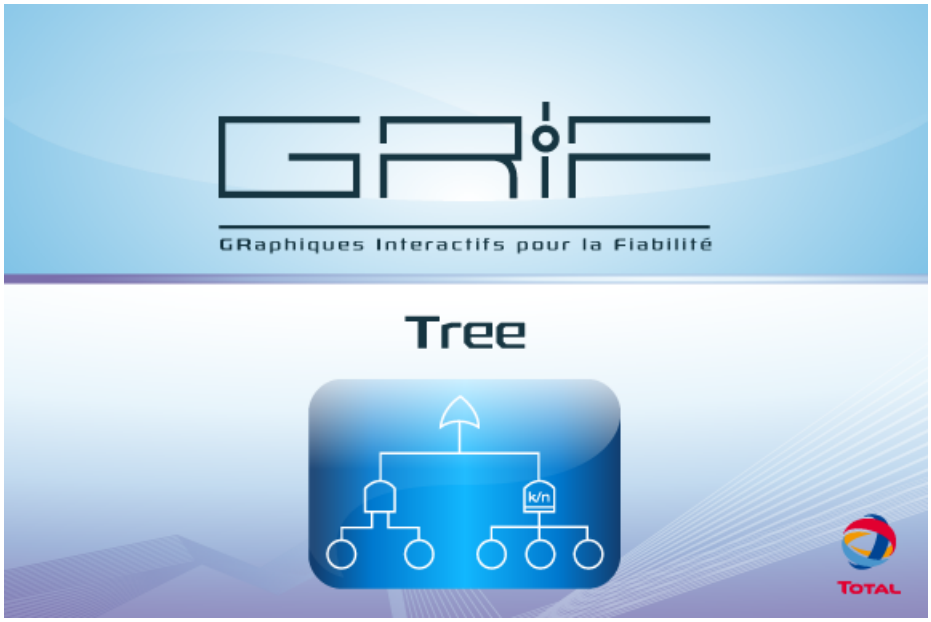
GRIF 2011

Fault Tree



User Manual

Version 31 January 2011

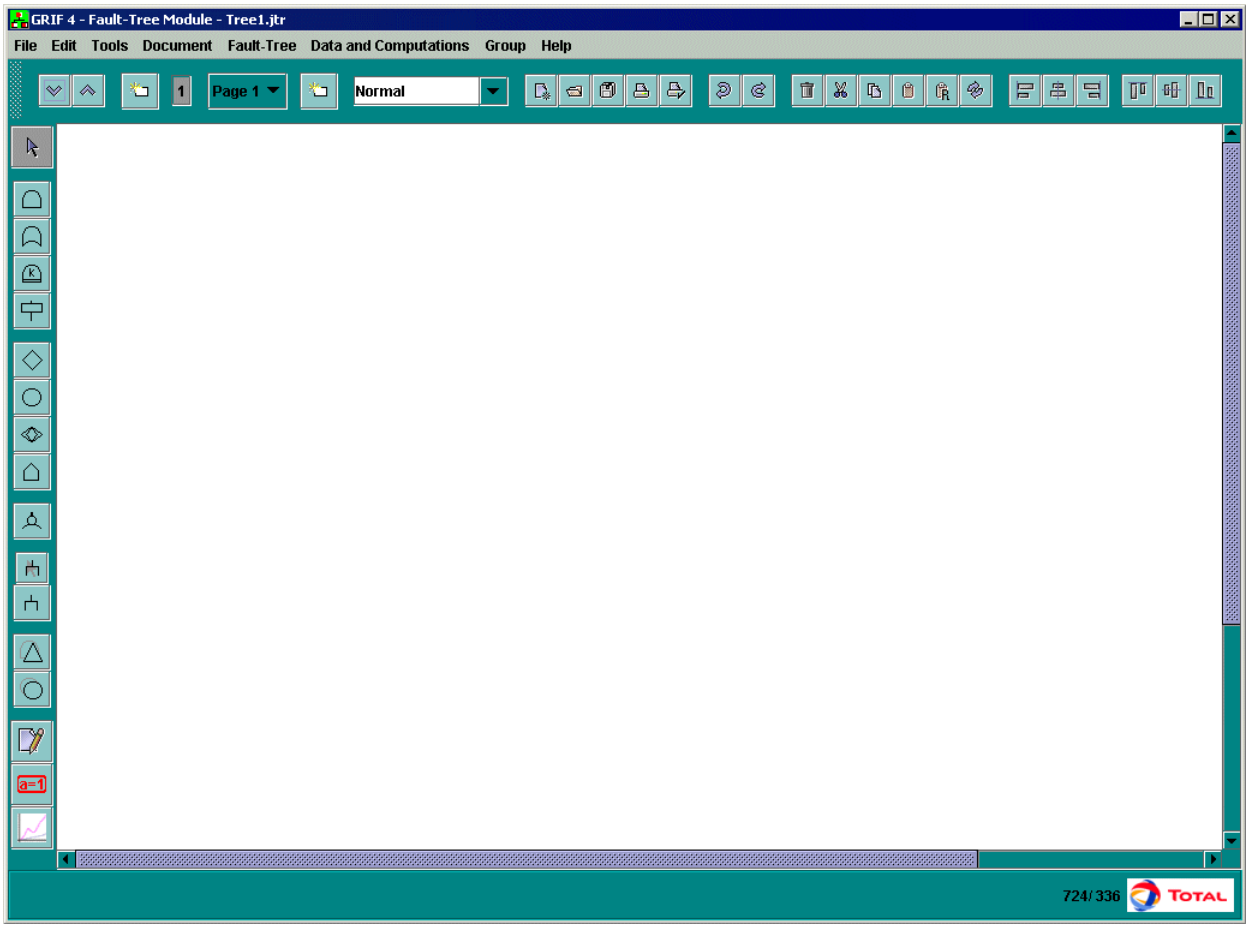
Table of Contents

1. Presentation of the interface

1.1. Main window of the Fault Tree module

The main window is divided into several parts:

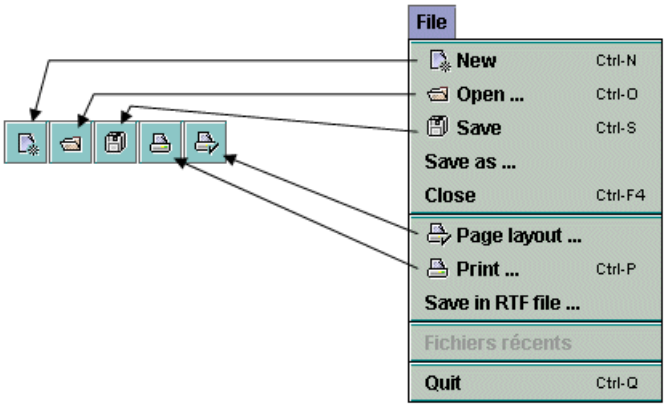
- **Title bar**: The title bar shows the names of the module and file being edited.
- **Menu bar**: The menu bar gives access to all the application's functions.
- **Icon bar (shortcuts)**: The shortcut bar is an icon bar (horizontal) which gives faster access to the most common functions.
- **Tool bar**: The tool bar (vertical) allows you to select the elements for modeling.
- **Input zone**: A maximum amount of space has been left for the graphical input zone for creating the model.
- **Tree**: A tree is "hiden" between input zone and tool bar. It enables to walk through pages and groups of the document.
- **Set of tables**: Tables are gathered in "hiden" tabs on the right.



1.2. Description of the Menus

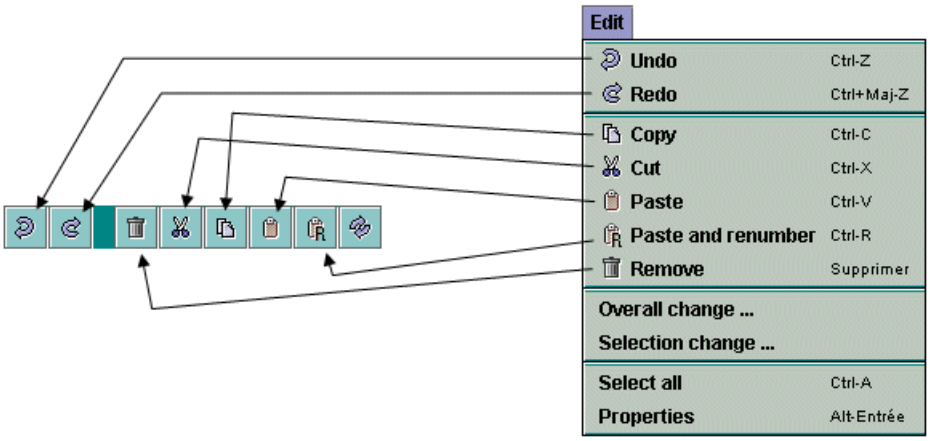
1. The **File** menu contains the standard commands used in this type of menu (open, close, save, print, etc.). The properties (name, creation date, created by, description, version) can be accessed and modified by selecting **Document properties**. The **Document statistics** provide information on the model's complexity. It is also possible to access a certain number (configurable) of recently modified files.

The icon bar just under the menus proposes shortcuts for most of the **File** commands:



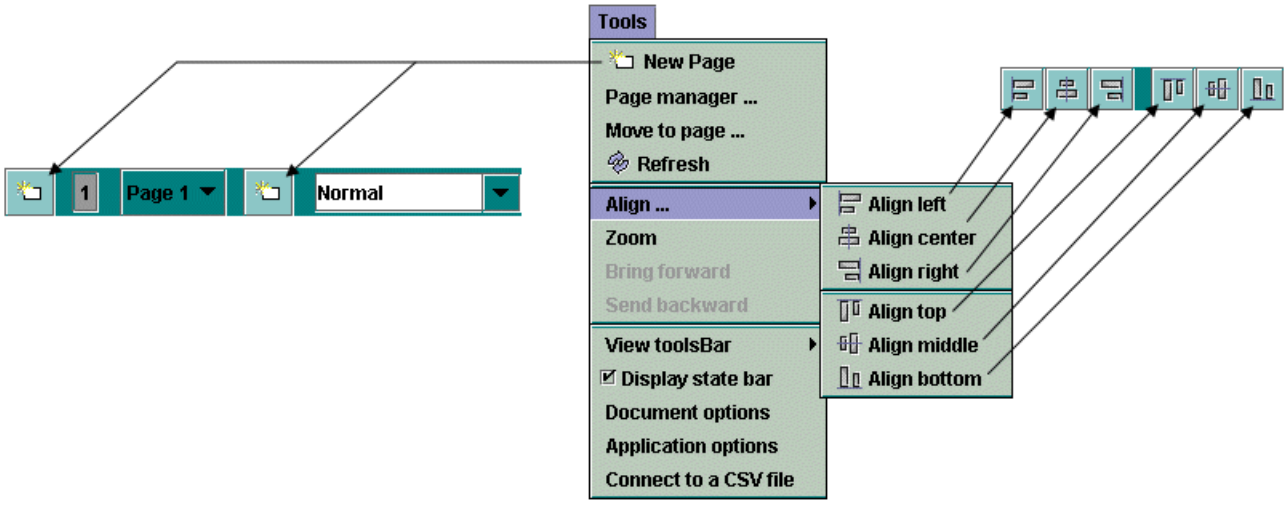
2. The **Edit** menu contains all the commands needed to edit the model being input graphically.

   The icon bar just under the menus proposes shortcuts for most of the **Edit** commands:

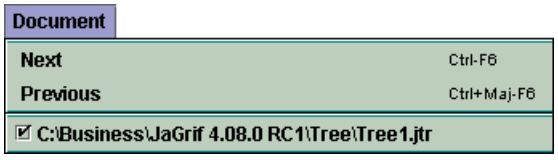


3. The **Tools** menu contains all the commands needed to manage the current model (page management, alignments, options, etc.).

   The icon bar just under the menus proposes shortcuts for most of the **Tools** commands:

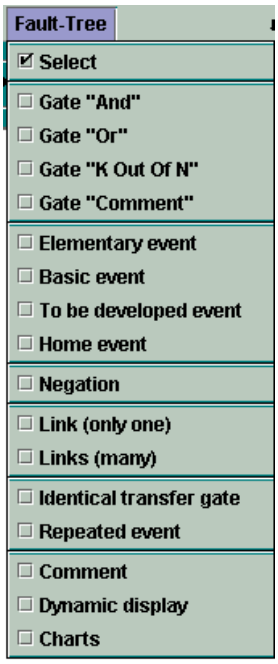


4. The **Document** menu gives access to all the documents being created or modified.

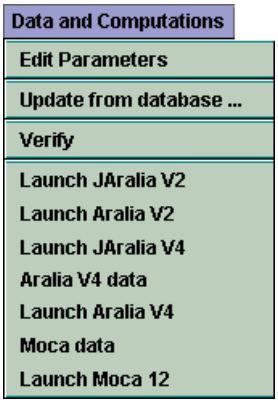


5. The **Fault Tree** menu contains all the commands needed to produce the graphical part of the current model.

   The vertical icon bar on the left of the application provides shortcuts for each of the **Fault Tree** commands (cf. vertical tool bar).



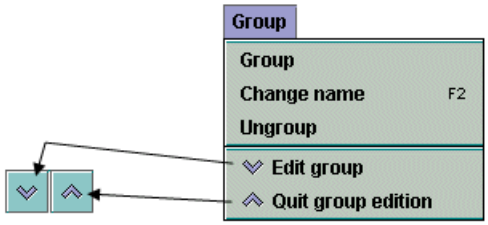
6. The **Data and Computations** menu is divided into two parts: data management (creation and management of the different parameters) and configuration/computation launch (computation time, desired computation, etc.)..



   NB: The **Verify** function detects any errors in the model: data without values (equal to **NaN**), events having the same name, etc.

7. The **Group** menu concerns the input and management of submodels grouped into independent subassemblies.

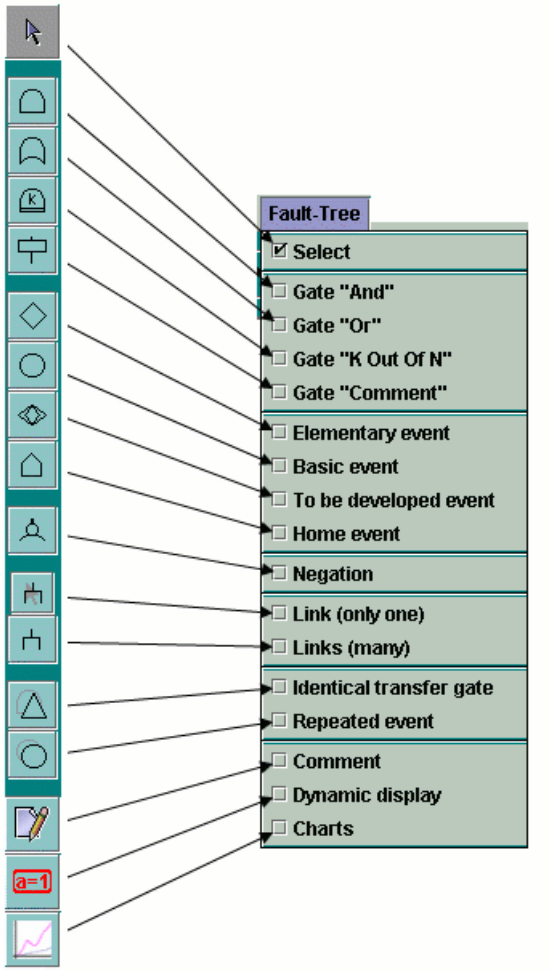
The icon bar just under the menus proposes shortcuts for two of the **Group** commands:



8. 9. Finally, the **Help** menu accesses the on-line Help, the Help topics and to "About".

1.3. Vertical toolbar

Each operating safety model has its own icons. All the graphical symbols for the fault trees are shown on the vertical icon bar on the left of the data input screen.



The vertical toolbar contains the following items:

- **Select** selects the desired elements.
- **"AND" gate** to add a logic gate of the type "AND" (represented by a flat-based geometrical figure).
- **"Or" gate** to add a logic gate of the type "OR" (represented by a curved-based geometrical figure).
- **"K out of N"** to add a logic gate of the type "K out of N" (represented by a geometrical figure with a double flat base).
- **"Comment" gate** to insert a block (represented by a rectangle) containing only comments in the model.
- **Elementary event** represented by a diamond shape.

- **Basic event** represented by a circle.
- **To be developed event** represented by two diamond shapes, one inside the other.
- **Home" event** represented by a shape vaguely resembling a house.
- **Negation** represented by a small circle.
- **Link (one only)** to create one connection (and only one) between an input (gate) and an output (gate or event).
- **Links (many)** to create connections between the inputs (gates) and the outputs (gates and events).
- **Identical transfer gate** represented by a triangle.
- **Repeated event** represented by a circle.
- **Comment** to add text directly to the graphic.
- **Dynamic display** to display the value of a model element.
- **Charts** to draw charts representing computations on the model.

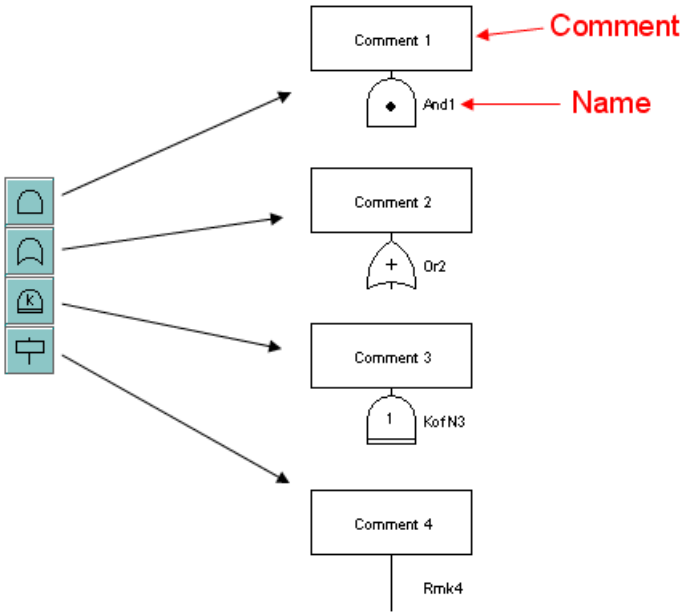
2. Creating a fault tree

2.1. Entering the tree

2.1.1. Entering gates

To enter the different **Gates**, select the corresponding symbol on the vertical toolbar. A new element is then created whenever you click right on the graphical entry area. Each of the model's gates has five parameters:

1. A **number**: These numbers are, with the type, the gates' true identifiers (those which will be used by the computation engine). That is why, when you wish to change the numbers of certain gates, you must remember that two gates cannot have an identical number. They are automatically incremented as new elements are created.
2. A **name**: It is a parameter which is defined automatically and which cannot be modified by the user. The name of each gate consists of its "type" followed by its "number" (e.g.: "And1" or "KofN3").
3. A **"K out of N" integer**: This field is only accessible in the case of **K out of N** gates. It allows you to choose the value of **K** (**K** equals 1 by default).
4. A **comment**: This field adds text inside the gate. This function makes the model more legible (by giving the specific features of these elements).
5. A **type**: When a gate has been created, its type can be modified to one of the five types available in the drop-down list.

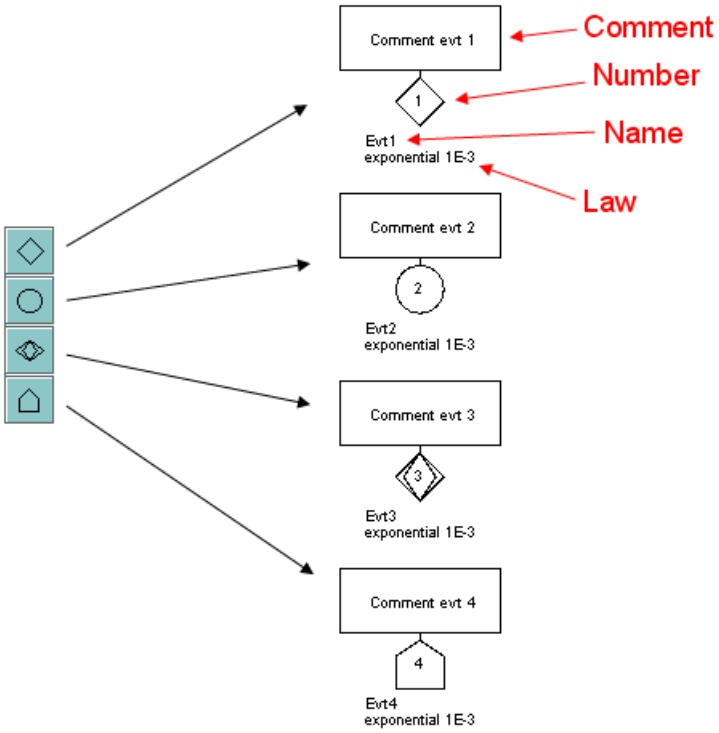


2.1.2. Entering events

To enter the model's **Events**, select the corresponding symbol on the vertical toolbar. A new element is then created whenever you click left on the graphical entry area. Each of the model's events has five parameters:

1. A **number**: These numbers are, with the type, the events' true identifiers (those used by the computation engine). That is why, when you wish to modify the numbers of certain events, you must remember that two events cannot have an identical number. They are automatically incremented as new elements are created.
2. A **name**: The default name assigned to the events is **Evti** for the "i" the element created. You are recommended to replace this name by something more mnemonic to increase the model's legibility.
3. A **comment**: This field adds text inside the event. This function increases the model's legibility (by giving the specific features of these elements).

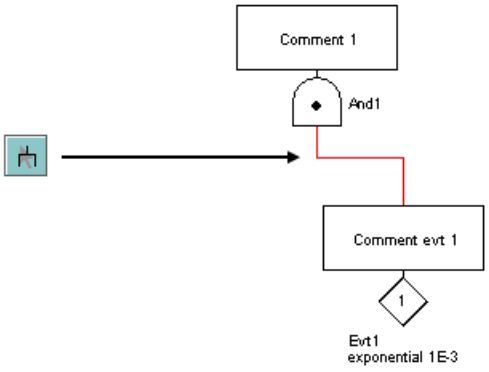
4. A **law**: This element is used to model the event's random aspect. You can choose from twenty-three laws which must then be configured (cf. detailed description of the laws later on in this document).
5. A **type**: When an event has been created, its type can be modified from the four types available in the drop-down list.



2.1.3. Entering links

When the gates and events have been created, they must be interconnected to establish the tree's logic. There are two possible types of connections: "gate -> gate" and "gate -> event" connections. To make a connection, proceed as follows:

1. Click the corresponding icon on the vertical toolbar.
2. Select the start gate by a click left on the specific zone (a dot for "AND" gates, a cross for "OR" gates, etc.) and keep the button pressed.
3. Move the mouse to the element to be connected.
4. Release the mouse button.



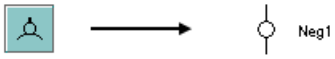
NB: The above icon only allows a single link to be created at a time. If you wish to create several links in succession without having to reselect the link creation icon each time, use the icon shown below: **Links (several)**.

2.1.4. NOT gate

It is a very specific gate which inverts the logic of the subtree which is downstream of it.

To insert a "Negation" in a tree, proceed as follows:

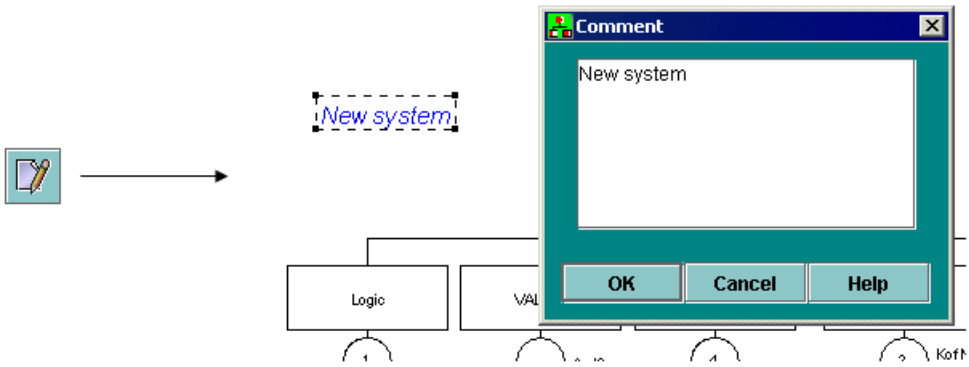
- change the type of an existing gate by using the drop down list;
- OR create a new a new gate with the type "Negation":
  1. Click left on the corresponding icon on the vertical toolbar.
  2. A new element will then be created whenever you click left on the graphical entry area.
  3. You then just have to configure and connect the "Negation" like a conventional gate: link the top part (above the circle) to the bottom part of a gate and link the bottom part (below the circle) to the top part of an event or gate.



2.1.5. Entering Comments

To add a comment anywhere on the chart, click the pencil icon and place yourself on a point in the graphical input zone. The **Comment** dialogue box opens where you can enter the desired comment.

Note: Character "%" is a reserved character, it must be type twice "%%" in order to display "%".



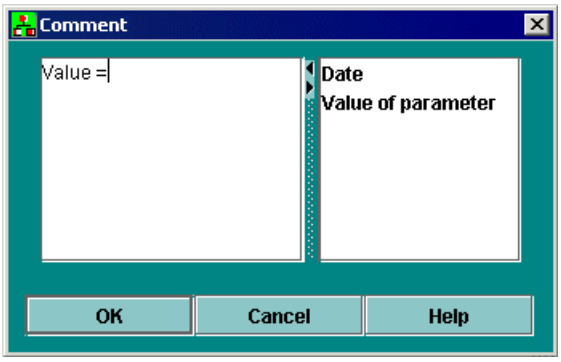
2.1.6. Dynamic fields

It may be useful to observe the change in the different parameters of the model. To do this, use dynamic fields by selecting the corresponding icon on the vertical tool bar:

The dynamic fields are a type of "improved comments". They can be used not only to enter words or phrases but also to insert model values.

- date;

- value of a parameter (you select the parameter from a drop-down list).

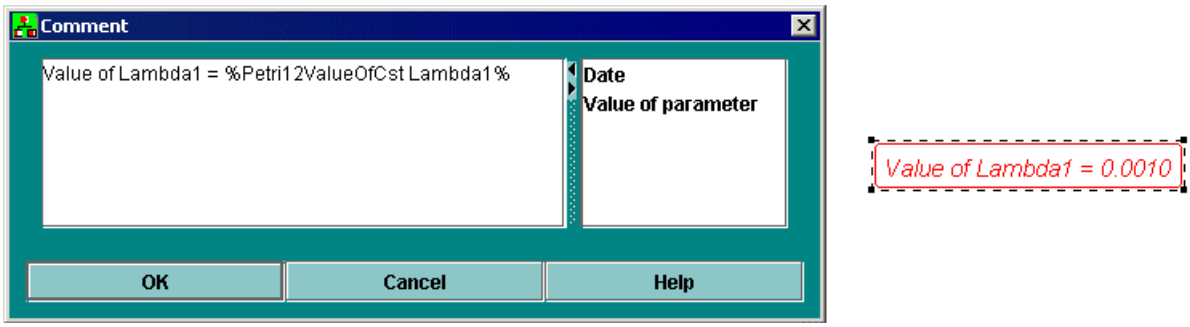


When you have made your choice from the five types of elements which it is possible to observe, a piece of code is inserted in the text part. This will give access to the parameter value. If the dynamic field inserted does not correspond to any of the model's elements (variable which no longer exists, place number not assigned, etc.) then the inscription **undef** is displayed.

Note: To differentiate them, the dynamic fields are displayed in red (unlike the comments which are displayed in blue).

Note2: Character "%" is a reserved character, it must be type twice "%%" in order to display "%".

Example of a dynamic field allowing the value of a parameter X to be observed:

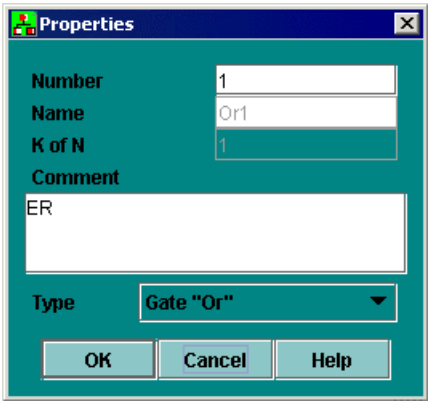


2.2. Configuring the elements

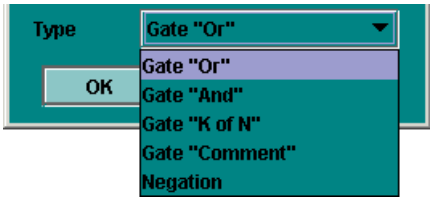
All the graphical elements can normally be edited with a double-click on them or using the **Edit - Properties** menu, or using the shortcut **Alt + Enter**.

2.2.1. Configuring the gates

When you click right on a gate, you can modify any parameter (except the name):

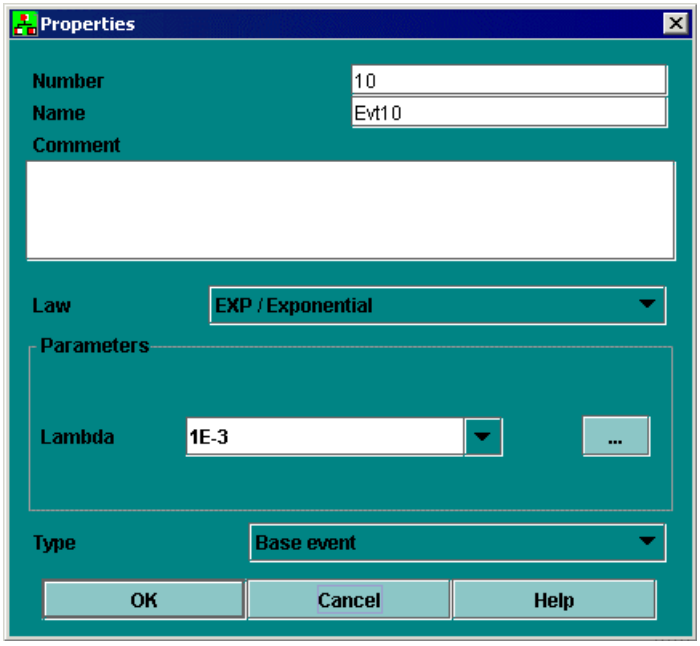


- change the **number**;
- specify the value of **K** if the gate is a "K out of N" type;
- read and/or modify the **comment** part;
- modify the type of gate to one of the five types available in the drop-down list:
  - "OR" gate: an "OR" type logic gate is applied to the elements connected downstream.
  - "AND" gate: an "AND" type logic is applied to the elements connected downstream.
  - "K of N": a "K of N" type logic is applied to the elements connected upstream.
  - "Comment" gate: this gate has no effect from the logic viewpoint and is only used to comment on the branch where it is located.
  - "NOT" gate: cf. above.

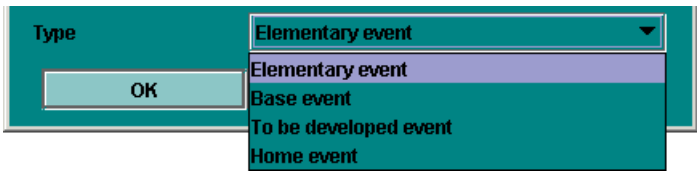


2.2.2. Configuring the events

When you click right on a gate, you can modify any parameter (except the name):



- to change the **number**;
- to enter the event **name**;
- to read and/or modify the **comment part**;
- to read and/or modify the law **governing** the event.
- to modify the type to one of the four available types in the drop-down list:
  - Elementary event;
  - Basic event;
  - To be developed event;
  - "Home" event.

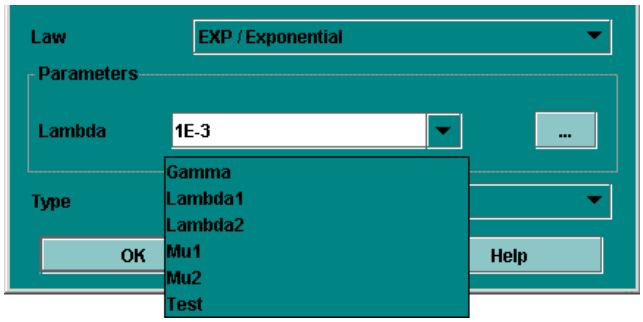


The names of these events simply have a "graphical" impact on the tree structure. There is no impact on the logic function which will be generated to perform the computations. The aim is simply to simplify re(reading) the fault tree

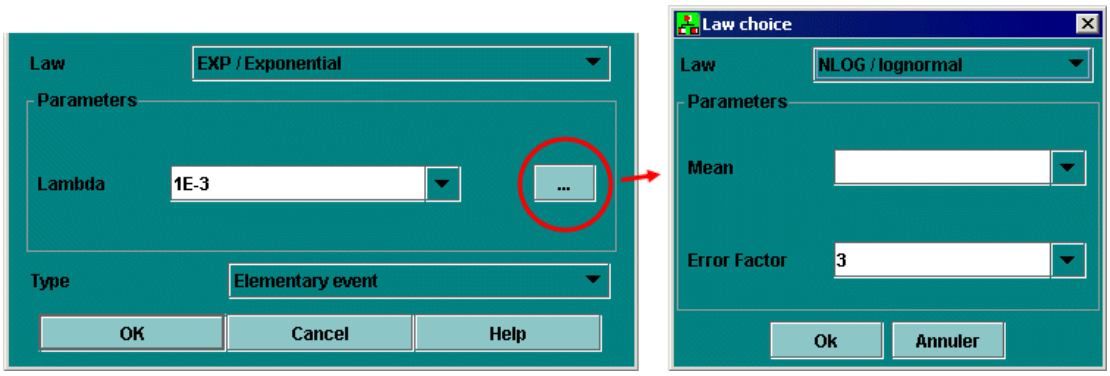
The law part is configured in several steps:

1. Choose the law from the twenty-three available in the drop-down list.

2. Configure the law (a drop-down list of the module's parameters is available for each field to be filled in).



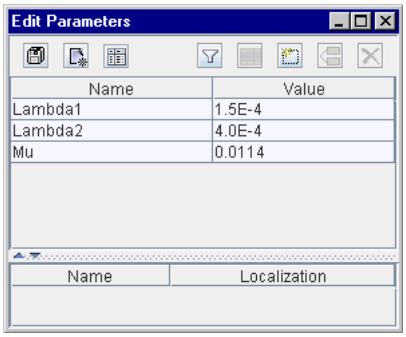
3. Uncertainty computations can be introduced for each of the parameters, with a choice of the law and of the corresponding parameters (cf. later on in this document: a detailed description of the uncertainty computations on the parameters).



2.3. Data Editing Tables

2.3.1. Description of the Tables

To create or modify data (parameters, variables, etc.), tables are available in the **Data and Computations menu**. All the GRIF 2011 data tables operate in the same manner.



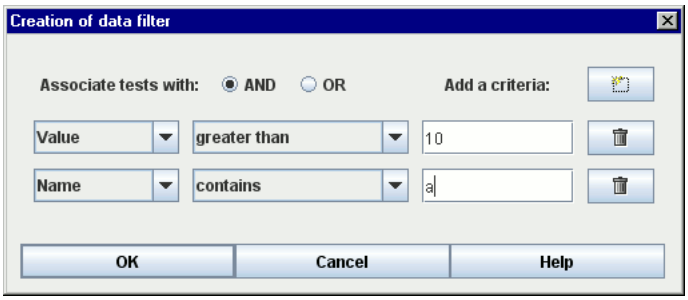
The data editing table/panel is divided into 3 parts:

- The top part containing the buttons.
- The main part containing the data table.
- The bottom part indicating what the selected data is used for.

	Saves the table in a text file.
	Opens the table in a text editor (that defined in the Options).

	
	Opens the column manager.
	When the **display selection** button is pressed, a click in the table leads to the selection in the input area.
	Displays the data filtering part.
	Multiple modifications made to all the selected data.
	Creates new data.
	Deletes the selected data (one or many).
	Enables data filtering or not.
	Defines the filter to be applied to the data.

Filtering allows you to display only what is necessary in a table. Several filtering criteria can be combined, as shown below:



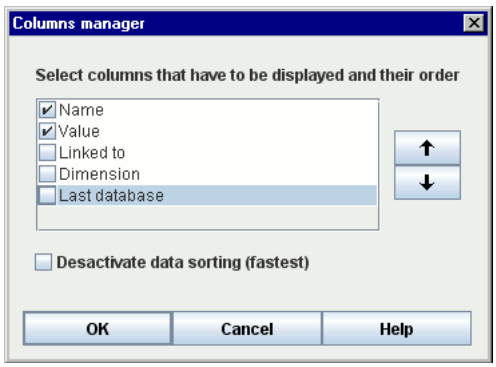
Select **AND** or **OR** to choose the type of association between each line (filter criterion). A line is a Boolean expression divided into 3 parts:

1. the first is the column on which the filter is used;
2. the second is the comparator;
3. the third is the value to which the data will be compared.

If the Boolean expression is true, the data will be kept (displayed); otherwise the data will be masked. When the filter is enabled its value is displayed between < and >.

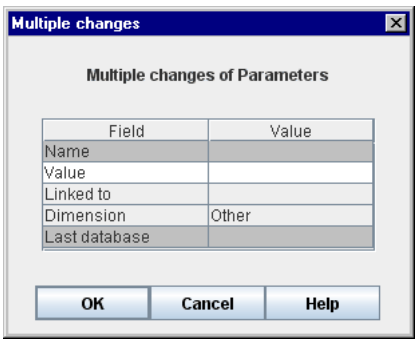
The data in a column can be sorted by double clicking the header of this column. The first double click will sort the data in ascending order (small triangle pointing upwards). The second double click on the same header will sort the column in descending order (small triangle pointing downwards).

A table can contain many columns, some columns may be unnecessary in certain cases. The "linked to database" column is unnecessary when no database is available. It is thus possible to choose the columns to be displayed and their order. To do this, click right on a table header, or click the **Columns Manager** button, the following window opens:



You can choose the columns to be displayed by selecting (or deselecting) the corresponding check boxes. The arrows on the right are used to move the columns up or down in the list to choose the order of the columns. The **Disable data sorting** check box disables the data sorting. This improves the application's performance with very complex models.

To modify data, double click the box to be modified. When several lines are selected (using the CTRL or SHIFT keys) changes can be made to all the selected data by using **Multiple changes**. A window then opens to allow you to make these changes.



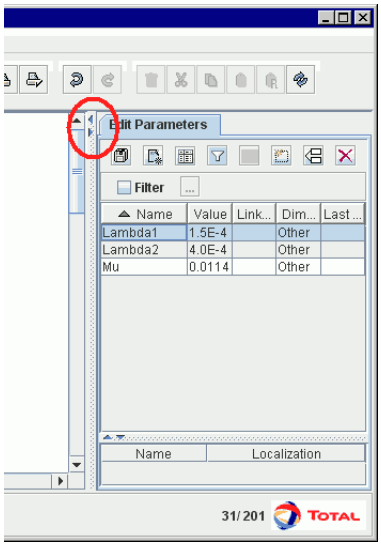
Items which cannot be modified are greyed. The white lines indicate that the selected data does not have the same value for the field in question. A new value can be entered which will be taken into account for all the selected data. The lines with no background colour indicate that all the selected data has the same value for this field (in this example the selected data is all "Float"); they can be changed to give a new value to all the selected data.

The bottom table in the data table indicates which elements in the model use the selected data. The first column of this table gives the name of these elements; the second indicates their location in the document (page, group). Clicking on a line in this bottom table opens the page where the element is located and selects the element.

2.3.2. Arrangement of tables

As said before, tables are available in **Data and Computations** menu, In this case, each table is openned in a separate window.

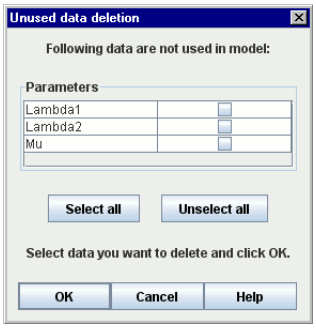
To decrease number of openned windows, tables are gathered in a tabbed pane at the right of the application. The pane can be "hiden" with the little arrows at the top of split-pane.



You can chose displayed tables with a right clic on the title of the tabs.

2.3.3. Table Cleaning

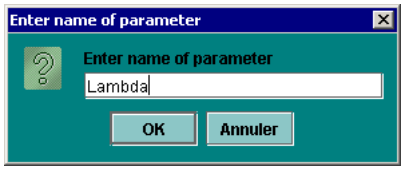
Data may not be used anymore, it can be used usefull to delete every unused data. To facilitate removal, use **Data and Computations / Unused data deletion** menu.



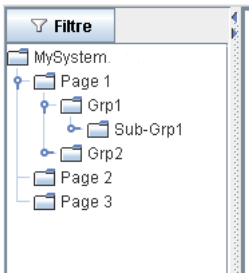
This window displays unused data. Select data you realy yan to delete and click OK.

2.3.4. Data creation

The **Parameter editor** is used to create "real" parameters. The following window is only used to choose the name of the new parameter. Its value must be entered later directly in the parameter table.



2.4. Arborescence



To help users to walk through the document (pages, groups ans sub-groups), a tree is available of the leaf of the application. By default, every element is displayed, you can use **Filter** button in order to select elements you want to display or not.

You can expand or collapse a node in a recursive way with a right click on the node.

As explained for tables on the right, you can "hide" the tree.

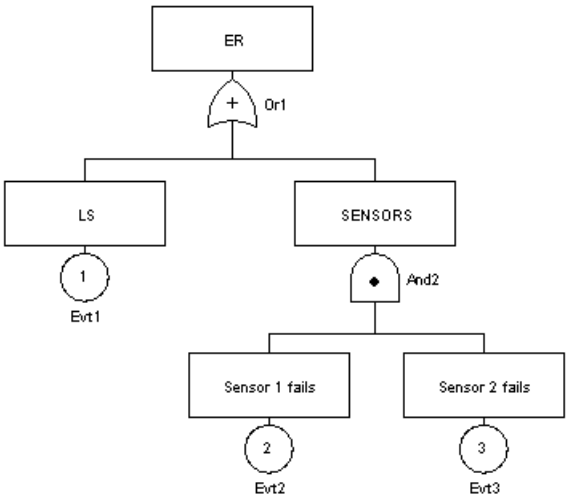
2.5. Using shortcuts

2.5.1. Identical Transfer Gates (or Shortcuts on gates)

The concept of a **shortcut** (or repeated element) was introduced in the Fault Tree module for four main reasons:

- To link together portions of the model;
- To avoid graphicaly complex model, and keep readability;
- To simplify the use of the **Group** function (cf. below);
- To highlight what is essential and what is not.

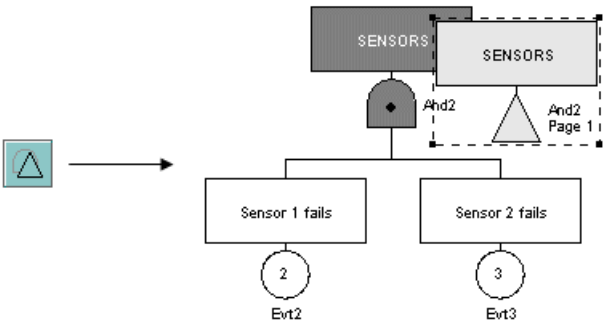
Let a fault tree contain three base events, one "OR" gate (critical event) and one "AND" gate.



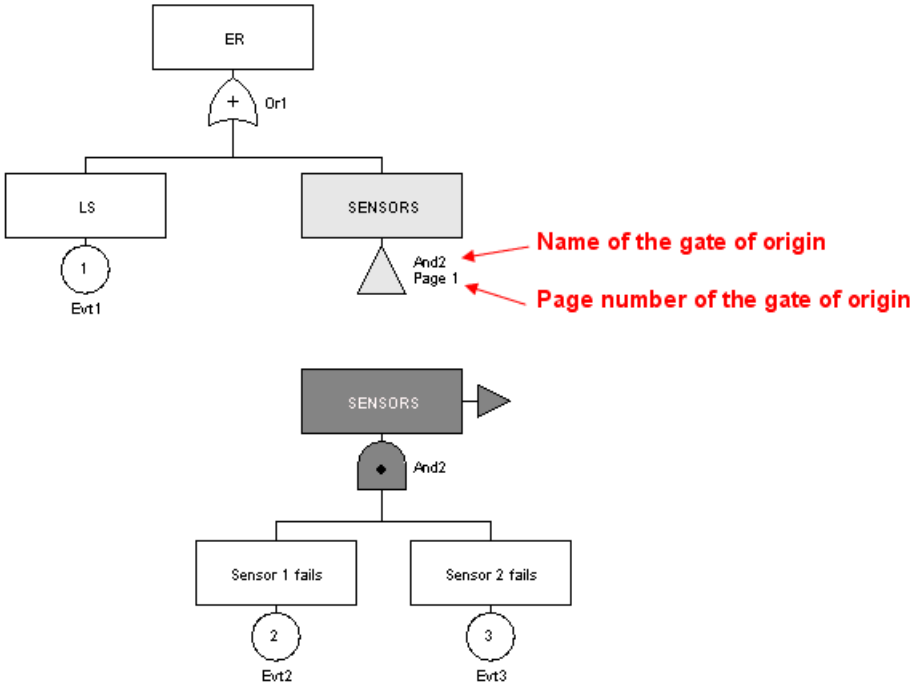
The aim here is to create a shortcut to the gate (identical trasfert gate) called "And2" to be able to dissociate the "And2" subtree from the main tree. Proceed as follows:

1. Delete the existing link between gate "Or1" and gate "And2".

2. Click left on the **Transfert Gate** de la barre d'outils verticale puis cliquer sur la porte "And2".



3. Connect the shortcut created in this manner to gate "Or1".

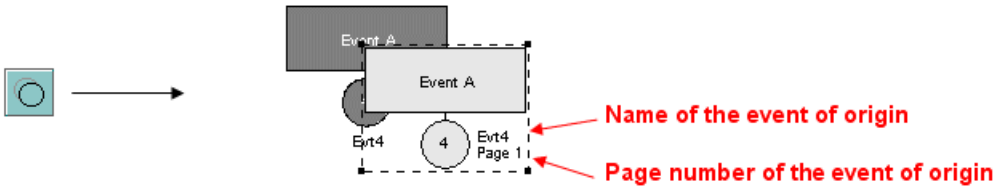


The name of the original gate and the page number where the original gate is located are shown beside the shortcut to gate "And2".

Although linked from the "computational logic" viewpoint, the two trees are now totally graphically independent. They can now be placed on different pages or in different groups (cf. later on in this document).

2.5.2. Repeated events (or Shortcuts on events)

From the logic viewpoint an event can have an "impact" on several "branches" of the same tree. To correctly model this case, this event must be duplicated. To do this, select the corresponding icon on the vertical toolbar, then click the event to be duplicated:



The event which has just been duplicated is now marked in dark grey whereas the duplicated event is shown in light grey. The name and number of the original event's page are shown beside the shortcut.

The repeated event must now be inserted in the model, given that at each instant its state will be equal to that of the original event.

NB: Obviously, if the original event is deleted then the duplicated event is also deleted.

2.6. Page and group management

The use of shortcuts allowed us to obtain two Fault Tree which have no graphical link between them. They communicate only by **shortcuts**. This can be used, for example, to place each subpart on a different page:

1. Create a new page by clicking the corresponding icon in the icon bar (or use menu **Tools - New Page**). A page number 2 is thus created.

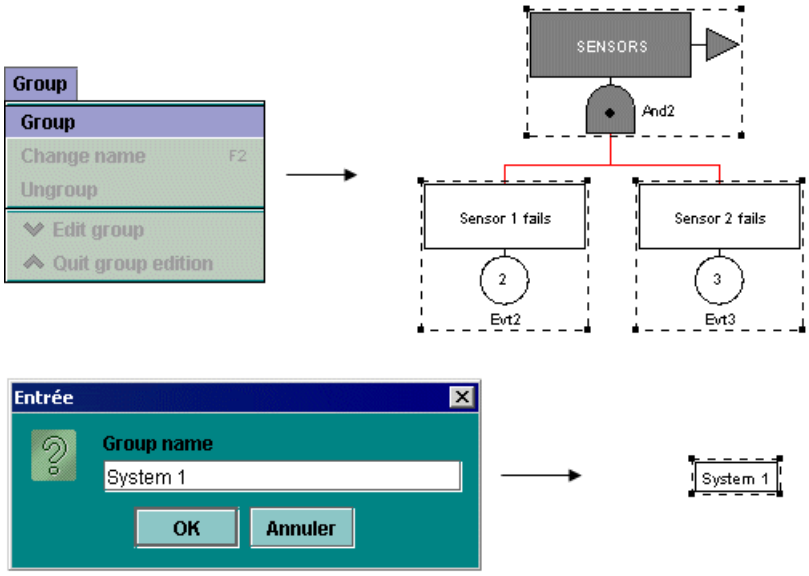
2. Return to page 1 by selecting the page using the page selector in the ideographic command bar (or use menu **Tools - Page manager**).
3. Select the part to be moved.
4. Open menu **Tools - Change page**.
5. Select page 2 and click **OK**. The part selected is transferred to page 2 but it continues to communicate with page 1 via the **shortcuts**.

Note: For large models the division method described above is very useful.

Another possibility for entering large Fault Tree is to use the **Group** concept. This is made possible by the **shortcuts** and the fact that the data is global for a document. This allows quite separate subparts to be created:

1. Select a subpart.
2. Use menu **Group - Group**. A dialogue box then opens asking for the name to be given to the group being created.
3. Enter the desired name and click **OK** (e.g.: "System 1"). The group is created: the subnet is replaced by a rectangle assigned with the chosen name.

You can also create an empty group with **Group - New Group** menu or group tool in the left toolbar.



Each group can then be **edited**, **renamed** or **ungrouped** using the commands in the **Group** menu. The group can also be edited with a click right or using the "cursor down arrow" on the left of the page manager. In Edit mode, the submodel can then be modified as you wish. When the modification is terminated you return to the previous figure by exiting group editing by menu **Group - Quit Group Edition**, or using the "cursor up arrow" on the left of the page manager. It's also possible to choose a picture for a group by using **Group - Change Picture** menu.

Note: Groups can be grouped recursively.

2.7. Data Entry Aids

To simplify model creation the Fault Tree module has different data entry aids to automate time-consuming operations.

2.7.1. Copy / Paste / Renumber (without shortcut)

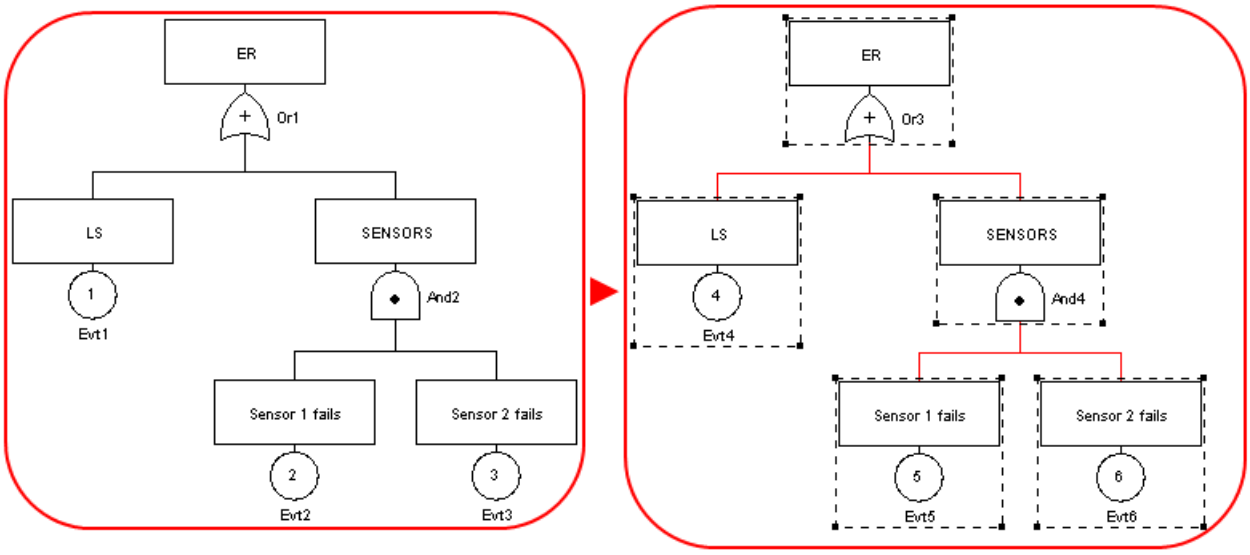
To assist with the entry of the repeated parts of the Fault Tree "Copy / Paste and Renumber" mechanisms have been provided. This operation is carried out in 6 steps:

1. Select the part to be copied.
2. Click the **Copy** icon, or use menu **Edit - Copy** or the shortcut Ctrl + C.

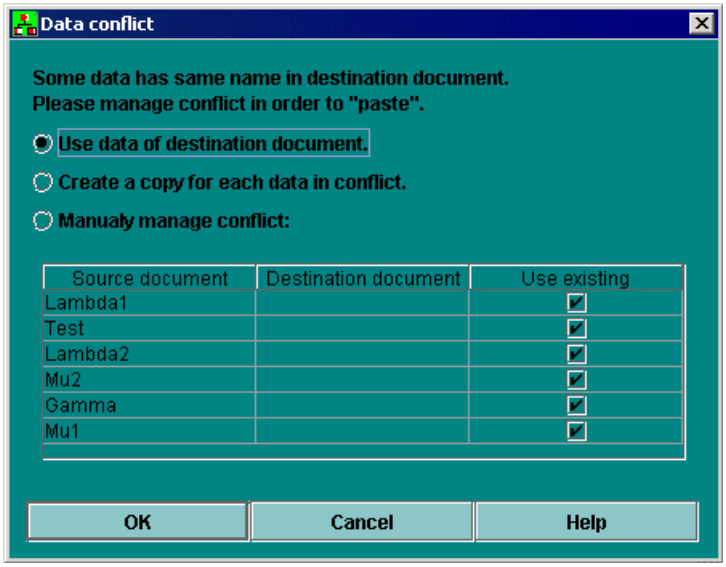
3. Click the **Paste and Renumber** icon, or use menu **Edit - Paste and Renumber** or the shortcut Ctrl + R.
4. A window appears where you choose the start number for the renumbering.
5. The previously selected part is copied and the copy is selected.
6. Move the copy to the desired location.

We then obtain the tree shown in the figure below:

- **Or1** and **And2** gates from original tree are become **Or3** and **And4** for the copy;
- **Evt1**, **Evt2** and **Evt3** events from original tree are become **Evt4**, **Evt5** and **Evt6** for the copy.



When copying to a new document, any data conflicts are handled in the following window:



This window shows all the data which has the same name in the source document and the destination document. There are three choices:

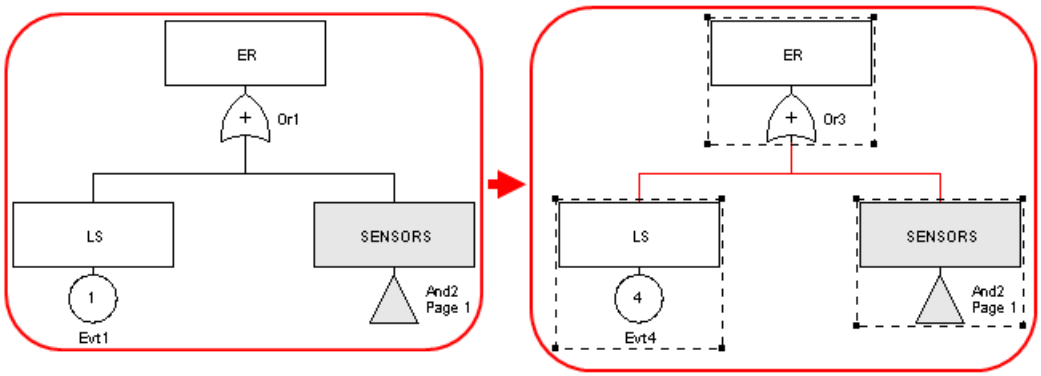
1. Use data of destination document, this will replace the occurrences of the data in the source document by the data with the same name in the destination document.
2. Create a copy for each data in conflict, this will replace the occurrences of the data in the source document by a copy with a name with the suffix "copy".
3. Manually manage conflict, this allows you to choose whether you use the existing data or not, depending on the data. You can also specify the name of the copy by double clicking on the box in the "destination document" column. The names in this column are normally masked when the **Use existing** check box is selected, since it is the data which is already in the destination document which will be used.

2.7.2. Copy / Paste / Renumber (with shortcut)

The "Copy / Paste and Renumber" command creates new "instances" i.e. new subtree similar to the subtree copied:

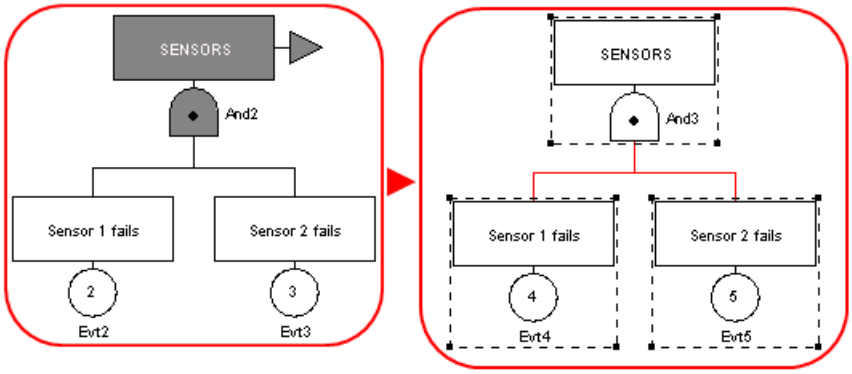
- Same graphical structure;
- Same parameters;
- The number and name of the events and gates change (new name: **Evti** for events and **"type of gate"i** for the gates, where **i** is the new number).
- Same comments.

When identical transfer gates are part of the selection to be Copied / Pasted and Renumbered, they will then remain unchanged for the copy. They shall always point to the same gate if this gate is not part included in the selection to be copied.



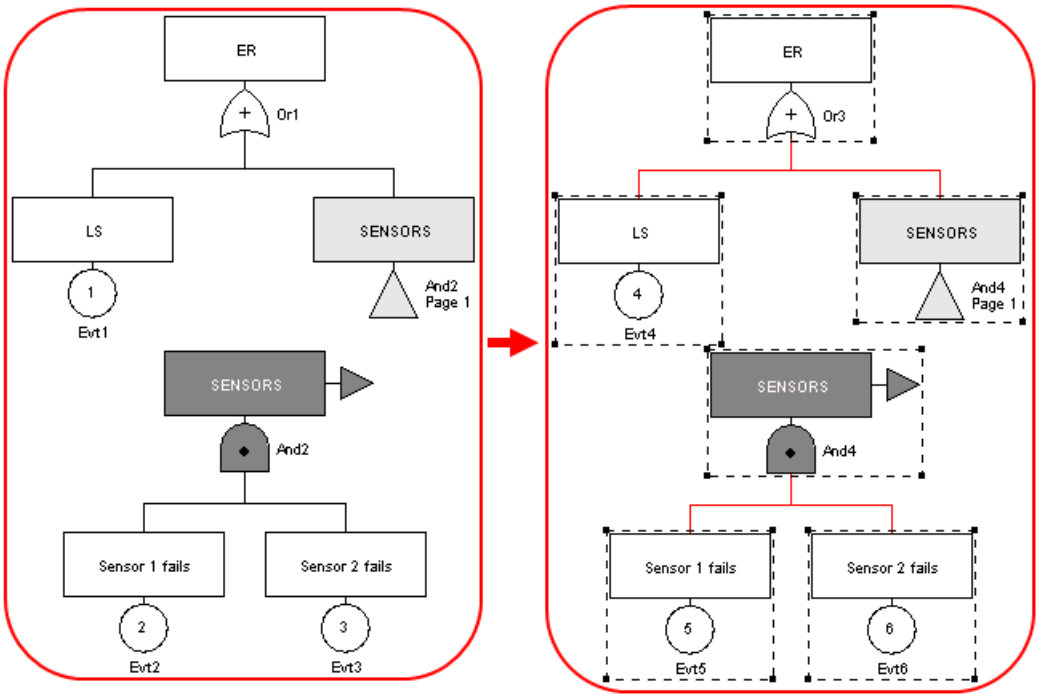
In the above example, gate **Or1** an event **Evt1** have been renumbered normally. The shortcut to gate **And2** has not been modified.

When a gate that part of a shortcut is also part of a selection hat is going to be "Copied /Pasted and Renumbered" and if the shortcut itself is not present, then the gate will be renumbered in the conventional manner.



In the above example, all of the events and gates have been renumbered normally.

When identical transfer gate (and their corresponding original gate) are included in the selection to be "Copied / Pasted and Renumbered", then new shortcuts will be created and they will be linked to the new gates.



In the above example, the gate that is linked to a shortcut has been renumbered (**And2** -> **And4**) and so its shortcut has also been modified.

You can navigate between an element's different shortcuts, using menu **Tools/Navigate to shortcuts**. A window opens and displays the list of shortcuts. Clicking on a shortcut automatically positions the view on this shortcut. You can return to the original element by clicking on its name at the top of the window.

2.7.3. Ordinary Copy/Paste

In addition to the "Copy / Paste and Renumber" command there is an ordinary "Copy / Paste" function. It is used to make a single copy without renumbering. We thus obtain double elements which, from a formal viewpoint, is incorrect but which must be temporarily tolerated to simplify data entry.

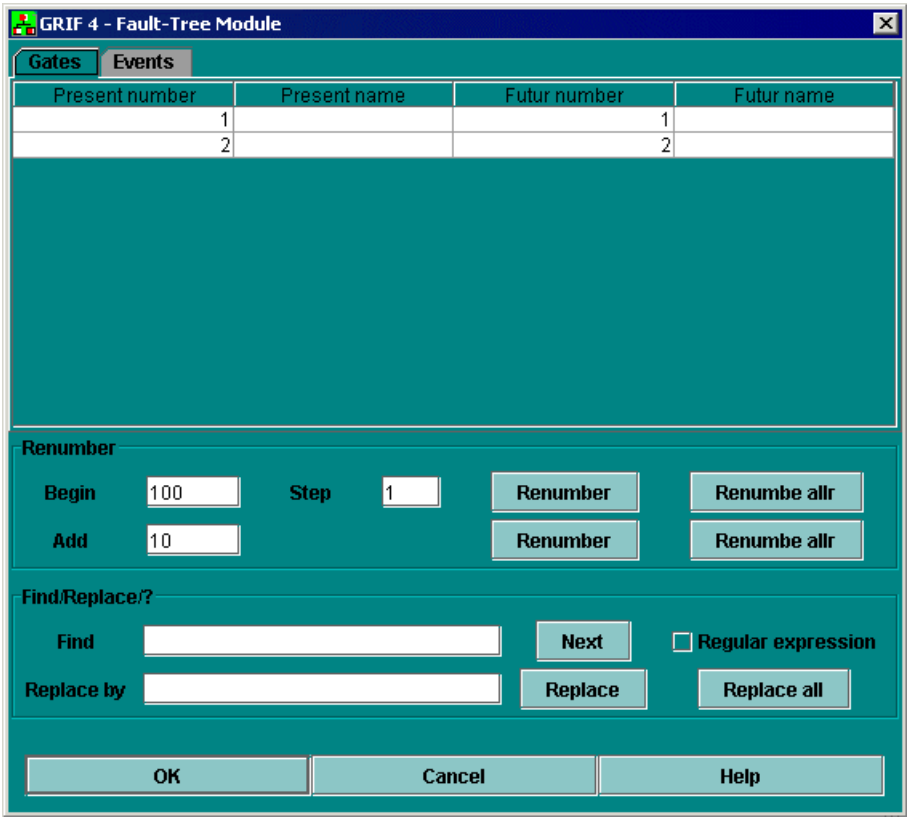
Where possible, the "Copy / Paste and Renumber" function must be used in preference to the simple "Copy / Paste" function to minimise the risk of errors. But when it is used you must take the necessary precautions to re-establish the correct numbering to eliminate the duplicates.

2.7.4. Overall change

When creating the Fault Tree it may be necessary to change a large part of the elements in the models: changing the names, numbers, etc. The "Replace all" function in the **Edit** menu allows you to perform overall changes:

- Use the **Edit / Overall changes** function.
- Choose the type of elements to be modified among available tabs.
- The "Find / Replace" part changes a character string present in one or more variable labels, place labels or transition labels. It is replaced by the string entered in the "Replace" part.
- The "Renumber" part only concerns the places. It is used to change place numbers. You indicate a **Start** number then specify a constant **Step**, or **Add** a constant value to the current numbers.
- Click **OK** to return to the chart. The changes are validated.

Note: The name changes and renumbering can be done manually if the necessary precautions are taken (avoiding duplicates, etc.). You click the **Future number** or **Future name** column and enter the change. Do not forget to validate it with the "ENTER" key.



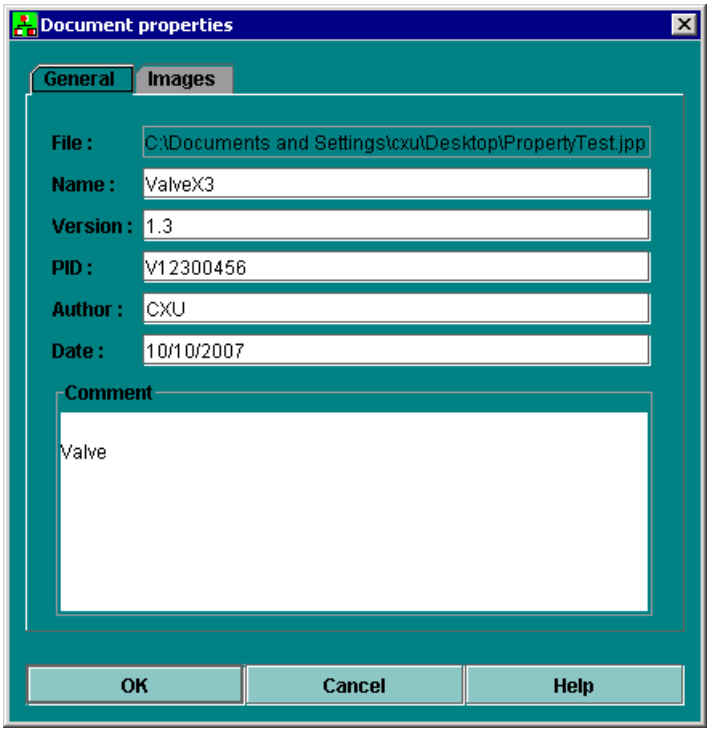
2.7.5. Selection change

The "Replace selection" function is equivalent to a "Replace all" but only applied to the selected elements. Only the selected gates and events can be replaced.

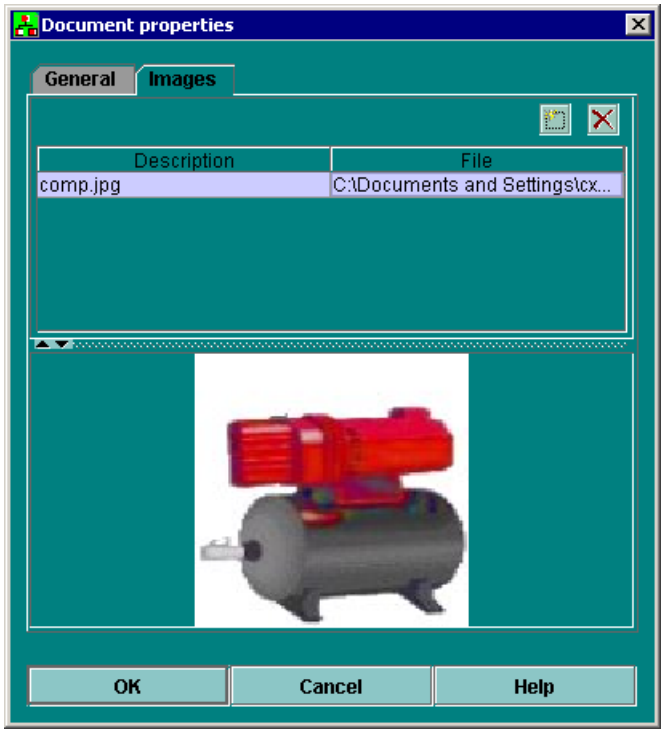
NB: The "Replace selection" function does not allow the model's parameters to be replaced.

2.7.6. Document properties / Images management

File - Doucument properties menu enable to save information about document : name, version, comment, ... These informations are available in **General** tab.



Images may be very useful to represent sub-system. GRIF 2011 enables to save images that can be used in different parts of software (groupes, prototypes, ...). Images management is made in **Images** tab.



To add a new picture into document, use  icon. A double click in **File** column enables to select an picture (jpg, gif or png). A double click in **Description** column enables to give a name or a description to selected image.

Once in document, picture can be linked to a groupe with **Group - Picture change** menu.

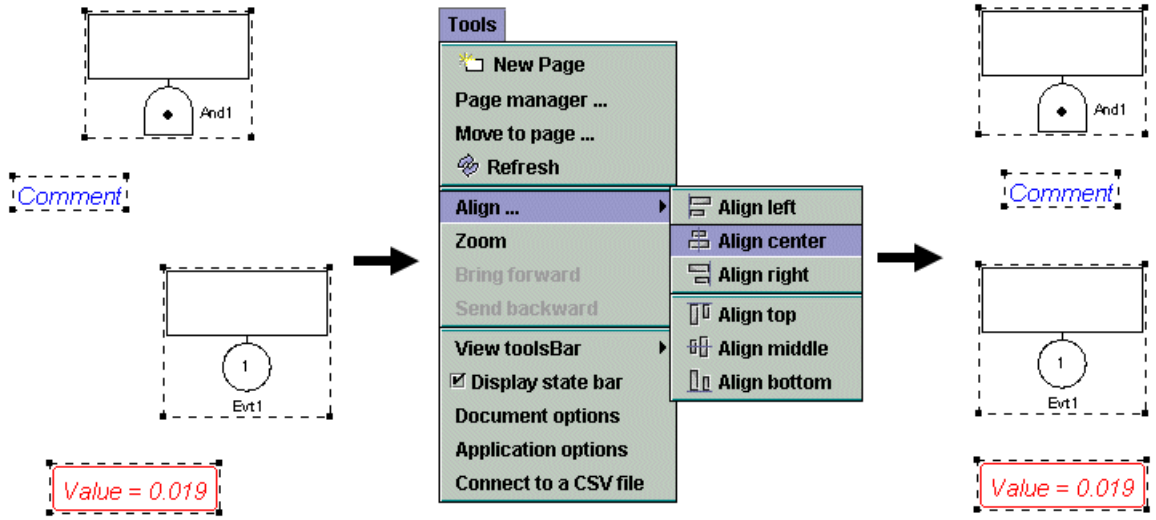
Images are saved indide document, pay attention to picture size. Because images are inside document, you have to re-add picture if picture is modified erternaly.

2.7.7. Alignment

To improve the legibility of the model the selected elements can be aligned vertically or horizontally. To do this, use the **Align** command in the **Tools** menu.

The following figure shows how the command works. For example, to align selected places and transitions vertically, proceed as follows:

1. Select the elements (places, transitions, comments, etc.) to be aligned;
2. Go into the **Tools** menu and select the **Align** function;
3. Choose the type of alignment: **Align center**;
4. Click left on the mouse.



Similarly, to align elements horizontally select the type **Align middle** which aligns the ordinates while keeping the abscissa constant. The principle is the same as that described above.

2.7.8. Multiple selection

It may sometimes be useful to select several elements located in the four corners of the input zone. To simplify this type of selection click on each of the desired elements one by one while holding down the Shift key on the keyboard.

2.7.9. Selecting connex (adjacent) parts

It is sometimes difficult to select an additional part of a model. To simplify the selection process, select a graphical element then use menu **Select connex part** in the **Edit** menu. The additional part can be selected directly by clicking on the element while keeping the Control button pressed.

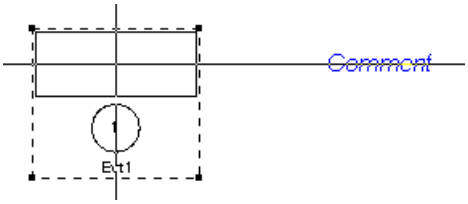
2.7.10. Page size

If, during modeling, the page size is insufficient it can be changed using menus **Increase page size**, **Reduce page size** or **Page size** in the **Tools** menu.

2.7.11. Cross hair

To be able to create an ordered and legible model quickly, the **cross hair** can be used to align the different elements with each other (but less accurately than the **Align** function in the Tools menu). The **cross hair** is enabled (or disabled) in the **Graphics** tab of the **Option** menu.

The following picture show how to quickly align two element of the model.



In order to align horizontally, select **Align au middle** which align keeping constant abscissa.

2.7.12. Gluing/Associating graphics

When objects are where you want, you can glue a set of object by right-clicking and selecting **Glue**. This command create a group (a graphical one, not a hierarchical one) with selected objects, so that moving one moves the others.

3. Laws and uncertainties

3.1. Description of the laws

A total of twenty-three laws are available in the Fault Tree module. Each of these laws has one or more corresponding parameters. Here is a list of the different "types" possible:

- Probability: value between 0 and 1 inclusive.
- Rate: value greater than or equal to corresponding to a failure rate.
- Duration: value greater than or equal to 0 corresponding to a duration or to a time.
- Factor: value strictly greater than 0.
- NatInt: integer value greater than or equal to 0.
- Boolean: can take a value of 0 or 1 corresponding to an option parameter.
- Other: any value.

In the remainder of this chapter, the parameter "types" will be specified for each law.

3.1.1. ALD/On-demand law (for Albizia: constant law)

This law has two parameters: the probability **q** and the inconditional failure rate **w** of the event. Whatever the time, the probability of the component failing is constant.

Parameter:

- **q** (Probability)
- **w** (Inconditional failure rate)

The law is defined as follows:

$$Q(t) = q$$

This law generally corresponds to the case where the only failure considered for the components is that of a refusal to change state (e.g.: Fails to start/stop, etc.).

3.1.2. EXP / Exponential law

This law only has a one parameter: the component's failure rate (supposed to be constant over time). It describes the time interval before the first failure for a non-repairable component.

Parameters:

- **Lambda** (Rate) = failure rate

The law is defined as follows:

$$Q(t) = 1 - e^{-\lambda t}$$

This law is widely used since it is almost the only one to make it possible to obtain analytical results. In addition, it describes the lifetime of a non-repairable component very well (at least when there are a large number of components) when the component is no longer young.

3.1.3. IND / Unavailability law (for Albizia: GLM)

This law describes the behaviour of a component (repairable or not), with (or without) failure to start, using exponential expressions. It generalises the exponential law with the **Lambda** parameter (failure rate).

Parameters:

- **Gamma** (Probability) = probability of initial start failure (at t = 0)
- **Lambda** (Rate) = failure rate
- **Mu** (Rate) = repair rate

The law is defined as follows:

$$Q(t) = \frac{\lambda}{\lambda+\mu} - \frac{\lambda - \delta(\lambda+\mu)}{\lambda+\mu} \times e^{-(\lambda+\mu)t}$$

The **Gamma** and **Mu** parameters are optional. Depending on the case, they can be zero.

- If the component is not repairable, set **Mu** to zero.
- If the component cannot fail to start, set **Gamma** to zero.

NB: The failure to start is only taken into account at t = 0.

3.1.4. WBL / Weibull

This law has three parameters: **alpha**, **beta** and **t0**. It describes the behaviour of a component which is not repairable and which does not fail to start. Its specific feature is that it takes account of the component's young and old periods.

Parameters:

- **Alpha** (Factor) = scale parameter
- **Beta** Factor) = form parameter
- **T0** (Time) = location parameter

The law is defined as follows:

$$Q(t) = 1 - \exp\left[-\left(\frac{t-t_0}{\alpha}\right)^{\beta}\right]$$

The significance of this law is that new distributions can be tested by varying the **beta** factor:

- If **Beta** is less than 1, the failure rate decreases and the law then allows the period when the component is young to be taken into account.
- If **Beta** is greater than 1, the failure rate increases and the law then allows the component's ageing period to be taken into account.
- If **Beta** is equal to 1, the Weibull law is equivalent to the exponential law.

3.1.5. TPS / Simple Periodic Test law

This law allows a component which fails to be represented according to an exponential distribution law and whose failure is found during a periodic test. The repair is then carried out instantaneously.

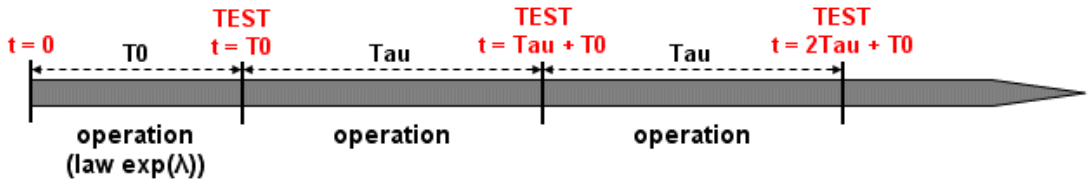
Parameters:

- **Lambda** (Rate) = failure rate
- **Tau** (Duration) = test period (time interval between two consecutive tests)
- **T0** (Time) = date of first test

The law is defined as follows:

$$Q(t) = \begin{cases} e^{\lambda t} & if \quad t < t_0 \\ e^{\lambda\left[(t-t_0)\bmod\tau\right]} & otherwise \end{cases}$$

Here is a small graph representing the different phases of the component's "life":



NB: This law is a simplified version of the "TPC / Full Periodic Test" law.

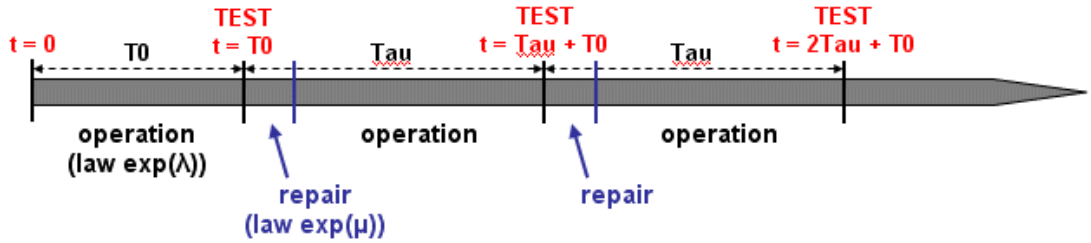
3.1.6. TPE / / Extended Periodic Test law

This law allows a component which fails to be represented according to an exponential distribution law and whose failure is found during a periodic test. The repair phase is then modelled by an exponential of the **Mu** parameter.

Parameters:

- **Lambda** (Rate) = failure rate
- **Mu** (Rate) = repair rate (when the failure has been found during a test)
- **Tau** (Duration) = test period (time interval between two consecutive tests)
- **T0** (Time) = date of first test

Here is a small graph representing the different phases of the component's "life":



NB: This law is a simplified version of the "TPC / Full Periodic Test" law.

3.1.7. TPC / Full Periodic Test law

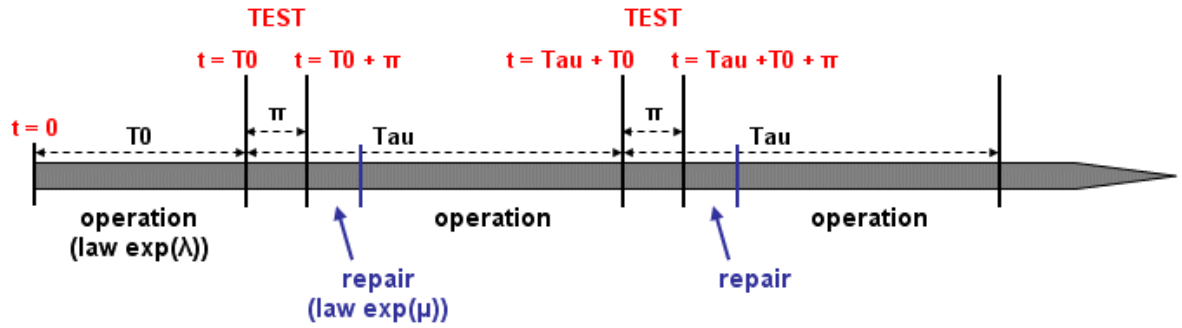
This law allows a periodically tested component to be represented as completely as possible. There are many parameters in play.

Parameters:

- **Lambda** (Rate) = failure rate during operation or on standby
- **Lambda*** (Rate) = failure rate during the test
- **Mu** (Rate) = repair rate (once the test has shown up the failure)
- **Tau** (Duration) = test period (time interval between two consecutive tests)
- **Teta** (Time) = date of first test (ignore parameter value: **Tau**)
- **Gamma** (Probability) = probability of failure due to starting the test (ignore parameter value: 0 = starting the test does not cause a failure)
- **Pi** (Duration) = duration of test (ignore parameter value: 0 (instantaneous test))
- **X** = (Boolean) indicator of component availability during the test (0 = component unavailable during the test; 1 = component available) (ignore parameter value: 1 = available during the test)
- **Sigma** (Probability) = test cover rate (probability that the component failure is detected during the test) (ignore parameter value: 1 = the test covers all the possible failures)
- **Omega 1** ((Probability) = probability of forgetting to reconfigure after the test (ignore parameter value: 0 = no reconfiguration problem)
- **Omega 2** ((Probability) = probability of forgetting to reconfigure after the repairing (ignore parameter value: 0 = no reconfiguration problem)

NB : the "ignore parameter value" is the value to type if you want parameter to do not affect component availability.

Here is a small graph representing the different phases of the component's "life":



3.1.8. NRD / No Recovery Before Delay law

This law takes two parameters: a repair rate **Mu** and a delay **Delay**. For non repairable components, it gives the probability of not succeeding to recover the component before a delay Delay.

NB: This law does not depend on the time, it is a short version of a constant law.

Parameters:

- **Mu** (Rate) = repair rate
- **d** (Duration) = recovery time

The law is defined as follows:

$$Q(t) = e^{-\mu d}$$

3.1.9. GLM / GLM Asymptotic law (for Albizia: asymptotic exponential law)

This law is a variation of the "IND / Unavailability" law. It corresponds to the probability of a "IND / Unavailability" law computed at t = infinity.

NB: This law does not depend on the time, it is a short version of a constant law.

Parameters:

- **Lambda** (Rate) = failure rate
- **Mu** (Rate) = repair rate

The law is defined as follows:

$$Q(t) = \frac{\lambda}{\lambda + \mu}$$

3.1.10. DOR / Dormant

This law has three parameters: a failure rate, a mean repair time and a delay. In addition, it does not depend on the time.

Parameters:

- **Lambda** (Rate) = failure rate
- **MTTR** (Duration) = average repair time

- **d** (Duration) = delay

The law is defined as follows:

$$Q(t) = \frac{\lambda d - (1 - e^{-\lambda d}) + \lambda . MTTR . (1 - e^{-\lambda t})}{\lambda d + \lambda . MTTR . (1 - e^{-\lambda d})}$$

3.1.11. CMT / Temps de mission constant

This law is a simplified case of the "IND / Unavailability" law. It corresponds to an exponential law with a fixed time given as parameter.

Note1: This law does not depend on the time, it is a short version of a constant law.

Note2: The parameter Q is optional.

Parameters:

- **Lambda** (Rate) = failure rate
- **T** (Duration) = mission time
- **Q** (Probability) = optional law

The law is defined as follows:

$$Q(t) = Q + 1 - e^{-\lambda T}$$

3.1.12. UNI / Uniform law

This law has two parameters: and upper limit and a lower limit.

Parameters:

- **a** = upper limit
- **b** = lower limit

The law is defined as follows:

$$Q(t) = \frac{(t - a)}{(b - a)}$$

3.1.13. NLOG / Log normal law

This law has two parameters: the mean and the standard deviation.

Parameters:

- **Mu** = mean
- **Sigma** = standard deviation

The law is defined as follows:

$$Q(t) = 1 - \int_0^t f(t)dt \qquad f(t) = \frac{1}{t\sigma\sqrt{2\pi}} e^{-\left(\frac{(\ln t - \mu)^2}{2\sigma^2}\right)}$$

3.1.14. NORM / Normale

This law has two parameters: the mean and the standard deviation.

Parameters:

- **Mu** = mean
- **Sigma** = standard deviation

The law is defined as follows:

$$Q(t) = 1 - \int_0^t f(t)dt \qquad f(t) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left(\frac{(t-\mu)^2}{2\sigma^2}\right)}$$

3.2. Uncertainties on the parameters

For each probability law used in the model, it is possible to introduce an uncertainty on each of the parameters. There are three laws available to model them:

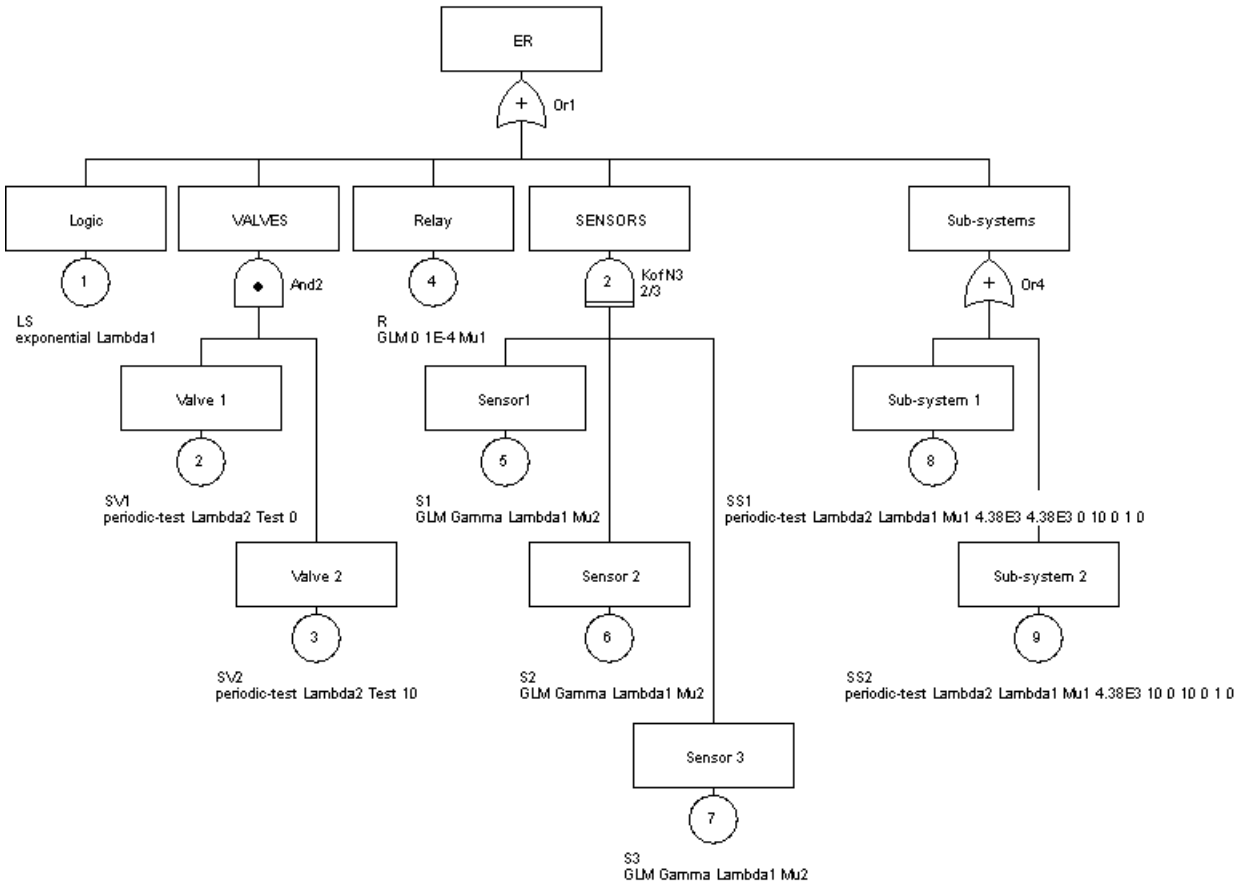
- "NLOG / Lognormal" law;
- "UNIF / Uniform" law;
- "NORM / Normal" law.

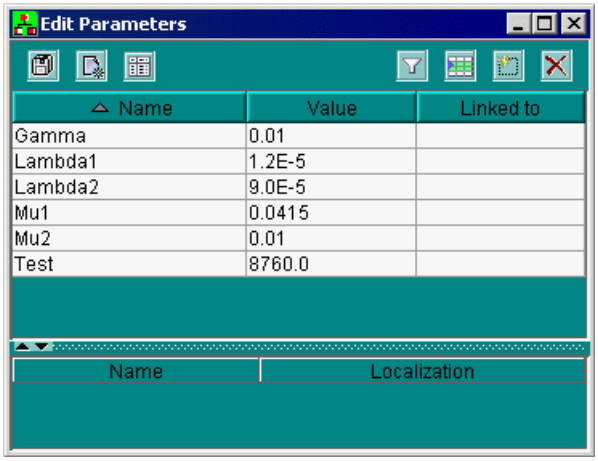
NB: Each of these laws is described in the previous subchapter.

Using this method, it is thus possible to introduce the impact of the uncertainties on the data into the final result.

4. Example of a Fault Tree

Here is a fault tree modeling the behaviour of any safety system with two possible states: "work" / "failed" (or "available" / "unavailable"). The aim is thus to construct a tree allowing us to evaluate the system's mean unavailability.





The above tree has nine events:

- **LS**
  - Number: 1
  - Comment: "Logic"
  - Law: **exponential** law with "Lambda" = **Lambda1**.

- **SV1**
  - Number: 2
  - Comment: "Valve 1"
  - Law: **simple periodic test** law with "Lambda" = **Lambda2**, "Tau" = **Test** and "T0" = **0**.

- **SV2**
  - Number: 3
  - Comment: "Valve 2"
  - Law: **simple periodic test** law with "Lambda" = **Lambda2**, "Tau" = **Test** and "T0" = **10**.

- **S1**
  - Number: 4
  - Comment: "Sensor 1"
  - Law: **unavailability** with "Gamma" = **Gamma**, "Lambda" = **Lambda1** and "Mu" = **Mu2**.

- **S2**
  - Number: 5
  - Comment: "Sensor 2"
  - Law: **unavailability** with "Gamma" = **Gamma**, "Lambda" = **Lambda1** and "Mu" = **Mu2**.

- **S3**
  - Number: 6
  - Comment: "Sensor 3"
  - Law: **unavailability** with "Gamma" = **Gamma**, "Lambda" = **Lambda1** and "Mu" = **Mu2**.

- **R**
  - Number: 7
  - Comment: "Relay"
  - Law: **unavailability** with "Gamma" = **0**, "Lambda" = **10e-4** and "Mu" = **Mu1**.

- **SS_1**
  - Number: 8
  - Comment: "Sub-system 1"
  - Law: **full periodic test** law with "Lambda" = **Lambda1**, "Lambda*" = **Lambda1**, "Mu" = **Mu1**, "Tau" = **4380**, "Teta" = **4380**, "Gamma" = **0**, "Pi" = **10**, "X" = **0**, "Sigma" = **1** and "Omega" = **0**.

- **SS_2**
  - Number: 9
  - Comment: "Sub-system 2"
  - Law: **full periodic test** law with "Lambda" = **Lambda1**, "Lambda*" = **Lambda1**, "Mu" = **Mu1**, "Tau" = **4380**, "Teta" = **10**, "Gamma" = **0**, "Pi" = **10**, "X" = **0**, "Sigma" = **1** and "Omega" = **0**.

The tree's logic is governed by four gates:

- **Div1**
  - Number: **1**
  - Name: **Or1**
  - Comment: "ER"
  - Type: "OR"
- **Div1**
  - Number: **2**
  - Name: **And2**
  - Comment: "VALVES"
  - Type: "AND"
- **Div1**
  - Number: **3**
  - Name: **KofN3**
  - Comment: "SENSORS"
  - Type: "K out of N"

- **Div1**
  - Number: **4**
  - Name: **Or4**
  - Comment: "Sub-systems"
  - Type: "OR"

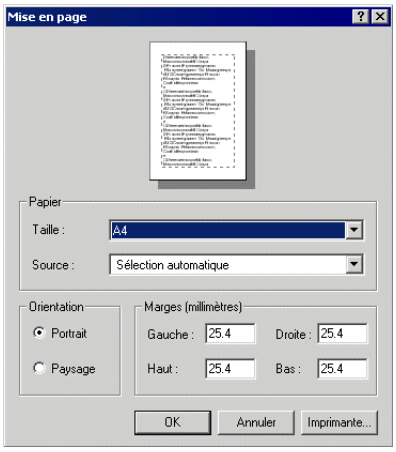
In this example, different types of more or less simple laws have been used. It was produced in a short time and allowed several more or less complex components to be modelled: non repairable, repairable, periodically-tested, with probability of failure on demand, etc.

Using this tree, we can now run various computations on the different gates or events: unavailability computations, unreliability computations, etc.

5. Printing

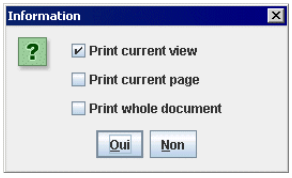
For printing, you have several commands at your disposal in the **File** menu **File**:

- The **Page setup** function function allows you to choose the page orientation, the size of the margins, etc.

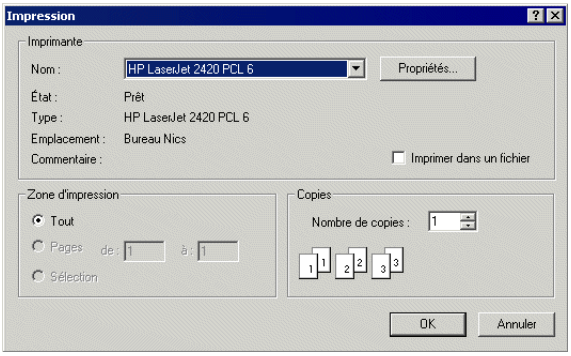


- The **Print** function initially gives access to a window called **Printing properties**. Then to another called **Information**. And thirdly, a window is displayed allowing you to direct the printout to one of the printers installed on your computer system.

When you select the **Print** function, the first box to appear is that shown above. You can then select your preference: Print border, Print filename, Print page number and/or Print date.



Secondly, an **Information** window appears. It allows you to indicate whether you wish to print the current view, print the current page or print the whole document.



The Print window will not be described here since it depends on your system.

- It is also possible to select the **Save to RTF file** function. Two windows are then displayed consecutively to you, called **Print properties** and **Information** (identical to those of the Print function). You are then asked to choose the folder in which the RTF file is to be saved.

6. Computations

The following two computation engines can be used in the Fault Tree module:

- Albizia;
- MOCA.

These two computation options are accessible in the Data and Computations menu on the task bar.

NB: Before running a type of computation in the Data and Computations menu, it is absolutely necessary to select one (and only one) gate which all the computations will be carried out on.

If no gates are selected, the following message is displayed:

6.1. Albizia computations

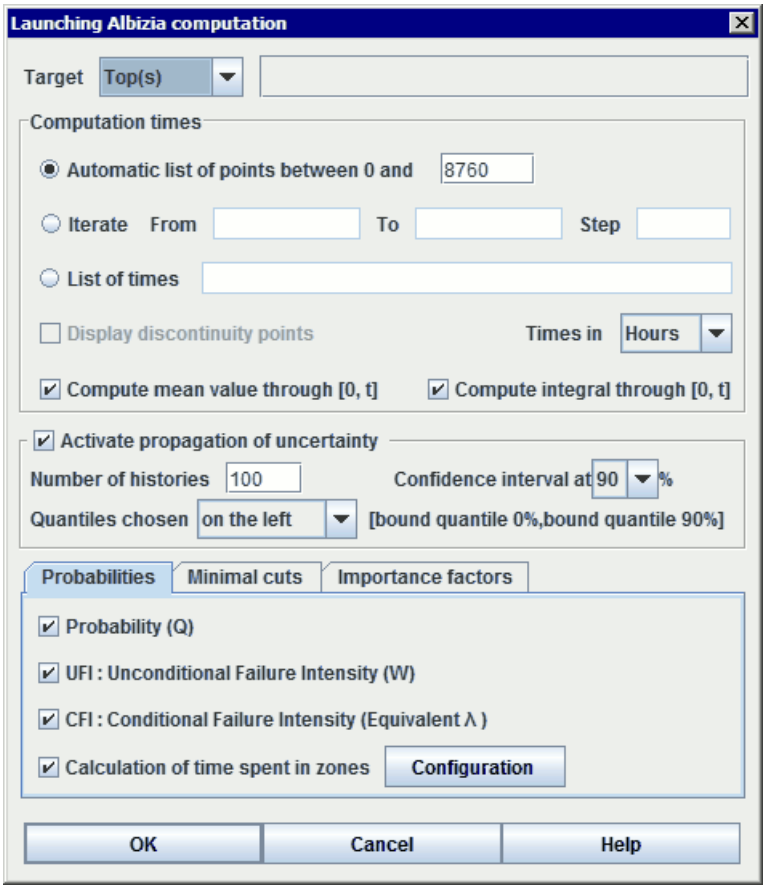
The computations by Albizia are performed in two main steps:

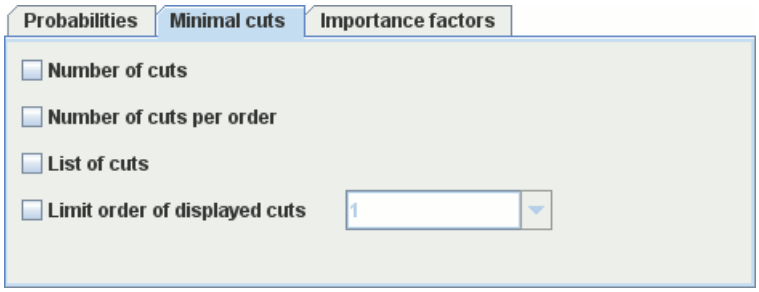
- general configuration of compuation;
- reading the results in the bank of results.

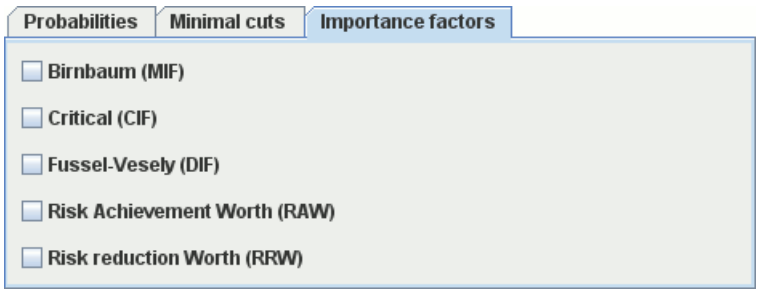
6.1.1. Configuring the computations

The computation configuration window can be accessed in two different ways: either via **Data and Computations - Computation settings** menu or via **Data and Computations - Launch Computation** menu. The difference between both is that, in the second case, the configuration step is directly followed by the computation launch step.

The configuration window which opens is called **Lauching Albizia computation** :







This configuration window is divided into six parts:

1. **Target**: specifies the target of the computations. Two choices are possible : **Top** for the top(s) of the tree and **Selected node** for the node currently selected in the tree.

2. **Calcul**: specifies the computation options.

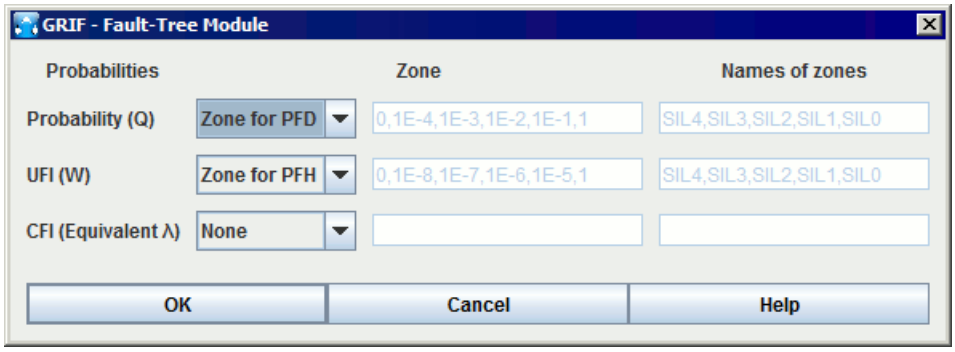
   - **Computation times : Iterate From** A **to** B **step** C: the computations will be performed for values of t ranging from A to B with a step of C.
   - **Computation times : List of times**: the computations will be performed for the values of t given in this list.
   - **Display discontinuity points**: the computation engine takes into account the discontinuity points if the option is selected.
   - **Times in**: The values entered are supposed to be hours. The unit can be specify among hours, days, months, years
   - **Compute mean value through [0, t]**: the computation engine computes the mean value of each variable to compute for each computation times.
   - **Compute integral value through [0, t]**: the computation engine computes the integral of each variable to compute for each computation times.

3. **Activate propagation of uncertainty**: activate the propagtion of uncertainties, and specifies parameters of computation and wanted results.

   - **Number of histories** : Number of histories (Monte-Carlo simulation) that have to be made.
   - **Confidence range at** : specifies the percentage of resultats that will be included in the confidence range.
   - **Quantiles chosen** : With all results of histoires, the software do a "quantile computation". But there are always many ways to chose bounds of an interval containing X % of the results. Here you can chose "on the left" (lower bound is minimum, upper bound is the quantile at X%), "onthe right" (lower bound is the quantile at 100-X%, upper bound is the maximum) and in the middle.

4. **Probabilities**: specifies probabilities to compute.

   - **Probability (Q)**:
   - **Unconditional Failure Intensity (W)**
   - **Conditional Failure Intensity (Lambda eq)**
   - **Calculation of time spent in zones**: for the three value aboves, this enable gives percentages of times spent in different intervals. These intervals can be setup with the configuration button. A windows is displayed for configuring intervals, by default intervals are selected for SIL computations.



5. **Minimal cuts**: specifies minimal cut values to compute.

   - **Number of cuts**: number of minimal cuts of the system (no maximum order limitation).
   - **Number of cuts per order**: summary of the number of cuts for each order (no maximum order limitation).
   - **List of cuts**: list of minimal cuts of the system. The maximum order can be set thanks to the **Limit order of displayed cuts** option.
   - **Limit order of displayed cuts**: specifies the maximum order of the displayed cuts. Cuts with order greater than the maximum order are not displayed.

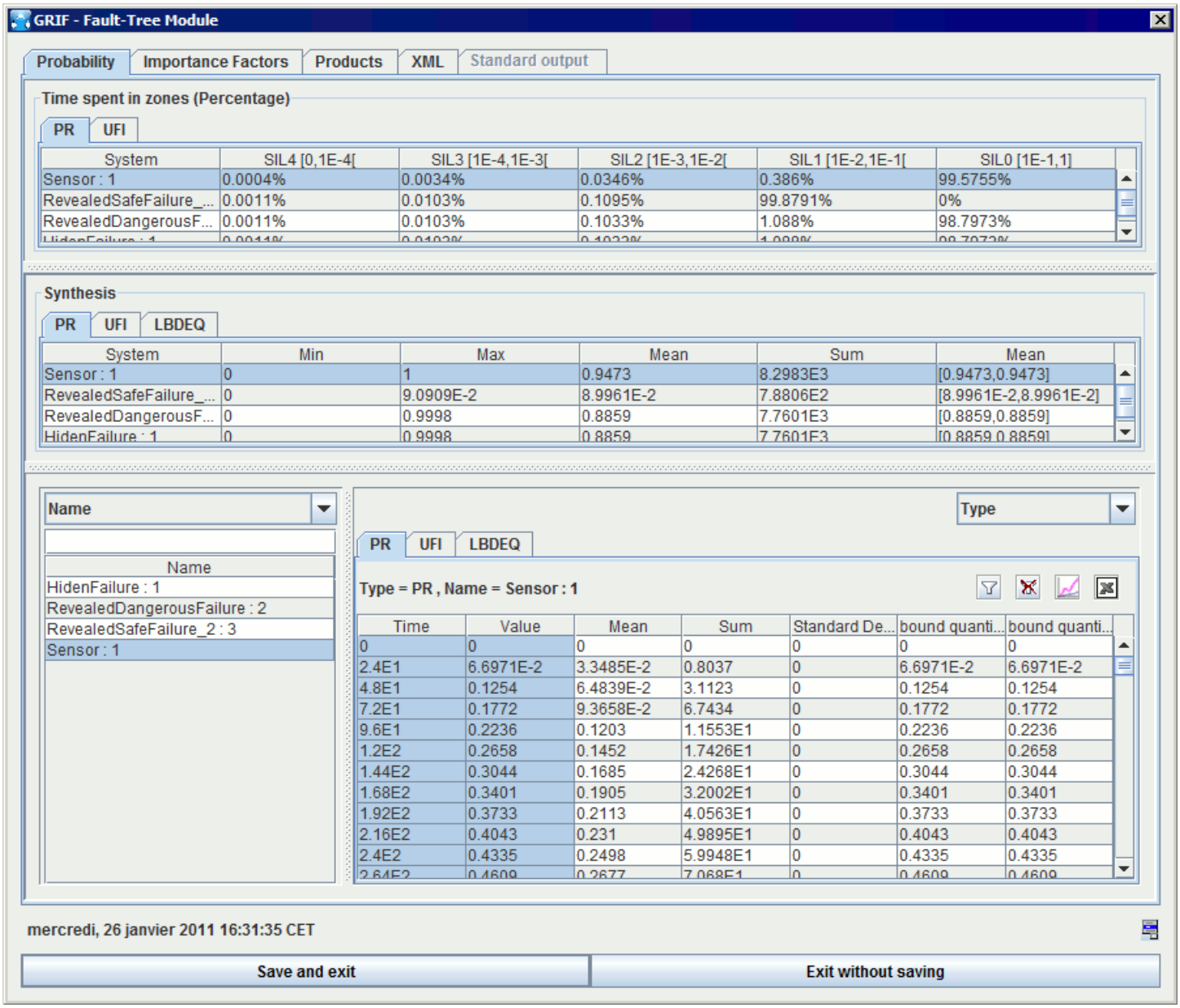
6. **Importance factors**: specifies the importance factors to compute.

   - **Birnbaum (MIF)**
   - **Critical (CIF)**
   - **Fussel-Vesely (DIF)**
   - **Risk Achievement Worth (RAW)**

- **Risk Reduction Worth (RRW)**

6.1.2. Results

The **Probabily** tab gathers all probability computations. The top part displays the percentage of time spent in each zone (if needed). Then a synthesis tablea diplays minimum, maximum, mean/average and sum. If it is a computaion with propagation of uncertainties, a column diplays the confidence range of the average.



Importance factors tab displays importance factors for each events and for each system.

Products shows results of cuts/products computations. In synthesis, a cut with a "0" order, means that the top event is always true. It may happen if some parts are "forced to 1".

XML tab contains Albizia output.

6.2. MOCA computations

The computations by MOCA are performed in three main steps:

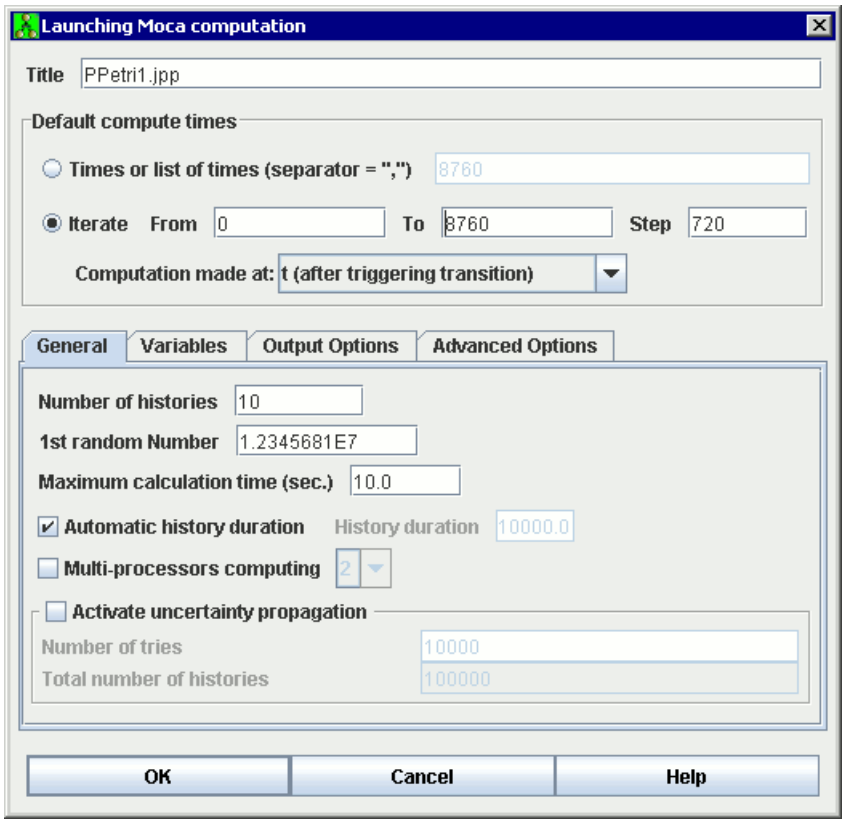
- general configuration;

- computation launch;
- reading the results file.

6.2.1. Configuring the computations

The computation configuration window can be accessed in two different ways: either via menu **Data and Computations - Moca Data** or via **Data and Computations - Launch Moca 12 ...**. The difference between the two is that, in the second case, the configuration step is directly followed by the computation launch step.

The configuration window which opens is called **General Information**:



This configuration window is divided into five parts:

1. **Title**: allows you to give a title to the results file.

2. **Default statistics configuration**: defines the types of computations which will be performed by default for all the statistic states.

3. **Default computation times for statistic states**:

   - **Iterate From** A **to** B **step** C: the computations will be performed for values of t ranging from A to B with a step of C.
   - **List of times**: the computations will be performed for the values of t given in this list.

   <listitem>
   Computation made at: by default, computations are made immediatly after trantion triggering, but you can do computation et t-Epsilon (just before triggering), or at both.
   </listitem>

4. **General**:

   - **Number of histories**: Number of histories (NH) to be simulated (each history has a time t indicated below).

- **First random number**: It is the seed of random number generator.
- **Maximum computation time** (MT): The computations are stopped and the results are printed even if the requested number of histories has not been reached.

  Note: the unit of time (MT) is the second.
- **Automatic history duration**: If this box is checked, GRIF will compute history duration using computation time of variables and statistical states. If not, user can choose a specific **History duration**
- **Multi-processors computing** Enables (or not) the multi-processor computing (when available).
- **Activate uncertainty propagation** Enables (or not) the uncertainty propagation computations (two-stage simulation): in this case we must specify the number of sets of parameters "played" (the real number of histories thus simulated will be the "number of sets of parameters x number of histories to be simulated" and will be displayed in the "Total number of histories" field).

5. **Variables**: This tabs reminds comuting configuration of variables. If document contains some statistical states, another tab is available.

6. **Output**: used to configure the output.

   - Prints the description of the Petri Net in the results file (or not)
   - Prints the results file allowing it to be loaded using a spreadsheet application (such as EXCEL)
   - Prints the censored delays (or not)
   - Number of outputs during simulation. If 2 outputs, there will be an output at NH/2 and at NH.

7. **Advanced options**: used to configure the advanced options.

   - You can choose the limit of transitions fired at the same time before loop detection.

6.2.2. Launching the computations

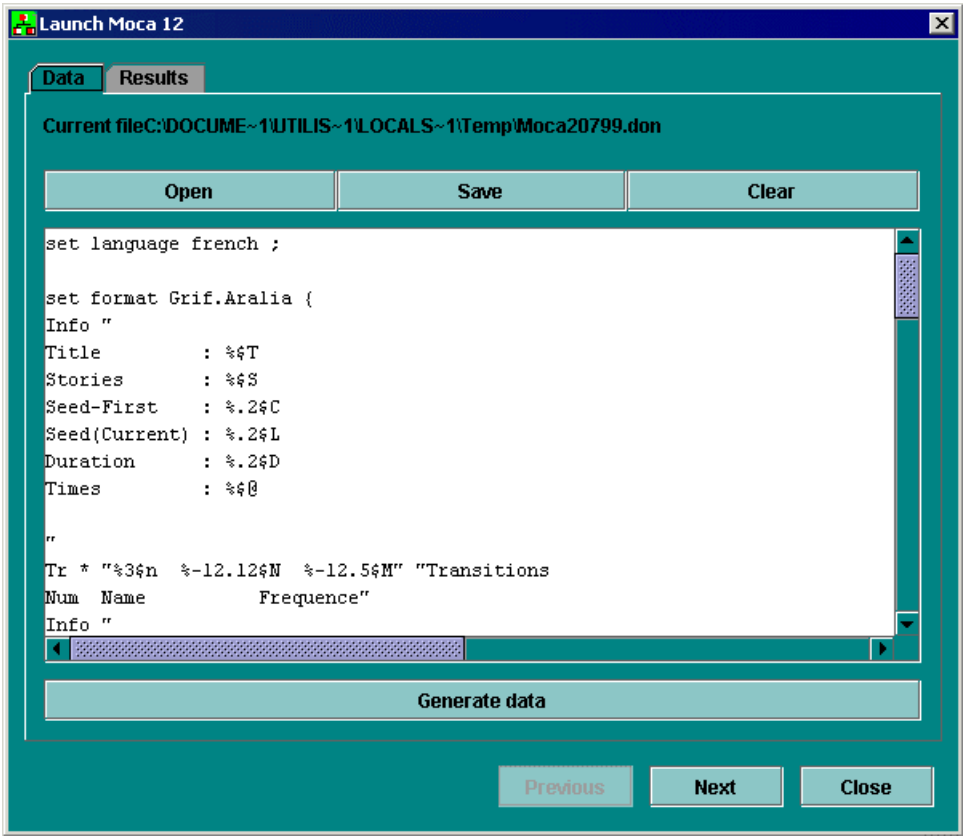
When the configuration part has been carefully completed, you reach a window allowing you to launch the computations. This window has two tabs: **Data** and **Results**.

6.2.2.1. Data tab

The **Data** tab displays the MOCA-RP V12 input data file (file type: ".don"). In addition to being able to modify this file manually, there are four buttons available allowing you to perform the following operations:

- **Open**: opens a data file;
- **Save**: saves the current file;
- **Clear**: clears the content of the current file;

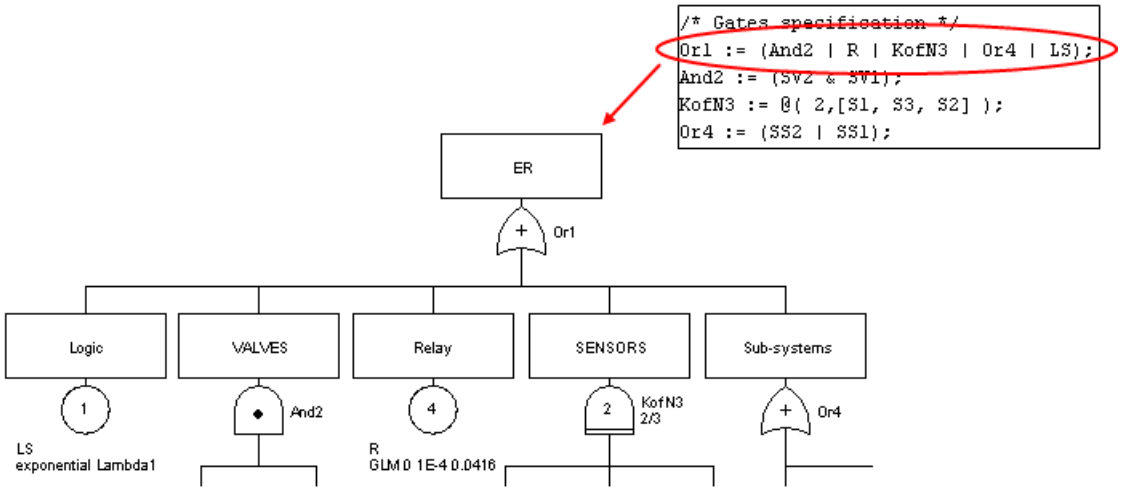
- **Generate data**: generates input data from document.



An input data file is a file describing the model in Moca language. The data entered during the general configuration step is displayed first. Then the rest of the file is divided into several parts (from top to bottom):

1. Gates specification: Each gate's logic is expressed according to the corresponding subtree elements (gates and/or events).

   Example:



   In the above example, it is specified that the logic expression at the level of gate **Or1** is equal to **And2** OR **R** OR **KofN3** OR **Or4** OR **LS**.

2. Parameters specification: All the model's parameters are listed (name and value).

3. Laws specification: For each block, the law is specified followed by all its parameters.

Example:

```
/* Laws specification */
law LS exponential Lambda1;
law SV1 periodic-test Lambda2 Test 0;
law SV2 periodic-test Lambda2 Test 10;
law R GLM 0 1E-4 0.0416;
law S1 GLM Gamma Lambda1 Mu2;
law S2 GLM Gamma Lambda1 Mu2;
law S3 GLM Gamma Lambda1 Mu2;
```

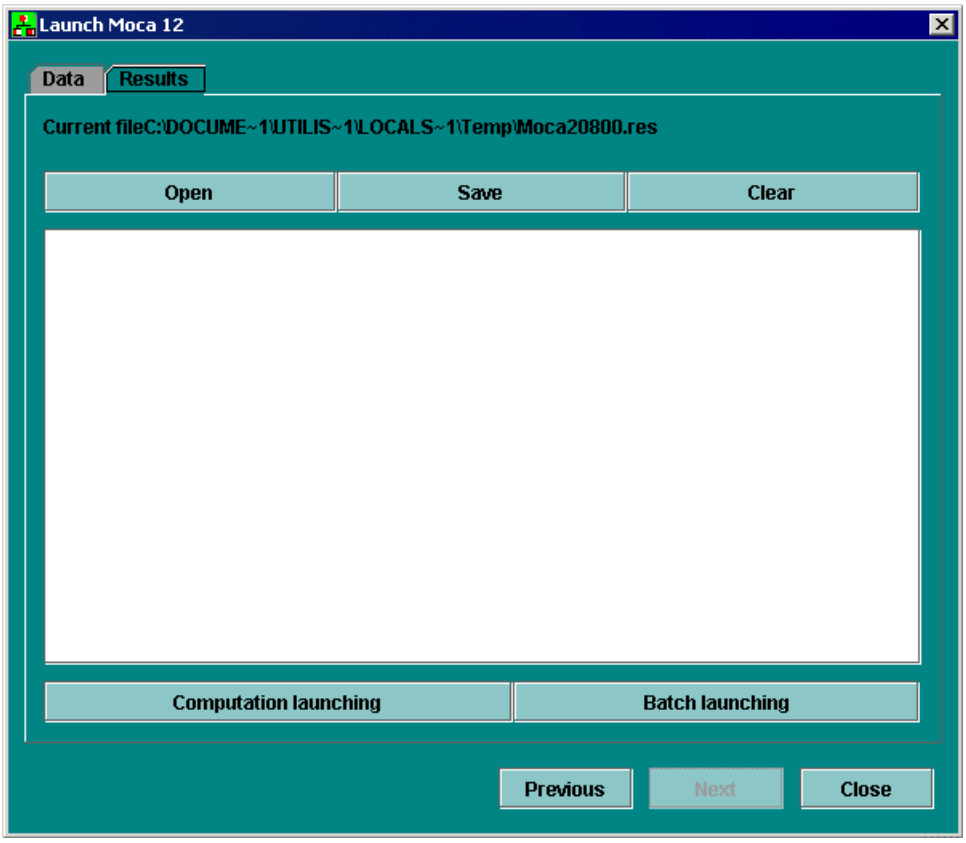
In the above example the behaviour of events **S1**, **S2** and **S3** is governed by a "GLM" law (in the Albizia sense) and thus "IND / Unavailability" in the GRIF sense, and its parameters are:

- "Gamma" = **Gamma**;
- "Lambda" = **Lambda1**;
- "Mu" = **Mu2**.

6.2.2.2. Results tab

The **Results** tab initially launches the computations and then displays the results file (file type: ".res"). Five functions are available here via buttons:

- open ".res" file;
- save current file;
- clear contents of current file;
- launch computations from graphical interface, a waiting window will be display, it allows to stop computation if need be;
- launch computations in **Batch** mode to have permanent access to the input interface throughout the computations. Computations are launched with low priority.



6.2.3. Reading the results

For MOCA computations, the results file is presented as follows (from top to bottom):

1. Data entered during the general configuration of MOCA:

```
Title          : <NULL>
Stories        : 10000
Seed-First     : 12345681.00
Seed(Current)  : 1335337645.00
Duration       : 10000.00
Times          : DURATION
```

2. List of transitions automatically generated for MOCA (and their firing frequencies from the simulation):

```
Transitions
Num  Name          Frequence
  1  Sol.C1        1.00000E+000
  2  Def.C1        1.19100E-001
  3  Rep.C1        1.27000E-001
  4  Sol.C2        1.00000E+000
  5  Def.C2        1.24700E-001
  6  Rep.C2        1.34200E-001
  7  Sol.C3        1.00000E+000
  8  Def.C3        1.18500E-001
  9  Rep.C3        1.26400E-001
 10  Def.LS        1.13900E-001
```

3. List of places automatically generated for MOCA and the associated different results from the simulation:

```
Places
Num  Name          MeanTime   StdDev   MeanMark   StdDev
  1  I.C1          0.00000E+000  0.00000E+000  0.00000E+000  0.00000E+000
  2  M.C1          9.98732E+003  5.06093E+001  9.98732E-001  5.06093E-003
  3  P.C1          1.26833E+001  5.06093E+001  1.26833E-003  5.06093E-003
  4  I.C2          0.00000E+000  0.00000E+000  0.00000E+000  0.00000E+000
  5  M.C2          9.98662E+003  5.21483E+001  9.98662E-001  5.21483E-003
  6  P.C2          1.33761E+001  5.21483E+001  1.33761E-003  5.21483E-003
  7  I.C3          0.00000E+000  0.00000E+000  0.00000E+000  0.00000E+000
  8  M.C3          9.98753E+003  4.99101E+001  9.98753E-001  4.99101E-003
  9  P.C3          1.24711E+001  4.99101E+001  1.24711E-003  4.99101E-003
 10  M.LS          9.42173E+003  1.89912E+003  9.42173E-001  1.89912E-001
```

4. Unavailability results and unreliability results for each type of statistics requested:

```
1 = Mean times in states.
-------------------------
Times   1.000000000000E+004
Name            Mean    Std-Deviation
UnAvail.Out.out 2.004324611157E+003     2.581826234964E+003
UnReliab.Out.out        9.990010233429E+003     2.715454299857E-001

2 = Mean of presence of state at the end of an history.
-------------------------------------------------------
Times   1.000000000000E+004
Name            Mean    Std-Deviation
UnAvail.Out.out 1.502000000000E-001     3.572852155807E-001
UnReliab.Out.out        1.000000000000E+000     0.000000000000E+000

3 = Mean value of the expression at the end of an history.
----------------------------------------------------------
Times   1.000000000000E+004
Name            Mean    Std-Deviation
UnAvail.Out.out 1.502000000000E-001     3.572852155807E-001
UnReliab.Out.out        1.000000000000E+000     0.000000000000E+000
```

5. Computation times.

7. Curves

The curves can be drawn to study the model and the results better. To do this, click left on the corresponding icon on the vertical task bar then draw a box. This box will be the space assigned to displaying the curve(s). Initially it is only a white box with two axes without graduation.

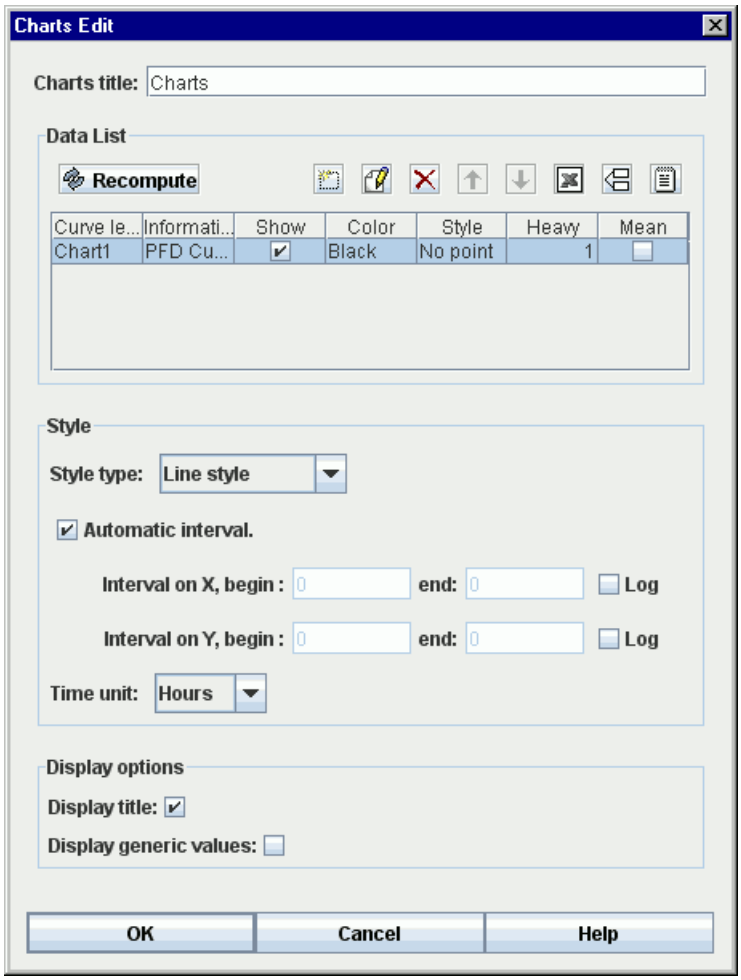
Charts icon:

We must now define the curves to be drawn. To do this, click right on the box to display the **Charts Edit** window.

7.1. Charts Edit window

Note: It is important to specify that drawing curves requires a computation to be launched which is completely independent of that accessible in menu **Data and computations - ...**.

The Charts Edit window is the same for all the GRIF modules



This window is divided into several parts:

1. **Charts Title**: allows you to give a title to the graphic.

2. **Data List**: This part contains a three-column table listing the chart's different curves (name, description, display, curve colour, curve style, curve thickness).Several buttons are available above this table.
   - **Recompute**: launches or relaunches the computations necessary to draw the curves (this operation must be performed each time the list of curves or the model is modified).
   - **Add**  : sends you to a Curve type window to add a curve to the chart (cf. following chapter).
   - **Edit**: modifies the selected curve.
   - **Delete**  : deletes the selected curve from the chart.
   - **Up**  : moves the selected curve upwards in the list.
   - **Down**  : moves the selected curve downwards in the list.
   - **Save**: the list of points computed for the selected curve in CSV format. This export doesn't contains generic values. In order to export with generic values, use right-click and select **Separate export**.
   - **Duplicate**: creates a new curve identical to the selected curve.
   - **Results**: display in a text editor the results of the selected curve.

   For each curve, you can specify its colour, its style of points, its thickness and its display options.

3. **Computation options**: allows you to configure the computation (optional depending on the module used).

4. **Style**: This part deals with displaying curves.
   - **Style type**: specifies the type of all the chart's curves (line or histogram).
   - **Intervals on X and Y**: Specifies the display interval for the X and Y axes (default interval or user-defined interval). This last function can, for example, be used to zoom in on the most interesting parts of the curve.

     The **log** check boxes are used to enable the logarithmic scale on the axis concerned. Important: 0 cannot be represented on a log scale, remember to give a strictly positive starting point (e.g.: E-10). If 0 is given, the log scale will start with an arbitrary value E-15.

     When domain axe deals with time, you can choose time unit among : hours, days, months, years. Default display is "hours" because it is the usualy used unit for modeling. It's only available in SIL module.

     When computation engine allows it, you can **display confidence range** checking the checkbox.

     With historam style, a checkbox allows to do a cumulated histogram.

5. **Display options**: enables (or not) the **Display title** function (displays the title of the chart) and the **Display generic values** function (displays the min., max. and mean values of each curve).

When a curve is edited, its edition window contains 3 parts : times used for computation, target of computation, further information (generic values) that be be displayed or not under the curve.

Remark: it's sometimes useful to refresh all charts in document. Use the **Tools / Refresh** command or press F5 or  icon.

7.2. Curve type

When you click the **Add** button in the **Data list** part you reach a window called **Curve type**. You then have four possibilities:

- **Use existing results**: draws the points that are in bank of results in document. This banks of results contains every computation made previously.

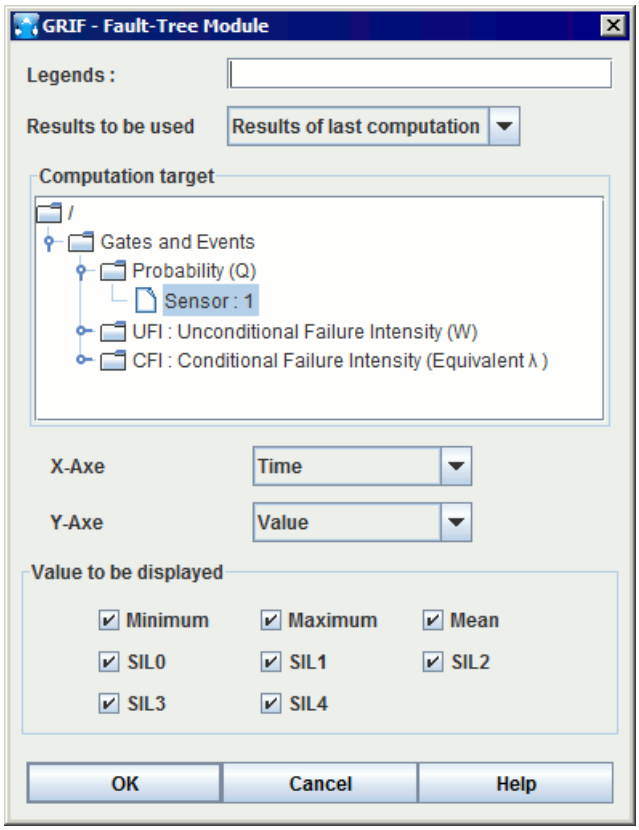
- **Moca 12 Curve**: draws an unavailability curve according to the points computed by the Moca 12 engine.

NB: an example curve for each type of computation will be given later.

Whatever the type of curve selected, a window is displayed allowing you to modify the computation times and types.

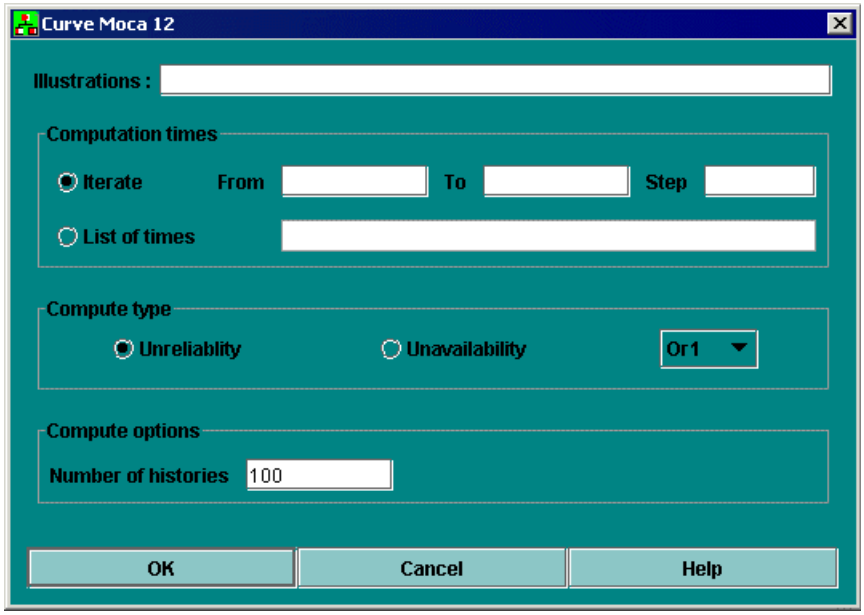
7.2.1. Use existing results

Users must select the result they want to display. Then the must select what will be used for x-axe and for y-axe.



7.2.2. Moca

When you select **Moca 12 Curve**, you must then configure the computations using the following window:



The above window bears the name of the type of curve selected (in this case: **Moca 12 Curve**). It is divided into four parts:

1. **Legend**: to name the curve.

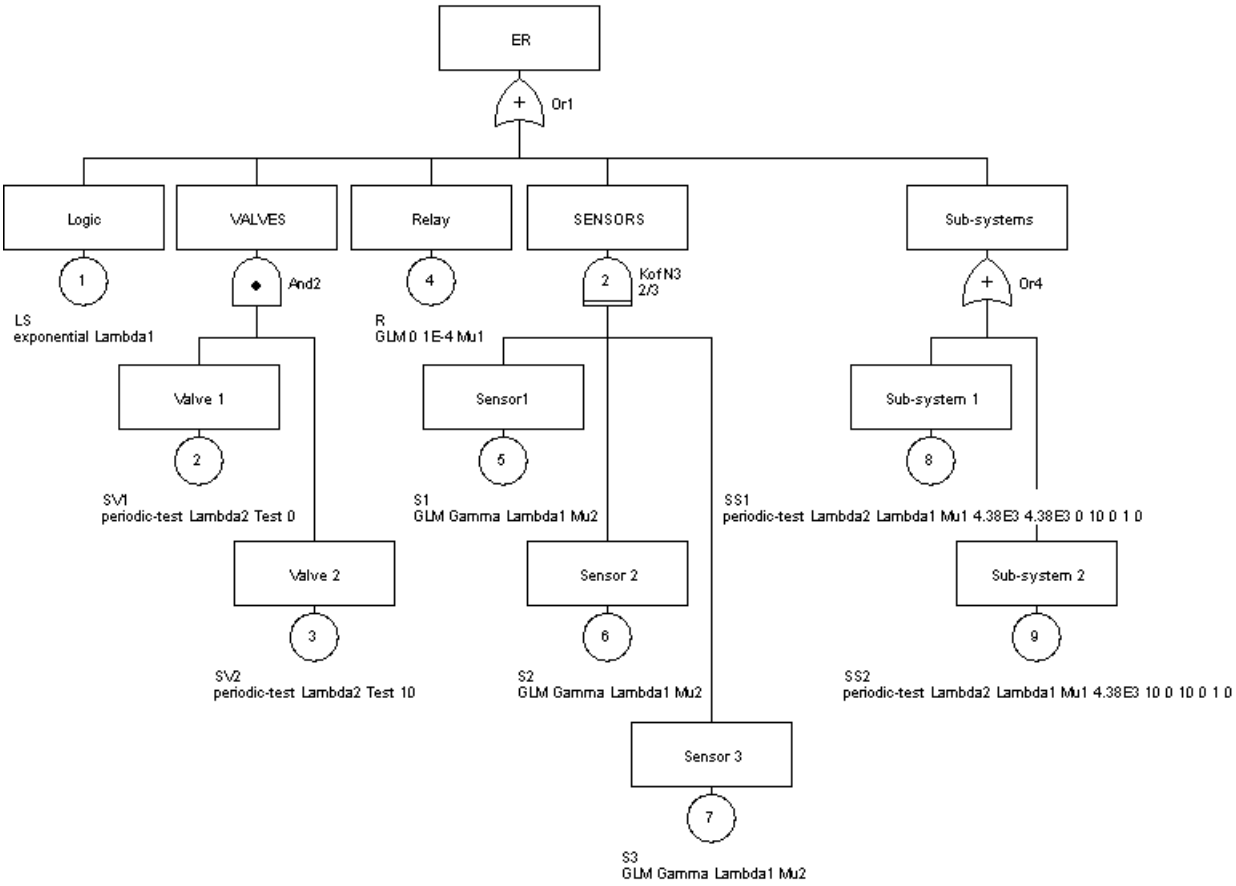
2. **Computation times**: time interval and step OR list of times (gives the computation engine the exact point to be computed).

3. **Computation type**:
   - used to select whether the computation will be an **unavailability** computation or an **unreliability** computation;
   - AND used to select the target which is to be the subject of the computation;

4. **Computation options**: specifies the number of histories to be simulated.

7.3. Examples of curves

Here is the Fault Tree which will be used to draw the different curves.

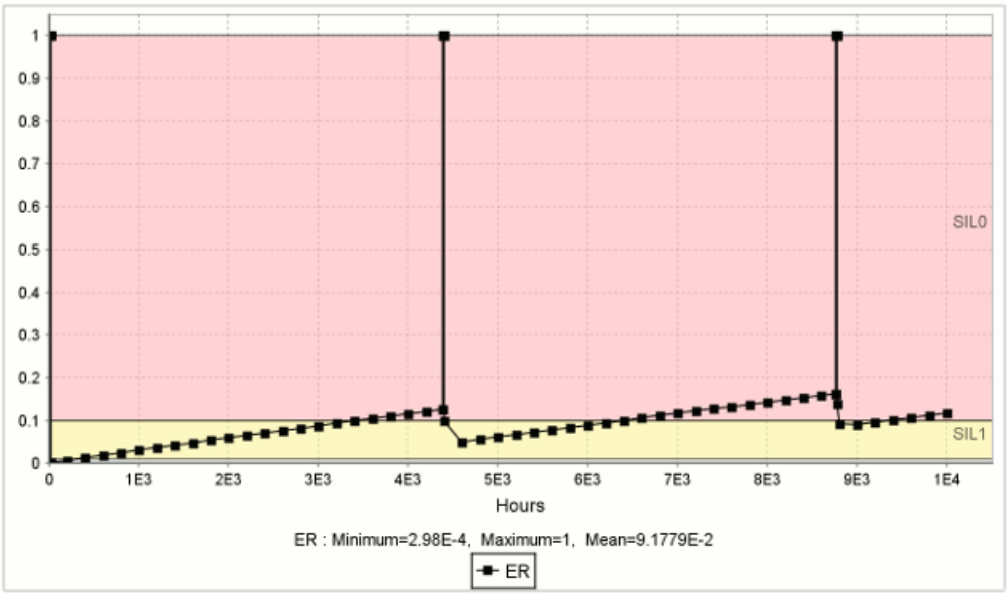


It is the example described previously and which has:

- 9 events
- 4 gates

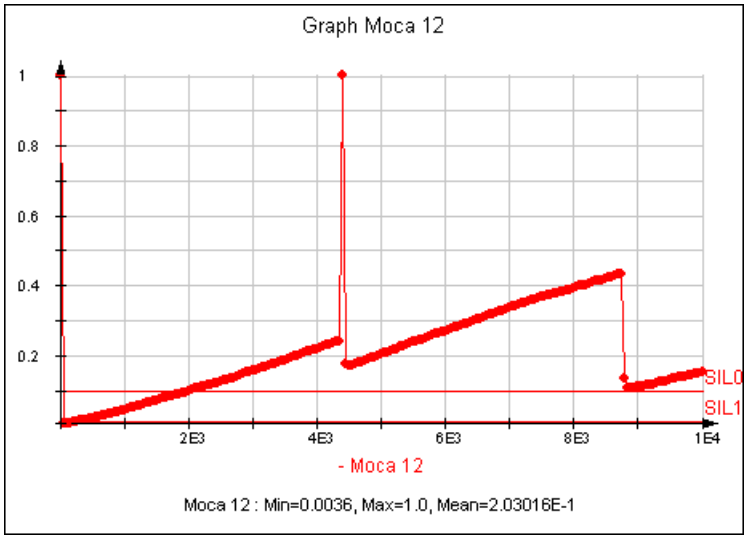
Each of the following gates represents the system's unavailability (over 10,000 hours) computed at the top of the tree **ER**.

7.3.1. Curve from bank of results



This points are thoses in bank of results. They have been computed during last computation. This picture shows probability of Top-Event, but you can draw everything you have computed.

7.3.2. Moca 12 Curve



The points have been computed at regular intervals (1 every 50 hours). 10,000 histories have been simulated for this graph. Only the first two peaks were found using the 50 hour time step. The third (t = 8760 h) was not taken into account.

Important NB: For the curves drawn using Moca, the discontinuity points are ignored and thus do not appear on the graph. However, the mean displayed does take account of each discontinuity point.

8. Databases

In each GRIF module a connection can be established to a database. It is possible to have two different types of connections:

- connection to a CSV file;
- connection via a JDBC link.

8.1. Connection to a CSV file

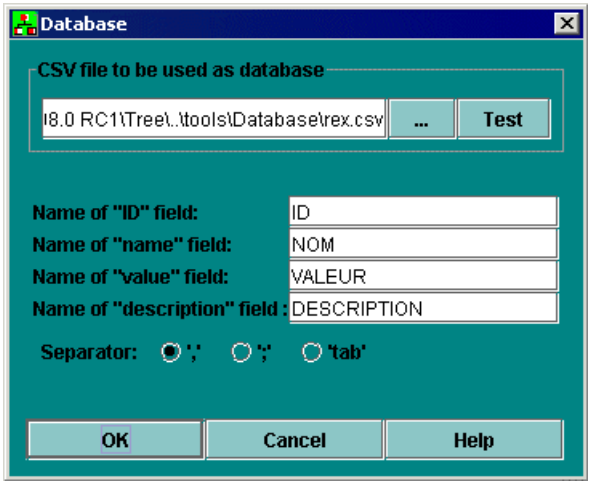
8.1.1. Form of the database

This type of connection is the simplest to make. A CSV file has the extension ".csv". It is a simple text file where the different fields are separated by commas, tabs or semi-colons. It is the simplest form of database.

```
ID;NOM;VALEUR;DESCRIPTION
1;Lp1comp;0.006;comment1
2;Lp2comp;0.004;comment2
3;Lp3comp;0.002;comment3
4;Lp4comp;0.001;comment4
```

8.1.2. Connection

To connect GRIF to this database, go into menu **Tools - Connection to a CSV file**. A dialogue box is then displayed:



This window is divided into three parts:

- You must initially enter the path leading to the CSV file. To do this, there is an explorer available (... button). A Test function is used to check the connection.
- You must then enter the names of the four fields of the CSV file.
- Finally, specify the types of separators used in the CSV file.

Note: A CVS connection must be made with a CVS File (which means generated from only one sheet of a EXCEL File).

8.2. Connection via a JDBC link (example with ODBC connector)

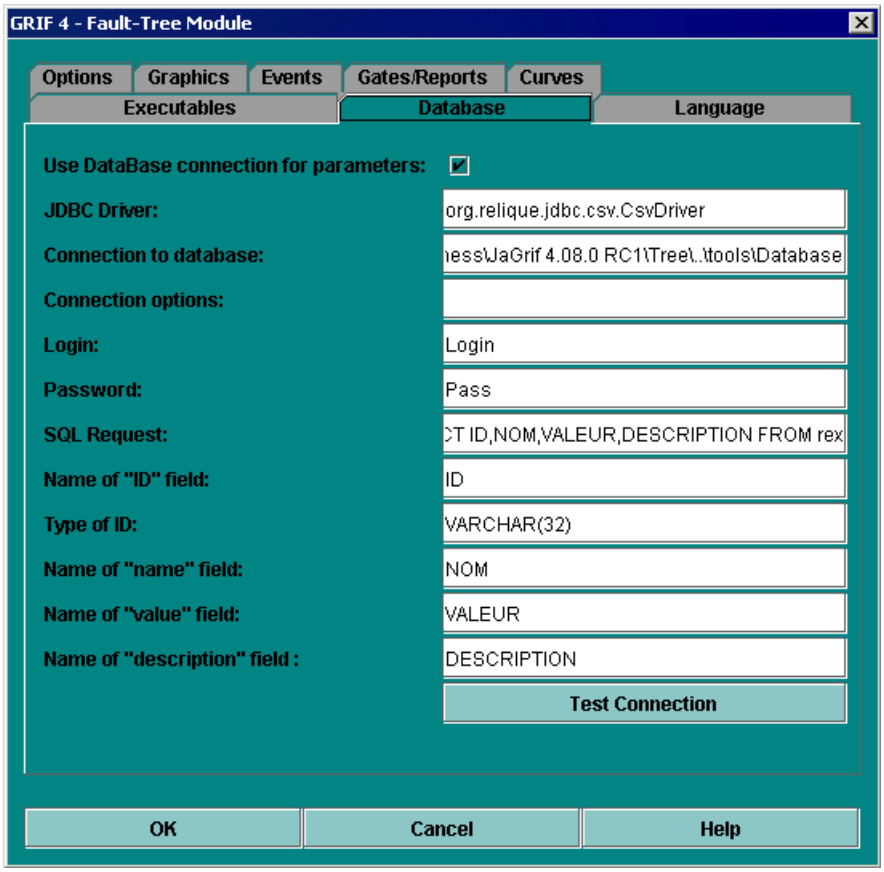
8.2.1. Form of the database

The database can initially be in the form of an EXCEL or ACCESS file. Then, using the operating system, an ODBC system data source must be created. In the case of WINDOWS, for example, this operation is performed in menu "Control Panel - Administration tools - data source (ODBC)". Here is an example of an EXCEL database:

	A	B	C	D
1	ID	NOM	VALEUR	DESCRIPTION
2	1	Lp1comp	0.006	comment1
3	2	Lp2comp	0.004	comment2
4	3	Lp3comp	0.002	comment3
5	4	Lp4comp	0.001	comment4

8.2.2. Connection

To connect GRIF to this ODBC database, go into menu **Tools - Application options - Database**. A window is then displayed which must be filled in as follows:

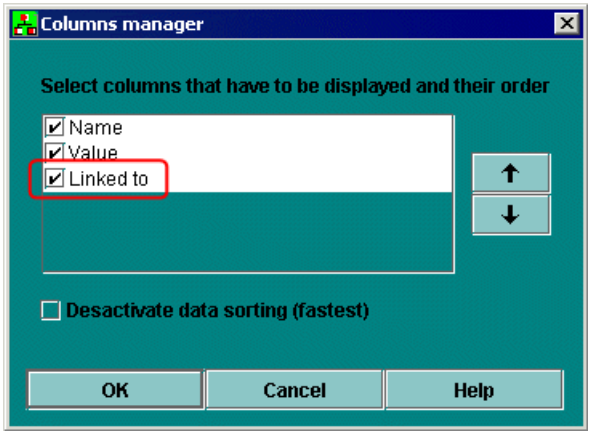


Notes:

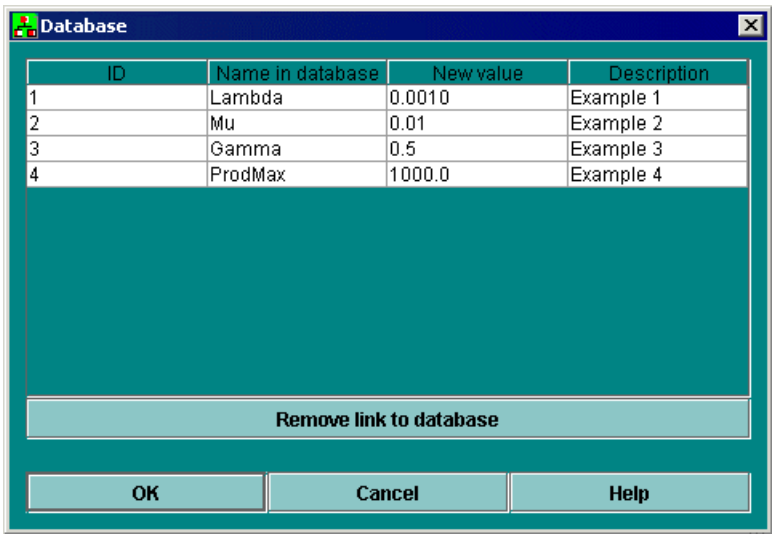
1. **sun.jdbc.odbc.JdbcOdbcDriver** is the driver name
2. **jdbc:odbc:REX** specifies that "REX" is the name of the ODBC link
3. The fields **Connection options**, **Login** et **Password** are unnecessary here.
4. **SELECT ID,NOM,VALEUR,DESCRIPTION FROM [Feuil1$]** $] is called the query where Feuil1 is the name of the EXCEL sheet containing the data.

8.3. Operation

The aim is now to link some of the model's parameters to the database. To do this, start by displaying the column **Linked to** in the parameters table (click right on the top of the columns).

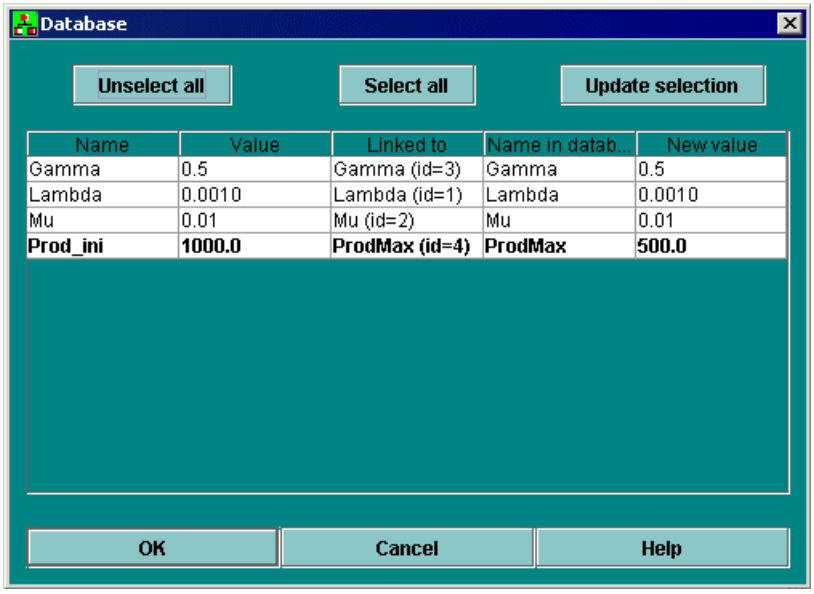


Then double click in the **Linked to** column to display the database items. When one of these items has been selected, click **OK** to validate the connection. The parameter then takes the value of the item to which it is now connected.



Note: The button called **Remove link to database** at the bottom of the table breaks the link between the parameter and the database item.

If some of the database values to which GRIF is linked are modified, the parameters connected to this database can be updated. To do this, select **Data and computations - Update from database...** and display the **Database window**.



The parameters whose values are not up to date are automatically detected and indicated in bold. One or more of these parameters can then be selected for updating using the **Update selection** button. Two other buttons are available to simplify the selection process: **Unselect all** (deselects all the table's parameters) and **Select all** (selects all the table's parameters).

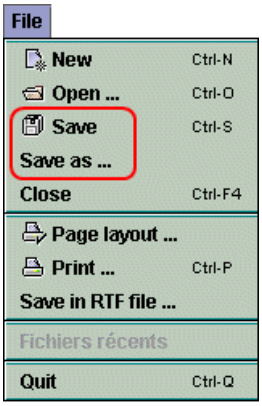
Remark: you can also directly copy parameter from database using menu **Data and Computation/Database/Copy parameters from database**. A window is displayed, you can select parameters you want to copy into document. Parameter will be automatically linked to the right paremeter in database.

9. Save

Here is a summary of all the data which can be saved from a same model.

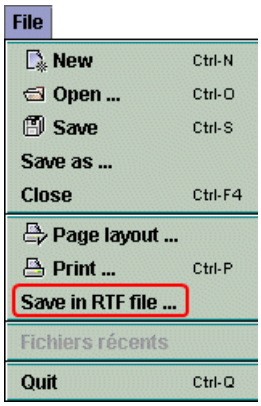
9.1. Model

It is obviously possible to save and reload the models which are made. To do this go into menu **File - Save** or into **File - Save as....**



9.2. RTF File

A model can also be saved in RTF format. This allows the saved model to be reloaded in WORD to insert the graphical part of the model in any document. To do this, go into menu **File - Save in RTF file...**.



Note: There is another way to insert model in a report. Select the part of the model, copy it, and paste it in Microsoft WORD or other software.

9.3. Input data

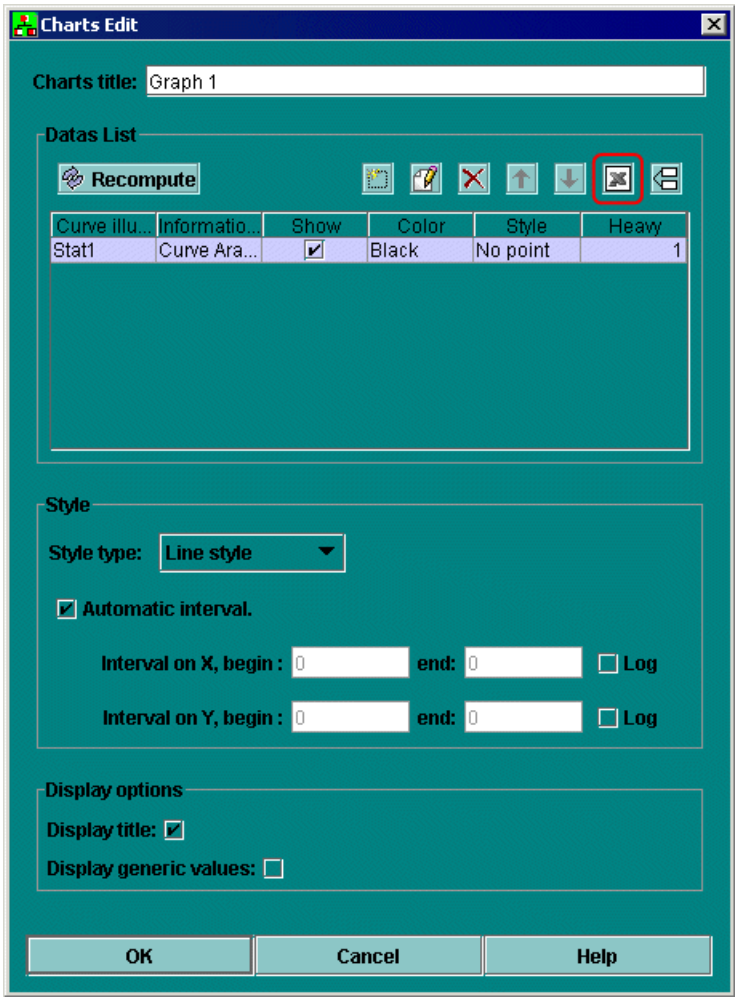
When the input data for the computation engine is generated, it can be saved. This type of file has the ".don" extension. These files can therefore be modified using a text editor then reloaded to launch computations on them (for example). This action should be made only by advanced user.

9.4. Results file

The results file can also be saved. This type of file has the ".res" extension. These files can therefore be reloaded into another program (e.g. EXCEL) to exploit the results in more detail.

9.5. Curves

For each curve drawn, the points which have been computed in CSV format can be saved. This list of points can then be used to draw new curves or to perform further computations.



10. Options of GRIF - Fault Tree

Tools - Application Options menu opens a window containing the following tabs:

10.1. Executables

Executables tab enables to specify path to external executables :

- **Editor path** : Specifies text editor path.
- **Automatically open PDF files** : Specifies if PDF reports must be openned avec generation.
- **Style-sheet from XML to DocBook.** : Style-sheet allowing converting from XML report to docbook file.
- **Style-sheet from XML to HTML.** : Style-sheet allowing converting from XML report to HTML file.
- **Style-sheet from DocBook to PDF.** : Style-sheet allowing converting from docbook file to PDF file.
- **Moca-RPC path** : Specifies Moca version 12 path.
- **Javaw path** : Path of javaw.exe executable.

10.2. Database

Database tab enables to configure database connection :

- **Use DataBase connection for parameters** : Select if database must be use.
- **Name** : Database name will be put into parameter during its update. It enables to know from which database parameter has been lastly updated.
- **JDBC Driver** : Enter name of JDBC driver to be used(sun.jdbc.odbc.JdbcOdbcDriver, oracle.jdbc.driver.OracleDriver, ...).
- **Connection to database** : Database Url.
- **Connection options** : Connection properties.
- **Login** : Login to be used to connect to database.
- **Password** : Password to be used to connect to database.
- **SQL Request** : Request that have to be executed to retrieve data from database.
- **Name of "ID" field** : Name of field containing data ID.
- **Type of ID** : Type of ID field (INTEGER, FLOAT, VARCHAR(32), ...)
- **Name of "name" field** : Name of field containing data name.
- **Name of "value" field** : Name of field containing data value.
- **Name of "description" field** : Name of field containing data description.
- **Test Connection** : Name of field containing data description.

10.3. Language

Language tab enables to choice language :

- **Language** : Language changes are taken into account when option windows is closed.Available language are French and English.

10.4. Options

Options tab enables to tune application behavior :

- **Save working document options as default options in application** : Save options of current doc as application default options.
- **Application manage default options of documents. Apply defaut options to current document** : Apply -Application options- to current document.
- **Number of undo** : Specifies number of possible undo/redo.

- **Number of recent files** : Specifies number of files in recent files list.
- **Window display** : Enables separate tables (external) or linked tables (internal).
- **Columns to be resized in tables** : Enables to specify the columns on which space will be taken for resizing.
- **Use net protection key (Red)** : Check this box only if a network key is used (reg key).
- **Manage new names to avoid name conflict** : Tries to avoid name conflict, creating new objects whose name is unik (when pasting for example).
- **Synchronise view with tables** : Select objects in tables (on the right) when they are selected in view.
- **Synchronise view with explorer** : Select objects in explorer (on the left) when they are selected in view.
- **Automatic cutting of imported files** : Automacally cuts of tree when a new file is imported (*.xml or *.dag)

10.5. Graphics

Graphics tab enables to modify GUI look :

- **Element Zoom** : Changes graphics size.
- **Comment size** : Changes comment font size.
- **Activate cross hair** : Activate cross hair which enables object alignment.
- **Activate smoothing for texts** : Activate anti-aliasing (smoothing) for texts, it can slow the display.
- **Activate smoothing for images** : Activate anti-aliasing (smoothing) for images, it can slow the display.
- **Activate tooltips** : Activate tooltip-system.

10.6. Digital format

Digital format tab enables to customize digits display :

- **Display of parameters** : Specifies the display of parameters (number of digits, ...).

10.7. Events

Event tab enables to change event display. :

- **Label size** : Specifies label font size.
- **Display name** : Enables to display name or not
- **Display description** : Enables to display description or not.
- **Display average probability** : Enables to display or not the average probability.
- **Display probability at the end of mission** : Enables to display or not the probability at the end of mission.
- **Display computation time** : Enables to display or not the computation time
- **Display law** : Enables to display law or not.
- **Use a default law** : Enables to use a specific law as default law.
- **Default law** : Enables to define the default law to be used.

10.8. Gates/Reports

Gates/Reports tab enables to change gates/reports display :

- **Label size** : Specifies label font size.
- **Display name** : Enables to display name or not
- **Display description** : Enables to display description or not.
- **Display K/N** : Enables to display K/N or not.
- **Display report location** : Display the set of reports for a gate.
- **Display average probability** : Enables to display or not the average probability.
- **Display probability at the end of mission** : Enables to display or not the probability at the end of mission.
- **Display computation time** : Enables to display or not the computation time
- **Display report source name** : Display name of the matching gate under identical transfer gate.
- **Display report source page** : Display page of the matching gate under identical transfer gate.

10.9. Curves

Charts tab enables to change charts drawing :

- **Set graphics borders** : Add borders to charts.
- **Set generic values borders** : Add borders to generic values under charts.
- **Display grid** : Display grid on curves area.
- **Display legends** : Display legends under curves.
- **Drawing zone transparency** : Activate curves area transparency.
- **Graphic transparency** : Activate charts transparency.
- **Title size** : Specifies charts title font size.
- **Generic values size** : Specifies generic values font size.
- **Point size** : Specifies point size on curves.
- **Coordinates size** : Specifies coordinates font size.
- **Legend size** : Specifies legends font size.
- **Max number of points** : Specifies maximum number of points to be drawn.
- **Max number of points to save** : Specifies maximum number of points to be saved.
- **Draw S.I.L** : Horizontal lines are drawn at E-1 E-2 E-3 E-4.
- **Save points in document** : Specifies if points of charts have to be saved in document.
- **Vertical abscise for histogram.** : Display coordinate of abscise verticaly.