GRIF 2022

Reliability Networks

User Manual

Version May 6th, 2022

Abstract

This document is the user manual of *Reliability Networks* module of *GRIF 2022*

Table of Contents

1. Presentation

1.1. Introduction

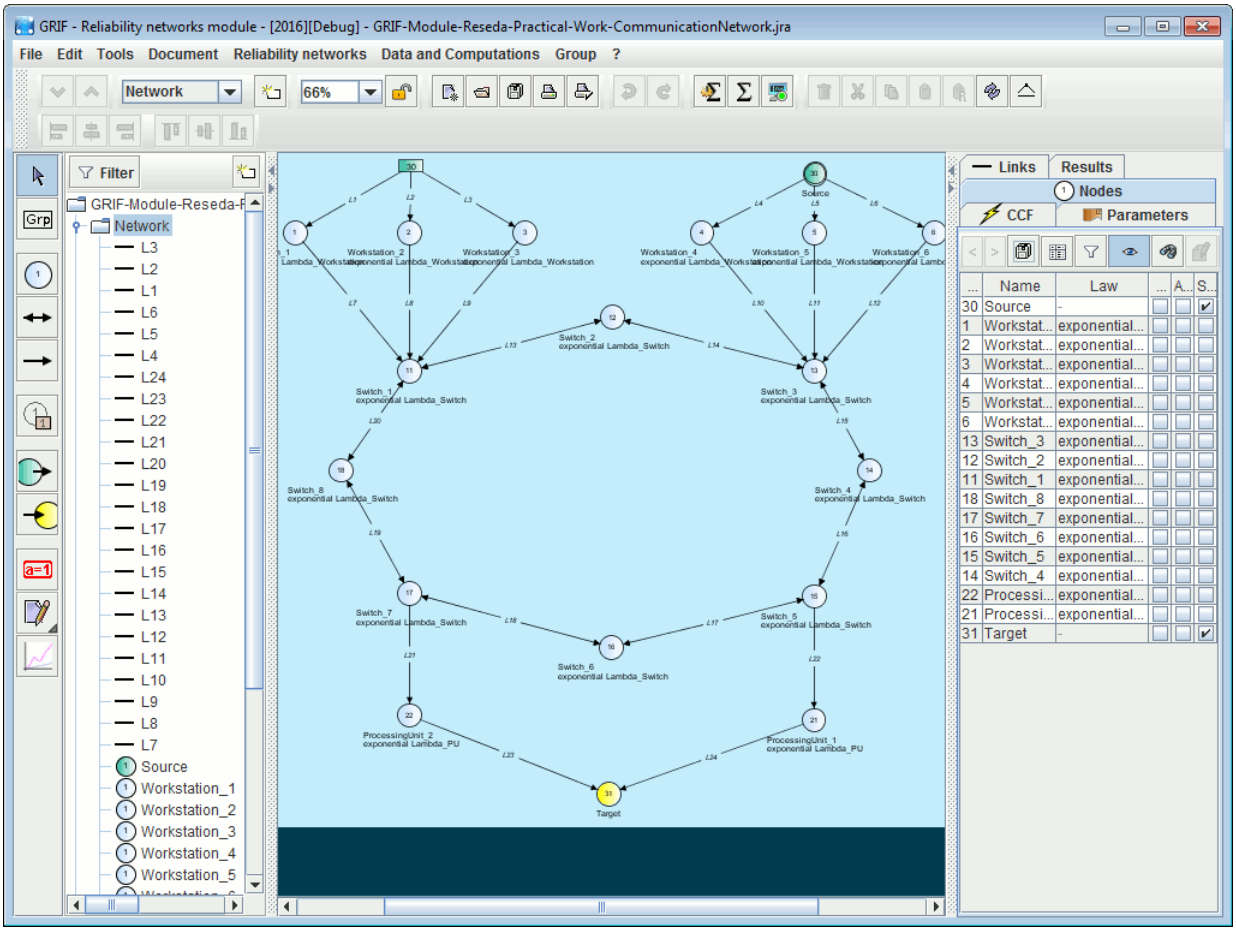
RESEDA is used to model a system as a reliability network made up with nodes and links which can failed. The links between nodes can be unidirectional or bidirectional to adapt as the system specificities.

The Reseda module uses ALBIZIA, the BDD (Binary Decision Diagram) computation engine developed by TotalEnergies. ALBIZIA offers the advantage of running accurate analytical computations and rapidly providing extensive information on the system under study.

1.2. Main window of the Reliability Networks 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) enables 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 between input zone and tool bar. It enables to walk through pages and groups of the document.
- **Template**: Templates are hidden behind the tree. They are grouped in two files following the save directory (User or built-in directory).
- **Set of tables**: Tables are gathered in "hidden" tabs on the right.



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:

	Selection tool Select the graphical objects in the input zone.
	**Group** Add a group (sub-page) to the model.
	**Node** Node of the reliability network, several links can be connected to it.
	**Bidirectional link** Link that let the flow (data, fluids, electricity, ...) goes in both way.
	**Unidirectional link** Link between nodes where the flow can only go in one way (the one defined by the arrow).
	**Repeated node (Shortcut)** Shortcut are used to display one node at several places. They are useful to create links between several parts of the same model (on different pages or in different groups).
	**Source** Input of the network, it can not fail.
	**Target** Output of the network, it can not fail.

	**Dynamic field tool** creates dynamic comments displaying the data in the model.
	**Comment tool** creates static comments.
	**Line tool** creates lines or arrows of different styles.
	**Rectangle tool** creates rectangular zones of different colours. These zones can be anchored to the page.
	**Polygon tool** creates a zones with an polygon shape. These zones can be anchored to the page.
	**Circle tool** creates circular zones of different colours. These zones can be anchored to the page.
	**Ellipse tool** creates a zones with an ellipse shape. These zones can be anchored to the page.
	**Curve tool** draws curves by selecting the computation results in the results base.

1.4. Data Editing Tables

1. Description of the Tables

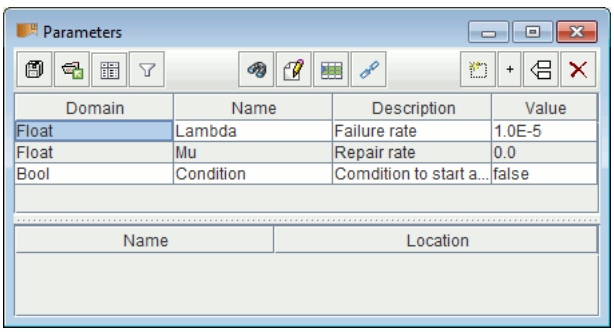
To create or modify data (parameters, variables, etc.), tables are available in the **Data and Computations menu** and in tabs at the right of the view. All the GRIF 2022 data tables operate in the same manner.

It is possible to edit all tables in another screen using **Data and Computations - Editing tables (new windows)** menu.

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

- The upper part consists of a toolbar;
- The main part containing the data table.
- The bottom part indicating what the selected data is used for. This table is available only if the given data can be used by another data. The first column of this table indicates the name of these elements, the second indicates their location in the document (page, group). A click on a line from this lower table will open the page where the item is located and select it.

Here is an example illustrating the parameter table



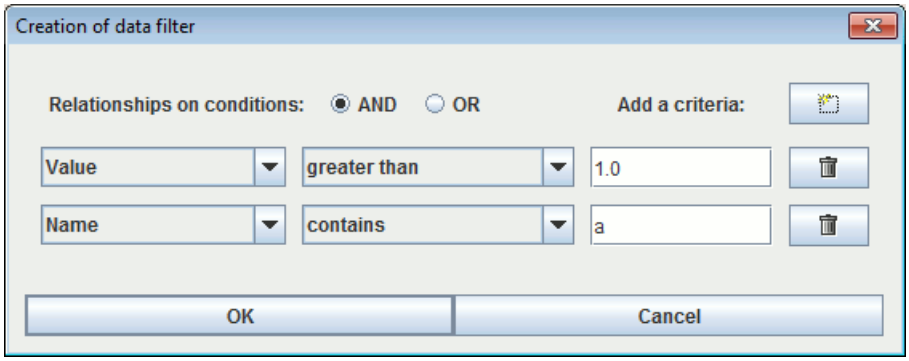
Different actions are available depending on the type of data displayed. Below is a non-exhaustive list of actions that can be found on the data tables.

	Saves the table in a text file.
	Import data from another Reseda model or from CSV file.
	Opens the column manager (cf. Section 1.2, “Column manager”).
	Displays a panel for searching or filtering data (cf. Section 1.1, “Filter and sorting data”).
	When the **display selection** button is pressed, a click in the table leads to the selection in the input area.
	Find and/or replace expression in the table .
	Edit the selection.
	Multiple modifications made to all the selected data.
	Permit to merge data in a unique data.
	Creates new data.
+	Create the number of data indicated by user.
	Duplicate the selected data (ask a new name)
	Deletes the selected data (one or many).

1.1. Filter and sorting data

The filter panel enables you to display only what is necessary in the data table.

It consists of a search part: the text entered is searched in all the cells of the table, only the lines whose text is present are preserved; and an advanced filtering part allowing to consider finer criteria according to the different fields of the data. It is possible to combine several filtering criteria, as 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.

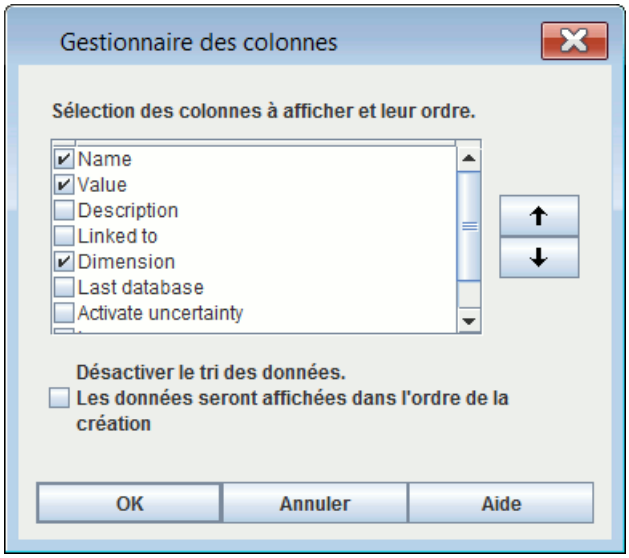
If the Boolean expression is true, the data will be kept (displayed); otherwise the data will be masked. When the filter is enabled its value is displayed between < and >.

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).

The choices that are made are kept on the current document. They will be reapplied when reopening your document and do not affect other documents in the application.

1.2. Column manager

A table can contain many columns and to improve its readability it is possible to choose the columns that will be displayed as well as their order. To do this, click on the **Columns Manager** button, the following window opens:

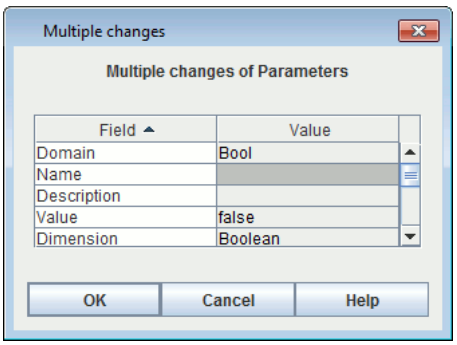


You can choose the columns to be displayed by selecting (or deselecting) the corresponding check boxes. The arrows on the right are used to move the columns up or down in the list to choose the order of the columns. The **Disable data sorting** check box disables the data sorting. This improves the application's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

The choices that are made are kept on the current document. They will be reapplied when reopening your document and do not affect other documents in the application.

1.3. Multiple edition

To modify data, simply double-click on the cell to modify. 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.

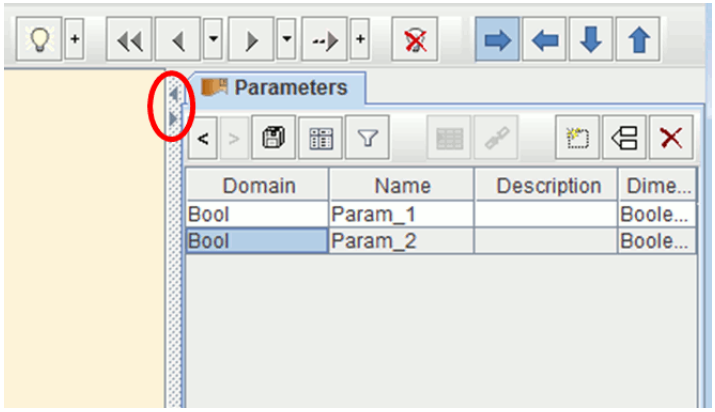


Items which cannot be modified are greyed. The white lines indicate that the selected data does not have the same value for the field in question. A new value can be entered which will be taken into account for all the selected data. The lines with no background colour indicate that all the selected 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.

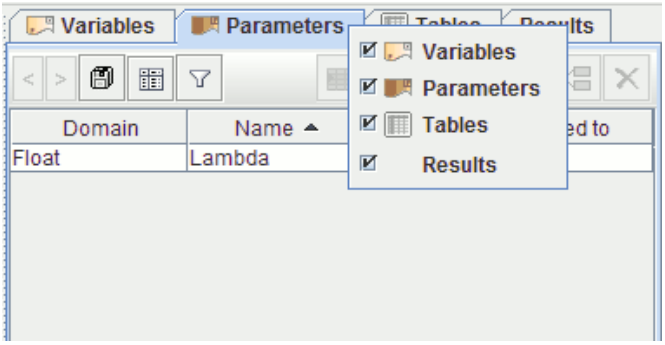
2. Table accessibility

As mentioned above, the tables can be accessed via the **Data and Computations** menu; in this case, each table is displayed in a separate window.

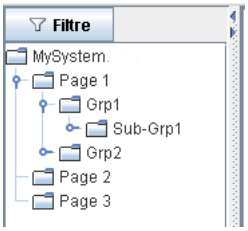
To avoid having too many windows open, all the tables are grouped together in tabs on the right-hand side of the application. This area can be hidden/displayed using the small arrows above the input zone.



It is possible to choose the tables in this zone by right clicking on the tabs. A contextual menu appears, in which the user can select the tables s/he wishes to display.



1.5. Tree view



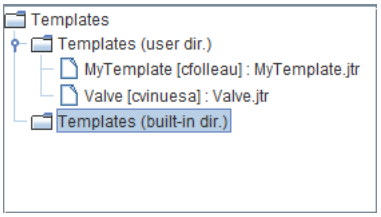
To help users to walk through the document (pages, groups and sub-groups), a tree is available on the left of the application. By default, every element is displayed, you can use **Filter** button in order to select elements you want to display or not.

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.

1.6. Template panel

Template panel located under the arborescence enables to visualize the various template saved.



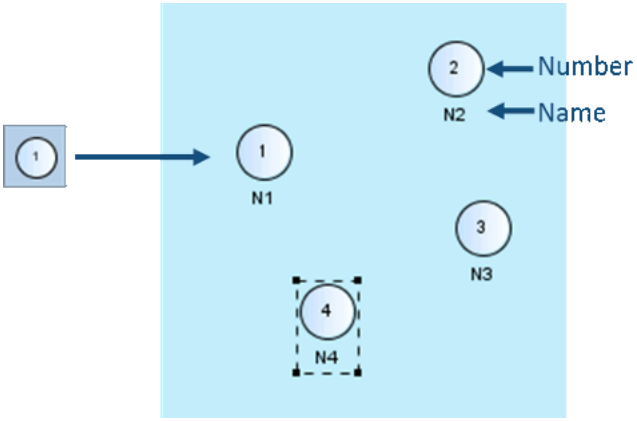
A drag'n'drop enables to inser quickly the template in the model.

2. Creating a reliability network

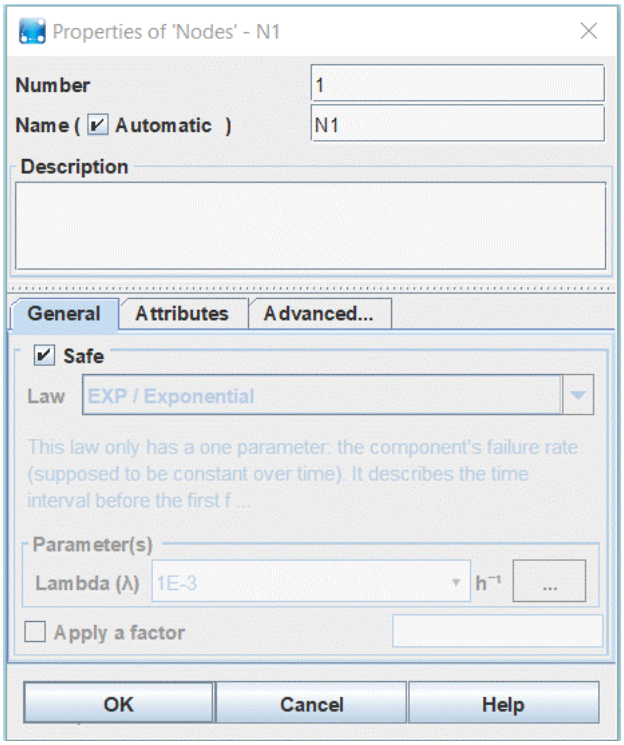
2.1. Entering the network

2.1.1. Nodes

To enter the various **Nodes** , select the corresponding symbol on the vertical toolbar. A new element is then created whenever you left click on the graphical entry area.



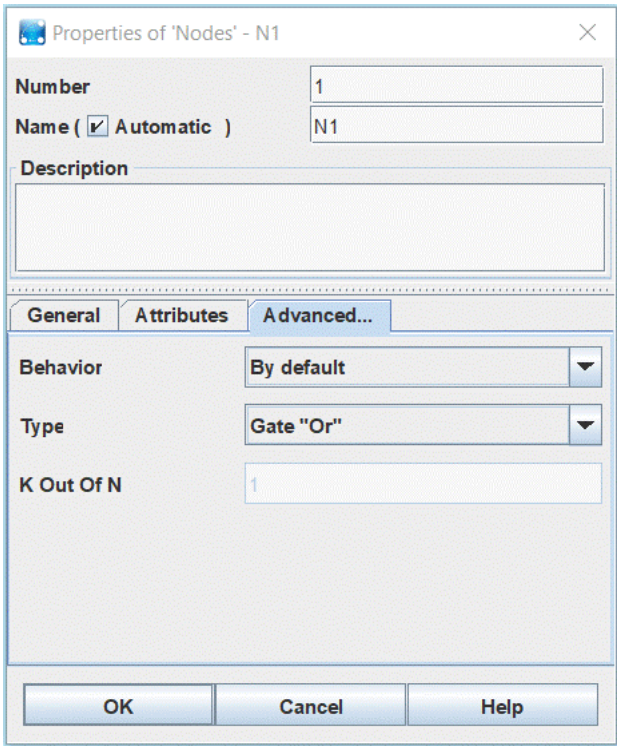
Each of the model's nodes has several parameters grouped in 3 tabs:



1. **General** with the following information :
   - A **number** : Located at the center of node, they are automatically incremented. These numbers are the true identifiers of the nodes which will be used by the computation engine. This is why two nodes cannot have an identical number.
   - A **name** : a default name is assigned to each node (Ni for node number i). As each node generally represents a specific component or sub-system, it is strongly advised to give it a more mnemonic name than the one given by default, which will make it easier for you to locate yourself in the model and, more specifically, in the results file.

- A **description** : this field adds text inside the nodes to specify characteristics. Descriptions increase the model's legibility.
- A **law** : This element is used to model the event's random aspect. You can choose from many laws which must then be configured (cf. Section 8.2, “Description of the laws”).
- If **Safer** is checked, the equipment cannot be failed.

2. **Attributes** tab to attach an attribute to the event.
3. **Advenced** tab to specified the node behavior with the following information :



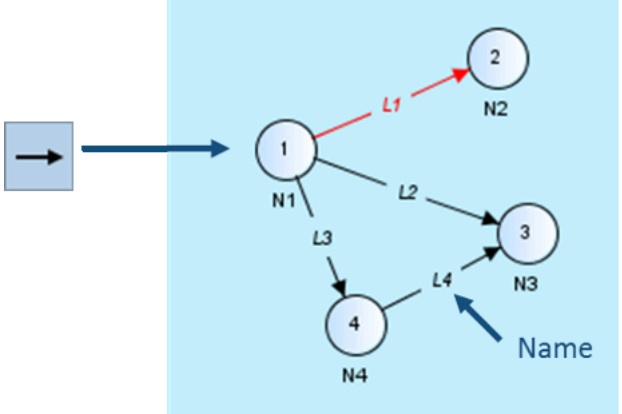
- A **Behavior** to change eventually the output value (by default,to 0 ou to 1).
- A **gate choice** to change the type of gate of the node (gate And, Or and K/N).
- Specify the value of**K** if the gate is a K/N type

2.1.2. Unidirectional link

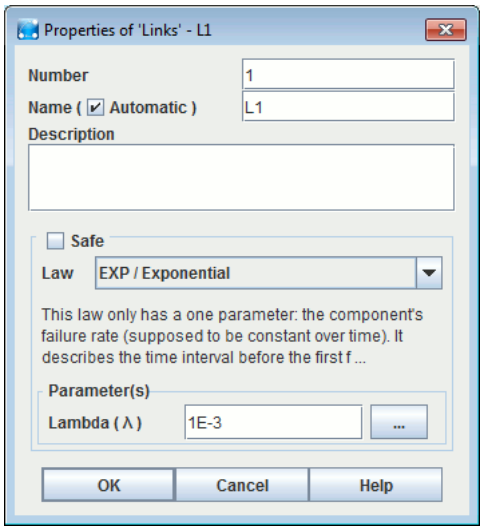
The **unidirectional links** allow to link directly links two nodes. The link is directional and in case of **unidirectional link** in one-way.

To enter the various **links** :

- select the corresponding icon on the vertical tool bar;
- select a start node by a click left on it;
- drag the mouse (without releasing the button) to the arrival element and release the button.



Each of the model's links has four parameters:



1. A **number** : they are automatically incremented. These numbers are the true identifiers of the links which will be used by the computation engine. This is why two links cannot have an identical number.
2. A **name** : a default name is assigned to each link (Li for link number i). As each link generally represents a specific component or sub-system, it is strongly advised to give it a more mnemonic name than the one given by default, which will make it easier for you to locate yourself in the model and, more specifically, in the results file.
3. A **description** : this field adds text inside the links to specify characteristics. Descriptions increase the model's legibility.
4. A **law** : this element is used to model the node's random aspect: it will determine at all times whether the state is **TRUE** or **FALSE** . You can choose between twenty-three laws which then have to be configured (cf. Section 8.2, “Description of the laws”).

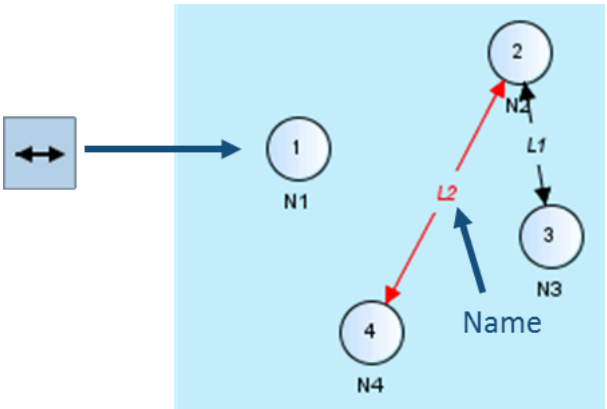
   If **Safe** is checked, link cannot be failed.

2.1.3. Bidirectional link

The **bidirectional links** allow to link directly links two nodes in the both direction.

To enter the various **bidirectionnel links** :

- select the corresponding icon on the vertical tool bar;
- select a start node by a click left on it;
- drag the mouse (without releasing the button) to the arrival element and release the button.



A **bidirectional link** have the same characteristic as a unidirectional link. It means a **number** ,a **name** ,a **description** and a **law** .

2.1.4. Entering Source and Target nodes

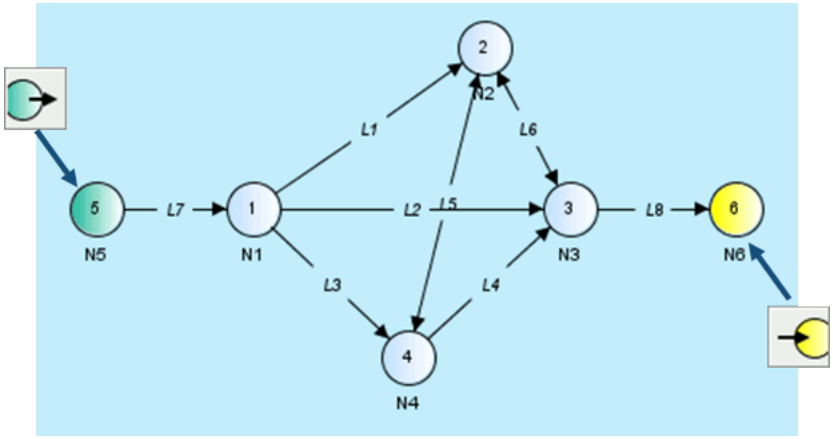
Each model must have at least one **Source** node and one **Target** node.

In the case of a reliability network, there can be several **Sources** and/or several **Targets**.

- **Sources** must be placed at the start of the network, it is impossible to create links directed to them.
- **Targets** must be placed at the end of the network, it is impossible to create links leaving from them.

To create these two types of nodes:

1. select the corresponding icon on the vertical tool bar;
2. click left on the desired location in the input zone.



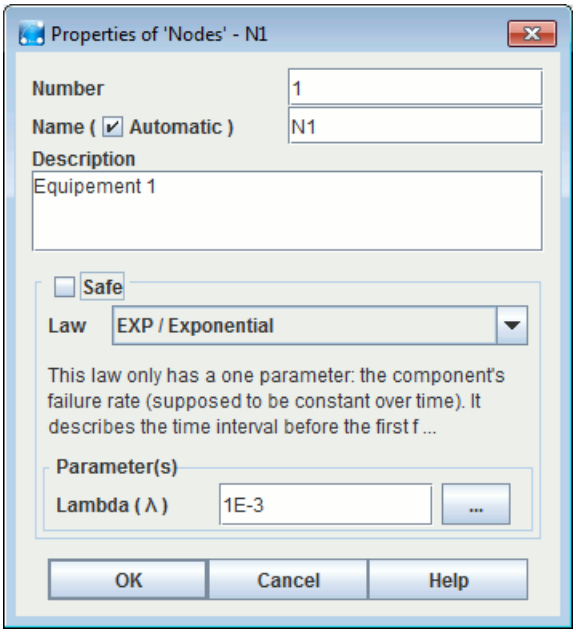
Computations will be performed at "Target" block level.

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 nodes

When you click right on a node, you can modify any parameter:



- change the **number**;
- change the **name**, the **automatic** checkbox generates an automatic name made of the base name and the ID/ Number ;
- modify the **description** part;
- specify that the node is **safe** (no failure);
- to read and/or modify the law **governing** the failure of the node.

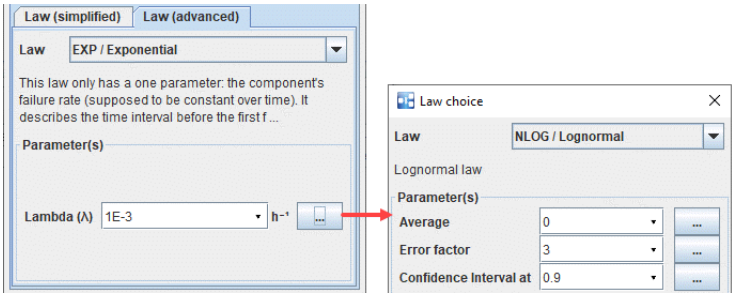
Parameters for the law part are set in two stages:

1. Chose the law from all the available laws in the drop-down list located in the upper section. Many laws are available and you can find the meaning for each law under Section 8.2, “Description of the laws”.

2. Set the parameters for the law in the lower part of the window. For each parameter, a numerical value, a parameter name or an expression comprising operators '+','-','*' and '/' can be entered. All the available parameters can be accessed by pressing the "down arrow"" key on the keyboard. . All the parameters that you can type are displayed when you press the "down arrow" key. When letters are entered, a drop-down menu gives suggestions to complete the name from among the parameters that correspond to the characters entered.

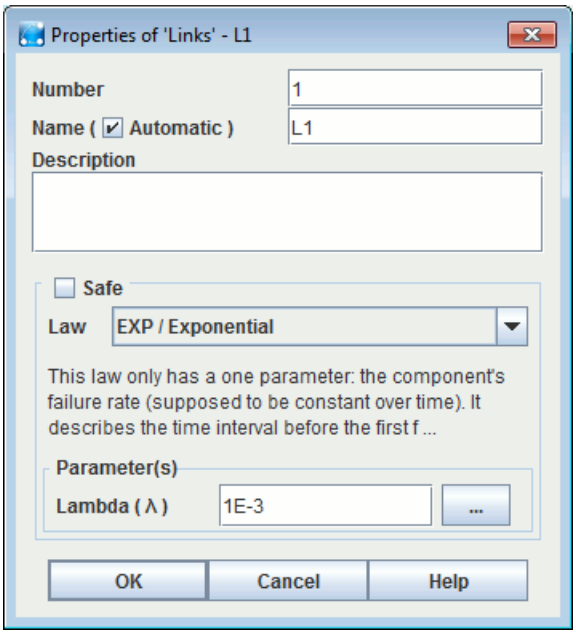
If the user needs to factor in uncertainties, these can be introduced on each of the parameters using the law choice and the corresponding parameters (see detailed description of uncertainty calculations on parameters further down). Uncertainties can be accessed via the **...** button located to the right of each parameter.

It is advisable to enter the uncertainty in the parameters as described in Section 8.3.10, “Consideration of the uncertainties”



2.2.2. Configuring the links

Unidirectional and bidirectional links can be edited by double clicking on it, you can modify any parameter:



- change the **number**;
- change the **name**, the **automatic** checkbox generates an automatic name made of the base name and the ID/ Number ;
- modify the **description** part;
- specify that the node is **safe** (no failure);
- to read and/or modify the law **governing** the failure of the link.

The probability law can be modified in the same way as the probability law of nodes

2.3. Using shorcuts

2.3.1. Nodes shorcuts

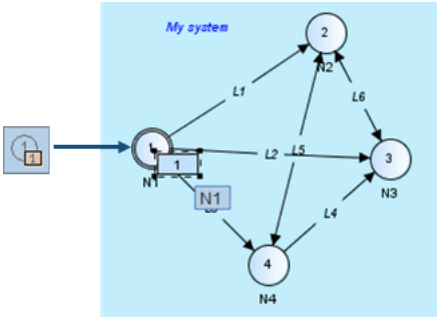
The concept of a **shortcut** (or repeated element) was introduced in the Reliability Networks module for four main reasons:

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

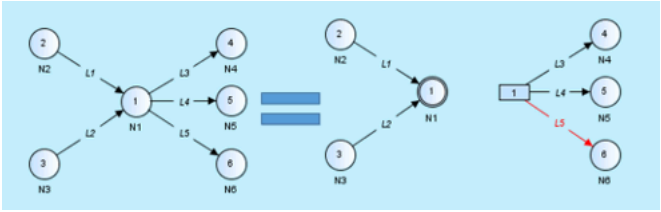
SLet a node be called N1. To create a shortcut to this node, simply:

1. select the corresponding icon on the vertical toolbar;

2. click on the state to be duplicated.



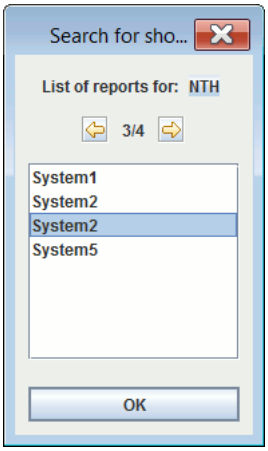
Lwhen a state has been shortcut, it is marked with an inner circle. Although linked from the "computational logic" point of view, the two states are now graphically completely independent. They can now be placed on different pages or in different groups (see further on).



2.3.2. Search shorcuts

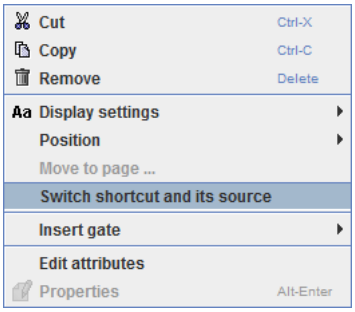
User can navigate between an element's different shortcuts, using **Search shorcuts**. This function is available in the contextual menu (with a right click on the element) or in the application menu **Search shorcuts**.

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.

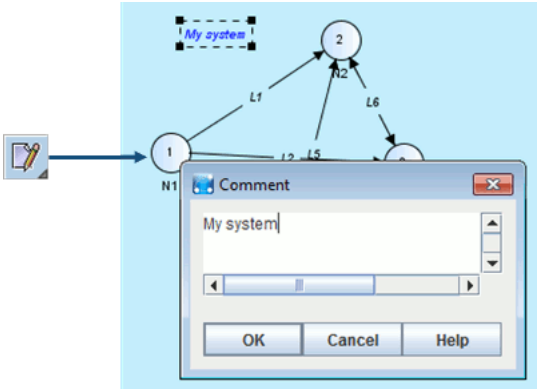
In the shortcut contextual menu obtained with a right click, it is possible to swich the shortcut and its source.



2.4. Entering Comments

To add a comment anywhere on the model, simply click on the pencil icon and position the cursor in a graphical entry zone. The **Comment** dialog box opens and you can then enter your comment.

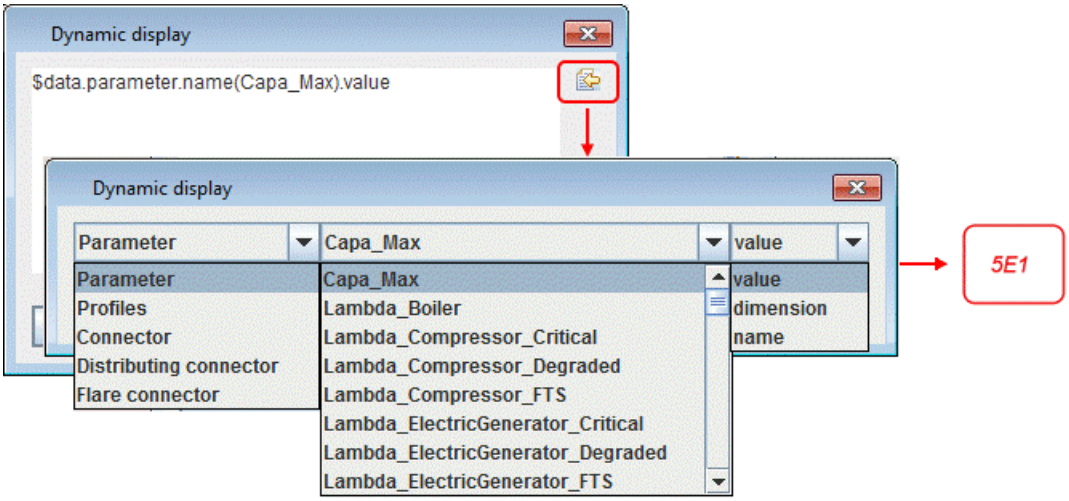
The "%" sign is a special character and you have to type it twice for a single "%" to be displayed.



2.5. Dynamic fields

It may be useful to observe the change in the different parameters of the model. It is also useful to see a result next to its corresponding system. 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 or results.



If you want to display information about a data of the model, you must use the following syntax:

$data.'type of data'.'field used o search data'('value that the field must match).'information you want to display for the selected data'

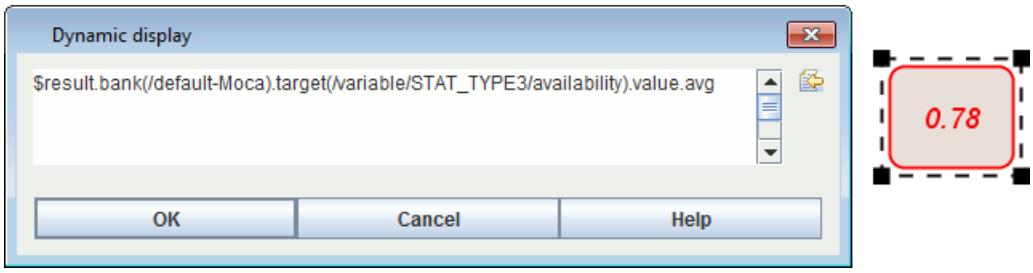
We can analyze the above windows as follows: I am looking for a "parameter" which "name" is 'Capa_Max", and I want to display its "value". When you type the first letters, a completion system helps to type script without error.

Button in right permits to enter complete expression but select what you want to appear.

If you want to display a result of the result-bank, the syntax is the following:

$result.bank('path in the bank').target('target result').'what you want to display'.'at what time'

We can analyze the next picture as follows: I am looking for a result which path in the bank is "default-Moca", I want results for "TS3 for 'available' valriable" and I want its value for the "last" time. If last is replaced by time(10) we obtain value at t=10.



You can also display a summary of result. Replace 'what you want to display' by **summary**. In this case, **summary** is the last word of this script.

2.6. Page and group management

The use of shortcuts allowed us to obtain two Reliability Network 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**).

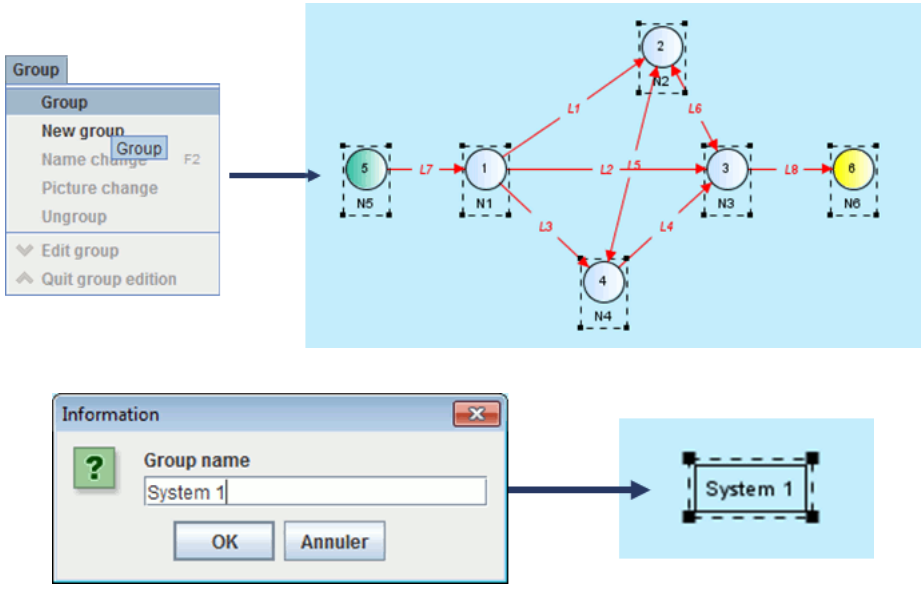
3. Select the part to be moved.
4. Open menu **Tools - Change page**.
5. Select page 2 and click **OK**. The part selected is transferred to page 2 but it continues to communicate with page 1 via the **shortcuts**.

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

Another possibility for entering large Reliability Network 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 enables 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.

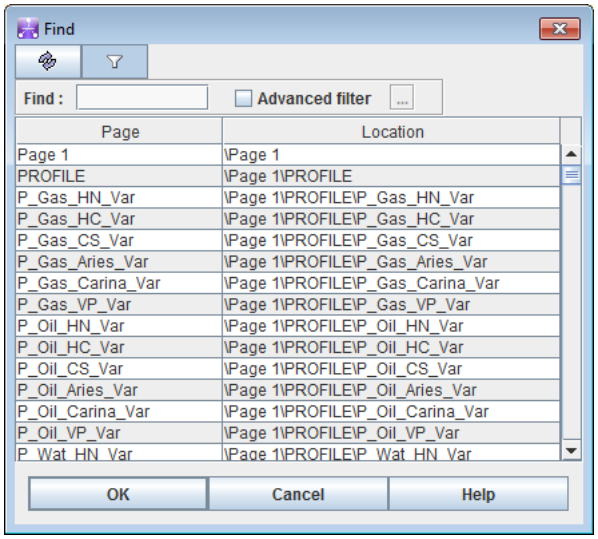


With a right click on the group, it is possible to view inside the group if **Overview of the contents** is checked.

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.

Groups can be grouped recursively.

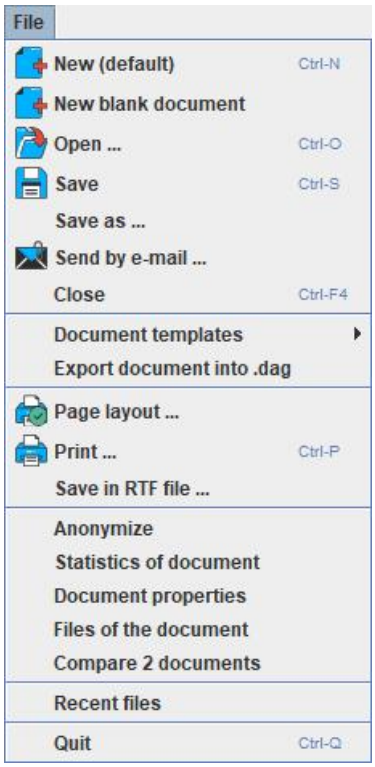
La combinaison **CTRL + F** permet d'effectuer une recherche dans les groupes. Une fois la liste des différents groupes affichée, il est possible de les filtrer ou d'effectuer une recherche dessus.



3. Menus presentation

3.1. File

The menu **File** contains the basics commands : open, close, save, print, etc.



The functionality **New (default)** opens a new document, which will be initialized from the default module's model. You can change the default's model, see Section 13.1, “Document template”

The functionality **New blank document** creates a new blank document.

The functionality **Open** opens an existing document.

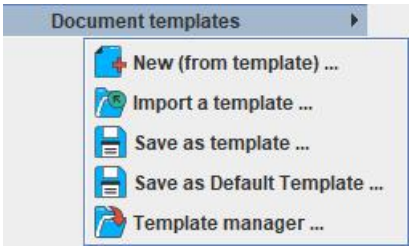
The functionality **Save** saves the current document into a file. The default proposed location for the backup is {répertoire home de l'utilisateur}/GRIF/2022/Reseda

The functionality **Save as ...** lets you save a copy of the file you are working on, with a different name or a different location.

The functionality **Send by e-mail** allows you to attach the current document to an e-mail and then to send it. The configuration of the messaging tool is to be done in the application options Section 14.2, “Executables”

The functionality **Close** lets you close the current document. A window offers to save the file if changes have been made.

The menu **Document templates** includes features related to document reuse and pre-configuration, see Section 13.1, “Document template”.



The functionality **Export document into .dag** : enable the export of current document into .dag file It is an ASCII representation of a fault tree compatible with other software.

The print functions **Page layout**, **Print** and **Save in RTF file** are described in the section Section 9, “Printing”

The functionality **Anonymize** deletes all the comments and names filled in by the user. The document does not contain any information helping to understand it.

The functionality **Statistics of document** allows to have some information about the document (number of pages, number of groups, etc.).

The functionality **Document properties** allows you to edit the properties of the current document. The fields include: name, creation date, creator, description, version, ... This function is described more specifically in the section Section 4.14, “Document properties / Track change / Images management”

The functionality **Files of the document** includes files within the current document. These files can then be exported in your reports. This feature is described more specifically in the section Section 4.16, “Files of the documents”.

The functionality **Compare 2 documents** highlights the changes made between 2 versions of the same document. This feature is described more specifically in the section Section 4.15, “Compare 2 documents”.

The menu section **Recent files** list recently opened files to access them faster.

The functionality **Quit** exits the application. Open documents will be closed.

3.2. Edit

The menu **Edition** contains all the commands needed to edit the current model.

The functionalities **Undo** and **Redo** allow you to cancel or redo the last actions performed. The size of the history of undoable actions are configurable in the application options.

The functionalities **Copy**, **Cut**, **Paste** and **Paste and renumber** are described more specifically in this section Section 4.1, “Copy / Paste / Renumber (without shortcut)”

The functionality **Remove** deletes selected graphic elements.

The functionalities **Overall change ...** and **Selection change ...** search and then replace names and identifiers of the current document or selection. This feature is described more specifically in the section Section 4.3, “Overall change” and Section 4.4, “Selection change”.

Actions **Glue** and **UnGlue** link or unlink graphical objects between them. This allows to fix the position of objects. This feature is described more specifically in the section Section 4.10, “Gluing/Associating graphics”

The functionality **Reverse links** reverses the direction of the selected unidirectional link.

The functionality **Straighten links** remove breaks from the selected link.

Function **Remove sources** : Transforms all sources of the document into single nodes.

Function **Remove targets** : Transforms all targets of the document into single nodes.

The functionality **Select all** selects all the graphical elements of the page.

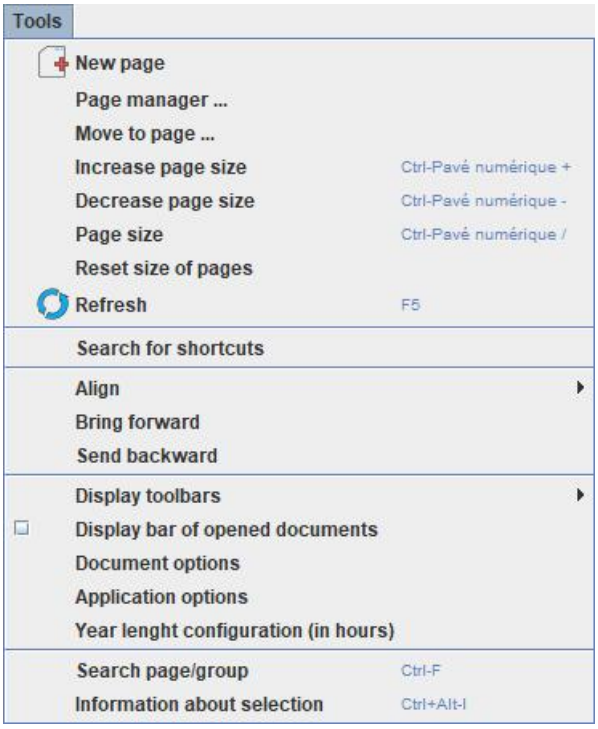
The functionality **Clear selection** deselects items in the current selection. The selection is then blank.

The functionality **Select connected part** selects all graphical elements connected to each other by a link. This feature is described more specifically in the section Section 4.7, “Selecting connex (adjacent) parts”

The functionality **Properties** edits the logical properties of the current selection.

3.3. Tools

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



The functionality **New page** : Create a new graphical page on the current document.

The functionality **Page manager ...** : Open a page manager on which you can rearrange the pages of the document.

The functionality **Move to page ...** : Move the current selection to another page or group in the document.

The functionality **Increase page size** : Increase the graphical input area of the current page.

The functionality **Decrease page size** : Decrease the graphical input area of the current page.

The functionality **Page size** : Open a window to manually configure the size and zoom of the current page. This feature is described more specifically in the section Section 4.8, “Zoom and page size”

The functionality **Reset size of pages** : All pages will be reset to factory format.

The functionality **Refresh** : Refresh the graphical objects in the current page.

The functionality **Search for shortcuts** : Opens a window listing the element's references and lead toward these references. This feature is described more specifically in the section Section 2.3.2, “Search shorcuts”

The menu **Align** provides alignment functions for graphical objects. These features are described more specifically in the section Section 4.5, “Alignment”.

The functionality **Bring forward** : Move the selected elements one layer forward.

The functionality **Send backward** : Move the selected elements one layer backward

The **Display toolbars** menu lets you show or hide certain shortcut groups from the toolbar.

The functionality **Display bar of opened documents** : Displays in the lower part of the application, a shortcut bar to access documents already opened in GRIF.

The functionality **Document options** : Opens a window to configure the document options. You have the possibility to configure a very large number of GRIF-Workshop's features (cf. Section 14, “Options of GRIF - Reliability Networks”). Some options only apply to the application and are accessible via the menu **Application options**, and others are relative to the document being edited and are defined in the menu **Document options**. However, to avoid having to redefine your options between each document, document options are also available in the application options.
These options will then be applied to all newly created documents.
You can also save the current document settings as the default settings for the application. To do this, open the window **Application options**, then the tabulation **Options** and finally check **Save the options of the current document as default options in the application**.
You will find in this same panel the possibility to override the document options by the application options. To do this, check **The application manages the default options of the documents. Apply the default options to the current document**.

The functionality **Application options** : Opens a window to configure the application options. This window is described more specifically in the section Section 14, “Options of GRIF - Reliability Networks”

The functionality **Year length configuration (in hours)** allows you to change the number of hours in a year. The scope of this option is global to all GRIF modules.

The functionality **Search page/group** : Find and locate a group or document page.

The functionality **Information about selection** : Display a window based on the selected graphical elements. This window gives additional information about the current selection.

3.4. Document

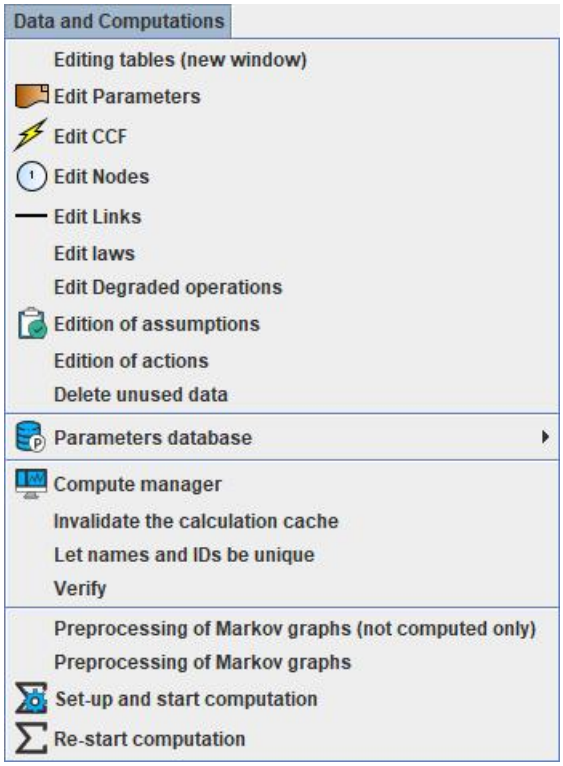
The menu **Document** gives access to all documents being modified or produced.

The functionality **Next** : Selects the next document

The functionality **Previous** : Selects the previous document

3.5. Data and Computations

The menu **Data and computations** is divided into two parts : data management (creation and management of the different parameters) and the parameterization / launch of the calculations (calculation duration, sought calculations ...).



Editing tables (new window) : Opens a new non-blocking window containing all the editing tables of the data.

Edit Parameters : Opens a new non-blocking window containing the editing table of parameters.

Edit CCF : Opens a new non-blocking window containing Common Cause Failure's data. The CCF's settings are detailed here Section 7, “Help with common cause failures”.

Edit Nodes : Opens a non-blocking window containing the node editing table. Nodes settings are detailed here Section 2.2.1, “Configuring the nodes”.

Edit Links : Opens a non-blocking window containing the link editing table. Links settings are detailed here Section 2.2.2, “Configuring the links”.

Edit laws : Opens a new non-blocking window containing the editing table of laws used in the document. The laws' settings are detailed here Section 8.2, “Description of the laws”.

Edit Degraded operations : Opens a new non-blocking window containing the editing table of degraded operations.

Edition of assumptions : Opens a new non-blocking window containing the editing table of assumptions. The assumptions' settings are detailed here Section 4.17, “Hypothesis”.

Edition of actions : Opens a new non-blocking window containing the editing table of actions. The actions' settings are detailed here.

The functionality **Delete unused data** : Cleans the document by deleting unused data. A window opens and proposes to manually select the elements to delete.

The menu **Parameters database** groups all the functionalities concerning the connection of the application to a specific parameters' database. For more details on the parameters databases, refer to Section 12, “Database of parameters”.

The functionality **Compute manager** : Opens a non-blocking window to manage the calculations launched by the application. For more details on the compute manager, refer to Section 10.6, “Compute manager”.

The functionality **Invalidate the calculation cache** : To optimize calculations, some calculations data are cached. Invalidate calculation cache allows you to completely empty these data and ensure authentic results. In normal use of the software, it is not necessary to use this function.

The functionality **Let names and IDs be unique** : Identifies and modifies duplicate data in the model. In normal use of the software, it is not necessary to use this function.

The functionality **Verify** : Checks model data and displays errors.

The functionality **Preprocessing of Markov graphs (not computed only)** : Perform a pre-calculation on Markov graphs that have never been computed or whose .jma have been modified since the last calculation. Pour plus d'information sur les lois de Markov, se référer à Section 8.2.19, “MKV / Markov model”.

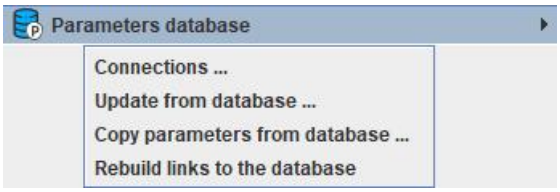
The functionality **Preprocessing of Markov graphs** : Effectue un pré-calcul sur tous les graphes de Markov utilisés dans les lois de type Modèle Markov. For more details on Markov laws, refer to Section 8.2.19, “MKV / Markov model”.

The functionality **Set-up and start computation** : Opens the calculation configuration window. This window is detailed in Section 10.1.1, “Configuring the computations”.

The functionality **Re-start computation** : Restarts the calculations with the last configuration.

3.5.1. Parameters database

The menu **Parameters database** groups all the functionalities concerning the connection of the application to a specific parameters' database. For more details on the parameters databases, refer to Section 12, “Database of parameters”.



The functionality **Connections ...** : Opens the parameter connection's manager.

The functionality **Update from database ...** : Updates the settings of the current document parameters that are connected to a database by updating their values. Opens a window to select the data to update.

The functionality **Copy parameters from database ...** : Imports from a parameter database a set of data in the current document. Displays a database parameter table, the user can select the data to import into his document.

The functionality **Rebuild links to the database** : Attempts to reconnect parameter's settings of a document to data from the database Opens a window that highlights parameters that can be reconnected.

3.6. Group

The menu **Group** concerns the capture and management of sub-models grouped into independent subsets.

The functionality **Group** : Puts the selected elements into a new group. A new group graphic object is created. Selected elements are moved within the group.

The functionality **New group** : Create a new empty group on the current page.

The functionality **Name change** : Edits the name of the selected group.

The functionality **Picture change** : Assigns or modifies the graphical rendering of the group, by adding an image. The name of the group will be displayed below the image.

The functionality **Ungroup** : Removes the group and creates all the elements that the group used to contain.

The functionality **Edit group** : Open the group page.

The functionality **Quit group edition groupe** : Go back to the parent page of the group.

3.7. ?

The menu **?** combines several GRIF global configuration functions and provides access to the module's online help.

The functionality **About ...** : Opens an information window about the software version used.

The functionality **Help ...** : Provides access to the module's online help.

The menu **Configuration** groups together several configuration elements of GRIF.

The functionality **Send errors logs** : Sends an email to your reseller with the module's log files.

The functionality **GRIF-Workshop update** : Updates GRIF. This function detects the existence of a more recent version of GRIF. If such a version exists, you will be offered to install it.

The functionality **Français** : Change the application language to French.

The functionality **English** : Change the application language to English.

3.7.1. Configuration

The menu **Configuration** groups together several configuration elements of GRIF.

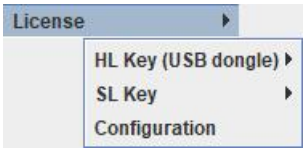
The menu **Licence** groups the configuration functions of the license server. For more information on the use of licenses, please refer to the GRIF installation manual.

The menu **Associate GRIF files** forces your operating system to associate the GRIF files and the different modules that open them.

The menu **Network configuration** : Configures network access to update the system.

3.7.1.1. License

The menu **Licence** groups the configuration functions of the license server. For more information on the use of licenses, please refer to the GRIF installation manual.



The menu **Hardware Licence (HL)** configures USB license dongles.

The menu **Software Licence (SL)** configures license servers that do not require a USB dongle.

The functionality **Configuration**: Configures the access to the license server.

3.7.1.1.1. HL Key (USB dongle)

The menu **Hardware Licence (HL)** configures USB license dongles.

The functionality **Generate c2v...**: Generates a c2v (Client To Vendor) file. This file will be requested by your reseller to create an update of your license.

The functionality **Apply v2c...**: Applies a v2c (Vendor To Client) file. This file will be returned by your reseller to apply the update of your license.

3.7.1.1.2. SL Key

The menu **Software Licence (SL)** configures license servers that do not require a USB dongle.

The functionality **Generate fingerprint...**: Generates a c2v (Client To Vendor) file. This file will be requested by your reseller to create your license.

The functionality **Generate h2h...**: Generates a h2h file (Host To Host)This file is needed to transfer your license to a new server. This feature must be used on the source server. For more information on the license transfer procedure, please refer to the GRIF installation manual.

The functionality **Generate c2v...**: Generates a c2v (Client To Vendor) file. This file will be requested by your reseller to create an update of your license.

The functionality **Apply v2c...**: Applies a v2c (Vendor To Client) file. This file will be returned by your reseller to apply the update of your license.

3.7.1.2. Associate GRIF files

The menu **Associate GRIF files** forces your operating system to associate the GRIF files and the different modules that open them.

The functionality **For current user** : Associates GRIF files to the current user

The functionality **For all users** : Associates GRIF files to every users. This operation requires administrator rights.

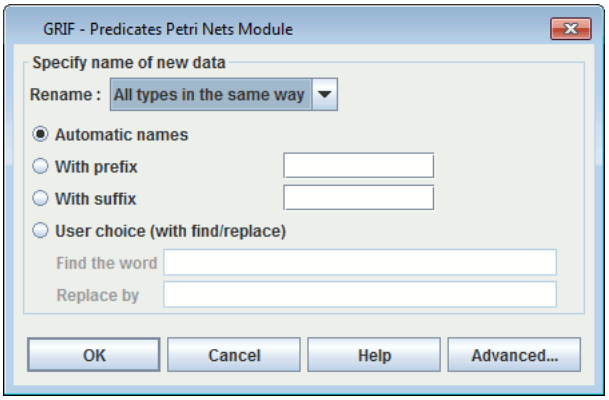
4. Data Entry Aids

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

4.1. Copy / Paste / Renumber (without shortcut)

To assist with the entry of the repeated parts of the Reliability Network "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 way to rename the elements.

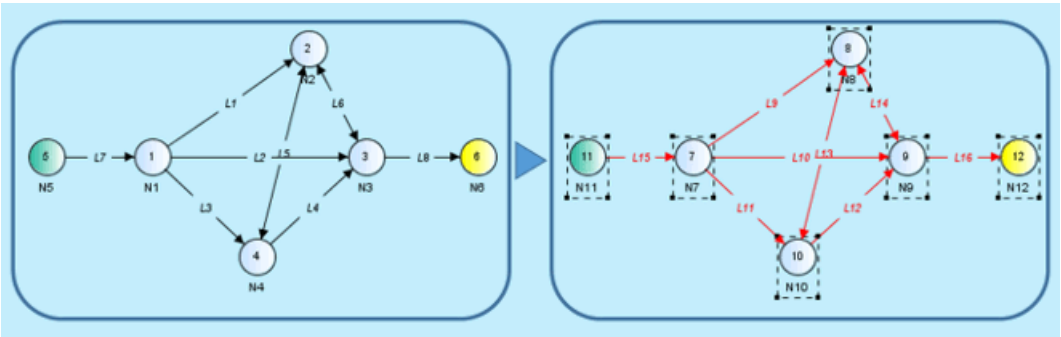


Automatic names choose allows to add a number of the name of the place.

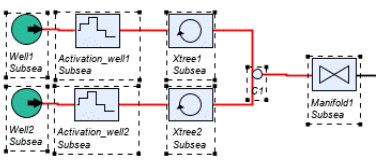
5. The previously selected part is copied and the copy is selected.
6. Move the copy to the desired location.

We then obtain the tree shown in the figure below:

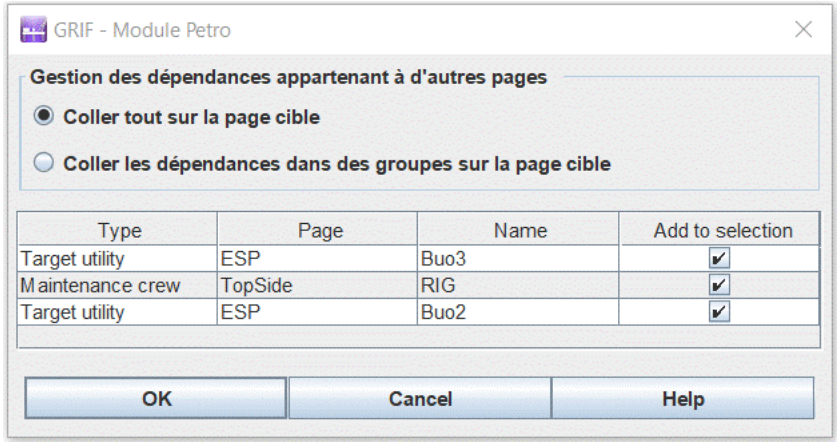
- **N1**, **N2**,**N3**,**N4**,**N5** and **N6** nodes from original network are become **N7**, **N8**,**N9**,**N10**,**N11** and **N12** for the copy;
- **L1**, **L2**, **L3**, **L4**, **L5**, **L6**, **L7** and **L8** links from original network are become **L9**, **L10**, **L11**, **L12**, **L13**, **L14**, **L15** and **L15** for the copy.



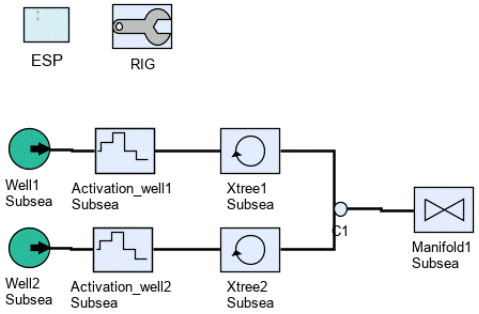
When copying to a new document, There may be dependencies with the copied data.



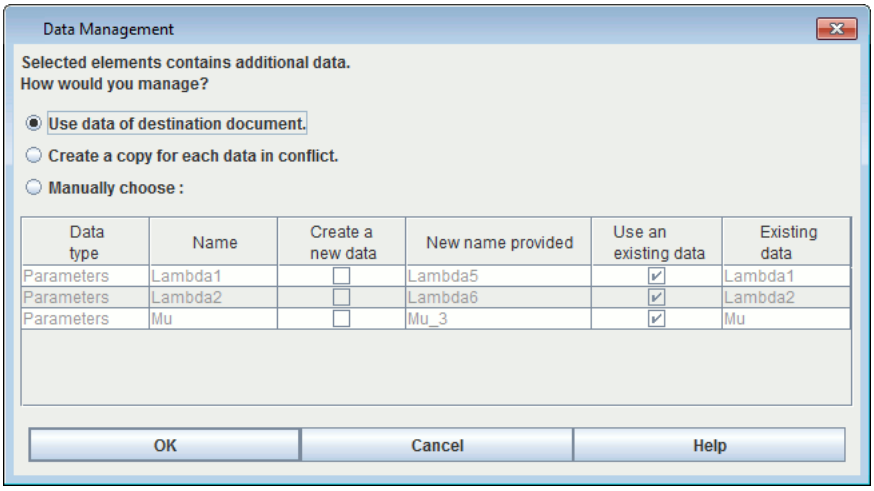
The following window opens and enables to manage indetified dependencies by GRIF :



After managing of dependencies, these are pasted with the selected data



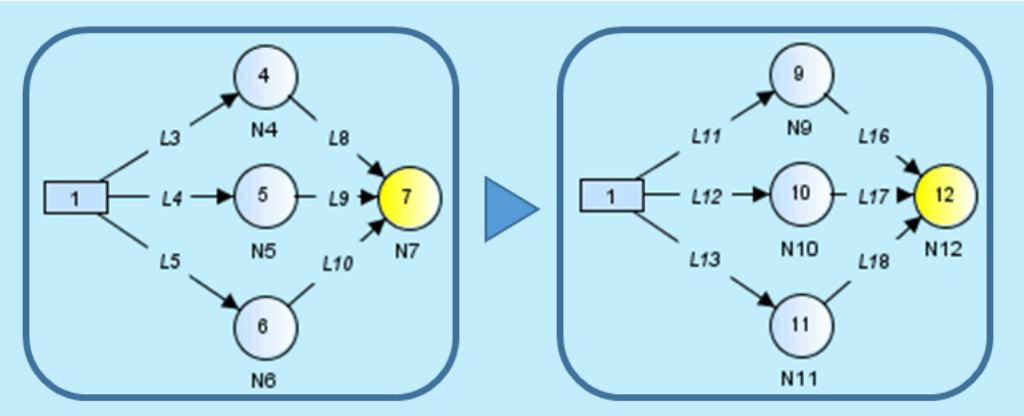
When copying to a new document, any data conflicts are handled in the following window:



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.

If the selected part is made up with a shortcut, the shortcut refers always at the same source.



4.2. 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.

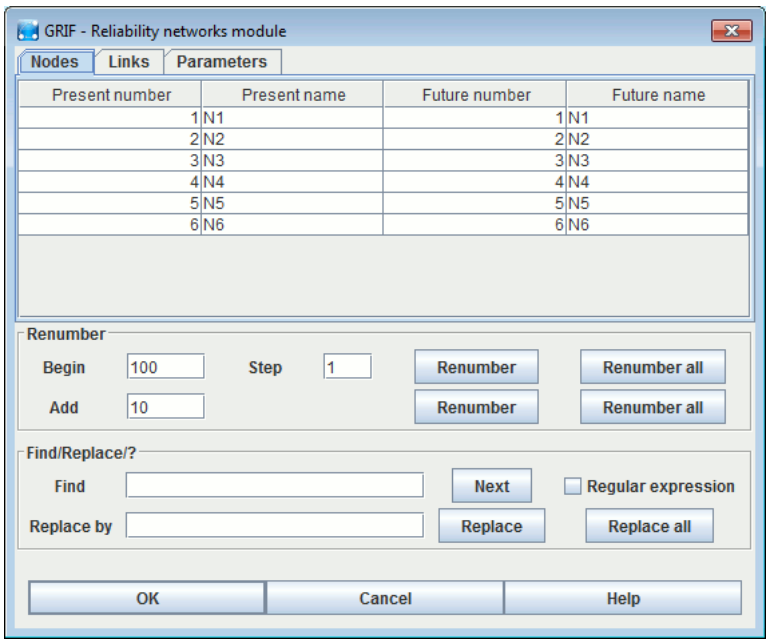
Where possible, the "Copy / Paste and Renumber" function must be used in preference to the simple "Copy / Paste" function to minimise the risk of errors. But when it is used you must take the necessary precautions to re-establish the correct numbering to eliminate the duplicates.

4.3. Overall change

When creating the Reliability Network 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 enables 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.

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.



4.4. 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.

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

4.5. 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.

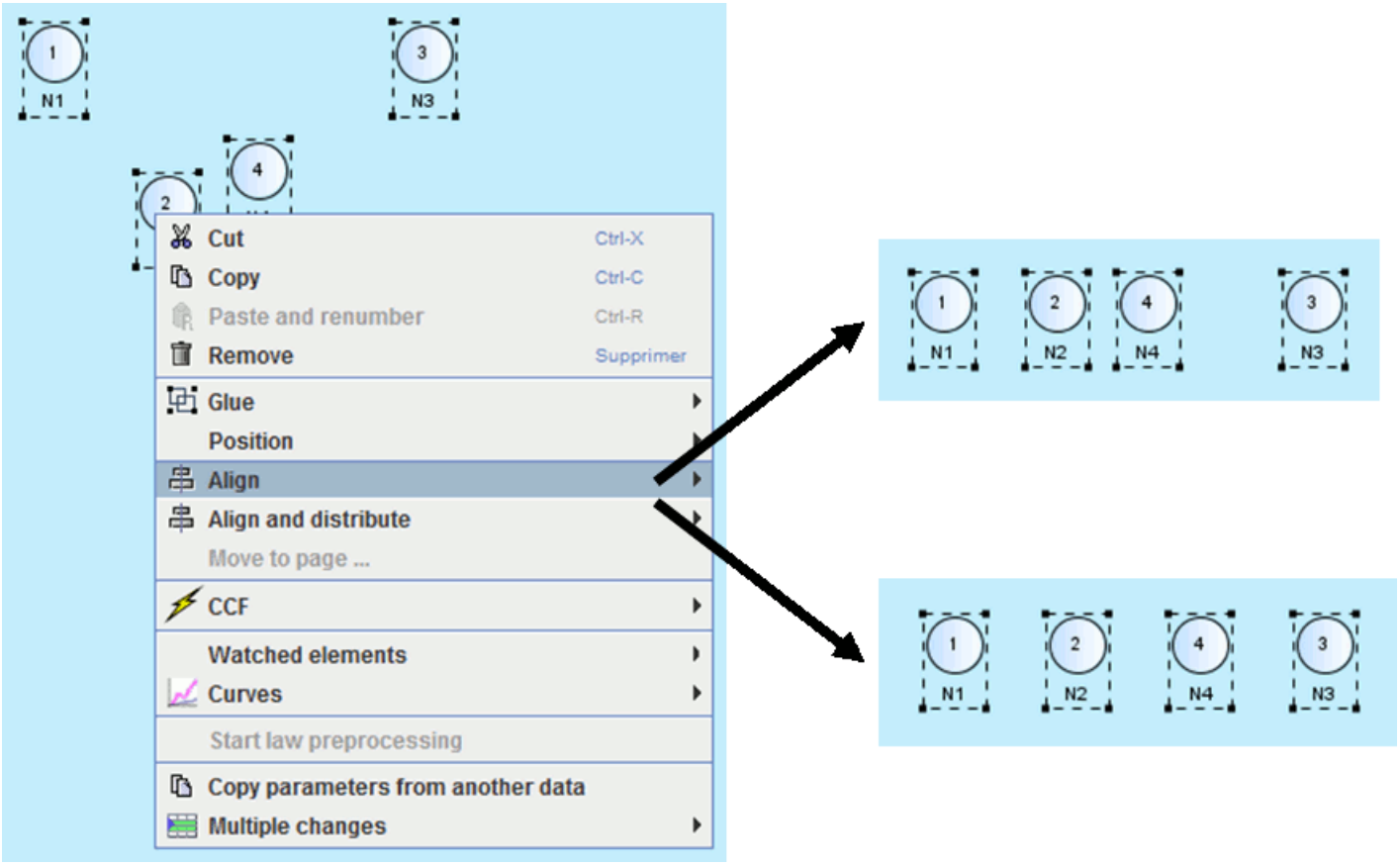
The following figure shows how the command works. For example, to align selected places and transitions vertically, proceed as follows:

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.

4.6. 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.

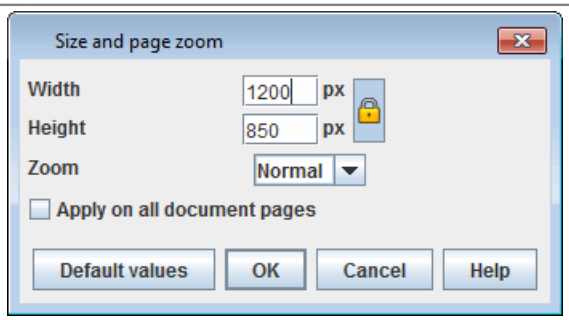
4.7. Selecting connex (adjacent) parts

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.

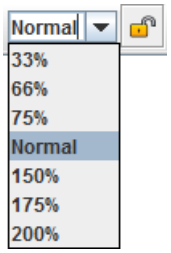
4.8. Zoom and page size

When creating a model, if the page size is not big enough, it can be changed using the menus: **Increase page size** (**Control**+**Keypad +**), **Reduce page size** (**Control**+**Keypad -**), **Page size** (**Control**+**Keypad /**) under the **Tools** menu.

The **Page size** menu enables the user to edit the page dimensions directly.



Page zooms can be modified either by using the toolbar menu:



Or by selecting the display and using **Control**+**mouse wheel scroll up** to zoom or **Control**+**mouse wheel scroll down** to zoom out.

The padlock on the toolbar is used to apply the zoom to the current page or to all pages in the document.

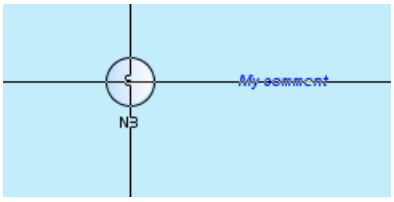
	The zoom applies to all pages in the document.
	The zoom is applied only to the current page.

Note that if an element is selected on the page, the zoom will centre the page on that element.

4.9. 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 elements of the model.



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

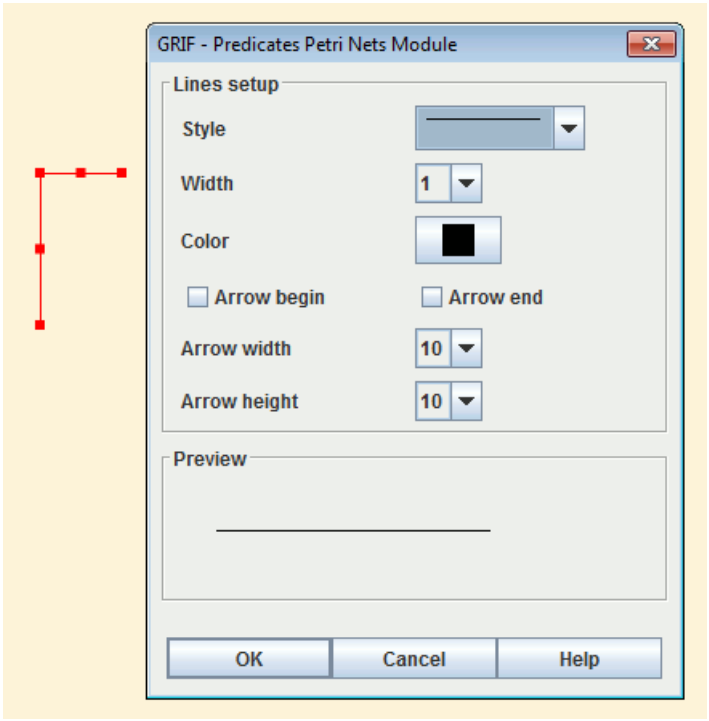
4.10. Gluing/Associating graphics

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

A double click on an element in the glue group opens the properties window of the element.

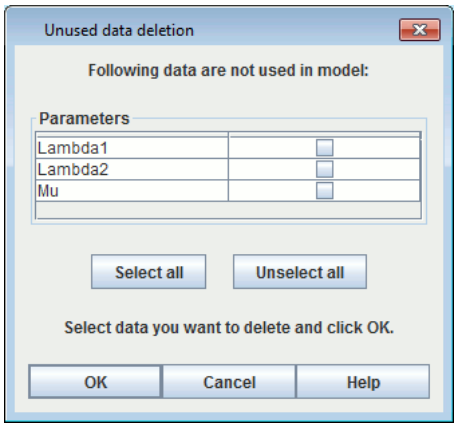
4.11. Line

To be able to draw a line, polyline or arrow, the **Line** can be used. Draw the line and edit properties of line to make an arrow.



4.12. Table Cleaning

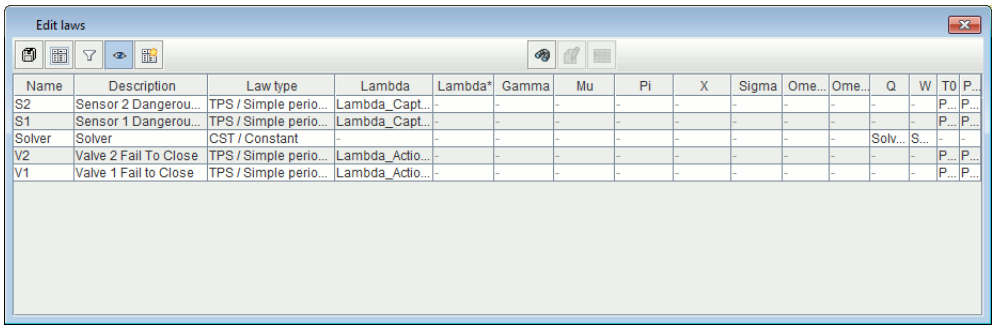
Data may not be used anymore, it can be used useful to delete every unused data. To facilitate removal, use **Data and Computations / Unused data deletion** menu.



This window displays unused data. Select data you really want to delete and click OK.

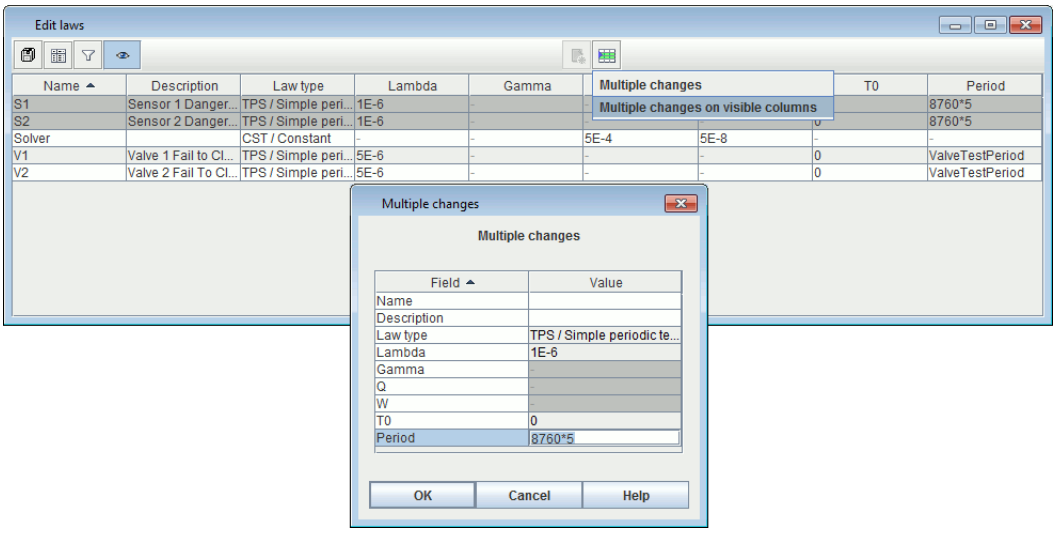
4.13. Edit laws

Data and computations / Edit laws enables you to work on all the laws used by the events.



All the events are listed with a detail of the law and its parameters, this table increases the readability on the realized model. For more details of the use of the laws and the parameters of law, you can refer to the section (cf. Section 8.2, “Description of the laws”).

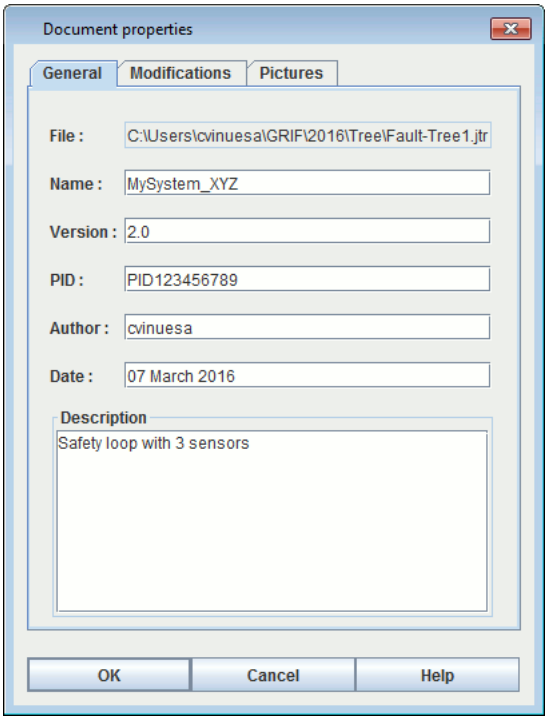
The modification of the laws or a parameters used by several laws can be made easier using multiple changes.



allow to hide columns that are not editable for the laws and to display columns that are editable.

4.14. Document properties / Track change / Images management

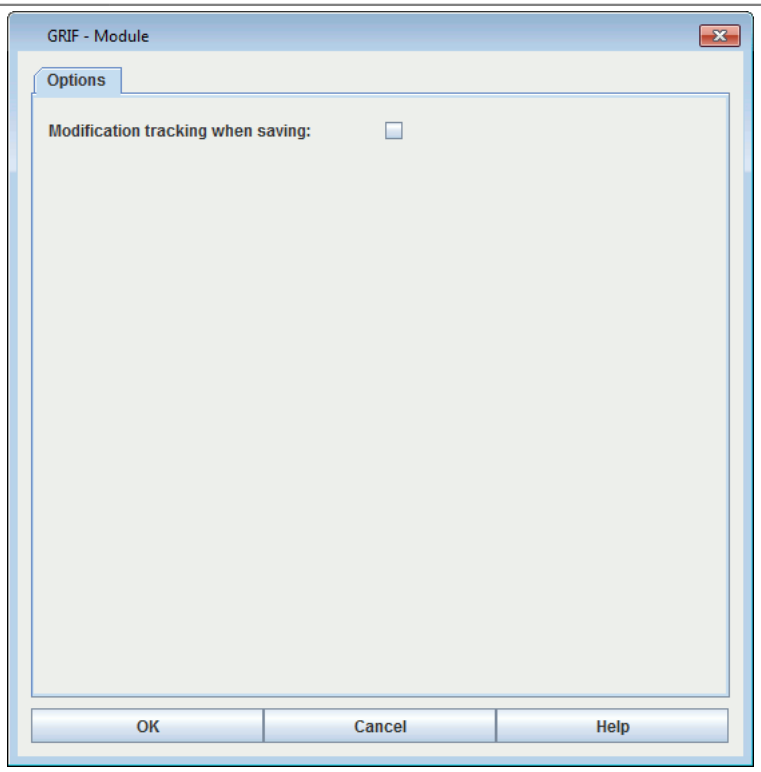
File - Document properties menu enable to save information about document: name, version, comment, ... These information are available in **General** tab.



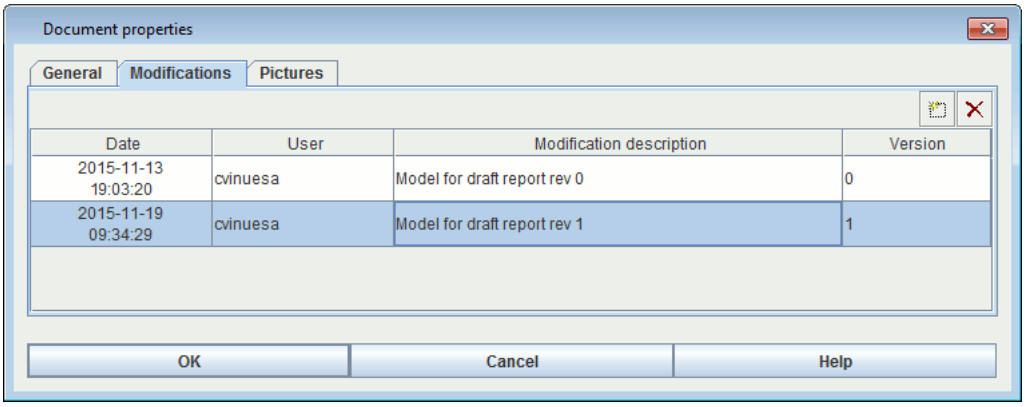
Modification tab enables to save A history of the modifications.

There are two different ways to save modifications:

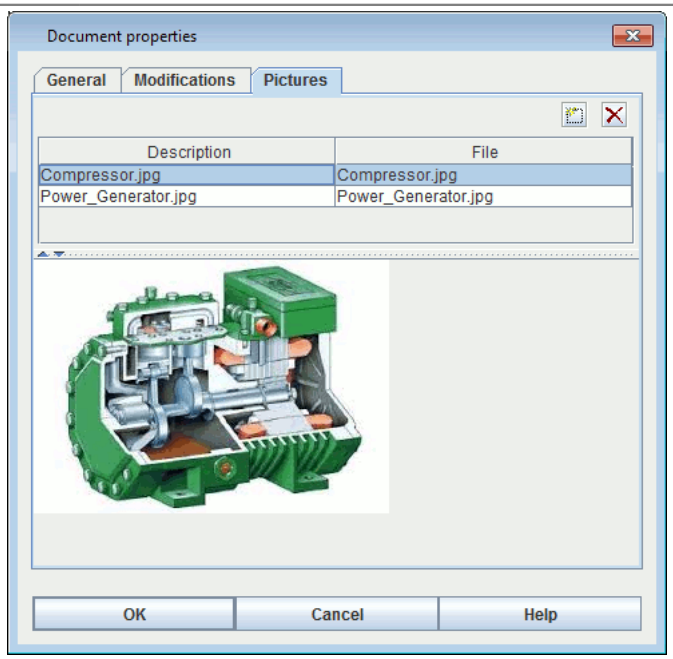
- At each saving by checking: **Modification track when saving** dans **Tools - Document (or Application) options** .



- When the user wants directly in **Modification** tab of the properties using the button 



Images may be very useful to represent sub-system. GRIF 2022 enables to save images that can be used in different parts of software (groups, prototypes, ...). Images management is made in **Images** tab.



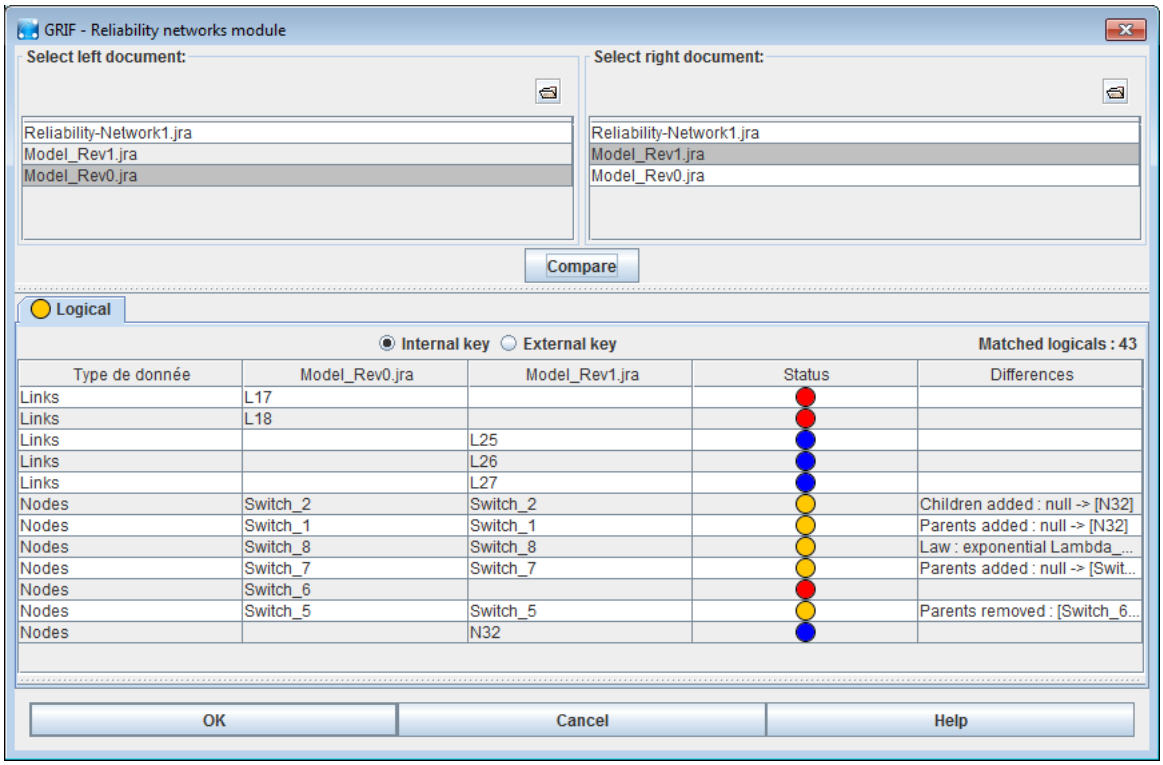
To add a new picture into document, use  icon. A double click in **File** column enables to select a picture (jpg, gif or png). A double click in **Description** column enables to give a name or a description to selected image.

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

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

4.15. Compare 2 documents

This function is accessible using **File / Compare 2 documents**. The following window appears:

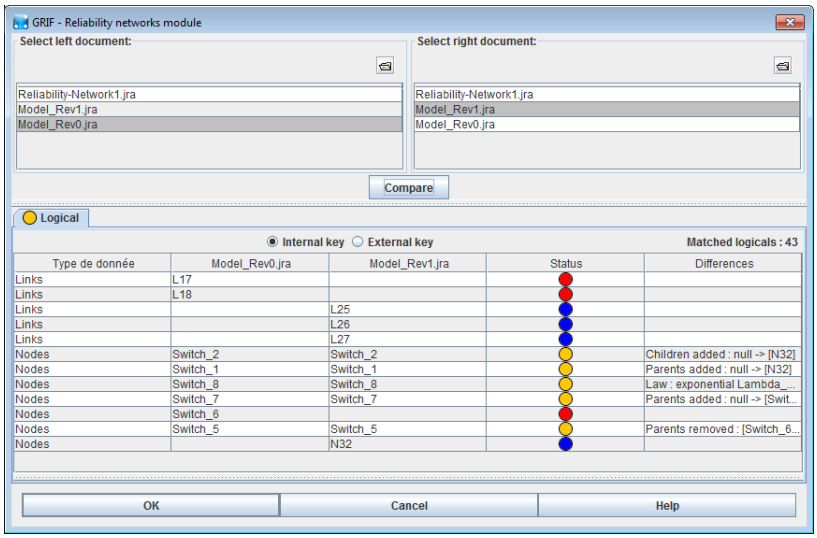


Icon  enables loading of the files to be compared.

Click on Compare to launch the comparison.

Difference can be sorted using 3 criteria: internal key, external key or name for nodes

- **Internal key** enumerates the differences according to internal elements of the model for example identifier, creation index, etc...
- **External key** differentiates elements according to the names of the elements of the model.
- **Name for nodes** differentiates nodes according to their names. The external key comparison will be used for others elements.

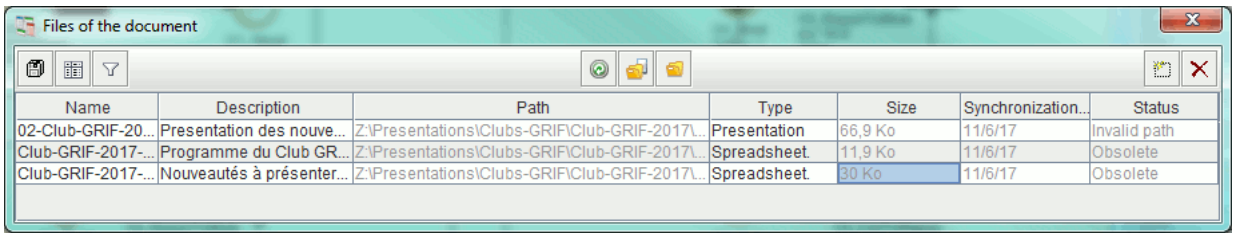


Colour signification is:

- : element is identical;
- : element is added;
- : element is modified;
- : element is deleted.

4.16. Files of the documents

It is possible to associate external file using **File - Files of the document** menu.

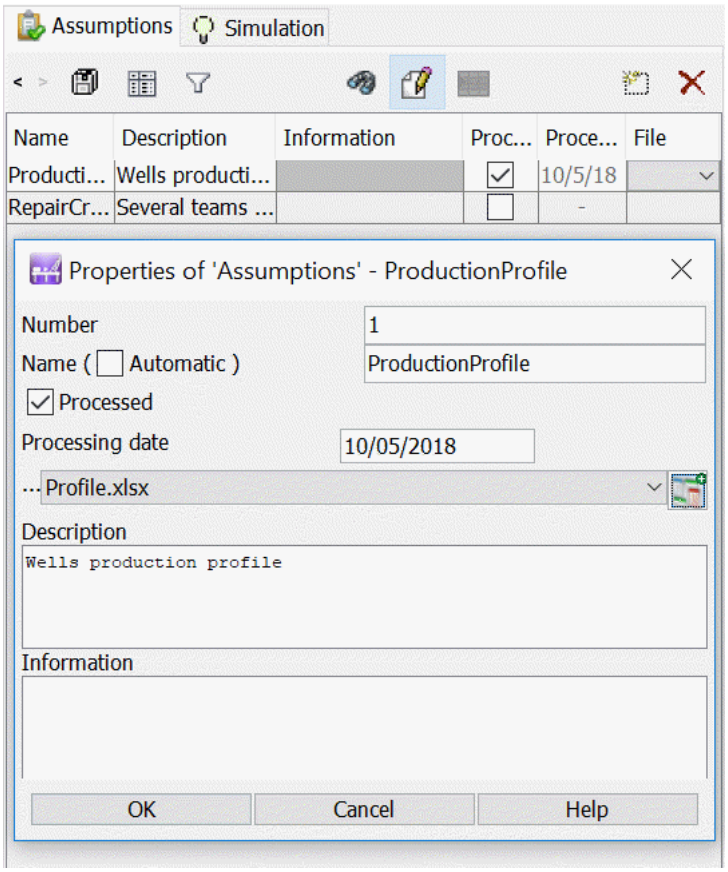


The following icons allow to:

- reload files;
- open files;
- open directory where file is saved.

4.17. Hypothesis

In the data table, in **Hypothesis** tab, it is possible to follow-up and track the studies hypothesis.

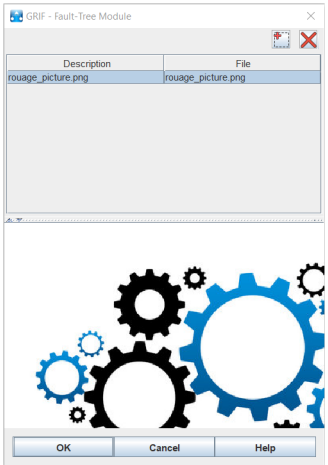


This table enables to take into account the study hypothesis and add file or date to indicate that this hypothesis is taken into account.

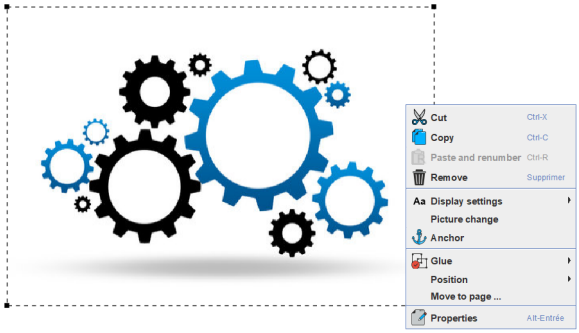
4.18. Picture Anchor

It's possible to anchor a picture in the background. use the action **Picture** of the **Tool barre**.

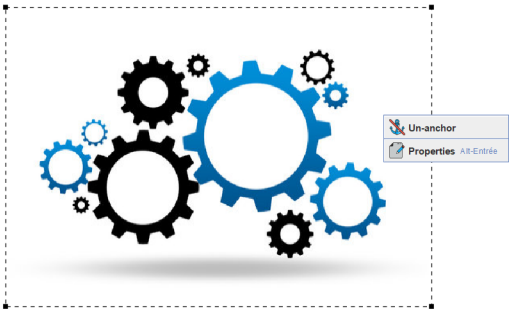
The following screen is display :



It's possible to select a specific picture that is display in background. To anchor the picture, with a right click, select the **Anchor** action. It's possible to change the picture with the **Picture change** action:



To unanchor the picture, with a right click, select the **Un-anchor** action :

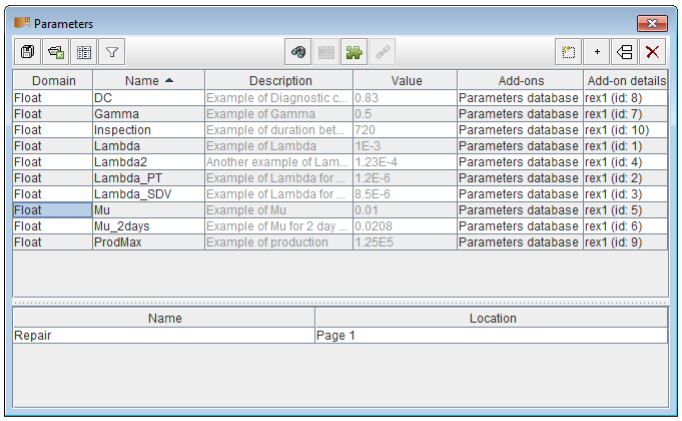


5. The parameters

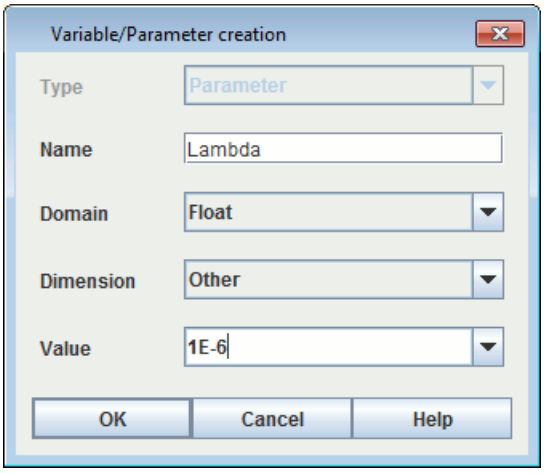
It is possible to create constants which can be booleans, integers or reals. These parameters can then be used for the configuration of different elements of the model (laws, events, transitions, ...)

5.1. Creation

The tab **Parameters** enables the user to define his parameters.



The toolbar enables to do basic operations of the data tables(Section 1, “Description of the Tables”). The button "New" opens the window to create a parameter :



A parameter has a name, a definition domain (Real, Boolean, Integer), a value and a dimension (Failure rate, probability, time, factor, ...) which allow to specify the parameter. This typing is at this moment informative.

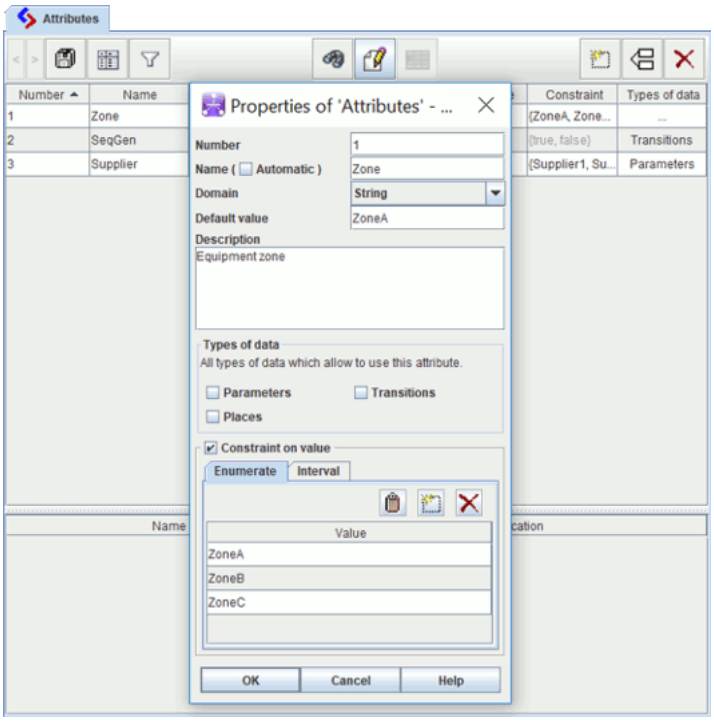
Others additional fields are available in the parameters' table.

Unit		enables to define an unit of the parameter
Uncertainties	**Activate uncertainty**	enables to define the parameter as an uncertainty law
	Law	enables to define the uncertainty law. The law is editable and taken into account only if **Activate uncertainty** is selected in the parameter. The uncertainties laws are detailed here Section 8.3, “Uncertainties on the parameters”
	Macro	if the parameter is defined by an uncertainty law, and if two events use this same parameter, then the user can choose to use the same uncertainty value for the two events, (**Macro** unselected) or values distinctly computed (**Macro** selected).
Add-On		enables to define the parameter by a GRIF add-on Reseda is delivered by default with 2 add-ons for the parameters : **Parameters database** : is an add-on which enables the user to get the data of his parameter in a database or in a CSV or Excel file. This database is more detailed in this section Section 12, “Database of parameters”. **Beta (61508)** : is an add-on which enables the user to calculate the value of his parameter (β) from a set of questions defined by the IEC 61508-6 Table D.1 standard - for the captors and finals elements.
Add-on details		gives a synthesis of the data defined by the add-on. A double-click on the cell enables the user to modify its definition.
Parameters database	**Database**	Displays the database name containing the parameter.
	Identifier	Displays the identifier of the data in the database.
	Update	Displays the date of the last update of the parameter from the database.
Beta (61508)	**MooN**	Define the configuration of the system (in functional logic) to use to calculate the beta.
	Beta	Displays a button allowing to modify the choices made in the Table D.1 of the standard IEC 61508-6

6. Attributes

6.1. Creation

The **attribute** tab enables the user to create attributes that are used to qualify elements defined on system.



The attribute properties are the following ones:

- name;
- domain ;
- default value;
- type of data: to choose where apply the attribute;
- constraint.

The domain type can be of the following values:

- **boolean**: This kind of attribute is a boolean;
- **integer**: This kind of attribute is used to affect an integer value;
- **float**: This kind of attribute is used to affect a float value;
- **string**: This kind of attribute is used to affect a free text.

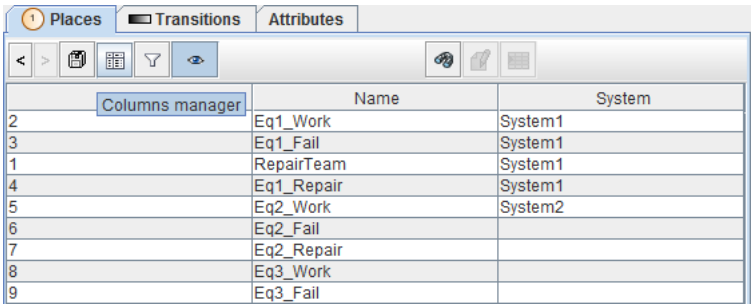
In **Constraint** field, user can enter a constraint on the attribute to ensure the proper use of the attribute in the model.

In addition, the attributes of **float** or **integer** type have a **Constraint type Enumerate** or **Interval**.

6.2. Use of the attributes

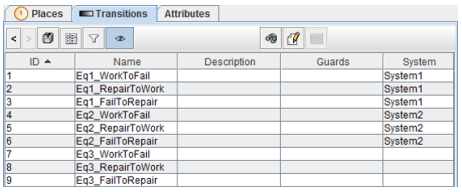
In a Petri net, it is possible to associate attributes:

- Either on places



	Name	System
2	Eq1_Work	System1
3	Eq1_Fail	System1
1	RepairTeam	System1
4	Eq1_Repair	System1
5	Eq2_Work	System2
6	Eq2_Fail	
7	Eq2_Repair	
8	Eq3_Work	
9	Eq3_Fail	

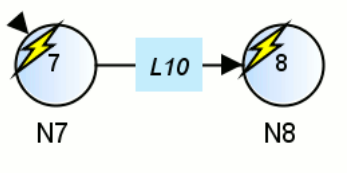
- or on transitions



ID	Name	Description	Guards	System
1	Eq1_WorkToFail			System1
2	Eq1_RepairToWork			System1
3	Eq1_FailToRepair			System1
4	Eq2_WorkToFail			System2
5	Eq2_RepairToWork			System2
6	Eq2_FailToRepair			System2
7	Eq3_WorkToFail			
8	Eq3_RepairToWork			
9	Eq3_FailToRepair			

7. Help with common cause failures

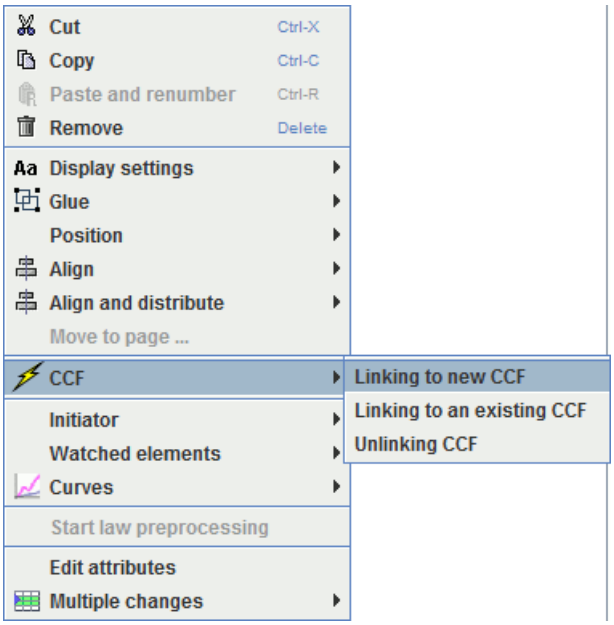
To facilitate the creation of model, the Reliability Networks module enables the creation of CCF (Common Cause Failure), and to link a logical entity(**Event**, **Block**) to one or more common cause failures. CCF are available in the data table. There is no graphical entity associated with CCF. The logical entity associated with an active CCF are graphically marked by a yellow flash:



7.1. Creating a CCF

The creation of a new CCF is possible in different ways:

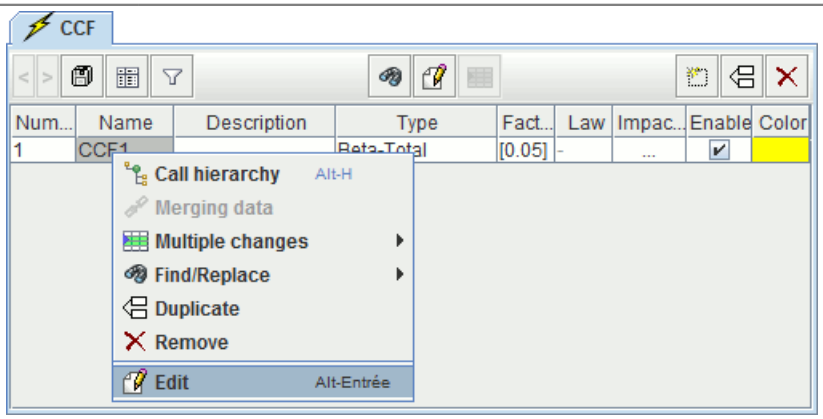
1. click **Add** button on table data,
2. Use the contextual menu on logical entities: **CCF - Add new CCF**



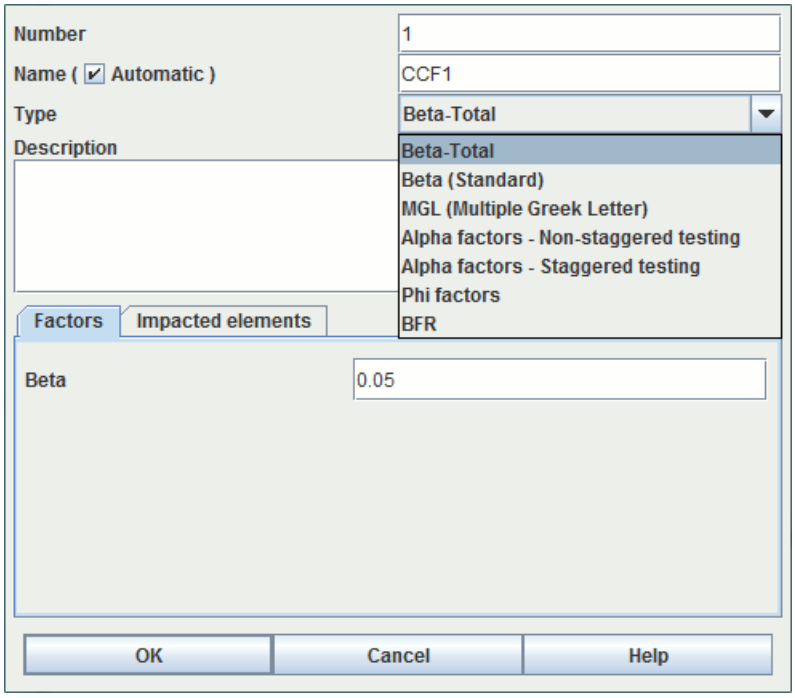
7.2. Editing a CCF

You can edit the properties of a CCF in different ways:

1. Double-Click on a cell of the CCF table, and edit.
2. Use the contextual menu on a table raw and click on 



A configuration window opens:



Several types of laws are now possible for a CCF:

1. The beta-total law: Beta parameter is applied to the laws of concerned components.

   Singularities:
   a. A component can be concerned by several CCF using beta-total law.
   b. The sum of the beta set on the CCF must be strictly less than 1 for a component.
   c. The supported laws for a component are exponential, constant and test-periodic.
2. The beta (Standard) law: The laws of the components are replaced by the law defined by the CCF.

   Singularities:
   a. A component must be linked to only one CCF using beta law.
   b. Laws of components are no longer used.
   c. All laws are supported.
3. The Multiple Greek letter model: apply for a group of n events.

   For a group of n events the aim is to have n - 1 factors ρ_2, ... ρ_{n-1}. ρ_k denotes the conditional probability that k components of the group fail given that k-1 failed with $2 \leq k \leq n$.

$$Q_k = \frac{1}{\binom{n-1}{k-1}} \times \left(\prod_{i=2}^{k} \rho_i \right) \times (1 - \rho_{k+1}) \times Q$$

4. The Alpha factor model (NUREG/CR-5485): α_k is the probability that when a common cause basic event occurs in a common cause group of size m, it involves the failure of k components.

   2 different testing mode are implemented:
   - Staggered testing (components tested sequentially)

$$Q_k = \frac{1}{\binom{n-1}{k-1}} \times \alpha_k \times Q$$

   - Non-staggered testing (all components tested simultaneously)

$$Q_k = \frac{k}{\binom{n-1}{k-1}} \times \left(\frac{\alpha_k}{\sum_{i=1}^{n} i \cdot \alpha_i} \right) \times Q$$

5. The Phi factor: with a manual definition of the coefficients.

$$Q_k = \Phi_k \times Q$$

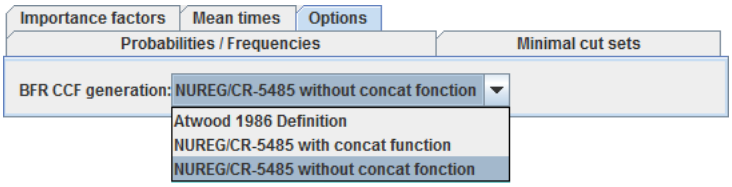
   The sum of the Φ_k's should equal 1.

6. **BFR**(Binomial Failure Rate): This method splits the faire rate (Atwood - 1986) in 3 different parts:
   - intrinsic failure rate;
   - lethale failure rate (w);
   - no-lethale failure rate (only some components are impacted with a p probability).

   According to Nureg/CR-5485:

$$Q = Q_{INTRINSIC} + p.\mu + w$$

   3 different implementations are included each given similar probability but different minimal cut sets. User chooses the implementation in the calculation **options**:



   - Atwood 1986 Definition:Events are generated according to Atwood definition (Intrinsic| Lethale | (Non-lethale & constant p)).
   - NUREG/CR-5485 with concat function: Events are generated in order to have results that are comparable with NUREG/CR-5485. Extrem case are concatenate with concat function:
     – individual failure with nonlethal failure of one component;
     – lethal failure with nonlethal failure of all components.
   - NUREG/CR-5485 without concat fonction: Events are generated in order to have results that are comparable with NUREG/CR-5485. Extrem case are concatenate with OR gate:
     – individual failure with nonlethal failure of one component;
     – lethal failure with nonlethal failure of all components.

7. **BFR ISOTR12489** is a variant of the BFR CCF, from the standard **ISO/TR 12489:2013**.

   In this CCF, the user has to enter its failure rate, common to the lethale part and non-lethale part, as well as the Beta (lethale and non-lethale).

The probability that the failure, within the non-lethale Beta, is independante (corresponding to the p in the BFR ccf) is given by this estimation figuring on the norme :

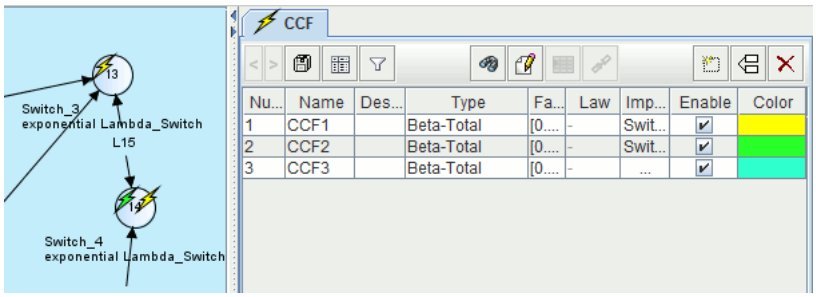
$$\gamma \approx \sqrt{\frac{C_N^2}{10.C_N^4}}$$

This CCF can not have less than four impacted elements.

8. **BFR ISOTR12489 TOTAL** is a variant of the BFR ISOTR12489.

   Its functionning is the same as the BFR ISOTR12489 CCF. The only difference is there is no law to enter : it will directly create its own failure rate, from the laws of its impacted events, like the Beta TOTAL CCF. Its impacted numbers must be higher than 4 here too.

All parameters can be edited directly using the CFF table and a color can be associated of each CCF.



8. Laws and uncertainties

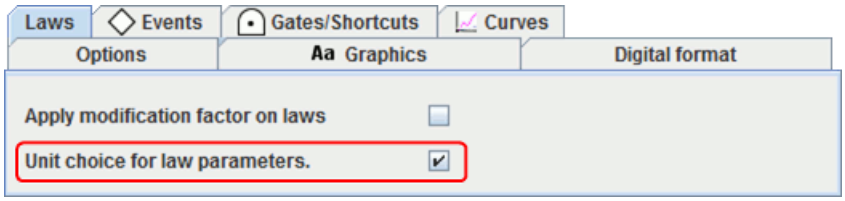
8.1. Setting

Several laws are available in the Reliability Networks module. Each of these laws has one or more corresponding parameters. Here is a list of the different "types" possible:

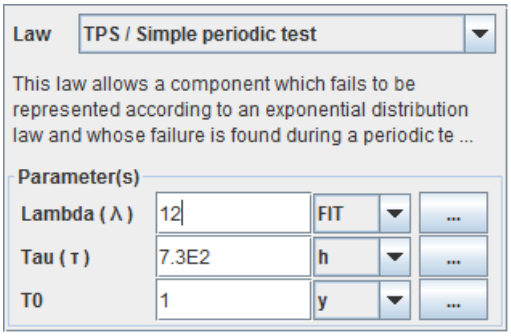
- Probability: value between 0 and 1 inclusive.
- Rate: value greater than or equal to corresponding to a failure rate.
- Duration: value greater than or equal to 0 corresponding to a duration or to a time.
- Factor: value strictly greater than 0.
- NatInt: integer value greater than or equal to 0.
- 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.

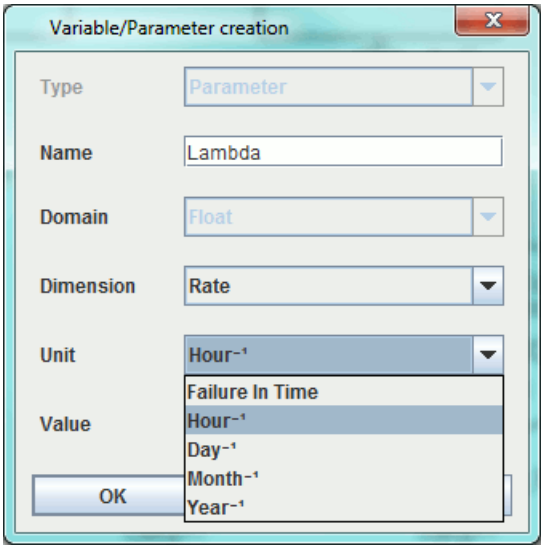
By default, unit used in this module is the hour. it is possible to change the unit in **Document options**



In this case, the unit can be specified in the laws parameters:

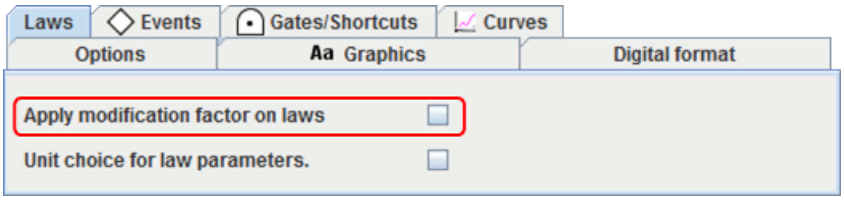


This option can be used with nammed parameters. In this case, unit is linked with the prameter when it creates and depends of the dimension choosen by the user.

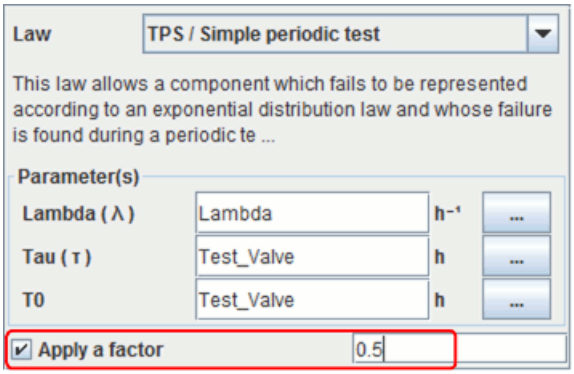


8.2. Description of the laws

A modifier factor can be applied in all the lawx by checking **Apply modification factor on laws** in **document options**.



Once the option selected, a field appears in the events to inform the factor:



In this case, the law is defined by:

$$Q(t) = factor * Qref(t)$$

8.2.1. UNDEF / Undefined

This law used as default law indicates as user, with an error message in the computation launching, that default law was not changed.

8.2.2. CST/ 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.).

8.2.3. 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.

8.2.4. EXPD / Dormant exponantial

This law is used to model the dormant events in a more precise way than with a simple dormant law. It has three parameters: the failure rate of thecomponent (supposed constant during the time), the test periodicity and the mission time. This last parameter is not seizes by the user. It corresponds to the last wanted calculation.

Parameters:

- **Lambda** (Rate) = failure rate
- **Tau** (Duration) = test period (time interval between two consecutive tests)
- **Tmax** (Time) = mission time (i.e. t maximum for all t to calculate) This parameter is automaticcally generated according to the last computation time.

The law is defined as follows:

$$Q(t) = 1 - exp^{-\lambda * t} \quad si\ Tmax \geq \tau$$
$$Q(t) = 1 - exp^{-\lambda * \frac{\tau}{Tmax} * t} \quad si\ Tmax < \tau$$

Results can be different when step by step calculation is made due to the fact that mission time is the maximum time calculation).

8.2.5. IND / Unavailability law

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:

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

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.

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

8.2.6. 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** (Time) = scale parameter
- **Beta** Factor) = shape 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.

8.2.7. WBP / Weibull periodic

This law follows the same logic as the classic Weibull law. It also makes it possible to take into account exclusively periodic preventive maintenance.

Parameters:

- **Age at t=0** (Time) = Virtual age of the component at the initial time.
- **Scale parameter (η)** (Time) = Failure rate scale parameter
- **Shape parameter (β)** (Factor) = Failure rate shape parameter
- **T0** (Time) = First date of preventive maintenance
- **Maintenance period (T1)** (Duration) = Duration between two preventive maintenance
- **Efficiency (α)** (Factor) = Preventive maintenance efficiency (age reduction factor)
- **ARA model** (0 or 1) = Age reduction model:
  - **0** : To use an ARA∞ model Following preventive maintenance (with or without induced corrective maintenance), the age of the component is reduced by a factor α.
  - **1** : To use an ARA1 model Following preventive maintenance (with or without induced corrective maintenance), the age of the component taken since the last preventive maintenance is reduced by a factor α.
- **Coeff. applicable to the failure rate** (Factor) = If x is the coefficient, the scale parameter will be multiplying by x^(-1/beta)

The definition of the law is as follows:

Either **(δ)** = "age reduction" parameter of the failure rate (in time units) calculated according to the specified ARA model.

$$h(t) = \frac{\beta}{\eta^{\beta}} \cdot (t - \delta)^{\beta - 1}$$

General assumptions of the age reduction model:

- No failure is present at the initial time.
- Failures are only detected during preventive maintenance
- All failures are detected at each preventive maintenance
- The first preventive maintenance is carried out at **T0**
- From **T0**, preventive maintenance is carried out periodically, depending on the period **T1**
- The duration of preventive maintenance is negligible.
- If a fault is detected during preventive maintenance, it is repaired immediately (the duration of corrective maintenance induced is negligible).

8.2.8. WBP10 / Weibull periodic (10 parameters)

Description	This law, like the Weibull law from which it is derived, makes it possible to model the component's young and old periods. It also makes it possible to take into account periodic maintenance with a different rejuvenation model between preventive and curative maintenance.
Parameters	• **Age at t=0** (AgeV0) (Time) = Virtual age of the component at the initial time. • **Scale parameter (η)** (Time) = Failure rate scale parameter • **Shape parameter (β)** (Factor) = Failure rate shape parameter • **T0** (Time) = First date of preventive maintenance • **Maintenance period (T1)** (Duration) = Duration between two preventive maintenance • **Ara model of preventive maintenance (Mp)** (0 or 1) = Age reduction model of preventive maintenance: – **0** : To use an ARA∞ model. Following preventive maintenance, the age of the component is reduced by a factor αp. – **1** : To use an ARA1 model Following preventive maintenance, the age of the component taken since the last preventive maintenance is reduced by a factor αp. • **Efficiency of preventive maintenance (αp)** (Factor) = Preventive maintenance efficiency (age reduction factor) • **Ara model of corrective maintenance (Mc)** (0 or 1) = Age reduction model of corrective maintenance: – **0** : To use an ARA∞. Following corrective maintenance, the age of the component is reduced by a factor αc. – **1** : To use an ARA1 model. Following corrective maintenance, the age of the component taken since the last preventive maintenance is reduced by a factor αc. • **Efficiency of corrective maintenance(αc)** (Factor) = Corrective maintenance efficiency (age reduction factor) • **Coeff. applicable to the failure rate** (Factor) = If x is the coefficient, the scale parameter will be multiplying by x^(-1/beta)
Definition	*n* = number of preventive maintenances carried out before time t. if t < T0, n = 0 if t >= T0, n = 1 + integer part of (t - T0) / T1 Age(t) = component age reduction function. This value is calculated according to the formulas described in the following subsections.
h(*t*)	$h(t) = \frac{\beta}{\eta^{\beta}} \cdot Age(t)^{\beta-1}$
Q(*t*)	$si\ t < T_0\ :\ Q(t) = 1 - e^{-\int_0^t h(u)du}$ $si\ t \geq T_0\ :\ Q(t) = 1 - e^{-\int_{T_0+(n-1)T_1}^{t} h(u)du}$

$w(t)$	$w(t) = h(t) \cdot (1 - Q(t))$
Text syntax	`'Weibull-periodic' '(' [expr]AgeV0 ',' [expr]eta ',' [expr]beta ',' [expr]t0 ',' [expr]t1 ',' [expr]mp ',' [expr]alphap ',' [expr]mc ',' [expr]alphac ',' [expr]lambdaCoeff ',' time ')' | 'Weibull-periodic' [expr]AgeV0 [expr]eta [expr]beta [expr]t0 [expr]t1 [expr]mp [expr]alphap [expr]mc [expr]alphac [expr]lambdaCoeff`
XML syntax	`<extern-function name='Weibull-periodic'> [expr]AgeV0 [expr]eta [expr]beta [expr]t0 [expr]t1 [expr]mp [expr]alphap [expr]mc [expr]alphac [expr]lambdaCoeff time </extern-function>`

8.2.8.1. *Weibull-periodic (10-parameter)* age reduction models

General assumptions	• No failure is present at the initial time. • Failures are only detected during preventive maintenance • All failures are detected at each preventive maintenance • The first preventive maintenance is carried out at **T0** • From **T0**, preventive maintenance is carried out periodically, depending on the period **T1** • If no failure is detected during the preventive maintenance, only the preventive maintenance effectiveness applies (depending on the model selected). • If a failure is detected during preventive maintenance, only the corrective maintenance effectiveness applies (depending on the model selected). • Preventive and corrective maintenance times are negligible.
ARA1 model	As a result of maintenance (preventive or corrective), the age of the component taken since the last preventive maintenance is reduced by a factor of α. If a failure is detected during preventive maintenance, the model selected for corrective maintenance applies with α = αc, otherwise the model selected for preventive maintenance applies with α = αp. NOTE: for the first preventive maintenance, it is the age of the element taken since t0 which is reduced by a factor α.
ARA∞ model	As a result of maintenance (preventive or corrective), the age of the element is reduced by a factor of α. If a failure is detected during preventive maintenance, the model selected for corrective maintenance applies with α = αc, otherwise the model selected for preventive maintenance applies with α = αp. NOTE: the model selected for preventive maintenance may be different from the model selected for corrective maintenance (Mc ≠ Mp).

8.2.8.2. *Weibull-periodic (10-parameter)* modeling algorithm

t = 0	n = 0 $Age^* = Age_0$
$0 \le t < T_0$	$Age(t) = Age^* + t$
$t = T_0$	n = n + 1 $Age^* = Q(T_0) \cdot \left[Age^* \cdot (1 - \alpha_c \cdot (1 - M_c)) + T_0 \cdot (1 - \alpha_c) \right]$

	$+ \ (1-Q(T_0))\cdot[Age^*\cdot(1-\alpha_p\cdot(1-M_p))+T_0\cdot(1-\alpha_p)]$
Begin loop	
$T_0+(n-1)T_1 \le t < T_0+nT_1$	$Age(t)=Age^*+t-(T_0+(n-1)\cdot T_1)$
$t = T_0 + nT_1$	n = n + 1 $Age^*=Q(T_0+n\cdot T_1)\cdot[Age^*\cdot(1-\alpha_c\cdot(1-M_c))+T_1\cdot(1-\alpha_c)]$ $+ \ (1-Q(T_0+n\cdot T_1))\cdot[Age^*\cdot(1-\alpha_p\cdot(1-M_p))+T_1\cdot(1-\alpha_p)]$
Return to beginning of loop	

8.2.9. WBD / Weibull with detected failures

Model whose failure follows a classical Weibull law and whose repair begins as soon as the failure appears and follows an exponential law with parameter Mu.

Parameters:

- **Age at t=0** (Time) = Virtual age of the component at the initial time.
- **Scale parameter (η)** (Time) = Failure rate scale parameter
- **Shape parameter (β)** (Factor) = Failure rate shape parameter
- **Mu** = Repair rate
- **Coefficient applicable to the failure rate** (Factor) = Given a coefficient x, multiply the scale parameter by x ^ (- 1 / beta))

General assumptions :

- No failure is present at the initial time.
- All faults are detected online (i.e. immediately).
- Repairs begin as soon as faults appear.
- Repairs cause downtime.
- There are no other causes of downtime than repairs.
- The repairs have no effect on the age of the element.

The definition of the law is as follows:

$$h(t)=\frac{\beta}{\eta^\beta}\cdot(t+AgeV_0)^{\beta-1}$$

$$Q(t)=1-e^{-\left(\frac{t+AgeV_0}{\eta}\right)^\beta-\mu.t}.\left[\mu.\left(\int_0^t e^{-\left(\frac{x+AgeV_0}{\eta}\right)^\beta+\mu.x}dx\right)+e^{\left(\frac{AgeV_0}{\eta}\right)^\beta}\right]$$

8.2.10. 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.

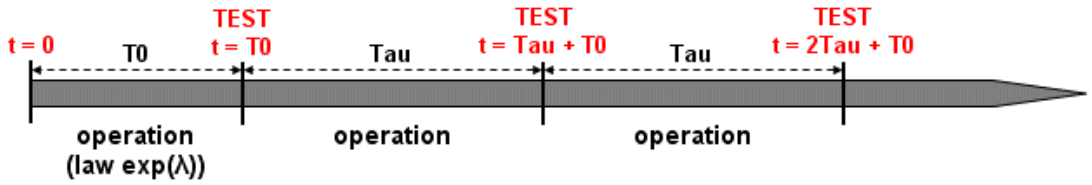
Parameters:

- **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:

$$Q(t) = \begin{cases} 1 - e^{-\lambda t} & if \quad t < t_0 \\ 1 - e^{-\lambda \left[(t - t_0) \bmod \tau \right]} & otherwise \end{cases}$$

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



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

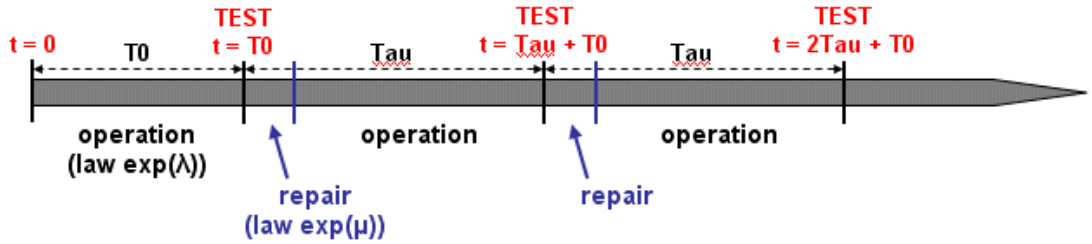
8.2.11. TPE / Extended Periodic Test law

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":



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

8.2.12. 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.

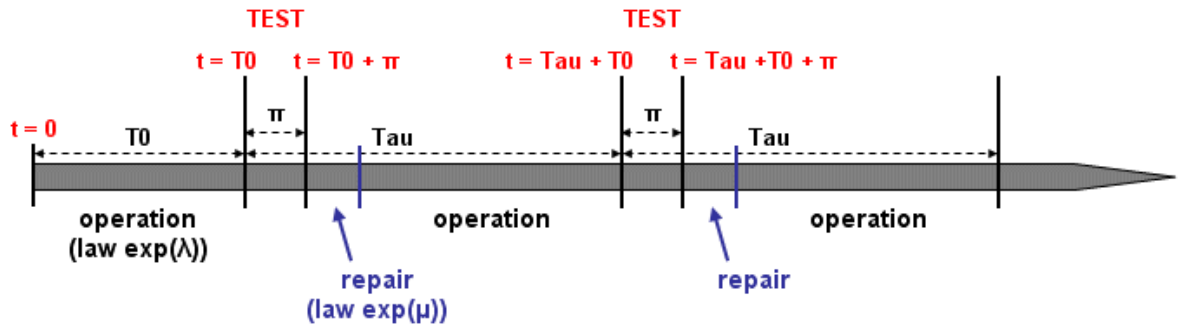
Parameters:

- **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)
- **Theta** (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)

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":



8.2.13. TPC / Full Periodic Test with defined times

This law is the same as the Full Periodic Test law with 11 parameters (see above). The difference is in times of tests. This law does not have **Tau** or **Teta**, but there is a **Times of tests** parameter where you can specify the times the tests will be made.

8.2.14. 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.

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:

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

8.2.15. GLM / GLM Asymptotic 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.

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:

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

8.2.16. 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:

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

8.2.17. CMT / Constant mission time

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

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

The parameter Q is optional.

Parameters:

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

The law is defined as follows:

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

8.2.18. EMP / Empiric

This not actually en law, you must enter probability and failure rate in a tableau according to the time.

If you ask for computation a times which are not in the table, the value will be interpolated according to other points.

8.2.19. MKV / Markov model

This law uses a Markov graph as definition. Select the path of the .jma file. In order to do Boolean computation, you need to do a preprocessing of the law. The preprocessing automatically start Markov module and retrieve necessary values. It can be done with a right-click on the object having the law, or in **Data and computations** menu.

8.2.20. MKVM / Markov matrix

Description

This law allows the use of a monophase Markov graph defined according to its transition matrix. Its use does not require precalculations.

This matrix is stochastic :

- $\forall(i,j)\ P_{ij} >= 0$
- $\forall i\ \sum_j P_{ij} = 1$

Parameters

Number of states (n) : Number of matrix states
Transition matrix : n^2-size vector of P_{ij}, the probability of moving from i to j
Probability at t=0 : n-size vector of probabilities at t=0 for each state
Availablity : n-size vector of availabilities for each state (0=unavailable, 1=available)

Example

Consider the following transition matrix:

State 1	State 2	State 3	State 4	State 5	State 6
-	2.1E-5	0	0	0	0
0	-	1.8E-5	0	0	0
0	0	-	1.5E-5	0	0
0	0	0	-	1.2E-5	0
0	0	0	0	-	9E-6
0	0	0	0	0	-

The following probabilities at t=0:

State 1	State 2	State 3	State 4	State 5	State 6
1	0	0	0	0	0

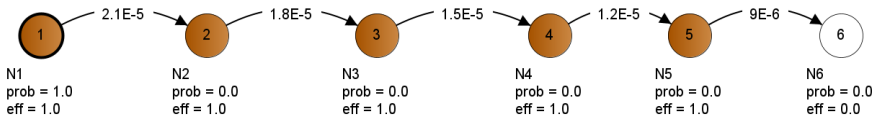
The following availabilities:

State 1	State 2	State 3	State 4	State 5	State 6
1	1	1	1	1	0

The textual syntax to use will be:

```
markov-matrix(time(),6,
       0,2.1E-5,0,0,0,0,
       0,0,1.8E-5,0,0,0,
       0,0,0,1.5E-5,0,0,
       0,0,0,0,1.2E-5,0,
       0,0,0,0,0,9E-6,
       0,0,0,0,0,0,
       1,0.0,0.0,0.0,0.0,0.0,
       1,1,1,1,1,0.0)
```

The equivalent markov graph that will be generated will have the following form:

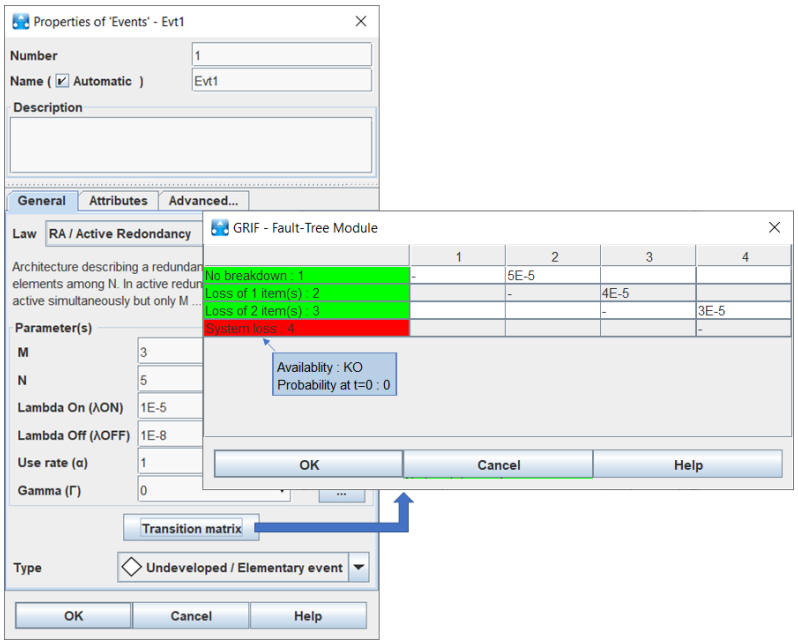


Textual syntax	`'markov-matrix' '(' time ',' [expr]nbStates ','`
	`[expr ',' ... ',' expr]Pij ','`
	`[expr ',' ... ',' expr]init ','`
	`[expr ',' ... ',' expr]avail ')'`

XML syntax	`<extern-function name='markov-matrix'>`
	`time`
	`[expr]nbStates`
	`[expr ... expr]Pij`
	`[expr ... expr]init`
	`[expr ... expr]avail`
	`</extern-function>`

8.2.21. Redundancy laws

GRIF 2022 offers several functions to calculate the reliability and the availability of a set of elements in redundancy m among n. These functions generate a single-phase Markov graph to perform the calculations. The generated transition matrix is accessible using the **Transition matrix** button displayed below the parameter entry.



The available states are shown in green, the unavailable states in red. By tooltip on the states, we can also display the initial probability of each state.

8.2.21.1. RA / Active Redundancy

Description	*Albizia* offers several functions to calculate the reliability and the availability of a set of elements in redundancy m among n. These functions generate a single-phase Markov graph to perform the calculations (cf. Section 8.2.20, “MKVM / Markov matrix”). In active redundancy configuration, the n elements are active simultaneously but only m elements are necessary to ensure the mission.
Parameters	*M* : Number of functional elements required to perform the function, *N* : Total number of items available, *Lambda On (λON)* : Element failure rate when the equipment is turned on, *Lambda Off (λOFF)* : Failure rate of an element when the equipment is switched off, *Alpha (α)* : The use rate α corresponds to the operating time of equipment over the total time of the mission. *Gamma (Γ)* : Probability of failure on demand.

Definitions

$\lambda_{Active} = \alpha * \lambda_{ON} + (1- \alpha) * \lambda_{OFF}$

At t = 0 the probability of being in the nominal state is 1- Γ

At t = 0 the probability of being in the failure state (KO) is Γ

The "System KO" state is a state where the system is unavailable. The system is available in other states.

Transition matrix

	N in operation 0 in fault	**N-1 in operation 1 in fault**	**N-2 in operation 2 in fault**	**...**	**M+1 in operation N-M-1 in fault**	**M in operation N-M in fault**	**M-1 in operation N-M+1 in fault System KO**
N in operation 0 in fault	-	$N * \lambda_{Active}$					
N-1 in operation 1 in fault		-	$(N - 1) * \lambda_{Active}$				
N-2 in operation 2 in fault			-	...			
...				-	$(M + 2) * \lambda_{Active}$		
M+1 in operation N-M-1 in fault					-	$(M + 1) * \lambda_{Active}$	
M in operation N-M in fault						-	$M * \lambda_{Active}$
M-1 in operation N-M+1 in fault Système KO							-

Textual syntax

```
'markov-ra' '(' time ',' [expr]M ',' [expr]N ',' [expr]λON
',' [expr]λOFF ',' [expr]α ',' [expr]Γ ')'
```

XML syntax

```
<extern-function name='markov-ra'>
  time [expr]M  [expr]N  [expr]λON [expr]λOFF [expr]α [expr]Γ
  </extern-function>
```

8.2.21.2. RP / Passive Redundancy

Description

Albizia offers several functions to calculate the reliability and the availability of a set of elements in redundancy m among n. These functions generate a single-phase Markov graph to perform the calculations (cf. Section 8.2.20, “MKVM / Markov matrix”).

In passive redundancy, the M elements necessary to ensure the function are active simultaneously. The (N-M) elements are activated successively following faults.

Parameters

M : Number of functional elements required to perform the function,

N : Total number of items available,

Lambda On (λON) : Element failure rate when the equipment is turned on,

Lambda Off (λOFF) : Failure rate of an element when the equipment is switched off,

Alpha (α) : The use rate α corresponds to the operating time of equipment over the total time of the mission.

Gamma (Γ) : Probability of failure on demand.

Definitions

$\lambda = \lambda_{Active} = \alpha * \lambda_{ON} + (1- \alpha) * \lambda_{OFF}$

$\lambda^* = \lambda_{OFF}$

At t = 0 the probability of being in the nominal state is 1 - Γ

At t = 0 the probability of being in the failure state (KO) is Γ

The "System KO" state is a state where the system is unavailable. The system is available in other states.

Transition matrix

	N in operation 0 in fault	**N-1 in operation 1 in fault**	**N-2 in operation 2 in fault**	**...**	**M in operation N-M in fault**	**M-1 in operation N-M+1 in fault System KO**
N in operation 0 in fault	-	Mλ+(N-M)λ*				
N-1 in operation 1 in fault		-	Mλ+(N-M-1)λ*			
N-2 in operation 2 in fault			-	Mλ+(N-M-2)λ*		
...				-	Mλ+λ*	
M in operation N-M in fault					-	Mλ
M-1 in operation N-M+1 in fault System KO						-

Textual syntax

```
'markov-rp' '(' time ',' [expr]M ',' [expr]N ',' [expr]λON
',' [expr]λOFF ',' [expr]α ',' [expr]Γ ')'
```

XML syntax

```
<extern-function name='markov-rp'>
  time [expr]M  [expr]N  [expr]λON [expr]λOFF [expr]α [expr]Γ
  </extern-function>
```

8.2.21.3. RDR / Redundancy with Reconfiguration Duration

Description

Albizia offers several functions to calculate the reliability and the availability of a set of elements in redundancy m among n. These functions generate a single-phase Markov graph to perform the calculations (cf. Section 8.2.20, “MKVM / Markov matrix”).

This configuration is characterized by an interruption of service in the event of failure of an active element during the entire duration of the Treconf reconfiguration.

Parameters

M : Number of functional elements required to perform the function,
N : Total number of items available,

Lambda On (λON) : Element failure rate when the equipment is turned on,

Lambda Off (λOFF) : Failure rate of an element when the equipment is switched off,

Alpha (α) : The use rate α corresponds to the operating time of equipment over the total time of the mission.

Gamma (Γ) : Probability of failure on demand.
Reconfiguration delay (Treconf) : Average switching time on one of the redundant elements

Definitions

$\lambda = \lambda_{Active} = \alpha * \lambda_{ON} + (1- \alpha) * \lambda_{OFF}$

$\lambda^* = \lambda_{OFF}$
tr = 1/Treconf

At t = 0 the probability of being in the nominal state is 1- Γ

At t = 0 the probability of being in the failure state (System KO) is Γ
The "System KO" state is a state where the system is unavailable. All "reconfiguration" states are also considered to be states where the system is unavailable. The system is available in other states.

Transition matrix

	0	**1**	**2**	**3**	**4**	**...**		**2(N-M)**	**2(N-M)+1**
No failure : 0	-	Mλ	(N-M)λ*						
Reconfiguration : 1		-	tr	(M-1)λ+(N-M)λ*					
Loss of 1 element : 2			-	Mλ	(N-M-1)λ*				
Reconfiguration : 3				-	tr				
Loss of 2 elements : 4					-				
...									
Reconfiguration : 2(N-M)-1							-	tr	(M-1)λ+λ*
Loss of N-M elements : 2(N-M)								-	Mλ
System KO : 2(N-M) +1									-

Textual syntax

```
'markov-rdr' '(' time ',' [expr]M ',' [expr]N ',' [expr]λON
',' [expr]λOFF ',' [expr]α ',' [expr]Γ ',' [expr]Treconf ')'
```

XML syntax

```
<extern-function name='markov-rdr'>
  time [expr]M  [expr]N  [expr]λON [expr]λOFF [expr]α [expr]Γ
[expr]Treconf
  </extern-function>
```

8.2.21.4. RER / Redundancy of Repairable Elements

Description

Albizia offers several functions to calculate the reliability and the availability of a set of elements in redundancy m among n. These functions generate a single-phase Markov graph to perform the calculations (cf. Section 8.2.20, “MKVM / Markov matrix”).

This configuration is characterized by the possibility of repairing an element taking into account its MDT. This function considers only one repairer.

Parameters

M Number of functional elements required to perform the function,
N Total number of items available,

Lambda On (λON) Element failure rate when the equipment is turned on,

Lambda Off (λOFF) Failure rate of an element when the equipment is switched off,

Alpha (α) The use rate α corresponds to the operating time of an equipment over the total time of the mission.

Gamma (Γ) Probability of failure on demand,
MDT (Mean Down Time) Mean down time (detection + repair or standard exchange)

Definitions

$\lambda = \lambda_{Active} = \alpha * \lambda_{ON} + (1- \alpha) * \lambda_{OFF}$

$\lambda^* = \lambda_{OFF}$

$\mu = 1/MDT$

At t = 0 the probability of being in the nominal state is 1 - Γ

At t = 0 the probability of being in the failure state (KO) is Γ
The "System KO" state is a state where the system is unavailable. The system is available in other states.

Transition matrix

	0	**1**	**2**	**...**	**N-M**	**N-M+1**
No failure : 0	-	Mλ + (N-M)λ*				
Loss of 1 element : 1	μ	-	Mλ + (N-M-1)λ*			
Loss of 2 elements : 2		μ	-			
...						
Loss of N-M elements : N-M					-	Mλ
System KO : N-M+1					μ	-

Textual syntax

```
'markov-rer' '(' time ',' [expr]M ',' [expr]N ',' [expr]λON
',' [expr]λOFF ',' [expr]α ',' [expr]Γ ',' [expr]MDT ')'
```

XML syntax

```
<extern-function name='markov-rer'>
  time [expr]M  [expr]N  [expr]λON [expr]λOFF [expr]α [expr]Γ
[expr]MDT
  </extern-function>
```

8.2.21.5. RRR / Redundancy Repairable with Reconfiguration Duration

Description

Albizia offers several functions to calculate the reliability and the availability of a set of elements in redundancy m among n. These functions generate a single-phase Markov graph to perform the calculations (cf. Section 8.2.20, “MKVM / Markov matrix”).

This configuration is characterized by an interruption of the function throughout the duration of the reconfiguration in the event of failure of an active element, considering that the elements are repairable.

Parameters

M Number of functional elements required to perform the function,
N Total number of items available,

Lambda On (λON) Element failure rate when the equipment is turned on,

Lambda Off (λOFF) Failure rate of an element when the equipment is switched off,

Alpha (α) The use rate α corresponds to the operating time of an equipment over the total time of the mission.

Gamma (Γ) Probability of failure on demand,
Reconfiguration delay (Treconf) : Average switching time on one of the redundant elements
MDT (Mean Down Time) Mean down time (detection + repair or standard exchange)

Definitions

$\lambda = \lambda_{Active} = \alpha * \lambda_{ON} + (1- \alpha) * \lambda_{OFF}$

$\lambda^* = \lambda_{OFF}$

tr = 1/Treconf

$\mu = 1/MDT$

At t = 0 the probability of being in the nominal state is 1 - Γ

At t = 0 the probability of being in the failure state (KO) is Γ
The "System KO" state is a state where the system is unavailable. All "reconfiguration" states are also considered to be states where the system is unavailable. The system is available in other states.

Transition matrix

	0	**1**	**2**	**3**	**4**	**...**		**2(N-M)**	**2(N-M)+1**
No failure : 0	-	Mλ	(N-M)λ*						
Reconfiguration : 1	μ	-	tr	(M-1)λ+(N-M)λ*					
Loss of 1 element : 2	μ		-	Mλ	(N-M-1)λ*				
Reconfiguration : 3			μ	-	tr				
Loss of 2 elements : 4			μ		-				
...									
Reconfiguration : 2(N-M)-1							-	tr	(M-1)λ+λ*
Loss of N-M elements : 2(N-M)								-	Mλ
System KO : 2(N-M) +1								μ	-

Textual syntax

```
'markov-rrr' '(' time ',' [expr]M ',' [expr]N ',' [expr]λON
',' [expr]λOFF ',' [expr]α ',' [expr]Γ ',' [expr]Treconf
',' [expr]MDT ')'
```

XML syntax

```
<extern-function name='markov-rrr'>
  time [expr]M  [expr]N  [expr]λON [expr]λOFF [expr]α [expr]Γ
[expr]Treconf [expr]MDT
  </extern-function>
```

8.2.22. OCC / Occurrences of failures

The Failure rate is calculated divided the numbers of observed failures by the observation period. The result is a constant law.

Parameters:

- **Number of failures**
- **Period** (Duration) = observation duration

The law is defined as follows:

$$Q(t) = \frac{n}{\tau}$$

8.2.23. SIL / SIL level

This law corresponds to a constant law with parameter Q = $1x10^{-(SIL-Epsilon)}$

$$Q(t) = 1x10^{-(SIL - \varepsilon)}$$

8.2.24. RRF / Risk Reduction Factor

This law corresponds to a constant law with a parameter Risk reduction Factor (RRF)

$$Q(t) = \frac{1}{RRF}$$

8.2.25. EXP / Expression

Law is defined buy user with an Albizia expression that contains time(). An Albizia expression can contain several operators and functions (*, +, -, /, gamma(), exp(), sqrt(), min(), pow(), sin(), ...).
Parameters:

- **Q(t)**: expression to evaluate Probability (must contained time());
- **w(t)**: expression to evaluate unconditional failure rate (must contained time()).

8.2.26. STO / Stored Electrical Component

This law corresponds to a constant law for stored electrical components according to the functioning time and the storage time on the mission time.

The result of the computation will be a constant probability calculated at the end of the mission.

Parameters :

- **Lambda** (rate) = failure rate
- **Tf** (Duration) = yearly functioning time
- **Ts** (Duration) = yearly storage time
- **K** (Rate) = reduction coefficient (functioning failure rate is equal to storage failure divided by this coefficient)
- **%FMD** (Ratio) = failure mode ratio
- **mission time** (Duration) = duration of the mission

The law is defined as follows :

$$Q(t) = \left(1 - e^{(-\lambda.TTf.\%FMD)}\right) + \left(1 - e^{(-\left(\frac{\lambda}{K}\right).TTs.\%FMD)}\right)$$

Mission time is taken into account in the computation of total functioning time (TTf) and total storage time (TTs) for the electrical component

TTf is defined as follows :

$$TTf = Tf \cdot \frac{DM}{8760}$$

and TTs is defined as follows :

$$TTs = Ts \cdot \frac{DM}{8760}$$

Assuming the number of hours in a year is set to 8760.

8.3. 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 several laws available to model them:

- "UNIF / Uniform";
- "NORM / Normal";
- "NLOG / Lognormal";
- "OBS / Observation";
- "OBS (#) / Periodic Observation" ;
- "GAM / Gamma";
- "BET / Beta";
- "TRI / Triangular".
- "HST / Histogram".

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

8.3.1. 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:

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

8.3.2. NLOG / Log normal law

This law has 3 parameters: the mean and the error factor and the percentage of confidence interval.

Parameters:

- **Average(Mu)** = The average
- **Error factor** = The error factor EF (= exponential(1.645*Sigma) for a 90% confidence interval)
- **Confidence interval at** = Percent of confidence interval (between 0 and 1)

A random variable is distributed according to a lognormal distribution if its logarithm is distributed according to a normal distribution. The law is defined as follows:

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

Where Sigma is equal to ln(EF)/coef, where coef is the quantile of the normal law conresponding to the chosen percentage (1.645 for 90%), and where Mu = ln(E(x)) - SigmaÂ²/2

8.3.3. 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:

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

8.3.4. OBS / Observation

This law has two parameters.

Parameters:

- **Number of events (N)** = Number of events observed
- **Observation duration (T)** = Observation duration

The probability density function of this distribution is:

$$f_x(T) = \frac{1}{2^{\frac{k}{2}}\,\Gamma(\frac{k}{2})}\; t^{\frac{k}{2}-1} e^{-\frac{T}{2}}$$

$$\text{With } \Gamma(z) = \int_0^{+\infty} t^{z-1} e^{-t} dt \;\; \textit{the Gamma function}$$

k represents the degrees of freedom.

In options, it is possible to choose the degrees of freedom

8.3.5. OBS (#) / Periodique Observation

This law has three parameters, it is based on F.Brissaud work published in Rel. Eng. Sys. Safety 2017 DOI:10.1016/j.ress.2016.11.003

Parameters:

- **Number failure revealed (N)** = Total number of failure observed
- **Duration between 2 tests (#)** = Inspection period

- **Number of proof tests (W)** = Total number od proof tests.

This function is partly based on a random number generator that uses a beta distribution (W-N + 1, N).

8.3.6. GAM / Gamma

The gamma distribution is a two-parameter probability distributions: the shape parameter and the scale parameter.

Parameters:

- **K** = Shape parameter
- **Theta (θ)** = Scale parameter

The probability density of the gamma distribution is:

$$f(x) = x^{k-1}\frac{e^{-x/\theta}}{\theta^k \Gamma(k)}$$

$$\text{With } \Gamma(z) = \int_0^{+\infty} t^{z-1}e^{-t}dt \ \ the\ Gamma\ function$$

8.3.7. BET / Beta

The beta distribution is parametrized by two positive shape parameters: Alpha et Beta.

Parameters:

- **Alpha (α)** = Shape parameter
- **Beta (β)** = Shape parameter

The probability density function for $0 \leq x \leq 1$, and shape parameters $\alpha, \beta > 0$ is :

$$f(x;\alpha,\beta) = \frac{1}{B(\alpha,\beta)}x^{\alpha-1}(1-x)^{\beta-1}$$

$$B(x,y) = \int_0^1 t^{x-1}(1-t^{y-1})dt$$

8.3.8. TRI / Triangulaire

This law has three parameters : a minimum, a maximum et an optimum.

Paramètres :

- **a** = minimum
- **b** = maximum
- **c** =optimum

The law definition is:

$F_c = \frac{c-a}{b-a}$:used during Z testing

$p_1 = \sqrt{(c-a)(b-a)}$:gradient between a and c

$p_2=\sqrt{(b-c)(b-a)}$: gradient between c and b

In propagation uncertainties:

Z randomly fired and equidistributed distributed between 0 and 1;

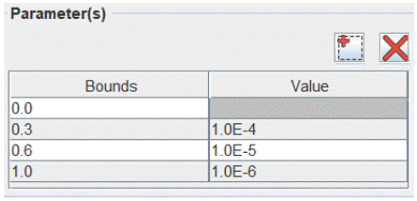
si $Z=0$
  $d=a$
sinon
  si $Z<F_c$
    $d=a+p_1\sqrt{Z}$
  sinon
    si $Z<1$
      $d=b-p_2\sqrt{1-Z}$
    sinon $d=b$

8.3.9. HST / Histogramme

Draw a random number between the minimal bound and the maximal bound, and return value corresponding to the interval containing the value. the law has as many parameters as desired bound.

The law definition is :

- **Bounds** = bound of the value in the histogram.
- **values** = Value between two bounds. the two corresponding bounds are [A;B], where A is the bound located in the row before the current value and B the bound located on the same row of the value. The value on the first row is always empty, since the firts bound is used as the minimal bound of the value on the second row.

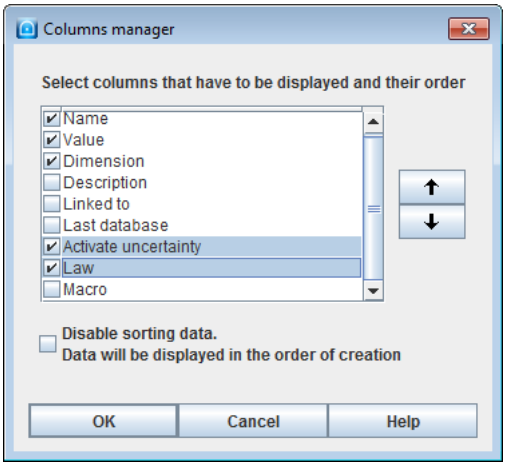


8.3.10. Consideration of the uncertainties

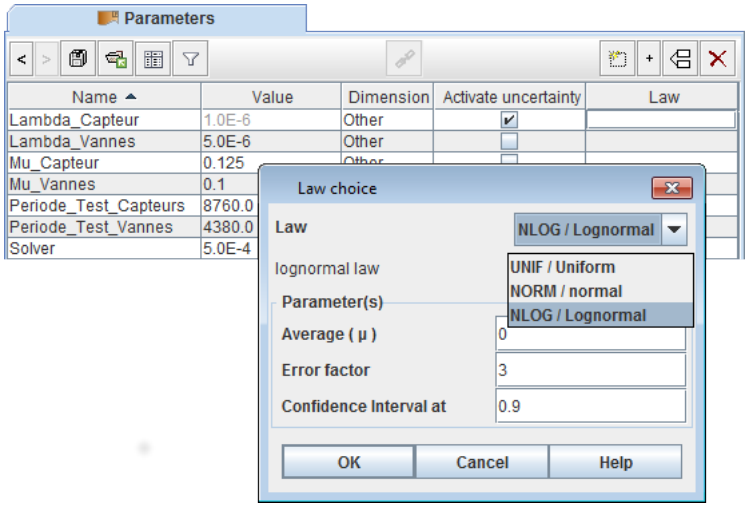
Uncertainties on parameters can be evaluated with 2 different ways:

- in the configuration of the laws as described in the chapter Configuring the laws [17]
- in the tab of parameters. In this case, ff a same parameter is used in 2 events, the same uncertainty is considered

  To do that, first it is necessary to select the column **Activate uncertainty** and **Law** using the columns manager.



After, in the tab of parameters, It is enough to choose or not to activate the uncertainties and the law will be applied in **Law** column.



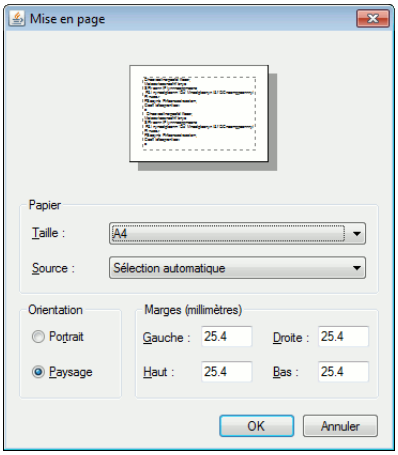
9. Printing

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

- **Page setup**
- **Print**
- **Save in RTF file**

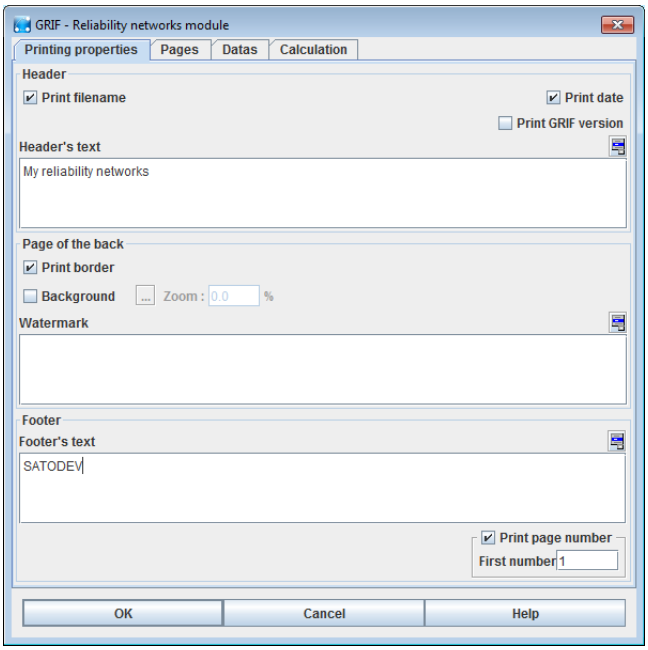
9.1. Page setup

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



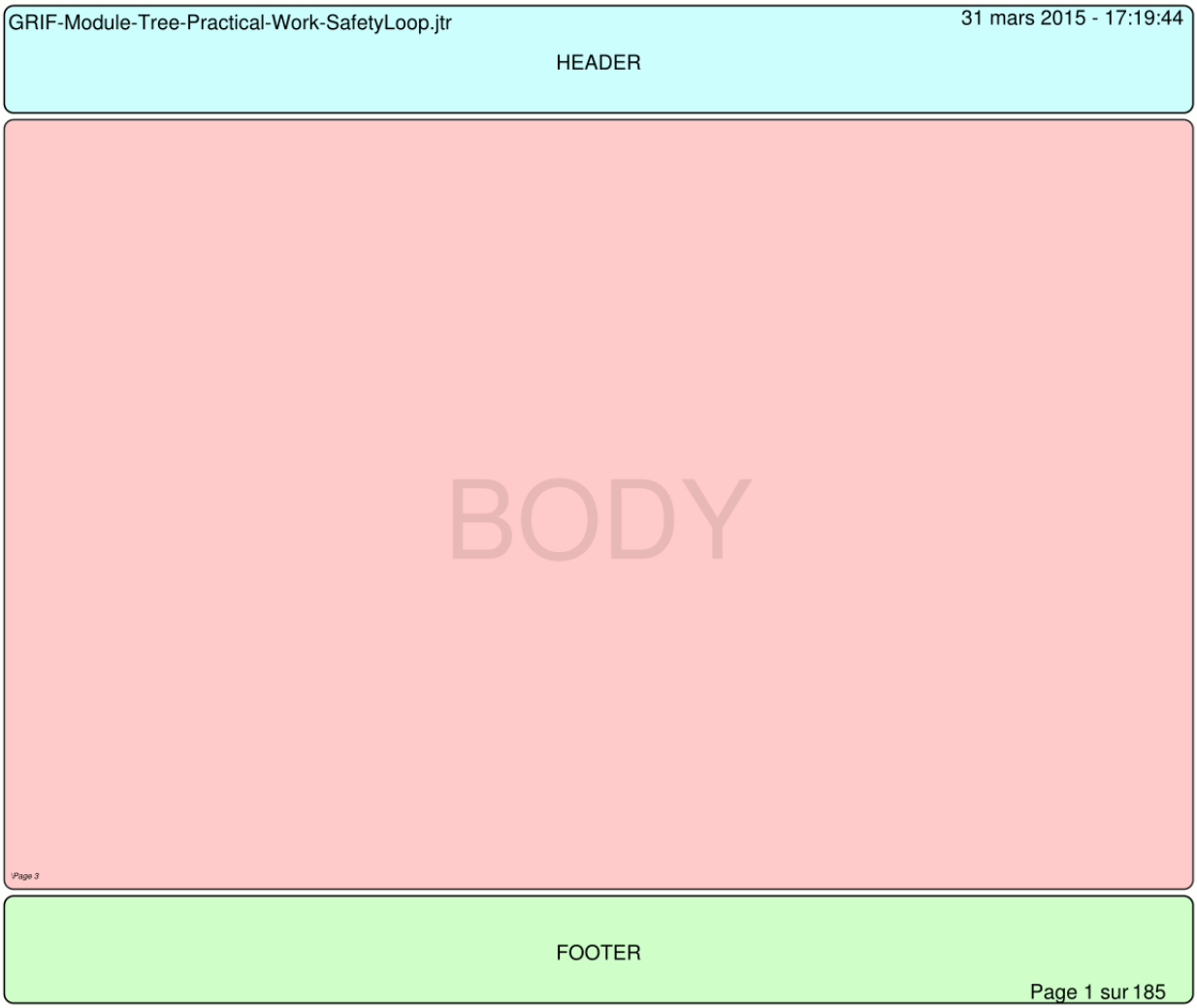
9.2. Print

The **Print** function enables you to export .pdf document pages. Graphics are exports in a vector graphics format in order to scale it without deterioration. All data table and the results of calculations can be also exported. Here is the window of configuration of the printing:

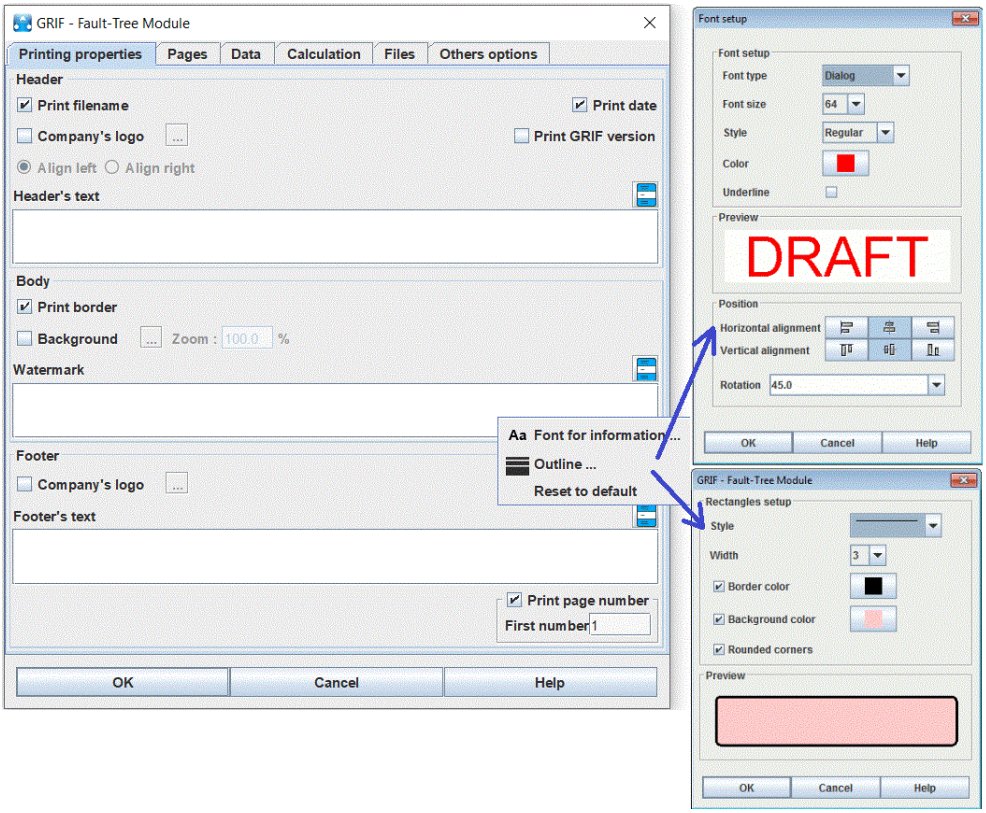


1. Printing properties

Printing properties tab gives the possibility of configuring what will be visible on all the printed pages. This tab contains three parts: the header, the body and footers. Below here is an example which illustrates the various zones on the PDF:



Each of three text fields is configurable. The user can so modify the police, the style, the color and the positioning of the text in the zone. He can also configure the zone itself by allocating a background color and a frame. A click-right on the text field shows a contextual menu: **Display settings**

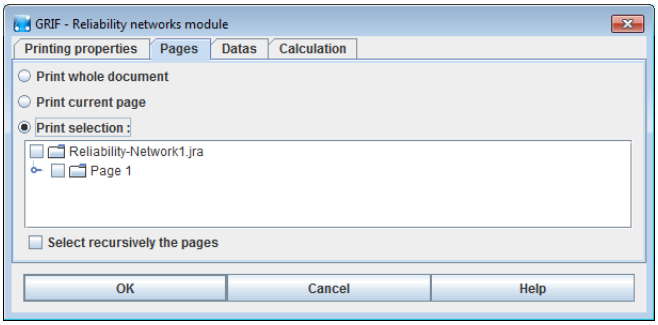


Several options are added:

- **Print file name** in the header at the left top.
- **Print date** in the header at the right top.
- **Print a border in the graphic pages** enables to bound visually the pages of graphs besides of the page of printing. Warning: this frame can be in conflict with a possible frame defines in the zone of body of page
- **Watermark** enables to seize an image to be printed on a background with colors which will be limited. The image can go out of the zone of body of page
- **Print number of page** in the footer in the lower right. The first number can be chosen to start not at 1.

2. Pages

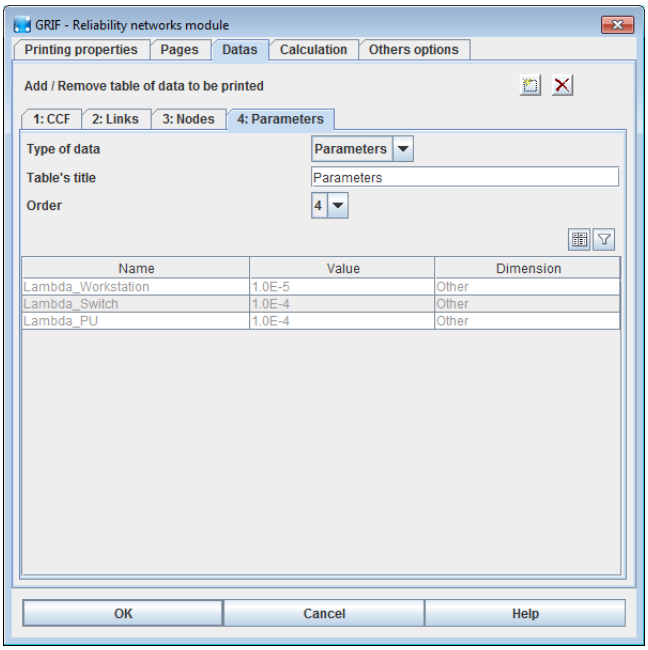
Pages tab enables to select the page will be printed.



- **Print all the page** : all the pages will be printed
- **Print current page** :only the current page will be printed.
- **Print selection** : select pages and groups will be printed. **Select recursively the pages** option is a help in order to select quickly sub-pages.

3. Data

Data tab enables to select date will be printed.

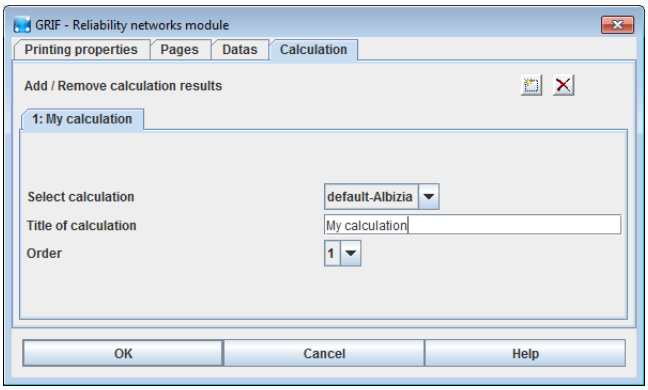


Each sub-tab will represent a table in the PDF document. The title and the print order of these tables can be modified.

By default all the types of data are represented (one by sub-tab). The upper right buttons allow to add it or to delete it. To note that we can print several times of the same data type in different tables. The data table can be filter using the usual filter. The Column manager can be also used.

4. Calculation

Calculation enables to select the calculation will be printed.

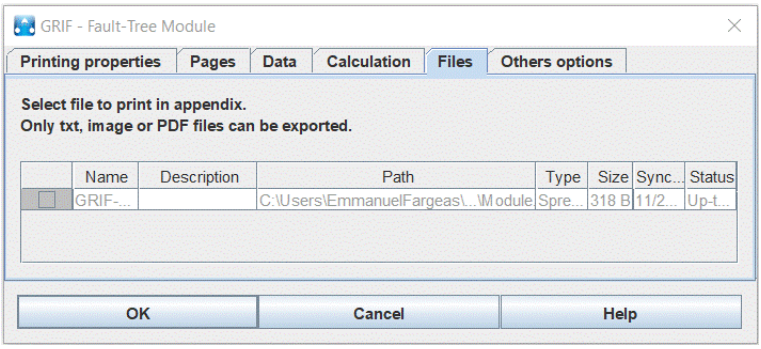


Each sub-tab will represent a part containing the various tables present in the results of the calculation. This part has a modifiable title and order which is the order of printing of the various results.

By default all the calculation results are represented (one by sub-tab). The upper right buttons allow to add to it or to delete it.

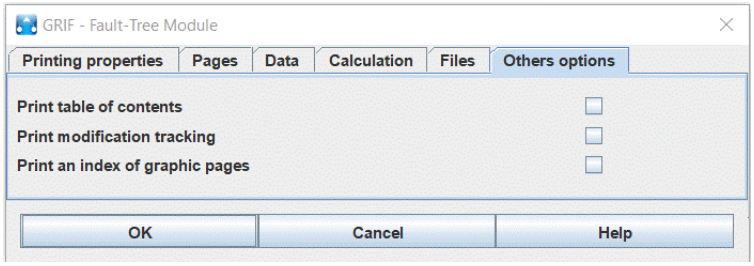
5. Files

Files enables to select the files related to the document to print in appendix. Only txt, image or PDF files can be exported.



6. Others options

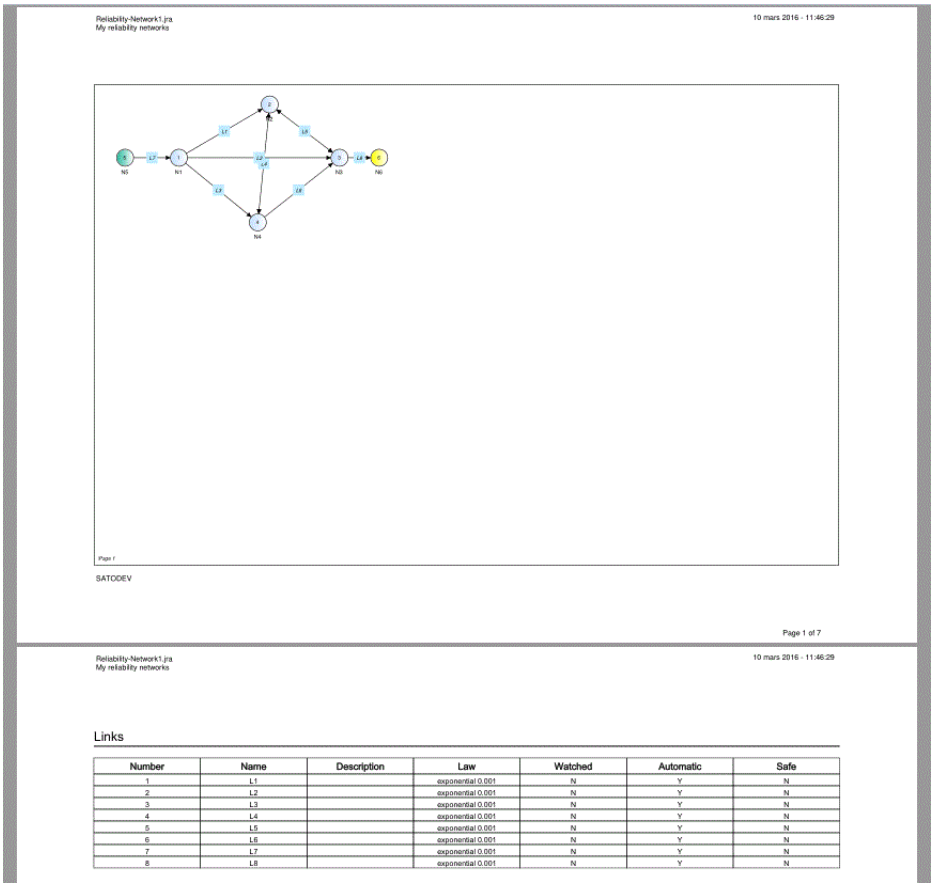
Others options .



- **print table of contents** : Allows to print the table of content of document, very useful for big documents.
- **Print modification tracking** : Allows, if the modification tracking optuion is selected, to print comment, author and date of modifications for each saving.
- **Print index of graphic pages** : Allows to print an index of graphic pages, very useful for big documents.
-
-
-
-
-

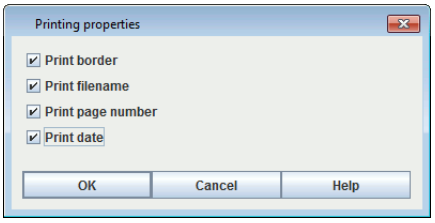
7. Example

To give an overview of a PDF printing:

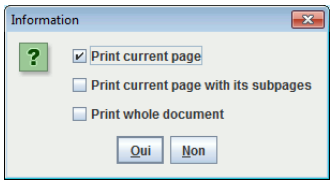


9.3. Save in RTF file

The **Save in RTF file...** function initially gives access to a window called **Printing properties** . Then to another called **Information** . And thirdly, a window is displayed allowing you to choose the folder in which the RTF file is to be saved.



When you select the **Save in RTF file** 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 enables you to indicate whether you wish to print the current view, print the current page or print the whole document.

10. Computations

The following two computation engines can be used in the Reliability Networks module:

- Albizia;
- MOCA.

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

10.1. Albizia computations

The computations by Albizia are performed in two main steps:

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

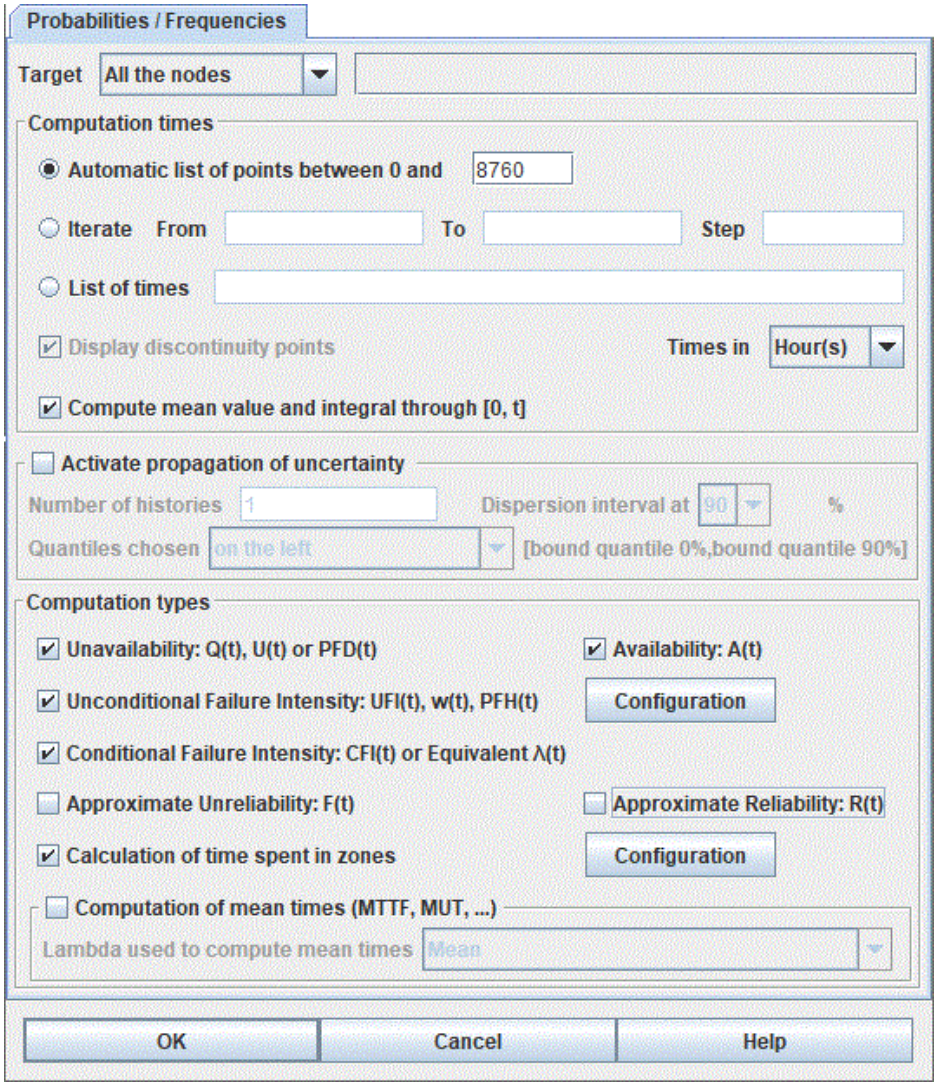
10.1.1. Configuring the computations

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 **Launching Albizia computation** .

The configuration window is divided into 3 tabs (1 for each type ofcomputation).

10.1.1.1. Configuration of probabilities computation



- **Target**: specifies the target of the computations. Four choices are possible: **All nodes** , **Top Events** for the top(s) of the tree, **Watched node(s)** for node in the watched element list, **Time Spent node(s)** for nodes in the Time Spent element list and **Selected node** for the node currently selected in the tree.

- **Computation times** : specifies the computation options.

  – **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.

  It is possible to make the calculation just before a test period by indicating a - after the chosen time for calculations

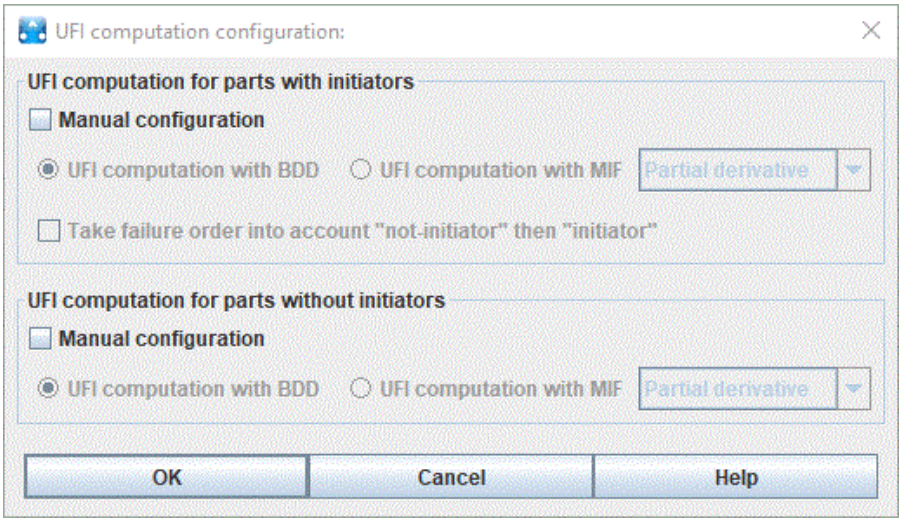
  – **Display discontinuity points** : the computation engine takes into account the discontinuity points if the option is selected.
  – **Times in** : The values entered are supposed to be hours. The unit can be specify among hours, days, months, years
  – **Compute mean value through [0, t]** : the computation 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.

- **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 (choice between 60%, 70%, 80%, 90%, 95%, 99% et 99.9%).
- **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.

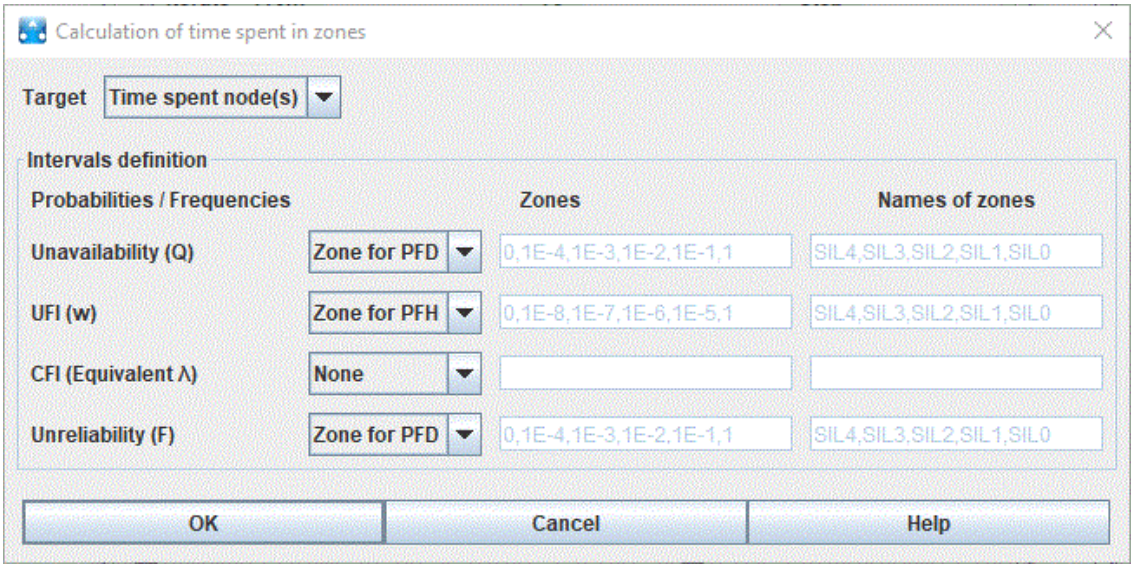
- **Probabilities** : specifies probabilities to compute.

  - **Unavailability** : Q(t), U(t) or PFD(t) according to different standards and countries.
  - **Availability** : A(t) = 1 - U(t)
  - **Unconditional Failure Intensity** : W(t), UFI(t) or PFH(t) according to different standards and countries. It is the probability that the system fails between t and t+dt, assuming system was OK at time t=0. It is possible to manually configure the computations of the CFI, with the "Configuration" button. (cf. Section 10.1.1.6, “UFI computation configuration”)



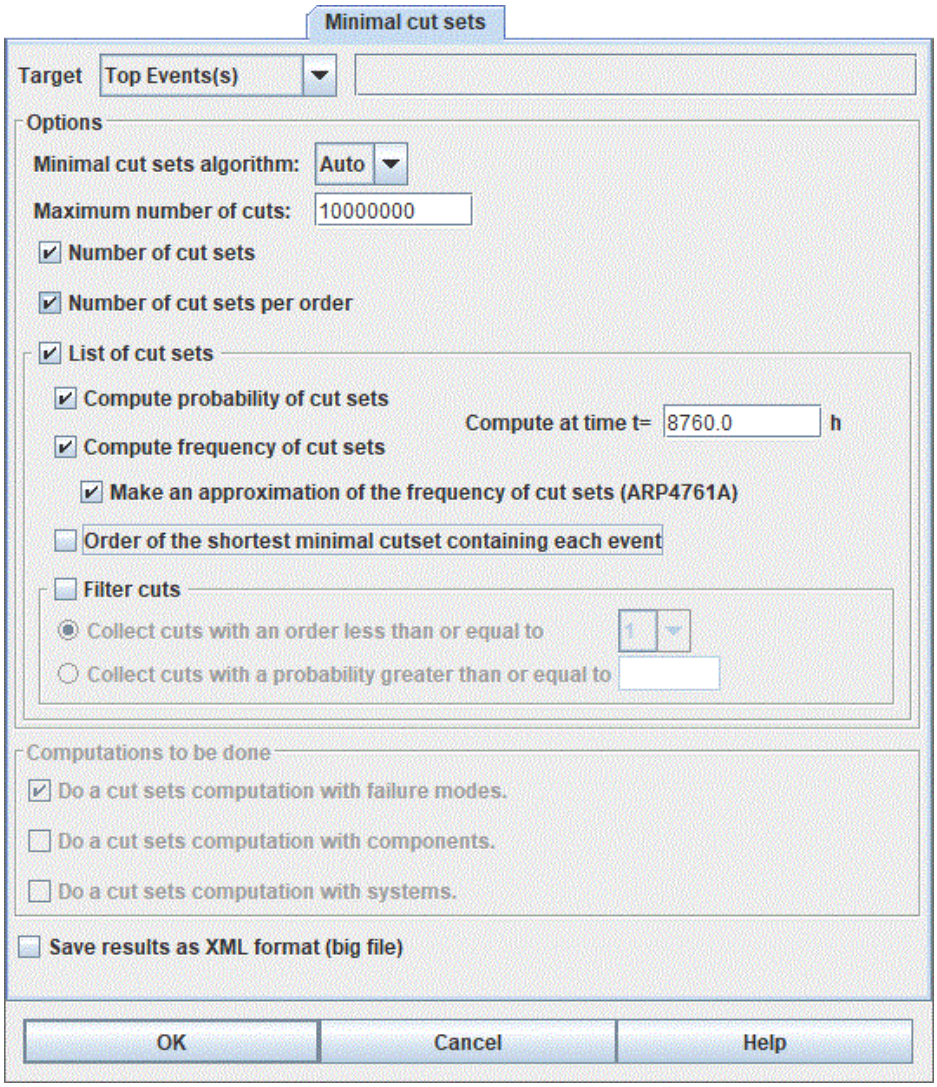
  - **Conditional Failure Intensity** : CFI(t), λ eq(t) or λ Vesely(t) according to different standards and countries. It is equal to W(t)/A(t) It is the probability that the system fails between t and t+dt, assuming system was OK at t and at time t=0.
  - **Unreliability** : F(t) = 1 - R(t)
  - **Reliability** : R(t) = R(t)=exp[-(Integral from 0 to t) of λ eq(u)du]. We can see here that this reliability is based on an equivalent lambda, and not on the real lambda. This is a good approximation that is conservative. Anyway, you can not compute the reliability with a fault-tree. For systems made with unrepairable components, the result is exact (because it is equal to Availability).

– **Calculation of time spent in zones** : For above values, this option enables to know percentage of time spent in each interval. These intervals are configurable using Configuration button. By default, SIL zones are used.



– **Configuration of mean times** enables you to configurate the computations to obtain the mean times. (cf. Section 10.1.1.5, “Configuration of mean times”)

10.1.1.2. Configuration of cut sets calculations



- **Target**: specifies the target of the computations. Four choices are possible: **All nodes** , **Top Events** for the top(s) of the tree, **Watched node(s)** for node in the watched element list, **Time Spent node(s)** for nodes in the Time Spent element list and **Selected node** for the node currently selected in the tree.

- **Minimal cut sets algorithm**: enables to choose between the two available algorithms. The **MCS** algorithm (Minimal Cut Set) gathers the cuts from the construction of the ZBDD, while the **PI** algorithm will create the cuts from the Prime Implicant. This last one enables the incoherent formulas, but not the first one. The **Auto** mode let GRIF choose the best algorithm (depending on the formula and the options).

- **Maximum number of cuts**: enables to inquire a maximal number of cuts. If the number of cuts exceeds this number, the cuts having the greater number of elements will not be saved.

- **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.

- **Compute probability of cut sets**: enables to add the probability to each cut of the list.

- **Compute frequency of cut sets**: enables to add the frequency to each cut of the list.

- **Compute at time t=** enables to inform the time when the probabilities and the frequencies of the cuts are calculated.

- **Make an approximation of the frequency of cut sets**: enables to compute the frequencies from the standard ARP4761A. The computations of frequencies are quicker but more approximative.

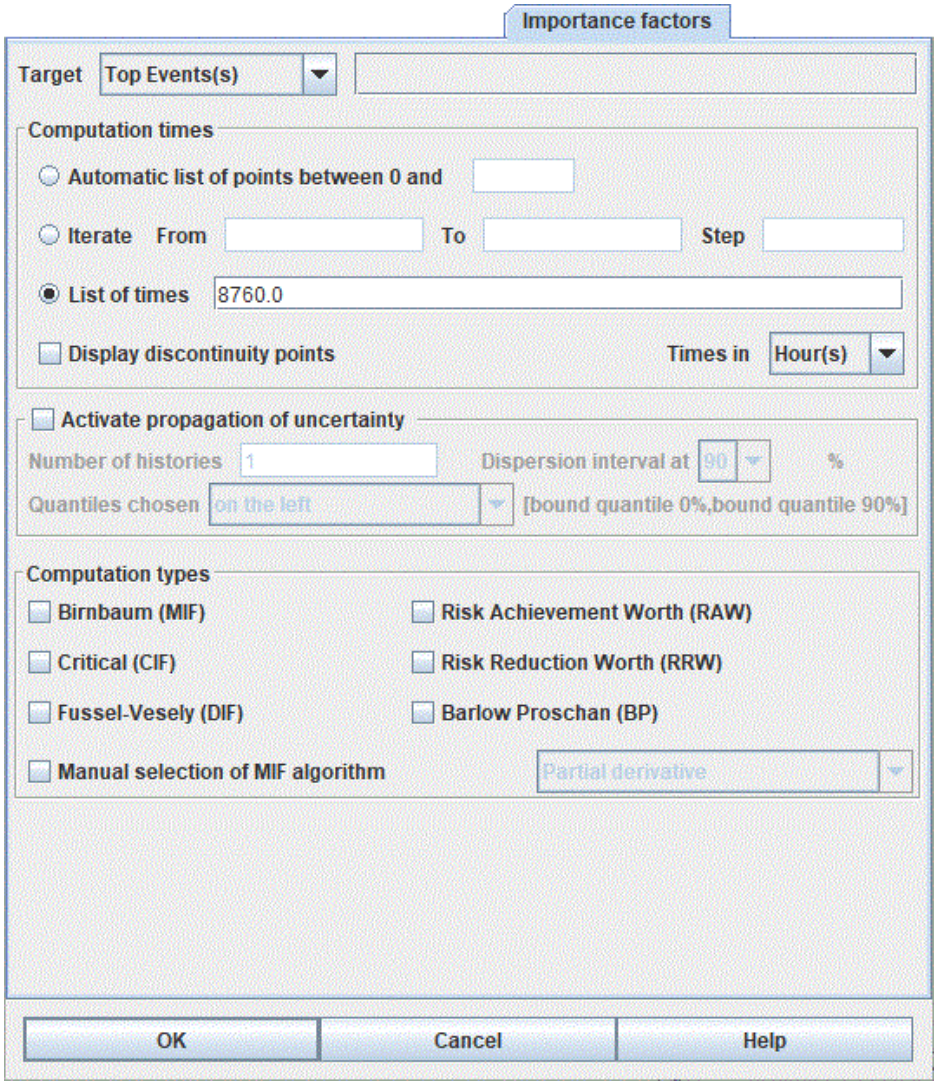
- **Order of the shortest minimal cutset containing each event** enables to know for each event what is the order of the smallest cut containing this event.

- **Filter cuts** enables to not take into account some cuts which do not have a probability or an order superior to the given limit.

- **Computations to be done** enables to inform what computations will be done. It is possible to do the computation on the failure mode of the formula, but depending to the module, it is possible to do the computations on the components of the formula, or the systems of the formula.

- A cuts save in the result file is possible by selecting the option **Save result as XML**, but the cuts being voluminous, the result file will be bigger.

10.1.1.3. Configuration of importance factor calculations



- **Target, times, uncertinties** : cf. probabilities calculation
- **Computation type** : specifies the importance factors to compute.
  - **Birnbaum (MIF)**

$$\mathrm{MIF}(S,e) = \frac{\partial p(S)}{\partial p(e)} = \frac{\partial [p(e).|p(S|e) - p(S|\bar{e})| + p(S|\bar{e})]}{\partial [p(e)]} = p(S|e) - p(S|\bar{e})$$

  - **Critical (CIF)**

$$\mathrm{CIF}(S,e) = \frac{p(e)}{p(S)} \times MIF(S,e)$$

  - **Fussel-Vesely (DIF)**

$$\mathrm{DIF}(S,e) = p(e|S) = \frac{p(e).p(F|e)}{p(F)}$$

  - **Risk Achievement Worth (RAW)**

$$\mathrm{RAW}(S,e) = \frac{p(S|e)}{p(S)}$$

  - **Risk Reduction Worth (RRW)**

$$\mathrm{RRW}(S,e) = \frac{p(S)}{p(S|\bar{e})}$$

– **Barlow Proschan (BP)**

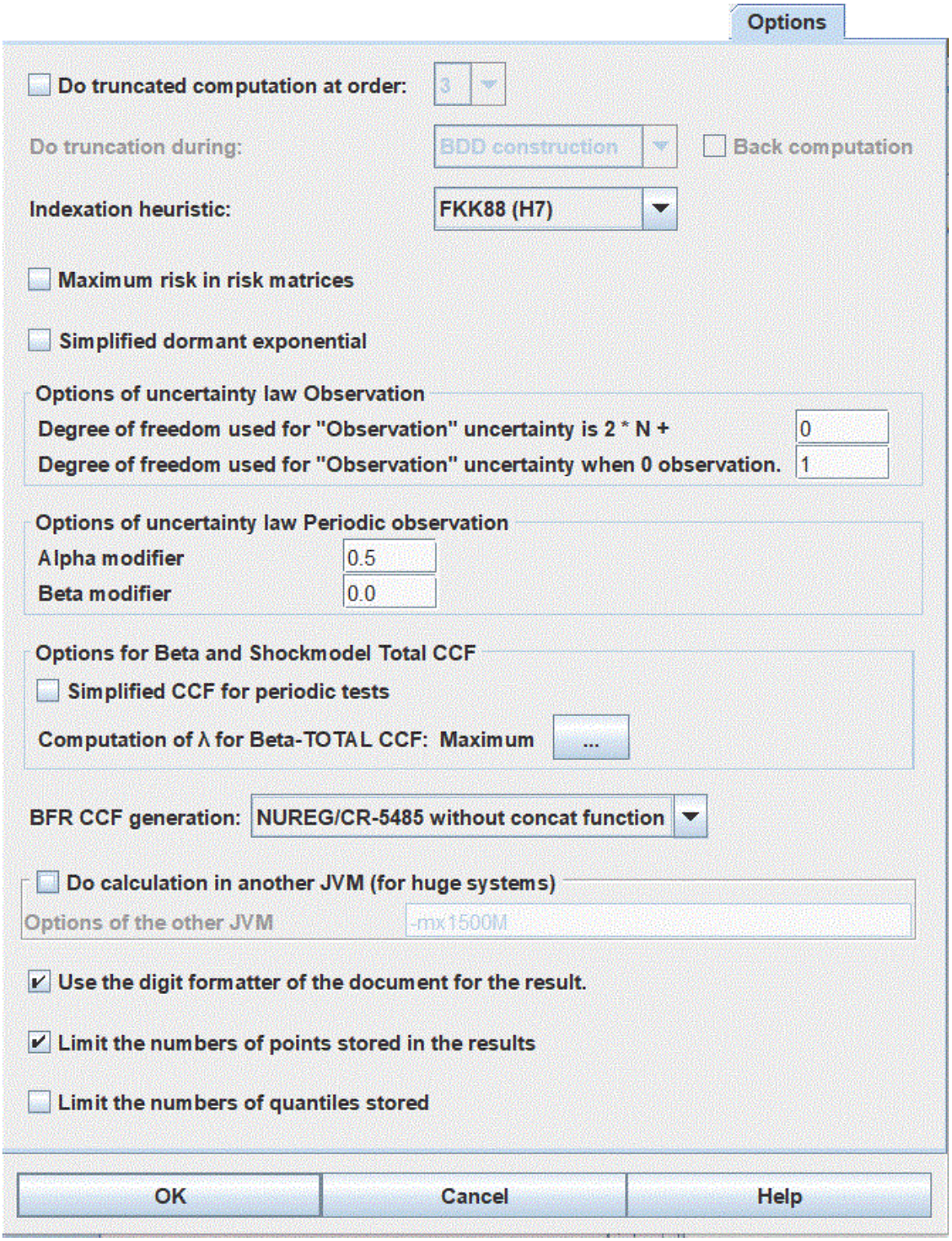
$$BP(S,C,t) = \frac{W(C,t) \times MIF(S,C,t)}{\sum_{c \in S} W(c,t) \times MIF(S,c,t)}$$

The manual configuration of MIF computation enables you to chose MIF algorithm.

- **Partial derivative:** Uses quick algorithm based on partial derivative. To be used with coherent fault trees only)
- **Exclusive Cofactor:** Uses (less quick) algorithm using Exclusive cofactor S#. It stays valid with non-coherent fault trees.
- **BDD:** Uses algorithm using BDD (only for coherent fault trees)

With automatic mode, the **Partial derivative** algorithm is used, execpt for non-coherent fault tree (Negation, XOR, IfThenElse ...) where S# is used.

10.1.1.4. Configurating computations' options



The options of the computations allow to inform some additional options, on the three parts seen previously:

- **Do truncated computation at order**: enables to not take into account the elements which have an order greater than the given order. For example, a AND gate with five sons will not be taken into account if we give four as the truncated computation order.

- **Do truncating during**: enables to inform when computations will be truncated. It can be during the **BDD Construction**, so on the probabilities, or during the **ZBDD Construction**, so on the cuts. The **Back computation** enables, when the truncation is on the BDD, to make a Back Computation, which means to

compute for all the targets the probabilities from the cuts of the ZBDD. This enables to have a better accuracy of the target probability when the BDD is truncated.

- **Indexation heuristic**: enables to inform which algorithm will be used by ALBIZIA to order the variables in the dataset. (cf. Doc Albizia)

- **Maximum risk in risk matrices**: enables to have on the risk matrices in the ordinates the medium frequencies (if not selected) or the maximum frequencies (if selected).

- **Simplified dormant exponential** enables to simplify the dormant exponential laws into constant laws, with parameter q equals to the maximum between the test period and the maximum of mission time.

- **Options of uncertainty law Observation**: enables to configurate the uncertainty laws of type Observation of the parameters in the document.

- **Options of uncertainty law Periodic observation**: enables to configurate the uncertainty laws of type Periodic observation of the parameters in the document.

- **Options for Beta-Total CCF**: enables to configure all the CCF of Beta-Total type in the document. The option **Simplified CCF for periodic tests** enables to set to 0 all the parameters of the tests for the CCF (Gamma, Pi, X, Sigma and the Omegas). The **Computation of lambda for Beta-TOTAL CCF**: enables to inform how the Lambda will be calculated : **Minimal Lambda** which is not recommended since there is a lost of precision, **Maximal Lambda** which enables to keep the precision, and the differents **Medium Lambda**.

- **BFR CCF generation** enables to inform which algorithm will be used to decompose the BFR CCFs.

  The algorithm **NUREG/CR-5485** will take into account during the lethal/non lethal failure every impacted elements by the CCF. These elements will then be under a new gate OR (in the case of **without concat function**), or under a new gate Concat (in the case of **with concat function**).

  The algorithm **Atwood 1986** enables to decompose an impacted event by a CCF in three parts: An intrinsic part, a lethal part and a no lethal part (made out of two parts : the non lethal part intrinsic of the event, and the non lethal part linked to the CCF)

- **Do calculation in another JVM** enables, when the computations has to be done on a huge model (and so going to take a lot of times), to launch the computations on a new process independent of GRIF. It is then possible to continue working on GRIF on the meantime. The **Options of the other JVM** allow to inform the options of the JVM, for example the given space allowed (-mx"Memory size").

- **Use the digit formatter of the document for the result** : this option enables to use this digit formatter for the saving or the display of the result.

- **Limit the numbers of points stored in the results** this option enables to limit the numbers of points stored in the results file. Consecutive points will be deleted if they have the same values

- **Limit the numbers of quantiles stored** this option enables to limit the numbers of quantiles stored in the results. Only the requested bounds will be saved.

10.1.1.5. Configuration of mean times

To obtain mean times results it means: MTTF, MDT, MUT, MTBF, number of failures, mean up time and mean down time, it is enough to check the box **Computation of mean times** in **Mean times** tab.

The different mathematical magnitude computed are these following:

- **MTTF**: Mean Time To Failure: time before the item fails. It is used to describe the time
  – to failure for a non-repairable item;
  – to the first failure for a repairable item.

$$MTTF = \frac{1}{\lambda_{avg}\ in\ end\ of\ mission}$$

- **MDT**:Mean Down Time: average time that a system is non-operational.

$$MDT = \frac{Q_{avg} \times Mission\ Time}{Number\ of\ failure} = \frac{\int Q}{Number\ of\ failure}$$

- **MUT**: Mean Up Time: average time that a system is working.

$$MUT = \frac{(1 - Q_{avg}) \times Mission\ Time}{Number\ of\ failure} = \frac{\int \mathcal{A}}{Number\ of\ failure}$$

- **MTBF**: Mean Time Between Failure: time between successive failures of a repairable item.

$$MTBF = \frac{Mission\ time}{Number\ of\ failures} = MDT + MUT$$

- **Number of failure**: number of failure over mission time.

$$Number\ of\ Failure = \int w$$

- **Up time**: duration of system is working.

$$Total\ up\ time = Mission\ Time\ \times (Q_{avg})$$

- **Down time**: duration of system is non-operationnal.

$$Total\ down\ time = Mission\ Time\ \times (1 - Q_{avg})$$

10.1.1.6. UFI computation configuration

GRIF (with Albizia engine) enables to compute UFI on non-coherent fault tree. The automatic mode takes into account almost cases, but user can select which algorithm to use. There is two way for UFI computation:

- **UFI computation with MIF:** It is "usual" method. Let be a System S made of many components c, the UFI (also called w) of S is equal to $UFI_s = w_s \Sigma MIF(S,c)*w_c$. This algotithme is less performant than the one based on BDD, but it works for non-coherent fault tree (if the MIF is well computed).
- **UFI computation with BDD:** It is the "fastest" methode which is base on BDD. This method doesn't work for non-coherent fault trees, except in the particular case of initiator events (cf. option below).

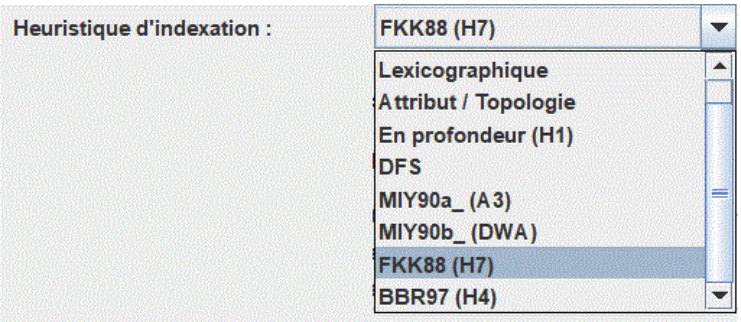
In order to exmplain the **Take failure order into account "not-initiator" then "initiator"** option, lets take a simple example: un system made of one safety barrier which set the system in a safety state if an initator event is detected. The top event is an initator event which is not detected by the barrier. The frequency of this top event is the result of two cases:

- The barrier is already out of order (with some probability) and the initiator event happens (with some frequency)
- the initiator event is already here (with some probability) and the barriers fails (with some frequency)

The second case doesn't matter because the system is set in a safe mode. That why this case can be removed from UFI computation. It is what is done if user check **Take failure order into account "not-initiator" then "initiator"** option. This options works the both algorithms. Moreover, this options enables you to use **UFI computation with BDD** if initiato part is coherent.

10.1.1.7. Ordering choices

It is possible to choose among various algorithms the indexation heuristics to order B.D.D. construction.



The algorithms for the indexing heuristic available are:

- **Not indexed :** variables are indexed according to their declaration order .dag file.
- **Lexicographic :** variables are indexed according to their name.
- **Attribute / Topology :** variables are indexed according to their "Indexing" attribute that depends of the topology.
- **Depth (H1) :** variables are indexed using depth first search algorithm.
- **Specific indexation heuristic:** DFS ; MIY90a_(A3) ; MIY90b_(DWA) ; FKK88 (H7) ; BBR97 (H4).

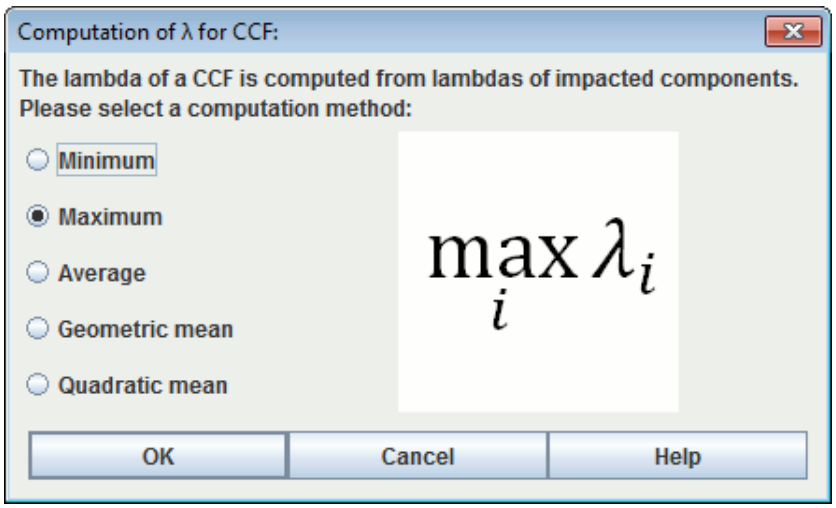
By default, the algorithm used is FKK88.

Important : When using BFiab and Reseda modules, it is usefull to opt for an indexation heuristic of the "Attribute / Topology" type, this option significantly improves the time of the B.D.D. construction (and thus of the model computation) of the BFiab and Reseda modules.

10.1.1.8. Configuration of Lambda computation method for CCF

When using common cause failure, the software must compute a lambdaCCF that will be used for CCF. It is the one that will be multiplied by Beta. Assuming each component impacted bay a CCF has a different lambda, there are many methods to compute the lambdaCCF from the list of lambdas. Five methods are available:

- Minimum: This method uses the minimum value of lambdas. Not recommanded.
- Maximum: Uses the maximum value of lambdas to be concervativ. This method was used in GRIF 2013 and previous version. It can be penalizing when lambda of components are very different.
- Average: This method uses the artimetic mean of lambdas.
- Geometric mean (Method detailed in PDS): This method uses the geometric mean of lambdas. It is PDS Method recommanded by SINTEF. It works fine with very different lambdas.
- Quadratic mean: This method uses the quadratic mean of lambdas.

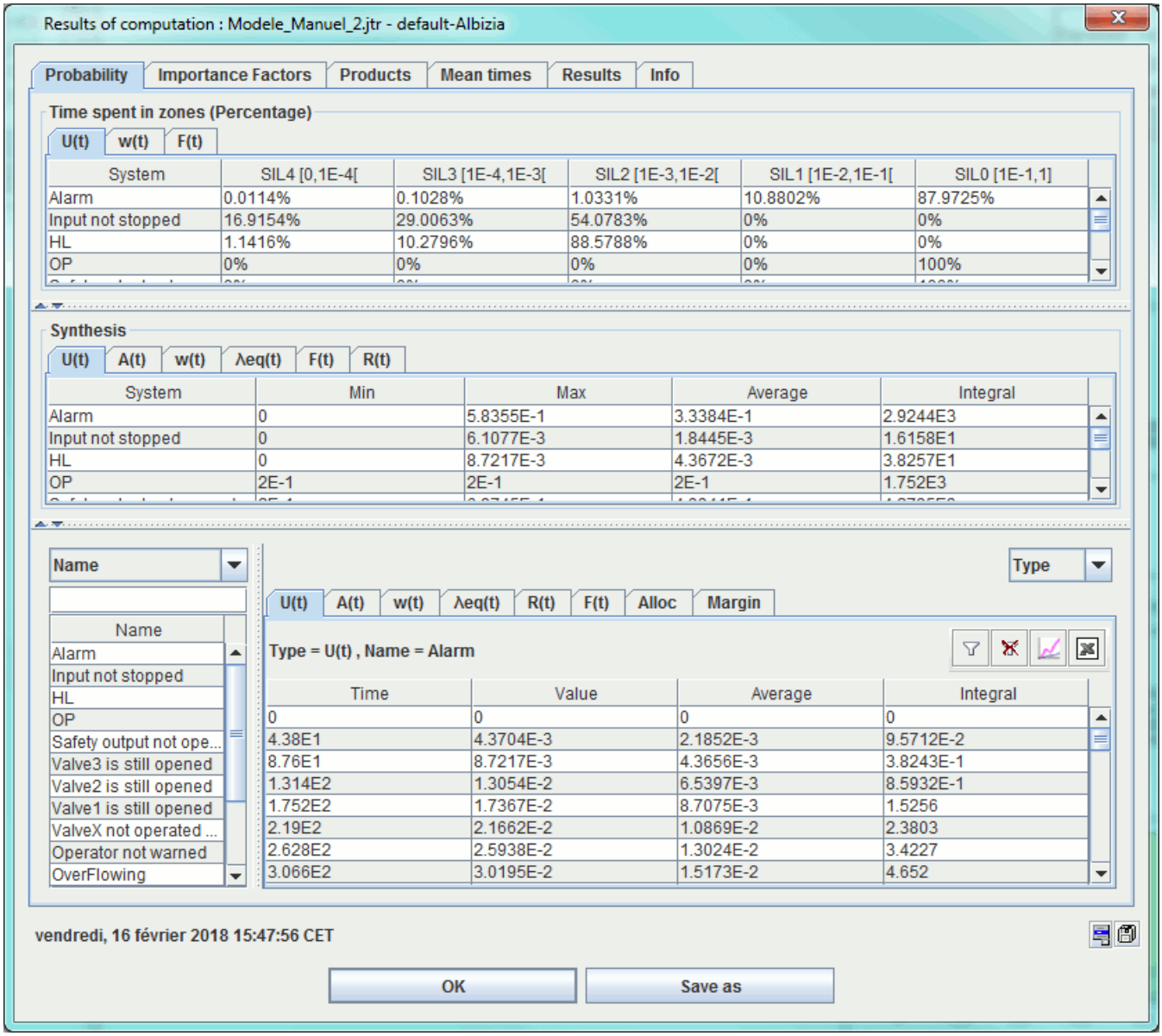


10.1.2. Albizia Results

Results window is divided into 5 tabs:

- **Probability**
- **Importance Factors**
- **Products**
- **Mean times**
- **Results**
- **Info**

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



Importance factors tab displays importance factors for each event 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".

Mean times tab give the different calculations of mean times (MTTF, MDT, ...).

Results tab contains Albizia output.

Info tab contains information about algorithm used. This information can be copied / pasted for any other use.

10.2. MOCA computations

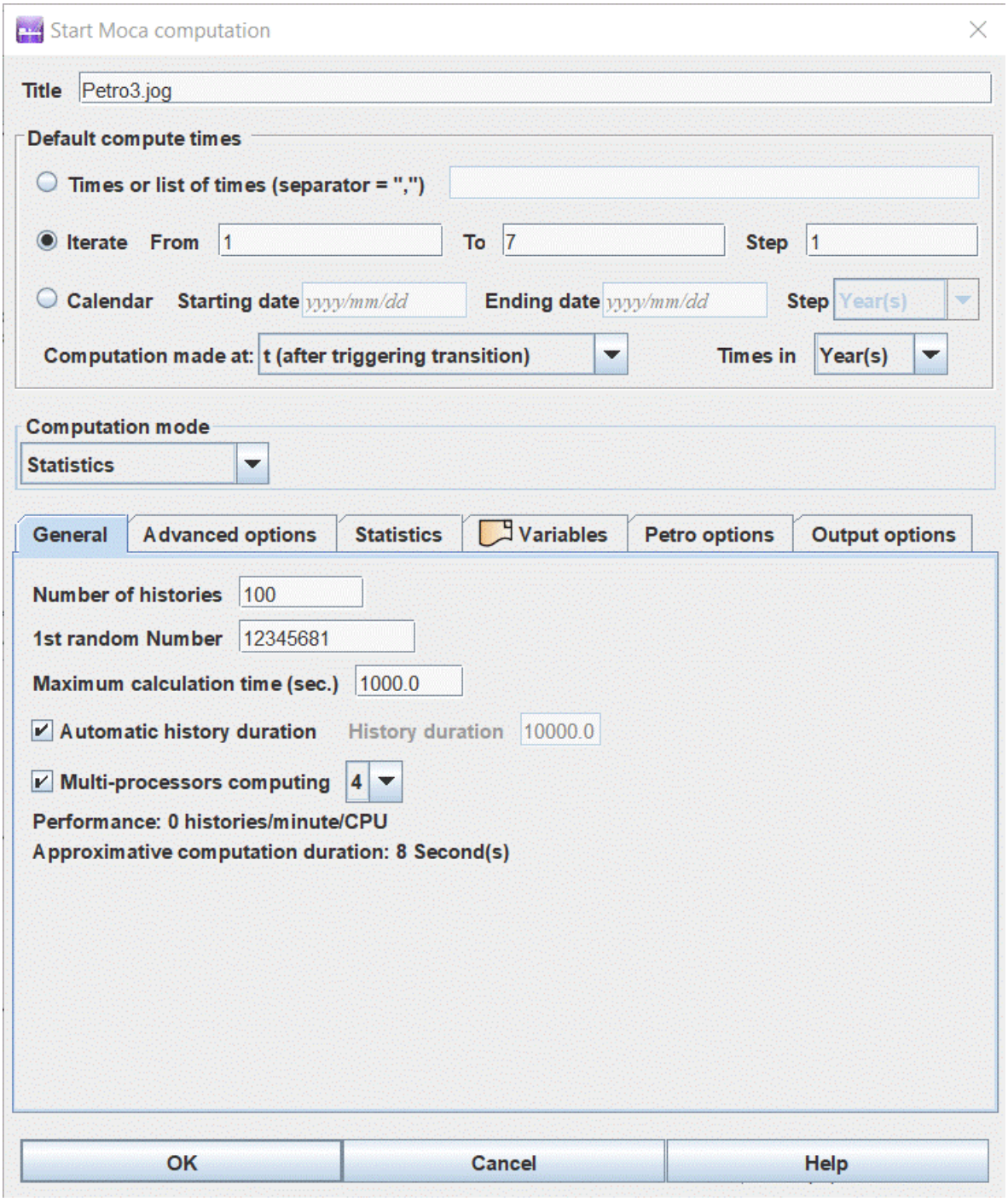
The computations using MOCA-RP V14 are performed in three main steps:

- general configuration of parameters;
- the launch itself;
- reading the results file.

10.2.1. 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 ...** . 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** : enables you to give a title to the results file.
2. **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.
   - **Computation made at** : by default, computations are made immediately after transition triggering, but you can do computation at t-Epsilon (just before triggering), or at both.
   - **Unit** : default times unit is "hour". You can choose a unit that will be used for computation times. N.b. results are always in hours.

3. **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.

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).

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

- **Loop detected when the number of transitions firing at the same time is grater than** : You can choose the limit of transitions fired at the same time before loop detection.
- **Max number of loops while()** : if using in a transition.
- **Continue calculation if errors** : If an error is detected, the current history is stopped and we pass to the following one without stopping the calculations.
- **Display seed history** : Display or not the seed used by the random number generator.
- **Use old seed management (version < 2018)** : From 2019, a new random number generator was developed to increase the number of playable story without seed repetition. It is recommended that you use this option only for backward compatibility for your old documents.
- **Computes every nodes** : Useful option in the boolean modules to have the calculations on all the nodes (by default the calculations are performed only in the top event).
- **Delay re-computation for dynamic transitions** : Selects the method for recalculating the delay of transitions marked as dynamic. For more information on the possible choices, refer to User manual Moca14.10.3 [2.7.10. Dynamic transitions]

5. **Statistics**
   - **Confidence interval** : Allow to choose the confidence interval at 90%, 95%, 99%, 99.9% and 99.99% (by default 90% is checked). .
   - **Disable statistics on places and transitions** : Allow not to display the statistics on places and transitions.
   - **unlimited histogram** : In case of histogram all the stories are taken into account not only the 1000 first ones.
   - **Do not save 0 value in history** : Option to not save the historic if the statistic value is 0.
   - **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).
   - **Histogram with every history of the tries (with uncertainty propagation)** : Allows to display the histogram with every history of the tries.

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

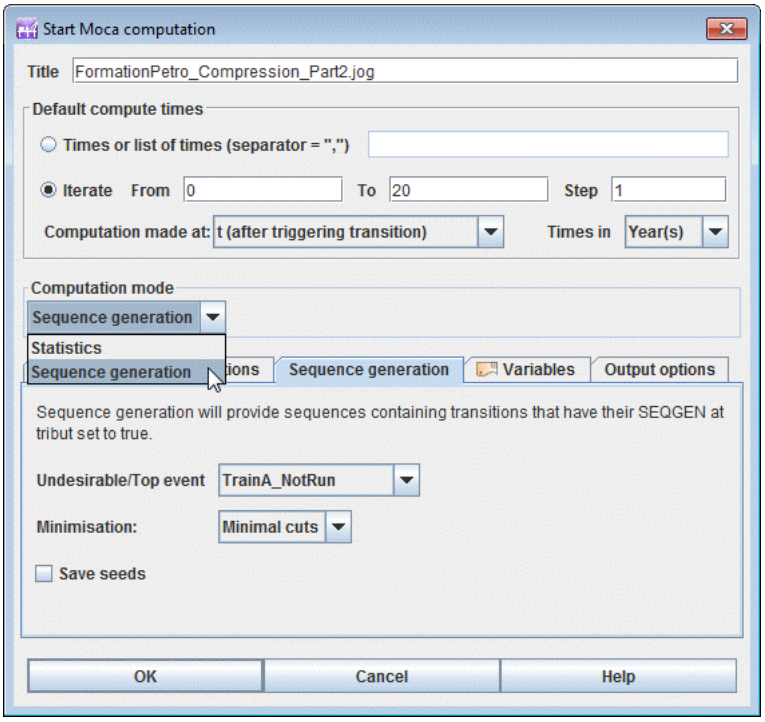
7. **Output options** : used to configure the output.

- **Print censured delays** : Prints the censored delays (or not).
- **Verbose** : Give internal information of Moca RP (launching, compilation, ...).

10.2.1.1. Sequence generation computations

The MocaRP computation engine enables to perform sequence generation. In this computation mode, it is possible to list all the sequences of transition fire which leads to undesirable event. However, statistical computation will not be made.

To activate this computation mode, in the option in the computation launching, select **Sequence Generation** in **Computation mode**. **Statistics** tab disappears in favour of **Sequence Generation** tab.



In the **Sequence Generation** tab, it is necessary to indicate the name of the **Undesirable event**. This event is a variable defined by a boolean expression. A `true` value indicates that the undesirable event has occurred during the current story.

Sequences that result in the undesirable event are grouped into an equivalence class. It is possible to choose the algorithm used to define this equivalence class:

- **None** : All transition sequences leading to the undesirable event will be returned. (no minimization)
- **Sub-words** : The minimality consists to search a common prefix, factor or suffix.
- **Minimal cut sets** : only the transitions are interested, without duplicates and without order, which led to the undesirable event. A minimal cut set includes all the sequences that include it in the same equivalence class.

See Manuel utilisateur Moca14.10.3 [3.4.5. Lancement d'une génération de séquences] for more information.

The computations options **Save seeds** enables to save the history seed and the occurrence time when undesirable event occurs.

Only the transitions with the flag `SEQGEN` with a true value are considered in the sequence. All others transitions are not taken into account. They generally correspond to transitions that don't contribute to the sequence generation (such as instantaneous reconfiguration transitions).

10.2.2. Reading the results

The results are presented in a window with different tabs and tables.

10.2.2.1. Moca Results

Moca results atre displayed in a window containing 6 main tabs: variables, places, transitions, XML, stantard output, info.

10.2.2.1.1. Tab of Variables

The **Variables** tab contains all the information computed for each variable (or statistical state).

- **Value**: Contains every value of a variable for every type of statistic.
- **History (at the end of histories)**: contains historical values for each computed statistic.
- **Fixed size Histogram**: Contains histograms computed by Moca (cf. chapter about histograms for Simulation package module)
- **Equiprobable classes Histogram**: Contains histograms computed by Moca (cf. chapter about histograms for Simulation package module)
- **User defined Histogram**: Contains histograms computed by Moca (cf. chapter about histograms for Simulation package module)
- **Timeline**: Contains a timeline for each variable. Times are automatically computed by Moca.

10.2.2.1.2. Tab of Places

It contains sojourn duration and mean mark for each place of Petri Net.

10.2.2.1.3. Tab of Transitions

It contains firing frequencies for each transition, and firing history for each history.

10.2.2.1.4. Other tabs

Other tabs display "raw" results. XML tab contains XML output of Moca, it is the file used to retrieve data. This file can be used for further post-treatments.

Standard output displays the standard output of Moca (available only after computing).

Info tab contains useful information about computation (simulation time, number of histories that have been done ...). This information can be copied / pasted for any other use.

10.3. Tables and Panels to display results

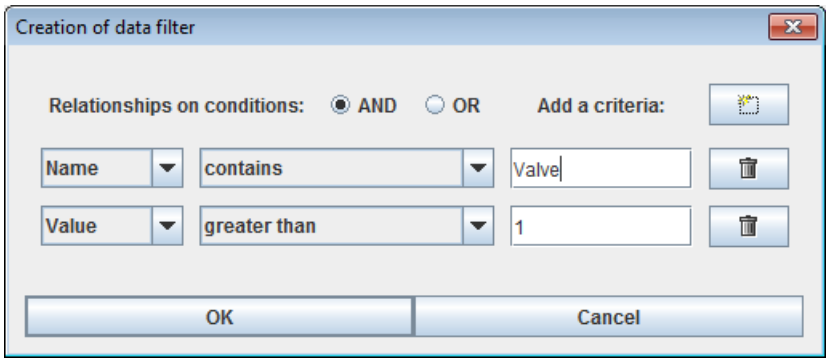
10.3.1. Result-tables

Result-tables are made of data and a top part to set table up.

Type = TS3 , Name = failures

Time	Value	CI 90%	Standard Devi...	CI lower bound	CI upper bound
0	0	0	0	0	0
8760 (- ε)	0.861	3.4305E-2	0.9355	0.8267	0.8953
8760	0.861	3.4305E-2	0.9355	0.8267	0.8953
17520 (- ε)	1.7215	4.7585E-2	1.2976	1.6739	1.7691
17520	1.7215	4.7585E-2	1.2976	1.6739	1.7691
26280 (- ε)	2.5685	5.7931E-2	1.5797	2.5106	2.6264
26280	2.5685	5.7931E-2	1.5797	2.5106	2.6264
35040 (- ε)	3.4355	6.815E-2	1.8584	3.3674	3.5036
35040	3.4355	6.815E-2	1.8584	3.3674	3.5036
43800 (- ε)	4.31	7.7185E-2	2.1048	4.2328	4.3872
43800	4.31	7.7185E-2	2.1048	4.2328	4.3872
52560 (- ε)	5.177	8.484E-2	2.3135	5.0922	5.2618
52560	5.177	8.484E-2	2.3135	5.0922	5.2618
61320 (- ε)	6.018	9.1258E-2	2.4885	5.9267	6.1093
61320	6.018	9.1258E-2	2.4885	5.9267	6.1093
70080 (- ε)	6.9245	9.8163E-2	2.6768	6.8263	7.0227
70080	6.9245	9.8163E-2	2.6768	6.8263	7.0227

Columns can be sort by clicking on their header. The filter icon activates a filter set-up with the following window:

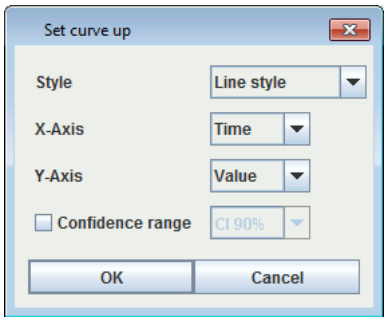


When filter is activated, a small (+) is diplayed near column title. Filter can be remove with button.

10.3.2. Export data

Values that are visible in this table can be exported in CSV file format with button.

Results can also be displayed with a Curve by clicking on . Data used for x-axe and y-axe must be specified in the following window:



Then, chart is displayed in a window:

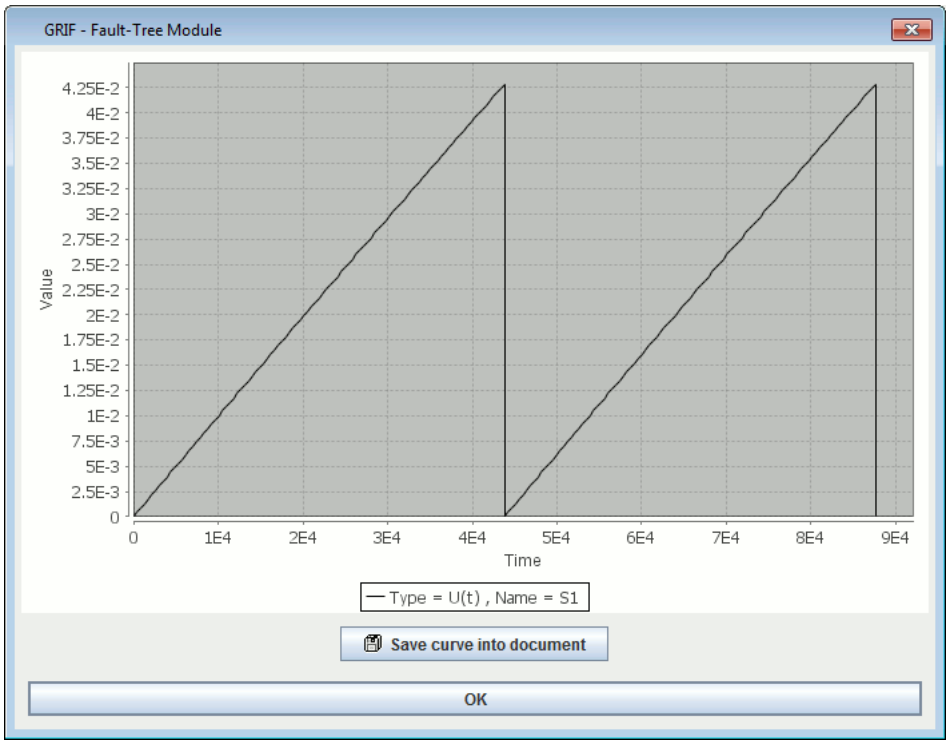


Chart can be saved in the current document with the button at the bottom.

When chart is in document, points are no more modifiable.

10.3.3. Result-Panels

10.3.3.1. Tab Probability

10.3.3.1.1. Time spent in each zones

The fisrt part shows for each target time spent in each zone. This parts displays only if the calculation is selected in the calculaption parameters.

Time spent in zones (Percentage)

U(t) W(t)

System	SIL4 [0,1E-4[	SIL3 [1E-4,1E-3[	SIL2 [1E-3,1E-2[	SIL1 [1E-2,1E-1[	SIL0 [1E-1,1]
Actuator	21.9668%	65.5645%	12.4688%	0%	0%
SIF_1	0%	7.2761%	92.7239%	0%	0%
Sensor	0.8876%	15.2291%	83.8833%	0%	0%
Solver	0%	100%	0%	0%	0%

10.3.3.1.2. Synthesis

In this part, for each target and for each calculation asked, table shows mean, maximum value, the average and the integral. Each calculation is displayed in different table.

Synthesis

U(t) A(t) W(t)

System	Min	Max	Average	Integral
A1.1-Ddnd_Full	0	0	0	0
A1.1-Ddnd_Partial	0	2.3602E-2	1.1943E-2	3.1386E3
A1.1a-Ddnd	0	0	0	0
A1.2-Ddnd_Full	0	5.4206E-2	2.7514E-2	7.2307E3
A1.2-Ddnd_Partial	0	1.1872E-2	5.9958E-3	1.5757E3

10.3.3.1.3. Global Results

Result-panels have been created to facilitate data access in tables with many columns. The aim is to make a prior filter to keep wanted data.

Name

Name
A1.1-Ddnd_Full
A1.1-Ddnd_Partial
A1.1a-Ddnd
A1.2-Ddnd_Full
A1.2-Ddnd_Partial
Actuator
CCF_Vannes_Full
CCF_Vannes_Partial
S1.1-Ddnd
SIF_1
Sensor
Solver

Type

U(t) A(t)

Type = U(t) , Name = A1.1-Ddnd_Partial

Time	Value	Average	Integral
0	0	0	0
1.314E3	1.1819E-3	5.9095E-4	0.7765
2.628E3	2.3624E-3	1.1816E-3	3.1051
3.942E3	3.5415E-3	1.7717E-3	6.984
5.256E3	4.7192E-3	2.3614E-3	1.2411E1
6.57E3	5.8956E-3	2.9506E-3	1.9385E1
7.884E3	7.0705E-3	3.5393E-3	2.7904E1
8.76E3	7.853E-3	3.9316E-3	3.444E1
9.198E3	8.244E-3	4.1276E-3	3.7966E1
1.0512E4	9.4162E-3	4.7154E-3	4.9568E1
1.1826E4	1.0587E-2	5.3028E-3	6.271E1
1.314E4	1.1756E-2	5.8897E-3	7.739E1
1.4454E4	1.2924E-2	6.4761E-3	9.3605E1
1.5768E4	1.4091E-2	7.062E-3	1.1135E2
1.7082E4	1.5256E-2	7.6475E-3	1.3064E2
1.8396E4	1.642E-2	8.2326E-3	1.5145E2
1.971E4	1.7583E-2	8.8172E-3	1.7379E2

This panel is made of a combo-box in the upper-left corner which enables to remove the column from the table and creates a list on the left which contains every value in the removed column. When you select a value in the left list, it modifies the table in order to show lines whose removed column contains the selected value.

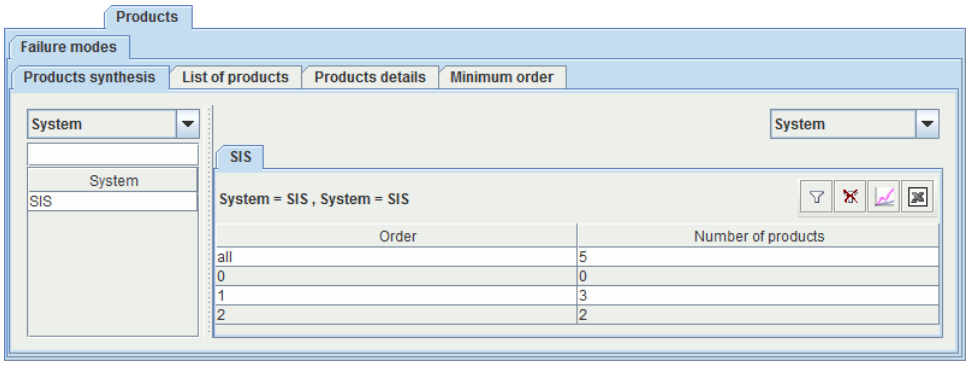
The combo-box in the upper-right corner enables to choose which column C will be used to cut table. The table will be cut in many tables, each one in a tab whose title is equal to the value used to filter the C column. Then C column is removed since it contains only the one value in a given tab.

 allows to select the different formats of display.

10.3.3.2. Minimal cut sets

10.3.3.2.1. Products synthesis

First tab shows the number of minimal cut sets and the number in function of the order.

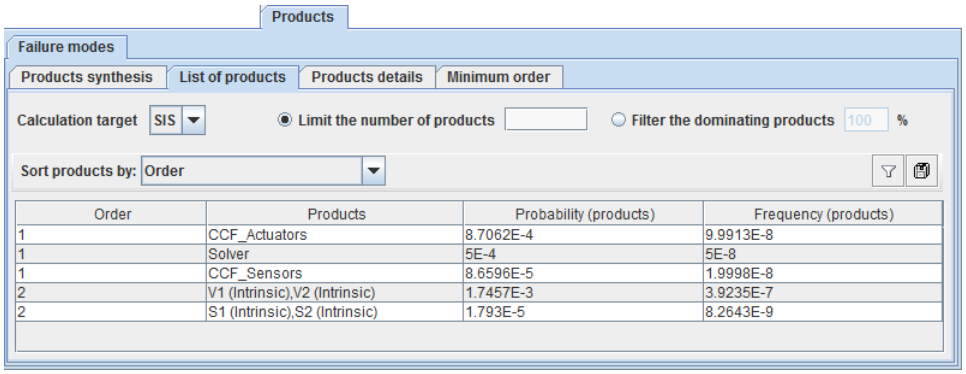


10.3.3.2.2. List of products

Second tab gives minimal cut sets details with associated probability. Products can be sorted out following:

- Order;
- Order/alphanumeric;
- Order/probability;
- Order/probability/alphanumeric;
- Probability/order;
- Probability/order/alphanumeric.

It is also possible to limit the display of products, either with digital way (reveal the X first ones), or display the dominating products (display those which represent XX % of the probability of all the cut sets).



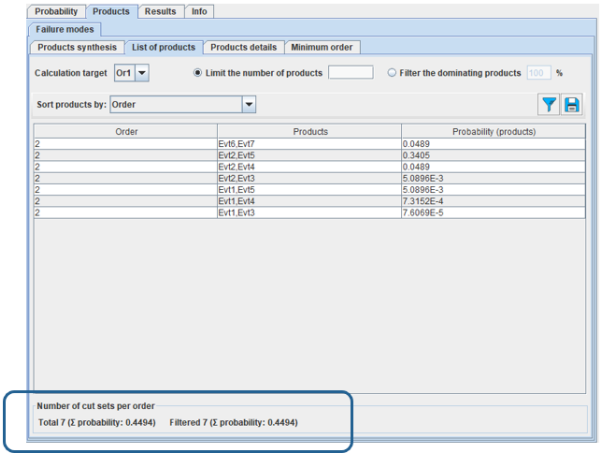
for each cutset, its probability and frequency of occurrence is given.

The frequency formula is :

$$UFI_{C(t)} = \sum_{\forall E_k \in C} \left\{ \left[\prod_{i=1, i \neq k}^{N} Q_{E_i(t)} \right] \times W_{E_j(t)} \right\}$$

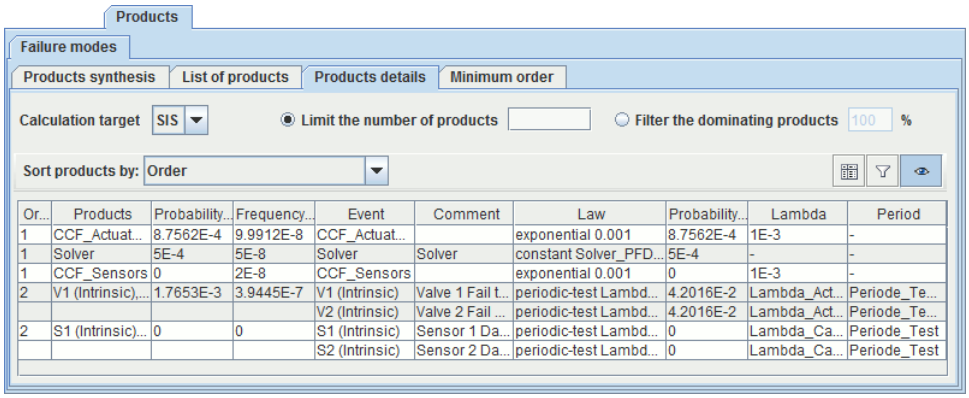
icon exports in dag format un fault tree made up with all the minimal cut sets. This fault tree is created with a gate OR of all the cuts.

The sum of probabilities of all minimal cutsets and the sum of probabilities of filtered minimal cutsets are displayed at the bottom of the tab.



10.3.3.2.3. Products details

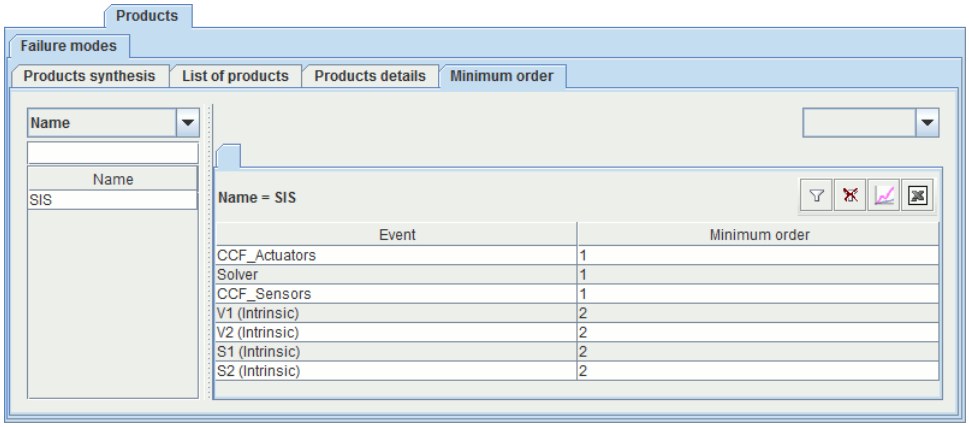
The third tab gives the minimal cups with the detail of the laws (Type of laws, failure rate, period tests) of the events. As the previous tab, it can be sorted out of different way and it is also possible to limit the display of products either with digital way (reveal the X first ones), or display the dominating products (display those which represent XX % of the probability of all the cut sets).



Or...	Products	Probability...	Frequency...	Event	Comment	Law	Probability...	Lambda	Period
1	CCF_Actuat...	8.7562E-4	9.9912E-8	CCF_Actuat...		exponential 0.001	8.7562E-4	1E-3	-
1	Solver	5E-4	5E-8	Solver	Solver	constant Solver_PFD...	5E-4	-	-
1	CCF_Sensors	0	2E-8	CCF_Sensors		exponential 0.001	0	1E-3	-
2	V1 (Intrinsic),...	1.7653E-3	3.9445E-7	V1 (Intrinsic)	Valve 1 Fail t...	periodic-test Lambd...	4.2016E-2	Lambda_Act...	Periode_Te...
				V2 (Intrinsic)	Valve 2 Fail ...	periodic-test Lambd...	4.2016E-2	Lambda_Act...	Periode_Te...
2	S1 (Intrinsic)...	0	0	S1 (Intrinsic)	Sensor 1 Da...	periodic-test Lambd...	0	Lambda_Ca...	Periode_Test
				S2 (Intrinsic)	Sensor 2 Da...	periodic-test Lambd...	0	Lambda_Ca...	Periode_Test

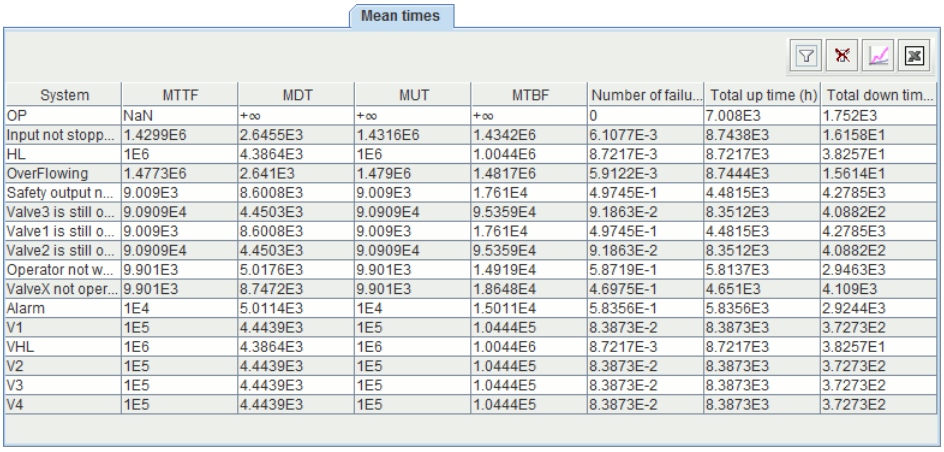
10.3.3.2.4. Minimum order

The fourth tab gives for each event the level of the lowest minimal cut set order in which it appears.



10.3.3.3. Mean times

The fourth tab gives the details of mean times.



System	MTTF	MDT	MUT	MTBF	Number of failu...	Total up time (h)	Total down tim...
OP	NaN	+∞	+∞	+∞	0	7.008E3	1.752E3
Input not stopp...	1.4299E6	2.6455E3	1.4316E6	1.4342E6	6.1077E-3	8.7438E3	1.6158E1
HL	1E6	4.3864E3	1E6	1.0044E6	8.7217E-3	8.7217E3	3.8257E1
OverFlowing	1.4773E6	2.641E3	1.479E6	1.4817E6	5.9122E-3	8.7444E3	1.5614E1
Safety output n...	9.009E3	8.6008E3	9.009E3	1.761E4	4.9745E-1	4.4815E3	4.2785E3
Valve3 is still o...	9.0909E4	4.4503E3	9.0909E4	9.5359E4	9.1863E-2	8.3512E3	4.0882E2
Valve1 is still o...	9.009E3	8.6008E3	9.009E3	1.761E4	4.9745E-1	4.4815E3	4.2785E3
Valve2 is still o...	9.0909E4	4.4503E3	9.0909E4	9.5359E4	9.1863E-2	8.3512E3	4.0882E2
Operator not w...	9.901E3	5.0176E3	9.901E3	1.4919E4	5.8719E-1	5.8137E3	2.9463E3
ValveX not oper...	9.901E3	8.7472E3	9.901E3	1.8648E4	4.6975E-1	4.651E3	4.109E3
Alarm	1E4	5.0114E3	1E4	1.5011E4	5.8356E-1	5.8356E3	2.9244E3
V1	1E5	4.4439E3	1E5	1.0444E5	8.3873E-2	8.3873E3	3.7273E2
VHL	1E6	4.3864E3	1E6	1.0044E6	8.7217E-3	8.7217E3	3.8257E1
V2	1E5	4.4439E3	1E5	1.0444E5	8.3873E-2	8.3873E3	3.7273E2
V3	1E5	4.4439E3	1E5	1.0444E5	8.3873E-2	8.3873E3	3.7273E2
V4	1E5	4.4439E3	1E5	1.0444E5	8.3873E-2	8.3873E3	3.7273E2

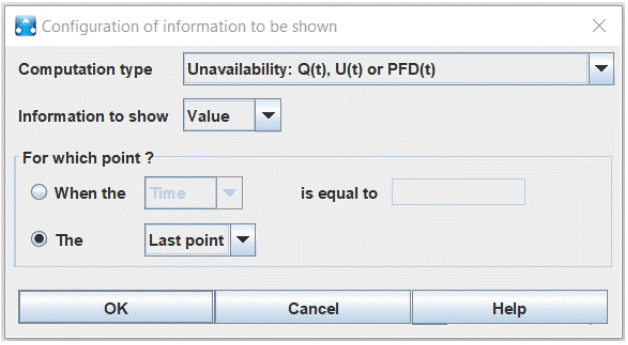
10.3.4. Another display of results

results are also available :

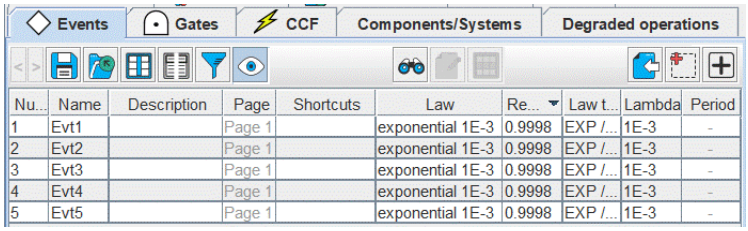
- by data tables and specific tab of element ;
- by "Document options" or "Application options" and specific tab of element.

10.3.4.1. Display by Data tables

results computed are diplay in specific tab of element with button "Configuration of teh results column"  The following screen allows to select computed results :



Selected results are display in the results column.

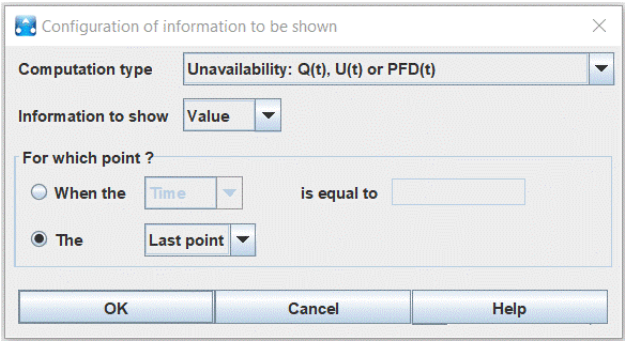


Nu...	Name	Description	Page	Shortcuts	Law	Re...	Law t...	Lambda	Period
1	Evt1		Page 1		exponential 1E-3	0.9998	EXP /...	1E-3	-
2	Evt2		Page 1		exponential 1E-3	0.9998	EXP /...	1E-3	-
3	Evt3		Page 1		exponential 1E-3	0.9998	EXP /...	1E-3	-
4	Evt4		Page 1		exponential 1E-3	0.9998	EXP /...	1E-3	-
5	Evt5		Page 1		exponential 1E-3	0.9998	EXP /...	1E-3	-

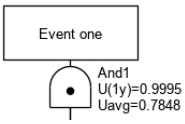
10.3.4.2. Display options

Computed results can be display under element (Gate, block,node, etc) by "Document options" or "Application options" and in specific element tab (gate, block, node, etc). The following "Additionnal information" option allows to select the configuration table of results displayed:

The following table allows to select the desired result :

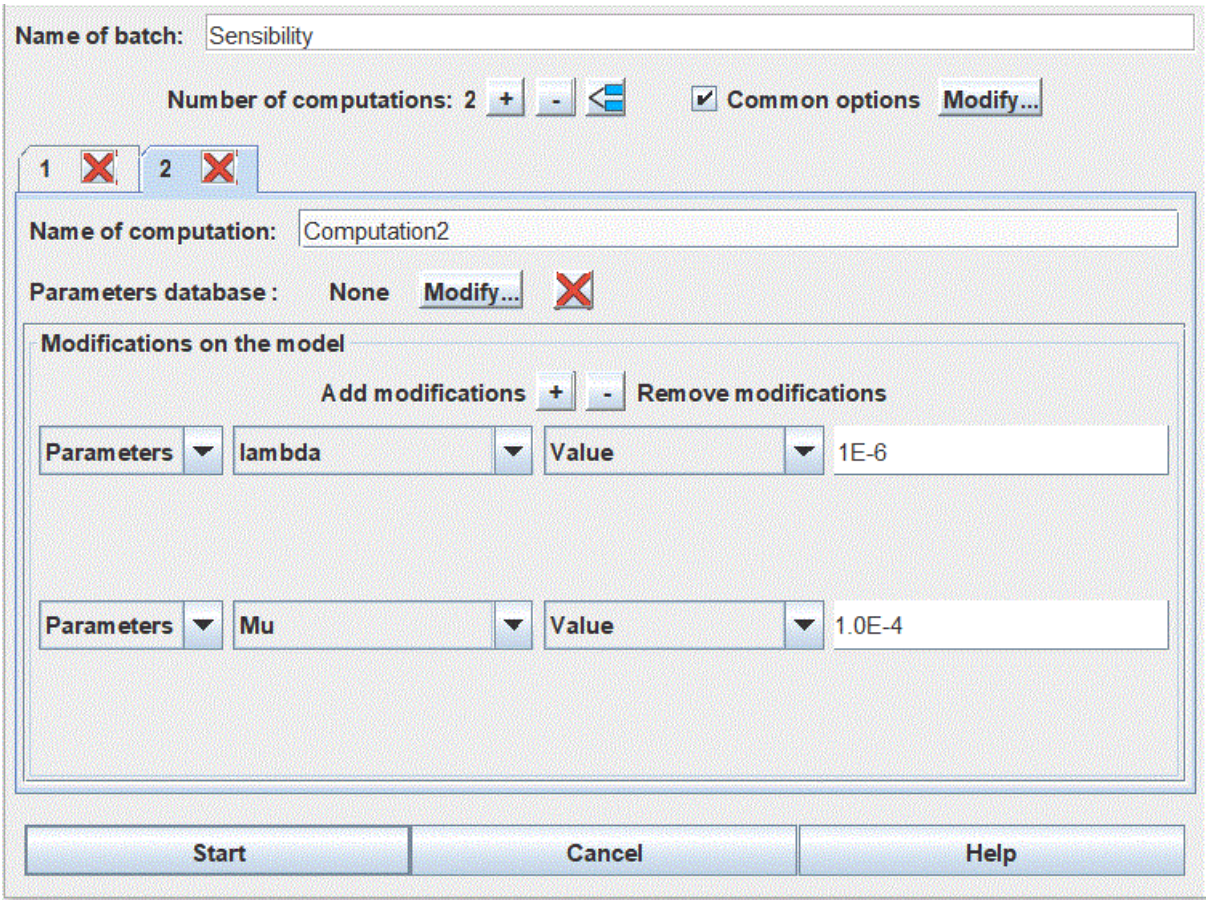


Selected results are display under impacted element.



10.4. Batch computation

In order to do fast sensibility analysis or to compare some results with different parameters, it can be very useful to do calculation one after another automatically. To do this, use the **Data and Computation / Batch computation ...** menu.



The batch launching window is made of two part, the first is for the name of the batch and the number of computations in the batch. Then each computation can be set up:

- **Name of computation:** for identification in results
- **Computation options:** contains every option related to this computation (times, types ...)

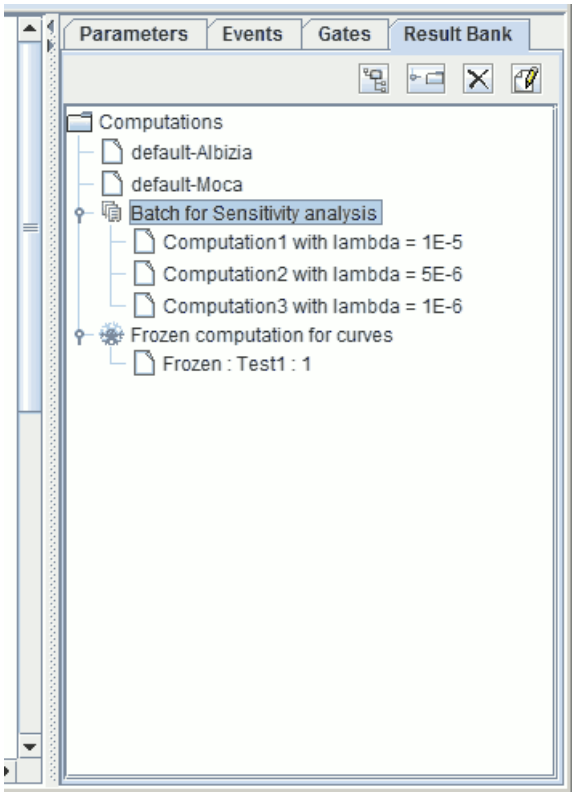
- **Modifications on the model:** specifies modifications that will be made on the model before computation launching. You can add as many modifications as you want with the + button. Each modification is made of 4 parts:
  1. 1 drop-down menu for object type
  2. 1 drop-down menu for the object that will be modified
  3. 1 drop-down menu to specify what will be modified on this object (value for a parameter, law for other object ...)
  4. Then you must enter the new value in the cell

The above example shows a batch with 2 computations, the first is made with a lambda parameter with 1.0E-5 value and a mu parameter with 0.1 value.

After a computation, the model is always reset up to an initial state without modification.

10.5. Result Bank

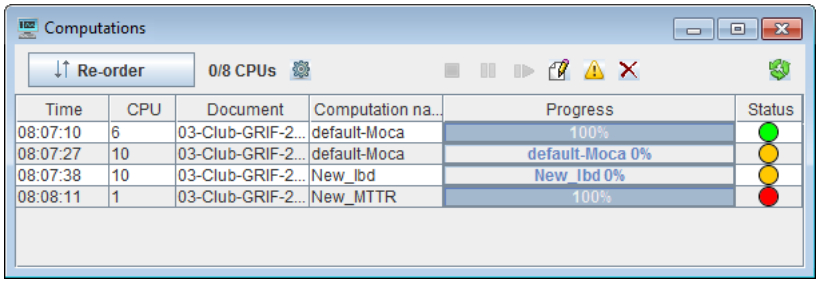
Every GRIF computation is stored in result bank which is available on the right of the module.



You can display a result with a double-click on it. There is a default result for each computation engine, it is the place where "standard" computations are stored. Then, each is a batch computation directory, it contains as many results as computations asked for the batch. Finally, the directory contains results for curves that have been frozen.

10.6. Compute manager

Compute manager shows the calculations. That are currently running or already performed.

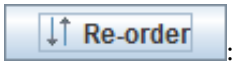


Compute manager is automatically displayed when calculations are performed. User can display the window using the following icon  .

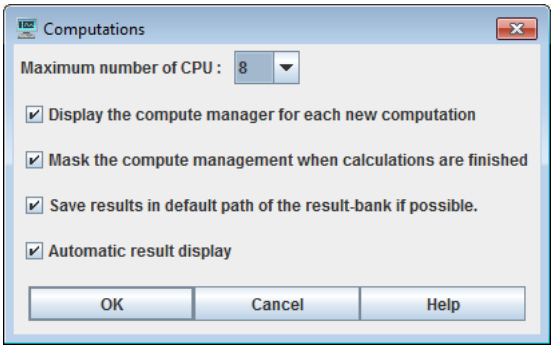
This tab is made of 6 columns:

- **Time**: The hour of calculation launch;
- **CPU**: number of CPU used;
- **Document**: document name;
- **Computation name**: name of results file;
- **Progress**: progress bar;
- **Status**: finished in green, in progress in yellow, error in red;

In **Compute Manager** some actions are available:

- 

: allow to reorganize the calculations order;
-  : display the following windows for computation settings:



-  : stop selected compute;
-  : suspend selected compute;
-  : resume compute in suspend;
-  : display results of selected compute;
-  : details errors;
-  : remove selected compute;
-  : clear all compute;

When a task is added to Compute manager, user is not blocked until the task is ended. He can continue to work on his model. He can even relaunch a calculation. The various tasks accumulate and are treated sequentially.

10.7. Probability target / Reliability allocation

It is possible under Tree module to set probability target or an reliability allocation to events.

10.7.1. Probability target

To set reliability targets for a tree under Tree, proceed as follows :

- **Set the main objective** ;
- **Compute target probability value for sub-tree** ;
- **Compare the results of the computations with the objectives** ;

10.7.1.1. Set the main objective

To set probability targets for a fault tree you must first set the main target and then allocate it to a gate, usually the top event but this is not obligatory.

10.7.1.2. Compute target probability value for sub-tree

To compute target probability value for sub-tree, you must use **Compute target probability value for sub-tree** action located in last position in **Données et calculs** tab.

10.7.1.3. Compare the results of the computations with the objectives

To check if the results of the fault tree computations reach the set objectives, you can see the **Gates** data table or see on the main view if you have selected the option that the display the objectives under the elements (gates and events).

10.7.2. Reliability allocation

To set the reliability allocation to events under Tree module, the same method should be followed as for the probability target.

11. Curves

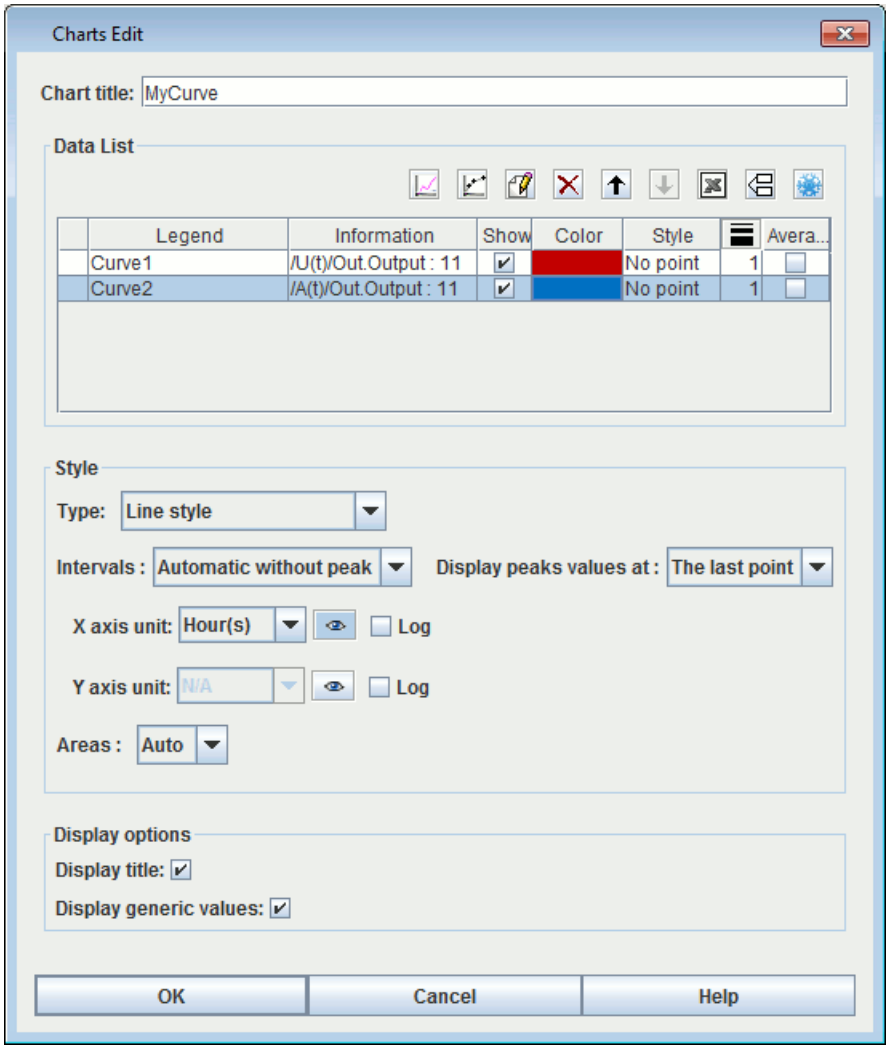
The curves can be drawn to study the model and the results better. To do this, click left on the corresponding icon on the vertical task bar then draw a box. This box will be the space assigned to displaying the curve(s). Initially it is only a white box with two axes without graduation.

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.

11.1. Edit curves window

The edit curves window is the same for all the GRIF modules.



The window is divided into several sections:

1. **Charts title**: enters a title for the graph.

2. **Data list**: this part includes a table with several columns in which the different curves on the graph are listed (name, description, display, curve colour, curve style, curve thickness, display average). A number of different buttons are available above this table.

-  : Selects a result of computations to display. It sends the user back to the Select results window to add a curve plot to the graph (see. Section 11.2.1, “Curves from data in result-bank”).
-  : Compares several results from different calculations for the same data. It sends the user to the Compare results window to add a curve plot to the graph (see Section 11.2.2, “Comparative curves from data in results bank ”).
- **Edit**: edits the plot of the selected curve.
- **Delete**  : deletes the plot of the curve selected on the graph.
- **Up**  : moves up the plot of the curve selected in the list.
- **Down**  : moves down the plot of the curve selected in the list.
- **Save**: saves the list of points calculated to plot the selected curves in .csv format. This export does not contain the generic values. To obtain an export with the generic values, right click on the curve and select **Individual export**.
- **Duplicate**: creates a new curve identical to the curve selected.
- **Freeze**  : freezes the display of the curve, which will no longer be updated automatically according computation results.

For each curve, the user can specify the colour, point style, line thickness and display.

3. **Computation options**: enables the user to enter settings for the computation (optional depending on the module).

4. **Style**: this section concerns the curve display.
   - **Type of style**: specifies the type of all the curves on the graph (line, histogram, etc.). N.B. In the case of a histogram, the bars that exceed the display area will be displayed in shading to show the user that s/he must change the display intervals so that the entire bar can be displayed.
   - **Intervals** defines the display limits for the curve. **Automatic without peak**: the graph will not display the "peaks" of specific cases of exceptional values which would make the graph illegible. Even if the peaks are not displayed on the graph, the user can display their values using the choices proposed in the option **Display peak values**.
   - **X and Y intervals**: specification of the display interval on the X and Y axes (default intervals or intervals defined by the user). The last function enables users to "zoom in" on the most interesting parts of the graph.
   - The axis unit can be selected according to the type of computation result. For example for units of time, the user can enter hours, days, months or years.
   - The  button determines whether or not the unit is displayed on the graph.
   - The **log** boxes are used to activate the logarithmic scale on the axis in question. N.B. 0 cannot be represented on a log scale, remember to enter a start value that is strictly positive (e.g. E-10). If 0 is entered, the log scale will begin at an arbitrary value E-15. Where the computation engine enables, the **trust interval** can be displayed by ticking the corresponding box.
   - **Areas**: distinguishes a range of values on a coloured background.
   - In the histogram style, a box can be ticked to create a cumulative histogram.

5. **Display options**: activates the **Display title** function (display graph title) and the **Display generic values** function (display min, max and average for each curve).

When a curve is edited, the edit curve window often includes 3 parts: the times at which the computations are performed, what has been calculated and the extra information (generic values) that should or should not be displayed below the curve.

Comment: it is sometimes necessary to refresh all the graphs in a document. This can be done using the **Tools / Refresh** command, or the keyboard shortcut F5 or the  icon.

11.2. Selection of results window

11.2.1. Curves from data in result-bank

When you click the **Add** button in the **Data list** part you reach a window for curves setup. Each curve displays data stored in the result-bank. The following window helps users to specify how to retrieve data.

- **Legend**: legend of the curve.
- **Computation selection**: select the computation in the result-bank.
- **Result to be displayed**: each computation contains many results. Select the one you want to be drawn.
- You can display a list a point whose X and Y will be taken from the data selected in the combo-boxes; or you can display the time spent in each zone.
- **Axes**: When a result is selected, select what must be in X-Axe and what must be in Y-Axe.
- **Value to be displayed**: Then you can display additional information about the result (min, max, average ....)

11.2.2. Comparative curves from data in results bank

When the user clicks on **Compare** in the **Data list** section, a window opens enabling the user to specify the curve to be plotted. S/he can then choose whether or not to display a result from several different computations. The following window is used to indicate the way in which the information is to be recovered.

- **Legend**: curve legend.
- **Computation selection**: the user can select the different computations to be used from the results bank. Hold down the Ctrl button to select several different computations.
- **Result to be displayed**: a computation often contains several results and this file tree structure is used to specify the result that the user wants to display.
- **Information to show**: indicates which data are to be displayed on the y-axis.
- **For which point?**: indicates which point of the computation is to be compared to the others.
- **Display x-axis values according to**: indicates which data must be displayed on the x-axis.
- **Value to be displayed**: finally, certain extra data can be displayed (min, max, average, etc.)

12. Database of parameters

In every GRIF module, a connection can be established with a database of parameters, to import parameters in GRIF. There are three ways to connect to a different database:

- connection to a .csv file
- connection to a .xls file
- other connection (via JDBC).

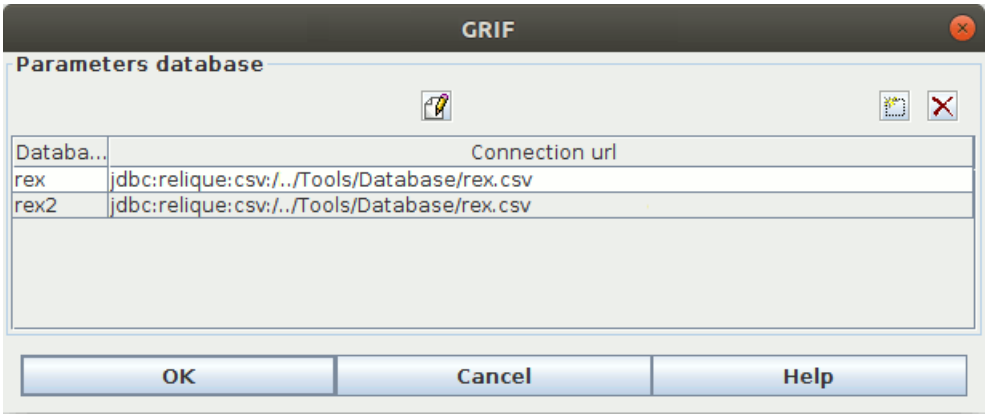
12.1. Format of the databases

The database must contain the identifier, the name and the value of the parameter. It is possible to add to the parameters more information, as the unit, the dimension and the description of the parameter. So we can have three to six columns, inquiring:

Data's type:	Possible values:
Parameter's identifier	Numbre, Text
Parameter's name	Text
Parameter's value	Number
Parameter's description	Text
Parameter's unit	HOUR : hours
	DAY : days
	MONTH : months
	YEAR : years
	HOUR_1 : $hours^{-1}$
	DAY_1 : $days^{-1}$
	MONTH_1 : $month^{-1}$
	YEAR_1 : $years^{-1}$
	FIT : Failure In Time (= 10^{-9} $hours^{-1}$)
Parameter's dimension	BOOLEAN, FACTOR, PROBABILITY, RATE, TIME, OTHER

12.2. Connect to a database

To access to the window to create the connections to databases, go to the menu **Data and Computations -> Parameters database -> Connections ...**. A window appears then:



From this window, it is possible to :

	Add a connection to a database.
	Modify a connection to an existing database. It opens the same window when adding a connection, but the fields are already filled by the data previously entered.
	Delete the selected connections of the databases.

12.2.1. Connection to a CSV file

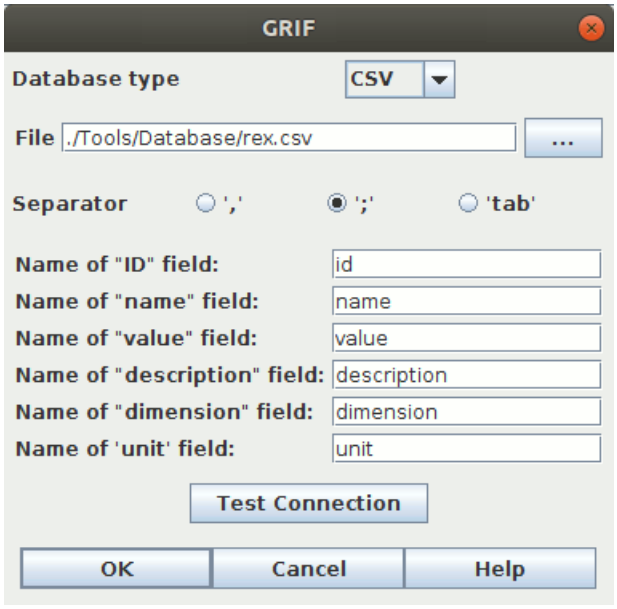
12.2.1.1. Form of the database

This type of connection is the simplest. The CSV file has for extension ".csv". It is a simple text file where the different fields are separated by commas, tabulations or semicolons.

```
ID,NOM,VALEUR,DESCRIPTION,DIMENSION
000001,Lambda,0.001,Exemple de Lamda,RATE
000002,Mu,0.01,Exemple de Mu,RATE
000003,Gamma,0.5,Exemple de Gamma,PROBABILITY
000004,ProdMax,1000.0,Exemple de Production maximum,OTHER
```

12.2.1.2. Connection

Once clicked on the button "Add a connection to a database", a window opens up:



This window has as a common base, the selection of the database, the fields for "ID", "name", "value", "description", "dimension" and "unit", and a button **Test Connection**. By clicking on this button, GRIF tries to connect to the database and so verifies the configuration provided by the user.

When adding a CSV database, the type **CSV** must be selected. A new field appears: the separators between the data. To sum up, there are three steps to add a connection to a CSV database:

- First, fill the path of the CSV file in. A file explorer is at your disposal (button **...**).
- Then, specify the type of the separators used in the CSV file.
- Finally, enter the six fields names of the CSV file. (Or only the ID, name and value fields) (Uppercase letters are taken into account as lowercase)

Warning : It's important to note that when creating a connection to a CSV database, you must have all of the data on a single sheet.

12.2.2. Connection to a XLS file

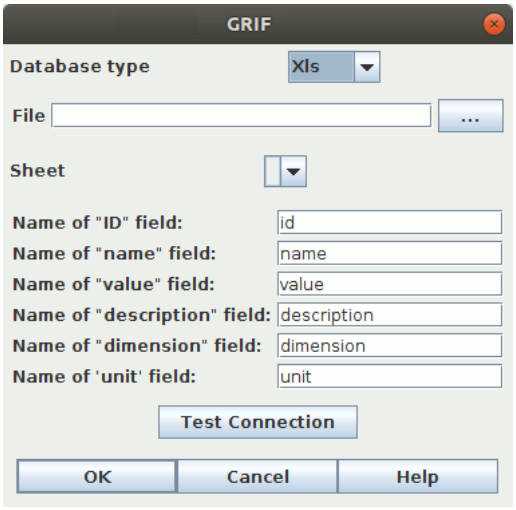
12.2.2.1. Form of the database

The databases of the .xls or .xlsx extensions correspond to EXCEL files. Here is an example of an EXCEL Database :

	A	B	C	D	E	F
1	ID	NOM	VALEUR	DESCRIPTION	DIMENSION	
2	1	Lambda	0.001	Exemple de Lamda	RATE	
3	2	Mu	0.01	Exemple de Mu	RATE	
4	3	Gamma	0.5	Exemple de Gamma	PROBABILITY	
5	4	ProdMax	1000.0	Exemple de Production maximum	OTHER	
6						
7						

12.2.2.2. Connection

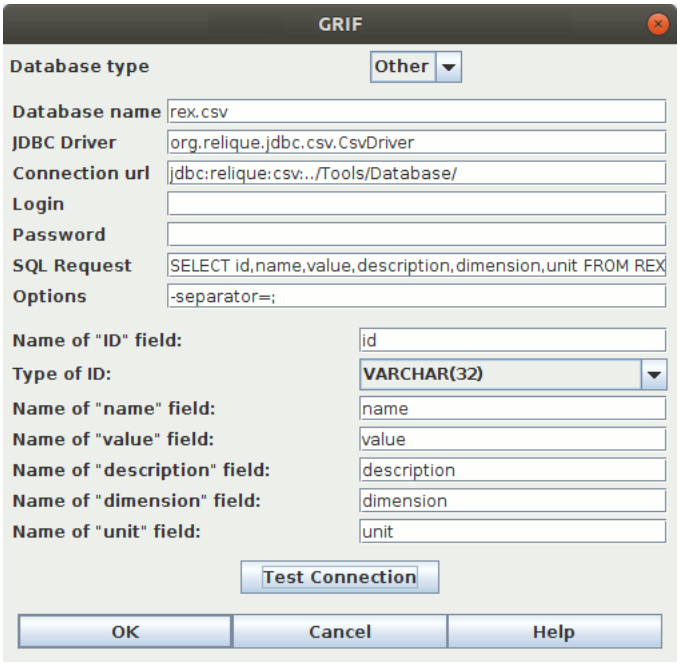
To connect GRIF to this database, select the **XLS** type in the connection window. The window is now as followed:



Sheet is the sheet's name where the data are located, and will be filled once a valid path to an EXCEL file has been entered.

12.2.3. Connection to a database (with a JDBC connection)

GRIF can connect to any database with JDBC, as long as the database follows the same rules of the databases seen earlier. The window for that kind of connection has multiples fields to fill:



1. **Driver JDBC** is the name of the JDBC driver (ex : sun.jdbc.odbc.JdbcOdbcDriver)

2. **Connection URL** is the URL of the database.

3. The fields **Login** and **Password** can be left empty.

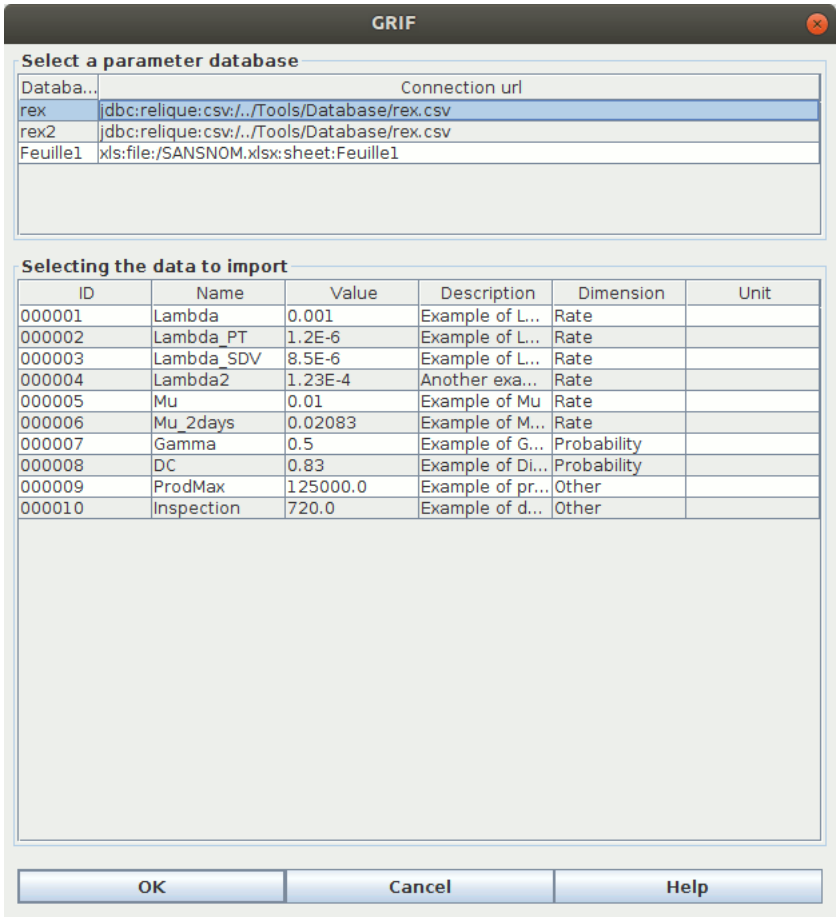
4. The SQL request **SELECT id,name,value,description,dimension,unit FROM REX** is used to gather the dates.

5. **Option** field inform of all of the database's options: separator, ...

Once a connection with a database is ready, GRIF can now import a set of parameters from the database, but also updates these parameters when modifications has been made in the databases, or recreate the links of these parameters so they can now take the values of another database.

12.3. Import parameters from a connected database

Once a database is connected, GRIF can import a set of parameters from the database, via the window reachable by the **Data and computations -> Parameters database -> Copy parameters from database ...** menu.

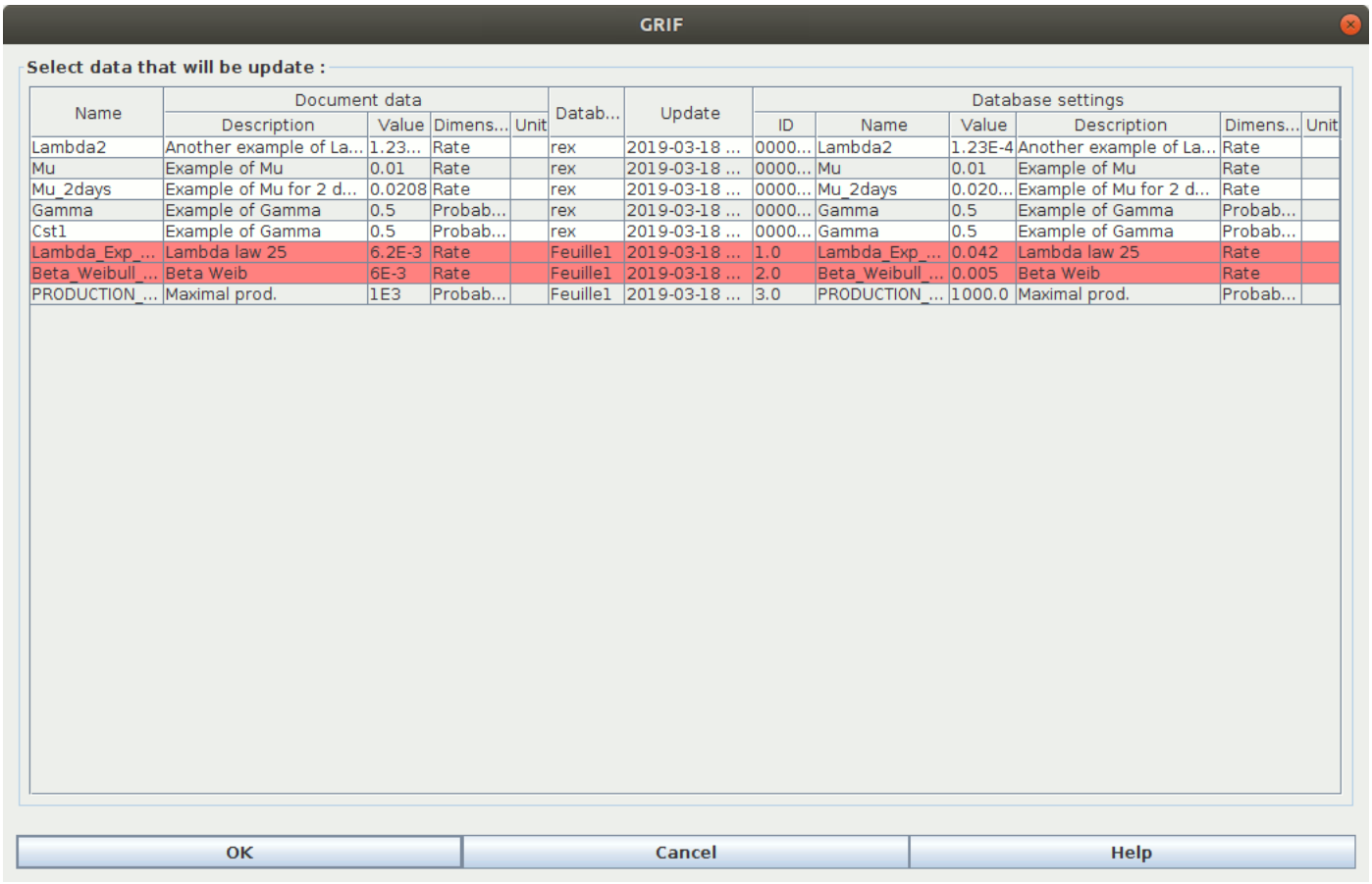


Select the parameters you want to import, and click on **OK**. The parameters are now created and imported in GRIF. The created parameters have the same names than the database's parameters, and the fields "Description" or "Dimension" are identical of those found in the database.

It is important to underline that it is possible to manually create a parameter in GRIF, and then with its **Add-On** menu, assign the parameter's value of the connected database. This operation is detailed in this link.

12.4. Update of the parameters from the database

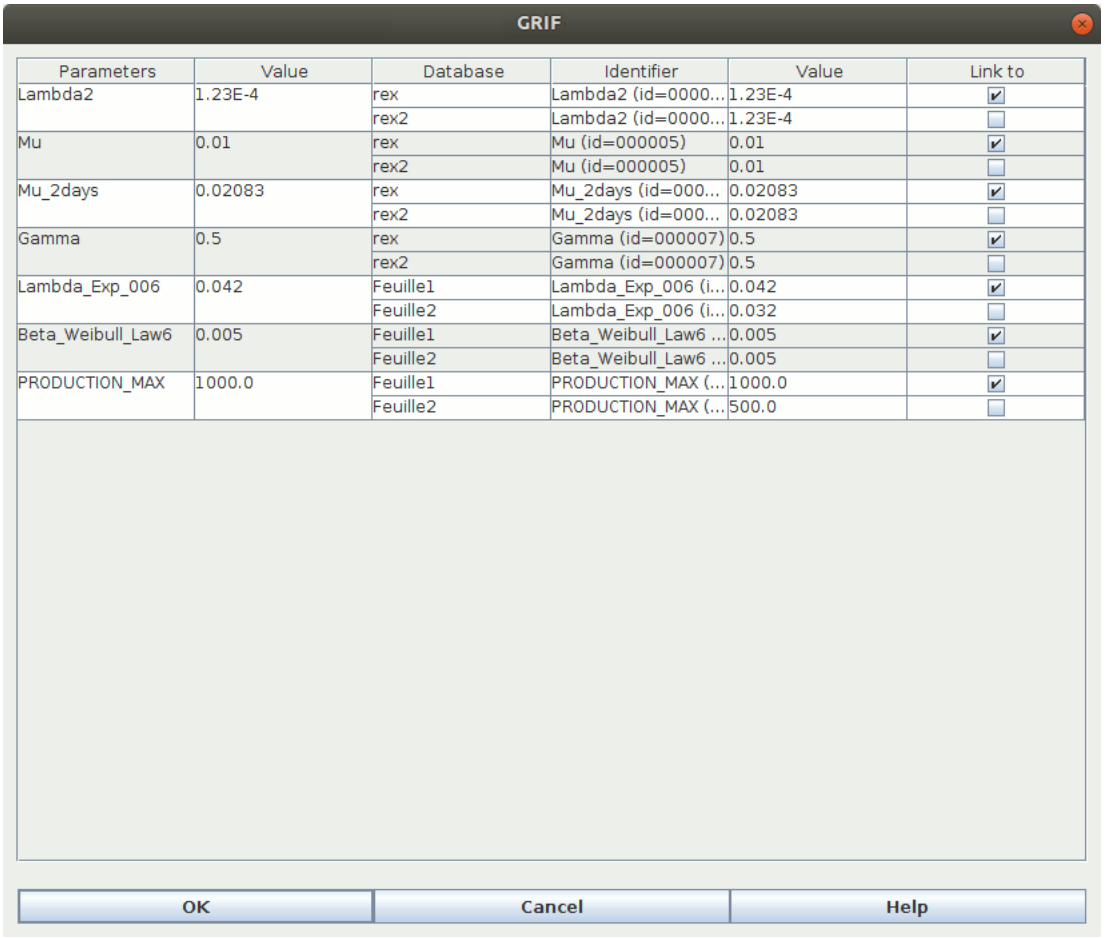
When an user, who has updated some of his data in his database, wants to have these modifications done on his parameters in GRIF too, he can then use the update action, from the **Data and Computations -> Parameters database -> Update from database ...** menu:



This window shows the parameters in GRIF which are connected to parameters from the databases. The red lines correspond to data which have been modified in the database. If the user wants to update some of his parameters in GRIF, he must select the lines of the wanted parameters, and then press the **OK** button. The parameters are now updated.

12.5. Rebuild of the links to the database

It is possible to modify an existing parameter's connection in GRIF, by changing the database of its associated parameter. However the parameter can only connect to the parameters with the same name. This action is available by the **Data and Computations -> Parameters database -> Rebuild links to the database** menu.



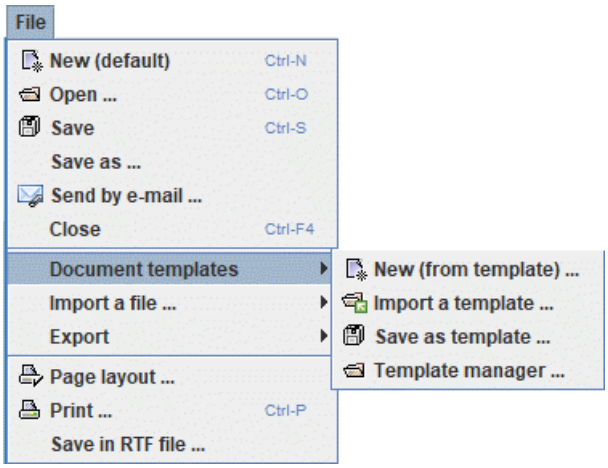
Here we can see the different parameters of the databases, which are imported in GRIF, and which are on multiples databases. So on the line of the parameters you want to rebuild the links, select the right database, and then validate your modifications by clicking on **OK**. GRIF then update the values of the parameters by rebuilding the links.

13. Save

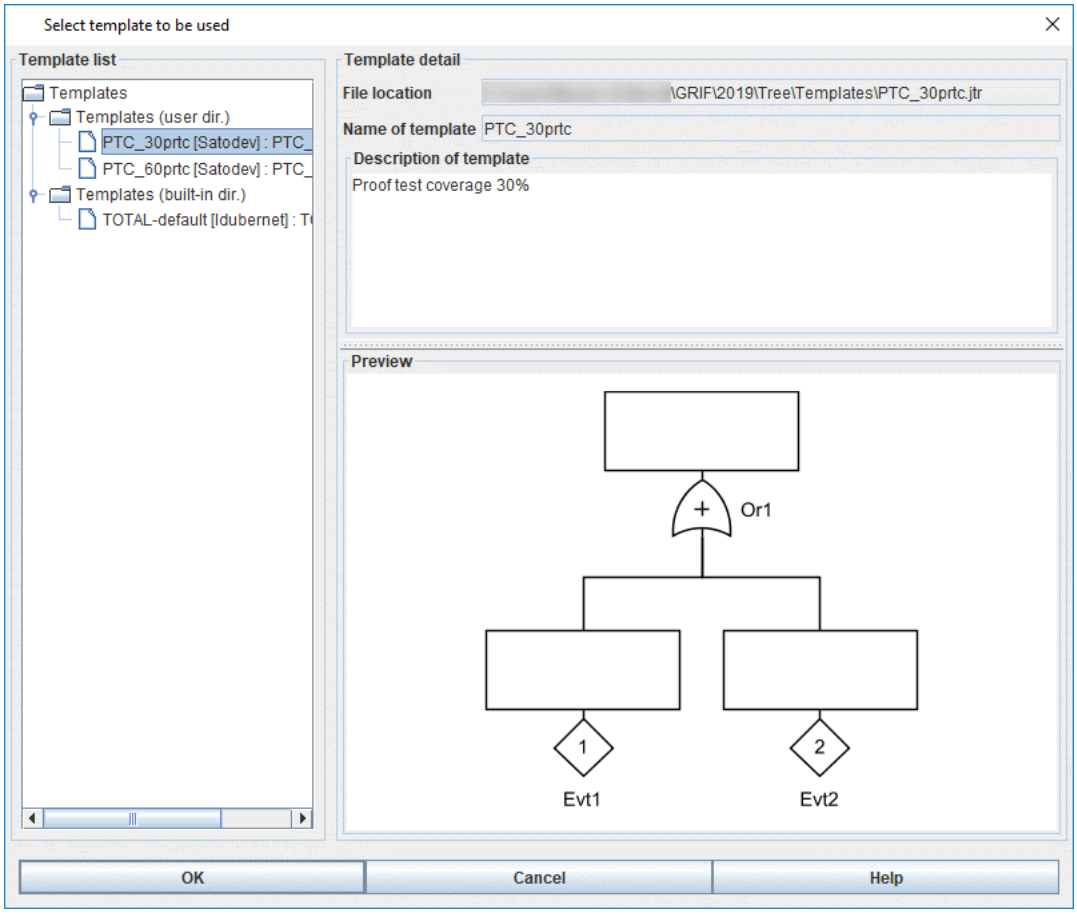
Here is a summary of all the data which can be saved from a same model.

13.1. Document template

It is possible to use an existing document as base to create a new document or as a part of a document. This functionality is accessible in **File - Document template** menu.

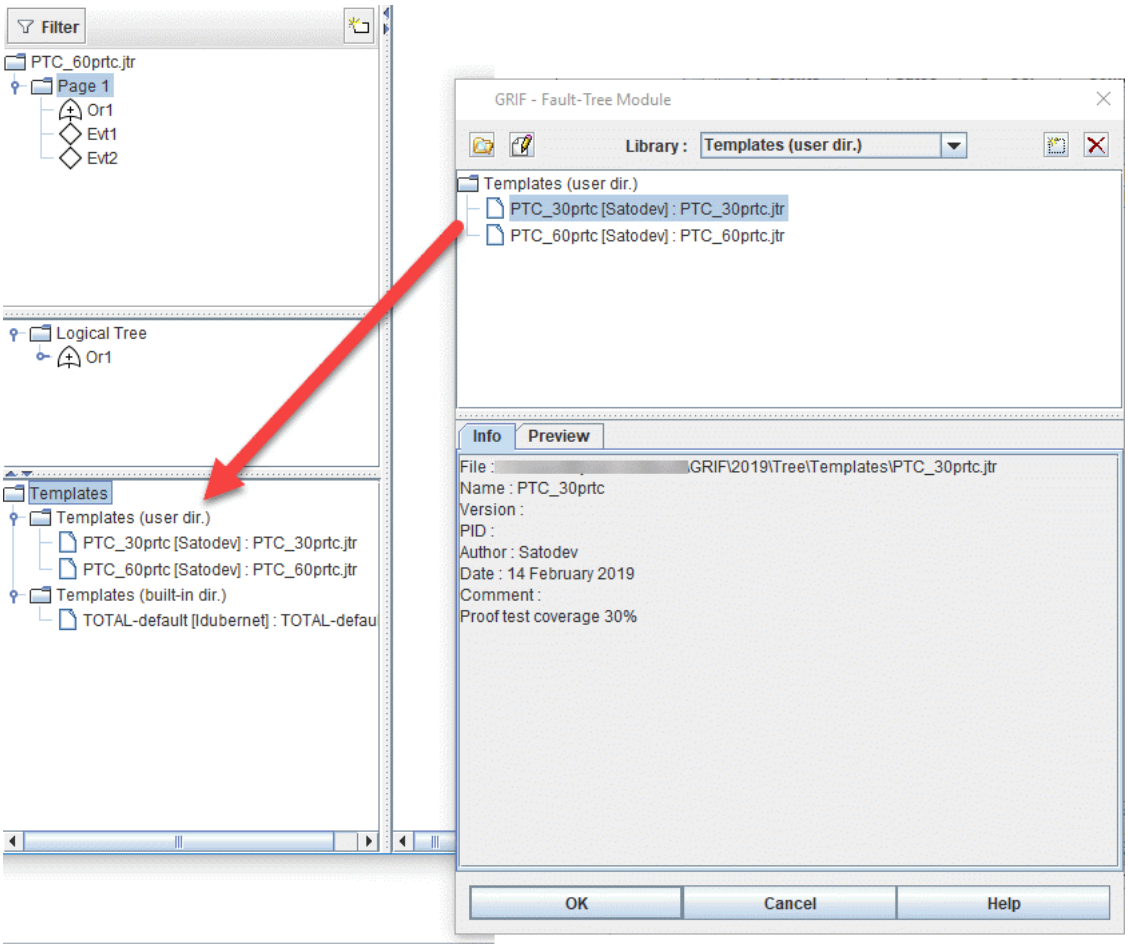


New (from template)... menu enables to open a new document and to initialize it with data from a model already build. A window appears to select the existing model.

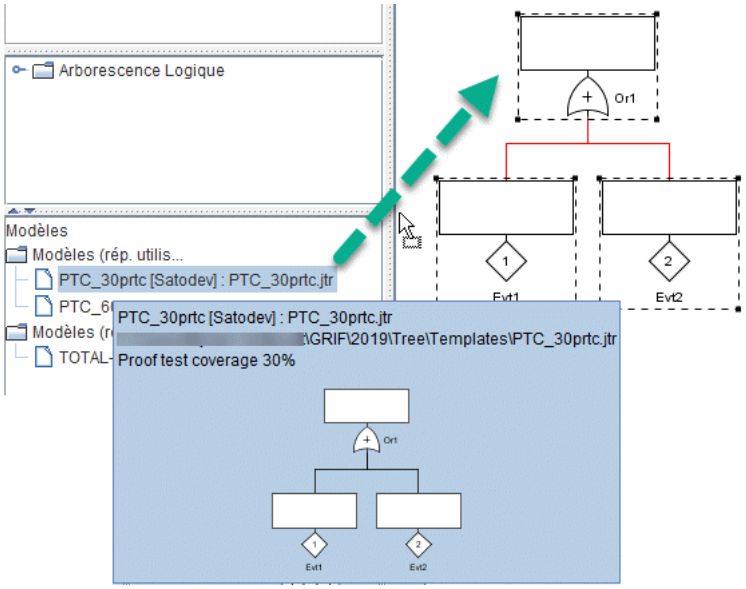


Import a template... menu enables to add to the current document data from a model already build.

Save as template enables to save the current document as template in the Template directory of the module. Once saved as a template, the document appears in the Template tree of the GRIF window as well as in the **Template Manager**.

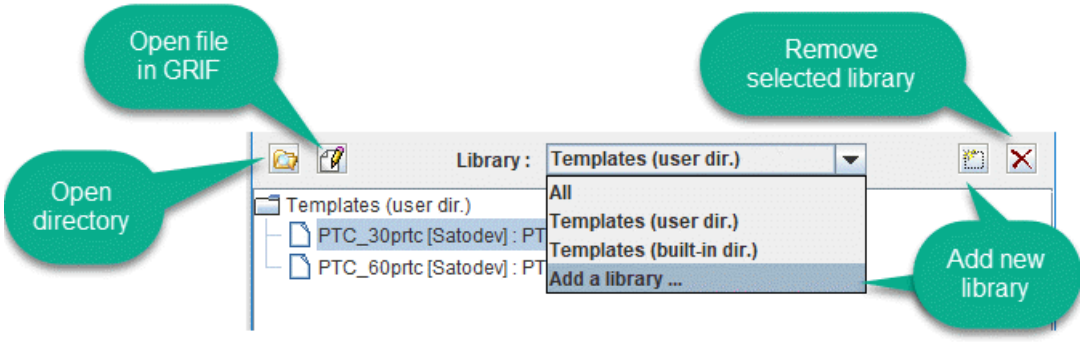


It is possible to create new files from this model using **New (from a template)...** action. A drag and drop to the templates from the input area enables to import the model quickly.



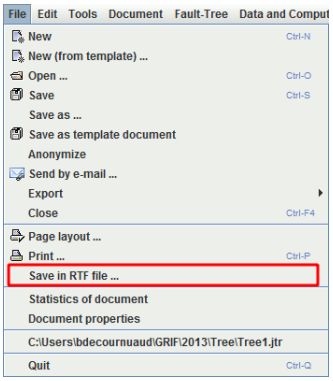
Save as default template menu enables to save the current document as default model in the module template directory. This model will also be the default model of the module. It will be used as base for creating a new document when **File - New (default)** action is used.

Template manager menu opens a window to manage the template of the document. New document libraries can be added/deleted. To add a new library it is necessary to select a directory of the file system. The tool analyzes the documents in this directory and builds a library that can be used by GRIF based on the compatible documents found.



13.2. RTF File

A model can also be saved in RTF format. This enables 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...**.



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.

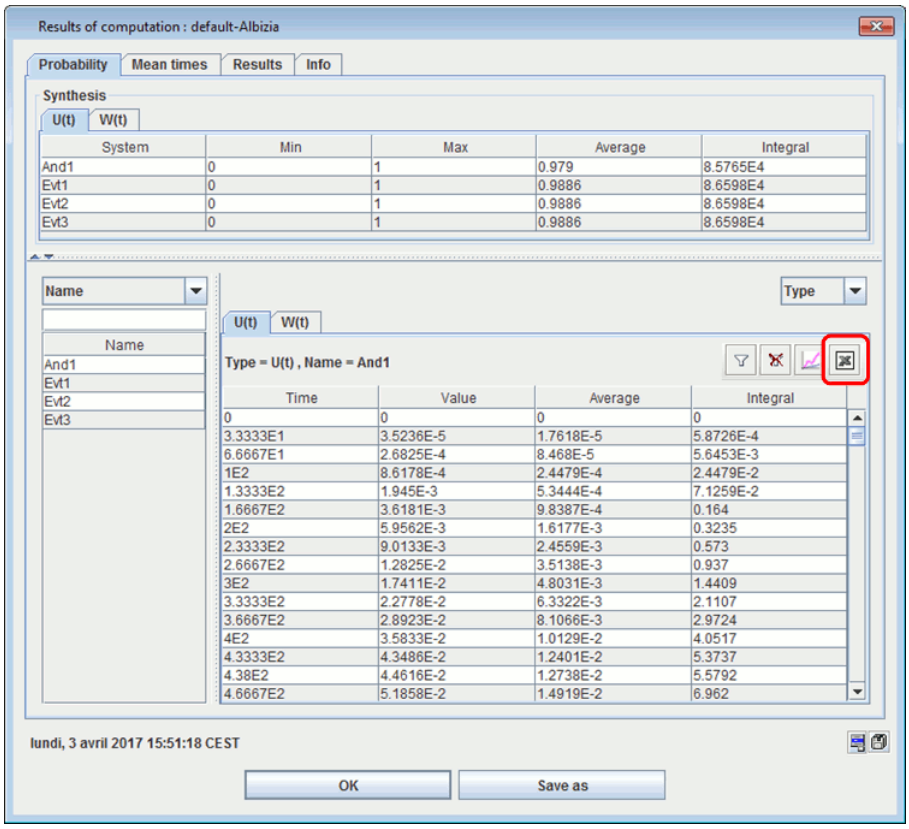
13.3. Input data

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.

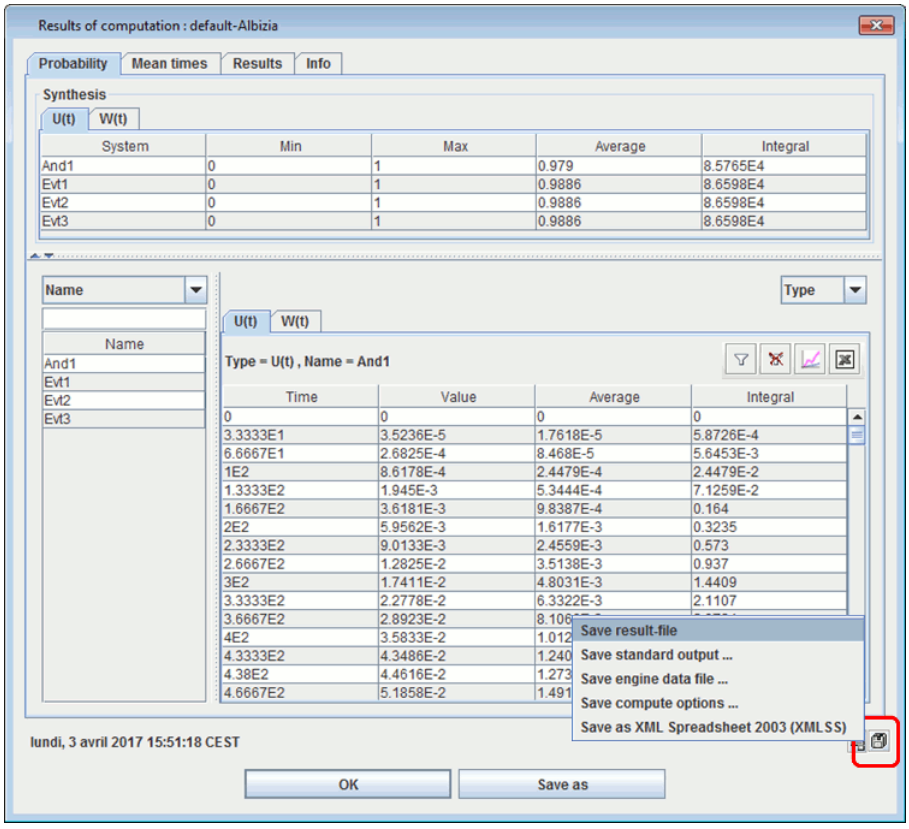
13.4. Results

Computation results can be saved in different formats:

1. Export of a table in particular in .csv format:



2. Export entire set of results:

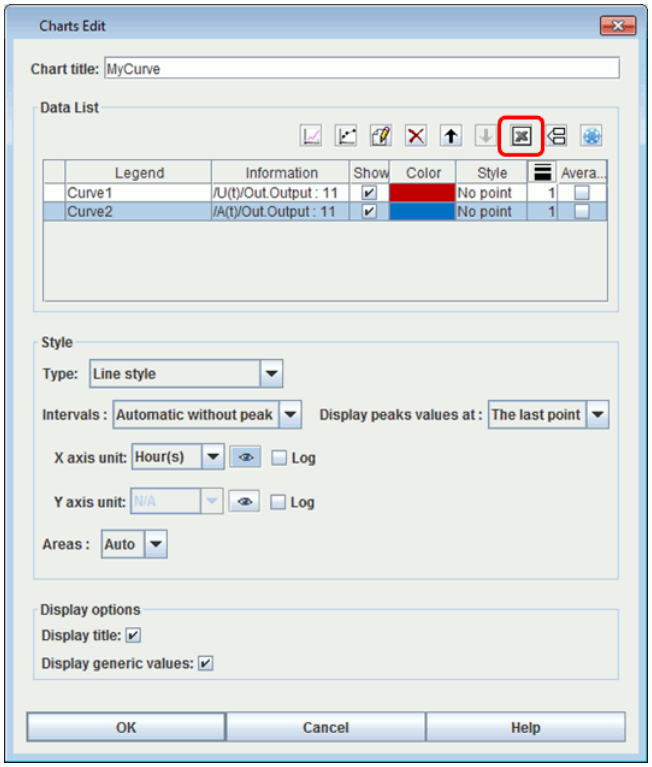


- **Save result file**: saves the contents of the Results tab (.xml format).
- **Advanced report**: generates reports using style sheets.
- **Save standard output**: saves the contents of the Info tab (.txt format).

- **Save engine data file**: saves the data file sent to the computation engine (.txt format).
- **Save as XML spreadsheet 2003 (XMLSS)**: saves all the results tables in an XML format compatible with Microsoft(r) Excel 2003 and later versions.

13.5. 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.



14. Options of GRIF - Reliability Networks

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

14.1. Options

Options tab enables to tune application behavior :

- **Save the options of the current document as default options in the application** : Save options of current doc as application default options.
- **The application manages the default options of the documents, apply the default options to the current document** : Apply -Application options- to current document.
- **Delay of automatic document saving (in minutes)** : Delay of automatic document saving (in minutes). A null value disables automatic saving.
- **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.
- **Ask for confirmation before deletion outside the input area** : When deleting an element in the graphic tree or in the table date, a dialog box will be displayed.
- **Manage new names to avoid name conflict** : Tries to avoid name conflict, creating new objects whose name is unique (when pasting for example).
- **Synchronize view with tables** : Select objects in tables (on the right) when they are selected in view.
- **Synchronize view with explorer** : Select objects in explorer (on the left) when they are selected in view.
- **Ask for confirmation if closing with close button** : When closing with the button at the top-right of a dialog box, the software will ask for a confirmation. Use OK or CANCEL buttons if you don't want to confirm closing.
- **Modification tracking when saving** : When saving, if tacking is activated, you can add a comment about modifications made on the document.

14.2. Executables

Executables tab enables to specify path to external executables :

- **Mail client** : Enable you to set the mail client to use
- **Automatically open PDF files** : Specifies if PDF reports must be opened with generation.
- **Moca-RPC path** : Specifies Moca version 12 path.

14.3. Graphics

Graphics tab enables to modify GUI look :

- **Use Windows look and feel** : Use the look and feel of your operating system instead of java look and feel (GRIF restart is needed).
- **Element Zoom** : Changes graphics size.
- **Filling and outline for dynamic fields** : Object outline configuration (line color, line width, background color, ...).
- **Font for dynamic fields** : Enables font configuration (color, size, italic ...) for information that are displayed under objects.
- **Shape filling and outline for commentaries** : Object outline configuration (line color, line width, background color, ...).
- **Font for commentaries** : Enables font configuration (color, size, italic ...) for information that are displayed under objects.
- **Shape filling and outline for groups** : Object outline configuration (line color, line width, background color, ...).
- **Font for groups** : Enables font configuration (color, size, italic ...) for information that are displayed under objects.
- **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.
- **Hide not computed additional info** : Additional information under nodes won't be displayed if it is related to a not computed result. It prevents from multiple "?" display.

14.4. Digital format

Digital format tab enables to customize digits display :

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

14.5. Computations / Results

Computations / Results :

- **Light Batch** : Deletes files used for each computation of batch computations, it decreases memory/disk use.
- **Preferred frequency unit** : Unit that will be used for displaying result which dimension is "frequency" in - main view, - data tables, - and some result synthesis.If no unit is displayed (especially in detailed results) the unit is (h-1).
- **Preferred duration unit** : Unit that will be used for displaying result which dimension is "duration" in - main view, - data tables, - and some result synthesis.If no unit is displayed (especially in detailed results) the unit is (h).
- **Apply modification factor on laws** : Enables probability modification factor. If checked, an "Apply factor" check-box will be available at the bottom of law editing panel.
- **Unit choice for law parameters.** : Activate unit selection for each parameter in law edition windows.

14.6. Nodes

Nodes :

- **Font set-up** : Enables font configuration (color, size, italic ...) for information that are displayed under objects.
- **Display name** : Enables to display name or not
- **Display description** : Enables to display description or not.
- **Display attributes** : Enables to display attributes or not.
- **Display default value for attributes** : It displays the default value of attribute for which no value is defined.
- **Display law** : Enables to display law or not.
- **Display CCF** : Enables to display or not commons causes failures.
- **Use a default law** : Enables the specification of a law that will be used when creating objects (instead of built-in Exponential 1E-3).
- **Default law** : Default law that will be used when creating objects.
- **Set of usable laws** : Allows you to define all the laws that can be used when configuring the entity.
- **Display name on shortcuts** : Enables to display the name of reference place on each shortcut.

14.7. Reseda links

OPTION_TAB_030_RLINK :

- **Link arrow width** : Specifies arrow width.
- **Link arrow height** : Specifies arrow height.
- **Show arrows links to the foreground** : Displays the direction of links on the foreground. Otherwise, the arrows will be drawn behind.
- **Font set-up** : Enables font configuration (color, size, italic ...) for information that are displayed under objects.
- **Display name** : Enables to display name or not
- **Display description** : Enables to display description or not.
- **Display attributes** : Enables to display attributes or not.
- **Display default value for attributes** : It displays the default value of attribute for which no value is defined.
- **Display law** : Enables to display law or not.
- **Display CCF** : Enables to display or not commons causes failures.

- **Use a default law** : Enables the specification of a law that will be used when creating objects (instead of built-in Exponential 1E-3).
- **Default law** : Default law that will be used when creating objects.
- **Set of usable laws** : Allows you to define all the laws that can be used when configuring the entity.

14.8. 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.