Instructions for use of the FRAM Model Visualiser (FMV)
These instructions refer to FMV version 2.1.4 – October 2020

*Please read the **Conditions of Use** at the end of this document.*

Installation

The FMV, as well as these Instructions, can be downloaded from the FRAM website: https://functionalresonance.com/the%20fram%20model%20visualiser/index.html or from the software developer website: http://zerprize.co.nz/FRAM/.

There are several versions available for different operating systems, including stand-alone installers for Windows and Apple Mac. If you are familiar with the original universal Adobe Air version of FMV, an update of this version is also available in the download links above.

All the downloads are provided free of charge and offer all the functionality needed to begin building FRAM models, from simple to reasonably complex. The software can be extended by purchasing a key to unlock the 'FRAM Model Visualiser Pro' version. This is entirely optional but may assist with the development and analysis of large or complex models. The extra functionality is explained in the later section of this manual.
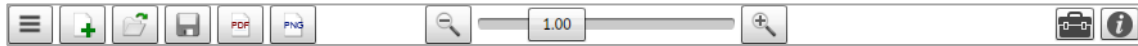
Layout

When the FMV starts, the following window appears:
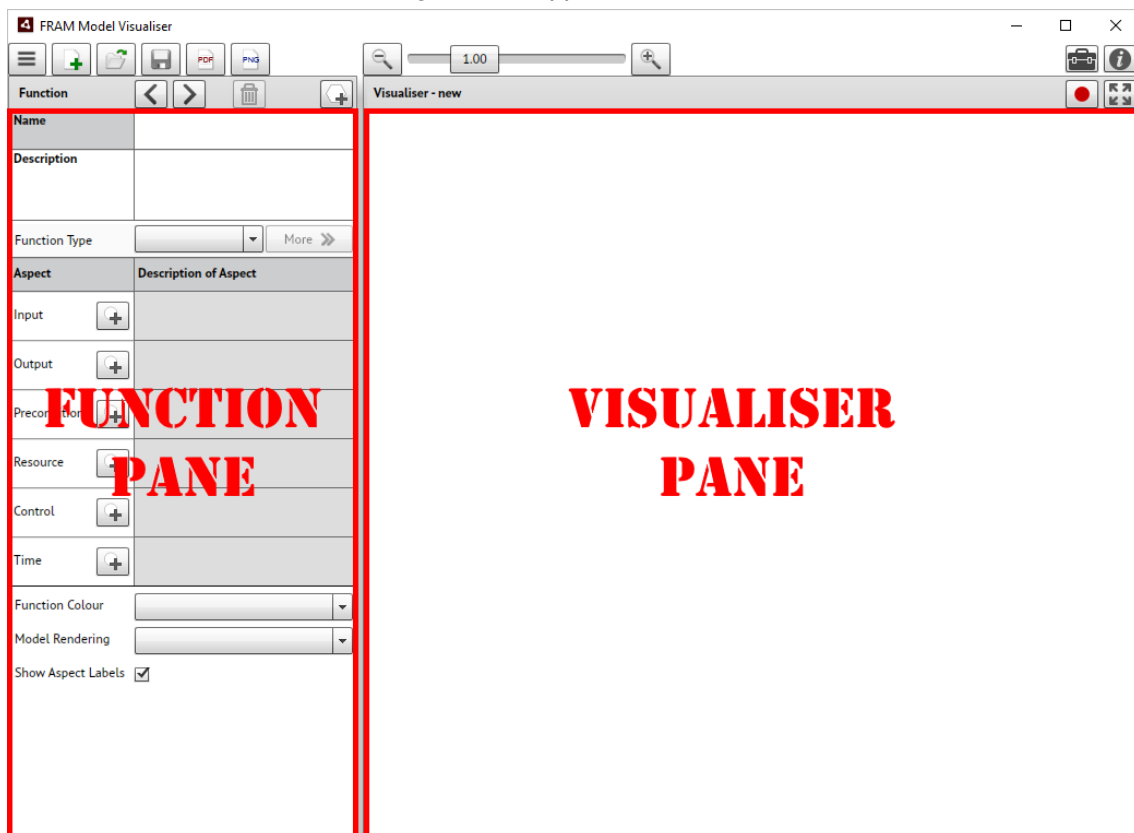
Using the FMV

Project Control

The top row contains the following items:

The purpose of the buttons – from left to right – is as follows:

- **Menu button.** This shows a drop-down menu with the following possible selections: [New, Open, Save, Export PDF Report, Save Image, Recent, Language, Exit]. The first five selections can also be made by the buttons to the right of the Menu button.
  The *Recent* button can be used to retrieve recently used models, rather than doing this through the standard *Open* file dialogue.
- **New.** Clicking on this button starts a new project (FRAM model). If an existing project already is active, the user will be given the choice to 'Save' it, 'Don't Save' it, or 'Cancel'.
- **Open.** This button is used to open a project file previously produced by the FRAM Model Visualiser (.xfmv).
- **Save.** This button is used to save the current project. This will open the usual Save File dialogue pane. The user can choose where to save the file and how to name it. The file extension will be .xfmv. A file save option dialogue will also appear on closing the FMV, if unsaved changes were made.
- **Export PDF Report.** The button generates a report for the current model. The report is in a standard PDF format and opens in the user's native PDF viewer. It contains a set of tables, one for each of the model functions that have been created. The information will be the contents of the Function Page for each function. The report will also include a visualiser image on the last page. The image resolution can be changed using the zoom level in the *Visualiser Pane*, like the *Save* function, but a larger image resolution will increase the file size. A zoom level of 1x is economical on file size, while 2x gives better image quality but still a reasonable file size. Orphan aspects are highlighted in red, consistent with the highlighting in the *Visualiser Pane*.
- **Image.** This will save the current image as a PNG file. The whole image is saved even if some of it is off-screen. The size and quality of the image is proportional to the zoom level. For example, at 2x zoom the saved image is twice the size (and hence better quality) than an image saved at 1x zoom. A 1x zoom is a relatively small file size. 2x zoom would be better for inserting into a document, while 4x is 'best'. The saved image is exactly what you see on screen and includes any highlighting if a function is selected. If you do not want to include the selected function highlighting in the saved image, then first click on the blank background to deselect the function. If you save the image while in the Playback record mode (described later) then the image includes the selected Playback highlighting. The Pro version includes an extra zoom level and the option to save the image as a vector graphic in an SVG format.
- **Zoom control.** The size of the image can be controlled in three ways. One is by the two zoom buttons, one is by the slider, and the other is by holding down the Ctrl key and using the mouse scroll wheel. If you double-click on the zoom slider button, the visualiser will resize automatically to fill the visible screen with the entire model.
- **Toolbox.** This is used to unlock the Pro version functionality as described in a later section.

- **Information**. This provides information about the software (version number) and the developers. It also allows the user to change the language of the interface. (The same selection can be made using the *Menu* button.). The current possibilities are:
  - English (United States)
  - English (United Kingdom)
  - Dansk (Denmark)
  - Deutsch (Germany)
  - Español (Spain)
  - Français (France)
  - Português (Portugal, Brazil)
  - 中文 (China)
  - 日本語 (Japan)
  - 한국어 (Korea)
  - Italiano (Italy)
  - Svenska (Sweden)
  - Nederlandse (Netherlands)
  - Welsh (United Kingdom)

The user can input all data in their respective language. In order to display the Chinese, Japanese or Korean language interfaces correctly, the user must first install the corresponding language support packages for their operating system.

The Function Pane

The top line of the *Function Pane* contains four buttons:

- **Create New Function**. When you click on this button, an empty hexagon appears in the Visualiser window. When you fill in the name of the function in the Name field (see below), the name will also appear inside the newly created hexagon.

- **Delete function**. When you click on this button, the currently selected function will be deleted. Before this happens, a 'delete function' dialogue box will appear to ask for confirmation. The currently selected function will be highlighted with a circular blue shading behind the hexagon.

- **Step through functions**. The two buttons here are used to step through the functions in the order in which they were defined (chronologically). They only work if a model has been loaded. Clicking on the right button [>] will highlight the first function that was defined and show the related information in the *Function Pane*. (If you start by clicking on the left [<] button, the function that was added last will be highlighted.) Clicking on the button again will highlight the next function (in the chronological order), and so one. Clicking on the left button [<] will move the highlight a step back in the sequence.
  This is followed by two fields that are used to describe the function.

The next item in the *Function Pane* describes the selected function:

- **Name**: This contains the name of the function. The name should be short but distinct. Function names should begin with a verb in the infinitive form (but without the 'to'), because a function describes an activity.

- **Description**: The description is a free text characterisation of the function, which may include who usually carries it out. It is generally useful to provide as much information as possible here, and to use the Description field for general notes that are relevant for characterising what the functions does.

In addition to describing the function, it is also possible to select the Function Type.

- **Set Function Type**. Here the function type can be specified. The possible options are:

undefined
Technological
Human
Organisational

When the function type has been specified, it is possible to describe the potential variability of the function. This is done by clicking on the button to the right, marked [More >>].

When you click on the [More >>] button, it opens the *Function Variability Pane* within the *Visualiser Pane*. At the same time, it changes to a [Less <<] button, as shown below.

Clicking on the [Less <<] button will close the *Function Variability Pane* and change the button to [More >>].

The next item in the *Function Pane* is a sub-pane to describe the Aspects of a Function. This sub-pane initially contains six lines corresponding to the six aspect types: **Input**, **Output**, **Precondition**, **Resource**, **Control**, and **Time**. Each aspect type is followed by a New Aspect button (a small circle with a '+' sign), which is used to create a new Aspect of that type. ***You must create a new (empty) Aspect before you can type anything into the aspect pane***.

When you click to describe a new Aspect, for instance a new **Input**, an empty pane opens to the right of the aspect type, followed by a *Delete* button (garbage can).

You can write the name of the Aspect directly in the pane. Remember that Aspects describe states (noun phrases) rather than actions. You complete the entry of the name by moving the mouse to a different field (e.g., by clicking on the corresponding hexagon in the *Visualiser Pane*, or another aspect name), or by pressing the 'Tab' key.

Caution: (If you press 'Enter' this will just create a new line in the aspect name. The key code for 'Enter' will become part of the Aspect name string, even though it is not visible. This may lead to problems during the automatic model check.)

> It is also possible to use keyboard shortcuts. Use 'Shift Tab' to go back to the New Aspect button and then press 'Enter' to add another Aspect. Pressing Tab twice will take you forward to the Add Aspect button of the next Aspect category.

As soon as you have completed the entry of the aspect name, it will be marked correspondingly in the *Visualiser Pane*. If the aspect name already exists for an Aspect of a different function, a thin blue connector will be drawn. If the aspect name does not yet exist for another function, the entry will be shaded red and the Aspect will be marked by a red ring in the *Visualiser Pane* (this is referred to as an orphan).

The same procedure can be applied to any of the six Aspects.

If you click on the New Aspect button for an Aspect for the second time, a new line will be added for that Aspect. This contains (as before) an entry pane and a *Delete* button. In this way it is possible to add new Aspects as required, and to delete already defined Aspects.
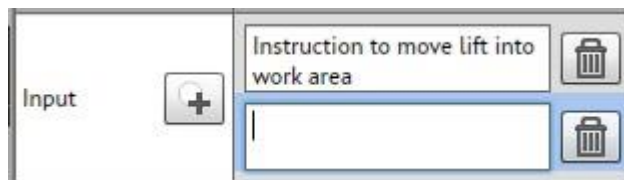
The names given to the Aspects can be edited/corrected directly in the name field of the Aspects. Any changes will immediately be shown in the *Visualiser Pane*, which thus represents the current status of the model.

Caution: If you add a new Aspect to a function, but do not fill in the Aspect name, it will be interpreted as the null string, even though this is not visible. This may lead to problems during the automatic model check.

Finally, after describing the Function and its Aspects, it is possible to specify details of the rendering in the *Visualiser Pane*.

- **Choose Function colour**: It is possible to choose the colour of a hexagon's edge. This may be useful to mark functions that somehow differ, for instance, because they are carried out by different parts of an organisation. The default colour is *white*, meaning no colouring of the edge. The choices are the following:

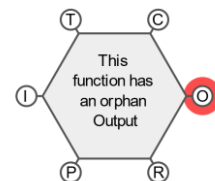| white |
|-------|
| blue |
| green |
| grey |
| red |
| yellow |
| purple |
| custom |

The last choice ('custom') opens a palette from which the user can freely choose a colour or directly enter any standard 'RGB' value.

- **Choose Model Rendering**. This provides three options. The default is 'Traditional', which means that both foreground and background functions are shown as hexagons with a white edge. The next is 'Modern'. Here foreground functions have a larger hexagon that extends to the Aspect connection points and has a very light grey background. Here foreground functions are shown as hexagons with a black edge, while background functions are shown as grey boxes. The 'Modern' rendering can be useful to simplify the rendering of a model with many functions. The third option is 'Floating', which is the same as Traditional with the exception that the Aspect connection points are not connected to the function's hexagon.

- **Show/Hide Aspect labels**. If this option is checked, the Aspect names will be shown on the connecting lines in the Visualiser Pane. These labels are anchored to the midway transition point of the connecting curve.

The Visualiser Pane

To the right is the *Visualiser Pane*. This either contains the image for the model that is being built, or the image of the project that has been opened. The image shows the functions (hexagons) as well as lines connecting the hexagons.

- For some functions the Aspects may be marked with a thick red circle. This means that the Aspects are 'orphans', or in other words that the model is incomplete. The designation of an Aspect as an orphan aspect is made automatically by the FMV according to the FRAM syntax.
  Caution: An Aspect is marked as an orphan if the Aspect name is unique, i.e., does not match the name of any other Aspect. This will happen when a name is entered for the first time, since it obviously will be unique, but also if the name has been misspelled. In addition to actual misspellings this may happen because the name includes a non-printing character, such as a carriage return, a tab, or a space. Conversely, two Aspects may become connected if they contain the same incorrect string, for instance the null string.

- Background functions are shown with a grey interior. A function is recognised as a background function if it only has one or more Outputs or one or more Inputs. (The latter is also called a *drain* or exit function.) The FMV will automatically detect whether a function is a background function.

- Foreground functions are shown with a white interior. A background function becomes a foreground function if one or more of the other four aspects (P, R, C, T) are defined. The FMV will automatically detect whether a function is a foreground function.
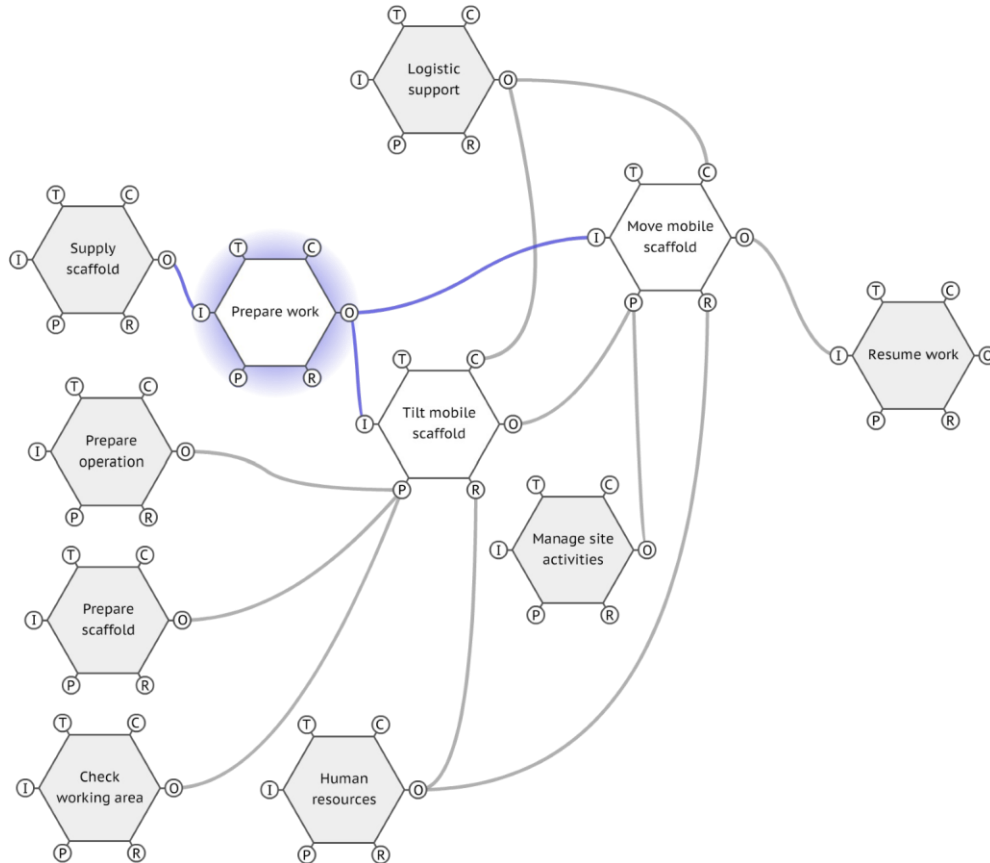
A function (hexagon) can be selected by clicking on it. It will be deselected if you click on another function or on the background.

When a function is selected, it is marked by a circular blue shading behind the hexagon. The *Function Pane* will also show the data for the selected function, as described above. All connecting lines associated with the selected function will be coloured blue. These represent the function's Aspects that are connected with the Aspects of other functions.

A function that is selected can be moved around in the *Visualiser Pane* by clicking and dragging with the mouse; the connectors to other functions will automatically follow the movement. If the image of the model extends beyond the visible window, then scroll bars will appear so you can scroll to any part of the model. You can also click and drag anywhere on the background to scroll the model.

The edge colour of a selected function can be changed via the *Choose Function Colour* button (cf., above). The colour will remain even when the function has been deselected.

Describing the variability of a function

The FMV enables the user to describe the potential variability of functions. In order to do this, the user must first set the *Function Type*, as described above. When the *Function Type* has been selected, the *Functional Variability Pane* can then be opened by clicking on the [More >>] button.

If the *Function Type* is *Technological*, the *Function Variability Pane* will look as follows:

Possible source of variability		Likelihood
Internal	Few, well known	Low
External	Maintenance, (mis)use	Low

Potential Output variability with regard to time

○	Too early	Unlikely
○	On time	Normal, expected
○	Too late	Unlikely, but possible if software is involved
○	Not at all	Very unlikely (only in case of complete breakdown)

Potential Output variability with regard to precision

○	Precise	Normal, expected
○	Acceptable	Unlikely
○	Imprecise	Unlikely

If the *Function Type* is *Human*, the *Function Variability Pane* will look as follows:

Possible source of variability		Likelihood
Internal	Very many, physiological and psychological	High frequency, large amplitude
External	Very many, social and organisational	High frequency, large amplitude

Potential Output variability with regard to time

○	Too early	Possible (snap answer, serendipity)
○	On time	Possible, should be typical
○	Too late	Possible, more likely than too early
○	Not at all	Possible, to a lesser degree

Potential Output variability with regard to precision

○	Precise	Possible, but unlikely
○	Acceptable	Typical
○	Imprecise	Possible, likely

And if the *Function Type* is *Organisational*, the *Function Variability Pane* will look as follows:

Possible source of variability		Likelihood
Internal	Many, function specific and/or relating to 'culture'	Low frequency, large amplitude
External	Many, instrumental or 'culture'	Low frequency, large amplitude

Potential Output variability with regard to time

○	Too early	Unlikely
○	On time	Likely
○	Too late	Possible
○	Not at all	Possible

Potential Output variability with regard to precision

○	Precise	Unlikely
○	Acceptable	Possible
○	Imprecise	Likely

In all three cases, the upper part summarises the characterisation of the internal (endogenic) and external (exogenic) variability as described in the FRAM book (and the FRAM handbook). This is purely a memory aid for the user.

The middle and the lower parts allows the user to describe the potential Output variability with regard to *time* and *precision*, respectively. This is done by marking one of the given alternatives using the radio buttons. The brief text describing each option will correspond to the *Function Type*.

- If the Output is described as variable (by marking *time* as one of [Too early, Too late, Not at all] or marking *precision* as one of [Acceptable, Imprecise]), then the function will be marked by a wave symbol in the *Visualiser Pane*. This is to remind the user that the function is described as potentially variable.

- The selection can be changed whenever needed by clicking on another radio button or the text associated with the radio button (for instance, 'Precise'). If the new selections are 'on time' and 'precise', the wave symbol will disappear.

- The selection can be cancelled by clicking the selected radio button or text again. The selection can also be cancelled by setting the Function Type to *undefined*. In both cases the wave symbol will disappear.

The *Function Variability Pane* will disappear when the [Less <<] button is clicked, but the selections will of course be remembered.

Playback

The FRAM is a method to build a model or representation of a system or a set of activities – of how something is done. The model can then be the basis for an analysis, either an investigation of something that has happened (accidents, incidents, etc.), an assessment of something that may possibly happen (risk assessment), or an evaluation of a design.

An analysis will usually be based on an instantiation of the model. One way of doing that is to describe or specify a specific set of circumstances (a scenario) and then use that to go through

the functions in order to develop a common understanding of how the variability of functions may interact – or how it did interact in the case of a retrospective analysis.

The current version of the FMV supports this kind of 'walk-through, talk-through' of an instantiation. It is possible to record the sequence in which functions are selected (and discussed), and afterwards to play back that sequence. This provides a way to capture how an analysis took place, and to replay that to illustrate how the upstream-downstream couplings were instantiated.

The Playback is controlled by two buttons on the top right part of the *Visualiser Pane*. The *Record* button to the left changes the *Visualiser Pane* to be in *Record* mode. The *Full Screen* button to the right changes the *Visualiser Pane* to be in *Playback* mode.
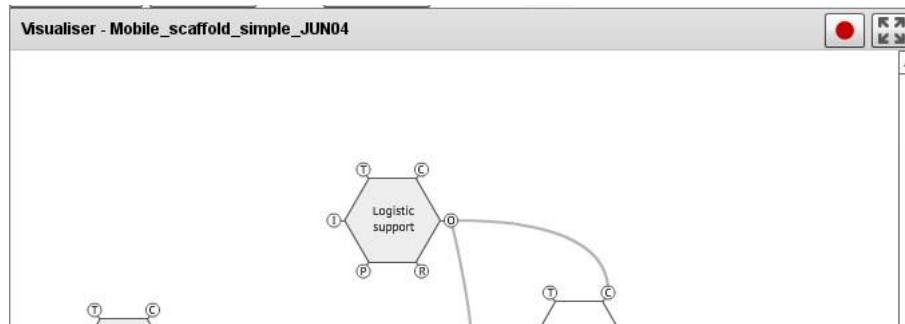
When you press the *Record* button, several controls are added to the top of the *Visualiser Pane* as shown below. Aspect labels will also appear on the connecting lines.
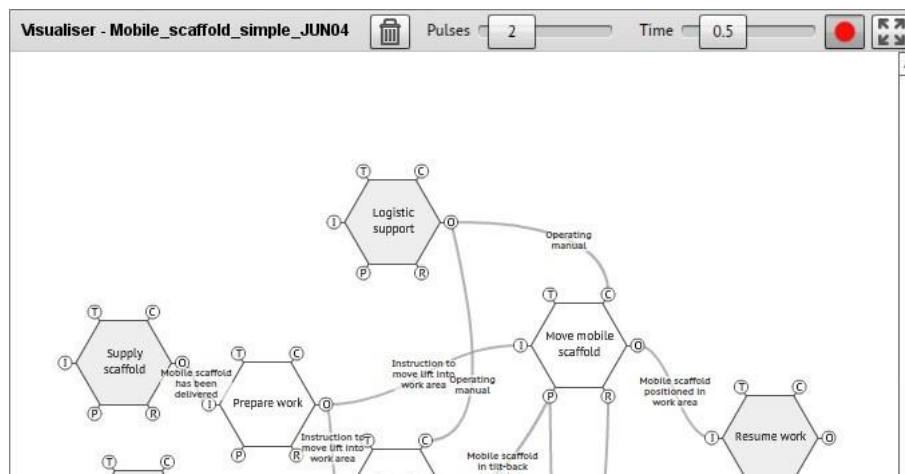
Recording a sequence

When the *Visualiser Pane* is in the *Record* mode, clicking on a Function will add it to the *Playback Animation List*. Clicking on an Aspect label, normally (one of) the Output(s) from the function, will add the connecting line (downstream coupling) to the *Playback Animation List*.

Functions and lines will be added to the *Playback Animation List* in the order that they are selected. Functions and lines are highlighted blue as they are selected. Red numbers will also appear to indicate the order of the selections.

Pressing the *Delete* button ('trash can') will delete and reset the entire selection.

The Pulses and Time settings can be used to adjust the appearance of the animation during Playback.

When the sequence (instantiation) has been completed, press the Record button again to exit the record mode. The display of the Aspect labels will now be determined by the status of the *Show/Hide Aspect Labels* checkbox.

Playback of a sequence

To begin Playback, first enter the Full Screen mode by pressing the *Full Screen* button. The display will zoom to fit the whole model within the screen size. The controls of the *Visualiser Pane* will now look like this.
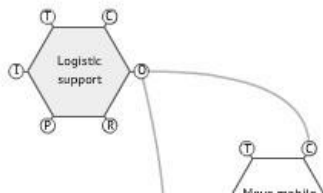
Prior to *Playback* the following settings can be adjusted: Display of Aspect labels, Number of Pulses per animation, Time of each Pulse in seconds.

To begin the Playback animation, press the Play button. Pressing the Play button again during Playback will pause the animation. Press it again to resume. Pressing the Space Bar will have the same effect of toggling the Playback between pause and resume.

The Playback animation can be cancelled at any time by clicking anywhere on the screen.

Functions can be moved and repositioned in the Full Screen mode in the same way as the normal editing mode.

When the use of the playback has been completed, press the Full Screen button again to exit the Full Screen mode and return to the normal editing mode.

Keyboard Short-Cut Keys

- **Ctrl+N** = New Function
- **Ctrl+D** = Delete Function
- **Ctrl+Left** = Previous Function
- **Ctrl+Right** = Next Function
- **Ctrl**+'**+**' = Zoom In
- **Ctrl**+'**-**' = Zoom Out
- **Ctrl**+ Mouse Wheel = Zoom model canvas in or out
- **Ctrl**+ Mouse Click **On Coupling Label** = Return a moved label to its default position
- **Double** Mouse Click **On Coupling Label** = Return a moved label to its default position

FRAM Model Visualiser Pro – extended features

Activation

- Open the FMV application and Click the 'Toolbox' button in the top right corner:
- Select 'Pro Pack 1'. You will be redirected to the payment page in your default internet browser
- After the payment is confirmed, return to the application and click the 'ACTIVATE' button on the pop-up window
- After a few seconds, the pop-up window will disappear, and the new buttons described below will appear.

New Toolbar Features

Grouping

- First, open a model. Then RIGHT-CLICK on a function with the mouse (on a Mac you can also use 'control + Click').
- This will select it, but with a GREEN outline instead of the usual left-click blue outline. This means that you are selecting a Group.
- The first Function that you right-click on will be the parent that the other functions in the group fall into.
- Now right-click on other functions that you want included in the group.
- All the functions you have selected will be outlined in green.
- To create the group, now click on this button:
- You should see all the selected functions collapse into the first function you selected. All their aspects now also belong to the parent function
- You can click the group button again to expand the group out again:
  This is a toggle button and can be used any time you select the parent function to collapse or expand the group.
- When the group is collapsed, note the double outline around the parent function. This tells you it is a group and can be selected for expansion at any time. The button we used above also has the double outline, as this is the visual key to denote a group of functions.
- When a group is collapsed if you change the colour of the parent, then all child functions within the group also have their colour changed. You will see the result when you expand the Group again.

Exporting

- When a group is selected the 'Export Group' button is enabled:
- Click on this button to save the selected group as its own FMV model file.
- You will be asked to check the file name and save location. The default name is the name of the parent function.
- The saved file can be opened and worked on in FMV the same as any model file.

Importing

- This button allows you to import any FMV model file into the current model:
- When you import another model, any matching aspects will make the appropriate couplings.
- If the imported model has functions with the same name as functions in the current model, it will add a _1 to the name, so not to double up on the names (you can't have two functions with the same name in one model).

Create extra white space around the Model

- Sometimes, especially if you are importing other models, you may want to create extra space above and to the left of the model.
- Hold down the 'Ctrl' key at the same time you left-click with the mouse on the white-space surrounding the model.
- You can now move the entire model around the Visualiser window with the mouse.
- Release the left mouse button to set the new position of the model.

Metadata – attach Key/Value pairs of metadata to individual functions

- Hold down the 'Ctrl' key at the same time you left-click with the mouse on a Function. On a Mac use the 'option' key.
- The Metadata view will appear at the top of the Visualiser window, with fields for attaching a 'Key' and a 'Value' to the selected function.
- Enter a 'Key' for the **name** of the data field that will be common across all functions. Not all characters will be allowed, XML naming rules are enforced.
- Note: When entering a new Key name, a new row will appear so that additional Key/Value pairs can always be added to the bottom of the list.
- Now enter a 'Value' for that Key that is specifically for the selected function.
- When you left-click and select another function, the Key list will remain, but the Values will be updated to display any that have been entered specifically for that function.
- You can continue to select functions and enter Values or add additional Keys.
- To hide the Metadata view, simply click on the white space surrounding the model.

Undo / Redo

- Multiple steps of Undo allow you to undo or reverse changes you make to a model; including all text changes, moving functions and labels, and grouping/ungrouping.
  The Undo memory is reset when you load a new model. After any number of Undo steps, you can Redo them again using the Redo function.

New *Function Pane* features

On Pro activation, a series of new buttons will appear at the bottom of the *Function Pane* after the 'Show Aspects Labels' option:
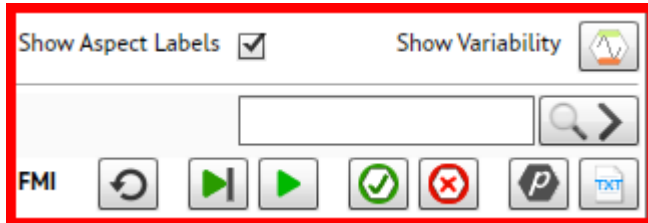
Variability Tracer

The **Show Variability** button activates a simple variability tracer that shows two coloured bars in each foreground function to represent Potential Output variability with regard to time at the top, and Potential Output variability with regards to Precision at the bottom. These represent the variability mentioned in the section above: '**Describing the variability of a function**' and are manipulated in the Functional Variability Pane by selecting a Function Type and clicking on the [More >>] button.

- The bars default to a green colour to represent a neutral or 'acceptable' variability.
- If you select a Potential Output variability with regard to time of 'On time' then the upper bar will change to a light blue colour. If you select 'Too early' or 'Too late', then it will change to an orange colour, and If you select 'Not at all' it will change to red.
- The upper bar of downstream functions that are connected will then also change to show the greatest variability from any upstream functions.
- Similarly, for Potential Output variability with regard to precision, if you select 'Precise' the lower bar changes to light blue, 'Acceptable' green, and 'Imprecise' orange. And again, this has a flow-on affect to downstream functions.

This simply alerts you to the potential variability from upstream-downstream couplings and the possibility of resonance.

Search

If you enter text into the search box and press enter or click the search button: then any Function name or Aspect label that contains that text will be highlighted yellow in the Visualiser Pane. This can be used to find specific aspects in a large model, or search for related aspects using key words to explore potential couplings. It can also be used to highlight a specific function or aspect for demonstration purposes.

- When you search, a function that contains the text will be selected and display its data in the *Function Pane*. Pressing enter again (or clicking the search button) will select the next function, and so on.
- To clear the highlights simply delete the text so the box is empty, and press enter or click the search button.

FMI - FRAM Model Interpreter

The FRAM Model Interpreter (**FMI**) is a software tool that can be used to interpret a FRAM model and through that determine how the described activity or task may develop. The FMI provides a realisation or interpretation of a given model in the sense that it examines the consequences of the couplings specified by the aspects of the model's functions and thereby shows how an event can develop. The FMI can therefore be used to determine how the potential couplings defined in the model will be realised as actual couplings for specified conditions – an instantiation.

The FMI is also offered as a stand-alone application with its own descriptive manual, available on the Functional Resonance website: https://functionalresonance.com.
This section describes how to use the FMI basic version as an integrated tool within the FMV, but the above reference should be used for a more detailed description of the method and the terminology used.

The row of FMI buttons at the bottom of the Function Pane perform the following functions:

Reset the interpretation and return the model to its original state.
Use this button at any stage to clear the results and start over.

Start or progress the interpretation one step at a time. The first step **Initialises** the model and will highlight the Entry, Exit and Background functions. Subsequent steps will continue the interpretation one cycle at a time.

Start and 'play' the entire interpretation from start to finish.
This initializes the model and progresses through all cycles until either all Exit functions have been activated, or no functions are activated in a cycle.

Highlight green all functions that were activated during the interpretation.
Usually checked at the end of an interpretation but can also be checked after any cycle.

Highlight red all functions that were NOT activated during the interpretation.
This and the preceding button can be used to help troubleshoot a model to find where or why a function is not being activated or a coupling is not being made.

Display the **Interpretation Profile** for the selected function.
By default, a function is activated during initialisation or during an interpretation cycle when all its Inputs and other Aspects are present. The Interpretation Profile allows you to deviate from this default position for each individual function in the following ways.

When you click the button the Interpretation Profile tool shown below will appear next to the selected function (if no function is selected, it will appear the next time you select a function). When you select a different function, it will move to the right of that function. The content displayed will always relate to the selected function shown with the blue highlighting.
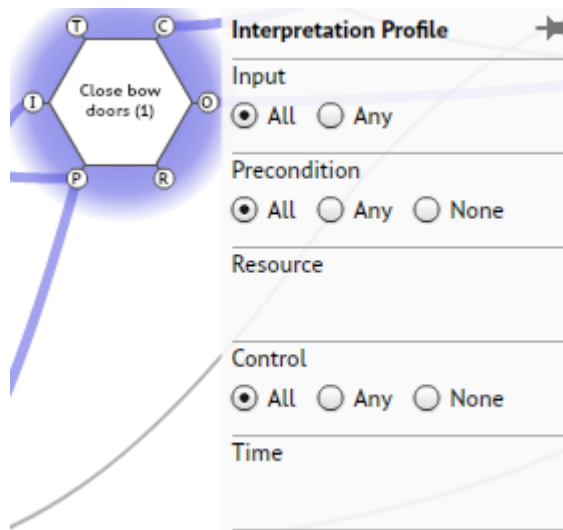
If you click the pin icon in the top right corner, the Interpretation Profile will turn into an independent window. You can move the window to a position of your choice by dragging it by the title bar, where it will stay as you select different functions.

Five sections are shown for the aspects, <Input>, <Precondition>, <Resource>, <Control> and <Time>. If at least one of these is present, the section will be populated with option buttons.

In the example to the left, the function has one input, two preconditions and one control aspect.

The options have the following meanings ('**All**' is the default setting):

For <Input>:
All means that the function will become READY only when all Inputs are present.
Any means that the function will become READY when at least one Input is present.
There is no difference between All and Any if there is only one Input.

For the other aspects, <Precondition>, <Resource>, <Control> and <Time>:
All means that the condition represented by the aspect will be considered fulfilled only when all of the aspects are present.
Any means that the condition represented by the aspect will be considered fulfilled when at least one of the aspects is present.
None means that the aspect is not considered, even though it has been specified.

When a function is READY, and all the aspect conditions have been fulfilled, then the Output is activated and available to the downstream functions for the next cycle.

Display the 'FMI LOG' window containing text results of the interpretation.
This is a toggle button that will both open then close the FMI LOG window. The window can be opened at any time and will display results up to the current cycle, and it can also be moved to any location on the screen by dragging the title bar.

If the model does **NOT** pass the initialisation on the first step, then the FMI LOG will display warnings explaining what needs to be completed before the interpretation can begin, such as orphans, missing Inputs and missing Outputs.

For example: `WARNING: <Leave harbour> does not have any Inputs`
`WARNING: <Finish loading> has an orphan`
`WARNING: <Trim vessel> does not have any Outputs`

If the model passes the first step initialisation, then interpretation results are displayed according to the following structure:

- Title and time stamp.
- Identification of Entry and Exit functions.
  For example: `Entry function <Finish loading>`
  `Exit function <Commence voyage>`

- Interpretation Profile – a summary of the Interpretation Profile settings for each foreground function. For example: `Function <Man harbour stations>`
  `Input: All Precondition: All Resource: All Control: All Time: All`
- Summary of FMIlog – results of the initialisation. First confirming the initialisation success, for example: `Begin initialization`
  `--- MODEL INTERPRETATION COMPLETED.`
  Next is a listing of the Background functions and Entry functions that have been activated ready for the first interpretation cycle.
- Cycle results. Each cycle begins with a heading, such as:
  `BEGIN CYCLE 1`
  Then there is a list of each function that was activated during that cycle, meaning that the function is ready, and all the aspect conditions have been fulfilled.

- If no functions activate then this message will be displayed:
  `No functions were activated during this cycle.`
  Interpretation will not proceed beyond this point. The button to highlight activated functions can be used here to identify the boundary of how far the interpretation progressed. This is common if there are feed-back loops and can usually be fixed by reconsidering the interpretation profile for the functions that receive the feed-back as aspects.

- When all cycles can be completed and all Exit functions have been activated then the final line in the log will display: `End`
  This is the final conclusion of the interpretation and shows that the model is syntactically correct, and that the current interpretation profile enables the model to progress from all Entry functions to all Exit functions.

The save button on the FMI Log window allows you to save the results as a text file.

Label Sizes

The scroll buttons on the Function Name and the Aspect heading are used to adjust the text sizes on the model, for the Function Name text, and the Aspect coupling labels, respectively.

- Click the up and down arrows to adjust the text size.
- When the mouse pointer is over the buttons you can also use the up and down arrow keys, or the mouse scroll wheel.
- To return the text size back to the default, put the mouse pointer over the buttons and press the 'Esc' key.

Keyboard Short-Cut Keys – ☑ FMI Pro functionality only

- **Ctrl+N** = New Function
- **Ctrl+D** = Delete Function
- **Ctrl+Left** = Previous Function
- **Ctrl+Right** = Next Function
- **Ctrl**+'**+**' = Zoom In
- **Ctrl**+'**-**' = Zoom Out
- **Ctrl**+ Mouse Wheel = Zoom model canvas in or out
- **Ctrl**+ Mouse Click **On Coupling Label** = Return a moved label to its default position (on a Mac use **command** + Mouse Click), or
- **Double** Mouse Click **On Coupling Label** = Return a moved label to its default position
- ☑ **Ctrl+G** = Group / Ungroup
- ☑ **Ctrl+Z** = Undo
- ☑ **Ctrl+Y** = Redo
- ☑ **Ctrl+M** = Show Metadata
- ☑ **Ctrl**+ Mouse **Click On Function** = Show Metadata (on a Mac use **option** + Mouse Click)
- ☑ **Ctrl**+ Mouse **Move** = Drag entire model to modify surrounding white space

Background

The FMV provides a powerful editor, visualiser, and model checker in a single package. Earlier software tools incorporating the principles of the method were the FRAM Visualizer (https://code.google.com/p/framvisualizer/) and the FRAM Model Builder (FMB). Both projects have provided inspiration for the FMV, but both have by now been discontinued.

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The Lab – Research Laboratory Experimental Features

Introduction

From time to time, features that are still under development and not officially released as part of the FMV Pro version, may be available here for the purposes of experimentation and feedback from users.

Activation

- Open the FMV application and Click the 'Toolbox' button in the top right corner:
- Select '☑ The Lab' checkbox to turn on the Research Laboratory experimental features.
- To show metadata and the experimental features, Ctrl-click a Function, or select a Function and press Ctrl-M.

Function Metadata – Variables and Calculations feature (2.1.4)

In combination with the FMI functionality, this feature provides the ability to calculate metadata values as Functions are activated during the FMI cycles. The calculations are expressed as user defined equations that can reference other metadata keys, standard variables, standard mathematical functions, logic conditions, and mathematical operators. One or two resulting metadata values can then be expressed as a coloured visualisation within each function. The colours and value ranges can be customised by the user.

When you Ctrl-Click a Function, or select and press Ctrl-M, the metadata section will appear above the model in the visualiser window and display the extended features.
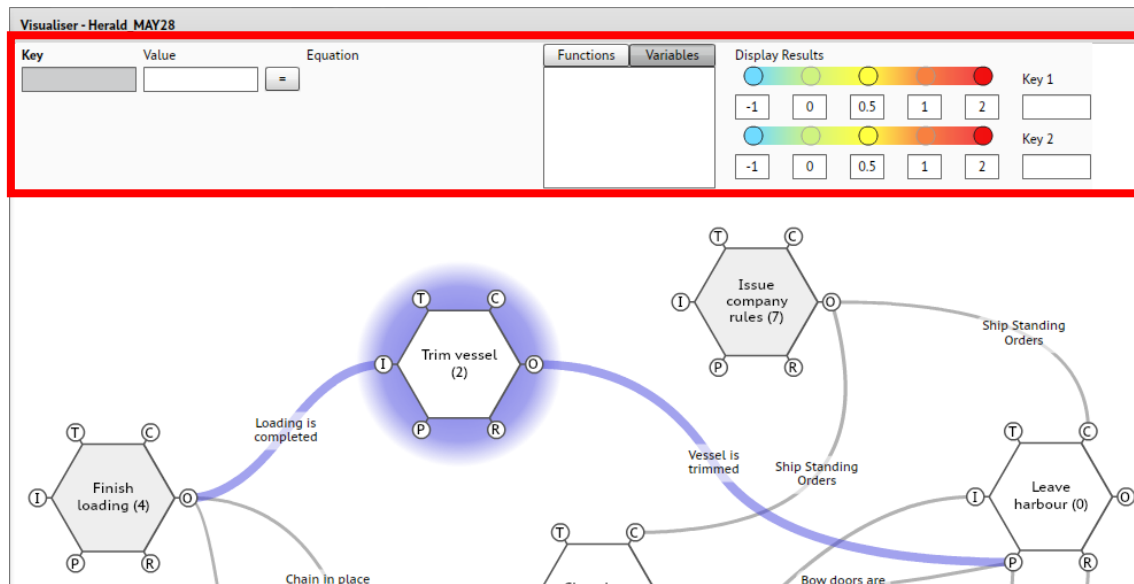
Key/Value pairs

The first two text boxes are for entering metadata as a list of key/value pairs, as is already available in the standard FMV Pro versions. A Key is entered in the first box shaded grey, but it will not be saved for the selected Function until a Value or an Equation is also entered for that Key. The corresponding Value is entered in the second text box.

When a Key is saved for a Function, It will be shown along with all saved Key names when any other Function is selected. As such, the Key names become common across all Functions. However, the corresponding Values are unique to each individual Function.

Key names can be used as Variable names and referenced in Equations if they start with a capital letter (this is to diferentiate between Variables and mathamatical functions).

Equations

To calculate the Value of a Key for a Funciton (when it is activated by the FMI) click the '=' button and another text input box will appear for entering an equation.

Eqauations can contain Key names to reference other Values that appear above them in the same Function, or Standard Variables can be used to reference Values from upstream Functions, connected by couplings that are activated during the FMI cycles. This is explained in further sections.

To turn the equation off, click the '=' button again (this is a toggle button) and the equation will disapear, it is still saved but will not be used to calculate the Value.

Functions/Variables List

The next section is a list of available mathematical functions and variables available for use in Equations. You can switch between these two types by using the Functions/Variables toggle buttons above the list. The Variables list is initially empty but will be populated as you create Keys and make selections wihin the model.

If you click on an item in the list it is copied to the clipboard. You can then select a position in the equation box and paste (Ctrl-V, or mouse right-click Paste). If you select a position in the equation box first, you can insert an item from the list by double-clicking with the mouse. If you hover over a mathematical function or variable in the list, a description will be displayed in the tooltip.

In addition to the standard mathematical expressions for addition (+), subraction (-), multiplication (*) and Division (/), the following operators and mathematical functions are also available:

Mathematical Functions	
? :	Conditional statement in three parts: [IF] ? [THEN] : [ELSE] Can be nested within the [ELSE] section, such as: [IF] ? [THEN] : [[IF] ? [THEN] : [ELSE]]
&&	Logical operator AND (a single & will also work)
||	Logical operator OR (a single | will also work)
!	Logical operator NOT (used to preceed a boolean expression to reverse its logic)
=	Comparison operator Equals (a double == will also work)
<	Comparison operator Less Than
>	Comparison operator Greater Than
<=	Comparison operator Less Than or Equal

>=	Comparison operator Greater Than or Equal
<>	Comparison operator Not Equal
!=	Comparison operator Not Equal
abs()	Absolute Value for the number specified
int()	Returns the Integer part of a number
round()	Rounds the value of the parameter up or down to the nearest integer
rnd()	Returns a pseudo-random number n, where 0 <= n < 1
sqrt()	Square Root of the specified number
^	Exponentiation, the value of the preceeding number raised to the power of the following number
π	The constant Pi
sin()	Sine of the specified angle in Degrees
cos()	Cosine of the specified angle in Degrees
tan()	Tangent of the specified angle in Degrees
exp()	Value of the base of the natural logarithm (e), to the power of the exponent specified in the parameter
log()	Natural Logarithm of the parameter

In the Variables list, the variables available will change as you select different Functions, as the list is specific to each Function based on the available Aspects, potential couplings and the list of Key names.

There are three types of Variables:

- **Key names**. Values associated with Keys can be used in an equation if they begin with a capital letter. If the value needs to be calculated from an equation itself, before being used, then it needs to be listed earlier, as quations are evaluated in the order that the Keys are listed.

- **Specific Variables**. These are specific to each Function and refer to individual Values from upstream couplings through the various Aspects. As such, the list will change as the model is built and potential couplings are created or deleted. The naming convention is as follows:

Specific Variables	
P0_key	The **first letter** refers to the Aspect of the given Function where the coupling from an upstream Function is connected. It is always I, P, R, C or T, representing Input, Precondition, Resource, Control and Time respectively.
P**0**_key	The **number** is simply an index to ensure a unique name if more than one Aspect type is present from different upstream functions. If you want to know which upstream Function contains the Value that the variable is referring to, then hover over the variable name with the mouse and the coupling and Function will be displayed in the tooltip.
P0_**key**	The **key** name that contains the Value returned by the variable. The list of available variables will be repeated for each Key that is present on the upstream Function.

- **Standard Variables**. These variables colate the Values from All Aspects, or from one of the five Aspect types. Similar to the Specific Variables, the list will be repeated for each Key that is present on the upstream Functions. Unlike the Specific Variables, the colation will be calculated using the potential couplings present at the time, and will adjust automatically as the model is edited. The standard colations availabe are:

Standard Variables	
A…	Standard Variables beginning with A refer to All Aspects (Input, Precondition, Resource, Control and Time)
An_key	The **number** of couplings from **All Aspects** where the **key** value is not null
Asum_key	The **sum** of **key** values from **All Aspects**
Aavg_key	The **average** of **key** values from **All Aspects**
Amin_key	The **minumum** of **key** values from **All Aspects**
Amax_key	The **maximum** of **key** values from **All Aspects**
I…	Standard Variables beginning with **I** refer to **Input** Aspects only
In_key	The **number** of couplings from all **Input** aspects
Isum_key	The **sum** of **key** values from all **Input** aspects
Iavg_key	The **average** of **key** values from all **Input** aspects
Imin_key	The **minumum** of **key** values from all **Input** aspects
Imax_key	The **maximum** of **key** values from all **Input** aspects
P…	Standard Variables beginning with **P** refer to **Precondition** Aspects only
Pn_key	The **number** of couplings from all **Precondition** aspects
Psum_key	The **sum** of **key** values from all **Precondition** aspects
Pavg_key	The **average** of **key** values from all **Precondition** aspects
Pmin_key	The **minumum** of **key** values from all **Precondition** aspects
Pmax_key	The **maximum** of **key** values from all **Precondition** aspects
R…	Standard Variables beginning with **R** refer to **Resource** Aspects only. The same five colations as above are also available.
C…	Standard Variables beginning with **C** refer to **Control** Aspects only. The same five colations as above are also available.
T…	Standard Variables beginning with **T** refer to **Time** Aspects only. The same five colations as above are also available.

Display Results

The top colour range is used to display results in the inside top of each funtion, the bottom range in the inside bottom of each function. Click on any of the three main colour circles to change the colour. The intermediate colours are blended from the three main colours.

The number boxes below the colour ranges are used to convert the Values to the colour range for dsiplay.

The last two text boxes on the right labeled 'Key 1' and 'Key 2' are for selecting which of the Keys provide values for displaying the results, Key 1 for the top range and Key 2 for the bottom range.

Example 1 – Mimic FMI Activation

This example uses the 'Herald_MAY28' test model.

- Ctrl-Click on the Entry Function [Finish Loading (4)].

- In the Key field, type 'Active' and then enter '1' into the Value field.

Key	Value
Active	1

  Here we are using the number 1 to represent TRUE (and 0 would represent FALSE) as a way to show that the Function is Active.

- Click on the Background Function [Issue company rules (7)]. The Active Key will appear. Enter '1' into its Value field.

- Click on Foreground Function [Trim vessel (2)]. You will now see Variables appear in the Function/Variables list.

- Click the '=' button and a text entry box will appear for entering an equation.

- Scroll down the Variables list until you find '**Aavg_Active**', and double-click. This will copy it to the Equation box.
  This variable takes the **average** of Values from the Key labelled '**Active**', from upstream Functions connected to **All Aspects**.

- Complete the Equation box so that it contains the following text:
 **Aavg_Active=1 ? 1 : 0**
  This is a conditional statement. First it evaluates the statement 'Aavg_Active=1', because it preceeds the '?'. This would only be TRUE if all of the Aspect values are 1, and none of them are 0. If TRUE, then it returns the value following the '?', in this case 1. If it is FALSE then it would return the value following the ':', in this case 0.

- Select and copy the Equation text entered above, then select each of the other four foreground Functions in turn, click the '=' button for the Active Key and paste the text into the Equation box. Now all foreground Functions should have the same equation.

Key	Value		Equation	Functions	Variables
Active		=	Aavg_Active=1 ? 1 : 0	Imax_Active	
		=		An_Active	
				Asum_Active	
				Aavg_Active	
				Amin_Active	
				Amax_Active	

- At the far right, enter the text 'Active' into the **Key 1** field.

- At this stage if you step through all of the cycles of the FMI the Funcitons will display an orange band representing the calculated result of 1. When you select a Function that has an equation, the calculated value will be displayed in the Value box.

- The default colour with orange representing a value of 1 does not suit the meaning of the Function or Output being Active. The colour and value ranges can be modified as follows.

- Click on the left circle in the top colour range, with the default light blue colour (cyan), and select a red colour, such as F00000 or FB5050.

- Click on the right circle with the default red colour, and select a green like 007F00 or 5FDF5F.

- Change the numbers below the first colour range to display a number range from 0 to 1, such as 0, 0.25 0.5, 0.75, 1.

- Now when you reset the FMI and advance through all cycles, the Functions will display a green bar.

- To test the equations, select the background Function [Issue company rules (7)] and change its value from 1 to 0.

- Now when you reset the FMI and advance through all cycles, the Functions that have this background Function as a Control aspect will show a red bar, representing that they have not been activated because one of their Aspects was not active.
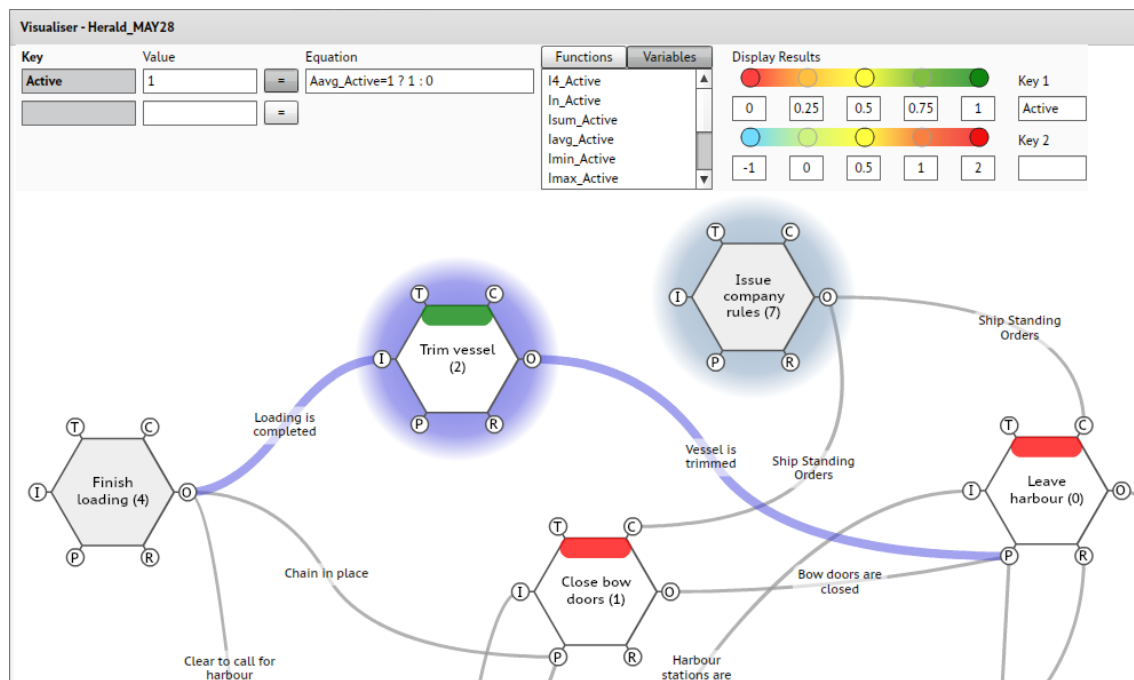
As a variation of this example, text can be used instead of values in Key/Value pairs, and in conditional statements. For example, the following uses a conditional statement to check a preceeding text assignment to return a value.

Key	Value		Equation
Status	Active	=	
IsActive	1	=	Status="Active" ? 1 : 0
		=	

In this example, a conditional statement is used to check a preceeding value calculation to return text.

Key	Value		Equation
IsActive	1	=	Aavg_IsActive=1
Status	Active	=	IsActive=1 ? "Active" : ""
		=	

Note that the first equation above is a comparison (=) that is not checked within a conditional statement. In a case like this, comparisons simply return 1 for true and 0 for false.

Example 2 – Mimic Variability Tracer

This example uses the 'Herald_MAY28' test model.

- Ctrl-Click on the Entry Function [Finish Loading (4)].

- In the Key field, type 'Time' and then enter '0' into the Value field.

- Enter a second Key named 'Precision' and enter '0' into the Value field.

| Key	Value
Time	0
Precision	0

- Click on the Background Function [Issue company rules (7)]. The two Keys Time and Precision will appear. Enter '0' into both of the Value fields.

- Click on Foreground Function [Trim vessel (2)] and click the '=' button to bring up the equation entry box for both Time and Precision.

- For **Time**, enter the equation: **Amax_Time**
  For **Precision**, enter the equation: **Amax_Precision**
  These will take the maximum value from upstream Funcitons for Time and Precision keys respectively.

- Repeat the same equations for the other four foreground functions.

- At the far right, enter the text 'Time' into the **Key 1** field, and the text 'Precision' into the **Key 2** field.

Key	Value	Equation	Functions / Variables	Display Results	
Time	0	= Amax_Time	Imax_Time / An_Time / Asum_Time / Aavg_Time / Amin_Time / **Amax_Time**	-1 0 0.5 1 2	Key 1 Time
Precision	0	= Amax_Precision		-1 0 0.5 1 2	Key 2 Precision
		=			

- Now if you step through all of the cycles of the FMI the Funcitons will display a green band at the top representing the Time value, and a green band at the bottom representing the Precision value. The green colour represents a neutral position of zero. To understand the range of these default colours, you can refer to the 'More>>' Function Type information where the colours are shown against the Potential Output Variability.

- To test the variability tracer, select the Function [Close bow doors (1)] and click the '=' button for the Time key to turn off the equation, and enter a value of '2'. This represents a known instantiation of 'Not at all' for the Potential Output Variability with respect to Time.

- Now when you reset the FMI and advance through all cycles, the [Close bow doors (1)] Function will display a red bar for Time, and this will be propogated to the downstream Function [Leave harbour (0)]. This works in exactly the same way as the 'Show Variability' button.
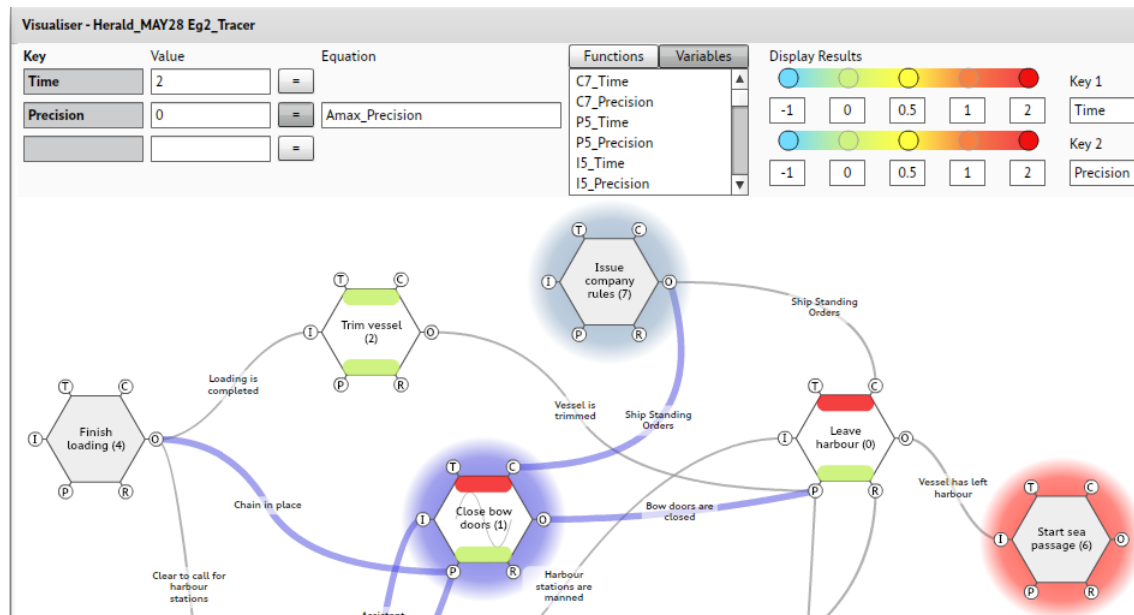
As a variation for this example, you could consider replacing the **Amax_** variables with **Aavg_** variables. Instead of propogating the maximum value downstream, this would moderate the downstream calculation with values from the other Aspects.

Another variation that could be more relevant to this specific case is to consider a different calculation for the [Leave harbour (0)] Function. It is possible to have different equations for each function, and to reference a different Key in the calcultion, such as the following in the Precision Key:

$$\overbrace{a} \quad \overbrace{b} \quad \overbrace{c} \quad \overbrace{d}$$

Precision = Imax_Time>0 ? 0 : Pavg_Time>0 ? Pavg_Time : Pavg_Precision

a. If the maximum Time From the Input is >0 (not on time or late) then Precision is 0.
b. Else, if average Time from the Preconditions is >0 (not on time or late)
c. Then Precision is the average Time from the Preconditions
d. Else, Precision is the average Precision from the Preconditions

In other words, if you force the Function to be on-time when the Input is present, but Preconditions are late or did not occur, then the Precision could be compromised.

This should simply be taken as an example of a cross-key nested conditional statement and not be used directly as a method to interpret or analyse other models.

The primary purpose of providing the equation and calculation functionality is to encourage research and experimentation. Ideally, any meaningful FRAM model interpretation methods that emerge would be published and reviewed. Initially there is scope for the functionality to be tested using interpretation and analysis methods that have already been published.