



## Deliverable Report

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Abstract	This deliverable is a first proposition for building up a knowledge base for the purpose of recognition tasks of WP2.
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## Chapter 1 Introduction and analysis of needs

The principal aim of this intermediate report is to start listing all information which is present in wiring diagrams and which is of use for building up a semantic knowledge base for recognition purposes. The data to be taken into consideration can be graphical or textual, they can deal with *representation* purposes or convey information about *physical characteristics* of the elements.

This report is based on:

- the graphical analysis of wiring diagrams for Airbus A318/A319/A320/A321 and for the ATR, which we described in deliverable D2.6.1;
- the analysis of the features of the PackElecBuilder software by Algotech;
- the analysis of the modeling features provided by the PIVOT language and described in deliverable D3.1.

Chapter [2](#) presents the information which is available at the moment. We then detail the proposed content and structure of the knowledge base in chapter [3](#). Finally, chapter [4](#) lists the work still to be done.

### Analysis of needs

Let us start by reminding about the tasks and processes:

1. The *segmentation* step separates the diagram into a text layer, a wire line layer and a symbol layer (see D.2.2.1).
2. The text layer is processed by the *text recognition* step which in its first phase proposes an ordered list of character hypotheses for each candidate character (see D.2.3.1).
3. The *symbol recognition* process starts by decomposing the symbol layer into a number of basic geometric and topological features (see deliverable D.2.2.4) which will then be used to provide an ordered list of possible symbols. These candidate models will then be matched with the symbol under consideration to provide the final hypothesis.
4. The whole process is under the supervision of a human operator who can correct recognition mistakes, provide feedback to the system and make decisions about recognition hypotheses (see deliverable D.3.2).

To answer the needs of the *symbol recognition* processes, the following information must be available in the knowledge base, for retrieval and editing:

- geometric composition,
- relative positioning of a symbol part with respect to another one,
- list of points where equipment is connected through wires,
- symbol drafting constraints

*Text recognition* has to use information about the syntax used in annotations of diagrams.

Dictionaries can be designed, providing the rules for a large part of the annotations in wiring diagrams. The association rules between graphical parts and textual parts also have to be represented, for helping the segmentation and recognition processes. This is all the more important because text recognition can improve and guide symbol recognition, and vice versa.

## Chapter 2 Available information

In this section, we list the information we can base the knowledge base on.

It is important to note that each component can be associated with

- one or several graphical representations,
- physical properties, which also have to be represented graphically,
- syntactical rules for combining the component with the other components of a diagram.

### 2.1 Information available in the segmentation subprocesses

The software designed is an interactive tool by which an operator can quickly identify and segment a diagram into wire lines, symbol bounding boxes and text bounding boxes (see deliverable D.2.2.1). The system automatically computes the connections of the symbols and records them. It is also able to produce subimages of the isolated symbols and characters.

### 2.2 Information available in the symbol recognition subprocesses

In developments prior to this project, a reference database of symbols has been designed, although not for aircraft wiring diagrams. In the existing reference bases, the following information is associated with each symbol :

- a vectorial representation of the geometric composition of the symbol and of the relative position of its textual parameters,
- the name of the symbol and the default syntax of the way the physical parameters of the component are represented,
- geometric constraints.

While analyzing ATA Specification No. 100 (see deliverable D.2.6.1), LORIA has built up a table providing a basic representation of the shapes present in symbols and their composition rules.

#### **Number of rectangles** —

To detect a rectangle, the system looks for 4 corners aligned, through template matching, and then checks if the rectangle is closed or open by tracking the lines joining these corners.

#### **Number of occlusions** —

Occlusion detection relies on a compacity test for small white connected components.

#### **Number and type of connections with occlusions** —

Once a small occlusion has been detected, the recognition system checks for the number of connections on the contour of this occlusion (Figure 2. 1 : **Detecting connections with small occlusions.**).

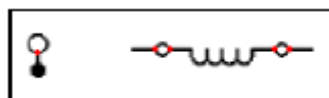


Figure 2. 1 : Detecting connections with small occlusions.

**Number of connected components —**

The system counts the number of the following types of connected components:

**thick:**

this is done through a mathematical morphology operator

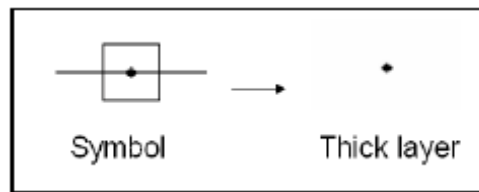


Figure 2. 2 : Detection of thick connected components.

**black without included white components:**

this is done using the inclusion tree of connected components built by the process and illustrated by Figure 2. 3: **Inclusion tree of connected components..**

**white without included black components:**

done in the same way...

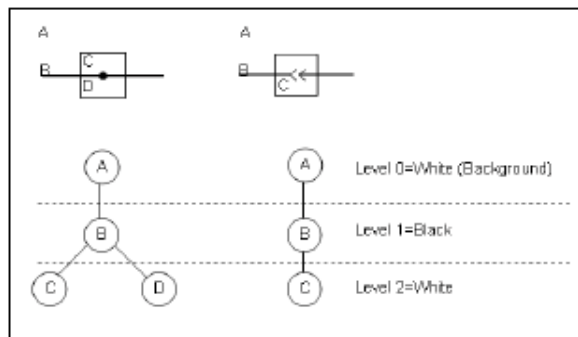


Figure 2. 3: Inclusion tree of connected components.

**Number of end points —**

this is the number of points “going out” from the symbol to connect to the wires.

## 2.3 Other possible sources of information

A source of information can be retrieved from the title block of the diagrams and the notes made by draftsmen. These pieces of information also contain handwritten notes which are probably too hard to process automatically. But if necessary, an operator could probably extract useful information.



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## Chapter 3 Content of the knowledge base

We will now propose a set of characteristics to be stored in the knowledge base. We begin by listing the geometrical properties, and we propose a possible formalism for describing them.

We will then complement with *semantic information*. By that, we mean information about the domain knowledge of wiring diagrams, and not only about the graphical representation. We have to concentrate first and foremost on the information necessary for recognition purposes. We will separate the semantical information stemming from technical knowledge about electrical wiring in aircraft, to that specific to its graphical representation.

Finally, we discuss possible representation formats for this knowledge base, including the possible use of the PIVOT language.

### 3.1 Choice of model description

The geometrical description of the representation of each possible wiring diagram component has to be as precise and complete as possible, to enable non ambiguous recognition of graphical symbols in the documents to be analyzed while leaving the possibility of adding new symbols when they appear.

We must take into account the noise which is present when dealing with wiring diagrams. One possibility would be to build a realistic model of the symbol through learning of a representation which takes into account the various possible deformations.

We choose a solution: separately describing the ideal symbol on one hand, and modeling the noise as well as we can on the other hand. This allows us to modify independently assumptions about deformations or adjust the matching tolerance, in a batch of documents to be processed, without reconsidering the geometrical symbol models themselves.

It is important to work with pixel-based models which are derived from higher-level representations of the symbols. Our current proposal is therefore to represent each model symbol in *vectorial* format, which has the following advantages:

- a distortion-free pixel-based representation can be derived from the vectorial model at any requested resolution;
- this representation is easily compatible with the expression of specific deformations or of the relative positioning of elements;
- complex symbols can be composed by geometrical assembly of simpler symbols, using their vectorial description;
- new symbols can be easily added to the database without having to recompute all the base with its signatures.

### 3.2 Specification of the description

We propose a framework for the description of all graphical elements' 2D geometry and semantic properties. Figure 3. 1 : **Proposed structure of the reference base.** presents the structure of the reference base we propose; it allows us to represent a large variability of symbol representations, and also to include related semantical aspects.

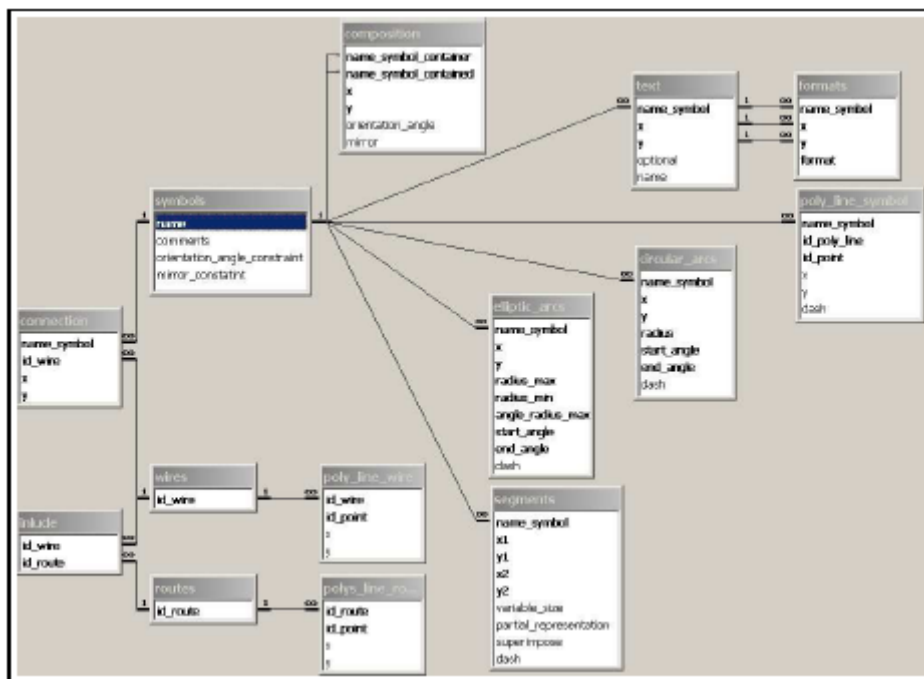


Figure 3. 1 : Proposed structure of the reference base.

#### 3.2.1 Simple symbols

The following symbols are considered as being simple:

- the symbols which cannot be composed by assembling other symbols already referenced in the base;
- connections which are not included in the description of a symbol
- A symbol has a graphical representation and may have connections. All symbols are not components, but we can choose to use some symbols which are just subparts of bigger symbols. They can also be associated with text.

The geometric description of each symbol is based upon the following graphical elements: segment, circular arc, elliptical arc, polyline, text. The coordinate framework for each symbol has its origin at the upper left corner of the symbol's bounding box.

### 3.2.1.1 Segments

A segment is identified by its coordinates and by the symbol to which it belongs. For a given symbol, there can only be one segment having the same coordinates. Segments are the only basic features which can be subject to the following distortions: important size change independently of that of other features, superimposition with wire lines and partial representation.

### 3.2.1.2 Circular and elliptical arcs

An arc is described by the coordinates of center. In addition, for a circular arc by the radius. And for an elliptical arc by the radius and by the starting and ending angle of the arc.

### 3.2.1.3 Polylines

A polyline is made of at least 2 segments. It is identified by the number of segments of the polyline, and by the coordinates of each point of the polyline;

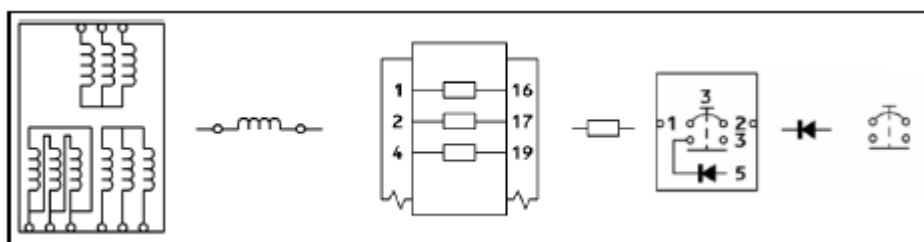
### 3.2.2 Text

The anchor point for a text zone is at the top left corner of its bounding box. At a given location of a symbol, there can only be one text block around the anchor point, but it can have various formats.

The text often complies with a specific format, which can be defined by a dictionary, a regular expression or a grammar. In the present proposal, we assume that the specific format of a text zone can be specified through a regular expression.

### 3.2.3 Composed symbols

Some symbols are said to be *composed* because they are built by the assembly of symbols already present in the base.




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Figure 3. 2 : Composed symbols.

The position of their component parts is not always specified in advance, it can vary depending on the diagram they appear in.

A choice which may not always be simple is that of deciding to which level of detail symbols have to be decomposed, especially for families having a common graphical base and differing only by a few graphical features

The *advantages* of such a decomposition are:

- It is possible to identify basic graphical which can be the vocabulary for a higher-level description language, to express compositions in a more powerful way than just by assembling segments and arcs;
- it is possible to identify symbols which are graphically similar, which can be useful in the choice of the best way to differentiate them;
- the reference base can be described in a homogeneous way—a recurring graphical feature keeps the same representation, independently of the symbol in which it appears;
- the decomposition can be directly used in a structural recognition method.

However, there are some *drawbacks* to such a choice:

- Such a decomposition would not be directly usable by the current method as there is no composition operator which applies to the descriptors used.
- When creating a new symbol, there is a risk that the user may unknowingly recreate graphical features which already exist in the reference base. To avoid that, it is however possible to use methods to assist the user in retrieving symbols already known in the database.

Final decision has yet to be reached on this choice of decomposition level.

### 3.2.4 Connections and wires

A *connection* has no representation per se, it is only a label to position the connection point with respect to the graphical representation of equipment. It must be noted that this positioning is very important to discriminate within some families of symbols.

## 3.3 Representation format for the base

We need the knowledge base to contain a number of basic graphical features which are already present in the PIVOT language, namely segments, polylines and arcs. Other geometrical attributes are not currently defined by PIVOT. We therefore will have to make a choice between various options:

- extend the PIVOT defined within WP3 to take into account all our attributes and basic features;
- continue using the CSV exchange format already in use within WP2;



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- extend on the VEC format used in various performance evaluation contexts for exchanging vectorial data or use some other vectorial de facto standard such as DXF.

## Chapter 4 Conclusion and perspectives

This intermediate report gives a view centered on WP2, i.e. symbol and text recognition. It may have to be complemented by information provided by the other partners, especially on knowledge around aircraft electricity, if the associated semantical knowledge is deemed to be necessary for recognition tasks.

The geometrical composition of each symbol should be available very soon.

The physical properties must be added by the various partners, so that each symbol can be represented by:

- a vectorial representation with all the attributes presented in this deliverable,
- an image of the symbol at a chosen resolution,
- the name of the symbol.