WITNESS
Training Reference Manual

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WITNESS Basic Training Course

Who Should Attend This Course?

- The Basic WITNESS Training Course has been designed for people who are new to WITNESS.
- No prior knowledge of simulation is necessary.
- Familiarity with computing is not necessary but will be advantageous.
- Course delegates need to be numerate.

Course Objectives

- To equip the delegates with the essential skills for solving problems using simulation.
- To help the delegates learn how to build and run simulation models using WITNESS.

Course Materials and Resources

This course workbook forms the core of the materials. It is supplemented by the WITNESS Quick Reference Booklet and the WITNESS online help system.

Course Manual Content

This section of the workbook details the content that is to be covered in the WITNESS Training Course, please note the course content may not be in the precise order in which the course will be delivered.

Discrete Event Simulation

- What is discrete event simulation and how does WITNESS work "behind the scenes"

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- Writing Data to Microsoft Excel from WITNESS
- Useful Functions for Model configuration

This workbook concentrates on the core WITNESS functionality although there are training options for virtual reality graphics, performing automatic optimization, linking to process planning packages etc.

On-line help is built into the product with the usual search facilities and hypertext links to move you quickly from topic to topic. Using the help system and the quick reference booklet when you need assistance should gradually increase your knowledge of WITNESS simulation modeling.

Simulation

Simulation has much to offer all organizations, whether they are in manufacturing or in the service industries.

The role of simulation is to evaluate practical alternatives available either in support of major strategic initiatives which might involve a large financial outlay, or in support of the continuous search for better performance at operational and tactical levels. Examples of such evaluations include changes to the product mix, increases or decreases in volumes, improvements in throughput, shorter lead times and improved customer response times.

Simulation provides the user with a greater breadth and depth of information on which to base decisions: it is not an optimizing tool. It is capable of handling the complexity of large systems, even a whole factory. In addition, the simulation approach supports sensitivity analysis by allowing rapid changes to the model logic and data.

What is Visual Interactive Simulation?

"Visual Interactive Simulation is one which has features for graphical creation of simulation models, dynamic display of the simulated system and user interaction with the running program. Interaction implies that the simulation halts and requests information from the user or the user stops the simulation at will and interacts with the running program."

R. D. Hurrion, Engineering Journal of Operations Research

WITNESS is Lanner Group's simulation software package. It is the culmination of more than a decade's development experience with computer based simulation. This experience has led us to evolve a visual, interactive and interpretative approach to simulation without the need for compilation.

There are currently more than 6,500 WITNESS systems in use worldwide, in organizations ranging from automotive to pharmaceutical, aerospace to electronics, hospitals to banks, airports to defence and more. The WITNESS Manufacturing Performance Edition is the version of WITNESS specially designed for manufacturing applications. It is ideally suited to a variety of production and storage layout and logistical modeling scenarios.

Discrete Event Simulation

Terminology	Meaning
Element	A building block used to represent a real life 'operation' in the simulation. For example a Call coming into a call centre, a Press in a car factory or a Clerk at a bank counter.
State	An element's state is the condition that it is in at a specific time e.g. it may be Busy, Idle or Blocked. There are also other states that an element can take, that are detailed later.
Event	An event occurs when an element changes its state. A change of state is instantaneous i.e. it has a zero duration time.

In discrete event simulation, the operation of a system is represented as a chronological sequence of events. Each event occurs at an instant in time and marks a change of state in the system. For example, an event could be "level 6 button pressed", with the resulting system state of "lift moving" and eventually (unless one chooses to simulate the failure of the lift) "lift at level 6".

In addition to the representation of system state variables and the logic of what happens when system events occur, discrete event simulations include the following:

Clock

The simulation must keep track of the current simulation time, in whatever measurement units are suitable for the system being modelled. In discrete-event simulations, as opposed to real time simulations, time 'hops' because events are instantaneous – the clock skips to the next event start time as the simulation proceeds.

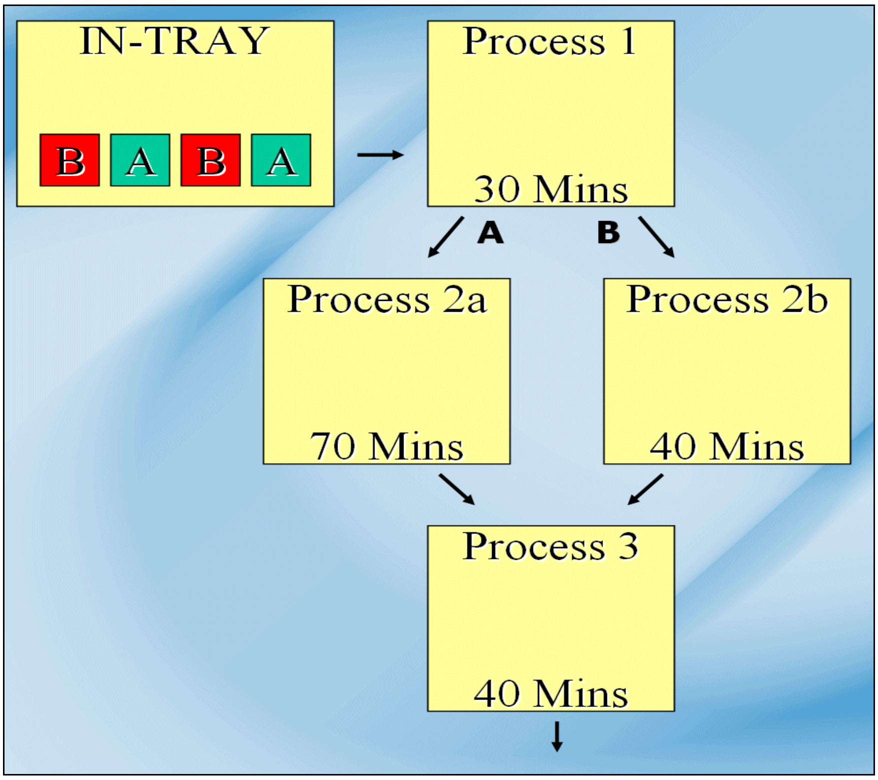
Events List

The simulation maintains at least one list of simulation events. An event must have a start time, some kind of code that constitutes the performance of the event itself, and possibly an end time. Events lists are sorted by their start time. Typically, events are "bootstrapped", that is, they are scheduled dynamically as the simulation proceeds. For example in a bank, the event CUSTOMER-ARRIVAL at time t would, if the CUSTOMER_QUEUE was empty and CLERK was idle, include the creation of the subsequent event CUSTOMER-DEPARTURE to occur at time t+s, where s is a number generated from a SERVICE-TIME distribution.

Events can be scheduled to occur at the same TIME, however they will be executed sequentially by WITNESS. Unless specified, events scheduled for the same time will occur in the order in which they were inserted in the event list. The WITNESS clock will not advance until all these events (and any others that can occur at the same time as a consequence) have been executed.

The following model represents a four-machine cell which, on average, produces two types of components, A and B, in equal quantities. The arrival pattern of A's and B's is sequential: A arrives first, then a B, then an A and so forth. The first operation, Process 1, processes both types of parts and is fed from a large hopper. The cycle time for Process 1 is 30 minutes. Components of type A are then processed by Process 2a, which has a cycle time of 70 minutes. Type B components are processed by Process 2B, which has a cycle time of 40 minutes. The final operation processes both component types and is carried out by Process 3, which has a cycle time of 40 minutes.

The model used in this example is very simple (shown below), however it becomes laborious to follow the model on paper as we move along the different time frames. This is started for you in the table below.



Event	**Clock Time**	**Narrative**
A enters Process 1	0	Part A enters Process 1 to start being 'processed'.
Process 1 Starts Cycle	0	As Process 1 now has a part the cycle can now start and the time that the Cycle will finish can be predicted as 30 minutes. As no other events that can occur at time 0 the clock can be advanced to 30 minutes.
Clock Advanced	To time 30	
Process 1 Finishes	30	Process 1 has completed its cycle time, part A has been processed and can be moved to the next point in the process.
Part A moves from Process 1 to Process 2a	30	Part A moves to the next point in it's processing route, in this instance Process 2a
Process 2a Starts Cycle	30	As Process 2a now has a part its cycle time can now start and the time that the Cycle will finish can be predicted as 30 + 70 = 100 minutes.
B enters Process 1	30	Process 1 is now empty allowing Part B to enter. Process 1 can now start its cycle.
Process 1 Starts Cycle	30	As Process 1 now has a part its cycle time can now start and the time that the Cycle will finish can be predicted as 30 + 30 = 60 minutes. As there are no other events that can occur at time 30 the clock can be advanced to the next time that an event will occur, this is 60 minutes.
Clock Advanced	To time 60	
Process 1 Finishes	60	Process 1 has completed its cycle time, the part has been processed and can be moved to the next point in the process.
Part A moves from Process 1 to Process 2b	60	Part A moves to the next point in it's processing route, In this instance Process 2b
A enters Process 1	60	Part A enters Process 1 to start being 'processed'.
Process 1 Starts Cycle	60	Process 1 may start it's cycle – finish time 60 + 30 = 90

Imagine how long it would take to follow this model of activity for a factory with 100 machines, multiple buffers, conveyors, and parts? This is the primary reason to use simulation programs like WITNESS; they keep track of the different events in the simulation. This allows you to spend time improving your process or processes rather than tracking the model itself.

There are two important observations we need to make regarding the previous model. Whenever numerous events take place at the same time, the computer program will give priority to the oldest event in the system, unless a specific priority is assigned in the model. In the event, where a machine (Process 1) has just finished processing a part, but it can not push it to next machine or buffer because it is busy or full, we say that the machine (Process 1) is blocked. Ideally, you want a system that runs without interruptions. Therefore, in some cases the goal of your simulation model will be to minimize the number of blockages in your system).

Conducting a Simulation Project

Overview

Projects that involve simulation have several unique aspects which must be managed particularly carefully to ensure their success. The topics in this chapter outline a typical sequence of events in a project, using a practical methodology:

- Establishing objectives
- Deciding the scope and level of detail in the model
- Collecting data
- Structuring the model
- Building and Running the model
- Generating reports
- Testing the model
- Experimenting with the model
- Documenting the model
- Presenting the results and implementing them

Establish Objectives

This is the first and most important phase of any simulation project. The aim of any simulation project should be to make a better business decision. You, as simulation modeller, must understand this business decision as it is likely to have important implications for the content of your simulation model.

Scope and Level of Model Detail

The scope of a simulation model refers to where it begins and where it ends. It is important to limit the scope of the model as far as possible. With regard to the level of detail contained within a model, the golden rule is to model the minimum necessary in order to achieve the model's objective.

At the beginning of the model-building process, small additions to the model lead to large increases in its accuracy. As the model becomes more detailed, however, each subsequent addition adds less to the model's accuracy. In fact, it could be argued that the addition of unnecessary detail could lead to an eventual fall in the accuracy of the model.

It is possible to use WITNESS elements to represent combinations of real world processes and therefore to model a process at a 'higher level'. For instance, a manufacturing cell or even an entire manufacturing plant could be represented solely as a WITNESS machine.

Data Collection

Information for a model is likely to fall into one of three categories;

1. Available - data is readily available and it is in an appropriate format that the model can use immediately.
2. Not available but collectable - data is either in an incorrect format or it has not been collated before. You might need to perform a small work study in order to collect this type of data (for example, timing certain processes manually).
3. Neither available nor collectable - data is not currently available and it is not easily collectable (for example, for a model of a new factory on a green-field site with new machinery). If the data is neither available nor collectable, you must use estimates.

Whenever you use an estimate, you should declare it as an assumption upon which the model is based. If the model later proves inadequate as a representation of the real world situation, then it is possible to scrutinize the assumptions upon which it was based.

Structuring the Model

An important final step before building the simulation model is to structure it. This will identify the most difficult areas for the model building and highlight any additional data requirements that may have been overlooked up to now, such as a transfer time for parts between processes.

This plan typically takes the form of a sketch of the facility to be modelled. The plan should identify which WITNESS element (or collection of elements) is to be used to model each real-life process. It may also contain information regarding the input and output rules to be used on key elements and a summary of the actions language that needs to be included in the elements to give the necessary degree of logical control.

Building the Model

It is recommended that you build the model incrementally, and that you test each stage thoroughly before you build the next stage. If you do this, it is easier to find problems in a model than if you have to search through an entire model. This ability to build a model incrementally, testing each section as you go, is a powerful aid to productivity, and generates confidence in the validity of your model.

The main steps in building a model are creating elements (defining, displaying and detailing them), then linking them together with rules.

You can also build more complex logic into your model by using actions.

Running the Model

After defining, displaying and detailing the elements of your model, you can run it immediately, then modify it by adding, changing or deleting elements. You can then run the model again in order to assess the impact of these changes.

There are many WITNESS features which aid analysis, including standard report tables and graphs (which list the basic mathematical behaviours of all elements in the model automatically), meteor trails, elements flows and process views. You can also create timeseries, pie charts, histograms and customized report tables and expressions in WITNESS.

Generating Reports

When you have built and run your model, you can use WITNESS reports to help you choose between alternative modeling scenarios.

Testing the Model

Testing a simulation model consists of verification and validation.

Verification ensures that the content of the model is consistent with your expectations. For example, establish that the parts are travelling along the correct routes between elements and that any labor used is attending to the correct elements in the correct priority order.

Validation (which usually follows verification) investigates the accuracy of the model compared with the real world. A typical validation exercise might involve providing a typical set of inputs (for example, a part arrival and production schedule) and studying a set of model outputs (for example, the average level of work-in-progress for a part, or part throughput times).

The verification and validation stages of a simulation study are usually iterative in that they involve re-visiting some of the stages already described. For example, the model may require the addition of some processes not yet modelled, thus increasing the model's scope.

Experimentation

When you are satisfied that the model resembles the behaviour of the real-life situation, you can investigate a number of what-if scenarios. The scenarios should have been defined within the original objectives of the simulation study.

Successful experimentation typically involves using a warm-up period or starting conditions, deciding on a suitable run-length, and running the model with more than one random number stream.

Documentation

It is a good idea to document the way in which you built the model, as it makes it easier to understand if you (or someone else) examines it at a later date. Such documentation should include the model structure diagram. WITNESS also provides other facilities for model documentation, either within the model itself, or externally to a file or a printer.

You can attach notes to most element detail dialogs and display the notes in the simulation window. You can use these to enter descriptions of how each part of the model should work. You can also use an exclamation mark in rules and actions in order to insert comments about the purpose of the rule or action.

The sources of data used, the assumptions made and the results obtained should also form part of the model documentation. If the project is documented as it proceeds then the documentation will prove to be a less onerous task. It is recommended that any project documentation is completed before the presentation of results as there is often less inclination to document a project which has been laid to rest.

Presentation of Results and Implementation

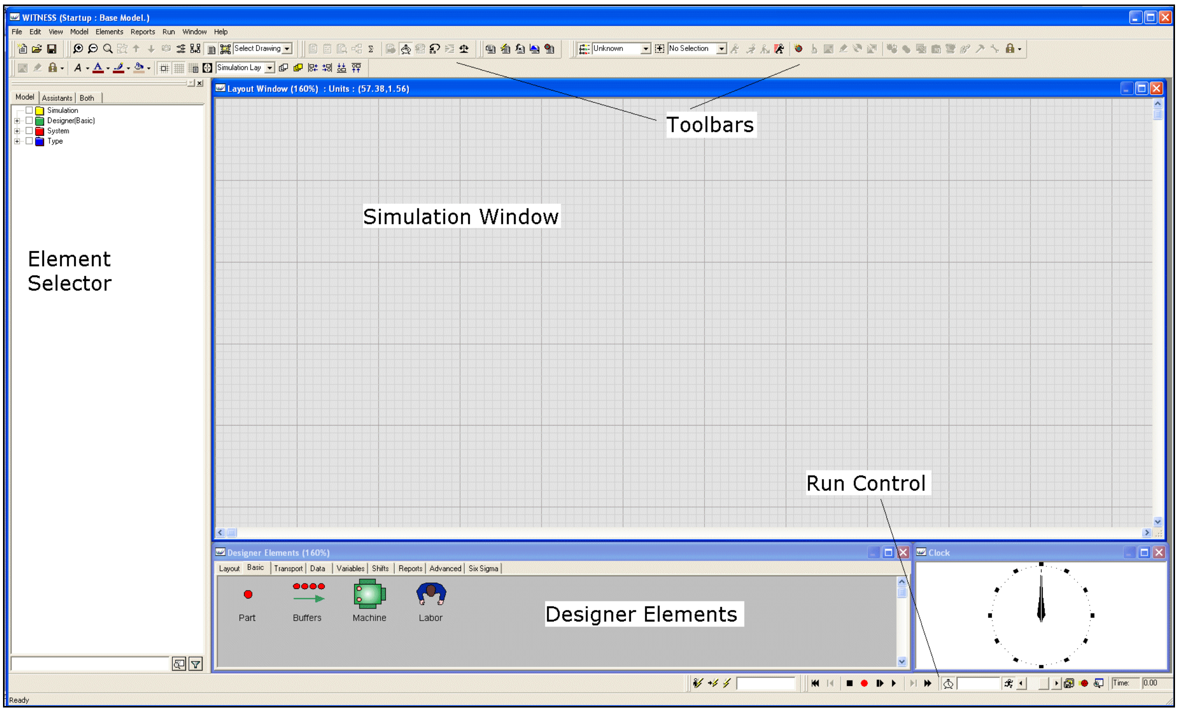
The method of presentation for results depends on the size of the simulation project and the culture of your organization. An animated model provides an effective communication tool to support business decisions, particularly if you have enhanced its graphical display.

WITNESS Software Environment

If WITNESS Power with Ease was installed with the default options, WITNESS can be opened via;

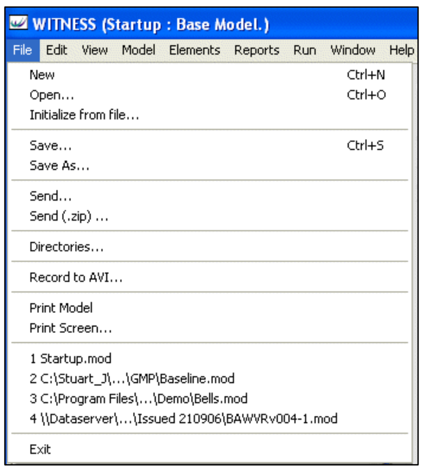
Start | All Programs | WITNESS Power with Ease | WITNESS PwE Manufacturing and Performance Edition
OR
Start | All Programs | WITNESS Power with Ease | WITNESS PwE Service and Process Performance Edition

The figure below shows a typical view of WITNESS when it is first opened. Note this may vary depending upon which version of WITNESS is installed and if a different Startup model has been selected.



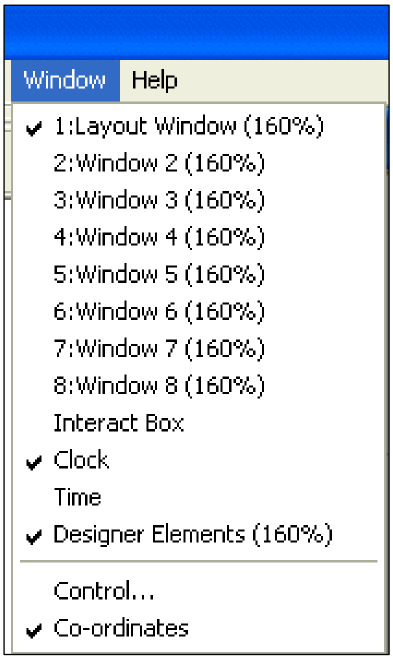
WITNESS Menu Bar

This is the standard menu bar enabling the user to access the commands within WITNESS such as saving a file, adding a toolbar or changing model options. The use of the Menu bar items will be discussed throughout the course as the functionality is introduced. If it is required that you select a menu item the name of the menu will be in bold italics e.g. File



WITNESS Windows and Window Control

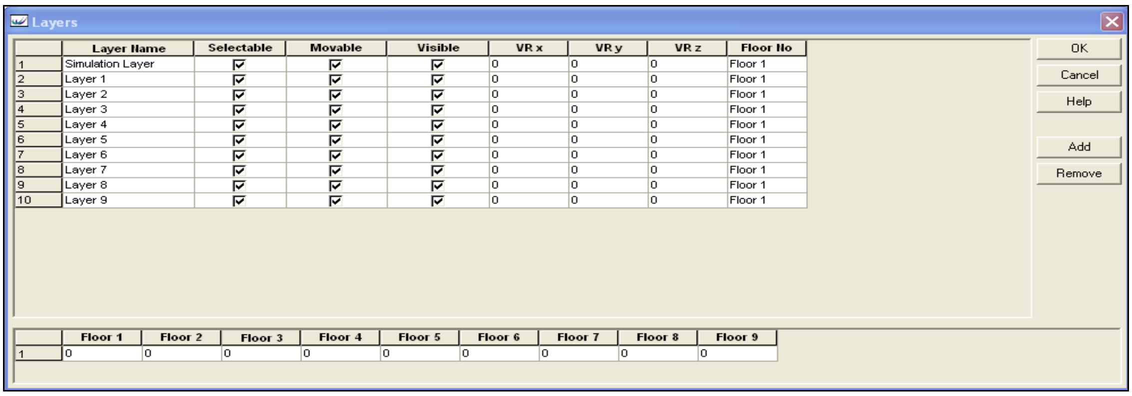
The main window views in WITNESS are the simulation windows. These windows (by default named Layout Window and Window 2 through Window 8) provide a view onto the virtual screen where the elements of the model are to be displayed. This is known as the "simulation space". The Interact Box is a window where information relating to the progress of the model is displayed.



All the windows shown can be open at the same time if required. They can be opened and closed from the Window menu; a tick next to a window name indicates that the window is currently open. Open windows may be scrolled through using the F9 key.

Layers

There are ten default Viewing layers within a Simulation View, each of which are positioned on top of the other. The top layer is called the Simulation Layer, with the subsequent layers beneath it being layers 1 to 9 (layer 9 is the lowest layer). Displays put on 'higher' layers will be positioned in front of displays put on lower levels, allowing backdrops to be used to give a realistic look to WITNESS simulation models.



	Layer Name	Selectable	Movable	Visible	VR x	VR y	VR z	Floor No
1	Simulation Layer	☑	☑	☑	0	0	0	Floor 1
2	Layer 1	☑	☑	☑	0	0	0	Floor 1
3	Layer 2	☑	☑	☑	0	0	0	Floor 1
4	Layer 3	☑	☑	☑	0	0	0	Floor 1
5	Layer 4	☑	☑	☑	0	0	0	Floor 1
6	Layer 5	☑	☑	☑	0	0	0	Floor 1
7	Layer 6	☑	☑	☑	0	0	0	Floor 1
8	Layer 7	☑	☑	☑	0	0	0	Floor 1
9	Layer 8	☑	☑	☑	0	0	0	Floor 1
10	Layer 9	☑	☑	☑	0	0	0	Floor 1

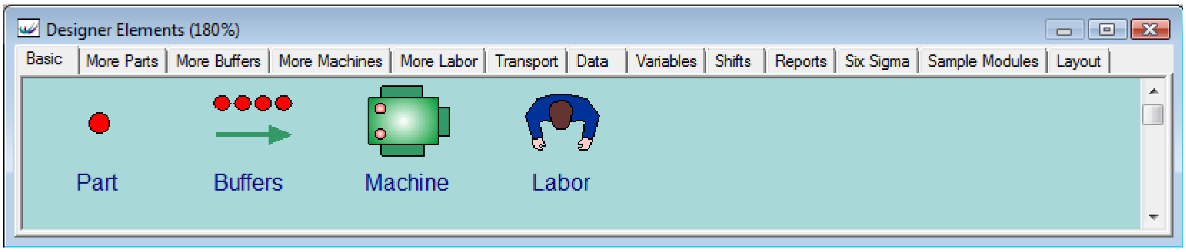
	Floor 1	Floor 2	Floor 3	Floor 4	Floor 5	Floor 6	Floor 7	Floor 8	Floor 9
1	0	0	0	0	0	0	0	0	0

The check boxes above (dialogue is accessed by the menu option View | Layers) allow the different layers to be non-selectable (remove the check from the Selectable check box), locked (remove the check from the Moveable check box), or invisible (remove check from the Visible check box).
Layers may be added or removed through the use of the Add and Remove buttons on the right hand side of the Layers dialogue. The names of the Layers can be edited by clicking on the layer to be renamed and typing the new name.

Designer Elements

Designer Elements are a palette of user-defined Elements with display and detail parameters already defined. When WITNESS first opens, it will open a model called **STARTUP.MOD**, which contains a basic set of these building blocks. These Designer Elements are used to generate the basic Elements included in your model. Later sections will show you how to create and customize your own Designer Elements.

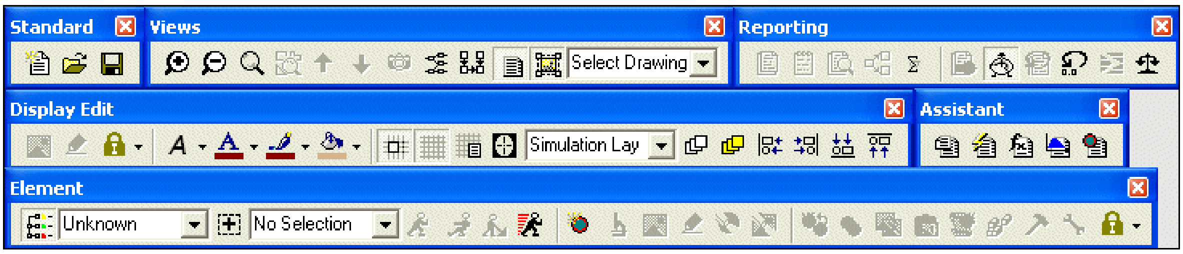
The elements in the Designer Elements window can be used to quickly place a copy of that element in the simulation model. This is done by clicking on the required element icon (a cross hair will appear) and then clicking in a simulation view.



The Designer Element window has numerous tabs that contain "groups" of designer elements. They are used to speed up model building. Each designer element may be modified by the user and saved either with the model or separately (to a designer elements file). Designer elements may be added or deleted. New tabs may be added to the Designer Elements window and populated with new designer elements. Designer elements files may be loaded into other models.

Toolbars

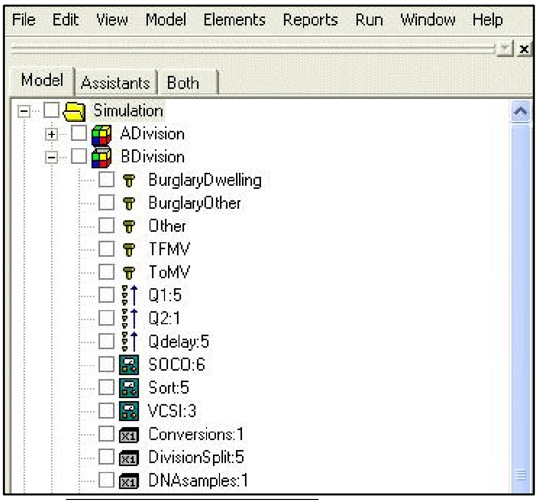
The figure below shows some of the standard toolbars in WITNESS. All toolbars can be docked or left free to float. They are be displayed from the View-> Toolbars menu. As the user becomes more familiar with the tool buttons that they use regularly they can choose to customize the toolbars through the View-> Toolbars-> Customize menu option. Toolbar buttons may be added or deleted and if necessary new user defined toolbars may be created using the customize menu.



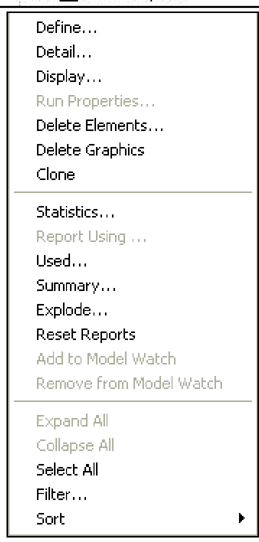
Many of the commands that are available through the standard WITNESS menus can be performed more quickly using the icons on these toolbars. When a command relates to a WITNESS element, that element must be selected (brought into "focus") first.

Element Selector

The element selector displays a hierarchical list of elements that have been defined in the model. The names and quantities may be edited directly in this list but other element details require the opening of the detail dialogue through double clicking on the element in the list or in the simulation window.

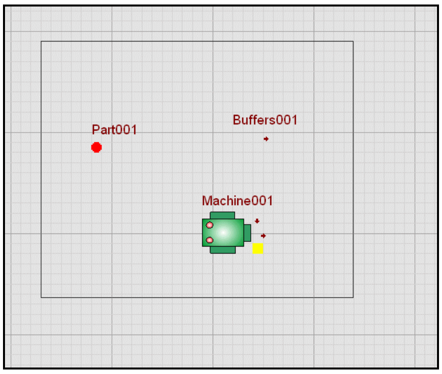


Witness also has right-click menus that give access to a range of options depending on the element that has been selected. The adjacent image shows the right click menu available after selecting an element in the element selector.



Multiple elements may be selected by ticking the check boxes next to the element name in the Element Selector. The same may be done by drawing a 'net' around a group of elements in the simulation space.

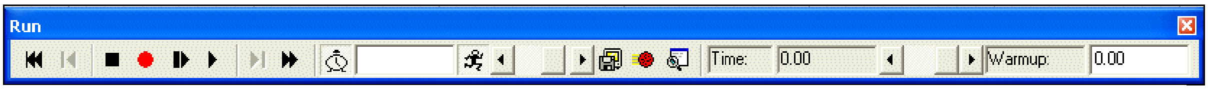
To draw a 'net' around elements press and hold the left hand mouse button at the top left or bottom right hand corner of the required area, then drag the mouse to the opposite corner (keeping the left button depressed). This will automatically tick the Element Selector check boxes of the elements that are within the net.



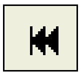
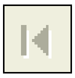
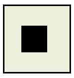
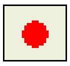
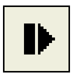
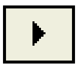
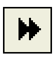
Individual elements can also be selected directly in the simulation space by single clicking on them with the left mouse button.

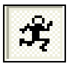
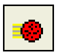
Running the Simulation

The Run Control bar is a toolbar that is dedicated to controlling the running of a model.



Explanation of toolbar functionality

Option	*Symbol*	*Description and Usage*
Begin		The Begin button resets the model (that is, it resets the clock to time zero, clears statistics and sets Elements to an idle state). Alternatively, use Run→Begin.
Auto step Back		The Auto step Backwards button allows you to step backwards in time to the previous **.sim** file in a sequence of saved **.sim** files. It also takes Run Until instructions into account.
Stop		Stops the simulation if running. This allows you to examine the model at any point in time. The Esc key and right mouse button also perform this function.
Record		Turns on the Auto step function which allows the user to step forward or back through the saved time slices.
Step		Advances the simulation to the next event. This is useful for verification and validation since it prints, to the Interact Box, the current time and a description of each event as it occurs. The left mouse button and the Enter key also advances to the next event.
Run		Standard running mode with animation on. This runs the simulation at a fast speed whilst providing the user with an animated display.
Batch		Standard running mode with animation off. This is useful for running long or multiple experiments since batch mode is many times faster than run mode.

Option	***Symbol***	***Description and Usage***
Run Until On/Off		Activates/deactivates the Run Until option.
Run Until		With the Run Until button toggled to ON, by entering a time, the simulation will automatically stop at that point. If an element name is typed in, the simulation will stop at the next event for that element.
Walk		Same as run mode, but slower. Parts and labor move between elements providing a much greater degree of animation - particularly useful when demonstrating the model.
Walk Speed Slider		The walk speed slider adjusts the speed of the walk mode move to the left for slower walk mode and to the right for faster walk mode.
Trace		Same as step mode, except all output is sent to a file, with the extension **.trc**.
Meteor Trail on/off		Turns the meteor trail logging on or off. Meteor trails allow the user to view the path of parts through the system.
Watch Mode		Turns the watch mode on or off. The watch mode prints details of changes to values in the model to the interact box.

Saving the Model

To save a WITNESS model select the File -> Save As option (can use File -> Save if you wish to use the same name), make sure that the file type is Model Files (*.mod) and Type the required file name in to the appropriate box.

WITNESS can also save the Model and Status, i.e. the model with all conditions as it is at the point where it is being saved (buffer levels, machine utilizations, part positions, etc). This is done in the same way as above however the file type selected should be Model & Status Files (*.sim).

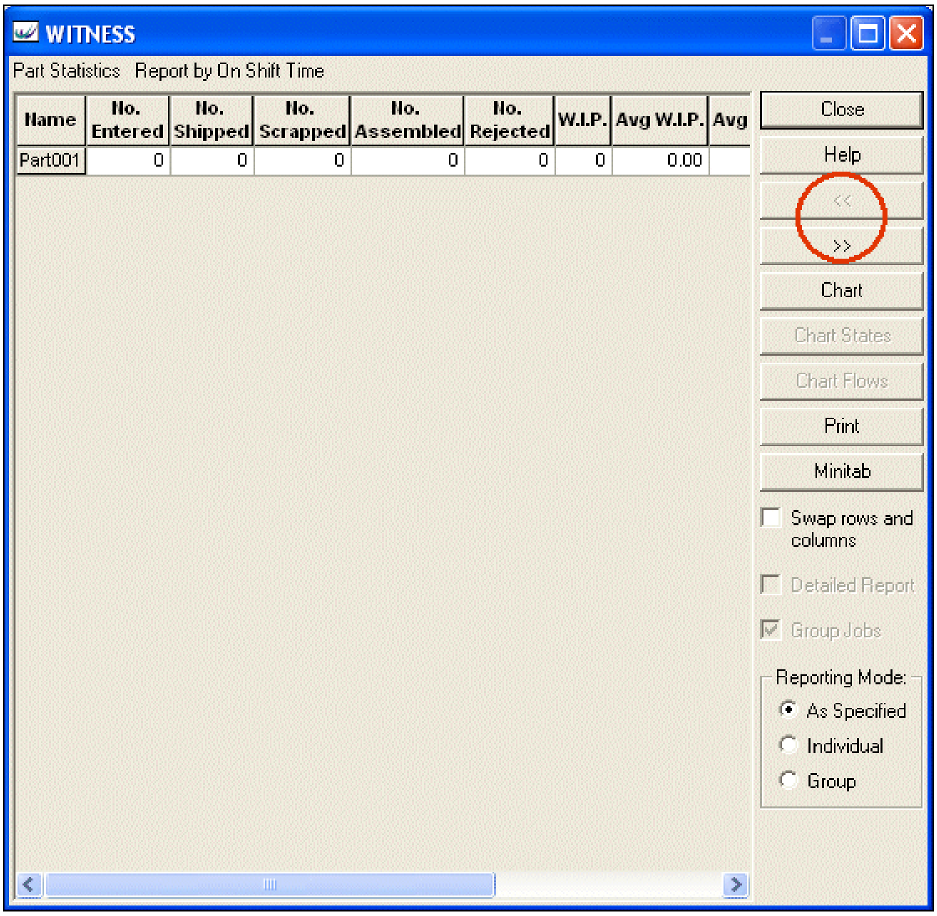
Standard WITNESS Statistics

WITNESS automatically collects data on all elements defined in the model (the exact meaning of which will be detailed in the section discussing the relevant element, however most are easy to interpret).

This data can be viewed when the model has been stopped. Note that when the Begin button is pressed on the run control toolbar all statistics collected are cleared at the same time as the model is returned to its initial state.

To display the statistics for an element or a selection of elements, select the elements, go to the menu, select - **Reports | Statistics**.

This will display a screen similar to the one below,



if multiple element types were selected the double arrow buttons on the right of the dialogue will navigate between the element types.

The tabular detail can be displayed in a horizontal or vertical format by checking the **Swap rows and columns** tick box.

The Witness Elements

Terminology

This manual uses terminology that relates to both manufacturing and non-manufacturing environments. The following list may be useful in seeing the different terminology used in these two environments.

Manufacturing (MPE)	***Service (SAPPE)***
PART	ENTITY
BUFFER	QUEUE
MACHINE	ACTIVITY
LABOR	RESOURCE
BREAKDOWN	STOPPAGE
IDLE	FREE
ASSEMBLY	JOIN
PRODUCTION	SPLIT
NUMBER SHIPPED	NUMBER SERVED
NUMBER SCRAPPED	NUMBER LOST
NUMBER REJECTED	DID NOT ENTER
NUMBER ASSEMBLED	NUMBER JOINED
WIP (Work In Progress)	NUMBER IN SYSTEM

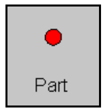
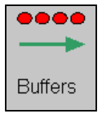
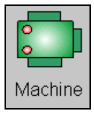
Elements: the WITNESS Building Blocks

This section provides an introduction to the basic building blocks of WITNESS. The description is designed to give an overall appreciation of the product before introducing the model building process where WITNESS's processes and features are explored in more detail.

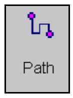
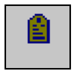
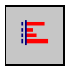
A business or commercial operation might produce a number of different items (parts or entities) using a variety of machines, conveyors, vehicles, other equipment and people. A WITNESS model uses the same combination of parts, people, machines etc. to simulate the operation being studied. It is possible to simulate virtually any aspect of a process or operation providing it can be adequately described.

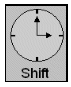
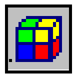
The first table shows the basic "physical" WITNESS elements. Other physical elements and a range of "logical" elements i.e. elements that have no physical form are shown in the second table. A number of more specialized elements that are not covered by the basic WITNESS training course appear in the third table.

Basic Elements

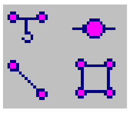
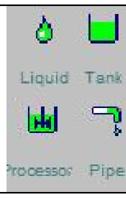
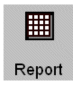
Element	Description	Examples	Designer element Icon
Part	Parts (Entities) are used to represent those discrete items that move around the model.	Parts can represent:- products (cars, engines, etc),product batches, calls in a telephone exchange, tiny electronic components or whole computers	
Buffer	These are places where parts can be held.	Buffers can represent: parts awaiting an operation on a factory floor, people in a queue, the space containing aircraft waiting to land.	
Machine	These are powerful elements which are used to represent anything that takes parts from somewhere, processes them and sends them on to their next destination.	Machines can represent a machine tool, lathe or a press. A complete shop or a single supermarket checkout. An entire plant or an individual work cell.	
Conveyor	These are used to move parts from one fixed point in the model to another over time	There are two types of conveyors. •Fixed conveyors maintain a constant distance between parts. If the conveyor stops, the distance between the parts on the conveyor remains the same. •Queuing conveyors allow parts to accumulate. If the conveyor becomes blocked, the parts will slide together until the conveyor is full.	

Other Elements

Element	Description	Examples	Designer element Icon
Labor	This element can be used to model both human and physical resources which may be required in the model.	For example, tools, people or equipment	
Path	A path is an element that parts or labor units can travel along in order to get from one element to another element	You can use it to represent the length and the physical route of a real life journey in your model.	
Attribute	These are characteristics of a specific part or labor unit.	For example, the number of cylinders in an engine could be held in an attribute, and you could then use this attribute to determine the amount of time required for tuning and adjustment	
Variable	Variables are values which can be accessed from anywhere in the model	For example, a variable could be used to record the value of items in an inventory	
Distribution	Distributions allow you to build variability into a model by including data which you have collected from the real world.	For example, if observations show that the milling operation on type X widgets takes between 5 and 10 minutes but most often takes 8.2 minutes, the information could be introduced into the model using a distribution.	
Function	WITNESS provides a large number of built-in functions which you can use to build intelligence into the logic of your model.	For example, you could use a function to detect the number of parts currently on a conveyor. You may also create your own functions.	

Element	***Description***	***Examples***	***Designer element Icon***
Shift	The shift element is used to simulate a shift pattern which is, in effect, a sequence of working and non-working periods	Shift patterns may be applied to labor and other elements in order to simulate shift working.	
Module	A module is an element consisting of a collection of other WITNESS elements.	Modules may be used to facilitate "black-box" or hierarchical model building.	
Pie chart	A reporting element to display a pie chart.	Pie charts allow you to present simulation results on the screen in the standard pie chart format	
Timeseries	A reporting element to display a time dependant values.	Timeseries allow you to present simulation results on the screen in the form of a graph which plots values taken from the simulation against time. Up to seven values may be plotted with seven different colors	
Histogram	Histograms allow you to present simulation results on the screen in the form of a bar chart.	This is useful for determining the range of values observed for some parameter of the simulation.	

Elements not covered by the basic WITNESS training course

Element	Description	Examples	Designer element Icon
Tracks and Vehicles	These are the vehicles and paths that vehicles follow when transporting parts.	These elements may be used for modeling Automatic Guided Vehicles, cranes or forklift trucks.	
Power & Free Elements	Power and free elements allow you to model the specialized form of material transportation systems	Power and free systems incorporate carriers, sections, stations and networks and are common in car factories.	
Continuous processing elements	These are used to simulate models where continuous flow is a factor	Commonly used to represent liquids or free-flowing products, such as powder. The continuous elements include Fluids, Processors, Tanks and Pipes.	
Reports	Report Elements allow the definition of a custom report.	This may either have the default display of a table of values or a chart. The report element contains the details of the calculations to generate the report which is usually based on the value of other functions or variables in a model.	

Building Your First WITNESS Model

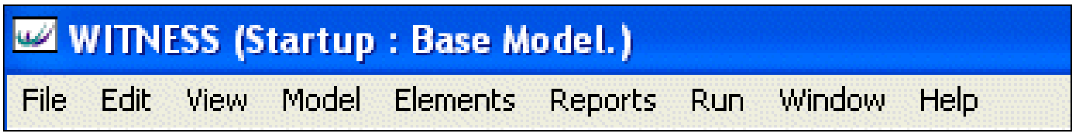
Models are built with a series of 'building blocks' or Elements. Anything you use in WITNESS is an element: a machine, an attribute, a histogram, etc. This section describes the first three basic elements, how to introduce them into a model and how to` link them together. The basic elements are Parts, Machines and Buffers. With these three elements the core of any WITNESS simulation can be created.

The Part Element

Parts (Entities) are used to represent those discrete items that move around the model. They can be used to represent small electronic components, large oil tankers, or anything in between. Parts (Entities) have even been used to represent calls in a telephone exchange and other types of information flow. WITNESS creates Parts (Entities) and introduces them into the simulation at the time and place dictated by the model. Parts (Entities) can be handled singly; they can combine into one; one can split into several; or a group can be batched together. Parts (Entities) can change into other Parts (Entities) as they progress through the model.

Defining, Displaying and Detailing a Part

First we must ensure that the correct start up model is loaded, the model should be **Startup.mod**. If this model is loaded the top left corner of the WITNESS application will be seen as below.



If this is not seen then **Startup.mod** will need to be loaded. This is done via the File | Open menu. The File will be in the directory C:/Delegate Files. (this model file can also be found in C:/program files/Witness 2008/Demo/ under the default installation options)

The definition of a part can be done two ways;

1) Creating from the designer elements or
2) Using the element Define Dialogue box.

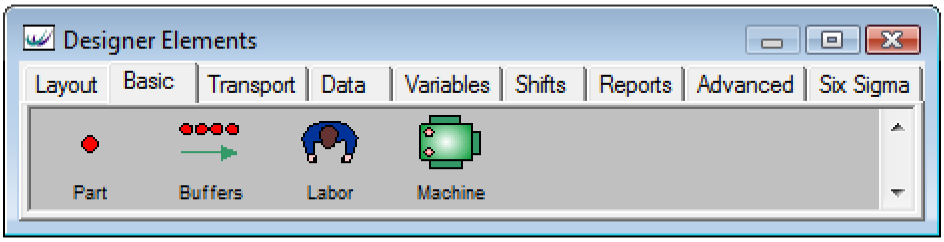
Both methods will be described, however it is recommended that initially you use the designer elements.

Creation of a Part from Designer elements

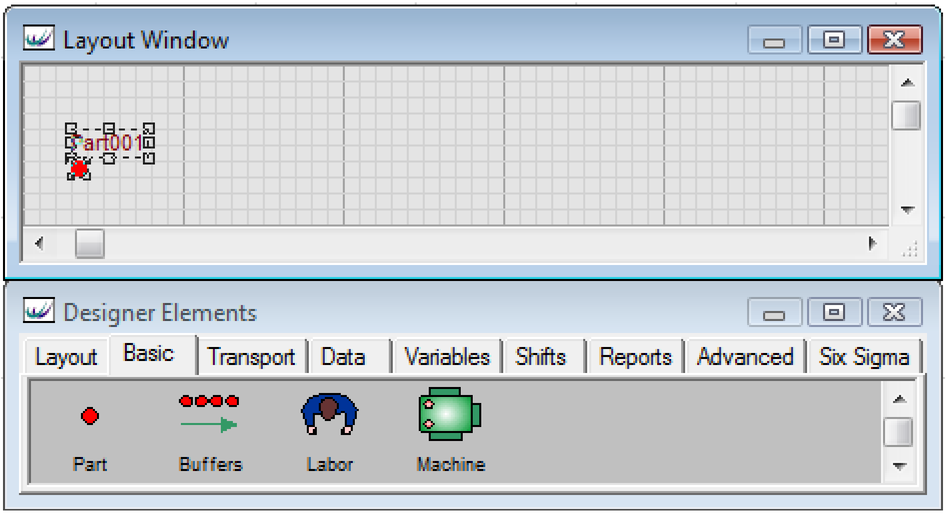
Click on the designer elements window and select (by clicking on) the Basic Tab.

If the designer elements window is not visible go to the Window menu and make sure that the designer elements window is 'ticked'. Once ticked, press the F9 key until the designer elements window is seen at the bottom of the screen.

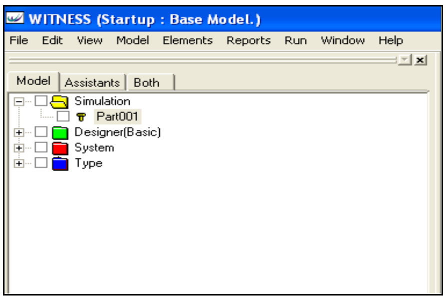
Click on the Part Icon (red dot with Part underneath), you will see a box appear around the part icon and the cursor will become a crosshair.



The Final action is to click on a Simulation View in the area that you wish to create the Part.



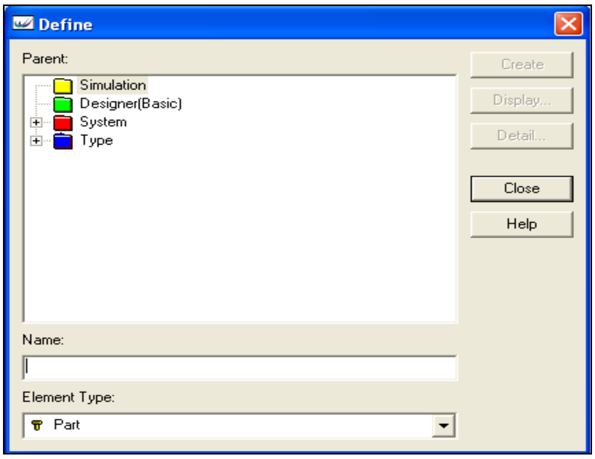
The Part will be displayed on the Simulation View and will also be shown in the Element Selector on the left of the screen.



Creation of a Part Using the Define Dialogue Box

Right clicking either on a Simulation View or Element Selector will cause a menu to be displayed (shown below).

Select the Define option. This will open the Define dialogue box. This Define dialogue box can also be opened using the Define button on the Element Toolbar.



Type a name (this must start with an alphabetic character, be less than 24 characters long and not contain any symbols (this includes spaces) other than an underscore. Check that the Element Type is set to Part and then click on the button labelled Create

A Part will now have been created and is shown in the Define Element tree. Exit the Define Dialogue using either the close button or the red cross in the top right hand corner of the box. You will notice that the Part (with the name you typed) has appeared in the Element Selector, but has not been displayed on the screen. This element will now need to be displayed on the Simulation View (if so required).

Displaying a Part

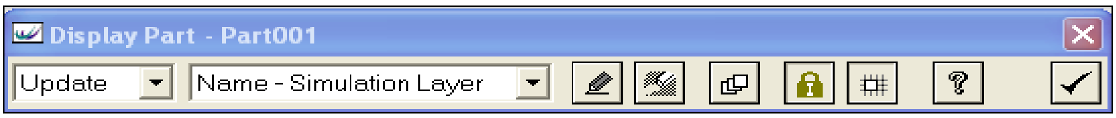
Once the Elements have been added to the model, you can change how they are displayed on the screen. Although the display is extremely valuable for understanding the model, it is not actually required in order to run the model.

A Part may have numerous display 'items' on screen to convey information about it, many of the items may be displayed more than once (marked with a * in the table below). The available display items for Parts are shown in the following table;

Part Display Item		***Description***
Name	*	Name of the selected Element
Style		The Style of the Part display that moves through the model
Notes	*	Notes entered on the detail form
Expression	*	Any WITNESS function or a calculation
Rectangle	*	A box
Ellipse	*	A circle/ellipse
Line	*	A line
Icon	*	An icon
Text	*	Descriptive text
Simulation items		Multiple selection of all of the simulation items (e.g. name, icon etc.)

The Display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.

The display toolbar is then shown as below.

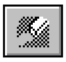
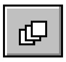
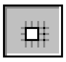
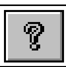
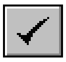


The use of the first drop down list enables different actions to be taken.

Option	**Description**
Draw	Enables you to draw on the screen the option selected. In some instances, you can draw an option more than once (e.g. two icons, two part queues).

Update	Enables you to update the display of the item selected. You cannot use Update to change layers.

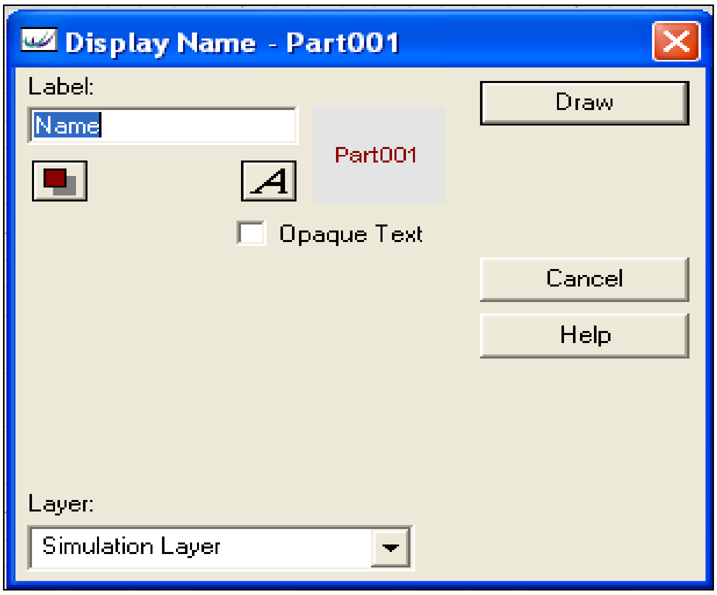
The use of each of the buttons on the display toolbar is detailed in the table below.

Button	Description
	Displays the Display Graphics dialog so that you can draw a new item or update an item that is already displayed. The contents of the Display Graphics dialogue vary according to the type of Element that you have selected.
	Displays a Delete Display dialog box from which you select the display item(s) to be erased the selected
	Displays the Layers dialog box. You can change the layer name and switch the status of the layer to movable and/or visible for all windows. If the move option for a specific layer is selected, you can move items on the layer as long as the window option you are on is also movable. If the visible option is off, the objects on the layer are no longer visible on your screen.
	Locks all of the display Elements together so they can be moved as a group by dragging the Element Name on the screen. You can only move locked display items that are drawn on the same layer. This lock toggles between Unlocked (all display items can be moved independently, Individual (all display items for individual instances of an element move together), Group (all display items of the same element move together) and Superlock (the displays of all elements within the same module move together).
	Switches Snap to grid facility off. With this selected the displays will snap to the top right hand corner of square grid, turning this off will allow displays to be positioned at any position.
	Access to WITNESS help
 	When you are displaying Elements singularly, the tick button exits the display palette. If you are displaying on a multiple selection, the tick proceeds to the next display palette whereas the cross cancels the display selection by returning to the Element selector.

Displaying the name of a Part (either one that is not displayed or repeating the display) is done by selecting Draw on first drop down menu on the display toolbar and then Name on the second.

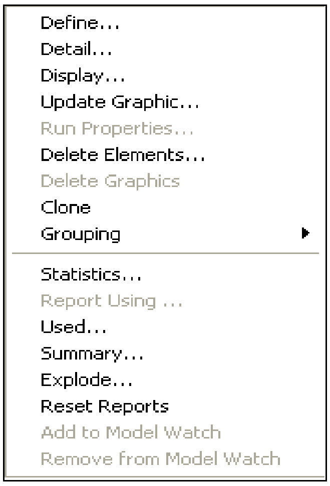
Clicking on the Pen Icon (detailed above) will Display the Display Graphics dialog box. This will allow you to change any options for the display, for example, font type, size or color.

Note that the Label is a tag to allow you to recognise which display item you are looking at, it is not what will be displayed.



To draw the name click on the button labelled Draw (if you are updating a name there will be another button labelled Update which updates the display with the changes made in it's current position).

A shortcut to updating the display of an item is to right click on the item that you wish to change, bringing up the following menu. Selecting Update Graphic will take you directly to the Display Graphics dialog. Make the required changes and re-draw the item.

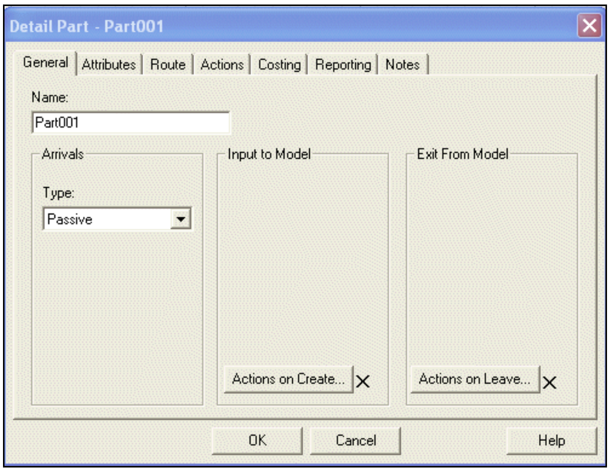


Detailing a Part

When detailing Parts (Entities), you need to decide whether they are Passive, Active or Active with Profiles. If parts are passive, it means they are always available. Elements in your simulation model can pull them from an infinite supply location at any point in time. On the other hand, if parts are active, they arrive into your model following a specific pre-determined inter-arrival time and lot size. Parts having the active with profiles option will be covered in another Chapter of this manual.

The information you enter in the detail dialog box of a part indicates when, where and how many parts should appear during the simulation; whether any actions must be taken when they arrive or leave the simulation; and whether statistics should be collected.

The information about the behaviour of a Part is entered (and viewed) via the Detail dialogue box;

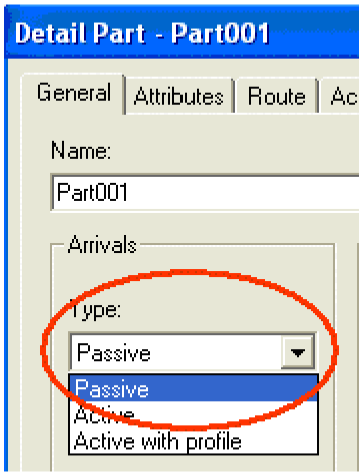


To open the detail dialogue box for a specific Part, double click on the element in either a simulation view or on the Element Selector (Right clicking on an element and selecting detail will perform the same action).

Tab Name	Description of Use
General	This is the primary tab which controls the properties of a part in the model, such as arrivals, lot sizes, etc.
Attributes	Allows the user to fix attributes values to specific values that can not be changed during the model run. This tab should **ONLY** be used if computer memory is a particular issue and should only be the case for extremely large models. See Attributes section for details.
Route	Allows the definition of a traditional 'Job Shop' routing system, where each part type follows a (sometimes circuitous) route around a factory during processing.
Actions	Allows the initialization of data to be conducted at the start of the model run.
Costing	Allows the introduction of costing information which can be reported on using WITNESS costing reports.

Tab Name	Description of Use
Reporting	Contains the option for turning off the WITNESS statistics collection for the element.
Arrival Profile	This tab is used to enter the arrival profile over a time period (typically 24 hours) and is used in situations where different arrival patterns exist for different periods of the day.
Notes	Allows the user to enter text to document what has been done in the element.

In this section, only the General tab will be covered, other tabs will be cover later in the manual. When detailing Parts, you need to decide whether they are Passive, Active or Active with Profiles. This is done by selecting the appropriate option in the Arrival Type drop down list;



If parts are passive, it means they are always available. Elements in your simulation model can pull them from an infinite supply location at any point in time.

On the other hand, if parts are active, they arrive into your model following a specific pre-determined inter-arrival time and lot size. Parts having the active with profiles option will be covered in another Chapter of this manual.

The information you enter in the detail dialog box of a part indicates when, where and how many parts should appear during the simulation. You will notice the boxes starting with 'Actions on' these allow action (instructions or code) to be taken when a part arrives or leaves the simulation.

The table below shows all the possible fields that could be entered on the general tab of a part, not all will necessarily be visible at one time. The words unlimited or undefined may be seen in some input boxes, where unlimited is seen the model will run without this been amended but where undefined is seen a 'value' must be entered (or a dialogue box will 'pop up' at run time requesting the information is entered).

Data Item	Description
Name	Name of the selected Element
Inter Arrival Time	Time between arrivals.
Lot Size	Number that arrive together. Inputs must be integer numbers.

To Button (Output Rule)	This will open a dialogue that will allow the routing of Parts to the next process in the model (for Parts with active and active with profile arrivals)
Maximum Arrivals	Maximum number that can arrive throughout a simulation run
First Arrival at	Time first one arrives in the model
Shift	The shift that is applied to the part arrival (i.e. parts will not arrive in off shift periods). Shifts will be covered in a later section of this manual.

The Machine Element

Machines are powerful Elements that are used to represent anything that takes parts (entities) from somewhere, processes them and sends them on to their next destination. Machines (Activities) are physical Elements that operate on a Part (Entity), often changing it in some way. Machines take time to process Parts (Entities), changing from one state to another as time advances. Examples of Machines and Activities are:

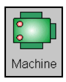
- A lathe
- A press
- A robot welder
- A palletiser
- A supermarket checkout
- An auto teller at a bank
- An ACD at a call centre

Defining, Displaying and Detailing a Machine

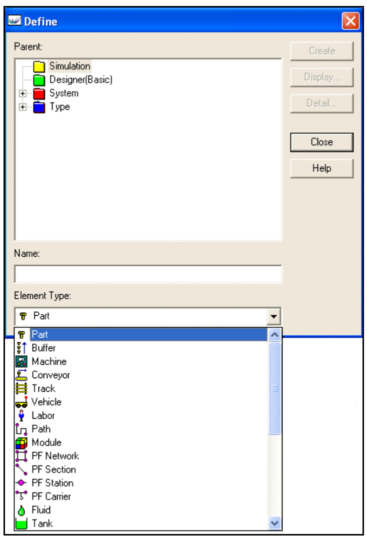
Machines (Activities) are physical Elements that operate on a Part (Entity), often changing it in some way. Machines take time to process Parts (Entities), changing from one state to another as time advances.

Defining a Machine

Defining a Machine is done using the same method as defining a part, as shown in the previous sections. The creation of a Machine from Designer Element is identical, except for the selection of the Machine Designer Element.

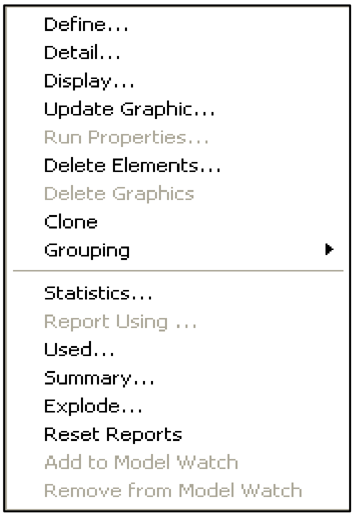


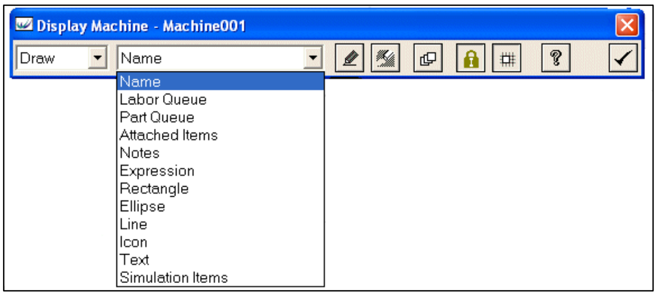
Defining a Machine through the Define Dialogue requires the selection of Machine in the Element Type Drop down list.



Displaying a Machine

The Display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.





As was the case with Parts, a Machine may also have numerous display 'items' on screen to convey information about it, many of the items may be displayed more than once (Marked with a * in the table below). The available display items for Machines are shown in the table below.

Machine Display Item		**Description**
Name	*	Name of the selected Element
Labor Queue	*	The Position where Labor working at the Machine will be shown. This can be displayed as a count or a queue showing the labor style icons.
Part Queue	*	The Position where Parts being processed at the Machine will be shown. This can be displayed as a count or a queue showing the part style icons.
Attached Items		Items that have been attached to the machine (not covered in this manual)
Notes	*	Notes entered on the detail form
Expression	*	Any WITNESS function or a calculation
Rectangle	*	A box
Ellipse	*	A circle/ellipse
Line	*	A line

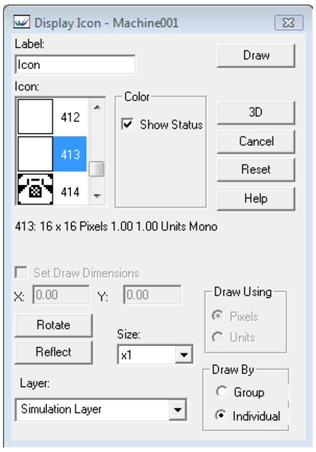
Machine Display Item		Description
Icon	*	An icon, this can be a 'picture' or a monochrome icon which will show the changes of machine state by changing colors.
Text	*	Descriptive text
Simulation items		A multiple selection of all of the simulation items (e.g. name, icon etc.)

The Display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option.

A shortcut to updating the display of a machine display item is to right click on the item that you wish to change (e.g. the icon), bringing up a menu. From this menu select Update Graphic, which will take you directly to the Display Graphics dialog for that display item. Make the Changes that you require and draw the item.

The states of the machine (what it is currently doing) can be displayed as icon that changes color:-

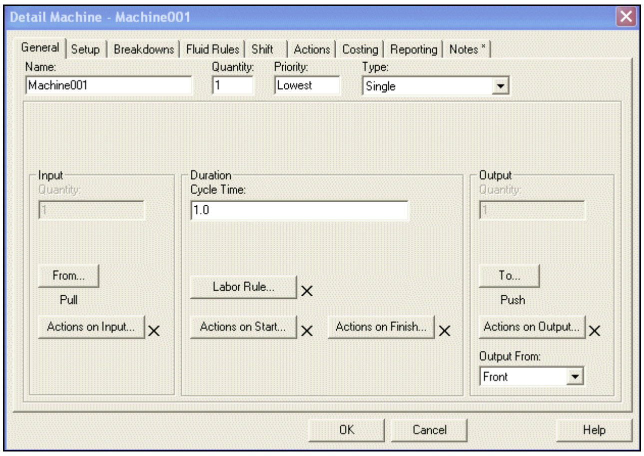
Idle - **Yellow**
Busy - **Green**
Blocked - **Magenta (pink)**
Broken Down - **Red**
Setting Up - **Cyan (light blue)**
Waiting (Labor) - Blue



To display this state icon, use the same procedure as for displaying a normal icon but an icon which is monochrome needs to be used. When a monochrome icon is selected "Mono" is shown on the end of the icon description and the Show status tick box becomes visible. To make the icon show the machines states, this tick boxes needed to be checked.

Detailing a Machine

The information about the behaviour of a Machine is entered (and viewed) via the Detail dialogue box. To open the detail dialogue box for a specific Machine, double click on the element in either a simulation view or on the Element Selector (Right clicking on a Machine and selecting detail will perform the same action). Below is the detail dialogue box for a Machine.



There are nine tabs on the Machine Detail Dialogue, a brief description of there uses is contained in the following table.

Tab Name	Description of Use
General	This is the primary tab which controls the properties the machines cycle time and the input and output of parts.
Setup	Allows the addition of a stoppage at the start of the cycle time. This is used to represent situations such a die changes, periodic maintenance, etc
Breakdowns	Allows the addition of stoppages to the machine. This can be used to represent unplanned failures of equipment, such as Drill breakages or power outages, etc.
Fluid Rules	Details the interaction of this machine with fluids. Not covered in this manual.
Shift	Allows the Machine to be constrained to work only on a shift
Costing	Allows the introduction of costing information which can be reported on using WITNESS costing reports.
Reporting	Contains the options for the WITNESS statistics collection for the element, allowing the statistics to be collected for individual 'instances' of the machine, by group or turned off.
Actions	Allows the initialization of data to be conducted at the start of the model run.

Notes	Allows the user to enter text to document what has been done in the element.

In this section we will be covering the General tab of the Machine Detail dialogue.

Data Item	Description
Name	Name of the selected Element
Quantity	The number of instances of the Machine. This will be covered in detail in a later section of the manual. Inputs must be integer numbers.
Priority	The Priority that the machine has, 1 being the Highest and 5 being the lowest. (lowest is equivalent to 5). The use of this will be covered in detail in a later section of the manual.
Type	This allows the characteristics of the machine to be changed. This will be covered in a later section of the manual
From Button (Input Rule)	Allows the manual input of rules for where a Machine should obtain a Part(s) from when it has the capacity to process one.
Cycle Time Duration	Time taken to process the part(s)
To Button (Output Rule)	Determines where the processed Part(s) will be routed to.

The Buffer Element

Buffers store Parts (Entities). They do not actively pull Parts (Entities) in. Parts (Entities) are pulled out by some other Element (there is an exception in Maximum Delay buffers which can push Parts to other Elements using an exit rule, this will be covered in a later section of the manual).

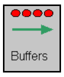
Examples of the uses of Buffers (Queues) include:

- A factory floor holding parts awaiting their next operation
- A storage rack holding circuit boards before flow soldering
- The space containing aircraft waiting to land (a stack)
- A hopper at an assembly station containing product components
- People waiting in a line or queue
- Telephone call queues
- Reports in an in-box
- A waiting room at a hospital

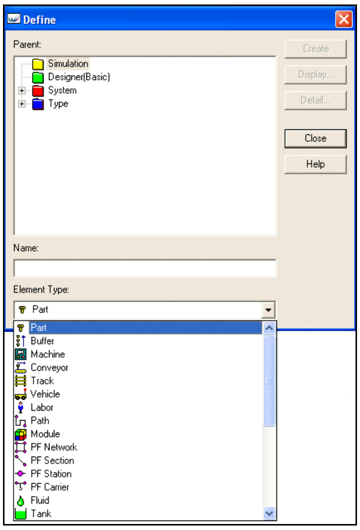
Defining, Displaying and Detailing a Buffer

Defining a Buffer

Defining a Buffer is done using the same method as defining a Part or Machine, as shown in the previous sections. The creation of a Buffer from Designer Element is identical, except for the selection of the Buffer Designer Element.

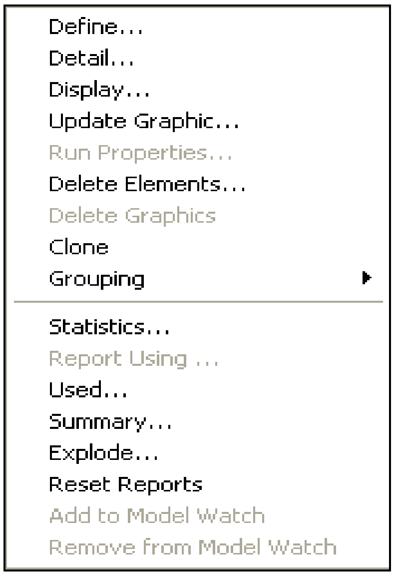


Defining a Buffer through the Define Dialogue requires the selection of Buffer in the Element Type Drop down list (shown below).

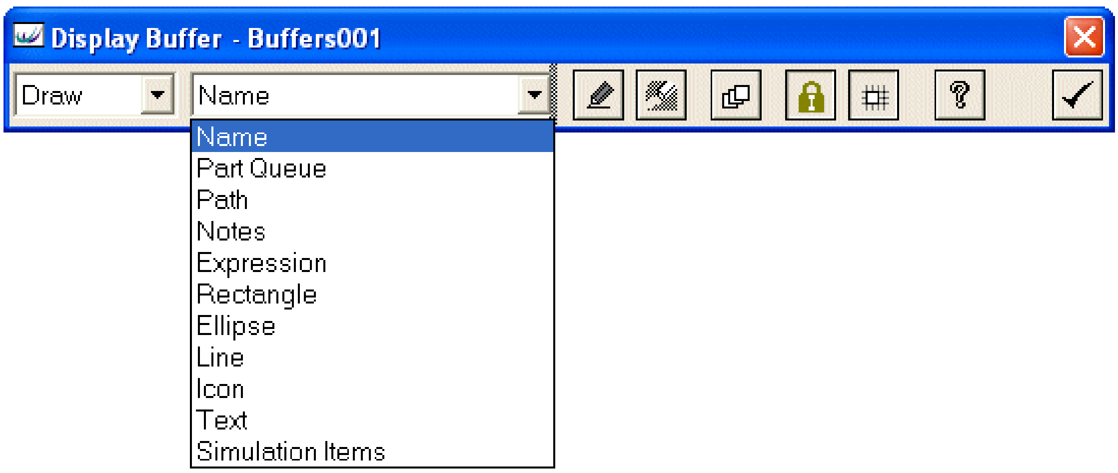


Displaying a Buffer

The Display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.



As was the case with Parts and Machines, a Buffer may also have numerous display 'items' on screen to convey information about it, many of the items may be displayed more than once (Marked with a * in the table below). The available display items for Buffers are shown in the table below.

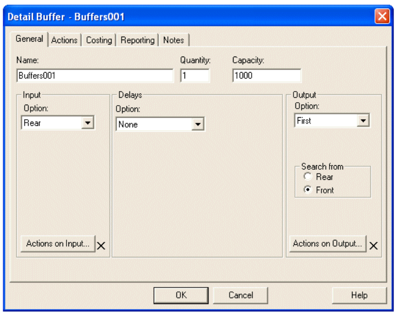


Buffer Display Item		**Description**
Name	*	Name of the selected Element

Part Queue	*	The Position where Parts in the buffer are displayed. This can be displayed as a count or a queue showing the Part style icons.
Path	*	This shows the style icons of the parts equally spaced on a path line. The path can be straight, curved, or 'jagged'.
Notes	*	Notes entered on the detail form
Expression	*	Any WITNESS function or a calculation
Rectangle	*	A box
Ellipse	*	A circle/ellipse
Line	*	A line
Icon	*	An icon, this can be a 'picture' or a monochrome icon which will show the changes of machine state by changing colors.
Text	*	Descriptive text
Simulation items		A multiple selection of all of the simulation items (e.g. name, icon etc.)

Detailing a buffer

The information about the behaviour of a Buffer is entered (and viewed) via the Detail dialogue box. To open the Detail dialogue box for a specific Buffer, double click on the element in either a simulation view or on the Element Selector (Right clicking on a Buffer and selecting detail will perform the same action). Below is the detail dialogue box for a Buffer.



There are 4 tabs on the Detail dialogue for a buffer

Tab Name	Description of Use
General	This is the primary tab which controls the properties the machines cycle time and the input and output of parts.

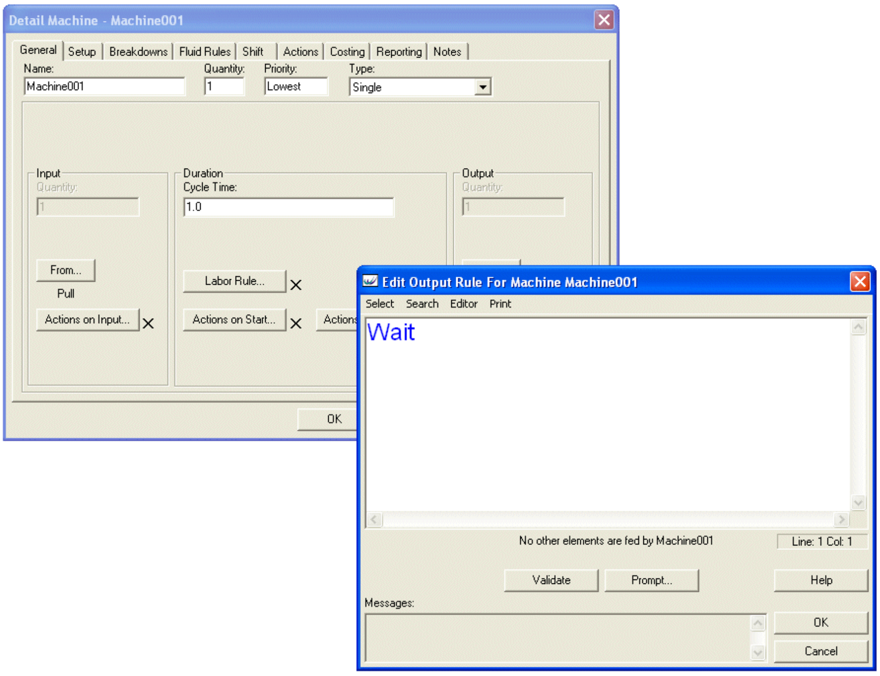
Actions	Allows the initialization of data to be conducted at the start of the model run.
Costing	Allows the introduction of costing information which can be reported on using WITNESS costing reports.
Reporting	Contains the options for the WITNESS statistics collection for the element, allowing the statistics to be collected for individual 'instances' of the machine, by group or turned off.
Notes	Allows the user to enter text to document what has been done in the element.

The data items that are used on the general tab of a Buffer and its meaning/use are defined in the table below.

Data Item	Description of Use
Name	Name of the selected Element
Quantity	The number of instances of the Buffer. This will be covered in detail in a later section of the manual. Inputs must be integer numbers.
Capacity	The maximum number of parts that can be stored in the buffer at any point in time.
Input Option	The position at which a part is placed in the Buffer when it enters. E.g. at the front or the back of the queue. This allows the representation of logic such as First in First Out (FIFO) or Last in First Out (LIFO).
Delays Option	Allows the addition of specific waiting options. For instance a minimum time that a Part must stay in the Buffer which could be used to represent a curing cycle. This will be covered later in the Manual.
Output Option	This changes the way in which a Part is selected for removal from the Buffer by other Elements. By default this is set to 'First' meaning that the first available part is selected.
Search from	Changes where the search for a Part is started, the front of the Buffer or the rear.

Basic Input and Output Rules

Once the Elements have been placed in the model, use **Input and Output Rules** to define the movement of Parts (Entities) between Elements. Input (**From** button) and output rules (**To** button) are used to route Parts through the Elements in the WITNESS model. These rules can be accessed from the Detail dialogue boxes of Elements by clicking on the 'To' or 'From' buttons on the general tab (if there are present on that element).



The default rule for either input or output is Wait, this means that the Machine will not actively route the Part only wait for the Part to be 'Pushed' to it or 'Pulled' from it.

The routing rules may be typed in to the Input or Output rules of the Element directly or the Visual Input and Output (or Quick Routing) buttons may be used to speed this process.

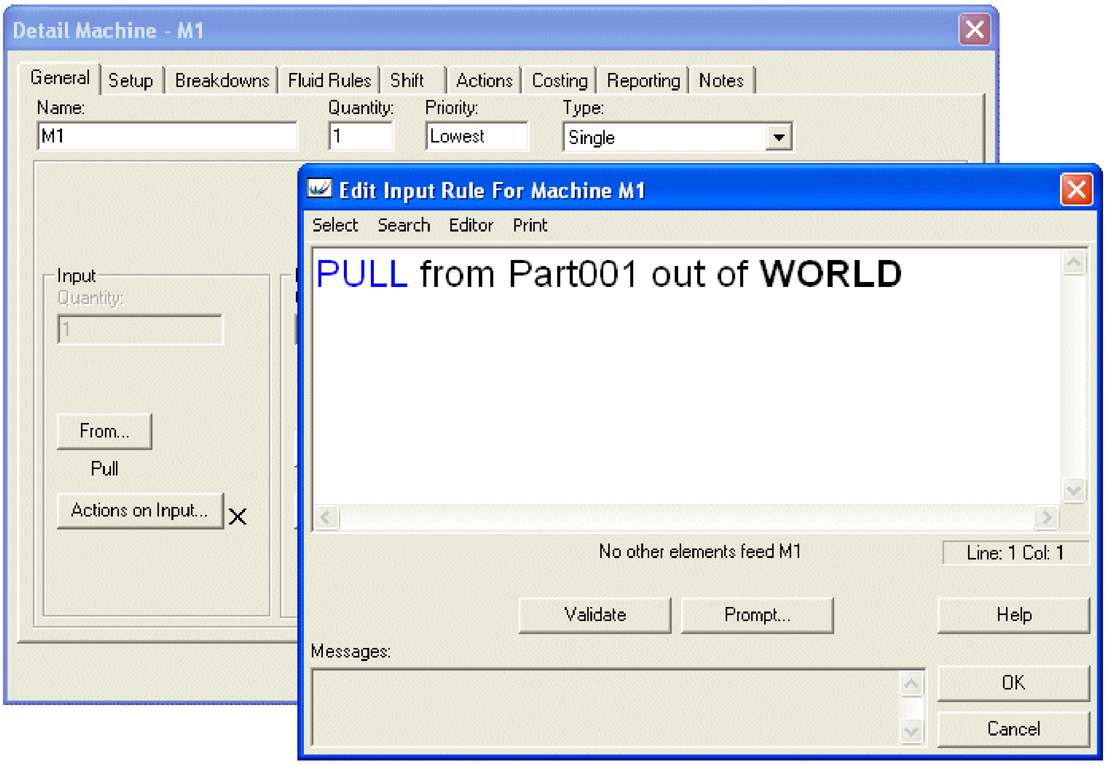
The primary input rule (**From** button) that is used is 'PULL' a Part from another element is ***PULL***, this takes (pulls) a Part from the specified Element when it is available and places it in the Element where the Rule is entered. The syntax used is;

Pull from 'Element Name'

Where Element Name is the name of a witness Machine or Buffer

A special case exists for passive Parts (those without arrivals set) using similar syntax:

Pull from 'Part Name' Out of World



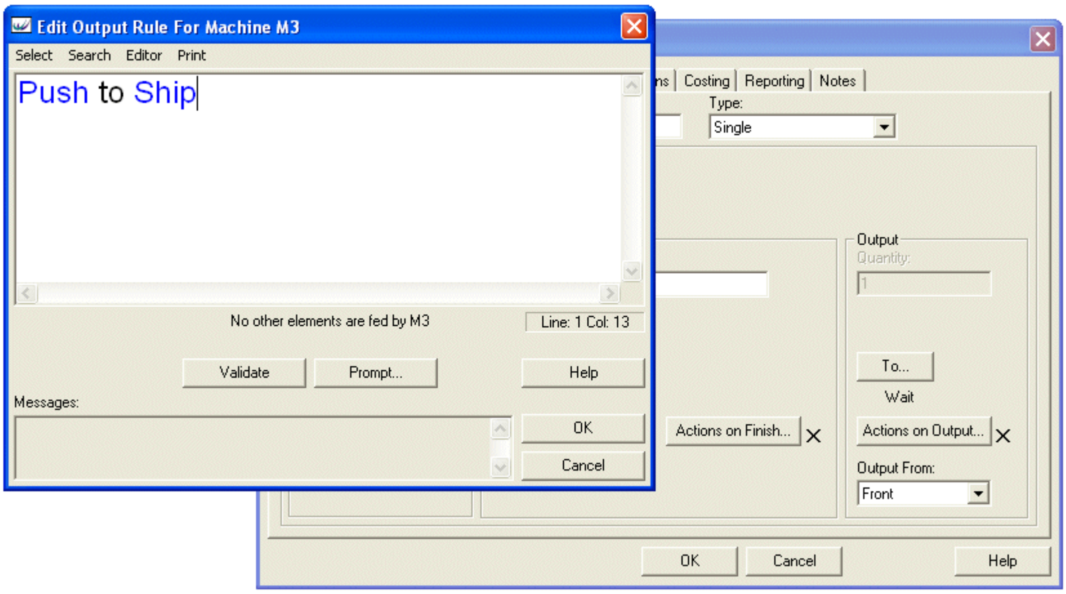
The primary output rule (**To** button) used is 'PUSH' Parts to another element is ***PUSH***, this sends Parts to the specified Element when the current element has processed it. The syntax used is;

Push To 'Element Name'

Where Element Name is the name of a witness Machine or Buffer

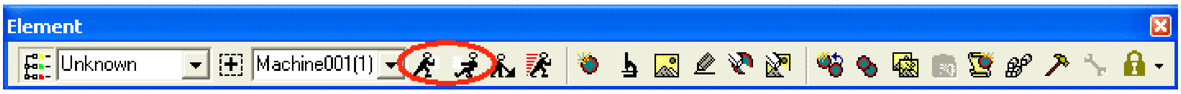
The final Element in the model (i.e. the Element that would export, ship or complete the processing of the Part requires a special destination in the place of 'Element Name', this is '***SHIP***'

Push to SHIP

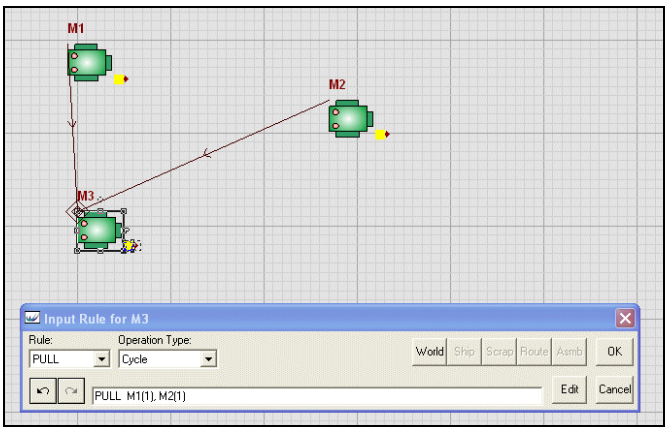


Visual Input and Output Rules

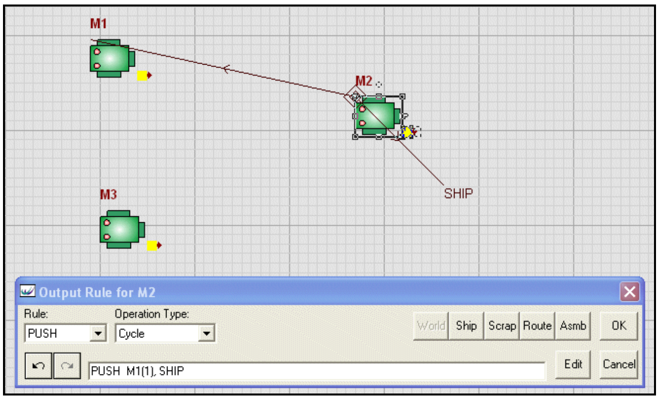
To allow the basic rules to be entered quickly, WITNESS uses Visual Rule buttons. The rules are selected by clicking on buttons on the Element Toolbar (shown below).



The Visual Input Rule button (the 'man' pulling icon) opens a dialog which allows the input rule to be built by selecting elements on a simulation view. Clicking on the Element will enter the Element name in the rule. The 'World' button must to be clicked to take a passive Part from the World (the Part name must be clicked first).

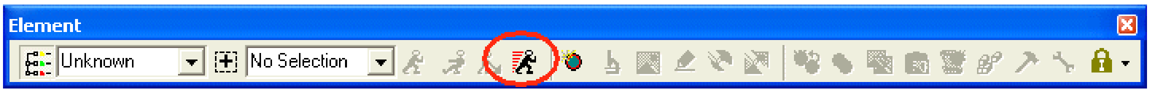


The Visual Output Rule button (the 'man' Pushing icon) opens a dialog which allows the output rule to be built by selecting elements on a simulation view. Clicking on the Element will enter the Element name into the rule. The SHIP destination has a dedicated button, to be clicked when you wish to send Parts to Ship.



Quick Rules

Quick rule mode is designed to allow you to easily create flow rules for an element. To enter quick rule mode, Click on the 'Quick Rule Mode' toolbar button.



Note: If your toolbars do not contain this button then you will need to configure your toolbars to add the button.

This then enables extremely quick and easy definitions of simple model rules for part flow. Once the mode is selected then the definition of a rule is completed in two mouse clicks, one where parts should flow from and one where parts should flow to. The rule defined will depend on the elements selected. When elements are selected the existing rules are shown where applicable and the new rules are shown when created – until the next element is clicked. The quick rule model is turned off by pressing the toolbar button again.

Element From	Element To	Rule
Part, Machine, Conveyor, Track, Section, Station	Any Valid Element	PUSH
Buffer	Any Valid Element	PULL from Element

Where a PUSH or PULL rule is already defined to or from an element the rule will be amended automatically. The rules for this are as follows:

1. Where a single PUSH destination was already in force the rule will be changed to PERCENT with equal chance of each route.

2. Where any other output rules were already in force (including multiple PUSH A,B) then the new destination will be tagged on to the end of the rule

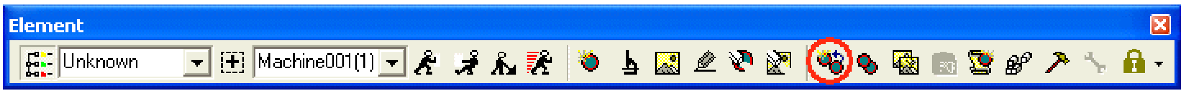
3. Where a PULL rule was already in force the new source will be tagged on to the end of the rule.

Useful Shortcuts for Modeling

In this section of the manual a number of shortcuts will be introduced to allow the user to develop models more efficiently.

Cloning of Elements

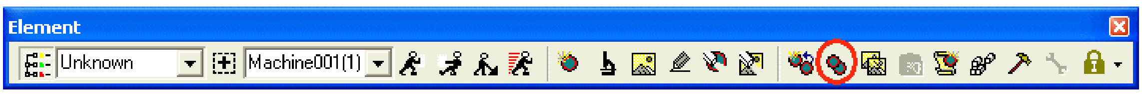
Cloning an Element creates an exact replica of that element (same Element Detail and Display), with the exception of the name (which must be unique for all Elements in WITNESS). A button has been provided on the Element Toolbar in WITNESS to perform the clone function.



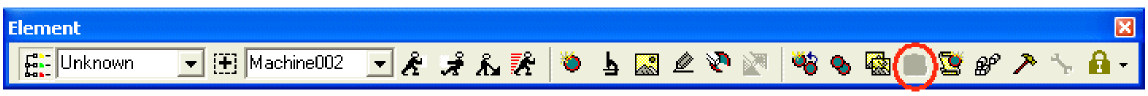
Select the Element that is to be cloned, by clicking on the Element either on a simulation view or the Element Selector and click the Clone button (as shown below). If the Element selected has a display on a simulation view, the cursor will be changed to a cross hair. Click on a simulation view in the position that the Element is to be placed (element has been created and will have a default name the same as the previous with either an 01 on the end or where the element name ended in a number a number incremented by 1).

Copying Element Details

When building a model there are situations that require multiple Elements to be created with the same details, Such as a factory with a number of stores the same size at different points in the Factory. Copying the Detail allows the Elements to be created and detailed without the need to enter each of the Elements in turn. A button has been provided on the Element Toolbar to perform the copy detail and paste detail functions.

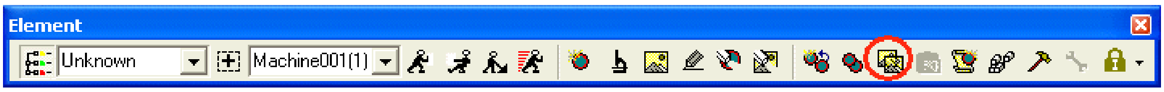


Select the Element that the details are to be copied from and click the Copy Detail button. Select the Element that the detail is to be copied to and click the Paste button (this button is used to paste either detail or display data depending upon the data type that has just been copied).

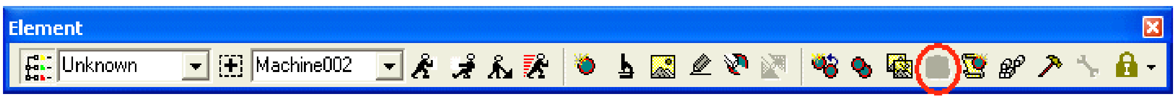


Copying Element Displays

When building a model there are situations that require multiple Elements to be displayed with the same display items and formats, Such all buffers or specific machine types in a factory. Copying the display allows the Elements display to be changed without the need to enter each of the Elements display dialogues in turn. A button has been provided on the Element Toolbar to perform the copy display and paste display functions.



Select the Element that the display is to be copied from and click the Copy Display button. Select the Element that the display is to be copied to and click the Paste button (this button is used to paste either detail or display data depending upon the data type that has just been copied).

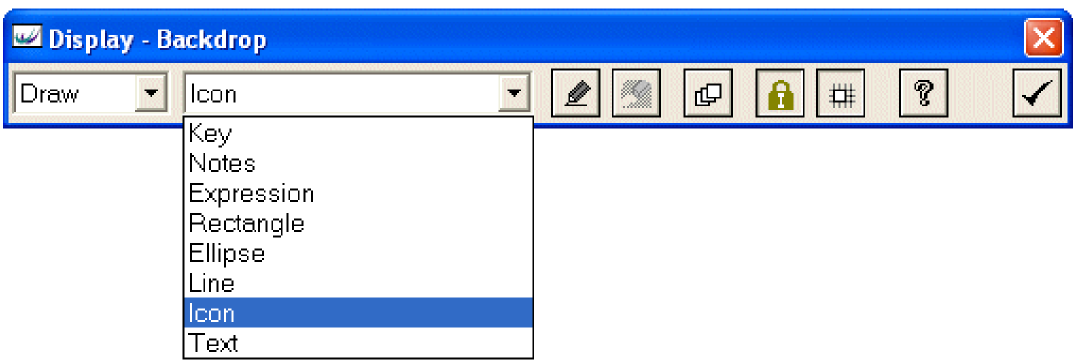


Graphical Editing - Screen Editor and Picture Gallery

WITNESS models can be very visual in nature, to aid in tailoring models to represent the many varied modeling applications a screen editor and picture gallery have been provided. These allow the addition of logo's, layout drawings, pictures, and the import of icons for elements.

Screen Editor

The Screen Editor enables the simulation views to be customised to enhance the visual nature of a witness model. The Screen Editor is accessed via the **View | Screen Editor..** menu, which will show the display toolbar for the backdrop (i.e. not connected to any element in the model).

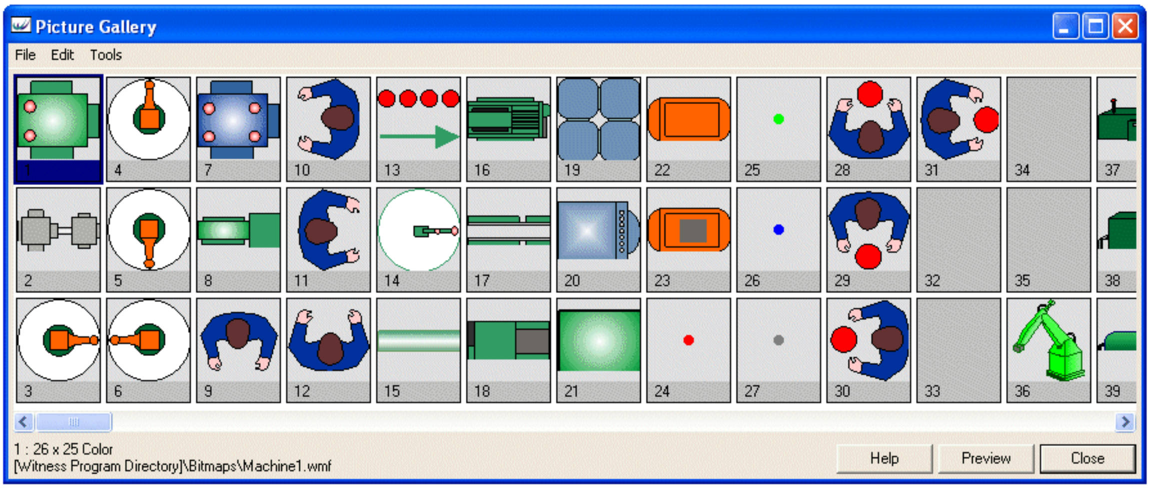


This then works in the same way as when displaying any of the display items for an Element.

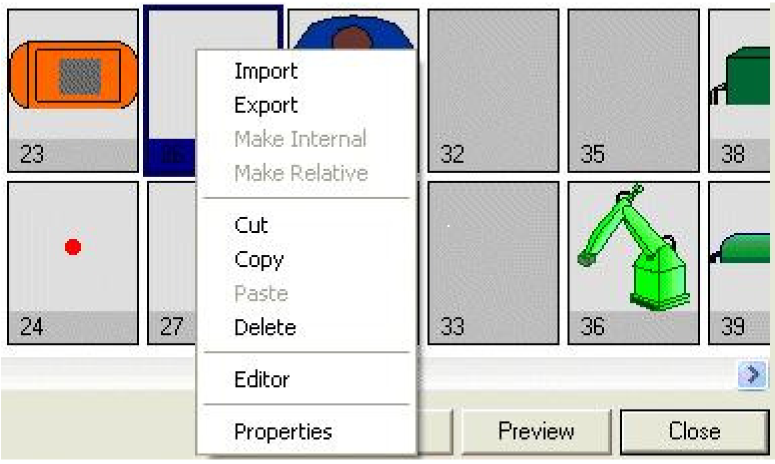
Backdrop Display Item	Description
Key	A key showing the status colors and descriptions for a selected element (selected in the draw dialogue).
Notes	Displays the Notes entered via **Model | Title** notes tab.
Expression	Any WITNESS function or a calculation
Rectangle	A box
Ellipse	A circle/ellipse
Line	A line
Icon	An icon, this can be a 'picture' or a monochrome icon which will show the changes of machine state by changing colors.
Text	Descriptive text
Simulation items	A multiple selection of all of the simulation items (e.g. name, icon etc.)

Picture Gallery

The Picture Gallery contains all the icons that can be used in a WITNESS model, and allows the user to import and create new icons and edit existing WITNESS icons. The Picture Gallery is accessed via the **View | Picture Gallery** menu.



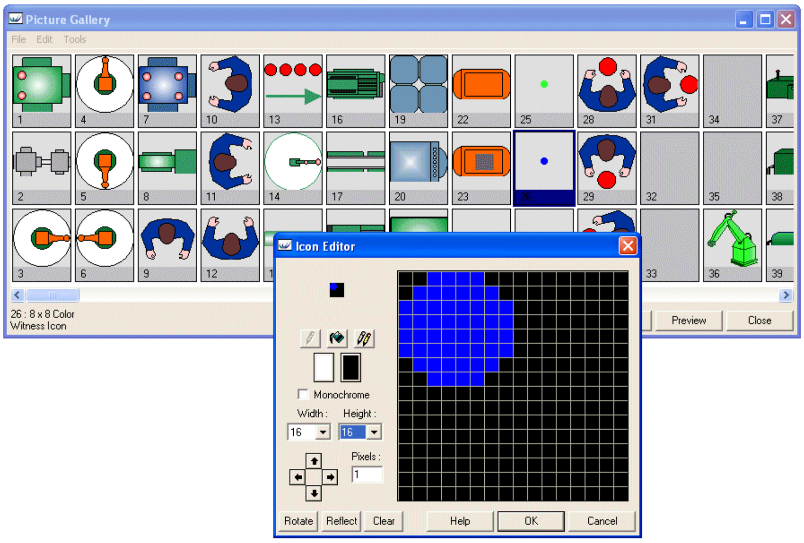
Right clicking on any of the pictures will bring up a menu of options.



Menu Option	Description
Import	Allows the User to import an Icon from an external file format. Acceptable file formats are; .bmp, .gif, .jpg, .dxf, .emf, .wmf. The most flexible file type is .wmf as this is fully scalable once inside WITNESS. This will creates a link to the file, which if the file is moved the link will be lost.
Export	Allows the export of an icon from witness to specified formats. This is generally to a .bmp file format.
Make Internal	This takes a linked file that has been imported and incorporates it into the WITNESS model, this allows the model to be distributed without having to send the linked files.
Make Relative	This makes the link to the file relative to the model directory.
Cut	As with standard windows applications
Copy	As with standard windows applications
Paste	As with standard windows applications
Delete	Deletes the icon.
Editor	Opens the Icon Editor which allows the creation of simple icons.
Properties	Shows the 'properties' of the icon. i.e. the background color, filename, etc.

Icon Editor

The Icon Editor is accessed by right clicking on an 'empty' icon and selecting the editor menu item. The screen below is then shown.



The Icon size is changed by altering the width and height. The pen color is changed by clicking on one of the two palette selectors, with the left of the two determining the left mouse button click color and the right selecting the right mouse button click color.

Clicking on one of the squares will change the color of the square, multiple squares can be 'colored' by selecting the 'paint fill' tool (the button with a paint can on it).

The Labor Element

Labor is a resource that may need to be present for an operation or task to take place. For example, operators, inspectors, tools, and fixtures may all be represented by Labor. Labor resource may be used for cycling (e.g. operating), repairing or setting-up a Machine or Activity and for repairing a Conveyor.

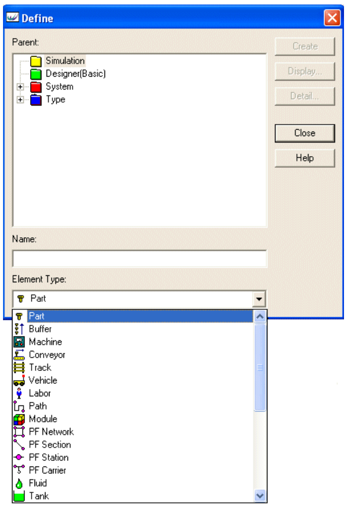
Defining, Displaying and Allocating Labor

Labor is a discrete element that represents a resource (for example, tools or human operators), which may be required by other elements for processing, setting up, repair or cleaning. You can model different skill levels for the same Labor unit by assigning attributes to specific Labor instances.

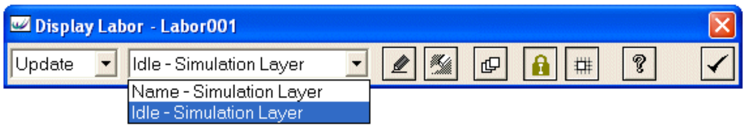
Defining, Displaying and Detailing Labor

Defining a Labor is done using the same method as defining a Part, Machine or Buffer, as shown in the previous sections. The creation of Labor from Designer Element is identical, except for the selection of the Labor Designer Element.

Defining Labor through the Define Dialogue requires the selection of Labor in the Element Type Drop down list (shown below).



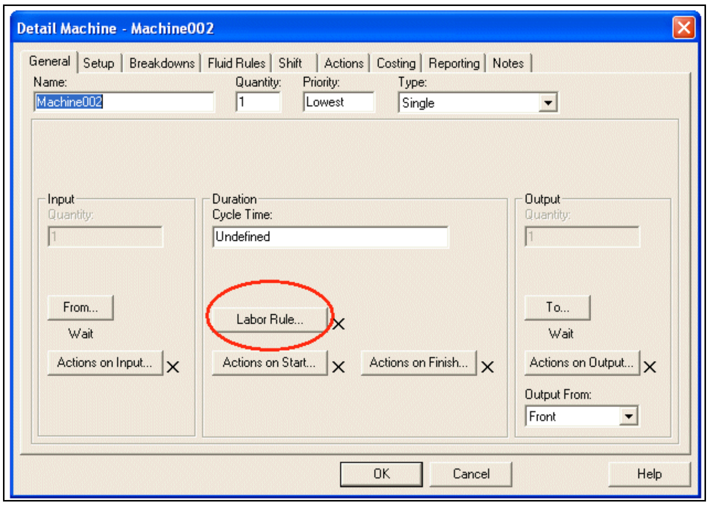
The Labor display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.



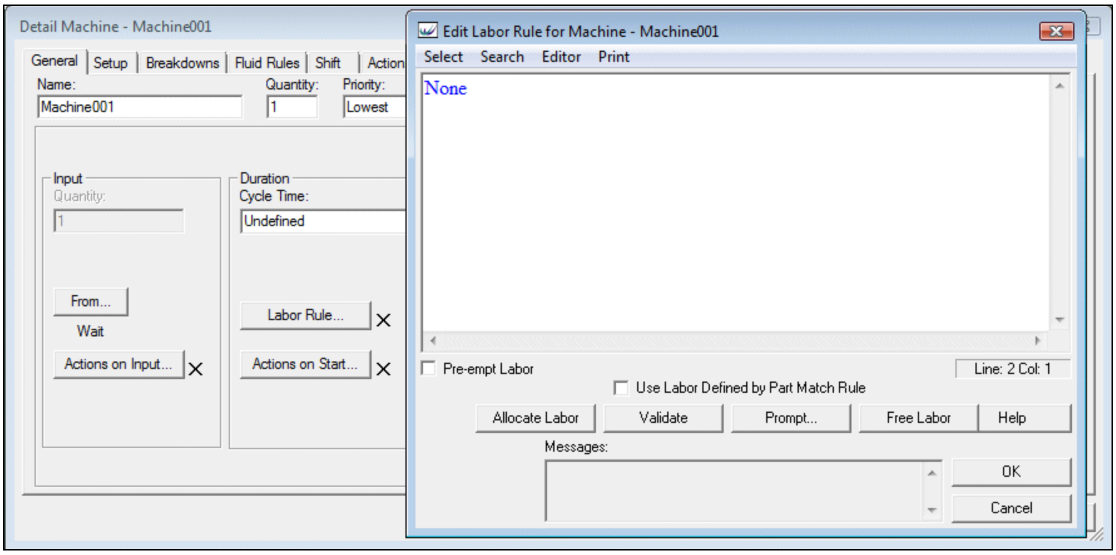
Labor Display Item		**Description**
Name		Name of the selected Element
Style	*	The Style of the Labor display that moves on screen throughout the model run.

Allocating Labor

Labor is allocated via the ***Labor Rule*** buttons which can be found in the detail dialogues of Machines (and the breakdowns and setups on any other Element – covered later in this manual).



Labor is allocated by entering the name of the labor required in the labor rule, with None being the default (meaning no labor is required). Clicking on the labor rule button in a machine will open the dialogue box shown below.

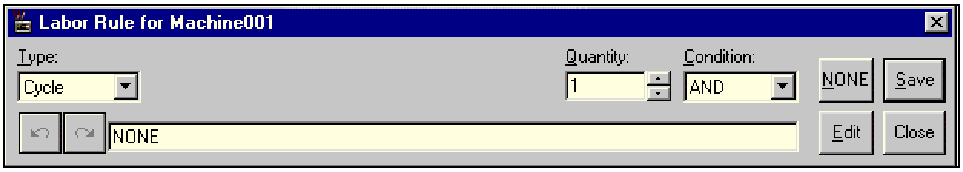


Examples of the sort of rules you may use include:

OPERATOR	1 operator required
OPERATOR#2	2 operators of the same type required (multiple quantities of elements will be covered later in the manual)
JANE AND WENDY	Both labor units are required
FRED OR JOE	1 of the 2 labor units is required

Visual Labor Rules

You can enter a simple labor rule by using the visual labor rules dialog. If the rule is longer than one line, click on the appropriate labor rule button on the element's detail dialog and use the rule editor to enter the rule.



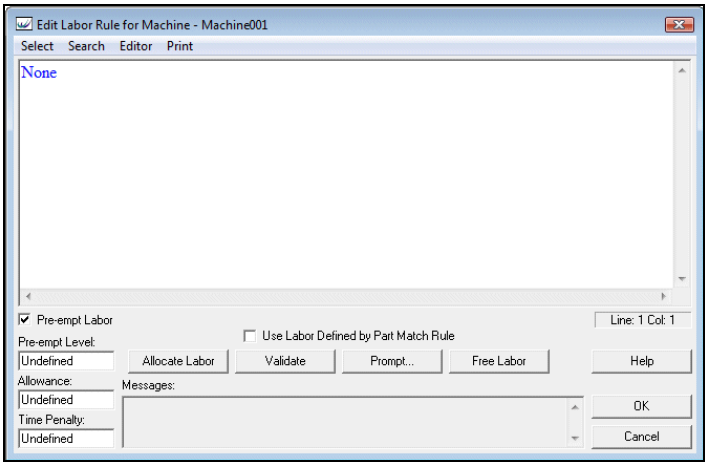
Operation type: If you can set a rule for more than one type of operation for the selected element, select the operation that the rule applies to from the drop list. For example, if you are creating a labor rule for a machine repair, you can choose whether to create a repair labor rule or an unload rule.

Click on the close button to close the dialog. Make sure that you have saved any changes by clicking on the save button first.

Note: when you close the visual rules dialog, the flow lines disappear from the modeling window. However, you can display them again at any time by selecting the view/element flow command. You can examine or edit the rule at any time by clicking on the appropriate rule button on the element's detail dialog.

Pre-emption

Normally, the Labor Resource will remain with an Element until the process is completed. However, it is possible to **pre-empt** the Labor resource from its current task in order to perform more critical operations. The labor resource will leave the job it is currently working on, before that job is complete, in order to work on a more important job.



A Pre-empt level can be set that specifies the difference in priority required (between the task the Labor Resource is currently carrying out and the task that is being Pre-empted to) to enable Pre-emption to occur. A sufficient difference in priority must exist for Pre-emption to take place. Look at the following formula, which determines if Pre-emption is to take place.

$$\textbf{Priority of Element which currently has the Labor} - \textbf{Priority of Element which requires the Labor} \geq \textbf{Pre-empt level of Element that requires the Labor}$$

It is also possible to specify an allowance to finish. If there is less than a specified amount of time before the completion of the current operation, the Labor will not be moved, but it will complete its current task.

In addition, if the Labor resource is pre-empted, it is possible to specify a penalty time. This time represents the fact that when the Labor returns to a job from which it was pre-empted, it may not be able to continue the job and complete it as if the job had not been interrupted. A penalty time may then be entered and this penalty time is incurred when Labor returns to the interrupted task. The penalty time is added to the time remaining on the interrupted task.

The Conveyor Element

Conveyors move Parts (Entities) across a facility, generally from one fixed point to another. Parts (Entities) enter a conveyor at the rear and move towards the front. You can identify parts at each position on the conveyor and load or unload the part at a particular position.

Examples of Conveyors are:

- A belt transporting luggage in an airport.
- A conveyor moving truck bodies along a production line.
- A roller conveyor moving empty cartons to a packing operation.

In WITNESS Four types of conveyor are available. These are

- Continuous fixed
- Continuous queuing
- Indexed fixed
- Indexed queuing

Fixed
The conveyor maintains a constant distance between parts. If the conveyor stops, the distance between the parts on the conveyor remains the same. When a part reaches the front of a fixed conveyor and it is unable to move off, the entire conveyor will stop moving until the part at front can move off.

Queuing
The conveyor allows parts to accumulate. If the conveyor becomes blocked, the parts will slide together until the conveyor is full.

Indexed Conveyors
Both types of indexed conveyors can be considered as number of positions, slots, or buckets, that each can contain one part regardless of its size. Parts are normally added at the last, or rear, position of the conveyor and move up one position after a specified index time until they reach the first or front position where they are normally removed.

In the case of queuing conveyors, the slots (or buckets) slide together when the front of the conveyor stops. The parts are considered to move in Steps along the conveyor, each step being simulated at the index time of the conveyor.

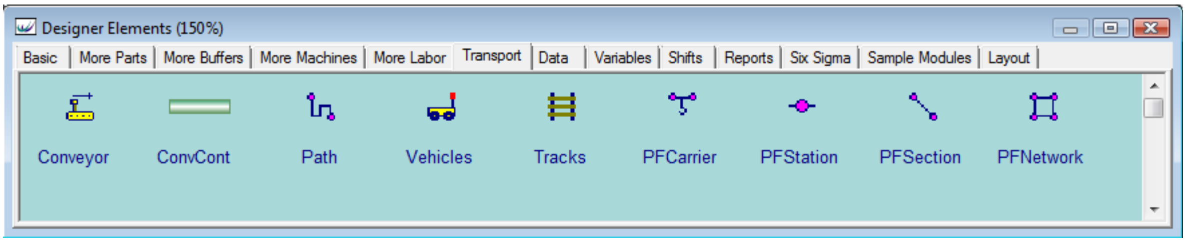
Continuous conveyors
For both types of continuous conveyor, parts move along the length of the conveyor from its rear to its front at a specified speed. Unlike the Indexed conveyors, the position of the parts on the conveyor is modelled in detail. When using continuous conveyors the physical size of the parts is taken into account. Specifically designed for multi-length part modeling the Continuous conveyors are available in both fixed and

queuing forms. Each is defined by length and speed, in the units you choose, with extra control for different spacing options.

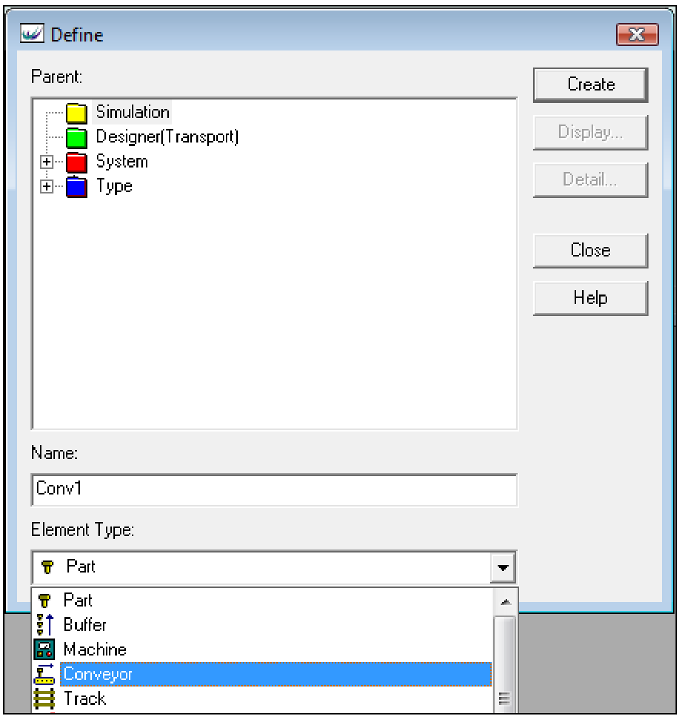
For models where the part size does not vary then either can be used. For the optimal model run speed, for typical models, the standard indexed conveyors are slightly quicker.

Defining a Conveyor

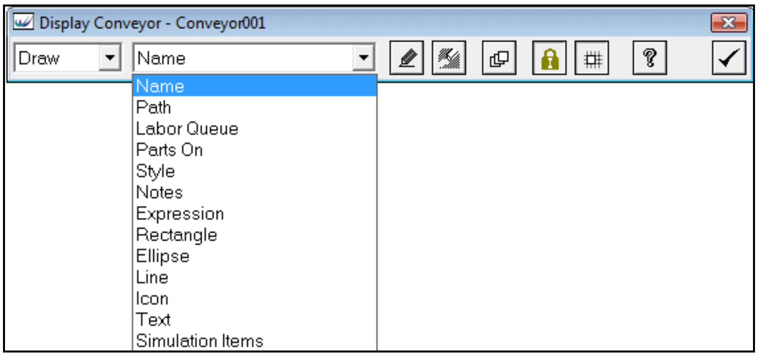
All Conveyors, irrespective of type, are defined in the same way, which is similar to the process for defining the other elements covered so far in this reference manual. Firstly select the Transport Tab on the Designer Elements, click on the conveyor icon and then click on screen in the position required.



Defining all Conveyor types through the Define Dialogue requires the selection of the Conveyor option in the Element Type Drop down list (shown below).



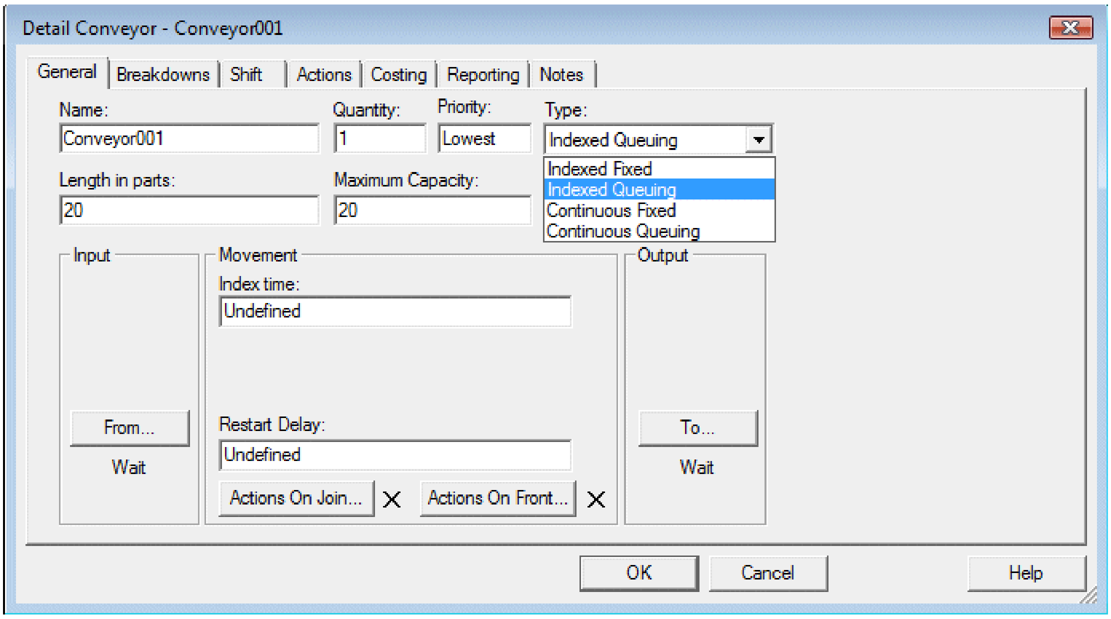
The Conveyor display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.



Conveyor Display Item		**Description**
Name	*	Name of the selected Element
Path	*	The display of the element showing parts moving along a line.
Parts On		The Display of the Parts on the conveyor in the order they were put on to it.
Style		The representation of the background of the conveyor
Notes	*	Notes entered on the detail form
Expression	*	Any WITNESS function or a calculation
Rectangle	*	A box
Ellipse	*	A circle/ellipse
Line	*	A line
Icon	*	An icon, this can be a ‘picture’ or a monochrome icon which will show the changes of machine state by changing colors.
Text	*	Descriptive text
Simulation items		A multiple selection of all of the simulation items (e.g. name, icon etc.)

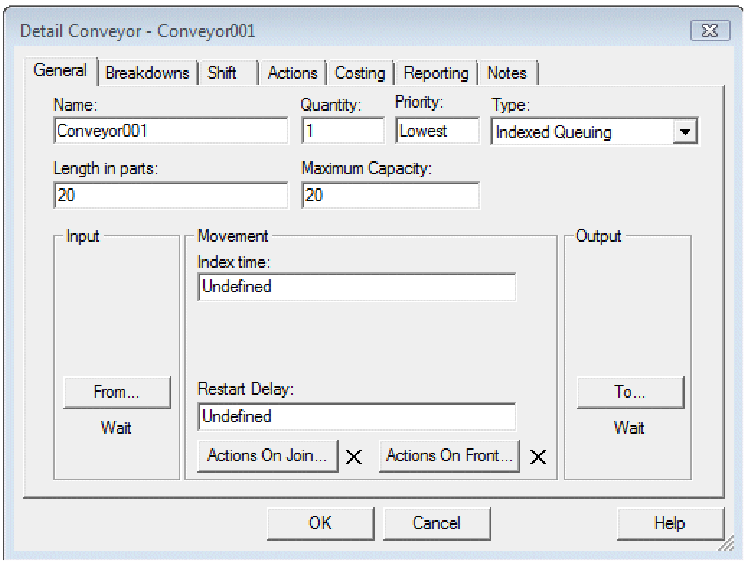
Selecting a Conveyor Type

The selection of a conveyor type is done in the Conveyors Detail Dialog box by selecting the required type from the drop down menu on the top right hand side.



Detailing an Indexed Conveyor

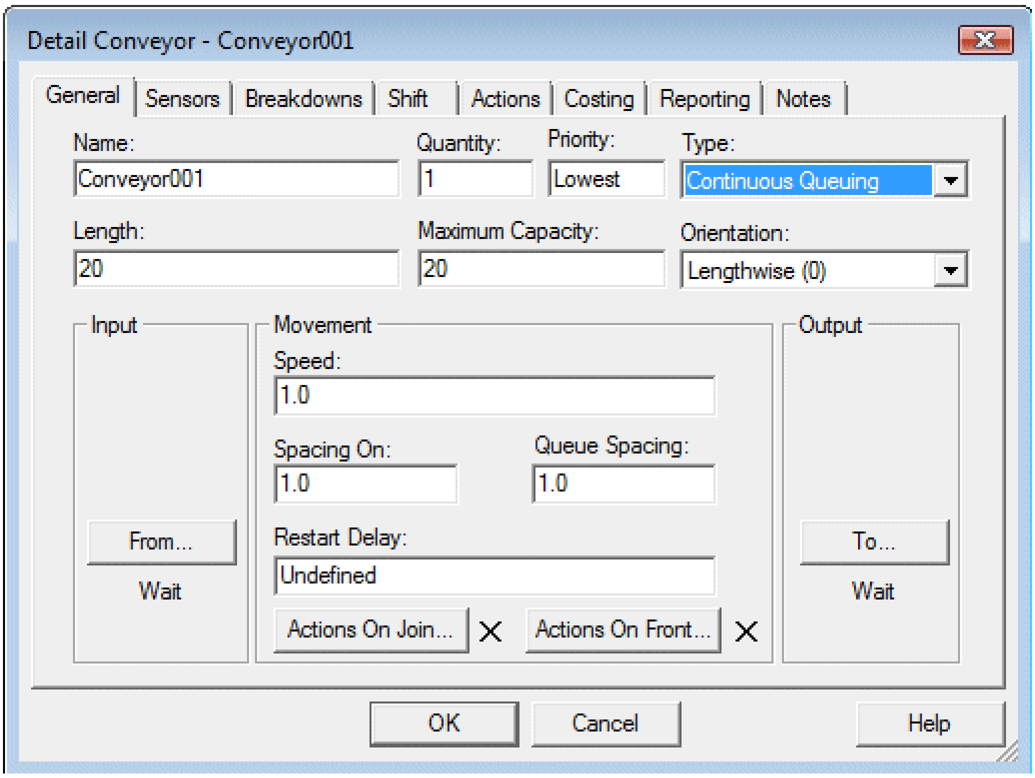
Both types of Indexed conveyor have the same inputs.



Field Name	Description
Name	Element Name
Length in Parts (Entities)	The number of Part (Entity) positions on the Conveyor is used to define the length of the conveyor. If the Conveyor is 30 meters long, and a Part (Entity) is 0.5 meters long, there is a maximum of 60 positions for the Parts (Entities).
Max. Capacity	May be less than the Part (Entity) length due to operating constraints e.g. weight restrictions.
Index Time	This is the time required to index or move one position on the Conveyor.
Restart Delay	Time that a conveyor motor takes to get up to speed if the conveyor has stopped because its destination was not free (that is, the conveyor has become blocked)

Detailing a Continuous Conveyor

Both types of Indexed conveyor have the same input fields but Queuing conveyors have an additional input of Queue spacing.



Field	Description
Conveyor Length	The length of the conveyor in the units chosen for modeling. These must be in the same units as the Speed definition to be used below. Unlike Indexed conveyors this does NOT specify how many parts will fit on the conveyor. It does however allow you to limit how many parts will be allowed on the conveyor at any one time. The number of parts which will fit on a WITNESS continuous conveyor depends on the length of the conveyor and the size of the parts (see below).
Maximum Capacity	Parts may queue either length-wise or width-wise on a continuous conveyor.
Orientation	The setting determines whether the length or width of a part is used to calculate the space it takes up on the conveyor.
Movement Speed	The speed of the conveyor in units of distance per time unit. The time unit is the base simulation time unit choice (default minutes). The distance units must match up with the units chosen for the conveyor length.
Movement Spacing On	The distance between parts when placed on the conveyor. (again these units must match those used for conveyor length)
Movement Queue Spacing	The distance between parts on a queuing conveyor (not a fixed conveyor) when the conveyor is blocked or slowed by a subsequent element. This distance is not allowed to be greater than the 'Spacing On' distance. The distance specified here is maintained after any block – i.e. the spacing on is not regained.

There are 3 new real system attributes for parts defined in WITNESS 2008.

- LENGTH
- WIDTH
- HEIGHT

Each of these attributes is set to 1 by default. To assign a different value use a simple = assignment in any actions code.

Example:

- LENGTH=2.4 sets the part length to 2.4
- 10 parts will now fit on a continuous conveyor of length 24

Conveyor Logic

The new continuous conveyors are linked to in the same way as the standard indexed conveyors. They have input and output rules and may be pushed to and pulled from other elements.

When a part is placed at the end of a continuous conveyor its front edge is at the rearmost point on the conveyor. The front edge travels along the conveyor until it reaches the head of the conveyor. The traverse time is determined by the speed of the conveyor.

If a part is transferred to another continuous conveyor the front edge is modelled at the end of the next conveyor and the remainder of the part (in length or width) blocks backwards along the conveyor from which it came.

If a part is transferred to a different WITNESS element (e.g. a machine) then it instantaneously moves clear of the conveyor so does NOT block back down the conveyor. The next part can therefore continue to the head of the conveyor.

Continuous conveyors may be fed at points other than the rear of the conveyor. However this is defined in a different way to the rules used for indexed conveyors. A continuous conveyor may only be fed at the rear or at a sensor (see below).

Sensors for Continuous Conveyors

Continuous conveyors have a new tab on the detail dialog that allows the definition of sensors. These can be placed at any position on the new conveyors and trigger events in order to model all manner of control. They also define access points where other elements can pull or push parts.

Sensors are placed at distances from the head of the conveyor. The distance used must match the units used for the length of the conveyor. (It is possible to defined the position based on the distance from the rear of the conveyor by using a negative number – e.g. for a conveyor of length 60 units positions of 18 and -42 are equivalent).

Each sensor has 4 actions code options.

- Parts On Called whenever a part front edge passes the sensor
- Part Off Called whenever a part rear edge passes the sensor
- CoverCalled whenever the sensor changes from uncovered to covered
- Uncover Called whenever the sensor changes from to covered to uncovered

Routing to Sensor Positions

The syntax for routing to a continuous conveyor at a sensor point is as in the following example:

PUSH to Conveyor001 at (2)

This rule will push a part to conveyor001 at the point defined by the position of Sensor number 2

(Note that this is the same syntax as for indexed conveyors but it has a different meaning).

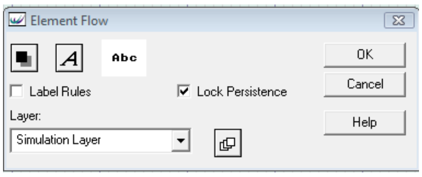
Displays for Sensors

A new display item on the display bar allows sensors to be drawn as descriptions or icons. The display of the sensor is shown in the centre of the conveyor at the appropriate point. Part displays appear over the sensor displays as the model runs.

Witness Utility Features

Witness has many features to aid in the development of models, below are some of the commonly used ones.

Element Flow – Accessed through View -> Element flow and then clicking the OK button on the Dialogue box shown below.



Lines will then be drawn on screen connecting all the elements in the WITNESS model that are linked by Push or Pull rules, enabling you to see where the flow of parts should go.

To remove the Element Flow lines uncheck the Element flow menu item View -> Element Flow.

Explode – the explode report allows users to see the parts that are currently in/on a machine, buffer, conveyor, etc. To view the Explode report the model must be stopped, elements that you wish to explode selected and right click on one of the selected elements, selecting the explode option.

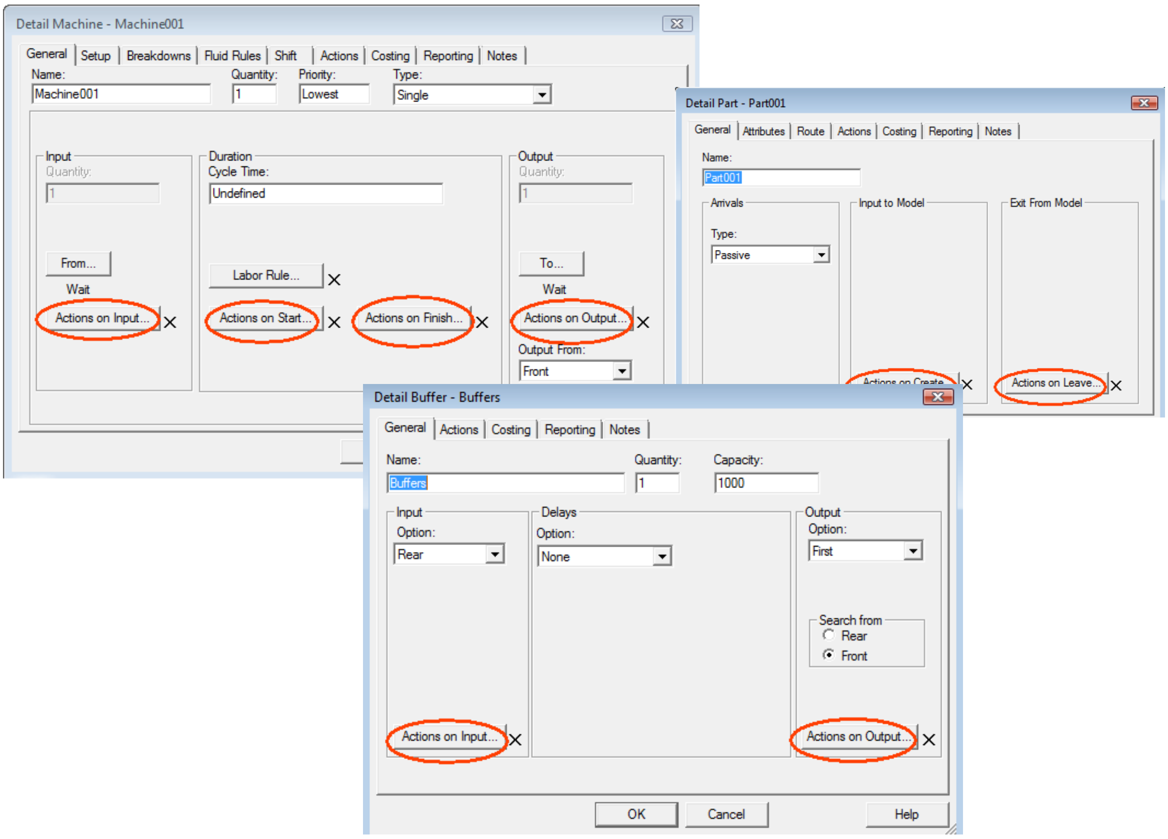
Used - The Used report shows all places in the model where the selected elements are referenced. To view the report right click on an element and select the Used option from the list.

Using Logical Elements

The use of actions and logical elements enables the modeling of more complex processes, this section of the manual explains how to use these logical elements.

Actions boxes

Actions Boxes are present in virtually all WITNESS elements, a selection are shown below.

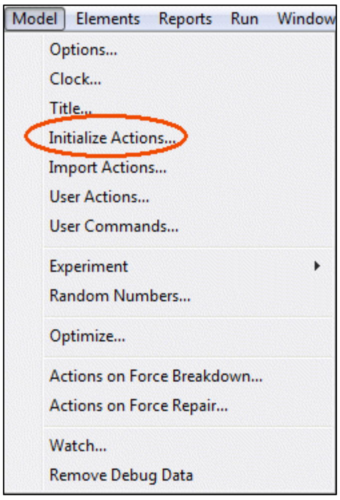


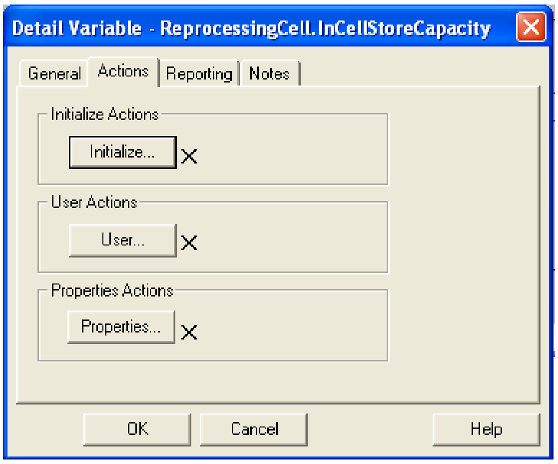
You will note that all the actions boxes have an Actions on …. title, such as Actions on Input or Actions on Create. The following table provides an explanation of what these mean.

Actions Box	Present in	Description
Actions On Input	Machine, Buffer	Executed when a part is input to the element. It is executed (run) for every Part that enters.
Actions On Start	Machine	Executed when a Machine element starts processing a part.
Actions On Finish	Machine	Executed when a Machine element finishes processing a part.
Actions On Output	Machine, Buffer	Executed when a part is output from the element. It is executed (run) for every Part that leaves.
Actions On Create	Part	Executed when a Part is created from the world, either by active arrivals or being pulled into the model (from the world) by another element.
Actions On Leave	Part	Executed when a Part Leaves the model. i.e. being pushed to Ship (or Scrap).

Initialize Actions

Initialize actions are executed when the model is started from TIME = 0.0. Initialize Actions occur on all elements as well as through the Model / Initialize Actions dialogue:





The Element initialize actions are accessed through the actions tab on the detail dialog of the element. Clicking on the initialize button will open an actions box.

Commenting Actions

Having written a complex set of Actions, it is sometimes easy to forget their purpose and meaning. It is therefore important to document your Actions - it will be very helpful. The "!" (Exclamation Mark) symbol may be used anywhere on a line to create a comment. The rest of the line (to the right of the exclamation point) may contain whatever text is desired. WITNESS will ignore the commented part of the line when the action(s) are executed.

Action editor options

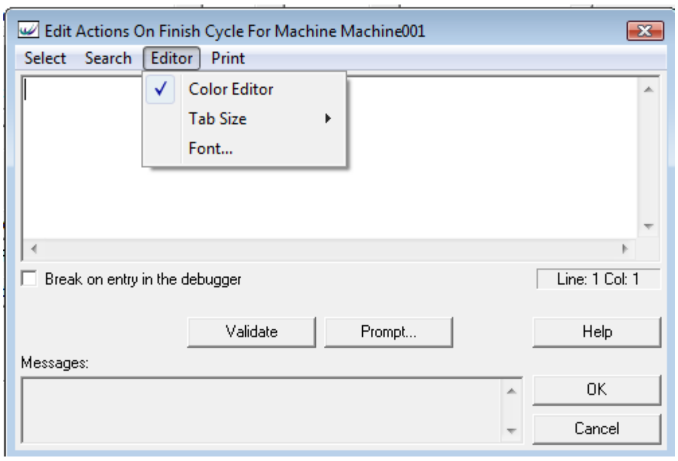
To make understanding the "code" in written in the actions boxes there are options which can be set by the User, these options are global settings for WITNESS.

In any Actions box selecting the editor menu item will bring up the options list.

Color Editor will show WITNESS functions / commands in blue, comments in green and any other text in standard text.

Tab Size indents the code where the Block IF (IF/ELSE/ENDIF) structure or looping constructs (FOR/NEXT, WHILE/ENDWHILE) are used.

Font allows the user to select the font used in the actions box.



Printing to Interact Box

A useful "construct" in WITNESS is the ability to Print data from points in the actions boxes to the interact box (a screen described briefly on page 17). Below are a number of typically used Print Statements.

Print "Actions Box Run"	Prints the text "Actions Box Run" in the interact box
Print "\f"	Clears the interact box
Print "Value of B is – ", VarB	Prints the 'text Value of B is – ' followed by the numerical value of VarB
Print NPARTS(OP10)	Prints the number of parts currently in OP10

Order of Execution

WITNESS follows a specific sequence of logic (an order of execution) whenever an event is processed. The actual sequence will depend upon the event itself.

Understanding these sequences will help you to interpret why a model is performing in a certain way, and also enable you to manipulate the logic sequence to some extent, below is the order of execution for a machine. Other elements order of execution can be found in the online help (search for order of execution).

Starting with the machine in an IDLE state.

1. Parts are obtained (if possible). As each part arrives at the machine, WITNESS executes the actions on input for that part.

2. If a setup is due, the machine sets up. WITNESS executes the machine's actions on start setup, evaluates the setup time, obtains any labor necessary for the setup and then executes the machine's actions on finish setup. Once the setup has finished, the machine enters the BUSY state, or the WAITING FOR LABOR TO CYCLE state if it requires labor to cycle.

3. The machine obtains any labor necessary for the cycle.

4. WITNESS executes the actions on start cycle for the first part in the machine only.

5. If the machine is filling a part with fluid, it enters the FILLING state. If it is emptying a part of fluid, it enters the EMPTYING state. Emptying takes precedence over filling.

6. WITNESS evaluates the machine's cycle time.

7. If a breakdown is due and breakdowns only occur at the start of a cycle, the machine breaks down and enters the BROKEN DOWN state.

8. The machine is repaired and enters the BEING REPAIRED state. Once it has been repaired, the machine is available to continue its cycle and enters the BUSY state. If the part at the machine was sent to SCRAP, the machine resumes at step 2. Otherwise, it resumes at step 4. Note that if breakdowns only occur at the start of a cycle, only one breakdown can take place per cycle.

9. The machine completes the cycle.

10. If the machine is filling a part with fluid, it enters the FILLING state. If it is emptying a part of fluid, it enters the EMPTYING state. Emptying takes precedence over filling.

11. WITNESS updates the machine’s operations completed statistics. For a multi-cycle machine, the count is only incremented when a full machine cycle has been completed.

12. WITNESS executes the machine’s actions on finish for the first part in the machine. On multi-station machines, this will be the first part in the last station. (If there are no parts in the last station, WITNESS does not execute the actions). The machine produces extra parts if required (for example, if it is a production machine).

13. Attribute values are transferred to the new parts (if required, and if it is possible to transfer them).

14. WITNESS executes the machine’s actions on finish for the remaining parts (if there are any). For a multi-station machine, these will be the parts remaining in the last station. (If there are no parts in the last station, WITNESS does not execute the actions).

15. Unless labor is required to remain at the machine for unloading, the machine relinquishes the labor. If labor is required for unloading, the machine relinquishes the labor when the last part has left the machine.

16. When a part leaves the machine, WITNESS executes the actions on output for that part.

17. If this is a multi-cycle machine, and this is not the last cycle, it resumes at step 2. Otherwise, it enters the IDLE state.

19. The machine enters the IDLE state.

WITNESS System Values

'System Values' allow information about the model to be obtained and used during the model run. The table below shows the most commonly used system attributes.

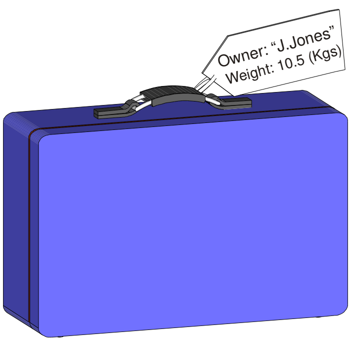
System Attribute	Used to
Time	Returns the current simulation time (i.e. the number of simulation time units since the model started).
Element	Returns the name of the Element that is currently 'executing' actions.

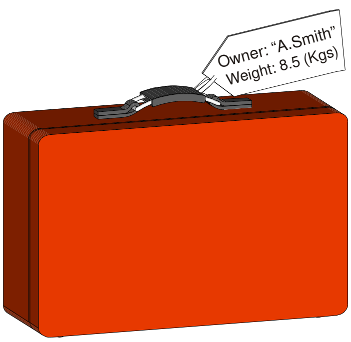
Attributes

An Attribute is a characteristic of a part or entity; e.g. color, size, cycle time duration, pass or reject, cost, value etc. There are 4 attribute data types that can be defined.

Type	*Can Store*	*Designer Element*
Integer	A whole number e.g. 1	Iattr
Real	Any decimal number e.g. 4.77	Rattr
String	A string value e.g. David	Sattr
Name	A WITNESS Element Name e.g. M1	Nattr

Each individual Part or Entity can have a number of characteristics (Attributes) associated with it and these can take different values at different times during the simulation. They are the 'real world' equivalent of the baggage label on a suitcase. For example, a Part could have a color Attribute with a value of 0 before it goes through a painting operation, but a value of 1 afterwards. The value of an attribute is specific to a part and the values for each of the attributes of a parts follow it around the model.





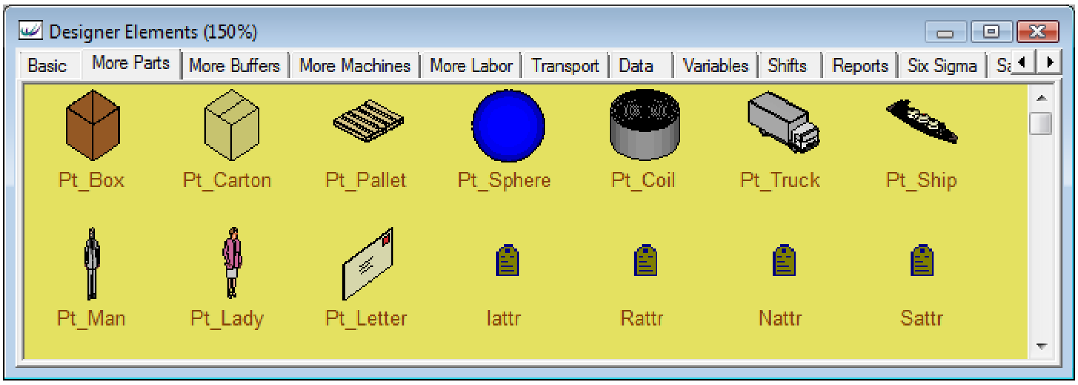
Attributes may be used almost anywhere in WITNESS e.g., Cycle Times, If Statements, Output Rules, Production Quantities etc. Their values may be set in Actions. The only restriction is that a part has to be present during access.

There are 3 steps to using Attributes in a WITNESS model:

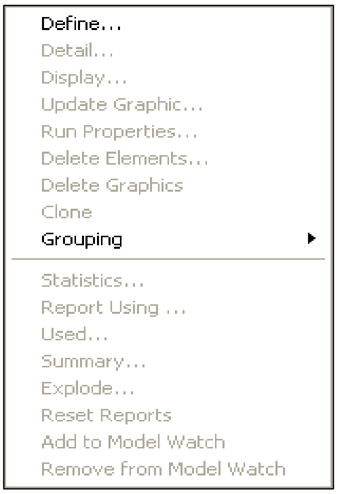
1. Define the Attribute in model;
   - Decide what your characteristic is (e.g. size, weight, value etc.)
   - Select the right Type (integer, real or name) for the characteristic.
   - Remember that the Quantity refers to the number of characteristics, NOT the number of possible values for that characteristic.
2. Set the value of the Attribute;
   - Choose the appropriate set of Actions (e.g. Actions on Create for a Part)
   - Enter action as follows: Attribute = Expression (e.g. SIZE = 3.5)
3. Use the Attribute;
   - Select the detail of the element which needs to read the Attribute.
   - Enter the name of the Attribute in the appropriate expression, rule or action (e.g. as part of a cycle time expression).

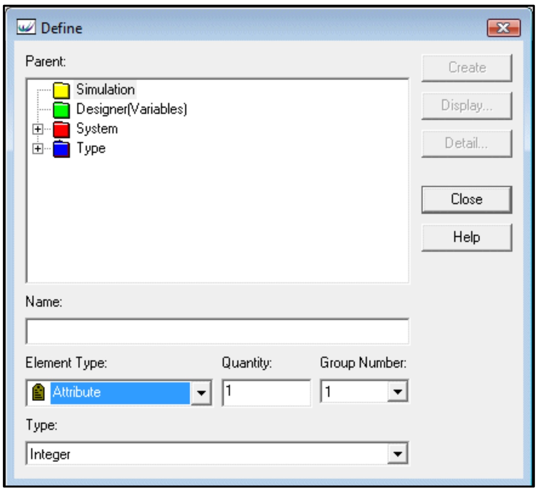
Defining an Attribute

Attributes are defined in the same way as the other elements that we have covered so far, except the designer elements are located on a different tab. To define an attribute from the Designer Elements, select the More Parts tab and then pick the designer element of the appropriate attribute type (integer, real, name or string).



To define an attribute using the Define Dialogue Box is very similar to the other elements covered previously. Right clicking either on a Simulation View or Element Selector will cause a menu to be displayed (shown below).

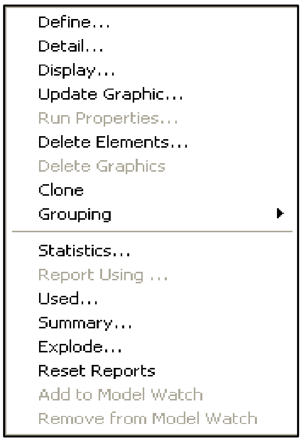


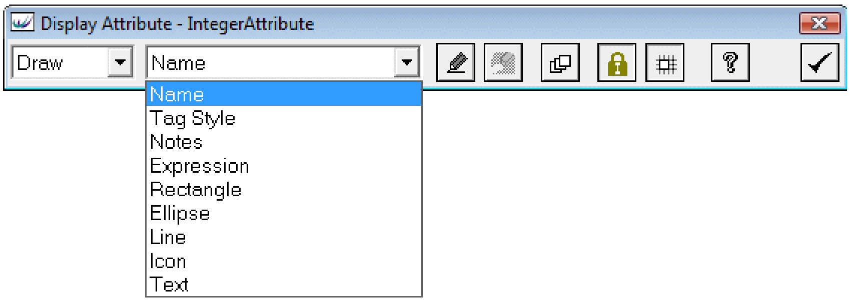


Select Element / Define from the top level toolbar. This will open the Define dialogue box where the element type (attribute) can be selected on the drop down menu. Another drop down menu is then shown to allow the definition of the attribute type i.e. Integer, Real, String or Name. By typing the required name and clicking Create, an attribute will be created and seen in the element selector tree.

Displaying an Attribute

The Display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.





Although it is possible to display an attribute it does not add a great deal of value to the display of the model. As was the case with other elements Attributes may also have numerous display 'items' on screen to convey information about it, many of the items may be displayed more than once (Marked with a * in the table below). The available display items for Attributes are shown in the table below.

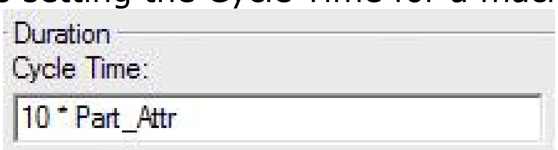
Attribute Display Item		Description
Name	*	Name of the selected Element
Tag Style		The style of the 'tag' to be displayed next to the part (this will be covered later in the manual).
Notes	*	Notes entered on the detail form
Expression	*	Any WITNESS function or a calculation
Rectangle	*	A box
Ellipse	*	A circle/ellipse
Line	*	A line
Icon	*	An icon, this can be a 'picture' or a monochrome icon which will show the changes of machine state by changing colors.
Text	*	Descriptive text

Assigning Values to Attributes

An Attribute value is uniquely assigned to an individual part. This means that different parts of the same type can have different values e.g. the time at which the part entered a machine. A value can only be applied to an existing part e.g. the time at which the part arrives in a machine can be set in Actions on Input which is executed as the part arrives at a machine.

Using Attributes to Control the model

Attributes can be set or changed in all Actions Boxes and can be used in expressions such as setting the Cycle Time for a machine.



Care must be exercised if using Attributes in Input rules since WITNESS may attempt to examine them when no part is present, in which case an error message will result.

Remotely Accessing Attributes

To inspect or change an attribute on a part elsewhere in the model use the following syntax:

Element {*AT position*} : attributename = *Value*

If there is a risk that a part will not be at the stipulated locations a check should first be carried out:

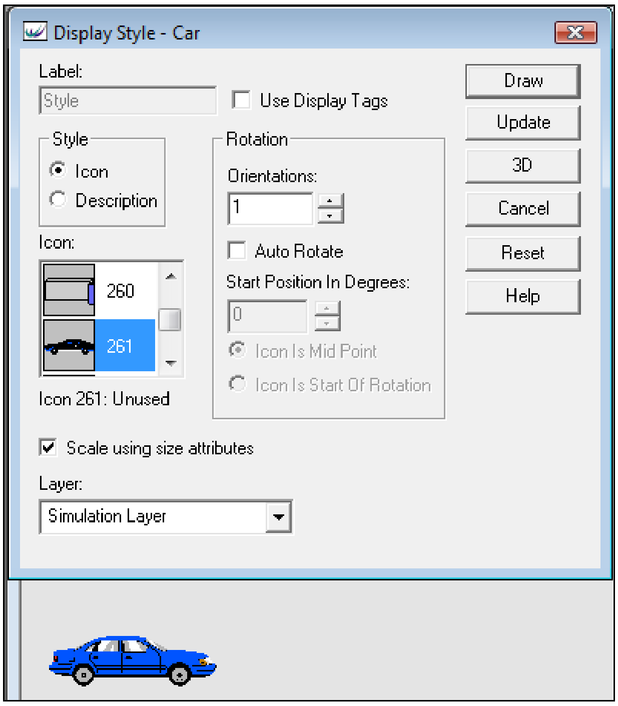
IF NPARTS(Element {*AT position*})>0

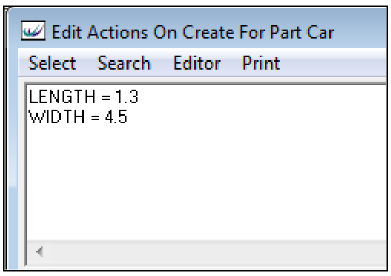
Pre-defined Attributes

WITNESS includes several pre-defined System Attributes:

Name	Description and Use
TYPE	The name of the Part or Entity.
ICON	Where a Part or Entity is to be displayed as an icon, set this to the number of the icon required.
DESC	A four character description for the Part or Entity.
PEN	The color in which the Part or Entity is displayed on the screen.
LENGTH	The length of the element.
WIDTH	The width of the element.
HEIGHT	The height of the element.

Length, Width and Height may be set for a part as shown below:





Variables

Data can be set directly into WITNESS elements e.g. cycle time duration and breakdown data but it can be useful to store data in Variables so that it can be changed more easily. As a rule of thumb, Variables are most useful when the data to be stored or used does not relate to individual parts or entities or cannot be used directly in the element's details.

Variables can be displayed on the screen and can be accessed from anywhere in the model. A Variable may hold data as a decimal number (real), a whole number (integer), the name of a WITNESS modeling element or as a text string.

Variables have their values assigned in the Actions Boxes. The most common place this is done is in Actions on Initialize, where data from an Excel spreadsheet is read at the start of a model run.

Variables may be defined to hold a single value or several values. A one-dimension array may hold thousands of values, in the form of a list. Variables may also be created as multi-dimensional arrays of between 2 and 16 dimensions. Two-dimensional arrays are common as they allow tables of data to be stored. Three-dimensional arrays can be used to hold a record of stock in a high-bay warehouse. Larger dimensioned arrays are less common.

Variables find use in the following areas:

User Statistics – Variables may be used to collect specific data that is not automatically collected by WITNESS. This data can be displayed in WITNESS and / or exported to Excel for further analysis.

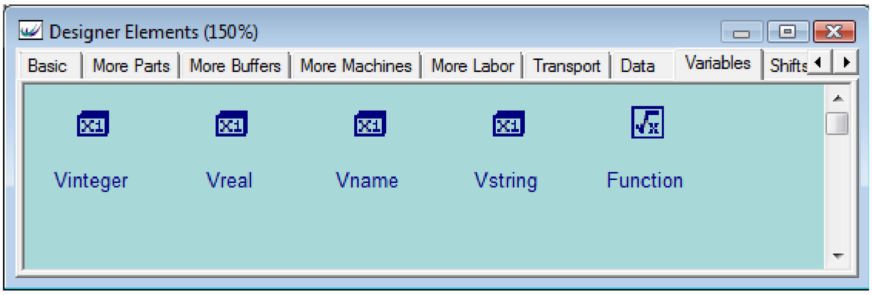
Holding Data - Variables may be used to store data that is liable to be changed e.g. the time it takes to do a task may reduce over time as an operator becomes more skilled.

Storing Data – Variables may be used to maintain records whilst the model runs. This data may be post-processed on completion of the model run or exported periodically to Excel whilst the model is running.

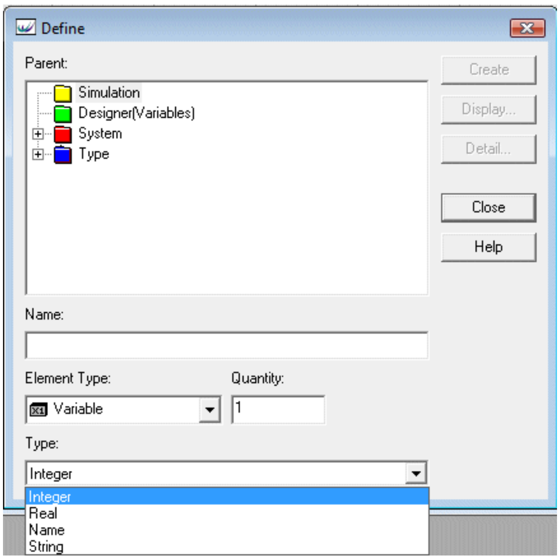
Control Logic – Variables may be used to trigger or prevent actions taking place and for more complex control within and between elements.

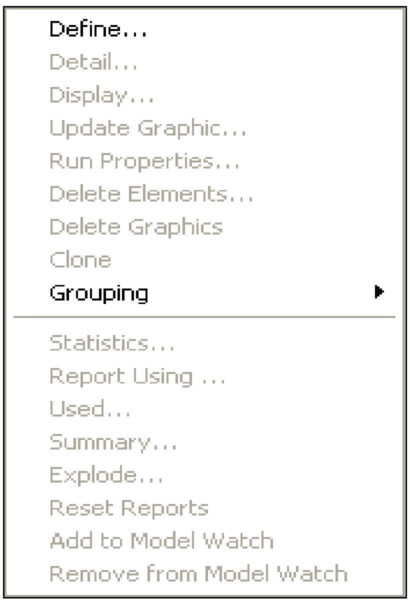
Defining Variables

Variables are defined in the same way attributes in the previous section. To define a Variable from the Designer Elements, select the variables tab and then pick the designer element of the appropriate Variable type (integer, real, name or string).



A Variable may also be defined using the Define Dialogue Box.

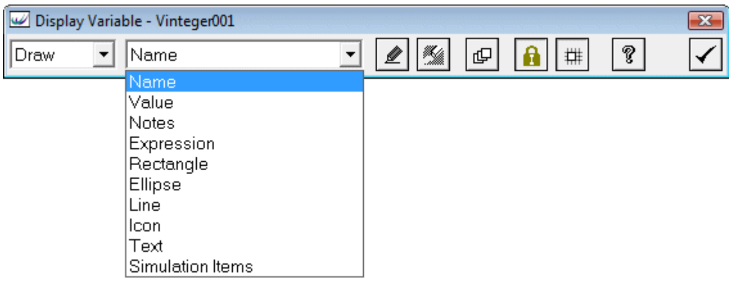




Select the Element / Define option, enter a name for the element, and then specify the type as a Variable from the drop down menu. Another drop down menu is then used to set the type of Variable i.e. Integer, Real, String or Name.

Displaying Variables

The Display Items are accessed through the drawing Toolbar, which is selected by right clicking on the element either in the Simulation View or the Element Selector and selecting the Display option. This may also be done using the Display button on the Element toolbar.



A variable may have numerous display ‘items’ on screen to convey information about it. Many of these items may be displayed more than once (Marked with an * in the table below). The available display items for Variables are:

Variable Display Item		Description
Name	*	Name of the selected Element
Value	*	The current value of the variable
Notes	*	Notes entered on the detail form
Expression	*	Any WITNESS function or a calculation
Rectangle	*	A box
Ellipse	*	A circle/ellipse
Line	*	A line
Icon	*	An icon, this can be a ‘picture’ or a monochrome icon which will show the changes of machine state by changing colors.
Text	*	Descriptive text

Using Variables

Variables can be used in any actions box or any input field that holds an the correct type of input (i.e. Integer, Real, string, Name)

Defining and Using Local Variables

A local variable is a variable that you create yourself within the action or function that uses it. The advantages of using a local variable rather than a global variable are;

- Safety - Local variables only exist while the action or function is being executed, so you can't use or change the variable by accident in another action or function. For example, the variable TOTAL_SHIPPED that has been defined in a machine's actions on finish can only be updated or accessed by that set of actions, not by other actions for that machine, or by any other element in the model.
- Speed - Actions and functions are executed more quickly when they use local variables rather than global variables.
- Convenience - Local variables are defined in the actions that use them. You do not need to define them in advance, as is the case with global variables.

However, local variables have some restrictions:

- No reports are generated.
- You cannot display them in the model.
- They cannot have a quantity greater than 1.
- You cannot access them from outside the action or function that creates them.

Local variables are created, used and deleted during the execution of a single function or set of actions. A typical sequence would be:

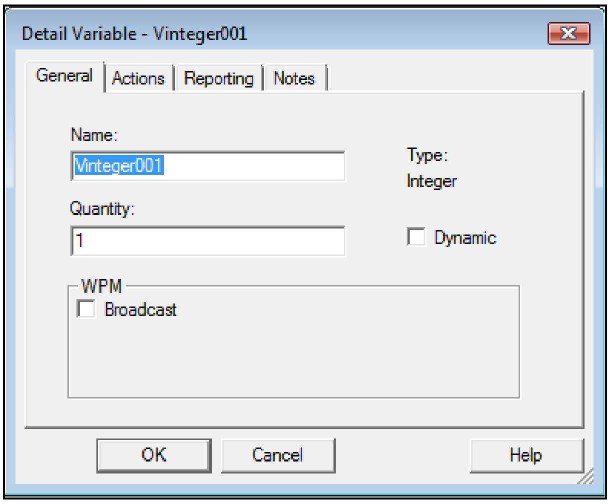
1. A statement in the action creates the local variable. The value is initialized to 0, 0.0, NONE or " " depending on the variable's data type.
2. Another statement assigns a value to the variable.
3. The variable's value is used in subsequent statements (for example, in a calculation or a comparison).
4. The other statements in the action are executed.
5. Once the action has been executed, the variable and its value are deleted.
6. The next time the action is executed, a statement in the action creates the variable again, and so on.

Below are examples of Local variable definitions, which should be placed at the start of the actions box where they will be used.

Dim *VarReal* as REAL
Dim *VarString* as STRING
Dim *VarInt* as INTEGER
Dim *VarName* as NAME

Dynamic Variables

Dynamic variables are a special type of variable, they are designed in through the same process as "normal" variables (in fact normal variables can be changed into dynamic variables). A dynamic variable will expand in size to store all the values that are "recorded" to is, so you do not need to know the number of values that are going to be stored. For example, a dynamic variable could contain the simulation time at which each part leaves the model. At the start of the simulation the variable would contain no values, then 1 value when the first part leaves, 2 values when the second part leaves and so on. A dynamic variable has a single dimension; it cannot have more than one dimension.



To make the variable Dynamic the Dynamic tick box is checked.

Adding Values to the variable

The RecordRealValue function (used in an action) adds another value to the end of the current list of the dynamic variable's values e.g.

RecordRealValue(TimeInSystem, TIME - TimeEntered)

adds a new record to the dynamic variable "TimeInSystem" that shows how long the current part has existed in the model by subtracting the time at which it entered "TimeEntered" from the current simulation time "TIME".

Conditional Input and Output Rules

Conditional input and output rules can be used to determine where parts are pulled from, or pushed to, based upon values in the model. Below is an example of the syntax in a To Rule:

IF NPARTS(Buffer1) > 5
PUSH to Machine1
ELSEIF NPARTS(Buffer1)<=5
PUSH to Machine2
ELSE
WAIT
ENDIF

WITNESS Functions

In simple terms, a Function may be described as a list of instructions or actions, which may take in values (parameters) passed by the “caller”, perform some task and (usually) return an answer the "caller.” The caller is the point in the model code from which the function was called.

Functions may be "called" from input and output rules, command lines such as the cycle time field in a machine and from within any of the actions boxes that occur within elements. Once the Function has been executed, WITNESS returns to the point from which the function was called and continues onward.

Built-in Functions

WITNESS provides a comprehensive list of built-in, or "intrinsic" functions. A function may return a real, integer, name, or string data type result. A function may be used in any place that a variable or constant of the same type would normally be used. Some of the main intrinsic functions are listed at the end of this manual. A full list can be found both in the on-line help and in the Quick Reference Booklet. Help with functions may also be found using the Functions Assistant on the Assistants tab of the Element Selector. The “Insert with Prompt” option in the Assistants tab may be used to help enter the correct data into a built-in function.

One example of a built-in function is NPARTS (as used just above here). NPARTS is a frequently required piece of code that allows the user to determine how many parts are currently resident in the element whose name is contained in the argument of the function (“Buffer1” above).

User-Defined Functions

User-defined Functions are useful whenever custom or unique calculations need to be made. They are especially useful when this calculation is required at more than one place in the model since it is preferable to refer to a single instance of the code rather than reproduce it many times over within the model.

One use of a function might be to calculate the cycle time for a Machine (Activity) when the cycle time cannot be expressed in the “one-line” format allowed in the cycle time field. If the same calculation is to be performed at more than one Machine, then a Function will provide the most economical form of modeling.

User-defined functions can also be used to consolidate similar action statements that would otherwise be repeated in several different locations into one-place in a model. Functions used in this fashion save time when model building and will undoubtedly reduce the amount of checking necessary when testing the model prior to hand-over. Furthermore, if a code change is subsequently required, then it only need be implemented in one place.

WITNESS functions support a full parameter passing mechanism, similar to many common programming languages. Parameters such as a Machine name can be passed into the function and used within that function's logic to help determine the value that the function is to return. Once calculated, the value is returned and used where the Function was called.

WITNESS action statements can be used in a function to create complex looping and conditional branching constructs interspersed with calculations, intrinsic function calls, and other user-defined function calls. The "language" of WITNESS actions is flexible enough to solve just about any situation requiring more complex logic and algorithm implementation.

A "void" Function is used where the Function carries out a set of actions such as manipulating values of variables or writing out to a data file, without being required to return a value to the “caller”. In a sense, a void function can be though of as a command that does something, whereas a regular function must return the calculated value to the point from which it was called. The concept of a void function in WITNESS is the same as the concept of a void function in the C programming language.

Extending the Use of Basic Elements

Modeling Stoppages

It is very unlikely that Elements within the model will run continually during a specified period of time. Simulating stoppages gives you the ability to replicate reality. Stoppages are a way to force the Machines or Activities or Conveyors to stop.

In WITNESS, you are able to model two types of stoppages:

- Setups
- Breakdowns

Each of these will be explained in detail, taking you through the stages of setting them up.

Adding Setups (Stoppages) to Machines (Activities)

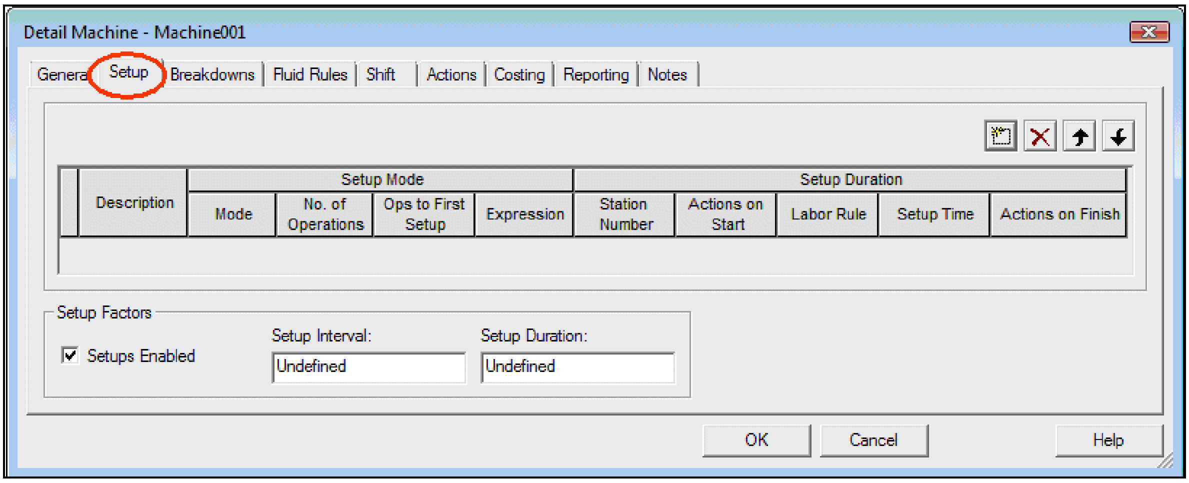
Regular stoppages can be modelled using setups. These can be used to model tool changes, maintenance, or similar stoppages that occur after a number of operations or because of a change in the process. Setups can only be applied to Machines (Activities) in WITNESS.

The basis for making a setup may be:

- A number of operations (frequency). In this case an initial life may be specified
- A change of value
- A change of Part or Entity type

A Setup Time must be specified in each case.

To access the detail for Machine (Activity) bring up the Detail Dialog of a Machine (Activity) and select the Setup (stoppages) Tab.



Up to 999 different setups (stoppages) may be added by clicking on the add button  and typing in the required data.

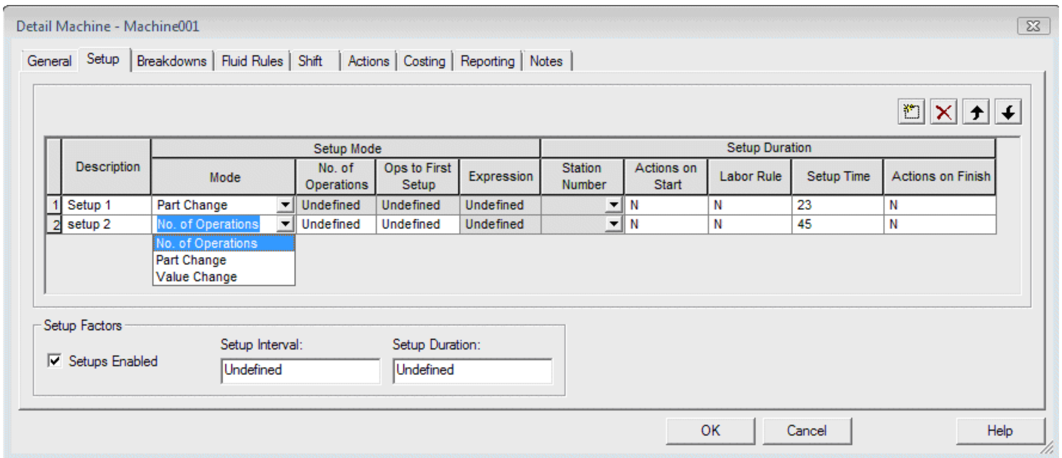
Enter the setup name in the description box, and then click the Add button to add that setup to the list of setups for the machine. Unless the setup is the only setup in the list, the setup is inserted immediately below the currently selected setup.

Repeat this process, until the machine has the required number of setups. Modify the list if necessary. To change the position of setups in the list, select a setup, then click the Move Up or Move Down buttons to move the selected setup up (or down) one place in the list. To remove a setup from the list, select the setup, then click the Remove button.

When the list is complete, click the OK button to close the add/remove dialog. You can edit the list later. Alternatively, you can view summary details of all the setup times for the machine by clicking the Summarize button.

Choosing when setups take place

The setup mode determines when setups take place. There are three setup modes;

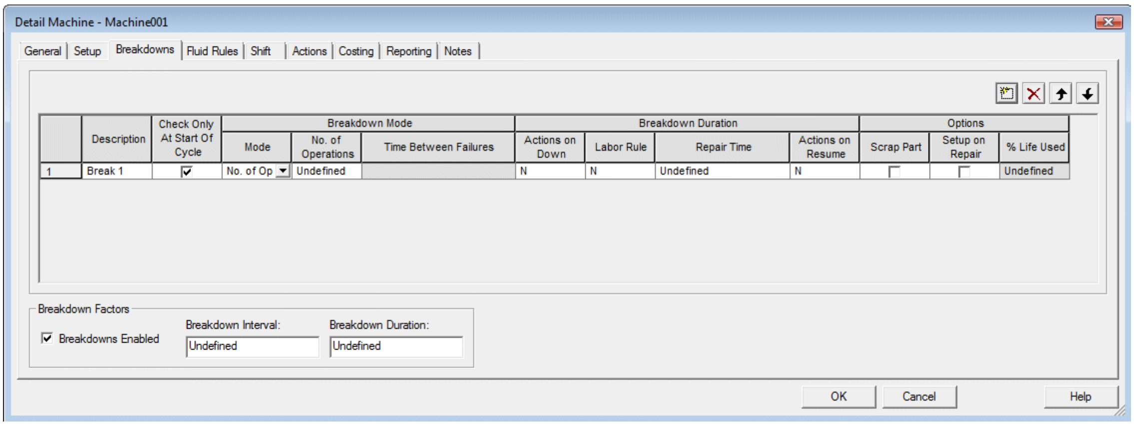


The Three setup modes are shown below;

Mode	**Description**
No. of operations	The setup takes place after the specified number of operations (or machine cycles) has taken place. For multi-cycle machines, an operation is regarded as a full cycle on the machine. You must also specify the number of operations to first setup (that is, the number of operations or machine cycles that you want to take place before the first setup occurs).
Part change	The setup occurs if the part about to be processed is of a different type to the part previously processed (that is, after the new part is input into the machine but before the first machine cycle). This is useful if, for example, different parts need different tools.
Value change	The setup occurs at the beginning of the cycle after the specified expression changes value.

Adding Breakdowns to Machines (Activities)

Machines (Activities) can break down in WITNESS. In order to include this it is necessary to specify that breakdowns will occur in the Element details.



The Three Breakdown or Stoppages Modes are shown below;

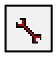
Mode	**Description**
Available Time	Breakdown occurrence takes into account all states except off-shift time for the machine.
Busy Time	Breakdown occurrence is dependent on the amount of busy time that the Element has incurred.
Number of Operations	Breakdown occurrence is dependent on the number of operations that the Machine has completed.

There is also the option to scrap the part or entity when the machine breaks down. If the part is scrapped, then after it has been fixed, a new part or entity is pulled in using the Input Rule. If the Part (Entity) is not scrapped, then when the machine restarts, it continues to process the part or entity present when it stopped.

The final option, Setup on Repair, on the Breakdowns property sheet enables you to specify that when the Machine (Activity) breaks down, any setup which is nearly due is done whilst the machine is being repaired. The **% Life Used** field enables you to specify how near to being due the Setup needs to be if it is going to be done when the machine breaks down. For example, if a setup is performed every 100 operations and a % Life Used of 75% is specified, then if the Machine breaks down after 75 or more operations the Setup is done; if it breaks down after less than 75 operations, the Setup is not done.

Forced Breakdowns and Repairs

Breakdowns and repairs can be “forced” on a machine using a user button or through “code” in the actions statements of a machine. To force a breakdown using the button, stop the model and select the machine to be broken down and click the forced breakdown button. 

The model can then be run and the machine will remain broken down until the model is stopped again and the repair button clicked. 

Breaking down a model from “code” in an actions box uses the **Breakdwn** and **Repair** commands in the actions boxes, but a machine can not break itself down.

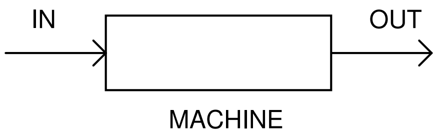
Breakdwn(Op10) - breaks down the machine Op10 if it is not already broken down.

Repair(Op10) - repairs the machine Op10 if it has been forced to break down (you can not repair a machine that has not been broken down using the Breakdwn function)

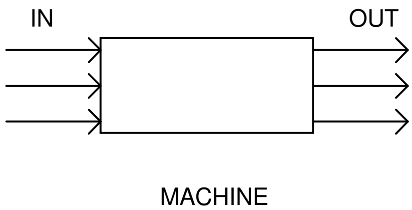
Machine (Activity) Types

A Machine (Activity) can process one Part (Entity) at a time or many at a time. It can assemble many together into one or produce many out of one. WITNESS provides six types of Machines (Activities) to cater to these requirements.

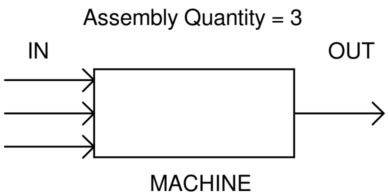
Single Machine/Activity - A single Machine or Activity processes one single Part or Entity at a time and outputs that single Part or Entity.



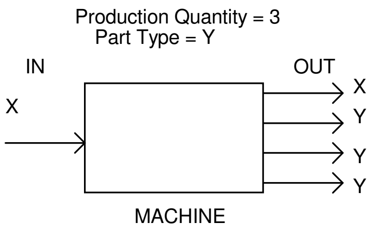
Batch Machine/Activity - A batch Machine (Activity) processes a batch of Parts (Entities) at a time. If the Machine is a BATCH Machine, set the type to BATCH and specify the minimum and maximum number of Parts (Entities), which would constitute a batch.



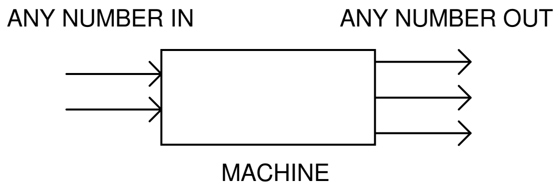
Assembly Machine or Join Activity - An Assembly Machine takes in a number of Parts and outputs a single Part. If the Machine is an ASSEMBLY Machine, set the type to ASSEMBLY and specify the number of Parts that are assembled into one new Part.



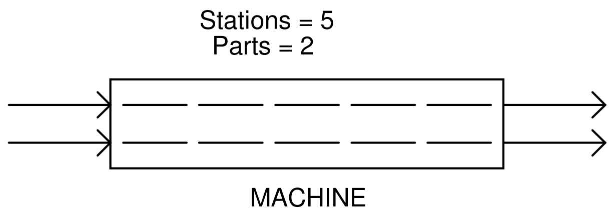
Production Machine or Split Activity - A Production Machine takes in a single Part and outputs a number of Parts. If the Machine is a Production Machine, set the type to Production and specify the production quantity. Remember that the number of Parts output from such a Machine equals the production quantity PLUS 1.



General Machine/Activity - A general Machine takes in a number of Parts and outputs a different number of Parts. If the Machine is a General Machine, set the type to General and specify the input quantity and the output quantity.

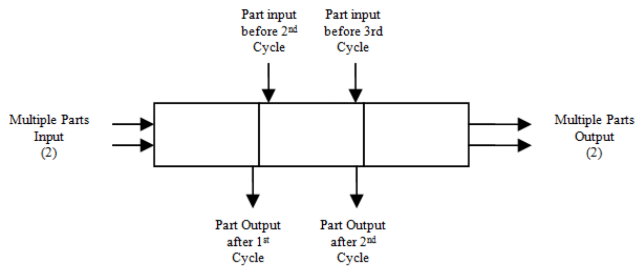


Multi-Station Machine (Activity) - A Multi-Station Machine processes one or more parts through a number of stations. Parts move in unison through the Machine and only advance if an input Part is available. This prevents 'gaps' in the Machine.
If the Machine is a Multi-Station machine, set the type to Multi and specify the number of stations and the number of Parts per station. If the number of Parts is more than 1, the Machine is effectively a Multi-Station Batch machine.



Multi-Cycle Machine (Activity) - In some cases, a Machine or Activity cycle consists of a number of sub-cycles or tasks. For example, a staged assembly operation may consist of the following tasks and represented in the diagram:

Input Two Parts (Entities)
Cycle for 3 minutes
Output 1 Part (Entity)
Input Third part (Entity)
Cycle for 1 minute
Output 1 Part (Entity)
Input fourth part (Entity)
Cycle for 5 minutes
Output assembled Parts (Entities)



Additional Input and Output Rules

There are more ways of routing Parts (Entities) through the model than the simple Push and Pull Rules, this section of the manual will show them.

Rule	Example Syntax	Description
SEQUENCE/WAIT	SEQUENCE/WAIT B1#(1),B2#(2),B3#(1)	Take 1 Part from B1 then from B2, then 1 from B3. If a Part is not available, wait until it is.
SEQUENCE/NEXT	SEQUENCE/NEXT B1#(1),B2#(2),B3#(1)	As above, but if a Part is not available, go on to try the next stage of the sequence.
SEQUENCE/RESET	SEQUENCE/RESET B1#(1), B2#(2), B3#(1)	As above, but if a Part is not available, reset the sequence and try from the beginning.
PERCENT	PERCENT B1 30.0, B2 30.0, B3 40.0	Sample from list of stations at random in the prescribed proportions. I.e. 30% from B1, 30% from B2 and 40% from B3.
MOST PARTS	MOST PARTS B1, B2	Take or send a Part from/to B1 or B2, whichever has most Parts.
Most FREE	MOST FREE B1, B2.	Take or send a Part from/to B1 or B2, whichever has most free space.
Least PARTS	LEAST PARTS B1, B2	Take or send a Part from/to B1 or B2, whichever has least Parts.
Least FREE	LEAST FREE B1, B2	Take or send a Part from/to B1 or B2, whichever has least free space.
SELECT	SELECT on X B1, B2	If X = 1 take a Part from B1 otherwise if X = 2 take a Part from B2.

Rule	Example Syntax	Description
BUFFER	BUFFER(5)	Create Input Buffer, for Machines (Activities) only, the example code would create an Input Buffer of capacity 5.
MATCH/ANY	MATCH/ANY (B1#1 AND B2#2)	Select one Part from B1 and two Parts from B2.
MATCH/ATTRIBUTE	MATCH/ATTRIBUTE COLOR CHASSIS#1 AND DOORBUFF#4	Selects Parts with the same value of a specified attribute. The example only takes Parts when WITNESS finds one item from the CHASSIS buffer and 4 items from the door buffer with the same color.
MATCH/CONDITION	MATCH/CONDITION (ATT2=5 AND ATT3=1) BUF1#1 AND BUF2#1 OR BUF3#2	Selects parts which meet certain conditions, which are normally, attribute based. The machine can obtain a Part from BUF1 and BUF2 or both from BUF3. The condition on the selection is that the attribute ATT2 is equal to 5 and ATT3 is equal to 1.

Multiple Quantities of Elements

Many elements in WITNESS may have quantities greater than 1. To increase the Quantities of an element increase the number in the Quantity field of the detail dialog for the element.

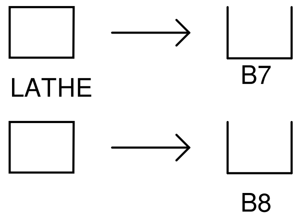
System Variables

There are 2 Variables which are always available and these are pre-defined in WITNESS. These pre-defined or system Variables are:

N is an integer Variable holding the index number of the current element.

For example, if there is a Machine MACH defined with a quantity of 3, then N will be set to 1 if MACH (1) has just finished its cycle (or is about to start its cycle), for MACH (2) N will be set to 2, and for MACH (3) N will be set to 3. If no quantity has been set against an element, N = 1.

For example, suppose LATHE was a machine defined with a quantity of 2 and all of the parts leaving LATHE(1) are sent to B7 and all of the parts leaving LATHE(2) are sent to B8 (see below).



The Output Rule on the LATHE required to achieve this is

```
IF N = 1
  PUSH to B7
ELSE
  PUSH to B8
ENDIF
```

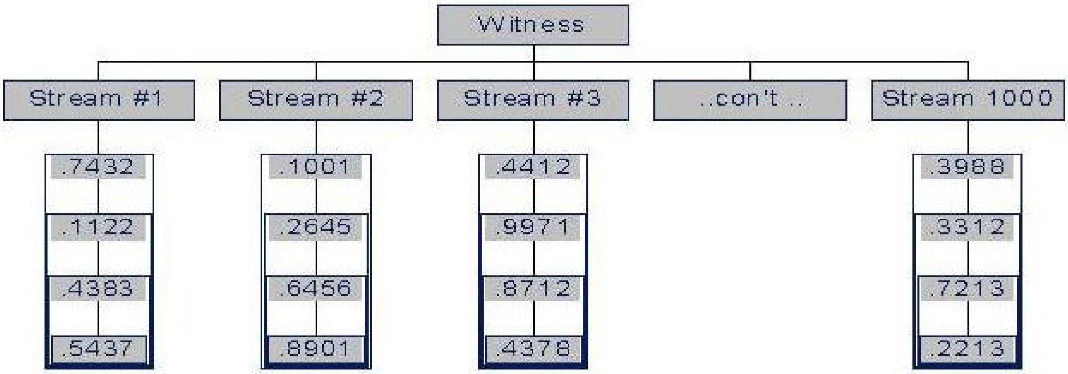
M is an integer Variable holding the current item number within a lot/batch.

For example if a Part enters the system with a lot size of 25, then M will be set to 1 for the first Part, 2 for the second Part and so on up to 25 for the last Part. If Machine MACH is a batch machine and the batch size is four, then when the machine finishes M will be set to 1 for the first part, 2 for the second, 3 for the third and 4 for the fourth. M may also be used as the plot number for a timeseries.

Adding Variability to the Model

Principal of Sampling Random Numbers

A random number is a real number between 0.0 and 1.0. Its value is equally likely to be any number in the above range. Truly random numbers are generated by repeated independent trials (e.g. tossing a coin, rolling dice). Computers do not have the ability to roll dice so they use mathematical formulae to create random numbers. Rather than store a large quantity of pre -defined random numbers on your computer's disk, WITNESS is equipped with the means to calculate virtually infinite series, or 'streams' of 'pseudo-random' numbers. Such numbers are not truly random since they are generated using a statistical algorithm, but the WITNESS pseudo-random number generator has been designed to produce numbers in the same fashion as an idealized 'chance device'. WITNESS provides one thousand different streams of pseudo-random numbers. The term 'pseudo-random-number' is often abbreviated to 'PRN'.



The PRNs generated by WITNESS have two important characteristics. WITNESS pseudo-random number streams are:

Unconnected - Each stream is completely unconnected to the others. Stream 1 will produce the same sequence of random numbers regardless of the number of samples taken from stream 2. It is important that each source of variability in your model e.g. each machine or activity, part or entity arriving, etc. should use a separate PRN stream.

Failure to do this may compromise the statistical impartiality of the model with the consequence inexplicable inconsistencies may manifest themselves in the model’s results.

Reproducible - When comparing different scenarios, you need to be confident that the random elements of the model are not changing. Since the streams of random numbers are reproduced faithfully each time the model is run, the conditions of the investigation are also reproduced. This ensures that you are comparing like with like between runs of the model.

In the real world, the patterns of randomness vary. The interval between customers arriving in a shop, the height of an adult male, the number of rainy days in a year, all produce a different pattern when graphed i.e. they display a different Distribution of results. To cope with this, the pseudo-random number generator may be used via functions that transform a uniform sample into a sample from the appropriate Distribution. The appropriate Distribution may be based on data collected or alternatively it may be based on statistical theoretical data. The next two sections describe these two types of Distributions.

Standard Theoretical Distributions (WITNESS Distributions)

WITNESS provides Distributions that return numbers that vary randomly according to specified 'curves' or 'Distributions'. In general, you should choose the Distribution which most closely fits the real-life data to hand, or which is known to characterize the variation, which you are trying to model. Commercial statistical packages are available to 'fit' curves or Distributions to data collected. Two types of Distribution are provided: Integer and Real. Integers are whole numbers; Real numbers have decimal places. As a rule of thumb, integers are used where a quantity is required and real numbers are used where a measurement, such as a measurement of time, is required.
Note: PRNs is used to denote a Pseudo Random Number Stream which should be a value between 1 and 1000.

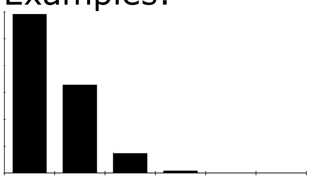
Integer Distributions

BINOMIAL (PROB, TRIALS, PRNs)

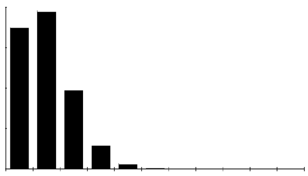
This provides a sample from the Binomial Distribution. This returns the expected number of successes, given a number of tries and a probability of success. For example, if light bulbs from a supplier are known to be 5% faulty, the Binomial Distribution may be used to estimate the number of faulty bulbs in a supplied batch.

Parameters: Probability of success: Real
Number of trials: Integer

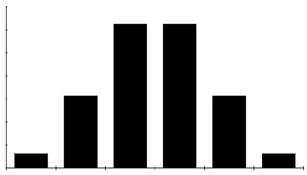
Examples:



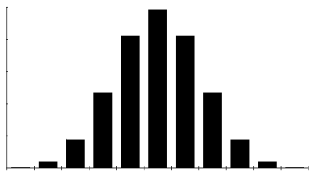
Probability = 0.1, trials= 5



Probability = 0.1,trials=10



Probability = 0.5, trials = 5



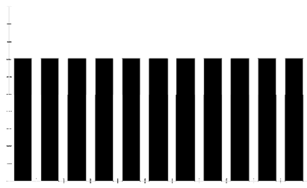
Probability =0.5, trials = 10

IUNIFORM (MIN, MAX, PRNs)

This provides a sample from the Integer Uniform Distribution. It may be used when there is equal probability of obtaining any integer value in the specified range.

Parameters: Minimum value: Integer
Maximum value: Integer

Example:



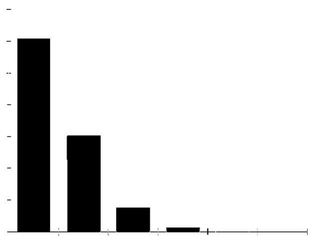
Min = 0, Max = 10

POISSON (MEAN, PRNs)

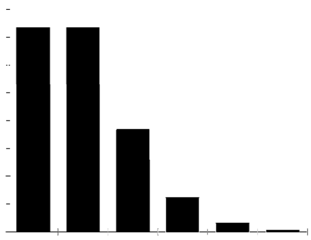
This provides a sample from the Poisson Distribution. It is typically used to estimate the number of arrivals within a period such as the lot size of a part. It may be thought of as the integer complement of the Negative Exponential Distribution.

Parameter: Mean: Real

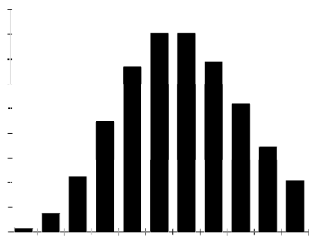
Examples:



mean = 0.5



mean = 1.0



mean = 10.0

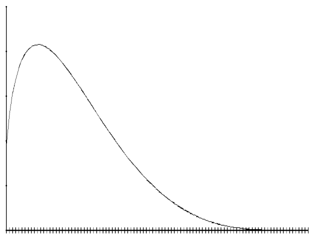
REAL DISTRIBUTIONS

BETA (SHAPE1, SHAPE2, PRNS)

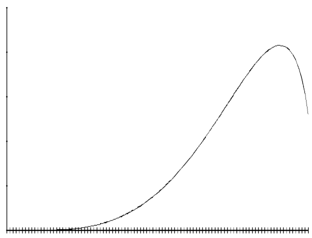
This provides a sample from the Beta Distribution. The Beta Distribution may assume a wide variety of shapes depending on the value of the shape parameters. This Distribution may be used to model the proportion of defective items.

Parameters: shape: Real
scale: Real

Examples:



shape = 1.5, scale = 5



shape = 5.0, scale = 1.5

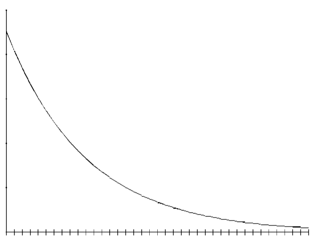
ERLANG (MEAN, K, PRNS)

This provides a sample from an ERLANG K Distribution. You are able to specify the value of K. The ERLANG is a family of Distributions; it has a different curve depending on the value of the K parameter. When K is 1, the ERLANG is identical to the Negative Exponential Distribution. When K is 2, the ERLANG is a bell-shaped Distribution strongly skewed to the left, roughly similar in shape to the Log Normal Distribution.

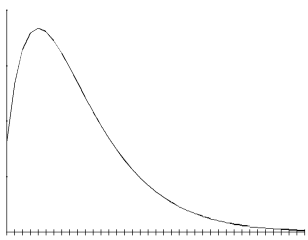
As K becomes large, the distribution tends towards the Normal Distribution. Note that unlike the Normal or the Log Normal Distribution, the ERLANG Distribution is characterised by its mean alone.
By changing the K parameter, the ERLANG Distribution may be used for sensitivity analysis. For example, for testing the effect of stoppages, low values of K cause maximum chaos, while higher values reduce chaos.

Parameter: Mean: Real
K value: Integer

Examples:



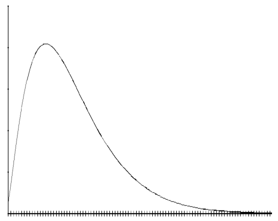
mean = 1.0, K =1



mean = 1.0, k=3

GAMMA (SHAPE, SCALE, PRNS)
This provides a sample from the Gamma Distribution with the specified shape and scale. It is often used to model stoppage times.

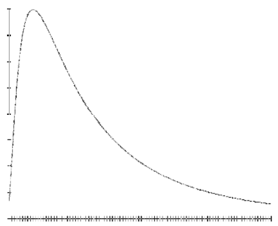
Parameters: shape: Real
scale: Real
Example:



shape = 2.0, scale = 1.0

LOGNORML (MEAN, STDEV, PRNS)
This provides a sample from a Log Normal Distribution. This is a bell-shaped distribution strongly skewed to the left, and is often used to represent repair times.

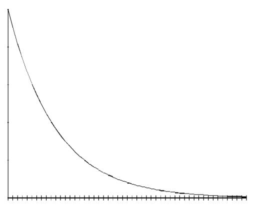
Parameters: Mean : Real
Standard Deviation : Real
Example:



mean = 1.65, St Dev = 2.16

NEGEXP (MEAN, PRNS)
This provides a sample from the Negative Exponential Distribution. It is typically used to model Part or Entity inter-arrival times or stoppage intervals, and may be said to be the real complement of the Poisson Distribution.

Parameter: Mean :Real
Example:



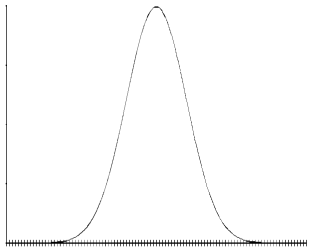
mean = 1.0

NORMAL (MEAN, STDEV, PRNS)

This provides a sample from the Normal Distribution. This is one of the most common distributions in nature, and has a symmetrical bell-shaped curve. It may be used to model those aspects of your model where values are evenly distributed around a mean, for example, tolerance on a measurement or load/unload times.

Parameters: Mean:Real
Standard Deviation:Real

Example:



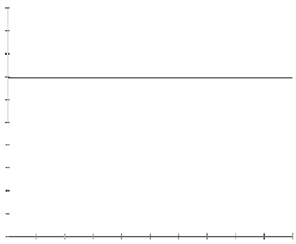
mean = 1.0, St Dev = 0.05

RANDOM (PRNS)

This provides a sample between 0.0 and 1.0 from a Uniform Distribution. You may use this value to calculate a random number using your own algorithm.

Parameters: None

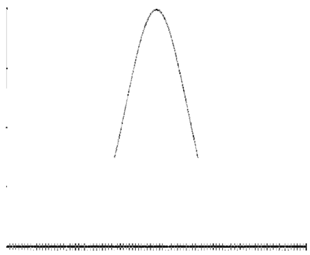
Example:



TNORMAL (MEAN, STDEV, MIN, MAX, PRNS)
This provides a sample from the Truncated Normal Distribution. This is similar to the Normal Distribution with the difference being that the minimum and maximum values for sampling are specified.

Parameters: Mean:Real
Standard Deviation:Real
Minimum Value:Real
Maximum Value:Real

Example:

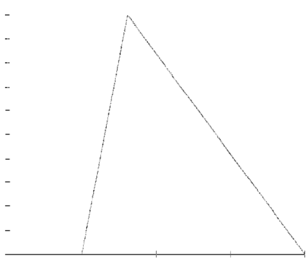


mean = 0.0, St Dev = 6.0, min = -4, max = 4

TRIANGLE (MIN, MODE, MAX, PRNS)
This provides a sample from the Triangular Distribution. As its name suggests, this distribution has a triangular 'curve'. It is typically used when statistical information on the area under study is hard to obtain, but the likely range of values and the most common value are known.

Parameters: Minimum value:Real
Mode (most likely) value:Real
Maximum value:Real

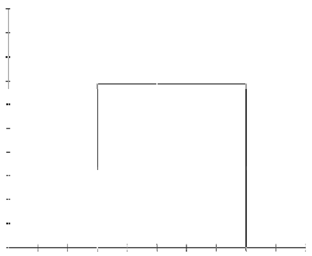
Shape:



min mode max

UNIFORM (MIN, MAX, PRNS)
This provides a sample from the Uniform Distribution. It may be used when there is equal probability of obtaining any real value in the specified range, typically where little is known about data except for the expected minimum and maximum.

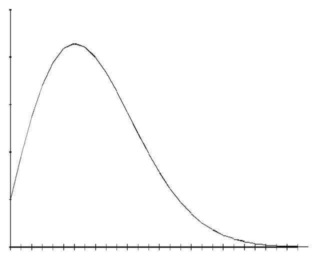
Parameters: Minimum value:Real
Maximum value:Real
Example:



Min Max

WEIBULL (SHAPE, SCALE, PRNS)
This provides a sample from the WEIBULL Distribution. It is typically used for reliability modeling and returns a sample from the distribution with a specified shape and scale.

Parameters: Shape: Real
Scale: Real
Example:

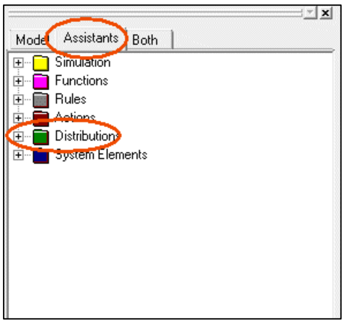


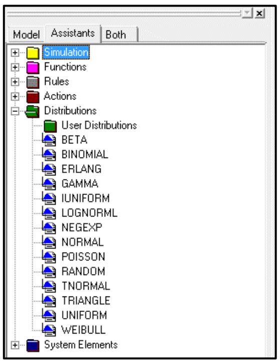
shape = 2.0, scale = 1

Using Standard Theoretical Distributions

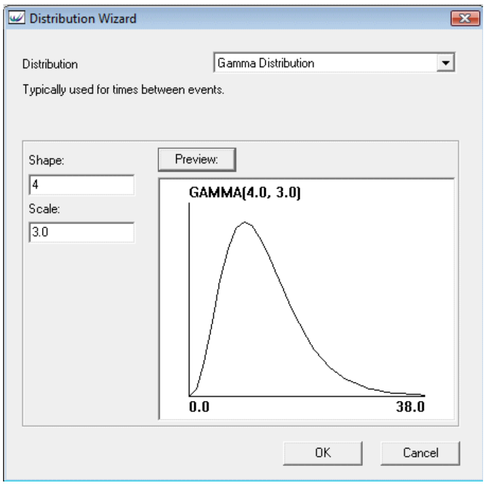
WITNESS allows the use of standard distributions in any of the fields that require a numerical input. The distributions can be typed in to the input field directly, however WITNESS provides a Distribution Assistant to help in getting the correct syntax.

To use the Distribution assistant, firstly the input field that the distribution is to be used in must be highlighted e.g. cycle time of machine M1. The Assistants tab on the element selector needs to be selected, and then clicking on the + next to the distribution Folder will expand the list to all the available Distributions.





Right clicking on the required distribution a menu is activated, selecting 'Insert with Distribution Wizard' will bring up the dialogue box below, allowing detailing of the parameters for the distribution.



Clicking on the OK button will insert the correct syntax for the use of the distribution in the input field selected. (*Note* If no input field is selected these actions will do nothing).

Using Your Own Data (User Distributions)

WITNESS allows you to build variability into a model by including data which you have collected from the 'real world'. If none of the WITNESS built-in distributions fits your data and you would like to supply your own distribution, WITNESS provides the facilities to define and detail it.

When defining a Distribution, you must specify its type. It may be:

- Integer: i.e. returns whole numbers.
- Real, i.e. returns numbers with a decimal fraction.
- Name, i.e. returns WITNESS element names.

When deciding on the Distribution type, the context in which it will be used must be considered. If the Distribution represents time (e.g. a machine cycle time or activity duration) it will be real, but if it represents quantities of items, e.g. a batch size for Entities, it will be integer.

Integer and Real Distributions may be either:

- Discrete, i.e. only the cell values supplied are ever sampled.
- Continuous, i.e. WITNESS samples uniformly between the cell values supplied to determine the sample value.

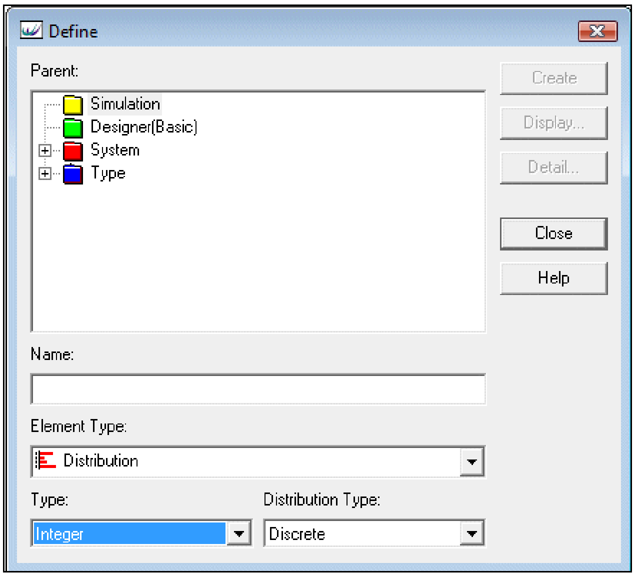
Name Distributions may only be Discrete. In general, Integer Distributions will be discrete and Real Distributions will be continuous. However, this may not always be the case, e.g. you may want to sample 1 of 5 possible values representing product weight, in which case a Real Discrete Distribution would be appropriate.

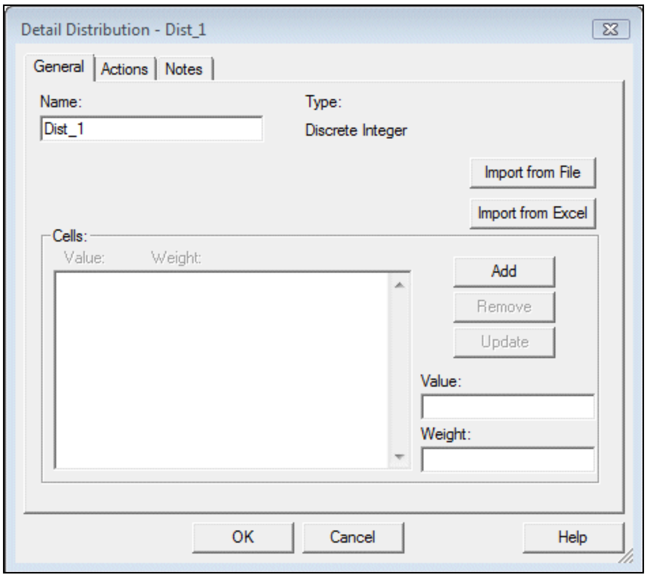
For Continuous Distributions, the first weight will be forced to zero in order to specify the left-hand end of the Distribution. When specifying the ranges, always specify the maximum value in the range for a Continuous Distribution. WITNESS will then sample uniformly between these values.

You can also create a Profile Distribution. This is in effect a real continuous distribution but with a time axis. It is used for applying factors to values that vary by time. For example recent research into human performance indicates many factors can affect performance – for example different temperatures at different times of day, different noise levels, humidity levels, the after lunch effect, etc.

This distribution type allows you to easily model factors that may affect your processes and apply different timings or other calculations at different times in a model.

Adding a user distribution is best done through the Define Dialog box, selecting the Distribution element from the dropdown menu.





Detailing the Distribution is done by entering the value in to the value field and the likelihood of that being selected from the distribution in the weight and clicking the add button. This process is repeated for all the values in the distribution.

Shifts and Graphical Elements

Shifts

The majority of operations include some form of shift pattern; e.g. operators on a production facility or tellers working in a bank. The complexity of shift patterns varies from operation to operation, however, each pattern may include some or all of the following elements;

- coffee and tea breaks
- meal breaks
- single, double and triple shifts
- varying quantities of labor on alternative shifts
- overtime

In some operations it is vital that shift patterns are modelled accurately, for example where;

- different areas of a plant work different shifts
- varying quantities of labor on different shifts
- some operations continue out of shift
- lengthy breakdowns are repaired outside shift

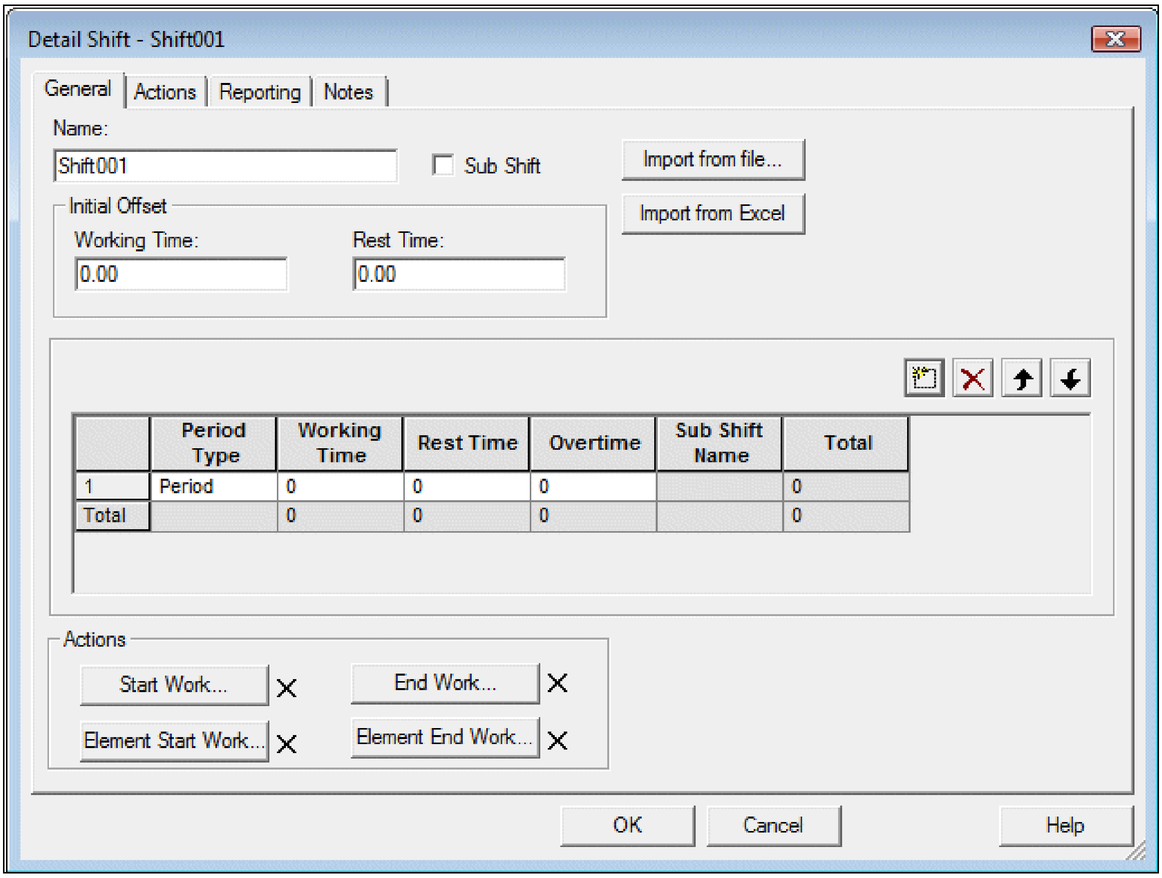
A shift pattern may be specified in WITNESS by use of the SHIFT element, which is defined either from the Shift designer elements tab or through the Define Dialog box as with other elements.

Creating a Shift Pattern

A Shift comprises a number of periods each of which has the following characteristics;

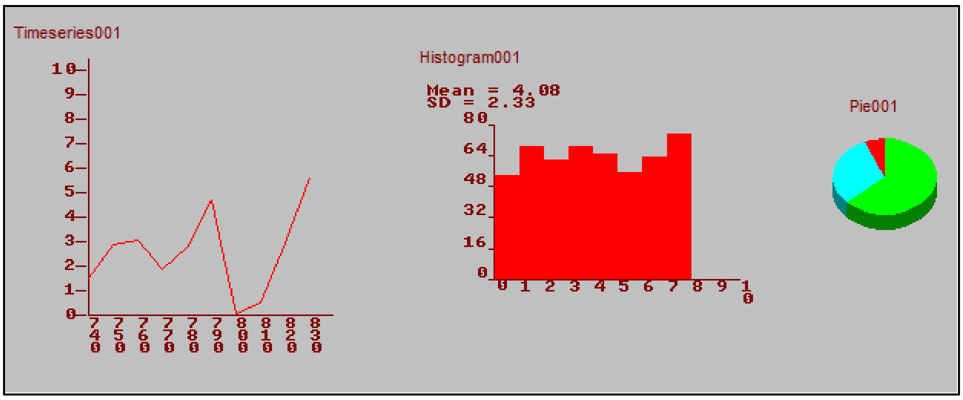
Input	Description
Period Number	The reference number for the period (between 1 and 999).
Working Time	The actual time worked for this period.
Rest Time	The break time following the working period.
Overtime	The overtime which will be worked, immediately following the working time for this period of the Shift. This will in effect reduce the rest time at the end of the period. The overtime must therefore be no more than the rest time

A period is added to the shift by clicking on the add button () on the shift dialog. Up to 999 periods may be defined and detailed with the information above. The shift will run through all periods before starting again at the first period.



Graphical Elements

There are three standard Graphical elements in WITNESS, the Pie chart, the Timeseries and the Histogram.

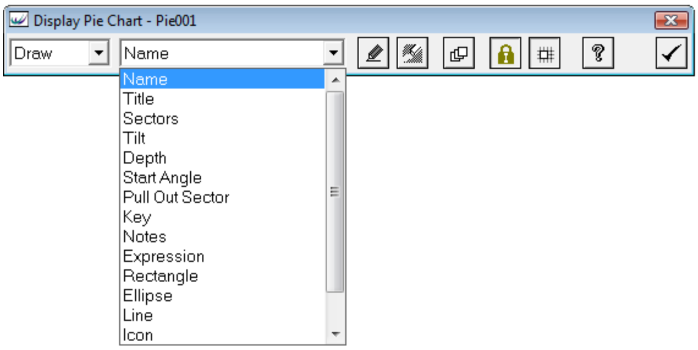


Pie Charts

A pie chart is a graphical element display that presents simulation results in the simulation window, or shows how an element or a group of elements is used. For example, you could use a pie chart to plot idle time, setup time and busy time over a given period of time.

A Pie chart can be defined through the same process as the other elements in witness, the default Designer Element can be found on the Reports tab in the start up model.

Displaying a Pie Chart

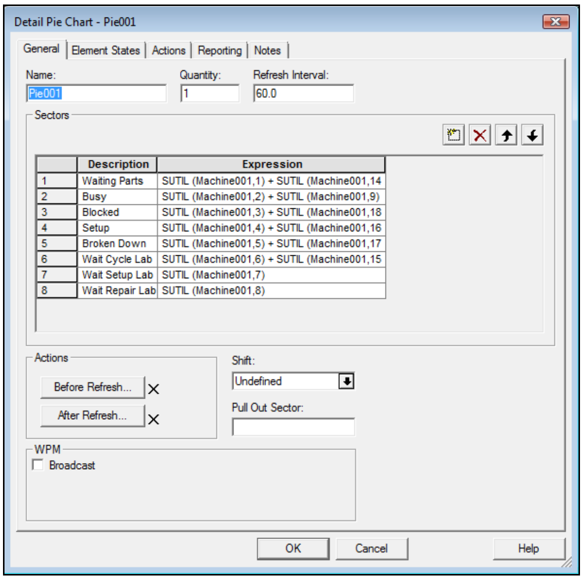


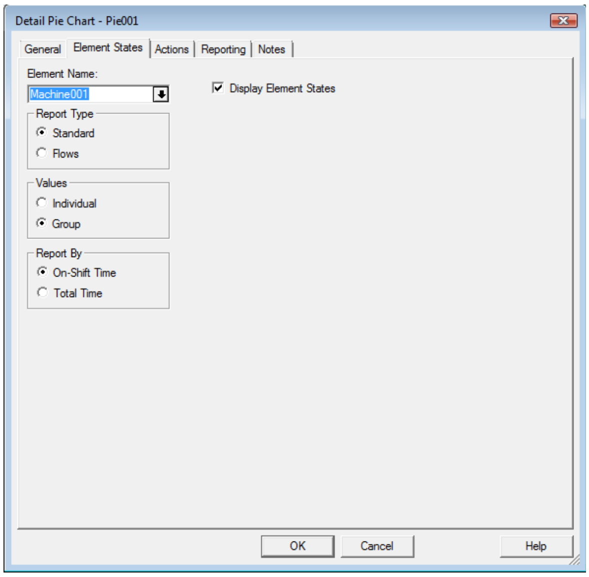
Display Item	Description
Name	You can choose a font and color to display the name.
Title	Display a title for a module or a pie chart. Select the font and color of the text.
Sectors	You can only use this option if you have already defined sectors for the pie chart on the pie chart's detail dialog. Select sectors and click on the draw button in order to display the sectors dialog. You can amend the size of the pie chart's display by clicking in the modeling window, then dragging the cursor until the pie chart reaches the required size.
Tilt	The cursor changes into a cross-hair. You can now click on a pie chart in order to tilt it. Once a pie chart is tilted you can also use the depth display bar option.
Depth	You can only use this option for tilted pie charts. Select depth and click on the draw button. The cursor changes into a cross-hair. Click on a pie chart and drag the pie chart in order to give it depth.
Start Angle	The cursor changes into a cross-hair. You can now click on the pie chart and drag the cursor in order to determine the angle at which the pie chart's first sector starts.

Display Item	Description
Pull Out Sector	You can only use this option if you have already specified a pull out sector on the pie chart's detail dialog. Select pull out sector and click on the draw button. The cursor changes into a cross-hair. Click the pulled out sector and drag the segment to the required position.
Notes	If you have entered notes already for an element on its detail dialog, you can display them using this display item.
Expression	As for other elements.
Rectangle	As for other elements.
Ellipse	As for other elements.
Line	As for other elements.
Icon	Display an icon that represents the element.
Text	As for other elements.

Detailing a Pie Chart

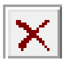
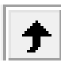
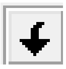
There are two main tabs in the detailing of a pie chart; one is used for defining a user defined pie chart, while the other allows the creation of an element utilization pie chart e.g. a machine's utilization.





Pie Chart General Tab

To define sectors of the pie chart click on the Add button, a new row will appear in the sectors list. Fill in the details in this sectors list to determine what is charted e.g. the Name "WIP A" and the expression NWIP(PartA) would create a sector called WIP A that would show the number of Parts of Type PartA that are in the model.

Data Item	Description
Name	The pie chart's name, as entered on the Define dialog
Quantity	The number of identical pie charts, up to 999.
Refresh interval	The amount of time that elapses between pie chart updates.
Sectors	The sectors of a pie chart reflect different characteristics of the item that the pie chart is reporting on (for example: an element, a group of elements or data).
Add 	Click the add button to add a sector to the pie chart.
Delete 	Click the delete button to remove a sector from it.
Move Up 	Moves the selected sector up in the list
Move Down 	Moves the selected sector down in the list
Actions Before refresh	Displays the actions editor, which allows you to specify actions that WITNESS executes before the pie chart is updated.
Actions After refresh	Displays the actions editor, which allows you to specify actions that WITNESS executes after the pie chart is updated.
Shift	Displays the select element dialog, which allows you to select a previously defined shift to assign the pie chart to. If the pie chart is assigned to a shift, readings displayed on the pie chart are only taken during on-shift time.
Pull out sector	You can identify one pull-out sector that WITNESS displays as slightly pulled out from the rest of the pie chart. This is useful for emphasizing a particular aspect.

Pie Chart Element States Tab

The element states tab is a short cut to display pie charts of element utilizations, To use this functionality check the Display Element States tick box which will un-gray the element selection box. Click on the down arrow, and double click on the element that you wish to display in the pie chart. If you return to the General Tab you will see that all of the sectors have been defined and detailed for you.

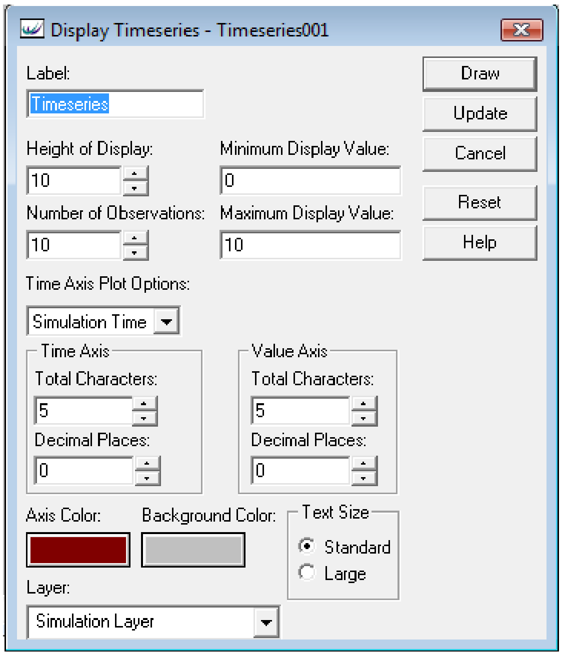
Data Item	Description
Display Element States	Check this box if you want to create a pie chart that shows the amount of time that a particular element spent in each state. WITNESS enters expressions for each sector automatically.
Element name	Enter the name of the element that the pie chart is reporting on. Alternatively, click on the arrow next to the field to display the select element dialog and double-click on the element that the pie chart reports on.
Report type	**Standard** - You can use standard reports for all elements. The description drop list on the pie chart general page lists the states of the individual element that the pie chart will report on. **Flows** - You can only use flows reports for tanks, processors and pipes. The description drop list on the pie chart general page lists the states of the individual element that the pie chart will report on.
Values	Individual - If the quantity of the element is greater than 1, WITNESS displays the values for each element on individual pie charts (that is, if there is an element with a quantity of 5, there are 5 pie charts). Group - if there is an element with a quantity of 5, one pie chart reports on all of them).
Report by	On-shift time - The pie chart only reports on the element while it is on-shift. Note that if you base pie charts on on-shift time, the percentages shown in the pie charts may add up to more than 100%. Total time - The pie chart reports on the element while it is on-shift or off-shift (that is, by total simulation time).

Timeseries

A timeseries is a graphical element that presents simulation results in the form of a graph that plots values taken from the simulation against time. The vertical Y axis represents values, and the horizontal X axis represents time. Timeseries are useful for determining the trends or cycles that underlie the model, since they provide a history of the specified value as well as a static mean and standard deviation.

Displaying a Timeseries

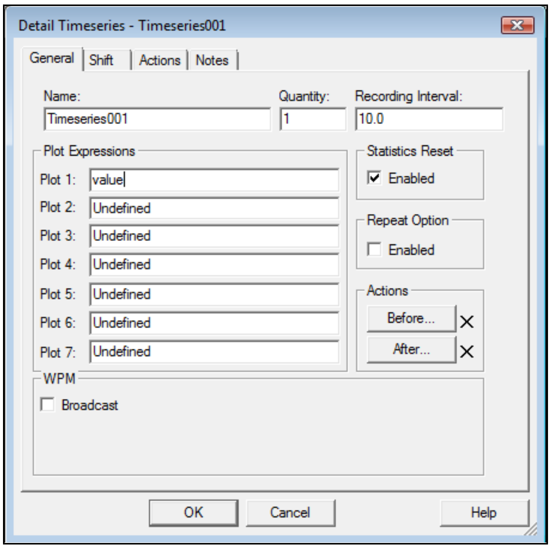
A timeseries has many of the same display options as other elements, which are drawn in the same way, so the Display of the actual timeseries will be shown here, the display dialogue for the Timeseries display item is shown below.



Field Name	Description
Label	Identifier of the display item, allows multiple display items to be identified.
Height of Display	The number of sections that the Timeseries will have on the Y-axis.
Number of Observations	The number of points that the Timeseries will have on the X-axis.
Minimum Display Value	Minimum value displayed on Y-axis
Maximum Display Value	Maximum value displayed on Y-axis

Field Name	Description
Time Axis Plot Options	**Simulation Time** – plots the actual time from the simulation clock. **Expression** – any numerical expression which is evaluated at the plot time for the Timeseries. **24 hour day** – takes the time the simulation clock and works out the hour based on a 24 hour clock. **12 hour day** – takes the time the simulation clock and works out the hour based on a 12 hour clock. **8 hour day** – takes the time the simulation clock and works out the hour based on a 8 hour clock. i.e. 00:00 to 07:00 **Hours** – works out the number of hours that the simulation has run.
Time Axis – Total Characters	How many characters are displayed on the axis, including the decimal point, on the X-axis.
Time Axis – Decimal places	How many numbers there are after the decimal point on the X-axis.
Value Axis - Total Characters	How many characters are displayed on the axis, including the decimal point, on the X-axis.
Value Axis – Decimal places	How many numbers there are after the decimal point on the X-axis.
Axis Color	The color that the Axis will be displayed
Background Color	The background color of the timeseries.
Text Size	There is a choice of large or small text.
Layer	Which layer should the timeseries be displayed on.

Detailing a Timeseries



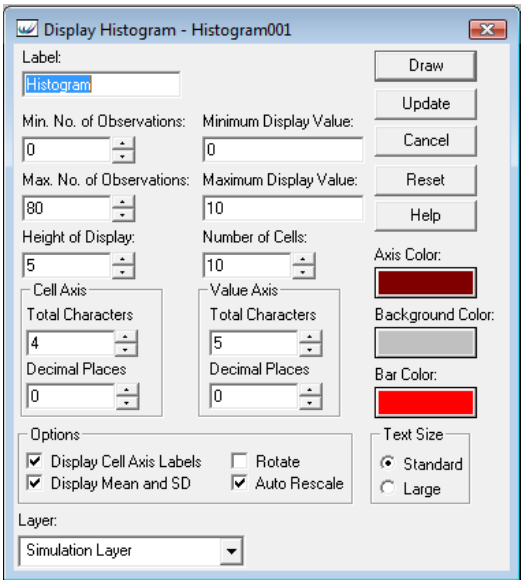
Data Item	Description
Name	The timeseries' name, as entered on the Define dialog.
Quantity	The number of identical timeseries, up to 999.
Recording interval	The amount of time that elapses between each recording.
Plot expressions	You can enter 7 expressions in the input fields, which determine the recording criteria of the timeseries. If a field is set to undefined, the expression in that field will not be stored or plotted. If you have enabled the repeat option, only the first plot expression is displayed.
Statistics reset	Check this box to reset the timeseries each time that WITNESS generates a periodic statistical report.
Repeat option	Check this box if you want to display the maximum (green), mean (red) and minimum (blue) plots for an expression. If the repeat option is enabled, the detail timeseries dialog only displays the first plot expression. Note that during the first plotting period the timeseries will only display one plot as several periods are needed in order to generate minimum, mean and maximum values.

Data Item	Description
Actions	Use the before and after options to display the actions editor, which allows you to specify actions that WITNESS executes before and after the set of plot expressions are evaluated. The order of execution is: 1. For each timeseries of this name(N = 1...Quantity) 2. For each plot in the timeseries(M= 1..7) If plot expression is defined Run actions BEFORE. 3. Evaluate the expression Run actions AFTER observation 4. Next plot 5. Update timeseries display 6. Next Timeseries This means that the actions will not be executed if there are no plot values. Note that you can use the WITNESS system variables N and M in the actions to determine the timeseries index and plot number respectively. (M=1 is the first Plot and M=7 is the last)

Histogram

A histogram is a graphical element that presents results in the simulation window in the form of a bar chart. A histogram is a Passive element (does not actively get data), so you need to record values in histograms by using the RECORD, DRAWBAR or ADDBAR actions at appropriate points in your model.

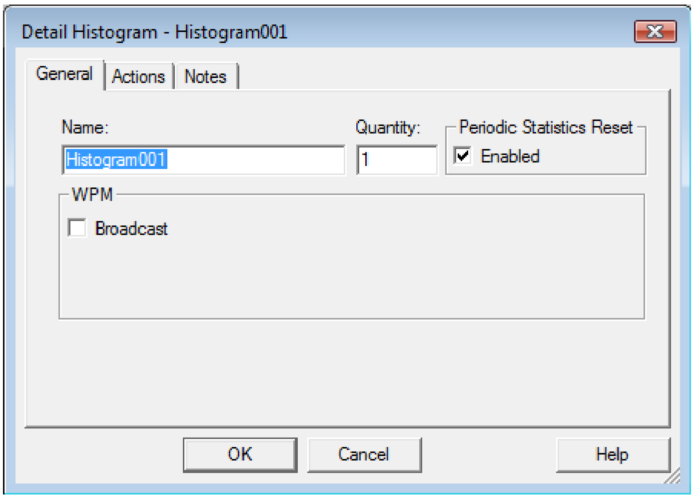
Displaying a Histogram



Display Field	Description
Label	Identifier for the histogram display
Min No of Observations	The minimum value of the Y-axis
Min No of Observations	The maximum value of the Y-axis
Height of display	The number of sections on the Y-axis
Minimum Display Value	The minimum value of the X-axis
Maximum Display Value	The maximum value of the X-axis
Number of Cells	The number of Buckets on the X-axis
Cell Axis – Total Characters	How many characters are displayed on the axis, including the decimal point, on the X-axis.
Cell Axis – Decimal Places	How many numbers there are after the decimal point on the X-axis.
Value Axis – Total Characters	How many characters are displayed on the axis, including the decimal point, on the Y-axis.
Value Axis – Decimal Places	How many numbers there are after the decimal point on the Y-axis.
Axis Color	The color that the Axis will be displayed
Background Color	The background color of the timeseries.
Text Size	There is a choice of large or small text.
Display cell axis Labels	Un-checking this box removes the labels from the X-axis.
Display Mean & SD	Un-checking this box will remove the display of the mean and standard deviation.
Rotate	Rotates the chart so that the axis are switch i.e. rotates the chart by 90 degrees
Auto Rescale	When checked the observation axis will automatically rescale to fit the number of observations when one “bucket” reaches the maximum observations.
Layer	Which layer should the timeseries be displayed on.

Detailing a Histogram

As a Histogram is "passive" there is little detail to enter. Name, Quantity and whether or not the statistics are reset are the only options.



Recording a value to a histogram is done using the Record action in an appropriate actions box i.e. recording the repair time of OP10 to a histogram in the actions on resume of OP10. The code below gives the syntax.

```
Record repairVar in HisogramRep
```

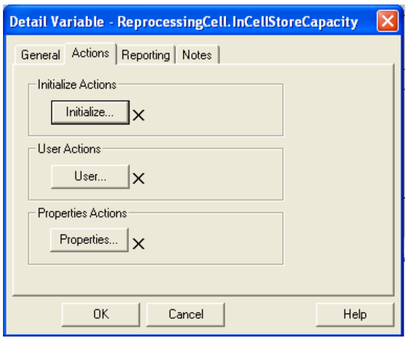
This will record the value of repairVar in the histogram called HistogramRep.

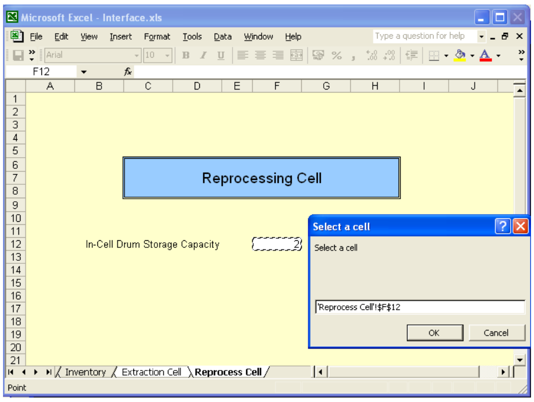
Data Import and Export

The value of WITNESS can be significantly improved by linking its use to an Excel as a repository for data and results of running a model. The benefits of this are both in terms of ease of use and in the breadth of analysis and reporting that can be achieved.

Data Import Using the Wizard to Read Variables.

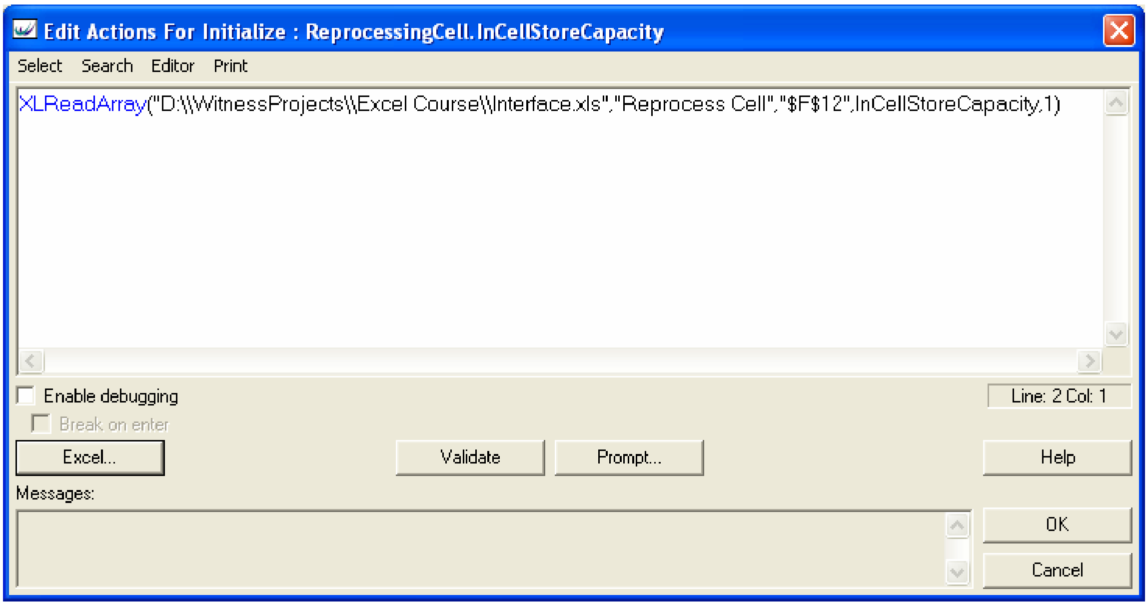
WITNESS variables may be read in from a cell or range in an Excel spreadsheet. WITNESS provides a basic wizard to help with this and this can provide a prototype for further reads from the spreadsheet.
To use the wizard bring up the Variables detail dialog and select the Actions tab. Click on the Initialize… button.





On the Edit Actions form click on the Excel… button. This will bring up a file selector form to select the workbook for input. Select the required workbook, and sheet where the data has been stored, then select the cell.

This will then return you to the Edit Actions form which should look like this:



Data Import Using the XLReadArray Function

The **XLReadArray** function has syntax as follows;

XLReadArray(WorkbookName,WorksheetName,Range,VariableName,FirstDimIsRow)

This function reads a range of values from an Excel spreadsheet into an array variable. The function returns an integer value of 1 (if it reads the values from the spreadsheet into the array successfully) or 0 (if it cannot read the values into the array).

Parameters	***Parameter data type***
WorkbookName	***String***
WorksheetName	***String***
Range	***String***
VariableName	***Name***
FirstDimIsRow	***Integer***

WorkbookName: The path of the spreadsheet's workbook that contains the cells that you want to access.

WorksheetName: The name of the sheet that contains the cells that you want to access.

Range: The name of the range. A range consists of a block of 1 or more cells on a worksheet; the range name usually contains the cells at the top left and bottom right corners of the block (for example: A1:F10).

VariableName: The name of a WITNESS variable that you have already defined in WITNESS.

FirstDimIsRow: If this parameter is 1 then the array Var(N1,N2) will be read as N1 rows and N2 columns in Excel.

If this parameter is 0 then the array Var(N1,N2) will be read as N2 rows and N1 columns in Excel.

If this parameter is set to any value other than 0 or 1, WITNESS treats that value as if it were 1.

If this parameter is omitted WITNESS treats this value as 0.

When to Read External Data into Variables.

The most efficient way to import data from Excel into WITNESS variables is at the start of a model run. The data may then be used in expressions (such as cycle times). However, it is possible to link at any point in a run using one of the many functions available. As an example, WITNESS could access Excel every time a breakdown occurs to find data to allow it to evaluate the repair time duration.

It is recommended that Excel functions are only embedded in expressions if the values taken from Excel change during a model run, because of the incremental delays that can be caused by the frequency of communication.

Where the WITNESS wizard provides a good prototype it is strongly recommended that all variables are read as part of Model/Initialize Actions or from functions called from within it. This gives explicit control of the order in which variables are read which may be vital.

Data Range Issues in Excel.

The method of defining the range to be read used above has a potential drawback during the period of model and spreadsheet development. It often happens that additional rows and columns need to be added to the spreadsheet or that ranges need to be extended to include additional data items. This can cause significant maintenance problems with the model as the read range may no longer be correct. It is recommended that named ranges be adopted in the spreadsheet. These will then "move" as rows and columns are added.

A further recommendation is that the name of the range in Excel should be the same as the WITNESS variable being read. This should aid in validating that the correct data is read.

Data Export Using XLWriteArray Function

In WITNESS output to spreadsheet is very much just the opposite of input from spreadsheet. The functions used are very similar. The most commonly used output function is XLWriteArray. Its parameters are the same as **XLReadArray;**

XLWriteArray(WorkbookName, WorksheetName, Range, WitnessVariableName , FirstDimIsRow)

This function writes a range of values from an array variable into an Excel spreadsheet. The function returns an integer value of 1 (if it writes the range of values into the spreadsheet successfully) or 0 (if it cannot write the range to the spreadsheet).

Parameters	**Parameter data type**
WorkbookName	String
WorksheetName	String
Range	String
WitnessVariableName	Name
FirstDimIsRow	Integer

WorkbookName: The path of the workbook that contains the cell that you want to access.

WorksheetName: The name of the sheet that contains the cell that you want to access.

Range: The name of the range. A range consists of a block of 1 or more cells on a worksheet; the range name usually contains the cells at the top left and bottom right corners of the block (for example: A1:F10).

WitnessVariableName: name of a WITNESS variable that you have already defined in WITNESS.

FirstDimIsRow: If this parameter is 1 then the array Var(N1,N2) will be written as N1 rows and N2 columns in Excel.

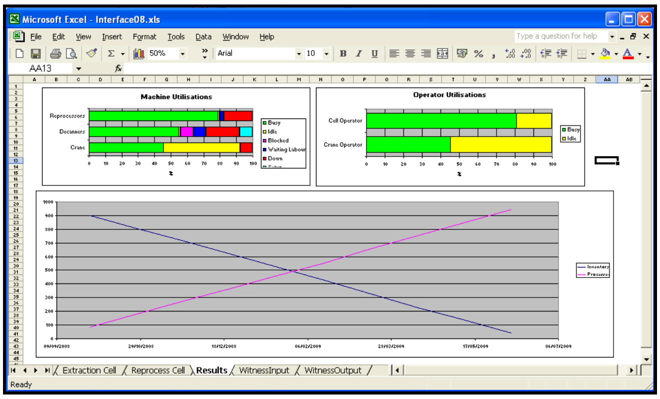
If this parameter is 0 then the array Var(N1,N2) will be written as N2 rows and N1 columns in Excel.

If this parameter is set to any value other than 0 or 1, WITNESS treats that value as if it were 1.

If this parameter is omitted WITNESS treats this value as 0.

Graphical Reporting in Excel

Results written to an Excel sheet can easily be used to provide graphical reporting in Excel, This is done by simply referencing the appropriate cells in the Excel charts.



Clearing Old Results in the Spreadsheet

If you write out results to Excel at the end of a run it is important that the results are is cleared at the beginning of the run. If the run stops for any reason you will be left with old results which have not been overwritten and this may be overlooked. WITNESS provides the **XLClearContents** function to do this;

XLClearContents(WorkbookName, WorksheetName, Range)

This function clears the contents of the specified range on an Excel spreadsheet. The function returns an integer value of 1 (if the range has been cleared successfully) or 0 (if the range cannot be cleared).

Parameters	**Parameter data type**
WorkbookName	String
WorksheetName	String
range	String

WorkbookName: The path of the spreadsheet's workbook that contains the range that you want to access.

WorksheetName: The name of the sheet that contains the range that you want to access.

Cell: The reference to the range to be cleared.

Benefits of Using Excel

A very important advantage of using an Excel "front-end" to a WITNESS model is how this can be tailored to make data entry easier for users who are unfamiliar with WITNESS but who have a great understanding of the system being modelled. Data entry can be supported with schematics and explanation and entry fields can be validated to ensure data is of the correct type and within allowed ranges. Command Buttons can be added to make navigation easier. This example just takes you to the Inventory sheet. This has been added using the Forms toolbar and attaching a macro to take you to the inventory sheet.

Useful Functions for Model Configuration

The following functions can be used to amend the model at initialize.

Function	Function syntax	Action of Function
Set Quantity	**Set Quantity** of ***Elementname*** to ***value***	Sets the quantity of the element to the value. This does not work for labor.
Set Quantity Labor	**Set Quantity Labor** of ***Elementname*** to ***value***	Sets the quantity of the Labor element to the value.
Set Capacity	**Set Capacity of** ***Elementname*** to ***Value***	Sets the capacity of the buffer Elementname to value. Only applicable to buffers.

Useful Programming Constructs

Although WITNESS has its own programming language, the basic constructs that are used follow the same structure as in other languages.

The For.. Next Loop

The For Next Loop is used to repeat a sequence of code a number of times. Several examples are shown below.

```
For Loop = 1 to 4
Print "hello", Loop
Next
```

The above code (where Loop is an integer variable defined by the User) would Print the text below to the interact box.

Hello 1
Hello 2
Hello 3
Hello 4

The loop variable can also be used within the "body" of the loop to change the actions that are carried out, particularly when used with multiple quantity variables. See below..

```
For Loop = 1 to 4
Print "Hello", Stringvar(loop)
Next
```

The code above would print the text below to the interact box (assuming that the Stringvar variable had been set to the appropriate values elsewhere in the model).

Hello Mike
Hello John
Hello Fred
Hello Pete

While .. Wend Loop

The While Loop is used when you wish to repeat some code until a condition is met, e.g. a particular value of a variable is no longer 1. NOTE be careful with this type of loop as it is easy to program a while loop that will never be exited, if this does happen try pressing CTRL – Q.

```
Var1=20
While Var1 <> 0
print Var1
Var1=Var1-5
Wend
```

The Code above would print the text below to the interact box (<> means not equal to).

```
20
15
10
5
```

Stop

The STOP command stops the simulation run at the current simulated time. It has the same effect as selecting the stop button ■ in the run toolbar.
Typically, you would use the STOP command when an emergency occurs (for example, a file error from which it is impossible to recover). It is helpful to use the PRINT action to indicate the reason for aborting the run before using this action.

Note: WITNESS stops the execution of actions automatically when it reaches the last line of an action block. However, if WITNESS is in the middle of executing a sequence of actions, the STOP command does not stop the execution of those actions immediately. If you want the execution of actions to stop immediately, use the RETURN action after the STOP command.

Other Course Offerings from Lanner

Lanner Group also offers the following courses to supplement the Basic Training course.

- Optimizer (1 Day)
- Virtual Reality (2 Days)
- Continuous Elements (1 Day)
- Tracks and Vehicles (1 Day)
- Using WITNESS with Excel (1 Day)
- Scenario Manager (1 Day)
- Witness Awareness (2 Days)

Appendix – Reference Material

Input/output rules

WAIT
Entities or items will wait until they are pulled from or pushed to another element.

PUSH
Entities or vehicles are sent to the first available element in a preferred order list which is capable of accepting them. Examples:
PUSH to m1,m2,m3
PUSH a to m1, b to m2

PULL
Entities are taken from the first available element in a preferred order list which is capable of supplying them. Examples:
PULL from m1, m2, m3
PULL a from m1, b from m2

LEAST
Entities or items are sent to (or taken from) the element with the least entities, items or free capacity. Examples:
LEAST PARTS m1,m2
LEAST FREE m2(1),m2(2),m2(5)
LEAST FLUID t1(2),t2 VOLUME 6 RATE 2

MOST
Entities or items are sent to (or taken from) the element with the most entities, items or free capacity. Examples:
MOST FREE act3,act4
MOST FLUID pr1,pr2 RATE 34
MOST FLUID s2,s3,s4 VOLUME 10 RATE 5

MATCH
Entities or resource are matched on an activity according to a condition, attribute or any Entity/Resource selection. You can also MATCH entities to load onto a vehicle. Examples:
MATCH/ATTRIBUTE ATT1 a#(1) and b#(1)
MATCH/ANY (a#(1) AND b#(2)) OR c#(3)
MATCH/CONDITION (ATT2 = 5) buf1#(2)
MATCH/CONDITION SKILL>5 ResA#(1) OR ResB#(1)

PERCENT
Entities or vehicles are sent to (or taken from) several elements on a random percentage basis. Example:

PERCENT /3 a1 2.5, a2 97.5

SEQUENCE
Entities or vehicles are sent to (or taken from) several elements, in a cyclic sequence. Examples:
SEQUENCE /WAIT act1#(3), act2#(5)
SEQUENCE /NEXT act2#(3), act4#(1)

SELECT
Entities or vehicles are sent to (or taken from) several elements, according to an integer value. Example:
SELECT on X act1,act2,act3

IF
Route to or obtain from an element, if certain conditions for the element are true. Example:

```
IF NPARTS(act1) > 5
        PUSH to act2
ELSEIF NPARTS(act1)=5
        PUSH to act3
ELSE
        WAIT
ENDIF
```

BUFFER
Adds a dedicated input or output queue to an activity that previously had no queue. Example:
BUFFER (5)

Attributes

Standard attributes

TYPE(N) Name of the part or labor.
DESC(S) Character description of the part or labor.
PEN(I) Color of the part or labor (code number).
ICON(I) Icon of the part or labor (code number).

Routing-related attributes

STAGE(I) Number of the current part route destination in the route.
NSTAGE(I) Total number of part route stages.
R_CYCLE(R)The cycle time for the current element.
R_SETUP(R)The setup time for the current element.

Machine-related attributes

LaborElement Contains the name of the labor element that will be allocated to a machine or (if the labor has already been allocated) the name of the labor element that will be released from a machine.

Changing an attribute's value remotely

To change the value of a part, carrier, vehicle or machine attribute (for example, from another element's detail dialog or from the model's Initial or User Actions) use the following syntax in an action:

Element {***AT position***} : **attributename** = ***Value***

If a part is not present at the specified position or the part does not have the specified attribute, an error message is displayed. For parts, position 1 is the front of the element that the part is in, position 2 is the second position and so on. Position 0 is the rear of the element. If you do not specify a position, WITNESS assumes position 1. For carriers, vehicles and machines, specify 0 to change the value of the carrier's (or vehicle's or machine's) attribute, or 1 to change the value of the attribute of the part in the carrier (or vehicle or machine). Machines can contain more than 1 part, so position 2 changes the attributes of the second part in the machine, and so on.

You cannot change a labor unit's attribute value directly from its own detail dialog; you can only change it via actions on another element's detail dialog, or via actions elsewhere in the model (such as Initial or User Actions).

For specific instances of labor at machines, conveyors, tanks, processors or pipes the system function LABORAT may be used.

System variables

TIME (R)	Current simulation clock value.
I (I)	Index value of the current vehicle.
M (I)	Batch or lot number of the current part, or the current timeseries observation number.
N (I)	Index value of the current element.
VTYPE (N)	Type of current vehicle.
ELEMENT (N)	The name of the current element.

Distributions

(Parameters are shown in italic type).

BETA (R)(shape (R), scale (R), stream (I), substream(I))
Beta distribution.

BINOMIAL (I)(probability (R), trials (I), stream (I), substream(I))
Binomial distribution.

ERLANG (R)(mean (R), K value (I), stream (I), substream(I))
Erlang K distribution.

GAMMA (R)(shape (R), scale (R), stream (I), substream(I))
Gamma distribution.

IUNIFORM (I) (minimum (I), maximum (I), stream (I), substream(I))
Integer Uniform distribution.

LOGNORML (R)(mean(R), std_deviation(R), stream (I), substream(I))
Log Normal distribution.

NEGEXP (R)(mean (R), stream (I), substream(I))
Negative Exponential distribution.

NORMAL (R)(mean (R), std_deviation (R), stream (I), substream(I))
Normal distribution.

POISSON (I) (mean (I), stream (I), substream(I))
Poisson distribution.

RANDOM (R)(stream (I), substream(I))
Uniform 0.0 - 1.0 distribution.

TNORMAL (R)(mean(R), std_deviation(R), minimum(R), maximum(R), stream(I))
Truncated Normal distribution.

TRIANGLE (R)(min (R), mode (R), max (R), stream (I))
Triangular distribution.

UNIFORM (R)(minimum (R), maximum (R), stream (I))
Uniform distribution.

WEIBULL (R)(shape (R), scale (R), stream (I))
Weibull distribution.