in parallel. Basically, the *Line* resembles a conveyor system transporting MUs at a given speed over a given distance.
- The **passive material flow objects** *Store* and *Track* do not automatically transfer MUs. An MU remains in the *Store* until it is removed, for example by employing a *Method*. You will only use the *Track* in a meaningful way in conjunction with the *Transporter*, which moves along the *Track* with the speed you set. Model diverging strategies and converging strategies with the *FlowControl*.

We also distinguish between active and passive MUs:

- **Active MUs** are objects that can move by themselves, such as the *Transporter* and the *Worker*.
- **Passive MUs**, such as the *Entity* and the *Container*, are objects that are transported from material flow object to material flow object, which process them.

In addition, we differentiate between:

- **Location-/point-oriented material flow objects** on which the *MUs* are located on a fixed processing station. For the *Source*, the *Drain*, the *SingleProc*, the *ParallelProc*, the *Assembly station*, the *DismantleStation*, the *Sorter*, the *Pla-*

ceBuffer and the *Buffer* their own real length and their dimension as well as the length and the dimension of the *MUs*, which transfer onto them, are irrelevant.

- **Length-oriented material flow objects** whose own real length and dimension as well as the length and the dimension of the *MUs*, which transfer onto them, are used during the simulation. Length-oriented objects are the *Line*, the *Track* and the *FootPath*, the *Container* and the *Transporter*.

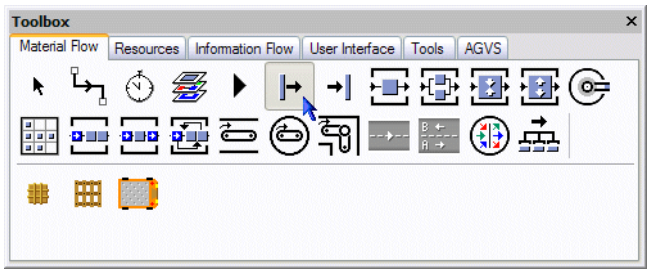
  As opposed to the regular length-oriented objects, the *AngularConverter* consists of two straight segments, not of a sequence of straight and curved segments. The *Turntable* consists of a single straight segment.

Producing Parts with the Source

To create the MUs, which the material flow objects in your simulation model handle, we use the object *Source*. It might, for example, represent the *receiving* department of your installation that introduces parts produced at another location into the plant. Or it can be a machine, which produces the parts that the other stations process.

To remove these parts from the factory to model, for example, the *shipping* department, we use the object *Drain*.

You can insert the *Source* into your simulation model from the folder MaterialFlow in the *Class Library* or from the tab Material Flow in the *Toolbox*.



Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Select How the Source Proceeds, When it Cannot Produce MUs

Select how the *Source* proceeds when it cannot create the MUs at the times (Time of creation) you entered because it cannot move the parts to its successor. This is the case when it fails, when it is paused or when it is blocked.

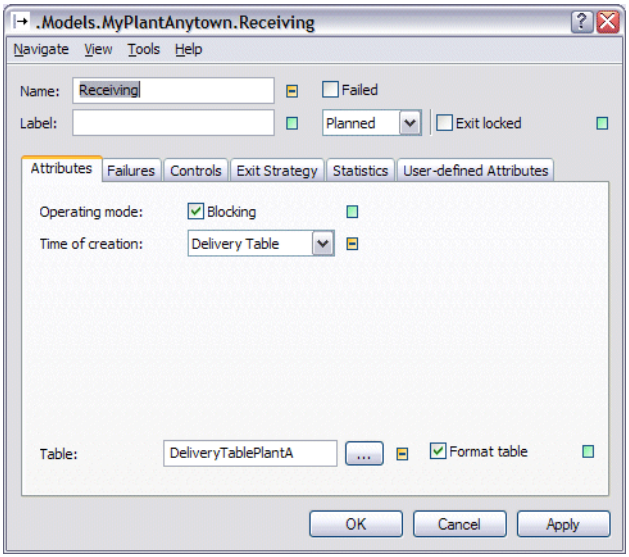
- Select Operating mode Blocking Blocking, so that the *Source* remembers the time when it was supposed to produce the next MU but could not. It then produces the following MU at the next possible point in time, i.e., when the MU, which blocked it, has moved on.
- Clear Blocking, so that the *Source* creates another MU exclusively at the time of creation you entered.

  Note: When the *Source* is temporarily not operational because it is failed, paused or blocked, the times of creation may shift, when you select Blocking. Then, the settings for the times of creation cannot be realized.

Produce Parts According to a Delivery Table

For the installation you are modeling you will, most likely, use a delivery table that contains the parts that a machine produces, parts provided by other departments within the same plant or parts delivered from other plants.

Most of the time the delivery table you receive from another department will be an Microsoft Excel file containing, among others, the name of the part, its amount, its arrival time, etc. You will then open this Excel (*.xls) file in an *Plant Simulation* table and save it there.



To automatically format the table, so that it has the correct format, select the check box Format table. Next to information about the name and number of the produced entities, the *Delivery Table* may also contain values of their attributes. The *Delivery Table* has five columns.

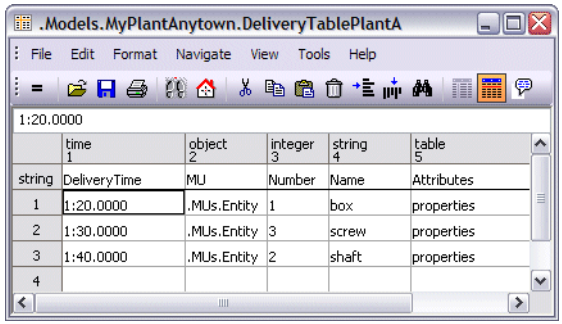
Note: Instead of the data type *time* for the Delivery Time you can also use the data types *date*, *datetime*, or *real*. When you use *date* or *datetime*, the start time of the simulation has to be before the time you enter.

Each row of the *Delivery Table* defines a single order for producing MUs:

- Enter the time at which the *Source* produces the MUs into the column Delivery Time.
- Enter the class of the MU into the column MU. You can also use drag-and-drop of the MU class to accomplish this.
- Enter the number of MUs to be produced into the column Number.
- Enter a name for the MUs to be produced into the column Name.

  Note: You have to enter the Delivery Time and the MU. When you do not enter a Number, *Plant Simulation* produces a single MU. When you do not enter a Name, the MUs, which the *Source* produces, use the name of their class.

- In addition you can, but you do not have to enter the name of a subtable into the column Attributes. Enter the attributes whose value the *Source* sets and the user-defined attributes that it creates, when it produces the MUs, into that subtable.



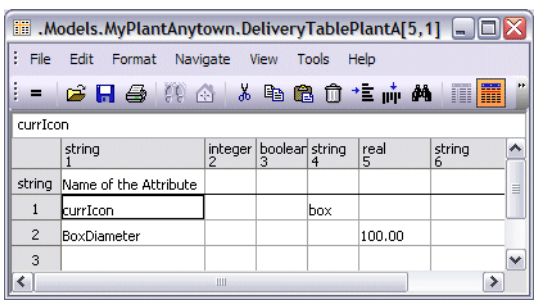
	time 1	object 2	integer 3	string 4	table 5
string	DeliveryTime	MU	Number	Name	Attributes
1	1:20.0000	.MUs.Entity	1	box	properties
2	1:30.0000	.MUs.Entity	3	screw	properties
3	1:40.0000	.MUs.Entity	2	shaft	properties
4					

To open the subtable, do one of the following:

- Click into the cell and press F2.
- Right-click into the cell and select Open Object.

Enter the name of a built-in attribute into the cells below column 1 of the attribute table. Enter the value you want to assign to this attribute into one of the cells to the right with the respective data type.

Enter the name of a user-defined attribute into the cells below column 1 of the table. When an attribute with that name does not exist yet, *Plant Simulation* creates it. Enter the value you want to assign to this attribute into the cell to the right, which has the corresponding data type.



	string 1	integer 2	boolean 3	string 4	real 5	string 6
string	Name of the Attribute					
1	currIcon			box		
2	BoxDiameter				100.00	
3						

Note: *Plant Simulation* assigns the data type of the column containing the attribute's value to the data type of the attribute itself. *Plant Simulation* assigns the value you enter into the cell to the generated attribute.

To produce MUs according to the time, the type, and the number of parts you entered into a *Delivery Table*:

- Select Time of creation > Delivery Table.
- Click ... and select the delivery table you would like to use in the dialog Select Object. Or

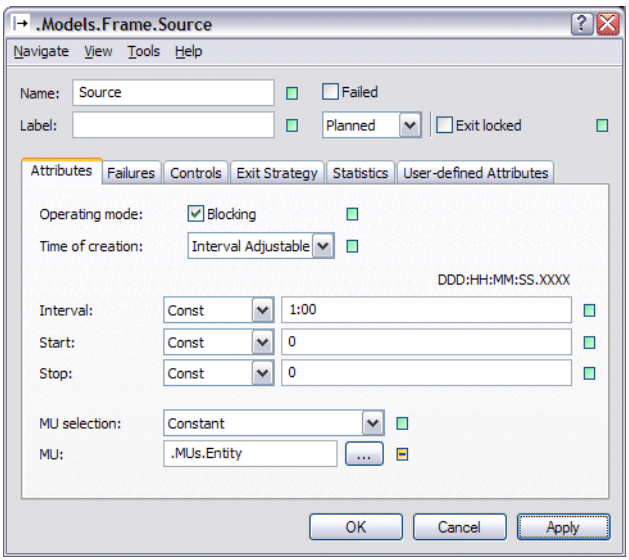
  Drag your delivery table over the text box Table and drop it there.

- Click OK.

Produce Parts During an Interval You Define

To produce MUs during the interval you define:

- Select Time of creation > Interval Adjustable.
- In our example, we chose to have the *Source* create one Constant type of MU, namely an Entity, every two minutes.
- Click OK.



The *Source*:

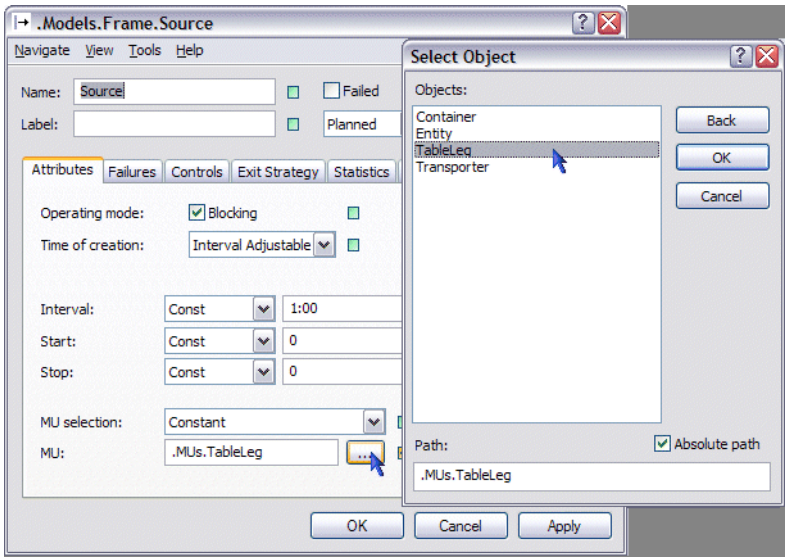
- Produces the first MU at the time you enter for Start.
- Produces the next MU after the time you enter for Interval has elapsed.
- Stops producing MUs at the point in time you enter for Stop. Enter 0 into the text box Stop if you do not want to apply a time limit.

When you select Time of creation > Interval Adjustable or Time of creation > Number Adjustable you can also select how the *Source* produces which types of MUs.

Produce One Type of MU Only

To make the *Source* produce one type of MU only:

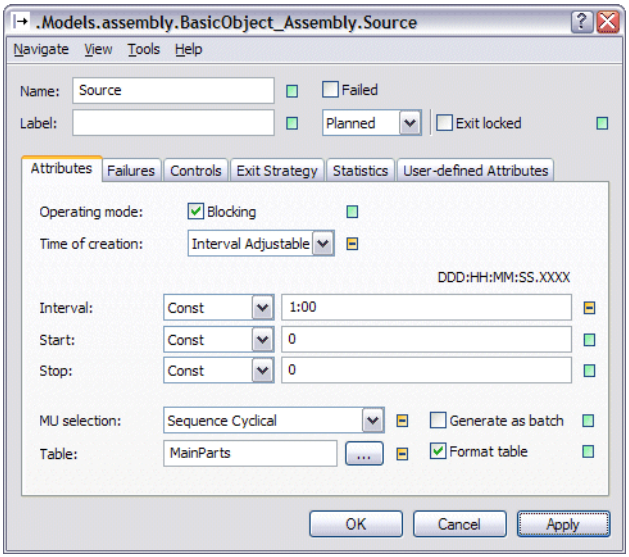
- Select MU selection > Constant.
- Click ... . In the dialog Select Object navigate to the folder where the MUs are located. Select the name of an MU class and click OK.

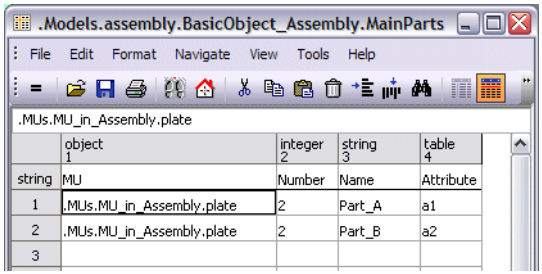


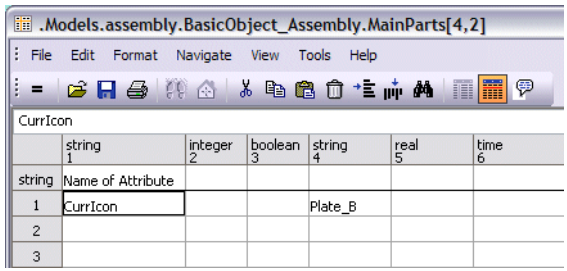
Produce MUs in A Fixed Sequence Over and Over Again

To make the *Source* produce MUs in a fixed sequence over and over again:

- Select MU selection > Sequence cyclical.
- Insert a table into a *Frame* or into a folder in the *Class Library*.
- To designate the MU class to be produced, do one of the following:
  - Click ... . In the dialog Select Object navigate to the folder where the table file is located into which you want to enter the MUs. Select the name of the Table and click OK.
  - Drag the table over the text box Table and drop it there.
  - Enter the name of and the path to the table into the text box next to Table.







- To make *Plant Simulation* assign the correct format to the table, select Format table.
- Enter the names of the MU classes to be produced into the cells below MU of the table.
- Enter the number of MUs to be produced into the cells below Number.
- You can, but you do not have to enter a Name and Attributes into columns 3 and 4 of the table.

  Note: When you do not enter a Name, the MUs that the *Source* produces use the name of their class.

- To make the *Source* produce the number of MUs you specified in a row of the sequence table all at once in a single batch, select Generate as batch. Once the *Source* has processed the entire sequence, it starts processing the information in the table again starting at the beginning of the sequence.

  To make the *Source* produce the MUs as a sequence of individual MUs, clear the check box. When the *Source* produces the MUs as a batch, it attempts to produce the entire set of entities at the given start time and to move them on to the next object.

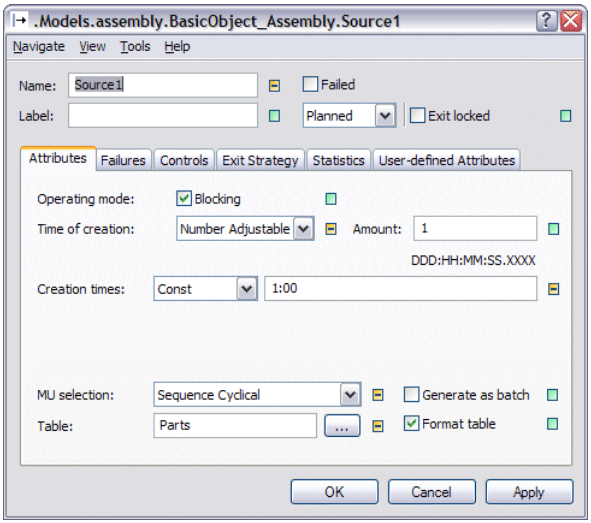
Produce MUs in A Fixed Sequence One Time Only

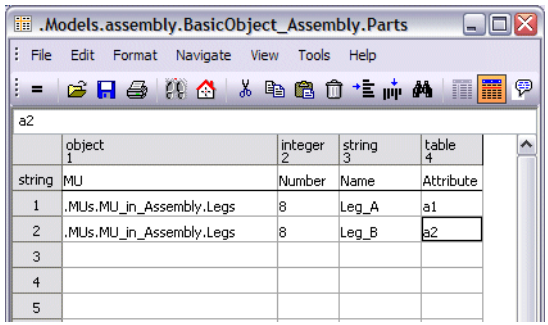
To make the *Source* produce MUs in a fixed sequence one time only:

- Select MU selection > Sequence.

  Note: The setting Sequence is not available, when you set Time of Generation to Number Adjustable.

- Insert a table into a *Frame* or into a folder in the *Class Library*.
- To designate the type of MU to be produced, do one of the following:
  - Click ... . In the dialog Select Object navigate to the folder where the table file is located into which you enter the MUs. Select the name of the Table and click OK.
  - Drag the table over the text box Table and drop it there.
  - Enter the name of and the path to the table into the text box next to Table.





- To make *Plant Simulation* assign the correct format to the table, select Format table.
- Enter the names of the MU classes to be produced into the cells below MU into the table.
- Enter the number of MUs to be produced into the cells below Number.
- You can, but you do not have to enter a Name and Attributes into columns 3 and 4 of the table.

  Note: When you do not enter a Name, the MUs that the *Source* produces use the name of their class.

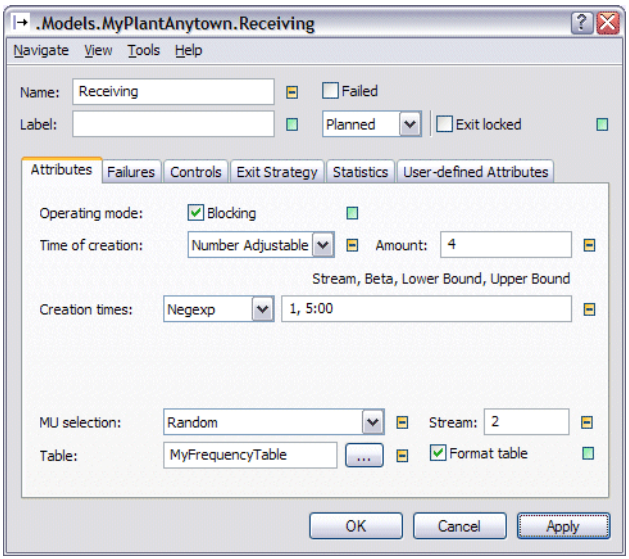
- To make the *Source* produce the number of MUs you specified in a row of the sequence table all at once in a single batch, select Generate as batch.

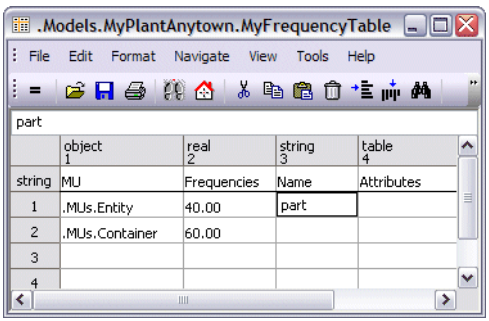
  To make the *Source* produce the MUs as a sequence of individual MUs, clear the check box. When the *Source* produces the MUs as a batch, it attempts to produce the entire set of entities at the given start time and to move them on to the next object.

Produce MUs with a Frequency You Enter into a Table

To make the *Source* produce MUs with a frequency, which you enter into a table:

- Select MU selection > Random.
- Insert a table into a *Frame* or into a folder in the *Class Library*.
- To designate the type of MU to be produced, do one of the following:
  - Click ... . In the dialog Select Object navigate to the folder where the table file is located into which you enter the MUs. Select the name of the Table and click OK.
  - Drag the table over the text box Table and drop it there.
  - Enter the name of and the path to the table into the text box next to Table.





- To make *Plant Simulation* assign the correct format to the table, select Format table.
- Enter the names of the MU classes to be produced into the cells below MU into the table.
- Enter the frequency number for each class of MU to be produced into the cells below Frequency.

  When the *Source* produces the MUs, *Plant Simulation* selects and processes a random generation order according to the frequency you entered here.
- You can, but you do not have to enter a Name and Attributes into columns 3 and 4 of the table.

  Note: When you do not enter a Name, the MUs that the *Source* produces use the name of their class.
- Enter the stream of the random number distribution into the text box Stream. When you use a distribution that requires a Stream as the Interval, enter another stream than the one used for the distribution.

Produce The Number of Parts You Need

To produce a certain number of MUs during the interval you define:

- Select Time of creation > Number Adjustable.
- Enter the Amount, i.e., the number of MUs to be created.

  Note: When you enter a very large Amount of MUs, the list of MUs to be created, including the time of generation, is very long also, which might result in a large consumption of memory. The *Source* creates the amount of MUs at the different times, which the random number generator generated at the beginning of the simulation.

- Select the Creation times, which determine the points in time at which the *Source* creates the MUs.

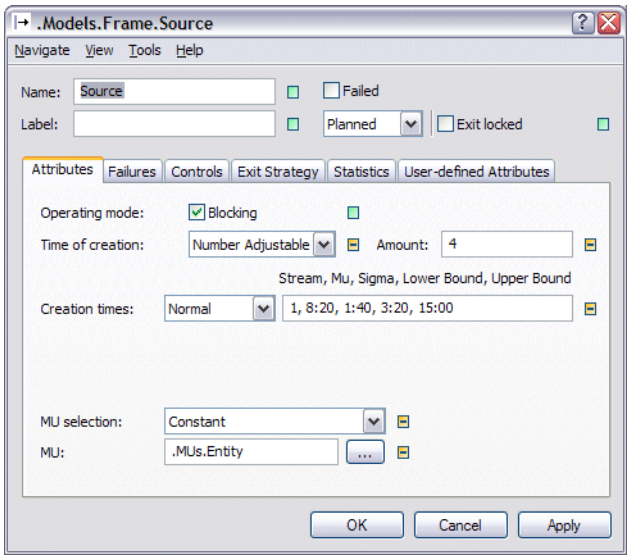
  Select a distribution from the drop-down list Creation times and enter the values that the distribution requires into the text box.

  Note: As opposed to Interval Adjustable, here the Creation times are a range, within which the *Source* creates MUs, and not a repeating interval.

  Note: When you select the Constant distribution, the *Source* creates the number of MUs all at one point in time, as here the Creation times are a point in time, not a range!

  Note: For this setting you cannot select Sequence from the drop-down list MU selection.

- Click OK.



When you select Time of creation > Interval Adjustable or Time of creation > Number Adjustable you can also select how the *Source* produces which types of MUs.

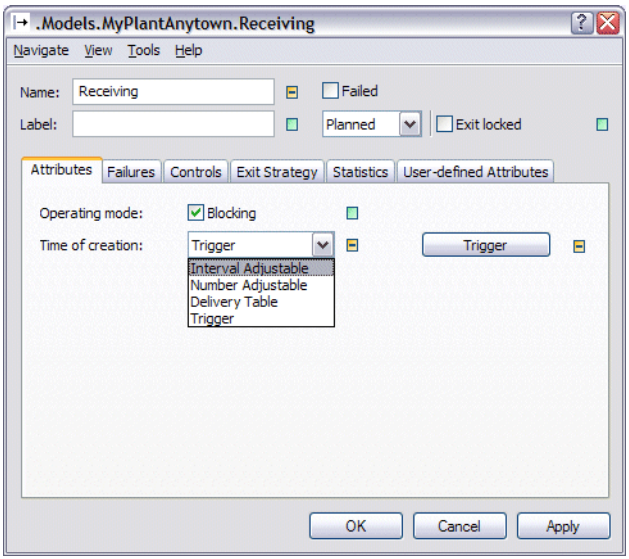
Produce Parts Using a Trigger Object

You might, for example, use a *Source* that is controlled by a *Trigger*:

- If you want to set a time of creation, such as with a delivery table, and
- If you would like to periodically repeat using the values in this list, for example when you select Sequence Cyclical from the drop-down list MU selection.

Proceed as follows:

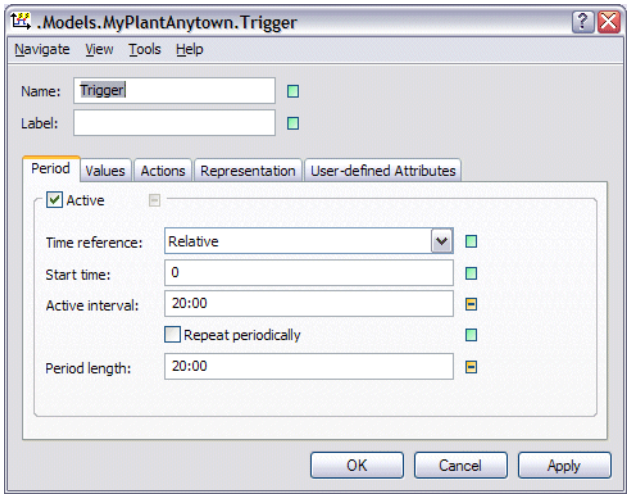
- Select Time of creation > Trigger in the dialog of the *Source*.



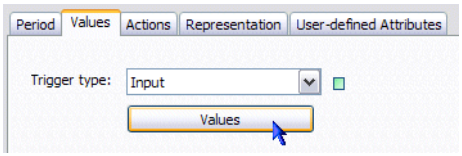
Before you can enter the *Trigger*, click the toggle button Inheritance, so that it looks like this .

- Click Trigger, drag the *Trigger* that controls the *Source* from the *Frame* over the list that opens and drop it there.
- In the dialog of the *Trigger* enter the Active interval, i.e., the interval during which the *Trigger* will be active.

  Enter the Period length, i.e., the duration of the *Trigger's* cycle.



- Click the tab Values and select the Trigger type > Input.



- Click the button Values and enter into the *TimeSequence* object that opens:

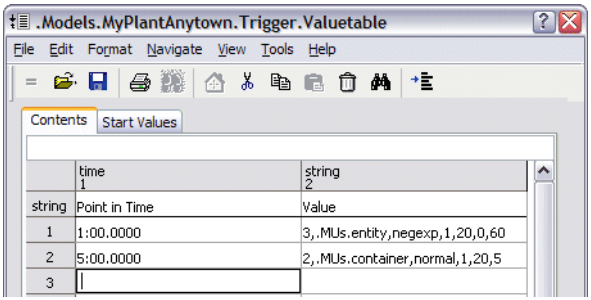
  The Point in Time at which the *Source* creates MUs into the cells on the left hand side.

  The current sequence of Values into the cells on the right hand side. An order is a *string* with this format: `<amount>,<mu_Type>,<distributionType>,<stream>[,<distribution arguments>]`.

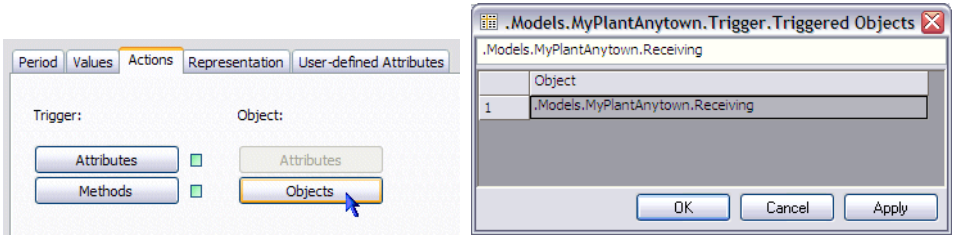
  Note: The string defining this sequence of values may not contain any blank spaces.

  You have to enter the amount of MUs to be produced, the type to be produced, and at least a constant value. When you enter just `Const`, the *Source* produces the MUs at the point in time, which you entered into the cell to the left. When you would like it to produce the MUs with an offset to the time you entered there, enter the number of seconds after which it produces them after `Const`.

  When you enter a distribution, its values set the time offset to the time you entered into the corresponding left cell. Note that the offset you enter has to be a positive number!



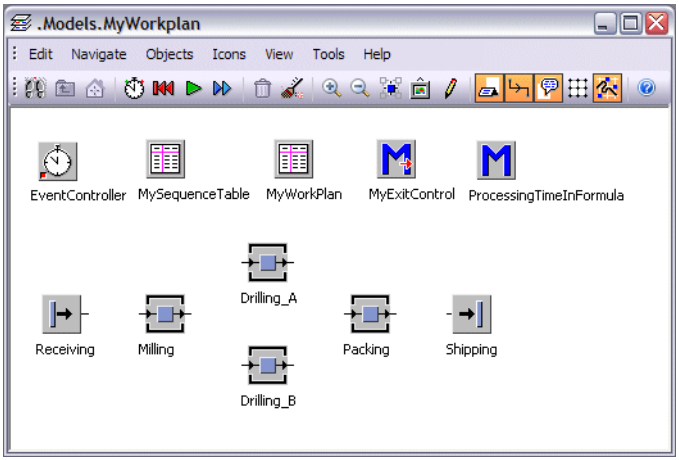
- Click the tab **Actions** and click **Objects**. The *Trigger* shows the *Source* in the table.



Producing and Processing Parts with a Work Plan

A **work plan** or operations plan determines how a product is produced. It lists the various production steps in the sequence in which they are executed. Note that in *Plant Simulation* we neither specify the cost center, to which each of the individual production steps is charged, nor the allowed time for each step. This you can do in *Process Designer*.

For simplicity's sake each operation can only be executed by a single station in our example. Our work plan thus is described by a sequence of stations. The *Source* holds position **0** in the work plan, the station *Milling* position **1**, the stations *Drilling_A* or *Drilling_B* position **2** and the station *Packing* position **3**.



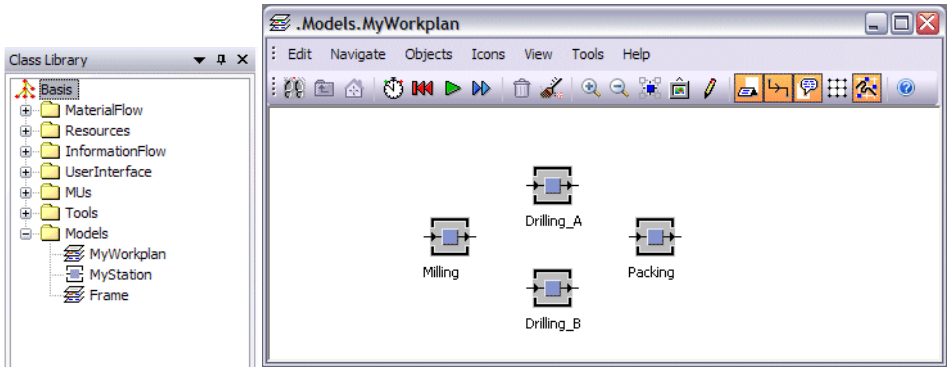
To facilitate quick and easy modeling:

- We create the work plan in a *TableFile* and insert it into the *Frame*, in which we create our simulation model. We enter the set-up times of the stations and the processing times of the different parts into subtables of the work plan.
- We produce two different types of parts in a *Source* using a sequence table. The parts need two user-defined attributes. One sets the name of the part. The other sets the position of the part in the work plan.
- We program a *Method* M, i.e., an exit control, which enables the processing station to find the next station in the sequence of operations after each processing step and moves the part onto this station. We place this method, which all stations access, into the *Frame*.

Create the Processing Stations

To be able to assign the operations and the stations in the work plan later on, we start out with creating the stations which execute the operations.

- To create the class of the processing station, right-click the object *SingleProc* in the folder Materialflow and select Derive on the context menu.
- To move the derived *SingleProc* to the folder in which we are going to create the model, hold down Shift and drag it to that folder.
- Insert it from there into the model three times. Rename the stations so that they match the names of the operations. In our example we named them `Milling`, `Drilling_A`, `Drilling_B` and `Packing`.

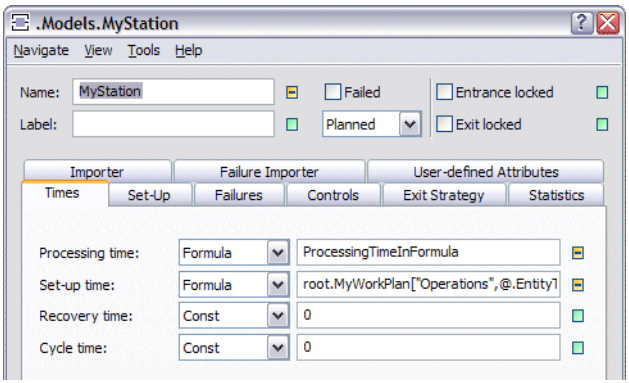


As the processing stations share a number of features, we set these in their class, *MyStation* in our example. The class object passes these properties on to its instances. We

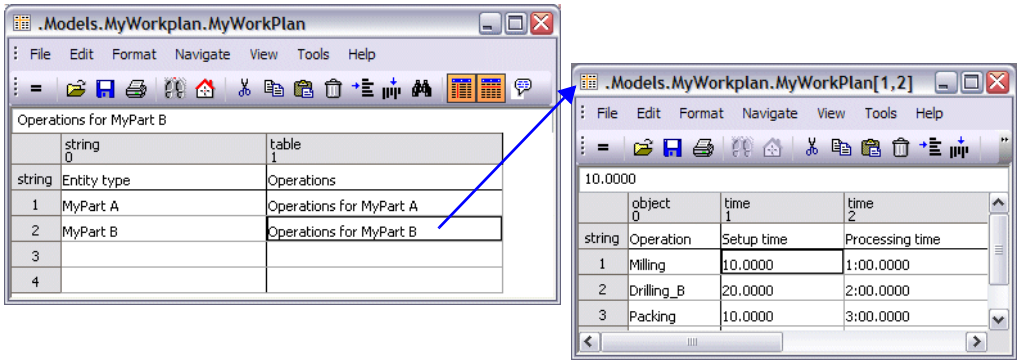
- *Define Times in the Class of the Processing Stations*
- *Define Set-up Behavior in the Class of the Processing Stations*
- *Enter the Name of the Exit Control in the Class of the Processing Stations*

Define Times in the Class of the Processing Stations

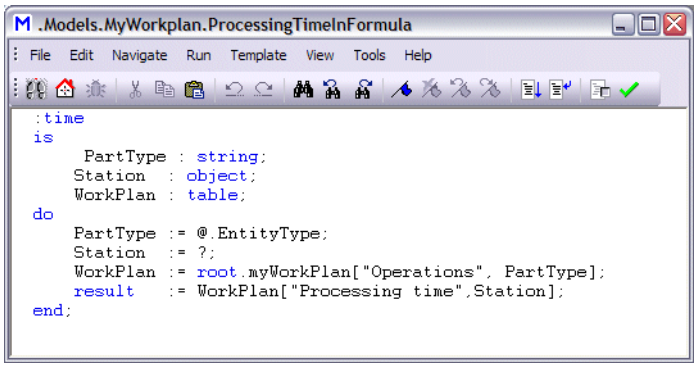
We define the Processing time and the Set-up time in a Formula.



- We want the stations to get the **processing time** of all parts from the work plan *MyWorkPlan*. This table object is located in the *Frame* in which we build the model, i.e., the *root Frame*. The station then opens the subtable Operations for the respective part and gets the times in the column Processing time of the respective station within this subtable.



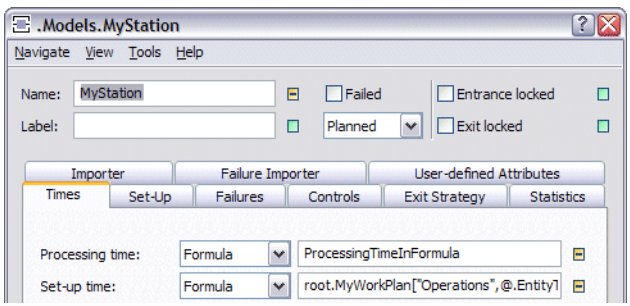
For the **processing time** we use a formula, which we programmed in the *Method ProcessingTimeInFormula*.



- We want the stations to get the **set-up time** of all parts from the work plan *MyWorkPlan*. This table object is located in the *Frame* in which we build the model, i.e., the *root Frame*. The station then opens the subtable Operations for the respective part and gets the times in the column Set-up time of the respective station within this subtable. `Self` identifies the station contained in the row in the subtable.

  The above instructions translate into this formula, which we directly enter into the text box:

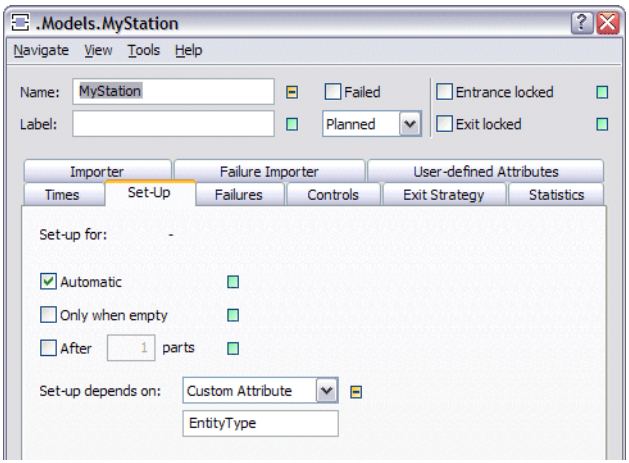
  ```
  root.MyWorkPlan["Operations",@.EntityType]["Setup time",Self]
  ```



Define Set-up Behavior in the Class of the Processing Stations

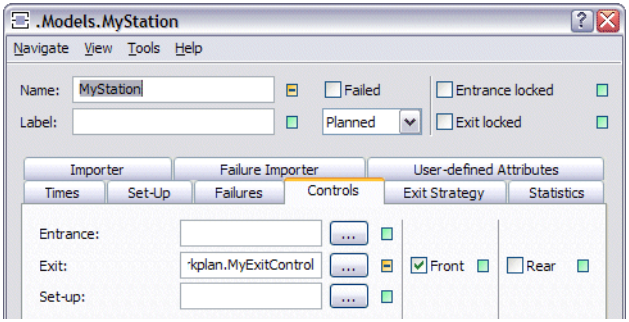
To automatically set the stations up depending on the name of a user-defined attribute of the MU:

- Select the check box Automatic.
- Select User-defined Attribute from the drop-down list Set-up depends on. Enter the name of the user-defined attribute which we defined in the Sequence table with which the *Source* produces parts, compare . We typed in `EntityType`.



Enter the Name of the Exit Control in the Class of the Processing Stations

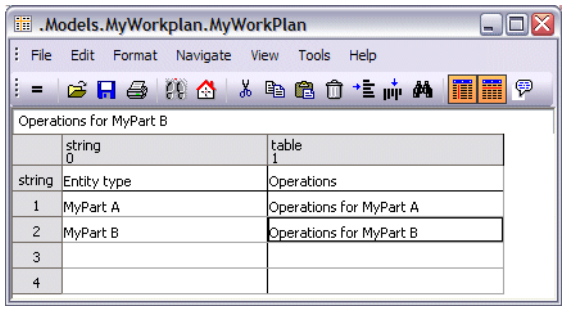
the station has to find the next station in the sequence of operations after each processing step and move the part on to this station, we enter the name of an



Create the Work Plan

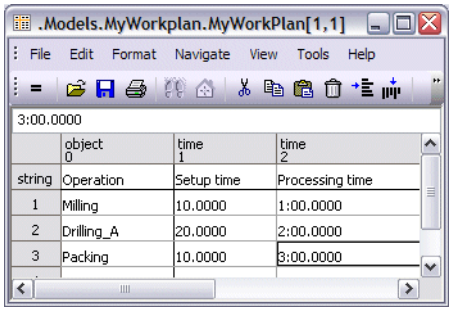
To create the work plan:

- Insert a *TableFile* into the *Frame*. For clarity's sake, let's activate the column index and the row index.
- Assign the data type Table to the column which contains the subtable into which we enter information about the operations. Format this column so that all subtables have the same format, compare Create Lists within Lists and Tables. Activate the column index and the row index in the subtables. Assign the data type Object to the column of the column index. Assign the data type Time to the next two columns.
- After we assigned the correct format to the subtables, we can then enter the contents:
  - Once we enter an identifier, *Plant Simulation* creates the subtable in this cell. We typed in `Operations for MyPart A` and `Operations for MyPart B`.

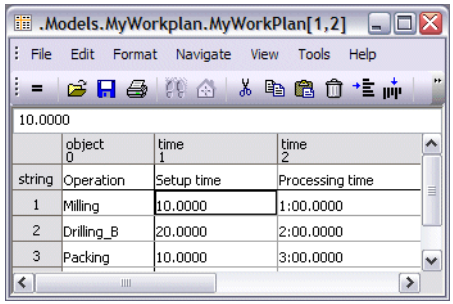


  - To open the subtable for the respective work plan, double-click the respective cell below `Operations`.
  - Enter the names of the operations/stations, their set-up times and the processing times of the parts.

Operations MyPart A



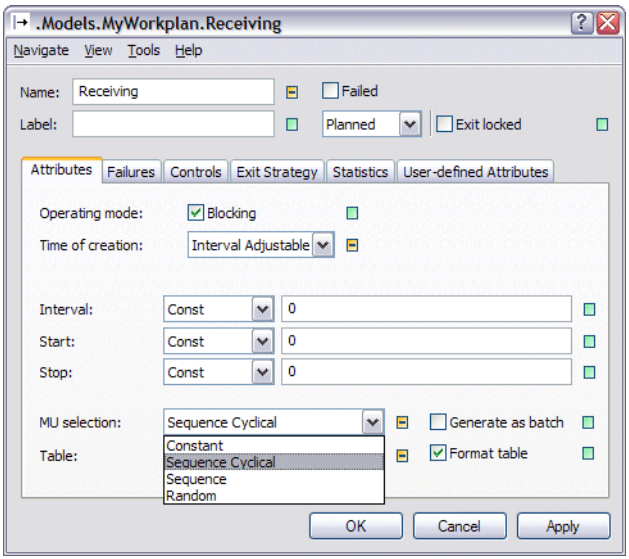
Operations MyPart B



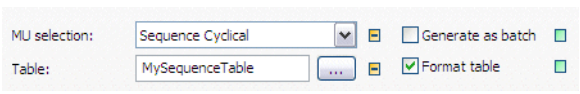
Produce the Parts with a Source Using a Sequence Table

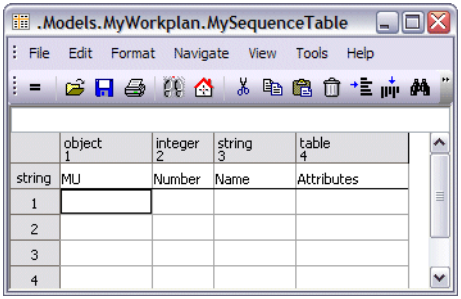
To produce the parts in the sequence, which we specify in a sequence table:

- Insert a *Source* into the *Frame*. Select MU selection > Sequence cyclical.



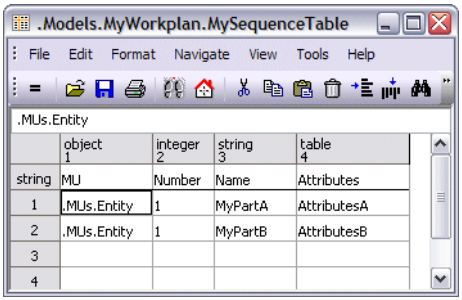
- Insert a *TableFile* into the *Frame*. Drag this table over the text box Table. Make sure that the check box Format table is selected, so that *Plant Simulation* assigns the columns in the table the correct data types and the correct column headers.





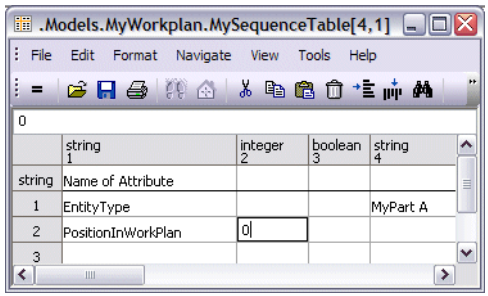
- Open the table and enter the type of part you want to produce, how many of them, their name and the name of the subtable containing the attributes of the part.

  In our example the *Source* is to produce `1` part of the MU class `Entity` each with the name `MyPartA` and `MyPartB`.

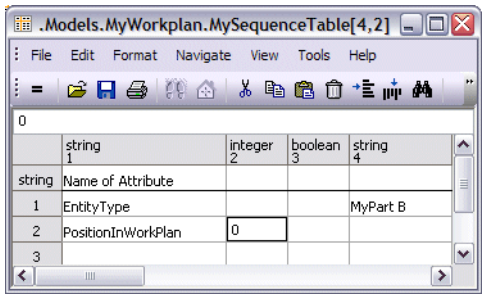


- To create a subtable for the user-defined attributes of the parts, enter an identifier into the cells below **Attributes**. To open this subtable, double-click the cell. Here we enter the names and the values of two user-defined attributes: One sets the name of the part, the `EntityType` is either `MyPartA` or `MyPartB`. The other sets the position of the part in the work plan (`PositionInWorkPlan`). In our case the sequence of operations always starts at position `0`, which is the *Source*. The counter, which we programmed in the exit control, then steps through the stations: *Milling* is position **1**, *Drilling_A* or *Drilling_B* are position **2** and *Packing* is position **3**.

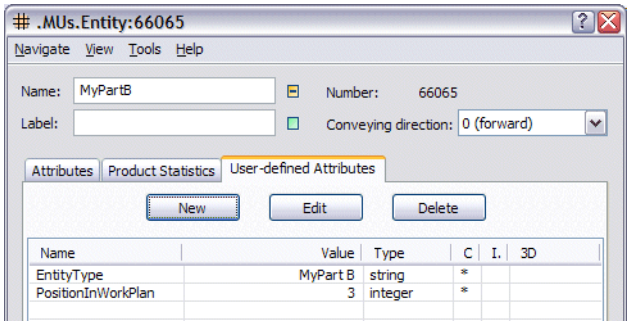
User-defined Attributes for MyPart A

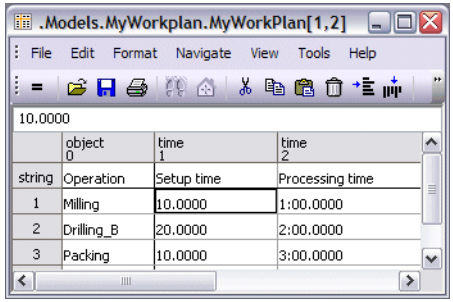


User-defined Attributes for MyPart B

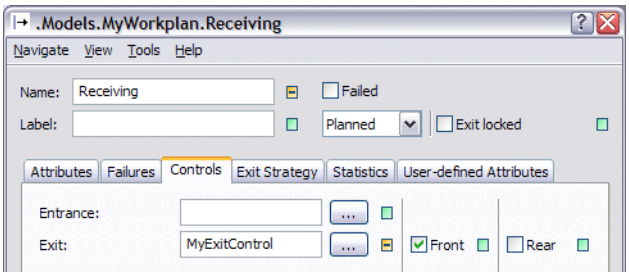


During the simulation run *Plant Simulation* enters these user-defined attributes into the created *Entities*. The *Entity* with the number **100343**, for example, is of type **MyPart B** and is located on station **3**, *Packing*, according to the position, which we defined in the work plan as operation.



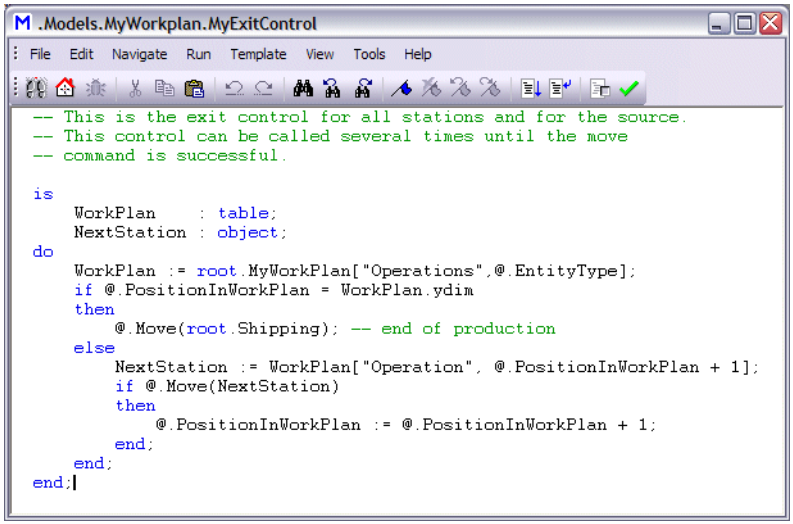


- Finally, enter the name of the exit control, which finds the processing station and moves the part onto it.



Program the Exit Control

finding the next station in the sequence of operations after each processing step and for moving the part on to this station, we program If just the stations were going to use this control, we could have programmed it in a user-defined attribute of type *method* of the class of the station.

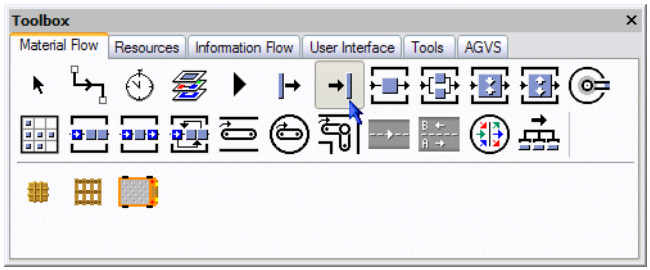


Removing Parts from the Installation with the Drain

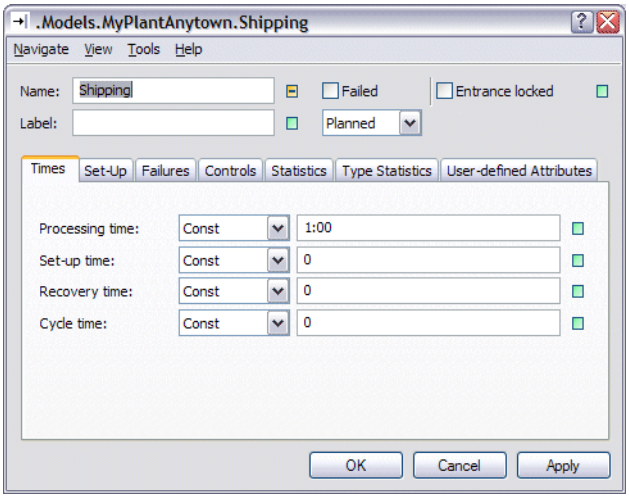
To remove the parts and workpieces from the plant after they have been processed, for example to model the *shipping department*, we use the object *Drain*.

The *Drain* has a single processing station. It removes the MU from the installation after setting-up for it and after processing it. The built-in properties of the *Drain* are the same as those of the *SingleProc*. The *Drain* destroys the MU after it processed it, instead of moving it on to a succeeding object in the flow of materials and it collects statistics about the MU.

You can insert the *Drain* into your simulation model from the folder MaterialFlow in the *Class Library* or from the tab Material Flow in the *Toolbox*.



Remember that we create these parts with the object *Source*.



Transferring Parts from Station to Station

When transferring parts from station to station in your simulation model, you can:

- Use the Standard Transfer Behavior, which employs the **push-block principle**. Or you can
- Select an Exit Strategy, which distributes the parts to the succeeding stations according to the criteria you set. Or you can
- Load, Unload, and Reload Parts with the TransferStation. Or you can
- Move the part, when an attribute of the processing station changes by employing an observer.

Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Use the Standard Transfer Behavior

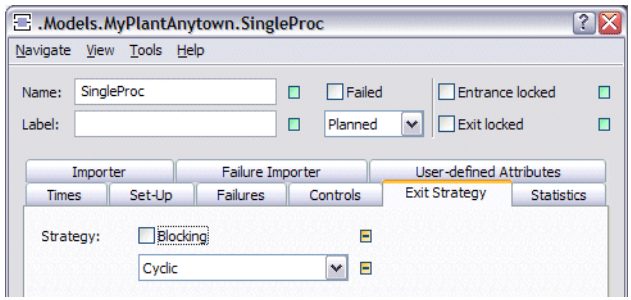
By default *Plant Simulation* uses the **push-block principle** when mobile parts from station to station, either along the connections you established with the *Connector* or by programming a method M.

An object that has processed the part, which is ready to be transferred, actively attempts to move that part on to its successor (**push**). If the successor cannot receive the part at the moment, the **block** principle will be activated, guaranteeing that the object ready to move the part is re-activated as soon the successor is ready to receive the part.

The push-block principle ensures that parts are transferred using the built-in functionality of the objects and that the stream of events is not interrupted by failures or pauses.

The standard transfer strategy is cyclic, non-blocking, meaning that the present object moves the MU to the first non-blocked succeeding object in the flow of materials. Once the object reaches the end of the list of successors,

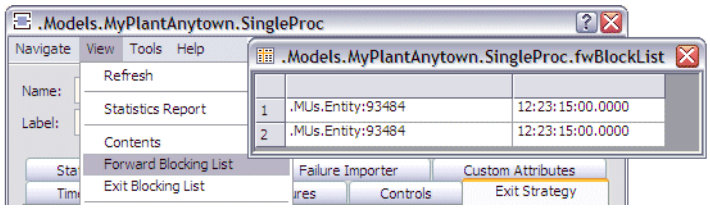
it continues the search at the beginning of the list and terminates the search when it reaches the successor from the previous search.



Suppose *Station1* is the first station in the sequence of stations in your simulation model, *Station2* is the second station, *MU1* is the first mobile object that entered the flow of materials, *MU2* is the second mobile object. Suppose *MU1* is located on *Station2*, and *MU2* is located on *Station1* and wants to move to *Station2*.

Once *MU2* is completely processed by *Station1*, *MU2* notifies *Station2* that it intends to move to it.

- When *Station2* can receive *MU2*, it notifies *MU2*, and *MU2* moves from *Station1* to *Station2*.
- When *Station2* cannot receive *MU2* because it is busy, its entrance is locked, etc., *MU2* enters itself into the forward blocking list of *Station2* and of all other stations it intends to move to.



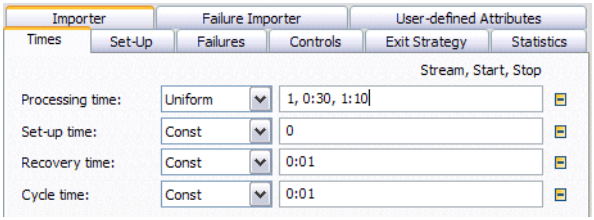
- When *MU1* exits *Station2*, *Station2* schedules an Out event for all entries, i.e., MUs, in the forward blocking list, including *MU2*. Afterwards *Station2* deletes all entries from its forward blocking list.
- Provided *Station2* can receive *MU2*, *MU2* deletes all references to itself from all blocking lists of all stations it entered itself into, and then moves to *Station2*.

The material flow objects *SingleProc*, *ParallelProc*, *Assembly*, *DismantleStation*, *Line*, *Sorter*, *PlaceBuffer* and *Buffer* handle the MUs that transfer onto them:

1. For these times, which you define:
   - The **processing time**. This is the time, which the MU remains on the object to be processed. It is the interval between setting-up for the present type of MU and the point in time when the material flow object moves it on to its successor.
   - The **set-up time**. This is the time it takes to set-up the object for processing a different type of MU. An identical name denotes that MUs are of the same type.

- The **recovery time**. This is the time during which the first gate at the entrance of a material flow object is closed after an MU entered the station. The recovery time is useful to model material handling equipment, such as a robot that requires a certain time to insert into or remove work pieces from processing stations. When you enter 0 the gate is always open, a value greater than 0 closes the gate for the specified interval as soon as the front of the MU has entered the object.
- The **cycle time**. This is the time during which the second gate at the entrance of a material flow object opens and closes cyclically, regardless of MUs entering the object. The cycle time is useful to model chain conveyors with a fixed chain interval that only transport material when a free hook is available.

Note: You do not have to define all of the times listed above for the object.

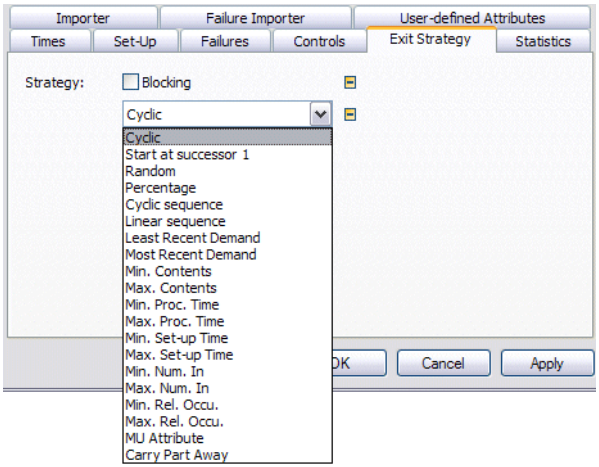


2. For failures you define and activate.

The material flow objects then transfer the MUs to the next object along the material flow connections using the exit strategy you select.

Select an Exit Strategy

If you do not want to transfer the MUs using the standard transfer behavior, click the Tab Exit Strategy and select another Strategy. As a rule you will use an exit strategy, which distributes the flow of materials, when the sequence of operations does not uniquely designate the next object that processes the MU. Your objective will be to make a choice that is close to optimal in some respect, say cost or time, but not in others.



- To make the *Worker* carry the MU to the target object, select Carry Part Away.
- To move the parts cyclically to the next successor in line, select Cyclic.
- To cyclically move the part to the successor according to the sequence of successors, which you entered into the list, select Cyclic Sequence.
- To move the parts to the successor that has been waiting the longest for an MU, select Least Recent Demand.
- To move the parts to the successor in a linear fashion, according to the sequence of successors, which you entered into the list, select Linear Sequence.
- To move the parts to the successor that contains the greatest number of MUs, select Maximum Contents.
- To move the parts to the successor that received the most MUs, select Maximum Number In.
- To move the parts to the successor with the longest processing time, select Maximum Processing Time.
- To move the parts to the successor with the highest relative occupancy, select Maximum Relative Occupation
- To move the parts to the successor with the longest set-up time, select Maximum Set-up Time.
- To move the parts to the successor that contains the smallest number of MUs, select Minimum Contents.
- To move the parts to the successor that received the smallest number of MUs, select Minimum Number In.
- To move the parts to the successor with the shortest processing time, select Minimum Processing Time.
- To move the parts to the successor with the lowest relative occupancy, select Minimum Relative Occupation
- To move the parts to the successor with the shortest set-up time, select Minimum Set-up Time.
- To move the parts to the successor that has been waiting the least amount of time for an MU, select Most Recent Demand.
- To move the MUs to the successor according to an attribute of the MU, select MU Attribute.
- To move the parts to the successor according to an attribute of the part, select Percentage.
- To move the parts to the successors according to a percentage distribution, select Percentage.

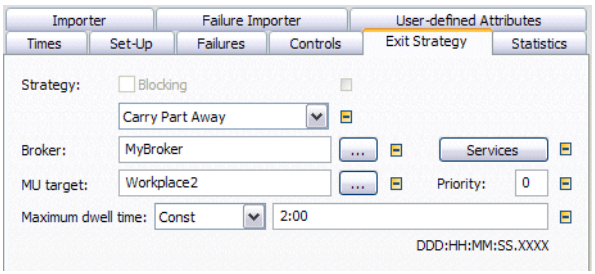
- To move the parts to the successors in a random fashion, select Random.
- To always move the part to successor with the number 1, select Start at Successor 1.

Note: Click Apply, to apply your new settings, and to display additional dialog items, which the selected exit strategy requires.

Carry Part Away

To make the *Worker* pick up and carry parts, which are ready to leave the station, to the destination object, select Carry part away from the drop-down list.

Note: Click Apply to display the dialog items of this strategy.



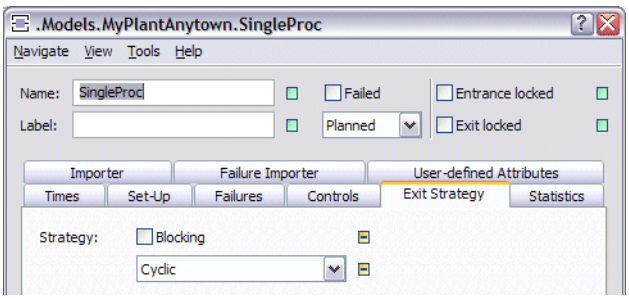
Select the *Broker*, enter the required Services into the services list, and enter the Priority with which the *Importer* provides these services. To prevent the *Worker* from waiting too long for additional parts to arrive, enter the Maximum dwell time. After it has passed, he moves to the target station, the MU target, and puts the part down.

The *Worker* evaluates the MU targets and moves to the closest one first. At the target station, he places all parts destined for this station. If he carries additional parts, he evaluates the next target and moves on to the closest one.

To send a *Worker* to a specific station, you can use the methods *goTo* and *goToPool*. To change the services for an available *Worker*, you can use the methods *setServices* and *getServices*.

Cyclic

To move the part cyclically to the next successor in line, select Cyclic from the drop-down list.

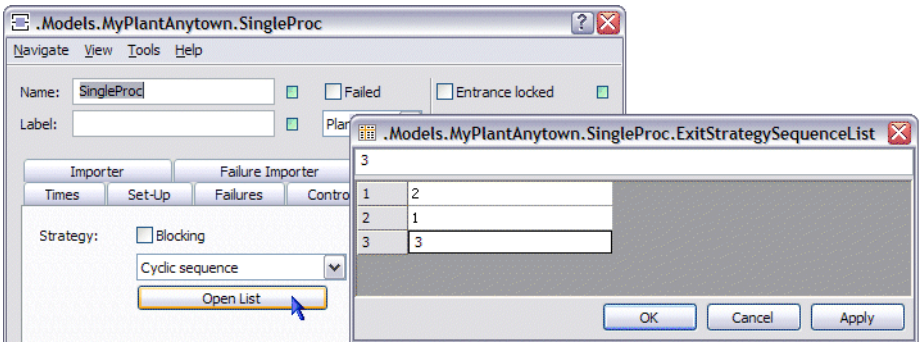


- When you select Blocking Blocking, the object moves the MU to the succeeding object immediately following the one from the previous search.
- When you clear Blocking Blocking, the object moves the MU to the first non-blocked succeeding object following the one from the previous search.

Once the object reaches the end of the list of successors, it continues the search at the beginning of the list and terminates the search when it reaches the successor from the previous search.

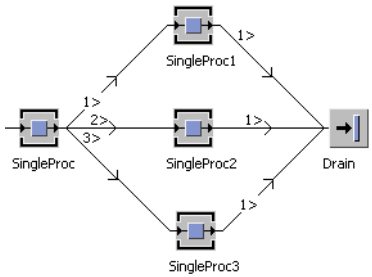
Cyclic Sequence

To cyclically move the part to the material flow object's successor according to the sequence of successors, which you entered into the list repeatedly, select Cyclic sequence from the drop-down list.



Note: Click Apply, to apply your settings, and to display the button Open List.

Click Open List and enter the number of the succeeding object into the corresponding cell of the list. When you enter 2 into the cell in row 1, the object first moves the MU to the successor with the number 2.



The successor to which the object moves the MU is the next one in line that can receive it in the sequence, which you entered into the list. When the object arrives at the last entry in the list (last object in the sequence), it returns to the first entry and processes the list again.

The same successor object may be contained several times, one after the other, in the list. Then the object attempts to move the part to this same successor as often as it is contained in the list.

- When you select Blocking Blocking, the object only moves the MU, when the designated successor is ready to receive it.
- When you clear Blocking Blocking, the object attempts to move the part to the corresponding successor, beginning with the active entry of the list.

When the object arrives at the last entry in the list, i.e., the last object in the sequence, it returns to the first entry and processes the list again.

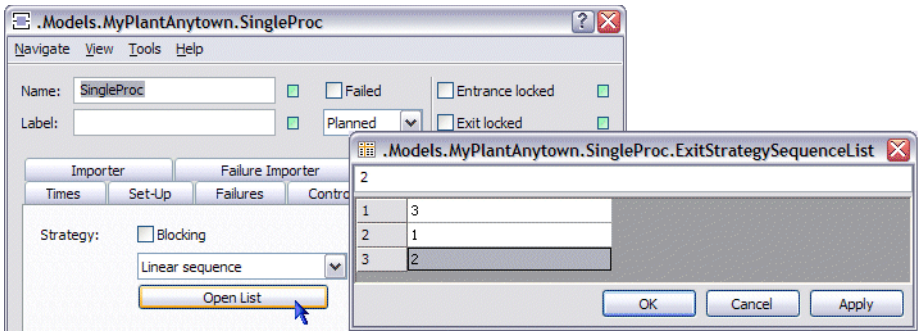
Least Recent Demand

To move the part to the successor that has been waiting the longest for an MU, select Least recent demand from the drop-down list.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

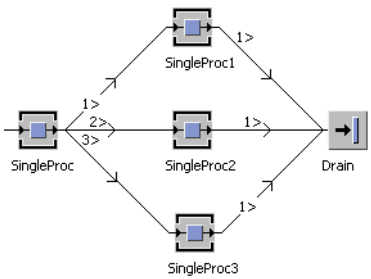
Linear Sequence

To move the part to the material flow object's successor in a linear fashion, one time only, according to the sequence of successors, which you entered into the list, select Linear sequence from the drop-down list.



Note: Click Apply, to apply your settings, and to display the button Open List.

Click Open List and enter the number of the succeeding object into the corresponding cell of the list. When you enter 3 into the cell in row 1, the object first moves the MU to the successor with the number 3.



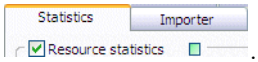
The successor to which the object moves the MU is the first one in line that can receive it in the sequence, which you entered into the list.

- When you select Blocking Blocking, the object only moves the MU to the first successor in the list of successors.
- When you clear Blocking Blocking, the object moves the MU to the first available successor in the list of successors.

Maximum Contents

To move the part to the successor that contains the highest number of MUs, select Max. contents from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active



- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Maximum Number In

To move the part to the successor that received the most MUs, select Max. num. in from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Maximum Processing Time

To move the part to the successor with the longest processing time, select Max. proc. time from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Maximum Relative Occupation

To move the part to the successor with the highest relative occupancy, select Max. rel. occu. from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Maximum Set-up Time

To move the parts to the successor with the longest set-up time, select Maximum set-up time from the drop-down list.

- When you select Blocking Blocking, the object moves the MU to the next successor.

- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Minimum Contents

To move the part to the successor that contains the least number of MUs, select Min. contents from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Minimum Number In

To move the part to the successor that received the least number of MUs, select Min. num. in from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Minimum Processing Time

To move the part to the successor with the shortest processing time, select Min. proc. time from the drop-down list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Minimum Relative Occupation

To move the part to the successor with the lowest relative occupancy, select Min. rel. occu. from the list.

Note: This only works correctly, when resource statistics of the successor or of the predecessor is active.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Minimum Set-up Time

To move the parts to the successor with the shortest set-up time, select Min. set-up time from the drop-down list.

- When you select Blocking Blocking, the object moves the MU to the next successor.
- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

Most Recent Demand

To move the part to the successor waiting the least time for an MU, select Most recent demand from the drop-down list.

- When you select Blocking Blocking, the object moves the MU to the next successor.

- When you clear Blocking Blocking, the object moves the MU the next non-blocking successor.

MU Attribute

To pass the parts on to a successor according to the values of attributes of the part, select Most recent demand from the drop-down list.

Note: Click Apply to display the dialog items of this strategy.

Click Open List to open a table, into which you can enter the names of the user-defined or the built-in attributes, their values, and the numbers of the successor. The object searches the table from top to bottom until it finds an attribute with the value you entered. It then passes the MU on to that successor.

Note: Create the user-defined attributes for the parts on the Tab User-defined Attributes.

- Default Successor

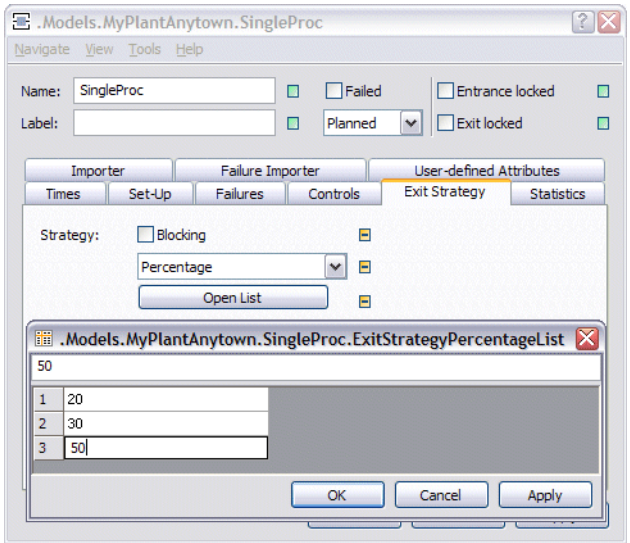
  Enter the number of the default successor. This is the successor to which the object moves the MUs, when none of the MUs has an attribute with the Value you entered into the *TableFile*.

- Attribute Type

  Select the data type of the attribute from this drop-down list, compare Supported Data Types.

Percentage

To move the part to the successors according to a percentage distribution, select Percentage from the drop-down list.



Note: Click Apply, to apply your settings, and to display the button Open List.

Click Open List and enter the percentages in the list that opens. The *n-th* row in the table defines the *n-th* successor's portion: When you enter 20 in row 1, for example, the object moves 20% of the MUs it received to the successor with the number 1, etc.

The object always moves the MU to the successor with the greatest difference between the rated value and the current value.

- When you select Blocking , it moves the MU to the successor with the highest deviation from the nominal percentage.
- When you clear Blocking , it moves the MU to the non-blocking successor with the highest deviation from the nominal percentage.

Note: The actual percentages reached may differ from the nominal ones due to a low number of total transfers and to the Blocking-state of successors.

Any previous transfers of MUs affect the Percentage strategy, as they alter the deviation from the nominal transfer frequencies.

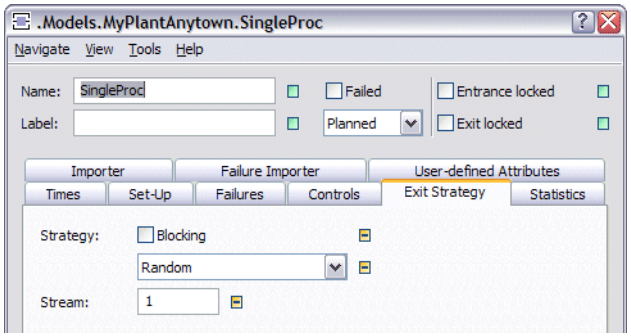
Plant Simulation sums up the values you entered into the list of nominal percentages to obtain the value that corresponds to 100%. The distribution pattern only depends on the relative size of the values, not on their magnitude. This way you can, for example, either enter `[1;2]` or `[0.3333…; 0.6666…]`, the result will be the same.

If the distribution pattern is periodic, then it is so right from the beginning. This means that the distribution pattern at the start of a simulation run does not differ from the distribution pattern at a later point in time. These examples demonstrate, how nicely the values are balanced:

- If you assign the values `1` and `2` to the exits 1 and 2 respectively, *Plant Simulation* generates this sequence of exits:
  2 1 2 2 1 2 2 1 2 2 1 2 2 1 2
- If you assign `2` and `3` to the exits 1 and 2, *Plant Simulation* generates this sequence of exits:
  2 1 2 1 2 2 1 2 1 2 2 1 2 1 2
- If you assign the values `1`, `2`, `4` and `8` to the exits 1, 2, 3, and 4, *Plant Simulation* generates this sequence of exits:
  4 3 4 2 4 3 4 1 4 3 4 2 4 3 4 4 3 4 2 4 3 4 1 4 3 4 2 4 3 4

Random

To move the part to the successors in a random fashion, select Random from the drop-down list.



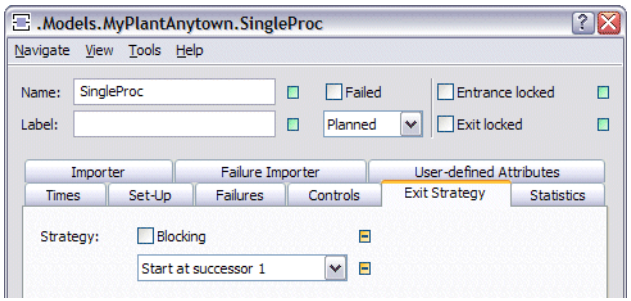
Enter the random number stream that controls this exit strategy into the text box **Stream**.

- When you select **Blocking** Blocking, the object determines the successor using the random-number generator.
- When you clear **Blocking** Blocking, the object determines the successor using the random-number generator until it either calculates a non-blocking successor or the object encountered all successors.

A previous call to the random number generator does affect the **Random** strategy. The order in which the successors are encountered is not predictable.

Start at Successor 1

To always move the part to the material flow object's successor with the number 1, select Start at successor 1 from the drop-down list.

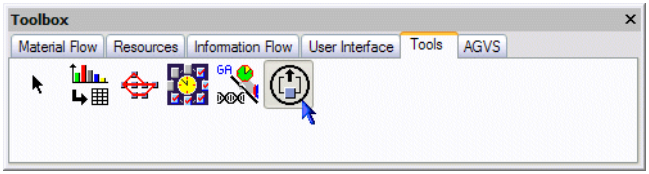


- When you select **Blocking** Blocking, the object moves the MU to the first successor in the list of successors.
- When you clear **Blocking** Blocking, the object moves the MU to the first non-blocked successor in the list of successors.

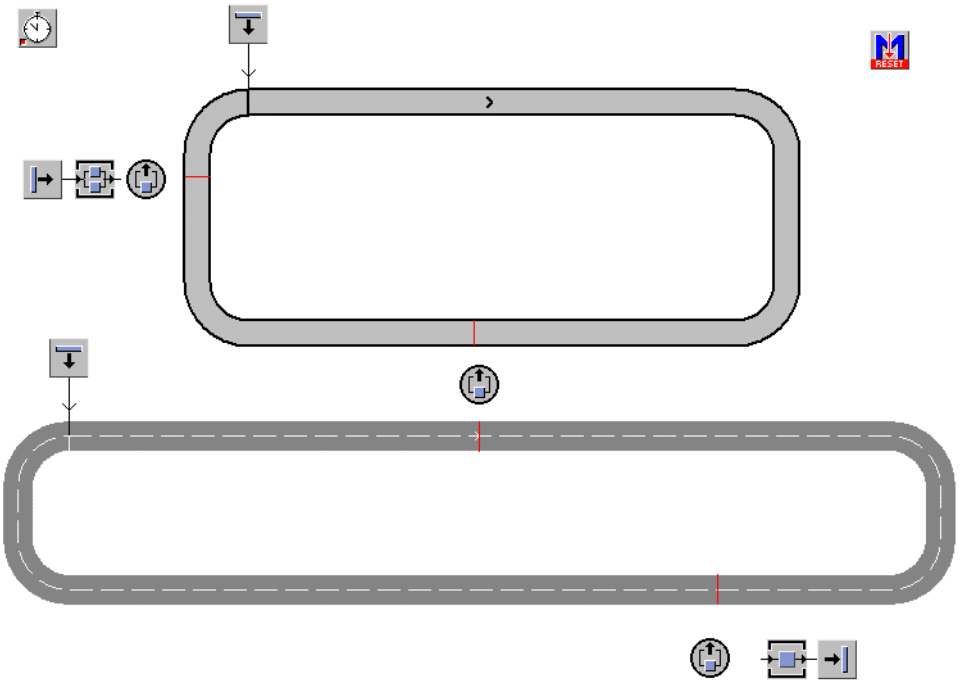
Note that a previous search for a successor does not affect the strategy **Start at successor 1**.

Load, Unload, and Reload Parts with the TransferStation

To define your own way of transferring parts from station to station, you can use the *TransferStation*. You can insert the *TransferStation* into your simulation model from the folder Tools in the *Class Library* or from the tab Tools in the *Toolbox*.



In our example below we load a block of four parts onto a pallet, which is transported to another section within the plant on a conveyor line. At the location in the plant, which is marked by a sensor, we unload parts in blocks of two from the pallets and reload them onto a transport vehicle. Finally, we unload parts in blocks of one from the transport vehicle onto a processing station and then remove them from the plant.



This way, we will demonstrate how to:

- *Load Parts*
- *Reload Parts*
- *Unload Parts*

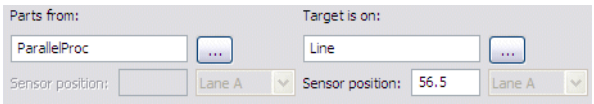
Load Parts

One of your most basic tasks when creating a simulation model will be to load parts onto a means of transport, a *Container* or a *Transporter* and to unload them from a means of transport.

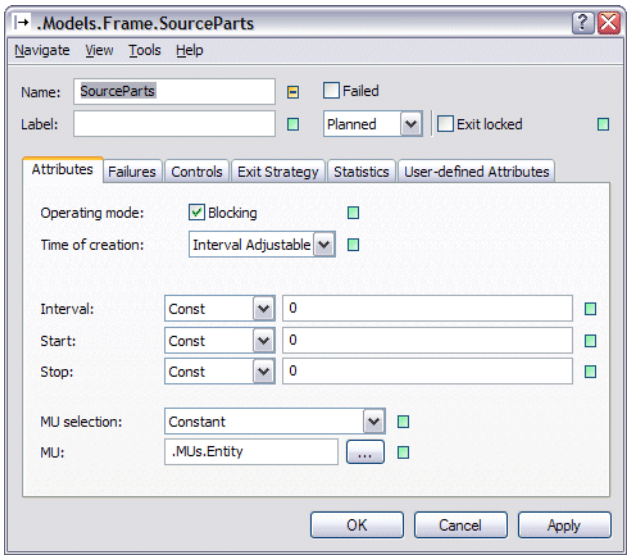
When **loading** parts, the *TransferStation* gets these parts from the parts station and loads them onto a means of transport, which has to be located at the target station. The loading process starts as soon as part and means of transport are ready.

To model a loading process, proceed like this:

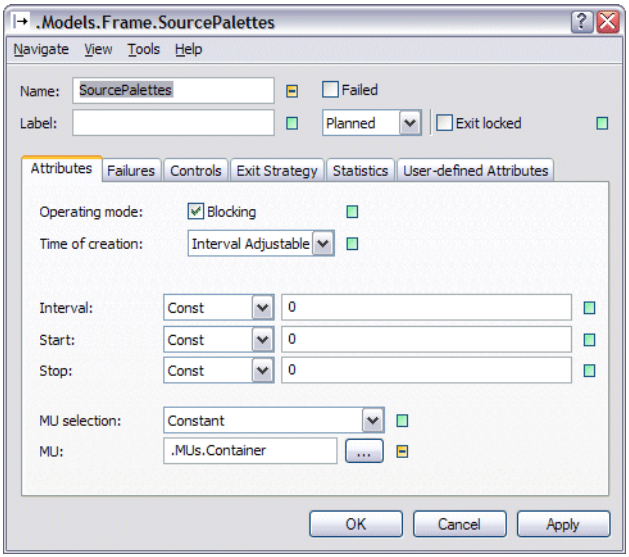
- Insert the conveyor *Line*, which transports the parts.



- Insert a *Source*, which creates the parts. In our sample model we named it `SourceParts`.

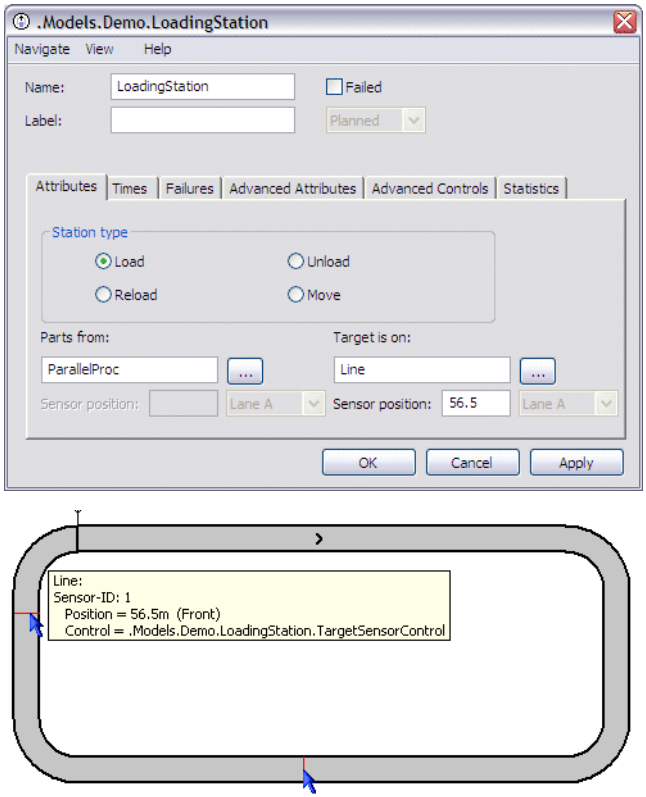


- Insert a *ParallelProc*, which processes the parts before they are loaded onto pallets.
- Insert a *Source*, which creates the pallets onto which the *TransferStation* loads the parts. In our sample model we named it `SourcePallets`.



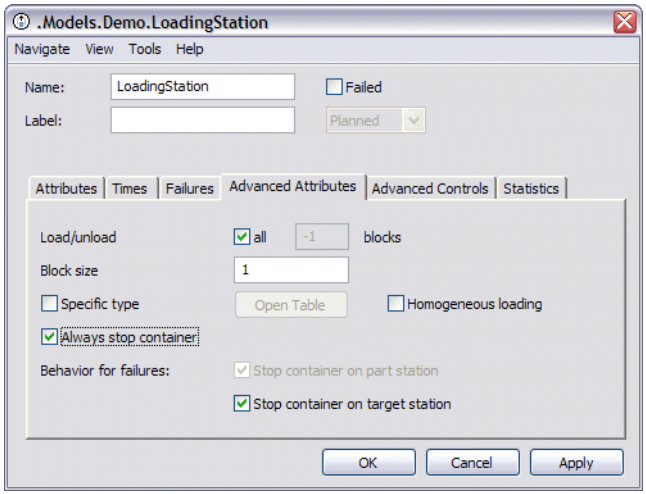
- Insert a *TransferStation*, which loads the processed parts onto the *Container*, i.e., the means of transport, which moves on the conveyor. In our sample model we named it `LoadingStation`. Then, we tell this station what we want it to do.
  - We want to load parts, so we select **Load** as the **Station type**.
  - Then, we have to tell it where the **parts** to be loaded **come from**. For this we click the ... button and select the parallel station *ParallelProc* in the dialog **Select Object**.
  - Next, we have to tell it where the **means of transport**, our *Container*, **is located**. For this we click the ... button and select the *Line* in the dialog **Select Object**.
  - Finally, we have to designate the exact spot on the line, where the *LoadingStation* loads the parts onto the pallets. For this we type `56.5` meters as the **position of the sensor** into the text box on the tab **Attributes**. The *LoadingStation* automatically inserts this sensor into the object *Line*.

Note: To successfully transfer the MU onto the target station, you have to make sure that the target station provides enough space to accommodate the incoming MU.



To define how we want the parts to be loaded, we click the tab Advanced Attributes.

- We want to load all blocks of parts in blocks of 4.

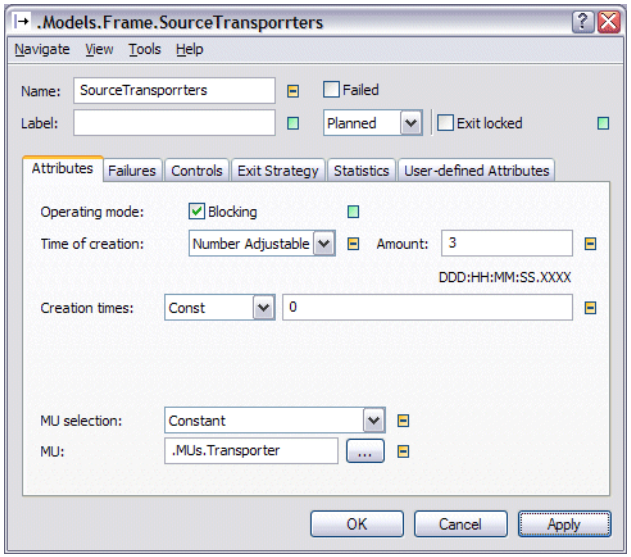


Reload Parts

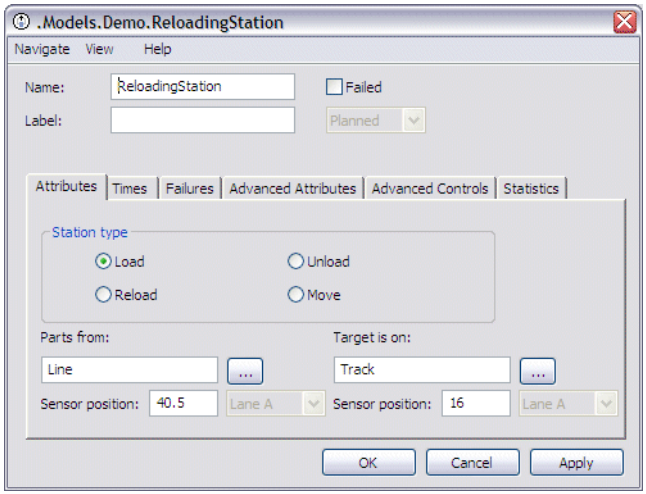
When **reloading** parts, the *TransferStation* takes these parts from a means of transport (*Container* or *Transporter*), which is located at the parts station, and places them onto a *Container* or a *Transporter*, which is located at the target station. The parts station is the station, which provides the parts to be transported. The target station is the station onto which the parts will be placed. The reloading process starts as soon as both means of transport are ready.

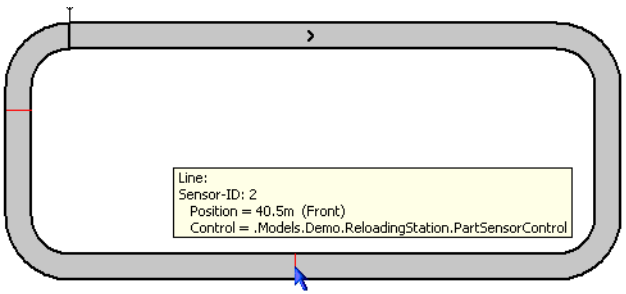
To model a reloading process, proceed like this:

- Insert a *Source*, which creates the *Transporters*. In our sample model we named it `SourceTransporters`.



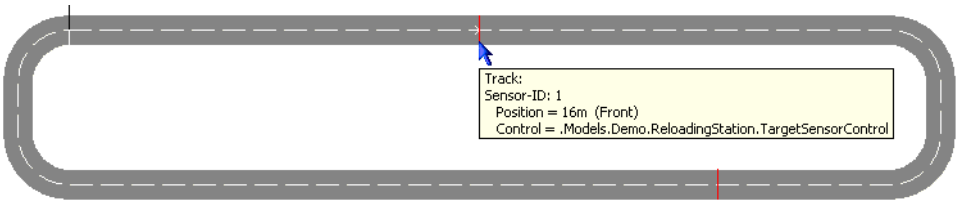
- Insert the *Track*, on which the *Transporter* transports the reloaded parts.
- Insert a *TransferStation*, which reloads the transported parts from the *Container* onto the *Transporter*. In our sample model we named it `ReloadingStation`. Then, we tell this station what we want it to do.
  - We want to reload parts, so we select Reload as the Station type.
  - Then, we have to tell it where the parts to be reloaded come from. For this we drag the *Line* from the *Frame* over the text box in the dialog of the *ReloadingStation* and drop it there.
  - Next, we have to tell it where the means of transport, our *Transporter*, is located. For this we drag the *Track* from the *Frame* over the text box in the dialog of the *ReloadingStation* and drop it there.
  - Finally, we have to designate the exact spot on the *Line*, where the *ReloadingStation* removes the parts from the pallets. For this we enter `40.5` meters as the position of the sensor, which the *ReloadingStation* automatically enters into the object *Line*.



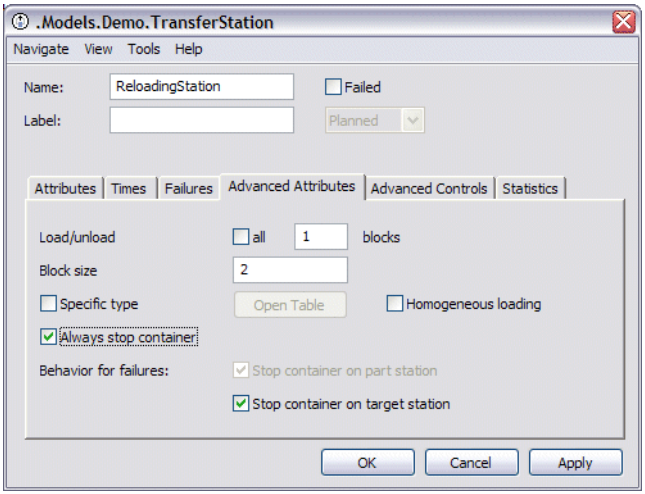


- As we want to reload the parts from the pallet onto a *Transporter*, we have to designate the exact spot on the *Track*, where the *ReloadingStation* loads the parts onto the *Transporter*. For this we enter `16` meters as the position of the sensor, which the *ReloadingStation* automatically enters into the object *Track*.

  Note: To successfully transfer the MU onto the target station, you have to make sure that the target station provides enough space to accommodate the incoming MU.



- To define how we want the parts to be reloaded, we click the tab Advanced Attributes. We want to load parts in blocks of `2`.

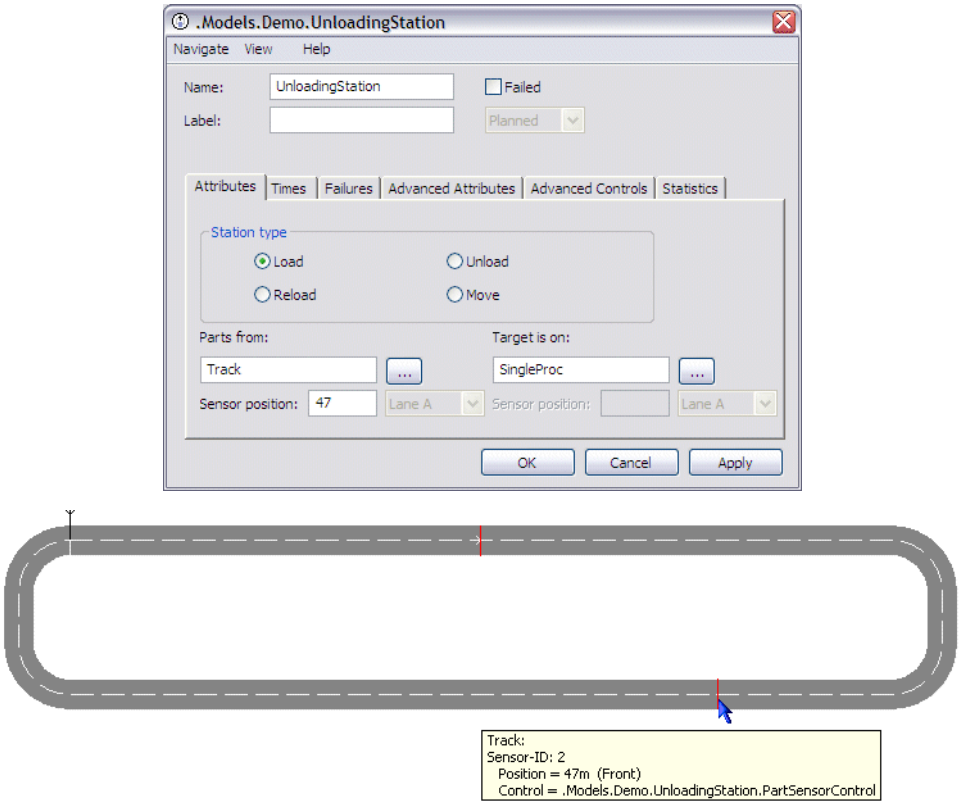


Unload Parts

When **unloading** parts, the *TransferStation* unloads these parts from a *Container* or a *Transporter*, which is located at the parts station, and places them onto the target station. The unloading process starts as soon as a means of transport is ready at the parts station.

To model an unloading process, proceed like this:

- Insert a *SingleProc*, onto which the *UnloadingStation* unloads the parts from the *Transporters*.
- Insert a *Drain*, which removes the parts from the plant.
- Insert a *TransferStation*, which unloads the parts from the *Transporter* and places them onto the processing station *SingleProc*. In our sample model we named it `UnloadingStation`. Now we tell this station what we want it to do.
  - We want to unload parts, so we select Unload as the Station type.
  - Then, we have to tell it where the parts to be unloaded come from. For this we drag the *Track* from the *Frame* over the text box in the dialog of the *UnloadingStation* and drop it there.
  - Next, we have to tell it where the means of transport, our *Transporter*, is located. For this we drag the *SingleProc* from the *Frame* over the text box in the dialog of the *UnloadingStation* and drop it there.
  - To designate the exact spot on the *Track*, where the *UnloadingStation* unloads the parts from the *Transporters* onto the processing station *SingleProc*, we to enter `47` meters as the sensor position. The *UnloadingStation* automatically enters this sensor into the object *Track*.



- To define how we want the parts to be unloaded, we click the tab **Advanced Attributes**. We want to unload **all blocks** of parts in blocks of `1`.
- Insert a *Method*, enter `deleteMovables` as the source code, and name the *Method* `reset`.
- Insert an *EventController* into the *Frame*, and run the simulation.

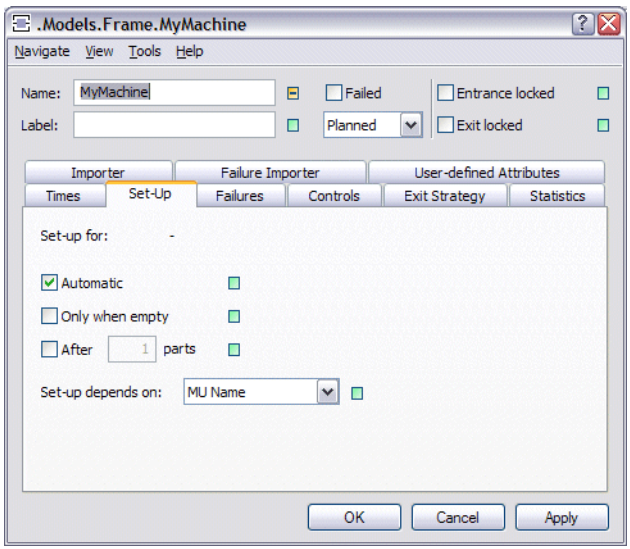
  You can then change a number of settings, such as the dimensions of the *Transporters* and the *Containers*, the block size, the number of blocks, etc. and watch how these changes affect the simulation model.

Setting a Station Up

You can define how to set up the objects *SingleProc*, *ParallelProc*, *Assembly*, *DismantleStation* and *Drain* to process another type of MU.

You can:

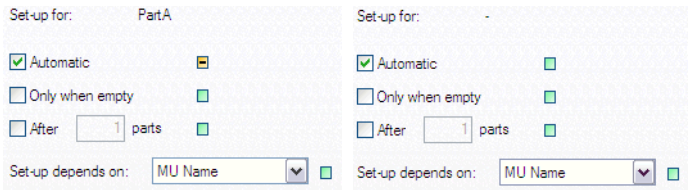
- *Select Set-up Options* on the tab Set-Up.
- *Select the Set-Up Time* on the tab Times.



Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Select Set-up Options

When you set up a station you will first select the set-up options. Next to Set-up for *Plant Simulation* shows which type of MU the object is presently set up for or is going to be set up for. If the object has not been set up yet at all, it shows a hyphen -. To tell one type of MU from the other, *Plant Simulation* either uses the name of the MU or a user-defined attribute of the MU.



First, you will select if you want to:

- *Set the Station Up Automatically*
- *Only Set the Station Up When it is Empty*
- *Set the Station Up after it Processed a Certain Number of Parts*
- After you have done this, you will *Select the Set-Up Criteria*.

Set the Station Up Automatically

To automatically set the object up, select Automatic. Then, the material flow object triggers the set-up process as soon as an MU of the corresponding MU type intends to move onto it.

To define the set-up process in a *Method*, clear the check box.

Only Set the Station Up When it is Empty

To only start setting-up the object for the next type of MU when it is empty, select Only when empty. MUs of the type for which the object is setting-up can only enter the object, after the set-up process is finished.

To allow MUs to enter the object although it has not been set-up for their type yet, clear the check box.

Their set-up time begins, when all set-up processes you specified are finished. MUs located on the object will be processed with the settings for the MU type the object was set-up before.

Set the Station Up after it Processed a Certain Number of Parts

To set the material flow object up, after a certain number of parts have been processed, select the check box After. Then, enter the number of parts into the text box after which you want the object to be set up. The object also sets up and starts counting anew, starting from 1, when the part type changes before the number you enter is reached. For this reason it may happen that the object does not reach the number of parts of a certain type for which it is to set up.

Note: The *ParallelProc* does not provide the setting After n parts.

You can emulate the setting Always, which previous versions of *Plant Simulation* provided, by selecting the check box and by entering `1` into the text box. Entering `0` into the text box deactivates setting-up after a number of parts has been processed.

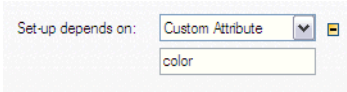
The object always sets up for the part type, which is going to enter next. For this reason the set-up process does not start immediately after the n-th part has been processed or when this part exits the object. setting-up starts as soon as the (n+1)-th part enters the station.

Note: Number of parts designates the number of parts, which enter the station. These parts do not necessarily have to be processed. The object also counts parts, which are removed from the station before they have been processed, for example during the set-up process or while the station is waiting for a service to be executed.

Select the Set-Up Criteria

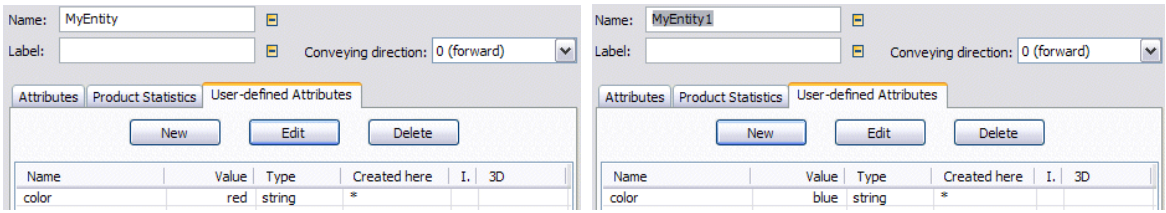
After you decided how the station sets-up, you can select when the object has to be set up:

- When the name of the MU (MU Name), which wants to move onto the station, changes.
- When the value of a User-defined Attribute **of the MU** changes.



  - Select User-defined Attribute from the drop-down list.
  - Enter the name of the user-defined attribute of the MU into the text box. This user-defined attribute has to be of type *string*. The material flow object sets up, when an MU, whose user-defined attribute has a different value, moves onto the station.

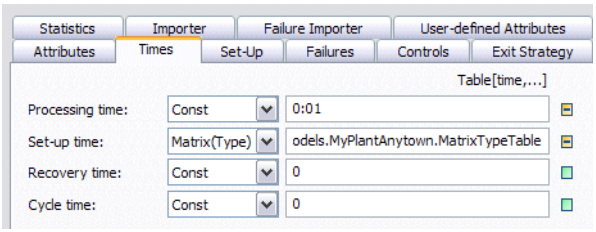
    In our example we created a user-defined attribute named `Color` for the MU types. Let us assume that the station is set up for `red`. When an MU with the user-defined attribute Value `blue` moves onto the station, it sets up for `blue`.



Select the Set-Up Time

The set-up time is the time it takes to set up the object for processing a different type of MU. An identical name denotes that MUs are of the same type. In this case the material flow object will not have to set up for a different MU type. It only needs to set up, when the MUs are of another type, denoted by a name that differs from the previous type.

For the set-up time, you can select a distribution from the drop-down list on the tab Times, depending on the type of MU, or the location on a station, or you can enter a constant time. When you selected a distribution, you will then enter the values, which that distribution requires, into the text box. *Plant Simulation* shows these values along the top border of the tab. In addition to any of the other distributions, you can select the Matrix(Type) distribution.



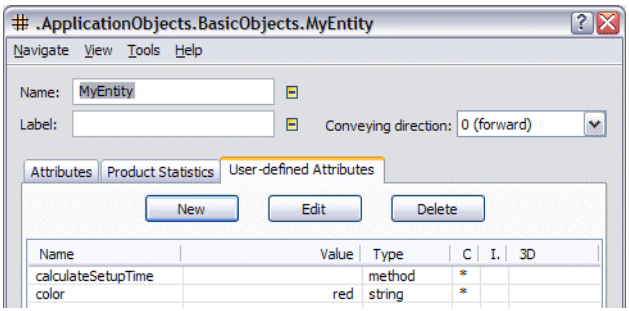
When setting-up, the time may not only depend on the target type, for which you want to set-up, but also on the source type. In this case you can define the times in a table. Activate the custom row index and the custom column index of the table. The row index designates the source type. The column index designates the target type.

	string 0	time 1	time 2	time 3
string		Entity	Container	Transporter
1	-	1:00.0000	1:12.0000	1:25.0000
2	Entity		1:37.0000	2:07.0000
3	Container	1:34.0000		2:09.0000
4	Transporter	1:46.0000	1:41.0000	

In our example above setting-up from no type, indicated by the hyphen, to the target type *Entity* takes exactly one minute. setting-up from the type *Entity* to the type *Transporter* takes two minutes and seven seconds.

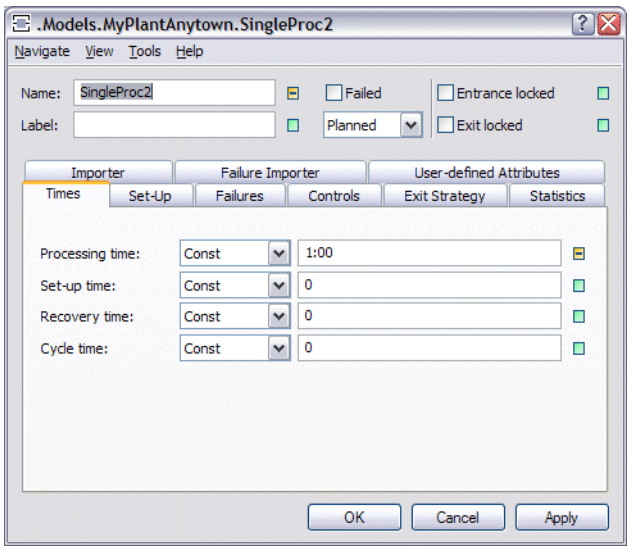
When you select the *Formula* distribution, you can enter a numeric expression or the name of a *Method*. You can use the anonymous identifier @ to access the MU for which the set-up time applies.

Note: You can also determine the set-up time in a user-defined attribute of type *method*, which you created for the **MU**!

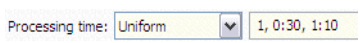


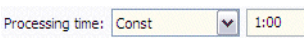
Defining Processing Times

The processing time is the time, which the MU remains on the material flow object to be processed. It is the interval between set-up and the time the material flow object moves it on to its successor.



On the tab Times you can:

- Select a distribution from the drop-down list 

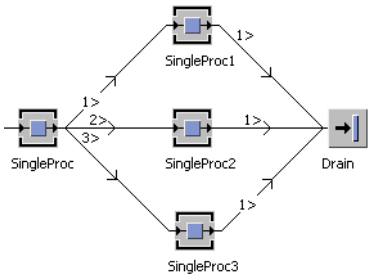
.
- Enter a constant time (Const). In our example we entered one minute 

.
- Select to process the MU depending on its type (List(Type)).
- Select to process the MU depending on the station on which it is located on a *ParallelProc* (List(Place)).

After you selected a distribution, you will then enter the values, which that distribution requires, into the text box. *Plant Simulation* shows these values along the top border of the tab. For the Recovery time in the example above, you have to enter values for the Stream, Beta, Lower Bound and Upper Bound.

When you select Formula, you can enter a numeric expression or a the name of a *Method*. You can use the anonymous identifier @ to access the MU for which the processing time applies. This *Method* may also be a user-defined attribute of type *method* of the MU.

The successor is the object that is connected to the selected object with a *Connector* and that succeeds it in the sequence of stations in the simulation model.



Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Enter Times

Plant Simulation inputs and outputs data referring to times in the format `1:00:00:00`, standing for, left to right, `days:hours:minutes:seconds.fractions of seconds`. `12:34` for example, means 12 minutes and 34 seconds.

If you do not want to write one day out in full, just type `1:::` and click Apply . *Plant Simulation* then translates this to the full format `1:00:00:00`.

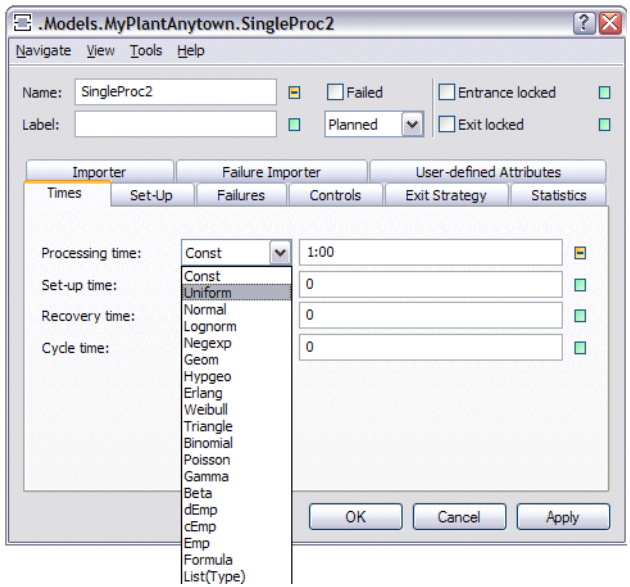
1 minute	1 hour	1 day
DDD:HH:MM:SS.XXXX Processing time: Const 1:	Processing time: Const 1::	Processing time: Const 1:::
DDD:HH:MM:SS.XXXX Processing time: Const 1:00	Processing time: Const 1:00:00	Processing time: Const 1:00:00:00

You can also enter numbers without the colon. *Plant Simulation* will then interpret the number as seconds and converts it into the above format. `111` (seconds), for example, is 1 minute and 51 seconds.

You can change time-related settings under Tools > Model Settings/Preferences > Units > Time scale.

Enter Data of a Probability Distribution

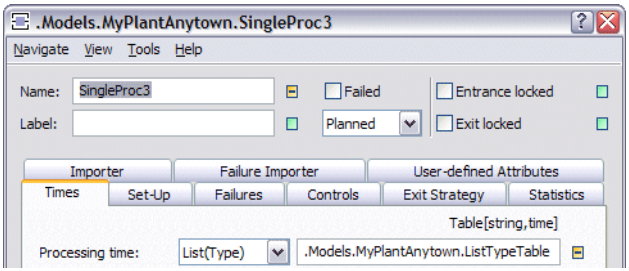
Select the distribution you want to use for the processing time from the drop-down list. Then, *Plant Simulation* shows the parameters, which this distribution requires, on the tab.



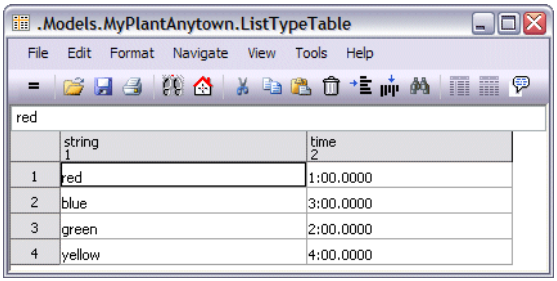
Enter the corresponding values into the text box. Note that the upper bound and the lower bound are optional, you can, but do not have to enter them.

Define Processing Times Depending on the Type of MU

To define the processing time of a station depending on the type of MU, you can use the *List(Type)* distribution.



- Select the List(Type) distribution as the Processing time.
- Enter the name of the *TableFile* object into the text box. Enter the names of all MUs to be processed into column 1 of the table and the corresponding times in seconds into column 2. *Plant Simulation* then uses this time as the processing time for the corresponding MU type.



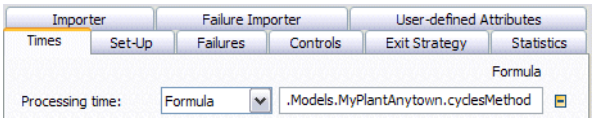
During the simulation run *Plant Simulation* reads the processing time from that table.

Define Processing Times in a Formula

You can also define the processing time of a station in a formula.

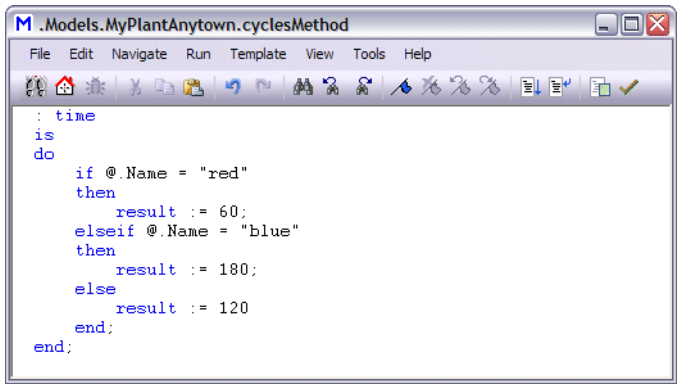
- Enter the name of a *Method* into the text box and program the formula in that *Method*.
- Enter the formula as a basic arithmetic operation directly into the text box.
- Enter the formula directly into the text box and access the MU for which the processing time applies with the anonymous identifier @.

To define the processing time of a station in a formula using a Method:



- Select Formula as the Processing time.

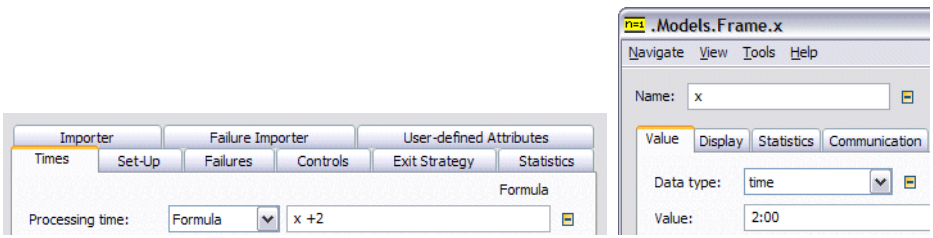
- Enter the name of a *Method* object into the text box. Enter the formula into the *Method*. This *Method* has to return a value of type *time*.



In our example, the formula, which we entered into the method *cyclesMethod*, sets how long the station processes the MUs in accordance to their color.

To define the processing time of a station in a formula with an arithmetic operator:

- Select Formula as the Processing time.
- Enter the expression into the text box. In our example we entered `x+2`. x is the name of an object of type *Variable*, of data type *time*. This variable adds two minutes to the processing time.

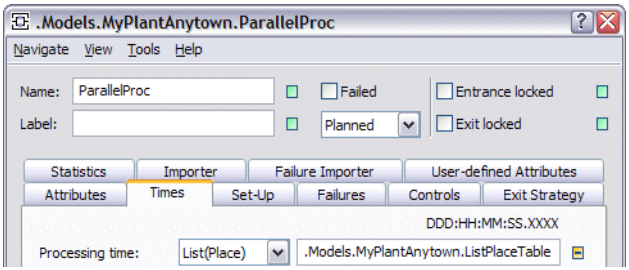


To define the processing time of a station by accessing the MU:

- Enter `@.timeRed` into the text box.
- Create a user-defined attribute for the MU and name it `timeRed`.

Define Processing Times for a ParallelProc

To define the processing time of a *ParallelProc* with several processing stations, which have different but constant processing times, you can use the *List(Place)* distribution.



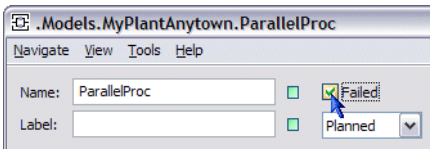
- Select the List(Place) distribution as the Processing time.
- Enter the name of the *TableFile* object into the text box. In this table, the entry [1,2] corresponds to the processing station located at position [1,2], for example.

  When an MU arrives at a processing station of a *ParallelProc* during a simulation run, *Plant Simulation* takes the appropriate time for that station from the table.

Modeling Failures

To closely model real situations, where machines fail at times, you can define one set or several sets of failures. Failures do affect the technical availability of the individual stations. You can:

- Manually fail the object by selecting Failed in the dialog of the material flow object. When you fail the object like this, you will also have to manually remove the failure by clearing the check box again.



- Define failures with the failure generator on the Tab Failures.

The state of the station then changes from *operational* to *failed*.

- By default a failed object shows a red dot in the LED display area along the top border of the icon.

  Note: The LED can simultaneously display **several** states that are active at the same time, while the state icon can only display the state it represents.

- To use an icon for each of the different states, create a new icon in the *Icon Editor*, and name it *failed*. Select Icon > Use State Icons in the *Icon Editor*, to make the object show state icons, instead of the LED.

Default LED	State icon

When you manually fail the object, it will be failed until you manually remove the failure again by clearing the check box Failed. When you fail the object with the failure generator, i.e., on the tab Failures, the failures will start, end and last for the times you enter.

As soon as the failure starts, the object changes to inactive for the duration of the failure. During this time it will not receive any parts. If a part is located on the object, its processing is interrupted for the duration of the failure and continues once the failure is cleared. *Plant Simulation* adds the duration of the failure to the processing time or to the dwelling time.

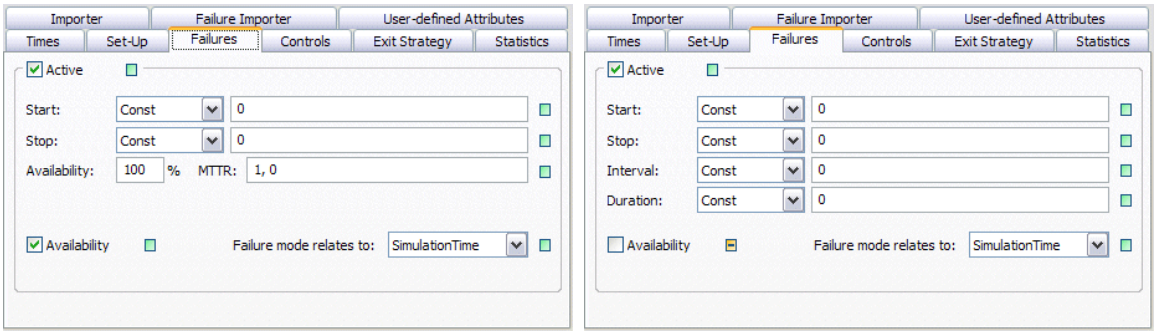
If an MU could not enter the object because of a failure, *Plant Simulation* reactivates the MU by the un-blocking mechanism as soon as the failure ends.

Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Define Failures

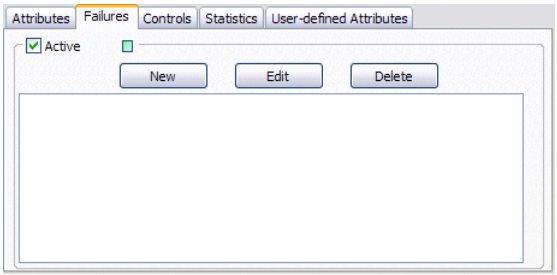
Note: When you change failure settings, we recommend to first clear the check box Active and to then click Apply. Then change your settings, apply them, and select the check box Active again. This ensures that the next failure event (DisruptionBegin/DisruptionEnd) will be calculated with a complete valid set of parameters.

Note: At present only the *Worker*, the *Exporter*, and the *Transporter* provide multiple downtimes. For the material-flow objects proper you can only define a single failure.

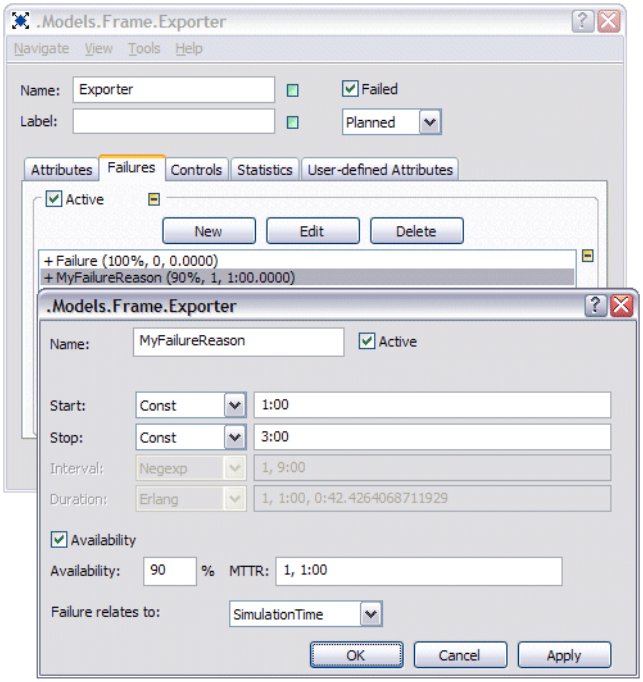


To define the failures of a station with the failure generator, proceed as follows:

1. To run your simulation model with failures in general, make sure that the check box Active is selected.

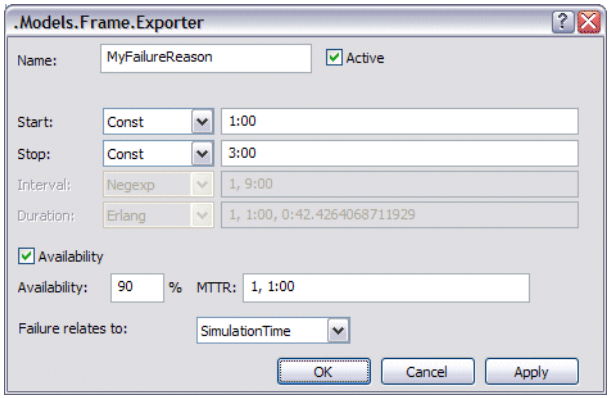


2. Click New and select and enter the parameters of the failure profile you are defining in the dialog that opens.
3. Enter a Name for the failure profile.



4. Select a distribution for the time at which the first failure takes place from the drop-down list Start.

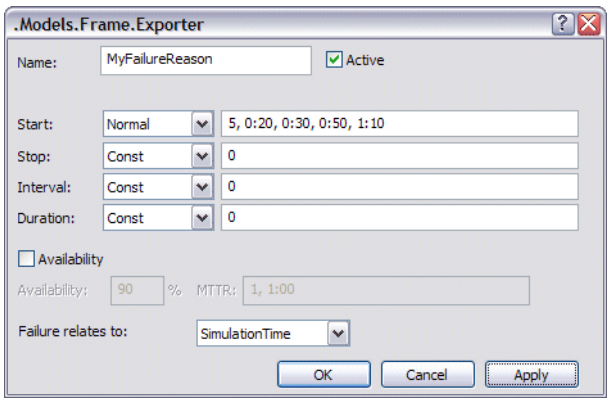
   Enter the values, which that distribution requires, into the text box. *Plant Simulation* shows these values along the top border of the tab.
5. Select a distribution for the time at which the last failure will take place from the drop-down list Stop. Enter the values, which that distribution requires. *Plant Simulation* shows these values along the top border of the tab.



When you do not enter a **Start** time and a **Stop** time, the first failure occurs after the **Interval** you entered is over. Any value you enter as the **Start** time overwrites this behavior.

6. Enter the **Availability** in percent and **MTTR**. If you would like to enter the **Interval** and the **Duration** of a failure instead, deactivate the check box **Availability**. Note that **Availability** and **MTTR** is just another kind for displaying the **Interval** and the **Duration** When you enter values for **Availability** and **MTTR** and click **Apply**, *Plant Simulation* computes the values for the **Interval** and the **Duration** and enters them into the respective text boxes. It also selects the **Negexp** distribution for the **Interval** and the **Erlang**-distribution for the **Duration**. *Plant Simulation* shows them in the dialog, when you clear the check box **Availability**. An availability of 100% has an MTTR of 0, as the machine is available and does not have to be repaired.
7. If you want to select a distribution for the **Interval** and the **Duration**, clear the check box **Availability**. Then select a distribution for the time between the end of the last failure and the beginning of the next one, i.e. the failure **Interval**, from the drop-down list. Enter the values, which that distribution requires, into the text box. *Plant Simulation* shows these values along the top border of the tab.

   Select a distribution for the **Duration** of the failure from the drop-down list. Enter the values, which that distribution requires, into the text box. *Plant Simulation* shows these values along the top border of the tab.



8. Select the time to which the failures relate from the drop-down list:
   - Processing Time

     Consumes the time you entered for the failure interval while the object is processing. An example could be a saw blade, which can only break, when the machine actually saws materials. The processing time is the time during which an MU is located on a material flow object and is being processed.
   - Simulation Time

     Consumes the time you entered for the failure interval, regardless of the state the object is in. An example could be the electronics of the installation, which may fail at any point in time. The simulation time is the time between the beginning of the simulation run (reset, start) and its end (stop).
   - Operating Time

     Consumes the time you entered for the failure interval only when the object is not paused. An example could be the coolant pump of the engine, which may fail any time during which the machine is on; the machine does not actually have to process parts. The operating time is the simulation time minus the pause time.
9. Click OK to add this failure to the list of failures. If you want to edit a failure profile, double-click it in the list or click Edit.
10. Repeat this procedure for any additional failure profiles you want to define.

Modeling Random Processes

Many computer programs use random number generators to create a stream of random numbers that generally are located in the interval between 0 and 1. Starting from given start values, the so called seed values, a large number of stochastically independent random numbers has to be available.

Compare these examples of the application of random numbers in computer programs:

- Gaming programs use random numbers to allow for a greater diversity of the operating sequence of the game.
- Database programs use random numbers to enter a large number of data sets and thus test the functionality of the database.
- Simulation programs, such as *Plant Simulation*, use random numbers to represent, among others, the interval between failures of machines.

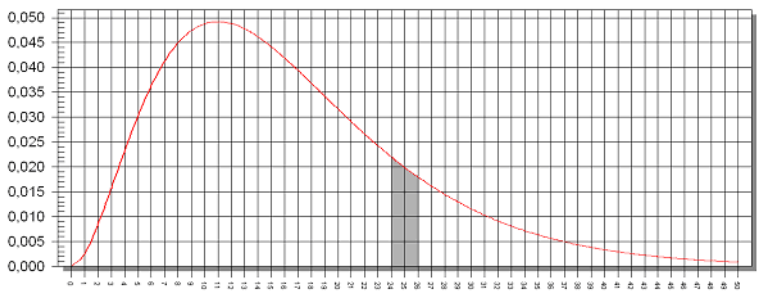
Random Numbers and Their Statistical Distribution

We know that there are deterministic processes and random processes. For a deterministic process, we can predict the result of the process, for example by knowing a law of nature. If we do not know all factors that characterize a process, its result is random. When we simulate a production processes, the occurrence of pauses is a deterministic process. Failures of machines or the rejects that are produces, on the other hand, are random processes. A random process results in a random number. The replication of the process results in the realization of the random number. Throwing the dice is a random process, the resulting number of points is the associated random number.

There are random numbers that can have individual, disjoined values. These may be a limited or an unlimited number of different values, such as the number of rejects over a long period of time or the number of orders on a day. A limited number may result from throwing the dice, an unlimited number can be a countable numbered amount. These types of random numbers are called **discrete**. To simplify matters, we suppose that these values can be 0, 1, 2, etc. For describing the random number we specify the probability for the individual numbers to be the result of throwing the dice. Adding up all probabilities has to result in 1, as one of the numbers will always be thrown.

A random number that can take all values within a limited or an unlimited interval of numbers is **continuous**. Examples of continuous random numbers are the mean time between failures (MTBF) and the mean time to repair (MTTR) of a machine. For describing a continuous random number, we cannot specify the probability for an individual number to occur. We rather have to specify the probability with which this random number is located between two given values, i.e., we specify an interval.

The **probability density function** best describes the distribution of a random number. The density function of a continuous random number only has values greater than 0 or equal to 0. It can be continuously drawn without interruption. The area underneath the function between two values a and b is the probability that the random number is located between these values a and b. Simply put the value of the density function at the location x describes how often a value will occur that approximates x. The entire area below the curve of the density function has the value 1, as with each realization of the random number a certain value occurs.



The picture above shows the density function of the gamma distribution with the parameters Alpha = 3 and Beta = 5,5. The most random numbers occur in the vicinity of the apex of the density function (random number x = 11). This value is called the **modal value**. When you build the mean of many realizations of this distribution, you will notice that the mean value is substantially greater than the mode/modal value. The mean value will be around 16.5. This gamma distribution will create random numbers between 24 and 26 with a probability of 0.04. This probability equals the gray area below the curve in the picture above.

Pseudo Random Numbers

On first sight it seems to be impossible to simulate random processes with a computer, as a computer calculates the numbers according to fixed stipulated calculation rules. A computer cannot create a truly random sequence of numbers. A computer-generated sequence of numbers can only approximately have the properties of random numbers. This is why they are called **pseudo random numbers**. The sequence of numbers that a computer creates is called random number stream. The computer calculates the following number starting from a random number. The

algorithm for creating random numbers starts out with the so-called **seed values** and can generate any number of values from them. By using different seed values you can model several random processes that are independent of each other.

For creating a random number it oftentimes suffices to create a uniformly distributed random number located in the interval between 0 and 1 (0,1). A random number is uniformly distributed, when the probability for an interval only depends on its length, and not from it position on the line of numbers. Using a uniformly distributed random number the computer can, for example, algorithmically create a normally distributed random number with a given mean value and standard deviation.

A uniformly distributed pseudo random number has to meet a number of requirements:

- The arrangement of the random numbers shows no typical characteristics, i.e., the algebraic signs of consecutive random numbers do not display any typical patterns.
- The algorithm for creating random numbers has to become periodic, as the computer only has a finite number of states. For this reason the period length has to be as large as possible.
- Starting from the given seed values a large number of stochastically independent random numbers has to be available for the simulation.
- The random processes of a simulation have to be reproducible to be able to use certain statistic methods, such as the variance reduction.

Work with Random Number Streams

In *Plant Simulation*, two random number generators create random integer numbers, using the Multiplicative Linear Congruential Generator (MLCG). These random numbers are then merged into a fraction located in the interval between 0 and 1.

Each of the two random number generators is initialized with a certain start value, the so called seed value. You can describe them in the Seed Values table, compare *Enter Seed Values*. Each random number stream in *Plant Simulation* is defined by a pair of integer values, which you enter into the two cells of one row.

Enter Seed Values

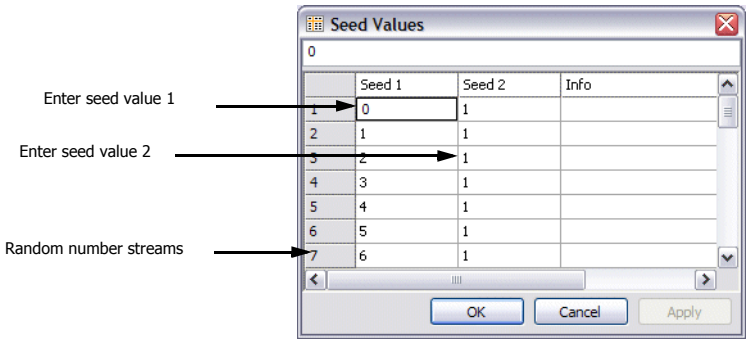
Select Tools > Seed Values in the program window:

Then:

- Add additional streams to the table. Or
- Edit any one of the existing streams, by entering different numbers.

Each random number stream in the Seed Values table is defined by a pair of integer values, which you enter into the cells below Seed 1 and Seed 2.

The two numbers you enter here stand for the seed values of two random number generators, which create integer values. *Plant Simulation* uses these two random numbers to calculate a real random number between 0 and 1.



You can tell *Plant Simulation* to start creating the random number anew from the seed values, when you start the simulation the next time:

- Select the *EventController* of your simulation model, press F8, double-click *seedReset* and enter `true`. Or
- Enter `root.eventController.seedReset := true` into a *Method*.

When the random number stream 1 has the seed values 0 and 1, the first call of the function (*Distribution Functions*) `z_uniform(1,0,1)` results in the value 0.391085897014842 and the second call in the value 0.503495287916464. The interval bounds of 0 and 1 will never be rolled.

Note: Make sure that each random process is assigned a random number stream.

The initial values, i.e., the seed values, should have different values, so that the associated events do not always occur the same point in time. You will, for example, not want all machines to fail at the same time, etc.

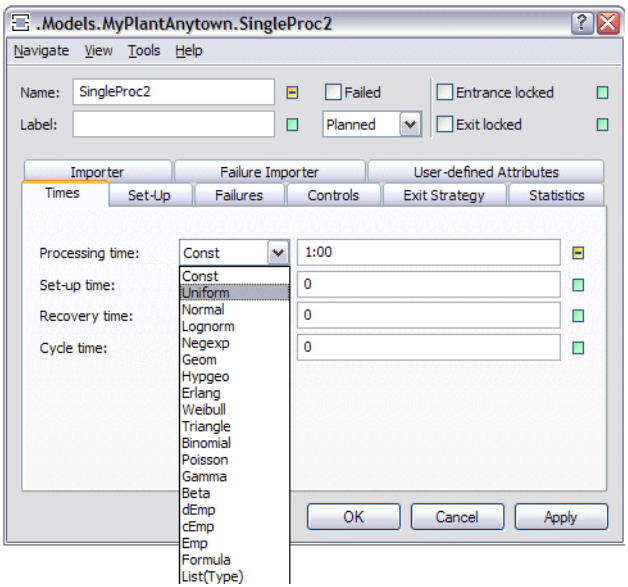
To detect how random number affect your simulation model, execute several simulation runs with different seed value tables.

Use Probability Distributions

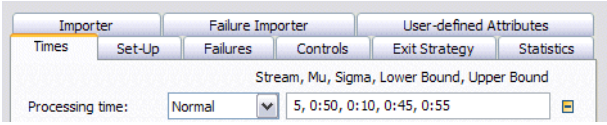
As a rule, only very few observed data about random process, such as the interval between two failures of a machine, will be available to you.

To enable you to reproduce these random processes in your simulation model, *Plant Simulation* provides a number of probability distributions, compare *Statistical Distributions*, *Empirical Distributions*, and *User-Defined Distributions* in the *Plant Simulation Reference*.

The topic *Step 3: Decide which Distribution to Use* assists you in picking the right distribution for your purpose.



Once you select the distribution from the list, *Plant Simulation* shows the parameters, which this distribution requires, on the tab.



Calculate the corresponding values in the observed data, which you received from your customer, and enter them into the text box. Note that the upper bound and the lower bound are optional, meaning that you can, but do not have to enter them.

Modeling the Flow of Materials, Advanced

In this chapter we introduce you to some of the more advanced features of modeling the flow of materials in your simulation model. You will learn:

- How to program entrance controls and exit controls that override the built-in, default transfer behavior of the material flow objects.
- How to define sensors.
- How to define observers.
- How to customize the behavior of the objects with controls and user-defined attributes.

Create Entrance and Exit Controls

You can modify the built-in transfer behavior of the material flow objects by programming Entrance and Exit controls. The object activates the *Method*, whose name you entered, as soon as an MU intends to enter or exit the respective object. Be aware that these controls override the standard transfer behavior, meaning that you yourself have to make sure that the MU moves to the correct station!

You can use control *Methods* in a number of ways. You might, for example, count the number of incoming MUs and then, after a specified number has been reached, move the following MUs to a different successor.

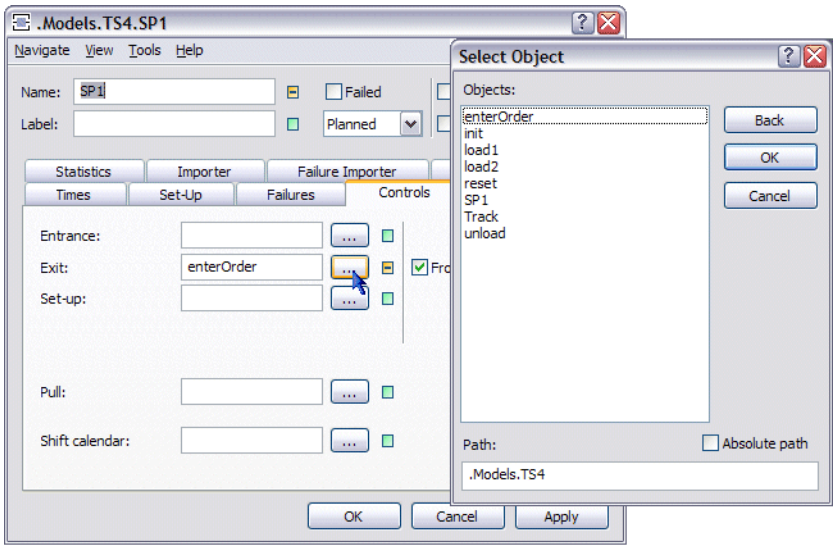
You will program the controls in a *Method*. This can either be:

- A **Method object**, which can be located in a folder in the *Class Library* or in a *Frame*. When you want a number of objects, which are located in the same *Frame*, to call the same method, you typically use a *Method* object, which you insert into that *Frame*.
- A **user-defined attribute of type method**, which only the object to which you added it, can use. When you want all instances of a class to provide the same control, you typically create that control as a user-defined attribute in the class.

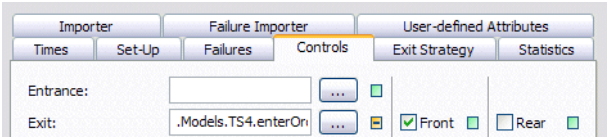
To tell *Plant Simulation* which *Method* to use, do one of the following. The process is the same for entrance and exit and backward entrance and backward exit controls:

- To select a *Method* in a *Frame*: Click the button ... and select a *Method* in the dialog Select Object. By default *Plant Simulation* enters the **relative path** into the text box.

  Note: You cannot set the processing time in the entrance control!

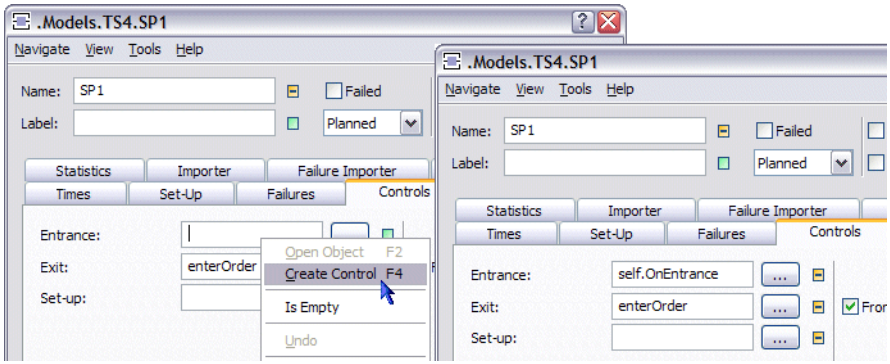


Select the *Method* in a *Frame*, drag it to the text box and drop it there. Here *Plant Simulation* enters the **absolute path** into the text box.



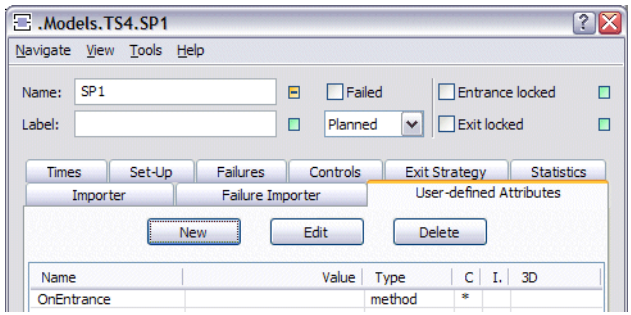
To open the dialog of the object, whose name you entered into the text box, either press F2 or right-click the text box and select Open Object or hold down Shift and double-click in the text box.

- To create a control method, which **belongs to this object**: Right-click into the text box and select Create Control on the context menu:
  - Enter a meaningful name into the text box and select Create Control. *Plant Simulation* then inserts `self.Name_you_entered_for_the_control`, such as `self.ExitControlEnginePlant`.
  - Select Create Control. *Plant Simulation* then inserts `self.OnBuilt_in_name_of_the_control`, such as `self.OnEntrance`.



Enter the source code of this control into the *Method* that opens.

Be aware that a control you create with Create Control is a user-defined attribute of the respective object, not a *Method* object, which you can open in the *Frame*.



Note: The exit control can have an optional argument of type *object*. When the method has this argument, then the successor object, which pulls the MU because the MU was contained in the blocking list of the object, will be assigned to this argument. The MU will be pulled, for example, when the successor becomes available again or when its entrance is opened.

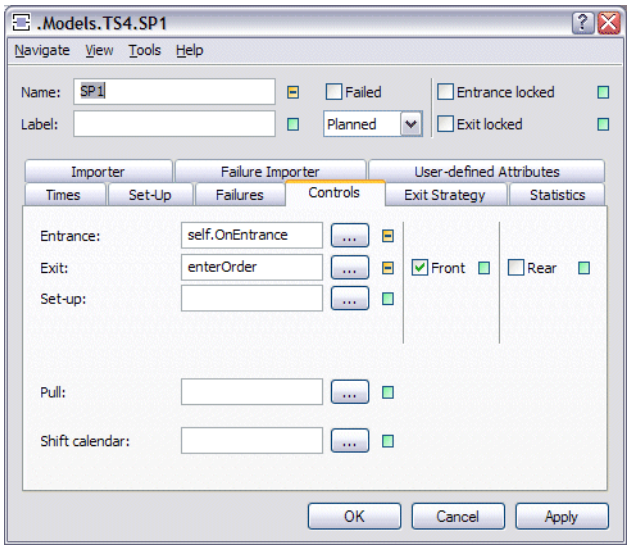
You can:

- *Define Controls for Point-Oriented Objects*
- *Define Controls for Length-Oriented Objects*

Define Controls for Point-Oriented Objects

Point-oriented objects are the material flow objects that provide one or more processing stations, but do not have a length and do not take the length of the MU into account.

The *SingleProc*, the *ParallelProc*, the *Assembly*, the *DismantleStation*, the *Buffer*, the *PlaceBuffer*, the *Store*, the *Sorter*, the *Source* and the *Drain* are point-oriented.



Plant Simulation activates the **entrance control** you entered:

- Once the MU has entered the object in its entirety, for the **point-oriented objects**, such as the *SingleProc*.

Plant Simulation activates the **exit control**, when an MU exits the object. The check boxes Front and Rear set, when the MU triggers the *Method*.

- Select Front to activate the control as soon as the MU is ready to exit the object. The exit control then has to move the part to another object, as the built-in behavior of the material flow object, i.e., moving the MU on to the successors along the *Connectors*, has been overridden by the exit control.

Note: The same MU can call the Front-activated exit control more than once, if that MU could not exit the object and entered itself into the Blocking List of the target object. As soon as the target object is ready to receive the MU, the MU is assigned a new Out event, which triggers the Front-activated exit control again.

Select Rear to activate the control as soon as the rear of the MU has completely exited the object. This control does not override the built-in behavior of how MUs move to the successor of the present object.

Note: The program calls the rear-activated exit control once only. It does not override the default exit strategy.

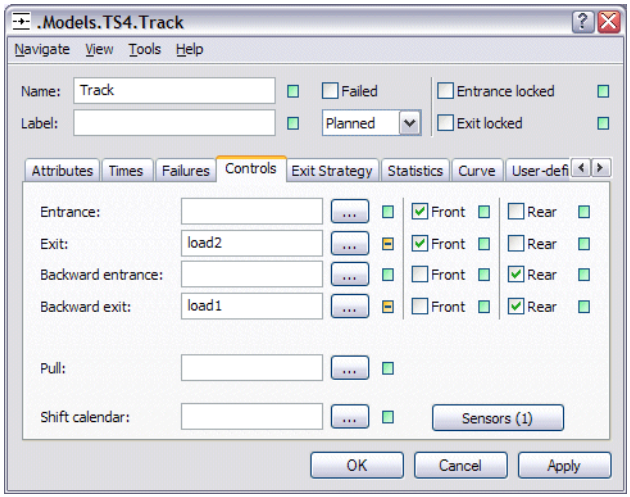
Note: Compare the out, outEnd and Reference events in the List of Scheduled Events.

- You can also select both check boxes, Front and Rear, for the entrance and the exit control. The MU then executes the control as soon as the front or the rear of the MU enters or exits the object.

Define Controls for Length-Oriented Objects

The **length-oriented objects** *Track*, *TwoLaneTrack*, *Line* and *Turntable* take their own length and the length of the MUs, which move on them, into account during the simulation runs.

In addition to the forward entrance and the forward exit controls they provide a Backward entrance and a Backward exit controls. *Plant Simulation* activates these controls, when the *Transporter* backs up on them.



Note: The *Transporter* backs up on the *Track*, it does not turn around. This means that it moves in reverse with its front end still pointing in the direction of the flow of materials instead of its front end pointing in the opposite direction!

Plant Simulation activates the **entrance control** you entered:

- When the Front or the Rear of the MU has entered the *Track* and the *Line*.

  Remember that an MU, for which you entered a length, does not move onto these objects all at once, but continually. Depending on the length and the speed of the MU, there will a delay between the time the front and the time the rear of the MU enters the object.

  - Select Front to activate the control as soon as the front of the MU has entered, i.e., is located on the object. This means that changing the processing time in the entrance control does not affect the MU that already entered the object. To set the processing time depending on the MU that arrives, define the processing time in a formula.
  - Select Rear to activate the control as soon as the rear of the MU has entered the object.

Plant Simulation activates the **backward entrance controls**:

When the Front or the Rear of the *Transporter* has moved onto the **length-oriented objects** *Track* or *Line* at their entrance while it backs up.

Remember that a *Transporter*, for which you entered a length, does not move onto these objects all at once while backing up, but continually. Depending on the length and the speed of the *Transporter*, there will a delay between the time the back and the time its front is located on the object:

- Select Rear to activate the control as soon as the rear of the *Transporter* has moved onto the object while moving in reverse.
- Select Front to activate the control as soon as the front of the *Transporter* has moved onto the object while moving in reverse.

Plant Simulation activates the **backward exit controls**:

When the Front or the Rear of the *Transporter* has moved onto the **length-oriented objects** *Track* or *Line* at their exit while it backs up. The check boxes Front and Rear set, when the *Transporter* triggers the *Methods*.

- Select Rear to activate the control as soon as the back of the *Transporter* has moved onto the object at its exit while backing up.

  Note: The program calls the rear-activated exit control once only. It does not override the default exit strategy.

- Select Front to activate the control as soon as the front of the *Transporter* has moved onto the object at its exit while backing up. The exit control then has to move the part to another object, as the built-in behavior of the material flow object, i.e., moving the MU on to the successors along the *Connectors*, has been overridden by the exit control.

  Note: The same MU can call the Front-activated exit control more than once, if that MU could not exit the object and entered itself into the Blocking List of the target object. As soon as the target object is ready to receive the MU, the MU is assigned a new Out event, which triggers the Front-activated exit control again.

Create Sensors

The material flow objects have built-in sensors, i.e., the entrance controls and the exit controls that the arriving or the exiting MUs trigger. A triggered sensor activates the *Method* object, whose name you entered as an Entrance or as an Exit control. These custom controls will then replace the built-in properties of the object.

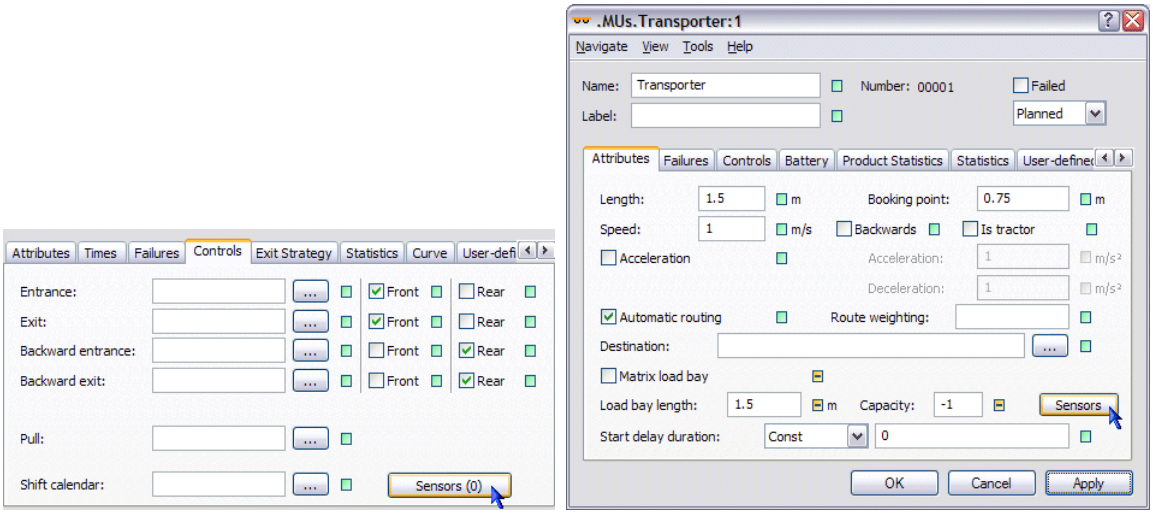
For the length-oriented objects *Track*, *TwoLaneTrack*, *Turntable*, and *Line* and for the *Transporter* you yourself can, in addition to the entrance controls and to the exit controls, define sensor controls anywhere on the object. The *Track* and the *Line* activate the *Methods* you assigned to the sensor, when an MU passes the sensor, which in your installation might be a light barrier, or some similar device. In the *Method* assigned to the control you can program the action you want *Plant Simulation* to execute. You might, for example define the conditions that apply when the parts are transferred onto the next material flow object, or you might change the target velocity, and the icon, of a transporter, when its front reaches the sensor.

To define sensors in the dialog of the *Track*, the *TwoLaneTrack*, the *Turntable*, the *Line* or the *Transporter*:

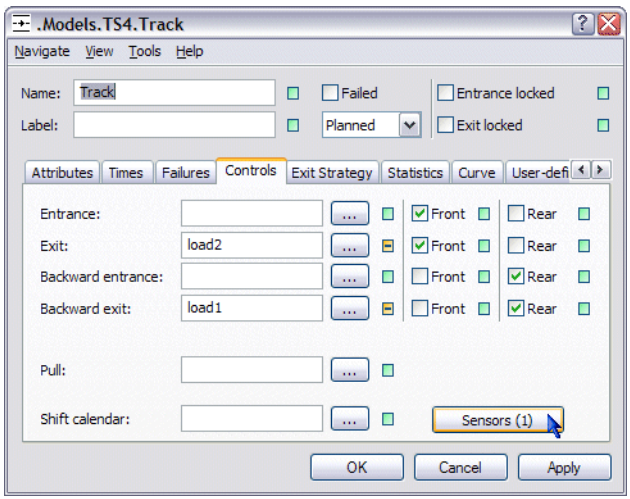
- Click the tab Controls.

  Note: The *Transporter* shows the button Sensors on the tab Attributes, when you clear Matrix load bay. Click Apply to activate the button.

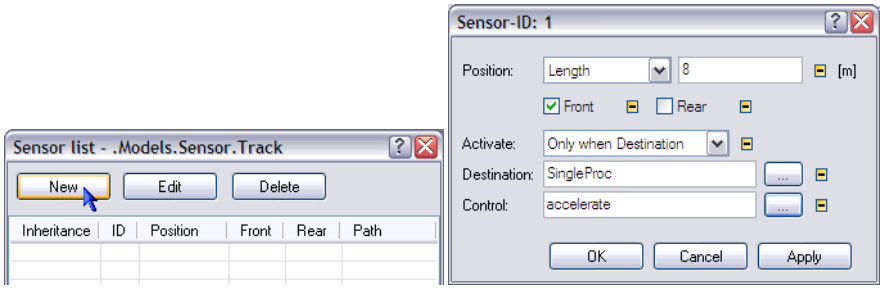
- Click ... and select the name of the control *Method* in which you programmed the action you would like the *Transporter* to execute. In our example, we want it to turn around, when its front passes the sensor.



- To add additional sensors, click Sensors.



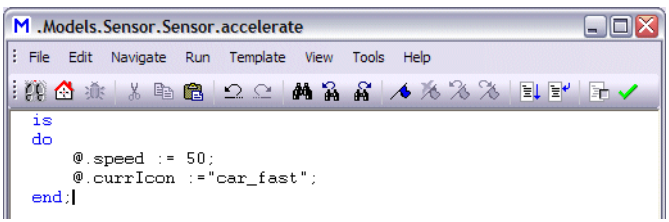
- To create a new sensor and open the dialog Sensor, click New.



- ID is the number that *Plant Simulation* automatically assigns to the sensor, when it creates it. You can use this unique identifier to access that sensor from within methods.
- Select the type of position, Relative or Length, from the drop-down list and enter the position of the sensor.
  - For Relative you can enter a value between `0` and `1`, and *Plant Simulation* shows 0..1 to the right of the text box.
  - For Length you can enter a value between `0` and the length of the object.

  Plant Simulation uses the length unit you selected under Tools > Model Settings/Preferences > Units > Length. When you enter an invalid value, *Plant Simulation* changes the color of the text box to red.
- When you define a sensor for a *Track*, you can select when a *Transporter* passing over it triggers the sensor: Always, independent of the destination of the *Transporter*. Or Only when the *Transporter* has the same destination, which you entered into the sensor.

  The *Transporter's* automatic routing feature also includes this destination object. When you assign a Destination to the *Transporter* while automatic routing is active, it drives to the sensor. There it activates the sensor Control and a destination control which you defined for the *Transporter*. The same destination object can be defined in several sensors. It may also be directly reached via different *Tracks*. Even when a direct route leads to the destination object, the *Transporter* drives to the nearest sensor, when this sensor can be reached on a shorter route than the destination object itself.
- Enter the name of the object to which the *Transporter* drives into the text box Destination.
- Click ... and select the name of the *Method* M, which the sensor calls, in the dialog Select Object. To open the dialog of the object, whose name you entered into the text box, press F2.



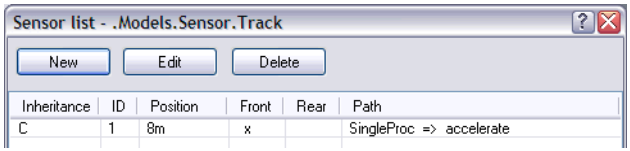
As soon as the sensor calls this *Method*, it passes the Sensor ID as argument. When the method expects an *integer* argument, the sensor passes the Sensor ID to the *Method*; if you do not enter an *integer* argument, the *Method* will be called without an argument.

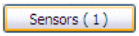
Or you can right-click in the text box. Then, select Create Control on the context menu to create a control method, which is a user-defined attribute of type *method* of this object:

- Enter a meaningful name into the text box and select Create Control. *Plant Simulation* then inserts `self.Name_you_entered_for_the_control`, such as `self.MySensorControl`.
- Select Create Control. *Plant Simulation* then inserts `self.OnBuilt_in_name_of_the_control`, such as `self.OnSelect`.

Enter the source code of this control into the *Method* that opens.

- Select Front, so that the front of the MU activates the *Method*. You can also select Front and Rear. Then both the front and the back of the MU activate the *Method*.
- Select Rear, so that the rear of the MU activates the *Method*. You can also select Front and Rear. Then both the front and the back of the MU activate the *Method*.
- Click OK to apply your settings and to close the dialog.



- When you click the Close button, *Plant Simulation* updates and shows the number of sensors on the button  in the dialog.
- To **edit** the sensor, which you selected in the list, click Edit. Or double-click the row that defines the sensor in the list.
- To **delete** the sensor, which you selected in the list, click Delete.
- To open the sensor that *Plant Simulation* inserts as a red line into the icon of the object, Alt+double-click the red line and change the settings in the dialog that opens.

Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

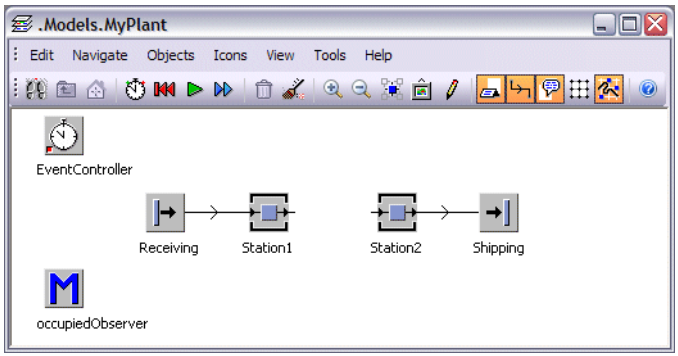
Define Observers

When you create your simulation model, it will often become necessary to trigger certain actions, when the observable values of attributes or methods of objects change. To accomplish this, you can create observers for most of the built-in objects.

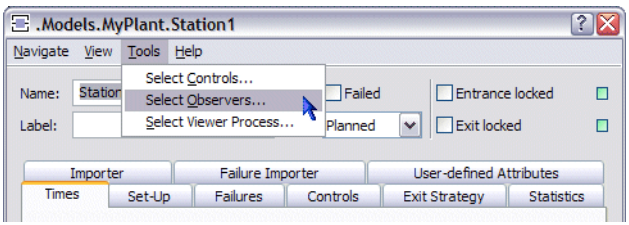
This observer observes the value of an *attribute* or of a *method* and then executes one or several *methods* when the value changes. This method can either be a *Method* object, which you insert into a *Frame*, or a user-defined attribute of type *Method*.

Note: This only works, if the attribute of the object is observable.

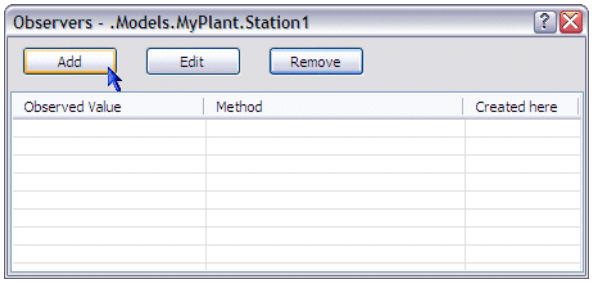
You can use observers for a wide range of applications. In our example, we show how to move the contents of *Station1* to *Station2*, when the value of the method of *Station1* changes.



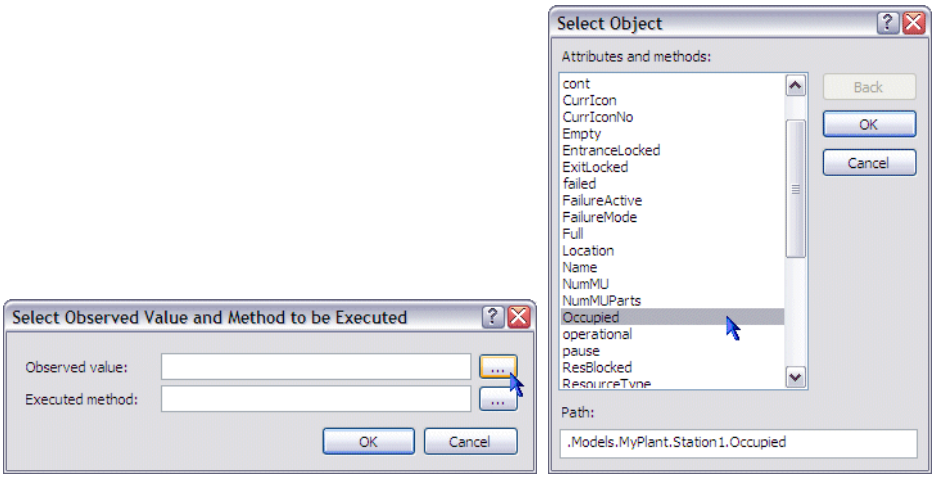
- Open the dialog of *Station1*. Select Tools > Select Observers.



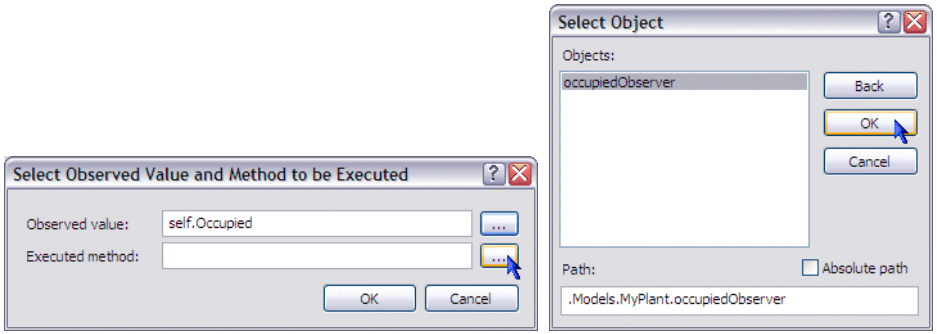
- To create the observer, click Add in the dialog Observers.



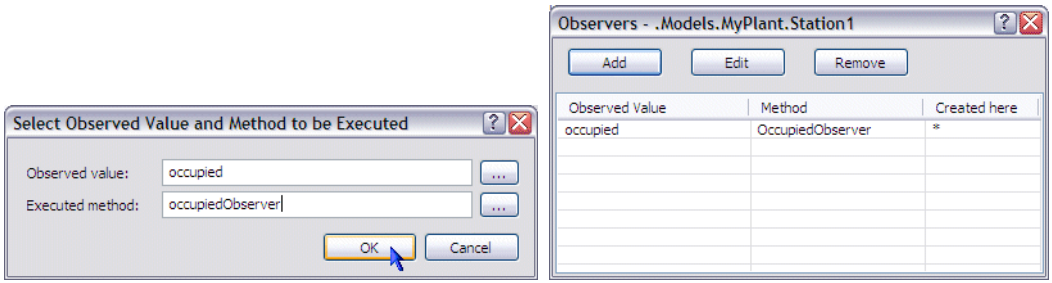
- To select the attribute or method whose value you want to watch, click [...] next to **Attribute** in the dialog **Select Observed Value and Method to be Executed**. Then, select the attribute in the dialog **Select Object**. We selected *occupied*.



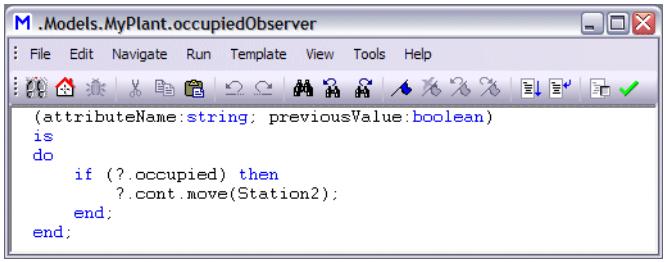
- To select the method that will be executed, when the value of the attribute or method changes, click [...] next to **Method**. Then, select the method in the dialog **Select Object**. We selected the method object *occupiedObserver* in which we programmed our transfer behavior.



- The dialog **Observers** then shows that our observer consists of the observed method *numMU* and of the method *occupiedObserver*. The asterisk shows that we created the observer in *Station1*, meaning that it is not inherited from its origin.



- The source code of our method *occupiedObserver* looks like this:



  - First, we declare the two arguments, which are passed to the *Method*:
    - The name of the attribute or the method, whose observable value changed. This allows you to use a single method as the method to be called for several attributes.
    - The previous value of the attribute or the method. This way you can still access the previous value after the executed method changed it to the new value.

- Then, we tell *Plant Simulation* to check if *Station1* is occupied, i.e., if it contains a part. If that is the case, we want it to move the part to *Station2*. Within the called *Method*, we can use the anonymous identifiers **?** and @ to address the object, whose method changed, *Station1* in our case.

Customize the Behavior of Objects

You can customize the behavior of most of the *Plant Simulation* objects to meet your modeling needs.

- You can program and assign control methods to an object. The object then reacts to certain user actions, such as inserting and deleting objects, etc.
- You can define user-defined attributes for an object, which it does not provide by default.

Define Controls

To assign a control method that makes the object take an action you want it to execute you can:

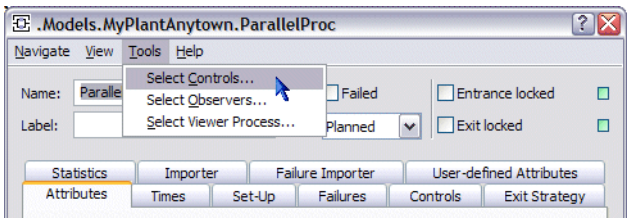
- Program the actions you want one or several objects to take in a *Method* object and insert it into a *Frame* in your simulation model or in a folder in the *Class Library*. This way you program actions that several objects can use.
- Create a control that only applies to the selected object. Then you will program the actions in a user-defined attribute of type *method* of this object. The control thus becomes part of the object and carries it with it, when you insert the object into other *Frames*.

Assign a Control Method

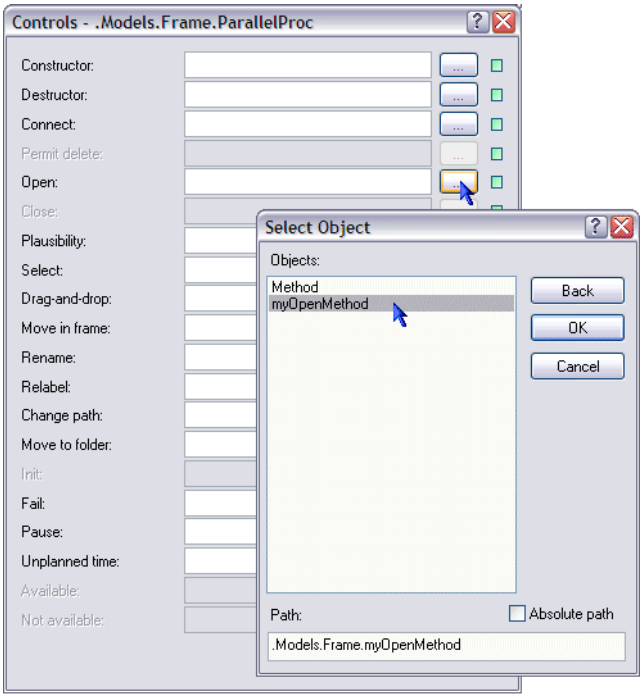
When you want a number of objects that are located in the same *Frame* to call the same method, you typically use a *Method* object, which you insert into that *Frame*.

To assign a control, which you programmed in a *Method* object:

- Program the control in a *Method* object.
- Click the object to which you want to assign the control in the *Frame*.
- Select Tools > Select Controls.



- In the dialog Controls select the *Method* to be activated, when the user or when *Plant Simulation* performs a certain action:
  - Click ... next to the name of the control. In the dialog Select Object navigate to the folder or *Frame*, in which the *Method* object is located, select it and click OK.

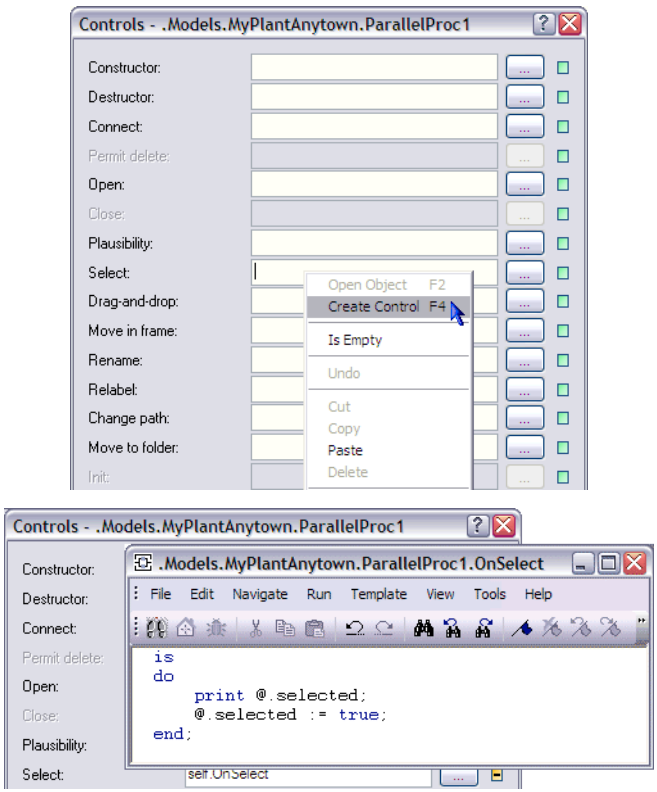


Create a Control which is Part of the Object

When you want all instances of a class to provide the same control, you typically create that control as a user-defined attribute in the class.

To create a control as a user-defined attribute of type *method* of the object:

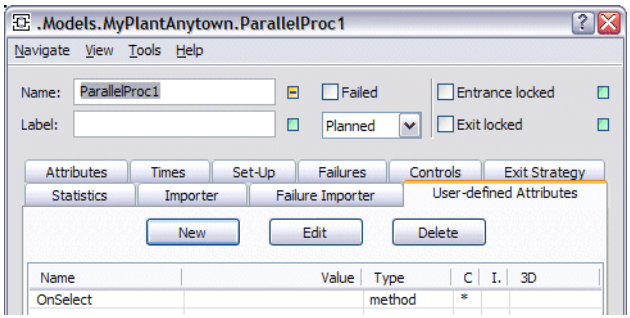
- Enter a meaningful name into the text box, right-click in the text box and select Create Control. *Plant Simulation* then inserts `self.Name_you_entered_for_the_control`, such as `self.mySelectControl`.
- Right-click in the text box and select Create Control on the context menu. *Plant Simulation* then inserts `self.OnBuilt_in_name_of_the_control`, such as `self.OnSelect`.



Enter the source code of this control into the *Method* that opens.

This control is a user-defined attribute of type *method*. To open and modify it, do one of the following:

- Click in the text box and press F2.
- Shift and double-click in the text box.
- Select the tab User-defined Attributes and double-click the name of the *Method* M in the list pane.



Create a User-Defined Attribute

In addition to the built-in attributes, which are part of the *Plant Simulation* objects, you can add user-defined attributes to meet your modeling needs to most objects. Naturally, these attributes do not affect the built-in properties of the object.

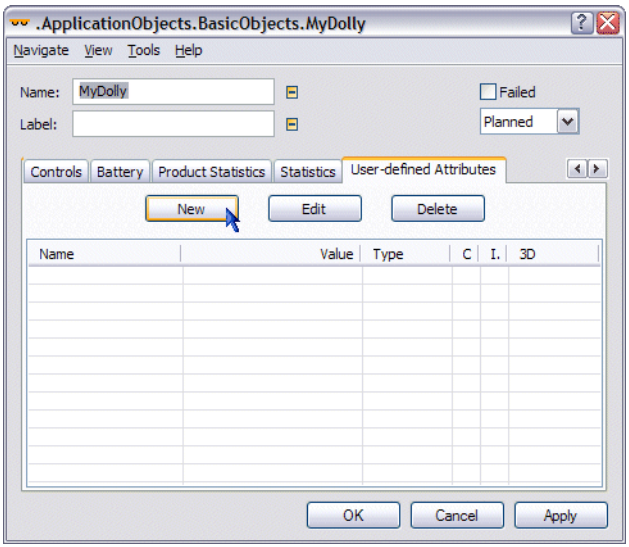
A user-defined attribute provides most of the functions that a global variable in any of the programming languages makes available. As a rule you will use a user-defined attribute for internal purposes, for example to attach the type of article, the order number, etc. to an MU.

You might, for example:

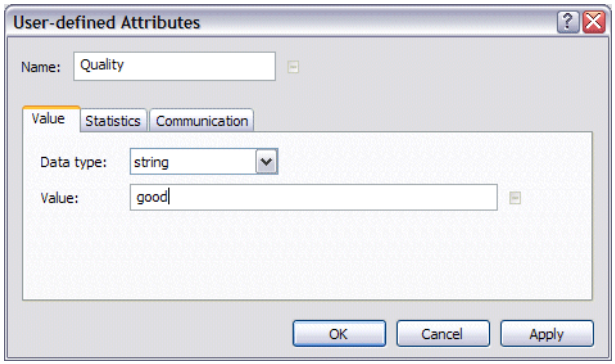
- Create the user-defined attribute with the name `Quality` for a part.
- Change its value with a *Method* to reflect a changed state, `good` or `bad` for example.
- Depending to its quality move the part either on to the next station or to a reworking station where it will be fixed to meet the quality criteria.

To create a user-defined attribute for the selected object:

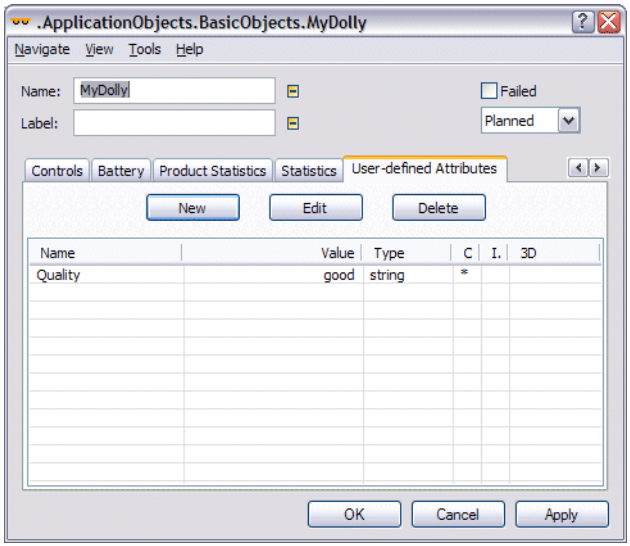
- Click the Tab User-defined Attributes, and click New.



- Enter a meaningful name for your user-defined attribute into the text box. The name has to be unique, i.e., no other built-in or user-defined attribute or method may have the same name!
- Select a Data type (compare Supported Data Types).
- Enter a value into the text box that is compatible with this data type you selected.



- Click OK to add the user-defined attribute you just created. *Plant Simulation* sorts the attribute at the correct location in the alphabet into the list.

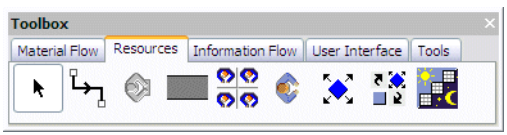


Modeling Workers and the Jobs They Do

When you simulate your installation, you also have to model workers who work at the machines (*Tab Importer*) or who repair the machines themselves (*Tab Failure Importer*). While the *Worker* works at the machine or while he repairs the machine, he stays on a *Workplace* at the associated machine. While the worker is waiting for a job, he stays in the *WorkerPool*, which might be the lounge or the staff room of your installation. When the worker has to perform one or several jobs at a machine, the foreman (*Broker*) tells him to do so. The worker then walks on a *FootPath* from the worker pool to the workplace of the respective machine and does his job.

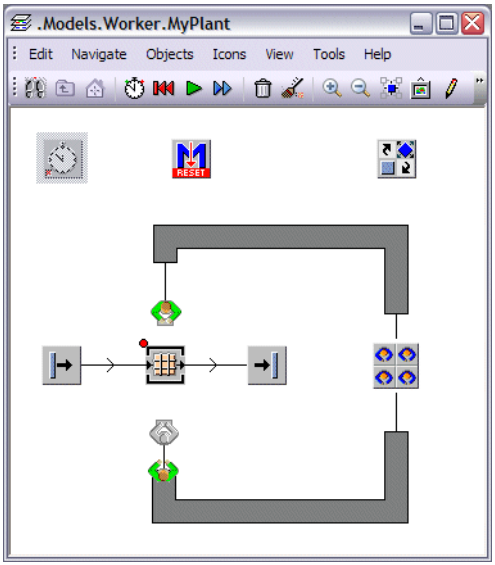
You can also use the *Broker* and the *Exporter* to model workers and the tools they need to do their jobs. As a rule, you will use the *Worker*, if the time it takes him to get to a machine is of importance to you. In addition, the *Worker* will be animated on the *FootPath* and the *Workplace* while he walks to the station and works there. You will use *Importer*, *Broker* and *Exporter* if producing a part requires shared resources and if the LEDs on these objects suffice for your animation needs.

You can insert the required objects into your simulation model from the folder Resources in the *Class Library* or from the tab Resources in the *Toolbox*.



In our examples we show how to:

- *Model a Worker Who Works at a Machine*
- *Model a Worker Who Repairs a Machine*
- *Model a Worker Who Carries Parts between Workplaces*
- *Model Workers with Importer, Broker and Exporter*



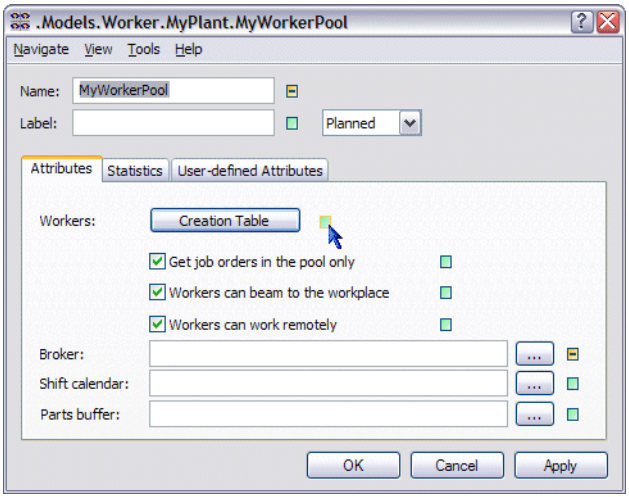
Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Model a Worker Who Works at a Machine

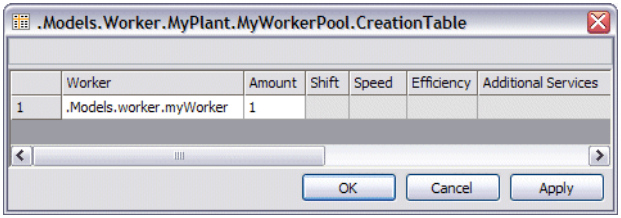
To simulate a *Worker* who works at a machine, you will typically proceed as follows:

- Configure the *WorkerPool*. This is the place where *Plant Simulation* creates the *Workers* and where they stay, when they do not work and are waiting for a job order.
  - Insert the object *WorkerPool* into your model.

    Deactivate inheritance of the Creation Table: Click the toggle button, so that it looks like this . Open the table.

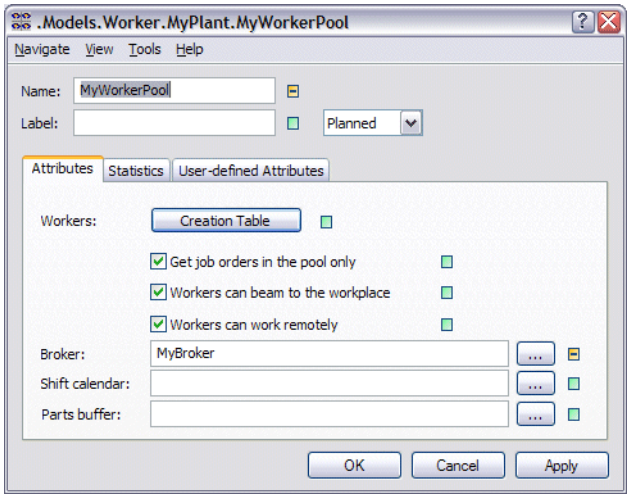


Add the path of the worker class .Models.Worker.myWorker to the Creation Table.

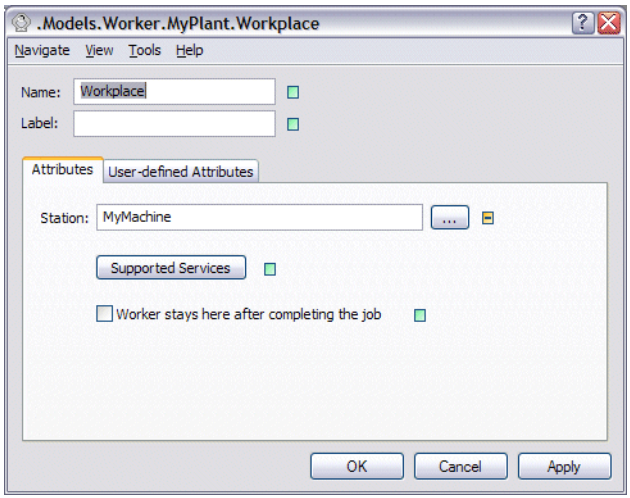


- Insert the object *Broker* into your model. He manages all of the *Workers* in your model.

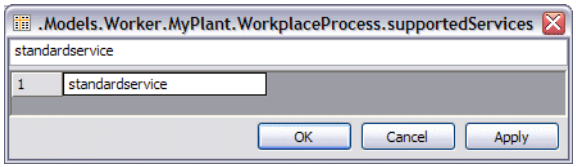
  Click the Browse button and add the *Broker* to the *WorkerPool* in the dialog Select Object.



- Insert a workplace into our model and attach it to the machine at which the *Worker* performs his job. Click the *WorkPlace* on the toolbar and place it next to the machine.
  - Drag the machine, in our example the *SingleProc* `MyMachine`, onto the dialog of the *WorkPlace* and drop it. This adds the machine to the text box Station the dialog of the *WorkPlace*.

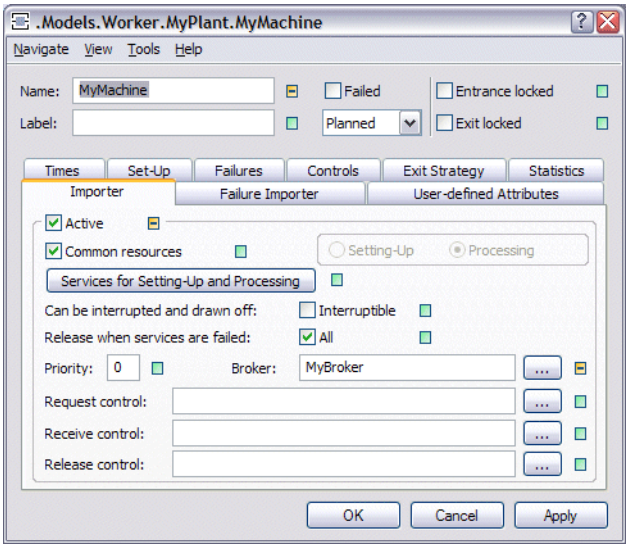


  - Deactivate inheritance: Click the toggle button, so that it looks like this . Open the table Supported Services. Type in the service `StandardService`.

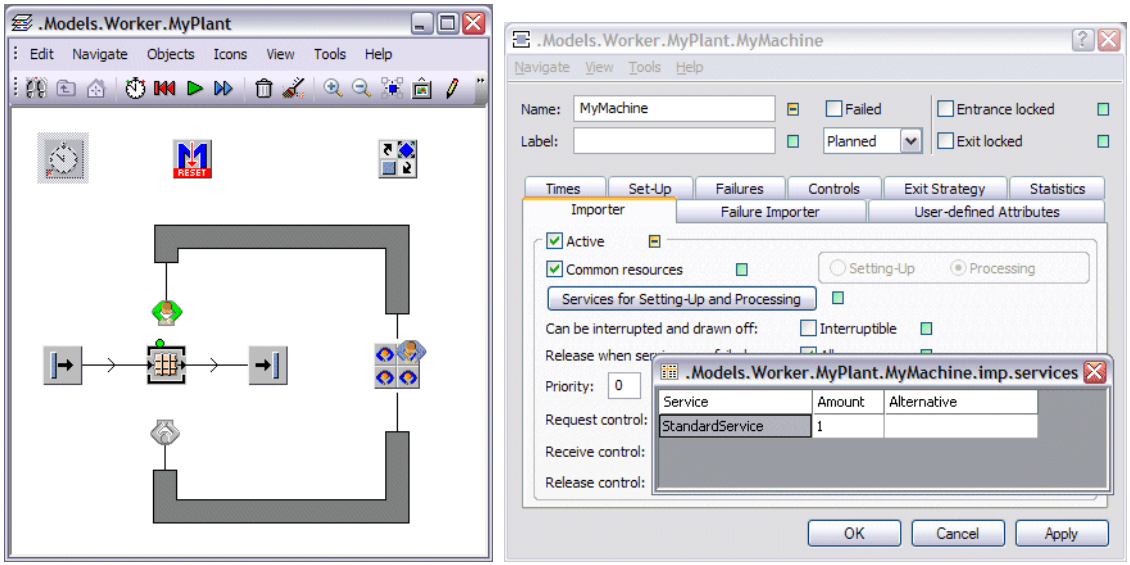


- Then, we have to tell the machine that it asks for the *Worker* to do a job: Select the check box **Active** on the tab **Importer** in the dialog of the machine.

  Click the **Browse** button and add the path of the *Broker* to the tab **Importer** in the dialog **Select Object**.



- Next, we will insert the *FootPath* on which the *Worker* walks from the *WorkerPool* to the *WorkPlace*. Finally, we have to connect the *WorkerPool* and the *FootPath* with a *Connector*.
- Open the *EventController* and reduce the simulation speed. Then, start the simulation. The *Worker* walks on the *FootPath* from the *WorkerPool* to the *WorkPlace*, works on a single part, and then returns to the *WorkerPool*. This is because he performs **1 StandardService**.

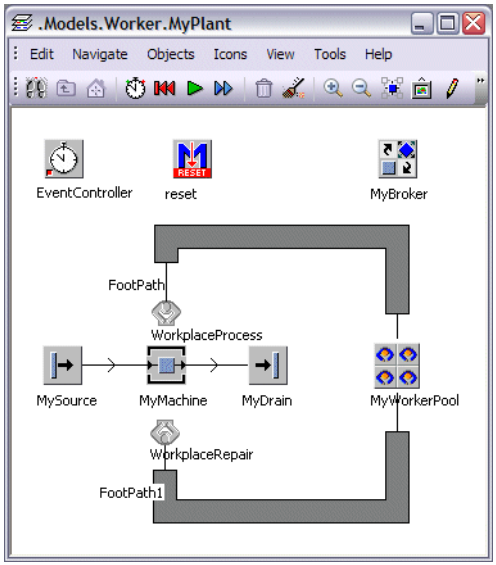


You can also click the tab Statistics and view the most important data, which the object collected.

Model a Worker Who Repairs a Machine

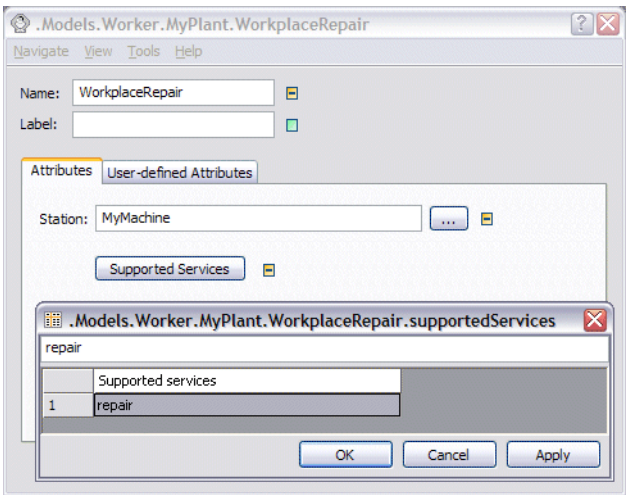
To simulate a *Worker* who repairs a machine, we continue modeling in the simulation model we created above.

- Insert a *Footpath* from the *WorkerPool* to the machine on which the repair worker gets to it. Connect *Footpath* and *WorkerPool*.

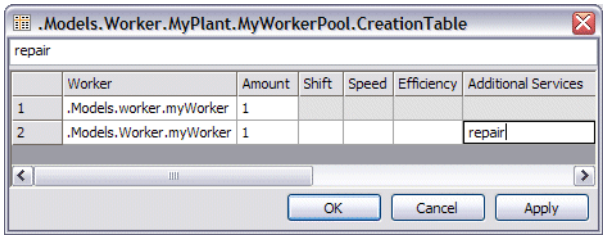


- Insert a *Workplace* on which the *Worker* stays, when he repairs the machine.

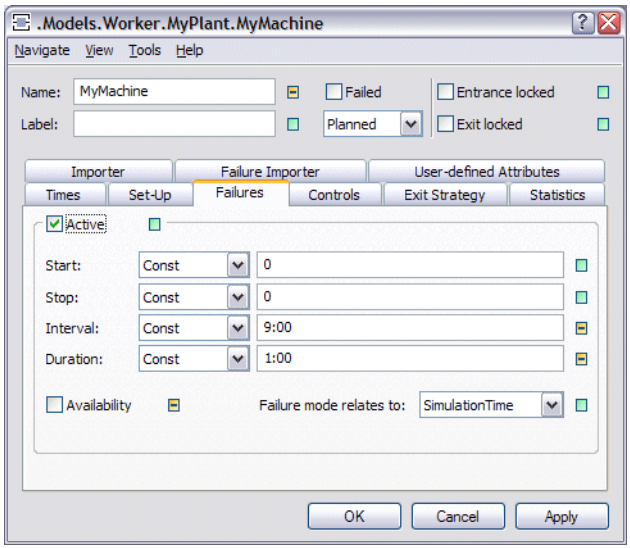
  Deactivate inheritance: Click the toggle button, so that it looks like this ▣. Open the table Supported Services. Type in the service `repair`.



- Add a second worker to the Creation Table of the *WorkerPool*: Right-click in the table and select Append Row in the context menu. Drag the worker from the *Class Library* to the cell Worker. Enter `repair` into the cell below Additional Services.

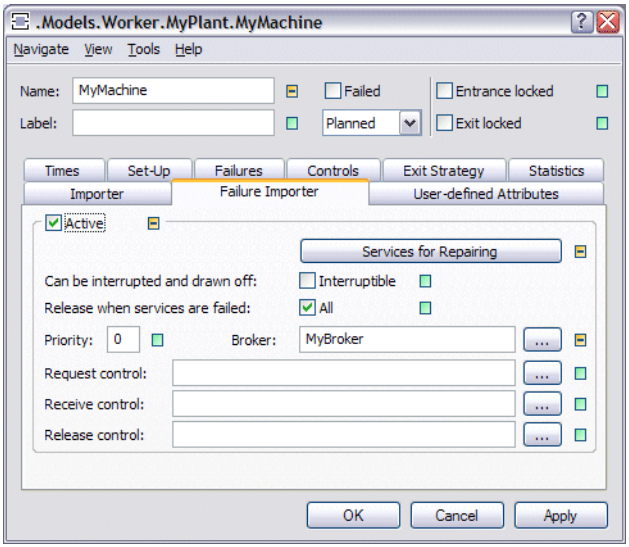


- Then, configure the machine, so that it creates failures and requests a worker for fixing this failure.
  - Select the check box **Active** on the tab **Failures** in the dialog of the machine. Type `9:` into the text box **Interval**; this is the mean time between failures. Type `1:` into the text box **Duration**; this is the mean time to repair.

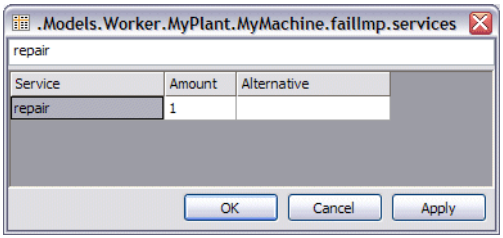


  - Select the check box **Active** on the tab **Failure Importer**.

    Click the ... button and add the path of the *Broker* to the tab **Failure Importer** in the dialog **Select Object**.



Deactivate inheritance: Click the toggle button, so that it looks like this ▫. and open the table Services for Repairing. Replace the StandardService with the service `repair`.



- Open the *EventController* and reduce the simulation speed. Then, start the simulation. You will see how the worker on the workplace at the top of the machine works on the part and how the worker on the bottom workplace repairs the machine, when it fails.

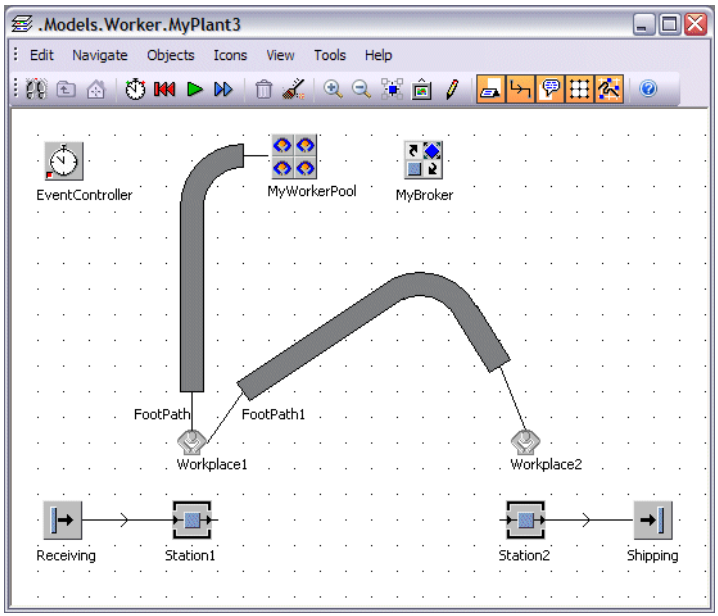
  You can also click the tab Statistics and view the most important data, which the object collected.

Model a Worker Who Carries Parts between Workplaces

To simulate a *Worker* who carries parts from workplace to workplace, you will typically proceed as follows:

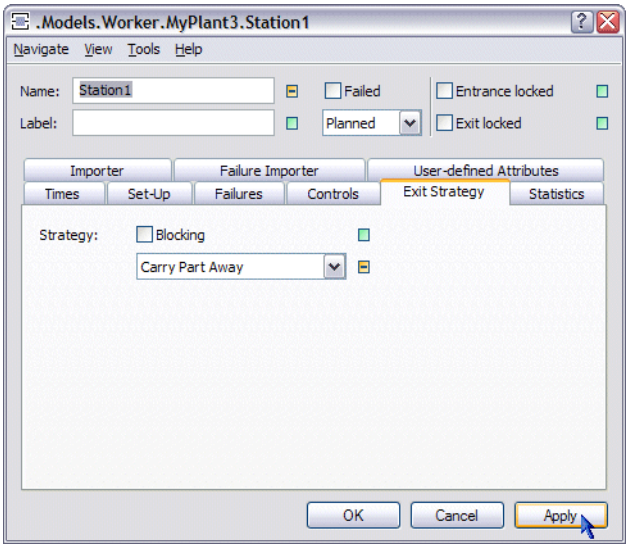
- Attach a *Workplace* to the work station at which the *Worker* picks up the part.
- Attach a *Workplace* to the target station at which he puts down the part. To automatically enter the Station, drag the *Workplace* close to one of the sides of the material flow object, which you want to use as the Station.
- Connect the *Workplaces* with a *Footpath*. The *Worker* walks on this footpath from one workplace to the next.

- Connect the *WorkerPool* and the *Workplace* at the work station at which the *Worker* picks up the part with a *Footpath*.

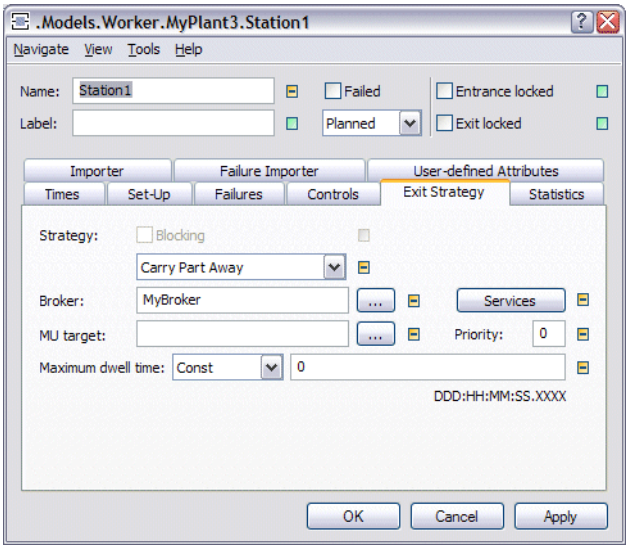


- Select the exit strategy Carry part away on the tab Exit Strategy in the dialog of the station, which is ready to send the part on. The part then requests a *Worker*. The parts wait at the station until the *Worker* arrives and picks them up.

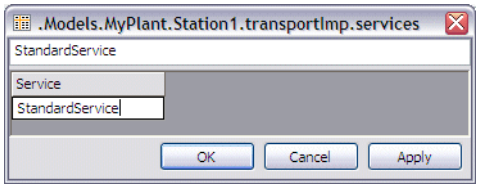
  Note: Click Apply to show the settings for this strategy.



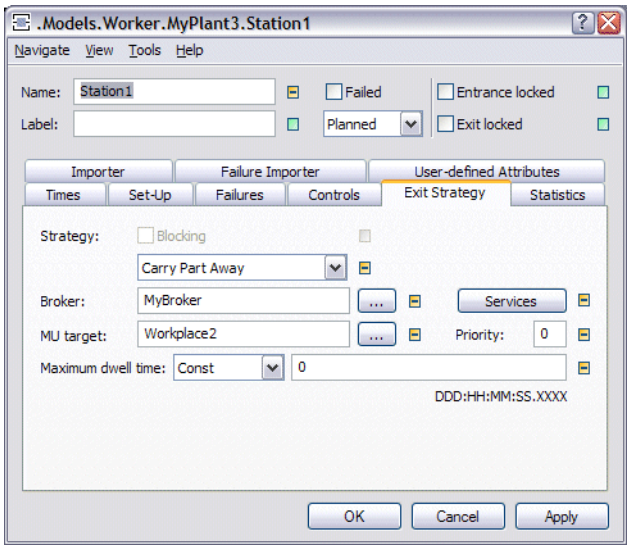
Select the *Broker* who manages the *Workers*. We selected *MyBroker*.



Enter the names of the Services which the *Broker* manages and which the *Transport-Importer* provides into the services table. We accepted the default setting, namely the `StandardService`.

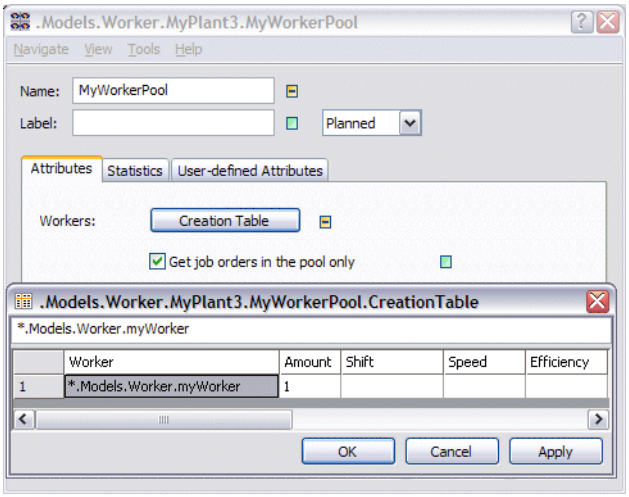


Select the MU target, i.e., the target station, at which the *Worker* places the parts. We selected *Station2*.

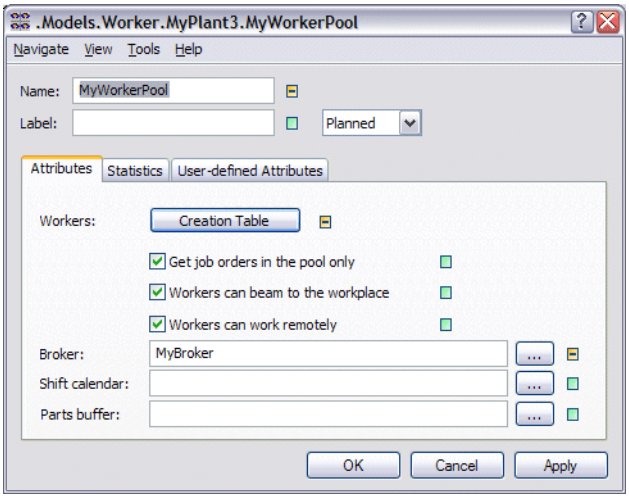


To prevent the *Worker* from waiting too long for additional parts to arrive, you have to enter the Maximum dwell time. After it has passed, he walks to the target station, the MU target. In our example we do not need to do this.

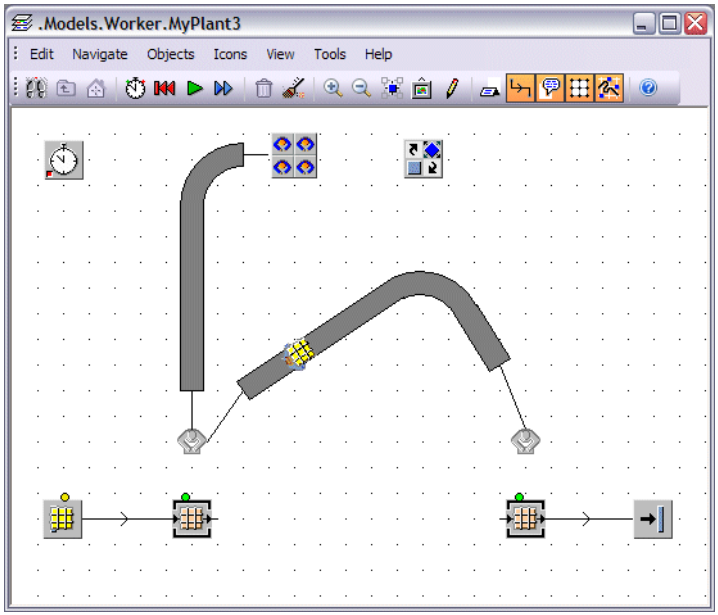
- Select the *Worker*, who carries the parts from station to station in the *WorkerPool*. We selected the worker myWorker.



- Select the *Broker* in the *WorkerPool* who manages the *Workers*. We selected *MyBroker*.

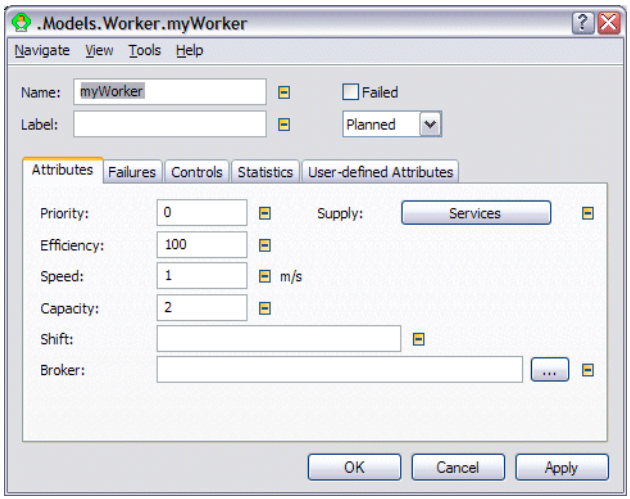


- Start the simulation run and watch the worker pick up the part at first workplace, walk on the footpath to the target workplace, put it down there, walk back to the first workplace, pick up the next part, and so on.

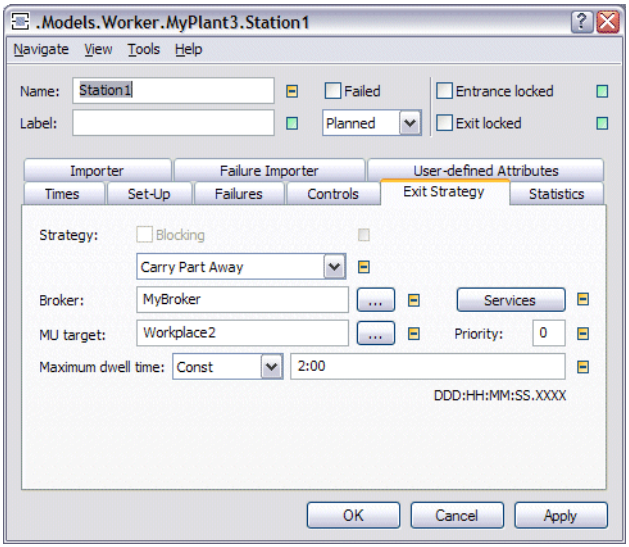


You can also model a *Worker*, who carries several parts. To do so, you just have to change these settings in the above sample model:

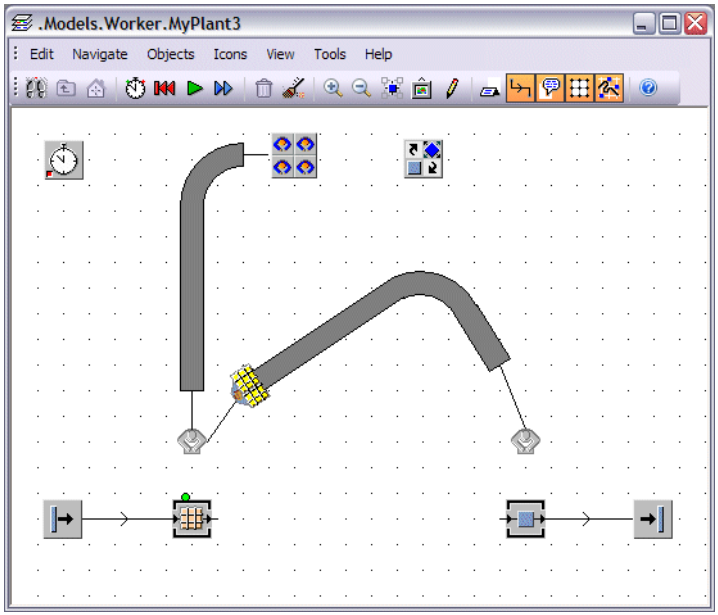
- Type the number of parts, which the *Worker* can carry into the text box Capacity. We typed in 2.



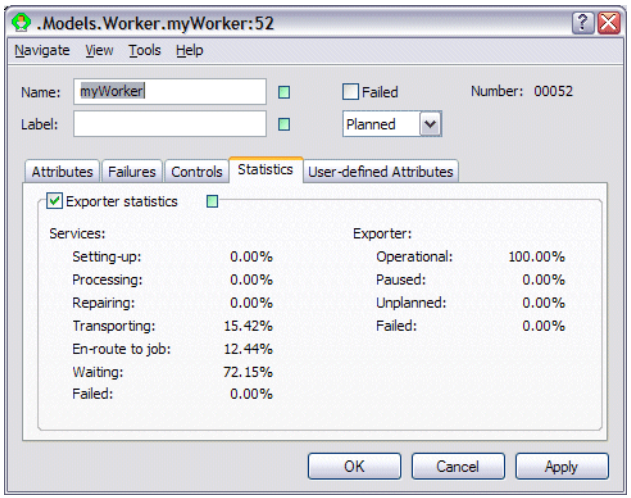
- To make the *Worker* wait for the second part, type the Maximum dwell time into die station, which wants to transfer the part. The dwell time has to be longer than the processing time.



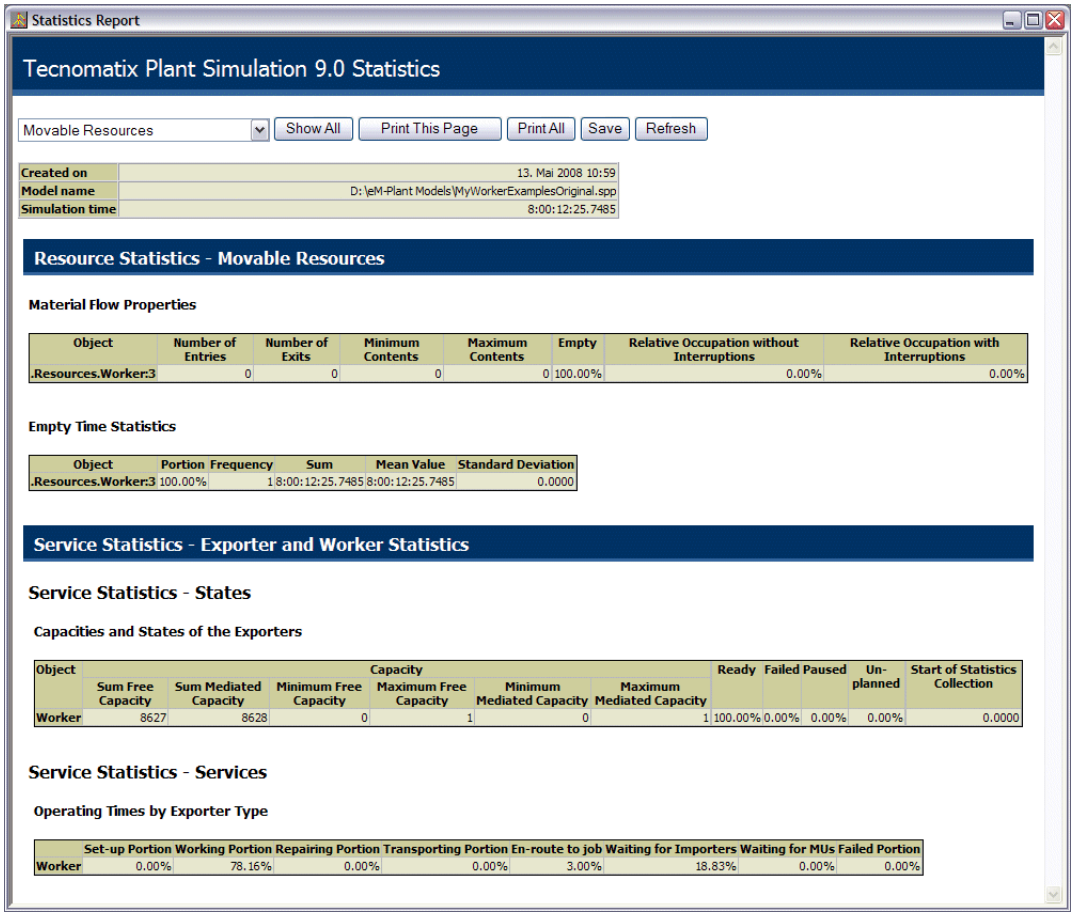
- Start the simulation and watch the worker pick up the two parts at first workplace, walk on the footpath to the target workplace, put them down there, walk back to the first workplace, pick up the next two parts, and so on.



The *Worker* shows the percentages of the carrying operations and of the en-route-times of the statistics collection time on the Tab Statistics next to Services > transporting and Services > en-route to job.



To show additional information in the *statistics report*, select the *Worker* and press the F6 key.



Statistics Report

Tecnomatix Plant Simulation 9.0 Statistics

Movable Resources | Show All | Print This Page | Print All | Save | Refresh

Created on	13. Mai 2008 10:59
Model name	D:\eM-Plant Models\MyWorkerExamplesOriginal.spp
Simulation time	8:00:12:25.7485

Resource Statistics - Movable Resources

Material Flow Properties

Object	Number of Entries	Number of Exits	Minimum Contents	Maximum Contents	Empty	Relative Occupation without Interruptions	Relative Occupation with Interruptions
.Resources.Worker:3	0	0	0	0	100.00%	0.00%	0.00%

Empty Time Statistics

Object	Portion Frequency	Sum	Mean Value	Standard Deviation
.Resources.Worker:3	100.00%	1	8:00:12:25.7485	8:00:12:25.7485	0.0000

Service Statistics - Exporter and Worker Statistics

Service Statistics - States

Capacities and States of the Exporters

Object	Capacity						Ready	Failed	Paused	Un-planned	Start of Statistics Collection
	Sum Free Capacity	Sum Mediated Capacity	Minimum Free Capacity	Maximum Free Capacity	Minimum Mediated Capacity	Maximum Mediated Capacity					
Worker	8627	8628	0	1	0	1	100.00%	0.00%	0.00%	0.00%	0.0000

Service Statistics - Services

Operating Times by Exporter Type

	Set-up Portion	Working Portion	Repairing Portion	Transporting Portion	En-route to job	Waiting for Importers	Waiting for MUs	Failed Portion
Worker	0.00%	78.16%	0.00%	0.00%	3.00%	18.83%	0.00%	0.00%

Model Workers with Importer, Broker and Exporter

Instead of using the *Worker*, you can also employ the *Broker*– Importer–*Exporter* mechanism to simulate the jobs, which a single person or a group of people do.

Employing this mechanism encompasses these basic steps:

- Telling the station which services are required for doing a job. You accomplish this by typing in the names of the **services** into the services list on the tabs Importer or Failure Importer.
- Telling the station which *Broker* assigns these services to it. You accomplish this by specifying the name of this *Broker* in the text box Broker on the tabs Importer or Failure Importer.

- Telling an *Exporter* which services it is to supply for the stations in your simulation model. You accomplish this by typing in the names of the **services** into the services list on the tab Attributes.
- Telling the *Exporter* which *Broker* manages the services it provides. You accomplish this by specifying the name of this *Broker* in the text box Broker on the tab Attributes.

As a rule, you will use *Importer*, *Broker* and *Exporter* to model workers, and the tools they need to do their jobs, if producing a part requires shared resources and if the LEDs on these objects suffice for your animation needs.

We show how to:

- *Model Processing Jobs*
- *Model Processing and Set-up Jobs*

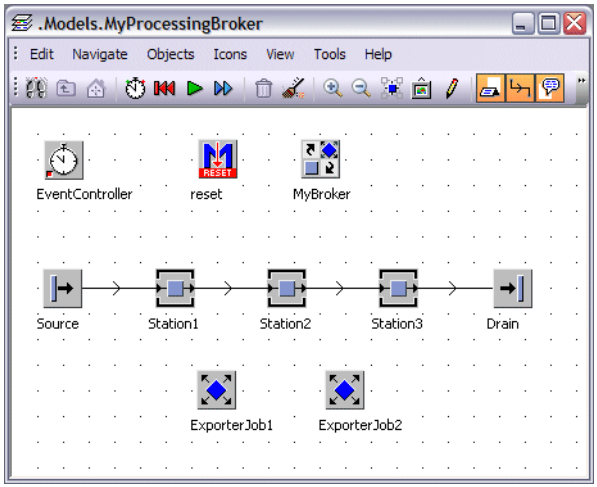
Model Processing Jobs

In our example we will demonstrate how to model jobs, which process parts.

The *Exporter* provides the services, while the *Broker* assigns the *Exporter* to the station, which we here model with the object *SingleProc*. The stations *Station1* and *Station3* both require the *Exporter* named *ExporterJob1*, which provides the service `Job1`. The station *Station2* requires the service `Job2`, which the *ExporterJob2* provides.

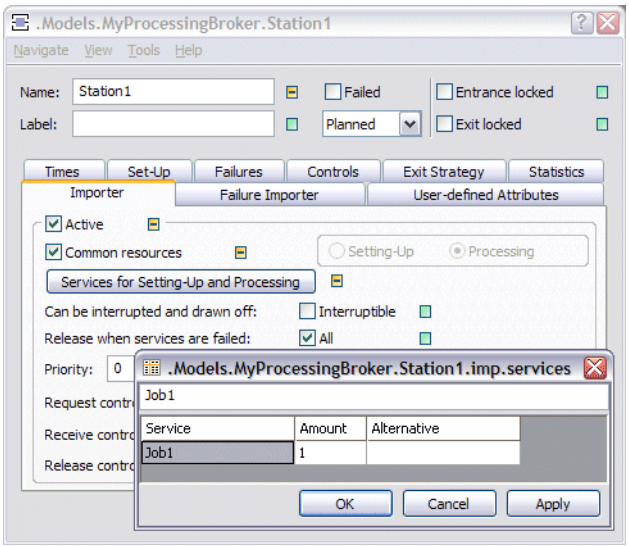
To model this, we proceed like this:

- Insert a *Source*, three *SingleProcs*, and a *Drain*. Connect them. Then, insert two *Exporters*, a *Broker*, and an *EventController*. Finally, insert a *Method*, name it `Reset` and enter `deleteMovables;` as source code.



- Open *Station1* and click the tab *Importer*.
  - Select the check box Active.
  - Make sure that the check box Common resources is selected. Deactivate inheritance for the resources: Click the toggle button to the right of Services for Setting-Up and Processing, so that it looks like this .

Click Services for Setting-Up and Processing and enter `Job1` into the column Service of the service list.

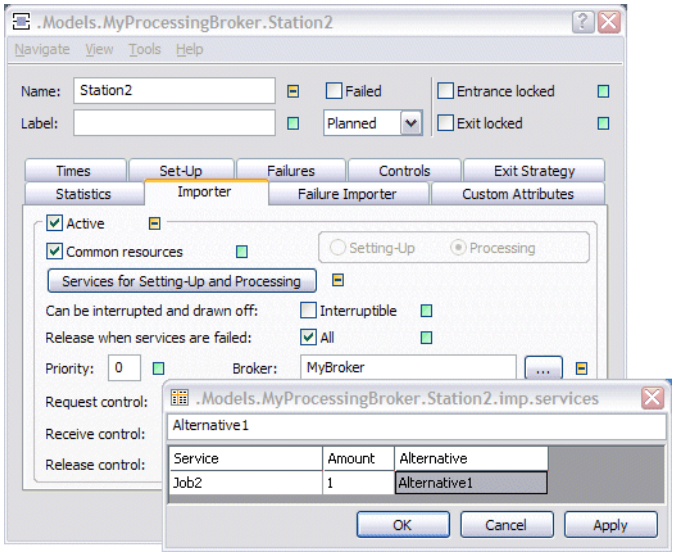


Click ... and select the *Broker*, which mediates the services, *MyBroker* in our example.

- Open *Station2* and click the tab *Importer*.
  - Select the check box Active.
  - Make sure that the check box Common resources is selected. Deactivate inheritance for the resources: Click the toggle button to the right of Services for Setting-Up and Processing, so that it looks like this ▣.

    Click Services for Setting-Up and Processing and enter `Job2` into the column Service of the service list.

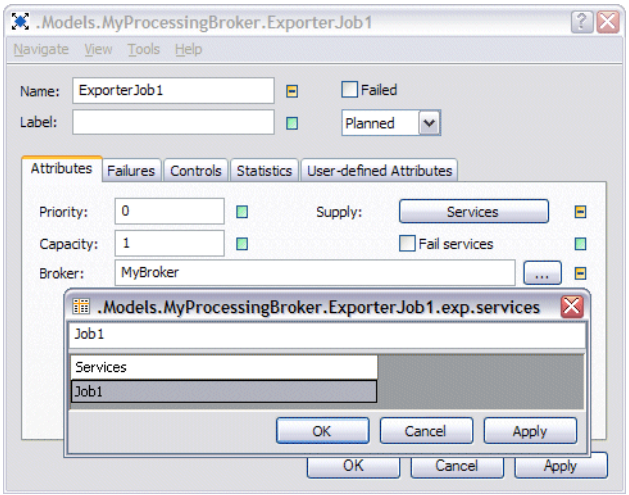
    Click ... and select the *Broker*, which mediates the services, *MyBroker* in our example.



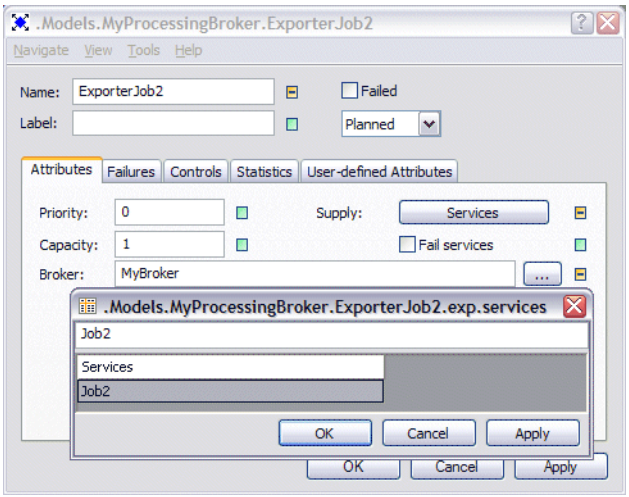
- Open *Station3* and click the tab *Importer*.
  - Select the check box **Active**.
  - Make sure that the check box **Common resources** is selected. Deactivate inheritance for the resources: Click the toggle button to the right of **Services for Setting-Up and Processing**, so that it looks like this ▣.

    Click **Services for Setting-Up and Processing** and enter `Job1` into the column **Service** of the service list.

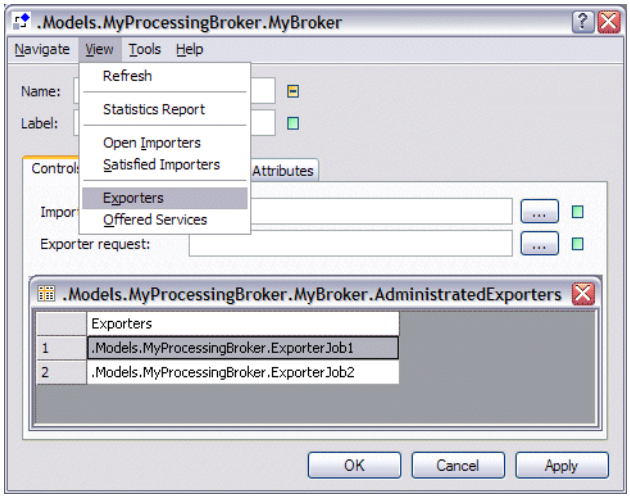
    Click ... and select the *Broker*, which mediates the services, *MyBroker* in our example.
- Next, we have tell the *Exporters*, which services they have to provide and which *Broker* mediates the services. Open *ExporterJob1*.
  - Deactivate inheritance for the services: Click the toggle button to the right of **Services**, so that it looks like this ▣. Click **Services** and enter `Job1` into the column **Services** of the service list.
  - Click ... and select the *Broker*, which mediates the services, *MyBroker* in our example.



Repeat this for *ExporterJob2*. Enter `Job2` into the column Services of the service list.



Plant Simulation automatically enters the *Exporters* and the services into the *Broker*, which we specified. To view them, open *MyBroker* and select View > Exporters and View > Offered Services.



- Finally, open the *EventController* and click Start. As the *Exporter* can only work at one station at a time, and because the stations *Station1* and *Station3* share the *ExporterJob1*, short standstills occur. *Station1* has to wait until *Station3* releases *ExporterJob1*, and thus is blocked. *Station3* in turn has to wait until *Station1* releases *ExporterJob1*, and thus is waiting.

  You can also click the tab Statistics and view the most important data, which the object collected.

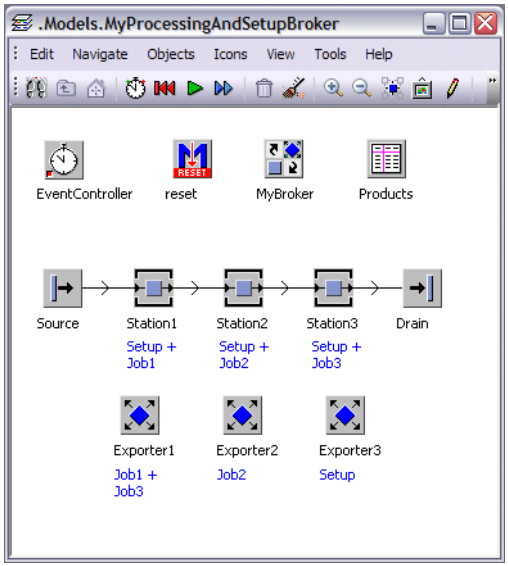
Model Processing and Set-up Jobs

In our example we will demonstrate how to model jobs, which process parts and which set the station up to process these different types of parts.

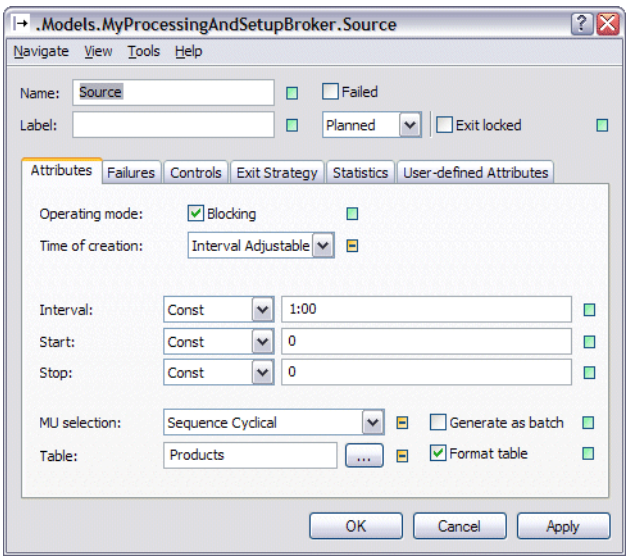
The *Exporter* provides the services, while the *Broker* assigns the *Exporter* to the station, which we here model with the object *SingleProc*. All stations need the service `Setup`, which *Exporter3* provides, for setting the station up for a new part type. *Station1* and *Station3* both require the *Exporter* named *Exporter1*, which provides the services `Job1` and `Job1`. The station *Station2* requires the service `Job2`, which *Exporter2* provides.

To model this, we proceed like this:

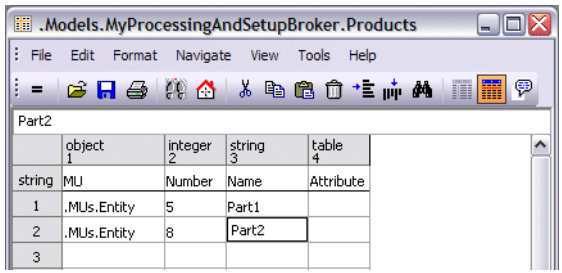
- Insert a *Source*, three *SingleProcs*, and a *Drain*. Connect them. Then, insert three *Exporters*, a *Broker*, a table, which contains the products, and an *EventController*. Finally, insert a *Method*, name it `Reset` and enter `deleteMovables;` as source code.



- First we have to tell the *Source* which type of part and how many of them we want it to create. Open the *Source* and select MU selection > Sequence Cyclical. Click ... next to Table and select the name of the table, which contains the products. This is the table, which we inserted above. Make sure that the check box Format table is selected.

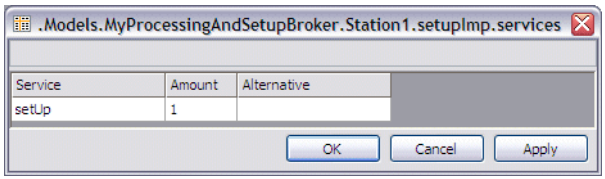


Double-click the table, `Products` in our example, and enter the name of the MU class into the column **MU**. Enter the amount of parts to be created into the column **Number**, and the name of the part into the column **Name**.

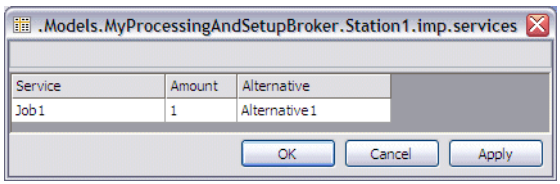


- Open *Station1* and click the tab *Importer*.
  - Select the check box **Active**.
  - Clear the check box **Common resources**. Deactivate inheritance for the resources: Click the toggle button to the right of **Services for Setting-Up** or of **Services for Processing**, so that it looks like this ▫.

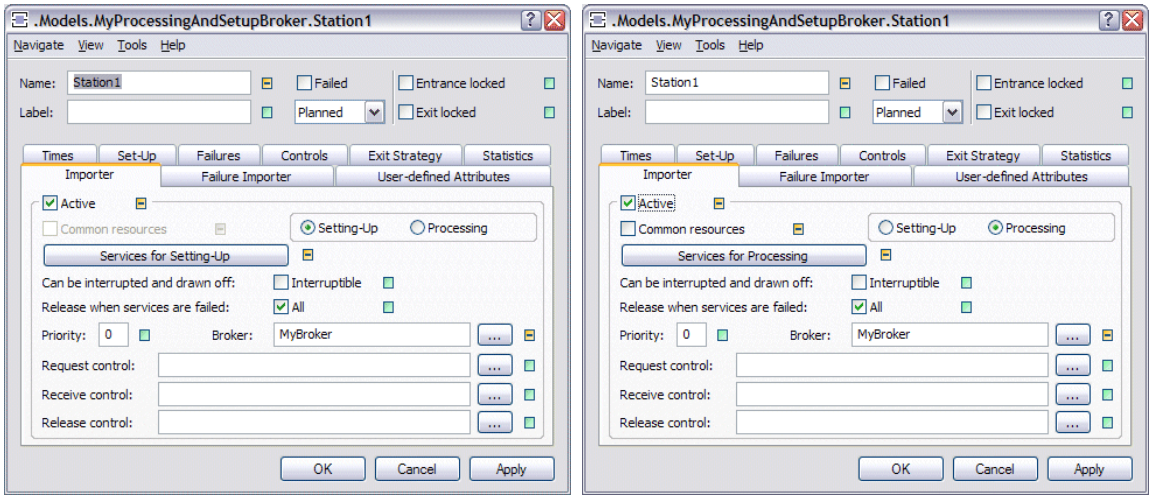
    Click **Services for Setting-Up** and enter `Setup` into the column **Service**.



    Click **Services for Processing** and enter `Job1` into the column **Service**.



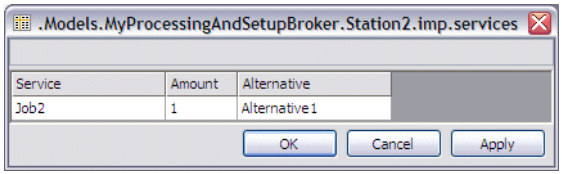
    Click and select the *Broker*, which mediates the services, *MyBroker* in our example.



- Open *Station2* and click the tab *Importer*.
  - Select the check box Active.
  - Clear the check box Common resources. Deactivate inheritance for the resources: Click the toggle button to the right of Services for Setting-Up or of Services for Processing, so that it looks like this .

    Click Services for Setting-Up and enter `Setup` into the column Service.

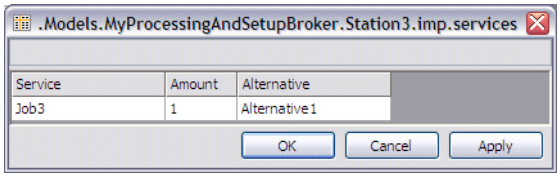
    Click Services for Processing and enter `Job2` into the column Service.



  Click ... and select the *Broker*, which mediates the services.
- Open *Station3* and click the tab *Importer*.
  - Select the check box Active.
  - Clear the check box Common resources. Deactivate inheritance for the resources: Click the toggle buttons to the right of Setting-Up and Processing, so that they look like this .

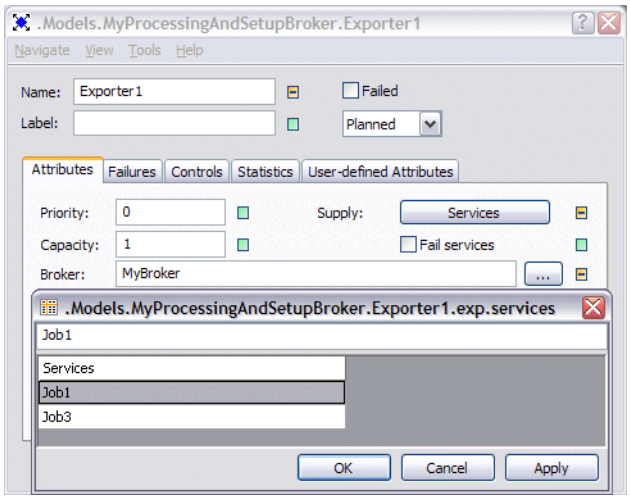
    Click Setting-Up and enter `Setup` into the column Service.

    Click Processing and enter `Job3` into the column Service.

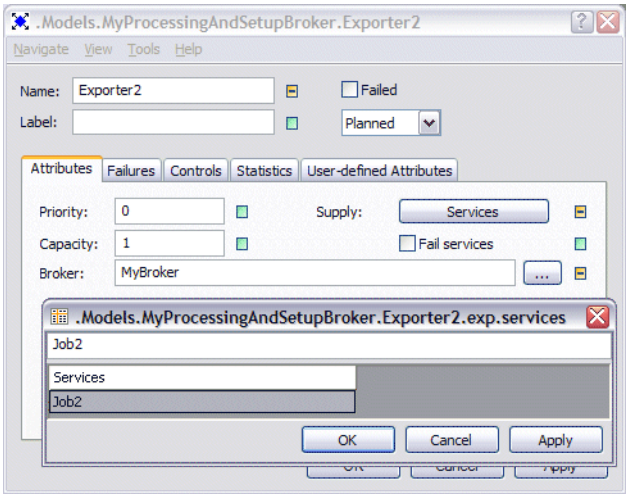


Click ... and select the *Broker*, which mediates the services.

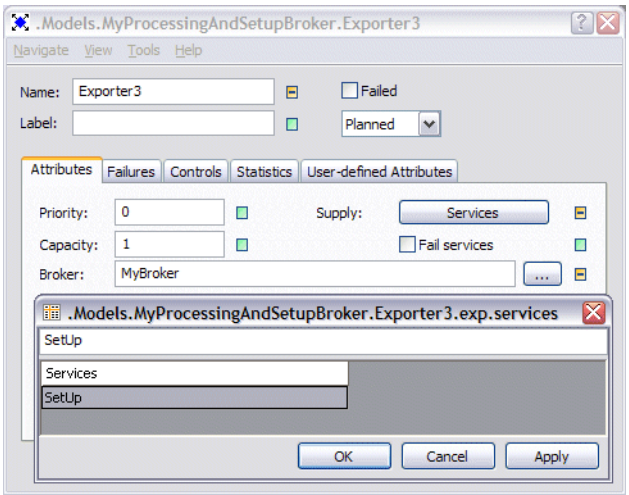
- Next, we have tell the *Exporters*, which services they have to provide and which *Broker* mediates the services. Open *Exporter1*.
  - Deactivate inheritance for the services: Click the toggle button to the right of Services, so that it looks like this ▫. Click Services and enter `Job1` and `Job3` into the column Services of the service list.
  - Click ... and select the *Broker*, which mediates the services, *MyBroker* in our example.



Repeat this for *Exporter2*. Enter `Job2` into the column Services of the service list.



Repeat this for *Exporter3*. Enter `Setup` into the column Services of the service list.



- Finally, open the *EventController* and click Start. As the *Exporter* can only work at one station at a time, and because the stations *Station1* and *Station3* share *Exporter1*, short standstills occur. *Station1* has to wait until *Station3* releases *ExporterJob1*, and thus is blocked. *Station3* in turn has to wait until *Station1* releases *Exporter1*, and thus is waiting. All stations receive the service `Setup` from *Exporter3*, which does not cause a problem as it is needed once only for each station.

  You can also click the tab Statistics and view the most important data, which the object collected.

Modeling a Shift System

When creating your simulation model, you will, more than likely, also have to integrate the shift system that applies to your installation. You can quickly and easily define these shifts with the object *ShiftCalendar*.

The *ShiftCalendar* can control the working hours as well as the paused times, the planned times and the unplanned times of these material flow objects: *Frame*, *SingleProc*, *ParallelProc*, *Assembly*, *DismantleStation*, *Buffer*, *PlaceBuffer*, *Store*, *Sorter*, *Line*, *AngularConverter*, *Turntable*, *Track*, *TwoLaneTrack*, *Source*, *Drain*, *WorkerPool* and *Exporter*.

Naturally, you can also control *Frames* in which you modeled components of your overall installation, with the *ShiftCalendar*. Here you employ methods as unplanned time and paused time controls of that *Frame* to propagate the shift settings to the objects, which you inserted into this *Frame*.

You can use the method *schedule* to make the *ShiftCalendar* set the date and time to start or to finish the production process.

Starting and Ending a Shift

When a *ShiftCalendar* starts a shift, it sets the attribute *Unplanned* of the material flow objects and of any of the *Frames* it controls to false, i.e., it deactivates unplanned times. If need be, you can program an *Unplanned-time* control that executes other actions, which your modeling situation requires.

The statistics of the material flow objects then starts to collect the unplanned time. This is the time when a resource is not planned to work.

When you define shifts that are active from 6 o'clock in the morning until 10 o'clock at night, for example, the **planned time** lasts from 6 o'clock to 22 o'clock. The **unplanned time** lasts from 22 o'clock to 6 o'clock the following morning.

When a *ShiftCalendar* finishes a shift, it sets the attribute *Unplanned* of the material flow object and *Frames* it controls to true, i.e., it activates unplanned times. Then, the objects stop processing the current part and release all services.

Starting and Ending a Break

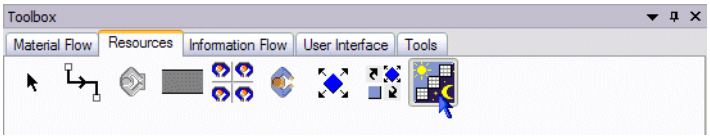
When a *ShiftCalendar* starts a break, it sets the attribute *Pause* of the material flow objects and of the *Frames* it controls to true, i.e., it activates pauses. For the material objects activating a pause also affects statistics. For *Frames Plant Simulation* only changes the state of the attribute. If need be, you can program a *Pause* control for your *Frames* that executes the actions your modeling situation requires.

When a *ShiftCalendar* ends a break, it sets the attribute *Pause* of the material flow object and *Frames* it controls to false, i.e., it deactivates pauses. For the *Frames* you can react to the end of a pause in a *Pause* control that executes the actions your modeling situation requires.

Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Defining Shifts with the ShiftCalendar

You can insert the *ShiftCalendar* into your simulation model from the folder Resources in the *Class Library* or from the tab Resources in the *Toolbox*.



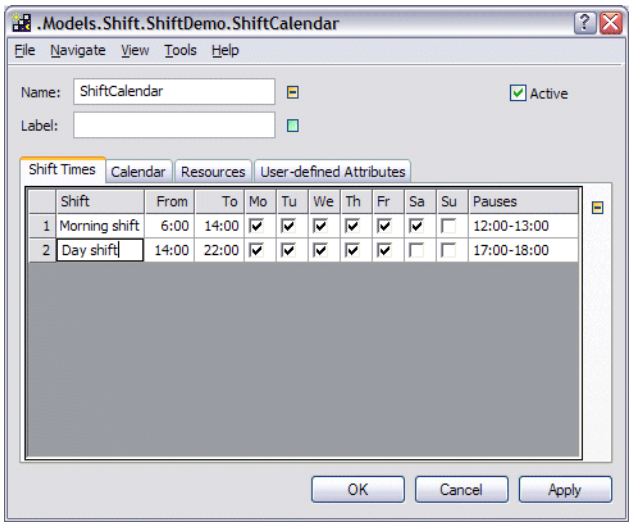
You can define the settings for the entire shift system in the *ShiftCalendar*. You can:

- *Enter the Names of the Shifts, the Corresponding Times and Days*
- *Enter Times During which the Installation Works Part of the Time*
- *Enter the Stations which the ShiftCalendar Controls*
- *Schedule Date and Time to Start or to Finish the Production Process*

Once you have entered all the settings for the shifts, you have to select the check box Active, so that *Plant Simulation* uses the shifts in your simulation model.

Enter the Names of the Shifts, the Corresponding Times and Days

Before you can enter data pertaining to the shift times, click the toggle button Inheritance, so that it looks like this .



Enter the data pertaining to one shift into the cells of one row.

- Enter the names of the different shifts into the cells below Shift. You might, for example, enter `Morning shift`, `Day shift`, `Evening shift`, `Graveyard shift`, etc.

The *ShiftCalendar* displays this icon for the day shift, and this icon for the night shift.

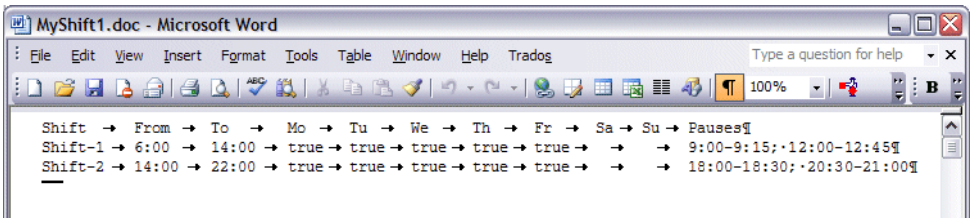
- Enter the times at which the shifts start in the cells below **From**. Enter a time between `0:00` o'clock and `24:00` o'clock. Note that you can only enter hours and minutes, not hours, minutes and seconds.
  - To define a shift located within one day, enter a greater number for the time it ends than for the time it starts. You might, for example, define a **Morning** shift that starts at `6:00` o'clock in the morning and ends at `14:00` o'clock on the same day.
  - To define a shift that spans two days, enter a smaller number for the time it ends than for the time it starts. You might, for example, define a **Graveyard** shift that starts at `22:00` o'clock at night on one day, and ends at `6:00` o'clock in the morning on the next day.
- Enter the times at which the shifts end into the cells below **To**. Enter a time between `0:00` o'clock and `24:00` o'clock. Note that you can only enter hours and minutes, not hours, minutes and seconds.
- To select the individual days on which the shift in the row is active, click in the cells below the days of the week.

  You might, for example:
  - Define a **Morning shift** that works from **Monday** up to and including **Saturday**.
  - Define an **Evening shift** that works from **Monday** up to and including **Friday**.
- Enter the times of the breaks for each shift in the cells below **Pauses**. Enter the hour and the minute when the break starts, a hyphen and the hour and minute the break ends. When you define several breaks during one work day, separate them with a semicolon.

  To define a coffee break from 9 o'clock to a quarter past 9 o'clock, and a lunch break from 12 o'clock to a quarter till 1 o'clock, enter `9:00-9:15;12:00-12:45`.

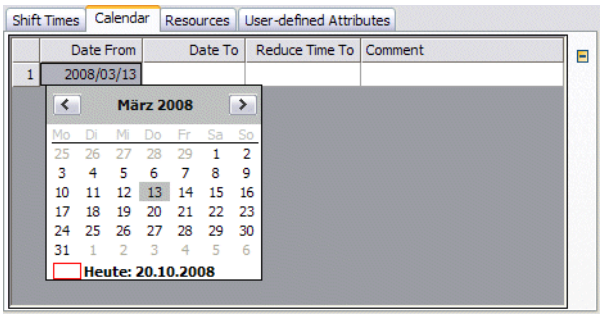
  To make the *ShiftCalendar* check if the values you entered for the breaks are plausible or not and if you used the correct format to enter the break times, click **Apply**.

You can also import the settings for the individual shifts, which you saved as a tab-delimited text file or which you received from factory management. Enter data, so that it matches the screenshot below. Or you can export a shift, which you defined, and then import it into another simulation model. To do so, right-click in the list field and select **Export** or **Import** on the context menu.



Enter Times During which the Installation Works Part of the Time

Before you can enter data pertaining to public holidays, retooling periods and times the installation only works part of the time, click the toggle button Inheritance, so that it looks like this .



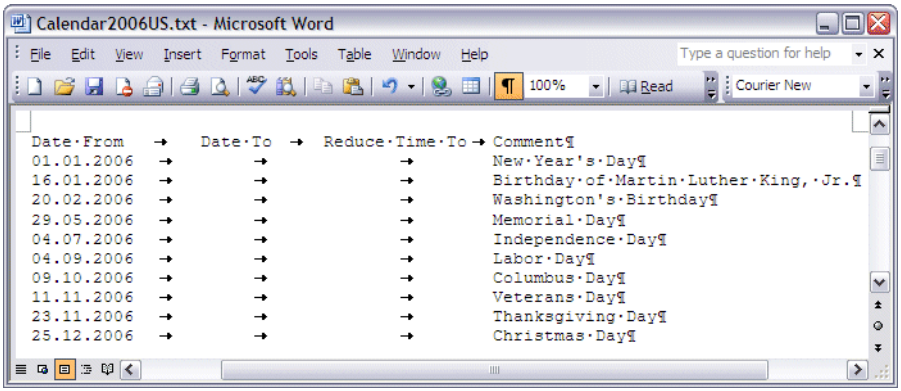
- To enter the date when your installation starts not working into the cells below Date From:
  - Double-click into the cell and click the down arrow .
  - Select a date in the calendar. Click the right or left buttons to move to another month.

  To designate an entire day as a day-off, only enter a start date and no end date (Date To), and no Reduce Time To.
- To enter the date when your installation stops not working into the cells below Date To:
  - Double-click into the cell and click the down arrow .
  - Select a date in the calendar. Click the right or left buttons to move to another month.
- To designate a single day on which your installation only works part of the time, enter its date in the cell in the column Date From. Enter the hour and the minute when the reduced working time starts, a hyphen and the hour and minute the reduced time ends in the cells below Reduce Time To.

  If your installation only works half a day on Christmas eve, for example the shifts from midnight to noon, you would enter `0:00 - 12:00` into the cell Reduce Time To.

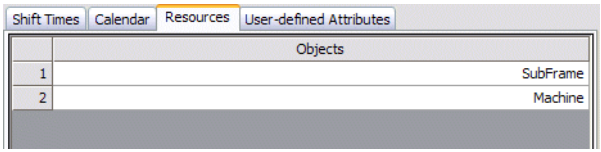
  Note: The *ShiftCalendar* combines the reduced time and the definition of the shifts for a day. If, for example, the start time of a day with a reduced working time falls on a break, then this work day starts with a break.
- Enter why your installation does not work into the cells below Comment.

You can also import a calender, which you saved as a tab-delimited text file or which you received from factory management. Enter data, so that it matches the screenshot below. Or you can export a calender you defined and then import it into another simulation model. To do so, right-click in the list field and select Export or Import on the context menu.



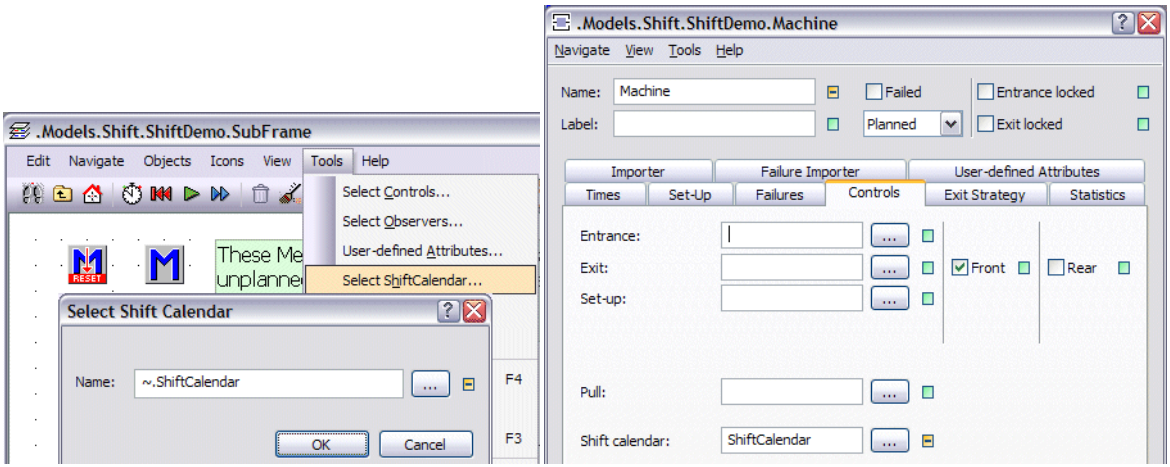
Enter the Stations which the ShiftCalendar Controls

Enter the name of any of the built-in material flow objects, or enter the name of a *Frame* you used to model a machine, whose working hours you would like to control with the *ShiftCalendar* into the cells of the list.



This automatically enters the *ShiftCalendar*:

- Into the dialog Select Shift Calendar that the command Tools > Select Shift Calendar in the *Frame* opens.
- Into the text box Shift calendar on the tab Controls of the material flow object.

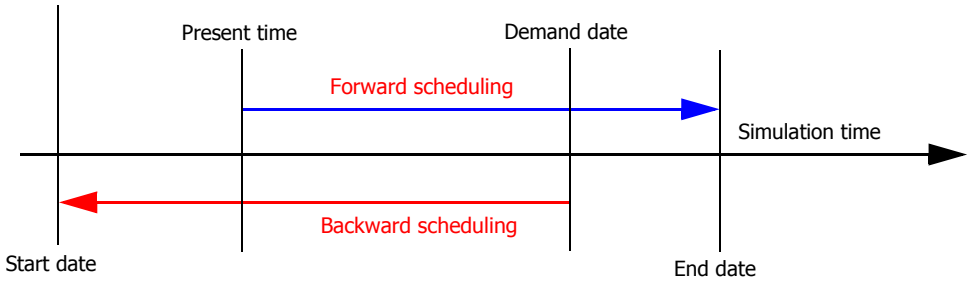


Schedule Date and Time to Start or to Finish the Production Process

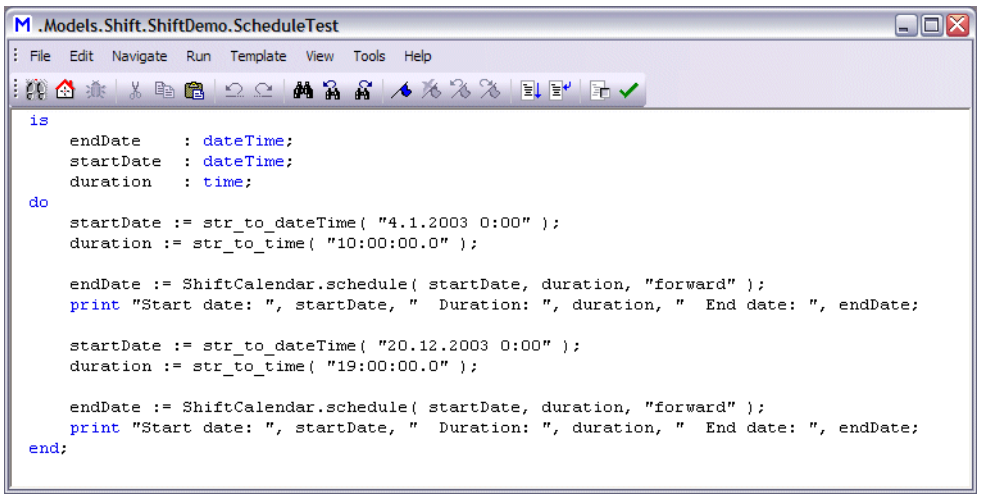
You can use the method *schedule* to set the date and the time to start or to finish the production process. We distinguish between:

- **Forward scheduling**, beginning from the start date forward into the future, and
- **Backward scheduling**, which calculates the start date going backwards in time from the demand date.

Normally you start with the demand date, and calculate the start date through backward scheduling. If this start date is located in the past though, you have to recalculate the dates beginning with the present time and forward-schedule the end date.

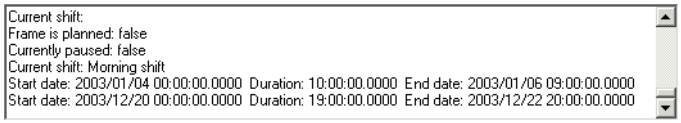


In our example below we programmed the method *schedule* to compute the end date of two jobs taking into account the shifts we defined in the *ShiftCalendar*.



The first job starts on January 4, 2003 at midnight and takes 10 hours to finish. The second job starts on December 12, 2003 and takes 19 hours. We want to know on what days and at which times the parts will be all processed, considering the morning and day shifts we defined in the *ShiftCalendar*.

We also programmed the method to print the results of its computations to the *Console*: The first job was done on January 6, 2003 at 9 o'clock in the morning. The second job will get done on December 22, 2003 at 8 o'clock in the evening.



Pausing Material Flow Objects and Pausing Frames

The *ShiftCalendar* interacts with the material flow objects and the *Frames* it controls by changing their Paused/Planned/Unplanned state. One of these objects is:

- Paused when it is not processing parts due to a pause. It resumes processing once you terminate the pause, either by selecting Planned from the drop-down list or by setting its attribute Pause to `false`.

  Note: When a station fails, and a pause occurs during the failure, the failure time of the station will still be consumed, although the station is paused. Statistics counts the times during which these two states overlap as **paused** time. Resetting your model removes both failures and pauses of the object.

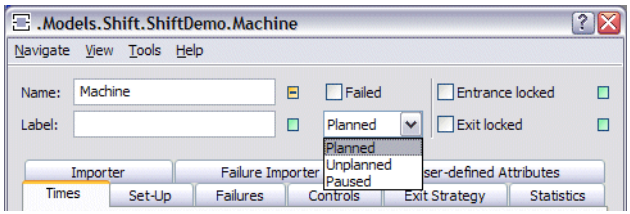
- Unplanned when it is not scheduled to work during the shifts which you defined in the *ShiftCalendar*.
- Planned when it is scheduled to work during the shifts which you defined in the *ShiftCalendar*. The scheduled/planned time is the processing time minus the times of the breaks.

We distinguish between:

- *Paused Material Flow Objects* and
- *Paused Frames*

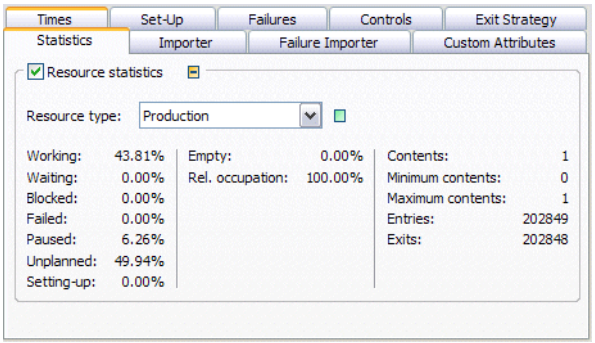
Paused Material Flow Objects

The *ShiftCalendar* interacts with the material flow objects by changing their Paused state according to the shifts you defined. During a simulation run the dialog of these objects also reflects this by selecting the present state in the drop-down list.



When it is paused, the material flow object does not receive any mobile parts. MUs can exit the object, when you program a *Method* to make them do so. *Plant Simulation* stops set-up and processing until the end of the pause or of the unplanned time.

The unplanned state is identical to the paused state. The only difference is how *Plant Simulation* counts the internal statistics of the objects. When you define shifts that are active from 6 o'clock in the morning until 10 o'clock at night, for example, the planned time lasts from 6 o'clock to 22 o'clock. The unplanned time lasts from 22 o'clock to 6 o'clock the following morning.

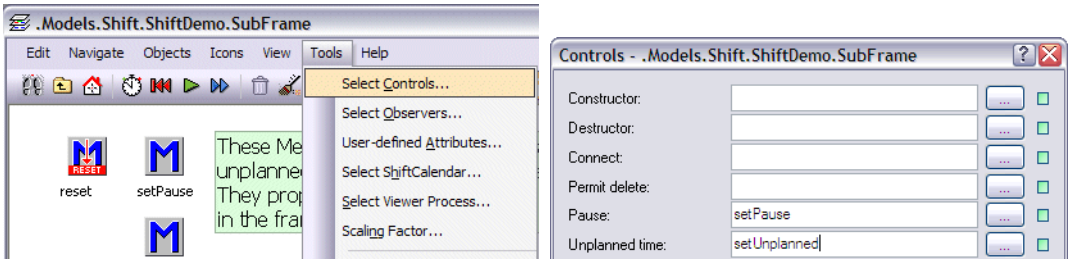


When it is planned/scheduled to work, the object receives and processes MUs and moves them on to the succeeding object in the material flow.

Paused Frames

As opposed to the material flow objects, which you can also pause manually, you can only change the paused and the unplanned states of the *Frame* with its attributes *Pause* and *Unplanned*.

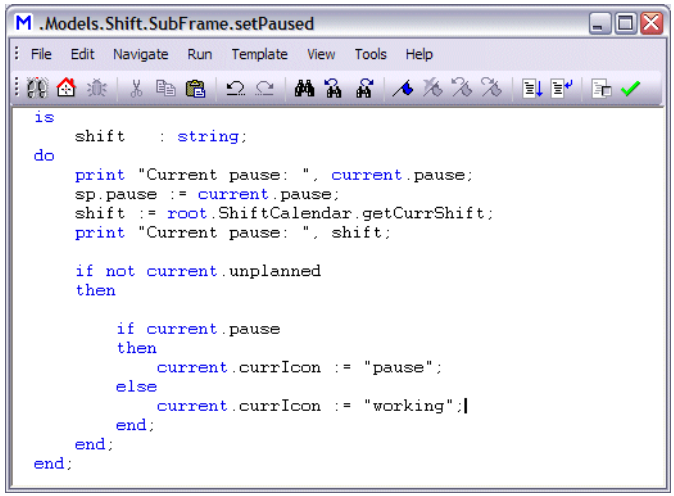
In addition, you can program a Pause and/or an Unplanned time control, both of which activate a method on changing the value of the attribute.



Example of a Pause Control

You can change the paused state of the *Frame* by assigning the value `true` or `false` to the attribute *Pause*. Use the anonymous identifier ? to access the object from within a control.

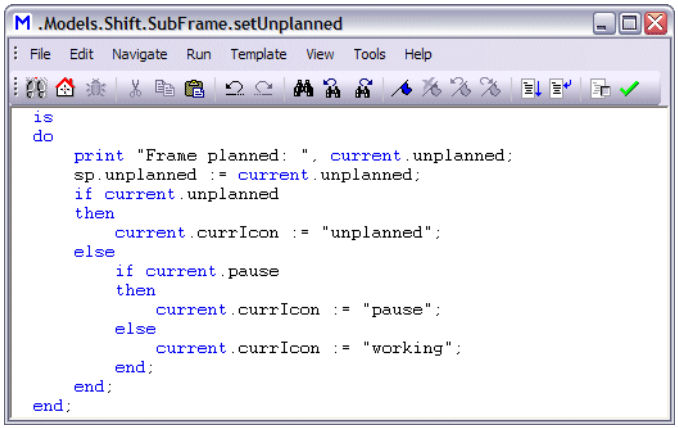
Plant Simulation executes the *Pause* control, whenever the *Paused* state of the *Frame* changes. When you get the paused state within the method, it shows the state after the change.



Example of an Unplanned Time Control

Plant Simulation executes the *Unplanned time* control, whenever the *Unplanned* state of the *Frame* changes, i.e., whether the *Frame* is not scheduled to work during the time you entered or whether it is scheduled to work.

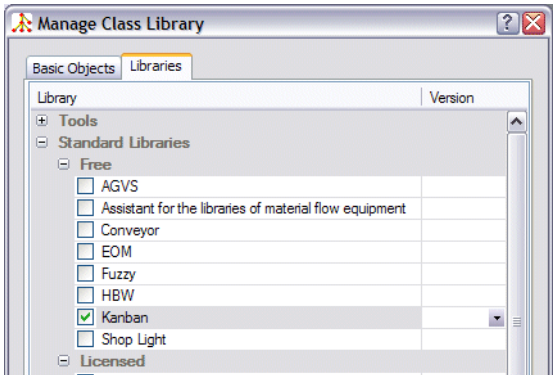
You can change the unplanned state by assigning the value `true` or `false` to the attribute *Unplanned*. Use the anonymous identifier ? to access the object from within a control.



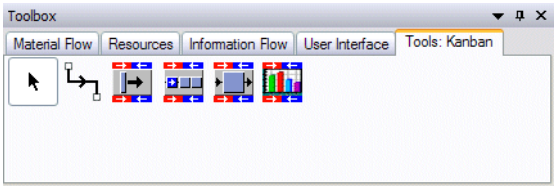
Modeling a Kanban System

You can use the *Kanban Objects* to model production facilities using *pull* strategies. The customer order at the end of the production plant determines which parts have to be produced.

To add the Kanban objects to your simulation model, click File > Manage Class Library > Libraries > Standard > Free > Kanban.



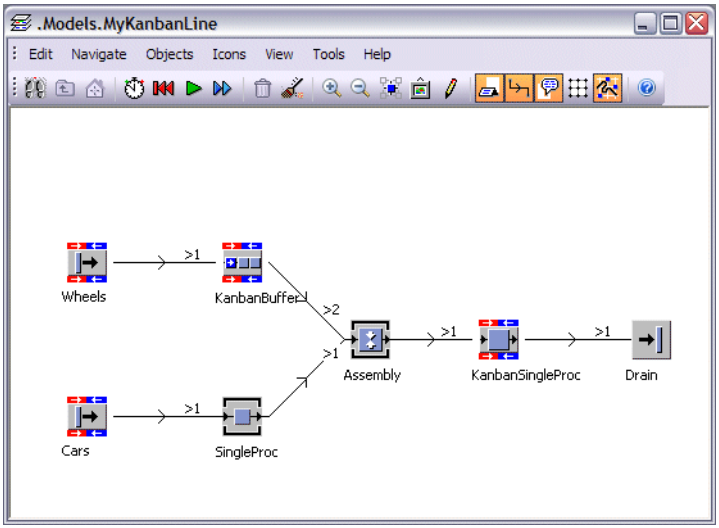
This then adds the toolbar Kanban to the Toolbox.



In our very basic simulation model a *KanbanSingleProc* at the end of a production line orders the parts, which the *Assembly* station, located directly before the *KanbanSingleProc* in the sequence of stations in the plant, requires to assemble cars. Two sublines feed wheels for two differing car models via a *KanbanBuffer* and two *KanbanSources* into the plant.

In addition to the stations we inserted above, we need:

- A control, which orders the wheels to be attached to the car, when it is ready to be moved to the *Assembly* station. We enter this control as an exit control into the *SingleProc Processing* on the bottom line.
- A bill of materials, i.e., a *TableFile*, which tells how many and which type of wheel the two car models need.
- An *Eventcontroller* to control the simulation.



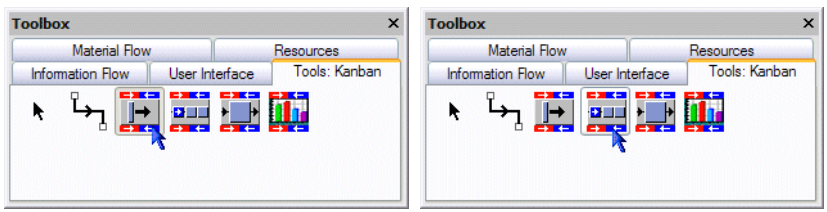
In our example we will:

- *Create the Sequence of Stations within the Line*
- *Configure the Assembly Station*
- *Configure the Kanban Station which Orders the Parts*
- *Configure the Kanban Sources which Produce the Parts*
- *Configure the Kanban Buffer which Manages Storing and Ordering of Parts*
- *Program a Control which Orders Parts from the Kanban Buffer*

Create the Sequence of Stations within the Line

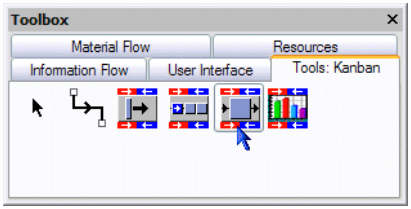
We'll start modeling our Kanban system by establishing the sequence of stations within the plant.

- Insert a *KanbanSource* and a *KanbanBuffer*, which feed the wheels for our cars to the *Assembly* station.



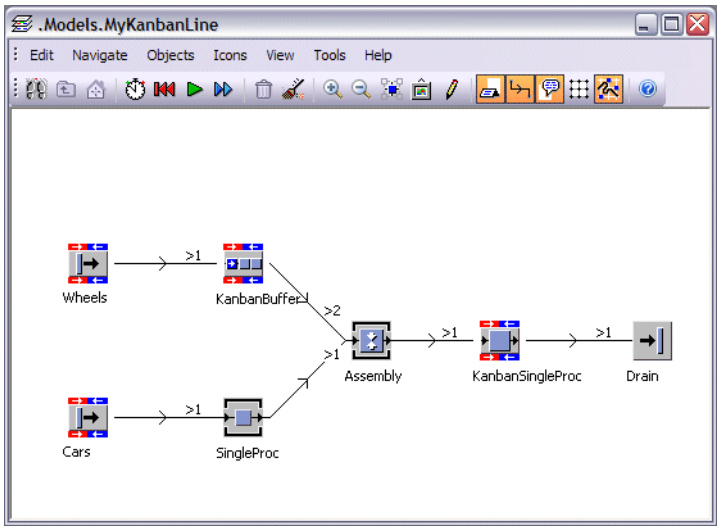
- Insert another *KanbanSource*, which produces the cars to which the wheels from the other line are attached. Insert a processing station, a *SingleProc* in our case, to the right of the *KanbanSource*.

- Insert an *Assembly Station* to the right of the two feeding lines. It attaches the wheels to the cars.
- Insert a *KanbanSingleProc* and a *Drain* . This *KanbanSingleProc* is the crucial station of the entire system as it orders the parts to be produced and assembled.



- Connect all objects with *Connectors*. Make sure that you connect the bottom line to the *Assembly* station **before** connecting the top line.

The model should then look like this:



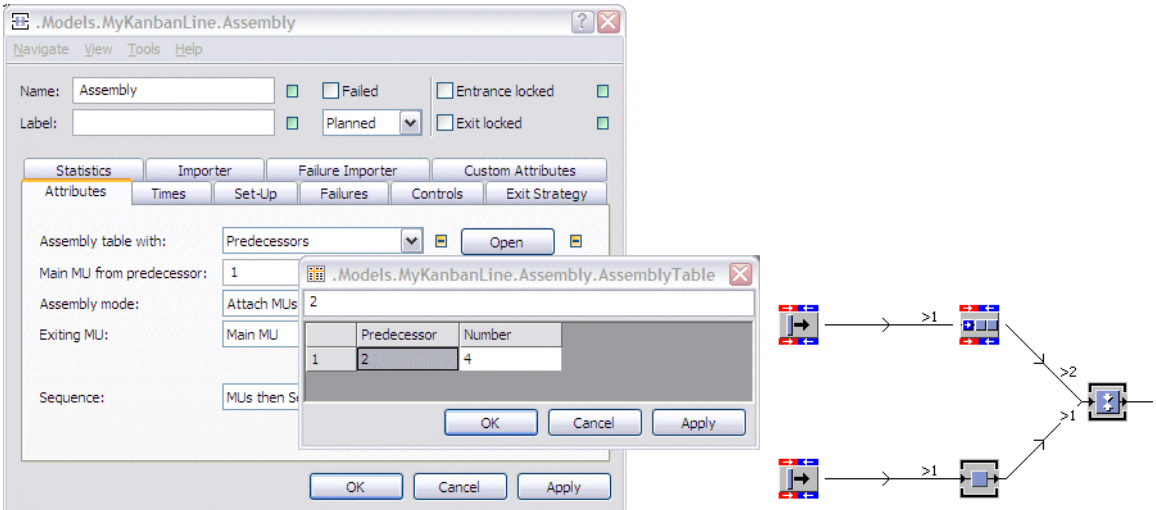
Note: To view the order in which you connect the stations, select View > Options > Show Predecessors.

After inserting the required objects into our simulation model, we have to configure them.

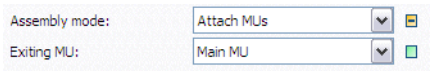
Configure the Assembly Station

We want the *Assembly Station* station to put four wheels, which it receives from the line at the top of the model, onto the cars, which the bottom line delivers. We choose these settings on the tab Attributes.

- Select Predecessors from the drop-down list Assembly table with. Then, click Open and enter the number of the predecessor into column 1 and the number of wheels into column 2. We want to assemble 4 wheels which predecessor 2 delivers.



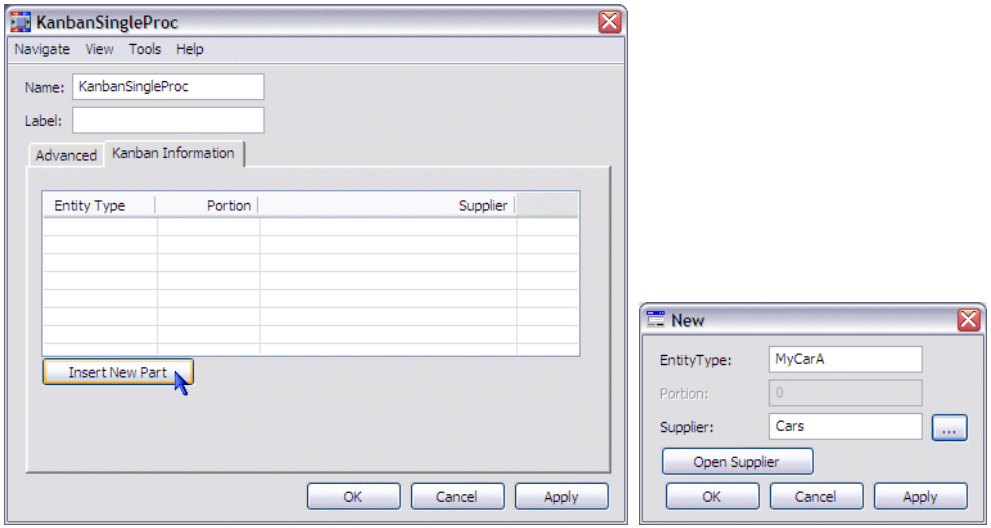
- As the main part, the car, comes from predecessor 1, we do not have to change the default setting 1 for Main MU from predecessor.
- To put the wheels onto the car, select Attach MUs as the Assembly mode.
- To send the car on to the next station, select Main MU as the Exiting MU.



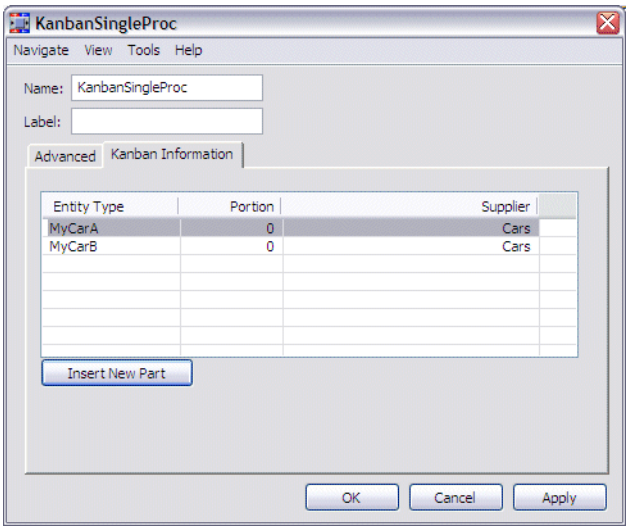
Configure the Kanban Station which Orders the Parts

To configure the *KanbanSingleProc*, which is the crucial station of the entire system as it orders the parts to be produced and assembled, when they are needed, double-click its icon .

- Click Insert New Part on the tab Part Information. Enter the types of parts you want to order and the supplier. We entered `MyCarA` and the *KanbanSource* `Cars` as the station producing it.

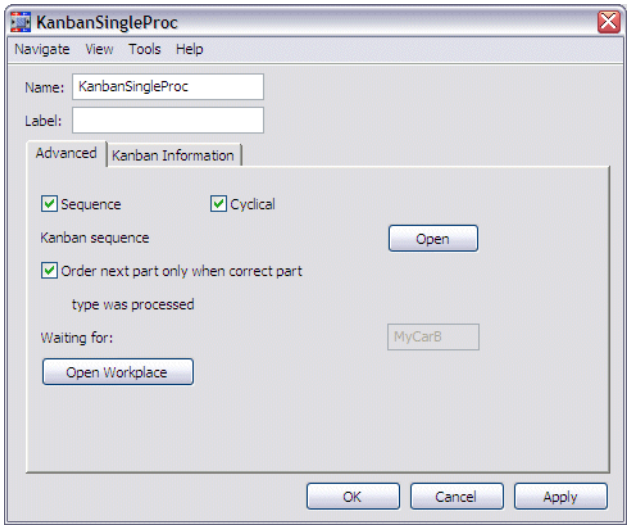


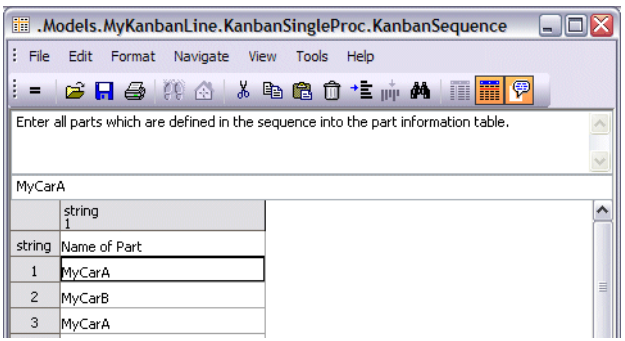
- Repeat this for the second car model, `MyCarB`.



Note: To delete an entry from this table, select Tools > Open Kanban Information Table and delete the respective row from that *TableFile*. Instead you can also double-click the entry on the tab, delete the EntityType and then close the dialog.

- As we want to define a sequence of orders, we have to select the check box Sequence on the tab Advanced. We also want the sequence of orders to be repeated, we have to make sure that the check box Cyclical is selected. Then, click Open and enter the sequence into the table. We entered `MyCarA`, `MyCarB` and `MyCarA` again.

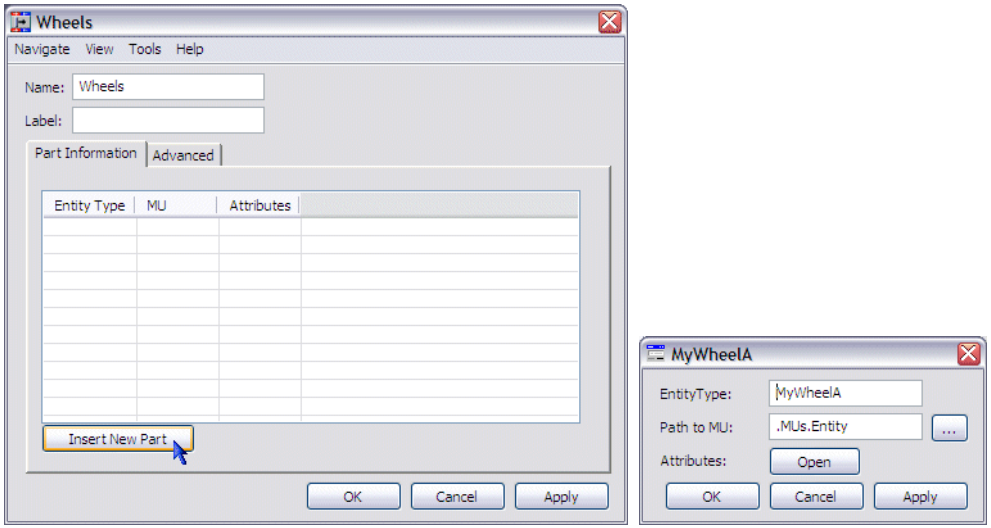




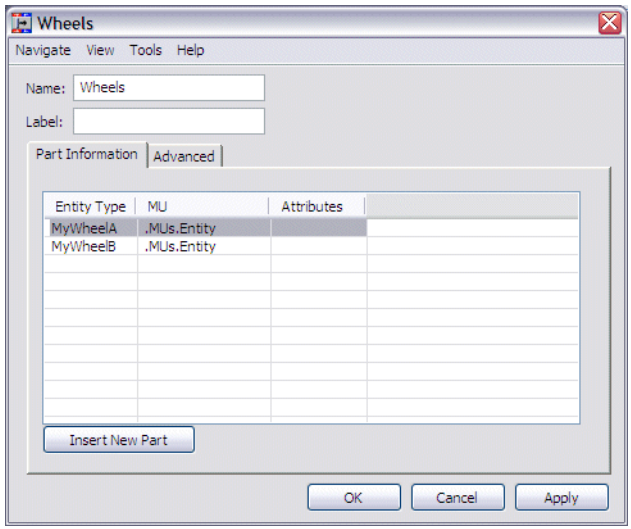
Configure the Kanban Sources which Produce the Parts

To configure the *KanbanSources Wheels* and *Cars*, which produce the parts, when the *KanbanSingleProc* and the *KanbanBuffer* order them, double-click their icon .

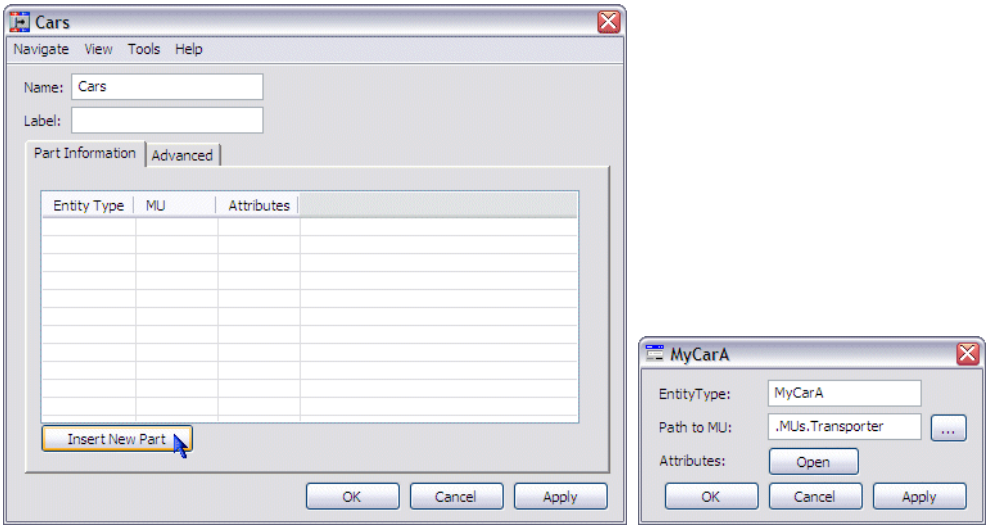
- Click Insert New Part on the tab Part Information of the *KanbanSource* named *Wheels*. Enter the type of parts you want to order and which MU class you want to use. We entered `MyWheelA` and the MU type `Entity`.



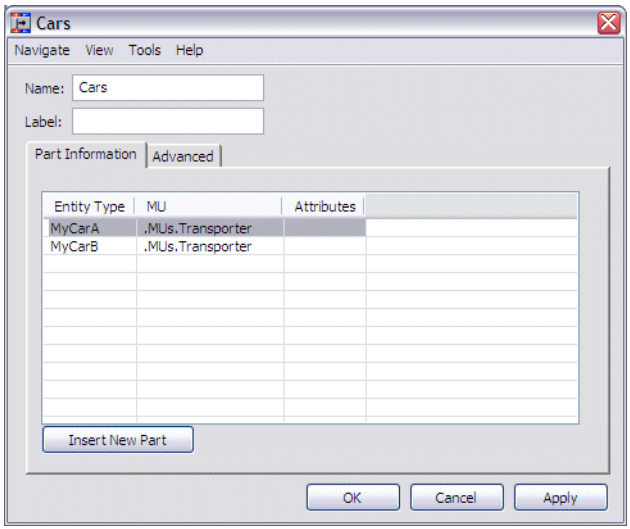
- Repeat this for the second type of wheel, `MyWheelB`.



- Click **Insert New Part** on the tab **Part Information** of the *KanbanSource* named *Cars*. Enter the types of parts you want to order and which MU class you want to use. We entered `MyCarA` and the MU type `Transporter`.



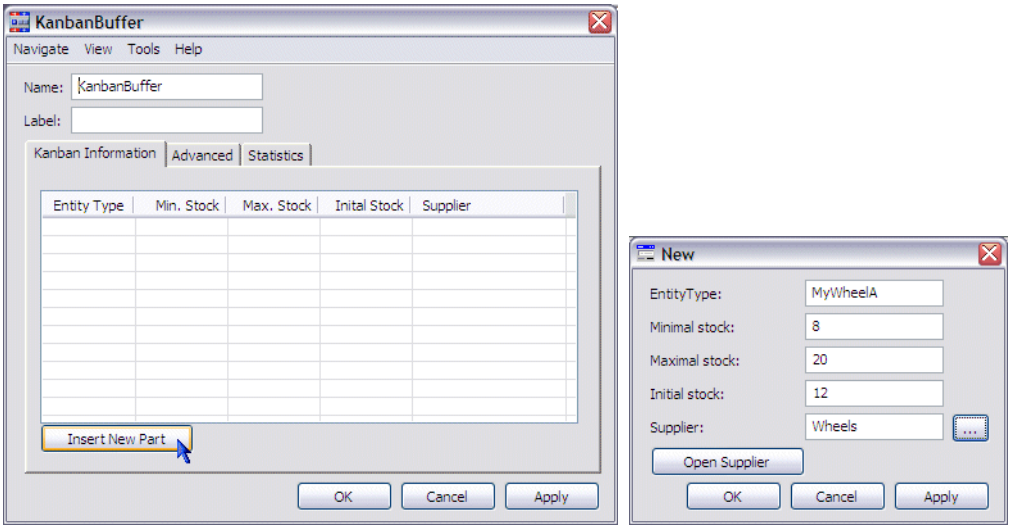
- Repeat this for the second car model, `MyCarB`.



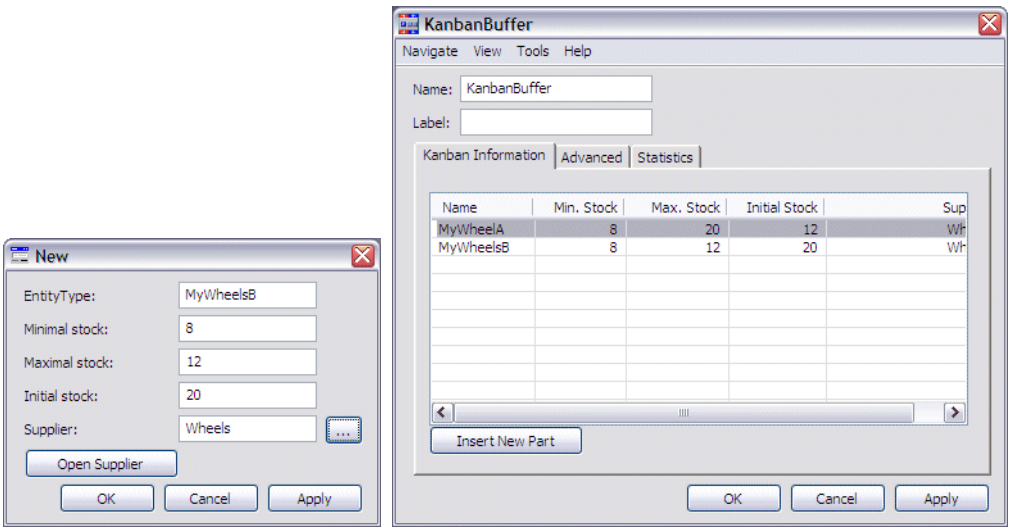
Configure the Kanban Buffer which Manages Storing and Ordering of Parts

To configure the *KanbanBuffer*, which temporarily stores parts, and orders replenishment when the stock dwindles, double-click its icon .

- Click Insert New Part on the tab Part Information of the *KanbanBuffer*. Enter the type of part you want to order, the amount of parts you want to keep in stock and the station which produces the parts. For `MyWheelA` we entered the information shown in the screenshot below.



- Repeat this procedure for `MyWheelB`.

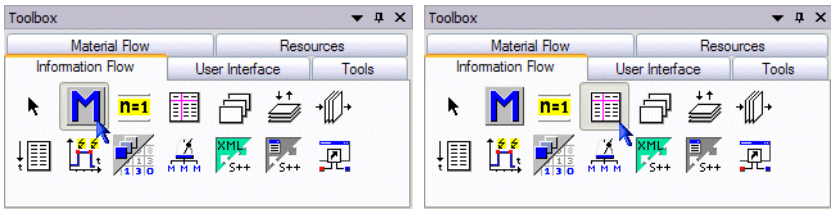


Program a Control which Orders Parts from the Kanban Buffer

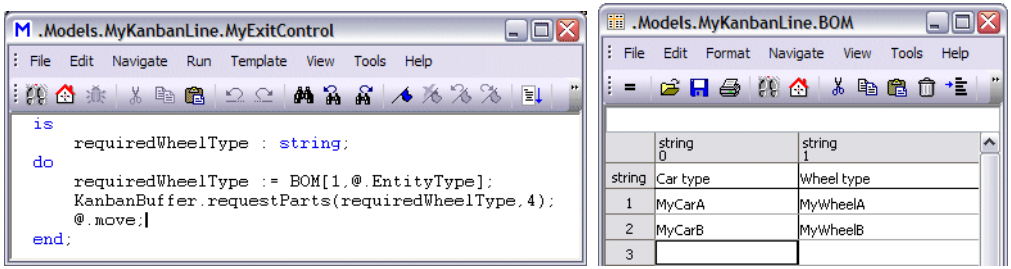
In addition to the stations we inserted above, we need:

- A control, which orders the wheels to be attached to the cars, when they are ready to be moved to the *Assembly* station. We enter this control as an exit control into the *SingleProc Processing* on the bottom line.
- A bill of materials, i.e., a *TableFile*, which tells how many and which type of wheel the different car models need.

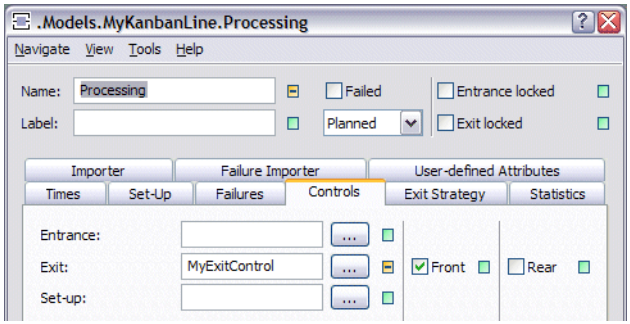
To accomplish this, insert a *Method* and a *TableFile* into the simulation model.



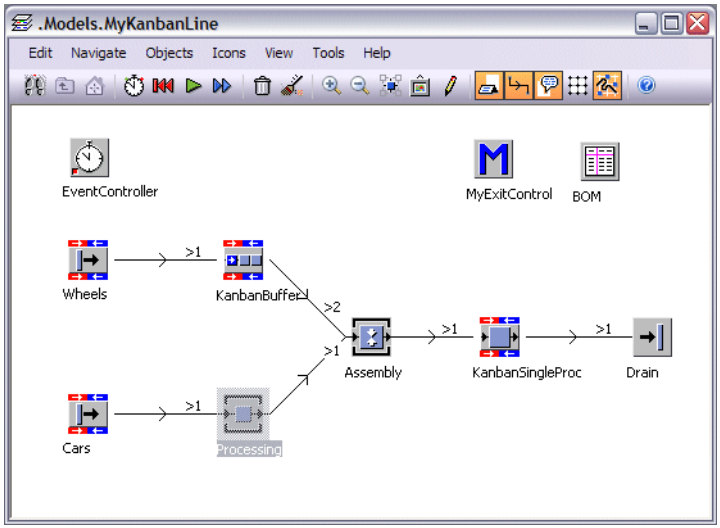
To make the *KanbanBuffer* order the type of wheels, *MyWheelA* or *MyWheelB*, for the car models, *MyCarA* or *MyCarB*, we entered these instructions into the method *MyExitControl*. They instruct the buffer to get the correct type of wheels according to the mapping you are going to enter into the *TableFile BOM* (bill of materials) in the next step. It then moves the part on to the successor. In the table, activate the column index and the row index.



Then, enter the method as the exit control into the *SingleProc Processing*.



Finally, insert an *EventController* and start the simulation.



Modeling Transport Systems

You will use transport systems in a variety of ways in your simulation models. You might have to model a simple conveyor that transports parts between two stations, as well as complex electric overhead monorail systems or fork-lifts that transport parts from one location to another, as well as cranes and automatic guided vehicle systems.

For this task you can use the *Line*, the *Track* and the *TwoLaneTrack*, which you find in the folder MaterialFlow in the *Class Library*.

- The *Line* is an active material flow object that has a propulsion system of its own. It transports passive parts that do not have a propulsion system of their own.
- The *Track* and the *TwoLaneTrack* are passive material flow objects without a propulsion system of their own. They mainly serve as the route on which the active material flow object *Transporter* moves, forward or in reverse.

When modeling your transport system keep these characteristics of *Line*, *Track* and *TwoLaneTrack* in mind:

- All three are length-oriented objects, i.e., *Plant Simulation* uses their own Length, and the MU length of the MUs, which you enter into their dialog windows to determine how many MUs they can hold. The point-oriented material flow objects on the other hand, such as the *SingleProc*, the *ParallelProc*, etc. do not use a length.
- You can *Define Controls for Length-Oriented Objects* and define sensors for them, compare *Create Sensors*.
- Parts transfer from a point-oriented object to a length-oriented object in their entirety, i.e., they are located on *Line* and *Track* in their full length as soon as their tip has moved onto these objects.
- Parts transfer from one length-oriented object to another length-oriented object with the speed (Speed) you enter into the dialog of the length-oriented object. This is of importance, when you employ entrance controls.

- To model simple transport systems, you will use the active object *Line*.
- To model cross-transfer systems, AGV systems, cranes, etc. you will use the passive object *Track*.

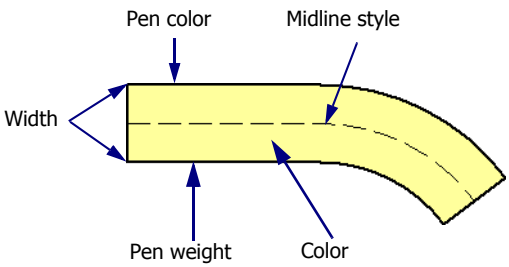
Working with Curved Objects

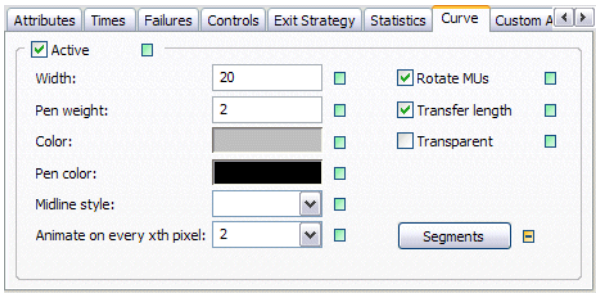
By inserting *Track*, *TwoLaneTrack*, *Line*, *Turntable*, *AngularConverter*, and *FootPath* as a sequence of curved segments and/or straight segments, you can realistically model the conveyor systems and tracks of your installation. The *mobile objects Entity*, *Container*, *Transporter* and *Worker* move to their destination on them, either to the *Workplace* attached to or directly to the designated material flow object.

Plant Simulation uses the length of the polygonal and curved objects during the simulation. The Scaling Factor you select in the *Frame* controls how *Plant Simulation* computes the length. *Plant Simulation* automatically animates and aligns mobile objects along the polygon or the curve.

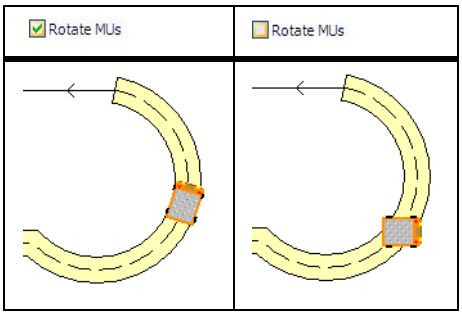
In the *3D Viewer* Curve mode corresponds to the Path type > ExtrusionPath, compare Polycurve.

The illustration shows the most important items of the curve you can define:

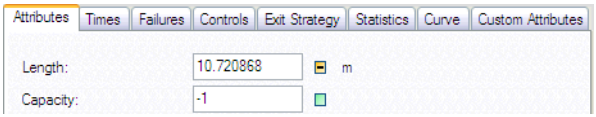




- To turn the MU in the direction of motion of the flow of materials, when it turns a curve, select Rotate MUs.



- To use the length of the curve in the layout within the *Frame* as the actual length of the *Track*, the *Line* or the *FootPath*, select this. When the dialog is open, *Plant Simulation* enters this value into the text box Length.



To create a class from a *Line*, *Turntable*, *Track*, *TwoLaneTrack* or *FootPath*, model this class in the *Frame*, and then drag this object from the *Frame* to the *Class Library*. You can then insert this class into the active and into any other simulation model.

You can:

- *Insert Curved and Straight Segments*
- *Draw Straight and Curved Segments with a 90° Angle (Fixed Values)*
- *Draw Straight and Curved Segments without Fixed Values*
- *Change the Shape of a Segment*
- *Create a Curved Object with SimTalk Commands*
- *Import Settings of a Curved Object from Another Simulation Model*

Insert Curved and Straight Segments

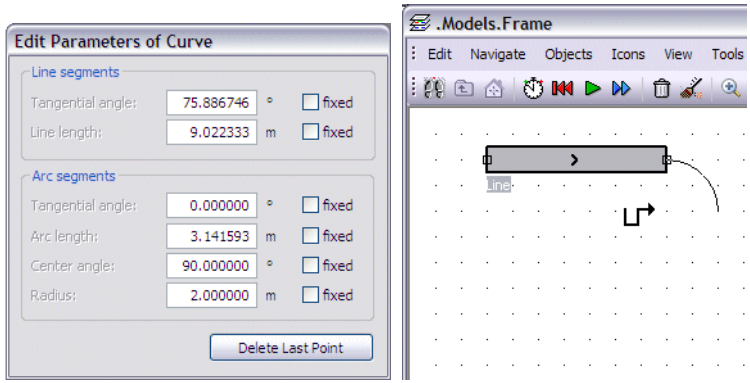
To insert a *Track*, a *TwoLaneTrack*, a *Line*, a *Turntable* or a *FootPath* with a sequence of curved and straight segments into the *Frame* that contains your simulation model:

- Zoom the *Frame* to a size that it can accommodate the object you want to insert. Note that the scaling factor you set also applies to curved objects.
- Make sure that Curve mode in the class of the object, either in the *Class Library* or in the *Toolbox*, is active Active. In Curve mode *Plant Simulation* animates the MUs using the number you entered into the text box Animate on every xth pixel.
- Click the *Track*, the *Line* or the *FootPath* in the *Toolbox*, and drag the mouse to the *Frame* window and click the point where the object is to start. This opens the dialog Edit Parameters of Curve.

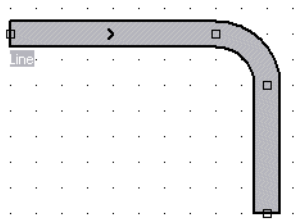
  Note: When you drag a length-oriented object from the *Class Library* to the *Frame*, *Plant Simulation* inserts it as a straight segment. You can then append points to it or insert points between existing anchor points.

  Note: In the *3D Viewer* Curve mode corresponds to the Path type > ExtrusionPath, compare Polycurve.

  To draw a straight segment, click a second time at the position, at which you want the end of the segment to be. To draw a curved segment, hold down Ctrl, drag the mouse down to draw the curve downward, and click the left mouse button once to set the curve.

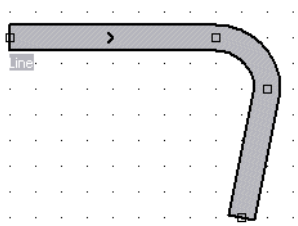


To draw the next straight segment of the line, release Ctrl, drag the mouse to the end point of the line and click the left mouse button once.



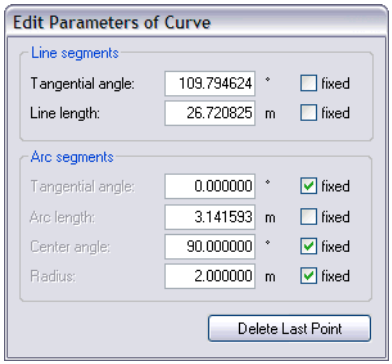
Click the right mouse button once to exit Insert mode. This also closes the dialog Edit Parameters of Curve.

When the grid is active , *Plant Simulation* places the points that make up the line onto grid points, provided this is possible. For this fixed vales take precedence. When you enter a radius of 2.5 meters, for example, the end point of the arc will not be placed onto a grid point. This results in a non-tangential transition between the end of the arc and the end of the next straight segment, which will be placed onto a grid point again.

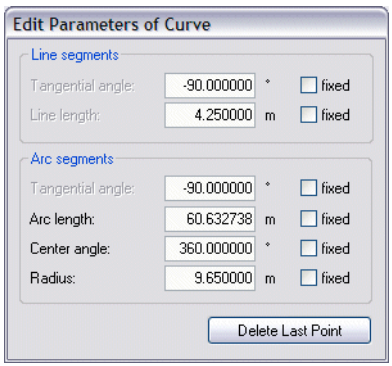


To insert the curved *Line*, *TwoLaneTrack*, *Track* or *FootPath* with fixed values, enter them into the text boxes in the dialog and select the check box fixed of the respective element to tell *Plant Simulation* that you want to use these fixed values.

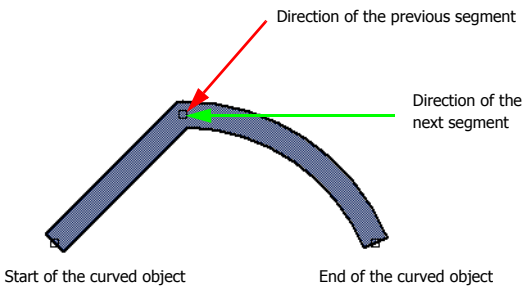
- For a line segment, you can enter the Line length in world coordinates and the Tangential angle as compared to the previous segment.



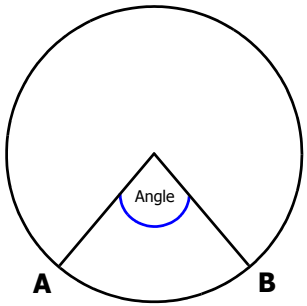
- For a curved segment, you can enter the Arc length and its Radius, its Tangential angle, and its Center angle in degrees as compared to the previous segment.



The **tangential angle** designates the change of the tangential direction. Enter a positive number for a clockwise angle. Enter a negative number for a counterclockwise angle. As a rule, the tangential angle is relative to the previous direction of a curved segment. For the first segment the tangential angle is the angle to the positive x-direction.



The **center angle** is the angle that is formed by the radius between the start point A and the end point B of the arc segment. A positive number denotes a clockwise angle. A negative number a counterclockwise angle.



Arc segment between A and B

Note: When you define a center angle of 360°, *Plant Simulation* automatically connects the end point the curve with its starting point.

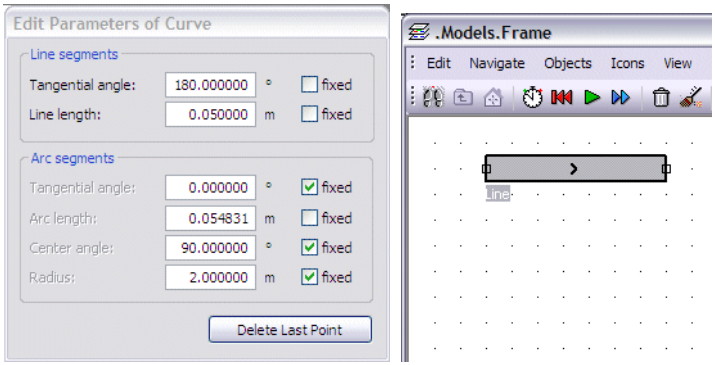
Hold down Alt to deactivate the snap to grid feature:

- When you insert an object or a vector graphics object into the *Frame*.
- When you move an object or a vector graphics object in the *Frame* with drag-and-drop.
- When you insert an anchor point of a *Connector* or of a curved object into the *Frame*.
- When you move an anchor point of a *Connector* or of a curved object with drag-and-drop.

Draw Straight and Curved Segments with a 90° Angle (Fixed Values)

To draw a *Line/Track/TwoLaneTrack/Footpath* with a straight segment, and a 90° curve followed by another straight segment:

- Click the icon of the *Line* in the *Toolbox*.
- Drag the mouse to the *Frame* window to the point where you would like to start the straight segment of the line.
- Click the left mouse button once to set the starting point of the line.

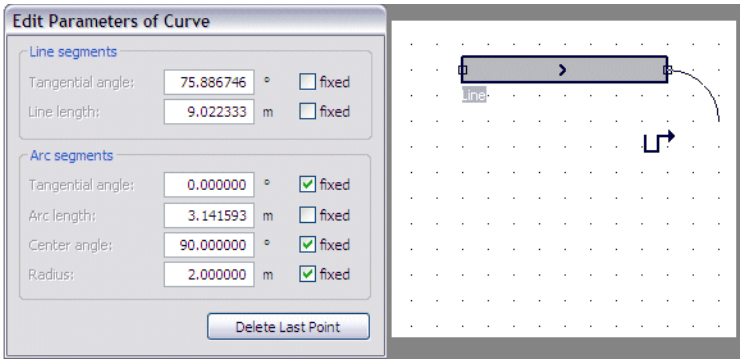


- *Plant Simulation* opens the dialog Edit Parameters of Curve. Here, we defined default settings for inserting a curve with a 90° angle, i.e., a fixed tangential angle of 0°, a fixed center angle of 90° and a fixed radius of 2 meters.

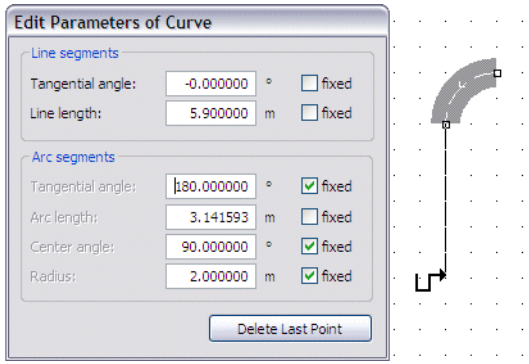
  You can either apply these values or you can enter a different radius to make the curve wider. To do so, drag the mouse to the dialog and enter another value into the text box.

  Note: *Plant Simulation* saves the last set of settings in the dialog, so that you can re-use them the next time you insert a curved object.

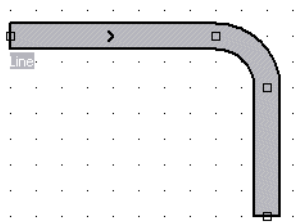
  To draw the curve, drag the mouse back to the *Frame* window, hold down Ctrl, drag the mouse down to draw the curve downward, and click the left mouse button once to set the curve.



To draw a curve pointing to the left: Drag the mouse back to the *Frame* window and hold down Ctrl. Make sure that fixed is selected for the tangential angle of arc segments and type in `180`. Then drag the mouse down to draw the curve downward, and click the left mouse button once to set the curve.

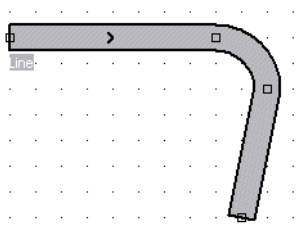


- To draw the next straight segment of the line, release **Ctrl**, drag the mouse to the end point of the line and click the left mouse button once.



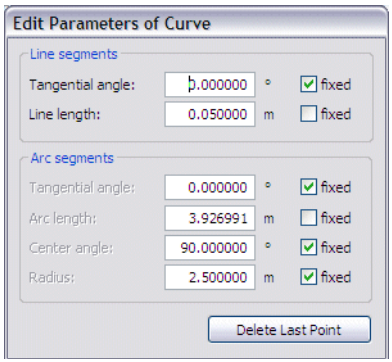
- Click the right mouse button once to exit **Insert** mode. This also closes the dialog **Edit Parameters of Curve**.

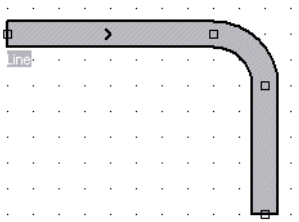
When the grid is active , *Plant Simulation* places the points that make up the line onto grid points, provided this is possible. For this fixed vales take precedence. When you enter a radius of 2.5 meters, for example, the end point of the arc will not be placed onto a grid point. This results in a non-tangential transition between the end of the arc and the end of the next straight segment, which will be placed onto a grid point again.



To get a tangential transition, you can:

- Deactivate Snap to Grid by holding down Alt, when you click the left mouse button to set the end point of the second straight segment.
- Enter a tangential angle of 0° and fix it for this straight segment. Then, deactivate it for subsequent straight segments again.





To draw a curved segment without using fixed vales, you will have to click the left mouse button three times. To activate curve mode, you have to hold down Ctrl, when you click the mouse button the first time!

- The first mouse click sets the tangential angle.
- The second mouse click sets the radius.
- The third mouse click sets the arc length or the center angle respectively.

Draw Straight and Curved Segments without Fixed Values

To draw a straight segment of *Track*, *Line* or *FootPath* not using fixed values:

- To set the starting point of the segment, click the left mouse button once. You will notice that *Plant Simulation* attaches the icon of the *Connector* to the front end of the cursor in the *Frame* window.

  The text boxes now show the actual values of the line segment.
- Drag the mouse in a direction of your choice and as far as you want the segment to be long. Click the left mouse button again to set the first anchor point. Now, *Plant Simulation* draws the segment with the settings you selected.
- Continue this until the object has the length and the shape you want.
- To set the end point of the segment, and to exit Insert mode, click the right mouse button.

To draw a curved segment of *Track*, *Line* or *FootPath* not using fixed values:

- To set the starting point of the curved segment, hold down Ctrl and click the left mouse button once.

  You will notice that the text boxes now show the actual values of the curve segment.
- To set the tangential angle, drag the mouse in a direction of your choice.

- To set the radius of the curved segment continue dragging the mouse until the curve has the radius you want it to be and click the left mouse button.
- To set the arc length, continue dragging the mouse until the curve is as long as you want it to be and click the left mouse button.
- To set the end point of the segment, click the right mouse button.
- To delete the last anchor point from the curve, drag the mouse pointer from the *Frame* window to the dialog Edit Parameters of Curve and click Delete Last Point.

Naturally you can combine both techniques to insert curved and straight segments in any sequence you like.

Change the Shape of a Segment

You can modify the shape of a segment in a number of ways:

- To change the shape of the straight segment, click an anchor point with the left mouse button, and drag it up and down or left and right until the shape meets your needs. Depending on how far you moved the anchor point, *Plant Simulation* lengthens the segment and compresses or expands it.
- To delete an anchor point from the curve, right-click it and select Delete Point on the context menu.
- To insert an anchor point between two existing anchor points, right-click at the location between those points and select Insert Point on the context menu.
- To append anchor points to the end of the curve, right-click anywhere on the curve and select Append Points on the context menu. Add additional anchor point with the dialog Edit Parameters of Curve.
- To flip the selected object on the y-axis, right-click it and select Mirror Vertical.
- To flip the selected object on the x-axis, right-click it and select Mirror Horizontal.
- To move the entire curved *Track*, *Line* or *FootPath*, click it once with the left mouse button and drag the mouse up or down or left or right. You can also use the arrow keys to move the object one pixel at a time or hold down Shift and press an arrow key to move the object one grid unit at a time.
- To delete the entire curved *Track*, *Line* or *FootPath*, click it once with the left mouse button and press Del.
- To extend an existing curved *Track*, *Line* or *FootPath*, without adding a new anchor point, grab the handle with the left mouse button and drag the mouse to the new location.
- To link two or more existing curved *Tracks*, *Lines* or *FootPaths*, insert a *Connector* between them.

Create a Curved Object with SimTalk Commands

Naturally, you can also create a curved object using the SimTalk commands *createObject* and *SegmentsTable*:

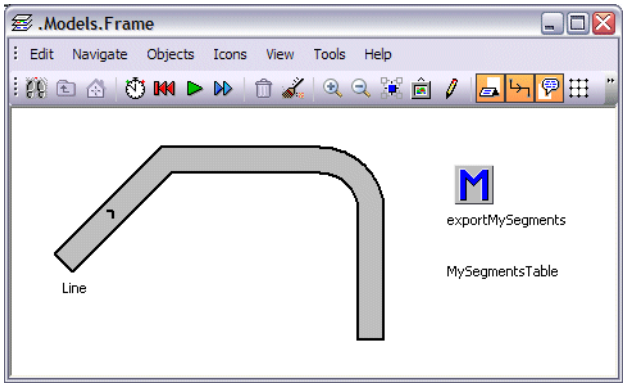
```
is
   obj,obj2 : object;
do
   obj := .Materialflow.Line.createObject(.Models.Frame,100,100);
   obj.SegmentsTable := InputTable;
   obj2 := .Materialflow.Line.createObject(.Models.Frame,40,40);
```

```
    obj2.SegmentsTable := InputTable1;
end;
```

In the example above, `InputTable` is a table that contains the information about the segments to be created for the first *Line*, `InputTable1` is a table that contains the information about the segments to be created for the second *Line*.

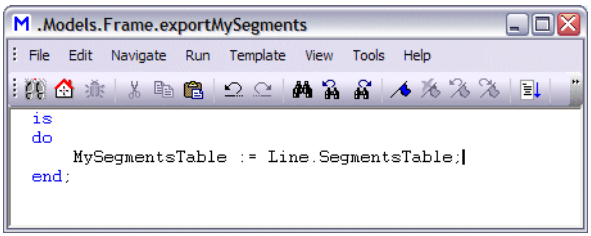
Import Settings of a Curved Object from Another Simulation Model

To transfer the settings of a curved object from one simulation model to another, we first have to write the segments table into a *Variable* with a *Method*. Then, we export this *Variable*, so that we can import it into the other model.

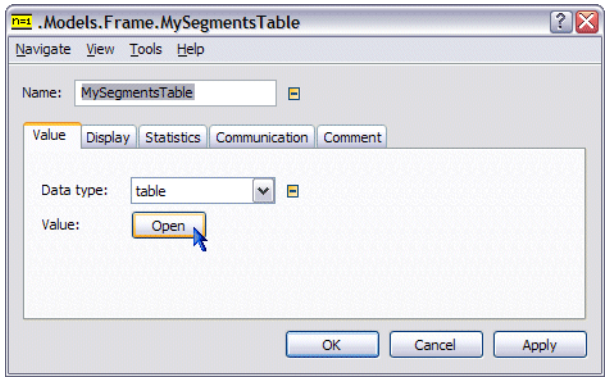


To export the segments table:

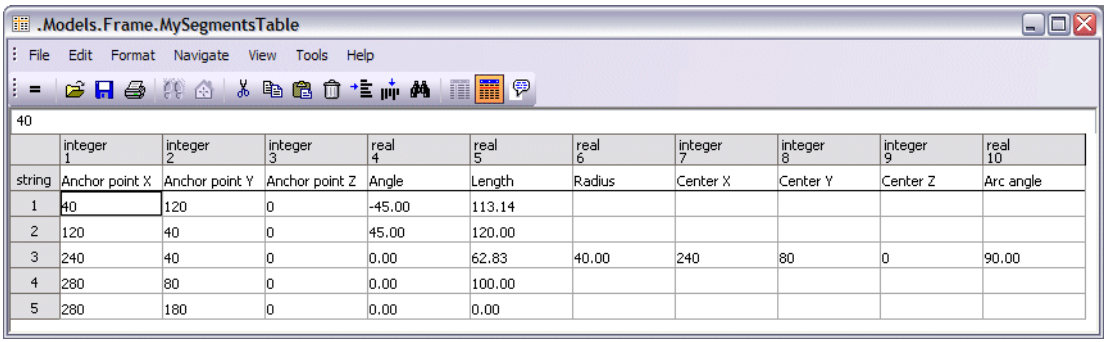
- Program a *Method* to export the coordinates of the curved object into a table using the attribute *SegmentsTable*.



Executing the method, *exportMySegments* in our example, writes this data into the *Variable*, *MySegmentsTable* in our example.



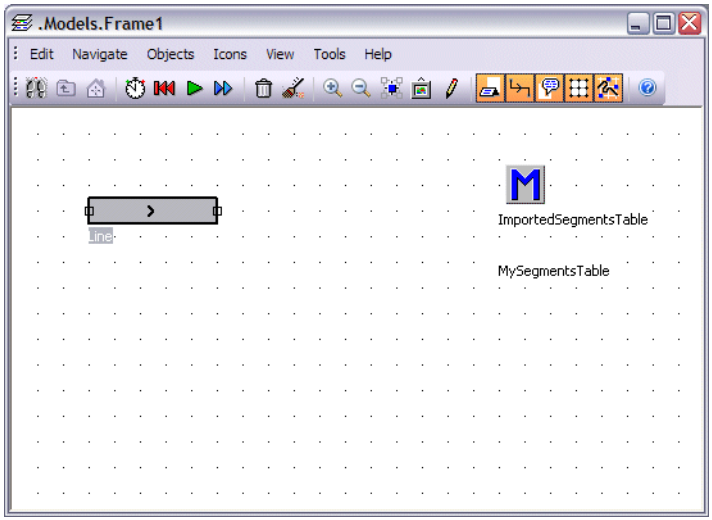
Clicking Open opens the segments table.



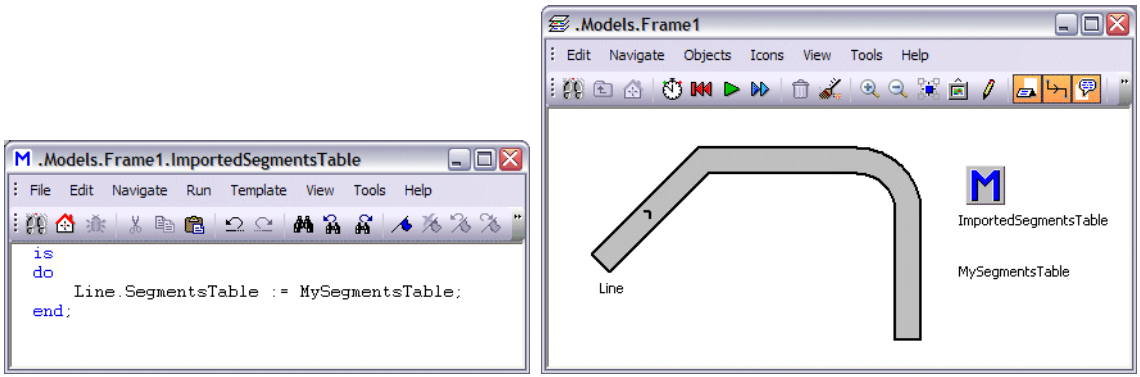
	integer 1	integer 2	integer 3	real 4	real 5	real 6	integer 7	integer 8	integer 9	real 10
string	Anchor point X	Anchor point Y	Anchor point Z	Angle	Length	Radius	Center X	Center Y	Center Z	Arc angle
1	40	120	0	-45.00	113.14					
2	120	40	0	45.00	120.00					
3	240	40	0	0.00	62.83	40.00	240	80	0	90.00
4	280	80	0	0.00	100.00					
5	280	180	0	0.00	0.00					

To import the segments table into another simulation model:

- Insert a *Line* of any shape into the other model. Insert the *Variable*, which we exported above into the model, *Frame1* in our example. Then, insert a *Method* into *Frame1*.



- Program the method to overwrite the settings of the *Line*, which we inserted, with the exported settings.



Keyboard Shortcuts for Inserting a Curved Object

When Curve mode is active these keyboard shortcuts apply, even before you click a mouse button for the first time.

To	Press/click
Set the starting point of a straight segment.	left mouse button
Set the starting point of a curved segment.	Ctrl+left mouse button
Deactivate the Snap To Grid feature.	Alt+left mouse button
Draw a straight segment horizontally or vertically and to deactivate Snap To Grid.	Shift+left mouse button

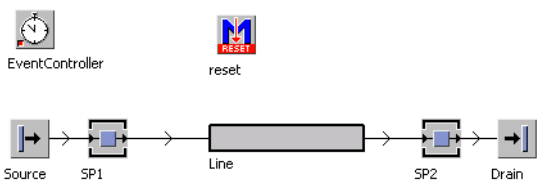
To	Press/click
Terminate Insert mode.	right mouse button
Terminate Insert mode and insert a new curved object of the same class without having to select it in the *Toolbox* again.	Ctrl+right mouse button, then left mouse button
Draw the last straight segment horizontally or vertically and to deactivate Snap To Grid. The right mouse button just refers to the last anchor point.	Shift+right mouse button
Terminate Insert mode and delete the curved *Line*, *Track*, *TwoLaneTrack*, *Turntable*, and *FootPath*.	Esc
Open the dialog Sensors	Alt+double-click the red Sensor line on *Line*/*Track*

Modeling a Transport System with Active Objects of Type Line

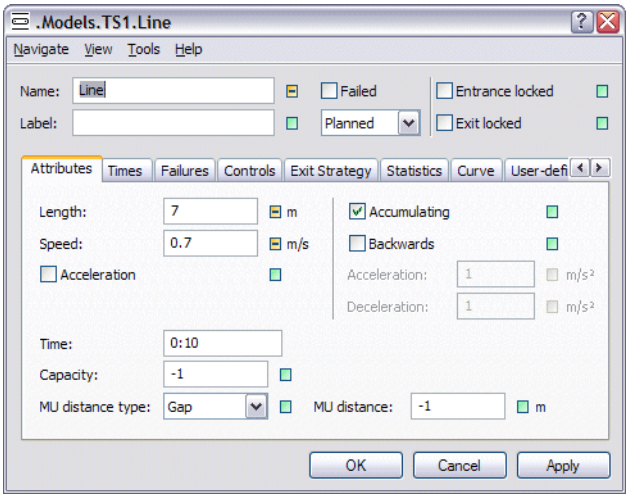
When you model transport systems with active objects, such as stationary belt conveyors, roller conveyors, etc., you will employ the *Line*. Below we outline in two simple examples how you can use the *Line*.

Model a Simple Conveyor Between Two Stations

In its most basic way, a transport system consists of a conveyor that moves parts between two processing stations. In our example we inserted a *Line* between two *SingleProcs*, *SP1* and *SP2*. The MUs are transferred from the point-oriented station *SP1* onto the length-oriented *Line*, which then transports them to the point-oriented station *SP2*.



The *Line* moves the MUs from the station *SP1* with the Final speed we enter to the station *SP2*. *Plant Simulation* calculates the transport Time using the final speed and the Length of the *Line*. Note that speed, length and transport time depend on each other. When you change speed or length, *Plant Simulation* recalculates the transport time anew. Changing the transport time also changes the speed.



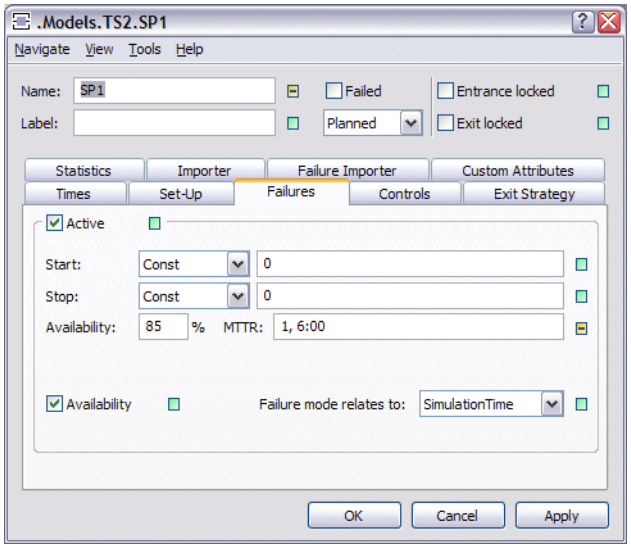
Model an Accumulating/a Non-Accumulating Conveyor Between Stations

You can also use the *Line* to model an accumulating or a non-accumulating transport system between stations.

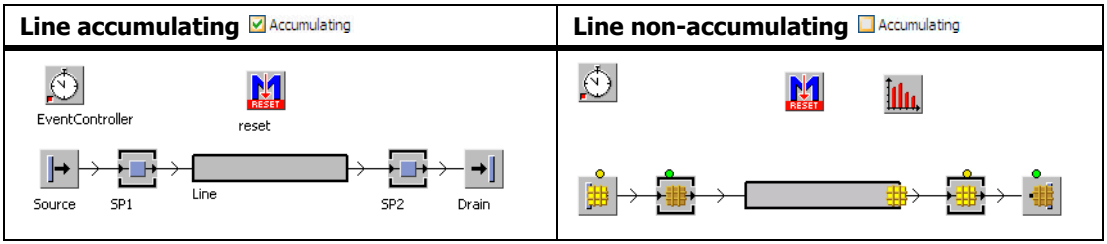
- To make the MUs accumulate on the *Line*, select the check box Accumulating. This allows the MUs to move front to end to each other, when the exit of the *conveyor* is blocked.
- To make the MUs retain their distance to each other, i.e., make all succeeding MUs stop moving when the preceding MU cannot exit, clear the check box to deactivate Accumulating.

As we want to apply the default behavior of the *Line*, we do not change its Capacity of -1, which stands for an infinite number of MUs. This way its capacity is defined by its own length and by the length of the parts (MU), which it transports.

In our sample we entered an Availability of 85% and an MTTR of 360 seconds for the two *SingleProcs*, *SP1* and *SP2*.



You can use an accumulating *Line* to decouple stations. Then, the *Line* behaves like a roller conveyor that allows the MUs to move up to those in front of them, when the exit of the conveyor is blocked.

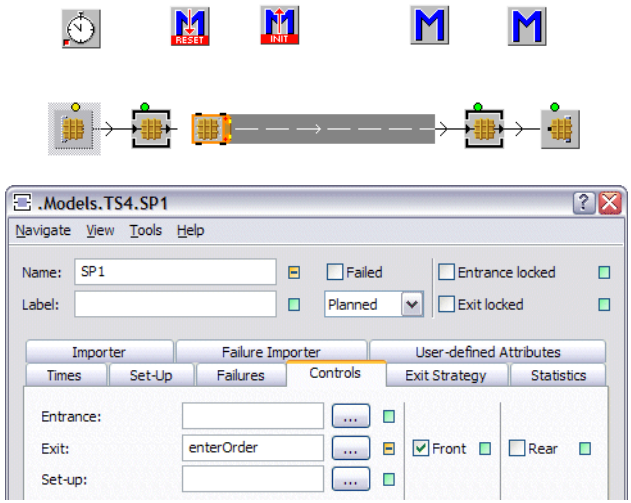


When you do not decouple the stations, the *Line* behaves like a belt conveyor, meaning that the belt stops when an MU blocks the exit of the *Line* and restarts as soon as the MU at the exit has moved on to the successor.

Modeling a Transport System with Passive Objects of Type Track

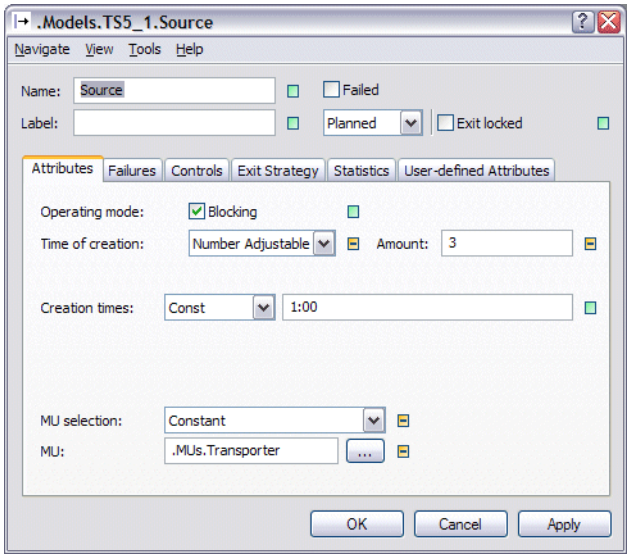
When you model transport systems with passive objects, you will employ the *Track* and the *Transporter*.

As the *Track* is a passive object, you cannot just connect it with two stations, but have to make sure that a *Transporter* is available, plus you have to load and unload this *Transporter*. To prevent the MUs from automatically transferring from the preceding station, in our example *SP1*, onto the *Track*, do not connect them with a *Connector*.



To create and insert a *Transporter* you can do one of the following:

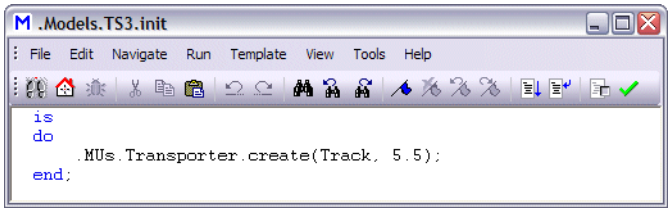
- Use the *Source*: Select Attributes > Time of creation > Number Adjustable and enter an Amount of 1. To tell it to create transporters, select MU > .MUs.Transporter.



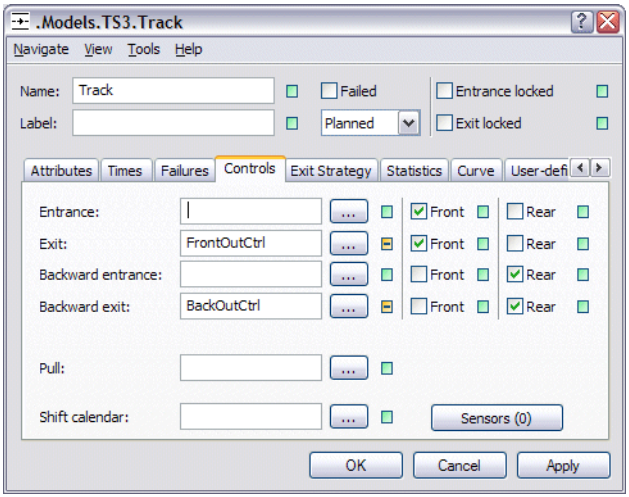
- Use the SimTalk method *create* and enter this command into the *init* method of your simulation model:

  ```
  .MUs.Transporter.create(Track);
  ```

  This inserts a *Transporter* at the end of the *Track*. If you want to insert a *Transporter* anywhere else on the *Track*, enter a position into the method. This example creates the *Transporter* 5.5 meters into the length of the *Track*:



As the *Transporter* is to move parts from station to station, *SP1* and *SP2* in our example, you have to load those parts onto the *Transporter* at the station *SP1* and unload them at the station *SP2*. For this you will program a control in a method and enter its name into the respective text box on the tab Controls.



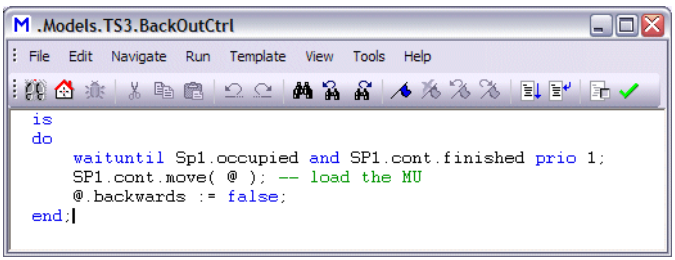
Without entering a control, the *Transporter* just moves to the end of the *Track* and stops there. To make the *Transporter* move back to the beginning of the *Track*, once it unloaded the parts, select the check box Front and enter these instructions into the Exit control, *FrontOutCtrl* in our example:

```
if @.empty then
   @.backwards := true;
end;
```

Once the *Transporter* backed up to the beginning of the *Track*, *Plant Simulation* activates the rear backward exit control, when you select Rear and enter the name of the *Method* M into the text box Backward exit. This control has to accomplish these tasks:

- Wait until an MU is ready to exit the station, *SP1* in our example.
- Load the MUs onto the *Transporter*.
- Move the *Transporter* to the end of the Track.

  In our example we entered these instructions.



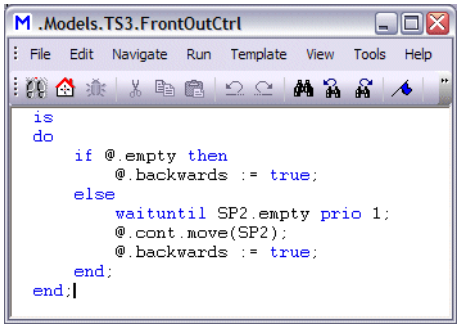
Line 3 tells *Plant Simulation* to wait until an MU is located on the station *SP1* and is processed all the way. *Line* 4 loads the MU onto the *Transporter*. Note that we use the anonymous identifier @ to address the *Transporter*. *Line* 5 tells the *Transporter* to move forward again to the end of the *Track*.

When the *Transporter* reaches the end of the *Track* you have to accomplish these tasks:

- Wait until the station, *SP2* in our example, is empty.
- Unload the *Transporter*.
- Move the *Transporter* back to the beginning of the *Track*.

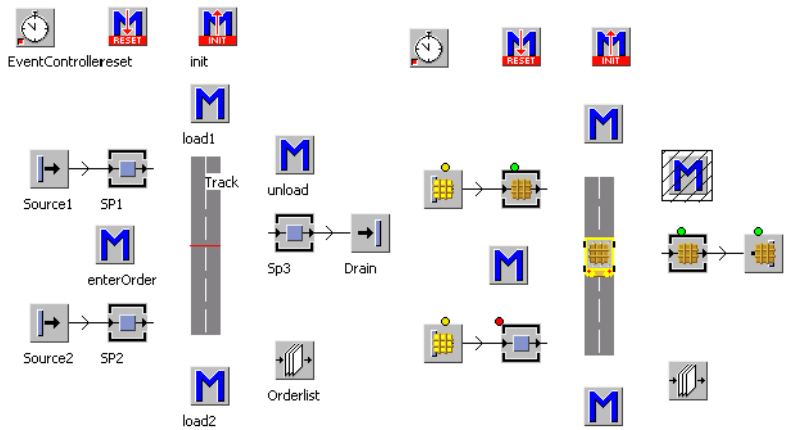
  As the *Transporter* initially moves to the end of the *Track* and then activates the following exit control while being unloaded, we query if it is loaded or empty.

  In our example we entered these instructions.

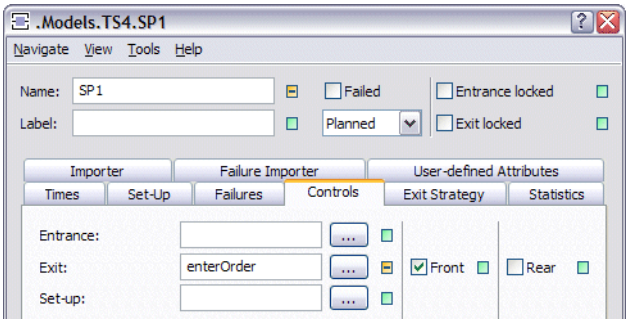


Model a Cross-Transfer System

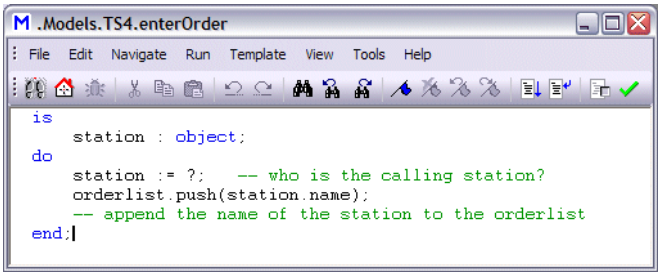
You can also use *Track* and *Transporter* to model a cross-transfer system. In our example parts arrive at two production lines, *SP1* and *SP2*. A cross-transfer vehicle moves these parts to the common production line *SP3*.



The production lines have different availabilities and different processing times, making it impossible to predict the order in which parts arrive. For this reason you will use an order list into which the part enters a transport order as soon as the production lines are finished processing it. You will tell the stations to do so in an exit control.

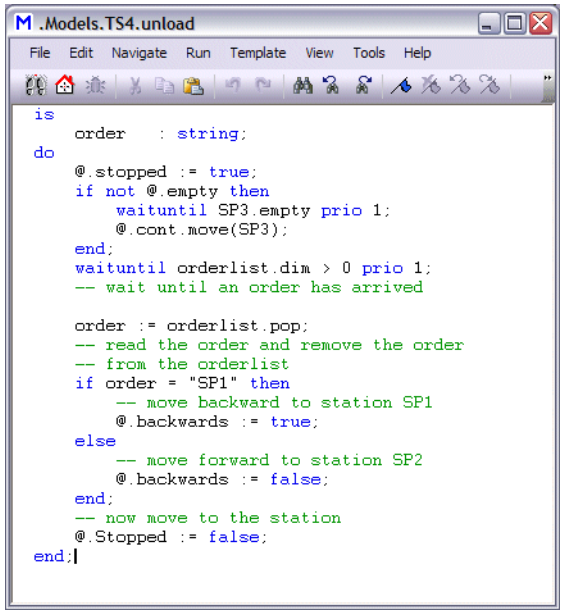


In our example we programmed the part to enter the name of the station at which the *Transporter* is to pick it up. Notice that both stations, *SP1* and *SP2*, use the method *enterOrder*. We use the anonymous identifier ? to identify the calling station.

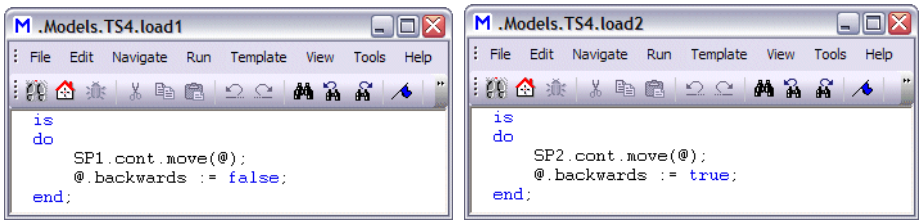


We programmed the *Init* method to create a *Transporter* at the position 1.5 m into the *Track*. Notice that the *Transporter* starts moving immediately. We also defined a sensor in the middle of the *Track*, which activates the method *unload*. We programmed the *Transporter* to stop with the instruction `@.Stopped := true`. If the *Transporter* transports parts, it will unload them, provided *SP3* is empty and can accept them. Then the *Transporter* waits until another order is entered into the order list. As we want to remove the order from the order list, we use the method *pop*. To leave the order in the order list, you could use the method *read*. Depending on the order, the *Transporter* moves into the respective direction.

Note: Make sure to enter the correct name, including upper- and lower casing, of the station.



As soon as the *Transporter* has arrived at the beginning or the end of the *Track*, the part is loaded from *SP1* or from *SP2* onto the *Transporter*, which then drives towards the middle of the *Track*.



You can also employ some or all of these techniques to model an elevator or a distributor vehicle that distributes parts according to their attributes to the different production lines. The only constraint is that one central *Track* has to be present. This allows to solve modeling tasks that are based on this central movement, which as a rule applies to track-based systems.

Model a Facility Using a Portal Crane

When your simulation model requires a portal crane or an overhead crane, you can use the application object *PortalCrane* . With it you can model four basic scenarios:

- *Automatically Place Parts into Stock and Remove Parts from Stock*
- *Automatically Place Parts into Stock, Remove Parts from Stock on Demand*
- *Place Parts into Stock on Demand, Remove Parts from Stock Automatically*
- *Place Parts into Stock on Demand, Remove Parts from Stock on Demand*

In addition you can:

- *Temporarily Store Parts, Put together the Order, Remove the Parts from Stock*
- *Load a Train with the Portal Crane*
- *Feed Machines with an Overhead Crane*

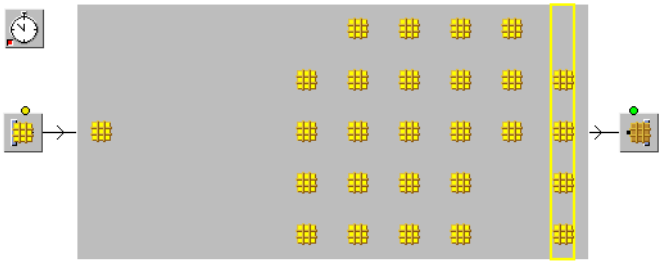
Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Automatically Place Parts into Stock and Remove Parts from Stock

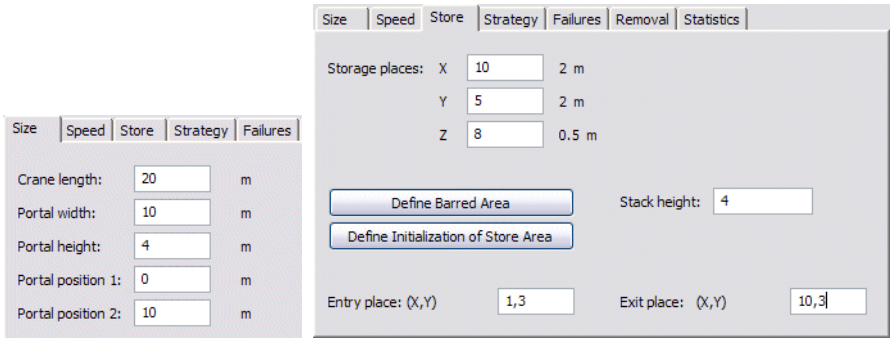
Note: Your *Plant Simulation* license determines how you can use the *PortalCrane*.

To model a portal crane, which automatically places parts into stock and which automatically removes parts from stock, proceed like this:

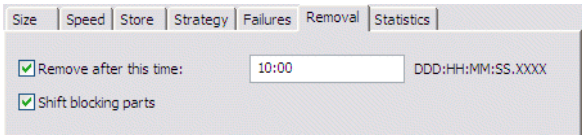
- Insert the *PortalCrane* into your simulation model. Connect it with its predecessor and with its successor.



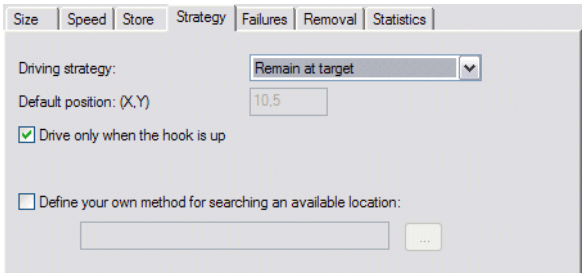
- Double-click the *PortalCrane* to open its dialog window. Define its properties, such as its size, the number of storage places, etc.



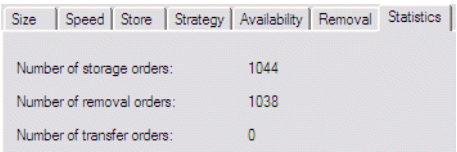
- Select the check box Remove after this time on the tab Removal. Then, enter the **time** after which the part is to be removed from stock. Note that this check box activates automatic stocking! When you select it the removal orders have the highest priority (100).



- Make sure that the check box Define your own method for searching an available location is not selected. When it is cleared, the internal mechanism of the crane automatically searches for an available storage location starting at the largest coordinate on the y-axis and the x-axis on the bottom level of the storage area and places the part onto it. It then proceeds to fill the free storage location toward the smaller coordinates on the y-axis. Then it goes to the second but largest coordinate on the x-axis and the y-axis and fills the free storage places, and so on. When the bottom level of the storage area is full, it starts filling the second level, i.e., the z-dimension (Stack height), starting at the largest coordinate on the y-axis and the x-axis, and so on.



- Insert an *EventController* into the *Frame*, start the simulation and watch the crane place parts into stock and remove them from stock without you having to interfere.
- Click the tab Statistics and check how many parts the portal crane placed into storage and how many it removed from storage.

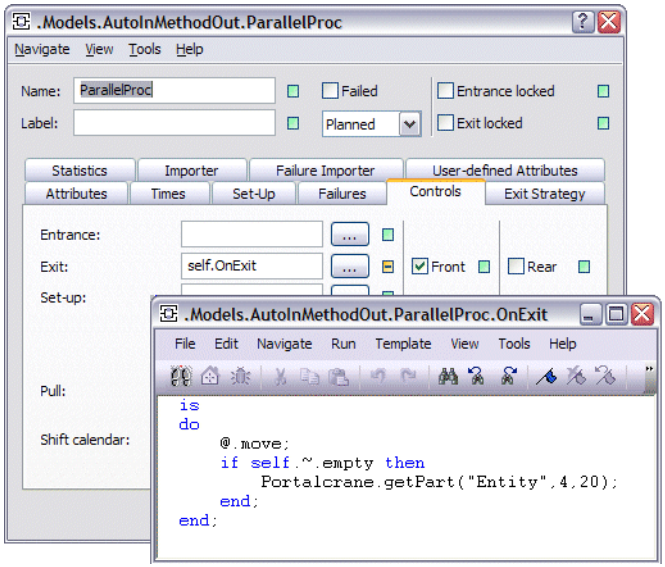


Automatically Place Parts into Stock, Remove Parts from Stock on Demand

To model a portal crane, which automatically places parts into stock and which removes parts from stock on demand, proceed like this:

- Insert the *PortalCrane* into your simulation model. Connect it with its predecessor.

- Double-click the *PortalCrane* to open its dialog window. Define its properties, such as its size, the number of storage places, etc.
- The successor has to ask the crane to remove parts from stock. For this you will employ the method *getPart*. In our example the crane removes `4` parts of type `Entity` with the priority `20` from the store.



- Insert an *EventController* into the *Frame*, start the simulation and watch the crane place parts into stock and remove them from stock.
- Click the tab Statistics and check how many parts the crane placed into storage and how many it removed from storage.

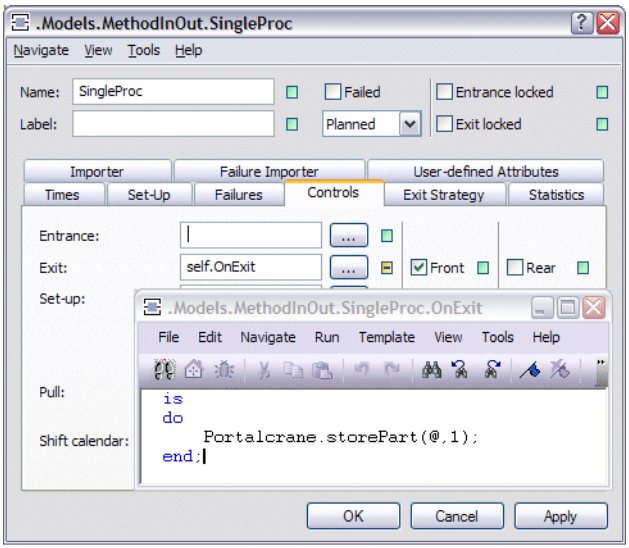
Place Parts into Stock on Demand, Remove Parts from Stock Automatically

To model a portal crane, which places parts into stock on demand and which automatically removes parts from stock, proceed like this:

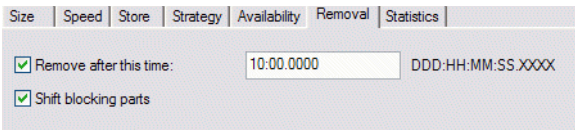
- Insert the *PortalCrane* into your simulation model. Connect it with its successor.

- Double-click the *PortalCrane* to open its dialog window. Define its properties, such as its size, the number of storage places, etc.
- The predecessor has to ask the crane to place the parts into stock. For this you will employ the method *storePart*. The instruction below moves the part (@) onto the entry place of the crane. The entry place of the crane then

enters an order to move the part into its order list. It fulfills the order with the priority you enter, in our example priority 1.



- Select the check box Remove after this time on the tab Removal. Then, enter the **time** after which the part is to be removed from stock. Note that this check box activates automatic stocking! When you select it, the removal orders have the highest priority (100).



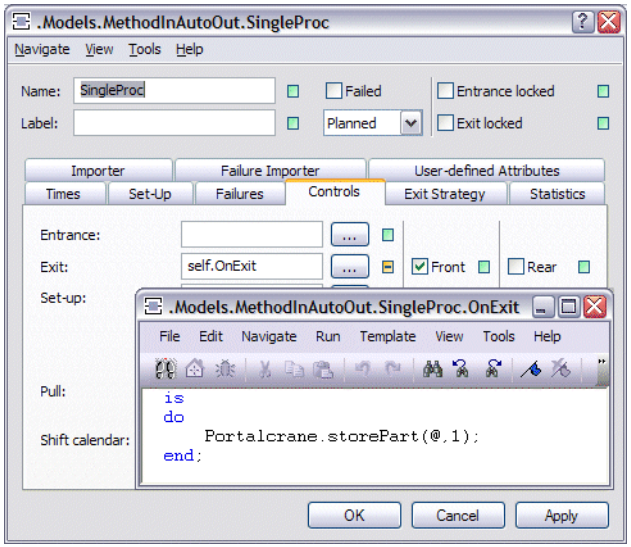
- Insert an *EventController* into the *Frame*, start the simulation and watch the crane place parts into stock and remove them from stock.
- Click the tab Statistics and check how many parts the crane placed into storage and how many it removed from storage.

Place Parts into Stock on Demand, Remove Parts from Stock on Demand

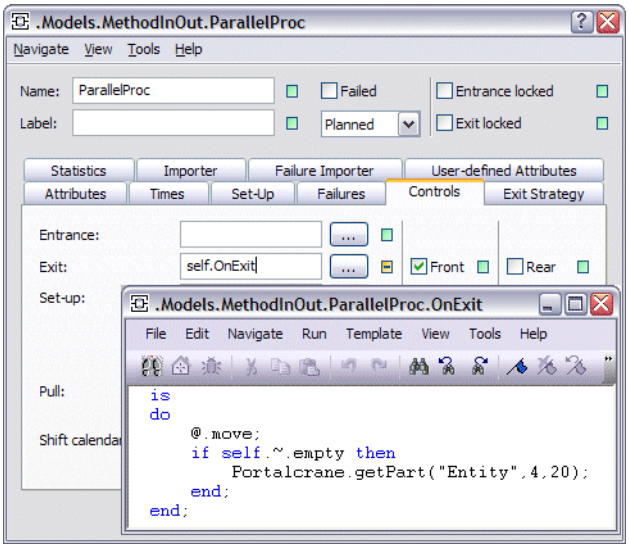
To model a portal crane, which places parts into stock on demand and which removes parts from stock on demand, proceed like this:

- Insert the *PortalCrane* into your simulation model.

- Double-click the *PortalCrane* to open its dialog window. Define its properties, such as its size, the number of storage places, etc.
- The predecessor has to ask the crane to place the parts into stock. For this you will employ the method *storePart*. The instruction below moves the part (`@`) onto the entry place of the crane. The entry place of the crane then enters an order to move the part into its order list. It fulfills the order with the priority you enter, in our example priority `1`.



- The successor has to ask the crane to remove parts from stock. For this you will employ the method *getPart*. In our example the crane retrieves `4` parts of type `Entity` from the store. The crane enters this order with the priority `20` into its order list.



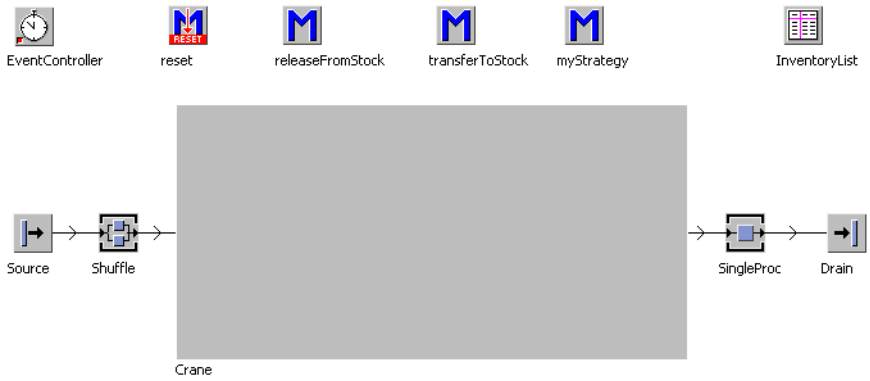
- Insert an *EventController* into the *Frame*, start the simulation and watch the crane place parts into stock and remove them from stock.
- Click the tab Statistics and check how many parts the portal crane placed into storage and how many it removed from storage.

Temporarily Store Parts, Put together the Order, Remove the Parts from Stock

Suppose you have to combine parts within a production facility to corresponding orders. To facilitate this, each part has an attribute called *OrderNo*, which designates the order number. The parts, which are to be combined into an order, arrive in an unordered sequence. They have to be placed into intermediate storage until all parts of the order are in stock. Then, the parts of the complete order can be retrieved from stock. Each order contains a different number of parts. The attribute *OrderQuantity*, which each part has, tells how many parts belong to an order.

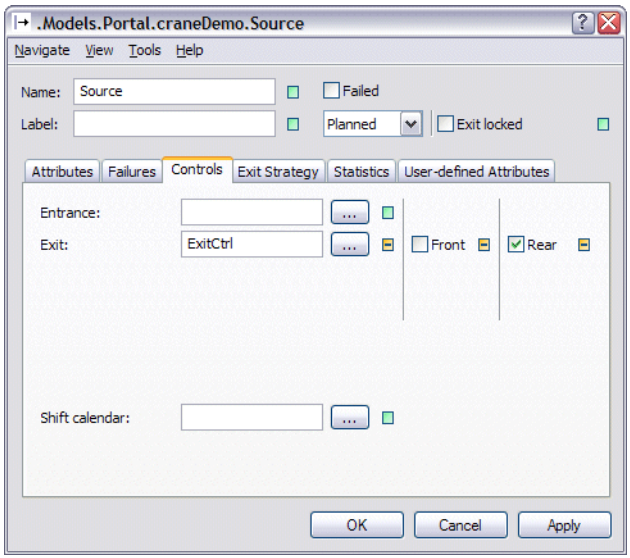
To solve this task, we will:

- *Define How the Source Creates Parts and Moves Them On*
- *Shuffle the Sequence of Orders*
- *Place Parts into Stock*
- *Remove Parts from Stock*

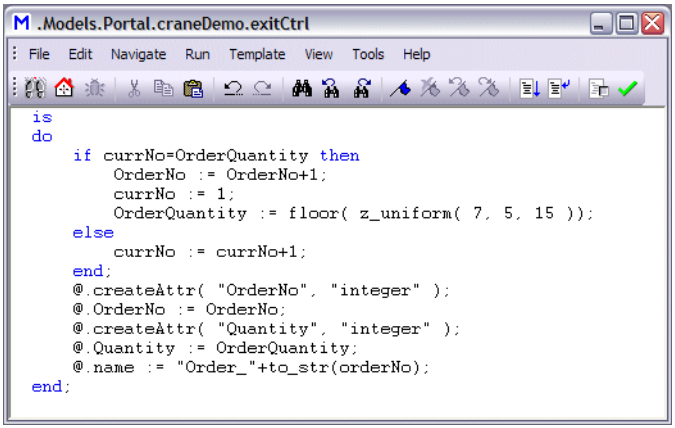


Define How the Source Creates Parts and Moves Them On

First, we enter an exit control into the *Source*.



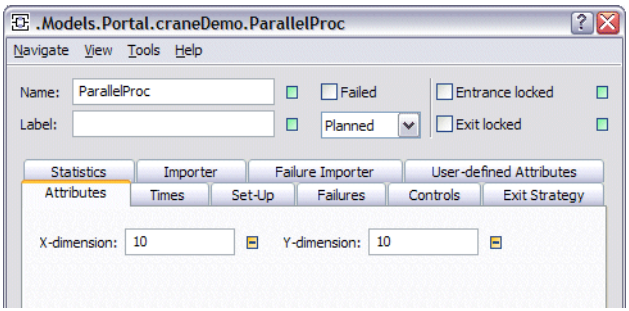
The method *ExitCtrl* checks if the value of the *Variable*, which shows the number of parts which were created for an order, is the same as the number of parts which was actually ordered. When this is the case, *Plant Simulation* increases the order number by 1. It also determines the order size, between 1 and 10 parts, using a uniform distribution. The bounds of the distribution, 1 and 11, are never reached. The mathematical function *floor* calculates the next-lower value.



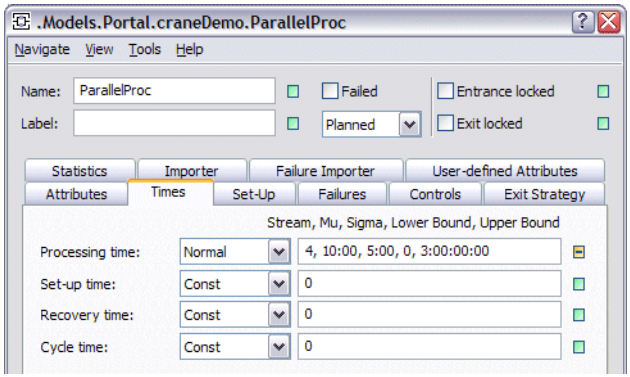
The method then creates the attributes *OrderNo* and *OrderQuantity*, which contain the number of the order and the size of the order. Finally, the method sets the name of the part to the order number.

Shuffle the Sequence of Orders

The second station in the sequence of stations, the *ParallelProc*, shuffles the sequence of orders. First, we define a **capacity** of 100 parts by entering `10` for the x-dimension and `10` for the y-dimension.



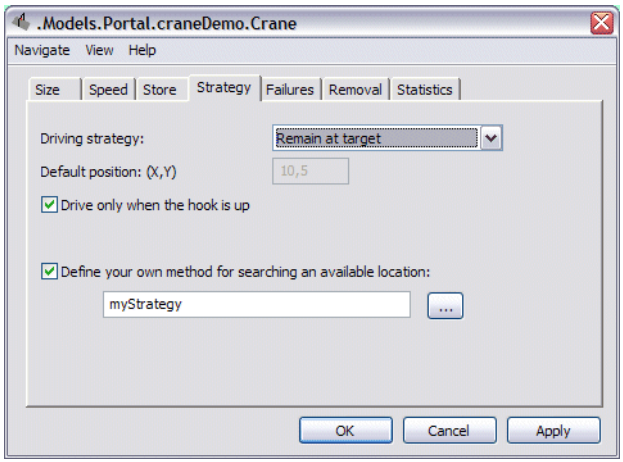
Then, we select the Normal distribution for the processing time. We enter a mean value of `10` minutes, and a sigma of `5` minutes. This way the processing time will be calculated anew for each incoming part and the parts will thus be shuffled.



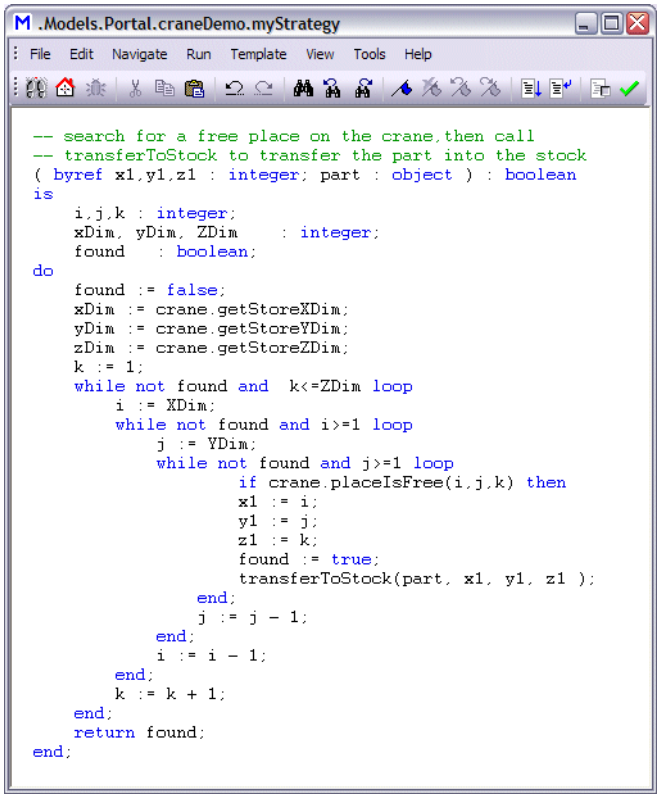
Place Parts into Stock

From the *Shuffle* station the parts move on to the *Crane*. It places them into intermediate storage until all parts of an order are in stock. The *Crane* then removes the completed order from stock.

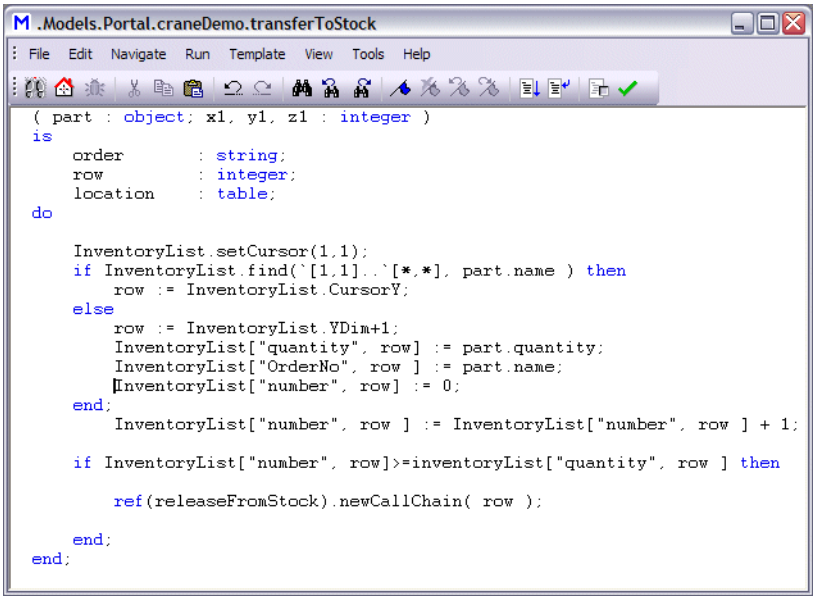
As we ourselves want to determine how the *Crane* places parts into stock, we select the check box Define your own method for searching an available location. We then enter the name of the *Method* M, in which we want to program our storage strategy: `myStrategy`. Finally, we type in our source code with the instructions.



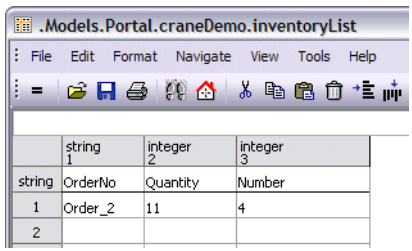
To format this *Method*, so that is has the correct format for our purpose, we can either click OK or Apply. The *for loops*, together with the built-in method *placeIsFree*, first search for a free storage place for stocking the parts.



As soon as a free place is available, the method *transferToStock*, which we programmed, places the part into stock.

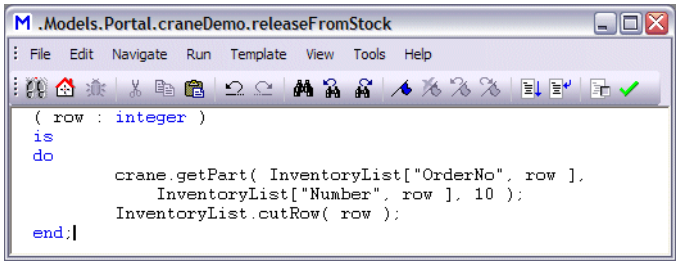


The method first checks the *InventoryList* if a part with this order number already exists in the store. When this is not the case, the *Crane* enters the order number and the order quantity into the *InventoryList*. As you remember, we defined order number and order quantity as user-defined attributes for the part. The *Crane* then increases the number of parts in the store by 1. When the number of stored parts is the same as the number of ordered parts, the *Crane* removes the parts of this order from stock. As this method call may only be activated after the part has been transferred to stock for good, we employ the method *newCallChain*.



Remove Parts from Stock

Once the number of parts in store is the same as the number of ordered parts, the *Crane* removes these parts from stock with the method *releaseFromStock*, which we programmed.

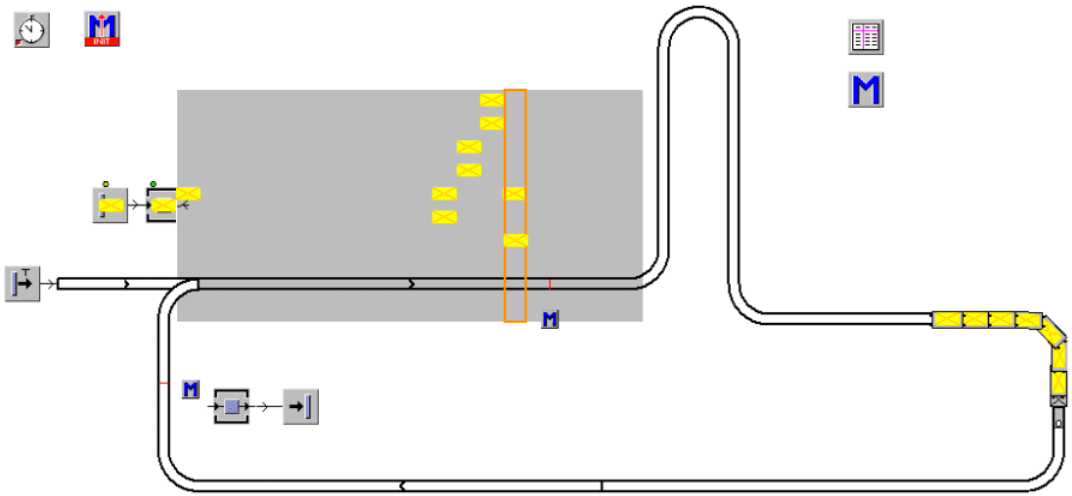


This method retrieves all parts of a certain type, identified by its name, employing the built-in method *getPart*. As we chose the name of the part to be identical with the order number, we can directly retrieve the order number and the order quantity. After this, the *Crane* deletes the order number from the *InventoryList*.

Load a Train with the Portal Crane

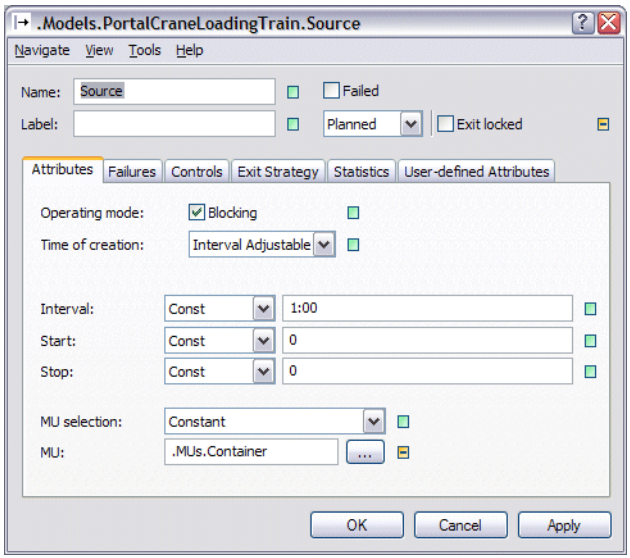
This example demonstrates how to load a train with a *portal crane*. For this we create parts in a *Source* and place them in the store of the crane. As soon as a train arrives at the loading station, the crane loads the parts onto it. The loaded train then leaves the storage area of the crane, and will be unloaded at another station along the tracks. Note that the loading station has to be located within the storage area of the *Portalcrane*. To accomplish this, we have to solve these tasks:

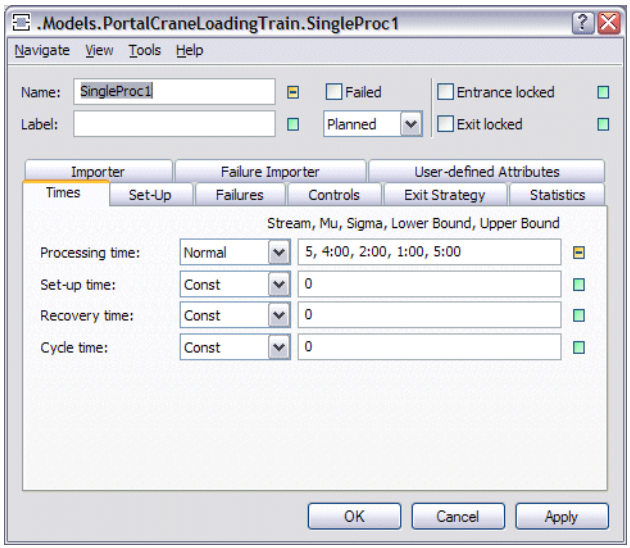
- *Produce the Parts and Place them into the Storage Area of the Crane*
- *Parameterize the Crane*
- *Create the Train*
- *Load the Train*
- *Unload the Train*



Produce the Parts and Place them into the Storage Area of the Crane

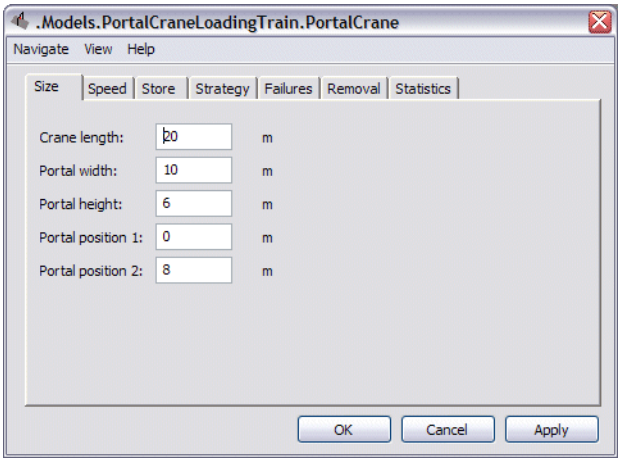
The parts, in our example *Containers*, will be created in an object of type *Source*. The succeeding station *SingleProc* delays the parts employing a normally distributed processing time. From the *SingleProc* the parts are directly moved to the entry station of the *portal crane*, which then automatically places them into stock.



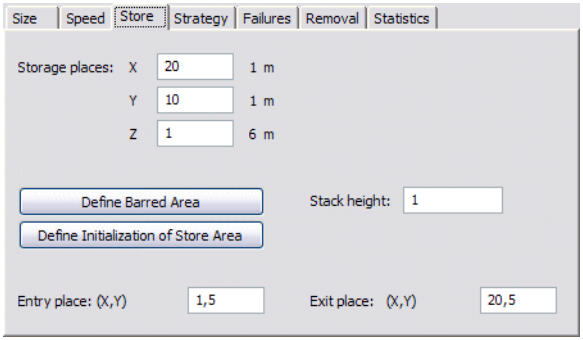


Parameterize the Crane

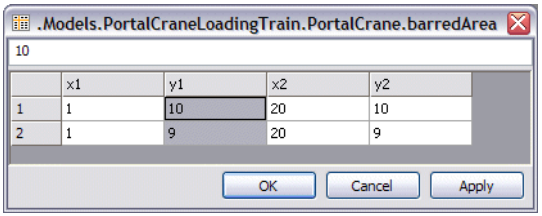
Our *Portalcrane* has a length of 20 meters and a width of 10 meters. The portal positions are located at 0 meters and 8 meters, meaning that the gantry juts out 2 meter over its columns. This is where the train is going to move.



We distribute 20 times 10 storage places across the store. Each storage place is 1 meter by 1 meter.

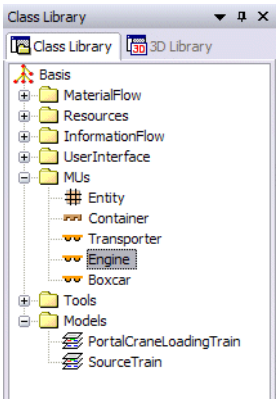


We mark rows 9 and 10 as barred area on which the tracks of the train run. Other than that, we do not change any of the default settings of the crane.

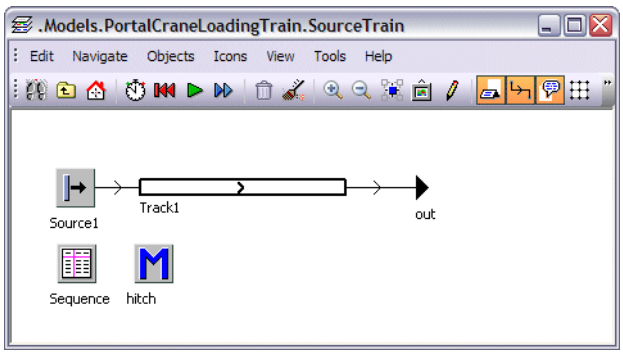


Create the Train

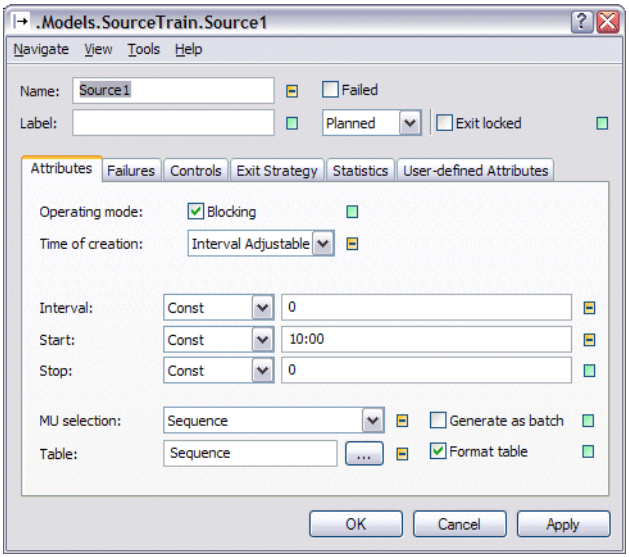
Model a Tugger Train describes in detail how to create a train. For our model we create two new object classes, *Engine* and *Boxcar*, in the *class library* by duplicating the *Transporter*:



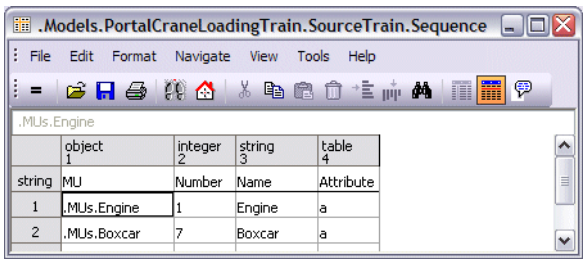
In a *Frame* of its own we combine the *Source*, the *sequence table*, the *collision control hitch* and a short piece of track.



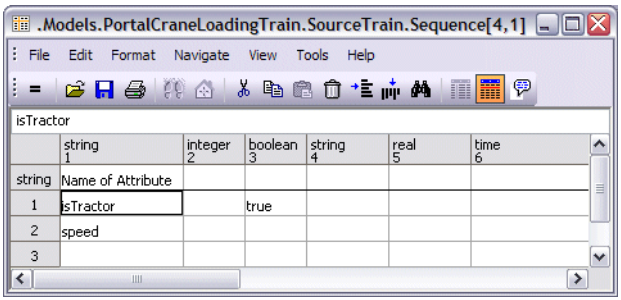
- We configure the *Source* so that it creates a train every ten minutes according to the settings, which we enter into the sequence table.



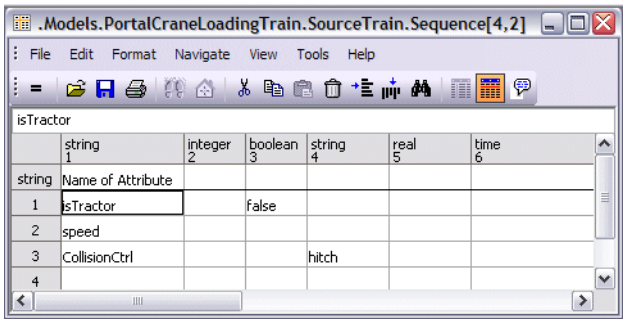
- In the sequence table we instruct the *Source* to produce one *engine* and seven *boxcars* per train.



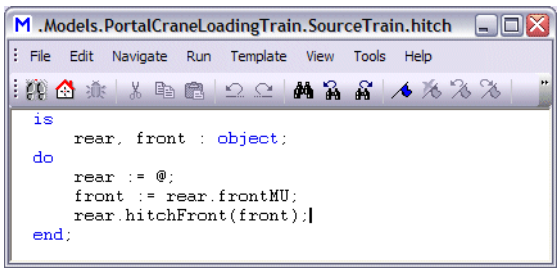
  - For the *engine* we set the attribute *isTractor* to `true` and the speed (in column 12) to 1 m/s.



  - For the *boxcars* we set *isTractor* to `false` and the speed (in column 12) to 1.1 m/s. This way we cause a collision event, which hitches the *boxcars* to each other and to the *engine*.

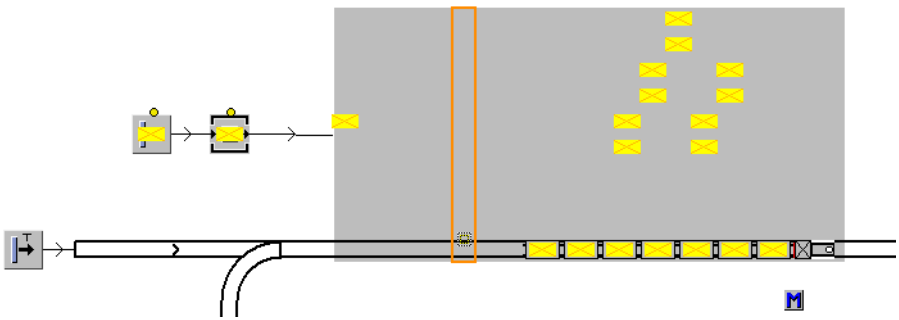


- We then program the control for the collision event in the method *hitch*.



Load the Train

We model the track of the train with the object *Track*. For this we have to make sure that a piece of track runs underneath the crane so that the crane can load the parts onto the train. We thus define a sensor on the far right side of the crane area. The exact position depends on the way we model our track. As sensor control we enter the method *load* in which we program how the train is to be loaded.



The method *load* is to be executed only, when the *engine* of the train triggered the sensor. Thus we first have to check if the respective car of the train is the *engine,* i.e. if the attribute *isTractor* is *true*. If so, the train stops and we retrieve the contents table of the crane. For safety purposes we wait until the store contains 10 containers at least.

The first *boxcar* is hitched directly to the rear of the *engine* (`engine.rearMU`). The loading position refers to the X-Position of the crane at which the first *boxcar* is located.

Then we create the loading orders for the crane. For this we always take the last entry in its contents list. We utilize the method *getPartFromPositionToObject* to instruct the crane to load the part from the specified position in the contents list with the priority `20` to the X-Position `loadPos`, and the Y-Position `10` onto the *boxcar*. As the *boxcar* can only hold a single container, we also enter the loading position (`1,1`). The priority `20` ensures that the loading orders have a higher priority than the storage orders.

Then we proceed to the next *boxcar* and adjust its loading position accordingly. This we repeat until we have given the loading orders for all *boxcars*. Note that until now we only have issued the orders, but that the *boxcars* have not necessarily been loaded yet! To ensure this, we pass over all *boxcars* again and wait until all *boxcars* are loaded. Only then can the *engine* start and pull the train away.

Our complete source code of the method *load* looks like this:

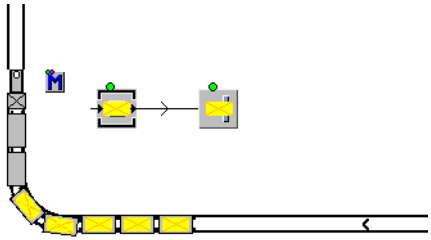
.Models.PortalCraneLoadingTrain.load

File Edit Navigate Run Template View Tools Help

```
is
    content : table[integer, integer, integer, integer, object];
    i, row  : integer;
    boxcar  : object;
    engine  : object;
    loadPos : integer;
    outcome : boolean;
do
    if @.isTractor then
        engine := @;
        engine.stop;
        content.create;
        repeat
            -- 10 containers at least need to be in the store
            PortalCrane.getStoreTable(content);
            if content.ydim<10 then
                wait( 300 );
            end;
        until content.ydim>=10;

        boxcar := engine.rearMu;
        loadPos := 18;

        -- generate all loading orders for the crane
        while boxcar/=void loop
            row     := content.ydim;
            outcome := PortalCrane.getPartFromPositionToObject(
                content[1,row], content[2,row], content[3,row],
                20, loadPos, 10, boxcar, 1, 1 );

            boxcar := boxcar.rearMU;
            loadPos := loadPos - 2;

            content.cutRow( row );
        end;

        -- wait until the train is completely loaded
        boxcar := engine.rearMu;
        while boxcar/=void loop

            waituntil boxcar.full prio 1;
            boxcar := boxcar.rearMU;
        end;
        engine.continue;
    end;
end;
```

Unload the Train

At another location along the track we define another sensor and assign it the method *unload* as its control. This method is only to be executed, when the *engine* triggers the sensor. First we stop the train. The first *boxcar* is located directly behind the *engine*. Starting from this *boxcar* we pass over the entire train. When the *boxcar* is loaded, we wait until the *SingleProc* named *SP* is empty and then move the *Container* onto this station. When all *boxcars* are unloaded, the *engine* can start pulling away the train again.



The complete source code of the method *unload* looks like this:

.Models.PortalCraneLoadingTrain.unload

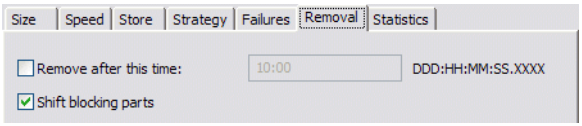
File Edit Navigate Run Template View Tools Help

```
(sensorID : integer)
is
    engine  : object;
    boxcar  : object;
do
    if @.isTractor then
        engine := @;

        engine.stop;

        boxcar := engine.rearMu;
        while boxcar/=void loop
            if boxcar.cont/= void then
                waituntil sp.empty prio 1;
                boxcar.cont.move( SP );
            end;
            boxcar := boxcar.rearMu;
        end;
        engine.continue;
    end;
end;
```

Feed Machines with an Overhead Crane

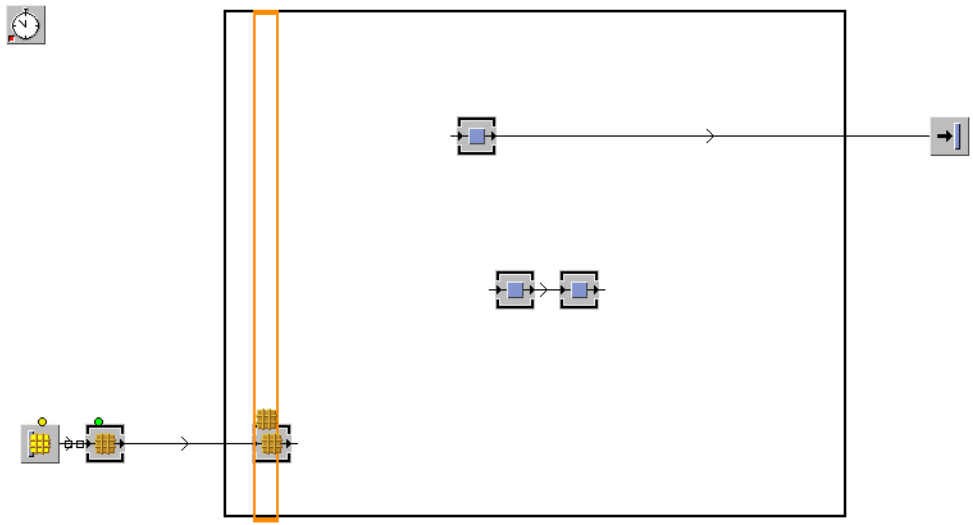
In this example we demonstrate how to transport heavy parts that are to be processed from one machine to another machine on the shop floor with an overhead crane.

For this we instantiate the object *PortalCrane*. The only setting of the *PortalCrane* which we change is to deactivate the automatic removal of parts (Removal > Remove after this time).

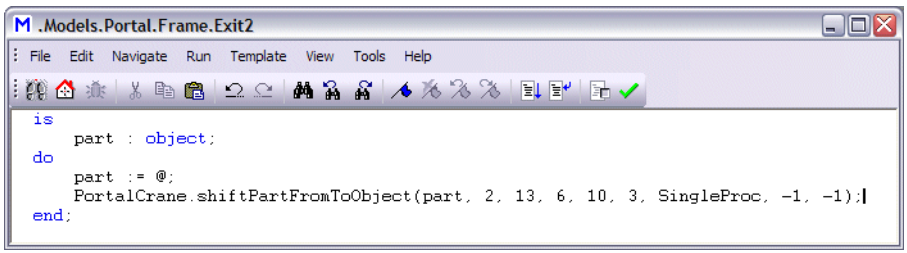


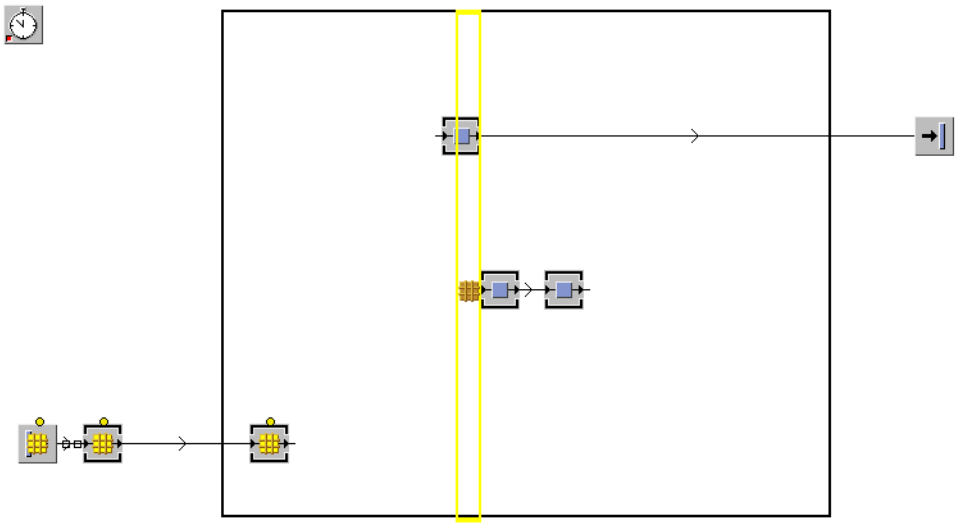
Next we place several instances of the *SingleProc* within the storage area of the crane. In order to be able see them, we set the icon of the *PortalCrane* to transparent by selecting View > Change Icon. Then, we connect two *SingleProcs*

each. Thus we created a processing machine and a removal station. For this removal station we enter an **exit control** and the short **processing time** it takes the part to be moved from the machine to the removal station.



Within the exit control we first assign the current part. Then we instruct the *PortalCrane* to transport the `part` with the priority `2` from the position at the coordinates (`13,6`) to the position (`10,3`) and to there place it onto `SingleProc1`. As the *SingleProc* only has a single processing station, we do not have to specify the station on the *SingleProc* and enter `-1` twice.





Model a Tugger Train

To model *Tugger Trains*, consisting of a *tractor* and a number of *trailers*, you will use a number of extended features of the *Transporter*. In our sample model a *tugger train* is loaded with parts, which will be unloaded at a station on the main line and on the side line each.

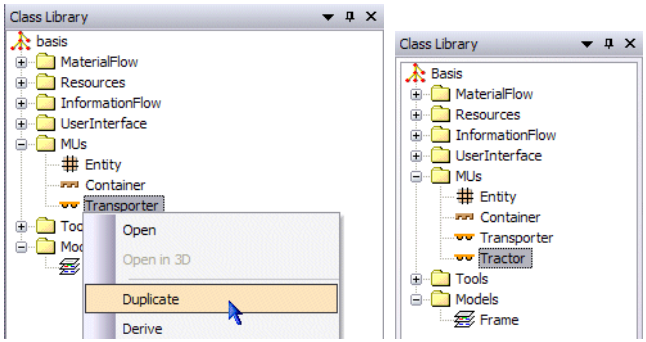
The model demonstrates how to:

- *Define the Tractor of the Tugger Train*.
- *Model the Source Creating the Tugger Trains*.
- *Model the Track System on which the Tugger Trains Move*.
- *Configure the Loading and Unloading Stations*.

Define the Tractor of the Tugger Train

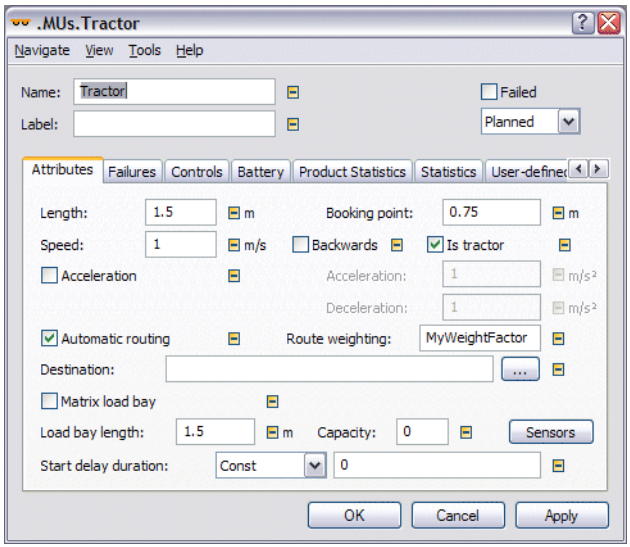
To define the *tractor* of the *tugger train*:

- Duplicate the object *Transporter* in the *Class Library*. Rename it `Tractor`.



- Double-click the object *Tractor*. To designate it as the *tractor* of the *tugger train*, which pulls the *trailer*(*s*), select the check box Is Tractor. This *Transporter* then shows the icon tractor instead of the icon Operational.

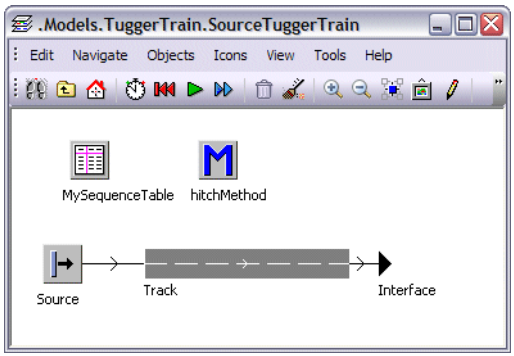
  To prevent the *tractor* from loading parts, we have to make the load bay length-oriented, as only a length-oriented load bay can take the capacity 0. To do so, we cleared the check box matrix load bay and entered 0 as the capacity.



Model the Source Creating the Tugger Trains

- *tugger trains*A Source object, which creates *tractors* and *trailers* according to the settings, which we enter into a *sequence table*.
- A *Track* object, which should be long enough to accommodate the *tugger train* with its entire length after the *Source* object has created it. This ensures that the *tugger train* is able to move onto the succeeding object as a whole. The

tugger train in our example consists of a *tractor* and four *trailers*, each of which is 1.5 meters long. So we entered a length of 8 meters for the *Track*.



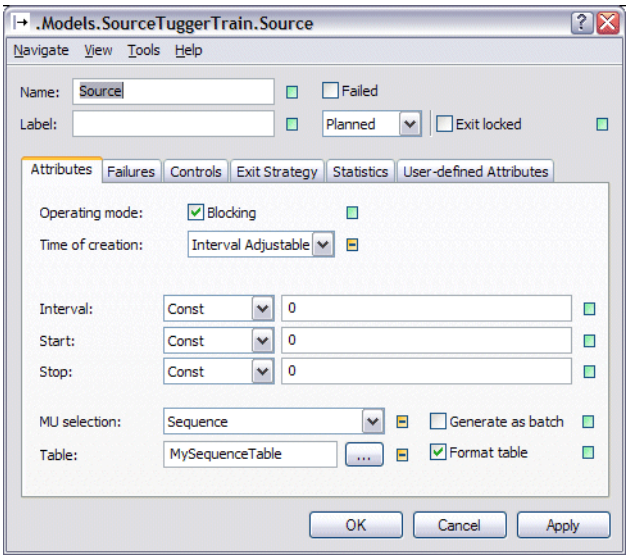
- A Method object, in which we program how the *trailers* are hitched up to the *tractor*, when they collide with the transporter driving in front of them.
- An *Interface* object, which provides the connection to the other objects within the simulation model.

Configuring the Source Object and Creating the Sequence Table

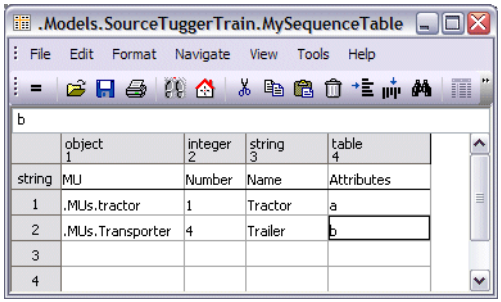
To configure the *Source* object, which creates the *tractors* and the *trailers*, which make up the *tugger train*, double-click its icon.

To produce the objects as a sequence according to the settings, which we enter into the sequence table:

- Select MU selection > Sequence.



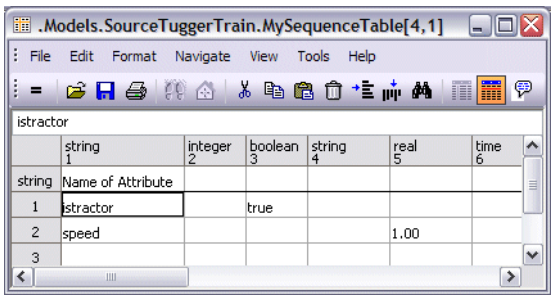
- Click ... and select the *TableFile MySequenceTable*, which we inserted above. To create a *tractor* object using the MU class `Tractor` and four *trailer* objects using the MU class `Transporter`, we entered the values shown in the screenshot below.



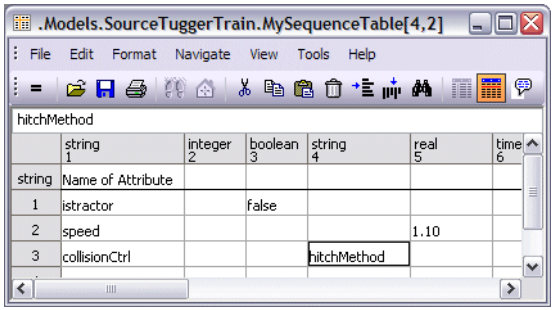
- The characters, which we enter into the column Attributes, only serve as a placeholder for the subtables contained in these cells. Within the subtables we set the attributes of the tractor and of the trailers.

  To designate the *tractor*, we entered the attribute `IsTractor` and set it to `true`. To set its speed, we entered the attribute `Speed` and entered `1.0` m/s.

  Note: We already defined the attributes of the *tractor* in the class Tractor. We just entered them again to make sure that the settings in the *tractor* are the correct ones, in case the settings of the class get changed.



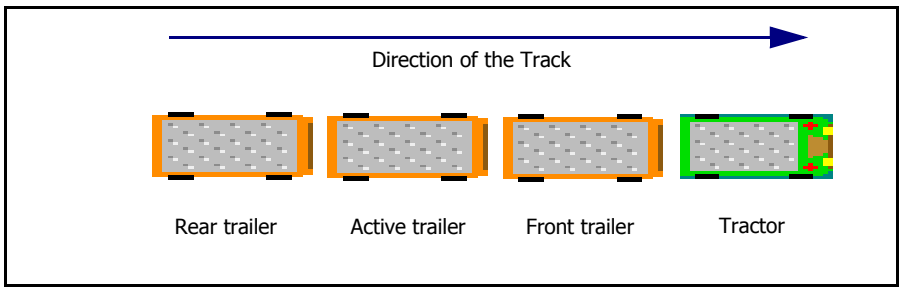
  To designate the *trailers*, we set the attribute `IsTractor` to `false`. As we want the *trailers* of drive faster than the *tractor* and to collide with the object in front of them, we entered `1.1` m/s as their `Speed`. To designate the collision control (`CollisionCtrl`), we entered the name of the method, which we inserted above, `hitchMethod` in our case. The collision control hitches the *trailers* to each other and the front *trailer* to the *tractor*.



Programming the Collision Control

To program the collision control *hitchMethod*, which we inserted above, double-click the *Method* object. We want this control to hitch the colliding *Transporter* to the one in front of it. To do so, we have to establish the *Transporter* moving in front of the active *Transporter*.

Finally, we are going to hitch the rear *Transporter* to the one moving in front of it to create the *tugger train*.

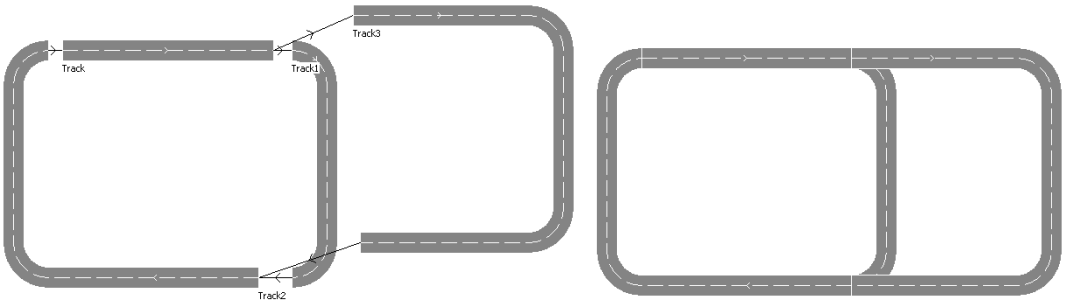


These instructions above translate into this source code in our *Method*:

```
is
   Rear, Front  : object;
   TractorSpeed : real;
do
   Rear := @;
   Front := @.frontMU;
   if Front.IsTractor then
       TractorSpeed := Front.Speed;
       Rear.hitchFront(Front);
   else
       Rear.hitchFront(Front);
   end;
end;
```

Model the Track System on which the Tugger Trains Move

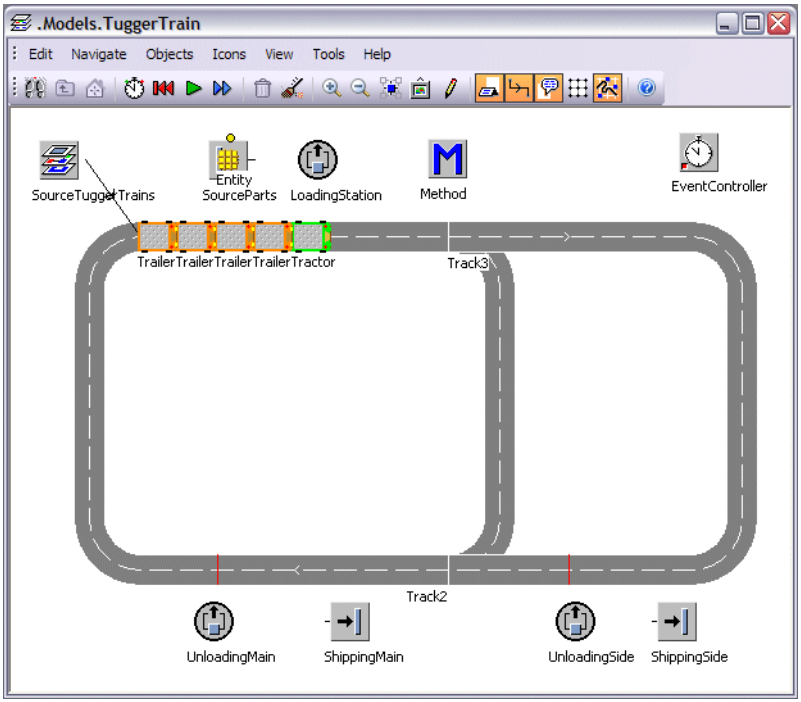
To demonstrate how the *tugger trains* move as a single unit on a track system, let's model a main line, from which a side line splits, which then leads back into the main line. For this we use four *Track* objects and connect them with *Connectors*. To move the side line over the main line, hold down the Shift and/or Ctrl keys and press the arrow keys.



After we have finished creating the track system, we have to insert:

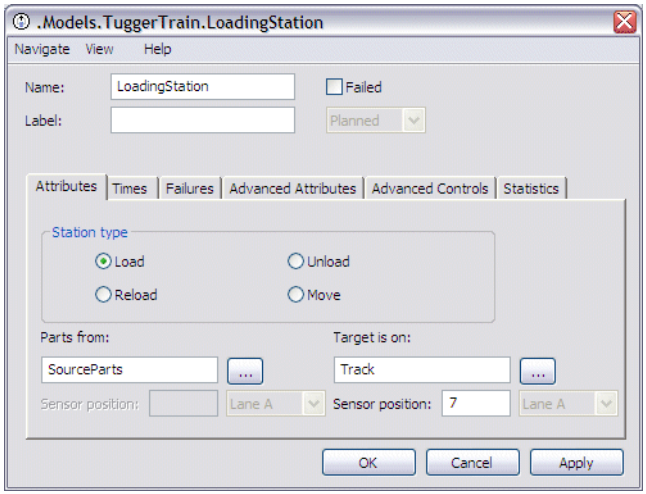
- The station producing the *tugger trains*, which we modeled in the *Frame SourceTuggerTrains*. We connect this *Frame* with the object *Track*.
- A *Source* which produces the parts with the default settings and a station, which loads them onto the *trailers* of the *tugger train*.
- An unloading station on the main line and the side line each, plus a *Drain* each, which removes the parts from the lines. For the two *Drains*, which we named *ShippingMain* and *ShippingSide*, we use the default settings.
- An *EventController* for running the simulation.

Our finished model looks like this.

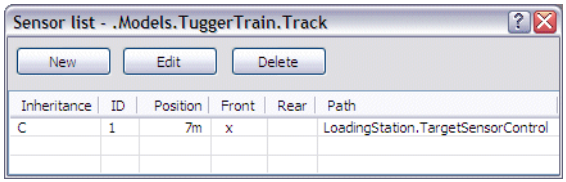


Configure the Loading and Unloading Stations

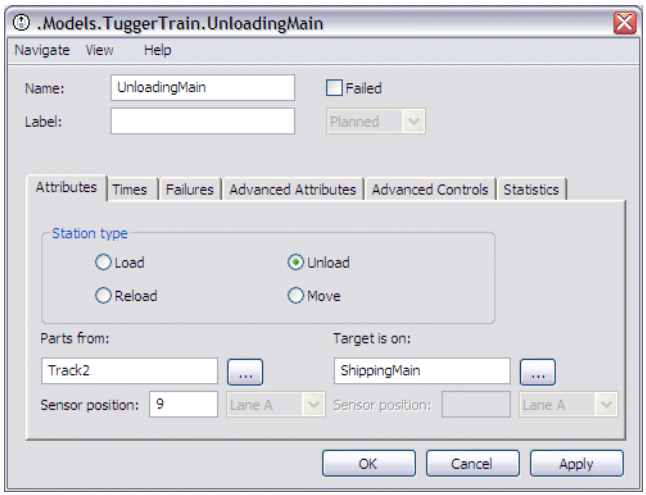
Configure the loading station on the tab Attributes. Select the object which provides the parts (parts from) and the object on which the *tugger train* moves (target is on). In our case this is the *SourceParts* and the *Track*.

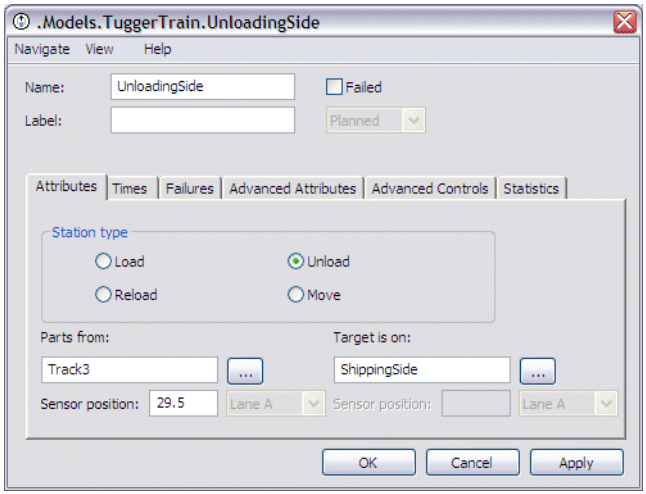


Enter the position of the sensor, which triggers loading the *tugger trains* with parts. We entered 7 (meters). The *TransferStation* then enters these settings into the dialog Sensor List of the *Track*.



Next, configure the stations *UnloadingMain* and *UnloadingSide* as shown in the screenshots below.





When you are finished, insert an *EventController*, run the simulation and watch how the *tugger trains* are loaded with parts, move on the main line, are unloaded, are loaded again and are unloaded on the side line on their second trip.

Preparing Data for the Simulation with DataFit

One of the purposes of your simulation study will be to optimize the availability of resources, such as machines, laborers, vehicles, etc. for an existing or a planned production facility. This means that you have to reduce the number of failures and down-times of machines. When a machine fails, it has to be repaired, which leads to delays in the production and costs money.

Oftentimes the *Mean Time Between Failures* (MTBF) and the *Mean Time To Repair* (MTTR) are stochastically distributed. Because of the qualitative properties of a system with failures, we know the type of distribution for the MTBF and for the MTTR. What we do not know are the parameters of the distribution.

Production planning specialists do observe the availability of resources, the MTTR and the MTBF. The availability is the MTBF divided by the MTBF plus the MTTR times 100%, i.e., $AV = \frac{100 \cdot MTBF}{MTBF + MTTR}$. So when we know two of the three values—AV (availability), MTTR and MTBF—we can calculate the third one. The *DataFit Wizard* calculates the parameters of the distributions for the MTTR and MTBF to arrive at the availability you want to achieve.

Step 1: Define the Task and the Objectives

You will start out with defining the task and the objective of the simulation study, being careful to not predefine any one solution you might expect or wish to be true.

Some of the questions you want answers for are:

- What throughput and what output can we expect?
- What is the optimal number of resources (machines, workers, tools)?
- Where in the installation are buffers necessary? What is the optimal buffer size?
- What is the optimal number of work piece carriers?
- Which control strategies are best suited for the task?
- How do some or all of the above factors interact and produce different results?

Then, you will have to decide the scope of the simulation.

- Do you only need to simulate the production facility?
- Or do you also have to simulate other areas, such as receiving the parts delivered by the suppliers, warehousing, shipping, etc.?

Step 2: Collect and Prepare Data

Collecting and preparing the data to use in the simulation study is one of your most important tasks.

This takes up about 35% of the project time! Creating the model takes up 25%, validating and correcting 15%, running experiments 10%, analyzing and evaluating 15% of the project time.

You will use:

Static data, such as:

- Data extracted from the production program, which you collected by watching the machines in the installation or which you received from the experts on the shop floor.
- Data extracted from the structure of the installation.
- Data from a shift model.

Stochastic data, such as:

- The failure behavior.
- The processing and set-up times.
- The amount of rejects.

For simulating the material flow of interlinked production and assembly facilities you need:

1. Data covering the entire production system (**model data**):
   - The production program, such as the produced products, the lot sizes, etc.
   - The layout of the installation, its structure, controls, and the points where parts are introduced into or discharged from the system.
   - Reworking, such as reworking times, the station that produces rejects, and the frequency of rejects.
2. Data covering the staff working in the installation (**object data**):
   - The number of workers, and their qualifications.
   - The shifts worked.
   - The distances covered and the required times.
3. Data covering machines, transport systems and work stations (**object data**):
   - Failures, including MTBF, MTTR, reference time, distribution, and variance.
   - Cycle times, capacities and cycle variance.
   - Set-up times.
   - Supply with materials.

Step 3: Decide which Distribution to Use

Once you have collected the data you need for the simulation study, you have to decide:

- Which distributions to select for the Processing time, the Set-up time, the Recovery time, the Cycle time, and the Failure times for the *Plant Simulation* objects.
- Which parameters to enter for the selected distribution.

For this, we provide *Statistics Wizards*.

You can:

- Employ Distribution-Fitting with DataFit.

- Use Distributions with Bounds.

Distribution-Fitting with DataFit

Use the object *DataFit* for distributions without bounds.

- Enter a sample of observations of a random number and a Level of significance.
- Then, the *Wizard* finds the parameters of the selected distribution.

  The *Wizard* estimates the parameters of the selected distribution(s) and then performs a goodness-of-fit test with the filtered data on the tab Fit.

  Note: The Level of significance is the probability with which a distribution with estimated parameters will be rejected by the goodness-of-fit test, although it is suitable for the sample.

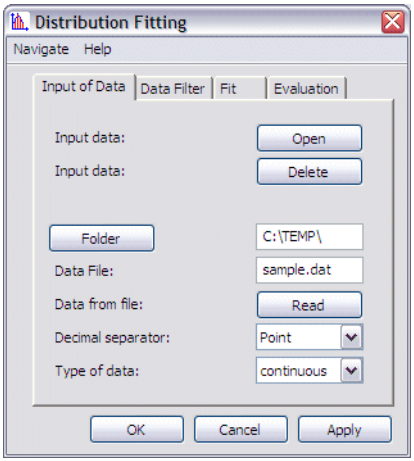
Compare the sample models: Select View > Start Page > Info Pages, scroll to Small Modeling Examples and click on the icon to the left of it. Then, select the Category, the Theme, and the Example in the dialog Examples Collection and click Open Model.

Input Data in DataFit

Note: *DataFit* only computes the distribution parameters for a sample with more than 10 values.

You can only proceed to the next tab, after you have selected the required settings and entered the data for them on the active tab. *DataFit* then activates buttons and/or text boxes on the next tab.

Most buttons are toggle buttons that activate and deactivate a feature.



Import data to be fitted on the tab Input:

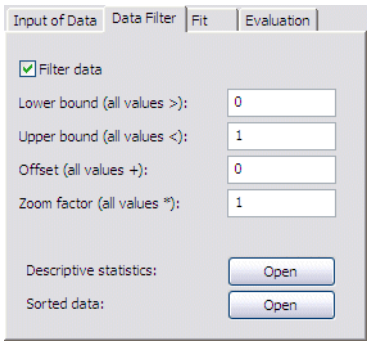
- Import the data you received—sample data observed on the shop floor, or the results of a previous simulation run—into a column of an *Plant Simulation* table file. Then, drag this table over the object *DataFit* in the *Frame* that contains your simulation model and drop it there.
- Select a column that contains the data you want to use in the dialog that opens and click Load.

  Or
- Click Read to import data from the file whose name you enter into the text box Data file.
- When you import data from other programs, for example from Excel, you have to select the same Decimal separator in *Plant Simulation* as you used in the other application. You might also paste the sample data into the table via the Windows-Clipboard. For this you have to click Open to open the input table.
- Select which type of data you want to investigate:
  - Discrete numbers, i.e., any integer number greater than or equal to 0, this is `0`, `1`, `2`, `3`, etc.
  - Continuous numbers, which include negative numbers, and floating point numbers, for example `-10`, `1.4`, `5`, ...

When you have entered all required data or selected the required settings, you can proceed to the tab Filter.

Filter Data in DataFit

Filter the data on the tab Filter.



Filtering serves three purposes:

1. It cuts off data that is atypical.
2. It eliminates outliers, i.e., if removes these values from the sample.
3. It transforms data to a certain range, i.e., it translates or zooms data.

To filter data:

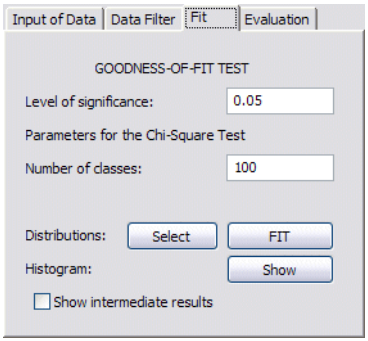
- You can, but do not have to enter a value for the Lower bound and a value for the Upper bound.
- Click Start to start filtering the data.
- This activates the buttons Show descriptive statistics and Open filtered data.
  - Clicking Show opens a table with descriptive statistics of the characteristics of the sample data.

- Clicking Open filtered data opens a table with the sorted data to be used for data fitting, i.e., after eliminating unwanted values.

When you have entered the required data or selected the required settings, you can proceed to the tab Fit.

Fit Data in DataFit

DataFit estimates the parameters of the selected distribution(s) and then performs a goodness-of-fit test with the filtered data on the tab FIT.

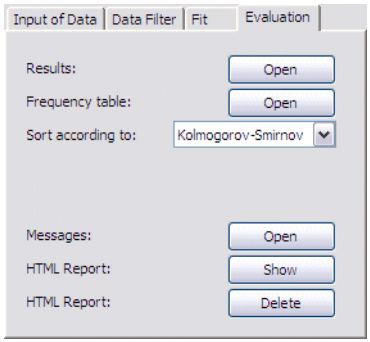


- Click Select and select one, several or all distributions in the dialog that opens.
- Enter a Level of significance for the values. You can enter a number between `0` and `1`. In most cases you will enter a number between `0` and `0.2`.
- Click Fit to estimate the parameters for the selected distribution or distributions using the sample.
- If you are investigating a large sample, you will have to use the *Chi-Square Test* as the Goodness-of-Fit Test. For this you have to enter the Number of classes. The Goodness-of-Fit Test describes how good the distribution with its parameters fits the given sample.
- Click Show to display a histogram of the sample in a chart.

When you have entered the required data or selected the required settings, you can proceed to the tab Evaluation.

Evaluate Data in DataFit

Perform an analysis of the filtered data on the tab Evaluation.



Select how *DataFit* sorts the fitting tests:

- The Chi-Square test suits all purposes. It splits up the sampled data into classes. The sample has to have more than 40 values.
- The Kolmogorov-Smirnov and the Anderson-Darling test are only suited for continuous distributions with 10 to 200 values.

Open the results table that shows which parameters of which distribution to enter in *Plant Simulation*.

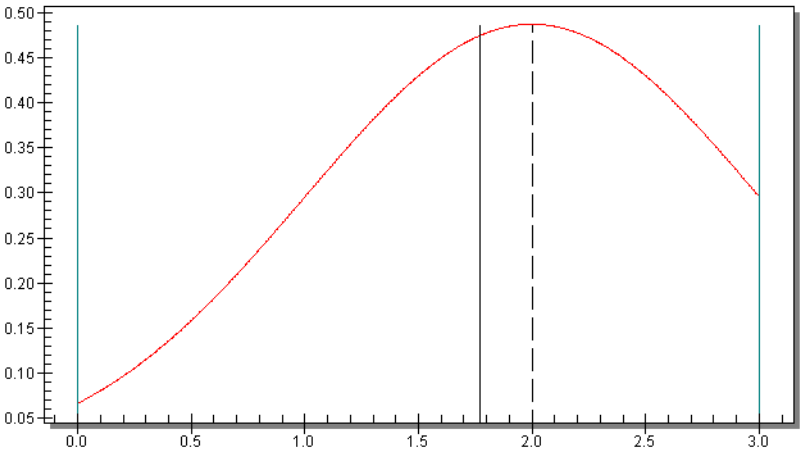
- The columns Result Chi, Result KS, Result AD tell, if the distributions are applicable to the sampled values or not. This is the case, when the corresponding value statistic is smaller than the corresponding value. Naturally, the evaluation takes the Level of significance into account.
- The columns labeled Parameter 1, Parameter 2, and Parameter 3 show the exact numbers and the names of the rounded parameters as you enter them into the dialogs of the *Plant Simulation* objects.
- To show a HTML Report of the parameters and the goodness-of-fit test, click Show.
- To reduce the size of the model, which might have been bloated by the HTML Report, click Delete.
- When none of the selected distributions adequately represent the properties of the sample, you can use an empirical distribution to model the data of the sample in *Plant Simulation*. Click Open to open the Frequency table.

Use Distributions with Bounds

The distributions you use in your simulation have realizations that may be arbitrarily large or small, respectively. For this reason, you will use distributions with upper and lower bounds, to cut off values you do not want to consider.

Be aware that using a distribution with bounds will change the mean value and the standard deviation.

When you use the normal distribution for modeling a random time, the lower bound automatically will be 0.



When you enter the parameters $\mu = 2.0$, and $\sigma = 1$ for the normal distribution, a real mean value of the distribution with the lower bound 0 and the upper bound 3 will be 1.77.

Use the object *TruncDistribution* for distributions with bounds.

- Select a distribution and both bounds.
- Type in a reasonable precision level for the calculations.

  One hundredth of the expected mean value of the distribution with bound suffices for most applications.
- Change to the tab Statistics Values. Enter the parameters of the distribution for which you want to investigate the effects of the bounds. Then, click Start to calculate the real mean value and the real standard deviation of the distribution with bounds.

  After the calculation is done, you can click Show to view the density function and the bounds. The density visualizes how the bounds cause the mean value to shift.

  The solid vertical line designates the real mean value of the distribution with bounds.

  The dotted line designates the mean value of the distribution without bounds.

  In addition, the *TruncDistribution* shows the probability of a hit, with which a random number of the distribution without bounds falls in between the bounds, which you entered.

  Plant Simulation rolls the dice until a random number falls in between the bounds of the distribution with bounds. When its probability is too small, it may happen that the maximum number of samples, which you entered under Tools > Preferences > Simulation does not suffice and *Plant Simulation* interrupts the simulation.
- On the tab Parameterization you determine the parameters of the distribution, so that the distribution with bounds arrives as the mean value, which you set.

  To a certain degree you execute the reverse conversion to the calculation task on the tab Statistics Values.

  Click Start to start calculating. Note that not each mean value between the bounds is viable.

- On the tab Normal you calculate the distribution parameter Sigma σ of the normal distribution with given quartering parameter Mu μ and probability of a hit.

  In addition, the *TruncDistribution* calculates the real mean value and the real standard deviation of the normal distribution with bounds.

Executing Simulation Experiments

After creating your model, you have to validate it, i.e., you have to make sure that the model displays the intended properties and shows the intended behavior. In a simulation study you will consider how certain model parameters as input values influence result values as output values.

You might, for example, execute a number of simulation experiments with the *ExperimentManager* to:

1. Arrive at **statistically safe results**.

   When you re-created an existing installation, you will compare the data you collected on the shop floor with the results of the simulation run.

   When your model contains random components, you will have to investigate how reliable the data resulting from the simulation runs is. This is especially important for data you use for drawing conclusions about the installation you modeled. Make sure to assign different seed values to the different random components of the random number streams. To consider how the random components statistically influence the results the *ExperimentManager* will change the seeds of the corresponding random number streams for each set of input values. This way you arrive at a set of observations for the output values under consideration.

   For this reason the *ExperimentManager* generates a statistical evaluation for each set of input values you enter. More detailed, for each output value and for fixed input values you will receive a confidence interval and a min-max interval with a desired level of confidence.

   A confidence interval, which results from the observations, is an interval of numbers that contains the true mean value of the random number with the confidence level which you entered. The mean value of a random component of the simulation model is unknown, and it cannot be measured exactly, as the simulation runs only provide a finite number of realizations of the corresponding random output values.

   To statistically hedge the resulting data for random data, you not only average out the results of the different simulation experiments, but you also have to decide if the data allows to draw conclusions about the simulated system, despite of fluctuations of the resulting data.

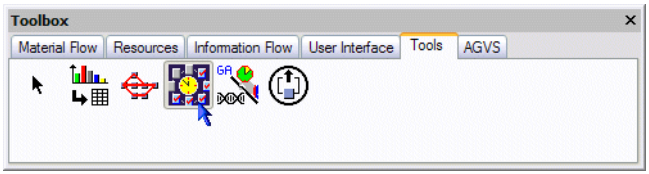
   Be aware that one cannot draw conclusions with absolute safety. One can only make statements about a system with random components with a confidence level (level of significance) you define. Compare the chapter about confidence intervals in the documentation that comes with the library *DataFit*.

2. **Optimize the results** of the simulation experiment.

   To determine the parameters that will lead to the desired simulation results, or to optimize the results of the simulation experiment, you can also use *Genetic Algorithms*.

Execute Experiments with the ExperimentManager

You find the *ExperimentManager* in the *Tools* folder in the *Class Library* or on the toolbar *Tools* in the *Toolbox*.



Your *Plant Simulation* license determines how you can use the *ExperimentManager*.

- With a runtime license you can execute experiments with a simulation model. You can modify parameters in tables. You cannot change the structure of the *ExperimentManager* model.
- With an application license, you can also change the structure of the model.
- With a development license and with a professional license, you can, in addition, define the experiments in a *Method*.

Note: Before using the *ExperimentManager* to execute your simulation experiments, insert the *ExperimentManager* into the root, i.e., the topmost, *Frame* in the hierarchy of your simulation model.

A **simulation study** contains several **experiments**. Each **experiment** executes several **simulation runs**, each of which leads to an observation.

Execute a Simple Simulation Study

You can execute a simple simulation study in three quick-and-easy steps:

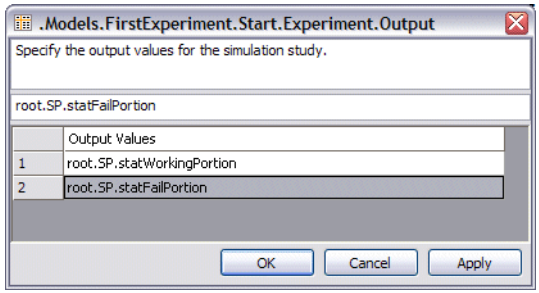
- *Step 1: Define input and output values of the experiment(s).*
- *Step 2: Run the experiment(s) with the settings you defined.*
- *Step 3: Evaluate the results of the simulation study.*

Naturally, you can also *Refine the Settings*.

Step 1: Define input and output values of the experiment(s)

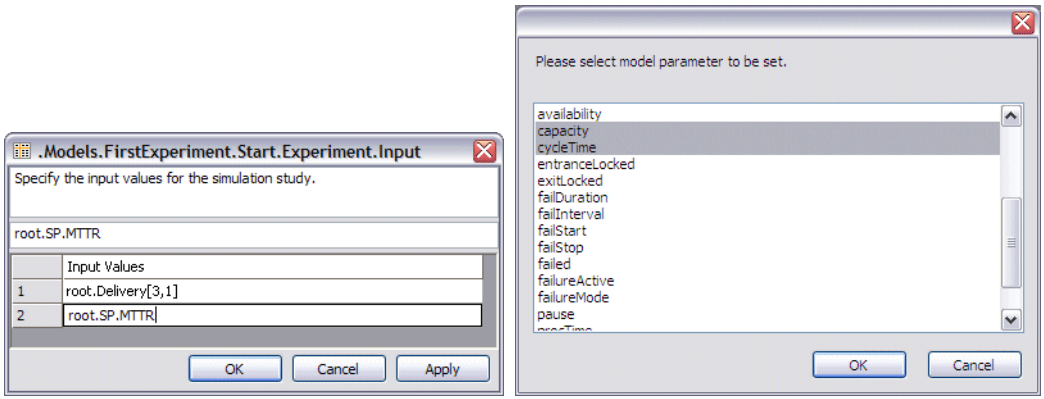
In a simulation study you consider how a set of input values (model parameters) affects output values. The output values can be observed after a single simulation run. Each simulation study needs at least one output value.

To open the table for defining the output value, click the button Output Values on the tab Define. An output value can be a method or an attribute of an object in your model.



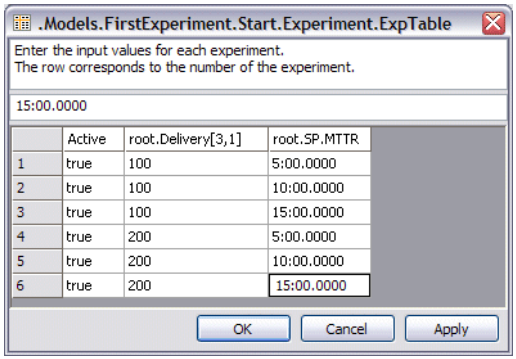
Before an executing an experiment, the *ExperimentManager* sets the input values in the simulation model. These input values are not changed in the simulations runs of an experiment.

Input values are parameters of statistical distributions and data you enter into table files. Drag a material flow object onto the *ExperimentManager* and drop it there. This shows all attributes of the object in a dialog. To select one or more attributes, hold down Ctrl and click the attributes your are interested in.



This opens the table file of all input values. Then, add other values. The *ExperimentManager* checks the entries by closing this table file. To open the table file, click Input Values on the tab Define.

To set the input values for the experiments, as shown in the figure below, click the button Define on the tab Define.

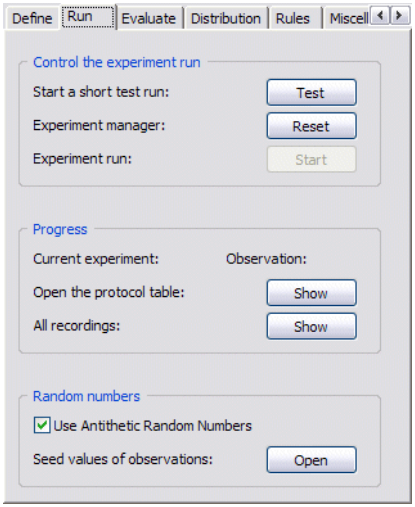


To set the simulation duration, use the attribute *End* of the *Eventcontroller*.

For our first example, we do neither use the Configuration method, nor the Evaluation method nor the User-defined seed values.

Step 2: Run the experiment(s) with the settings you defined

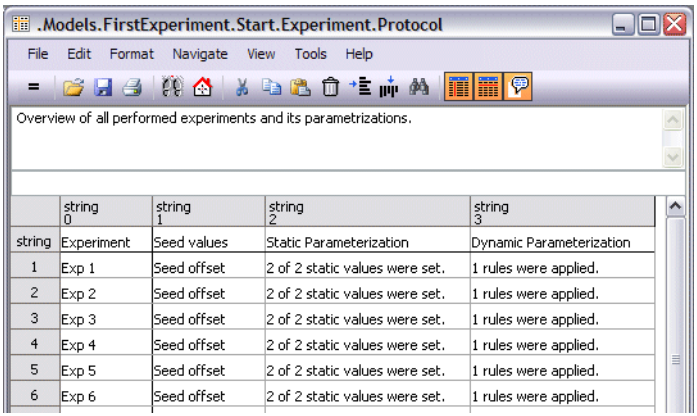
When you defined several experiments with many simulation runs that take a long time to be executed, you can run them overnight.



1. Click Reset to reset the *ExperimentManager*.
2. Click Test to start a short test run.

   Note: We recommend to execute a test run and to Show its protocol table to make sure that the settings you selected do work.

3. Click Show to check the results of the Test run. Since all setting are defined in the table, you will only detect if the so-called static *parameterization* succeeded. Please check the number of input values.



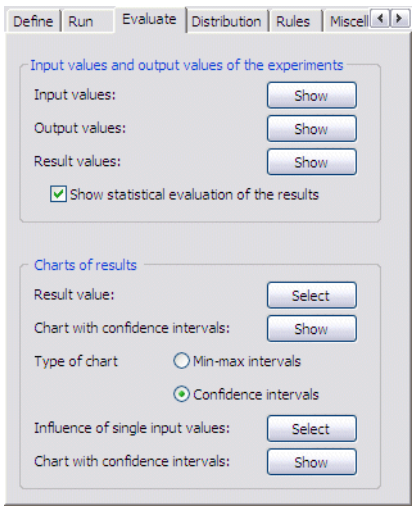
	string 0	string 1	string 2	string 3
string	Experiment	Seed values	Static Parameterization	Dynamic Parameterization
1	Exp 1	Seed offset	2 of 2 static values were set.	1 rules were applied.
2	Exp 2	Seed offset	2 of 2 static values were set.	1 rules were applied.
3	Exp 3	Seed offset	2 of 2 static values were set.	1 rules were applied.
4	Exp 4	Seed offset	2 of 2 static values were set.	1 rules were applied.
5	Exp 5	Seed offset	2 of 2 static values were set.	1 rules were applied.
6	Exp 6	Seed offset	2 of 2 static values were set.	1 rules were applied.

4. Click Start to start the Experiment run.

   Depending on the size of your simulation model, running the experiments may take a while. *Plant Simulation* shows the currently running simulation on the tab Run. At the end of the experiment run it opens a HTML report.

Step 3: Evaluate the results of the simulation study

After the *ExperimentManager* executed the simulation experiments, you will want to examine the results.



You can:

- *View the Results as a Table.*
- *View the Results in a Chart.*
- *View the Results as a Report.*

View the Results as a Table

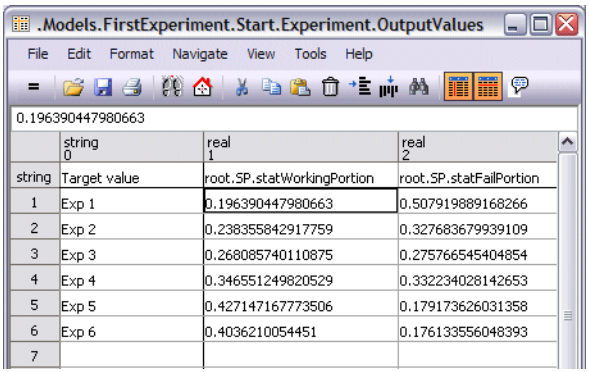
To display the results of the simulation experiments in tables:

1. Click Show next to input values to show the values, which the attributes had before executing the simulation experiments.

   Note: You can perform an experiment run without any input values.

2. Click Show next to output values to show the values, which the attributes had after executing the simulation experiments.

   Note: Each experiment run requires at least one output value.



	string 0	real 1	real 2
string	Target value	root.SP.statWorkingPortion	root.SP.statFailPortion
1	Exp 1	0.196390447980663	0.507919889168266
2	Exp 2	0.238355842917759	0.327683679939109
3	Exp 3	0.268085740110875	0.275766545404854
4	Exp 4	0.346551249820529	0.332234028142653
5	Exp 5	0.427147167773506	0.179173626031358
6	Exp 6	0.4036210054451	0.176133556048393
7			

Depending on whether you did or did not select the check box Show statistical evaluation of the results, the table file Results shows a statistical evaluation or the mean values of the observations of the output values only. You can open all observations in the subtables in the columns 7, 14, … Observations. Press F2 to open the subtable contained in these cells. For the observations of an experiment, belonging to a set of input values, we prepared these statistical values:

Column 1, 8, …	mean value
Column 2, 9, …	standard deviation
Column 3, 10, …	minimum
Column 4, 11, …	maximum
Column 5, 12, …	left bound of the confidence interval
Column 6, 13, …	right bound of the confidence interval

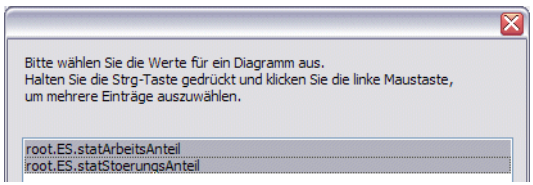
For a mathematical explanation of the process of calculating confidence intervals, we assume that the sample is provided by a normally distributed random number. On the one hand this assumption for evaluating simulation results is met in most cases. On the other hand proof of this assumption is not always possible and it would be most welcome to be able to check the calculation of a confidence interval.

When many observations of the mean value exist, the interval can be calculated, within which the true mean value with the given confidence interval is located.

View the Results in a Chart

To display the results of the simulation experiments as a chart:

1. In models with random components the output values usually fluctuate around a mean value. You can select to show min-max-intervals or confidence intervals for the output values. Type in the confidence level for the confidence intervals into the text box Confidence level [%] on the tab Define.
2. To select the output values for this evaluation, click Select the values, which a chart shows on the tab Evaluate. This opens a dialog. You can select several values by holding down Ctrl and clicking these values. To insure readability, the output values should have a similar order of magnitude.



Selecting output values of interest

3. To open the chart with the selected output values, click OK. The output values for the individual experiments are connected with each other. The chart draws the confidence intervals or the min-max intervals around the mean values of the output values.

View the Results as a Report

1. Select the menu item Report > Show to show the results of the simulation experiment as a *Report*.

   You can, but do not have to enter a headline the *Report* shows in the *display* pane on the tab Miscellaneous, compare Describe the Project.

   - Click ⊞ in the tree pane to show the items located within that branch in the display pane.

     Click on a link to show an item: The input values and the output values (results) in a table. Or a chart showing, for example, the filling level of the buffers for each experiment run, etc.

     The *Report* shows the same values as the tables the buttons Show input values, and Show output values display.

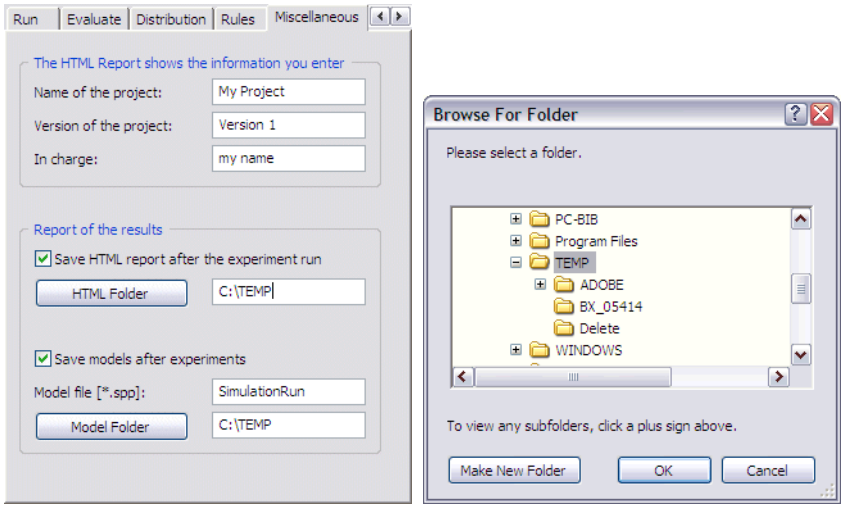
     The *Chart* portion shows the values you defined under Select values a chart shows.
   - Click ⊟ in the tree pane to hide the items located within that branch in the display pane.
   - To add a *Chart* you inserted into your model to the *Report*, drag the *Chart* over the icon of the *ExperimentManager* and drop it there.

The *Report* then shows the *Charts*. When you enter a Label for the *Chart* the *Report* shows that label in the display window. When you do not enter a Label, the *Report* shows the name of the *Chart*.

- Click to save your report as a file. You can then open this file in the *Internet Explorer* without having to open *Plant Simulation*.

Note: When you click Delete after you saved the file, the *ExperimentManager* deletes the graphics and the files it stores in the model. This decreases the size of the model.

2. To automatically save a *Report* after the experiment run is finished, select the check box Save HTML report after the experiment run on the tab Miscellaneous.
3. Click HTML Folder and select the folder you want to save the HTML files to.



Refine the Settings

The topic *Execute a Simple Simulation Study* describes the most basic way of running experiments with the *ExperimentManager*.

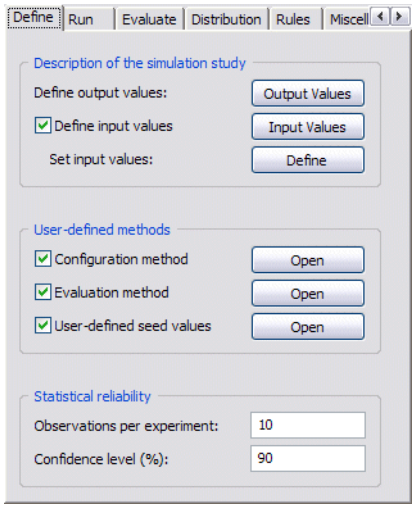
Here you learn how to refine the settings when you *Set Static Parameters* or when you *Set Dynamic Parameters*.

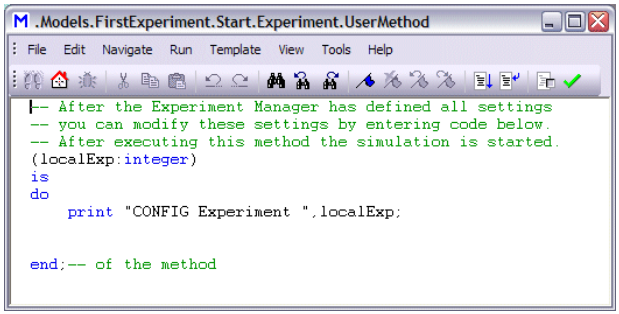
Set Static Parameters

Static parameters are specific values for each experiment for each parameter. If you want to, you can also *Modify Settings in the Configuration Method*.

Modify Settings in the Configuration Method

Select the check box Configuration method, click Open to open the method object *UserMethod* and program additional settings for each experiment. You can use all commands SimTalk provides. Note that the code you enter into this method modifies the settings for the experiment we programmed.



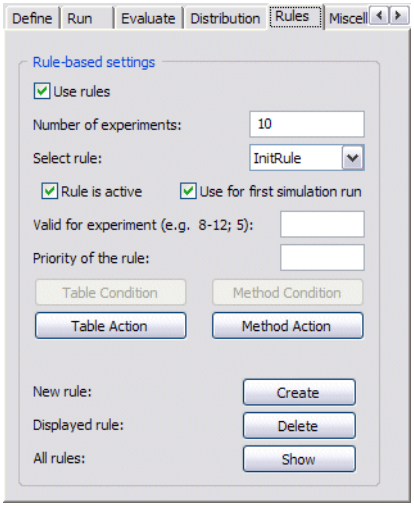


Set Dynamic Parameters

Define *dynamic parameters* on the tab Rules. Here the results of previous simulation runs yield the values of the parameters for the present simulation run.

The *ExperimentManager* checks if the conditions you entered into the table and method of the upper row on the tab are true. It then takes the action(s) you entered into the table and programmed in the method of the lower row.

If you want to use *dynamic parameters* in your simulation experiment, you will define rules on the tab Rules. First, enter the number of experiments you want to execute.



A **rule** is a logic expression that consists of a condition and an action. As soon as the condition of a rule is met, the associated action of the rule is taken.

Enter the **condition** into the Table and the Method in the row starting with If.

Enter the **action** into the Table and into the Method in the row starting with then.

1. To use dynamically changing parameters, select the check box Rule-based settings.
2. Select one of the built-in rules from the drop-down list Select rule, or *Define a Rule of Your Own*.
3. Select the check box Rule is active, to activate the rule you selected. This rule will then be executed before the simulation experiment.
4. If you want to, you can enter the number of the experiment(s) for which the rule applies.
5. Enter a Priority. The greater the number you enter, the higher the priority will be: A job with priority `10` is executed before a job with priority `1`.
6. To use the rule you selected for the first experiment, select the check box Use for first simulation run. When you do not select it, the *ExperimentManager* only uses the rule from the second experiment on.

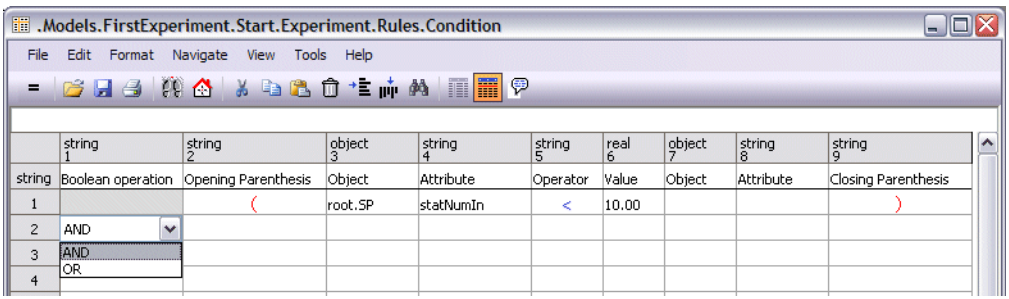
Define a Rule of Your Own

To define a rule of your own:

1. Click the button Create, and enter a name for the rule into the dialog that opens.

The *Plant Simulation* conventions for the Name of an object apply.

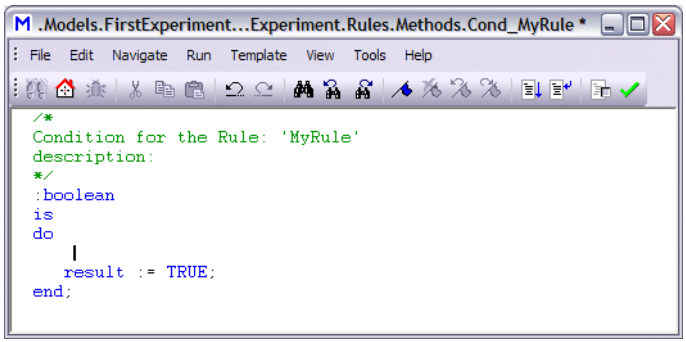
2. Click Table Condition. Enter your values into the table that opens.



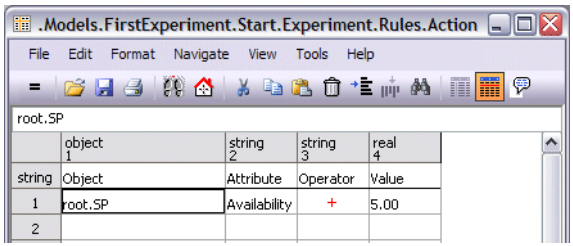
- Click into the cell and select the level of the Opening Parenthesis. *Plant Simulation* evaluates expressions in parenthesis from the inside to the outside, i.e., it evaluates the contents of the innermost expression in parenthesis first and then proceeds to the outside step by step.

- Enter the name of the **Object** whose attribute value you want to compare to another object.
- Enter the name of an **Attribute** of this object.
- Click into the cell and select an **Operator** that compares the attribute values: < (less than), > (greater than), = (equal to), == (about equal), or /= (unequal to).
- Enter a **Value** that the operator compares.
- Enter the name of the **Object** whose attribute value is compared to the object you entered above.
- Enter the name of an **Attribute** of this object.
- Click into the cell and select the level of the **Closing Parenthesis**.
- Click into the cell **Boolean Operation** and select an **operator**, AND or OR that connects the boolean values that result from evaluating the logical expression you defined in a row of the query table.

3. If you want to, you can also test a condition in a *Method*. For this, click **Method Condition** and enter your source code into the *Method* that opens.

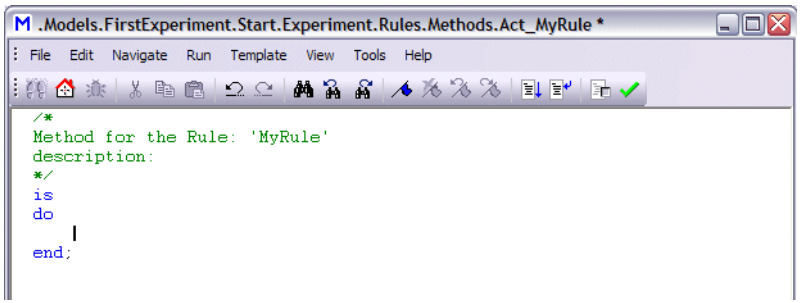


4. Click **Table Action**. Enter your values into the table that opens:



- Enter the name of the **object** whose attribute value you want to manipulate.
- Enter the name of an **attribute** of this object.
- Click into the cell and select an **operator** that manipulates the attribute value.
- Enter the **value** the operator adds, subtracts or equates to the value of the attribute you entered above.

5. If you want to, you can also program a *Method* that executes an action. For this, click Method Action and enter your source code into the *Method* that opens.

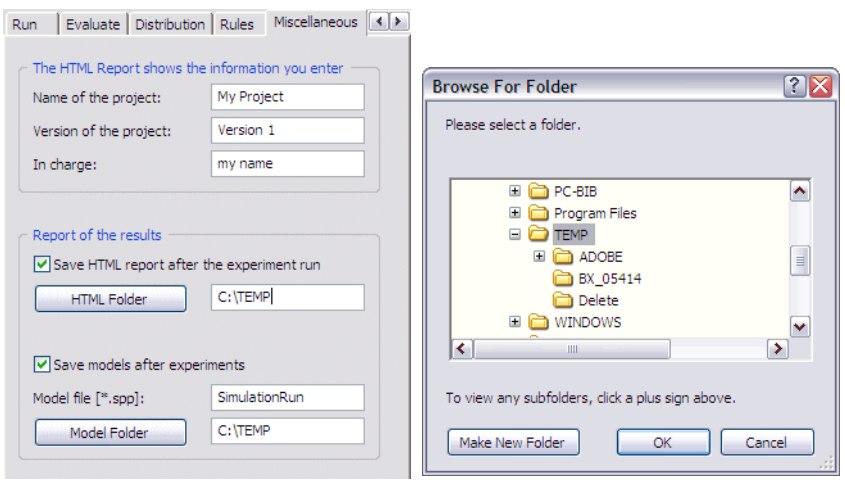


Save the model after each simulation run

If you want to save the simulation models, which a single simulation run generated, select the check box Save models after the experiments on the tab Miscellaneous. Then, you can check the conditions that produced the result in your simulation model again later on.

When you do not select the check box, the *ExperimentManager* does not save the models after a simulation run.

Enter the name into the text box Model file with which the *ExperimentManager* saves the simulation models. It appends the number of the simulation run to the name, so you can tell which experiment generated which results.



Click Model Folder and select the folder you want to save the model files to.

Describe the Project

Enter information describing the project on the tab Miscellaneous.

The object *Report* shows these items along the top of the HTML page, when you View the Results as a Report:

1. Enter the Name of the project into the text box.
2. Enter the Version of the project into the text box.
3. Enter the name of the person in charge of the project or of the simulation experiment into the text box. You can also add the department, the phone number, the e-Mail address, etc. to the name.

Optimize Models with Genetic Algorithms

When your optimization task has a large number of different solution variants, we recommend to use *Genetic Algorithms*.

The *GAWizard* supports you in integrating genetic algorithms into an existing simulation model. Use it for optimizations where the evaluation is based on a simulation run as well as for optimizations where the evaluation is based on calculations in methods.

Note: Your *Plant Simulation* license determines how you can use the *GAWizard*.

Genetic algorithms are stochastic optimization procedures that in most cases only produce an approximate solution. For the most common practical applications these approximate solutions do suffice. *Genetic algorithms* manage several solution proposals during the optimization. According to evolution in biology these solution proposals are called **individuals**. The individuals managed in a single optimization step are combined into a **generation**. The quality of a solution proposal is evaluated through a numerical value, the so-called **fitness value**.

Solutions generated by *Genetic Algorithms* are passed to the simulation model, which in turn will be configured accordingly. When you do not use the Batch-Mean method, *Plant Simulation* starts the simulation run with the settings typical for this solution. At the end of the simulation run the simulation model is going to pass the resulting fitness value back to the object *GAWizard*.

The Batch-Mean method starts a single simulation run for the entire optimization run. After a warm-up period, it uses time sectors for evaluating the solution. At the beginning of a time sector the method configures the model for a solution. At the end of the time sector the fitness value will be determined.

When your evaluation takes place via a model containing random components, such as failures of machines, then you have to execute several simulation runs for each newly created individual. The fitness value is called observation. The genetic algorithm uses the mean value of all observations of the fitness values of an individual. Enter the number of observations per individual on the tab Define of the *GAWizard*. For a deterministic simulation, you will use a single observation per individual.

When the genetic algorithm creates individuals defining the same parameterization, the *GAWizard* recognizes this and uses the fitness values of the already evaluated individuals. The optimization run thus does not waste additional time for multiple evaluations of an individual.

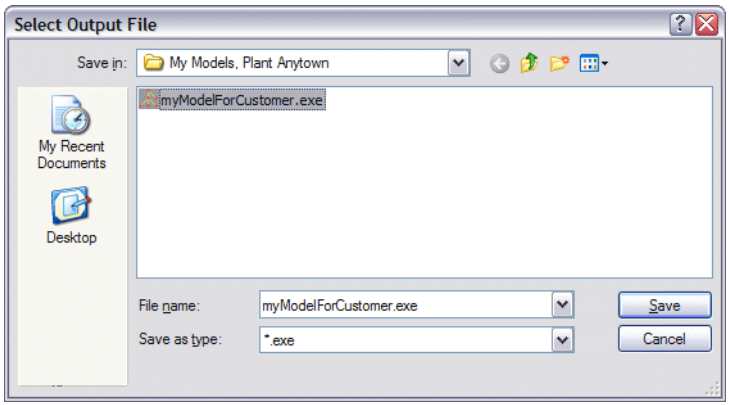
Packing a Model and Sending it to Somebody Else

To pack and send a *Plant Simulation* model to somebody, who does not have *Plant Simulation* on his computer, you can use *Pack and Go*.

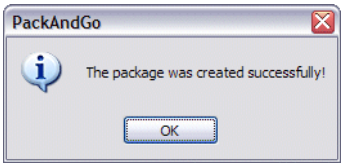
Pack and Go takes all files needed for starting the selected simulation model with a *Plant Simulation Viewer license*, packs the files and saves them as a self-extracting executable. You can send this packed model to a customer for example, who can open the model by simply double-clicking it.

Note: *Pack and Go* only works on Windows XP, Service Pack 2 and on higher operating systems.

- To start *Pack and Go*, select File > Pack and Go in the program window.
- If you would like to save your model, before sending it, click Yes in the dialog that opens.
- Navigate to the folder into which you want to save the model file. Enter a name and click Save.



- Click OK after *Pack and Go* successfully created the package. Then, distribute the file, for example by sending it as an e-mail or by putting it in your intranet, etc.



- The recipient can double-click the file you sent and run the simulation to view what you wanted to show.

  Be aware that the *Plant Simulation Viewer license* only provides a restricted set of features, which are described under View > Start Page > Info Pages > Product Information.

Animating the Simulation Model and Viewing the Results

Animating the simulation model and viewing the results provides information about these topics:

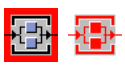
- *Animating Your Simulation Model*
- *Viewing and Visualizing Statistics*
- *Working with Evaluation Tools*

Animating Your Simulation Model

One of your tasks when creating your simulation model will be to visually show the flow of materials through the installation you are modeling. For this you can either animate the built-in icons of the material flow objects and the mobile objects or you can create a model in the *3D Viewer*.

- By default *Tecnomatix Plant Simulation* shows the state of the material flow objects, and of the *Frame* itself, during your simulation runs as one or more colored dots in the LED display along the top border of the icons of the objects you inserted into the *Frame*.
- You can also create an icon each for the different states the objects may take to display the state of operation of an object, such as *failed*, *paused*, etc. during a simulation run.

  To use state icons instead of the LEDs, right-click the material flow object and select Edit Icons. In the *Icon Editor*, select Object > State Icons/LEDs > Use State Icons, so that the latter shows a check mark in front of it .

Default LED	Sample state icons
	

For this, you can modify any of the built-in icons or design new one icons in the *Icon Editor*. Here you can also create and modify the animation structures, i.e., the animation points and animation lines, to define the route and the paths the mobile objects take.

Activate and Deactivate the Animation

Note: As the animation slows down the simulation, only turn it on, when you actually want to show the simulation model to somebody. For your overnight batch runs we recommend to turn it off.

We differentiate between:

- **Icon Animation** , i.e., the animation of the icons of the material flow objects themselves. When it is active, the objects show the state they are in. This way you can easily detect which object obstructs the flow of materials.
- **MU Animation** , i.e., the animation of mobile objects in your simulation model. During the simulation run the animation shows the state of the objects and the positions and movements of the MUs.
  - When you activate MU Animation, you immediately detect the flow of the mobile objects and can detect blocked stations, where the MUs pile up.
  - When you deactivate MU Animation while an object intends to change its state, *Plant Simulation* delays its display on screen until you activate the animation again or until the object is selected.

To deactivate:

- **Icon Animation**, click View > Icon Animation in the program window. The button then looks like this .
- **MU Animation**, click View > MU Animation in the program window. The button then looks like this .

To run the simulation with the setting you selected, click Start in the *EventController*.

Note: Clicking in the *Frame* window activates MU Animation and Icon Animation. To start the simulation without animating objects and MUs, click .

Working with Object Icons

Note: The icons of an object are a property of its class, i.e., an object in the *Class Library* and all of its instances share the same set of icons. Modifying the icons of an instance will change the icons of all objects of this class!

Plant Simulation uses the icon of an object to display it in the *Class Library*, in the *Toolbox*, and in the *Frame*. The icons can also serve to display the state of operation of the object, such as *failed*, *paused*, *unplanned*, etc. You can modify the built-in icons, including any of the animation paths, or design new ones in the *Icon Editor*.

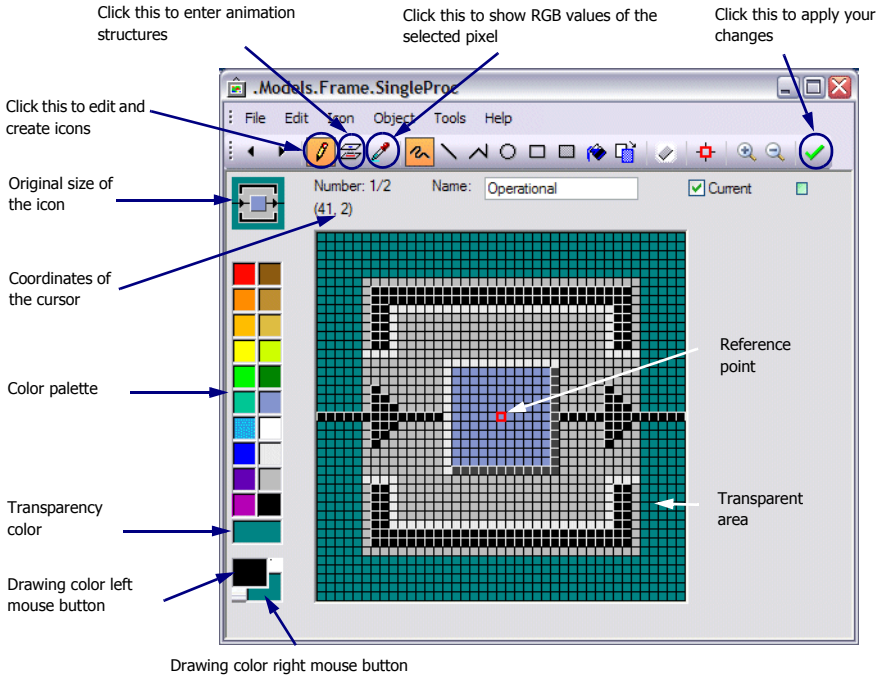
At times you have to edit one of the existing icons of an object or you will want to add different icons to it.

Editing an Icon

To edit the icons of an object, do one of the following:

- Right-click the object in the *Frame* and select Edit Icons or press Ctrl+I.
- Select the object in the *Frame* and select Icons > Edit Icons or press Ctrl+I.
- Right-click the object in the *Class Library* and select Edit Icons.
- To edit the icons of a *Frame*, you can also click in the toolbar of the *Frame*.

- Click to apply the changes you made.



Creating an Icon

To create a new icon and to then open an existing drawing you would like to use, do one of the following:

- Select Icon > New. If the drawing you open is larger than the default icon size of 41 by 41 pixels, enter another width and/or height.
- Select File > Open, navigate to the folder that contains the drawing you would like to use as an icon, select the file and click Open.
- Drag a graphics file (.gif, .bmp, .ppm, .ppm raw, .dxf or .dwg) from the Windows Explorer, etc. over the drawing window and drop it there.
- Enter a meaningful Name for the icon.
- To draw a line or a shape, select a drawing color and one of the drawing tools , and draw the shape in the drawing window.
- To move the reference point, click and then click the position you would like to move the reference point to.
- To change the color

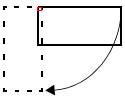
  - of one or several pixels, select a color in the color palette and click the pixel(s) whose color you would like to change with one of the drawing tools.
  - of a contiguous color area, select a color in the color palette and click the area whose color you would like to change with .
- To draw with two colors, you can assign a color each to the left mouse button and the right mouse button:
  - Click a color in the color palette with the left mouse button to add this color to the top drawing color field. Or
  - Double-click the color field and define a color of your choice in the dialog Color.
  - Then, click the respective mouse button to draw with that color.
- To make transparent
  - one or several pixels, click the transparency field and click the pixel(s), which you would like to make transparent with one of the drawing tools.
  - a contiguous color area, click the transparency field and click the area, which you would like to make transparent with .

  Note: The background of the *Frame* shines through any area you marked as transparent.
- Click to apply the changes you made.

Defining the Rotation of an Object

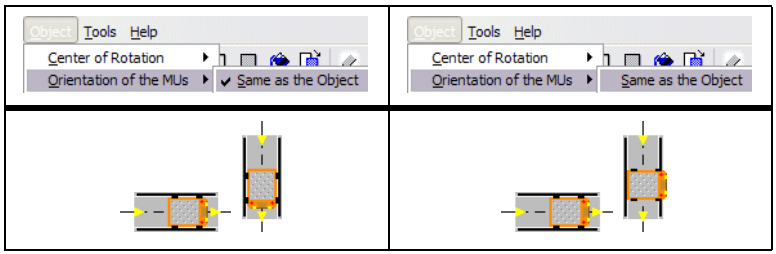
To define how *Plant Simulation* rotates the selected material flow object itself, select Object > Center of Rotation > Rotate around Reference Point. The reference point of an object is located in the center of the icon by default.

- When you use the default setting Rotate around Reference Point, *Plant Simulation* rotates and zooms the icon around the reference point. You can compare this to pushing a pin through the center of a photograph and then turning the photograph around this pin.
- When you deactivate Rotate around Reference Point, the upper left corner of the icon remains at the same location when rotating and zooming the icon.

Reference point located in the center		
Reference point located in the upper left corner		

In addition to defining the rotation of the material flow object, you can define, if an MU that transfers onto a material flow object uses the same orientation, i.e., the same rotation angle, as the icon of the material flow object it is animated on.

- When you use the default setting, Same as the Object, the front end of the MU points in the same direction as the right border of the material flow object.
- When you deactivate Same as the Object, the front end of the MU points in the direction it had, when it transferred onto the material flow object.



Making Areas of an Icon Transparent

To make a contiguous area of a graphics file, which you opened, transparent, so that the background color of the *Frame* shines through, proceed as follows:

- Open the *Icon Editor* (Icons > Edit Icons).
- Click ◂ or ▸ to navigate to the icon you want to make transparent.
- Click the eyedropper and click in the background of the icon. This makes that color the active drawing color, which we want to replace.
- Select the transparency color that replaces the active drawing color with in the *Color Palette* proper, not in the transparency color field!

  If the transparency color is not part of the color palette proper, double-click any field in the *Color Palette* that contains a color you do not need, and enter `0`, `128`, `128` into the dialog Color. Then, click Add to Custom Colors, and OK.
- Make sure that Icon > Transparent is active.
- Click Apply Changes to make the area transparent.
- To use the changed icon as the current icon of the object, make sure that Current is selected.

Not transparent	Transparent

To make individual pixels of the icon transparent:

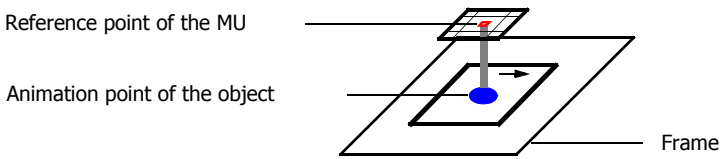
- Click the transparency color field with the left or right mouse button to make the transparency color the drawing color.

- Select one of the drawing tools , click the respective mouse button and change the color of a single pixel or draw a shape.
- Click to make the area transparent.

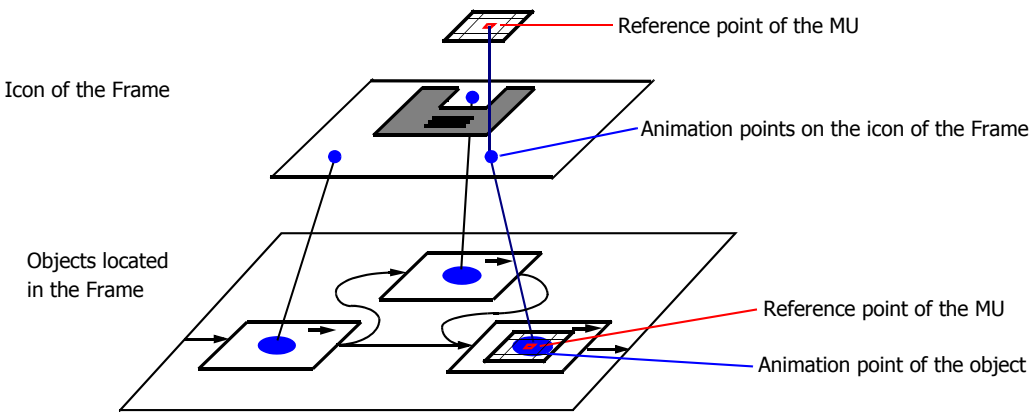
Set and Link Animation Points and Animation Lines

During the simulation run the MU moves along the connecting lines, which you established with the *Connector*, from material flow object to material flow object and/or material flow object to components you modeled in a *Frame*. In your animated simulation model, *Plant Simulation* places the **reference point** of the icon of the MU onto the **animation point** of the icon of the material flow object or the **animation line** of the icon of the *Frame*.

For a material flow object the correlation looks like this:



For a *Frame* the correlation looks like this:



To **insert an animation point** or an animation line into the icon of the **class** of a material flow object or of a *Frame*:

- To open the *Icon Editor*, right-click the *Frame* into which you would like to insert an animation structure and select Edit Icons.
- To activate *Animation Mode*, which allows you can insert animation points and animation lines, click .

  To insert an animation point or an animation line into the icon of the class of an object, select Tools > Edit Class. You will notice that *Plant Simulation* opens the class object of the selected object. If you want to insert an animation point into the icon of the active instance of the icon, do not select Edit Class.

- To insert an **animation point** into the icon of a point-oriented object, click . Then, click into the drawing area with the left mouse button at the location of your new animation point.
- To insert a straight **animation line** into the icon of a length-oriented object, click . Then, click into the drawing area with the left mouse button, hold the mouse button down to insert the beginning of the line, drag the mouse until the line is as long as you want it to be and release the mouse button. This inserts the end of the line.
- To insert a non-straight **animation line** into the icon of a length-oriented object, click .Then, click once into the drawing area with the left mouse button to set the starting point of the line, click again to set the next anchor point. *Plant Simulation* connects the anchor points to create the line. Continue this until the polyline meets your needs.
- To move an animation point or an animation line to a different location, click .

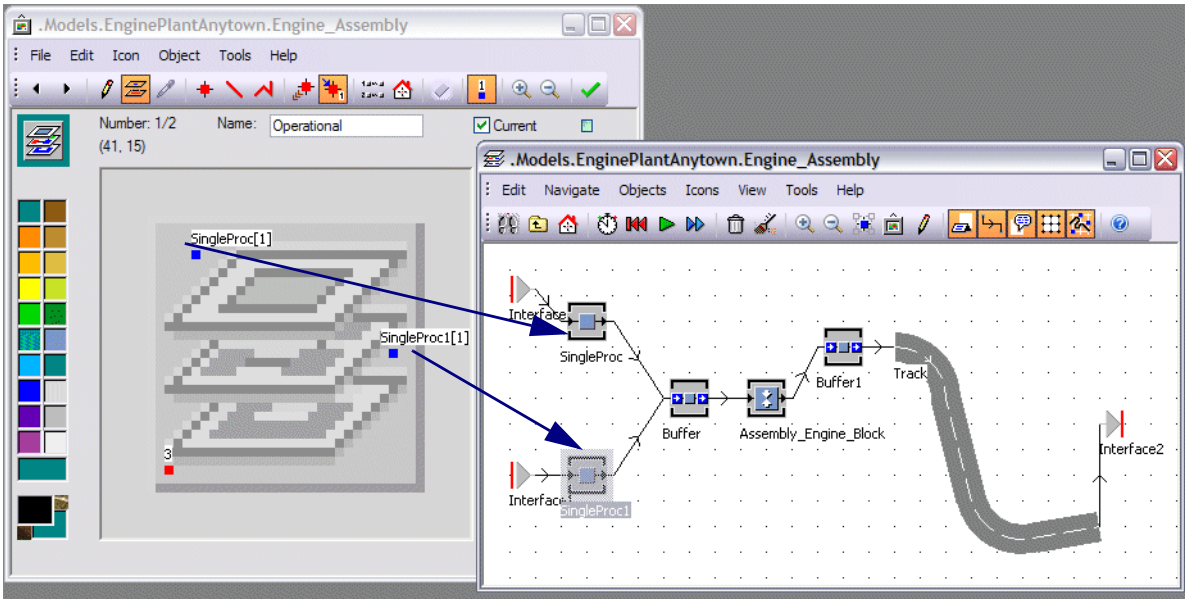
  These colors represent the different states of an animation point:

  - Blue: Is the standard color for all objects, except for the *Frame*. For a *Frame Plant Simulation* shows that the animation point is linked to an object located within that *Frame*.
  - Light blue: Is the same as blue. In addition, it shows that an animation point of a *Frame* is linked to this animation point.
  - Red: The animation point in a *Frame* is not linked to an object located within that *Frame*. For this reason *Plant Simulation* does not show an animation for this point.
- When you are done inserting, close the class object, and click Yes to save the changes to the icon of the class.

To **link an animation point**, which you inserted into the class of an object, with the animation point/line of a *Frame*:

- Select the *Frame* in which you would like to link the animation structure with the right mouse button and select Edit Icons.
- To activate *Animation Mode*, which allows you to link animation points and animation lines, click .
- To display the name of the model or object next to the animation point/line in the drawing window, select Tools > Show Animation Numbers. This makes assigning animation points easier.
- Click Link/unlink animation point and select the animation point/line in the icon of the *Frame*. *Plant Simulation* shows the selected animation point or the animation line in red.

  This opens the window of the *Frame* you selected above. Click the material flow object to which you want to assign the animation point/line. You will notice that the color of the assigned animation point or the animation line changes to blue. When an MU moves to this animation point/line during the simulation run, *Plant Simulation* shows it on this animation point/line.



- To apply the settings, click .

To delete all animation points/lines of an object, click or click the animation line with the right mouse button.

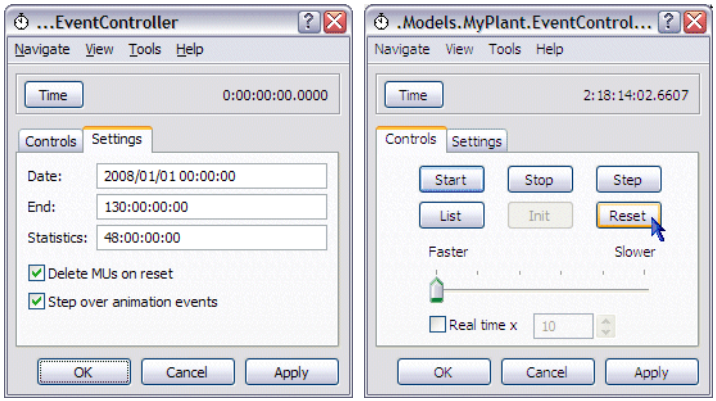
Note: You can delete an animation point and insert a new one immediately afterwards without the correlation getting lost.

Viewing and Visualizing Statistics

By default all material flow objects collect statistics values from the beginning to the end of the simulation runs. If you don't want them to do so, deactivate statistics collection by clearing the check box Resource statistics Resource statistics on the tab Statistics or Product statistics Product statistics on the tab Product Statistics.

The *EventController* controls, when statistics collection starts and when it will be reset, i.e., started anew.

- Click the tab Settings. Click in the text box Statistics and enter the time at which the *EventController* resets statistics and deletes all statistics values it collected up to that time, compare *Statistics Collection Period*. *Plant Simulation* starts collecting statistical data for all material flow objects anew from this time on. This way you can discard data collected during warm-up phases, which might distort the validity of the simulation results.



- When you reset your simulation model, by clicking Reset, *Plant Simulation* deletes statistics data of all objects and resets the statistics values to 0. During a simulation run you can achieve the same effect using the method *initStat*. This way you can restart the collection of statistical information after a warm-up period of a machine, for example.

Covering *Plant Simulation* statistics in detail would go beyond the scope of the *Plant Simulation Step-by-Step Help*. It is described under the topic *Statistics of Material Flow Objects* in the *Plant Simulation Reference*.

You can view and visualize the statistics results of your simulation runs in a number of ways.

Viewing Statistics in the Dialogs of the Objects

In its most basic form you can view the statistics, which the objects collected during a simulation run, in their dialogs, either on the tab Statistics or by opening the statistics tables of the objects:

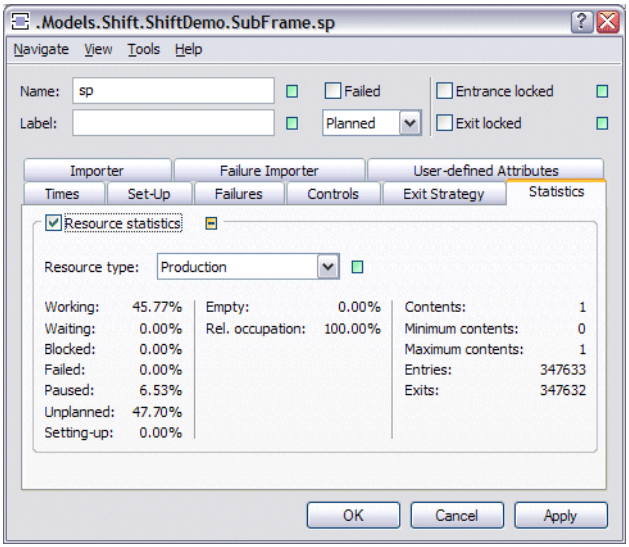
- The **material flow objects** proper show the most important statistical data they collect on the tab Statistics.

  By default, the resource type used most often is pre-selected:

  - Production: for the *SingleProc*, *ParallelProc*, the *Assembly* station, and for the *DismantleStation*.
  - Transport: for the *PlaceBuffer*, *Buffer*, *Sorter*, *Track*, *Line*, *Transporter*, and for the *Container*.
  - Storage: for the *Store*.

  The resource type you select here affects statistics of mobile objects.

  Note: The percentages for Waiting, Working, Blocked, Setting-Up, Failed, Paused and Unplanned should add up to 100 percent.



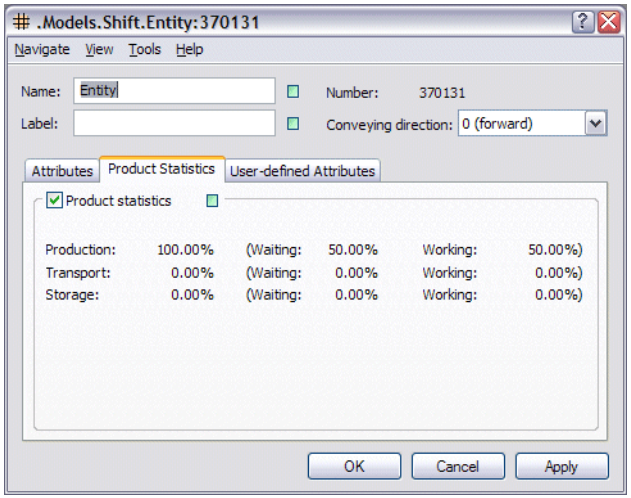
Note: *Plant Simulation* does not dynamically update the values during a simulation run when the dialog window is open. To accomplish this, select **Refresh** on the **View** menu of the object or press **F5**.

Working	Shows the portion of the statistics collection period during which the object was working.
Waiting	Shows the portion of the statistics collection period during which the object was waiting.
Blocked	Shows the portion of the statistics collection period during which the object was blocked.
Failed	Shows the portion of the statistics collection period during which the object was failed.
Paused	Shows the portion of the statistics collection period during which the object was paused.
Unplanned	Shows the portion of the statistics collection period during which the object was unplanned, i.e., is not scheduled to work.
Setting-up	Shows the time portion of the statistics collection period during which the object was setting-up.
Empty	Shows the portion of the statistics collection period during which the object was empty.
Relative occupation	Shows the capacity-based portion of the time during which the object was occupied, not paused and not failed to the time the object was not paused and not failed as a *real* number.
Contents	Shows the number of MUs, which are located on the object. The rules described under **Entries** apply.

Minimum contents	Shows the minimum number of MUs that was located on the object. The rules described under Entries apply.
Maximum contents	Shows the maximum number of MUs that was located on the object. The rules described under Entries apply.
Entries	Shows the number of MUs that entered the object as an *integer*. When an MU enters the object, it only counts the MU itself, not its contents: When a *Container* holding several entities enters the object, the number of entries increases by 1, not by the number of entities located on the *Container*!
Exits	Shows the number of MUs that exited the object as an *integer*. When an MU exits the object, it only counts the MU itself, not its contents: When a *Transporter* holding several MUs leaves the object, the number of exits increases by 1, not by the number of MUs the *Transporter* transports!

To view the statistics, which the object collected, select View > Statistics Report. You can query most of these values with the methods that are listed next to the name of the value in the description of the statistics table.

- The **mobile objects** show the most important statistical data they collect on the tab Product Statistics.

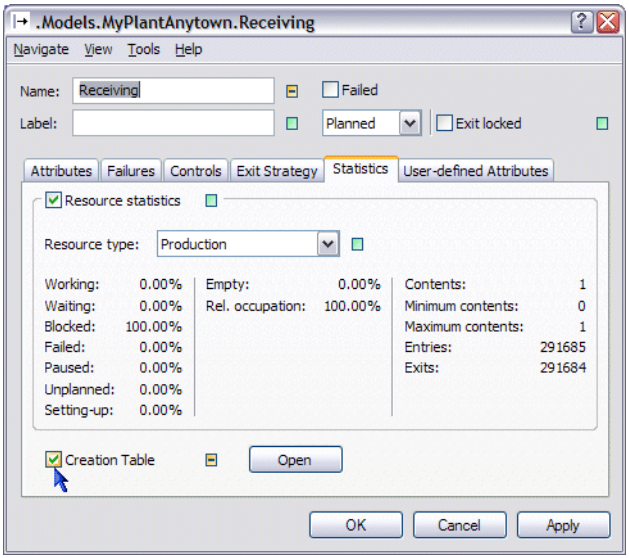


You will:

- *Check How Many Parts Were Introduced into the Plant*
- *Check How Many Parts Left the Plant*
- *Check Statistics of the Individual Stations*
- *Check Product Statistics of Parts*
- *Check Statistics of Exporter and Worker*

Check How Many Parts Were Introduced into the Plant

Next to the values described under Viewing Statistics in the Dialogs of the Objects, you can make the *Source* record which MUs it actually created at which point in time.



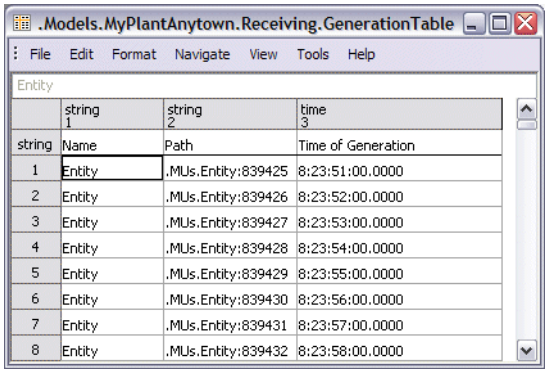
- To write all events for which the *Source* produced MUs during a simulation run to a table, select Creation table on the tab Statistics.

  Note: The *Source* records these events in addition to the resource statistics it collects in any case.

- To open the creation table, click Open.

  Each row in the table shows an event for which the *Source* produced an MU:

  - The column Name shows the name of the produced MU class.
  - The column Path shows the path of the MU class, the name of the MU and its number.
  - The column Time of Generation shows the time when the *Source* produced the individual MU.

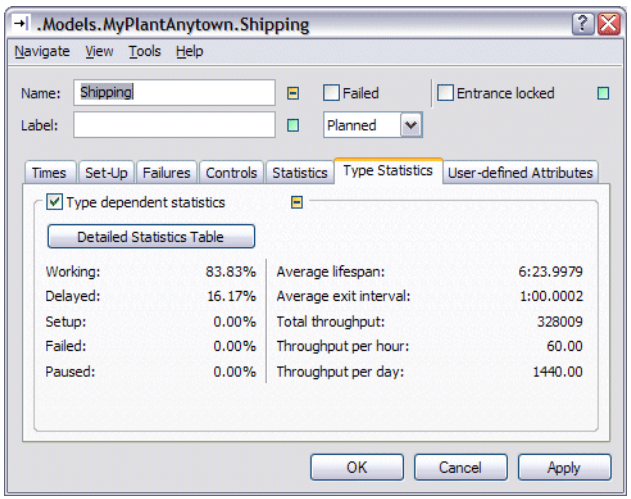


	string 1	string 2	time 3
string	Name	Path	Time of Generation
1	Entity	.MUs.Entity:839425	8:23:51:00.0000
2	Entity	.MUs.Entity:839426	8:23:52:00.0000
3	Entity	.MUs.Entity:839427	8:23:53:00.0000
4	Entity	.MUs.Entity:839428	8:23:54:00.0000
5	Entity	.MUs.Entity:839429	8:23:55:00.0000
6	Entity	.MUs.Entity:839430	8:23:56:00.0000
7	Entity	.MUs.Entity:839431	8:23:57:00.0000
8	Entity	.MUs.Entity:839432	8:23:58:00.0000

Check How Many Parts Left the Plant

Next to the values described under Viewing Statistics in the Dialogs of the Objects, you can make the *Drain* record statistics for MUs with the same name, i.e., product statistics, which pass through the simulation model.

The numbers for the average exit interval and for the throughput are of special interest for production planning and production control specialists.



- To collect statistics data depending on the type of MU, select Type dependent statistics. *Plant Simulation* will show this statistical data after the simulation run on the tab:

Working	Shows the percentage of the sum of the times during which the MUs were located on a working object, in relation to the statistics collection periods of all MUs. In general, this is the life time of the MUs.

Delayed	Shows the percentage of the delayed times of the MUs, in relation to the statistics collection periods of all MUs. In general, this is the life time of the MUs, compare *Waiting*.
Setup	Shows the percentage of the times that the objects were setting-up for the MUs, in relation to the statistics collection periods of all MUs. In general, this is the life time of the MUs, compare *Waiting*.
Failed	Shows the percentage of the sum of the times that the MUs were located on a failed object, in relation to the statistics collection periods of all MUs. In general, this is the life time of the MUs.
Paused	Shows the percentage of the sum of the times that the MUs were located on a paused or unplanned object, in relation to the statistics collection periods of all MUs. In general, this is the life time of the MUs.
Average lifespan	Shows the average life-span of MUs, which were created and destroyed during the statistics collection period. Only those MUs are counted whose product statistics was active.
Average exit interval	Shows the average time interval between exits of the MUs, which the *Drain* removed from the installation. It results from adding up the times of all intervals, and then dividing them by the number of intervals. Statistics only starts counting from the time the first MU arrived!
Total throughput	Shows the number of MUs, which the *Drain* removed from the installation, starting at the time, at which you activated Type dependent statistics.
Throughput her hour	Shows the number of MUs, which the *Drain* removed from the installation in an hour on average, covering all observed times during which MUs arrived.
Throughput her day	Shows the number of MUs, which the *Drain* removed from the installation in a day on average, covering all observed times during which MUs arrived.

To view the statistics, which the *Drain* collected, select View > Statistics Report. You can query most of these values with the methods that are listed next to the name of the value in the description of the statistics table.

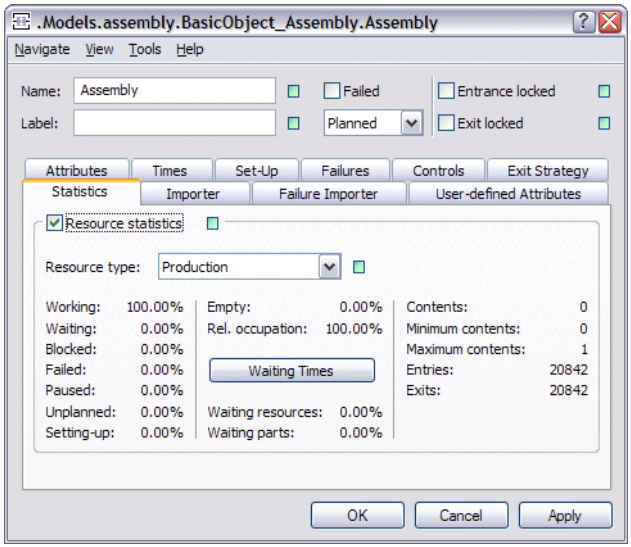
Check Statistics of the Individual Stations

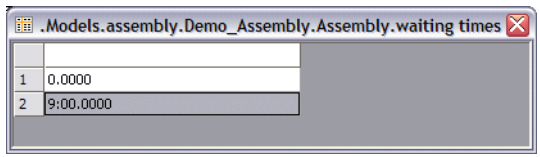
All material flow object show the values described under Viewing Statistics in the Dialogs of the Objects on the tab Statistics. The *Assembly Station* and the *DismantleStation* record additional statistical values.

The *Assembly* station records the percentage of the time it was:

- Waiting for parts, i.e., for mounting parts in relation of the statistics collection period.
- Waiting for resources. This is the portion of the time the *Assembly* station was waiting before the main MU entered into it, or from the time set-up is finished, until assembly starts in relation of the statistics collection period.

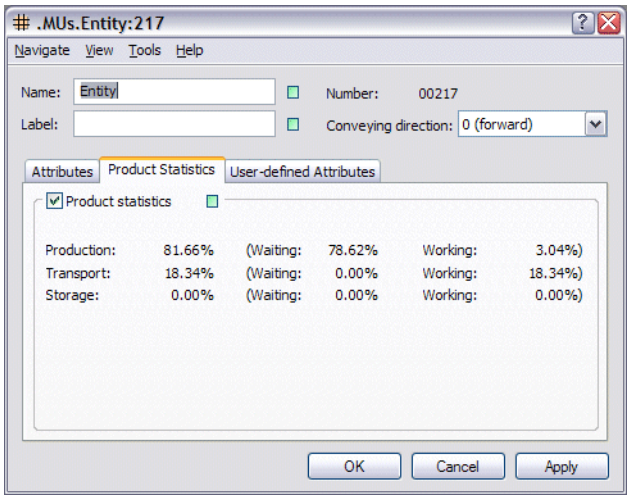
Click the button to open the table Waiting Times, which shows the sum of the waiting times of the MUs for each predecessor.



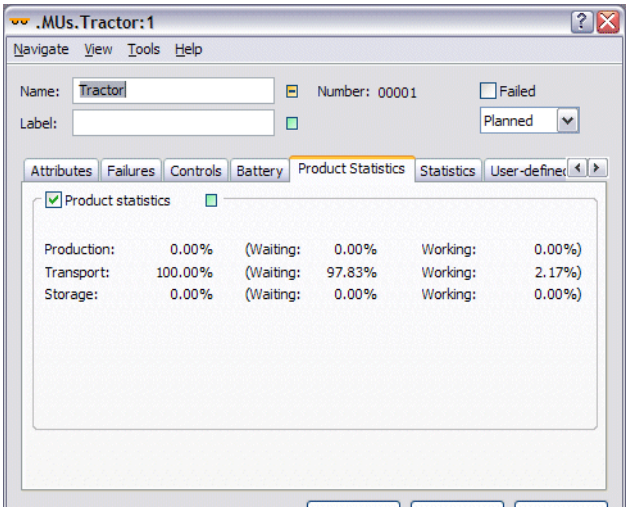


Check Product Statistics of Parts

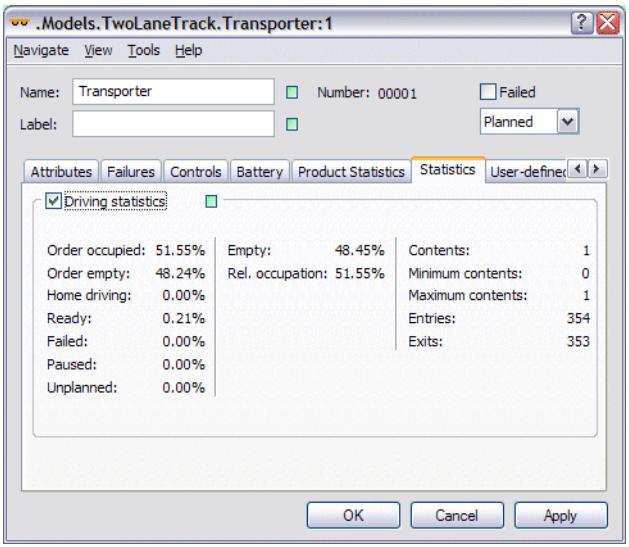
All parts, represented by the MUs *Entity*, *Container* and *Transporter*, show the percentages of the times the part spent waiting or working on a resource of type Production, Transport or Storage on the tab Product Statistics.



To view all product-related statistics data, which the MU collected, select View > Statistics Report. You can query most of these values with the methods that are listed next to the name of the value in the description of the statistics table.

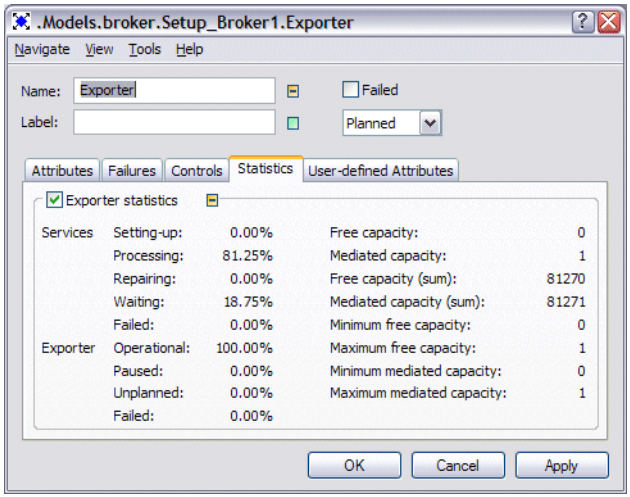


As the *Container* and *Transporter* can load and transport other parts, they provide resource statistics as well, compare Viewing Statistics in the Dialogs of the Objects.

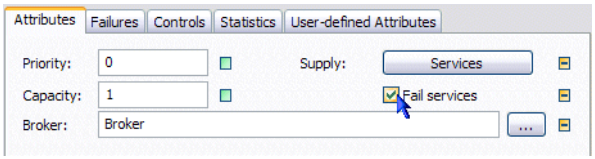


Check Statistics of Exporter and Worker

The Tab Statistics shows the values split up by *Services* and by *Exporter*. For each of these blocks, adding up the individual values yields 100%. You can query most of these values with the methods that are listed next to the name of the value in the description of the *Statistics Report*.



When you select the check box **Fail services** on the tab **Attributes**, the *Exporter* collects the failure times of the *Services* and of the *Exporter*. When you deactivate it, the *Exporter* only collects the failure times of the *Exporter*.



The *Exporter* only collects *Failed* times that take place during the processing and the set-up time, i.e., times that are located outside of the *Paused* time and of the *Unplanned* time.

Waiting times only accumulate during the times, when the *Exporter* is available, i.e., when these times are located outside of the *Paused*, the *Unplanned* and the *Failed* times.

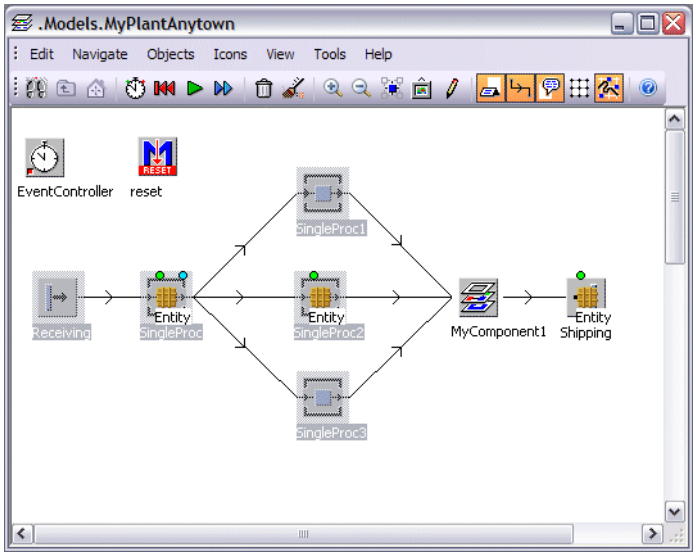
Services setting-up	Shows the portion of the set-up time for services of the statistics collection period of the *Exporter*, weighted with the capacity.
Services processing	Shows the portion of the working time of the services of the statistics collection period of the *Exporter*, weighted with the capacity.
Services repairing	Shows the portion of the statistics collection period, which the *services* spent for repairs, weighted with the capacity.
Services waiting	Shows the portion of the statistics collection period, which the *services* spent waiting for an *Importer* plus the time the *services* spent waiting for an MU at the *Importer*, weighted with the capacity.

Services failed	Shows the portion of the statistics collection period during which the *services* were failed.
Exporter operational	Shows the portion of the statistics collection period during which the *Exporter* was working, weighted with the capacity.
Exporter paused	Shows the portion of the statistics collection period during which the *Exporter* was paused.
Exporter unplanned	Shows the portion of the statistics collection period during which the *Exporter* was unplanned.
Exporter failed	Shows the portion of the statistics collection period during which the *Exporter* was failed.
Free capacity	Shows the capacity that is available at the moment.
Mediated capacity	Shows the capacity that is occupied at the moment.
Free capacity (sum)	Shows the sum of the released capacity that the *Exporter* placed with any *Importer*.
Mediated capacity (sum)	Shows the sum of the occupied capacity.
Minimum free capacity	Shows the minimum capacity that is available. When the *Exporter* did not collect any valid value yet, the tab shows -1.
Maximum free capacity	Shows the maximum capacity that is available. When the *Exporter* did not collect any valid value yet, the tab shows -1.
Minimum mediated capacity	Shows the minimum occupied capacity. When the *Exporter* did not collect any valid value yet, the tab shows -1.
Maximum mediated capacity	Shows the maximum occupied capacity. When the *Exporter* did not collect any valid value yet, the tab shows -1.

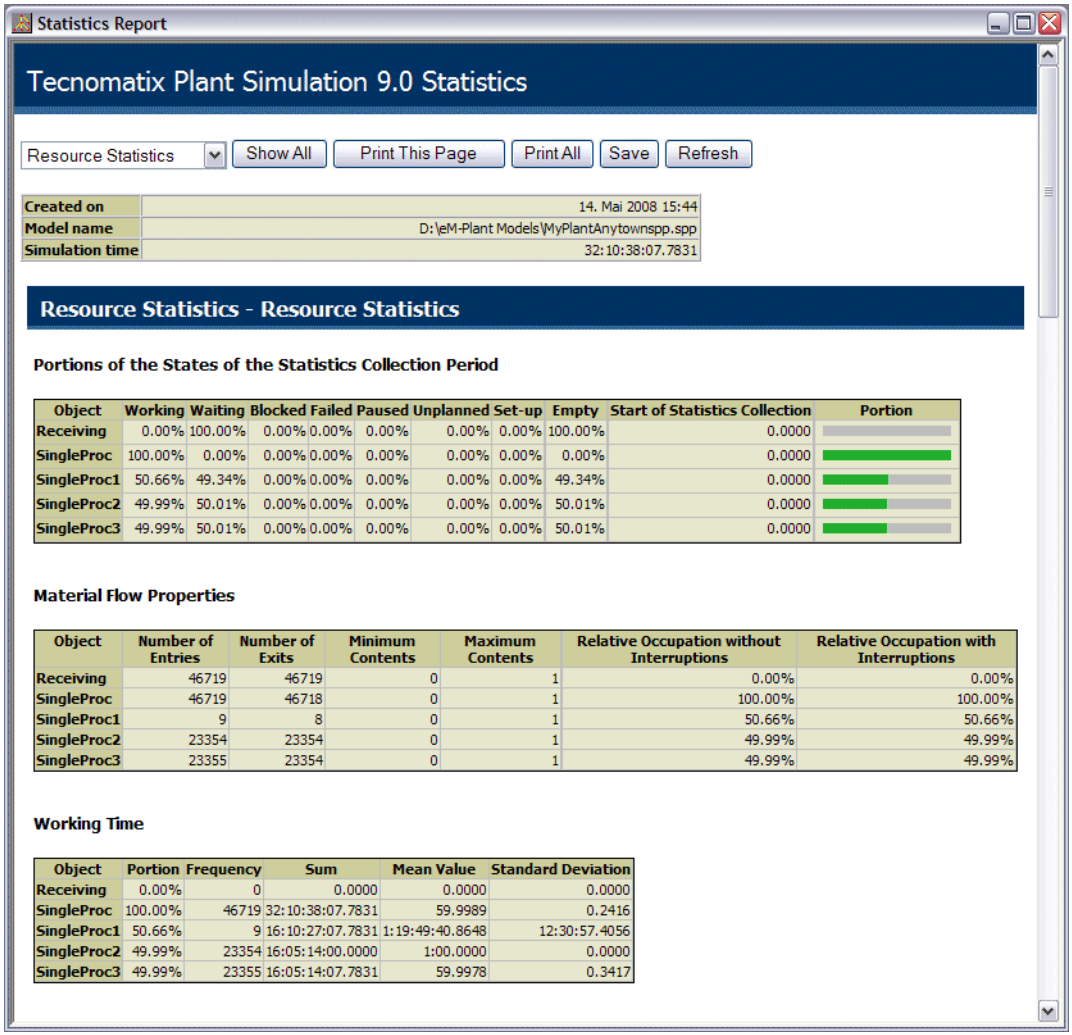
Viewing the Statistics Report

The most comfortable way of viewing statistics values of one or of several objects is to open the *Statistics Report*. Below we demonstrate how to use it.

- Let us assume that we want to show the statistics of several objects in a single report. To do so, we select them (Shift+click, or drag a marquee over them) and press F6. Compare this example:



- This opens the report, which looks like this:



Statistics Report

Tecnomatix Plant Simulation 9.0 Statistics

Resource Statistics | Show All | Print This Page | Print All | Save | Refresh

Created on	14. Mai 2008 15:44
Model name	D:\eM-Plant Models\MyPlantAnytownspp.spp
Simulation time	32:10:38:07.7831

Resource Statistics - Resource Statistics

Portions of the States of the Statistics Collection Period

Object	Working	Waiting	Blocked	Failed	Paused	Unplanned	Set-up	Empty	Start of Statistics Collection	Portion
Receiving	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.0000	
SingleProc	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0000	
SingleProc1	50.66%	49.34%	0.00%	0.00%	0.00%	0.00%	0.00%	49.34%	0.0000	
SingleProc2	49.99%	50.01%	0.00%	0.00%	0.00%	0.00%	0.00%	50.01%	0.0000	
SingleProc3	49.99%	50.01%	0.00%	0.00%	0.00%	0.00%	0.00%	50.01%	0.0000	

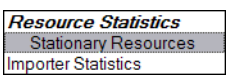
Material Flow Properties

Object	Number of Entries	Number of Exits	Minimum Contents	Maximum Contents	Relative Occupation without Interruptions	Relative Occupation with Interruptions
Receiving	46719	46719	0	1	0.00%	0.00%
SingleProc	46719	46718	0	1	100.00%	100.00%
SingleProc1	9	8	0	1	50.66%	50.66%
SingleProc2	23354	23354	0	1	49.99%	49.99%
SingleProc3	23355	23354	0	1	49.99%	49.99%

Working Time

Object	Portion	Frequency	Sum	Mean Value	Standard Deviation
Receiving	0.00%	0	0.0000	0.0000	0.0000
SingleProc	100.00%	46719	32:10:38:07.7831	59.9989	0.2416
SingleProc1	50.66%	9	16:10:27:07.7831	1:19:49:40.8648	12:30:57.4056
SingleProc2	49.99%	23354	16:05:14:00.0000	1:00.0000	0.0000
SingleProc3	49.99%	23355	16:05:14:07.7831	59.9978	0.3417

- The report adds the statistics of the objects, which you selected, to the drop-down list in the top left corner of the display window. In our example these are the statistics values of the Stationary resources *Source* (Receiving), SingleProc, SingleProc1, SingleProc2, and SingleProc3 as well as the Importer Statistics. To jump to any of the topics, which interest you, select that topic from the drop-down list:



- One of the main topic shows the Resource Statistics of the material flow objects split up by the states these objects were in, i.e., the Working time, Waiting time, Blocked time, Failed time, Paused time and the Unplanned time. Note that these times add up to 100%. The Setup time and the Empty time, which follow, may be part of the Working time, Waiting time or of the Blocked time. For details compare the *Statistics Report*.

Portions of the States of the Statistics Collection Period

Object	Working	Waiting	Blocked	Failed	Paused	Unplanned	Set-up	Empty	Start of Statistics Collection	Portion
Receiving	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.0000	
SingleProc	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0000	
SingleProc1	55.56%	44.43%	0.01%	0.00%	0.00%	0.00%	0.01%	44.43%	0.0000	
SingleProc2	49.99%	50.01%	0.00%	0.00%	0.00%	0.00%	0.00%	50.01%	0.0000	
Shipping	99.97%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.0000	
SingleProc3	49.99%	50.01%	0.00%	0.00%	0.00%	0.00%	0.00%	50.01%	0.0000	

The subtopics further down in the report show details about the Working time, the Waiting time, the Blocked time, the Failed time, the Paused time, the Unplanned time, the Setup time and the Empty time in the order in which they appear here.

The bar chart on the right hand side shows the respective portions of the times.

A bar with this color	means that the object is
Green	working
Gray	waiting
Yellow	blocked
Red	failed
Blue	paused
Brown	setting-up

- This is followed by material flow values of general interest.

Material Flow Properties

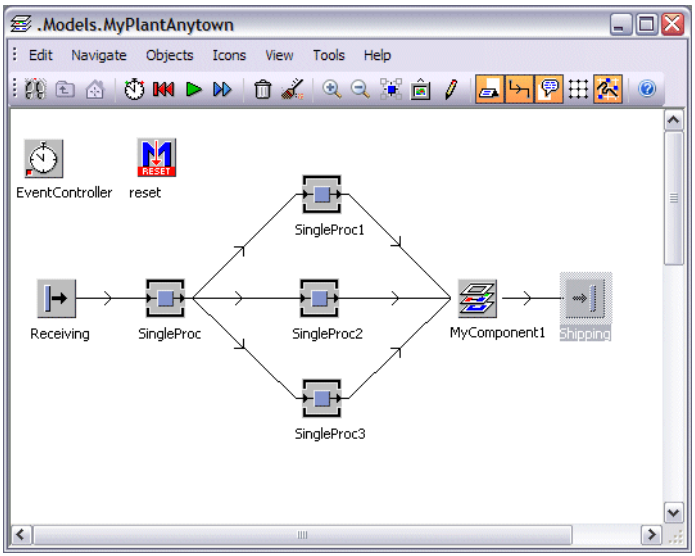
Object	Number of Entries	Number of Exits	Minimum Contents	Maximum Contents	Relative Occupation without Interruptions	Relative Occupation with Interruptions
Receiving	19457	19457	0	1	0.00%	0.00%
SingleProc	19457	19456	0	1	100.00%	100.00%
SingleProc1	4	3	0	1	55.57%	55.57%
SingleProc2	9726	9725	0	1	49.99%	49.99%
Shipping	19451	19451	0	1	99.97%	99.97%
SingleProc3	9726	9726	0	1	49.99%	49.99%

- The subtopics show details of the Working time, the Waiting time, the Blocked time, the Failed time, the Paused time, the Unplanned time, the Setup time and the Empty time in the order in which they appear in the first table. For details compare the *Statistics Report*.

Working Time

Object	Portion	Frequency	Sum	Mean Value	Standard Deviation
Receiving	0.00%	0	0.0000	0.0000	0.0000
SingleProc	100.00%	6064	4:05:03:04.2907	59.9908	0.7154
SingleProc1	52.43%	2	2:04:59:04.2907	1:02:29:32.1453	1:06:24:59.5222
SingleProc2	49.98%	3031	2:02:30:04.2907	59.9816	1.0119
SingleProc3	49.97%	3030	2:02:30:00.0000	1:00.0000	0.0000

- To add one or several objects in your model, which collect statistics to an open report, select it/them in the *Frame* and press F6. In our example we added the *Drain* object called *Shipping*.

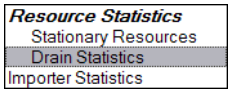


You will notice that the report added the object *Shipping* to the list of stationary resources as well as to the drop-down list of available topics.

Portions of the States of the Statistics Collection Period

Object	Working Time	Waiting Time	Blocked Time	Failed Time	Paused Time	Unplanned Time	Set-up Time	Empty Time	Start of Statistics Collection	Partition
Receiving	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.0000	
SingleProc	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0000	
SingleProc1	52.43%	47.55%	0.02%	0.00%	0.00%	0.00%	0.02%	47.55%	0.0000	
SingleProc2	49.98%	50.02%	0.00%	0.00%	0.00%	0.00%	0.00%	50.02%	0.0000	
SingleProc3	49.97%	50.03%	0.00%	0.00%	0.00%	0.00%	0.00%	50.03%	0.0000	
Shipping	99.91%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.09%	0.0000	

- To jump to the statistics of this *Drain*, select Drain Statistics from the drop-down list. For details compare the *Statistics Report*.



Resource Statistics - Drain Statistics

Cumulated Statistics of the Parts Which the Drain Deleted

Object	Working Time	Waiting Time	Failed Time	Paused Time	Set-up Time	Delay Time	Mean Life Time	Mean Exit Time	Total Throughput	Throughput per Hour	Throughput per Day
Shipping	5:48.2955	26.9713	0.0000	0.0000	0.0115	26.9598	6:15.2668	1:00.0000	5230	60	1440

Part Types which the Drains Deleted

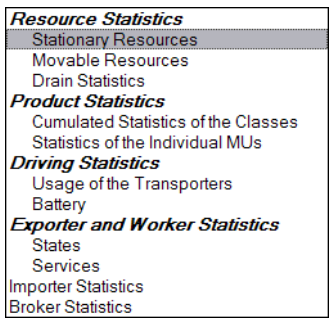
Object	All Types	Entity
Shipping	5230	5230

Detailed Statistics of the Part Types which the Drain Deleted

Shipping	Production							Transport							Storage						
	Process-ing	Wait-ing	Failed	Paused	Set-up	Delay	Sum	Process-ing	Wait-ing	Failed	Paused	Set-up	Delay	Sum	Process-ing	Wait-ing	Failed	Paused	Set-up	Delay	Sum
Entity	72.76%	0.00%	0.00%	0.00%	0.00%	0.00%	72.76%	4.07%	0.00%	0.00%	0.00%	0.00%	0.00%	4.07%	15.99%	7.18%	0.00%	0.00%	0.00%	7.18%	23.17%

Shipping	Life Time				Exit Time				Throughput		
	Mean Value	Standard Deviation	Minimum	Maximum	Mean Value	Standard Deviation	Minimum	Maximum	Total	Per Hour	Per Day
Entity	6:15.2668	39:49.2358	5:15.2668	2:00:05:15.2668	1:00.0000	0.0000	1:00.0000	1:00.0000	5230	60	1440

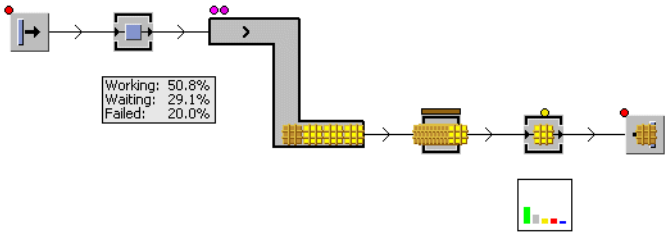
- You can add any of the objects, which collect statistics, to the report. It then adds these objects to the drop-down list:



- To save the report as an html file (*.htm or *.html) or as a text file (*.txt) click Save. Enter a name for the file and select the folder into which you want to save it.
- To update the report with the current values, click Refresh.
- To print the report, click Print.

Showing Statistics with Display Panels in Your Model

To quickly and easily show values of interest during a simulation run in your simulation model, you can define a *Display Panel* each for the individual objects in the *Frame*. The display panel is kind of a dashboard that watches statistics values or states of the objects and shows them in different ways: As **text**, as a **bar** or as an **LED**.



When you deactivate Icon Animation

Plant Simulation shows the *display panel*, but does not update its values and continues showing the previous values. It does not update the values either, when no simulation is running. To still show current values, it updates them:

- When the simulation stops, either because you stopped it or because the End time has been reached.
- When you click OK or Apply in the dialog of an object.
- When you select View > Update in the dialog of an object.
- When you press F5 in the *Frame* window.
- When you call the method *redraw* of an object.

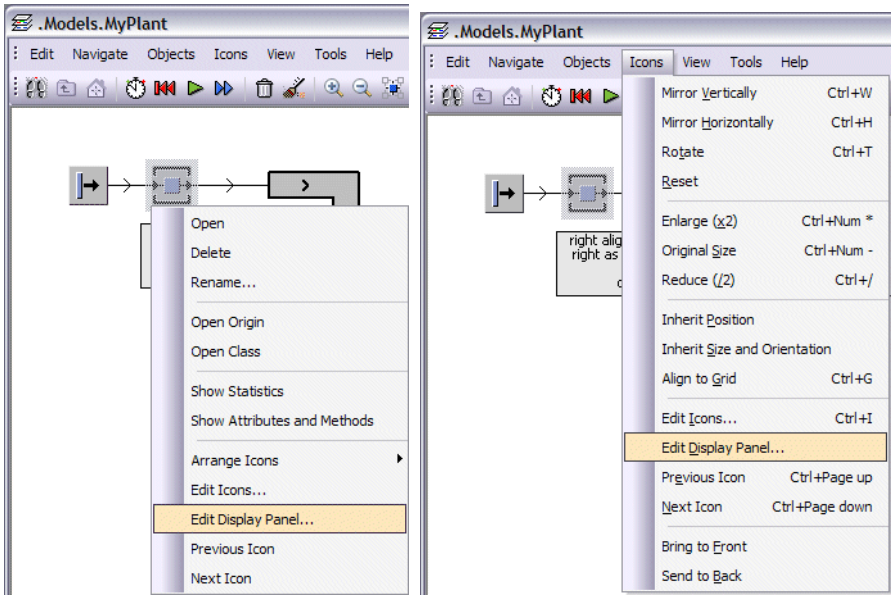
You can:

- *Show Values as Text*
- *Show Values as Bars*
- *Show States with LEDs*

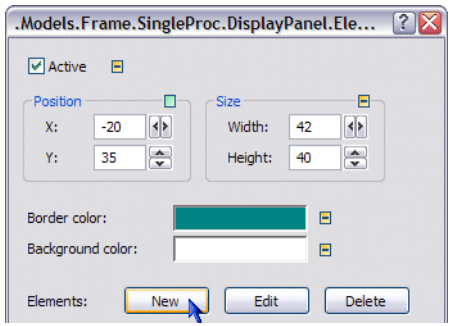
Show Values as Text

Suppose you want to display the working portion of a station. To do so, you'll first add the label `Working` and then the value proper, i.e. the value that a method records, to the right of it.

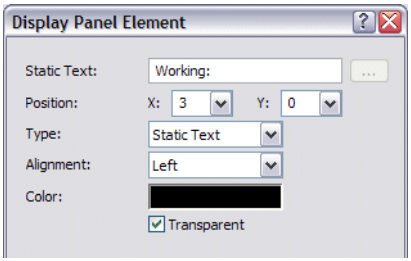
- Click the station for which you want to show the value with the right mouse button and select Edit Display Panel or select Icons > Edit Display Panel.



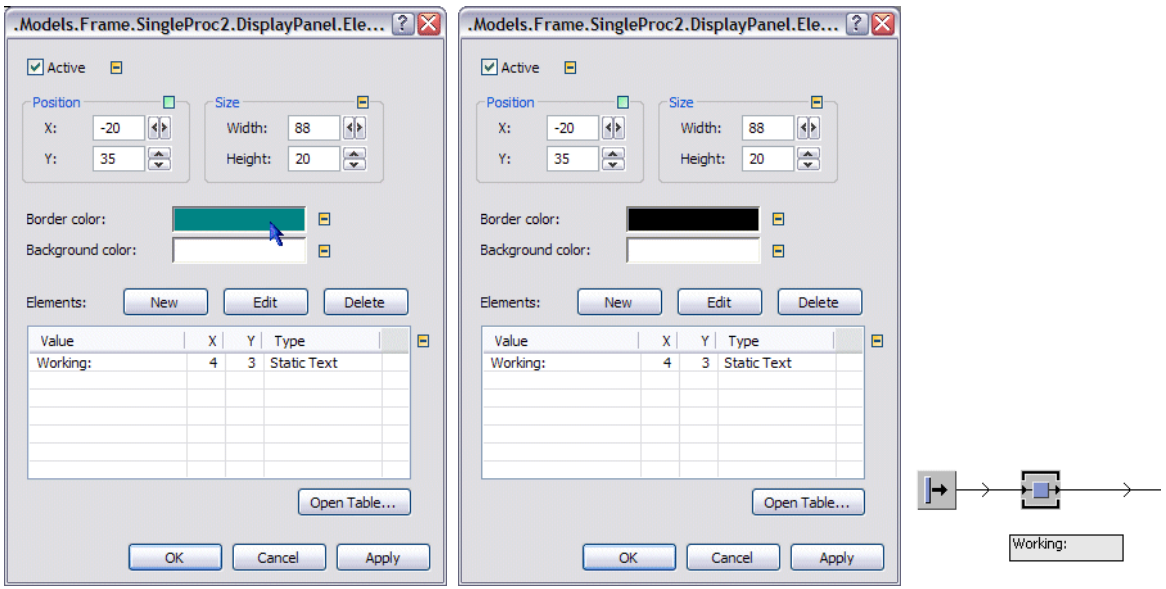
- Select the check box **Active** to show the *Display Panel* in the *Frame*.
- Enter the **Width** and the **Height** of the display panel in the *Frame*. If need be, adjust the **X-position** and the **Y-position**.



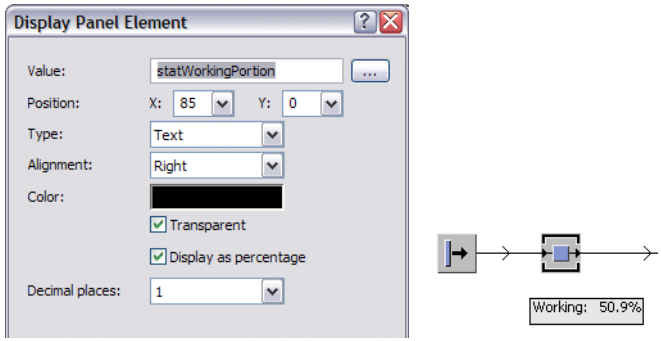
- Click **New** to add a new element to the display panel.
  - To add the label, select **Static Text** as the **Type** and enter `Working:` into the text box above it.
  - To make the background color of the display panel shine through the text, select **Transparent**.
  - Enter the **X-position** of the label on the display panel and click **OK**.



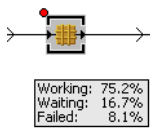
- Then, define the Border color around the display panel and its Background color to make the display panel stand out in the *Frame*. Click in the color box and select a color in the dialog Color. We selected black as the border color and light gray as the background color.
- Click Apply to show the display panel with the element you defined so far in the *Frame*. As you'll want to show the value to the right of the label, increase the Width of the display panel.



- Next, select the value you want to display next to the label. Click New.
  - In the dialog Display Panel Element click ... and select the Value you want to show. As we want to show the working portion of our station, we select the statistics method *statWorkingPortion*.
  - Select the display Type Text and select Display as percentage. Finally, adjust where *Plant Simulation* shows the value on the display panel by moving the X-position to the right of the label `Working:`.



As we want to show several values aligned correctly one below the other, we align them right.



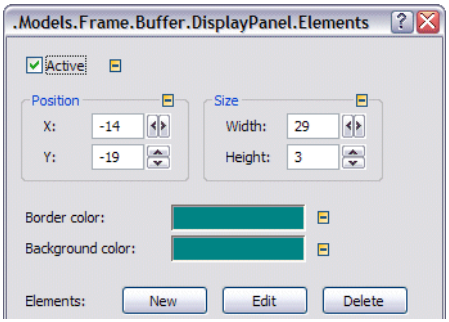
- Click OK to close the dialog Display Panel Element.

- Click OK again to finish defining the display panel.

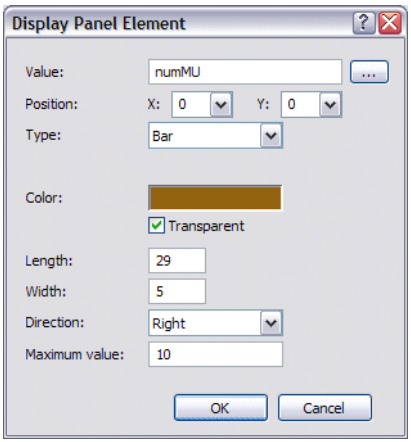
Show Values as Bars

Suppose you want to display the number of parts in a buffer as a bar above the icon of the object.

- Click the station for which you want to show the value with the right mouse button and select Edit Display Panel.
- Select the check box Active to show the *Display Panel* in the *Frame*.
- To display the bar above the icon, move the X-position and the Y-position to the top left corner of the icon.
- Enter the width and the height of the display panel in the *Frame*. In this case it corresponds to the width and the height of the bar itself.

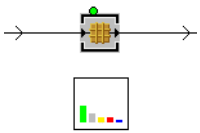


- Click New to add the new element.
  - In the dialog Display Panel Element click ... and select the Value you want to show. As we want to show the number of parts in the buffer, we select the method *numMU*.
  - Select the display Type Bar.
  - Select the Color of the bar and enter its Length and its Width.
  - Finally, select the Direction into which the bar deflects starting at the X-position of the element. We selected right.
  - Click OK to add the element.

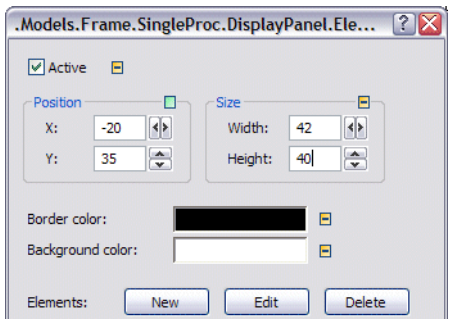


- Click OK again to finish defining the display panel.

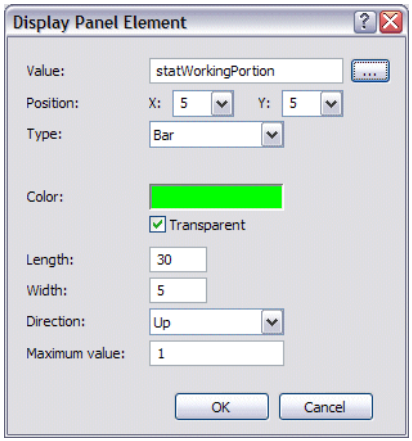
Suppose you want to display the working, waiting, blocking, failed and paused portions of a station on a display panel below the object.



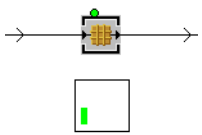
- Click the station for which you want to show the values with the right mouse button and select Edit Display Panel.
- Select the check box Active to show the display panel in the *Frame*.
- Enter the position and the width and the height of the display panel in the *Frame*.



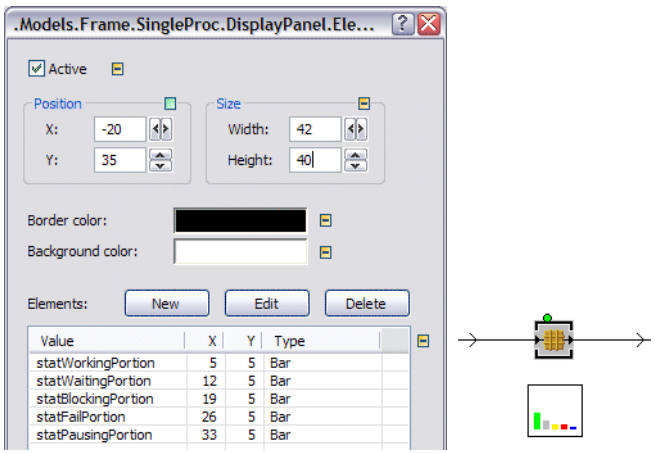
- Click New to add the new element.
  - In the dialog Display Panel Element click ... and select the Value you want to show. We selected the statistics method *statWorkingPortion*.
  - Select the display Type Bar.
  - Select the Color of the bar and enter its Length and its Width.
  - Select the Direction into which the bar deflects starting at the X-position of the element. We selected up.
  - Click OK to add the element.



- Click OK again to finish defining the display panel. It then looks like this.

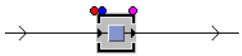


- Repeat the steps described above to add the values *statWaitingPortion*, *statBlockingPortion*, etc. to the display panel. Select a different color for each value and to shift the X-position of each value to the right so that they do not overlap. The result will then look like this.

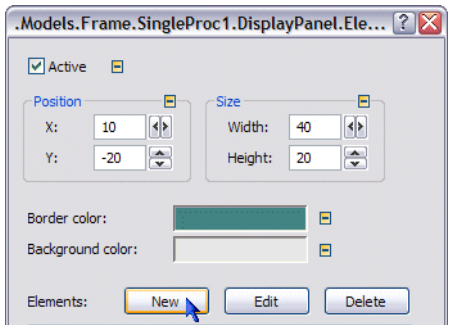


Show States with LEDs

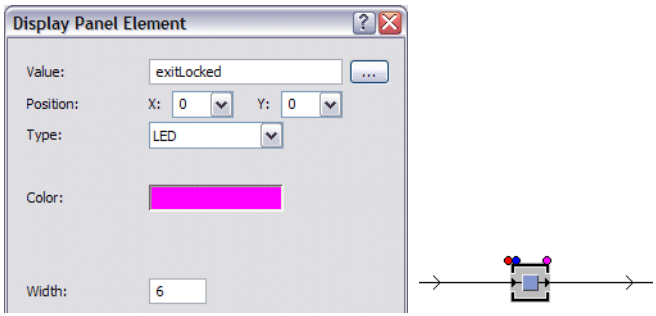
Suppose you want to add a light-emitting diode to display more states on the icon of the object than the built-in LEDs show. You can, for example, show an LED if the exit of the station is locked.



- Click the station for which you want to show the LED with the right mouse button and select Edit Display Panel.
- Select the check box Active to show the *Display Panel* in the *Frame*. Enter the position and the width and the height of the display panel in the *Frame*.

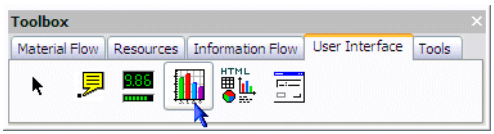


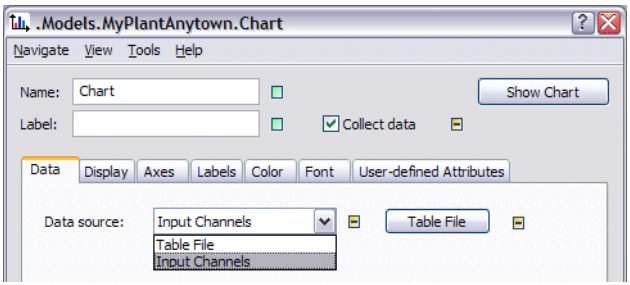
- Click New to add the new element.
  - In the dialog Display Panel Element click ... and select the Value you want to show. We selected the attribute *ExitLocked*.
  - Select the display Type LED.
  - Select the Color of the LED and enter its Width.



Showing Statistics in a Chart

When you want to present the results of your simulation runs to colleagues and management, you will use the *Chart*. You can insert the *Chart* into your simulation model from the folder UserInterface in the *Class Library* or from the tab User Interface in the *Toolbox*.





The *Chart* graphically displays the data sets that *Plant Simulation* recorded during a simulation run. You can select to show:

- Data from a table, into which you saved the simulation results, for example.
- Data from input channels you define that dynamically record the values of attributes of interest of objects that your are interested in.

To show statistics values of an object in the *Chart*, which you inserted into a *Frame*, you can use drag-and-drop:

To	Drag a	To a
Show the statistics of a material flow object	material flow object	*Chart*
Show the frequency distribution of the number of MUs	*PlaceBuffer*, *Buffer*, *Store*	*Chart*
Show the contents of a table	*TableFile*, *TimeSequence*	*Chart*
Show the value of the *Variable* you inserted into a *Frame*	*Variable*	*Chart*

- To apply the settings you selected in the dialog and to show the records, click Apply. When you resize the *display* window, *Plant Simulation* also resizes the shown graph.
- To show the data the *Chart* collected in the *display* window, click Show Chart.
- To open the dialog of the *Chart*, double-click anywhere in the *display* window.
- To make a *Chart* of type Histogram or Plotter collect data during the simulation run, select Collect data in the dialog. To deactivate data collection, clear the check box.
- To delete all values that the *Chart* collected, select Tools > Reset Values.

The *Chart* lets you select settings in a number of ways. You can:

- *Select Settings in the Statistics Wizard*
- *Select Where the Data Comes From*

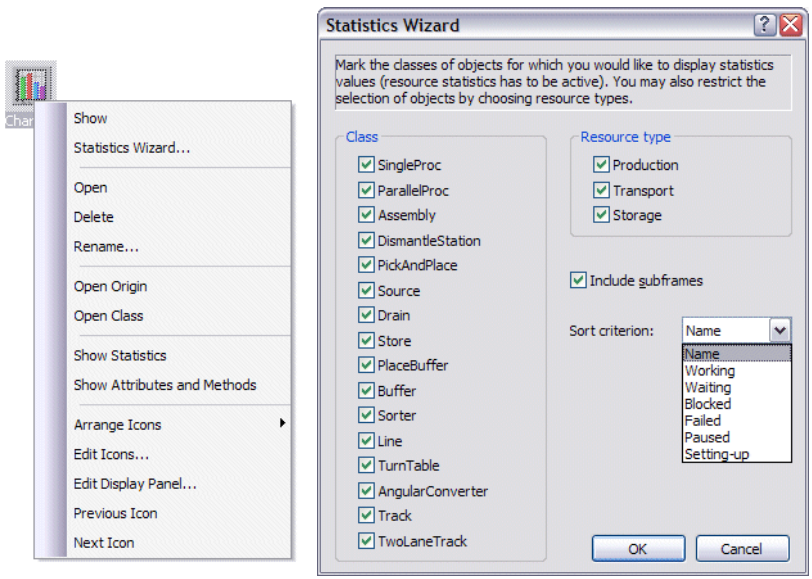
- *Selecting How the Chart Shows the Data*
- *Add Labels, Format Them and Add a Legend*

When you select another **Category**, the *Chart* automatically shows the icon of this category in the *Frame* window.

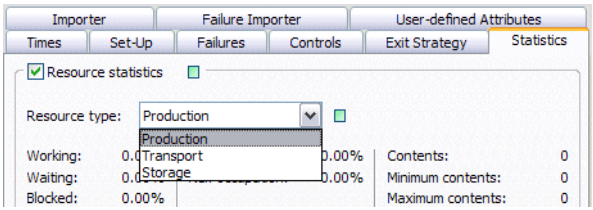
Chart	Histogram	Plotter

Select Settings in the Statistics Wizard

A *Chart*, which you insert into a *Frame*, provides a *Statistics Wizard*. Right-click the *Chart* and select **Statistics Wizard** on the context menu.



- Select the class(es) of object(s) for which you would like to show statistical data in the *Chart* under the group box **Class**. The *Chart* only adds material flow objects to the display for which you selected the check box **Resource statistics** on the **Tab Statistics**.
- Select the type(s) of resource(s) for which you would like to show statistics of the selected object(s) in the *Chart* from the drop-down list box **Resource type: Production**, **Transport** or **Storage**. Select the **Resource type** on the tab **Statistics** of an object collecting statistical data. Use the check boxes in the **Statistics Wizard** to restrict which objects *Plant Simulation* shows.



- If you would like *Plant Simulation* to also show statistical data of objects within *Frames* that you inserted into the *Frame* in which the *Chart* is located, select the check box Include subframes.
- Select the criterion which *Plant Simulation* uses when sorting statistical data from the drop-down list Sort criterion: Either the Name of the object, or one of the states it is in: Working, Waiting, Blocked, Failed or Paused.

  To sort the stations by their name in alphabetical order from A to Z, select Sort criterion > Name. To sort the stations in the order that suits your needs, drag the stations onto the *Chart* in the order it is to show them. To change the order at a later point in time, edit the table of the Input channels by cutting the respective columns and pasting them in the desired order.
- Finally, click OK to open the *display* window of the *Chart* with the settings you selected in the dialog.

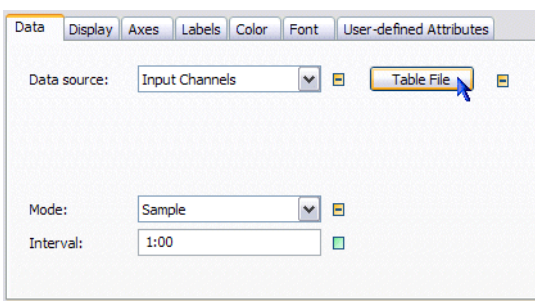
Select Where the Data Comes From

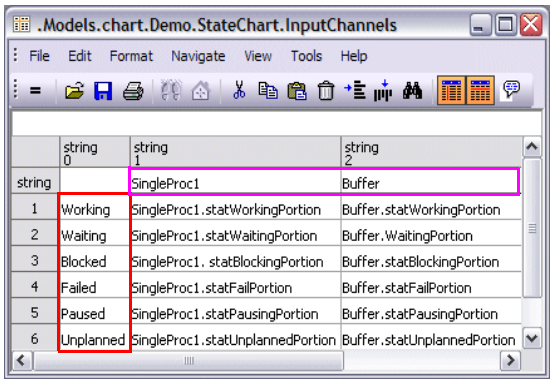
Before you start your simulation run, you can tell the *Chart* what to use as the source of the data it displays and in which mode it collects data.

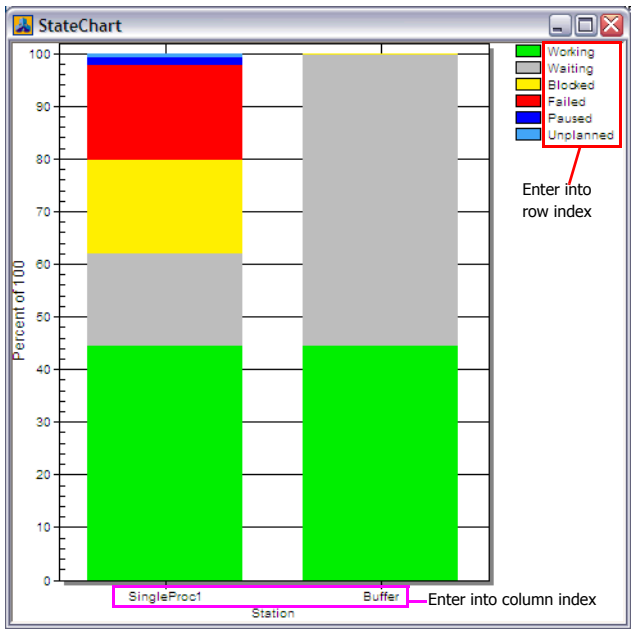
- Select the Data source, i.e., whether the *Chart* takes the data you want to display from a set of input channels or from a table.
  - To show values of channels you define in a table file, select Input Channels from the drop-down list.

    To open a table into which you enter the input channels, click Table File. These channels are, as a rule, the paths to attributes or methods of objects, whose values you want to display. You can also enter complex expressions, such as the sum of two attributes, etc.

    Enter any text you want to add as the **legend** to the *Chart* into the row index.







- To show the contents of a table as a diagram, select Table File. This might, for example, be a table into which you saved the results of a simulation run.

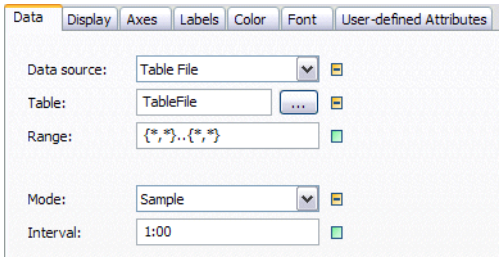
  Enter the name and the path of the table file containing the data, or click the button ... and select the table in the dialog Select Object.

  Enter the Range of the table cells you want to show.

  - To show all cells in all columns and rows, enter `{0,0}..{0,0}`.
  - To show the first four cells of column one, enter `{1,1}..{1,4}`.
  - To show all cells in column one, enter `{1,1}..{1,0}`.

  You can also enter negative numbers:

  - To show the one but last column of the table, enter `{-2,0}..{-2,0}`.
  - To show the one but last and the last column, enter `{-2,0}..{0,0}`.



- Select which mode the *Chart* uses to update the data it shows.
  - Sample mode updates the *Chart* periodically and takes the next sample after the time span you enter into the text box Interval.
  - Watch mode updates the *Chart*, whenever the value of an observable method, for example *numMU*, *numMU-Parts*, *statMaxNumMU*, *statNumIn*, *statNumOut*, etc. or of an observable attribute changes, for example *Pause*, *Speed*, *Unplanned*, etc.

    The column Observable in the dialog Show Attributes and Methods of the individual objects shows all methods and attributes *Plant Simulation* can watch.
  - Plot mode updates the *Chart*, whenever a simulation event takes place.

Selecting How the Chart Shows the Data

After you have selected where the *Chart* takes the data from that it displays, you will select the settings for displaying this data.

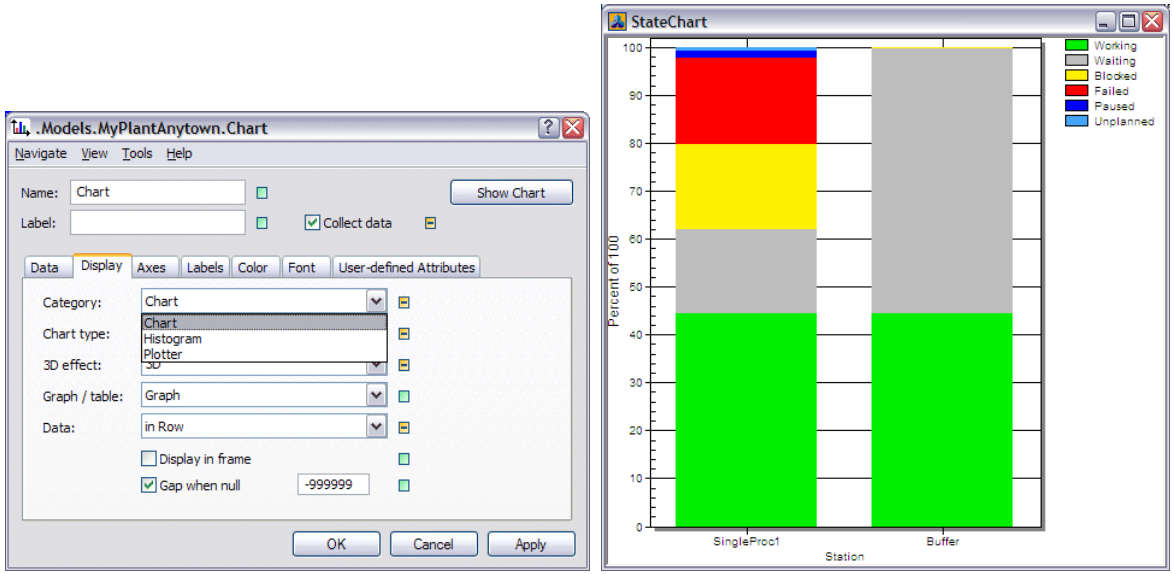
You can select to:

- Show a number of values or several sets of a number of values, see *Show Values in a Chart*.
- Show the frequency distribution for one or several input channels, see *Show Values in a Histogram*.
- Show the progression of one or more values over time, see *Show Values as the Chart Plots Them*.

  Note: When you select another Category, the *Chart* automatically shows the icon of this category in the *Frame* into which you inserted it.
- Show a number of x-y pairs of values or several sets of x-y pairs of values, see *Show Values as an XY Graph*.

Show Values in a Chart

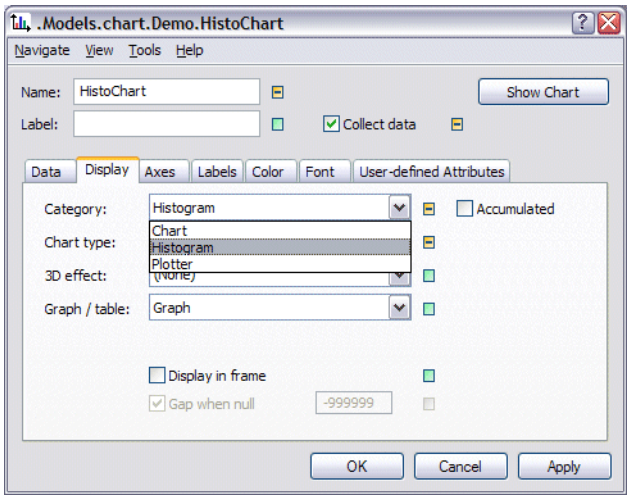
To show a number of values or several sets of a number of values as a chart, click the tab Display and select Chart from the drop-down list Category.

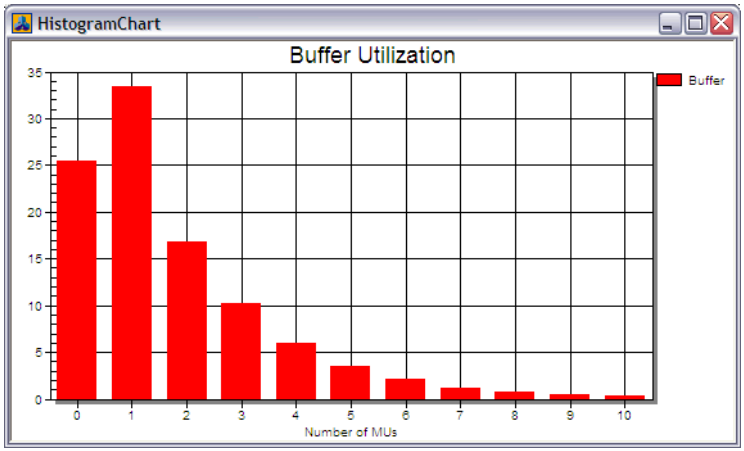


Show Values in a Histogram

To show the frequency distribution for one or several input channels as a histogram, click the tab **Display** and select **Histogram** from the drop-down list **Category**. A histogram graphically summarizes the distribution of a data set.

To make the *Chart* collect data during the simulation run, select **Collect data** in the dialog. To deactivate data collection, clear the check box.

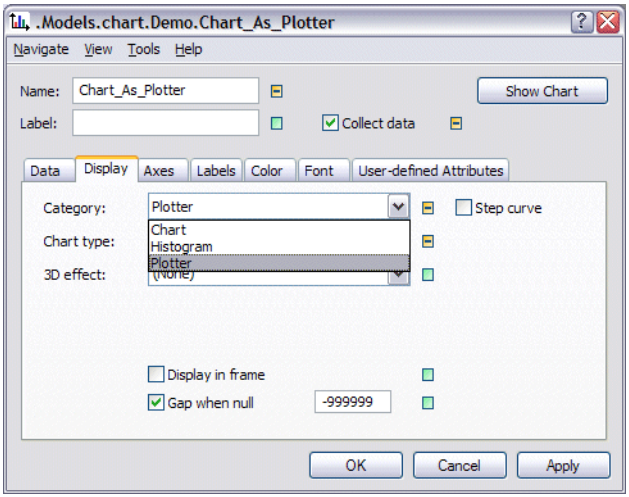


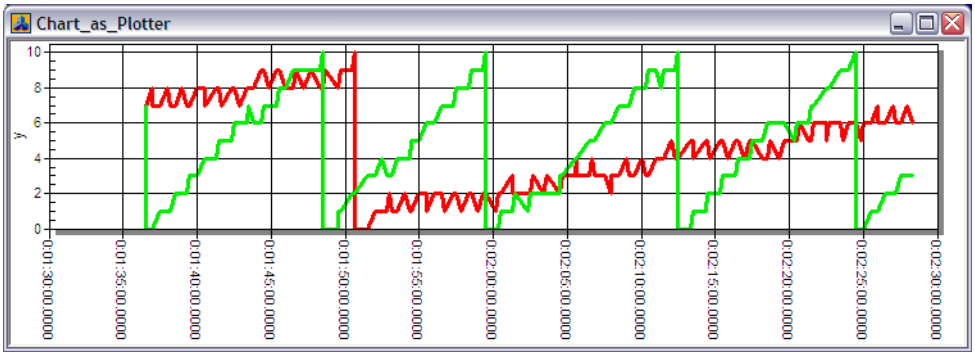


Show Values as the Chart Plots Them

To show the progression of one or more values over time, click the tab Display and select Plotter from the drop-down list Category.

To make the *Chart* collect data during the simulation run, select Collect data in the dialog. To deactivate data collection, clear the check box.

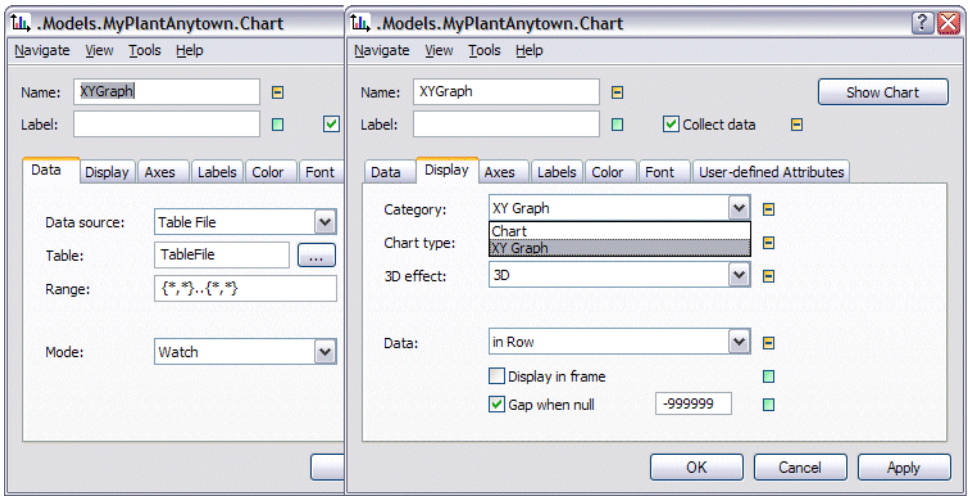


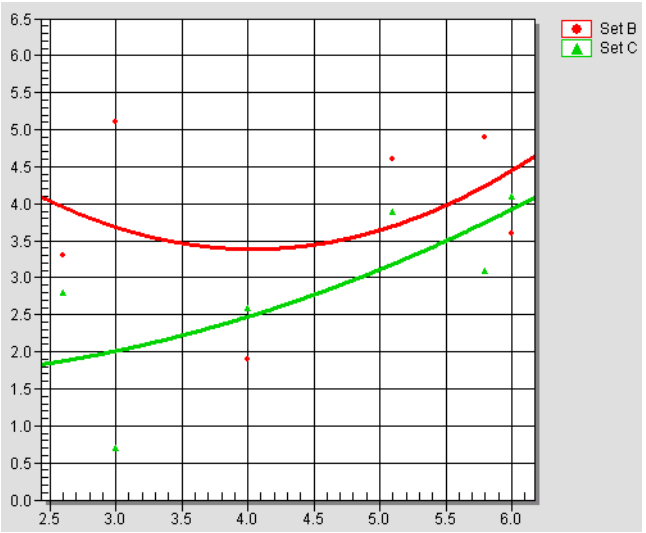


Show Values as an XY Graph

To show a number of x-y pairs of values or several sets of x-y pairs of values, click the tab Display and select XY Graph from the drop-down list Category.

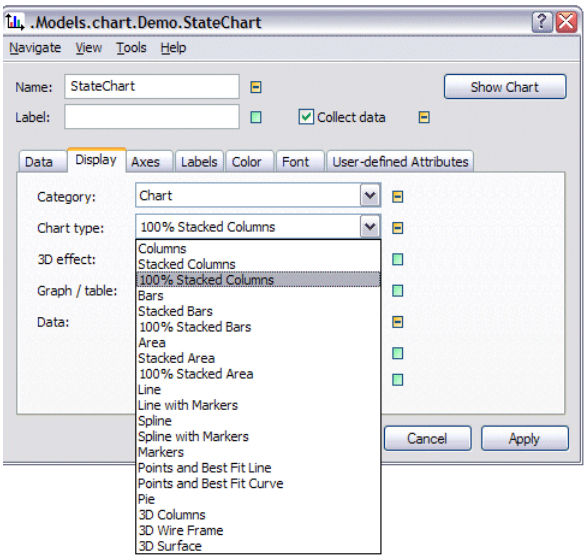
Note: You can only show values as an XY graph, when you select Data > Data source > Table File.

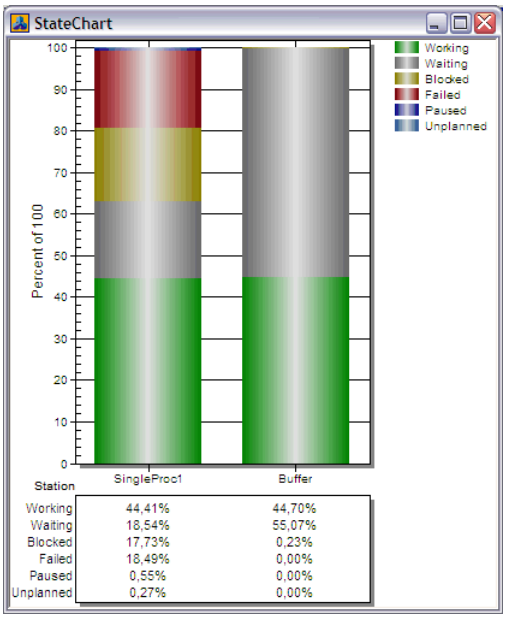




Select the Chart Type

Select the type of *Chart* for displaying the recorded data. A record consists of the entries of a row or a column, depending on the setting you selected under Display > Data.



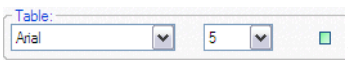


Depending on the **Category** you selected (**Chart**, **Histogram** or **Plotter**), the *Chart* provides some or all of the following chart types:

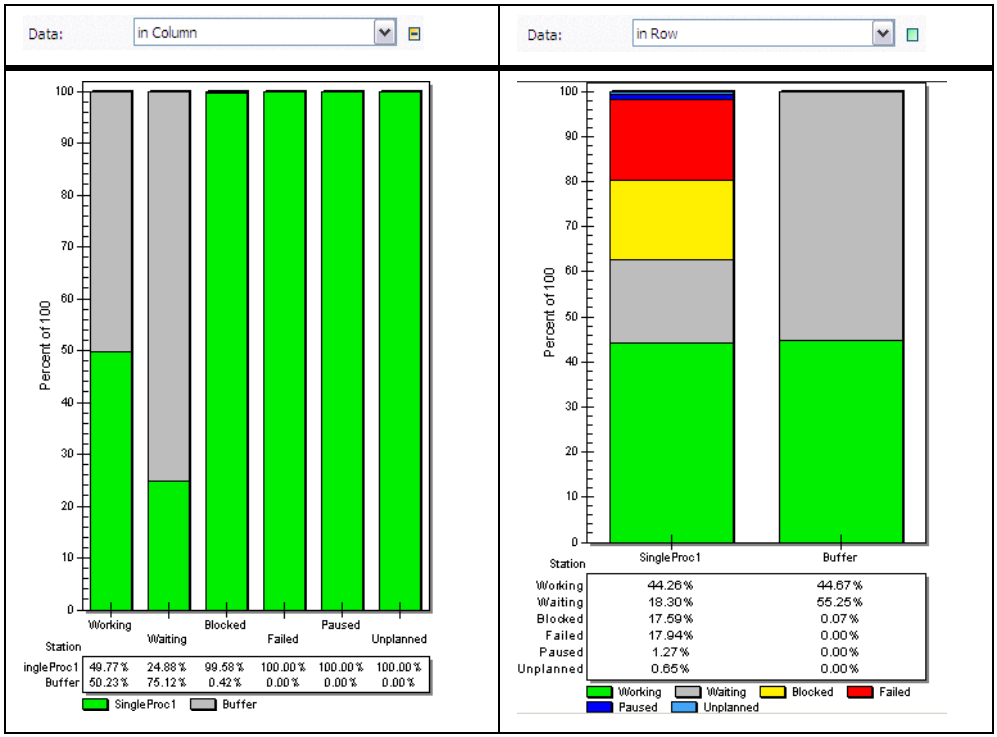
Columns	shows each record as a column. When displaying several records, the *Chart* places the columns next to each other. Use this to compare values across categories.
Stacked Columns	shows each record as a column. When displaying several records, the *Chart* places the columns of the individual records on top of each other. It stacks positive values upwards, negative values downwards.
100% Stacked Columns	shows each record as a column, stacked one on top of the other, showing the respective percentage of the entire set of 100%.
Bars	shows each record as bars positioned horizontally on top of each other. When displaying several records, the *Chart* places the bars of the individual records next to each other. Use this to compare values across categories.
Stacked Bars	shows each record as a set of bars stacked horizontally next to each other. Positive values are stacked to the right, negative values are stacked to the left.
100% Stacked Bars	shows each record as a set of bars, one stacked horizontally next to each other, showing its respective percentage of the entire set of 100%.
Area	shows each record as areas. When displaying several records, the *Chart* stacks the areas from the individual records one behind the other. Use this to show the trend of the contribution of each value over time or categories.
Stacked Area	shows each record as areas. When displaying several records, the *Chart* stacks the areas from the individual records one on top of the other.
100% Stacked Area	shows each record as a set of areas, one stacked on top of the other, showing the respective percentage of the entire set of 100%. Displays the trend of the percentage each value contributes over time or categories.
Line	shows each record as a line.
Line with Markers	shows each record as a line with markers.
Spline	shows each record as a curve.
Spline with Markers	shows each record as a curve with markers.
Markers	shows each record as a set of different markers.
Points and Best Fit Line	shows each record as a set of data points, and fits the best straight line to them. The line is calculated from least-squares-approximations of the data set.
Points and Best Fit Curve	shows each record as a set of data points, and fits the best curved line to them. The curve is calculated from least-squares-approximations of the data set.

Pie	shows each record as a slice of a pie, depicting its percentage of the whole. Enter a negative prefix, so that the *Chart* offsets this slice from the rest of the pie. Use the scroll bar to scroll from record to record. Use this to show the contribution of each value to a total.
XY Points	shows the x-y pairs as data points. The first record contains the x-coordinates. The *Chart* interprets all additional records as the associated y-coordinates. Use this to compare pairs of values.
Line	shows the x-y pairs as data points and connects them with a line. The first record contains the x-coordinates. The *Chart* interprets all additional records as the associated y-coordinates.
Sticks	shows a vertical bar for each x-y pair, starting from the zero line. The first record contains the x-coordinates. The *Chart* interprets all additional records as the associated y-coordinates.
Area	connects the points belonging to the x-y pairs and fills the areas thus created. The first record contains the x-coordinates. The *Chart* interprets all additional records as the associated y-coordinates.
3D Columns	shows each record as columns stacked in three-dimensional space. To turn the chart left or right you can enter an angle of Rotation or you can also drag the horizontal slider in the display window. To turn the chart up or down, you can enter the Height or you can drag the vertical slider.
3D Wire Frame	shows each record as wireframes stacked in three-dimensional space. To turn the chart left or right you can enter an angle of Rotation or you can also drag the horizontal slider in the display window. To turn the chart up or down, you can enter and the Height or you can drag the vertical slider.
3D Surface	shows each record as solid areas stacked in three-dimensional space. To turn the chart left or right you can enter an angle of Rotation or you can also drag the horizontal slider in the display window. To turn the chart up or down, you can enter the Height or you can drag the vertical slider.

Select Additional Display Options

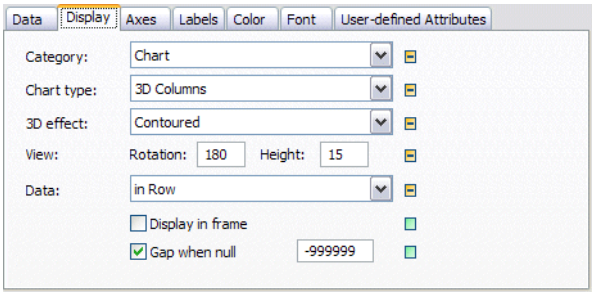
- Select how the *Chart* shows the **records** i.e., the entries of a row or of a column.
  - Graph shows the records as a graph only in the *display* window.
  - Table shows the records as a table, i.e., as text only in the *display* window. Select a font and a relative font size on the tab Font 

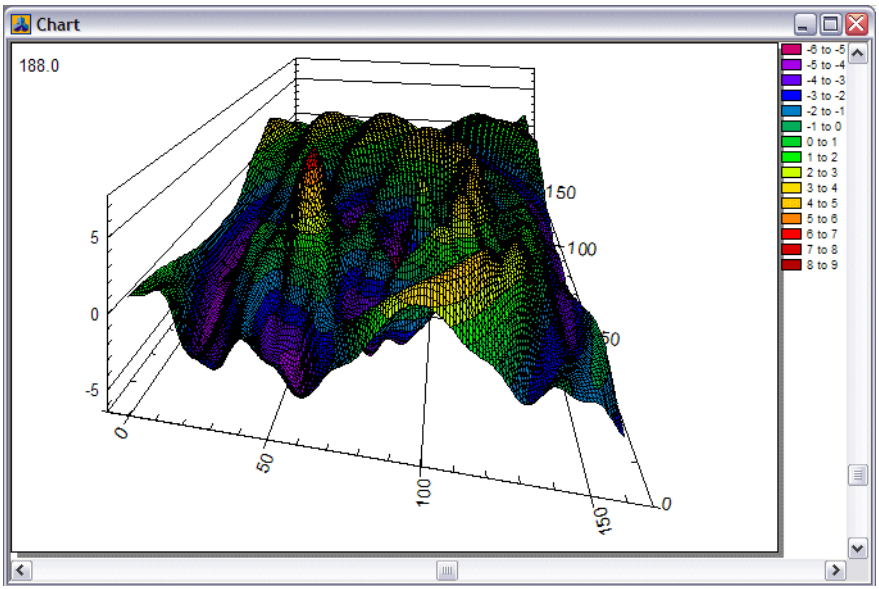
.
  - Graph and Table shows the records as a graph and as a table in the *display* window.
- Select how the *Chart* shows the **data**. This way you can present different views of the same record.



- If you want to, you can also select a 3D effect for some of the Chart Types:
  - None adds no 3D effect to the Chart Type you selected.
  - Shadow adds a black shadow to the chart type you selected.
  - 3D adds three-dimensional depth to the chart type you selected.
  - Gradient bars adds an effect between a gradient and a 3D look to the chart type you selected.
  - Contoured for the chart types 3D Columns and 3D Surface.

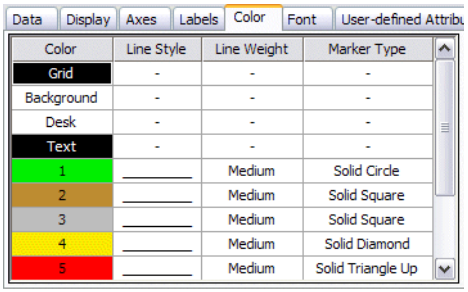
    You can also enter the Rotation angle and the Height of the columns/surface. To turn the chart left or right, drag the horizontal slider in the display window. To turn it up or down, drag the vertical slider.





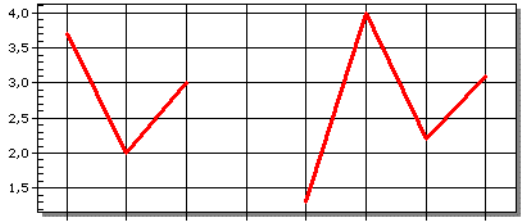
Note: Some chart types do not provide 3D effects.

- To change the background color of the *Chart* proper in the display window, click the tab Color. Double-click the cell labeled Background and select another color. Click Apply to change the color.



- To change the color around the *Chart* proper in display window, click the tab **Color**. Double-click the color field next to **Desk** and select another color. Click **Apply** to change the color.
- To display the *Chart* in the *Frame*, instead of the icon of the object, select **Display in frame** on the tab **Display**.

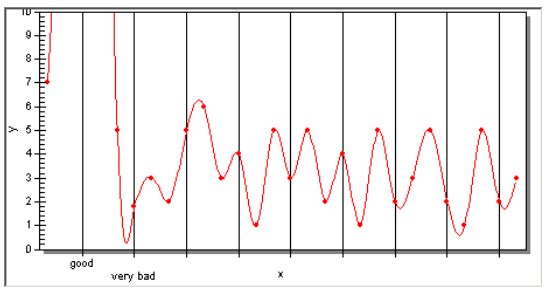
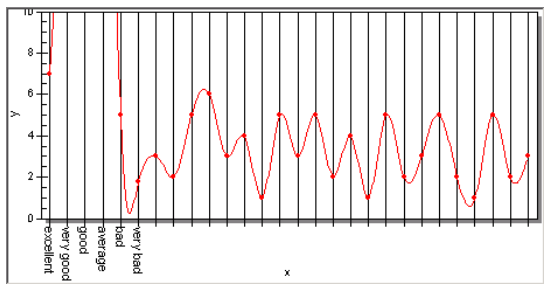
  We advise to increase the size of the icon of the *Chart* in the *Frame*: Hold down **Shift+Ctrl**, grab one of the four corners of the icon with the mouse and drag the icon to a convenient size.
- To interrupt the line the *Chart* draws for values that are not defined, select **Gap when null** on the tab **Display**. To continue drawing the line, clear the check box.

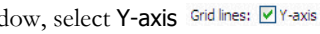


- To print the *Chart*, select **Tools > Print**.
- To copy the contents of the display window to the *Clipboard* as a bitmap, select **Tools > Copy to Clipboard**. You can then paste it into another application with **Ctrl+V** or **Edit > Paste**.
- To show **Grid lines** on the x-axis in the *display* window, select **X-axis** on the tab **Axes**. Enter the maximum number of grid lines on the x-axis. This feature is especially handy, when the *Chart* displays a large number of points within a limited space and you want to regulate how many grid lines the display window shows.

  To hide them, clear the check box.

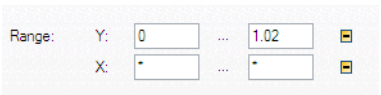
Compare these screenshots:

10 grid lines on the x-axis	20 grid lines on the x-axis
	

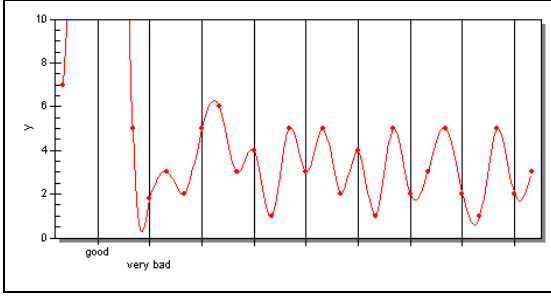
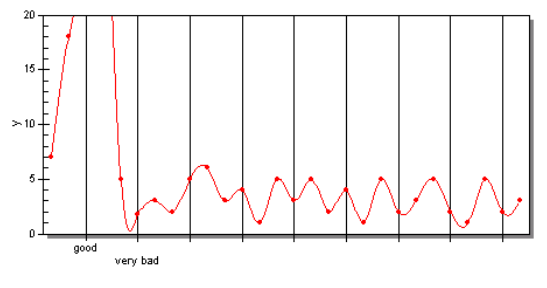
- To show grid lines on the y-axis in the *display* window, select Y-axis  . To hide the grid lines, clear the check box.
- To define the range the *Chart* is to display scaled on the y-axis, enter the first value of into the left text box. The default setting `0 ... 0` means that *Plant Simulation* scales automatically.

  Enter the last value of the range the *Chart* is to display scaled on the y-axis into the right text box.

  Note: When you enter neither Title nor Subtitle, the *Chart* might, under certain circumstances, cut off the upper part of the y Range. To prevent this, you can enter a blank space into the text box Subtitle.

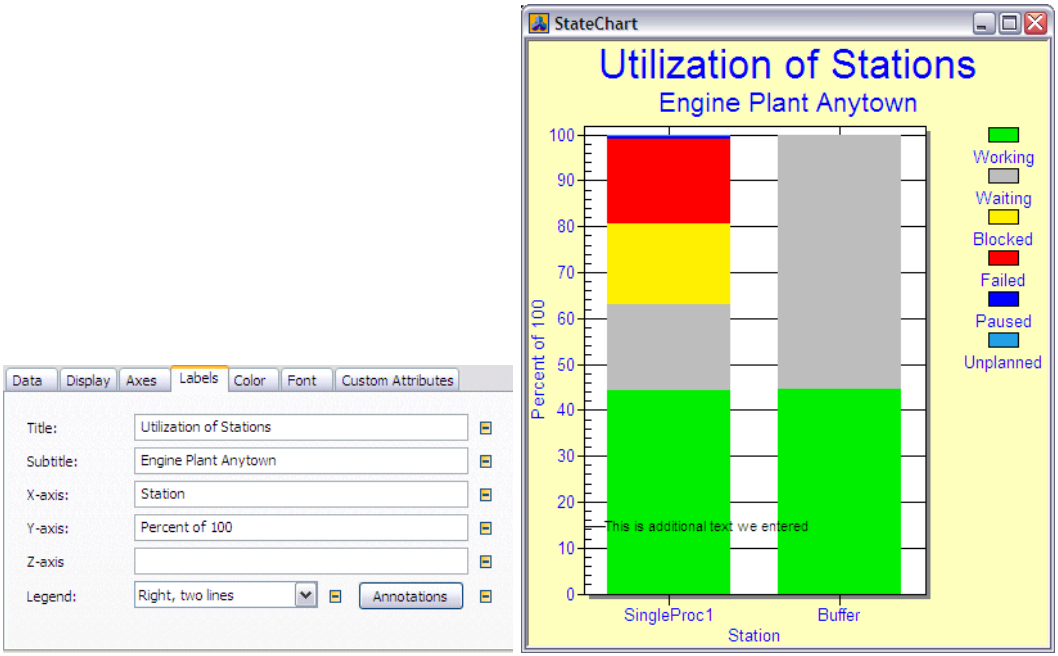


Compare these screenshots:

Scaling on the y-axis, 10 units	Scaling on the y-axis, 20 units
	

Add Labels, Format Them and Add a Legend

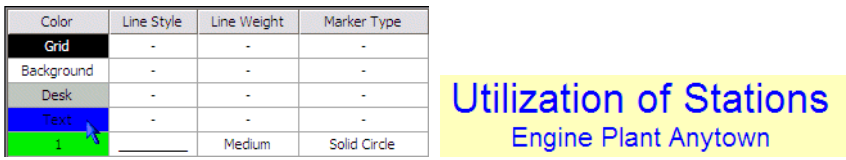
Naturally, you will also want to add a title and a subtitle to your chart, and format them, add text to the x-axis and to the y-axis and add a legend that tells what the values mean.



- Enter any text that *Plant Simulation* shows as the title of the *Chart* in the *display* window into the text box Title. In our example we entered `Utilization of Stations`.

  Select a font, if you want to **bold** face or *italicize* the text and a relative font size on the tab Font.

  Select a color for all text in the *display* window on the tab Color. Double-click the color field next to Font and select another color. Click Apply to change the color.

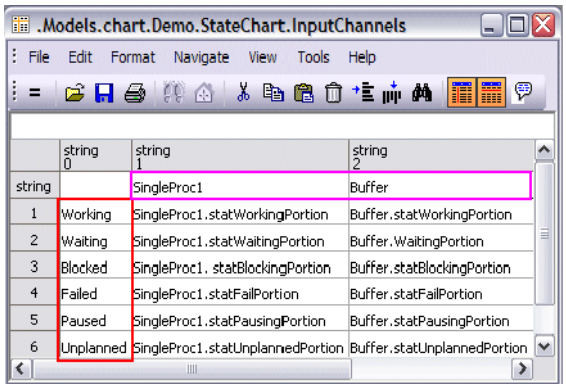


- Enter any text that *Plant Simulation* shows as the subtitle of the *Chart* in the *display* window into the text box Subtitle. In our example we entered `Engine Plant Anytown`.
- Enter any text that *Plant Simulation* shows in the *display* window on the x-axis. In our example we entered `Station`.

  Select a font, if you want to **bold** face or *italicize* the text and a relative font size on the tab Font.

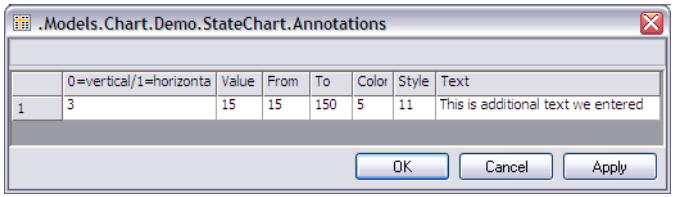
  Note: This font applies to all labels, except for the Title, the Subtitle and data displayed in Table format in the *display* window
- Enter any text that *Plant Simulation* shows in the *display* window on the y-axis. In our example we entered `Percent of 100`.
- Select if and on which side of the *display* window *Plant Simulation* shows the legend for the values the *Chart* displays.

  As you remember, you enter the text you want to show as the **legend** into the row index of the table when you select Data source > Input Channels > Table File.

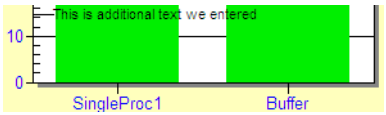


	string 0	string 1	string 2
string		SingleProc1	Buffer
1	Working	SingleProc1.statWorkingPortion	Buffer.statWorkingPortion
2	Waiting	SingleProc1.statWaitingPortion	Buffer.WaitingPortion
3	Blocked	SingleProc1. statBlockingPortion	Buffer.statBlockingPortion
4	Failed	SingleProc1.statFailPortion	Buffer.statFailPortion
5	Paused	SingleProc1.statPausingPortion	Buffer.statPausingPortion
6	Unplanned	SingleProc1.statUnplannedPortion	Buffer.statUnplannedPortion

- If need be, you can also add additional lines and/or text to the display window. Click Annotations and fill in the table that opens.



	0=vertical/1=horizonta	Value	From	To	Color	Style	Text
1	3	15	15	150	5	11	This is additional text we entered



  - Type: Enter `0` for displaying a vertical line or enter `1` for displaying a horizontal line. Enter `2` or `3` for labeling the x-axis or the y-axis. Enter `4` for any text.
  - Value: Enter the value where the *Chart* displays the line in the *display* window. For a vertical line this is the x-value, for a horizontal line this is the Y-value.

- From: Enter the starting point of the line here. If you do not enter a value, the *Chart* extends an existing line.
- To: Enter the end point of the line here. If you do not enter a value in the cells From and To, the *Chart* draws the line from the left to right, or from the top to the bottom of the display window.
- Color: Enter the number of the color of the line here. This is the number of one of the lines you defined on the tab Color.
- Style: Enter the style of the line here, such as dotted, dashed, etc.

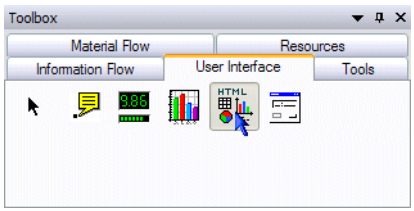
0	is a thin solid line
5	is a medium thin solid line
10	is a medium thick solid line
6	is a thick solid line
11	is an extra thick solid line
1	is a dashed line
2	is a dotted line
3	is a dash-dot line
4	is a dash-dot-dot line

- Text: Enter any text that describes the line.

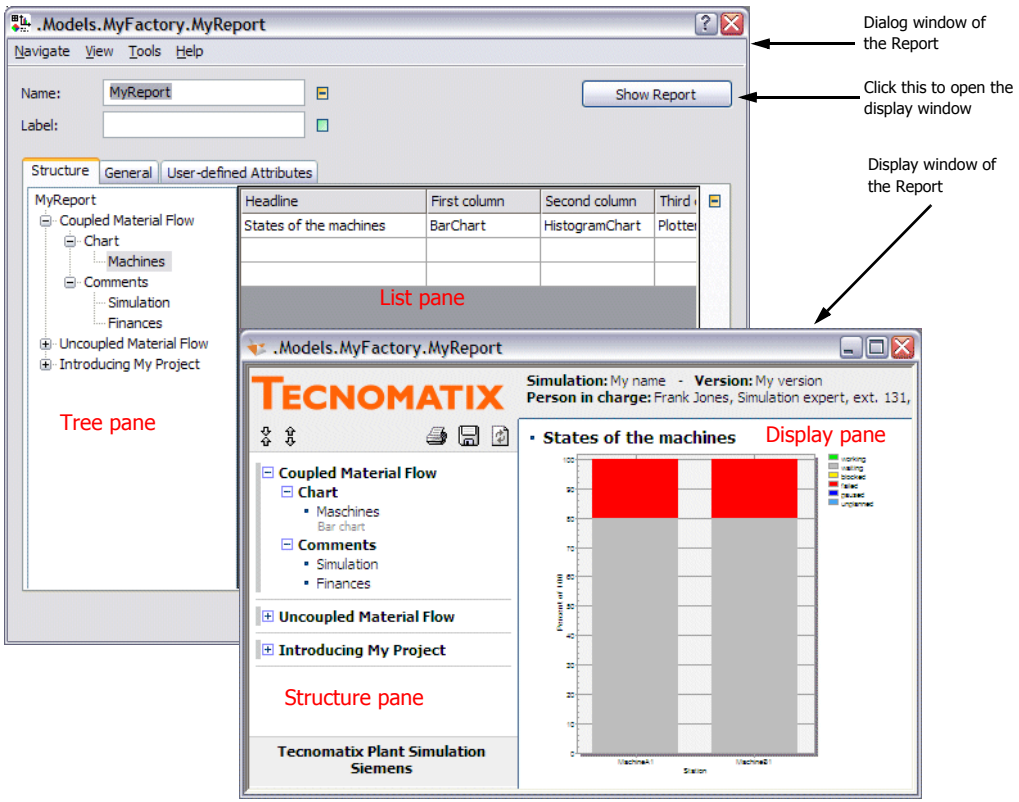
Showing Statistics in a Report

When you want to present all of the results of a simulation run, which *Plant Simulation* outputs to tables and diagrams, on a number of HTML pages on screen, you will use the object *Report*. You can also print, and save, this set of HTML pages for sharing it with your colleagues or for displaying it on a web site.

You can insert the *Report* into your simulation model from the folder UserInterface in the *Class Library* or from the tab User Interface in the *Toolbox*.



One *Report* object per simulation model defines the general layout of the HTML pages. Define the data the object displays in the dialog of the report, and view the data in the *display* window, which Show Report opens.

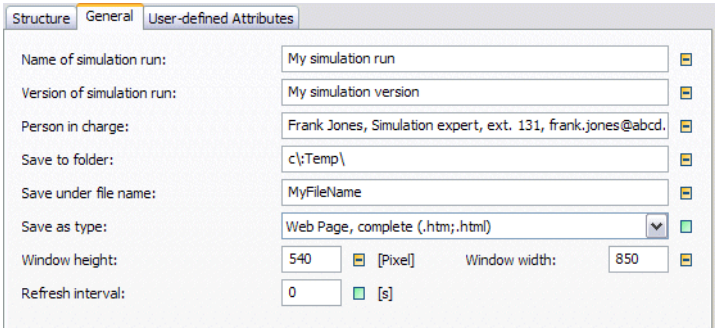


You will:

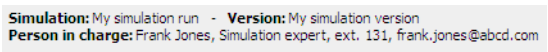
- *Enter General Information which the Report Shows*
- *Define How the Report Shows the Data*
- *Work with the Display Window*

Enter General Information which the Report Shows

Enter some or all of the following information, which the *Report* shows, in the *display* window into the text boxes:



- Enter a name for the simulation run. The *display* window shows the text you enter along the top border of the report next to Simulation. In our example we entered `My simulation run`.



- Enter the version number of the simulation run within the simulation experiment. This can be any combination of letters and numbers. The *display* window shows the text you enter along the top border of the report. In our example we entered `New My simulation version`.
- Enter the name of the person who is in charge of this simulation experiment. You can append this with the phone number, the e-Mail address, the department. etc. The *display* window shows the text you enter along the top border of the report. In our example we entered `Frank Jones, Simulation expert, ext. 131, frank.jones@abcd.com`.
- Enter the name of the folder you would like to save the report to as an HTML file.
- Enter the file name you want to save the report with as an HTML file. This creates a folder with the name you enter and places the HTML files and the graphics that the HTML files show into it.
- Select the file type you want to save the report with as an HTML file.

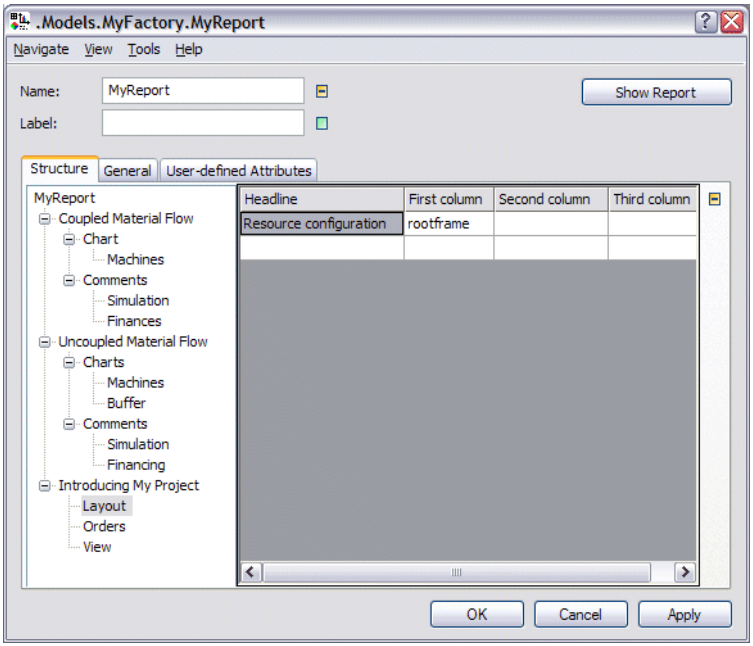
  Note: At present you can only select Web Page, complete. This saves all of the files needed to display this page, including graphics, frames, and style sheets. Web Page, complete saves each file in its original format.

- Enter the width of the *display* window in pixels in which *Plant Simulation* shows the report.
- Enter the height of the *display* window in pixels in which *Plant Simulation* shows the report.
- Enter the interval, in seconds, after which the *Report* dynamically updates the results of the simulation run in the *display* window. To manually update the *display* window, click Refresh in the *display* pane.

Define How the Report Shows the Data

When you define which data the *Report* shows and how it shows it, you will:

- *Create a Structure for Displaying Data*
- *Apply Formatting to the Structure Pane*
- *Add the Objects Whose Data You Want to Show*

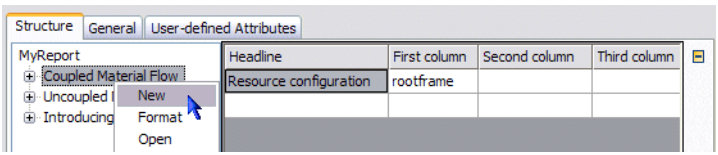


Create a Structure for Displaying Data

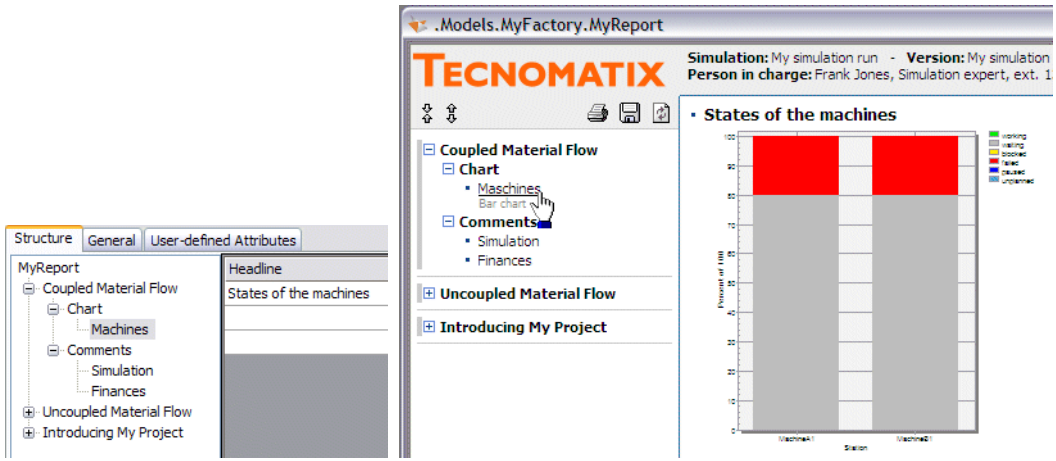
To add clarity to your report, you will first **create a structure** that shows the results of the simulation runs.

- To create a new page in the structure below a branch, right-click that branch and select New. Type in another name instead of *New Page*. Repeat this until the structure has the form that meets your needs.

  Instead you can also right-click the new page and select Rename or enter a different name in the dialog Format. In our example we entered `Coupled Material Flow`.



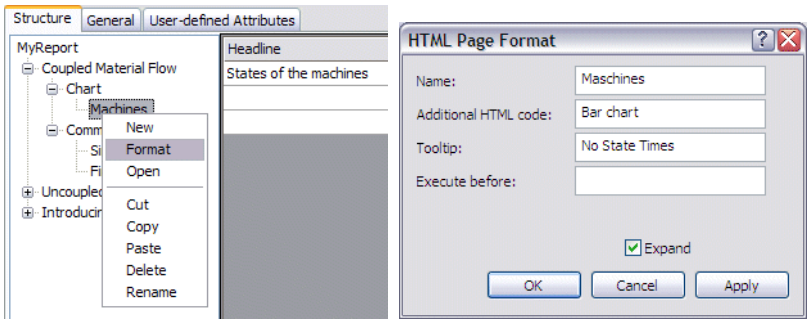
- To enter the title of the page that the *display* pane shows, select the page, click into the cell below Headline and enter the text. In our example we entered `States of the Machines`.



Apply Formatting to the Structure Pane

If you want to, you can **apply formatting** that the branches in the structure pane in the *display* window show.

- Right-click the branch that you would like to apply formatting to and select Format on the context menu.



- Enter the text that the tooltip shows, when you roll the mouse over the name of the branch in the structure pane of the *display* window. In our example we entered `No State Times`.
- For the topmost node of a branch, such Coupled Material Flow or Uncoupled Material Flow in our example, you can enter color for the vertical bars to the left of the branches in the structure pane. You can enter the HTML code of a color, for example, `DARKBLUE` or `#00008B`, etc. In our example above we entered `green`.
- To show the branch and its sub-branches, i.e., with all of its subpages, in the structure pane, when you open the *Report*, select Expand.

- If you want to execute certain actions before *Plant Simulation* creates the HTML page, enter the name of the *Method* M in which you programmed these actions into the text box Execute before.

Add the Objects Whose Data You Want to Show

After you have created the structure, you will **add the objects** whose data you want to show.

Note: You can only show data, and thus enter a title and add objects for it, on the individual pages that do not have a ⊟ on their left on the tab Structure in the dialog of the *Report*.

Below we demonstrate how to:

- *Show the Contents of a Chart in the Display Pane*
- *Show the Contents of a Table in the Display Pane*

Show the Contents of a Chart in the Display Pane

To show the contents of a *Chart* in the *display* pane of the *Report*:

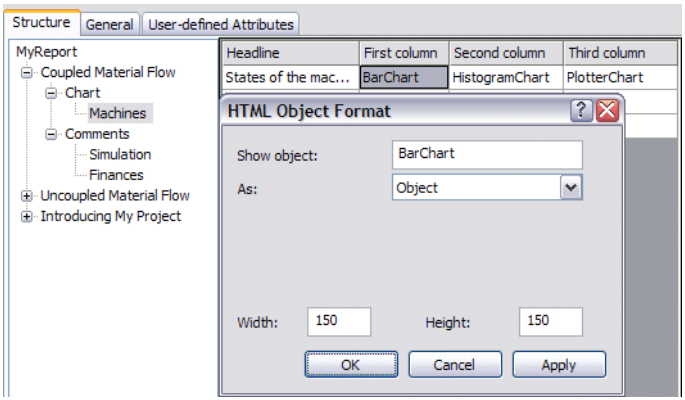
- To enter the title of the page that the *display* pane shows, select the page, click into the cell below Headline and enter the text. In our example we entered `States of the machines`.

  Note that headlines are preceded by a bullet in the *structure* and the *display* windows ⊟ Chart ▪ Maschines . Enter a hyphen (-) in the first cell below the header to show a horizontal rule below the headline in the *display* window.
- Click the page in the structure and double-click the cell below First column to show the data in column one of the *display* pane of the *display* window.
- Enter the name of the object you want to show in the *display* pane. In our example we entered the name of the *Chart* object `Chart` that we inserted into our simulation model.

  Or **drag** the object from the *Frame* or the *Class Library* to the cell **and drop** it there.
  - A *TableFile*.
  - A *Chart* object.
  - A *Comment* object you saved as Text Only, i.e., for which you cleared the check box Save the contents in rich-text format.
  - A *Frame* that contains icons of the objects you inserted.
  - An *Attribute*.
  - An *AttributeExplorer* object.
  - A *Method* object that returns a value of type *string*.
  - One of the basic functions, such as *to_str*.

- Select how you want to show the data:

Setting	Sample object	Sample table
As Text, i.e., as plain text.	▪ Press Statistics Results PressUtilizationChart	▪ Table of Orders Shows the orders for the current press simulation DeliveryList
As an Icon of the object. Enter the name of an icon of the object. Enter the Width and the Height of the icon in pixels that the *Report* shows in the *display* window.	▪ Press Statistics Results 	▪ Table of Orders Shows the orders for the current press simulation
As an Object, depending on the type of object. Enter the Width and the Height of the object in pixels in the *display* window.	▪ Press Statistics Results 	▪ Table of Orders Shows the orders for the current press simulation MU | Amount | Name | Attribute .MUs.EntityA | 4 | PartA | Table : instantiated .MUs.EntityB | 2 | PartB | Table : instantiated .MUs.EntityC | 3 | PartC | Table : instantiated



- To apply the settings you entered, click Apply.

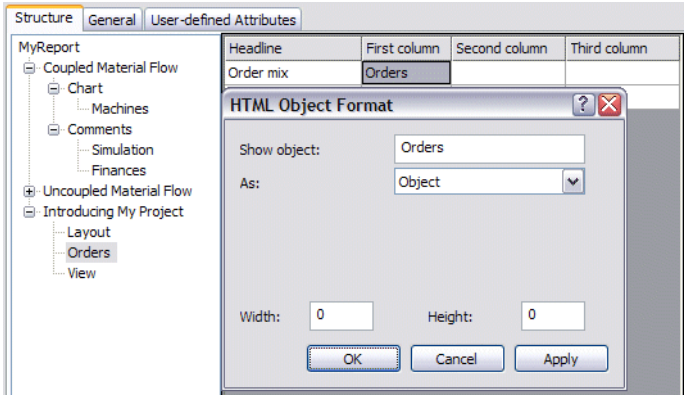
Show the Contents of a Table in the Display Pane

To show the contents of a *TableFile* in the *display* pane of the *Report*:

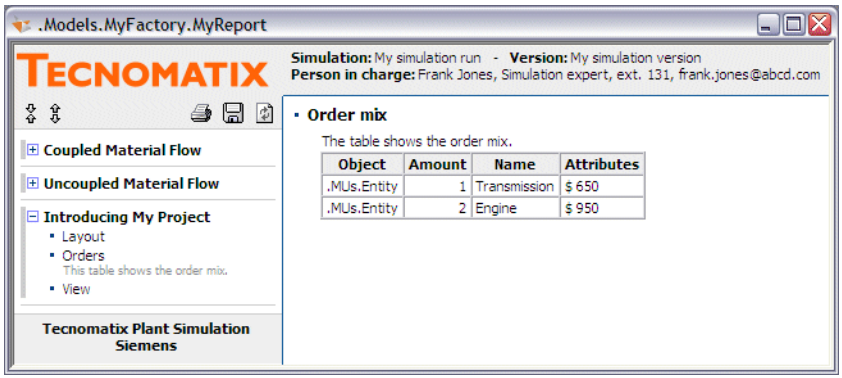
- To enter the title of the page that the *display* pane shows, select the page, click into the cell below Headline and enter the text. In our example we entered `Table of Orders`.
- Click the page in the structure and double-click the cell below First column to show the data in column one of the *display* pane of the *display* window.

  Enter the name of the object you want to show. In our example we entered the name of the *TableFile* object `DeliveryList` that we inserted into our simulation model. You can also **drag** the object from the *Frame* or the *Class Library* to the cell **and drop** it there.

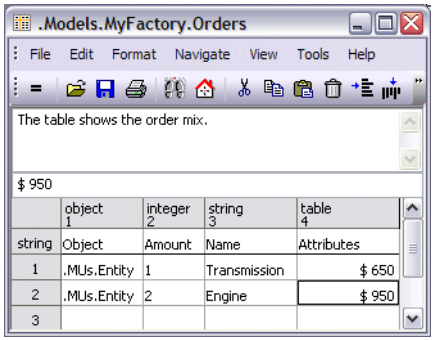
- Select to show the data as **Object**.



- To apply the settings you entered, click **Apply**.

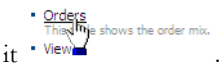


Looking at the screen shot above, you are probably wondering where the sentence `The table shows the order mix.` above the table comes from. For this we opened the **Orders** table, selected **View** > **Comment** and entered `The table shows the order mix` into the comment field.



Work with the Display Window

Once you have entered data about the simulation run and defined what you want to show, you can view that data in the *display* window. To do this, click Show Report.

- To display the contents of a single branch in the *display* pane of the *display* window, click it 

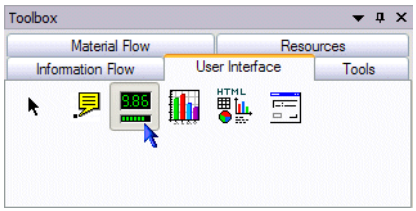
.
- To show the next level of a branch in the structure pane, click the ⊞ sign in front of it.
- To open all branches of the tree, click Expand All.
- To hide the next level of a branch, click the ⊟ sign in front of it.
- To close all branches of the tree, click Collapse All.
- To print the currently displayed page to your default printer, click Print.
- To save the report as a web page, click Save. Select a folder, a file name and the format of the file in the dialog Save As. This creates a folder with the name you enter and places the html files and the graphics that the HTML files show into it.

  Note: At present you can only select Web Page, complete. This saves all of the files needed to display this page, including graphics, frames, and style sheets. Web Page, complete saves each file in its original format.
- To manually update the *display* pane, click Refresh.
- To replace the icon SIEMENS, which the HTML page displays in the upper right corner of the tree window with the logo of your company, right-click the icon of the object *Report* and modify the icon called Logo in the *Icon Editor*.
- To replace the icon TECNOMATIX, which the HTML page displays in the upper left corner of the display window with the logo of your company, right-click the icon of the object *Report* and modify the icon called Header in the *Icon Editor*.

Showing Values During the Simulation Run with the Display

When you want to show a value of an attribute, of a method, or of a *Variable* at all times throughout the entire simulation run, we will use the *Display* . The *Display* is, for example, ideally suited to dynamically show the fill level of a *Buffer*.

You can insert it into your simulation model from the folder UserInterface in the *Class Library* or from the tab User Interface in the *Toolbox*.



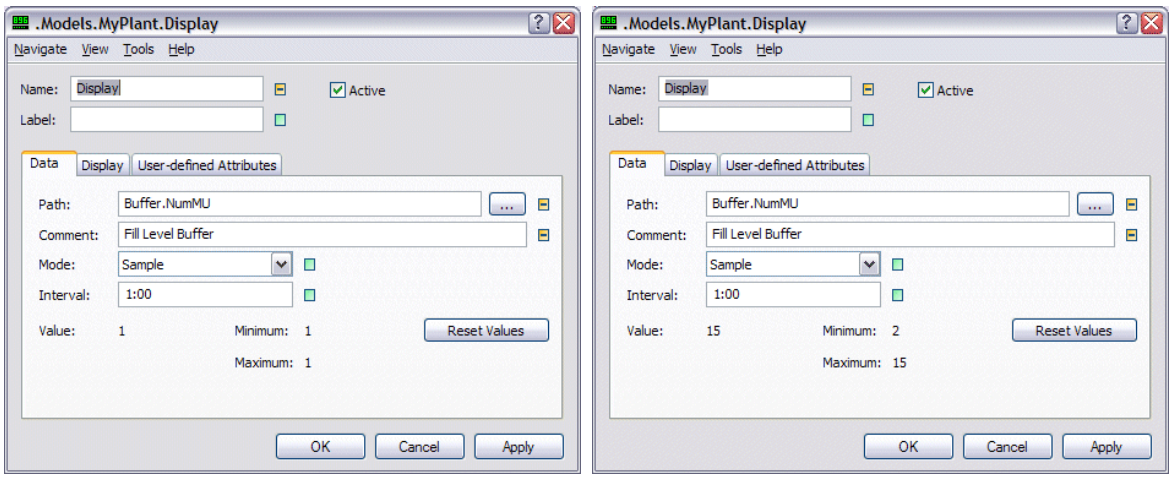
- When you deactivate the *Display*, it shows its icon in the *Frame*, into which you inserted it.
- When you activate it by selecting Active , the *Display* shows a value in the *Frame* window, such as Fill level Buffer 3 .

You can:

- *Select which Data the Display Shows*
- *Select How the Display Shows the Data*

Select which Data the Display Shows

Before you start your simulation run, you have to tell the *Display* which value it displays and in which mode it collects the data.



- Click ... to enter the path to and the name of the object whose data you want to view. Then, enter the value of a global variable (*Variable*), of an attribute or of a method of an object into the text box after the path. You might, for example, enter `buffer.numMU`, `.Models.Frame.parallelProc.statNumOut`, `store.XDim`, etc.

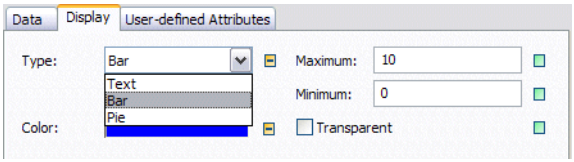
  The *Display* supports the data types *boolean, integer, real, string, object, time, money, length, weight, speed, date* and *datetime*. When the path you enter is invalid, the background of the text box changes to red.
- If you want to, you can also enter a brief description (Comment) of the displayed value. You might, for example enter a description of the attribute that the *Display* displays, such as `Fill level Buffer`. The *Display* shows this text below the value in the *Frame* window.

  Note: When you select to display the value as Text, we recommend to enter one or two spaces after the last word, so that the value does not appear too close to the comment.
- Select which mode the *Display* uses to update the displayed data.
  - Sample mode updates the *Display* periodically and takes the next sample after the time span you enter into the text box Interval.
  - Watch mode updates the *Display*, whenever the value changes of an observable method, for example *numMU*, *numMUParts*, *statMaxNumMU*, *statNumIn*, *statNumOut*, etc. or of an observable attribute, for example *Pause*, *Speed*, *Unplanned*, etc.

    The column Watchable in the dialog Show Attributes and Methods of the individual objects shows all methods and attributes *Plant Simulation* can watch.

Select How the Display Shows the Data

Before you start your simulation run, you have to tell the *Display* how to show the value it collects. In Sample mode it updates the value periodically, in Watch mode, whenever the displayed value changes.



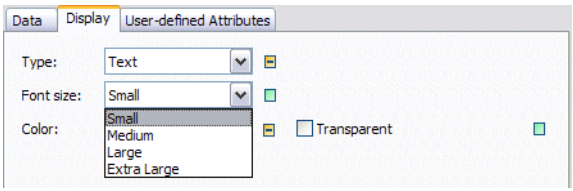
- Select how you want the *Display* to show the value: As Text, as a Bar or as a slice of a Pie. The *Display* can only show numerical values as a bar and as a slice of a pie. These are easy to comprehend, but not very well suited if accuracy is important.

Text	Bar	Pie
Fill Level Buffer 3 Display	 Fill level Buffer	 Fill level Buffer

- When you select Bar or Pie, the *Display* shows the value in relation to the Minimum and the Maximum value of the range you enter. An empty bar/pie indicates values smaller than or equal to the lower bound of the range. A full bar/pie represents values greater than or equal to the upper bound of the range. You can also change the height and the width of the bar/pie graphic by dragging its outline with the left mouse button while holding both the Shift and the Ctrl keys down.

  The *Display* shows the actual minimal and maximal values as dashed lines in the *Frame* window, which is not as accurate as you might need it to be. To view the current values, click the tab Data and look at the boxes Minimum and Maximum.

  To reset the values on the tab to 0, click Reset Values.
- When you select Text, the *Display* shows the value as a number or as text in the *Frame* window. Then, you can select a Font size for displaying the value itself and for displaying the Comment you entered. Enter a blank after the text you enter as so that the Comment value is not shown attached to the text.



- To make the background of the *Display* you inserted into a *Frame* transparent, select Transparent.

  Then, the *Display* shows the space around the text in the color you selected as the Color for the background of the *Frame*, i.e., the background color of the *Frame* shines through the hollow parts of the text.

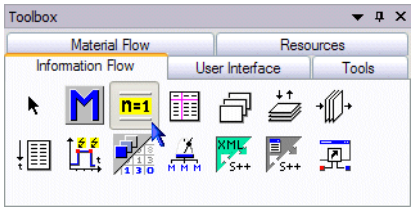
Not transparent	Transparent
Fill Level Buffer 3 Display	Fill Level Buffer 3 Display

- To select a color for the text the *Display* displays and for the outline of its display graphic, click in the field next to Color and select a color in the dialog Color.

Showing Statistics During the Simulation Run in Excel

You can dynamically show statistics values, which *Plant Simulation* records in a global variable, at all times throughout the entire simulation run on an Microsoft Excel data sheet. You can thus use the spreadsheet functions and the graphic display options that Excel provides to visualize values. *Plant Simulation* and Excel exchange data via DDE.

You can insert the *Variable* into your simulation model from the folder InformationFlow in the *Class Library* or from the tab Information Flow in the *Toolbox*.



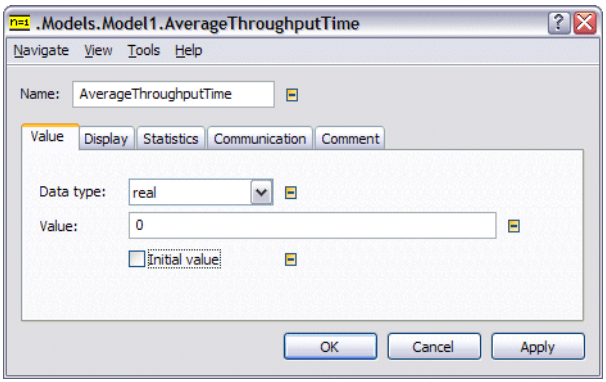
You will:

- *Set the Variable Up*
- *Set Excel Up*
- *Embed the Excel File into the Model with the FileLink*

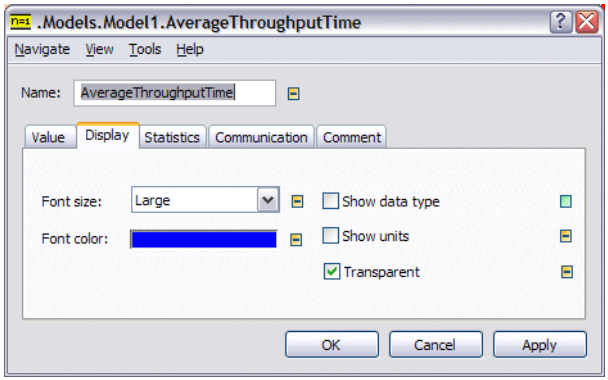
Set the Variable Up

For visualizing the value, which the global variable records, you will first insert an object of type *Variable* into the simulation model. Then, select settings for displaying the value in the *Frame* and for sending it to Excel:

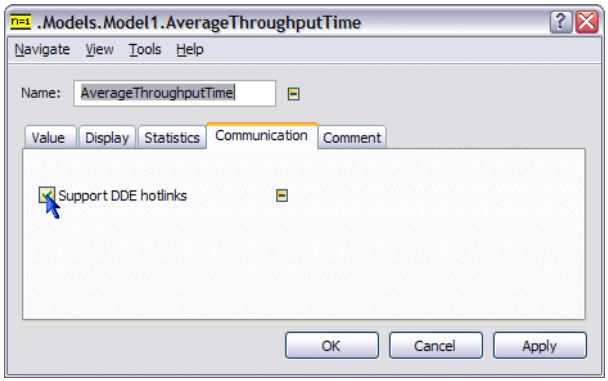
- Enter a meaningful **Name**. In our example we entered `AverageThroughputTime` as we want to record the average throughput time.
- Select the **Data type** of the value to be recorded. As we want to measure the throughput, we use the default setting *integer*.



- Select how to display the value, which the *Variable* records, in the *Frame*. We selected to show the *Variable* transparent, in blue with a large font size on the background of the *Frame* AverageThroughputTime=62.56 .



- As we want to send the value of the *Plant Simulation Variable* to Excel, we select Support DDE hotlinks.

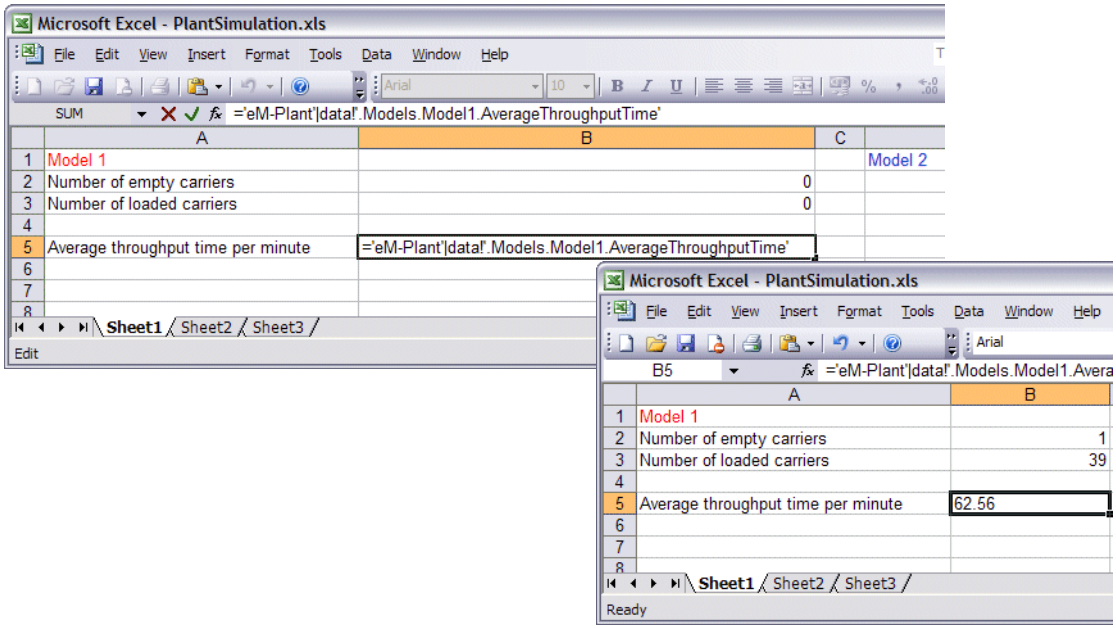


Set Excel Up

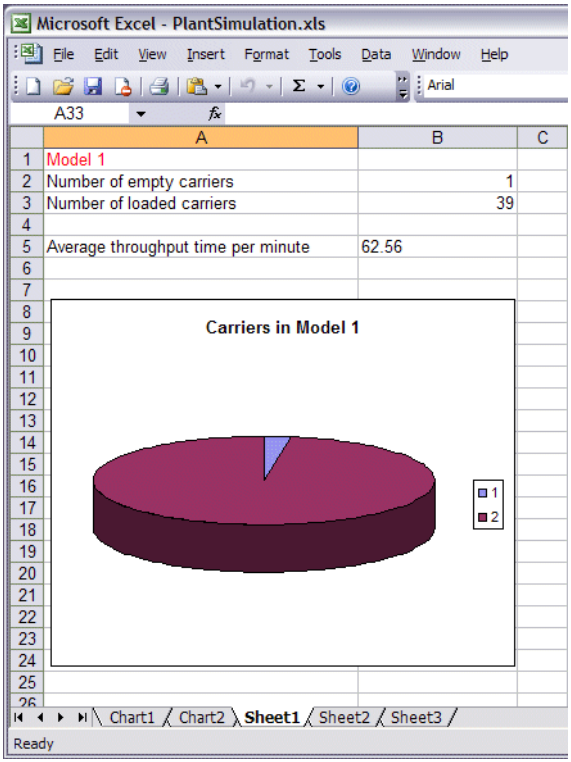
After you have inserted and set up the *Variable* whose value you want to show in Excel in *Plant Simulation*, you have to set up Excel.

- Start Excel.
- Enter explanatory text into the cells of the first column.
- Enter `='eM-Plant'|data!'.<absoute path to the Variable>'` into the cell that is to show the value of the *Variable*.

  To show the Average throughput time for model 1 (cell A5) per minute, we entered `='eM-Plant'|data!'.Models.Model1.AverageThroughputTime'/60` into the cell B5.

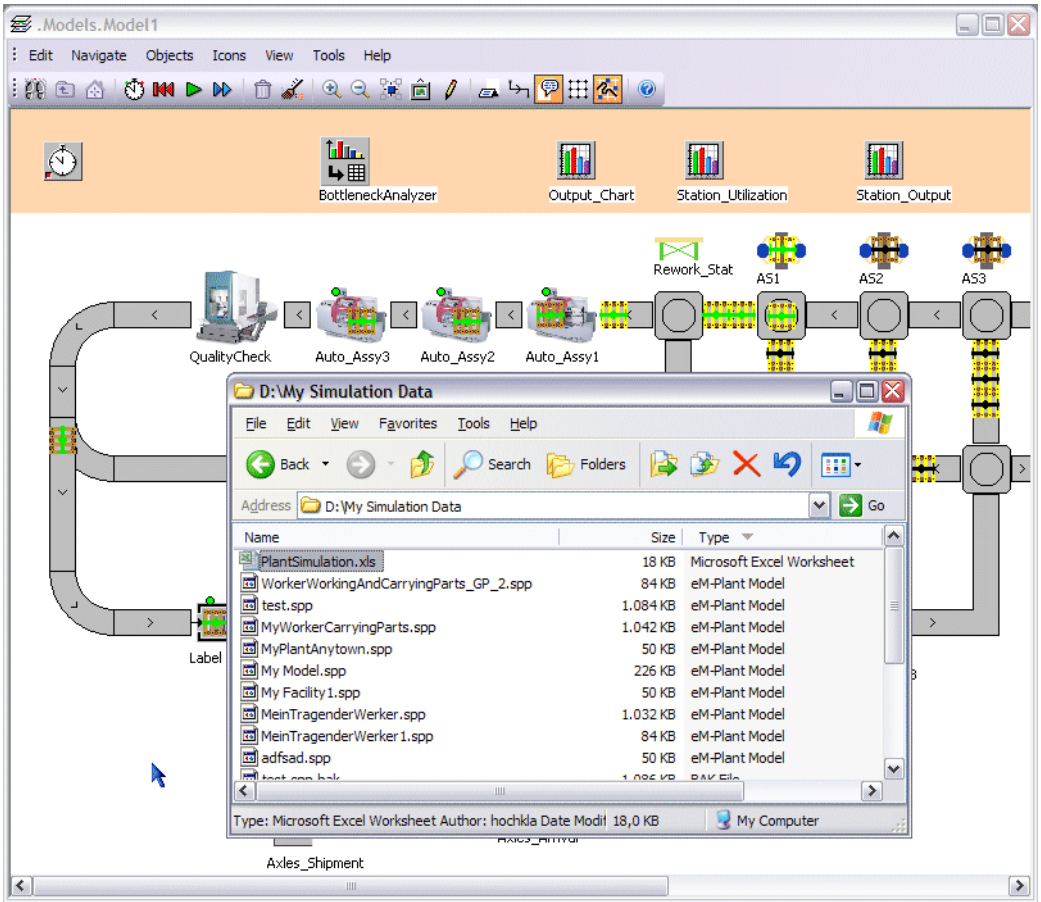


- Then, add additional display options of the values, such as charts, etc. to the cells below. Consult the *Microsoft Excel Help* for details of how to accomplish this. Save the file.



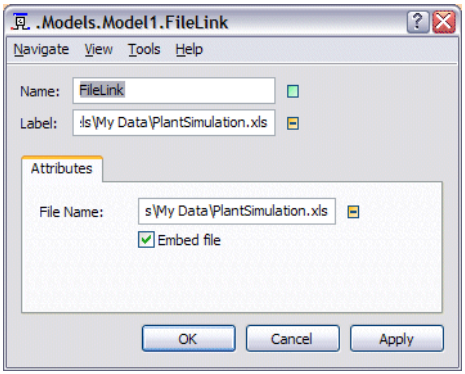
Embed the Excel File into the Model with the FileLink

To be able to open the Excel file from within your *Plant Simulation* model, drag it from the Windows Explorer to the *Frame* and drop it there.



To embed the Excel file into the simulation model, click **Yes**. Then, you can double-click the icon of the Excel file to open it.

This connection between the Excel and the *Plant Simulation Frame* is established with a *FileLink* object. To open it, click with the right mouse button and select **Open**.



Accessing Statistics with Methods and Attributes

Naturally you can access most of the statistics values with methods and attributes:

- For the *material flow objects* the names of the methods are listed next to the name of the value in the description of the *Statistics Report*.
- For the *Drain* the names of the methods are listed next to the name of the value in the description of the *Statistics Report*.
- For the *Exporter* and the *Worker* the names of the methods are listed next to the name of the value in the description of the *Statistics Report*.
- In addition, you might want to check the topics *Methods for Accessing Statistics of the Material Flow Objects* and *Attributes for the Statistics of the Material Flow Objects*.
- For the *MUs* the names of the methods are listed next to the name of the value in the description of the Product Statistics of the MUs and of the Resource Statistics of the MUs.
- For the object *Transporter* the names of the methods are listed next to the name of the value in the description of the Driving Statistics of the Transporter.
- In addition, you might want to check the topics *Methods for Accessing the Statistics of Mobile Objects* and *Attributes of All Mobile Objects*.

Working with Evaluation Tools

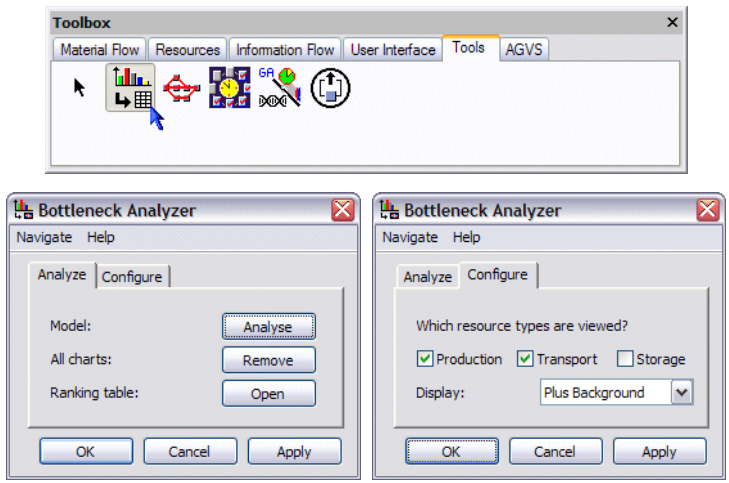
Plant Simulation provides the objects *BottleneckAnalyzer* and *SankeyDiagram* for analyzing and displaying the flow of materials through a plant.

BottleneckAnalyzer

The *BottleneckAnalyzer* visualizes the standard statistics of the material flow objects and sorts the data into a table. It displays the statistics of the material flow objects that are located in the same *Frame* as the *BottleneckAnalyzer* or in sub-frames. The bottleneck analyzer works statically, i.e., it does not collect data during the simulation run. For this reason that you can insert it even after the simulation run is finished.

You can Analyze the model, Remove the statistics charts, and Open the ranking table. You can also configure the *BottleneckAnalyzer*: you can select the type of Resources and select Display options.

You can insert the *BottleneckAnalyzer* into your simulation model from the folder Tools in the *Class Library* or from the tab Tools in the *Toolbox*.



Configuring the BottleneckAnalyzer Through Other Objects

When an object has the user-defined attribute *_BNanalysed*, of data type *boolean*, and when you set this attribute to `false`, this object will not be part of the *BottleneckAnalyzer's* analysis. You can create this attribute for an object by dragging the object over the *BottleneckAnalyzer* and by dropping it there.

Analyze

To visualize the statistics, click the Analyze button. For a *Frame*, the *BottleneckAnalyzer* shows the statistics of the *critical* resource, which is the material flow object processing the highest number of parts.

Note: The *BottleneckAnalyzer* only shows the statistics of a material flow object when the statistics is activated and for the type of resource you selected in the dialog Configure.

This color	designates this state
green	working
brown	setting-up
gray	waiting
yellow	blocked
red	failed
blue	paused or unplanned

Remove

To delete the displayed values, click the Remove button.

Open

To select the sorting criteria of the statistical values, which the *BottleneckAnalyzer* shows and which it then writes to a table file, click the Open button.

When you click OK, the *BottleneckAnalyzer* opens a table file that lists all material flow objects, showing the statistical values for the states you selected.

Resources

Select if the *BottleneckAnalyzer* displays statistical data for a resource of type Production, Transport and Storage on the tab Configure.

Display

Select how the *BottleneckAnalyzer* displays the statistics values from the drop-down list:

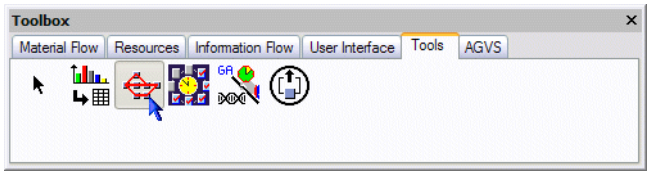
As Only Bars, as Plus Scale, or Plus Background.

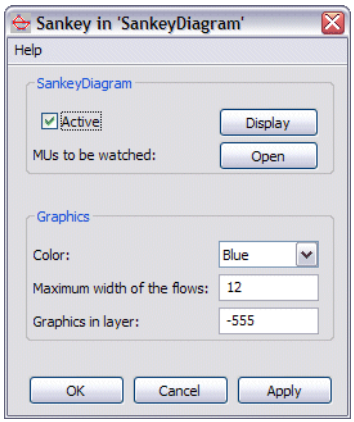
SankeyDiagram

The *SankeyDiagram* watches instantiated MUs of MU classes. You can select the MUs to be watched, the Resources to be watched, enter the Maximum width of the flows, enter then number with which to Display the flows on layer, select a Color and Display Sankey flows.

The context menu of the *SankeyDiagram* also provides commands for some of the above actions. In addition, you can open the *Frame* with the objects we used for creating the *SankeyDiagram* object (Open Object).

You can insert the *SankeyDiagram* into your simulation model from the folder Tools in the *Class Library* or from the tab Tools in the *Toolbox*.





MUs to be watched

To designate the classes of MUs, which the *SankeyDiagram* watches, click the Open button and enter the MU classes whose instances *Plant Simulation* watches into the table that opens.

You might, for example, enter `.MUs.part`, `.MUs.entity`, `.MUs.transporter`, etc.

Resources to be watched

Select if the *SankeyDiagram* displays statistical data for a resource of type Production, Transport and Storage, when MUs move through your model.

Note: Select the resource type of a static material flow object on the tab Statistics > Resource type.

Color

Select a color for the *Connectors* in the diagram:

Red, Cyan, Blue, Magenta, Green, Yellow, Black or White.

Maximum width of the flows

Enter the maximum width of an element for displaying the flows.

Display the flows on layer

Enter a sufficiently great negative number to ensure that the Sankey flows are always displayed in front of all objects and vector graphics.

Display

To display the Sankey flows, click the Display button.

Note: *Plant Simulation* only displays Sankey flows, when you activate the menu command View > Options > Show Connections in the *Frames*.

The *SankeyDiagram* uses the Constructor and the Destructor interaction controls of the movable objects. You cannot use it in models in which you programmed your own Constructor and the Destructor controls for movable objects.

Importing Data for the Simulation

When you create your simulation model, you will work with data provided by the departments of the installation you are modeling, such as production lists, data, which machines output, etc. As a rule you will import this data from a spreadsheet program, such as Microsoft Excel, or from a database, into an *Tecnomatix Plant Simulation* list or table. From the data bulk you will have to filter out the data you actually do need to use for your simulation project. The material flow objects can then access these lists and use the data for the simulation.

Naturally you may also want to export some or all of the data, which the simulation runs created, so that you can use and manipulate it in other programs.

Importing and Exporting Data

Plant Simulation provides a number of ways to import data from other applications into *Plant Simulation*. In some cases you will import data into an *Plant Simulation* list or a table, process it there and then pass it on to the material flow objects. In other cases you will directly provide imported data to the material flow objects, for example by employing the *FileInterface*.

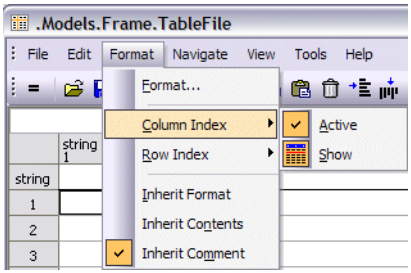
You can:

- *Import a Text File or an Object File into a List*
- *Import Data from a Microsoft Excel Worksheet*
- *Import a Services List, a List of Shifts, etc. into an Object*
- *Import Data in XML Format*
- *Import Data from a Database*
- *Import or Export Data in ASCII Format*
- *Import or Export the Contents of a List*

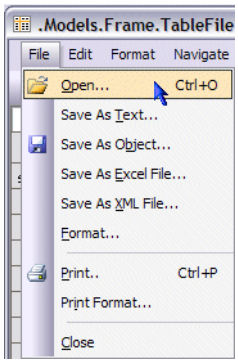
Import a Text File or an Object File into a List

The *Plant Simulation* lists *TableFile*, *CardFile*, *QueueFile and StackFile* (and) and *TimeSequence* can open text files, *Plant Simulation* object files and Microsoft Excel files, which contain the data you want to use in your simulation project.

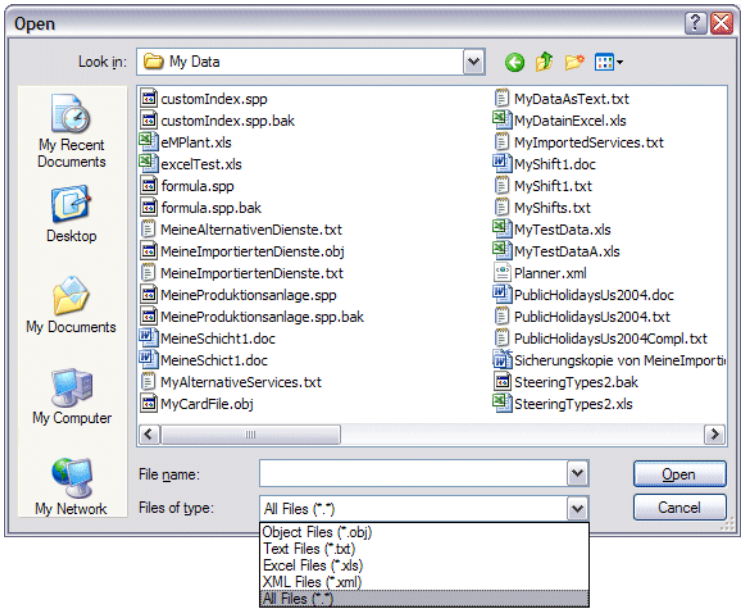
- Before you open a text file, we advise to select the correct data type that fits the data you are going to import into the individual columns of the *TableFile*. If the text file has a column header, which you want to also use in your *Plant Simulation* list, activate and show the column index in the *Plant Simulation* list.



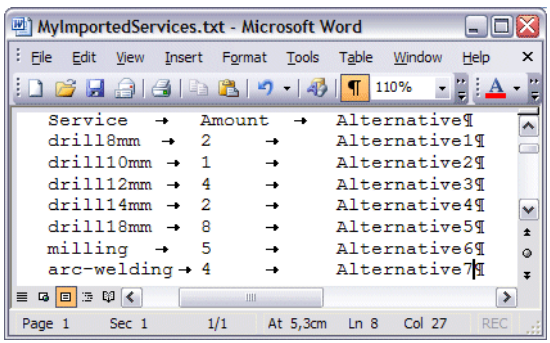
- To open a text file or an *Plant Simulation* object file in a list, select File > .



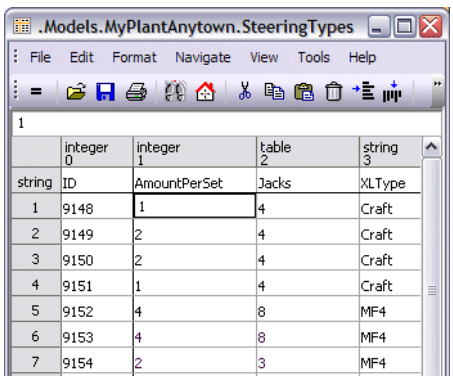
- Navigate to the folder where you stored the file. Select the type of file you would like to open and click Open.



Text file opened in Word, sample



Opened Plant Simulation object file, sample



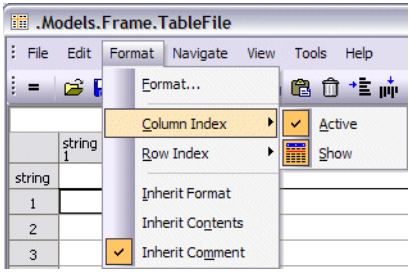
Note that *Plant Simulation* opened the object file with the formatting, which the original file had. For the text file we had to manually select the correct data types.

- To export the contents of an *Plant Simulation* list or table, select File > Save As Text or File > Save As Object.

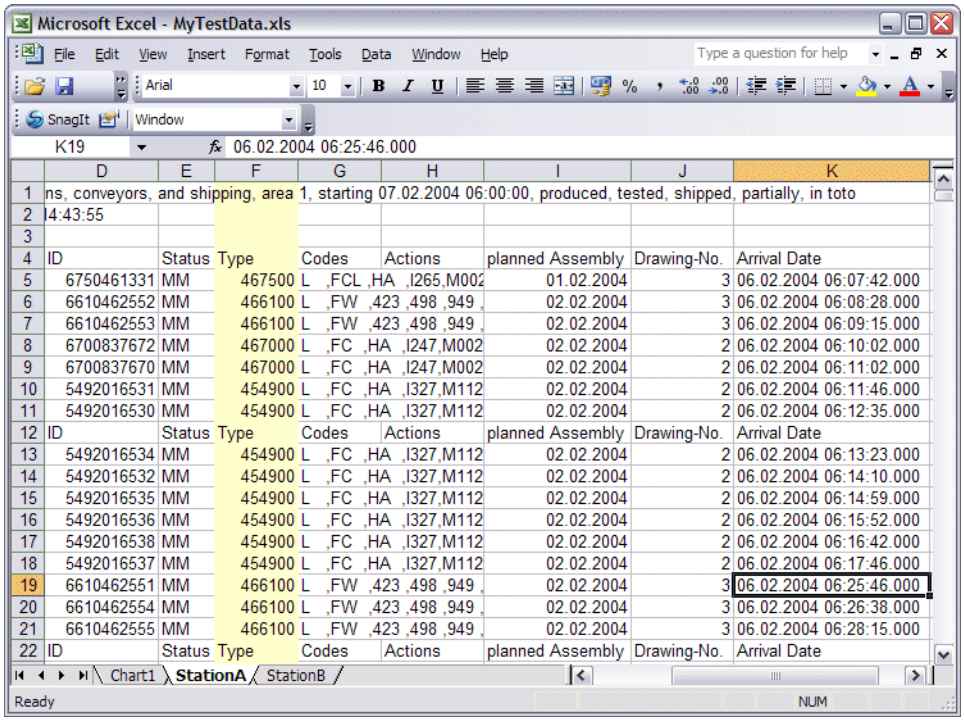
Import Data from a Microsoft Excel Worksheet

When *Plant Simulation* reads an MS Excel table, it attempts to convert the values in the individual column to the data types of the columns in your *Plant Simulation* table. This only works, when you created the columns on the Excel worksheets so that they only contain a single data type, meaning that, when you, for example, assign the data type *String* to a cell of a column, the entire column may only be of data type *String*. After importing the data into *Plant Simulation*, you have to check the data types of the individual columns, you might have to correct the type of some, and you will have to filter out data you do not need. You can either do this manually in the open *Plant Simulation* table, or you can program a *Method* to manipulate the data while importing it.

If the Excel file has a column label, which you want to also use in your *Plant Simulation* list, activate and show the column index in the *Plant Simulation* list.

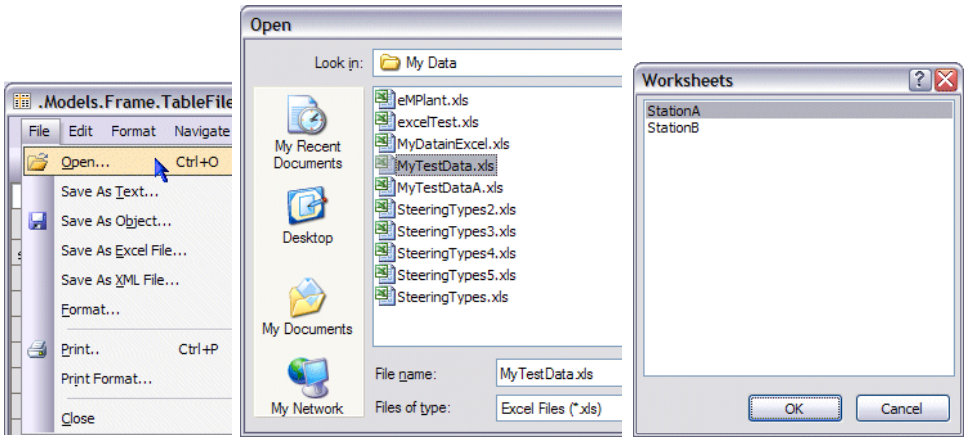


- For our example we used the file *MyTestData.xls*, which looks like this in Excel.

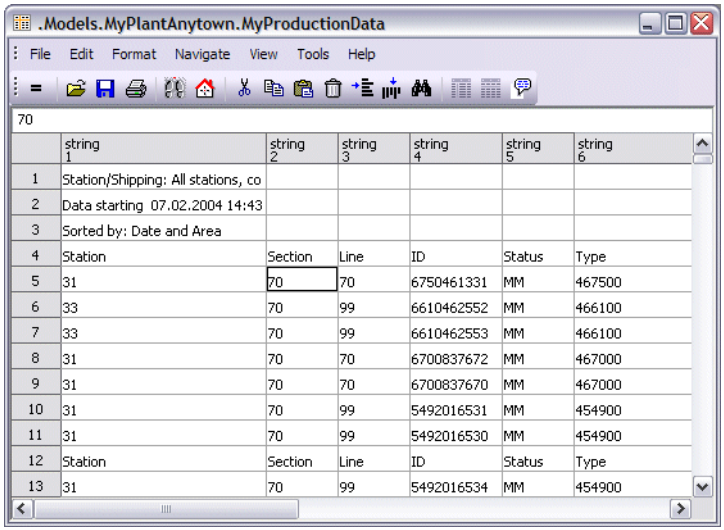


- To open the Excel file in an *Plant Simulation* table, select File > Open.

  Navigate to the folder where you stored the file. Select the file you would like to open and click Open. Select the Excel worksheet you want to import and click OK.



- The imported Excel worksheet looks like this in our *Plant Simulation* table.



	string 1	string 2	string 3	string 4	string 5	string 6
1	Station/Shipping: All stations, co					
2	Data starting 07.02.2004 14:43					
3	Sorted by: Date and Area					
4	Station	Section	Line	ID	Status	Type
5	31	70	70	6750461331	MM	467500
6	33	70	99	6610462552	MM	466100
7	33	70	99	6610462553	MM	466100
8	31	70	70	6700837672	MM	467000
9	31	70	70	6700837670	MM	467000
10	31	70	99	5492016531	MM	454900
11	31	70	99	5492016530	MM	454900
12	Station	Section	Line	ID	Status	Type
13	31	70	99	5492016534	MM	454900

  Check the file for correct data types, data you do not need, etc. You can also pre-process or post-process the data by programming a *Method*.
- To export the contents of an *Plant Simulation* list or table as an Excel file, select File > Save as Excel File.

Import a Services List, a List of Shifts, etc. into an Object

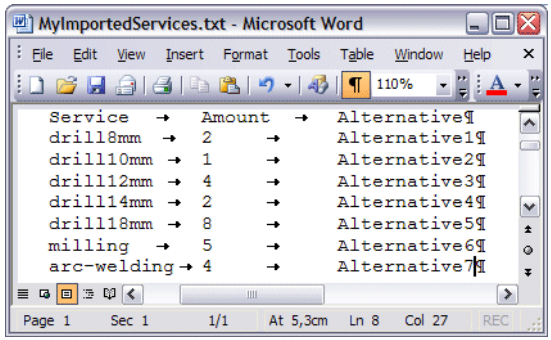
To import a services list, a list of shifts or a worker creation table into one of the lists, which are embedded in an object:

Note: In most cases importing one of the above lists involves two lists.

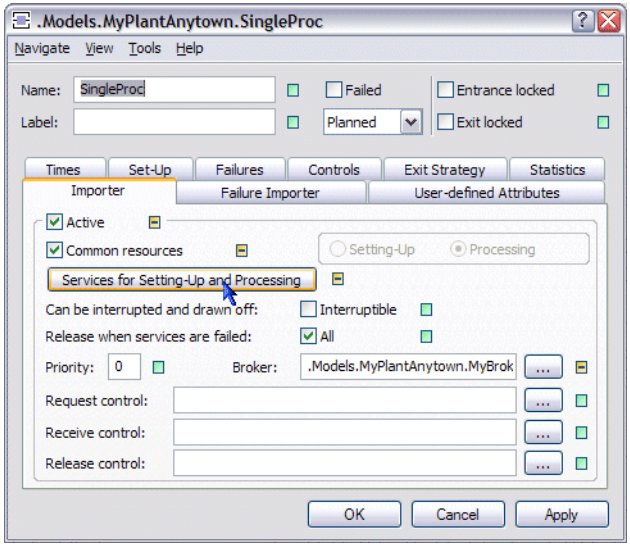
The first list contains any expression of your choice, which serves as a placeholder for the subtables. You might, for example, enter different names for the different services to group them by name.

The second list, i.e., the sublist, contains the names of the actual services and the number to be provided.

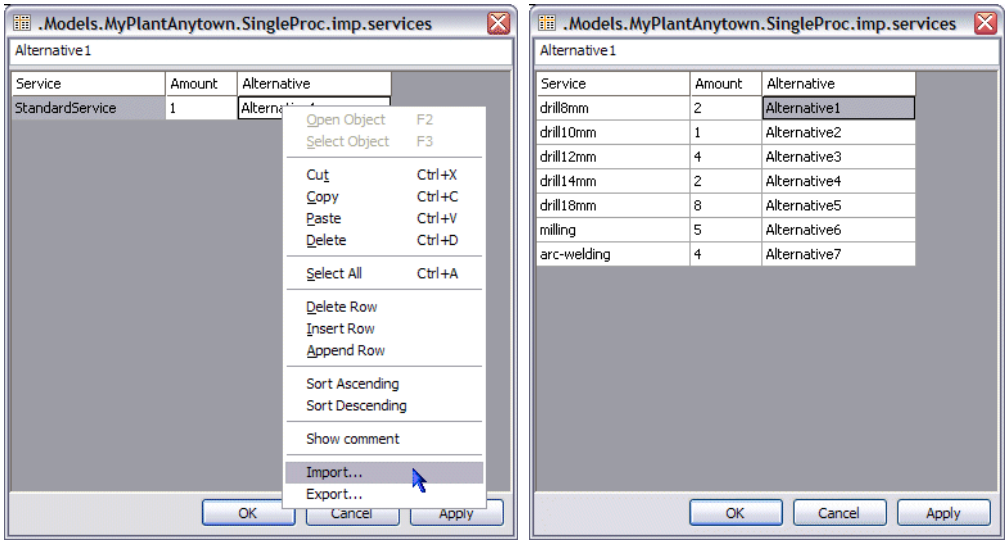
- Open the files, which you received in a text editor. Make sure that the text, which appears in the column header, is the first line in the file. Separate the columns with tabs. Save the files as text files (.txt).



- Click the inheritance button to the right of Services for Setting-up and Processing so that it looks like this ▣. Click Services for Setting-up and Processing.



- Right-click in the list and click Import. Navigate to the folder where you saved the text file and click OK.



If need be, you can then manipulate the contents of the list with the commands on the Context Menu of Embedded Lists. You might, for example, add rows or sort the list in ascending or descending order.

- To export the contents of an embedded list as a tab-delimited text file, right-click in the list and select Export.

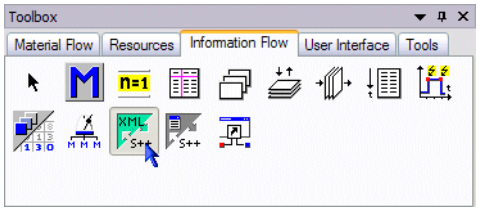
Import Data in XML Format

You can import data stored in XML format into *Plant Simulation* and extract data from the XML file. You may, for example, use the *XMLInterface* to read data, which you exported from Process Designer, the Siemens program for planning, analyzing and managing manufacturing processes, or from an XML database.

You can then use the data, which the *XMLInterface* imported, and which you manipulated with a *Method*, to run a simulation in *Plant Simulation*. You might afterwards use the methods *write* and *writeElement* to write the simulation results back to an XML file and continue working with these simulation results in Process Designer or another program.

To get the most out of the *XMLInterface*, you have to be familiar with *XPath* (*XML Path Language*) instructions. You might, for example, check the web site http://www.w3.org/TR/xpath for more information. In addition, you have to be familiar with programming in SimTalk.

You can insert the *XMLInterface* into your simulation model from the folder InformationFlow in the *Class Library* or from the tab Information Flow in the *Toolbox*.



You can:

- *Select the File Name, the Context and the Import Method*
- *Read and Write Data Sequentially*
- *Read and Access Data Randomly*
- *Access and Traverse Data Randomly*

Select the File Name, the Context and the Import Method

When you work with the *XMLInterface*, you will make extensive use of *XPath* (XML Path Language) instructions and of the *Plant Simulation* methods and attributes of the *XMLInterface* itself.

Into the dialog of the *XMLInterface* you:

- Enter the File Name of the XML file, which the *XMLInterface* opens, when you want to import data. When you export data, it specifies the name of the file, which it saves.
- Enter the context of the data you want to import. The context designates the node of the structure of the XML document at which the *XMLInterface* starts reading data. You might, for example, enter the names of certain data, or of certain objects that you are interested in, for example `Data/Objects`. This way you can restrict the data to be read, i.e., if you do not need to work with all of the data contained in the XML file, you will enter a context.

  If you do not enter a context, the *XMLInterface* imports the entire file, which may contain a large amount of data, some of which you do not need. This might take some time to import and use up a large amount of your computer's RAM.
- Click ... to enter the path to and the name of the *Method* into the text box in which you programmed how to extract and to sequentially process the imported data.

Read and Write Data Sequentially

You can **sequentially read the data line-by-line**, write it to an Import Method, and then immediately process that data line-by-line. To restrict the amount of data to be imported, enter a Context.

This method demonstrates how to sequentially write an XML file.

```
is
do
    XMLInterface.filename := "D:\MSXML 4.0\writeSequentially.xml";
```

```
    -- opens the XML document for sequential writing
    XMLInterface.openWrite;
    XMLInterface.startElement("catalog");
         XMLInterface.startElement("book");
         -- adds attributes to the element 'book'
         XMLInterface.addAttribute("id", "bk01");
         XMLInterface.addAttribute("xmlns","myBooks");
         XMLInterface.addAttribute("xmlns:aa","specAth");
         -- these are the children of the element 'book'
         XMLInterface.writeElement("aa:author","Gambardella, Matthew");
               -- adds an attribute to the element 'author'
               XMLInterface.addAttribute("age","16");
               XMLInterface.writeElement("title","XML Developer's Guide");
               XMLInterface.writeElement("genre","Computer");
               XMLInterface.writeElement("price","44.95");
               XMLInterface.writeElement("publish_date","2000-10-01");
               XMLInterface.writeElement("description","An in-depth ...");
          -- terminates the element 'book'
          XMLInterface.endElement;
    -- terminates the element 'catalog'
    XMLInterface.endElement;
    XMLInterface.close;
end;
```

Read and Access Data Randomly

You can **read the data** in its entirety, and then **randomly** process it as a whole. Here *Plant Simulation* imports the entire document first and then processes and analyzes all data in the method, which you program. Randomly accessing data requires that all data you want to use is in RAM. The larger the amount of data, the more RAM the *XMLInterface* uses!

You might, for example:

- Select data from the XML document.

```
-- randomly accesses data via XPath instructions
is
   tbl:table;
do
   XMLInterface.filename := "D:\MSXML 4.0\books.xml";
   -- load the XML document for random access into RAM
   XMLInterface.openDocument;
   -- select nodes via XPath instruction
   -- selection starts at the Context node which you entered in the XMLInterface
   -- the second argument is the selection depth for each node
   -- 0 means that no children will be selected
   -- the result is passed to a table
   tbl := XMLInterface.getNodes("book[title='Midnight Rain']", 1);
```

```
   XMLInterface.close;
end;
```

- Delete existing data from the XML document.

```
-- deletes all nodes specified by XPath instructions
is
do
   XMLInterface.filename := "D:\MSXML 4.0\books.xml";
   -- load the XML document for random access into the RAM
   XMLInterface.openDocument;
   -- delete all book nodes of genre 'Fantasy'
   XMLInterface.deleteNodes("book[genre = 'Fantasy']");
   XMLInterface.filename := "D:\MSXML 4.0\tmp.xml";
   -- write the document to a file
   XMLInterface.write;
   -- remove the document from RAM
   XMLInterface.close;
end;
```

- Insert new data into the XML document.

```
-- inserts new data into the XML document
is
   tbl:table;
do
   XMLInterface.filename := "D:\MSXML 4.0\books.xml";
   -- load the XML document
   XMLInterface.openDocument;
   -- get an empty table for writing the data to
   -- depth=1 means that we want to write nodes with children
   tbl := XMLInterface.getContainer(1);
   -- set the parent node for the new data
   XMLInterface.setContext("/catalog");
-- designate the node to append to the 'catalog' nodes
   tbl[1,1] := "book";
   -- are the attributes of the 'book' node
   tbl.createNestedList(4,1);
   -- explicit namespace
   tbl[4,1][1,1] := "xmlns:aa";
   tbl[4,1][2,1] := "specAth";
   -- additional attributes
   tbl[4,1][1,2] := "id";
   tbl[4,1][2,2] := "bk113";
   -- child nodes
   tbl.createNestedList(5,1);
   tbl[5,1][1,1] := "aa:author";
   tbl[5,1][2,1] := "specAth";
   tbl[5,1][3,1] := "XYZ";
```

```
    tbl[5,1][1,2] := "title";
    tbl[5,1][3,2] := "UNKNOWN";
    tbl[5,1][1,3] := "genre";
    tbl[5,1][3,3] := "also";
    tbl[5,1][1,4] := "price";
    tbl[5,1][3,4] := "12,45";
    tbl[5,1][1,5] := "publish_date";
    tbl[5,1][3,5] := "12.1.02";
    tbl[5,1][1,6] := "description";
    tbl[5,1][3,6] := "xx0011";
    XMLInterface.insertNodes(tbl);
    -- save the changed document
    XMLInterface.filename := "D:\MSXML 4.0\tmp.xml";
    XMLInterface.write;
    -- close the document
    XMLInterface.close;
end;
```

- Update the XML document.

```
-- updates the selected nodes of the document
is
    tbl:table;
do
    XMLInterface.filename := "D:\MSXML 4.0\books.xml";
    XMLInterface.openDocument;
    -- select the nodes to be changed
    tbl := XMLInterface.getNodes("/catalog/book[title='Midnight Rain']", 1);
    -- update the values
    tbl[5,1][3,3] := "TEST";
    -- write the changed values
    XMLInterface.updateNodes(tbl);
    XMLInterface.filename := "D:\MSXML 4.0\tmp.xml";
    XMLInterface.write;
    XMLInterface.close;
end;
```

- Create a new XML document.

```
-- creates a new document by calling the method newDocument
is
    tbl:table;
do
    XMLInterface.newDocument("catalog");
    tbl := XMLInterface.getContainer(1);
    XMLInterface.setContext("/catalog");
    -- parent node
    tbl[1,1] := "book";
    -- default namespace
```

```
   tbl[2,1] := "MyBooks";
   -- attributes
   tbl.createNestedList(4,1);
   -- explicit namespace
   tbl[4,1][1,1] := "xmlns:aa";
   tbl[4,1][2,1] := "specAth";
   -- additional attributes
   tbl[4,1][1,2] := "id";
   tbl[4,1][2,2] := "bk113";
   -- child nodes
   tbl.createNestedList(5,1);
   tbl[5,1][1,1] := "aa:author";
   tbl[5,1][2,1] := "specAth";
   tbl[5,1][3,1] := "XYZ";
   tbl[5,1][1,2] := "title";
   tbl[5,1][3,2] := "UNKNOWN";
   tbl[5,1][1,3] := "genre";
   tbl[5,1][3,3] := "also";
   tbl[5,1][1,4] := "price";
   tbl[5,1][3,4] := "12,45";
   tbl[5,1][1,5] := "publish_date";
   tbl[5,1][3,5] := "12.1.02";
   tbl[5,1][1,6] := "description";
   tbl[5,1][3,6] := "xx0011";
   XMLInterface.insertNodes(tbl);
   XMLInterface.filename := "D:\MSXML 4.0\tmp.xml";
   XMLInterface.write;
end;
```

Access and Traverse Data Randomly

You can extract data in its entirety from an XML document and then **randomly traverse the data**. You might, for example, define the starting point for traversing the structure with the method *selectNodes*. Then, you could get the next node with the method *getNodeName*, check for attributes of this node with the method *getNumberAttributes*, output the names of the attributes and recursively check all children of the selected node, to detect those that meet the condition.

```
-- selects the starting nodes and calls the method visitChildren
-- recusively for each node
is
   numberAttributes,i:integer;
do
   XMLInterface.filename := "D:\Public\XML\books.xml";
   -- load the XML document to be randomly accessed into RAM
   XMLInterface.openDocument;
   -- select some nodes using XPath instructions
```

```
    XMLInterface.selectNodes("book[genre = 'Computer']");
    -- define the loop for the selected nodes
    while XMLInterface.getNextNode = true  loop
        print XMLInterface.getNodeName;
        -- check for attributes of the nodes
        numberAttributes := XMLInterface.getNumberAttributes;
        for i := 0 to numberAttributes-1 loop
            -- print the data of the attributes
            print XMLInterface.getAttributeName(i)+":"
+XMLInterface.getAttributeValue(i);
        next;
        -- check the children of the current node
        VisitChildren;
    end;
    -- remove the XML document from RAM
    XMLInterface.close;
end;
```

Import Data from a Database

You can import data from a database into *Plant Simulation* and run your simulation in *Plant Simulation* with this data. You can then write the data resulting from the simulation runs back into the database.

To get the most out of importing data from a database, you have to be familiar with *SQL* (*Structured Query Language*) instructions. You might, for example, check the web site http://sqlzoo.net for more information and consult the documentation that comes with the database you are using. In addition, you have to be familiar with programming in SimTalk.

You can:

- *Import Data from an ODBC Database*
- *Import Data from an Oracle Database*

Import Data from an ODBC Database

To import data from an ODBC database into your *Plant Simulation* simulation model, you will use the *Plant Simulation* object *ODBC* . To access several databases at the same time, you can insert several objects of type *ODBC* into your simulation model, each of which communicates with another database.

You can also access the same database with several *ODBC* objects. We advise against doing so, as this may result in inconsistent data caused by conflicting commands. It might, for example, happen that one *Method* deletes a data set, while another *Method* attempts to access just this data set. Using a single *ODBC* object ensures that the sequence of instructions conforms to your intentions.

This holds especially true for real databases for which you have to apply any data manipulations, such as read, write delete, etc. with the SQL instruction `commit`, before they take effect.

To import data from an ODBC database into your *Plant Simulation* simulation model you have to:

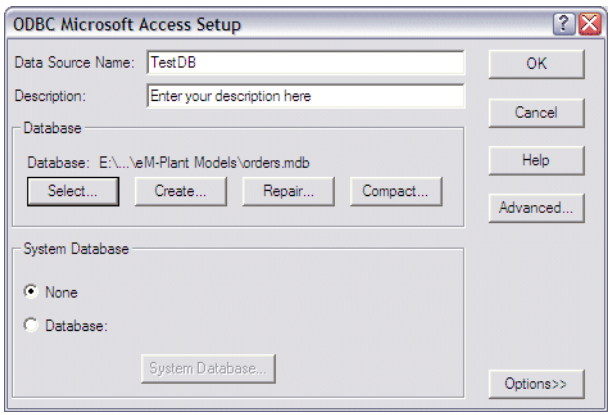
- *Set the Data Source Up*
- *Import Data into Your Simulation Model*

After the simulation runs are finished, you can also export the simulation results back into the database, compare *Export Data to the Database*.

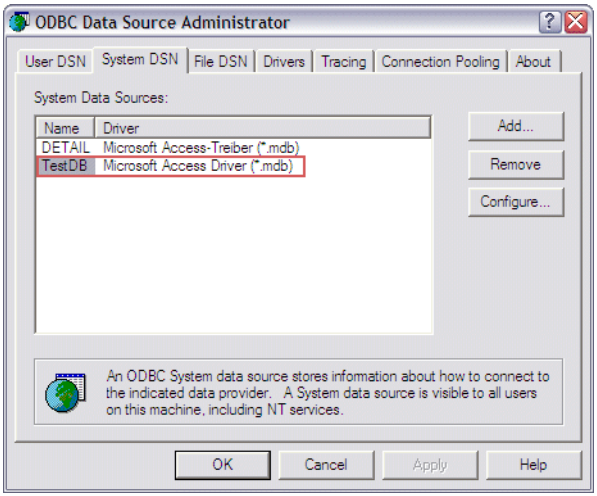
Set the Data Source Up

Before you can import data from an ODBC database into your *Plant Simulation* model, you have to set up the ODBC data source on your computer:

- Click Start > Control Panel > Administrative Tools > Data Sources (ODBC).
- Add a new data source in the dialog ODBC Data Source Administrator. Depending on who will use the database you can do this on the tab User DSN or on the tab System DSN. As a rule, you will add it on the tab System-DSN.
  - Click Add on the tab System DSN.
  - In the dialog Create New Data Source select the ODBC driver for the data source you would like to use. In our example we selected the Microsoft Access Driver. Click Finish.
  - Click Select in the dialog ODBC Microsoft Access Setup and select the database in the dialog Select Database. Type in the Data Source Name. If you want to, you can also add a Description of the database. As *Plant Simulation* addresses the database with this name, mind the *Plant Simulation* conventions for the Name!



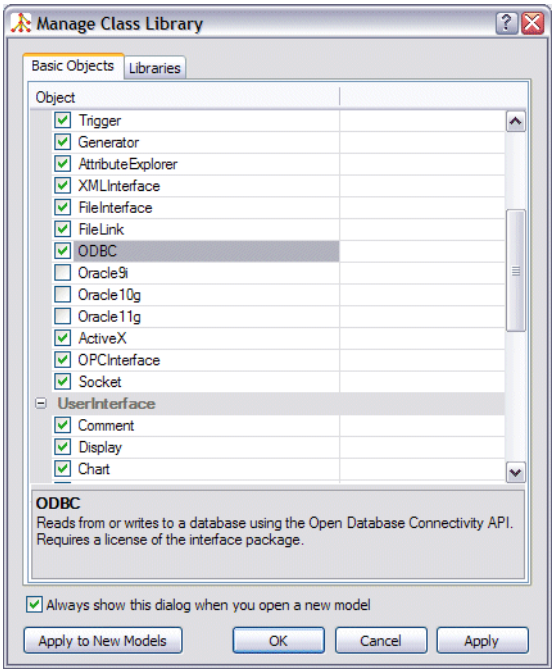
After successfully concluding this action, the dialog ODBC Data Source Administrator shows the System data source, which we added.



Import Data into Your Simulation Model

After setting-up the ODBC data source, you have to insert the object *ODBC* into your *Plant Simulation* simulation model. This object establishes the connection with the database and enables you to import data from it. You can write this data into *Plant Simulation* tables, manipulate them there and use them in your simulation runs and re-export the changed data back into the database.

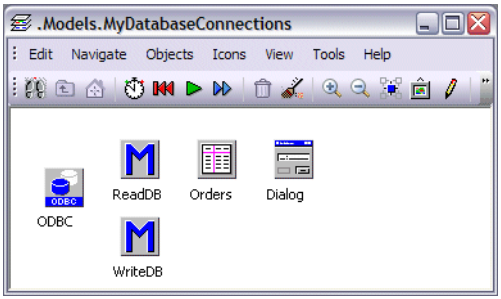
- To add the object *ODBC* to the *Toolbar Information Flow* of your simulation model, select File > Manage Class Library > Basic Objects > InformationFlow.



Click the object on the *Toolbar Information Flow* and insert it into your simulation model.

In our example we inserted into our simulation model:

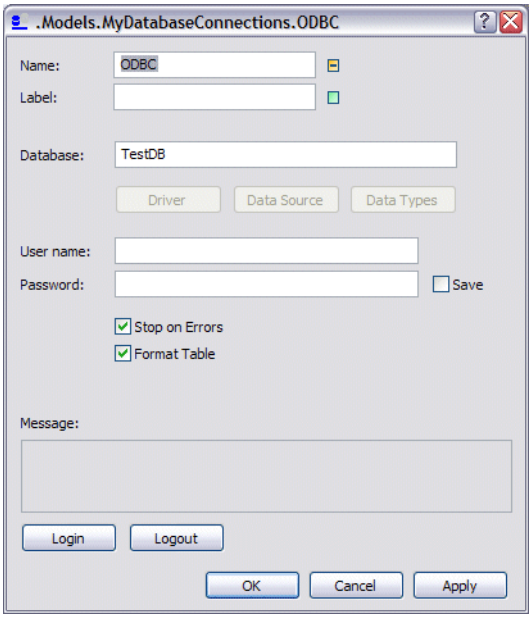
- An *ODBC* object, which controls the communication with the database.
- A *Method* for reading data from the database.
- A *Method* for writing data to the database.
- An *Plant Simulation Table* into which we import the data, and from which we export it back to the database.



- Double-click the object *ODBC* and type the name of the database into the text box Database. In our example we entered `TestDB`. Note that this is the same name that we entered into the dialog ODBC Microsoft Access Setup above.

  When you use a database with user management, such as SQL-Server, Oracle, etc., you also have to enter a User name and a Password. To apply your changes, click Apply.

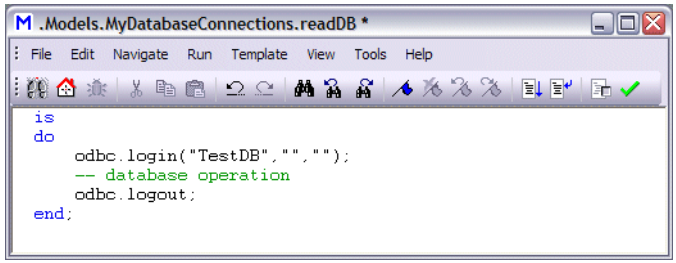
  To log on to the database, click Login.



  When all your settings worked out, *Plant Simulation* grays out the box with the name of the database and shows Ok in the box Message. When *Plant Simulation* encountered problems, it shows an error message describing the problem.

- Then, insert a *Method* into your simulation model. Within this *Method* you program, which data will be imported and what happens to this data.

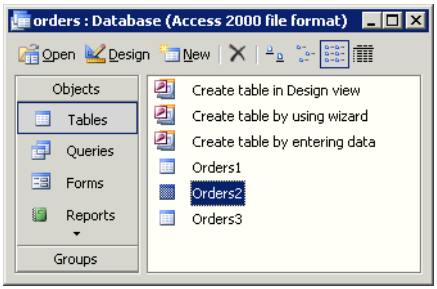
  Reading and writing data only works, when *Plant Simulation* is connected to the database. For this reason the methods *login* and *logout* frame the database operation proper.

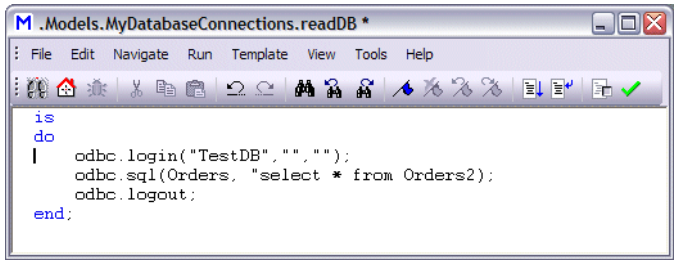


- Then you can read data from the database and write the results of the database query into an *Plant Simulation* table. Instead, you could also write the data into a local variable.

  You'll always start the query with the command *.sql*. Then, define the target, in our example this is the *Plant Simulation* table `Orders`. Next, you'll enter SQL standard queries within quotes. The syntax you have to use depends on your database system, consult the documentation that came with your database. The ODBC driver of the database determines the range of commands you can enter.

  In our example we'll read the entire contents of the table `Orders2` from our Access database and write it into the *Plant Simulation* table `Orders`.





  When you want to format the columns of the target table in *Plant Simulation* according to the formatting in the database while reading the data, make sure that Format Table ☑ Format Table in the dialog of the object *ODBC* is checked. This only applies, when *Plant Simulation* provides its own formats, which correspond to the formats in the database. *Plant Simulation* does, for example, not provide a counterpart for the typical date format in Oracle. The documentation of your database provides information about filters for changing formats during the query.

.Models.MyDatabaseConnections.Orders

File Edit Format Navigate View Tools Help

	string 1	string 2	string 3	string 4
string	DeliveryTime	MU	Amount	Name
1	0.000	.MUs.panel	200	panel
2	0.000	.MUs.rod	400	rod
3	0.000	.MUs.wheel	900	wheel
4	12:00:00.0000	.MUs.panel	200	panel
5	12:00:00.0000	.MUs.rod	400	rod
6	12:00:00.0000	.MUs.wheel	900	wheel
7				

- You can then use and manipulate this data in *Plant Simulation* in a number of ways. When working with large amounts of data, we recommend to use SQL queries with filters, as these are oftentimes considerably faster than searching large *Plant Simulation* tables.

  In our example the query for `DeliveryTime` and `Amount` of all parts of type `panel` yields this result in our *Plant Simulation* table:

.Models.MyDatabaseConnections.readDB *

File Edit Navigate Run Template View Tools Help

```
is
do
    odbc.login("TestDB","","");
    odbc.sql(Orders, "select DeliveryTime, Amount from Orders2 where MU = 'MUs.panel'");
    odbc.logout;
end;
```

.Models.MyDatabaseConnections.Orders

File Edit Format Navigate View Tools Help

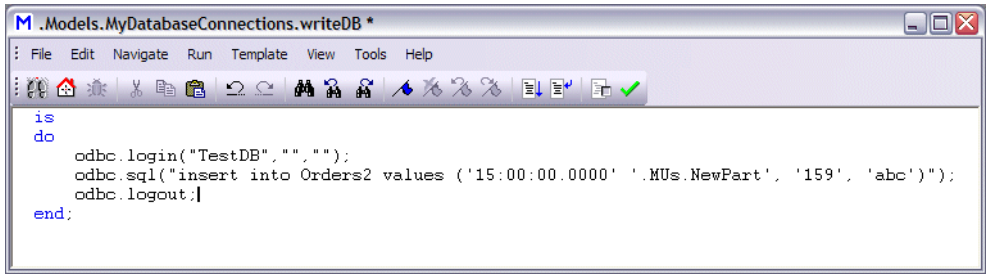
0.0000

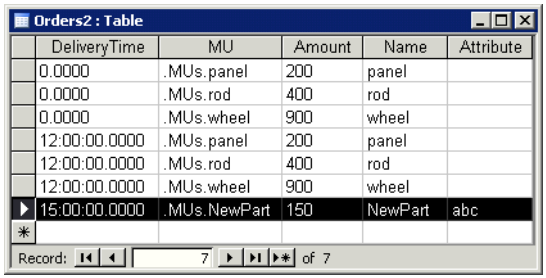
	string 1	string 2
string	DeliveryTime	Amount
1	0.0000	200
2	12:00:00.0000	200

Export Data to the Database

You can also export selected results of your simulation runs back to the ODBC database. For this, you use the method *.sql* and a number of SQL instructions.

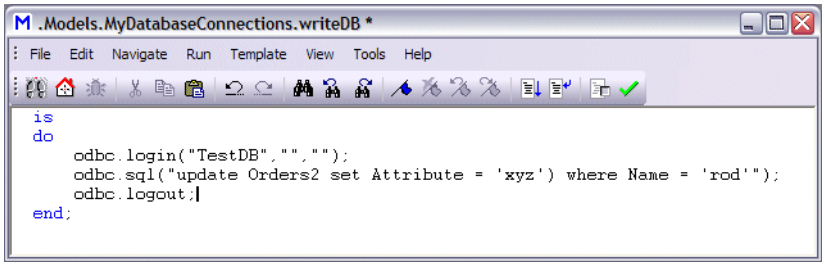
In our example we add a new row to our Access table *Orders2* using the SQL instruction `insert into`.

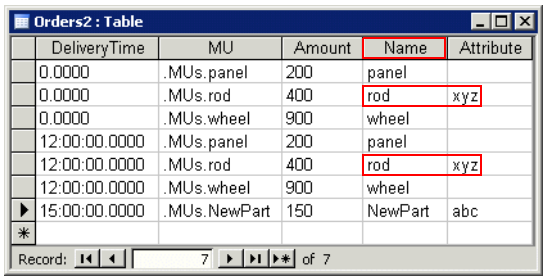




Note: As SQL does not provide a single statement for adding the contents of a row or of the entire table to the database, you have to type the contents of each cell into the *Method*.

To add data to an existing data set, thus updating the database, we use the SQL instruction `update`:





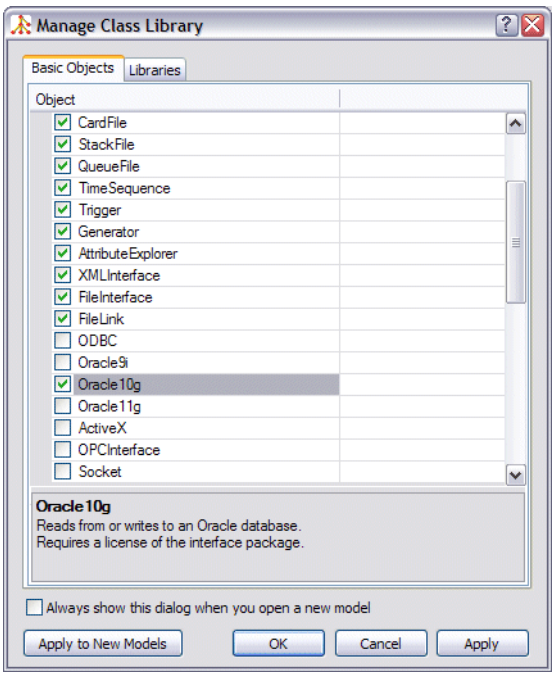
Import Data from an Oracle Database

In principle you will use the object *Oracle10g* in pretty much the same was as you do the object *ODBC*. First, establish a connection with a database instance, which exists on the Oracle Server. This database instance determines the name of the database, which you enter into the object *Oracle10g*. Microsoft Windows does not provide Oracle settings.

If the Oracle Server is not installed on the same computer on which you execute *Plant Simulation*, you have to install an Oracle Client on that computer, which establishes the connection to the server. If the Oracle Client is not included in your Oracle Installation, contact your Oracle dealer to obtain it.

If you have to handle large amounts of data, the object *Oracle10g* performs better and provides more commands than the object ODBC.

After you established the connection to an external Oracle database server within the computer network that your local computer can access, insert the object *Oracle10g* into your *Plant Simulation* simulation model. It connects to the database and imports data from it. You can write this data into *Plant Simulation* tables, manipulate them there and use them in your simulation runs and re-export the changed data back into the database.



To add *Oracle10g* to the *Toolbar Information Flow* of your simulation model, select File > Manage Class Library > Basic Objects > InformationFlow.

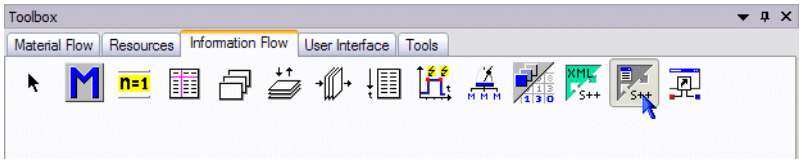
Click the object on the *Toolbar Information Flow* and insert it into your simulation model.

Note: You can also use ODBC together with Oracle! Then, you do not have to install an Oracle Client. Be aware that the SQL instructions, which you use, are not necessarily compatible with the ODBC version. This may cause problems if, for example, you want to switch between an Oracle database and an Access-database for test purposes. In this case, we recommend to use ODBC for all databases.

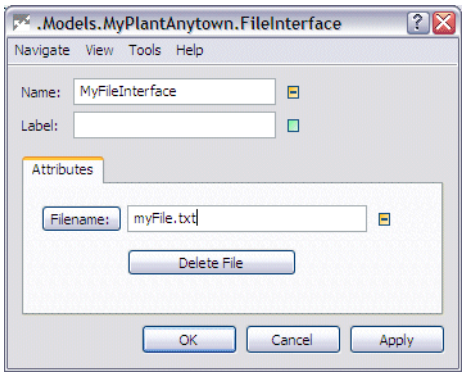
Import or Export Data in ASCII Format

You can import data for a simulation run from a text file with the *FileInterface*. You can also export data directly into a text file with the *FileInterface*: You can write log files of your simulation runs or record statistics data, etc. The *FileInterface* only processes ASCII characters, i.e., letters, numbers and special characters. It provides a number of methods to move within the file.

You can insert the *FileInterface* into your simulation model from the folder InformationFlow in the *Class Library* or from the tab Information Flow in the *Toolbox*.



Enter the File Name of the text file, which the *FileInterface* opens, when you want to import data. When you export data, it specifies the name of the file, which it saves.



The method *readLn* opens the file and reads a single line from it. It then increases the internal line counter by one and closes the file again.

The *FileInterface* transforms the contents of the line it read into a *string*. You can manipulate these *strings* with the methods for *Functions for Manipulating Strings*, such as *copy*, *omit*, *strlen* and with the methods for *Functions for Converting Data Types*, such as *str_to_num*, *str_to_time* etc.

Calling the method *readLn* again and again moves to the respective next line in the text file. The method *gotoLine* moves to the line within the text file, which you pass as an *integer*. You can then import that line with the method

readLn. If you would like to access the same file several times in a row, we advise to open the file beforehand, as that will increase access speed. If you do not need a file any longer, close it.

Note: The *FileInterface* can keep ten text files open at any one time.

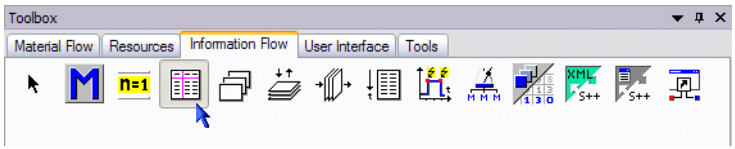
When writing data, for example with the method *write*, the *FileInterface* opens the file and sets its internal line counter to the end of the file by calling the method *goBottom*. Then, the *FileInterface* saves the data to the file and closes it. The *FileInterface* always adds new data to the end of the file, it does not overwrite any existing data.

If you would like to access the same file several times in a row, we advise to open it beforehand, as it buffers the data before saving it. The *FileInterface* saves data before the next reading access of the file or when closing it.

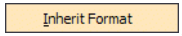
Working with Lists and Tables

Plant Simulation provides several types of lists. They differ in the way they access data they contain. This way you can insert just the right list object to meet your specific modeling needs. You can use lists to provide the material flow objects with data with which they work during the simulation run. You can also write data, such as the results of your simulation runs into lists, export the data and further process them in other applications.

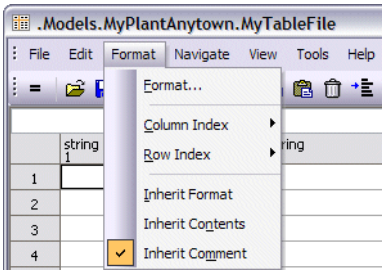
You can insert a *TableFile*, a *CardFile*, a *StackFile*, a *QueueFile* and a *TimeSequence* into your simulation model from the folder InformationFlow in the *Class Library* or from the tab Information Flow in the *Toolbox*.



- The *CardFile* has one column. It accesses the cells randomly by their position. You can add new cells at any position within the *CardFile*. When you remove a cell, all cells with a higher number move up one position.
- The *StackFile*, compare *QueueFile and StackFile*, has one column. It accesses the cell you added last. The contents of the last cell you added is the first to be processed. When you add a cell to the top of the stack, all existing cells move one position down. When you remove a cell, the remaining cells each move up one cell.
- The *QueueFile*, compare *QueueFile and StackFile*, has one column. It accesses the cell you added first: The contents of the first cell you added is the first one to be processed. It adds new cells after the last existing cell.
- The *TableFile* has several columns. It accesses the cells by their column number and their row number. New data you type in overwrites and replaces the existing contents of the cell.
- The *TimeSequence* has two columns. It accesses all pairs of cells randomly by their column number and their row number. It adds new entries in ascending order according to the time. Entries with a higher position move up by one position when you remove a previous entry.

The procedures described below are the same for all types of *Plant Simulation* lists, which you insert into your simulation model. Before you can select your own settings, you have to deactivate inheritance: Select Format > Inherit Format, so that it does not show a check mark to the left 

. Once you have done this, you will notice that the menu command Format is not grayed out any more, meaning that you can now change settings.



You can:

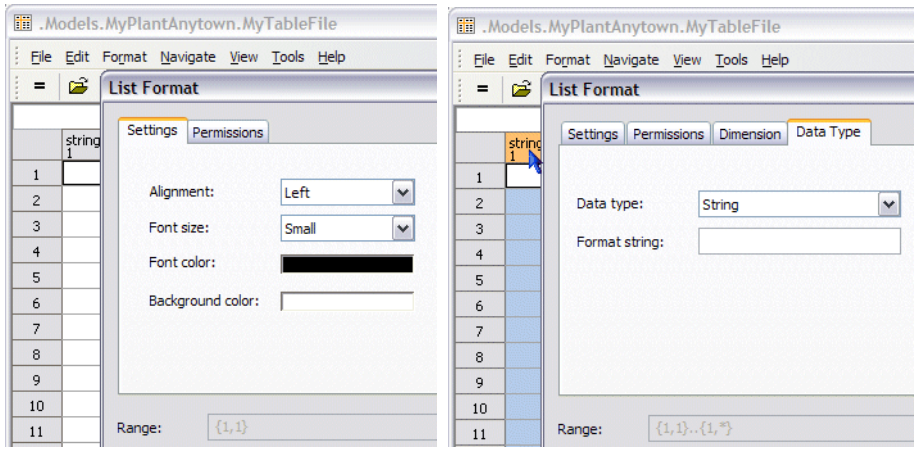
- *Set the Data Type of a Column*
- *Set the Dimension of a List*
- *Set Alignment and Colors of Cells*
- *Insert, Cut and Delete Rows and Columns*
- *Work with Data in a List*
- *Work with Data in the TableFile*
- *Accessing Data in Lists*
- *Search Lists with Methods*
- *Search Lists Interactively*
- *Create Lists within Lists and Tables*
- *Sort CardFile, TableFile and TimeSequence*
- *Perform Calculations with a Formula*
- *Import or Export the Contents of a List*

Set the Data Type of a Column

For the *CardFile*, the *StackFile*, and the *QueueFile*, which only have one column, you set the data type for the entire list. For the *TableFile* you can select the data type for each individual column or for a range of columns. To set the data type of a list or table:

- Deactivate inheritance: Select Format > Inherit Format, so that it does not show a check mark

.
- Select Format > Format.
- To show the tabs Dimension and Data Type, click in the column header of a column.

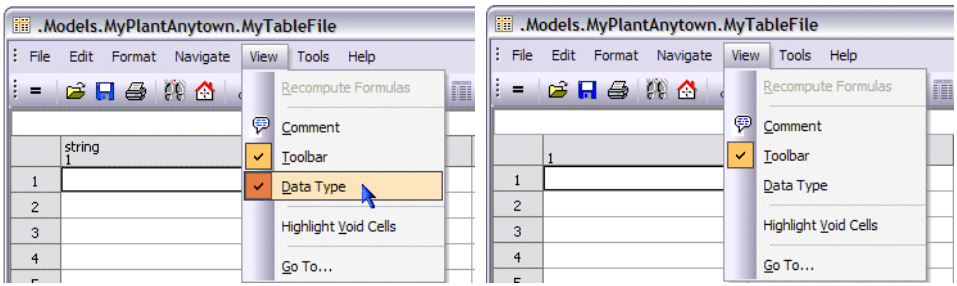


- Select one of the data types from the drop-down list.

Acceleration	applies for the objects *Line*, *Track*, *TwoLaneTrack*, and *Transporter*; the value depends on the unit you selected for the Acceleration
Boolean	true or false
Date	date statement (dd.MM.yyyy). *Plant Simulation* enters it in the date format of the language of the model when you apply it, yyyy/MM/dd for English
DateTime	date statement, including the time (dd.MM.yyyy HH:mm:ss)
Integer	integer value, such as 1, 20, 300, etc.
Length	floating point number, the value depends on the unit you selected for the Length
List	list with one column, shares properties of the *CardFile*
Money	floating point number, such as `3.1415`
Object	reference to an object or to a simulation model
Queue	list with one column, shares properties of the *QueueFile* (*QueueFile and StackFile*)
Real	floating point number, such as `3.1415`
Speed	floating point number, the value depends on the unit you selected for the Speed
Stack	list with one column, shares properties of the *StackFile*
String	characters, numbers and special characters
Table	table with one or more columns, shares properties of the *TableFile*
Time	time statement (hh:mm:ss.ss)

Weight	floating point number, the value depends on the unit you selected for the Mass

- For the data types Integer, Real and String you can also enter a Format string.
- If you want to hide the data type of the cells in the column, select View > Data Type, so that it does not show a check mark to the left.



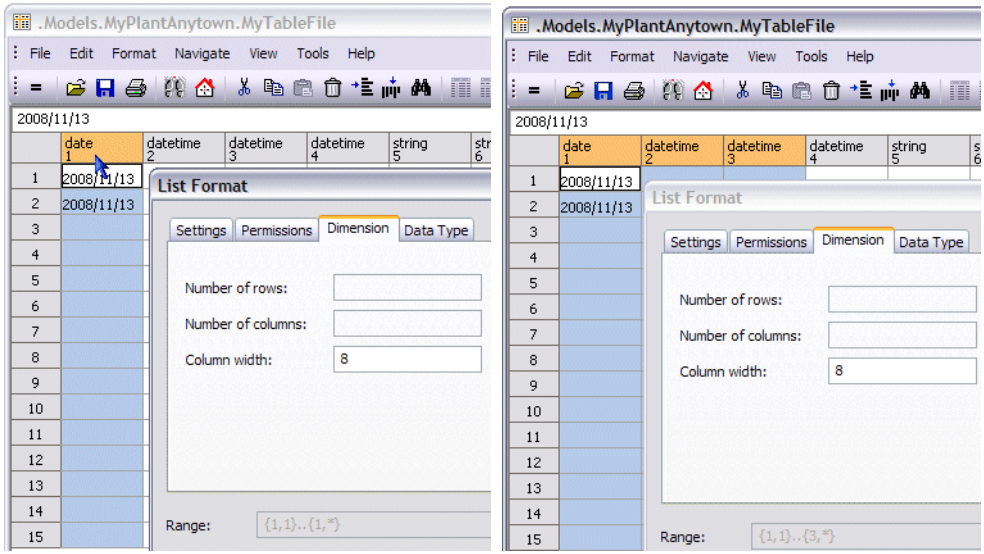
Set the Dimension of a List

To set the dimension, i.e., the borders of a list or a table:

- Deactivate inheritance: Select Format > Inherit Format, so that it does not show a check mark

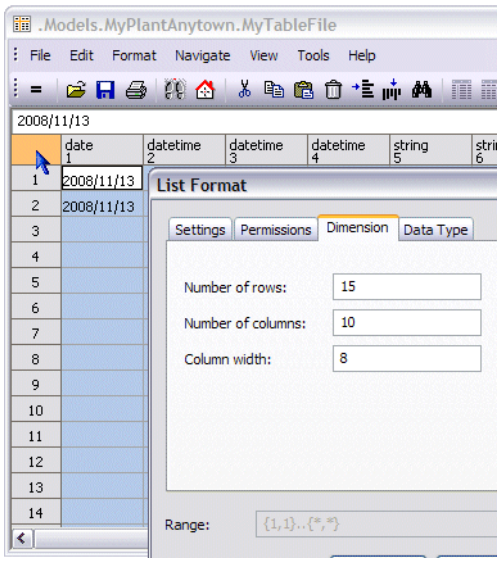
.
- Select Format > Format.
- To set the standard width of a single column, click in the column header. This shows the tabs Dimension and Data Type. Enter the column width in character widths of a non-proportional font that fit in a cell into the text box Column width.

  To simultaneously change the width of several columns, mark the range of columns before you enter the width. To do so, click in the first column, hold down the mouse button and drag the mouse to the last column. The box Range shows which columns you have selected.



- To limit the size of a table, click Select All in the top left corner of the table area. For all lists you can enter the Number of rows.

  For the *TableFile* you can, in addition, enter the Number of columns. If you do not enter a Number of columns and/or a Number of rows, the size of the list is not limited, which might be memory consuming.



- To insert a blank column to the left of the selected column, right-click it and select Insert Column. *Plant Simulation* assigns the data type string to this new column. You can change it afterwards as described above.
- To insert a blank row above the selected row, right-click it and select Insert Row.
- To delete the selected column or row, right-click it and select Cut.

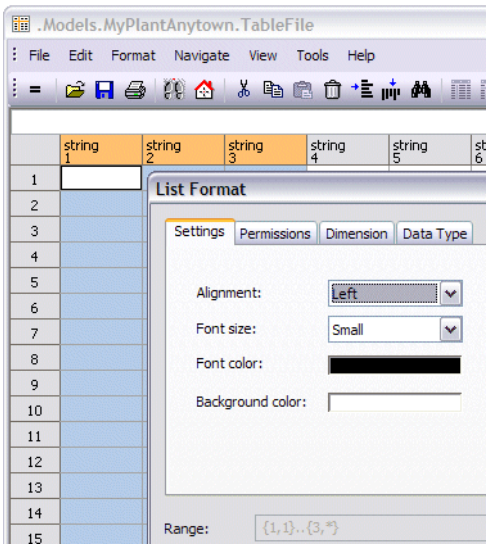
Set Alignment and Colors of Cells

To set the alignment, the font size, the font color of cells and the background color of a list or of a table:

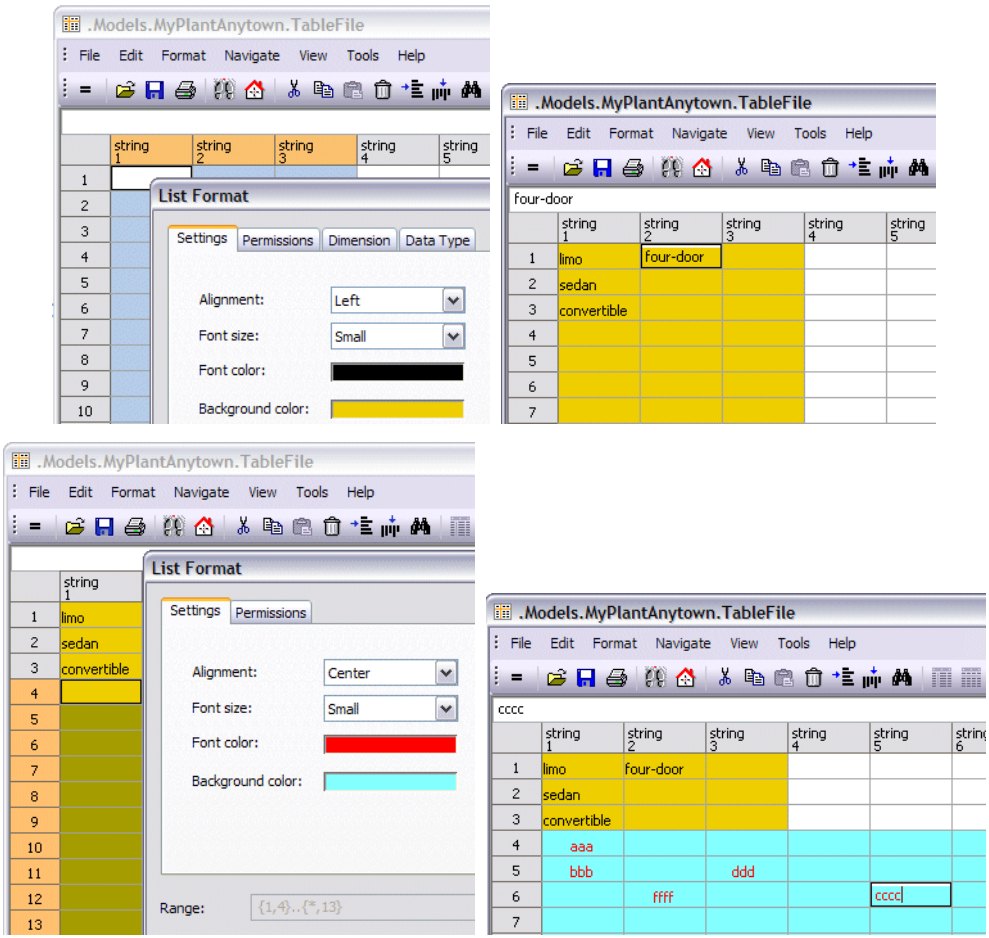
- Deactivate inheritance: Select Format > Inherit Format, so that it does not show a check mark

.
- Select Format > Format.
- Click in the column header and select the columns to which you want to apply the settings. Or

  Click in the row header and select the rows to which you want to apply the settings. The box Range shows which columns or rows you have selected.



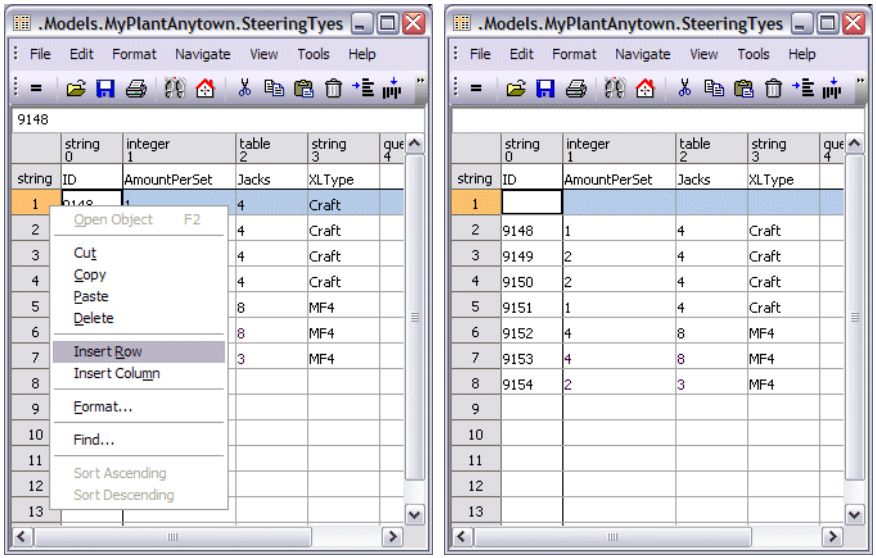
- Select the Alignment, the Font size, the Font color and the Background color of the selected columns and rows.



Insert, Cut and Delete Rows and Columns

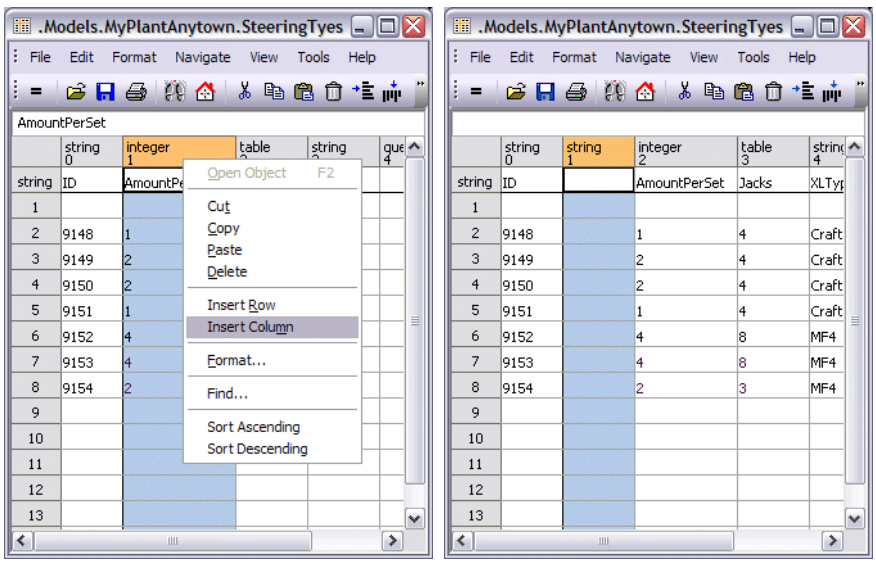
To insert a row of blank cells:

- Right-click into any cell in the row above which you would like to insert a row of blank cells. In our example, we clicked a cell in row 1 to insert a new row above row 1.
- Select Insert Row.



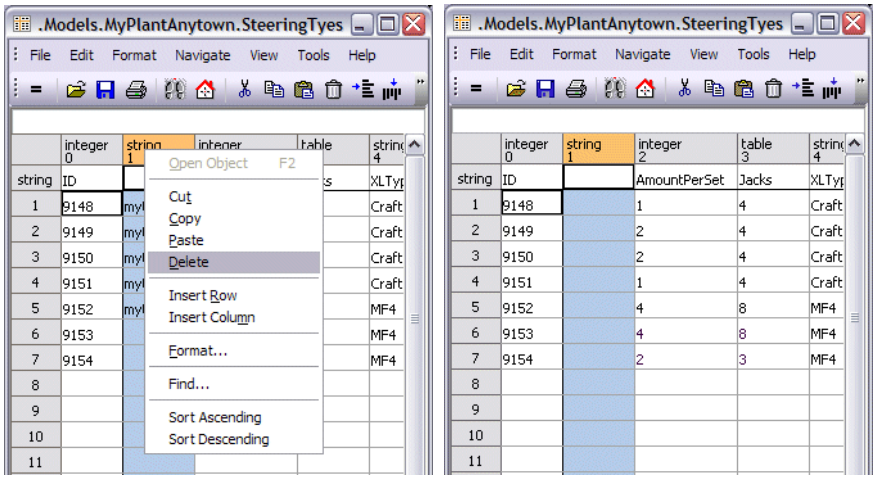
To insert a column of empty cells:

- Right-click into any cell in a column to the left of which you would like to insert a column. In our example, we clicked a cell in column 1 to insert a new column to the left of column 1.
- Select **Insert Column**.

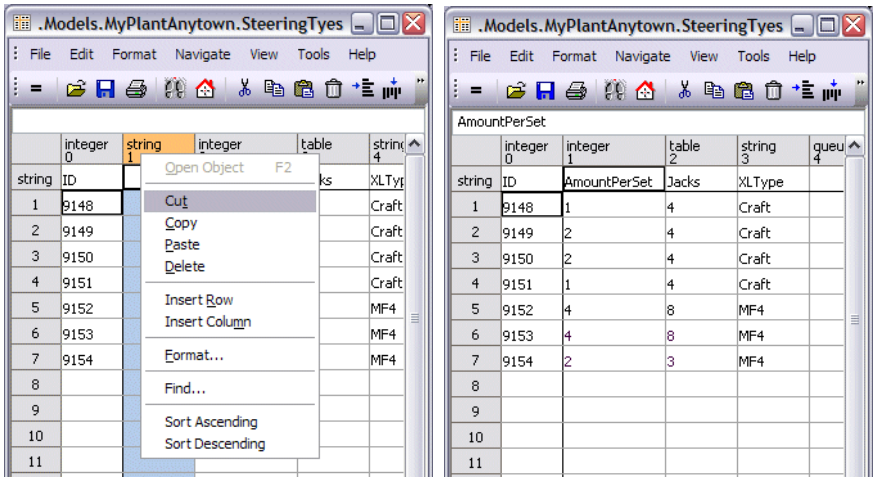


To **delete the contents** of an entire row or of an entire column of cells but to leave the empty row or column in the list, right-click it and select Delete.

To **clear the contents** of the selected cell, double-click, right-click it and select Delete.



To **delete an entire row or an entire column of cells** from the table, right-click in the row header/column header and select Cut.



Work with Data in a List

You can work with a list or table, which you inserted into a *Frame*, like this:

- Click the cell into which you would like to enter data and type in your data. Or type in data into the text box above the columns and rows.

  When you click in a cell that contains data and start typing, *Plant Simulation* deletes the current content of the cell and enters the characters you type in.
- To apply the data you entered, press the Enter key or move the cursor into another cell (Shift+arrow keys).
- To restore the previous contents of the cell while the cursor is still located in that cell, press Esc.
- To move the cursor within the edit field, press one of the arrow keys.
- To move the edit field, i.e., the active cell, in any direction within the table, hold down the Shift key and press one of the arrow keys.
- To delete the contents of a cell, double-click it, right-click it and select Delete.
- To move or to copy the contents of a cell to another location, you can use drag-and-drop within the list or table:
  - Click the cell once and drag the mouse over a border of the cell until the cursor changes into crosshairs .
  - Press the mouse button, and drag the contents of the cell to **move** it to another location. The move cursor looks like this .
  - Hold down the Ctrl key, press the mouse button, and drag the contents of the cell to **copy** it to another cell. The copy cursor looks like this .
- To paste data, which you copied to the clipboard with Edit > Copy into other applications, select Edit > Paste.
- To scroll up or down in a column, roll the mouse wheel or use the scrollbars.
- To select an entire column or row, their visible and invisible areas, click the column header or the row header.
- To select several contiguous columns of a *TableFile*, click in the column header of the first column, hold down the mouse button and drag the mouse in the column header until you have selected the range you want.
- To select all columns and rows of the list, click Select All , i.e., the button in the top left corner of the list file, where column and row headers meet. Or press Ctrl+A.
- To show blank cells in a different color in a list, select View > Void.
- To create a sublist in a cell of type *Table*, *List*, *Stack* or *Queue*, you can either type in its name and path or employ drag-and-drop to enter it.
- To open the sublist or an object, which is contained in a cell of type *Table*, *List*, *Stack*, *Queue* or *Object* hold down Shift and double-click the cell. Instead, you can also right-click the cell and select Open Object or press F2.
- To set the standard column width, select Format > Format > Dimension > Column width and enter a value. Or you can change it by dragging the cursor:
  - Place the cursor into the topmost row of the column. The cursor changes into a double-headed arrow .
  - Drag the mouse to the left or to the right until the width of the column meets your needs.

Work with Data in the TableFile

You can work with a *TableFile*, which you inserted into a *Frame*, like this:

- **Cutting or Copying a Range**

  To cut or to copy a range within a *TableFile*, select the range: Click into the cell that is to be the first corner point of the range, hold the mouse button down, and drag the mouse to the opposite corner of the range. *Plant Simulation* highlights the selected range.

  When you cut a range (Edit > Cut), *Plant Simulation* just removes the contents of these cells, but leaves the blank cells in the table. When you insert the range you cut at a new location, by clicking in the cell that is to be the upper left corner of the range and then select Edit > Paste, *Plant Simulation* overwrites the contents of the cells in that range. You can also select entire columns or rows: Click in the gray range outside the column or row where the system index is located, i.e., the numbering of the columns and rows. When you select Edit > Cut, *Plant Simulation* removes the entire column or row. It then shifts the remaining columns to the left, and the remaining rows up. When you select an entire column or row by clicking in the column or row index, *Plant Simulation* pastes a column you cut, to the right of the current column and pastes a row you cut below the current row.

- **Working with Drag-and-Drop**

  Note that *Accelerator* designates the listed key on the keyboard.

To	Drag from	To	Accelerator
Move the selected text	table window	table window	
Copy the selected text	table window	table window	Ctrl
Insert selected text	any	table window	any
Copy the selected text	table window	any	Ctrl
Cut the selected text	table window	any	

- **Inserting a Range**

  You can paste a range, which you cut or copied from a table, into another range. This only works, when the target range, which you selected, has the same number of columns and rows or is an integer multiple of the number of columns and rows. If the data types of the copied range are not compatible with the data types of the target range, *Plant Simulation* marks it in red.

- **Hiding and Showing Columns**

  You can hide and then show contiguous columns again:

  - Drag the cursor to the left or right border of the topmost row of the column or the range of columns you would like to hide. The cursor changes into a double arrow ↔.

- Click the left mouse button and drag to the left until the columns you want to hide are not visible any more.

  In the example we hid columns 2 through 14

. You recognize hidden columns by the symbol that appears at the end of column 1.

To show hidden columns again, drag the cursor over the symbol. The cursor changes into an arrow pointing to the right

. To expand the columns to their original width, click the left mouse button once.

Accessing Data in Lists

To access a cell in a list or table with a method, you can either use the **system index**, i.e., the **number**, which *Plant Simulation* assigns to columns and rows or you can define your own **custom index**, which can be **any meaningful expression**.

System index

	string 1	integer 2	string 3
1	limo	6	Bar, HE stereo
2	sedan	4	
3	convertible	2	

Custom index

	integer 0	string 1	integer 2	string 3
string	#1	Vehicle	Doors	Accessories
1	1	limo	6	Bar, HE stereo
2	2	sedan	4	
3	3	convertible	2	

The advantage of a custom index over the standard system index is that assigning names to columns and rows is more meaningful than the numbers, which *Plant Simulation* assigns by default. The custom index `Vehicles["Truck",#1]` may tell you and your co-modelers more than the system index `Vehicles[3,1]` when debugging your model. Both expressions access the same cell. As a custom index you might, for example, enter:

```
Switch["Light","220 Volts"];
Vehicles["Truck",#1];
Plant["Chicago",.building1.drill]
```

In addition, the custom index is not as error-prone as the system index: When you add an additional column or a row to the table, *Plant Simulation* increases the system index of the succeeding columns or rows by one. This naturally make any assignment in a method to the previous system index invalid. The identifier of the custom index, on the other hand, remains the same and is still valid. Be aware that accessing a custom index is slightly slower than accessing the system index.

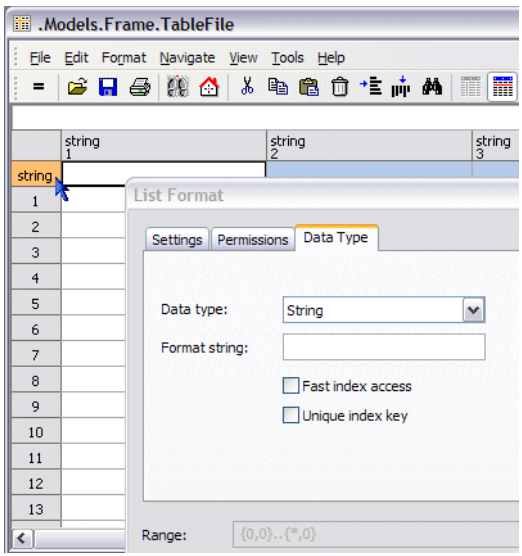
You can:

- *Set the Column Index*.
- *Set the Row Index*.
- *Define a Custom Column Index and a Custom Row Index*.
- *Set and Get the Upper Bound of a List*.
- *Address Columns and Rows with Methods*.

Set the Column Index

To set the column index:

- Click the menu command Format > Column Index > Active.
- Select the row of the column index located above the first row of cells and select Format > Format.
- Select the data type of the column index from the drop-down list on the tab Data Type. For the data types Integer, Real and String you can also enter a Format string to limit the number of digits the user can interactively enter into these cells.

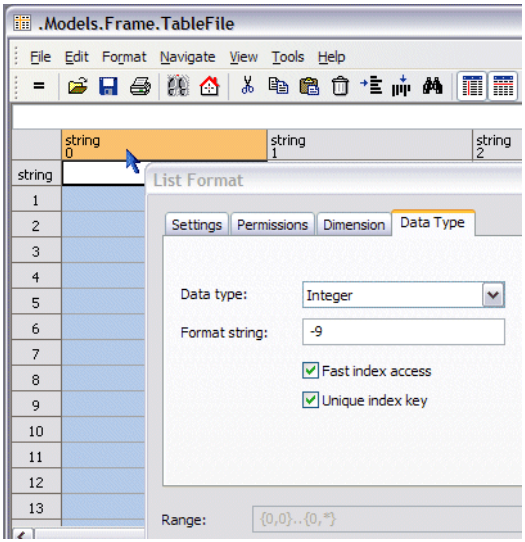


- To allow for quickly accessing the custom column index, select the check box Fast index access.
- To only allow unique entries in customized indexes, depending on the data type, select the check box Unique index key.

Set the Row Index

To set the row index:

- Click the menu command Format > Row Index > Active.
- Select the column of the row index and click the menu command Format > Format. Select the data type of the row index from the drop-down list on the tab Data Type. For the data types Integer, Real and String you can also enter a Format string.
- To allow for quickly accessing the custom row index, select the check box Fast index access.
- To only allow unique entries in customized indexes, depending on the data type, select the check box Unique index key.



- To allow for quickly accessing the custom column index, select the check box Fast index access.
- To only allow unique entries in customized indexes, depending on the data type, select the check box Unique index key.

Define a Custom Column Index and a Custom Row Index

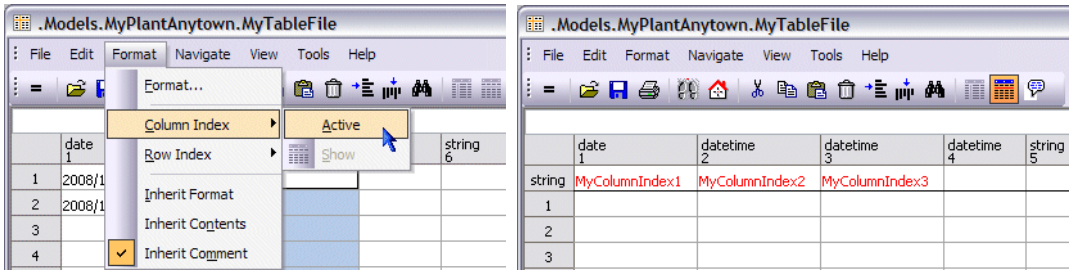
To define a custom column index and a custom row index:

- Deactivate inheritance: Select Format > Inherit Format, so that it does not show a check mark

.
- To activate and to show the column index, select Format > Column Index > Active. Enter a meaningful term into the first row of cells to the right of string.

  This also activates the button , so that you can show or hide the column index in the table.

  In most cases, you will select the data type String for the custom column index. When you select Integer, you have to enter a number sign # in front of the term you enter as your custom index to distinguish it from the system index.



- To activate and to show the row index, select Format > Row Index > Active. Enter a meaningful expression into the first column of cells below string 0.

  This also activates the button , so that you can show or hide the row index in the table.

  In most cases, you will select the data type String for the custom row index. When you select Integer, you have to enter a number sign # in front of the expression, which you enter as your custom index, to distinguish it from the system index.

Note: When both column and row index are active, the cell [0,0], i.e., the cell at which column and row index intersect, counts as part of the **column** index, not as part of the row index.

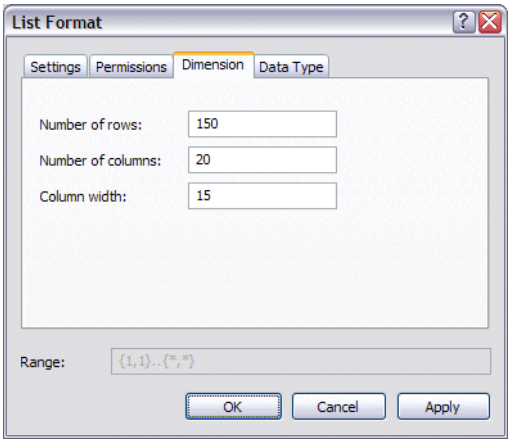
Set and Get the Upper Bound of a List

To set the upper bound of a list or table:

- Deactivate inheritance: Select Format > Inherit Format, so that it does not show a check mark

.
- To select the entire list or table, click Select All

or press Ctrl+A.
- Select Format > Format.
- Click the Tab Dimension. Enter the Number of columns and the Number of rows. *Plant Simulation* automatically sets the lower bound to 1. When you use a customized index the lower bound is 0.

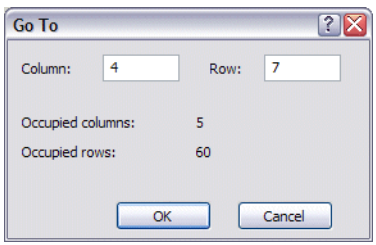


For lists with one column, you can also set the upper bound with the attribute *MaxDim*. For lists with two columns you can set it with the attributes *MaxXDim* and *MaxYDim*. For tables the methods *xDim* and *yDim* return the dimension of the current occupancy.

The method *indexXDim* returns the last cell of the column index, which contains an entry. The method *indexYDim* returns the last cell of the row index, which contains an entry.

The dialog Go To also shows the number of occupied columns and rows.

To move to a certain cell within a list or table, select View > Go To and type in the location of the cell.



Address Columns and Rows with Methods

Plant Simulation uses these conventions when addressing columns and rows in a *TableFile* in methods. You can:

- *Set the Format of Columns and Rows*
- *Get the Format of Columns or Rows*

Set the Format of Columns and Rows

- The syntax for setting the format of columns and rows is: `setXX(<any>,...<any>,<integer>);`
- The number of arguments always is greater than or equal to 2.

- The last argument sets—depending on the action you wish to perform—the column or row:
  - You can use the system index, i.e., the absolute number of the column or row. Or
  - You can use a custom column or row index. To set a common format for a contiguous range of columns or rows, first define a range. For column functions it only applies to the columns within the specified range. Enter an asterisk (*) to designate all rows within the specified range. For row functions it only applies to the rows within the specified range.

    Compare this example:

    ```
    TableFile.setDataType({3,*}..{4,*},6,"column1","real");
    ```

`{3,*}..{4,*}`	designates the range, all cells in columns 3 and 4 in this case
`6`	designates the system index of a column
`"column1"`	designates a column index
`"real"`	designates a value

Get the Format of Columns or Rows

- The syntax for getting the format of columns and rows is: `getXX(<any>);`
- There is only one argument.
- The argument stands for the row or column:
  - You can use the system index, i.e., the absolute number of the column or row. Or
  - You can use a custom row or a custom column index.

    Compare this example:

    ```
    TableFile.getDataType(1);
    ```

    This method returns the data type of column 1.

Search Lists with Methods

Lists and tables have an internal cursor pointing to a cell of the list. You can query the current position of the cursor with the attribute *Cursor* and set it anew by assigning an integer value to it. A search, for example with the method *find*, begins at the current cursor position. Before starting the search, make sure that the list cursor is placed at the cell from which on you want to search.

After a successful search, *Plant Simulation* places the cursor in the cell where it found the value. If the list contains the value you searched for more than once, a new call of the method *find* finds the next value starting at that cell, and so on.

When you set a range for the *find* command, *Plant Simulation* determines the starting position of the cursor by combining the cursor and the range. The search begins at the first entry of the list in the range you entered, starting at the cursor position. The search ignores any range, which is located before the current cursor position. If the cursor is located in the middle of the range you entered, *Plant Simulation* does not search for entries before of the cursor

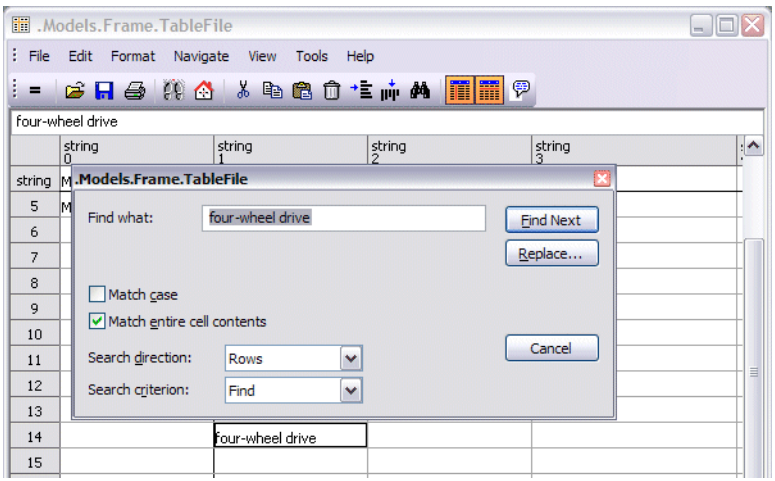
position! The search goes on until *Plant Simulation* finds the value or reaches the end of the list. When *Plant Simulation* finds the value you searched for, it places the cursor into the cell, which contains the value. A new search begins at the next cell. If the search does not find the value, the internal cursor remains in the cell it had before the search.

The same principle applies to tables. As a table has rows and columns, it naturally has two cursors: *CursorX* designates the column and *CursorY* designates the row, which identifies the cell.

Note: Set the cursor anew after inserting or deleting rows, to determine its position.

Search Lists Interactively

To search and optionally replace a string with another string, right-click in the list and select Find or press Ctrl+F.



- Enter the expression you would like to find into the text box Find what.
- Select Match entire cell contents to only find the characters in cells, which exactly and completely match the expression you entered into the text box Find what.
- Select Match case to only find text that has the same pattern of upper and lower case as the expression you entered into the text box Find what.
- Select if you want to Search in Rows, i.e., to the right across rows, or down through Columns.
- Select the Search criterion from the drop-down list:

  Find: Finds the expression you entered into the text box Find what, compare the method *find*.

  Find ceil(ing): Finds a value greater than or equal to the expression you entered into the text box Find what, compare the method *findCeil*.

  Find floor: Finds a value smaller than or equal to the expression you entered into the text box Find what, compare the method *findFloor*.

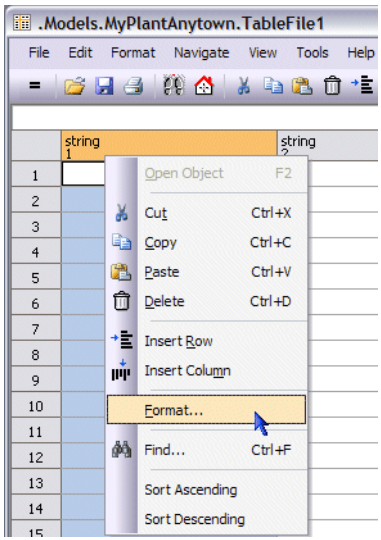
- Click Find Next, so that *Plant Simulation* finds the next instance of the expression, which you enter into the text box Find what.
- Click Replace, so that *Plant Simulation* shows the text box Replace with. Enter the expression into the text box Replace with that is to replace the expression you entered into the text box Find what.
- Click Replace to replace the expression.

Create Lists within Lists and Tables

To **create a sublist** or a subtable in a cell of the *CardFile*, the *StackFile*, the *QueueFile*, or the *TableFile*:

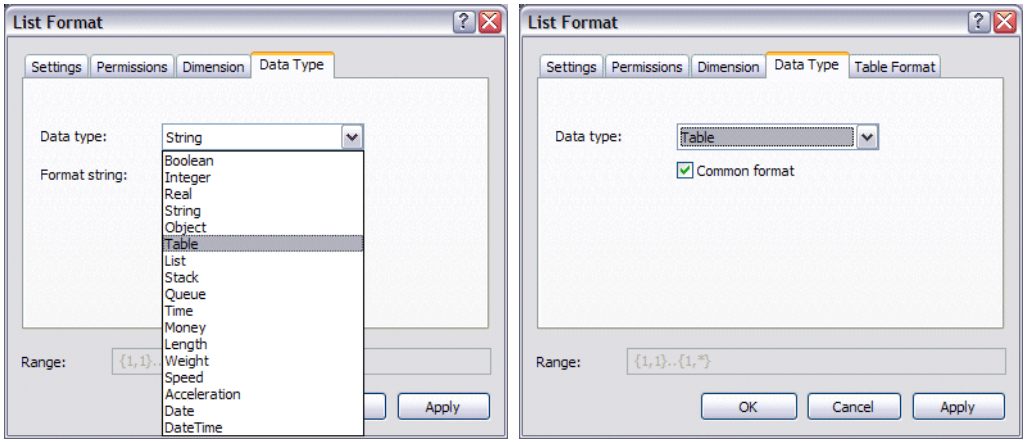
- Open the list object to which you want to add a sublist/subtable.
- Select Format > Inherit Format, so that it does not show a check mark next to it

.
- Right-click the column header of the column to which you want to add a sublist and select Format.

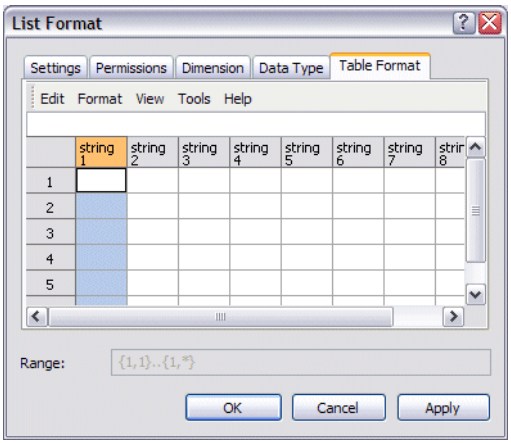


- Select the data type of the sublist you want to insert: Table, List, Stack or Queue. You will choose the data type depending on how you want to access the entries of the sublist.

  If you want all sublists in that column to have the same formatting, select Common format.

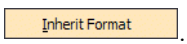


- Apply formatting properties on the Tab Table Format. Click OK.



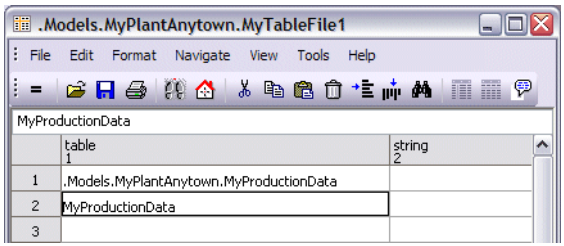
- Enter a name of your choice, which identifies the sublist, into the cells of this column.
- Click OK.

To **insert a list object** from a *Frame* or the *Class Library* into a cell of the list objects *CardFile*, *StackFile*, *QueueFile*, or *TableFile*:

- Open the list object to which you want to add a sublist/subtable.
- Select Format > Inherit Format, so that it does not show a check mark next to it 

.
- Right-click the column header of the column to which you want to add a sublist and select Format.
- Select the data type Object.
- **Drag the table** to a cell of the list and drop it there. This inserts the **absolute path** of the inserted list.

Type the name of the list you want to insert into the cell, when this list is located in the same *Frame*. This way *Plant Simulation* uses the **relative path**.



To open the sublist or a list object, which is contained in a cell of type *Table*, *List*, *Stack* or *Queue*, hold down the Shift key and double-click into the cell. Instead, you can also right-click the cell and select Open Object or press F2.

Sort CardFile, TableFile and TimeSequence

To sort the contents of a *CardFile*, a *TableFile*, or a *TimeSequence*:

- To sort the selected column in ascending (A to Z, or 0 to 9) order, select Edit > Sort Ascending.
- To sort the selected column in descending order (Z to A, or 9 to 0), select Edit > Sort Descending.

You can also only sort the *CardFile*, the *TableFile* and the *TimeSequence* with methods:

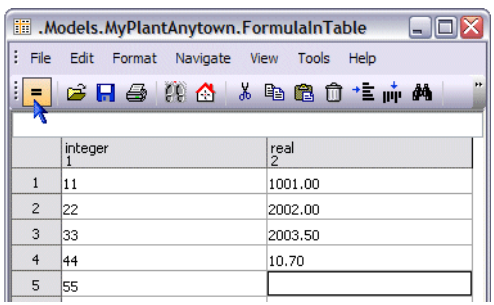
- The method *sort* sorts the lists in ascending (A to Z, or 0 to 9) or in descending order (Z to A, or 9 to 0).
- The method *inOrder* sorts a value into an existing sequence of values at the position where you want it to be.

Perform Calculations with a Formula

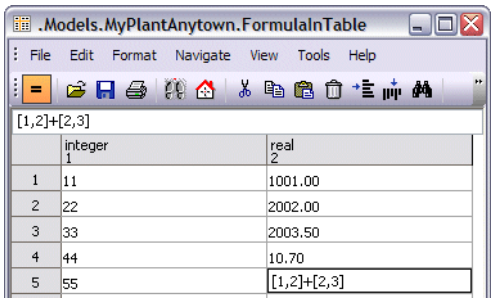
A Formula is any expression, which accesses and links other cells within the list or which access any of the attributes of the objects. With these values, the formula then performs the calculations you defined.

For linking the operands within a formula, you can use the same arithmetic operators and mathematical functions as you use in methods, compare Operators and Expressions.

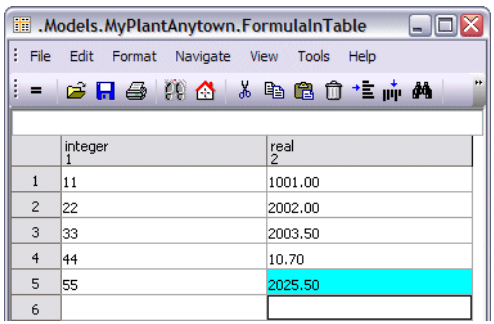
1. To activate *Formula* mode, click = in the toolbar, so that it is selected .



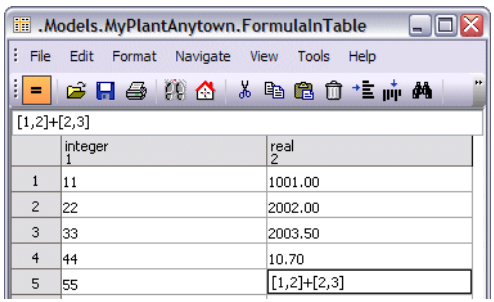
2. To enter a formula into a cell, click in it and type the expression in. Instead, you can also type it into the text box above the list. In our example we add the value of cell 2 in column 1 to the value of cell 3 in column 2.



3. To show the result of the calculation of the formula, i.e., its value, in the cell, press Enter.



4. To show the formula itself in the text box, double-click in the cell containing the formula. Then, you can change the formula.



The list shows cells containing a formula in color. Turquoise designates a formula with a correct syntax, red a formula with syntax errors.

Within a formula you can access the value of another cell of the same list with the anonymous identifier @:

Formula	Executes
`@[1,1]+@[1,2]`	adds the contents of the cell [1,1] to the contents of the cell [1,2].
`@[1,1]*track.length`	multiplies the contents of cell [1,1] with the length of the object track.
`@[1,@.ydim]+5`	adds 5 to the value of the last cell in the first column.
`@[xSelf+1,ySelf]-7`	subtracts 7 from the value of the neighboring cell to the right
`@.sum({3,*})`	calculates the sum of the third column.
`@.min({1,2}..{1,*})`	determines the smallest value of the first column, starting from cell 2.

Note: The data type of the result of a formula has to have the same data type as the cell or the column in which the cell containing the formula is located.

In sublists, you can access the list, into which you inserted the sublist, with the anonymous identifier ?. Note that for user-defined attributes of lists, the anonymous identifier ? accesses the object for which you defined the user-defined attribute.

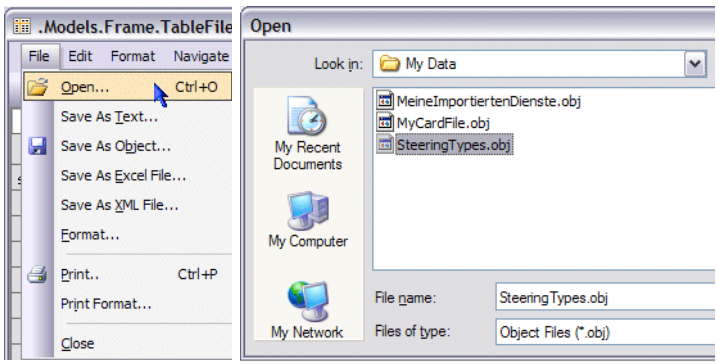
`xSelf` and `ySelf` contain the number of the column or the number of the row respectively, which contains the formula. This way you can easily access neighboring cells.

Import or Export the Contents of a List

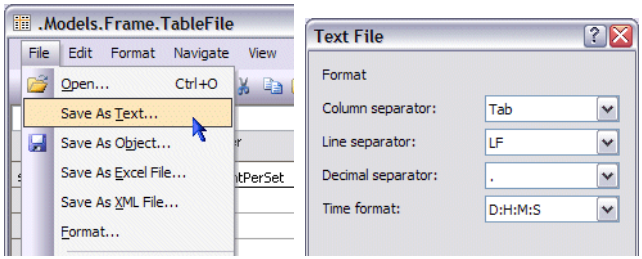
You can save an *Plant Simulation* list in several formats:

- To save the list with all of its *Plant Simulation* formatting as an *Plant Simulation* list, select File > Save As Object. You can then open the saved list object within a list in other *Frames* or in other simulation models.

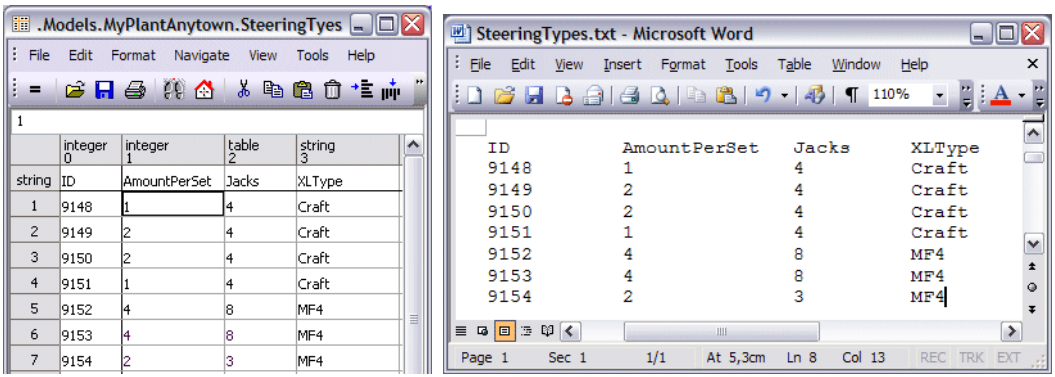
  To import a *TableFile*, which you saved as an .obj file into another *TableFile*, select File > Open. To import a list with one column into a *TableFile*, select the same data type for the left column that the list with one column has.



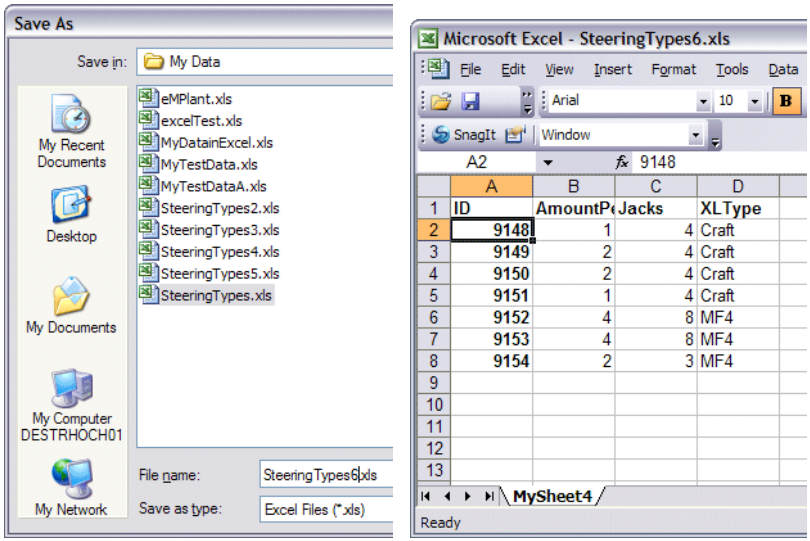
- To only save the contents of the list, without any of its formatting, select File > Save As Text. To change the settings with which *Plant Simulation* exports ASCII data, select File > Format. Then, you can select which sign you want to use for separating columns, etc., depending on the program into which you want to import the data.



The sample table shown below, which we exported with the default settings, looks like this, when we open it in a word processing program. We chose Microsoft Word to show the tabs, which *Plant Simulation* exported.



- To save the contents of the *Plant Simulation* list as an Excel worksheet, select File > Save As Excel File.
  Enter the name of the worksheet, on which Excel opens the data, into the dialog Worksheets.



When *Plant Simulation* exports data to Excel, it applies these conventions:

Plant Simulation data type	Excel data type	Excel format
String	String	
Boolean	Boolean	
Integer	Number	
Real	Number	
Object	String	
Table	String	
List	String	
Stack	String	
Queue	String	
Money	Number	
Length	Number	
Weight	Number	
Speed	Number	
Acceleration	Number	
DateTime	Number	dd/mm/yyyy hh:mm:ss.000

Plant Simulation data type	Excel data type	Excel format
Date	Number	dd/mm/yyyy
Time	Number	dd:hh:mm:ss.000

Note: *Plant Simulation* only exports integers in the range between -536.870.912 and 536.870.911 in the required format. *Plant Simulation* saves values outside of this range as 0.

When you open the .xls file in Excel, it looks like this. You might still have to adapt settings of the imported file in Excel.

When *Plant Simulation* reads an Excel table, it attempts to adapt the data types of the individual columns to the available *Plant Simulation* data types. This only works, when you created the columns on the Excel worksheets, so that they only contain a single data type, meaning that, when you, for example, assign the data type String to a cell of a column, the entire column may only be of data type String.

Row 0 (zero) is an exception to this rule: When the table, which *Plant Simulation* reads, has a column index, it interprets row 0 as the column index and it will not be part of the data type designation of the columns.

Setting Parameters in Your Model

Tecnomatix Plant Simulation provides a number of ways to enter parameters into your simulation model and to execute simulation runs with these parameters.

You can:

- *Set Parameters for Objects in Your Own Dialog*
- *Set Parameters with the AttributeExplorer*

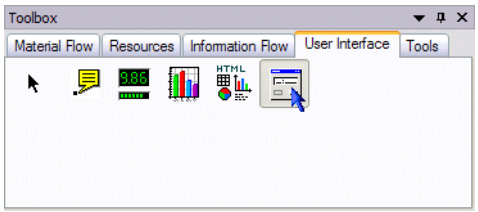
Set Parameters for Objects in Your Own Dialog

When you want to get information from the user of your simulation model, be it you yourself, a colleague in another department or one of your suppliers, you can create dialog windows, which look like the built-in *Plant Simulation* dialog windows and which work in the same way, too.

With the object *Dialog* you can:

- Provide the user of your simulation model with a simple user interface for complex simulation models. This way you can ask the user to select or to enter information, which *Plant Simulation* needs to carry out a task.
- Prevent the user from manipulating a *Frame* in which you modeled a complex machine, etc. To accomplish this, enter a *Method* object as an Open control for the *Frame* and insert a user-defined dialog with simulation settings into the *Frame*. When the user double-clicks the *Frame*, *Plant Simulation* will not open the *Frame* as such, but call the method whose name you entered. The method in turn executes the Open control, i.e., it opens a user-defined dialog, where the user can then select the settings for the simulation run.

You can insert the *Dialog* into your simulation model from the folder UserInterface in the *Class Library* or from the tab User Interface in the *Toolbox*.



Each *Dialog* object manages a single dialog window. If you need more than one user-defined dialog window in your simulation model, insert as many *Dialog* objects as you need *Dialogs*.

You will:

- *Plan the Layout and the Structure of Your Dialog*
- *Design a Simple Dialog*
- *Design a Tabbed Dialog*
- *Program Actions which the Dialog Items Execute*
- *Program Actions for Interacting with the Dialog*

In which order you go about creating the user-defined dialog is up to you and depends on your personal work habits. You can first design the layout and then do your programming. You have to program the actions, which the individual dialog items execute, and the actions, which *Plant Simulation* executes, when the user opens the user-defined dialog, when he clicks Apply, and when he closes it. Or you can start programming and then design the layout. Or you can mix both techniques to achieve the best result.

Plan the Layout and the Structure of Your Dialog

Before you start designing your dialog, take a few moments to think about its layout. Orient the dialog items in the direction the user reads, in Western countries this is from left-to-right and from top-to-bottom. Place the primary dialog item with which the user interacts as close to the upper corner of the dialog as possible. Do the same when orienting dialog items within groups in your dialog. Place the major command buttons stacked along the right border of the dialog or lined up across the bottom of the dialog. Place the most important button as the first button in a set of buttons.

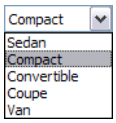
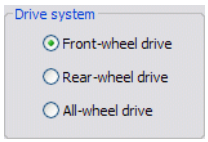
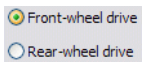
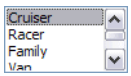
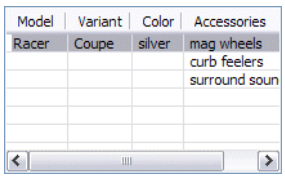
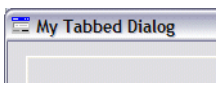
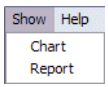
Also, take a few moments to decide about the structure of your dialog. Ask yourself which dialog items you do need, and if you can show them all in a flat hierarchy in the dialog or if you need to present the information on tabs.

The structure you decide upon determines how and in which order you create the dialog items. Let us say, you want to show the dialog items on tabs. Then, you first have to create the Tab Control, which is the container that accommodates the individual tabs. After this you have to create the individual tabs, and finally you can insert the dialog items onto each one of these tabs.

The same applies to **groups** of dialog items. First, create the group and then insert and position the items you want to add to that group. The y-coordinate you enter for items in a group relate to the y-coordinate within that group, not within the overall dialog.

For both dialog types you can create menus and you can create these types of dialog items.

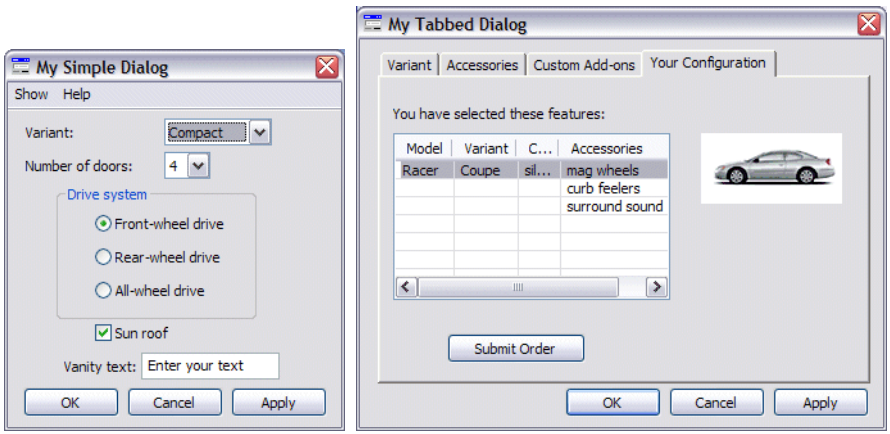
Dialog item	icon	looks like this
Static Text Box	Aa	Number of doors:
Text Box	ab|	Enter your text
Button		Submit Order

Dialog item	icon	looks like this
Drop-Down List Box		
Group Box		
Check Box		
Radio Button		
List Box		
Image		
List View		
Tab Control		
Tab Page		
Menu/menu command		

Depending on your modeling needs, you will:

- *Design a Simple Dialog*
- *Design a Tabbed Dialog*

For both types you have to program the actions, which the dialog items execute, when the user selects them.



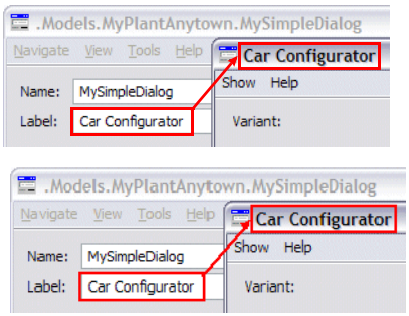
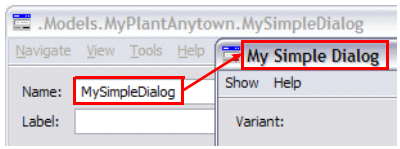
Note: *Plant Simulation* shows the dialog with the settings you select under Display Properties > Appearance > Font size as well as with the Font and the Size you can select, when you click Advanced. When you change these settings, the dialog scales text, while the images always retain their size in pixels. For this reason it can happen that text overlaps the image. We recommend to test your dialogs with different display settings to make sure that everything works as you expect it.

Design a Simple Dialog

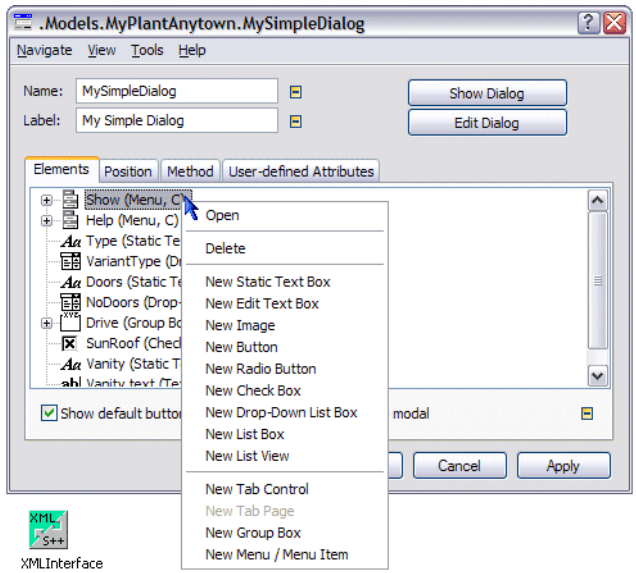
When you only need the user to select or to enter a small number of items, you can present them directly in the dialog in a flat structure. When you want the user to select or to enter several different types of information, you will *Design a Tabbed Dialog*.

To start designing your own dialog:

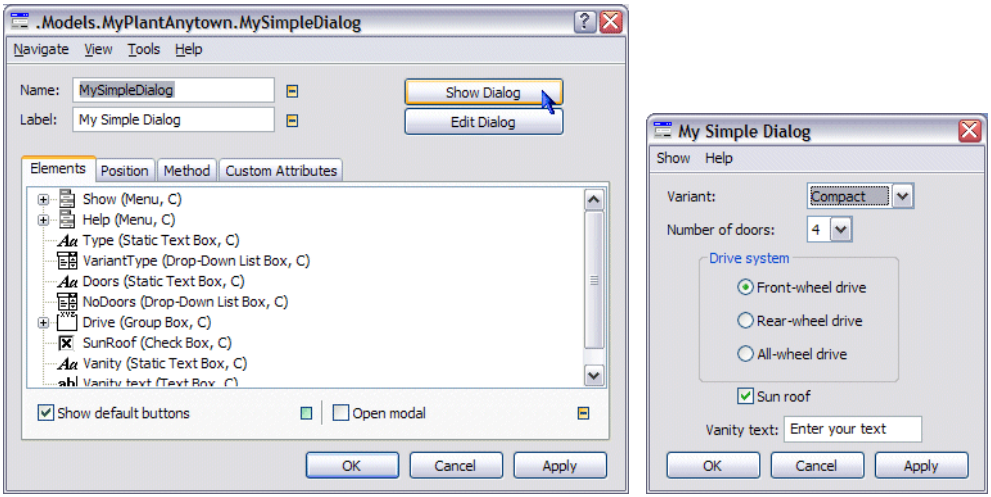
- Insert the *Dialog* into the *Frame* in which your are creating your simulation model. You can do this from the folder UserInterface in the *Class Library* or from the tab User Interface in the *Toolbox*.
- Enter a name and a label into the respective text boxes. As opposed to the name, you can enter any term of your choice as the label. This includes special characters and blank spaces.
  - If you enter a label, *Plant Simulation* shows that label in the title bar of your dialog.
  - If you do not enter text for the label, *Plant Simulation* shows the Name of the *Dialog* object in the title bar.

Label	No label
	

- To insert a dialog item, right-click in the tab Elements and select the respective dialog item on the context menu.



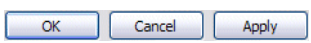
- To show the dialog you are creating with the dialog elements you already created, click Show Dialog.



- To modify an existing dialog item, right-click it and select **Open** on the context menu. This opens the dialog of the **Dialog Item** where you can change it.
- To delete a dialog item, right-click it and select **Delete** on the context menu.
- To change the position of a dialog item in the dialog you are creating, first click **Show Dialog** and then click **Edit Dialog**. Select the dialog item you want to move

and drag the mouse to a new location. This way you can, for example, roughly re-position an existing dialog item and then enter the exact coordinates to place it exactly where you want it to be.

  Note: The *Dialog* applies the changed coordinates immediately. Once you have moved an item, you cannot undo the move action. To restore the previous settings, you have to re-enter them into the respective dialog.

- To show the default buttons 

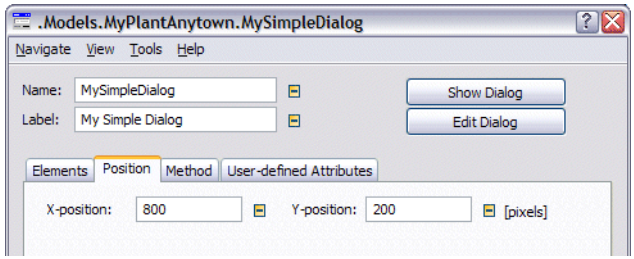
in the dialog you are creating, select the check box. To hide these buttons, clear the check box.

  If you do not show this button combination, you have to define your own buttons to provide the user with a way to apply or to discard settings he chose!

- To open the dialog window you are creating modal, select **Open modal**. Then the user cannot open any other *Plant Simulation* windows until he has completed interacting with the user-defined dialog and closed it.

  To allow the user to open other dialog windows, in addition to the user-defined dialog you are creating, clear the check box.

- To define the position at which the *Dialog* opens on your computer's screen, click the tab **Position** and enter the **X-position** and the **Y-position** in pixels into the text boxes. The default setting `-1` for both **X-position** and for **Y-position** centers the *Dialog* on screen. The zero point is located in the left top corner of the screen.

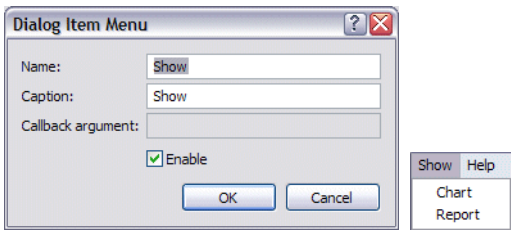


Add a Menu and Menu Commands

To add a menu to your dialog:

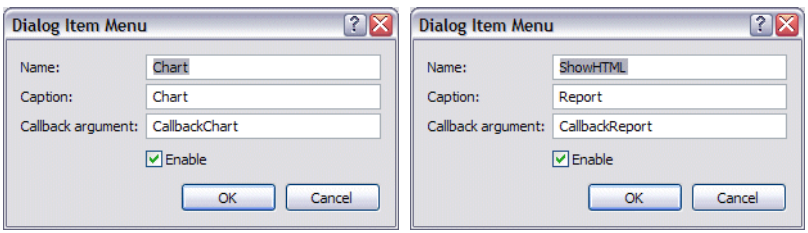
- Right-click in the tab Elements and select New Menu/New Menu Command.
- Enter the Name of the menu. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption, which the menu displays. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks. In our example we entered `Show`.

  Note: For the top menu itself, you do not have to enter a Callback argument.

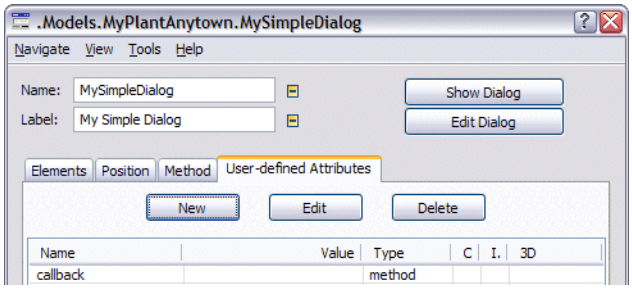


To add a menu command to the menu you added above:

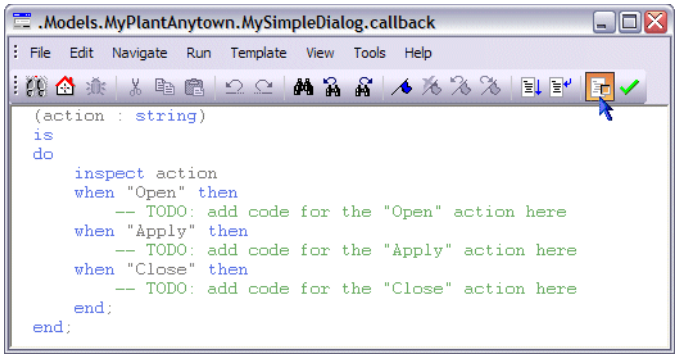
- Right-click the name of the menu on the tab Elements and select New Menu/Menu Command.
- Enter the Name of the menu command.
- Enter the Caption, which the menu command displays. In our examples we entered `Chart` and `Report`.



- So that the dialog opens the *Chart* or the *Report*, when the user selects Show > Chart or Show > Report, you have to program it to do so. For this you have to enter the Callback argument, which will be passed to the callback method. In our examples we entered `CallbackChart` and `CallbackReport`.
- Then, enter the code for actually opening the *Chart* or the *Report* into the callback method. As the callback method is a user-defined attribute of type *method*, click the tab User-defined Attributes.



Double-click callback and click Open in the dialog User-defined Attributes. To be able to enter commands into the method, click the button Inherit Source Code, so that it is released .



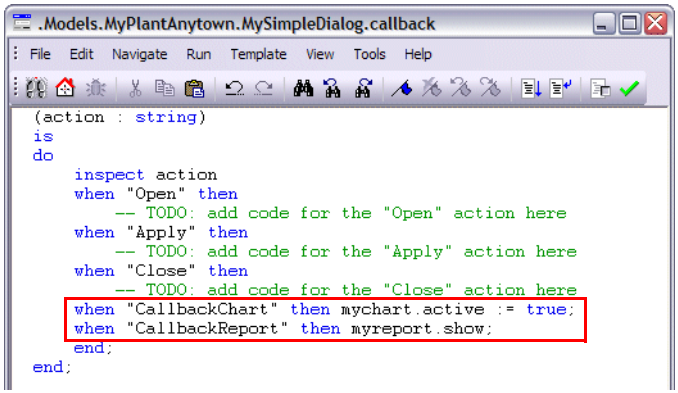
Double-click callback and click Open in the dialog User-defined Attributes.

To open the object *MyChart*, we entered:

```
when "CallbackChart" then mychart.active := true;
```

To open the object *MyReport*, we entered:

```
when "CallbackReport" then myreport.show;
```



- To change the order of the menu commands on a menu, select a menu command on the tab Elements, hold down the Shift key and press the Up arrow to move this menu command up or press the Down arrow to move this menu command down.

Add a Static Text Box

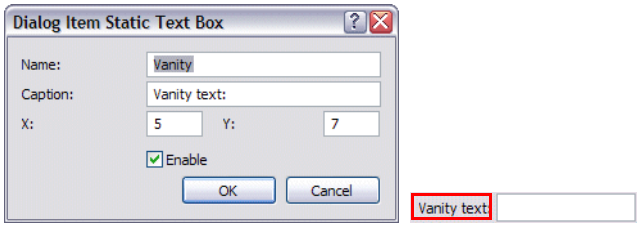
A static text box shows text that the user can view, but not edit. To add it to your dialog:

- Right-click in the tab Elements and select New Static Text Box.
- Enter the Name of the static text box. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption, which the static text box displays. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks.
- Enter the X-coordinate and the Y-coordinate of the static text box in the *Dialog*.

  The position corresponds to the average width of characters of your system font, not to pixels. Changing the font size under Start > Settings > Control Panel > Display > Settings > Advanced > General > Font Size, affects this setting.

  Note: If you cannot see a dialog item after you inserted it, check the settings for the position first. If you entered identical values for different dialog items, the *Dialog* places them on top of each other, so that you can only see the first item(s) you inserted.

- Select if you want to Enable the static text box Vanity text: or not Vanity text:.
- To insert the dialog item into your dialog, click OK.



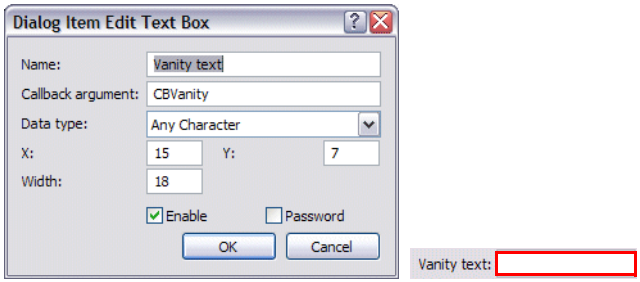
Add a Text Box

A text box is a field into, which the user can enter text or edit text it already contains. To add it to your dialog:

- Right-click in the tab **Elements** and select **New Edit Text Box**.
- Enter the **Name** of the text box. A *Method* object can call this dialog item using the **Name** you entered.
- Enter the **Callback argument**, which will be passed to the callback method.
- Select what kind of data the user can enter from the drop-down list **Data type**.

Selection	The user can enter
Any Character	any character, which includes special characters, lower and upper case letters and numbers.
Alphanumeric Characters	a blank space, lower and upper case letters, and numbers.
Letters	lower and upper case letters.
Decimal Numbers	0123456789
Signed Decimal Numbers	decimal numbers with a negative or a positive sign: -0123456789 or +0123456789, for example.
Hexadecimal Numbers	ADbf09, for example.
Octal Numbers	01234567, but not 18 for example.
Binary Numbers	0 or 1
Floating Point Numbers	12.3E-43, for example.

- Enter the **X**-coordinate and the **Y**-coordinate of the text box in the *Dialog*.
- Enter the **width** of the text box in the average width of characters of your system font. The default value of 0 sets the width to the values defined by us.
- Select if you want to **Enable** the text box or not. The user can only enter text, when the text box is enabled.
- To show text that the user enters into the text box with superscripted lower case xes [••••••••], instead of as clear text [mypassword], select **Password**.
- To insert the dialog item into your dialog, click **OK**.

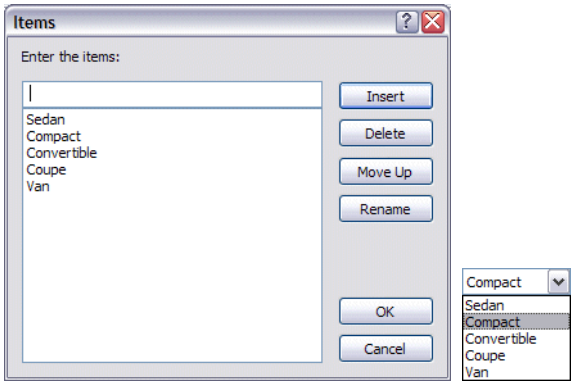


Add a Drop-down List

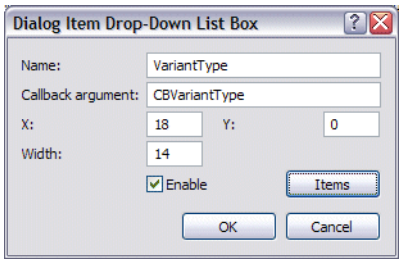
The user can select a single item from the drop-down list. When it is closed, it displays the current value. When the user clicks the down arrow, it opens and displays more items for changing the value.

To add it to your dialog:

- Right-click in the tab Elements and select New Drop-Down List Box.
- Enter the Name of the drop-down list. A *Method* object can call this dialog item using the Name you entered.
- Enter the Callback argument, which will be passed to the callback method.
- Enter the X-coordinate and the Y-coordinate of the drop-down list box in the *Dialog*.
- Enter the Width of the drop-down list in the average width of characters of your system font. The default value of 0 sets the width to the values defined by us.
- Click Items and enter the items, which the list box shows, into the dialog Items.
  - To add an item to the list field, enter its name into the text box and click Insert or press the Enter key.
  - Repeat this for all the items you want to add.
  - To delete an item from the list, select it in the list field and click Delete.
  - To move an item up one position in the list, select it in the list field and click Move Up.
  - To change the name of an item in the list, select it in the list field, type another name into the text box, and click Rename.
  - To apply the items you entered and to close the dialog, click OK.
  - To discard what you have done so far, click Cancel.



- Select if you want to Enable the drop-down list box or not.
- To insert the dialog item into your dialog, click OK.



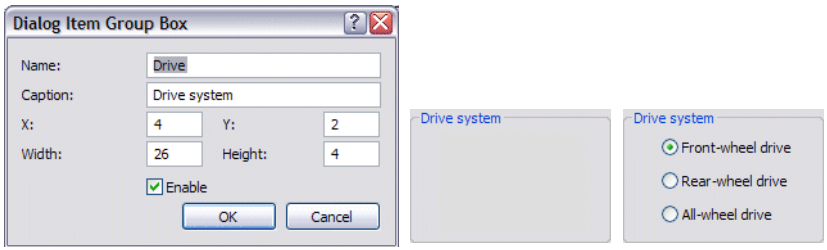
Add a Group Box Around Dialog Items

A group box graphically groups a set of dialog items or controls by drawing a frame around it. When you want to **group** dialog items, first create the group and then insert and position the individual items within that group. Note that the y-coordinate you enter for items within a group relate to the y-coordinate within that group, not within the overall dialog.

To add a group box to your dialog:

- Right-click in the tab Elements and select New Group Box.
- Enter the Name of the group box. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption, which the group box displays. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks.
- Enter the X-coordinate and the Y-coordinate of the group box in the *Dialog*.
- Enter the Width and the Height of the group box in the average width of characters of your system font. The default value of 0 sets the width to the values defined by us.

- Select if you want to Enable the group box or not.
- To insert the dialog item into your dialog, click OK.



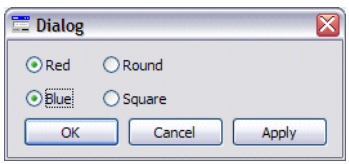
- To change the order of the items within a group, select an item within the group on the tab Elements, hold down the Shift key and press the Up arrow to move this item up or press the Down arrow to move this item down.

Add a Set of Radio Buttons

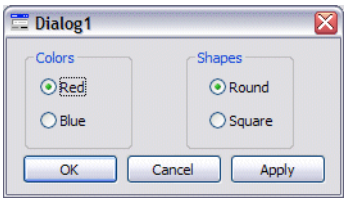
A set of radio buttons allows the user to select a single setting from a fixed set of choices that exclude each other. To add it to your dialog:

- Right-click in the tab Elements and select New Radio Button.
- Enter the Name of the radio button. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption that describes what the radio button does and that the *Dialog* shows. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks.
- Enter the Callback argument, which will be passed to the callback method.
- Enter the X-coordinate and the Y-coordinate of the radio button in the *Dialog*.
- Enter a group id, i.e., a number, for grouping any number of radio buttons to denote which radio buttons belong together. Group ID 1 might stand for one set of radio buttons, while Group ID 2 might stand for another set. The user can only select one radio button of a group at a time.

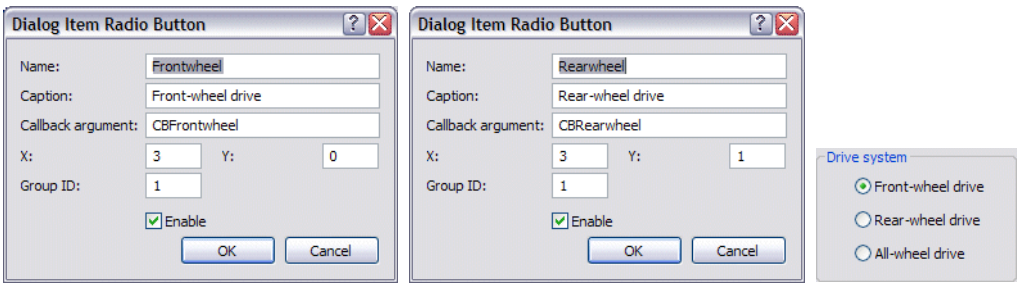
  Note: You have to create all elements of a group of radio buttons sequentially because *Plant Simulation* creates the elements according to their line and column position.You cannot arrange two sets of radio buttons as shown below, where the radio buttons Red and Blue on the left hand side and the radio buttons Round and Square on the right hand side form a group each. Windows ignores the Group ID you enter and groups the radio buttons line by line according to the Y-coordinate, i.e. it treats Red and Round are one group and Blue and Square as the other group.



If you want to model like this, do not place the radio buttons loosely onto the dialog, but group them within group boxes.



- Select if you want to Enable the radio button or not.
- To insert the dialog item into your dialog, click OK.
- Repeat these steps to add additional radio buttons.



Add a Check Box

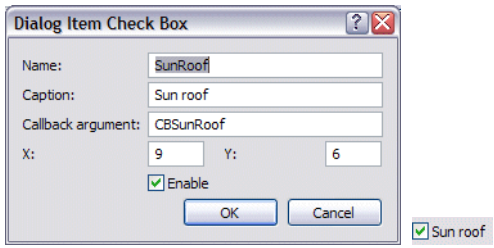
A check box displays a setting or a set of settings that do not exclude each other. The user can select or clear one or several check boxes at the same time. To add it to your dialog:

- Right-click in the tab Elements and select New Check Box.
- Enter the Name of the check box. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption that describes what the check box does. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks.
- Enter the Callback argument, which will be passed to the callback method.
- Enter the X-coordinate and the Y-coordinate of the check box in the *Dialog*.

  The position corresponds to the average width of characters of your system font, not to pixels. Changing the font size under Start > Settings > Control Panel > Display > Settings > Advanced > General > Font Size, affects this setting.

  Note: If you cannot see a dialog item after you inserted it, check the settings for the position first. If you entered identical values for different dialog items, the *Dialog* places them on top of each other, so that you can only see the first item(s) you inserted.

- Select if you want to Enable the check box or not.
- To insert the dialog item into your dialog, click OK.



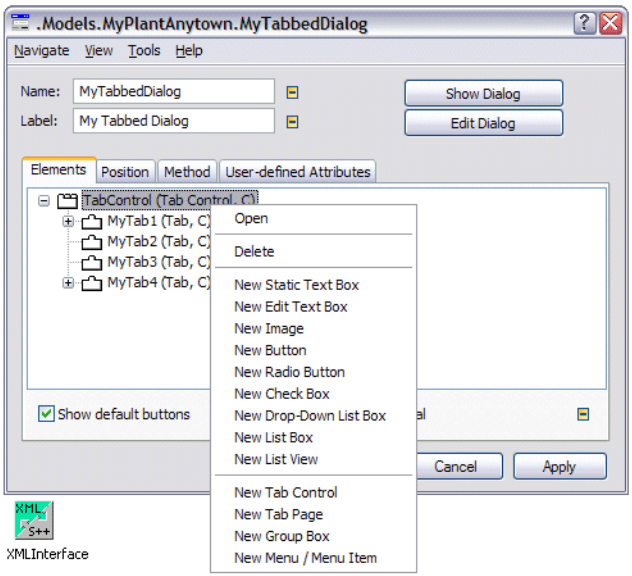
Design a Tabbed Dialog

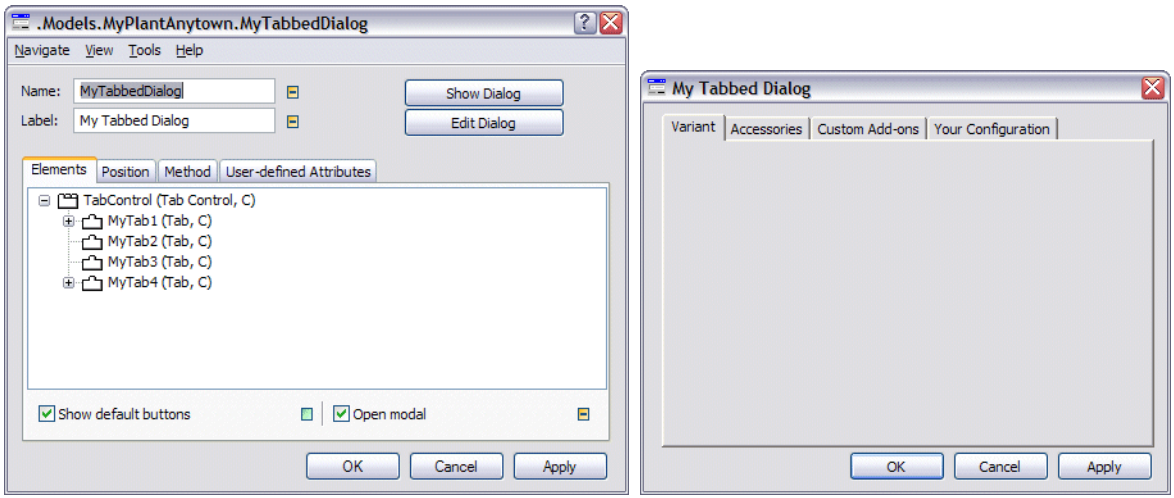
When you want the user to select or to enter several different types of information, you will create a tabbed dialog.

When you only need the user to select or to enter a small number of items, you can present them directly in the dialog in a flat structure, compare *Design a Simple Dialog*.

To start designing your own dialog:

- Insert the *Dialog* into the *Frame* in which your are creating your simulation model. You can do this from the folder UserInterface in the *Class Library* or from the tab User Interface in the *Toolbox*.
- Enter a name and a label into the respective text boxes. As opposed to the name, you can enter any term of your choice as the label. This includes special characters and blank spaces.
  - If you enter a label, *Plant Simulation* shows that label in the title bar of your dialog.
  - If you do not enter text for the label, *Plant Simulation* shows the Name of the *Dialog* object in the title bar.
- To insert a dialog item, right-click in the tab Elements and select a dialog item on the context menu.



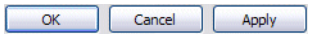


- To modify an existing dialog item, right-click it and select **Open** on the context menu. This opens the dialog of the **Dialog Item** where you can change it.
- To delete a dialog item, right-click it and select **Delete** on the context menu.
- To show the dialog you are creating, click Show Dialog.

- To change the position of a dialog item in the dialog you are creating, first click Show Dialog and then click Edit Dialog. Select the dialog item you want to move

and drag the mouse to a new location. This way you can, for example, roughly re-position an existing dialog item and then enter the exact coordinates to place it exactly where you want it to be.

  Note: The *Dialog* applies the changed coordinates immediately. Once you have moved an item, you cannot undo the move action. To restore the previous settings, you have to re-enter them into the respective dialog.

- To show the default buttons 

in the dialog you are creating, select the check box. To hide these buttons, clear the check box.

  If you do not show this button combination, you have to define your own buttons to provide the user with a way to apply or to discard settings he chose.

- To open the dialog window you are creating modal, select Open modal. Then the user cannot open any other *Plant Simulation* windows until he has completed interacting with the user-defined dialog and closed it.

  To allow the user to open other dialog windows, in addition to the user-defined dialog you are creating, clear the check box.

- To define the position at which the *Dialog* opens on your computer's screen, click the tab Position and enter the X-position and the Y-position in pixels into the text boxes. The default setting `-1` for both X-position and for Y-position centers the *Dialog* on screen. The zero point is located in the left top corner of the screen.

Add a Tab Control

When you are going to create a tabbed dialog, you will first have to create the tab control. The tab control resembles a notebook that contains any number of pages (tabs). The user can navigate between different tabs and/or sections of information within the dialog window.

Note: Do not confuse the tab control with the tabs themselves. The tab control is the container that holds the individual tabs (pages).

When the user selects another tab, the *Dialog* calls the *Callback method*, which in turn executes the actions you programmed with the first argument you entered as Callback argument.

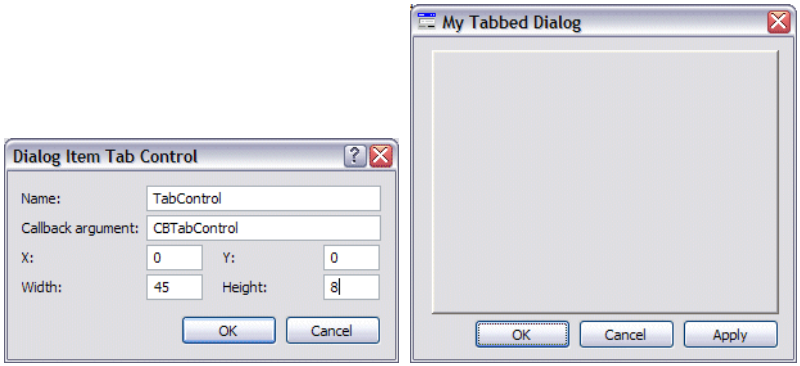
To add it to your dialog:

- Right-click in the tab Elements and select New Tab Control.
- Enter the Name of the tab control. A *Method* object can call this dialog item using the Name you entered.
- Enter the Callback argument, which will be passed to the callback method.
- Enter the X-coordinate and the Y-coordinate of the tab control in the *Dialog*.

  The position you enter corresponds to the average width of characters of your system font, not to pixels. Changing the font size under Start > Settings > Control Panel > Display > Settings > Advanced > General > Font Size, affects this setting.

- Enter the width and the height of the tab control in the *Dialog*. The default value of 0 sets the height and the width to the values defined by us.

- To insert the **tab control** into your dialog, click OK.



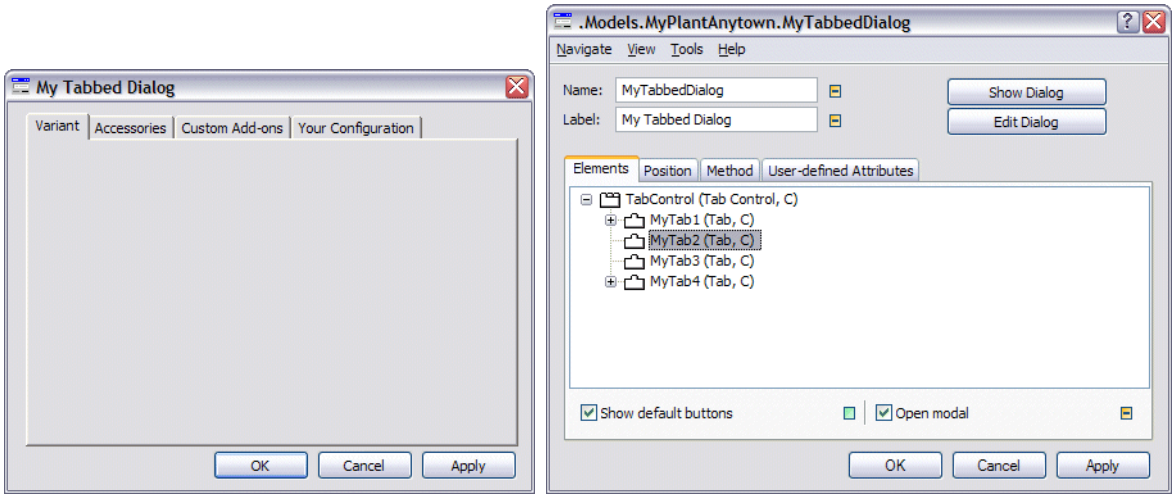
- To add one **tab** at the time to the **tab control**, click it with the right mouse button on the tab Elements and select on the context menu.
- To change the order of the tabs in the dialog, select a tab on the tab Elements, hold down the Shift key and press the Up arrow to move this tab to the left or press the Down arrow to move this tab to the right. The dialog shows the first tab in the structure as the leftmost tab.

Add Tabs to a Tab Control

To add one **tab** at the time to the **tab control**:

- Right-click in the tab Elements and select New Tab Control
- Enter the Name of the tab into the dialog Dialog Item Tab Page. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption of the tab. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks. The tab on the tab control shows this caption as the title on the tab itself.
- To insert the dialog item into your dialog, click OK.

- To change the order of the tabs in the dialog, select a tab on the tab Elements, hold down the Shift key and press the Up arrow or the Down arrow to move this tab to the left or to the right. The dialog shows the first tab in the structure as the leftmost tab.

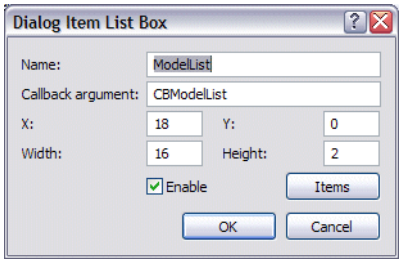


Add a List Box

A list box displays a list of choices. The user can double-click one of the items in the list to select it. As opposed to the drop-down list box, the list box has a fixed size and does not collapse.

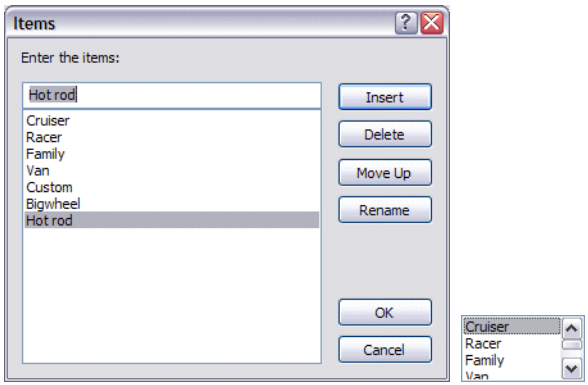
To add it to your dialog:

- Right-click in the tab **Elements** and select **New List Box**.
- Enter the **Name** of the list box. A *Method* object can call this dialog item using the **Name** you entered.
- Enter the **Callback argument**, which will be passed to the callback method.
- Enter the **X**-coordinate and the **Y**-coordinate of the list box in the *Dialog*.
- Enter the **width** and the **height** of the list box in the *Dialog*. If you do not enter values, the *Dialog* sets the width and height to the values defined by us. When you enter a value for the height, it adds a vertical scrollbar to the list, when the list contains more items than the height.



- Click **Items** and enter the items the list box displays in the dialog **Items**.
  - To add an item to the list field, enter its name into the text box and click **Insert** or press the **Enter** key.

- Repeat this for all the items you want to add.
- To delete an item from the list, select it in the list field and click Delete.
- To move an item up one position in the list, select it in the list field and click Move Up.
- To change the name of an item in the list, select it in the list field, type another name into the text box, and click Rename.
- To apply the items you entered and to close the dialog, click OK.
- To discard what you have done so far, click Cancel.



- Select if you want to Enable the list box or not.
- To insert the dialog item into your dialog, click OK.

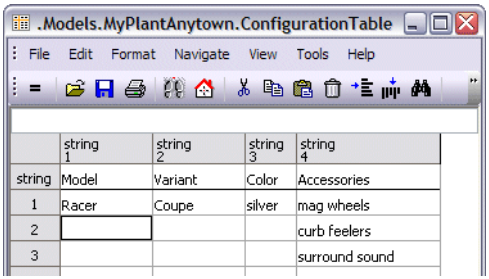
Add a List View

A list view displays a set of objects in a table-like format. To add it to your dialog:

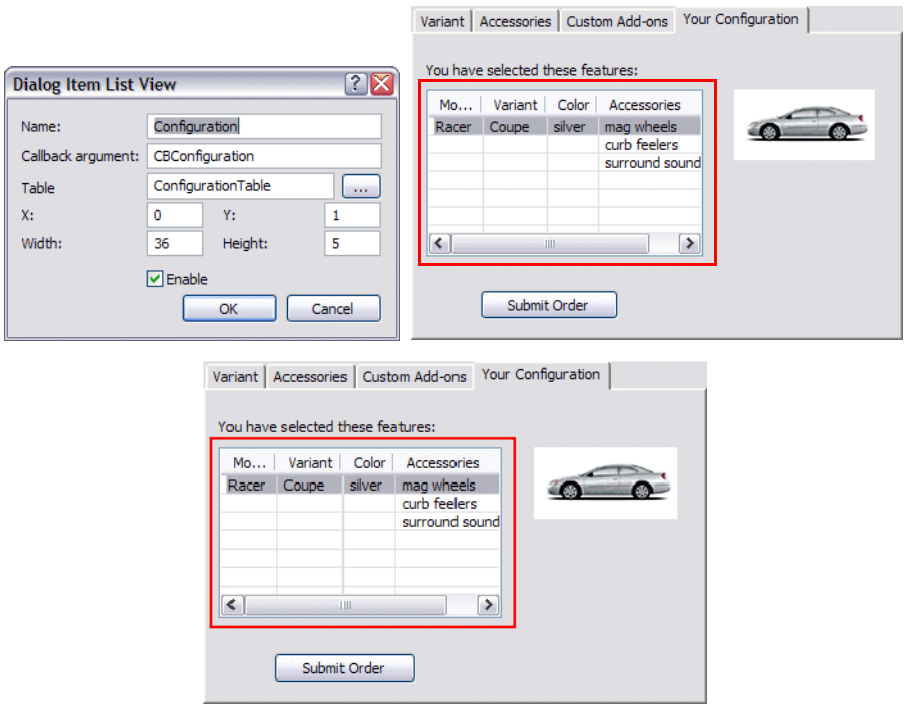
- Right-click in the tab Elements and select New List View.
- Enter the Name of the list view. A *Method* object can call this dialog item using the Name you entered.
- Enter the Callback argument, which will be passed to the callback method.
- Enter the contents of the header row and the contents of the rows in the list view into a Table. When the user double-clicks a row to select it, the *Dialog* calls the *Callback method*, which in turn executes the actions you programmed in the first argument you specified as Callback argument.

  Note: You can only select rows, but no columns or individual cells.

  - Enter the name of a table or click the button and select a table in the dialog Select Object.
  - Activate the column index in the *TableFile* and enter the column headings the list view shows into the header cells.
  - Enter the items the list view shows into the cells of the columns.



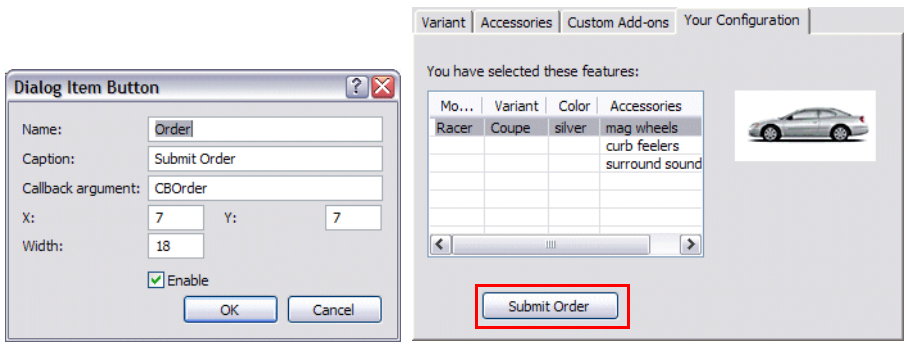
- Enter the X-coordinate and the Y-coordinate of the list view in the *Dialog*.
- Enter the width and the height of the list view in the *Dialog*.
- Select if you want to Enable the list view or not.
- To insert the dialog item into your dialog, click OK.



Add a Button

When the user clicks a button, it calls the *Callback method* with the argument you entered into the text box Callback argument. It in turn executes the actions you programmed. To add it to your dialog:

- Right-click in the tab Elements and select New Edit Text Box.
- Enter the Name of the button. A *Method* object can call this dialog item using the Name you entered.
- Enter the Caption, which the button displays. A caption is especially handy if you develop application object libraries in several languages and want the user to be able to switch languages. In addition you can enter special characters and blanks.
- Enter the X-coordinate and the Y-coordinate of the button in the *Dialog*.
- Enter the width of the button in the *Dialog*. The default value of 0 automatically sets the width of the button to the width of the OK button.
- Select if you want to Enable the button Submit Order or not Submit Order.
- To insert the dialog item into your dialog, click OK.



Add an Image

An image is a picture, i.e., an icon you defined for the object *Dialog*. You can enter a number, or a name, such as `Icon1`. To add it to your dialog:

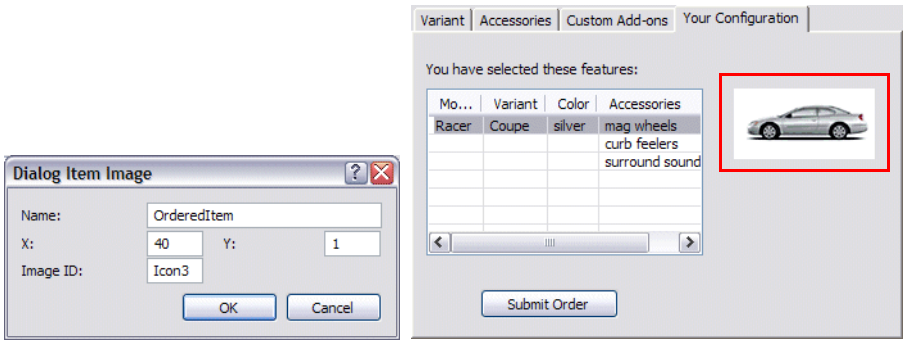
- Right-click in the tab Elements and select New Image.
- Enter the Name of the image. A *Method* object can call this dialog item using the Name you entered.
- Enter the X-coordinate and the Y-coordinate of the image in the *Dialog*.

Note:

- Enter the width and the height of the image in the *Dialog*.
- Enter an Image ID, i.e., the number of the icon, or an image name. This image is an icon of the *Dialog*.
- To insert the dialog item into your dialog, click OK.

Note: *Plant Simulation* shows the dialog with the settings you select under Display Properties > Appearance > Font size as well as with the Font and the Size you can select, when you click Advanced. When you change these settings, the dialog scales text, while the images always retain their size in pixels. For this reason it can hap-

pen that text overlaps the image. We recommend to test your dialogs with different display settings to make sure that everything works as you expect it.



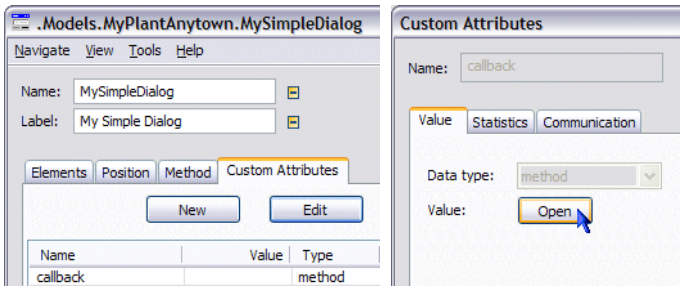
Program Actions which the Dialog Items Execute

During or after you inserted the dialog items you need, you will have to program the actions, which these dialog items execute, when the user enters or selects a setting. For this you have to enter the respective instructions into a callback method.

- By default the callback method is a user-defined attribute of type *method* named `self.callback`. In most cases you will use that.

  To open the default callback method, do one of the following:

  - On the tab Method, click into the text box Callback method and press F2 or by hold down Shift and double-click callback.
  - On the tab User-defined Attributes, double-click callback and then click Open in the dialog User-defined Attributes.



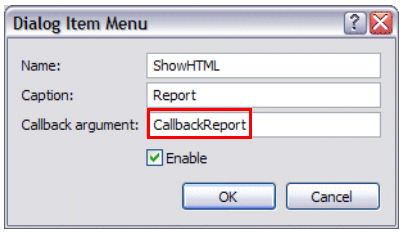
- If your modeling needs warrant it, you can also use a method, which you inserted into a *Frame* or into a folder in the *Class Library*. This will be the case, when several of your dialogs, which do not inherit items, can use the same callback method and, for this reason, have to store the method at a single location.

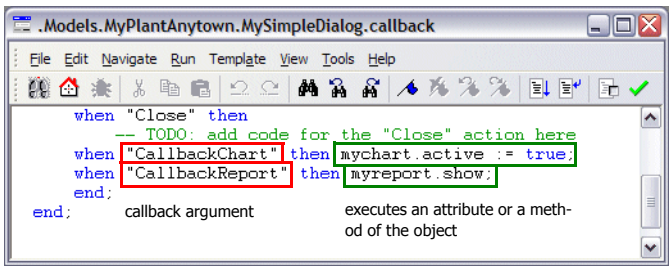
Enter the Callback argument for each of the dialog items into this method and type in the instructions (source code) you want it execute. This argument is the same argument that you entered into the dialogs of the individual dialog items. Be aware that the arguments are case-sensitive! The methods and the attributes of the *Dialog* enable you to program callback actions with as much complexity as you need.

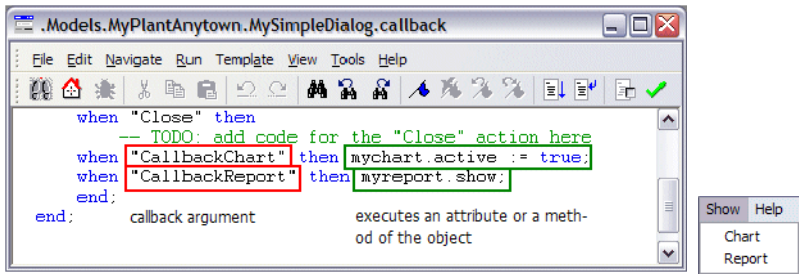
The callback method executes the callback argument when the user:

- Closes a drop-down list box.
- Selects and double-clicks an item in a list box.
- Changes the contents of a text box and selects another dialog item afterwards, clicks in another text box, or clicks OK, Apply or Cancel.
- Clicks a button.
- Selects or clears a check box.
- Selects a radio button.
- Selects a row in a list view and double-clicks it.
- Selects a tab in a tab control.
- Selects a menu or a menu command.

Compare this example:





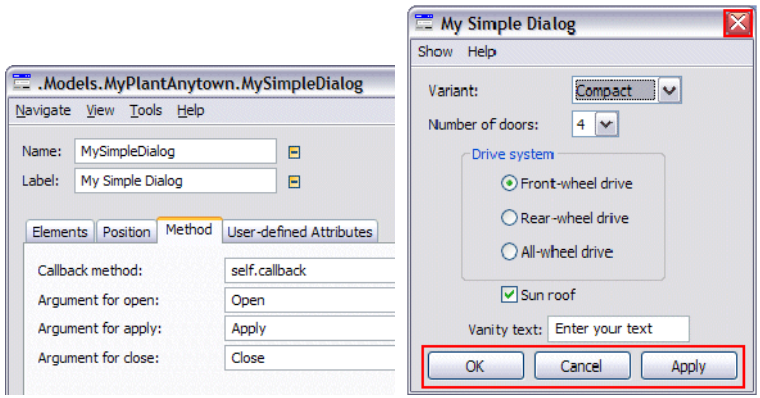


To open the object *MyChart*, we entered: `when "CallbackChart" then mychart.active := true;`

To open the object *MyReport*, we entered: `when "CallbackReport" then myreport.show;`

Program Actions for Interacting with the Dialog

After you created your dialog, you will have to program what happens, when the user opens the dialog, when he applies settings, and when he closes it. Enter these actions as callback arguments into the *Callback method*.



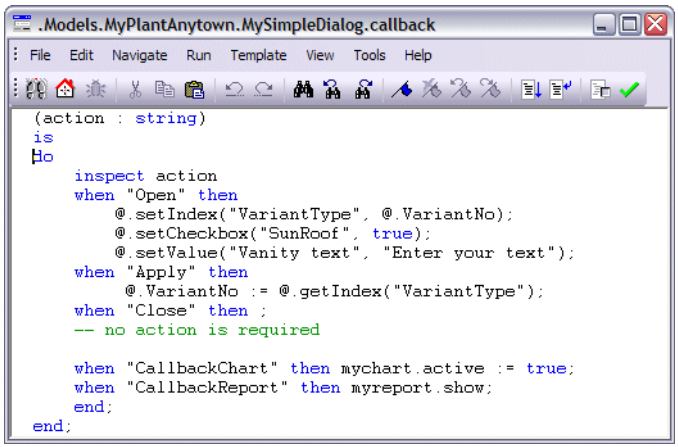
- The *Dialog* executes the Open section of the *callback* method when the user opens the dialog. It initializes the contents of the dialog window or sets the dialog items to values of your choice.
- The *Dialog* executes the Apply section of the *callback* method, when the user clicks OK or Apply in the *Dialog*. The instructions you enter may evaluate new or changed values.

  Note: When the user clicks OK, the *Dialog* executes the *callback* method twice. The first time it calls the Apply section. The second time it calls the Close section. When the user clicks Apply, the *Dialog* only executes the Apply section of the *callback* method.

- The *Dialog* executes the Close section of the *callback* method, when the user clicks Cancel in the *Dialog* or when he closes it with Close on the title bar.

For our sample dialog we started defining the settings shown below. When the user opens the dialog, *Plant Simulation* sets the variant of the car to the number of the user-defined attribute *VariantNo*. It selects the check box for the

sun roof and it prompts the user to enter vanity text he wants added to his paint job. Naturally, you can preallocate as many values as you want.



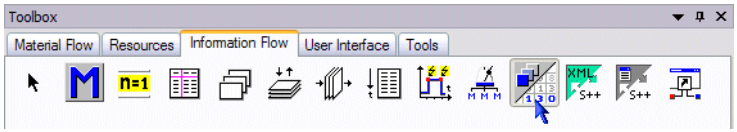
Set Parameters with the AttributeExplorer

Instead of opening the dialog of each and every material flow object in your model and entering values for a single attribute or for a number of attributes into the text boxes, you can define which attributes of which objects the *AttributeExplorer* gets and shows in a list window, when you click Show Explorer.

This way you can manage the attributes defining the settings of the individual stations in your simulation model at a single location. You can then enter different values for the capacities, the times, etc. *Plant Simulation* writes these values back to the dialogs of the objects and uses them in your simulation model. You can also export this settings table as a tab-delimited text file and import this file into the *AttributeExplorer* of another simulation model, thus using identical settings in several of your simulation models.

You can also use the *AttributeExplorer* to find objects of the type you define, to find attributes, for example the position of a number of objects, to align them in the *Frame*, etc.

You can insert the *AttributeExplorer* into your simulation model from the folder InformationFlow in the *Class Library* or from the tab Information Flow in the *Toolbox*.



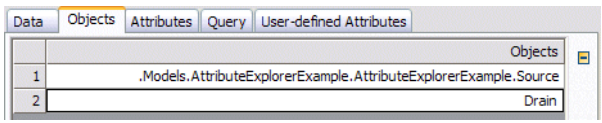
Depending on what you would like to accomplish, you will:

- *Enter the Objects You Want to Parameterize*
- *Enter the Attributes You Want to View or Change*
- *Select How to Show the Objects and the Names*
- *Find Objects and Attributes*

Enter the Objects You Want to Parameterize

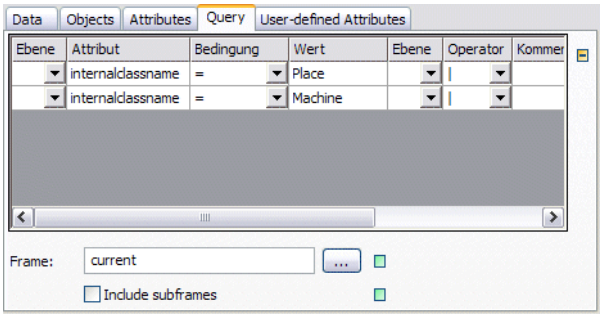
Before you can enter data, click the toggle button Inheritance so that it looks like this .

- To view or to edit the attributes of an object, drag that object from the *Frame* window over tab Objects in the open dialog of the *AttributeExplorer* and drop it there. *Plant Simulation* enters the absolute path to and the name of the object into the selected cell of the list.
- To just enter the name of the object, drag that object from the *Frame* window over the icon of the *AttributeExplorer* and drop it there.

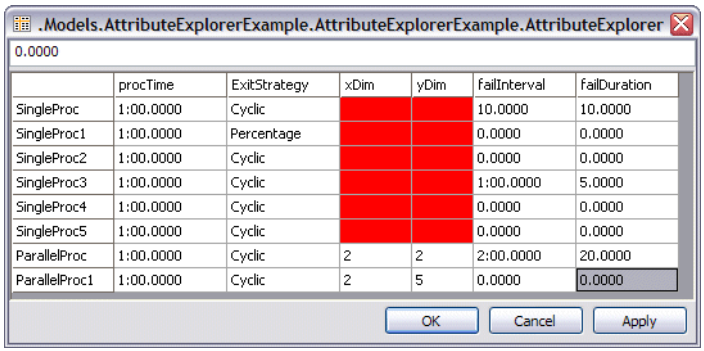


- To view or to edit the attributes of **all objects of one class**, click the tab Query and enter `internalclassname` as the Attribute and the actual internal class name of the object as the Value of the object there.

  Note: For the built-in objects, the method *internalClassName* returns the unique name that describes the type of the object.



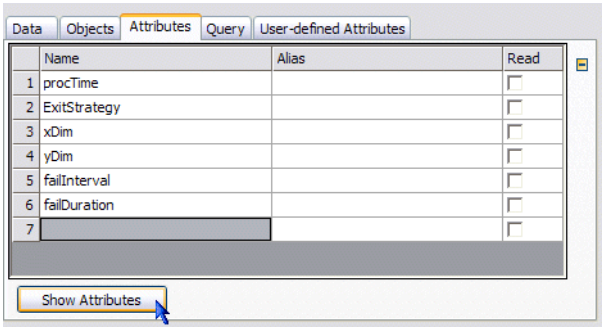
- To show what you have defined, click Show Explorer.



Enter the Attributes You Want to View or Change

Before you can enter data, click the toggle button **Inheritance** so that it looks like this ▫.

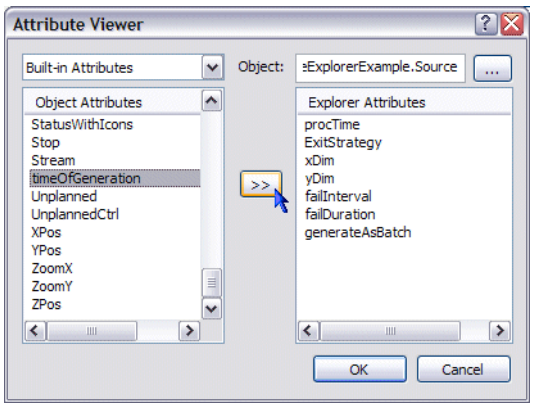
To enter the names of the attributes whose values you want to edit or view into the cells in the column **Name**, click **Attribute Viewer**.



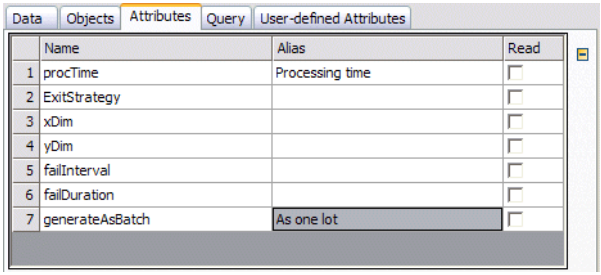
In the dialog **Attribute Viewer**:

- Click ... to enter the path to and the name of the **Object** whose attributes you want to show.

  Select the **Object**, whose attributes you want to show, in the dialog **Select Object**.
- Select from the drop-down list if you want to view the **Built-in Attributes** of this object, or its **User-defined Attributes**, which you, or a co-worker defined. The *AttributeExplorer* then displays these attributes in the left hand list box.
- Select a single, or several contiguous attributes (**Shift+click**), and click this >> to add these attributes to the attributes to be shown in the right hand pane.
- Click **OK** to add these attributes to the list, which the *AttributeExplorer* displays, on the tab **Attributes**.



If the predefined name of an attribute is not meaningful enough for your purposes, you can enter a descriptive term for that attribute that suits your modeling situation into the corresponding cell in the column Alias.



If you want an attribute to be read only, click into the cell Read. Then, you can just view, but not edit that value in the list that the button Show Explorer opens.

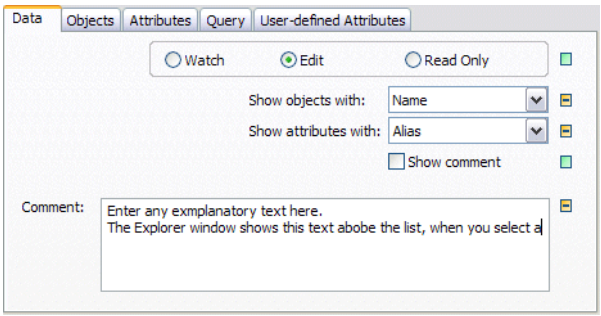
Plant Simulation displays the background of the cells in different colors to show if the attribute is observable or not.

blue	the attribute is not observable.
white	the attribute is observable.
gray	you entered a wrong name for a built-in attribute.

To manipulate the contents of the list, use the commands on the *Context Menu of Embedded Lists*.

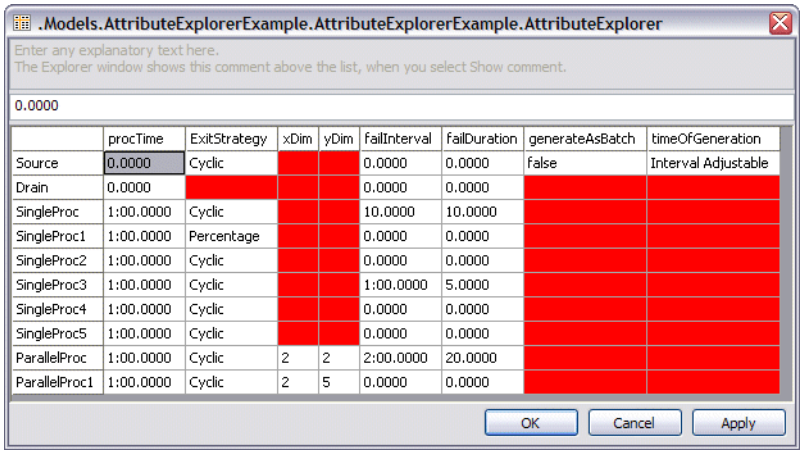
Select How to Show the Objects and the Names

You can only change the settings, when the toggle button Inheritance is deselected .



Select what you want to do with the attributes you added to the *AttributeExplorer*:

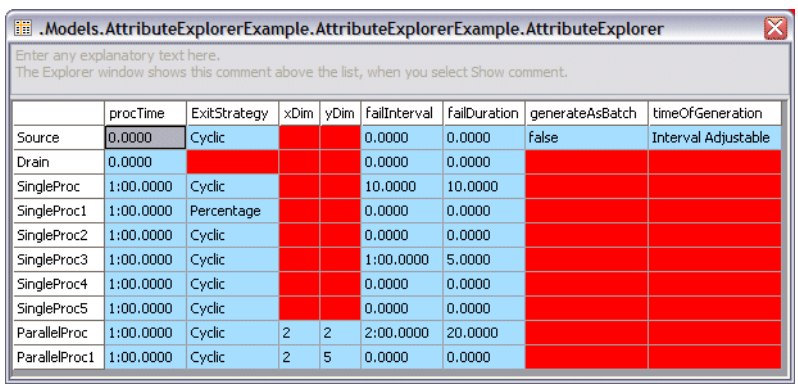
- To allow you to edit the values of the attributes of any one of the stations you entered, select Edit . Then, click Show Explorer, click in any of the cells that are not grayed out, and enter another value. *Plant Simulation* writes the values you changed back to the dialogs of the objects, when you click Apply/OK.



	procTime	ExitStrategy	xDim	yDim	failInterval	failDuration	generateAsBatch	timeOfGeneration
Source	0.0000	Cyclic			0.0000	0.0000	false	Interval Adjustable
Drain	0.0000				0.0000	0.0000		
SingleProc	1:00.0000	Cyclic			10.0000	10.0000		
SingleProc1	1:00.0000	Percentage			0.0000	0.0000		
SingleProc2	1:00.0000	Cyclic			0.0000	0.0000		
SingleProc3	1:00.0000	Cyclic			1:00.0000	5.0000		
SingleProc4	1:00.0000	Cyclic			0.0000	0.0000		
SingleProc5	1:00.0000	Cyclic			0.0000	0.0000		
ParallelProc	1:00.0000	Cyclic	2	2	2:00.0000	20.0000		
ParallelProc1	1:00.0000	Cyclic	2	5	0.0000	0.0000		

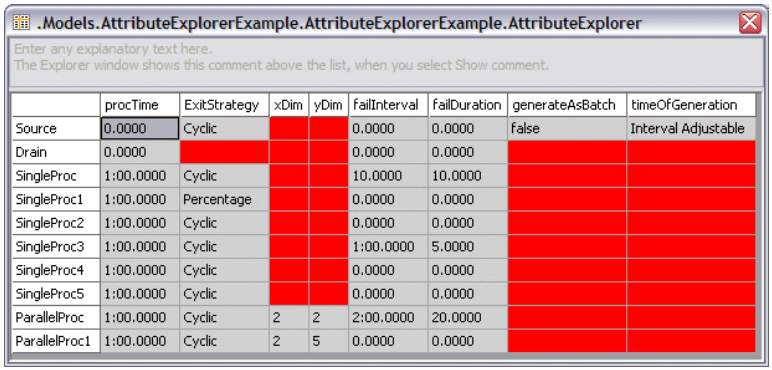
- To display the values of the observable attributes of any of the stations you entered, select Watch . Then, click Show Explorer. You will notice that you can only view the values, but not edit them. *Plant Simulation* displays the background of the cells in different colors to show if the attribute is observable or not.

blue	the attribute is not observable.
white	the attribute is observable.
gray	you entered a wrong name for a built-in attribute.



	procTime	ExitStrategy	xDim	yDim	failInterval	failDuration	generateAsBatch	timeOfGeneration
Source	0.0000	Cyclic			0.0000	0.0000	false	Interval Adjustable
Drain	0.0000				0.0000	0.0000		
SingleProc	1:00.0000	Cyclic			10.0000	10.0000		
SingleProc1	1:00.0000	Percentage			0.0000	0.0000		
SingleProc2	1:00.0000	Cyclic			0.0000	0.0000		
SingleProc3	1:00.0000	Cyclic			1:00.0000	5.0000		
SingleProc4	1:00.0000	Cyclic			0.0000	0.0000		
SingleProc5	1:00.0000	Cyclic			0.0000	0.0000		
ParallelProc	1:00.0000	Cyclic	2	2	2:00.0000	20.0000		
ParallelProc1	1:00.0000	Cyclic	2	5	0.0000	0.0000		

- To just show the values of the attributes of the stations you entered, select Read only . Then, click Show Explorer. You will notice that you can only view the values, but not edit them.


.Models.AttributeExplorerExample.AttributeExplorerExample.AttributeExplorer

Enter any explanatory text here.
The Explorer window shows this comment above the list, when you select Show comment.

	procTime	ExitStrategy	xDim	yDim	failInterval	failDuration	generateAsBatch	timeOfGeneration
Source	0.0000	Cyclic			0.0000	0.0000	false	Interval Adjustable
Drain	0.0000				0.0000	0.0000		
SingleProc	1:00.0000	Cyclic			10.0000	10.0000		
SingleProc1	1:00.0000	Percentage			0.0000	0.0000		
SingleProc2	1:00.0000	Cyclic			0.0000	0.0000		
SingleProc3	1:00.0000	Cyclic			1:00.0000	5.0000		
SingleProc4	1:00.0000	Cyclic			0.0000	0.0000		
SingleProc5	1:00.0000	Cyclic			0.0000	0.0000		
ParallelProc	1:00.0000	Cyclic	2	2	2:00.0000	20.0000		
ParallelProc1	1:00.0000	Cyclic	2	5	0.0000	0.0000		

- Select how you want to **show the objects** in the *Explorer* window in the leftmost column:
  - With their entire **Path**:

	procTime	ExitStrategy
.Models.AttributeExplorerExample.AttributeExplorerExample.Source	0.0000	Cyclic
Drain	0.0000	
*.Models.AttributeExplorerExample.AttributeExplorerExample.SingleProc	1:00.0000	Cyclic

Note: We dragged the *Source* from the *Frame* window over tab **Data** in the open dialog of the *AttributeExplorer* and dropped it there. This entered its absolute path. We dragged the *Drain* from the *Frame* window over the icon of the *AttributeExplorer* and dropped it there. This entered its name only.

  - With their **Name** only:

	procTime	ExitStrategy
Source	0.0000	Cyclic
Drain	0.0000	
SingleProc	1:00.0000	Cyclic

  - With their **Label** only:

	procTime	ExitStrategy
Receiving	0.0000	Cyclic
Shipping	0.0000	
Lathe	1:00.0000	Cyclic
	1:00.0000	Percentage
Drill9m	1:00.0000	Cyclic

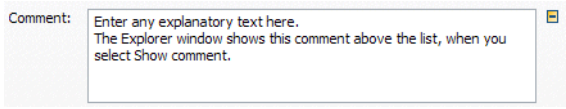
- Select how you want to **show the attributes** in the *Explorer* window:
  - With their **Name**.

	procTime	ExitStrategy
Source	0.0000	Cyclic
Drain	0.0000	
SingleProc	1:00.0000	Cyclic

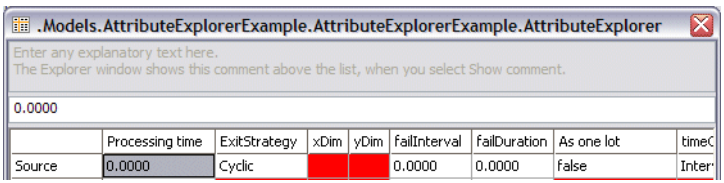
  - With their **Alias**. Note that you enter the alias on the tab **Attributes**.

	Processing time	ExitStrategy	xDim	yDim	failInterval	failDuration	As one lot	timeOfGeneration
Source	0.0000	Cyclic			0.0000	0.0000	false	Interval Adjustable
Drain	0.0000				0.0000	0.0000		

- If you want to, you can enter an explanation for the objects and values you defined into the text box. To create a line break, press Shift+Enter.

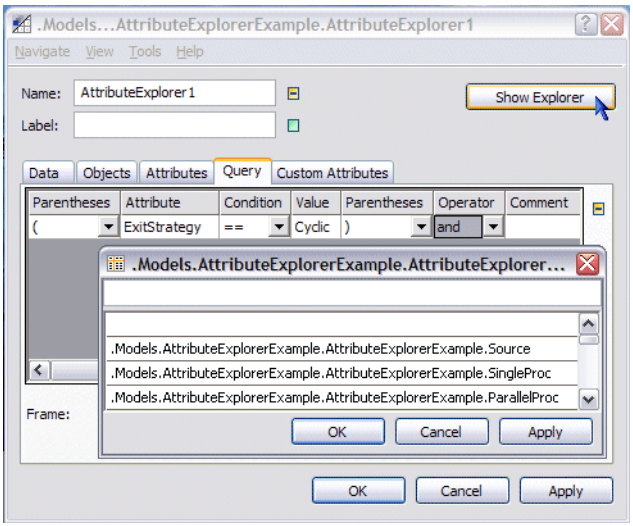


To display the text you entered above the list field in the *Explorer* window, select Show comment.

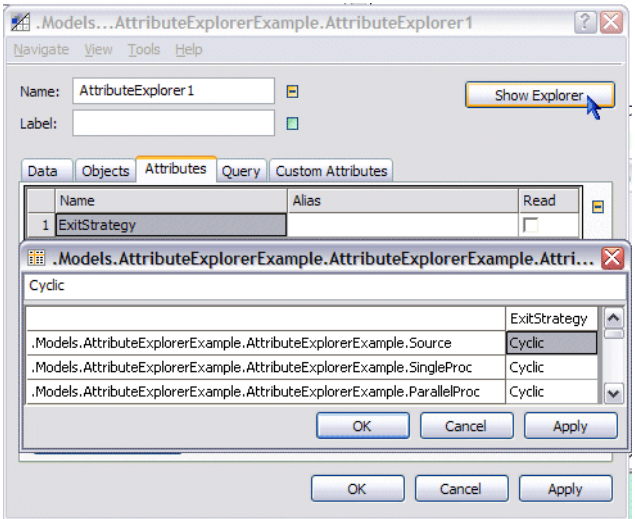


Find Objects and Attributes

You can also use the *AttributeExplorer* to find objects in your simulation model. First, enter the criteria into the cells of the list on the tab Query. Then, click Show Explorer. The *Explorer* window shows only the objects, which meet the search criteria you entered.



If you also want to change the attributes, enter their names on the tab **Attributes**. Then, click **Show Explorer**. Next to the objects the *Explorer* window now also shows the attribute, which you can also change, when you selected **Edit** on the tab **Data**.



You can:

- Select the number of opening **Parentheses** of the query.
- Enter the name of any of the attributes of the object, which the dialog Show Attributes and Methods displays.
- Click in the cell once with the left mouse button and select a **Condition** from the drop-down list. The value of the attribute can be:
  - **<** (less than)
  - **<=** (less than or equal to)
  - **>** (greater than)
  - **>=** (greater than or equal to)
  - **=** (equal to), compares attributes of data type *real*, *length*, *weight*, *speed*, and *time* for the exact value
  - **==** (equal to, case-insensitive) compares if strings are equal not considering lower and upper casing, or compares if the values of attributes are about equal
  - **/=** (not equal to)
  - **Expression**, which is a regular expression, compare Show Structure. You might, for example, enter `^Inf`, which finds any word beginning with `Inf`.
  - **Exists**, checks if the object has the designated attribute or not.

  Then enter the value into the corresponding cell in the column **Value**.

- Enter the Value of the attribute which the *AttributeExplorer* is to find.
- Select the number of closing Parentheses of the query.
- Click in the cell once with the left mouse button and select a boolean Operator from the drop-down list. This operator connects the boolean values of the active row with the next row. The boolean values result from evaluating the logical expression you defined in a row of the query table.
  - and
  - or
- Enter a Comment.
- Select the *Frame* in the dialog Select Object where you want to start finding the attributes of the objects.

  To also include any *Frames* that are located within the *Frame* you selected, select the check box Include subframes.

  Note: Select to show the objects with their path on the tab Data for this setting.

Modeling in the 3D Viewer

The *Tecnomatix Plant Simulation 3D Viewer* is an object-oriented modeling and visualization tool for displaying and animating an existing *Plant Simulation* 2D simulation model in three-dimensional space. Naturally, you can also start creating a model from scratch in the *3D Viewer*.

Note: The *3D Viewer* is not part of the *Plant Simulation* Standard License. You can upgrade the Standard License with a *3D Viewer* license though.

The *Plant Simulation 3D Viewer* is not a program of its own, but fully integrated into *Plant Simulation*. Once you start the *3D Viewer*, saving the *Plant Simulation* 2D model also saves the 3D part of the model to the same *.spp file. As you then cannot tell which *Plant Simulation* 2D model also contains a 3D part, we recommend to select the check box Save Preview in the dialog Save As, to save a snapshot of the active 3D viewer window. *Plant Simulation* also shows this graphic, when you open the model again, enabling you to see, which model has a corresponding 3D part.

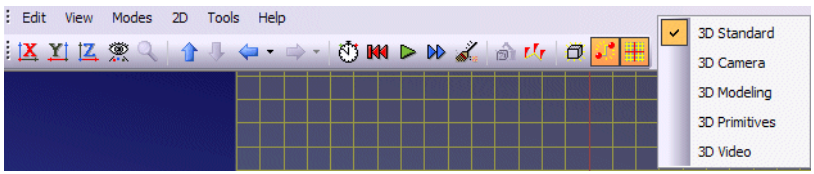
Note: In our description **2D model** refers to the *Plant Simulation* **2D part** of your simulation model, **3D model** refers to the *3D Viewer* **part**.

Create a Model in 3D

Tecnomatix Plant Simulation 2D and the *3D Viewer* are fully integrated. Both store data pertinent to their part of the model in the *spp* model file saved on disk, employing Microsoft's structured storage technology.

Note: We created our sample model with the built-in menus, menu commands, toolbars and viewers.

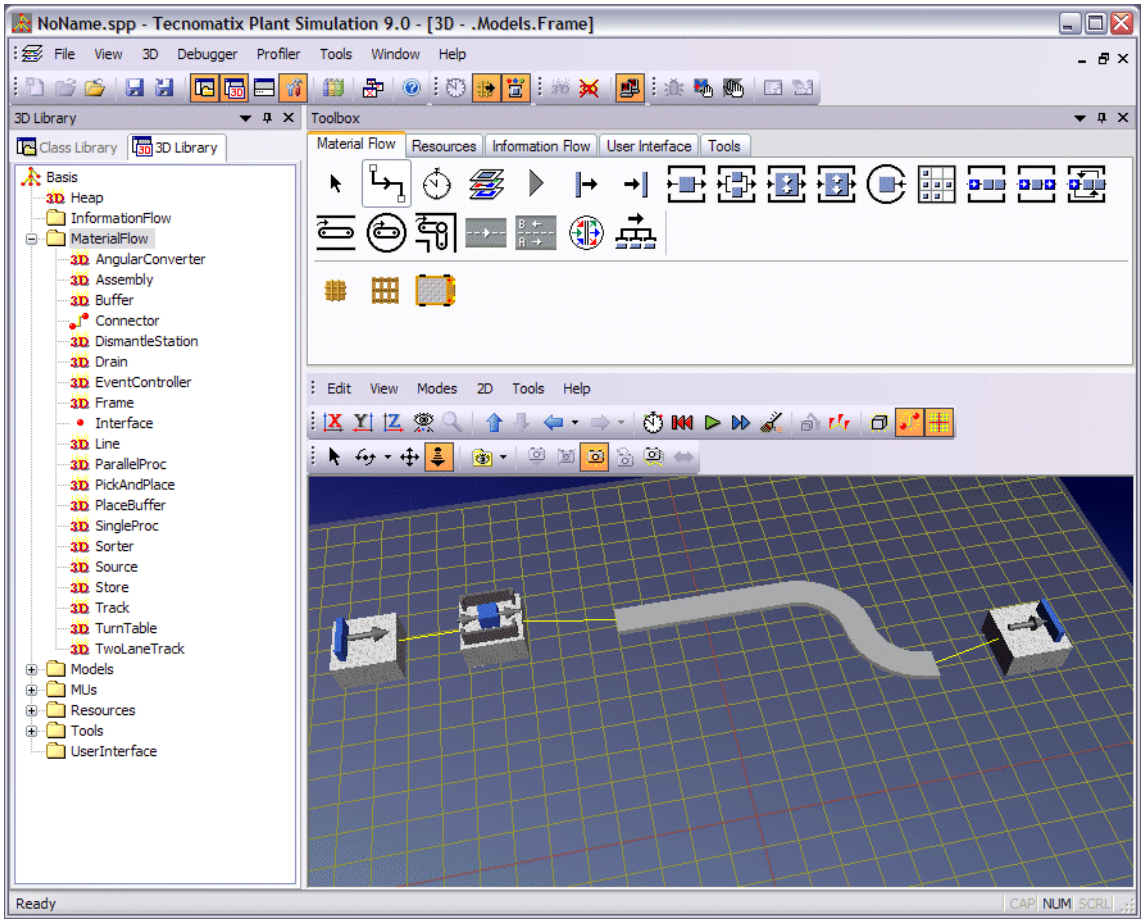
To show or hide additional 3D toolbars, right-click the gray area along the top of a 3D window and select the name of the toolbar you want to show or hide on the menu that opens.



To create a model in the *3D Viewer*, you will basically proceed as follows:

- To open a new *Plant Simulation* 2D model, click on the Standard toolbar, or select File > New.
- To start the *3D Viewer*, click on the 3D toolbar, or select 3D > Start 3D Viewer.

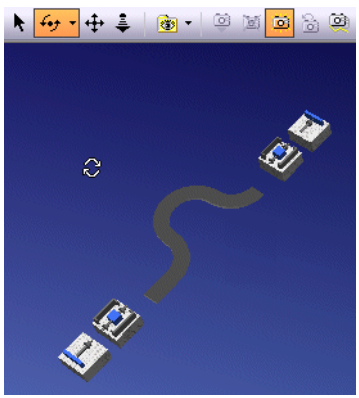
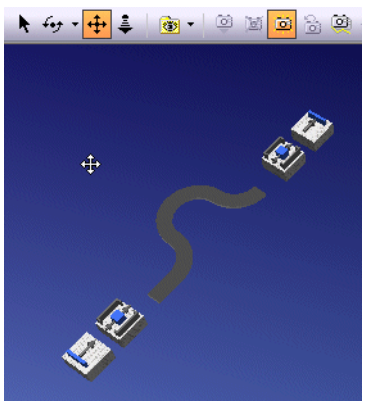
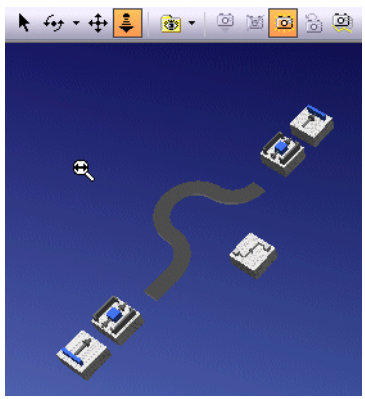
This shows the 3D Library and a new, empty *Frame* in the 3D scene window.



- To show the built-in 3D material flow objects and their graphics, you can, for example, right-click the folder MaterialFlow in the 3D Library and select Open > Active 3D Window or Open > New 3D Window.

  Using this technique, you can also show the contents of the other folders.

- To rotate, pan, or zoom the scene, click the respective button on the 3D Camera toolbar. Then, click into the scene window and drag the mouse.

Rotate scene	Pan scene	Zoom scene
		

To **rotate** the scene, click on the Rotate Scene button and select how the *3D Viewer* rotates the scene: Around the Scene, the Selection or Zoomed. Hold down the mouse wheel or the left mouse button and the right mouse button and drag the mouse.

- Rotate Scene > Scene rotates the scene around the center of the grid. Dragging the mouse up or down rotates the scene vertical. Dragging it left or right rotates the scene horizontal.
- Rotate Scene > Selection rotates the scene around the center of the selected object.

You can also rotate, pan, and zoom the scene with the mouse buttons and the mouse wheel, when you click Select .

To **rotate** the scene, hold down the right and left mouse button and drag the mouse.

To **pan** the scene left and right or up and down, hold down the right mouse button and drag the mouse. This moves the scene orthogonal to the view direction.

To **zoom** the scene, turn the mouse wheel or hold down the mouse wheel and drag the mouse.

Note: If you have a three-button mouse, click the middle mouse where the description calls for clicking the mouse wheel.

Note: If manipulating the scene with the mouse does not work, check the Mouse Properties for the Wheel in the Mouse Control Panel.

- To open a new 3D scene window, change to the 3D structure in the 3D Library. Then right-click the corresponding folder and select Open > Active 3D Window.
- To insert an object into the 3D scene window:
  - Click Select .
  - Click Grid , so that it is pressed , compare *Show and Hide the Grid*.

We recommend to show the grid before you insert an object into the scene window. This way you can place the object at the exact location, where you want it to be.

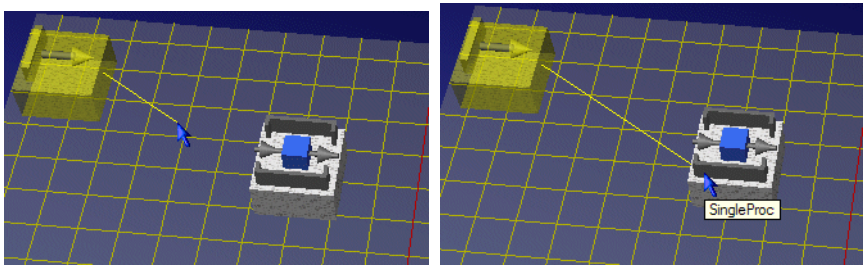
When you insert an object without displaying the grid, you have little control over where the *3D Viewer* places the object. By default it uses the same coordinates that the source object had, an effect you might not want.

- Select the object you want to insert in the *Toolbox* or in its folder in the 3D Library. Hold the mouse button down, drag the object to the location of your choice on the grid and drop it there.
- Insert a *Source*, a *Line*, a *SingleProc* and a *Drain*.

- To connect two objects:

  Note: The *3D Viewer* only inserts *Connectors* at the correct position, when the grid is active.

  - Click the *Connector* in the *Toolbox* on the tab MaterialFlow.
  - Click the source object, where the connection will start, once with the left mouse button. *Plant Simulation* attaches a yellow line symbolizing the *Connector* to the mouse pointer.



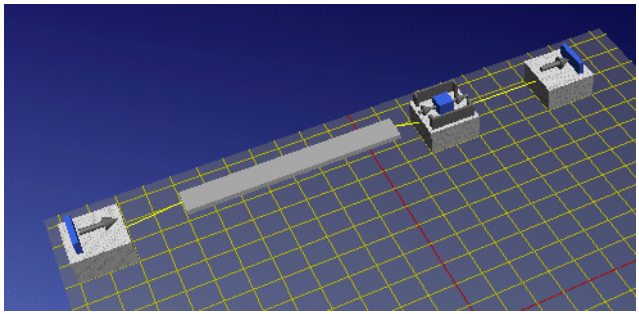
  - Drag the mouse to the destination object at which the connection will end, and click once with the left mouse button to establish the connection.

    The *3D Viewer* shows the *Connector* it inserted as a line between the connected *Interfaces* of the source and destination objects.
  - To terminate connect mode before you click the destination object, click the right mouse button or press Esc.

  To connect several objects one after the other, without interrupting the connecting process, hold down Ctrl.

  - Attach the outgoing connection to the first object.
  - Drag the mouse to the succeeding object.
  - Click the left mouse button to attach the incoming *Connector* to the successor.
  - You can also connect the objects in the 2D part of your model, which will simultaneously insert the connections into the 3D part, when you opened the *3D Viewer*.
  - To update the connections between objects, which you established with the object *Connector* in *Plant Simulation* 2D without the *3D Viewer* having been started, select 2D > 2D → 3D > Connections.
  - To show or hide connections in the scene window, click on the 3D Standard toolbar.

  Connect the *Source*, the *Line*, the *SingleProc* and the *Drain* you inserted above.



- Next, insert an *EventController*, either from the *Toolbox* or from the 3D Library.
- Finally, run the simulation:
  - Control the simulation by clicking the buttons on the 3D Standard toolbar

    or
  - Double-click the icon of the *EventController* and click its buttons.

About 3D Objects

The *3D Viewer* uses 3D graphics of objects. You can exchange these graphics for each object or you can load a complete, user-defined library with objects for your specific task before you start modeling. Although the *3D Viewer* provides elementary geometric shapes and basic modeling functions for creating primitive 3D graphics for an object, you will create 3D graphics for objects in dedicated programs, such as eM-Workplace NT, 3D Studio MAX, Factory CAD, etc.

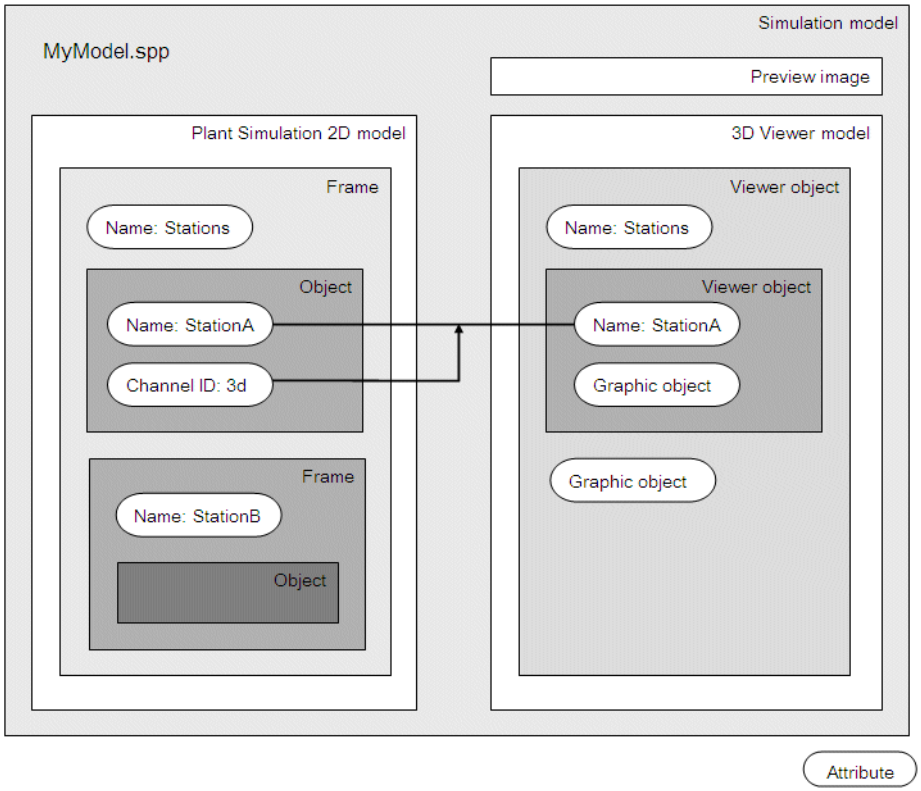
The *3D Viewer* differentiates between a **viewer object** and a **plain graphic object**.

- A plain graphic object is just that, namely a graphic.
- A viewer object has a number of attributes that describe its state. The graphic of the viewer object is one of these attributes.

  A viewer object is, as rule, connected to its corresponding object in *Plant Simulation* 2D via its name, provided it has a counterpart.

  Note: To show the plain graphics, right-click anywhere in the background in the 3D Library and select Display Plain Graphics on the context menu.

The 3D Library shows the complete structure of the *3D Viewer* objects. Here you see that they consist of a plain graphic and of a viewer object that ensures the communication with the 2D model.



Plant Simulation 2D and the *3D Viewer* establish if an object in 2D correspond to an object in 3D by checking its name and its path in the model. The online connection between objects exists as long as:

- They are located at the **same position in the structure** in the 2D Class Library and in the 3D Library. An example for the position might look like this: .UserObjects.Stations.
- They have the **same name**.
- The attribute Channel ID *Plant Simulation* 2D is set to `3d`.

As soon as you start the *3D Viewer*, *Plant Simulation* 2D establishes an online connection between the 2D part of the model and the corresponding 3D part in the 3D library. When you insert an object into your 2D model that has a counterpart in 3D, *Plant Simulation* 2D also inserts the corresponding 3D object into the 3D part of the model, and vice versa. The same applies when you delete an object, it will be deleted in the 3D part and in the 2D part. The online connection is active as long as the button on the Standard toolbar is selected.

When you click to deactivate the online connection and you then rename an object in either part of the model, *Plant Simulation* 2D does not consider the objects to be identical any more. You will typically deactivate the online

connection, when you want to insert a graphic object into the 3D part of the model, which you do not want to appear in the 2D part of the model.

Note that not all elements of a 2D model are relevant for the *3D Viewer* model, such as the objects in the folders *InformationFlow* (*Methods*, *tables*,) and *UserInterface*. The *3D Viewer* part of the model, on the other hand may also contain elements that are irrelevant for the simulation in *Plant Simulation* 2D, such as room dividers, safety fences, etc. For this reason the *3D Viewer* shows the structure of the 3D objects in a tree of its own in the 3D Library. For most objects of the 2D model you will also want a graphic representation in the 3D model and vice versa.

You can create a 3D model from an existing 2D model with the command 2D > 2D to 3D or you can create a 2D model from an existing 3D model with 2D > 3D to 2D. This only works when the online connection is active.

Modeling in 3D or in 2D?

Before you start creating a new *Plant Simulation* model, you may ask yourself, if you should model in *Plant Simulation* 2D or in the *3D Viewer*. A 3D model basically serves for illustrating production sequences. The 3D visualization of an *Plant Simulation* 2D model does not create any additional analytical information, such as about blockages or accumulations caused by geometry collisions. Be aware that you cannot use the 3D model for an exact analysis of geometry collisions. The same is true for the definition of robot movements or for the animation of complex insert or processing processes!

Modeling in the *3D Viewer* especially makes sense, when you want to present the 3D model to customers, to the buyer of a simulation study or to management. In addition 3D show models can impress visitors at trade fairs or at in-house exhibitions.

Simulation experts can discuss the simulation results, such as the effects of storing or control strategies onto the material flow, based on the more schematic 2D display in *Plant Simulation* and draw their conclusions. For employees, who have no simulation expertise and who are not familiar with the abstract display of data, find it easier to follow the a 3D visualization. This way a suitable 3D visualization supports the integration of employees from the operative field into the discussion and evaluation of the simulation results.

The following criteria facilitate creating a 3D model and should be met if possible:

- The essential material flow and/or the 3D animations occur on a single hierarchy level.
- The connecting materials handling equipment can be modeled on a single hierarchy level.
- The activities within a station can be encapsulated hierarchically/object-oriented. You then have to set the visibility correctly across the hierarchy levels of the modeled station.
- You are provided with suitable graphics for showing the machines and the materials handling equipment in your 3D model.

  Note: The level of detail of CAD data, which you can use, often is too detailed. Naturally you cannot use these detailed graphics for an efficient visualization of entire production facilities. Just reduce the level of detail of the geometry in the *3D Viewer* or in other programs.

- You are provided with enough time for editing the object geometries. You will, for example, have to add animation paths to imported graphics on which the parts will be animated or you will have to add graphics for visualizing the states of the material flow objects.
- You are provided with enough time for creating the 3D model. Modeling and designing appealing models in 3D requires to work accurately, for example when exactly positioning objects, when adjusting animation paths, etc., and to use 3D geometries, which fit the model and the other graphics used within.

  Be aware that effective presentation models, as a rule, also require graphics, which are not relevant for the simulation but are very important for the optical impact on the viewer.

Creating a 3D Model from a 2D Model

You can quickly and easily create a *3D Viewer* simulation model from an existing *Plant Simulation* simulation model in which you invested a considerable amount of time and effort.

Although this is a largely automated process, you still have to:

- Define three-dimensional shapes (graphics) for the 3D counterparts of the corresponding *Plant Simulation* objects.
- Define the paths on which the *3D Viewer* animates the mobile objects, compare the dialog Path.
- Define which of the objects located inside of a *Frame* you want to visualize in the *3D Viewer*.
- Place the objects in the 3D scene, compare the dialog Transformation.

Note: *Plant Simulation* 2D and the *3D Viewer* establish if an object is the same in 2D and in 3D by checking its name and its path in the model.

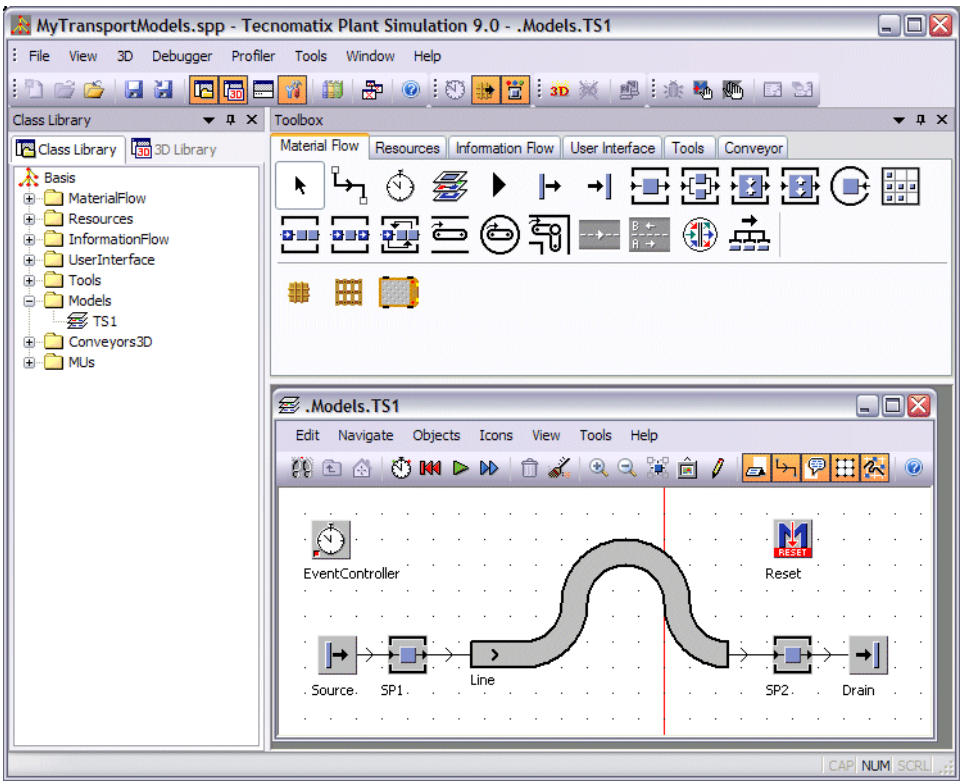
Be aware that a considerable amount of work might await you, when you created the simulation model in a previous version of *Plant Simulation*:

- When you modeled the flow of materials and parts across several hierarchy levels, you have to mark each and every object, which you want to show in the 3D animation, i.e., you have to enter the channel ID `3d`!
- When you employed *Tracks* and *Lines* without curves, the *3D Viewer* creates straight segments for these objects with the respective lengths. You will have to replace these objects with curved *Tracks* and *Lines*. Make sure to not changed the lengths defined in the original objects, otherwise your simulation model might produce other results than before!
- When you did not assign any 3D geometries yet to the object classes in the *3D Viewer*, the *3D Viewer* inserts gray cubes as placeholders for these objects, when you update the model from 2D to 3D. You than have to replace these geometries in the 3D class.

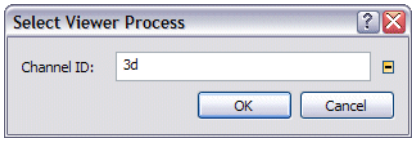
Synchronizing the 2D View and the 3D View

To create the three-dimensional view of an existing *Plant Simulation* simulation model:

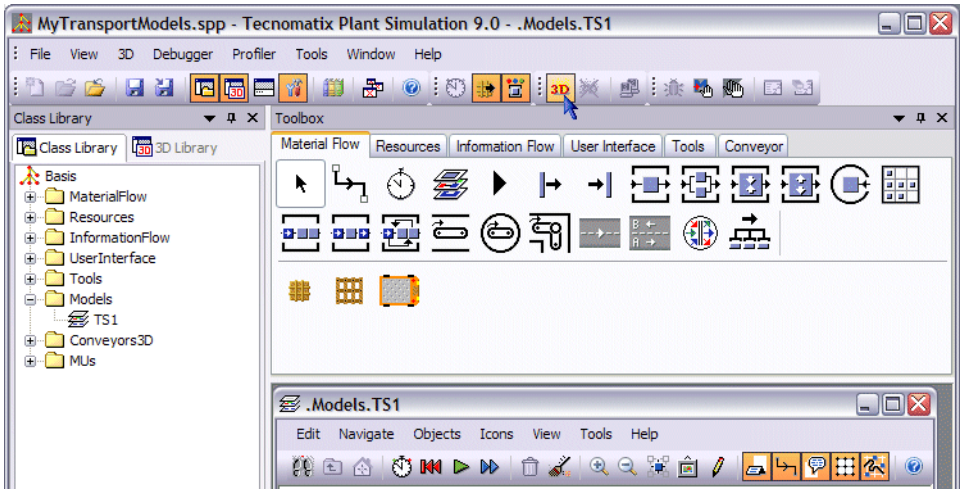
- Start *Plant Simulation* and open the simulation model for which you would like the *3D Viewer* to automatically create a three-dimensional view.



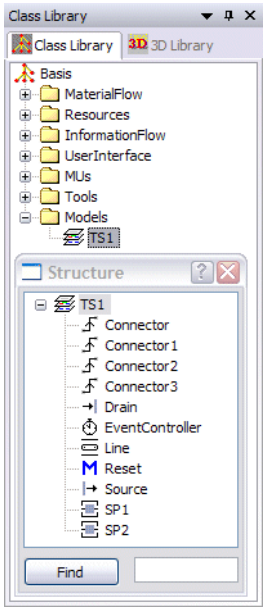
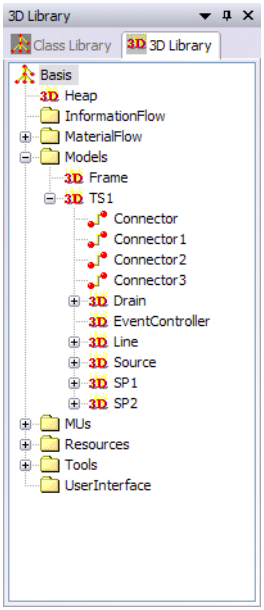
- Then, you have to tell *Plant Simulation* for which objects you want it to transmit data to the *3D Viewer*:
  - If you just modeled with the built-in objects from the *Class Library*, you do not have to do anything, as we already entered the channel id `3d` for these objects.
  - If you modeled your own objects, especially in *Frames*, open the dialog/window of each object, select Tools > Select Viewer Process, and enter `3d` into the text box Channel ID.
  - You can also delete the Channel ID for objects, which you do not want to show in the 3D view.



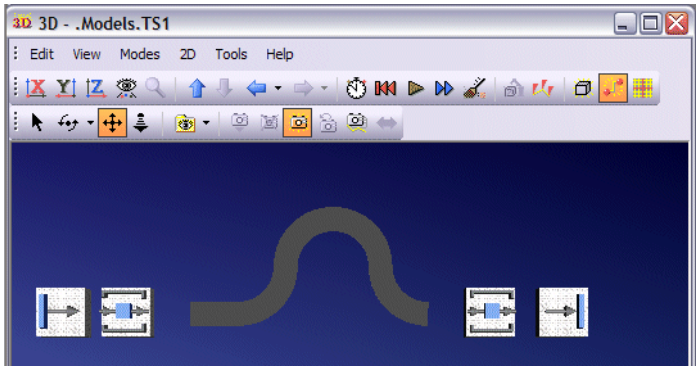
- Start the *3D Viewer*: Either click 3D on the 3D toolbar, or select the menu command 3D > Start 3D Viewer in the *Plant Simulation* main window.



→The *3D Viewer* automatically creates the three-dimensional part of the model. You will notice that the structure of the 3D view matches the structure of the simulation model in *Plant Simulation* 2D. As the *3D Viewer* just visualizes the simulation, it does not show objects, which are irrelevant for the animation, such as the objects from the folders *InformationFlow* and *UserInterface*, such as *Methods*, tables, user-defined *Dialogs*, etc. After updating our sample file, the 3D Library shows the *Frame TS1*, which contains our 3D model.

Structure of the 2D model	Structure of the 3D model
	

- Then select the Window menu and the name of the window starting with 3D to change to the *Frame*, which contains the newly created 3D view of our model.



Note: By default the *3D Viewer* does not show *Connectors*, when you create a model in 2D and then update it in 3D. To display them, click on the 3D Standard toolbar.

Working with the 3D Model

After you have synchronized the *Plant Simulation* 2D part and the *3D Viewer* part of the simulation model, you can work with the 3D model.

- You can continue modeling in 3D with the online connection open. This way the 3D part and the 2D part of the model will always be synchronized.
- You can continue modeling in 3D or in 2D with the online connection closed. Be aware that then you have to update the model again to bring both parts up-to-date.

You can run the simulation to visualize the flow of materials that *Plant Simulation* 2D simulates in the *3D Viewer*. To do so, either click the buttons on the 3D Standard toolbar in the *Frame* in 3D or in the *Frame* in 2D .

Within the scene you can navigate:

- *Navigate in the Scene with the Mouse* in the scene.
- Select if you want to look at the scene from the Right, the Left, the Back, the Front, the Top, or from the Bottom, compare *Align the View to the Main Directions*.
- Open and step into the objects, which you inserted into the scene, compare *Navigate Through the Hierarchy of the Scene*.
- Select how you look on the 3D scene, compare *Controlling Your View*.

You can manipulate the existing objects in the scene and continue modeling in the 3D part:

- Show the grid , when you want to insert or manipulate objects, compare *Working with the Grid*.
- Replace the default cubes that the *3D Viewer* inserts as placeholders for the objects, when you did not use a 3D library, compare *Using a Different Graphic for an Object*.
- Edit the animation paths to ensure a good-looking animation by:
  - Changing the length of a path, compare *Working with Paths*.
  - Rotating the edges of a path, thus also turning the mobile object moving on that path, compare *Define an Animation Path that Rotates Objects*.
- *Model with the Built-In Object Classes* to expand your model. You will:
  - *Insert an Object*.
  - *Connect Objects*.
  - *Pick and Select an Object*.
- Set when and at which hierarchy level in the model an object, and the objects located on that object, are visible, compare *Setting the Visibility of an Object*.

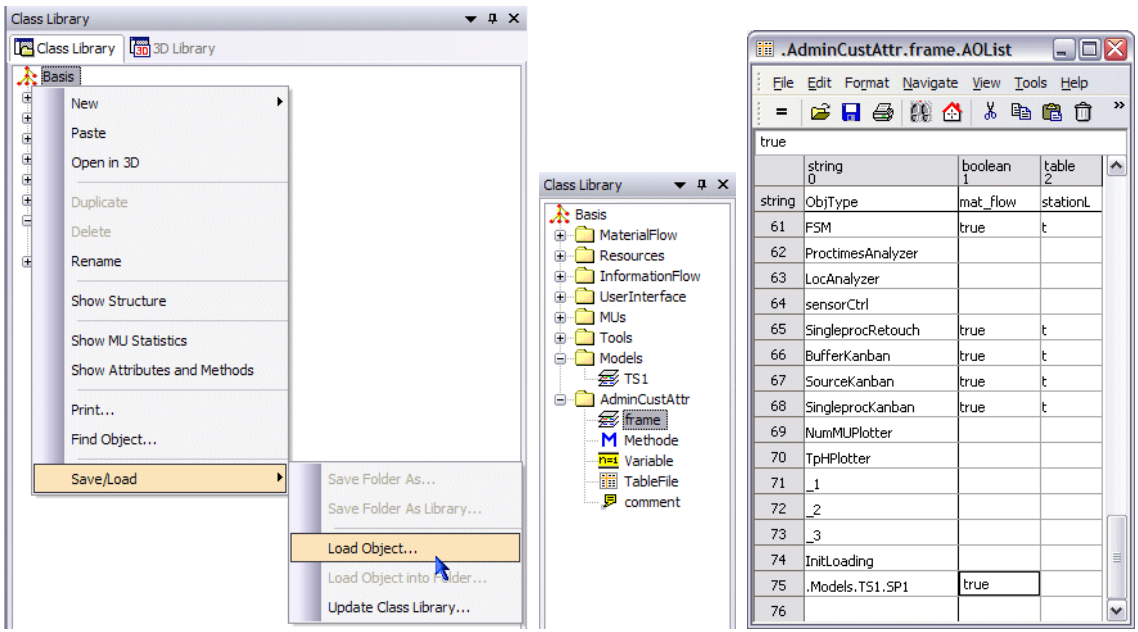
Creating a 3D Library from an Existing 2D Library

To create an application object library in the *3D Viewer* from an existing *Plant Simulation* 2D application object library, execute the steps described below, first *In 2D* and then *In 3D*.

In 2D

1. Open the application object library.
2. Decide which objects from the *Plant Simulation* Library you want to be available in its *3D Viewer* counterpart. As a rule this will be the material flow objects, objects whose dialogs in *Plant Simulation* control *ustAttr.frame.CreateAndWrite*.

   Note: We already set the ChannelID for all folders in the *3D Viewer*.



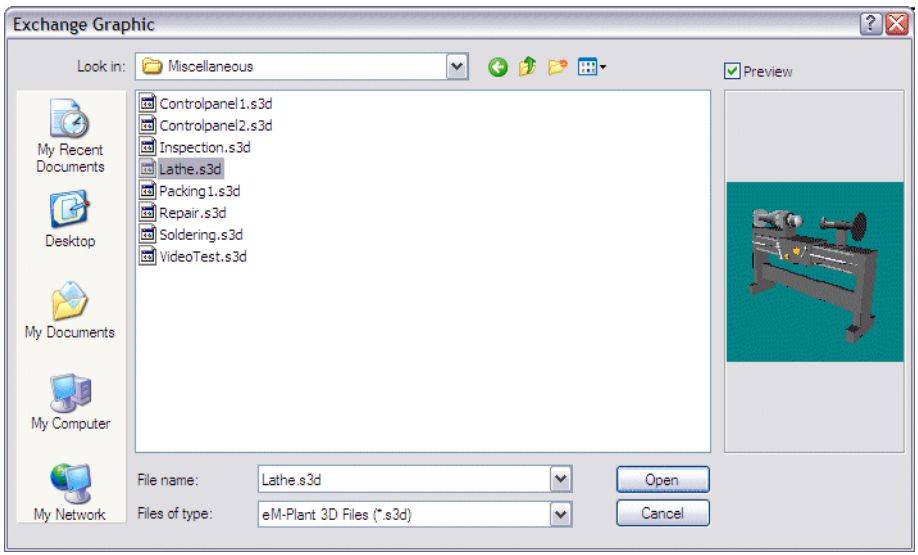
3. When an *Plant Simulation* 2D object contains instances of other *Plant Simulation* 2D objects, where you set the ChannelID to `3d`, but you are not interested in its contents in the *3D Viewer*, we advise to delete the ChannelID from those instances. This results in a lean object in the *3D Viewer*, containing no unnecessary information.

   Let us illustrate this in an example: Many objects in the application object library *Plant Simulation* Assembly are constructed from instances of the built-in *Plant Simulation* Assembly objects. To be able to instantiate the built-in objects directly in your simulation models you have to set the ChannelID of the built-in objects to `3d`, but not of the instances.

In 3D

1. Open a new *3D Viewer* basic library:
   - Select File > New.
   - Start the *3D Viewer*: Either click 3D on the 3D toolbar, or click the menu command 3D > Start 3D Viewer in the *Plant Simulation* main window.
2. Navigate to the highest level of the hierarchy, by clicking until the *3D Viewer* deactivates it. Then, update the *3D Viewer* library recursively with the menu command 2D > 2D → 3D > All.

   The *3D Viewer* now creates all folders and 2D objects, whose ChannelID you set, and shows them as cubes, yellow for folders, gray for objects.
3. Delete folders in the *3D Viewer* that do not have a corresponding folder in *Plant Simulation* in the object library, such as .InformationFlow and .UserInterface. Do not delete the folders .Heap and .Tools.
4. Next we have to edit the graphics of the newly created objects to be able to distinguish them. You can use either one of these techniques or you can combine them at will.
   - To use any of the 3D graphics that are part of your program package, select Edit > Exchange Graphics. Note that we saved these files in *s3d* format that we already defined animation paths for most of them, and that they are scaled correctly so that they fit in size with the other objects.



   - To open any other 3D graphic, select 3D > Import 3D Geometry and Edit > Graphic > Create Primitive.
   - If you are still missing suitable graphics for the objects, you can use the icons of the *Plant Simulation* 2D objects and map them to the 3D cube.

- To tell one folder from the other, you can also assign them different colors and/or 3D text. Or you can copy the default graphic for folders, the rack, from the object .Tools.Primitives.folder.

5. Note that the objects in the *3D Viewer* do not have to contain the same number of objects as their counterpart in *Plant Simulation* 2D. Quite the opposite is true, for performance reasons we advise to make sure that you only recreate those *Plant Simulation* 2D objects in the *3D Viewer* that are really required. If you do omit material flow objects though, you have to define their animation paths in the respective parent object.

   Let us illustrate this in an example: You modeled an object in *Plant Simulation* 2D as a *Frame*, which contains a *Track* on which the MUs move. You now want the *Frame* in the *3D Viewer* to display a graphic showing the three-dimensional MUs. In this case you do not have to model the *Track* as a three-dimensional object in the *3D Viewer*. It suffices when the *Frame* in the *3D Viewer* has an animation path named `Track`. This way the *3D Viewer* animates MUs on the path of the *Frame* named `Track`, which *Plant Simulation* 2D animates on the 2D object *Track*.

6. You can also display states of the simulation in the *3D Viewer*, which *Plant Simulation* shows with different state icons or as colored dots in the LED.

   You do not have to take any action for visualizing the default states *failed*, *pause* and *waiting*, as the temporary change in color to red, blue and yellow of the graphic of the object should suffice.

   Instead of, or in addition to, you can display each *Plant Simulation* 2D icon with a 3D state object with the same name and with a graphic of your choice, see *Displaying State Objects in the 3D Viewer*. Create this graphic as a child of the *3D Viewer* object that is going to change its state, and designate it as a state object in the dialog Create State Object. If you would like a state object to **replace**, instead of to amend, the graphic of the object in its normal state, define its standard graphic in a state object for its normal state, normally this is operational.

7. If necessary, delete CameraMarks that do not apply any more after you deleted folders or objects, and define new CameraMarks afterwards.

8. Finally test your new application object library.

Modeling Hierarchically

Using hierarchical modeling techniques you can add any level of detail to the areas and machines you insert into your simulation model. Hierarchical modeling means that you create a machine, a production area, etc. in a *Frame* using the built-in object classes or classes you yourself designed. You can then insert this *Frame*, *Machine* for example, into another *Frame* in which you modeled a production area, and then insert the production area *Frame* into the *Frame* that contains your entire factory.

Move within the Hierarchy

To freely move within the different levels of the hierarchy, i.e., step into and out of objects at will, you can use the buttons and the lists some provide on the 3D Standard toolbar. Note that camera marks also keep track of the hierarchy levels of your model!

- To change to the parent object of the object displayed in the *scene window*, click .
- To change to the next lower level in the hierarchy of objects and to view the children, i.e., the objects contained in the object, select the object, and click .
- To change to the previous settings of the camera view point as defined in the Previous list, click .

  To go back more than one view, click the small down arrow next to the button and then on a view in the list.
- To change to the next setting of the camera view points defined in the Next list, click .

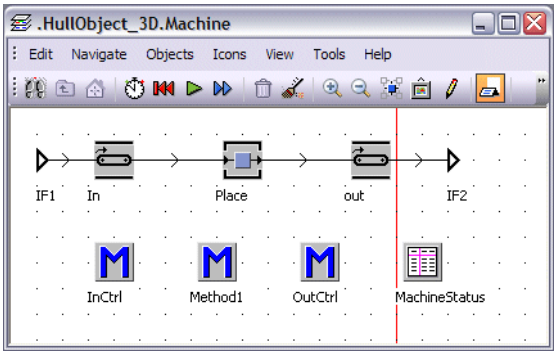
  To go forward more than one view point, click the down arrow next to the button and then on a view in the list.

  Note: The *3D Viewer* deletes the Next list when you select another hierarchy level without selecting a view point of either the previous or next view point list, or when you load a different model or exit the *3D Viewer*.

Map Complex 2D Objects to a 3D Graphic

Oftentimes you will want to map a complex *Plant Simulation* 2D object, i.e., a *Frame* into which you inserted material flow objects and programmed SimTalk methods, to a single 3D object. *Plant Simulation* enables you to do this.

Compare this example, where we modeled a machine in a *Frame*. Here a *Line* transports the part to be processed to the processing station, and another *Line* transports it from the processing station to the next station.



To map this object to a simple 3D graphic that correctly animates the parts, you just have to define animation paths on the graphic of the *Frame*. These animation paths have to have the same names as the objects you inserted into the 2D *Frame*.

To define animation paths:

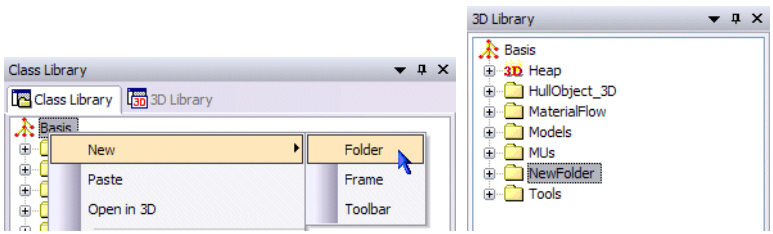
- Before you built a demonstration model in *Plant Simulation* 2D, make sure that there is no active online connection between *Plant Simulation* 2D and the *3D Viewer*, i.e. that Connect 3D Viewer is released. Then, build the model in *Plant Simulation* 2D, so that it matches the screenshot above. Name the *Frame* `Machine`.

  Note: We do not want the connection between the *3D Viewer* and *Plant Simulation* 2D because we do not want the *3D Viewer* to create these objects. If they would be created, the *3D Viewer* would animate the MUs on the objects within the *Frame* `Machine` and not on the graphic of the *Frame* itself!

- Delete the Channel ID for all material flow objects you used in the *Frame* `Machine`; do not delete it for the *Interface* objects: Select Tools > Select Viewer Process in the dialog of each object, and delete 3d from the text box.

  Note: By default, we entered `3d` as the Channel ID for all material flow objects. This ensures that the corresponding objects share the same data in the 2D part of the model and in the 3D part.

- After you did this for all objects, you inserted into the *Frame* `Machine`, reactivate the online connection with the *3D Viewer* again, click Connect 3D Viewer, so that it is pressed.
- Click the Class Library. Right-click Basis on top of the structure and select New > Folder. Notice that the 3D Library also shows this NewFolder.

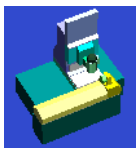


- Click the object `Machine` in the Class Library, hold down Shift, and drag it into the NewFolder.

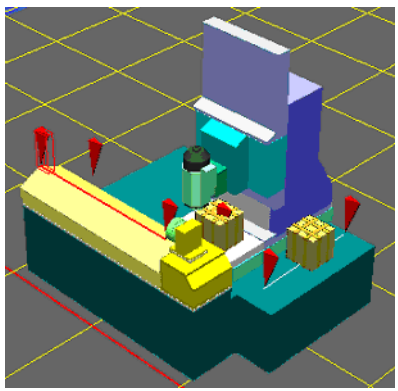
Click 3D Library. Right-click *Machine*, select Open > Active 3D Window or Open > New 3D Window, and click . You will notice that the 3D part only shows the default graphic of the *Frame*, and that *Plant Simulation* created the two objects of type *Interface IF1* and *IF2* as children of the graphic, while it did not create any of the other 2D objects.

Note: We need the *Interface* objects, so that we can connect the object *Machine* with *Connectors* to other material flow objects.

- Exchange the graphic of the *Frame*, with the graphic of a machine: You might, for example, use the object *HorizontalDrillingMachine.s3d* located in the folder where you installed *Plant Simulation*. This is by default C:\Program Files\Plant Simulation\Plant Simulation\3D\graphics\Machines\Style2.



- Now create an animation path for each of the two conveyors (compare , i.e., for the *Lines* named *In* and *Out*, and for the processing station named *Place*. Place the animation paths for the lines and for the processing station where you want the MUs to be animated. Make sure that the **animation paths have the same names as the 2D objects** they will animate.



The *3D Viewer* then shows and animates the MUs located on one of the conveyors or on the processing station, on the animation paths that have the same name as the object you inserted into the *Frame* named Machine in *Plant Simulation* 2D.

Note: The 3D animation paths of the *Conveyors*, i.e., of the length-oriented objects, are not directly coupled to the lengths of the corresponding *Lines* in *Plant Simulation* 2D.

Working with the Scene

The *3D Viewer* provides a number of ways for working with the active scene, as opposed to working with the objects you insert into that scene.

Navigate in the Scene with the Mouse

You can manipulate the scene, and the objects with mouse and keyboard, you can move within the scene, and change your view of the scene.

Instead of using a normal mouse, you can also navigate in the scene with a Space Navigator mouse.

By default the Select button on the 3D Camera toolbar is selected. Here you can use the Alt, the Shift or the Ctrl keys, together with the left mouse button to rotate, to zoom, and to pan the scene.

Note: If you have a three-button mouse, click the middle mouse where the description calls for clicking the mouse wheel.

If manipulating the scene with the mouse does not work, check the Mouse Properties for the Wheel in the Mouse Control Panel.

- To **rotate** the scene, hold down the Alt key and drag the mouse. The rotate mouse pointer looks like this .

  Click next to the button and select how the *3D Viewer* rotates the scene.

  - To rotate the scene around the center of the grid, select Scene and drag the mouse in the *scene window*
  - To rotate the scene around the center of the selected object, select Selection and drag the mouse in the *scene window*
  - To rotate the scene as the previous versions of the *3D Viewer* did, select Zoomed and drag the mouse in the *scene window*

  Or

  Click , hold down the left mouse button, and drag the mouse in the *scene window*.

- To **pan** the scene, hold down the Ctrl key and drag the mouse. The pan mouse pointer looks like this .

  Or

  Click , hold down the left mouse button, and drag the mouse in the *scene window*.

- To **zoom** the scene, hold down the Shift key and drag the mouse. The zoom mouse pointer looks like this .

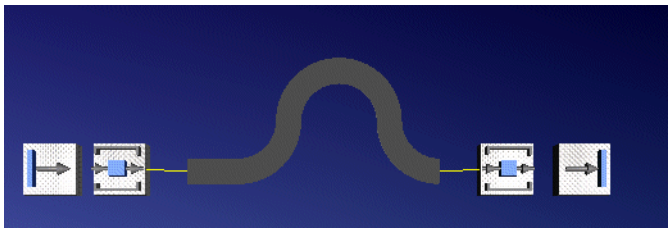
  Or

  Click , hold down the left mouse button, and drag the mouse in the *scene window*.

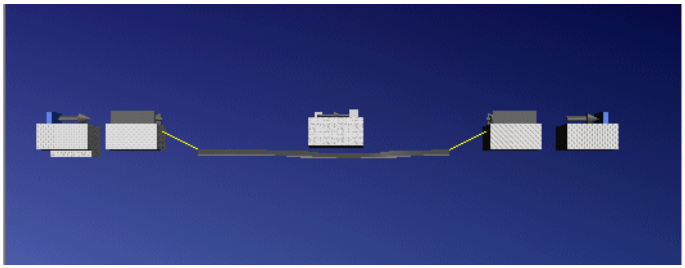
Align the View to the Main Directions

You can select from which predefined direction you look at the scene using View > Orientation: From the Right, from the Left, from the Back, from the Front, from the Top, or from the Bottom.

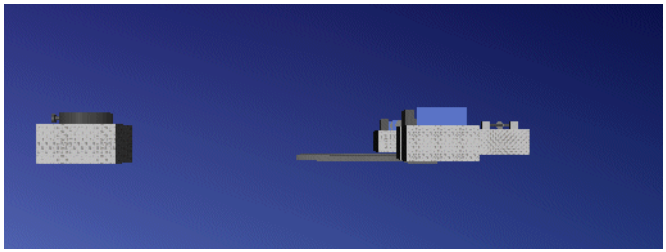
- To view the entire scene from top looking down, you can also click . on the 3D Standard toolbar.



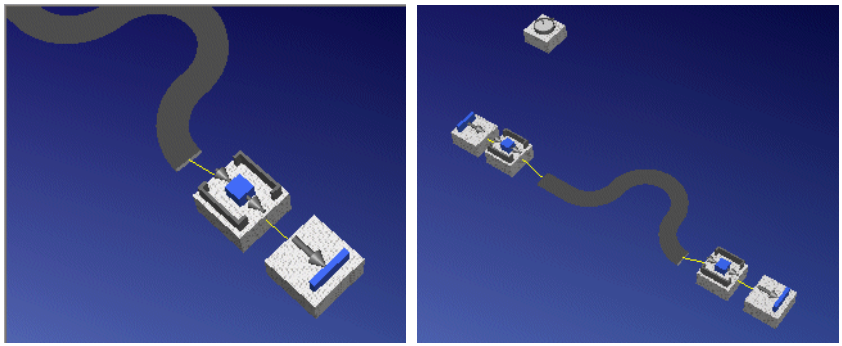
- To view the entire scene from the front, you can also click .



- To view the entire scene from the left side, you can also click .



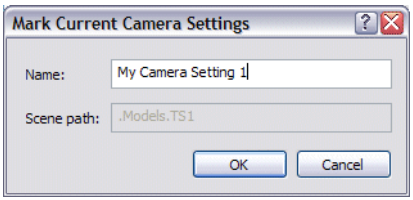
- To fit the entire scene into the scene window and to show all objects in the scene if you moved part of the scene out of view, select View > View All or click .



Save a View with a Model and Return to a View

To save the current position and orientation of the camera with the model file, click the eye in the folder icon Camera Marks on the 3D Camera toolbar.

- Enter a Name for the current camera setting into the dialog Mark Current Camera Settings.

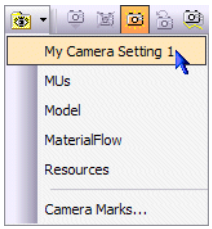


- The *3D Viewer* shows the path of the scene in the field Scene path.
- Click Save to set the name. This saves this setting together with the active root object of the scene in the model file. Then, you can easily return to this saved view after you changed the scene or reopened the model.

To return to a view you saved later on, or to navigate to the different predefined folders:

- Click the down arrow on the Camera Marks button.

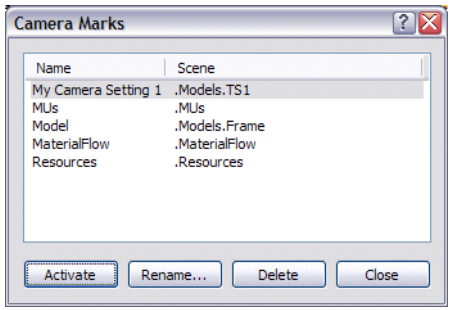
  Select the camera mark, i.e., the view for which you defined it, on the list.



Or

- Select the command Camera Marks.
- To switch to one of the saved scenes, select it in the list, and click Activate.

To rename or delete a camera mark, select it in the list, and click Rename or Delete.



Navigate Through the Hierarchy of the Scene

You can navigate through the hierarchy of the objects you inserted into the scene in a number of ways. You can step into and step out of a viewer object and move to the next and previous scene you viewed.

To return to the parent object of the object displayed in the scene window, do one of the following:

- Click on the 3D Standard toolbar.

  Select View > Scene > Up.

  Double-click anywhere in the background of the scene window with the left mouse button.

  Press Shift+Enter.

  Note: The parent object is the object located one level above the selected object in the hierarchy of objects.

To change to the next lower level in the hierarchy of objects, do one of the following:

- Select the object and click .

  Select View > Scene > Open.

  Press the Enter key when an object is selected.

  Then, you can view and edit the objects contained within the selected object.

To return to the level in the hierarchy of objects that was active before the current one, do one of the following:

- Click Previous .

  Select View > Scene > Previous.

  This changes to the previous setting of the camera view point, as defined in the Previous list. To go back more than one view, click the down arrow next to the button and then on a view in the list. Compare *Save a View with a Model and Return to a View*.

To move to the next level in the hierarchy of objects, do one of the following:

- Click Next .

  Select View > Scene > Next provided you selected the menu command Previous before.

  This changes to the next setting of the camera view point, as defined in the Next list. To go forward more than one view point, click the down arrow next to the button and then on a view in the list.

  Note: The *3D Viewer* deletes the Next list when you select another hierarchy level without selecting a view point of either the previous or next view point list or when you load a different model or exit the *3D Viewer*.

Automatically Saving a View Point

Whenever you change the view, the *3D Viewer* saves the active view point, i.e., the setting of the main camera and a link to the root object of the scene, in the Previous list with the name of the active root object of the scene.

This list stores 12 view points at the most. It adds the most recent view point to the top of the list, and deletes the oldest view point from the bottom of the list, when the number exceeds 12.

The *3D Viewer* saves the view point when you:

- Change the hierarchy level of the scene, i.e., when you click the buttons or on the 3D Standard toolbar, or when you select View > Scene > Up or View > Scene > Open.
- Click the buttons , , , or on the 3D Standard toolbar, or when you select View > Orientation > Right, View > Orientation > Back, or View > Orientation > Top.
- Select one of the Camera Marks .

Selecting an Automatically Saved View Point

As soon as the *3D Viewer* saved a view to the Previous list, you can return to a view point saved there. To do so, do one of the following:

- Click on the 3D Standard toolbar to return to the most recent setting.
- Click the down arrow on the button on the 3D Standard toolbar and select any of the view points saved in the list to return to this view point.

The *3D Viewer* moves all view points that are more recent than the selected view point to the Next list, from which you can then select them.

The *3D Viewer* deletes the Next list, as soon as it automatically saves another view point, a view point that you do not select from the Previous or Next list.

The *3D Viewer* also deletes the Previous and Next lists, when you load another model, or when you exit the *3D Viewer*.

Move Through the Scene on a Predefined Path

You can move through the scene on one of the predefined animation paths of an object in the folder.

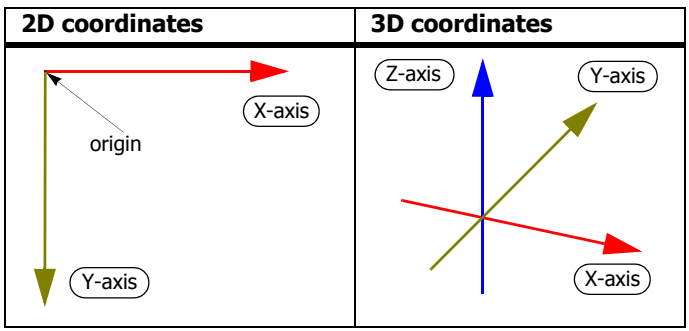
- Click an object with the left mouse button to select it.
- Click on the 3D Camera toolbar to open the dialog Fly on Path. If you did not select an object before, the dialog refers to the current root object of the scene.
- Select one of the predefined animation paths to move your view point along that path.

You can also define animation paths of your own or edit any existing path in the dialog Path to suit your needs.

Map Coordinates in Plant Simulation 2D and in the 3D Viewer

When you insert objects into your 3D scene, you will notice that *Plant Simulation* 2D places them at roughly equal positions in the corresponding *Plant Simulation* 2D *Frame*, and vice versa.

To accomplish this, *Plant Simulation* 2D converts the pixel-based coordinates of the 2D *Frame* into 3D coordinates, where the unit 1 corresponds to 1 meter. In addition, it flips the y-axis, so that it points up.



You can:

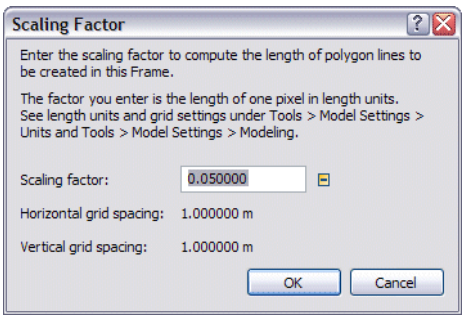
- *Edit how Plant Simulation 2D maps 3D Viewer Coordinates*

Edit how Plant Simulation 2D maps 3D Viewer Coordinates

To edit how *Plant Simulation* 2D maps *3D Viewer* coordinates:

- Navigate to the *Plant Simulation* 2D *Frame* that contains your model.
- Select Tools > Scaling Factor:

  Enter the scaling factor.



Controlling Your View

The *3D Viewer* provides several ways of setting how you look at the 3D scene, i.e., of controlling the camera that represents the eyes of the viewer looking at the scene.

Set the Main Directions

Independent of the active camera setting, you can adapt the view to any main direction of the view or of an object at any time. When you selected an object, the *3D Viewer* zooms out this object and adapts the direction of the camera to the selected main direction of the coordinate system of the object.

Set View Points

You can save any view of the scene, i.e., the position and orientation of the main camera within the scene, at any time, and return to this view later on.

- The *3D Viewer* automatically saves the active camera view, together with the active root object of the scene, before you change the view. You can then return to these views using the Previous and Next lists.
- You can also save the active camera setting, together with the active root object of the scene, with a meaningful name as one of the Camera Marks.

As opposed to the view points that the *3D Viewer* saves automatically, you can save any number of Camera Marks, which it saves in the model file. You can then rename and delete them at will.

Attach a Camera to an Object and Detach it

You can attach a camera to any viewer object, so that you can view the scene through the lens of this object, and detach a camera from it again, when you do not need it any more. When the object moves through scene, for example because you started the simulation, the camera will move along with the object you attached it to.

In addition, the *3D Viewer*:

- Visualizes the camera you attached, i.e inserts a viewer object that represents the camera.
- Allows you to change between **object view** and **normal view**.
- Allows you to interactively transform the camera you attached: By changing the view while in object view, or by manipulating the object, while in normal view.

Animate the Camera

You can make the camera move on any animation path of the selected viewer object or of the root object of the scene. Here, you fly on this path and view the scene from it.

In addition, the *3D Viewer*:

- Visualizes the animated camera, i.e inserts a viewer object that represents the camera.
- Allows you to change between **animation view** and **normal view** during the animation.
- Allows you to interactively transform the animated camera: By changing the view while in animation view, or by manipulating the object, while in normal view.
- Allows you to define the speed of the animation and the direction of the animation.
- Allows you to pause, continue and stop the camera animation, independent of other animations and simulations.

Working with the Grid

Before you can insert a viewer object, position, and rotate it in the 3D scene, show the grid.

Note: We recommend to show the grid before you insert an object into the *scene window*. This way you can place the object at the exact location, where you want it to be.

When you insert an object without showing the grid, you have little control over where the *3D Viewer* places the object. By default it uses the same coordinates that the source object had, an effect you might not want.

The *3D Viewer* employs the grid as the surface onto which it inserts objects.

Be aware that showing or hiding the grid affects how objects behave:

- When you **show** the grid, manipulating objects always refers to the grid plane.
- When you **hide** the grid, manipulating objects refers to your view plane, i.e., the plane perpendicular to the direction in which you look at the scene.

To change and define grid settings and to open the dialog Grid Settings:

- Right-click in the background of the scene and select Grid Settings.
- Click on the 3D Modeling toolbar.
- Select Tools > Grid > Settings.

Show and Hide the Grid

To show or hide the grid, do one of the following:

- Right-click in the background of the scene and select Display Grid.
- Click on the 3D Standard toolbar or on the 3D Modeling toolbar.
- Press the Ins key on your keyboard.
- Select Tools > Grid > Display.

Set Grid Properties

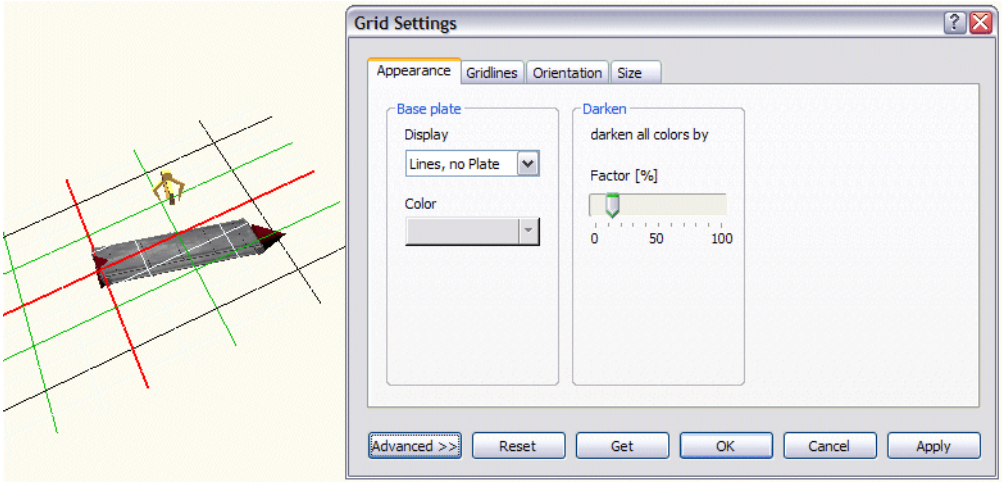
To set the properties of the grid to fit your modeling needs, click the tab Appearance. Compare the examples below.

- To automatically apply any changed values without having to click Apply each and every time you change a value, click Advanced and select Auto-apply.
- To just display gridlines without a plate underneath it, select Lines, no Plate. This way you can see the object underneath the grid that the grid plate would otherwise obscure.

  To display the grid lines you defined and a base plate underneath the grid lines, select Lines and Plate.

  To display the base plate without the grid lines, select Plate, no Lines.

- To change the color of the base plate, click the down arrow of the drop-down list Color and select a different color in the color selector.
- To darken the colors of the plate and of the grid lines, drag the slider to the right. Normally, the grid and the plate will appear more unobtrusive as compared to the objects in the scene.



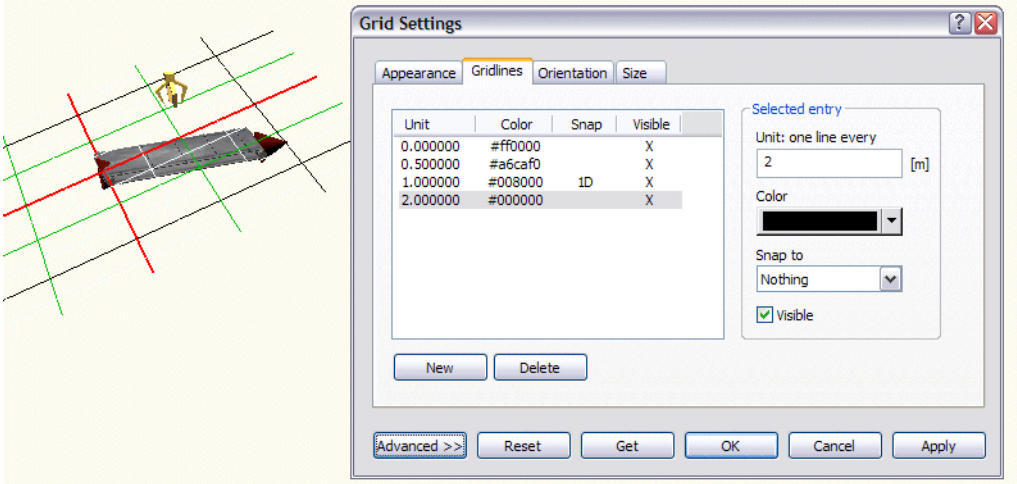
Edit Grid Lines

To edit existing grid lines or to add new grid lines, click the tab Gridlines.

- To add another grid line, click New.

  Enter the distance between two grid lines, which you want to add; we entered 2 meters.

  Select a color for the grid line, we selected Dark Gray.
- To show this grid line in the grid in the scene, select Visible.
- Then, Set the Snap Points. Making objects snap to grid points allows you to precisely place objects interactively.
- To edit an existing grid line, select it in the list field and edit the settings below Selected entry.



Set the Grid Size

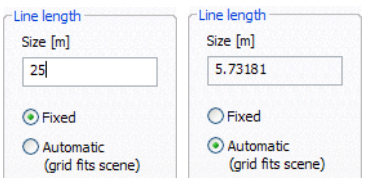
To set the size of the grid, click the tab Size:

- Select settings that define the size of the entire grid, i.e., the length of the grid lines:

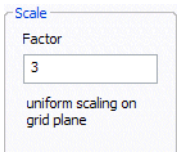
  The grid lines can take a Fixed length, which you enter into the text box.

  Or

  You can make the *3D Viewer* fit the size of the grid to the size of the scene (Automatic).



If you need to, you can also scale the grid in the scene. Enter a smaller number, for example `0.5` or `1`, to scale it down; enter a larger number, for example `2` or `3`, to scale it up.



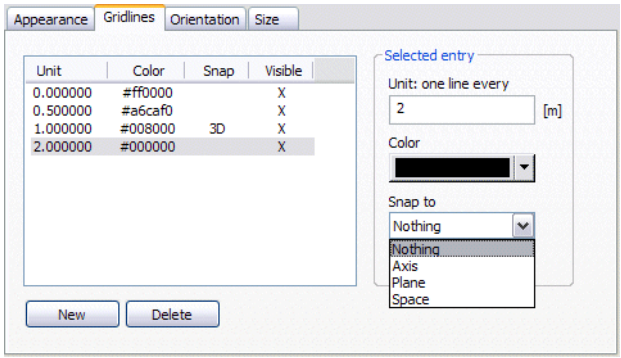
Note: To save changes to the grid settings, select 3D > 3D Preferences in the *Plant Simulation* main window and click OK or Apply in the dialog. You might, for example, leave the grid active, but make the grid lines and

the base plate invisible. If you do not save these 3D settings, the *3D Viewer* will show them again, when you open your model the next time.

Set the Snap Points

Note: Snapping only works when you click Snap to Grid on the 3D Modeling toolbar or when you select Tools > Grid > Snap To.

Select the dimension of the grid the object you insert or move snaps to:



- Select the grid line you want to snap the object to.

  Note: When you select Axis, Plane or Space for the red grid line with the unit 0.0, the *3D Viewer* deactivates Snap to Grid, and places the object onto the center of the grid. You cannot move it from there, as it is the only point of the selected grid line to which objects snap.

- To insert the object anywhere in the scene and to move it around without any constraints, select Nothing for all grid lines.

  Objects always snap to snapping points whose distance from the origin of the grid is a multiple of the unit of the selected grid line.

- To make the object snap to the snapping points on the horizontal axis of the grid, i.e., the red line running from left to right, select Axis. This shows 1D in the list field.

  Move the object left and right with the Pan tool.

- To make the object snap to the snapping points on the grid plane, i.e., the cross-over points of the selected grid line, select Plane. This shows 2D in the list field.

  Move the object left or right, and to the back or the front with .

- To make the object snap to the snapping points in three-dimensional space, select Space. This shows 3D in the list field.

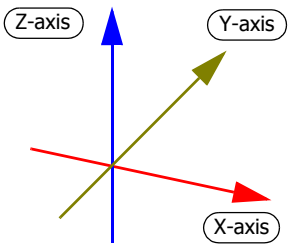
  Move the object left or right, and to the back or the front with ; move it up or down with .

- When you insert an object, Snap to places the object at the snapping point closest to the point where you position the mouse and click the left mouse button.
- When you move an object with , Snap to places the object closest to the snapping point to which you dragged the object and where you released the mouse button.

Position the Grid on Different Planes

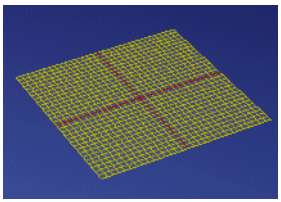
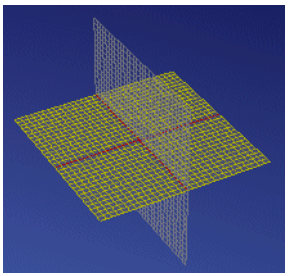
You can display the grid on the different planes in three-dimensional space. As you remember the *3D Viewer* uses a left-handed coordinate system:

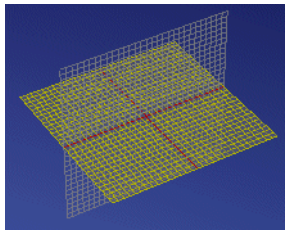
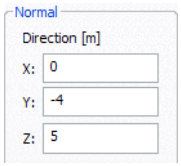
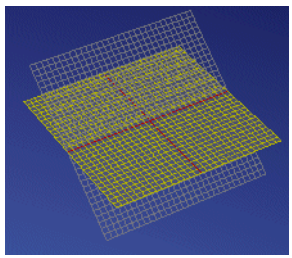
The **x-axis** runs from **left-to-right**, the **z-axis** runs from **bottom-to-top**, and the **y-axis** runs from **front-to-back**.



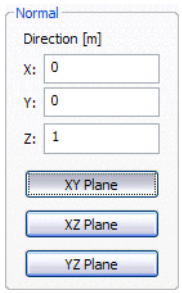
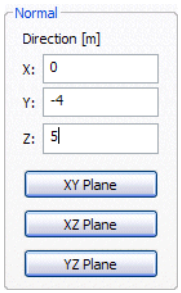
- To position the grid on the planes defined by the axes, you can also right-click the background of the scene and select Grid Settings or click on the 3D Modeling toolbar.

  Then, click the tab Orientation and the button with the name of the plane below Normal.

To position the grid on the plane defined by the x-axis and the y-axis, select Tools > Grid > Position > XY Plane.	
To position the grid on the plane defined by the y-axis and the z-axis, select Tools > Grid > Position > YZ Plane.	

To position the grid on the plane defined by the x-axis and the z-axis, select Tools > Grid > Position > XZ Plane.	
To freely change the orientation of the grid in the scene, enter different values for the x-y-z-components of the normal vector of the grid. The normal vector defines the grid plane by dropping a perpendicular onto it. 	

The latter tilts the grid more precisely than *Manually Tilt the Grid* does.

Grid placed onto the xy plane	Grid placed onto a user-defined plane
	

- To move the grid up or down, edit its Origin.

Manually Tilt the Grid

Instead of editing the Normal Direction of the grid, you can also manually accomplish this.

To manually tilt the grid to create an inclined plane on which to insert objects:

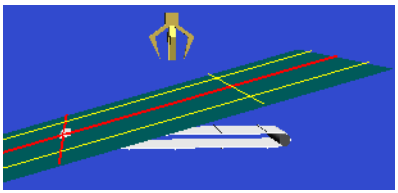
- Hold down the Shift and Ctrl keys simultaneously, and click any face of any object in the scene window with the left mouse button.

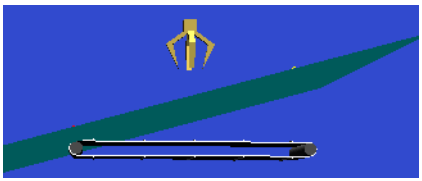
- This aligns the grid in the direction of the face you selected.

  It also designates the point where you clicked the left mouse button as the origin of the grid.

Note: The *3D Viewer* renders all shapes of three-dimensional objects as polygons. When you zoom the graphic of an object far enough, you will recognize them as colored triangles or rectangles. This also applies to objects with rounded corners, which are subdivided into faces. When you select a face on a rounded object, the *3D Viewer* aligns the grid to that face.

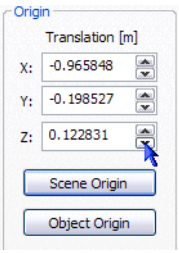
We used this technique to position the grid onto the rounded corner of the object *Sorter*.





Move the Grid in the Scene

To move the origin of the grid, click the tab Orientation and use the spin boxes and the buttons below Origin.



- To move the position of the Origin of the grid on the x-axis to the **right**, click the up arrow of the spin box.

  To move the Origin of the grid on the x-axis to the **left**, click the down arrow.
- To move the position of the Origin of the grid on the y-axis to the **back**, click the up arrow.

  To move the Origin of the grid on the y-axis to the **front**, click the down arrow.
- To move the position of the Origin of the grid on the z-axis **up**, click the up arrow.

  To move the Origin of the grid on the z-axis **down**, click the down arrow.
- To reset the values for the x-axis, the y-axis and the z-axis to their predefined default values of 0, 0, 0, click Scene Origin.
- To set the values for the x-axis, the y-axis and the z-axis to the values of the position of a single object you selected, click Object Origin.

In addition, you can define settings for rotating objects on the tab Rotation, compare *Manually Rotate an Object*.

Working with Objects

The *3D Viewer* provides a number of ways for working with the objects you insert into the scene.

Model with the Built-In Object Classes

The *3D Viewer* provides The Folder MaterialFlow, The Folder MUs, The Folder Resources, The Folder Tools, and The Folder Models. They contain the major built-in objects the *Plant Simulation Class Library* provides. Insert these classes (prototypes) of objects into your *3D Viewer* scene to model the corresponding objects.

After you have inserted the objects, the *3D Viewer* will use the online connection it established at start-up to place these objects into the *Plant Simulation* 2D part of the simulation model.

Note: The *3D Viewer* uses the **names** of objects to establish whether they are identical with the objects in *Plant Simulation* 2D or not. The *3D Viewer* and *Plant Simulation* 2D only exchange data between objects with the same name, and you entered the Channel ID `3d` into the respective objects in *Plant Simulation* 2D!

You are probably wondering how to create a new object in the *3D Viewer*. Nothing is easier than that:

- Click on the 3D Standard toolbar to activate *Insert* mode.
- Copy an existing viewer object with Copy on the context menu in a *3D Viewer* window or in the 3D Library.
- Paste the object you copied with Ctrl+V or with Paste on the context menu or hold down Ctrl and click the left mouse button.

  Note: If you would like the new object to be a class, paste it into any folder. If you paste it into a *Frame*, it will be an instance.

Press Del on the keyboard to delete the object from the scene.

Insert an Object

You can insert a material flow object and a mobile object into the 3D scene from the:

- *3D Library*

  This is the easiest way, as here the *3D Viewer* only shows the material flow objects and the mobile objects you can insert into your 3D model.

- *Class Library*

  This is a little more complicated, as the *Class Library* is the repository for all objects you can insert into your *Plant Simulation* 2D model, which contains a number of objects the 3D model does not use.

- *Toolbox*

  This is handy, when you hid the *Class Library*, by clicking on the Standard toolbar, to preserve space.

  The *Toolbox* also contains a number of objects the 3D model does not use.

- You can also paste an object you copied to the clipboard.

To insert an object from the *Toolbox*:

- Click on the 3D Standard toolbar to activate *Insert* mode. You can also select Tools > Grid > Display.
- If you want the object to snap to the closest intersection of two grid lines of where you click the mouse button, click on the 3D Modeling toolbar or select Tools > Grid > Snap To.
- If you want place the object freely, do not click on the 3D Modeling toolbar.
- Click the object you want to insert with the left mouse button to select it. Then, drag the mouse to the location where you want to place it and release and click the mouse button.
- If need be, you can fine-tune the location of the object in the dialog Transform that clicking on the 3D Modeling toolbar, Ctrl+T or Edit > Positioning > Transformation opens.
- To open the dialog of the *Plant Simulation* 2D object, double-click the object in the 3D scene or right-click it and select Open > 2D Counterpart. Modify settings here.
- To open the 3D object, click on the 3D Standard toolbar or right-click the object and select Open > Active 3D Window or Open > New 3D Window.

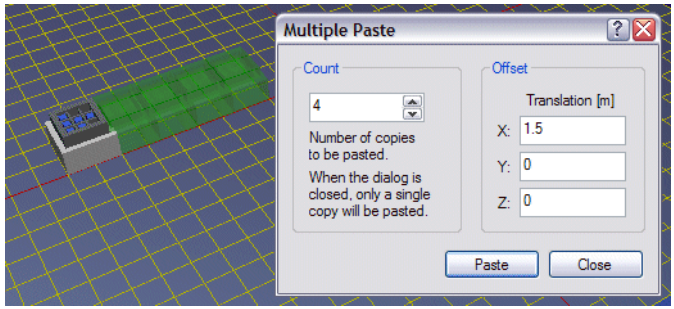
Note: Inserting an object into the 3D scene also inserts the corresponding object into the corresponding *Plant Simulation* 2D *Frame*!

Simultaneously Paste/Insert Multiple Copies

At times you may want to paste more than one copy of the object you copied at one time. You might, for example, want to create a *Store* with a number of shelves.

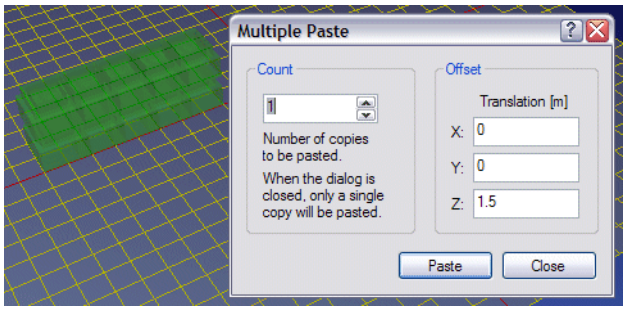
To paste multiple copies of an object:

- Insert an object, for example a *Store*, into the scene.
- Select the *Store* and copy it by pressing Ctrl+C.
- Select Edit > Multiple Paste.
- Enter the number of storage racks you would like to paste into the combo box Count. We entered `4`.
- Enter the offset from the object you originally placed on the axes. Note that our *Store* is `1.5` meters wide:
  An offset of `1.5` meters on the x-axis pastes `4` copies of the *Store* next to the original towards the right.
  Click Paste.



A count of `1` and an offset of `1.5` meters on the z-axis pastes `1` copies of all selected *Stores* on top of the original racks you pasted.

Click Paste.



You can also use the dialog Multiple Paste to insert more than one objects of the same class:

- Select Edit > Multiple Paste.
- Enter the number of objects you would like to insert into the combo box Count.
- Enter the distance of the objects from each other.
- Select the object class you want to insert in the 3D Library or the *Toolbox*, drag it into the 3D scene, and drop it there. This inserts the number of instances you entered next to each other, provided the dialog is open.

Connect Objects

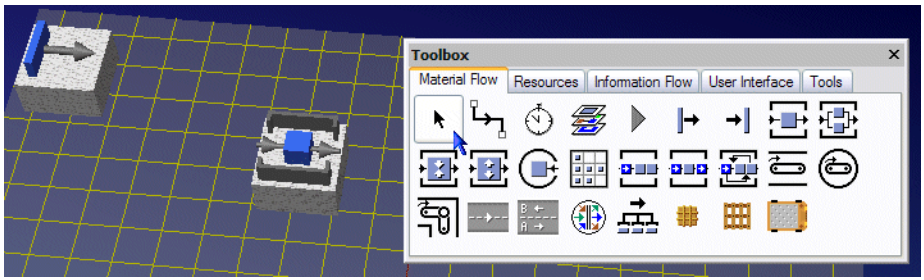
To connect material flow objects, which you inserted into your model, with the object *Connector* :

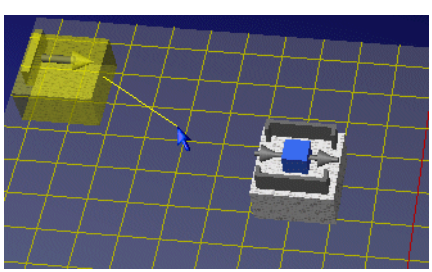
- Click to display the grid.

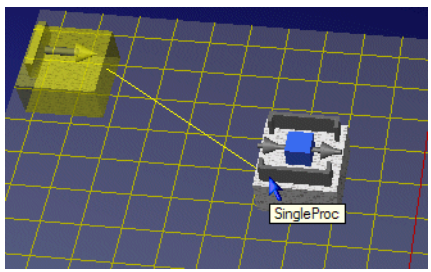
  Note: The *3D Viewer* only inserts *Connectors* at the correct position, when the grid is active.

- Click the *Connector* in the *Toolbox* on the tab MaterialFlow.

- Click the source object, where the connection will start, once with the left mouse button. *Plant Simulation* attaches a yellow line symbolizing the *Connector* to the mouse pointer.







- Drag the mouse to the destination object at which the connection will end, and click once with the left mouse button to establish the connection.
- To terminate connect mode before you click the destination object, click the right mouse button or press Esc.

To connect several objects one after the other, without interrupting the connecting process, hold down Ctrl.

- Attach the outgoing connection to the first object.
- Drag the mouse to the succeeding object.
- Click the left mouse button to attach the incoming *Connector* to the successor.
- You can also connect the objects in the 2D part of your model, which will simultaneously insert the connections into the 3D part, when you opened the *3D Viewer*.
- To update the connections between objects, which you established with the object *Connector* in *Plant Simulation* 2D without the *3D Viewer* having been started, select 2D > 2D → 3D > Connections.

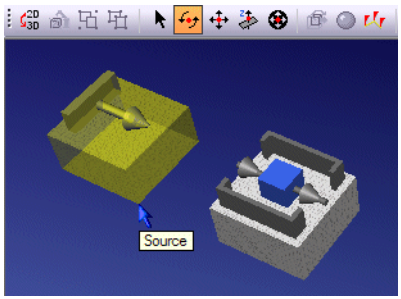
To show or hide connections in the scene window, click on the 3D Standard toolbar.

Note: By default the *3D Viewer* does not show *Connectors*, when you create a model in 2D and then update it in 3D.

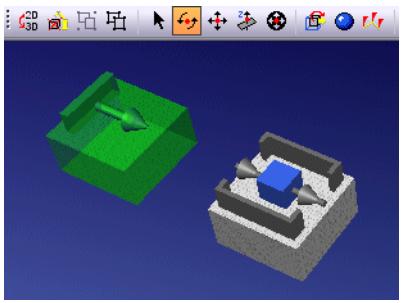
Pick and Select an Object

At times it may be difficult to select an object in the scene window, especially when objects are located very close to each other. When you click any of the buttons for manipulating an object , the *3D Viewer* shows the object in a different color, when you drag the mouse over it.

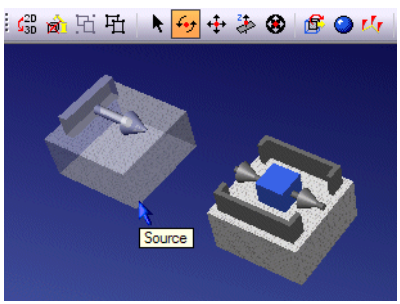
- It shows the object **yellow** indicating that you picked it.



To select that object and to edit it, click the left mouse button. The *3D Viewer* then shows the object **green** indicating that you selected.



- When the object is already selected and you drag the mouse away from and back over it, it shows the object **white**, indicating that you picked and selected the object.



To only select part of the object **graphic**, point the mouse at the part you would like to select. Provided the graphic of the object has been modeled hierarchically, you can also select subordinate parts of the graphic. Press the + key until the part you want to manipulate is picked. The white bounding box designates the part of the graphic you pre-selected. Click the left mouse button once to select that part and manipulate it.

Press the - key to step out of the object again.

Note: You can only select parts of the graphic, when the graphic is modeled hierarchically.

Manipulate an Object with the Mouse

To manipulate an object, click Rotate Object or one of the other object manipulators on the 3D Modeling toolbar.

When you show the grid, manipulating the object relates to the grid plane. When you hide the grid manipulating relates to the view plane.

- To **rotate** an object, click , select the object, hold down the left mouse button, and drag the mouse.

  The object rotates around the normal vector of the grid or around your view plane respectively.

- To **pan**, i.e., move an object, click , select the object, hold down the left mouse button, and drag the mouse.

  The object moves on the grid plane or vertical to your line of sight respectively.

  If you also want to move the corresponding object in the 2D *Frame* to the position, which corresponds to the object in 3D, select the menu command 2D > Connect Data > 3D Position to 2D Position.

- To **move** an object vertically, click , select the object, hold down the left mouse button, and drag the mouse.

  The *3D Viewer* zooms the object along the normal vector of the grid or along your view axis respectively.

- To **scale** an object, click , select the object, hold down the left mouse button, and drag the mouse.

  The *3D Viewer* scales the object uniformly in its coordinate system.

Move an Object Vertically

You can move an object in the scene window vertically like this:

- To move the object closer to you, or farther away from you, click on the 3D Modeling toolbar. Then, click the object(s) of your choice, hold down the left mouse button, and drag the mouse in the *scene window* up to zoom in or down to zoom out.

  Zooming an object works differently when you show or hide the Grid:

  - When you show the Grid , you zoom the object perpendicular to the grid, i.e., you can only move the mouse up or down.
  - When you hide the Grid , you zoom the object perpendicular to your plane of view, i.e., you can move the mouse to the back and the front, in the direction you look at at the scene.

- To center and zoom the selected object in the scene window, click on the 3D Standard toolbar. This way you can closely inspect and then manipulate it.

  To show all objects you inserted into the scene again, click on the 3D Standard toolbar.

Precisely Manipulate an Object

You can modify the objects in the scene of your simulation model interactively with the mouse, i.e., by clicking the Rotate Object, Move Object, Move Object Vertically, and Scale Object buttons.

Note: When the object is selected, you can press Esc to undo any modifications. Press Esc repeatedly until you return to the object in its unselected state.

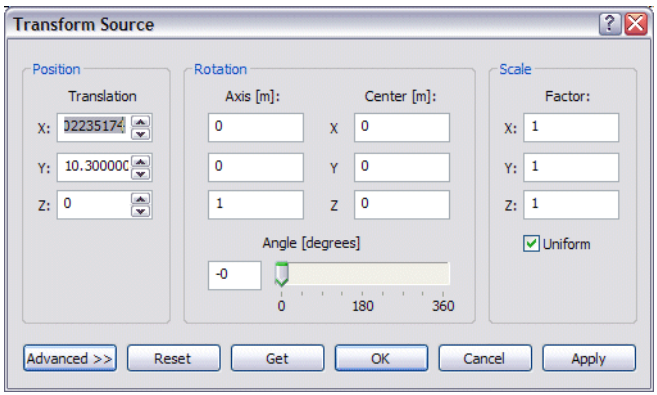
For some purposes this will not be precise enough. Then, you can enter exact values into the text boxes in the dialog Transformation to fine tune the position, the rotation and the scale of the selected object:

- Select the object you would like to edit.
- Click on the 3D Modeling toolbar, press Ctrl+T or select Edit > Positioning > Transformation.

  The *3D Viewer* shows the current values for the object in the dialog Transform.
- Edit the values for the position, the rotation and the scale and click Apply to apply your changes.

  Or

  Click Advanced and select Auto-apply to immediately apply and show your changes without having to click Apply.



Note: You can also open the Transform dialog two times for the object, temporarily edit the settings of the object in one dialog and then return to the previous settings by clicking Apply in the unchanged Transform dialog. This workaround provides a function similar to Undo!

Precisely Move an Object

At times manually moving an object with the Move Object tool will not be accurate enough for your purposes.

Note: If you also want to move the corresponding object in the 2D *Frame* to the position, which corresponds to the object in 3D, select the menu command 2D > Connect Data > 3D Position to 2D Position.

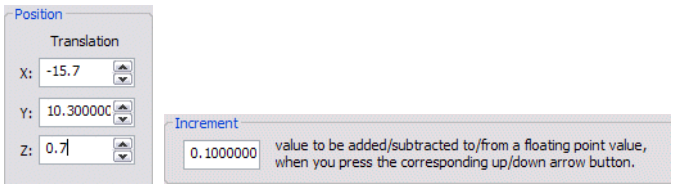
To precisely move an object:

- Click it with the right mouse button to select it, and

  Select Edit > Transformation.

  Or

  Click on the 3D Modeling toolbar.
- Click Advanced and select Auto-apply to immediately detect your changes without having to click Apply.
- Enter the value in meters by which you want to move the object into the text box Increment, when you click the spin box.



- To move the object to the **right** on the x-axis, click the up arrow of the spin box.

  To move the object to the **left** on the x-axis, click the down arrow.
- To move the object to the **back** on the y-axis, click the up arrow.

  To move the object to the **front** on the y-axis, click the down arrow.
- To move the object **up** on the z-axis, click the up arrow.

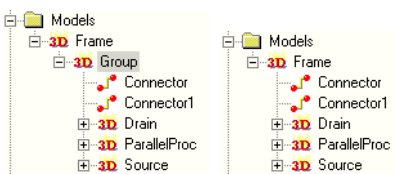
  To move the object **down** on the z-axis, click the down arrow.

Manipulate a Group of Objects

To move, rotate or scale several objects at the same time while retaining their positions to each other, you can group them and manipulate the group as a whole.

You can group:

- **Viewer objects**. For these the *3D Viewer* viewer creates a new viewer object called Group, Group1, etc. with viewer attributes of its own. You can watch the effect of grouping in the structure in the 3D Library.



Note: This group of viewer objects looses the connection with the 2D part of the model, i.e., the simulation will not run in the 3D part of the model analogous to the 2D part any more! Use the Group feature only to move the group as a whole and Ungroup the group after you are done moving it!

- **Plain graphic objects and viewer objects**. The grouped plain graphic object will be part of the graphic of the viewer object.
- **Plain graphic objects**. The *3D Viewer* creates a single new plain graphic object.

To group several objects:

- Shift+click the objects to select them.
- Click on the 3D Modeling toolbar, select Edit > Group, or press Ctrl+G.
- Then, move, rotate or scale the group, either with Move Object, with Rotate Object or with Scale Object on the 3D Modeling toolbar.
- Naturally you can also move, rotate or scale the group in the dialog Transform.
- Depending on the setting you selected under Modes > Selection, the *3D Viewer* selects a group of **viewer objects** in different ways:
  - For the default setting Select Children clicking an object that is part of a group, only selects this object, not the entire group.
  - For the setting Select Groups clicking an object that is part of a group, selects the entire group. You can then manipulate the group as a whole.
  - When you group plain graphic objects, clicking the group always selects the entire group.

To restore the structure of the 3D part, so that it matches the structure of the 2D part again:

- Select the group.
- Click on the 3D Modeling toolbar, select Edit > Ungroup, or press Ctrl+U.

Rotate an Object

The *3D Viewer* provides several ways of rotating an object in the scene window.

You can:

- *Manually Rotate an Object*
- *Precisely Rotate an Object*
- *Reset a Rotation*
- *Accept Rotating the Object*

Manually Rotate an Object

When you manually rotate an object around an axis with the rotate tool, the *3D Viewer* uses the settings on the tab Rotation in the dialog Grid Settings. You can either use the default settings or define the settings that meet your modeling needs.

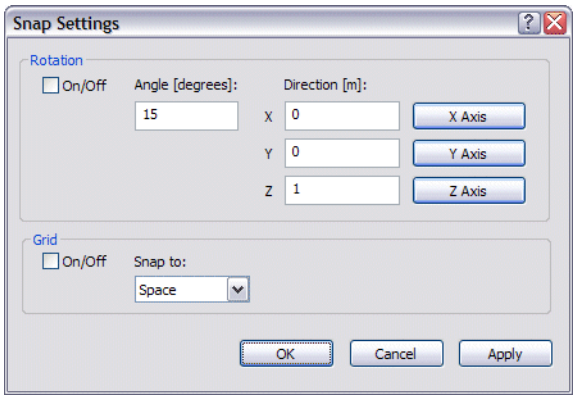
To manually rotate an object with the settings you define:

- Click to show the grid.
- Click on the 3D Modeling toolbar.
- Click the object you want to rotate.
- Hold down the left mouse button and drag the mouse in the direction you want to rotate it. This rotates the object on the grid plane.

Naturally, you can also Precisely Rotate an Object.

To define settings for manually rotating an object:

- Select Tools > Snap Settings.
- Select if you want the object to Snap to an angle (On/Off) and enter the angle into the text box.



- Define the settings how the *3D Viewer* rotates the object in the text boxes below Direction.

  You can either click one of the buttons to rotate the object around that axis or you can define the rotation axis yourself.

  Note: This only applies when the Grid is active.

  To rotate the object around the x-axis, when you click and drag the mouse in the direction you want to rotate it, click X-Axis.

  To rotate the object around the y-axis, when you click, click Y-Axis.

  To rotate the object around the z-axis, when you click, click Z-Axis.

- To rotate the object around an arbitrary axis, defined by the x-component, y-component and z-component of this axis:

  Enter a value for the x-component of the rotation axis.

  Enter a value for the y-component of the rotation axis.

  Enter a value for the z-component of the rotation axis.
- Then, click **Apply** to apply these settings, so that they are active when you rotate the object.

Precisely Rotate an Object

At times manually rotating an object with the **Rotate Object** tool will not be accurate enough.

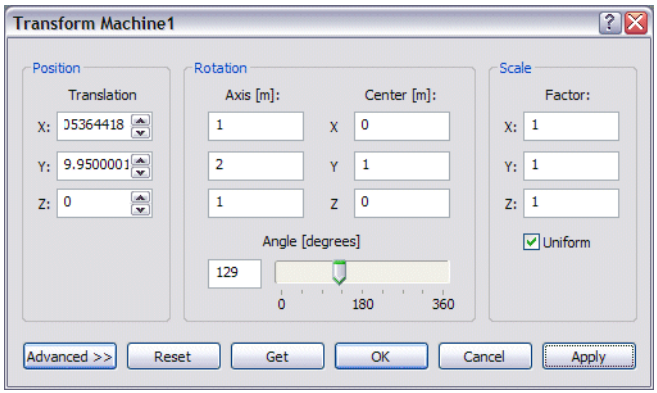
To precisely rotate an object:

- Select it.
- Click on the **3D Modeling** toolbar, press **Ctrl+T** or select **Edit > Positioning > Transformation**.
- Click **Advanced** and select **Auto-apply** to immediately apply and check your changes without having to click **Apply**.
- To rotate the object around an arbitrary axis, defined by its x-component, y-component and z-component:

  Enter a value for the x-component of the rotation axis.

  Enter a value for the y-component of the rotation axis.

  Enter a value for the z-component of the rotation axis.



- Enter an offset off the center of the object for the rotation around the x-axis, the y-axis and the z-axis. Normally you will not enter a different value, but accept the predefined settings of **0**, **0**, **0**. This rotates the object around its origin.
- Enter the angle of rotation in degrees into the text box, or drag the slider to rotate the object by that angle.

Reset a Rotation

At times you may want to reset the rotation of an object in 3D, when you reset the simulation in 2D.

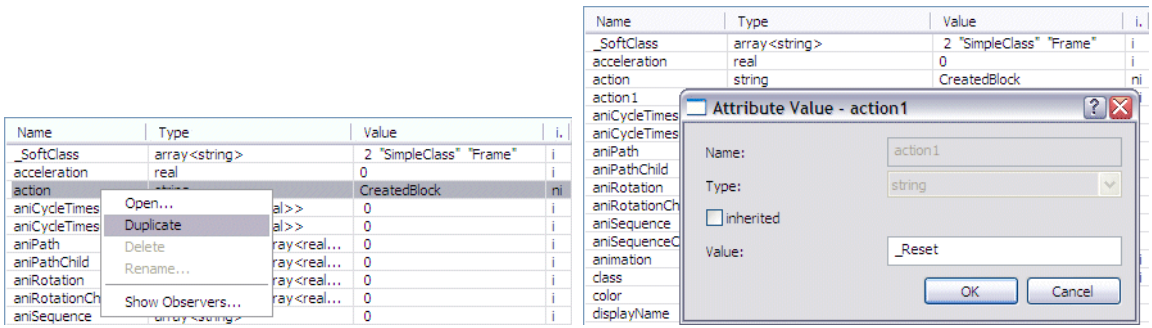
Compare the sample model *3dRobot.spp* that, by default, is located in C:\Program Files\Plant Simulation\Examples\3D, and watch the effects of the procedure we describe below.

This is what you see, when the *3D Viewer* animates the simulation in 2D.

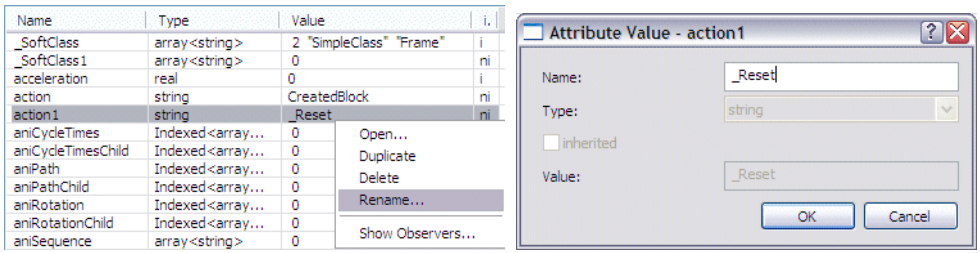
When you click ⏮ to reset the simulation, the arms of the robot return to their original resting position.

To reset the rotation of an object, when you reset your simulation model:

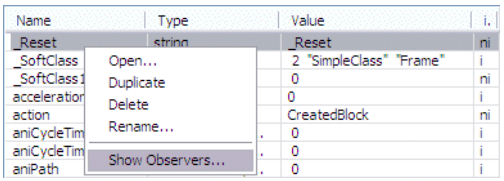
- Click the object, whose rotation you want to reset, Robot in our case, in the 3D Library with the right mouse button and select Show Attributes.
- Right-click any attribute of Type string and select Duplicate. Enter `_Reset` as the value.



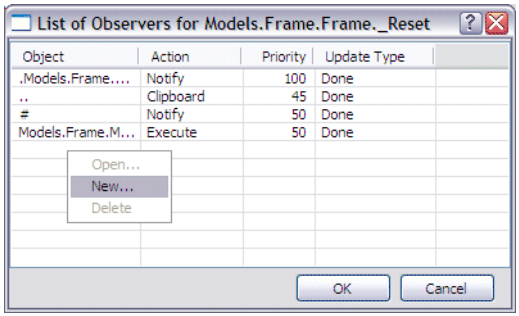
- Right-click the new attribute, select Rename, and enter `_Reset` as the name.



- Right-click the `_Reset` attribute and select Show Observers.

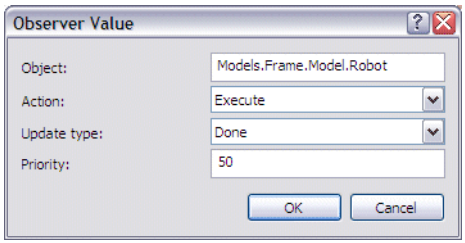


- Right-click in the dialog List of Observers and select New:



Note: Right-click in the dialog List of Observers, click Delete to delete any observers, which the dialog contains. If it does or does not contain an entry, depends on the attribute you copied.

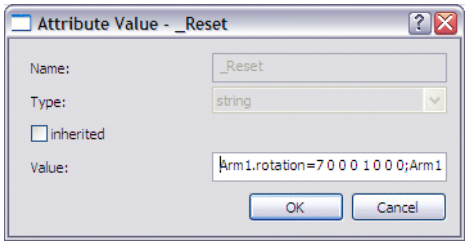
- Enter into the dialog Observer Value:
  - The path to the Object, for example `.Models.Frame.Model.Robot`.
  - Select the Action `Execute` from the list.
  - Select the Update type Done from the list.
  - Enter any Priority.



- Double-click the `_Reset` attribute.
- Into the dialog Attribute Value:

  Enter the **name** of the object, whose rotation you would like to reset, followed by a **period**, the attribute **rotation** and position of the unrotated object. You can also reset several objects at the same time, and separate their individual values with a semicolon. In our sample we entered:

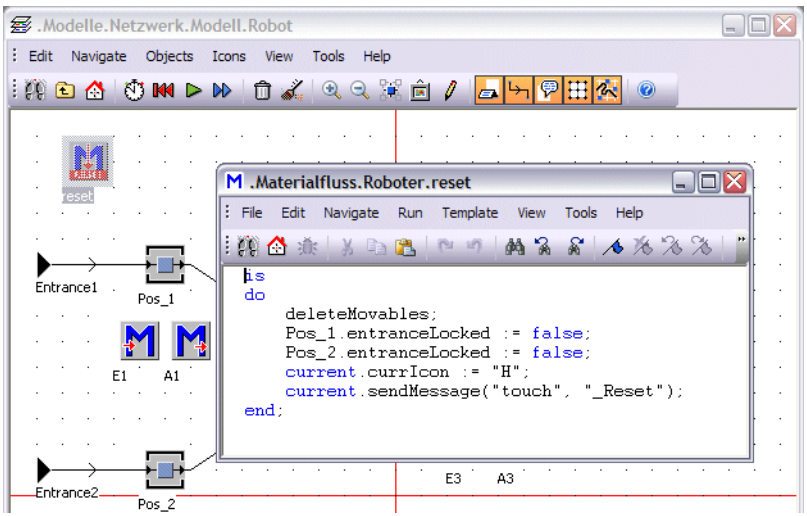
  ```
  Arm1.rotation=7 0 0 0 1 0 0 0;Arm1.Arm2.rotation=7 0 0 0 1 0 0 0;Arm1.Arm2.Arm3.rotation=7 0 0 0 1 0 0 0;
  ```



This resets the rotations of the arms of the robot.

- In the *Plant Simulation* 2D part of the model, enter this command into the *reset* method of the object whose rotation you want to reset. (In the sample model this would be the *reset* method in the *Frame* named *Roboter*.)

```
current.sendMessage("touch","_Reset");
```



Accept Rotating the Object

When you rotate a viewer object, the *3D Viewer* rotates the graphic of the object itself, and of all other objects located on or contained in it. This preserves the orientation of the objects to each other.

When *Plant Simulation* 2D moves an MU onto the object, the *3D Viewer* shows this MU rotated also. At times you might not want that kind of behavior. You might, for example, only want to rotate the graphic, the animation paths, etc. but not the MU.

To not rotate the objects that the simulation moves onto the viewer object, right-click that viewer object and select Edit > Positioning > Accept Rotation.

Then the *3D Viewer* resets the attribute *Rotation* of the viewer object to "`0,0,0`", i.e., it undoes the rotation of the viewer object and instead rotates the plain graphic object.

Default setting	Accept rotation

Precisely Scale an Object

At times manually scaling an object with the Scale Object tool will not be accurate enough.

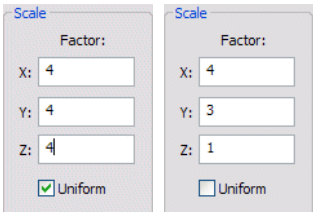
To precisely scale an object:

- Click it with the right mouse button to select it, and

  Select Edit > Transformation.

  Or

  Click on the 3D Modeling toolbar.
- Click Advanced and select Auto-apply to immediately detect your changes without having to click Apply.



- Select Uniform, so that the *3D Viewer* scales the object with the same factor for all three dimensions and does not distort it while scaling it. This automatically enters the value you enter into one text box into the remaining two text boxes. This way you do not have to manually enter the same value into each text box again and again.

  Click into another text box after entering the value, so that the *3D Viewer* enters that value into the remaining text boxes.
- Enter a value into the text boxes for the x-axis, the y-axis and the z-axis to scale the object on the respective axis with that factor. Entering `0.5`, for example, halves the size of the object on the axis for which you entered it, entering `2` doubles its size on that axis.

  Note: You can only enter positive values.
- When you clear Uniform, the *3D Viewer* scales the object with the factors you enter for the different dimensions. When you enter different values, it does distort the object, for example prolongates or compresses it.
- Enter a value into the text boxes for the x-axis, the y-axis and the z-axis to scale the object with that factor on the respective axis.

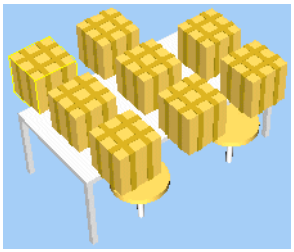
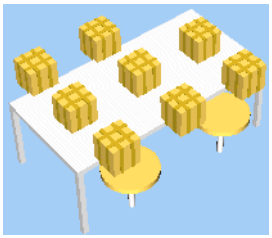
Accept Scaling the Object

When you scale a viewer object, the *3D Viewer* scales the graphic of the viewer object, and of all other objects located on or contained in it. This preserves the relative size and position of the objects to each other.

When *Plant Simulation* 2D moves an MU onto the object, the *3D Viewer* shows this MU scaled also. At times you might not want that kind of behavior. You might, for example, only want to scale the graphic, animation paths, etc., of the object, but not the MU located on it.

To not scale the objects that the simulation moves onto the viewer object, right-click that viewer object and select Edit > Positioning > Accept Scale.

Then the *3D Viewer* resets the attribute *Scale* of the viewer object to "1,1,1", i.e., it undoes the scaling of the viewer object and instead scales the plain graphic object.

Default setting	Accept scale
	

Define a Color of the Object

To define the color of the object:

- Select Edit > Appearance > Material and edit the color of the object.
- To apply a Diffuse color, i.e the base color, click the down arrow of the drop-down list and select a color in the color selector.

  Instead, you can also enter the values of the RGB components into the text boxes.
- To apply the color you selected to the object, click Apply.
- To delete the color you applied to the object, click Remove.

Using a Different Graphic for an Object

In some cases it will suffice to model the machines of your plant with the default graphics we defined for the material flow objects and the mobile objects. In other cases you will want to replace these default graphics with pictures that resemble the actual machines used in your plant.

We saved the graphics that are part of your program package in *s3d* format, we already defined animation paths and for most of them, and we scaled them correctly, so they fit in size with the other objects.

To assign a different graphic to an object:

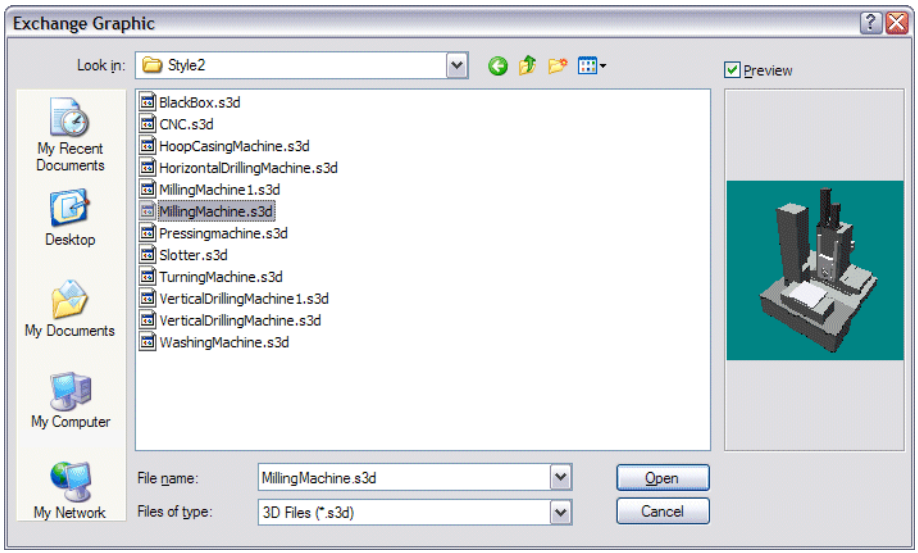
- Select the object, and click on the 3D Modeling toolbar.

  Or

  Right-click the object and select Edit > Graphic > Exchange.

  The *3D Viewer* opens the dialog Exchange Graphic. By default it opens to the folder where you installed *Plant Simulation*, by default this is C:\Program Files\Plant Simulation. Change to Plant Simulation\3D\graphics, select one of the folders contained within.
- Select the graphic you want to use.

  Note: Make sure that Preview is selected, so that you can see what the graphic looks like.



Instead, you can also:

- Create a graphic in the *3D Viewer*. Show the 3D Primitives toolbar and select the shape you want to create. Instead, you can also select Edit > Graphic > Create Primitive.

  You can also create complex shapes by manipulating and transforming primitive geometric shapes and by then grouping them to a graphic.
- Use the icons of the *Plant Simulation* 2D objects and map them to a 3D cube.

Note: You will have to scale the objects you yourself created, define animation paths for them.

Place Objects onto Other Objects Using Animation Paths

When the *3D Viewer* places objects, such as MUs, pallets, etc. onto other objects, you naturally want to control where on that object it places them.

In the dialog Edit Locations you can define how the two-dimensional capacities, which the *Plant Simulation* 2D objects use, are mapped to the three-dimensional locations of the corresponding *3D Viewer* viewer objects.

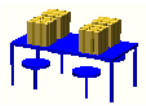
The *3D Viewer* computes the locations of a viewer object, as soon as you click Apply in the dialog Locations. It then also shows the locations it computed on screen.

We already defined locations for the viewer objects *ParallelProc*, *Sorter*, *Store*, *Transporter* and *Container*. These should meet your most basic modeling needs. If you change the predefined capacities or graphics though, you may want to change these settings to correctly display the MUs on the objects.

A location is an animation path that usually contains a single anchor point.

For the *ParallelProc* the default locations are the ChildAnimation Paths named `#0#0`, `#0#1`, `#1#0`, and `#1#1`. They place the MUs flush onto the table top.

Note: If these paths are not defined, the *3D Viewer* uses the `Default` child animation path.

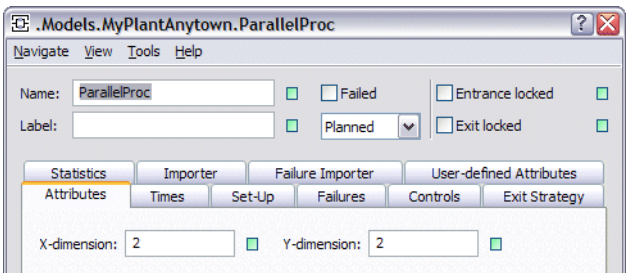


When you increase the capacity of the *ParallelProc*, you can:

- Add an additional Path for each new location by, for example, entering `#2#0`, `#2#1`, etc. This is practicable, when you just add a few locations, but will become cumbersome, when adding a large number. The main advantage is that you have full control over where you place the path.
- Define the positions in the dialog Locations. This is handy, when you add a large number of positions. Be aware that here you are restricted to a grid.

Define the Capacity of a Material Flow Object in Plant Simulation 2D

You can enter the capacity—the number of parts the objects *ParallelProc*, *Store*, *Transporter* and *Container* can hold—into the text boxes X-dimension and Y-dimension on the tab Attributes.



Plant Simulation 2D places the MUs onto the animation points you defined in the icon of the class of the object.

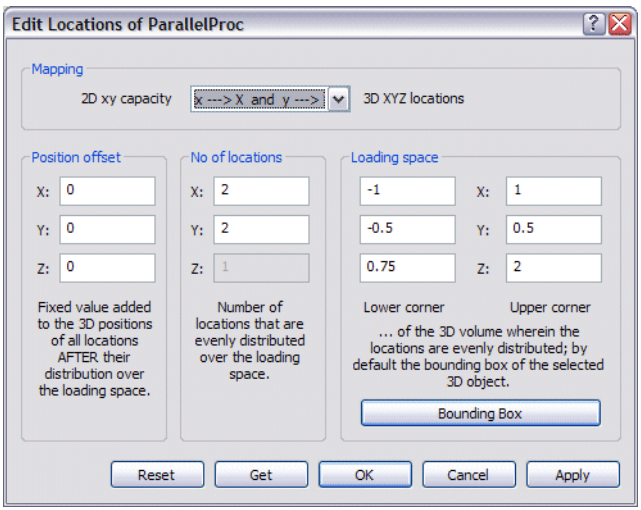
To view and to set animation points in the icon of a built-in object, click *Animation mode* on the toolbar of the *Icon Editor*, compare *Set and Link Animation Points and Animation Lines*.

Define Locations on a 3D Viewer Object

Whereas you define the capacity of the objects in *Plant Simulation* **2D** in **two dimensions**, the *3D Viewer* shows the location of another object on the *3D Viewer* viewer object in **three dimensions**.

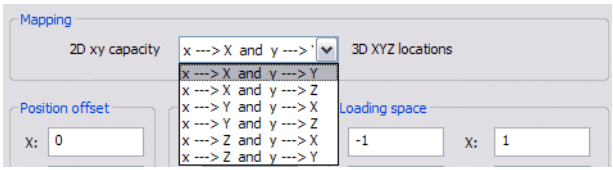
To define the locations of a viewer object:

- Right-click the object to select it.
- Select Edit > Positioning > Locations.

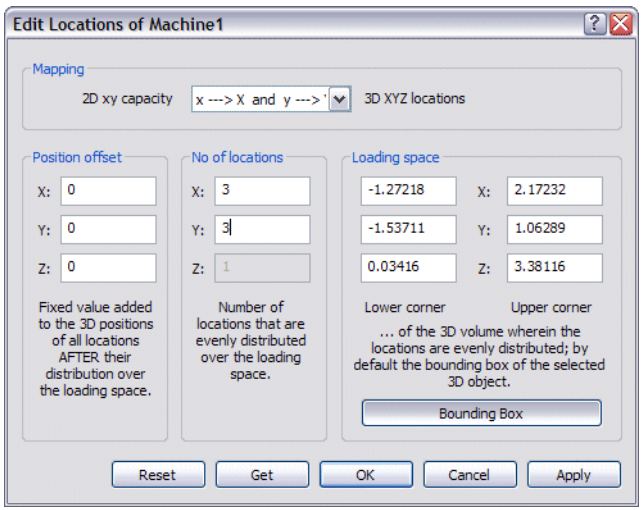


Select How Coordinates are Mapped

Select how the two-dimensional position of the MU on the material flow object on the x-axis and the y-axis in *Plant Simulation* is mapped to a three-dimensional location on the x-axis, the y-axis and the z-axis in the *3D Viewer*. This defines how and in which order on the axes the *3D Viewer* stacks the MUs on the object.



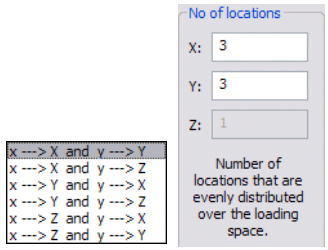
Depending on the setting you select, one of the text boxes for the x-axis, the y-axis or the z-axis below No of locations will be grayed out, as *Plant Simulation* does not provide a third dimension yet.



Enter the Number of Locations

Note: Depending on the setting you select below Mapping, one of the text boxes for the x-axis, the y-axis or the z-axis will be grayed out, as *Plant Simulation* does not provide a third dimension yet.

Enter the number of locations, i.e., storage places, per axis into the text boxes that are not grayed out. The *3D Viewer* evenly distributes these storage places in each dimension over the loading space.



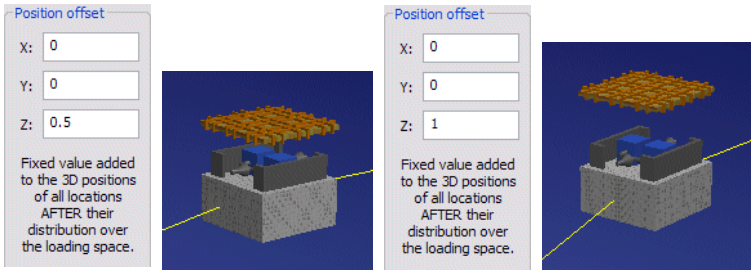
Note: The number of locations may not be identical with the Capacity of the corresponding object you enter under Attributes > X-dimension and Y-dimension in *Plant Simulation*. The number of locations defines the maximum capacity of your three-dimensional object. Every time you edit the capacity in *Plant Simulation* to values less than or equal to the corresponding number of locations in the *3D Viewer*, the *3D Viewer* computes these locations on the object. A *Store*, for example, with its locations set to 3 x 3, places every incoming *Entity* it receives onto one of its nine (3x3) locations, even though you can have set its capacity in *Plant Simulation* to 2 x 2, or 3 x 1, or some other number. When the capacity you set in *Plant Simulation* is larger than the number of locations in the *3D Viewer*, the *3D Viewer* distributes all mobile objects evenly in the loading space or the bounding box.

Enter a Position Offset

The Position offset allows you to move the storage places that are evenly distributed over the loading space to adapt those to carrying elements of the 3D graphic. For the *Store*, for example, the offset of `-0.25` meters on the z-axis prevents mobile objects from being placed into "thin air" instead of flush onto the shelf boards.

Note: Changing the size of the loading space also effects the size of the offset you have to enter!

The Position offset is the value the *3D Viewer* adds to, or deducts from, the three-dimensional positions of all locations where it places mobile objects. The settings below apply when the bounding box is active, symbolized by the pressed button.



- To move all storage places **up**, enter a positive value into the text box Z. The *3D Viewer* adds this value to the three-dimensional positions of all locations after it distributed them evenly across the loading space.
- To move all storage places to the **back** in the scene, enter a positive value into the text box Y.
- To move all storage places to the **right** in the scene, enter a positive value into the text box X.

- To move all storage places **down**, enter a negative value into the text box Z.
- To move all storage places to the **front** in the scene, enter a negative value into the text box Y.
- To move all storage places to the **left** in the scene, enter a negative value into the text box X.
- To move all storage places in several directions at the same time, enter values into the respective text boxes.
- To check if the number you entered produces the result you want, click Apply.

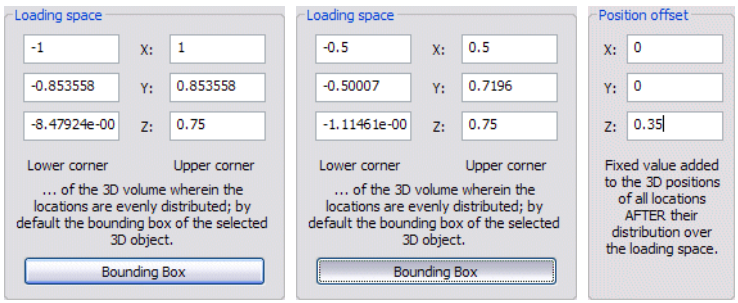
Note: The *3D Viewer* changes the position only after it distributed the MUs over the loading space.

Define the Loading Space

The Loading space defines the size of the 3D volume onto which the *3D Viewer* places and distributes the storage places. For the *ParallelProc* in our sample model top of the station.

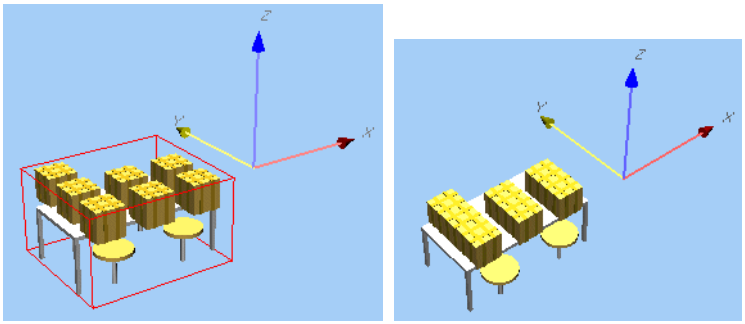
- By default, the loading space is the bounding box of the selected *3D Viewer* object, symbolized by the pressed button.

  The bounding box is the smallest possible cuboid that encloses the entire 3D object graphic. For the *ParallelProc* the bounding box encloses the table and the slightly protruding chairs.
- If you do not want to distribute the storage places within the Bounding Box, but within another 3D volume, enter an appropriate value into the text boxes, and click Apply. This way, you might, for example, limit the loading space to the table.



For the *ParallelProc* the graphic on the left hand side shows the setting Bounding box. The graphic on the right hand side shows a manually defined loading space. For the setting x → X, y → Y, both use a Position offset of `0.35` meters on the z-axis, which places the boxes flush onto the table top. Without the Position offset the boxes would be placed below the table, as the distribution algorithm places the loading spaces at half the height of the table, i.e., the middle of the z-axis of the loading space.

- Enter the values that define the Lower corner on the x-axis, the y-axis and the z-axis of the three-dimensional cuboid within which the *3D Viewer* evenly distributes the locations it places mobile objects on.
- Enter the values that define the Upper corner on the x-axis, the y-axis and the z-axis of the three-dimensional cuboid.



Use Identical Lengths and Positions

In most cases you want the corresponding objects in the *3D Viewer* and in *Plant Simulation* 2D to have the same lengths to represent your installation as true-to-life as possible. In addition, a smooth animation of an *Plant Simulation* simulation model in the *3D Viewer* requires animation paths that match the length of the corresponding objects in *Plant Simulation*.

- To use the same values for the length of **all objects**, or a single object you selected, in the *3D Viewer* and *Plant Simulation*, select 2D > Connect Data > 3D Length to/from 2D Length.
- To make *Plant Simulation* match the position of an object in the 2D part of the simulation model with the position of a **single selected object** in the 3D part, select 2D > Connect Data > 3D Position to 2D Position.

  Note: This only transmits the position of the *3D Viewer* viewer object to the corresponding object in the *Plant Simulation* 2D *Frame*!

Update the Model

Normally, you want to ensure that the 3D part of your simulation model and the 2D part use the same data, i.e., are in a consistent state. When you work on one part of the model, while the other part is closed, the model will be in an inconsistent state. Updating the model only works, when both parts are open at the same time.

- When you changed values in the *Plant Simulation* 2D part of the model, select 2D > 2D → 3D > All to update the 3D part with the 2D data.

  This updates the values of attributes that *Plant Simulation* and the *3D Viewer* share. It also creates 3D objects that are present in the 2D part of your simulation model in the 3D part, when they do not exist there yet. Note that this only works for objects for which you entered `3d` as the Channel ID in the dialog of the object in *Plant Simulation*.
- When you changed values in the 3D part of the model, select 2D > 3D → 2D > All to update the 2D part with the 3D data or click on the 3D Modeling toolbar.

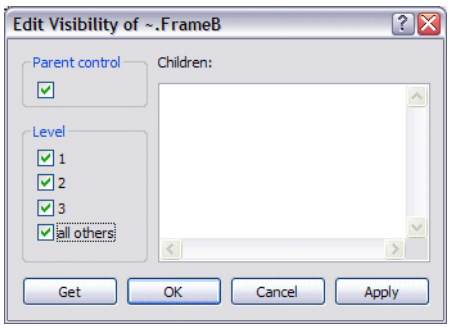
  This transmits—among others—the values of the *3D Viewer* viewer attributes *Length* and *Velocity* to *Plant Simulation* and writes them to the corresponding *Plant Simulation* attributes.

Setting the Visibility of an Object

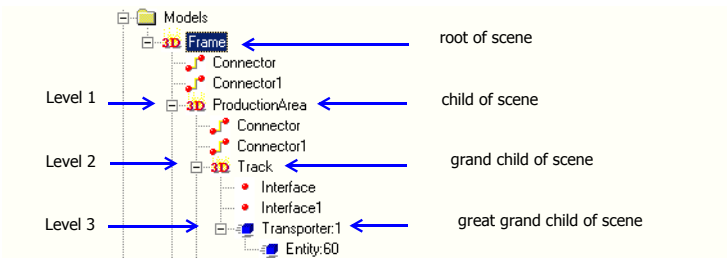
The Visibility described on page 2310 in the *Reference Manual* sets when and at which hierarchy level in the model an object, and its children, i.e., the objects located on that object, are visible. This prevents your model from appearing cluttered when you present it. It also improves performance, as it reduces render time.

To set the visibility of the object:

- To make the children of the object visible, when the object itself is visible, select Parent control.



- Select the hierarchy level or levels at which the object will be displayed.



You can select any one level or any combination of levels.

- To show the object that is a child of the current root of the scene, which usually is the *Frame* located in the folder *Models*, the object is located in, check Level 1.
- To show the object that is a grand child of the current root of the scene, check Level 2.
- To show the object that is a great grand child of the current root of the scene, check Level 3.
- To show the object at all other hierarchy levels, check all others.

- Enter the names of the Children whose visibility will be controlled by the object into the list. Enter one child per line. The *3D Viewer* then activates the check box Parent control for the child you entered.

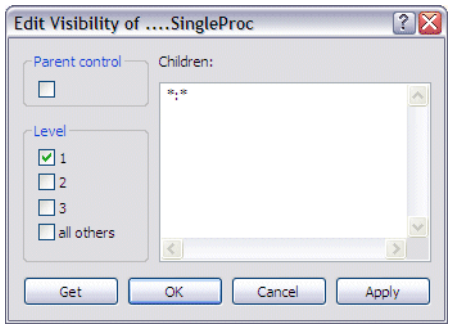
  When you enter mobile objects without a token number—for example `Entity` instead of `Entity:1`— all objects of type *Entity* will be controlled like this. This way you can define that mobile objects of type *Entity* will always be displayed, when they are located on the object. This corresponds to animation structures you might

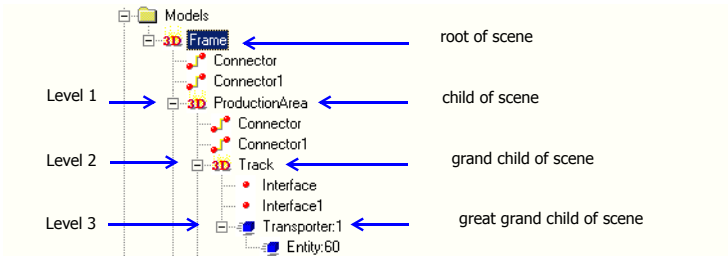
know from *Plant Simulation*. To control all mobile objects, which are transferred onto the object, i.e., which will become a child of the object, enter `*:*` into the list box.

Illustrating the Visibility of Objects

For the default setting, shown in the example below, the *3D Viewer* shows:

- All objects that are located on the first hierarchy level below the *Frame*, which, for this example, is the root of scene (Level 1).
- All *MUs* located on the *SingleProc* we inserted into the *Frame*. This applies because of the default setting `*:*` we defined for Children of the selected object. Remember that children are all objects located on the *SingleProc*.

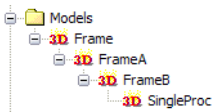




Let us illustrate the visibility with some examples, which you yourself can easily re-create.

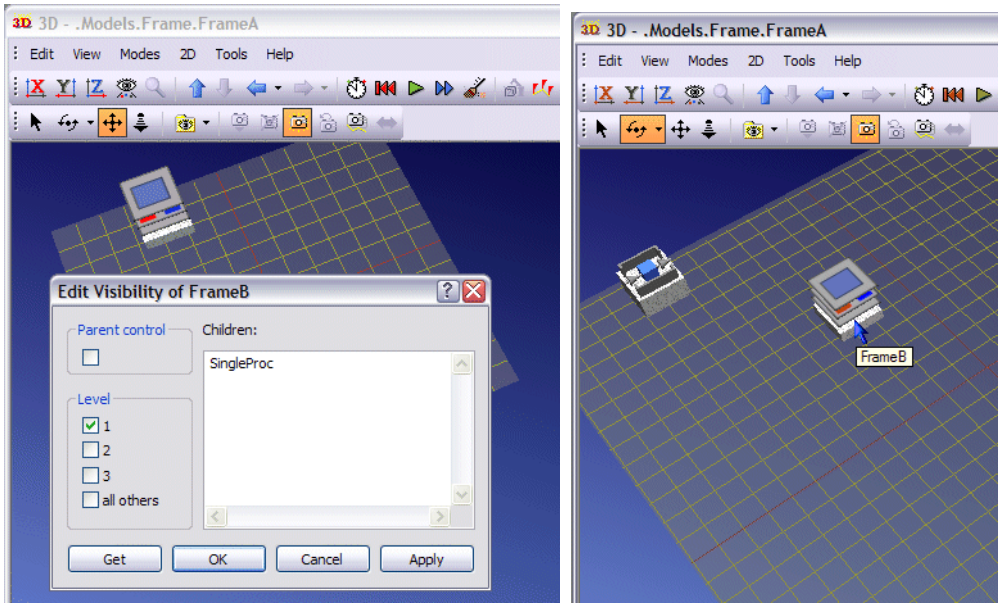
Example 1

We inserted *FrameA* into the *Frame*, *FrameB* into *FrameA*, and then a *SingleProc* into *FrameB*. The path of the *SingleProc* looks like this: *.Models.Frame.FrameA.FrameB.SingleProc*.



To display the *SingleProc* in *FrameA*, and in *FrameB*, into which we inserted it, we can:

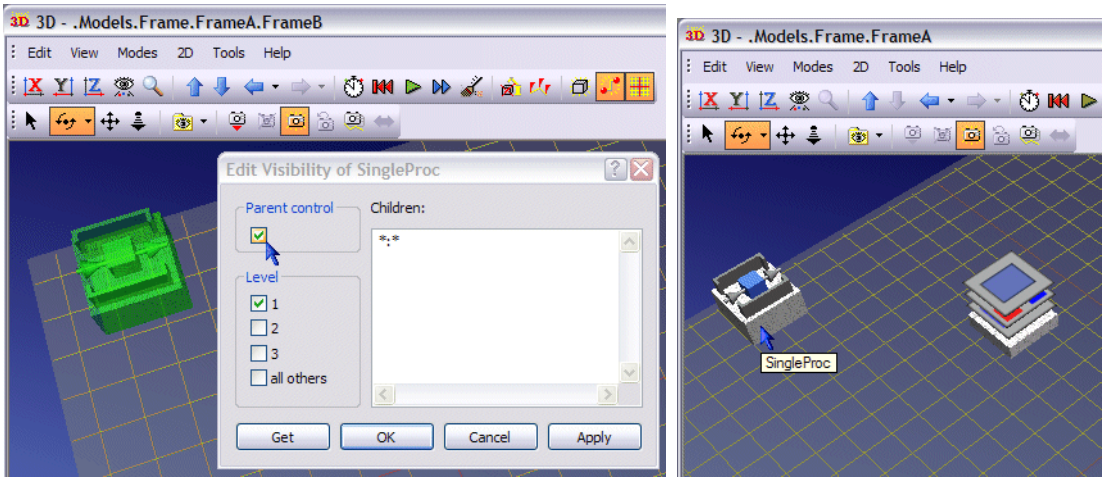
- Edit the Visibility of *FrameB* by selecting Edit > Appearance > Visibility. Enter `SingleProc` into the list Children.



Note: By default, the *3D Viewer* shows the default graphic of *FrameB* in *FrameA* next to the graphic of the *SingleProc*. It places the *SingleProc* at about the same coordinates where you inserted it into the corresponding 2D *Frame*. If you cannot see it in the 3D *Frame*, click on the 3D Standard toolbar, to quickly show all objects in the active scene. If necessary, move the *SingleProc* to the position, where you need it to be.

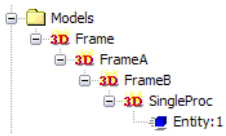
Instead, we can also:

- Edit the Visibility of the *SingleProc*: When we select Parent control the *3D Viewer* also shows the *SingleProc*, when *FrameB* is visible in *FrameA*.

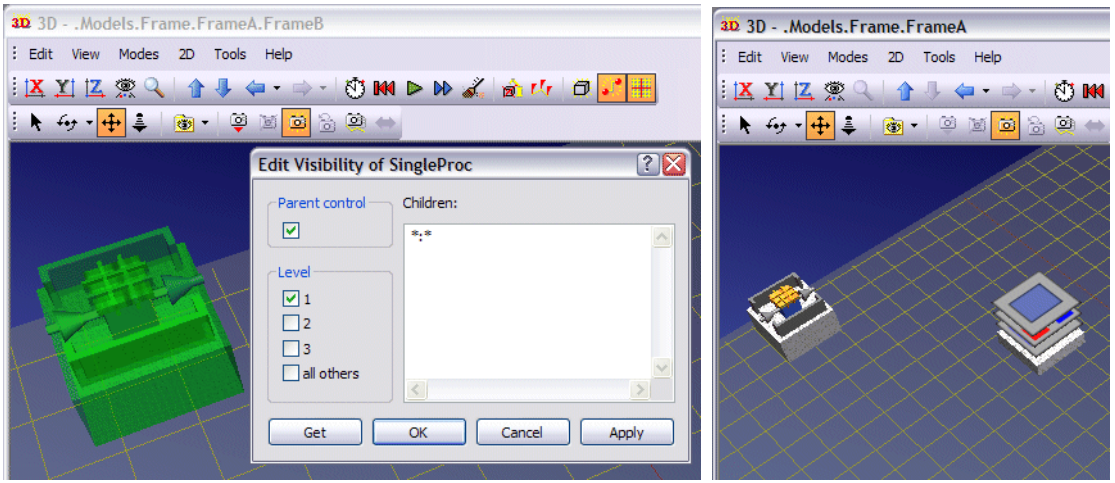


Example 2

We inserted *FrameA* into the *Frame*, *FrameB* into *FrameA*, and then a *SingleProc* with an *Entity* on it into *FrameB*. The path of the *Entity* looks like this: *.Models.Frame.FrameA.FrameB.SingleProc.Entity:1*.



For displaying the *SingleProc* and the *Entity:1* in *FrameA*, and in *FrameB*, into which we inserted it, we can edit the Visibility of the *SingleProc*: When we select Parent control, select Level 1 and enter * : * into the list Children, the *3D Viewer* shows the *Entities* on the *SingleProc* and *FrameB* in *FrameA*.



Creating Your Own 3D Objects

To create your own 3D viewer object:

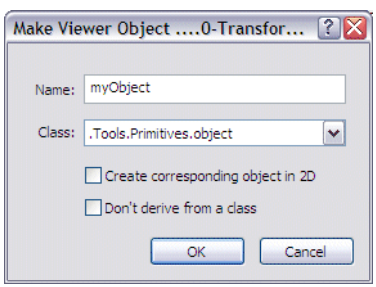
- You can copy any of the predefined standard objects that we provide in The Folder MaterialFlow and The Folder MUs that have similar properties as the one you would like to create.

  You can then edit the behavior of this object, so that it fits your needs, i.e., exchange the graphic, update the animation paths, etc. Compare *Attaching a 3D Shape to an Object*.

- You can import a three-dimensional graphic from the *3D Viewer* graphics library, from your own graphics library or from a graphics program that can save files in *VRML 2.0 (wrl)* or .co format, into your simulation model.

  You can then transform this graphic into a viewer object, compare *Import a 3D Geometry*.

  - Click the graphic with the right mouse button and select Make Viewer Object on the context menu.



  - Enter a Name for the newly created object.
  - Select a Class from the list.

- Activate Don't derive from a class to not derive the object from any of the existing classes and to deactivate the drop-down list Class.
- Activate Create corresponding object in 2D to also create a corresponding object in *Plant Simulation*.

Note: When you only want to create a 3D object, and not a corresponding 2D object also, you do not have to select a class.

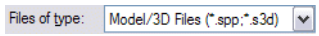
- You can create simple three-dimensional graphics in the *3D Viewer*, compare Create Primitive. Then, click the object with the right mouse button and select Make Viewer Object on the context menu.

  You can also use it as a plain graphic object, for example as the background of your three-dimensional model to model your installation as close to its actual look as possible.

Import a 3D Geometry

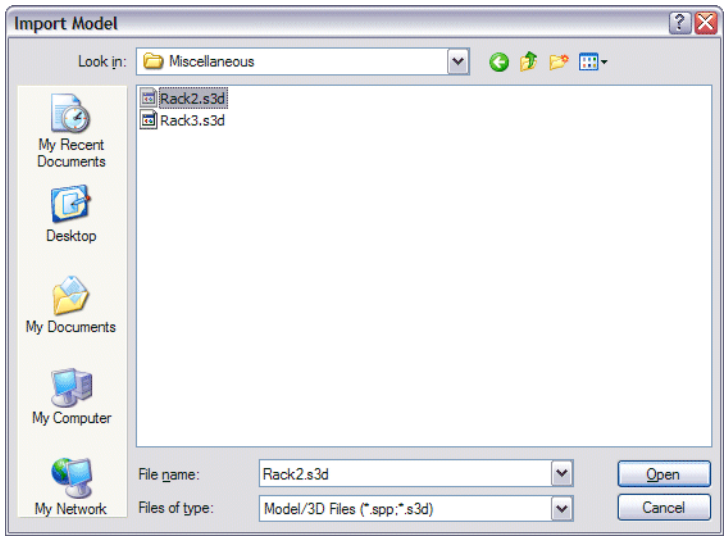
To create your own 3D objects, you can import geometries into your 3D simulation model:

- You can import a *s3d* graphics file:
  - You can import a graphic that contains animation structures you, or a colleague, defined:

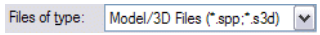
    Select 3D > Import 3D Geometry. Select 

, navigate to the folder that contains the graphic, select it and click Open.

    These *s3d* files can either be files that are part of your program package or files you yourself created using Export 3D Scene.

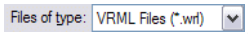


  - You can replace the graphic of an object with another graphic that contains animation structures:

Select an object and then select Edit > Graphic > Exchange. Select 

, navigate to the folder that contains the graphic, select it and click Open.

- You can import a *VRML 2.0 (wrl)* file that may also contain animation structures.

  Select 3D > Import 3D Geometry. Select 

, navigate to the folder that contains the graphic, select it and click Open.

  Compare *Work with an Imported VRML 2.0 Animation*. You can then start this animation from within *Plant Simulation*, compare *Start the Animation from 2D*.

Employing Graphic Inheritance

Employing graphic inheritance allows you to re-use graphics, so that your model file does not get too large. In general all graphic information is inherited, except when you duplicate an object in *Plant Simulation* 2D.

Graphics inheritance works in both directions in 3D: from class to instance and from instance to class! When you delete the graphic of a derived object, the *3D Viewer* also deletes the graphic of the associated class.

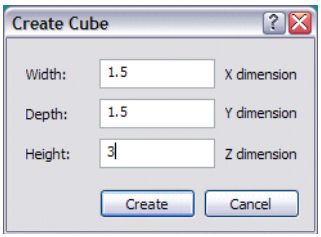
The plain graphic object holding the three-dimensional geometry data of the object is not stored in an attribute. You can select the menu command Edit > Graphic > Inheritance on the context menu to activate or deactivate inheritance of geometry data. Activating Graphic Inheritance restores the graphic to the graphic of the origin of the object, while deactivating Inheritance retains the graphic you modified in the instance.

InheritanceCreate a 3D Shape

To create a three-dimensional shape, a Cube, a Cylinder, a Sphere, a Cone, a Facet, or a Box:

- Show the 3D Primitives toolbar .

  Or select Edit > Graphic > Create Primitive.
- Click the shape you want to create. In our example we create a cube.
- Enter the Width, the Depth, and the Height of the cube into the dialog Create Cube.



- To create and insert the cube at the center of the scene, click Create.
- To move the cube to the location of your choice, click Move Object, and drag the mouse.
- To assign a color and a material, select the cube and select Edit > Appearance > Material or click on the 3D Modeling toolbar.

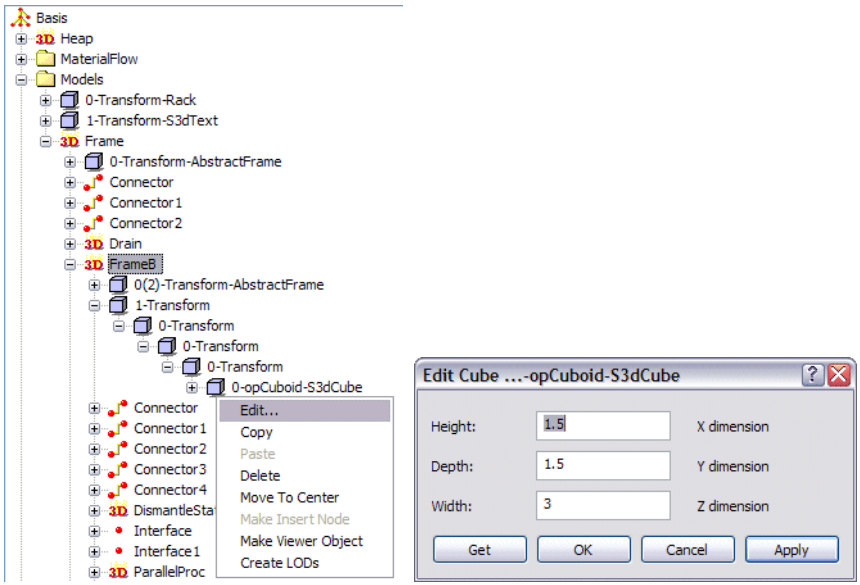
Note: Press F5 or select View > Refresh if the *3D Viewer* does not immediately show the object.

Edit the Size of a 3D Shape

To edit the size of a three-dimensional shape you created using Edit > Graphic > Create Primitive:

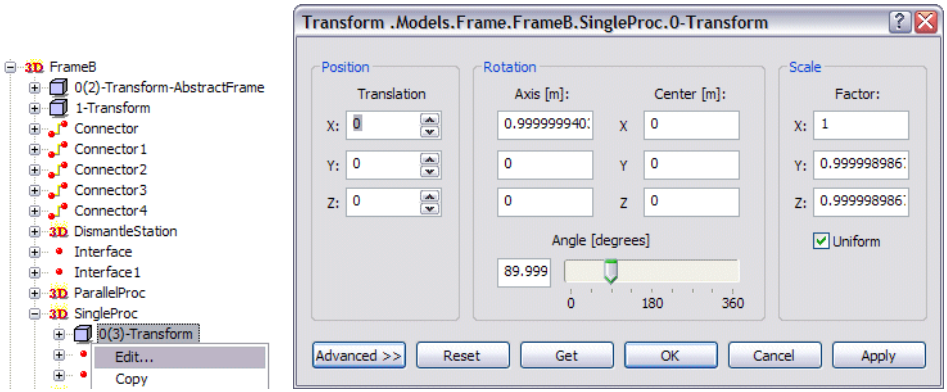
- Select the object in the 3D scene window to show its name in the status bar.
- Click the 3D Library.

  Make sure that Display Plain Graphics is active, shown by the check mark ☑ in front of the command.
- Open the branch with the name of the object in the structure.

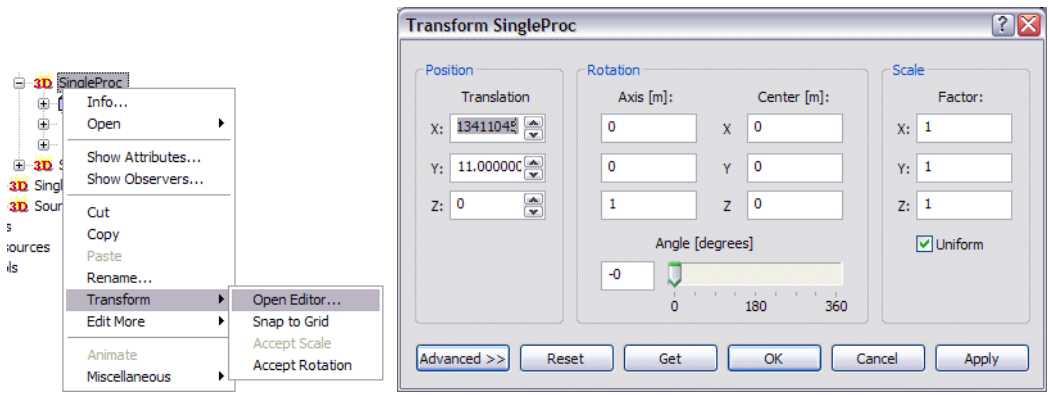


- Right-click the object and select Edit on the context menu.
- Enter a different value for the Width, Height, Depth, etc.

To edit the graphic the topmost **transform node** that clicking the plain graphic of an object in the 3D Library selects, select Edit on the context menu or select Edit > Positioning > Transformation. This applies to all graphics nodes, shapes and other transform nodes that are children of the selected transform node. It does not apply to other viewer objects.



To scale the **viewer object**, right-click it in the 3D Library and select Edit > Transformation or manipulate it with the manipulator. Keep in mind though that this also scales child viewer objects of the selected viewer object.



Attaching a 3D Shape to an Object

The main task of the *3D Viewer* is to establish a connection between a three-dimensional shape, for our purposes a three-dimensional graphic, and arguments transmitted by the simulation in *Plant Simulation*.

To attach any three-dimensional shape to an object:

- Select a viewer object.
- Click to open the viewer object. The *3D Viewer* shows an empty background.
- Click on the 3D Modeling toolbar to display plain graphics and select the graphic of the object.
  - Cut, copy, paste, group, ungroup, or move the existing graphic.

    Or
  - Import or create a new graphic, using the tools on the 3D Modeling toolbar.

When you import plain graphic objects you downloaded from the internet or created in a 3D modeling program, you will most likely have to scale these graphics.

You can roughly scale them using Scale Object.

You can accurately scale the entire object, i.e., the **viewer object** and the **plain graphic object**, in the dialog Transformation.

When you scale the viewer object, this also scales mobile objects that transfer to the object during the simulation. To prevent this, select Edit > Positioning > Accept Scale. Then, mobile objects that move onto the object are not scaled, while the graphic of the object remains scaled.

Note: When you scale the **plain graphic object**, this does not apply.

- Click on the 3D Modeling toolbar to hide plain graphics.
- To step out of the object and return to the next higher hierarchy level, click on the 3D Standard toolbar.
- Activate or deactivate Graphic Inheritance by selecting object and selecting Edit > Graphic > Inheritance.

In addition to static shapes, you can also use extrusion objects. Extrusion objects contain graphics that are defined by a path and a specific profile. This way any change of the length of a simulation object is directly mapped to a change of the graphic.

Animating the Simulation Model

The *3D Viewer* **animates** the simulation you run in *Plant Simulation*. What the *3D Viewer* displays in its part of the model corresponds to the actual state of the simulation model in *Plant Simulation*. When running the simulation and the animation concurrently, there will be a slight delay in time between the event times in the simulation and the animation.

This is always true when you run *Plant Simulation* in the default event triggered mode: When a mobile object, for example a *Transporter*, moves along a *Track*, the **simulation** needs to know that it takes 20 seconds to move from point A to point B. Knowing this, the simulation is able to proceed immediately. If you would like to watch the **animation**, you will have to wait for these 20 seconds to pass. Thus, the animation slows down the simulation. The *3D Viewer* transmits a message to *Plant Simulation* if the simulation is running ahead of the animation. You can also click Stop in the dialog of the *EventController* of the *Plant Simulation* simulation model to receive the exact state the simulation is in.

Control the Animation from 2D

When you start modeling with the three-dimensional part of the simulation model, you do not have to proceed any different from the way you are used to when you work with two-dimensional simulation models. *Plant Simulation* 2D automatically transmits all messages required for a three-dimensional animation to the *3D Viewer*.

Once you want to fine-tune performance, to add special effects or to attach a three-dimensional animation model to an existing *Plant Simulation* simulation model that you did not create starting from a new three-dimensional model, be aware of the following:

Marking Objects for Transmitting Messages

To tell the object in *Plant Simulation* 2D to transmit messages to its counterpart in the *3D Viewer*, select Tools > Select Viewer Process, in the *Frame*, into which you inserted the object, enter `3d` into the text box ChannelID and click OK.

Messages that result from changes to the object in *Plant Simulation* are sent to the *3D Viewer* only after you enter `3d` into the text box ChannelID! You can also set the channel id in SimTalk using the attribute *ChannelID*:

```
.<path>.ChannelID := "3d";
```

We mark objects for transmitting messages because a simulation model in *Plant Simulation* usually contains a large number of objects, only a small number of which the animation in the *3D Viewer* uses. If you did not select which objects transmit messages, program performance would suffer tremendously as data transmission is time-consuming and a large part of the data transmitted would not even be used by the *3D Viewer*!

You can also employ this mechanism to selectively activate or deactivate the animation of parts you would like to view or not view.

Automatically Generated Messages

Plant Simulation automatically transmits all messages used for the two-dimensional animation in your two-dimensional *Plant Simulation* simulation model to the *3D Viewer*: *create*, *delete*, *rename*, change of icon, change of speed, change of length, and change of movement.

Manually Generated Messages

In *Plant Simulation* you can generate and send messages manually to the *3D Viewer* by using the SimTalk method:

```
<path>.sendMessage(<string1>,<string2>);
```

This method makes the *Plant Simulation* object designated by `<path>` send the value `<string2>` with the attribute identifier `<string1>` to the object in the *3D Viewer* that has the same name as `<path>`.

Note: The first argument of type *string* is case-sensitive!

You can use the method *sendMessage* and the *Attributes of the 3D Viewer as Such* or the *Attributes of the 3D Objects* to generate special effects. Compare the example described under *Start the Animation from 2D*.

Opening and Closing 3D Windows with the Method sendMessage

Usage: `<path>.sendMessage(<string1>,<string2>);`

You can use the method *sendMessage* to open an object in a 3D window.

Note: The first argument of type *string* is case-sensitive!

Example: `SingleProc.sendMessage("NewFrame"," ");`

You can also use the method *sendMessage* to close all 3D windows. As you cannot address an individual 3D window after opening it, you can only close all windows at once and thus send the message to any of the open 3D windows.

Example: `SingleProc.sendMessage("CloseAllWindows"," ");`

Setting a Simple Attribute with the Method sendMessage

Usage: `<path>.sendMessage(<string1>,<string2>);`

This method sets the attribute designated by <string1> to any text you enter as <string2>.

Note: The first argument of type *string* is case-sensitive!

Example: `SingleProc.sendMessage("Info", "Master SingleProc for the project.");`

In our example the dialog Info, which you open by right-clicking an object and selecting Info, shows the text Master SingleProc for the project.

If you would enter this information into the dialog Edit > Data > Any Attribute, it would look like this:

Setting an Array Attribute with the Method sendMessage

Usage: `<path>.sendMessage(<string1>,<string2>);`

This method sets the attribute designated by <string1> to the values you enter as <string2>. <String2> contains a set of *real* numbers.

Note: The first argument of type *string* is case-sensitive!

Example: `SingleProc.sendMessage("Rotation", "7 1.570796 0 0 1 0 0 0");`

In our example we set the attribute *Rotation* of the *SingleProc* to the values we pass as *real* numbers.

First, we enter the name of the attribute as a string, `"Rotation"` in our example.

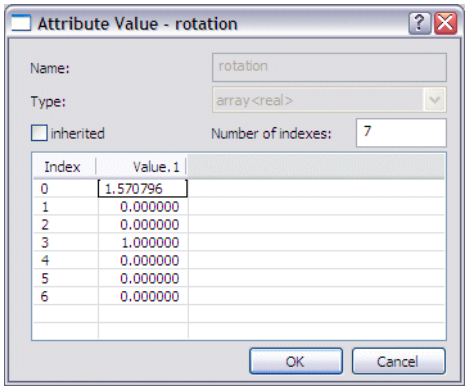
For data types of type array we then enter the number of entries of the outermost array. In our example `7` designates that for the attribute *Rotation*, we enter `7` real numbers.

The second number stands for the angle of rotation in radians; in our example the number `1.570796`, which is Pi/2, defines an angle of 90 degrees.

The next set of three numbers designates the axis around which the object is rotated; in our example `0 0 1` defines the z-axis.

The last set of three numbers designates the origin as the center of rotation.

If you would enter this information into the dialog Show Attributes > Attribute Value, it would look like this:



Setting an Indexed Array Attribute with the Method sendMessage

Usage: `<path>.sendMessage(<string1>,<string2>);`

This method sets the attribute designated by <string1> to the values you enter as <string2>. <String2> contains a set of *real* numbers.

Note: The first argument of type *string* is case-sensitive!

Example:
```
SingleProc.sendMessage("AniPathChild", " 2 \"Default\" {{0 0 0}{2 0 0}}
\"Camera\" {{0 0 0.2}}");
```

In our example we set the attribute *AniPathChild* of the *SingleProc* to the values we pass as real numbers within an indexed set, i.e., each one of the sets has a name of its own.

First, we enter the name of the attribute as a string, `"AniPathChild"` in our example.

Then, we enter an opening quotation mark, to denote the beginning of the string and the number of paths for which we enter data, `"2` in our example.

Then, we enter the name of the path, i.e., the *index* of the indexed<array<array<real>>> attribute, enclosed by protected quotation marks, `\"Default\"` in our example.

Note: We have to protect the quotation marks with the backslash, so that SimTalk does not mistake the closing quotation mark as the end of the command string.

Next, we enter the positions of the individual path nodes of that path in curly brackets, `{{0 0 0}{2 0 0}}` in our example. The first set of numbers defines the first path node, the second set the second path node we defined.

We then repeat this for the second path we define, `\"Camera\" {{0 0 0.2}}` in our example.

Finally, we enter a closing quotation mark, to designate the end of the command string.

Note: The *3D Viewer* does not append the paths you define to any existing paths, but replaces those existing paths!

To also rotate the path nodes, we have to set the attribute *AniRotationChild* in addition.

Controlling the Camera in 2D

You can control the camera not only using the features Attach Camera, Detach Camera and Animate Camera in the *3D Viewer*, but also by setting 3D attributes in *Plant Simulation* in a *sendMessage* method.

Attaching the Camera in 2D

Usage: `<path>.sendMessage("action","AttachCamera");`

This method causes the *Plant Simulation* object designated by `<path>` to attach an object camera to its counterpart in the *3D Viewer*.

Note: The first argument of type *string* is case-sensitive!

Example: `track.sendMessage("action","AttachCamera");`

Detaching the Camera in 2D

Usage: `<path>.sendMessage("action","DetachCamera");`

This method causes the *Plant Simulation* object designated by `<path>` to detach the object camera from its counterpart in the *3D Viewer*.

Note: The first argument of type *string* is case-sensitive!

Example: `track.sendMessage("action","DetachCamera");`

Animating the Camera in 2D

Usage: `<path>.sendMessage("animation",<string2>);`

This method causes the *Plant Simulation* object designated by `<path>` to send a message to its counterpart in the *3D Viewer* and to start the camera animation on the animation path designated by <string2>.

For a path of type ChildAnimation, you have to enter a tilde followed by a dot (~.) in front of the path name. For a path of type MyAnimation, enter just the name of the path. For both path types, ChildAnimation and MyAnimation, the number sign (#) designates the string for the path as a camera animation, as opposed to an animation of an MU.

If you would like to animate the camera on a ChildAnimation path named Default of the object *Line*, you would enter:

Note: The first argument of type *string* is case-sensitive!

Example: `Line.sendMessage("animation","#~.Default");`

If you would like to animate the camera on a MyAnimation path named Default of the object *Line*, you would enter:

Example: `Line.sendMessage("animation","#Default");`

Start the Animation from 2D

You can generate messages in *Plant Simulation* for any attribute the *3D Viewer* provides, and send theses messages with the method *sendMessage*.

Example: `.MaterialFlow.SingleProc.sendMessage("animation","roboAnim");`

Note: The first argument of type *string* is case-sensitive!

The expression `.MaterialFlow.SingleProc` is the path to and the name of the object for which you define the animation, the string `"animation"` is the name of the attribute to be set, and the string `"roboAnim"` stands for the name of the animation, which will be set as the new value of the attribute.

Note: If you have imported a *VRML 2.0 (wrl)* file, the value of the attribute would probably be `SingleProc`, since the default name of animations from a *VRML 2.0* import is the same as the name of the object.

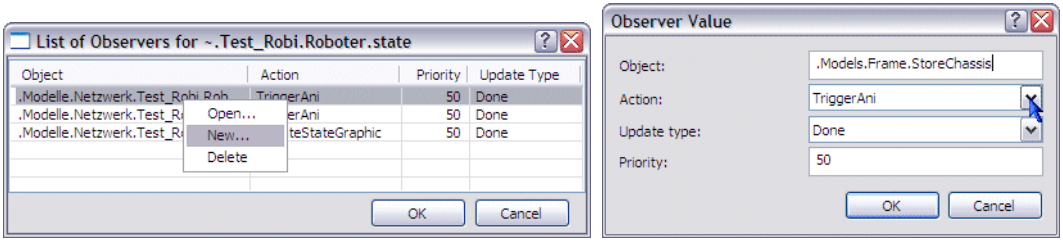
In the example above the method *sendMessage* animates the viewer object *SingleProc* in the folder *MaterialFlow* on the MyAnimation path named `roboAnim` in the *3D Viewer*.

Start the Animation When the State or the Icon Changes

Whenever the state of the object in *Plant Simulation* changes during a simulation run, the corresponding viewer object in the *3D Viewer* automatically reflects that in its attribute *State*.

To start an animation by changing the state in *Plant Simulation*:

- Make sure that the names of the animations in the *3D Viewer* are the same as the names of the different state icons in *Plant Simulation*.
- Click the object, to which you want to attach an action to the attribute *State*, with the right mouse button:
  - Select Show Observers to open the dialog List of Observers.
  - Right-click anywhere in the table and select New to open the dialog Observer Value.



  - Enter the path of the object into the text box Object in the dialog Observer Value: We entered `.Models.Frame.StoreChassis` in our example.
  - Select TriggerAni from the list Action.
  - Select Done from the list Update type.
  - Enter any priority value into the text box Priority. The value you enter indicates in which order the actions are executed if there is more than one action attached to that attribute. In most cases though, it doesn't matter in which order they are executed.
  - Click OK to set the animation attribute to the value of the state attribute, whenever that state attribute changes. This, in turn, will start the animation.

We employed this mechanism in the sample model *Robot3D.spp*. Check it out to see how we attached the actions.

Displaying State Objects in the 3D Viewer

Note: Compare the sample model *demo.spp* that is part of your program package, and watch the effects of the procedure we describe below.

For performance reasons the *3D Viewer* does not use state objects for the states *failed*, *paused*, *waiting*, etc. Instead, the color of the object in the *3D Viewer* itself changes to red, blue, yellow, etc. when the object enters into one of these states, just like the color of the dot in the LED display of the corresponding object in *Plant Simulation* does. If you would like to use a state object for a specific state, you have to create one for the respective viewer object.

During the simulation run *Plant Simulation* 2D displays the state of an object, either as one or more colored dots in the LED display of the icon or by showing a different icon. In addition to the built-in icons, you can define different states and draw corresponding icons that suit your modeling needs.

The *3D Viewer* proceeds in much the same way. According to the state the object is in, the *3D Viewer* shows, i.e., makes visible, a viewer object with the corresponding name. Note that these state objects have to be child objects of the object whose state changes and that they have to be named according to the state.

To define a new state object:

- Select Edit > Appearance > Create State Object. Type the name of the state object into the dialog.
- Edit its attributes, by assigning a different color, by changing its graphic, etc.
- Create a new icon with the same name in *Plant Simulation*. Then the *3D Viewer* shows the new state object, every time the state of the object changes to the new icon in *Plant Simulation*.

Start the Animation When an MU Moves Onto the Object

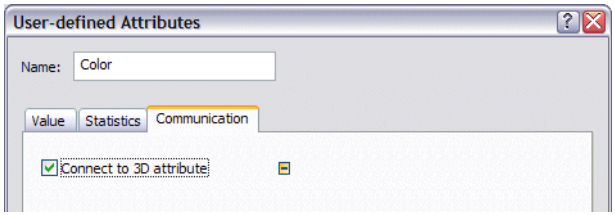
Starting the animation, whenever an MU enters the object basically uses the same mechanism as described under *Start the Animation When the State or the Icon Changes*.

You can also use the fact that the attribute *Event* is set to the value MUEnter, whenever an MU enters the object, and to the value MULeave, whenever it leaves the object.

If you only want to start animations, when an MU enters the object or when it exits the object, you can name the corresponding animations MUEnter and MULeave.

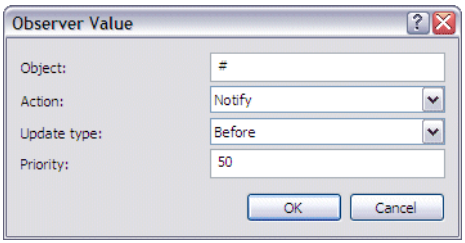
Create User-defined Attributes

You can create user-defined attributes in *Plant Simulation* and in the *3D Viewer*. After you selected the check box Connect to 3D attribute on the tab Communication in the dialog User-defined Attributes of a user-defined attribute in *Plant Simulation* for sending messages, *Plant Simulation* transmits changes of that attribute to the *3D Viewer*.



If you want the *3D Viewer* attribute to transmit changed values back to the *Plant Simulation* attribute, you have to enter an observer:

- Click the attribute of the object to which you want to add an observer with the right mouse button and select Show Observers.
- Right-click into the dialog List of Observers and select New. This opens the dialog Observer Value.



Enter # into the text box Object. # is the symbol for the channel *Plant Simulation* and the *3D Viewer* use to communicate.

Select the Action Notify. The observer watches the attribute, and notifies the channel, i.e., *Plant Simulation*, when the value of the attribute changes.

Select the Update type Done, as we want to notify *Plant Simulation* after the value changed.

Enter any Priority, and click OK.

Work with an Imported VRML 2.0 Animation

You can run an imported animation in *VRML 2.0 (wrl)* format in the *3D Viewer*.

- Create an animation in an animation tool, such as eM-Workplace, 3D Studio MAX, etc., and save it as a *VRML 2.0 (wrl)* file. Note that we do not support java or java script nodes in the *VRML 2.0 (wrl)* files.
- Exchange an existing graphic of an object in the *3D Viewer* with the *VRML 2.0 (wrl)* model.
  - Open the viewer object, for example navigate to the folder *MaterialFlow*, select the *SingleProc* and then click . Make sure that Plain Graphics are displayed.
  - Select the graphic of the object, in our example the table and chair of the *SingleProc*. When in doubt, check the status bar to see if you have selected the viewer object or the plain graphics object. In case the viewer object is selected, click to open the plain graphic of the viewer object.

- Delete the graphic, if you want to exchange the graphic.

- Import the *VRML 2.0 (wrl)* file: Select 3D > Import 3D Geometry and select VRML Files as the data type. After successfully completing the import, the *3D Viewer* reports that it attached an animation to this object.

  You can attach more than one animation to the same object, by importing a *VRML 2.0 (wrl)* file with the same geometry, but with a different animation stored with it. If you exported a robot animation from eM-Workplace, for example, you can define another animation in eM-Workplace for the same robot, export that one, and import that *VRML 2.0 (wrl)* file to the same place where you imported the first one. The viewer recognizes that it is the same geometry and will thus not import the geometry, but only the animation data. After this second import, the *3D Viewer* reports that it appended an animation and the name of this new animation.

- Next, select how to start the imported animation. The *3D Viewer* starts an animation when you set the attribute *Animation* of the corresponding object. Whenever that attribute changes its value, it checks for an appropriate MyAnimation path that is it checks if a path with the name of the value of the attribute *Animation* exists for the attribute *AniPath*. If this is the case and if the object has a velocity, i.e., the attribute *Velocity* has a value other than zero, the *3D Viewer* starts the animation.

  Note: To convert 3D file formats, install the Crossroads software from your program DVD.

Working with Paths

The *3D Viewer* uses a set of points in space as paths for animating objects and extruding shapes.

- **Animation paths** describe the route an animated mobile object takes when it moves on objects or through the scene. The cameras, through which you view the scene in a fly-through, also use animation paths.
- **Extrusion objects** are objects with a shape built from a profile expanded along a path. The length-oriented objects *Track*, *Line* and *FootPath* in the standard library do use **extrusion paths**.

You can create and edit a path in the dialog Edit Path.

Animation Paths

Animation paths are a set of points in space that describe the route an animated mobile object takes when it moves on objects or through the scene. The cameras, through which you view the scene in a fly-through, also use animation paths.

The viewer objects provide these animation paths:

- ChildAnimation

  The ChildAnimation path nodes are the vertices of the polygonal line on which incoming MUs are animated. This animation path can be a single **straight line** or a sequence of straight lines. When an MU transfers onto a material flow object, it usually moves on the Default ChildAnimation path. For numbered 2D animation points you can define corresponding 3D ChildAnimation paths that use the same name. In addition, 2D capacities (x,y) are mapped to 3D locations as ChildAnimation paths named #x#y.

- ChildSplineAnimation

  The ChildSplineAnimation path nodes are the anchor points of a spline **curve**.

  Editing the ChildSplineAnimation path updates the ChildAnimation path, which approximates the spline curve by a polygonal line on which incoming MUs are animated. The value you enter as the Curve distance is the maximum distance of the individual nodes on the computed polygonal line.

- ChildPolycurveAnimation

  Note: As opposed to 2D, you can define polycurve paths for all 3D viewer objects.

  The ChildPolycurveAnimation path nodes are the anchor points of a curved object, i.e., a sequence of **curved and straight lines**, on which MUs are animated, when they are transferred onto a material flow object.

  Editing the ChildPolycurveAnimation path updates the ChildAnimation path, which approximates the curved object by a polygonal line on which incoming MUs are animated. The value you enter as the Curve distance is the maximum distance of the individual nodes on the computed polygonal line.

- MyAnimation

  The MyAnimation path nodes are the vertices of the polygonal line on which the selected object itself moves. You can, for example, use it to simulate the movement of a robot.

- MyPolycurveAnimation

The MyPolycurveAnimation path nodes are the anchor points of a curved object, i.e., a sequence of **curved and straight lines**.

Editing the MyPolycurveAnimation path updates the MyAnimation path, which approximates the curved object by a polygonal line on which the selected object itself moves. The value you enter as the Curve distance is the maximum distance of the individual nodes on the computed polygonal line.

- MySplineAnimation

  The MySplineAnimation path nodes are the anchor points of a spline curve.

  Editing the MySplineAnimation path updates the MyAnimation path, which approximates the spline curve by a polygonal line on which the selected object itself moves. The value you enter as the Curve distance is the maximum distance of the individual nodes on the computed polygonal line.

Extrusion Objects and Extrusion Paths

Extrusion objects are objects with a shape built from a profile expanded along a path. Note that the length-oriented objects *Track*, *Line* and *FootPath* do use extrusion paths.

Note: As opposed to 2D, you can define any 3D viewer object as an extrusion object, compare *Creating an Extrusion Object*.

The viewer objects provide these extrusion paths:

- ExtrusionPolycurve

  The ExtrusionPolycurve path nodes are the anchor points of a curved object, i.e., a sequence of **curved and straight lines**.

  Editing the ExtrusionPolycurve path updates the ExtrusionPath, which approximates the curved object by a polygonal line which expands the ExtrusionProfile and the PaintableProfile to a three-dimensional shape. The value you enter as the Curve distance is the maximum distance of the individual nodes on the computed polygonal line.

- ExtrusionPath

  The ExtrusionPath path nodes are the vertices of the polygonal line, which expand the ExtrusionProfile and the PaintableProfile to a three-dimensional shape. We call objects, which are built from this kind of variable geometry, extrusion objects. When you define a length-oriented object of type *Track*, *Line* and *FootPath* as an extrusion object, their attribute Length can automatically correspond to the length of its graphic.

  Editing the ExtrusionPath path updates the Default ChildAnimation path, so that the animation will follow the shape of the graphic.

- ExtrusionProfile

  The ExtrusionProfile path nodes are the vertices of the polygonal face, which will be expanded along the ExtrusionPath to a three-dimensional shape, such as a groove, a half-pipe, etc.

- PaintableProfile

  The PaintableProfile path nodes are the vertices of a second polygonal face, which, in addition to the ExtrusionProfile path, will be expanded along the ExtrusionPath to a three-dimensional shape.

This additional extrusion geometry, such as a groove, a half-pipe, etc., will be painted by MUs for which you activated the painting property, instead of the extrusion graphic defined by the ExtrusionProfile. You might, for example, use the optional PaintableProfile path to only paint a part of the graphic of the extrusion object to simulate a trace.

- ExtrusionSpline

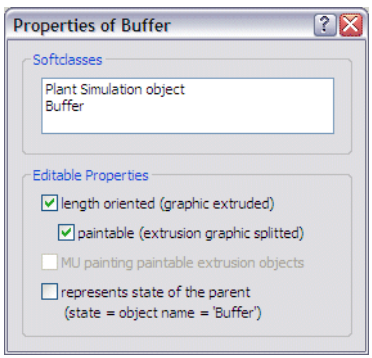
  The ExtrusionSpline path nodes are the anchor points of a spline curve.

  Editing the ExtrusionSpline path updates the ExtrusionPath, which approximates the spline curve by a polygonal line, which expands the ExtrusionProfile and the PaintableProfile to a three-dimensional shape. The value you enter as the Curve distance is the maximum distance of the individual nodes on the computed polygonal line.

Creating an Extrusion Object

To create an extrusion object, do one of the following:

- Select any object and select Edit > Data > Properties.



  Select Length-oriented (graphic extruded). The *3D Viewer* then replaces the default graphic of the object with an extrusion graphic. To remove extrusion properties from the selected extrusion object, clear the check box. The *3D Viewer* then deletes all extrusion properties, but retains the extrusion graphic of the object.

- Copy a *Line*, a *Track* or a *FootPath*, rename it, and modify its settings.

Editing a Path

To work with **paths of an object**, do one of the following:

- Select the object, and click on the 3D Modeling toolbar.
- Select the object and select Edit > Positioning > Path.

To work with **paths of the scene**, do one of the following:

- Do not select any object, and click on the 3D Modeling toolbar.
- Select Edit > Positioning > Path.
- Right-click anywhere in the scene and select Edit Path.

This opens the dialog Edit Path, described on page 2287.

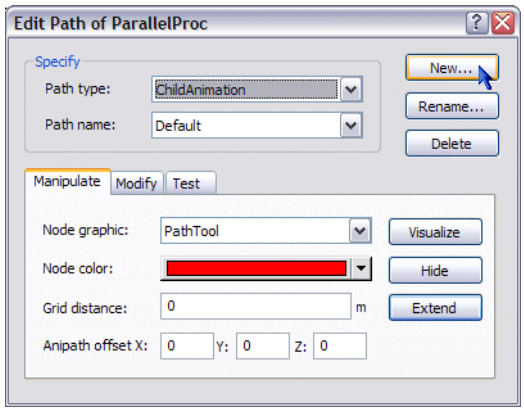
In the dialog you can:

- *Create a Path.*
- *Edit a Path with the Mouse.*
- *Edit a Path by Entering Values into the Dialog Nodes.*
- *Define an Animation Path that Rotates Objects.*
- *Test an Animation Path.*
- Rename an animation path.
- Delete an animation path.

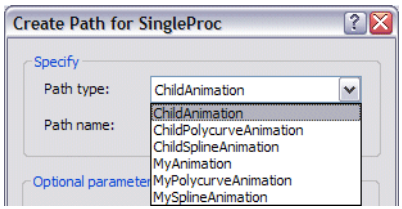
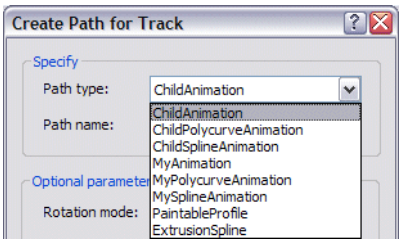
Create a Path

When you create a new, initial path, you will follow these basic procedures.

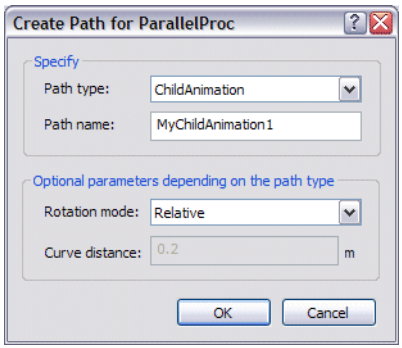
- Open the dialog Edit Path either for an object you inserted into the scene or for the scene object, the *Frame*, itself.



- Click the button New.
- Select the type of path (Path type) you would like to create. The different types of objects provide different types of paths.

Point-oriented objects	Length-oriented objects
	

- Enter a unique name for the path, if you are creating an animation path. Most of the time you will use the unique Default path for the animation.



Note: As you can define only one extrusion path for a viewer object, such as a PaintableProfile, an ExtrusionPolycurve or an ExtrusionSpline, you cannot enter a name for it.

When objects, such as the *Store*, have several defined locations for receiving incoming mobile objects, you will define additional animation paths for each location. In *Plant Simulation* you can move an MU to the position defined by the x-coordinate and the y-coordinate of the object. In the *3D Viewer* this corresponds to a child animation path named `#x#y`. For the *Store*, we already defined paths from the locations #0#0 to #2#2. If you do not define such child animation paths, the *3D Viewer* uses the `Default` animation path to place an MU that transfers to the object.

- Select a Rotation mode:

  Relative: Uses the difference of the rotation angle between the selected object and the preceding object. When moving from object to object, a relative rotation angle makes the rotated MU continue its way on the path with the rotation angle of the preceding object. If you do not want this, select Absolute.

  Absolute: Uses the absolute rotation angle in relation to the 0 value, which is the x-axis of the local coordinate system. When moving from object to object, an absolute rotation angle makes the MU continue its way on the path not rotated on to the next object.

Note: The setting Absolute prevents the summing-up of rotation errors that may occur with the setting Relative, where the *3D Viewer* not only takes the rotation angle of the path into consideration, but also the rotation angle of the material flow object itself.

- When you create one of the spline or polycurve paths, you can also enter the Curve distance, i.e., the distance in meters between two points of the curve.

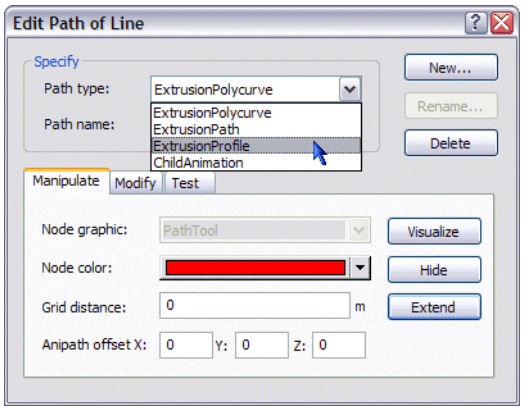
  Note: Each object provides only one curve distance. Changing it also changes each path that uses the curve distance!

  A spline path creates the impression of a path with rounded corners; the curved segments of a polycurve path consist of rounded corners also. The smaller the distance between the points of the curve, the better the approximation will be. Be aware that this creates a greater amount of data, and might thus decrease performance.
- Then, click OK to create the path you just defined. Initially this path consists of a single path node located at the origin of the selected object.
- Extend and/or edit the new initial path in the dialog Edit Path.

Edit a Path with the Mouse

When you edit a path in the scene window with the mouse, you will follow these basic procedures.

- Open the dialog Edit Path, see Editing a Path.
- Select the type of path (Path type) you would like to edit.



- When you are editing an animation path, select the name of this path (Path name).
- To show the selected path in the scene window, click Visualize. Then, the *3D Viewer* shows one or several node graphics, connected by a line that symbolizes the path positions, in the scene. Note that you can display several paths at once, but that only one path is active at any one time. Select any of the node objects of the path to activate it.

The *3D Viewer* also shows the grid, whenever you display a path in the scene window. When you hide the grid, it also hides all paths displayed at the moment.

- To hide the selected path in the scene window, click Hide.
- To add new anchor points to the end of the path, click Extend and click the left mouse button at the location where you would like to insert a new anchor point. Repeat this as often as you need, until the path has the shape you want.
- To change the shape of the path, select a node and manipulate it with the tool or the tool, and/or use the dialog Transformation.
- To rotate a path node, click it, click , hold down the left mouse button, and drag the mouse, and/or use the dialog Transformation.

  Note: When you rotate a path node describing an animation path, this also rotates any MU moving along that path.
- To delete a part of the path, select a node and press Del. This removes the selected node from the path, thus modifying its shape.
- To hide all paths, click on the 3D Modeling toolbar. This deletes all path nodes and lines representing paths in the scene.

Edit a Polycurve Path with the Mouse

In addition to editing any of the path types with the mouse, you can edit polycurve paths as follows:

- Enter the Curve distance, i.e., the maximum distance in meters between two points of the curved parts of the polygonal line, which approximates the curved object.

  The smaller the distance between these points, the better the approximation will be. The curved segments of a polycurve path approximate curves, i.e., they create the impression of a path with rounded corners. Be aware that this creates a greater amount of data, and might thus decrease performance.

  Note: Each object provides only one curve distance. Changing it also changes each and every path that uses the curve distance!
- When you edit an extrusion path, you can enter the Extrusion distance, i.e., the maximum distance in meters between two points of the polygonal line, which approximates the extrusion path. This is the length of the segments of the extrusion path.

  Note: Each object provides only one extrusion distance. Changing it also changes each and every path that uses the extrusion distance!
- To add new anchor points/nodes to the end of the path, click Extend.
  - To add a **straight segment**, click the left mouse button at the location where you would like to insert a new anchor point.
  - To add a **curved segment**, hold down Ctrl, and click the left mouse button at the location where you would like to insert a new anchor point.

- Repeat this as often as you need, until the path has the shape you want.

- To change the shape of a straight segment, select a node and manipulate it with the tool or the tool.

Note: When you insert a *Track*, *Line* or *FootPath* with active Curve mode in *Plant Simulation* 2D, you have to select the corresponding 3D object in the *3D Viewer* and create an ExtrusionPolycurve path for it. Then, edit the path as described above.

Edit a Path with an Offset to the Grid

Whenever you extend the path of an extrusion object that is visible in the scene window, or move one of its path nodes, while the feature Tools > Grid > Snap to is active, the new or changed path tool also snaps to the grid. To prevent the path from snapping to the grid, deactivate Grid > Snap to.

At other times you might want Snap to to be active, but modify the positions to which the path tool snaps. This is especially helpful, when you manipulate path nodes that are positioned on top of the graphic.

To modify the default positions of the Snap to feature:

- Open the dialog Path, select the path you would like to edit, and click Manipulate > Grid distance. Enter the distance between the grid plane and the points in space to which the *3D Viewer* snaps the path nodes you manipulate to.

  The path then uses this value to temporarily switch the offset of the grid, provided you activated the path of the extrusion object and visualized it in the scene window.

- Edit the value for the offset under Tools > Grid > Settings > Orientation > Distance > Offset.

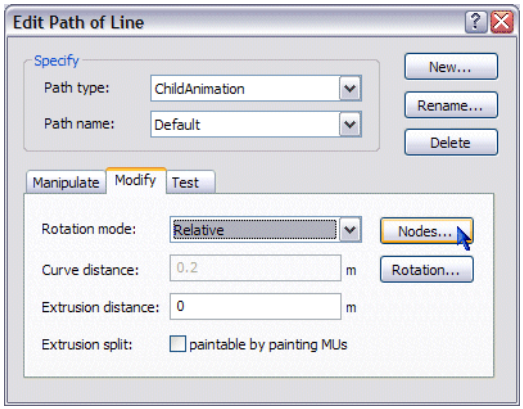
- Manually change the position or the orientation of the grid.

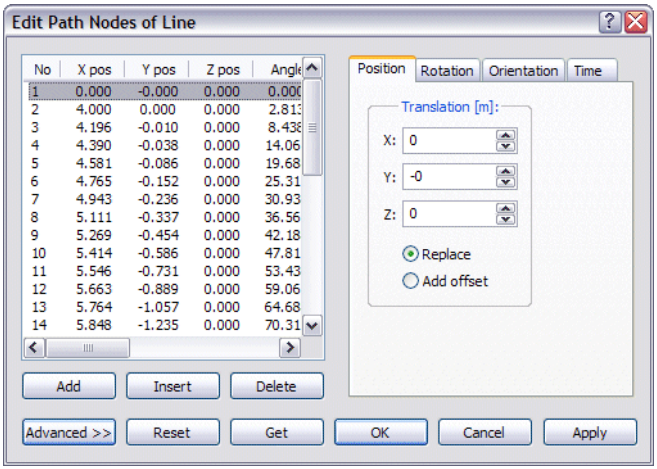
Edit a Path by Entering Values into the Dialog Nodes

- At times it may not be precise enough to In the dialog Edit Path, select the Path type you would like to edit.

- When you edit an animation path, select the Path name you assigned to that Path type.

- Click the tab Modify and then click the button Nodes.





Note: To see how your changes manipulate the path node without having to click Apply each and every time you change a value, click Advanced and select Auto-apply!

Note: Which tabs the *3D Viewer* displays at the right hand side depends on the type of the path you are editing. You can, for example, only edit the Rotation, Orientation and Time for animation path nodes.

- To add new path nodes to the end of the selected path, click Add. The list adds the settings of the new path node you added to its bottom. Once you have added a node, you can manipulate its settings on the tabs to the right.
- To insert new path nodes between or before existing path nodes, select the node in front of which you would like to insert the new path node, and click Insert.
- To delete a path node, select it in the list, and click Delete.

  To delete contiguous path nodes, hold down Shift and click the first node in the range and then the last node.

  To delete non-contiguous path nodes, hold down Ctrl and click the nodes you want to delete one after the other.
- Move path nodes on the Tab Position:

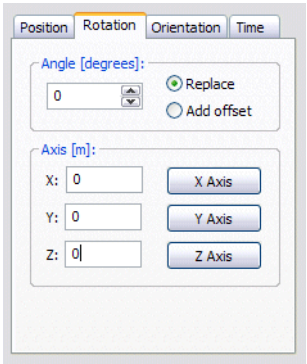
  To **move a single path node** you selected, click Replace.
  - To move the selected path node on the x-axis to the **right**, click the up arrow of the spin box. To move it to the **left**, click the down arrow.
  - To move the selected path node on the y-axis to the **back**, click the up arrow. To move it to the **front**, click the down arrow.
  - To move the selected path node on the z-axis **up**, click the up arrow. To move it **down**, click the down arrow.

  To **move several path nodes** you selected all at once, click Add offset. Then, either enter a value into the text boxes or click the arrows of the spin box to move the nodes.

  Note: When you select several path nodes, the *3D Viewer* automatically selects Add offset.

Note: At present you have to click the radio button Add offset after you made changes to show these in the scene window.

- Rotate path nodes on the Tab Rotation.



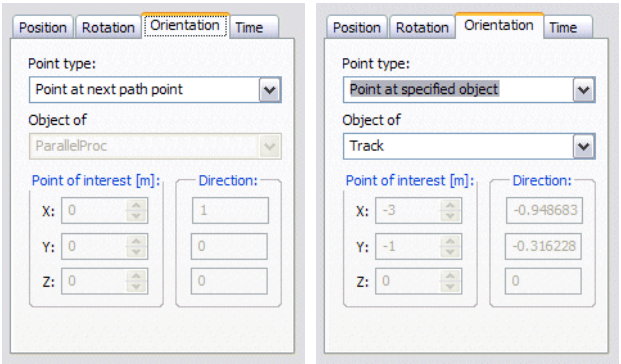
To rotate a single path node you selected, click Replace, and do one of the following:

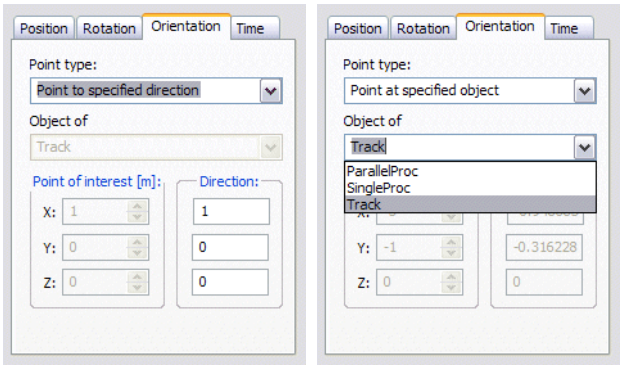
- Enter the rotation angle and click one of the buttons (X-Axis, Y-Axis, Z-Axis) to rotate the node around this axis.
- Enter the rotation angle and then enter a value of your choice into one or more of the text boxes to rotate it around the axis you thus define.

To rotate several path nodes you selected, click Add offset, then proceed as described above.

Note: At present you have click the radio button Add offset after you made changes to show these in the scene window.

- Align the selected path node(s) of the animation path to the points you select on the Tab Orientation.

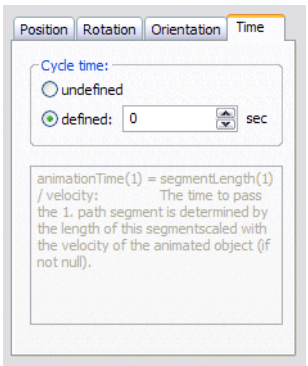




The x-axis of the animated mobile object then points in the direction you select, when it moves on the path. You can select to make the x-axis of the animated mobile object:

- Point at next path point of the selected path. This is the default setting.
- Point at previous path point of the selected path.
- Point at rotation center, provided a common rotation center exists for all selected nodes. This is, for example, the case when you defined a rotation movement.
- Point away from rotation center, provided a common rotation center exists for all selected nodes. This is, for example, the case when you defined a rotation movement.
- Point at specified object. Then, select an object of the active scene from the list Object of interest.
- Point away from specified object. Then, select an object of the active scene from the list Object of interest.
- Point to specified position. Then, select the position of the Point of interest in the three-dimensional space.
- Point away from specified position. Then, select the position of the Point of interest in the three-dimensional space.
- Point to specified direction. Then, enter the Direction in three-dimensional space.

- Define the cycle time on the Tab Time:



In general you will enter a time, when you model point-oriented movements, such as rotating the object around the selected node or it remaining on the selected point.

You can:

- Use an undefined time. Or you can
- Use a defined Cycle time.

  Enter a value in seconds into the text box, or use the spin box to set the time the *3D Viewer* uses for animating the object, scaled with the reciprocal value of the speed of the animated object, provided the speed is not 0.

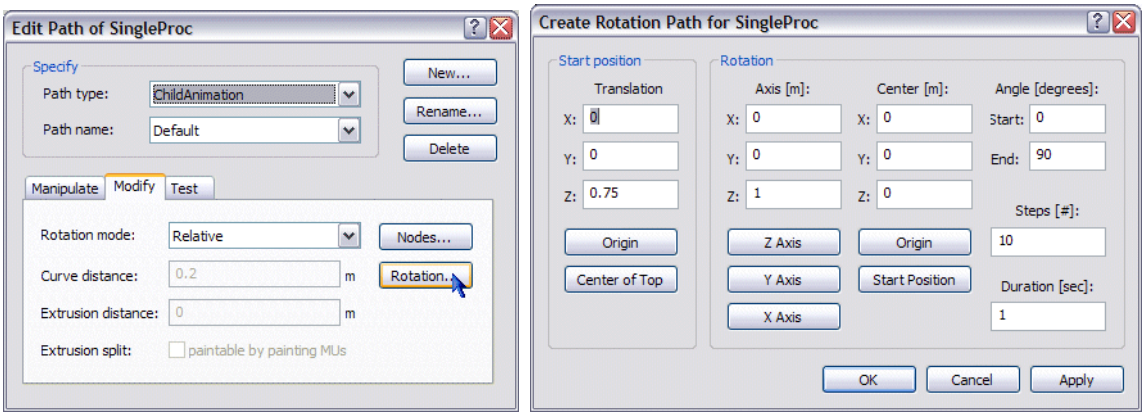
  When you only defined a Cycle time for one or several nodes of an animation path, the *3D Viewer* uses the cycle time of the last node, for which you defined a cycle time, for all nodes for which you did not define one.

Define an Animation Path that Rotates Objects

To define an animation path, which causes a circular rotation of an object, for example the movement of the arm of a crane, by setting parameters for the rotation instead of by editing path nodes:

- Select the material flow object or the scene object and select Edit > Positioning > Path.
- Select the path you would like to edit. The path type depends on the object(s) you would like to rotate:
  - To rotate the selected object itself, select MyAnimation.
  - To rotate the MUs that the selected object processes, select ChildAnimation.

  You cannot define a rotation path for any of the other path types.
- Click the tab Modify and then click Rotation. Edit the settings in the dialog Create Rotation Path that opens.



- Enter the Start position where the rotation starts in the coordinate system of the selected object. You can select two predefine positions by clicking one of these buttons:
  - Origin of the selected object, i.e., (0,0,0). This is useful for the MyAnimation paths, where you want the selected object to rotate around its center axis. In that case the start, end and center positions have to be identical.

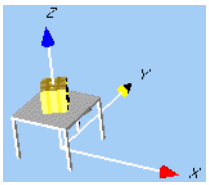
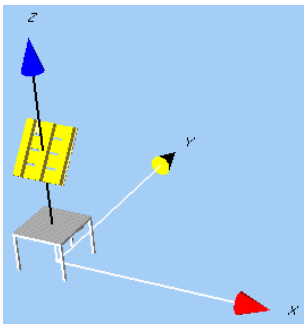
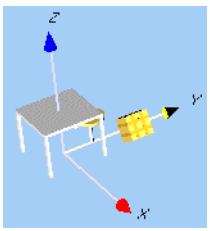
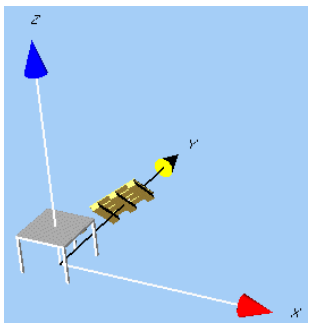
  - Center of Top of the graphic of the selected object. This is useful for the ChildAnimation paths where, for example, you want the incoming MUs to rotate on a table top.
- Enter the values for the Axis around which you want to rotate the object or the MUs.
  - Normally, you will use the Z-Axis (0,0,1) to rotate the object on the **XY** plane.
  - You also can define the Y-Axis (0,1,0) to rotate the object on the **XZ** plane or the
  - X-Axis (1,0,0) to rotate the object on the **YZ** plane.

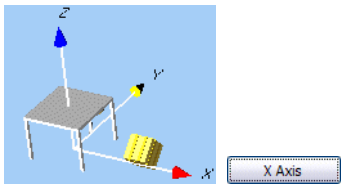
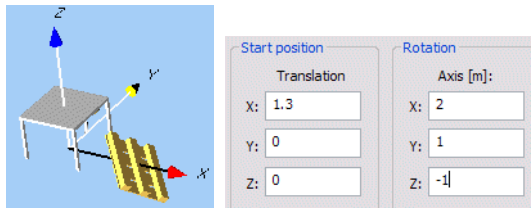
  Naturally you can also define any other axis to rotate the object diagonally in 3D space.

  To tilt the rotation axis, and thus the way the MU rotates, you would enter a value into at least two text boxes.

  You can change one, two or three settings to tilt the axis the MU rotates around on the surface of the object.
- Enter the Center point of the rotation in the coordinate system of the selected object. If the center is not the same as the start position, the rotated object moves on a circular arc and stops at a different position than its starting point, except after a 360 degree rotation.

  To rotate an object around its own center, you can click one of the following:
  - Origin, which rotates the selected object itself. This applies to MyAnimation paths.
  - Start position, which rotates MUs that are transferred to the object. This applies to ChildAnimation paths.

Straight rotation axis	Tilted rotation axes and their settings
	
	

Straight rotation axis	Tilted rotation axes and their settings
	

- Enter the Angle in degrees where the rotation starts and ends. The values may not be identical, otherwise the *3D Viewer* does not execute any rotation at all. They can be greater than 360 degrees and smaller than -360 degrees to cause more than one total revolution.

  The Start and the End angle define the direction of the rotation, depending on which value is the greater one:

  - An end angle greater than the start angle results in a clockwise rotation.
  - An end angle smaller than the start angle results in a counterclockwise rotation.
- Enter the number of rotation Steps. Every step the rotation proceeds is defined by End angle minus Start angle divided by the number of Steps. The more steps you define, the smoother the rotation will be, but also the more RAM-intensive.
- Enter the Duration in seconds you want the entire rotation to last and enter the Realtime scaling factor into the dialog 3D Preferences. A small number slows down the animation, a large number speeds it up.
- Click Apply to calculate the animation path. This path is the trace on which the animated object moves. The movement on this path is the rotation.

  Note: The result of the calculation overwrites the previous nodes of the selected MyAnimation or ChildAnimation path.
- To test the rotation path you defined, click the tab Test in the dialog Path, select an Animated graphic and start the test animation.
- If the rotation movement does not meet your expectations, open the dialog Create Rotation Path again, and edit the parameters there. Then, click Apply and test the settings again until the rotation meets your needs.
- To change the duration of one or more individual rotation steps, click the tab Modify in the dialog Path, and click Nodes to open the dialog Edit Path Nodes.

  On the tab Time you can edit the Cycle time of every node, which corresponds to the rotation steps.

Test an Animation Path

After defining the animation path, you can test the settings you chose on the tab Test, and modify them, if the results do not meet your expectations. This way, you do not have to run a simulation to test your settings.

- Select the Animated graphic, i.e., an MU whose graphic the *3D Viewer* copies and uses as the test object.
- Enter the Velocity with which the test object moves on the path.
- Select if the test object moves in a forward direction or if it moves Backwards.

  The *3D Viewer* automatically enters a negative Velocity, when you select Backwards.
- Click Play to play the animation with the settings you selected.
- Click Pause to pause the test animation.
- Click Stop to stop the test animation.

Modeling a Fly Through

To view the scene "through the lens" of an object you can attach a camera to it. This camera then moves along with the object through the scene during a simulation run. By turning or tilting the camera, you can control the direction and the angle at which you look at the scene.

The *3D Viewer* visualizes the camera with a viewer tool object as the icon of the camera. At present the *3D Viewer* provides three different cameras:

- The **main camera** through which you view the scene in normal view.
- The **object camera**, which you attach to a specific object and which moves with this object through the model.
- The **animation camera**, which moves along an animation path you defined.

Once you have attached a camera or started a camera operation, you can toggle the object camera or the animation camera and the main camera:

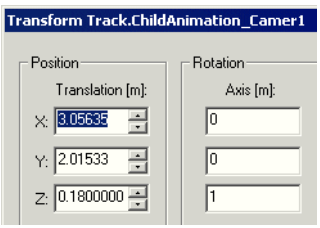
- By clicking on the 3D Standard toolbar.
- By pressing the F4 key.
- By selecting View > Camera > Toggle.

Attach a Camera to an Object

To attach a camera, through the lens of which you look at the scene, to an object:

- Select a single viewer object.
- Click on the 3D Camera toolbar or select View > Camera > Attach.
- Depending on the settings described below, the *3D Viewer* attaches the camera at a defined location:
  - If you defined a path of type ChildAnimation for the selected object, and named that path Camera, the *3D Viewer* attaches the camera at the location defined by the first point of the vector array named Camera of the attribute *AniPathChild*. It also uses the corresponding rotation, i.e., the value of the attribute *AniRotationChild* to set the animation of the attached camera.

    To define or to change the point where the *3D Viewer* inserts the camera, edit this camera path of the selected object in the dialog Edit Path:



  - If you did not define a ChildAnimation path named Camera, the *3D Viewer* uses the first position of the ChildAnimation path named Default. If this position is not defined either, the *3D Viewer* uses the center of the top

of the bounding box of the selected object as the location where it inserts the camera. Note that the *3D Viewer* adds an offset of `0,0,0.1` to these makeshift points, so that your eyes will be located above the top plane.

By default the object camera faces on the positive x-axis using the positive z-axis as Up direction.

As soon as the object, with a camera attached to it, moves, the camera moves along with it automatically.

Manipulate the Icon of the Camera

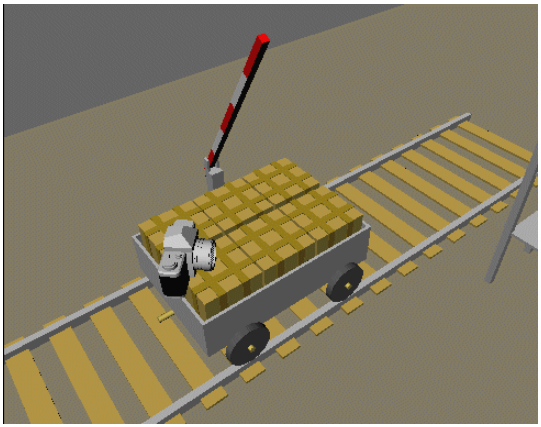
To control the direction and the angle at which you look at the scene, as well as the position and orientation of the corresponding camera view, you can turn or tilt the icon of the camera. You can compare this to turning your head left or right, and up or down to watch your surroundings while riding a roller coaster.

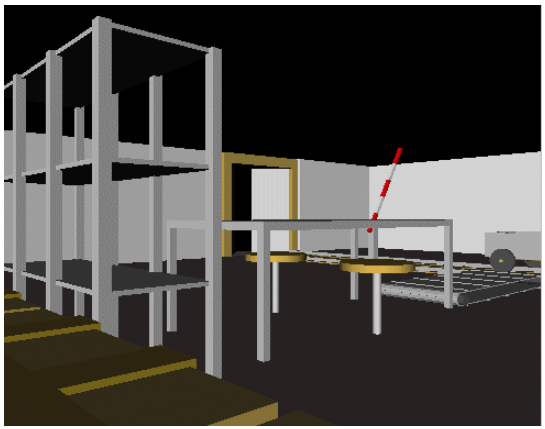
To transform the icon of the object camera or of the animation camera :

- To **rotate** the camera icon, select it, click on the 3D Modeling toolbar and drag the mouse, and/or use the dialog Transformation.
- To move the camera left or right, and to the back or the front, select it, click , hold down the left mouse button, and drag the mouse.
- To move the camera up or down, select it, click , hold down the left mouse button, and drag the mouse.
- To scale the camera icon, select it, click , hold down the left mouse button, and drag the mouse.
- To test your new settings with the lens of the camera, select View > Camera > Toggle or click on the 3D Camera toolbar.
- To reset the camera, click on the 3D Camera toolbar.

  This removes any of the transformations you defined and returns the object camera or animation camera to the initial settings the cameras had before you attached a camera or started the animation.
- To animate the camera, select an object for which you defined an animation path and click .

  This creates the impression of you flying on the animation path of the selected viewer object or of the root object of the scene.





Detach the Camera from an Object

To detach the camera, which you attached to an object, from it:

- Click or select View > Camera > Detach. The *3D Viewer* then returns to normal view.

The *3D Viewer* also detaches an object camera:

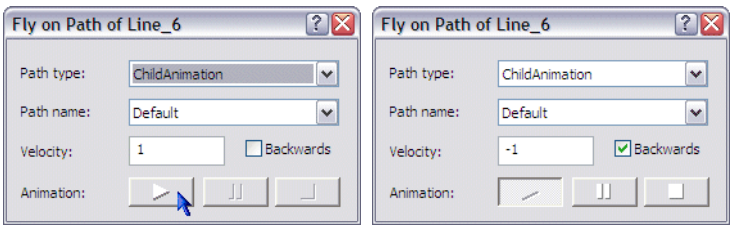
- When you delete the object the camera is attached to.
- When you change the scene.

Animate the Camera

You can animate the camera on any animation path of the selected viewer object or of the root object of the scene, thus creating the impression of flying through the scene.

To move the animation camera:

- Select a single viewer object or no object at all to select the root object of the scene.
- Click on the 3D Camera toolbar or select View > Camera > Animate.
- In the dialog Fly on Path of select one of the types of animation paths you defined for the selected viewer object or the root object of the scene from the list Path type.



- Select the name of the path for the selected viewer object or the root object of the scene from the list Path name.
- Enter a positive number for the forward Velocity in meters per second, which the *3D Viewer* uses for the animation.

  Enter a negative number for the Velocity in meters per second to move the camera backwards.
- Select Backwards if you want the camera to move backwards towards the starting point of the animation path. Note that the *3D Viewer* automatically enters a negative velocity into the text box when you select the check box.
- To start the animation, click Play . The *3D Viewer* now shows the scene through the lens of the animation camera, which moves on the path you designated with a lens offset of (0, 0, 0.1).
- To pause the animation of the camera, independent of the simulation, click Pause .
- To stop the animation of the camera, independent of the simulation, click Stop .

At the end of the animation the viewer sets the main camera to the last point where the animation camera was located and deletes the animation camera. To return to the last view of the main camera, click .

To test the camera animation path you defined, you can click the tab Test in the dialog Edit Path, select an Animated graphic and start the test animation.

Switch Between the Cameras

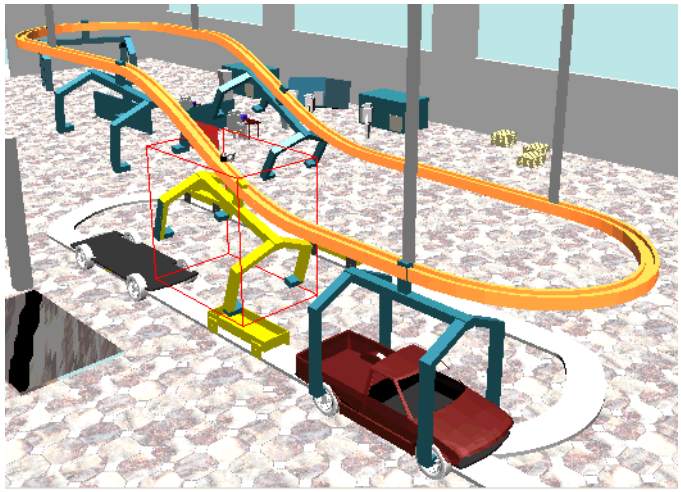
Toggling the cameras allows you to view the scene from different angles and from different points of view.

To switch between the **object camera** or the **animation camera** and the **main camera**:

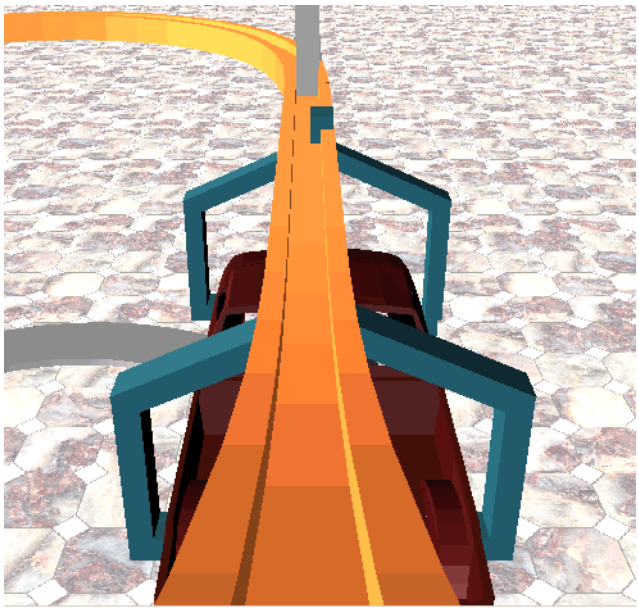
- Click on the 3D Camera toolbar or select View > Camera > Toggle.

  In our sample model we attached a camera to the hanger marked with a bounding box in the screenshot below.

  When you click on the 3D Camera toolbar in normal view, the *3D Viewer* shows the three-dimensional tool object, which the visual camera represents.



When you view the scene through the lens of the camera, the three-dimensional tool object disappears behind the eye of the viewer.



Recording a Video

You can record a video of the crucial parts of your simulation model. This way, you can pass the video on to anybody or publish it on the intranet or the internet, without the person viewing the video having to install *Plant Simulation* on his computer. The recorder creates an AVI file that any multimedia player can play.

The 3D Video toolbar provides all tools for recording and playing the video.

Set Up the Scene for Recording

There are a number of items to keep in mind **before** you start recording the scene:

- Drag the scene window to a size that shows all you want to show to the viewer, but not more, unnecessary information.

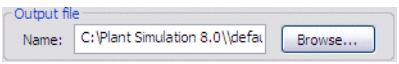
  The size of the scene determines the size of the video, a large scene uses more processor time and might take a long time to animate and creates a larger video files.
- Select the check box Record client area only in the dialog Video Settings to only record the contents of the actual scene window, without the title bar, the menu bar and the toolbars. This not only reduces the physical size of the play back window but also the size of the recorded file.
- Decide from which position and which angle you want to view and record the scene. Then, rotate and zoom the scene accordingly before starting the simulation. Be aware that when you manipulate the scene, the *3D Viewer* might react sluggishly while recording.

Selecting Video Settings

After you prepared the scene, select settings for recording it. Click on the 3D Video toolbar.

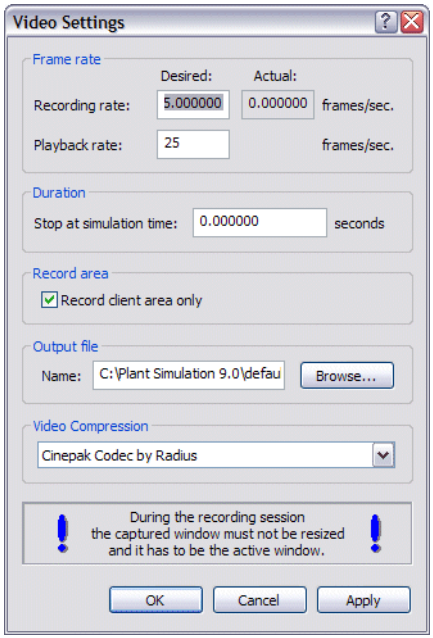
- Depending on what you want to show, you can enter a different number of frames per second as the Playback rate.

  When the Playback rate is twice the Recording rate the playback will be half as long.
- Select the check box Record client area only to only record the contents of the actual scene window, without the title bar, the menu bar and the toolbars. This not only reduces the physical size of the play back window but also the size of the recorded file.
- Enter the location and the name of the recorded AVI file into the text box

  . You can also click Browse, select a location and enter a file name into the dialog Save As.

  Note: To prevent the *3D Viewer* from overwriting the last AVI it recorded, rename it before recording another scene.



Selecting a Video Compressor

Selecting the correct codec for your purpose can be a difficult task. As with any kind of compression you have to find the right trade-off level between file size and quality of the AVI. As a rule, you will select *MPEG-4* or *DivX*.

When selecting a video codec you have to take into consideration: the time it takes to encode the video, how widely known and available the video codec is, and which compression ratios can be achieved for an acceptable quality level.

Cinepak is a widely used AVI codec. It still provides really fast playback. *Indeo 3.2* provides similar or slightly superior image quality for same compression, while Indeo decompression is much more CPU-intensive than *Cinepak*. *Cinepak* is the best codec to use to insure ease of playback. *Cinepak* is based on Vector Quantization and Frame Differencing to compress the video.

Other technologies, such as the Block Discrete Cosine Transform and Motion Compensation, achieve superior compression, with smaller files for the same subjective visual quality. Codecs that are better than *Cinepak* in that respect are *Microsoft H.263*, *MPEG-4*, and *Indeo Video 5.x*.

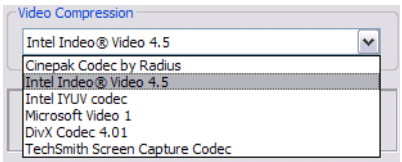
In October 2002 we found information on these web sites:

http://www.synthetic-ap.com/qt/codec2.html (Bob Currier)

http://www.jmcgowan.com/avicodecs.html (John McGowan)

http://www.slashcam.de/katalog/Wissen_Codecs.html

Note: Some codecs provide more or less refined configuration settings. Click the Help button in their dialogs and consult the Help file for details about the settings you can choose.



Microsoft Video 1

To save your AVI file with 8 bit color or 16 bit color, select this.

Cinepak

Cinepak provides the fastest playback of compressed video files. While *Intel Indeo Video 4.5* provides similar or slightly superior image quality for same compression, Indeo decompression is much more CPU intensive than *Cinepak*.

Cinepak is asymmetric, i.e., it takes much longer to compress the video than it does to decompress and display it.

Unlike other codecs, *Cinepak* handles video containing a lot of motion quite well. In more static video, such as taking head shots, there is noticeable temporal aliasing, or pixel crawl.

Intel Indeo Video 4.5

Just like *Cinepak* Intel Indeo 4.5 is an asymmetric codec, but it compresses the AVI faster.

Indeo produces a sharper, more color correct, image with low motion video, while *Cinepak* produces better results for video with a lot of motion.

DivX

The DivX Codec is based on MPEG-4 and provides just as high compression rates.

Note: In the present version the *3D Viewer* and the DivX codecs do not work together very well. We recommend to not use it until further notice.

Record the Video

After you set up the scene and selected the video settings, you can record the video by using the features on the 3D Video toolbar .

- If you do not want to record the scene from the beginning of the simulation, start the simulation and let the animation proceed to about the time you want to start recording. Then, click to start recording.
- If necessary, reset the simulation model by clicking .
- To start the simulation, click Start .
- To start recording the animation, click on the 3D Video toolbar.

Note: Be aware that the recorder records the contents of the currently active window. If you click into another window during the recording session, or roll the mouse over a button to display a tooltip, these will show up in your recorded video. This might ruin your recorded video.

- To cancel recording, click .
- To pause recording, click . This deactivates the Pause button .

  You might pause recording if you do not want to show a certain section of the animation, and start recording the next section of interest by clicking again.
- To stop recording the video, click .

  The *3D Viewer* shows a dialog telling you that it saved the AVI file to the location and with the name you entered. Click OK to close the dialog and to continue working.
- To stop the simulation, click on 3D Standard toolbar.

  Note: If you want to view the video after you recorded it, we recommend to stop the simulation, as it uses a considerable amount of your computer's resources.

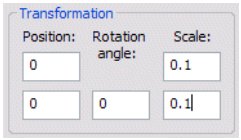
Play the Video

After you have recorded the video, you can play it the way you recorded it. Or you can edit it with a digital video application, such as Adobe Premiere, etc.

- To play the video, click .
- At present the *3D Viewer* plays the video back in the *Windows Media Player*, not in the player you select as the default player under MS Windows.

Advanced Features

The more detail you add to your simulation model, the more time it takes the *3D Viewer* to render and to show the scene. From a certain point on the *3D Viewer* will react sluggishly to your interactions. For this reason we provide a number of ways for optimizing performance by using the most efficient visualization.



Adding a Material to an Object

You can define the surface qualities, i.e., the material of the object: how well it reflects light, what color it reflects, and what color it emits.

You can also view these settings in the dialog, which the command Show Attributes on the context menu opens, under the attributes *Color* and *Material*. Note these two attributes interact, i.e., the first value, *Material*, matches the value of the attribute *Color*, compare *Define a Color of the Object*.

Define a Material

To define material properties:

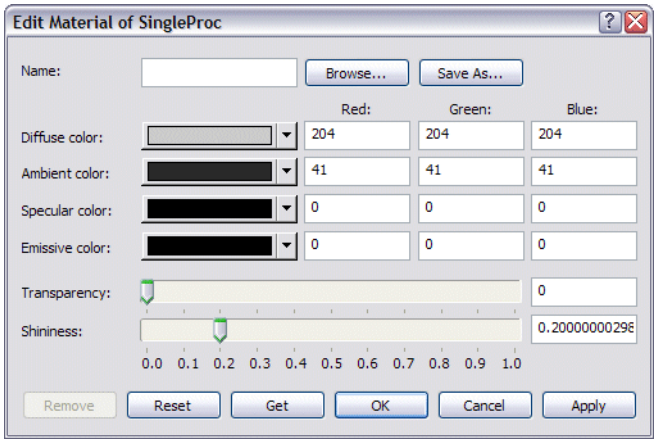
- Select the object and click on the 3D Modeling toolbar.

  Or

  Right-click the object and select Edit > Material.

  Or

- Select Edit > Appearance > Material to edit the material of the object.



- To select one of the materials, which are part of your program package, click Browse, navigate to the folder in which the materials are located, by default C:\Program Files\Plant Simulation\Plant Simulation\3D\materials\..., and pick one of the *VRML 2.0 (wrl)* files.

  For these materials we already defined all color properties, as well as the Transparency and the Shininess.

  You can use one of these materials to create your own material with different settings. Modify any of the settings, and click Apply to check your changes. Then, click Save As and enter a name into the dialog that opens to save this new material.

  Instead, you can also enter the values of the RGB components into the text boxes.
- To apply an Ambient color, click the down arrow and select a color in the color selector.

  The Ambient color is the color of the light reflected from the object when it is lit by another ambient object in the scene. Enter a value between `0`, for a weak reflection, and `255`, for a strong reflection.
- To apply a Specular color, click the down arrow and select a color in the color selector.

  The Specular color is the reflected color of the object's highlights.
- To apply an Emissive color, click the down arrow and select a color in the color selector.

  The Emissive color is the color emitted by the object. A lamp shade might have a base color of yellow. When you turn the lamp on, though, the emissive color might be white.
- To apply a Transparency, drag the slider or enter a value between `0.0`, for opaque, and `1.0`, for completely transparent, into the text box.

  The Transparency sets how opaque or clear the object is. Water, for example, might be more clear than opaque.
- To apply a Shininess, drag the slider or enter a value between `0.0`, for a very dull surface, and `1.0`, for a highly polished surface, into the text box.

  The Shininess sets how sharp light is reflected by the object. A billiard ball, for example, has a large shininess, making for small and sharp highlights.

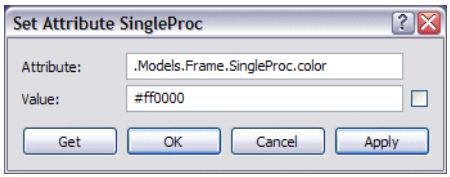
- To apply the material you selected to the object, click Apply.
- To delete the material you applied to the object, click Remove.

Edit the Attributes for Color or Material

Instead of using the dialog Material you can also edit the attributes *Color* or *Material*.

Select Edit > Data > Any Attribute.

The dialog Attribute shows the path and the name of the object in the text box Attribute. Enter a period (.) and Color after what is displayed in the field.



- Enter the name of one of the eight primary colors, `black`, `blue`, `cyan`, `green`, `magenta`, `red`, `white` or `yellow` into the text box or of any other color that is located as an *VRML 2.0 (wrl)* file in the folder Materials in the folder where the *Plant Simulation* is installed.

  Note: When the *3D Viewer* does not find the name of color you entered, the object keeps its current color. The main advantage of this approach is that you can also access the attributes from *Plant Simulation*.

- Click Get, to show the current color of the object as a packed RGB value, for example `#000000` for the color `black`, `#ff0000` for the color `red`, etc.

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