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Document Title:	Document presenting the MMI and relevant MMI mock-up

Abstract	**This document presents** the **MMI and relevant MMI mock-up of the Harness Geographic Plan at T0 +27.**

Keyword List	WP4, wiring diagram, display, link

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1 Manipulation of harness elements

1.1 Creation of an equipment

To create an equipment needs three steps.

1) the user has to choose which type of equipment he wants to create. He does it by clicking on the adequate button which has a special icon and a caption.
2) a click on the folio places the equipment at the clicked point. If the equipment is placed on other equipment that can contain it, it is added to the content of this one.
3) a window is displayed and the user types in data of the equipment.

1.2 Creation of a link

To create a wire, a cable or a bundle needs four steps.

1) the user has to choose which type of link he wants to create. He does it by clicking on the adequate button which has a special icon and a caption.
2) a click on the folio places the first extremity of the link. If this first point is a part of equipment, the link is connected to the equipment. Else, the link is not connected at this extremity.
3) a second click on the folio places the second extremity of the link. If this point is a part of equipment, the link is connected to the equipment. Else, the link is not connected at this extremity.
4) a window is displayed and the user types in data of the equipment.

1.3 Selection of an equipment

Equipment can be identified thanks to its graphic. To select the equipment, the user makes a click on it. Once the equipment is selected, its color changes and the user can execute several functions: a right click makes appear a popup menu that allows choosing one of them.

1.4 Selection of a link

The selection of a wire, a cable or a bundle is the same as the selection of equipment.

1.5 Selection of a group of objects

The user both selects each object as explained before and presses “Shift”.

Other method: the user presses the left button of the mouse and drags it. It draws a rectangle in which each object became selected.

1.6 To display properties of an equipment or properties of a link

The user selects the object and makes a right click. A popup menu is displayed and the user chooses “Properties”. It displays a window in which we can see:

- data typed in at the creation of this object,
- name of objects connected to this one,
- the hierarchy of objects that it contains.

1.7 Suppression of an equipment or a link

To suppress an equipment or a link, the user has to select it. Then, two possibilities:

- either he presses the key “Suppr”
- or he makes a right click and chooses “Delete” in the popup menu.

If the suppressed object contains other objects, those ones are suppressed too.

There is a third method to suppress a link:

- to select the link
- to make a click on one of its extremities and move it on the other extremity. This last click suppresses the link.

1.8 To move an equipment

Firstly, the user selects the equipment. Secondly, three possibilities:

- the user press the key “D”
- or he makes a right click and choose “Move” in the popup menu
- or he makes a second click on the selected equipment.

Thirdly, the user makes a click on the folio to design the new place of this object.

If this equipment is linked, extremities of links are moved too and the equipment is not disconnected.

1.9 To move a link

It is the same method as moving an equipment.

If the link is not connected, both the two extremities move at the same time.

Else, if exactly one extremity is connected, the only extremity that moves is the other.

Else, if each extremity is connected, the link doesn’t move.

1.10 To move a group of objects

The user selects a group of objects and method and result are the same as explained before.

1.11 To copy an equipment or a link

Firstly, the user selects an equipment. Secondly, two possibilities:

- the user press the key “C”
- or he makes a right click and choose “Copy” in the popup menu

Thirdly, the user moves the copy and designates its place by clicking.

And last, a window is displayed and the user type in data of the copy.

1.12 To add an equipment to the content of another

Two possibilities:

1) The user has to move the equipment on another that can contain it.
2) The user creates and places a new equipment on another that can contain it.

1.13 To select an extremity of a link

The user has to select a link and to make a click on the extremity he wants to select.

1.14 Connection of a link to an equipment

The user has to select an extremity of the link and to move it on an equipment that he can design by clicking. If the user displays properties of the equipment or properties of the link, he can see at the bottom of the window to which object it is connected.

1.15 Disconnection of a link

The user has to select a connected extremity of the link and to move it to another place that he can design by clicking.

1.16 Insertion of a link in another

If the user wants to a link goes throw another, he has to execute three steps:

1) select the adequate tool by clicking on its button which has a special icon and a caption
2) select the link that he wants to insert in another
3) select the link that will contain the first one.

2 Tools that prevent identification and manipulation errors

2.1 Pen of a link

A click on the tool “pen” makes appear a window which allows choosing several attributes in order to define the line which represents a link (wire, cable or bundle): line style, color and sickness.

2.2 Line style

Several line styles are available: continuous, broken, point, axis, double axis, invisible. The user chooses one by clicking on it.

2.3 Color

A click on the colored rectangle makes appear a window which allows choosing the adequate color:

2.4 Sickness

Thickness is fixed at 1/10mm. If the user enters a value of 10, this corresponds on the diagram to a pen with a 1mm thickness.

2.5 To underline a link

When a cable pass throw several bundle, it can be difficult for the user to follow it. That’s why a function allows underlining each link that contains a particular link.

Example

Consider a simple wiring diagram that contains:

- a blue bundle T2 that contains two red wires F1 and F2
- a green bundle T1 that contains a third red wire F3 and a part of the blue bundle T2

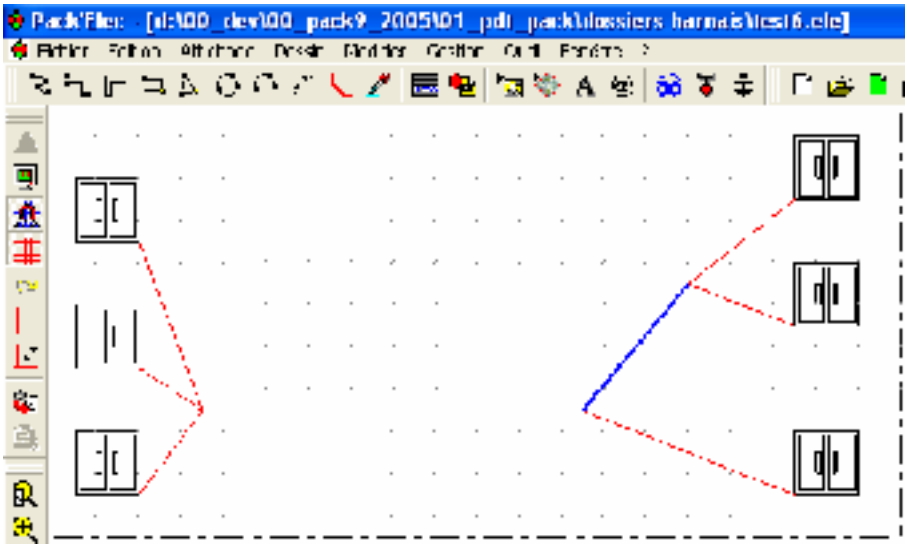

Figure 1 a harness

If the user wants to display the whole road of the wire F2, he can select it and press the adequate button. To select it, the user makes a click on one of its sections (bundle T2 in this example), press properties button and select the wire in the tree at the top of the windows. Icon of the button is a bulb.

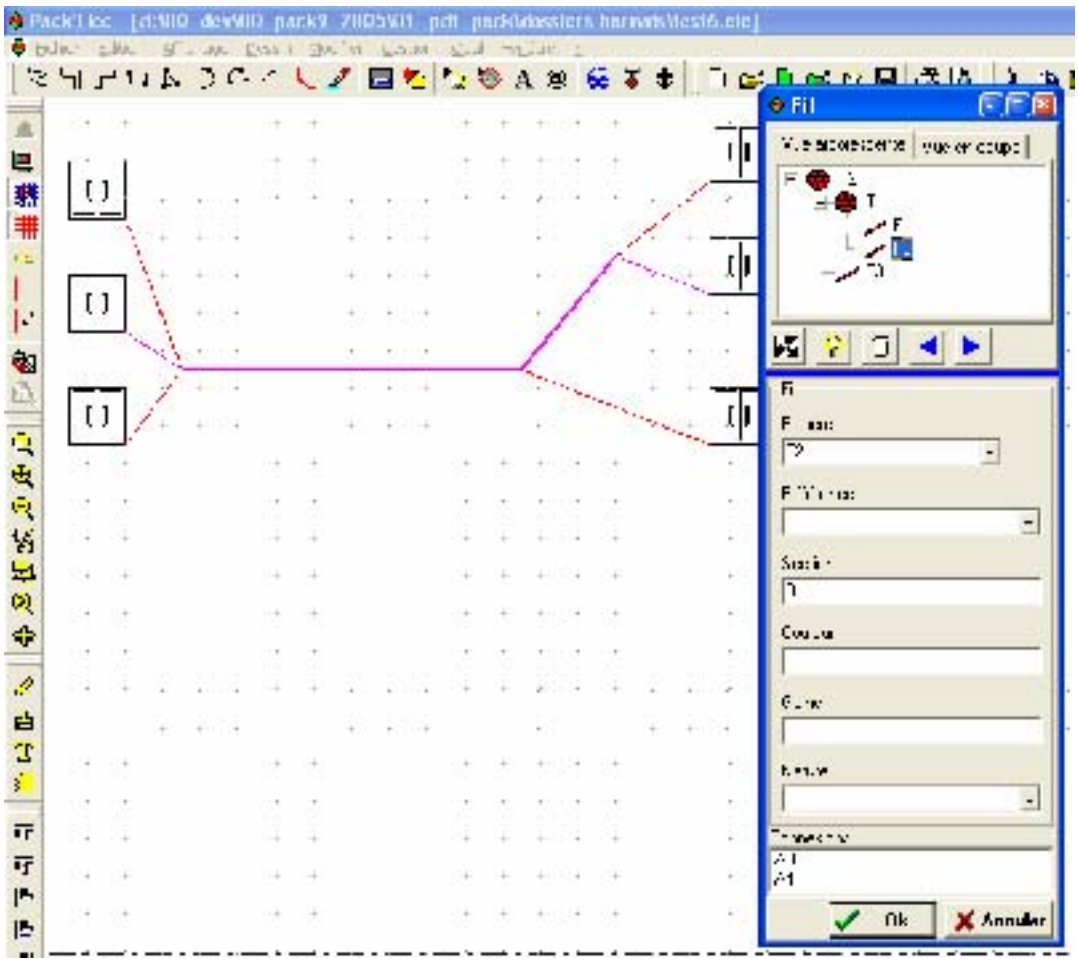

Figure 2 Road of F2 underlined thanks to a pink coloration

As a result, the whole road of the wire F2 is colored in pink.

2.6 To underline equipments connected to a link

The same function can be applied to equipments connected to this wire: the user just has to select it in connection list equipments that he wants to underline:

2.7 To move from a section to another

Other way to see the road of a link is to display properties of one of its section and to go to its adjacent section and so on. This is possible thanks to buttons with blue arrows.

2.8 Error management

Number of message box is limited as much as possible in order not to irritate the user with error messages but the result of an action is always easily visible. Consequently, if an action doesn't provide the expected result, the user sees it immediately and can correct it.

2.9 Error correction

An error never implies a loss of data. The user can always use undo function in order to go back to a previous state.

Each function of the interface has its opposite function. For example, the opposite function of connecting a wire to an equipment is disconnecting the wire and the equipment. So, other way to correct an error is to execute the opposite function of witch has lead to this error.

2.10 Display name of links on their graphic representation

In order to prevent errors, the user has to identify a link easily. The name of each object is already visible in the property window but it displays only one object at a time. That's why we choose to display the name of wires, cables and bundles directly on their graphic representation. The next figure shows that it is like a label on the wire.

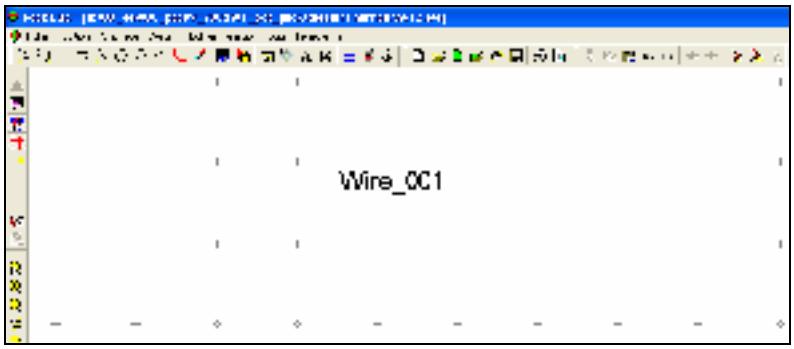

Figure 3 The name of the link is displayed

This label can be moved by the user: he just has to select it by a click and to drag it at the place of its choice. If the link is moved, the relative place of the label toward the link is kept.

2.11 Real time update of label of links

If the user changes the name of a link, its label is automatically updated in real time.
If the link is moved, the label moves at the same time.
If the link is suppressed, its label disappears at the same time.

2.12 Addition of textual data in graphic representation of equipments

In the same idea, we add textual data on equipments. The difference with label of links is that data is directly written on the graphic representation of equipments: it can not be dissociated from it.

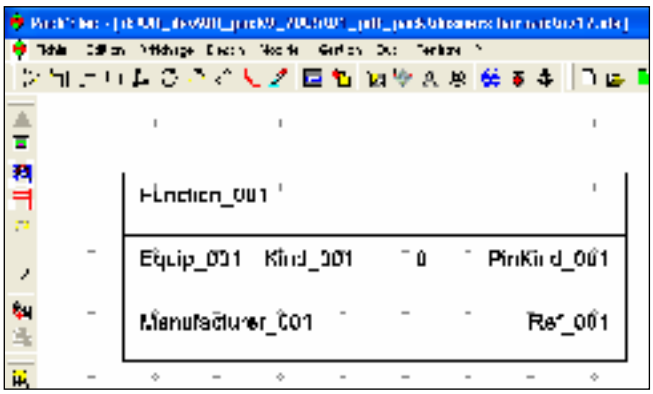

Figure 4 Displaying data on an equipment

This function allows to know characteristics of each equipment without displaying the property window.
It can be modified by the user at any time. Display is automatically updated is real time.

3 Link with a file that allows to know equipment data thanks to its reference

Data of an equipment are known thanks to a file that can be provided by manufacturers: it contains references and data of equipments and their connections.

When the user chooses a reference for the equipment that he is creating in the harness, the software loads this Excel file, allots its data to the object and display it.

The graphic user interface allows changing the path of this file at any time.

4 Automatically create graphic representation of each connection of an equipment

Each connection (or pin) of an equipment has its graphic representation. When an equipment is drawn, its connections are drawn at the same time.
The Excel file can inform about number of connections of an equipment. It allows to automatically create it when the user creates an equipment.
If the reference of the equipment is changed, connections are replaced in real time by connections associated to the new reference in the Excel file.

5 Addition of textual data in graphic representation of a connection

Data of connections are not stored in a file, it deals with links which are connected: the name of the link and the equipment connected to the other extremity of the link.

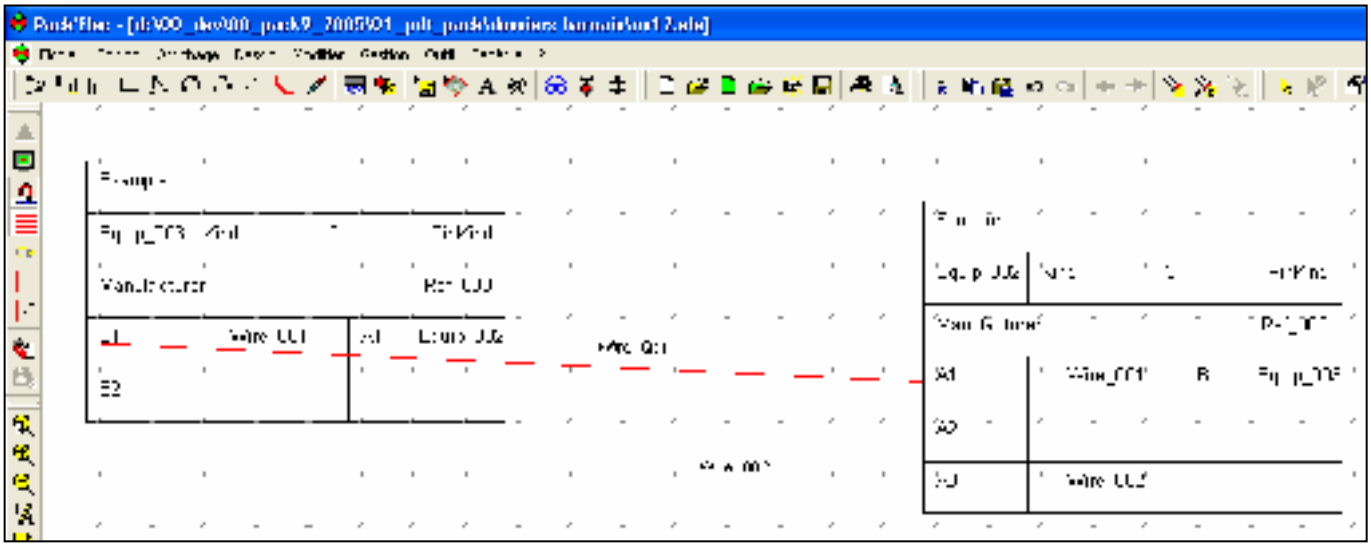

Figure 5 Connection data

Figure 5 shows a red link, Wire_001, which goes from connection B1 of Equip_003 to connection A1 of Equip_002. Wire_002, is only connected to Equip_002.

Connection data is written on each connection of each equipment, like cross-references.
This graphic representation doesn't allows more than one link on one connection.

5.1 Real time update of connection data

If a link is disconnected, data written on the connection is automatically updated in real time.

This function allows:

- to keep coherence between the harness and its graphic representation.
- To prevent errors by showing which equipments are connected to a particular one and thanks to which links.

To draw a harness on several pages implies to be able:

- To make a link between two objects which are not on the same page
- To move objects from a page to another
- To copy objects from a page to another
- To insert a cable into a bundle which goes from a page to another
- To view on a page an object already drawn on an other page

6 To make a link between two objects which are not on the same page

If a link is drawn from a source page to a destination page, its graphic representation must show a cut on the side of the source page. An other cut on the side of the destination page must show its continuation. Consequently, this link has two graphic representations: one on the source page and the other on the destination page but each graphic representation gives an access to data of the same link.

7 To move objects from a page to another

To move objects is a functionality already implemented but the change of page adds some difficulties. The user must be able to select the object on the source page, to change the page and to put the object on the new page. Moreover, if the object was linked, the link (wire, cable or bundle) must still exist and be redrawn.

There are three possible configurations:

1) If the object is linked to an object of the source page, the link has to go from the source page to the new page. It implies that the link has to be cut on the source page and restored on the new page.
2) If the object is linked to an object of the new page, the two objects must be linked directly.
3) Last case: the object is linked to an object of a third page.

8 To copy objects from a page to another

Copy an object doesn't imply copy its links. So there is no management of links: the new object is created without any link.

9 To insert a cable into a bundle which goes from a page to another

If a cable is inserted into a bundle which goes from a page to another, there are four possibilities:

1) extremities of the cable are on the same pages than extremities of the bundle
2) the two extremities of the cable are on the same page and this page contains one extremity of the bundle

3) one extremity of the cable is on a third page different from pages of extremities of the bundle.
4) extremities of the cable are on two several pages different from pages which contains extremities of the bundle.

Each of those cases would need a particular solution. If the comportment of the software is not always the same for an action, it can disturb the user and be hurtful to its understandability. That is why we choose to forbid cases 2) 3) and 4). Case 1) is the only which will be implemented: a cable can be inserted in a bundle if their extremities are on the same page(s).

10 To view on a page an object already drawn on an other page

It can be useful for the user to draw a second view of an object which already exists on another page.
In this case, it is not a copy: there is only one object (and its data) but it has two graphic representations. Consequently, if the name of this object is changed, it will be updated both on its two graphic representations: each view gives an access to the same data of this object.

11 Interface on several pages

Conception aspects of using more than one page for harness Man Machine Interface has been studied in previous report (WR-FRESH- WP4-ALGO-T5).

12 Harness Man Machine Interface

In Man Machine Interface of the harness, a window is specially useful: this windows allows

- to display properties of an element of the harness,
- to modify these properties.

13 To offer two ways to automatically rename elements after a copy

When the user selects elements and copies them, he has to change the name of the copies in order to prevent duplication of names.
An automatic renaming has been developed. It offers two ways to rename elements:

14 To ensure ATA coherence between wires and cables

Wires and cables have an ATA value. The ATA value depends on the function for which the wire or the cable is used. Wires of a cable must have the same ATA value as the cable. If wires have no value for ATA they take the ATA value of the cable but ATA can be not valuated and a wire can have an ATA value even if it is not inside any cable.
In order to prevent errors, an automatic control ensures that all ATA values are coherent for each cable and wire.
If it is not, the user is informed that he has to modify ATA value of this element.

15 To display more than one graphic representation of a same element

Sometimes, it can be useful to have several graphic representations of the same element.
For example, if the user wants to design a harness with one function by folio, and an element is involved in several functions, he has to use several graphic representations of this element.
It is now possible: when the user creates an element, he can check the box “Several graphic representations”.
Properties of the element are the same for each of its graphic representation.

An element exists while it has at least one graphic representation. When the user suppresses the last graphic representation of an element, this element is suppressed too.

16 To use outputs of Zenon’s Component

Zenon’s component calculates the best place for each object of the harness in order to prevent their overlapping and crossing of wires cables and bundles.

Outputs of the component consist in the expression of the place of each object. The difficulty is that the size and the origin of the folio are not taken into account by the component.
That is why some process has to be applied on those results in order to be usable by the Computer Assisted Design software. This work consists in calculating a translation and a homothetie in order to centre and stretch position of objects without loosing their position the ones against the others.

17 Bundles use

The user can create bundles in order to link several equipments and/or areas. He can also connect a bundle to another bundle if he wants to draw a way. Then, wires and cables will go throw this way.

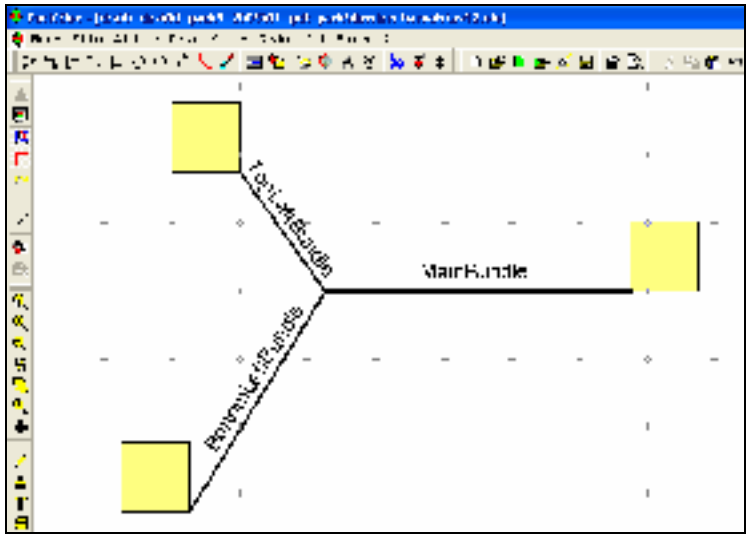

Figure 6 Way made with bundles

Remark: When the extremity of a bundle is moved, extremity of each wire, cable or bundle which go throw this one are moved at the same time: they are linked.

18 Automatic search of possible ways for a new link created between two equipments

When the user creates a link, the software automatically suggests existing way for this new link. The user chooses one and the new link is automatically inserted it in this way.

Figure 7 shows how the user can select a way in order to create a new link between Equip_002 and Equip_003. To ways are possible:

1) direct (without any bundle)
2) a way made by TopLeftBundle and MainBundle.

When the user selects one of them, it is underlined in pink.

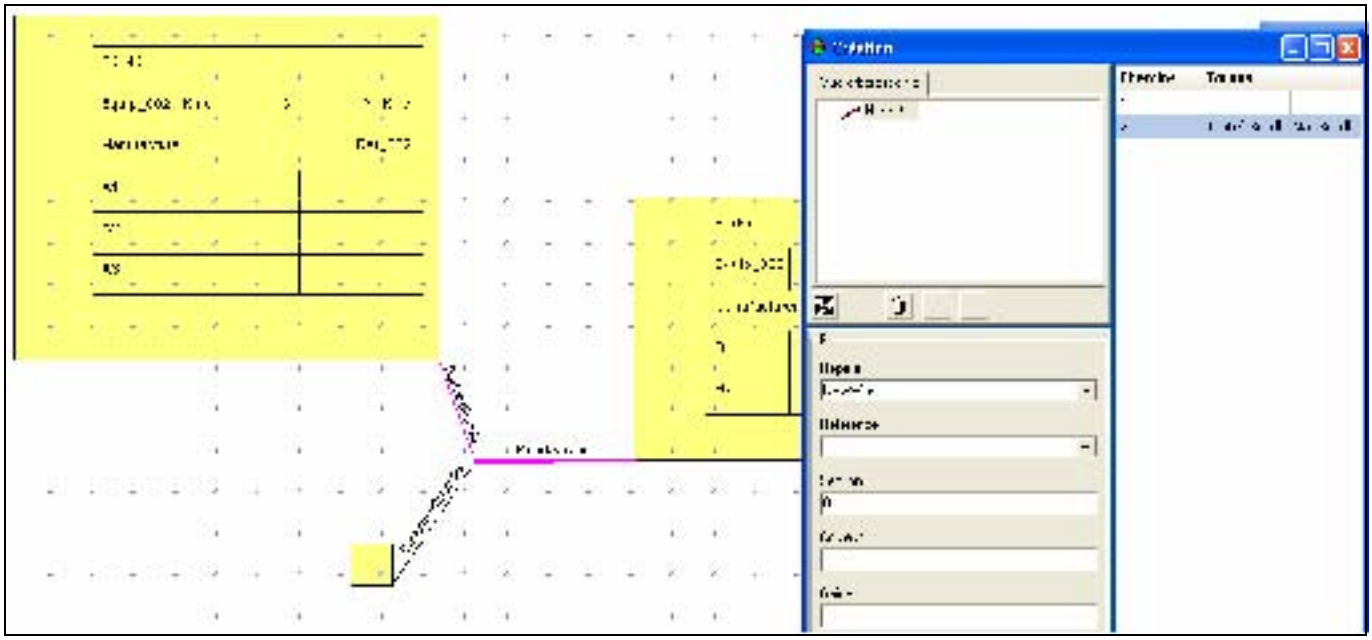

Figure 7 Selection of a way made of bundles

The user gains time thanks to this function which automatically insert the new link in a way automatically suggested.

19 Memorization of several colors already used

It was already possible to choose the color of the link before to draw it.
But in order to easily choose, each color ever used to draw a link is memorized.

20 Default color for each type of link

Several types of links are wire, cable and bundle. We can suppose that the user would like to use a particular color for each type of link.
This new functionality consists in memorizing the last color used to draw a type of link. This color is the default color for drawing this type of link. Each time the user draws this type of link, the color automatically changes to the default color.

21 Use of polyline to draw a link

Until this moment, links can only be straight lines. This is the standard way to represent links in harness. It is an important constraint for the user: it can be difficult to draw a straight line between two objects without crossing or overlapping other objects.
That's why we choose to give the possibility to the user to draw a link thanks to a polylines. Like shown on the ext figure, a polyline allows outlining an object.

Figure 8 Polyline

This functionality prevents crossing and overlapping. It increases readability of the harness.

22 Place of the link's name on the polyligne

The name of a link is always written on this link.
We choose to write it on the middle of the longer segment.

Representation of a harness on more than one folio

As a harness can now be drawn on more than one folio, we define a new object: "go to". This object aims at indicate that the graphic representation of a wire goes on another folio. A "go to" is associated to another one which is on another folio.

22.1 Manual Creation of a "go to"

This object can be created "manually":

- Clic on the button "go to",
- Clic on the folio in order to place the "go to",
- A window appears,
- the user can type in
    - the name of the "go to",

- the name of the other “go to” that has to be associated to this one,
- and clic on OK to valid the creation.

This object can be linked to a wire, like others.
Difference with other objects: when the user creates a new wire connected to a “go to”, the software allows defining that this wire is one of those which are already connected to the associated “go to”.

22.2 Automatic creation of a “go to”

Wires can be automatically created if the harness is drawn thanks to the wiring list.
If two objects that have to be linked are each one on a different folio, the wire is automatically created from a folio to the other:

- “go to” are automatically created with default name,
- they are automatically associated,
- they are automatically linked to the wire on each folio.

23 Dynamic links between folios

A new function is added to “go to” object. Its aim is to easily display the folio which is linked thanks to the “go to”.
This function is activated when the user moves the mouse on a “go to” maintaining the control key pressed: a different cursor is displayed showing that a “left clic” changes the folio.

This is an easy way to see a link (wire, cable or strand) from its beginning to its ending showing each folio the one after the other.

24 To extend a cable after the extremity of a strand

A strand can contain cables. If contained cables are cut at the extremities of the strand, the user can decide to choose one cable in order to make it longer and be able to manipulate it independently from the strand in which it is contained. A new tool has been developed and give the possibility to extend a cable after the extremity of a strand.

25 Filter of folio in the MMI

The man machine interface shows details and properties of selected objects.
It is now also possible to choose to display all elements which are on the displayed folio or on another one.
This new function can be accessed thanks to a combo box: the user chooses a folio in the list and the window is reloaded in order to display properties and details of elements drawn on the selected folio.

26 Filter of type of element in the MMI

The user can choose to display only wire or only cable, or only areas etc.
When a type of element is selected in the list, the window is reloaded in order to display details and properties of each element of this type.

27 New drawing for wires, cables and bundels

The user can already choose the colour and the thin that he wants to draw a wire, a cable or bundle. A new possibility is given to the user: to choose the type of trait.

Different type of trait can be applied:

- Polyline,
- Opened tube,
- Closed tube,
- Splin.

We can notice that in case of a tube, the user can choose a colour for the lines which border the tube different from the colour which fills the tube.
In all cases, the user is able to change the place of control points at any time in order to modify the route of the wire, cable or bundle.

Moreover, the last type of trait used to draw a type of link (wire, cable or bundle) is automatically stored by the software.
The same memory function is applied to the colour.

Those memory functions allow saving time during drawing operations.

Appropriate choice of colours and type of trait can help the user to prevent errors by drawing harness easily readable and understandable.

28 Man Machine Interface to compare the harness and the wiring list

In a previous report (WR-FRESH- WP4-ALGO-T4), the use of a wiring list is evocated:
The wiring list is a file that contains, for each wire, its two equipments connected and other specific data of wires and equipments. This is an Excel file automatically created by exporting an electrical schema drawn in Elec'View (the Computer Assisted Design software of Algo'Tech Informatique).

The new function developed is a Man Machine Interface which does a comparison between the content of the wiring list and the content of harness.

The content of the wiring list is displayed on the right and the content of the harness is displayed on the left. A color is attributed to each element which constitutes the content.

This code of colors allows seeing immediately differences between the wiring list and the harness drawn: the user save time.

This function helps the user if he is drawing the harness thanks to the wiring list: this comparison helps to prevent the user from forgetting to represent on the harness an element which is in the wiring list.