Degree Project - Metadata implementation through the Digital Mock-Up

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I dedicate this report to all my teachers who have taught me all the things that have made me an Engineer. I also thank my supervisor Florent Excoffier and the whole team at Airbus which make me discover the Airbus Company and Team Spirit.
1 Introduction

Airbus is one of the two leaders in commercial aircraft manufacturing. This field of production is the biggest in amount of parts to design, products and assemblies. Moreover, as nowadays computing has become the fastest way to work, not only it has surrounded the current work places physically but also digitally speaking.

In fact, the big issue of all companies and in particular Airbus, is to manage the flow of data provided by the different engineering teams like design, simulations, testing or production. Currently, the management of this Metadata is poorly developed and it creates loss of time and frustration when the time has come to find it.

To counteract to this growing concern, the Airbus solution project can be resumed by one sentence : "Configure Digital Mock-Up as master". It aims at gathering all the data from the different engineering teams and to provide an intuitive way to exploit them through the DMU.

In the case of my study, I had to work on one aspect of this big project. I discovered the Airbus way of working and supported several projects to improve the cDMU (configured Digital Mock-Up) as Master.

2 A350 Program

2.1 Brief history of A350 program

With the continuously growing price of the petroleum and in the race of competition between Boeing and Airbus, the A350 program began in October 2005 in response to the Boeing 787. The first versions of A350-900 could carry from 250 to 300 passengers with a maximum range of 16 300 kilometers. The body and wing structures are composed of more than 50% of carbon fiber materials, the wing tips and the Rolls-Royce Trent XWB engines make the A350 design the most efficient aircraft of its category. With the success of A350-900 orders and in the willing to replace the old A340, the A350-1000 project was launch. It reuse a great part of the design of the A350-900 in the target to have a maximum of communality with this previous version to reduce as much as possible the costs.

Not only has the A350 program technical and design improvement but also in the industrial and R&D management. Indeed, the A350 program is the first to have experimented a full DMU (Digital Mock-Up) and in which the most of the studies are lead through it.

2.2 Presentation of the team and its work

For the Degree Project I had to be part of the DMU integration Team (siglum ESKG). The team is the guarantor of the DMU configuration. That is to say it has to control its releasing process, its maturity and the major part of the work is to make the link between the different services and the DMU.

The DMU is the 3D representation of all the parts contained in the plane. The parts are arranged in a precise order named the Definition Dossier. The Definition Dossier is composed of the following order :

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MSN .................................................... "Manufacturer Serial Number"
  ▼ Several ATA .................................. "Air Transport Association of America"
    ▼ Several ATA Zone
    ▼ Several CI.................................................... "configuration Item"
    ▼ One LO.................................................. "Link Object"
    ▼ One DS..................................................
    ▼ Several Assemblies
        ▼ "...
        ▼ Several Parts
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In this tree, the top organization is invariant for an MSN to another. That means that for two A350 the ATA, the ATA Zones and the CI are the same. The ATA represent the different "functions" of the aircraft defined by the "Air transport Association of America". The ATA-Zones correspond to a cutting of the ATA. Finally the CI (Configuration Item) correspond to the invariant functions of assembly or installation to build the ATA-zone.
In fact the LO represents the relationship between CI/DS (Design Solution) and stores the effective of the DS. The DS or Design Solution correspond to a variant technical solution for the function represented by the CI. For example, the DS could be different depending on the cabin installation (water pipes, electrical installation) or it could be different because of main Changes of a required by a CR (Change Request).

Knowing this organization, the precise point on which the team focus on are:

- The Interface Management
- The DMU Integration and SSCI (Structure, System and Cabin Integrators)
- The DMU Quality Gates
- The Product evolution
- Cabin DMU Customization

Let’s describe briefly all these points.

2.2.1 The Interface Management

The interface management begins with a request made by designers in order to settle a part of an ATA on another. For example it can be a wire of the electrical devices (ATA-92) which has to be set on a frame of the structure (ATA-53). For these interfaces, several solutions can be proposed, they are named "Interface Node" (IN) which under it you can find the "Interface Point" (IP) with the Load Dossier which gathers the mechanical specifications (stress and fatigue) and finally the part which answers to the need (brackets, harnesses...).

2.2.2 The DMU Integration and SSCI (Structure, System and Cabin Integrators)

The aim of the DMUi (DMU Integrator) and SSCI is to check the validity of the designed parts. For example, they have to check if the part is respecting integration rules (environment temperatures, shapes...) and also the possible interferences between the parts. In general they study the evolution of the maturity of the mock-up.

The aim of the manager is then to generate these processes through the DMU and to propose continuous improvement of the methods.

2.2.3 The DMU Quality Gates

The DMU Quality Gates supervisors have to control the validity of the planning regarding all the data around the DMU. These Milestone are here to ensure the reliability of the process from the design to the production.

The supervisors mainly take part to the ramp-up of production between R&D and manufacturing.

2.2.4 The Product Evolution

The product evolution is the process of changes during the time of life of a program. Indeed from a early design, the change process is here to meet as much as possible the cost reduction, the manufacturing simplification and the weight saving. But to implement the change on the future aircraft, the change has to pass some steps. Main changes are applied on a plane decided in advance. The change gather a great number of changes. These milestones are called Step. For now the Step 5 is in production, which means that the A350-900 has already at least 5 previous versions.

| InflowBoard | ICB | TRS | Release |

First, the person who has an idea must present his proposal during the Inflow Board. If the idea seems reasonable, a more precise presentation has to be done with some details on saving it could generate during the Inflow Control Board.
Then an invest is done to define precisely the parts which could be impacted by the change and the delivery is the TRS (or Technical Repercussion Sheet). Finally between the TRS and the release the final study of design, mechanics and manufacturing are done in order to implement it for the next step.

2.2.5 Cabin DMU Customization: Enabling Platform

The most challenging part of the aircraft production is the cabin since you must develop quickly on demand the configuration the customer want inside its airplane. To avoid delays and anticipate the installation of cabin equipment, the idea of a customizing DMU has rose up to simplify and accelerate the configuration of a certain MSN.

Once again, the Enabling platform manager has to control the project, managing the different services to complete this particular DMU and also to guarantee his quality (maturity, design checking...)

3 The projects led

3.1 DMU4All

3.1.1 Project presentation

DMU4All project aims at that all the Airbus community can consult the DMU quickly and with a possibility to add data to display.

In the frame of my Degree project, one of my missions was to make a proof of compliance of a new DMU light viewer named "NOVO" selected by the project DMU4All.

3.1.2 NOVO presentation

NOVO is a DMU light viewer, this means that it can load a huge amount of parts of an aircraft. Indeed, for now, only persons who have a CAD PC (which means high performances PC) can load a full DMU of a aircraft. In the strategy of A350 program, the DMU should become a portal to access to the wanted data. Another advantage of NOVO is that properties can be added to the parts loaded. This means that thanks to this functionality, views of particular properties could be done through it. This functionality could enable people to have a global vision of the task remaining to do and to the manager to follow the way forward of the project. For example, in the aim of reducing costs coloring the part in detail depending on their materials, their manufacturing processes and assembly phase. All these items can give a clue on priority changes to implement.

Here below is an example of a nose fuselage loaded in NOVO and an example of the properties displaying.

![Figure 1: View of the Nose fuselage and filtering on the sheet metal parts.](image.png)

Nevertheless, NOVO is just a light viewer. It does not enable to specify the context you want to work with. For example, if you just want to load Structures of the nose fuselage then you have to create the product structure presented in chapter 2.1 in order to retrieve the part into the folders.

For this, the project DMU4All has created a web page named the Context Builder in which you can create your own working context.
3.1.3 The Context Builder

The context builder is a web page on which you can filter the data you needed for your study.

![Main page of the Context Builder.](image)

On figure 2 you can see the organization of the page. Let’s define a little bit more in detail the functionalities. For the different frame the function is:

1. The Version of the A350 you want to study (A350-900 or A350-1000)
2. The MSN you want to study
3. The search bar: To make a proximity criteria from a part
4. You can draw a box of definer give coordinates to define a zone to study
5. You can add filters on ATA or section
6. Finally, you can check your criteria in the context menu

Once you have finished to select your context, you can launch the process for the different viewers available (Catia V5, NOVO, Load 3D...)

3.1.4 Conclusion of DMU4All project

DMU4All project is a long project with a lot of test phases with the different users coming from the many services of Airbus. I had the chance to see the capability of such a tool but also the difficulty to implement it on a structure such as Airbus. I think the way this tool is taking totally fit to the new strategy of digitalization and is a competitive software for the future.

3.2 CLOSER project

3.2.1 Project presentation and General context

The CLOSER project (meaning Configured Link Of StrEss Report) is a project aiming at creating a link between the Design and the Stress configurations.

For now, the two departments do not work in collaboration: they have their own configurations, their own data bases.
The issues deriving from this is that both of the parts do not know the different configurations. To focus on the Stress department: in the Stress Dossier, the list of parts impacted is given and mistakes can occur due to this ignorance. Moreover, depending on the fields studied in the Stress department (such as systems, structures...) the Stress Dossier does not have the same template. This two factor make the establishment of the link impossible.

It explains why the priorities of the CLOSER project were to focus on the establishment of a common template and also to create a common method to retrieve the right information into the Stress Dossier.

3.2.2 The Table 1.5.2

The main concern about the normalization of the Stress Dossier has been the Table 1.5.2. in fact it is the Chapter in which the Part numbers involved are written. Depending on the different fields of the Stress department, the needs were not the same and meeting were organized to find a compromise between all parties. Indeed, some of them were used to put drawing set numbers, materials, etc. But finally the final result is is described on Figure 3.

The information retained is necessary and sufficient for the well understanding of the Stress Dossier, its development and the future link to establish between design and Stress.

Once, the table well defined, a reliable method to fill it was needed.

As the aim of the A350 program is the DMU as Master, the opportunity to take part of this project came to us. The aim was to use the DMU as an intuitive way to generate automatically the table.

My task was to code a program on Catia and precisely on the Airbus Module called TreND to answer to the needs.

3.2.3 A word about TreND

As a plane is composed of millions of parts, it is understandable that loading a whole plane, or even a section of it, would overload the RAM of the computers. The TreND module was developed by Airbus with IBM in order to convert the native files into one CGR file (Catia Graphical Representation).

It enables to load larger sections and to retrieve parts selected and to know its position in the product structure.

On Figure 4 you can see a typical view of the use of Trend with on the right the Catia window and on the left the TreND module window. You can notice that there is no develop product structure in Catia whereas on TreND the Product Structure is visible.
3.2.4 The final macro

On the left figure you can see the easy functioning of the macro:

1. Select the parts studied into the Catia window
2. Extract on an Excel file the part numbers
3. Run the macro
4. The macro retrieve you the final Table in a Excel file

In much more details: the macro calls browser windows to inform paths of the extract made on previous step. Then it searches inside the PLM (Product Life Management) database to retrieve all the data and call again a browser window this time to ask where to save the final Excel file.

After the macro written, communication and feedback had to done. That is why I attended and commented during presentations to all services after discussions and I made some improvement such as the addition of the product structure of the impacted parts into the final excel or the possibility to download the Norm Documentation of materials. Another point was also the study of fasteners which I develop in the next section.

3.2.5 CLOSER project results and conclusion

The macro was really appreciated by the people of the Stress department. However, the only problem is that most of this people do not use Catia or do not have access to it.
Concerning the CLOSER project, it has continued, merging with another project aiming at displaying RF on the DMU for the repairs.

As a conclusion of this project, I would say that it enabled me to have a transverse vision of the Stress certification. Since I studied at KTH structures stressing, it was an opportunity to see the way of working at Airbus.

It was also interesting on a project management point of view. As I worked with the project leader, I had the opportunity to see how much you need to communicate and to support such projects.

Finally, it brought me other skill thank to the knowledge I acquire coding in VBA through Catia.

3.3 The fasteners display project

3.3.1 General Context

As said before the A350 DMU is the best managed and complete DMU of all program : each part is present into it. However, it exist an exception for the fasteners (rivets, bolts...). As the number of them used is astronomic (about 6 million of references of fastener for all the aircraft defined since the beginning of the A350 program) they are not represented into the DMU as 3D parts. They are gather into different DS corresponding to fasteners tightened in the assembly lines and are represented by line parts in the native files. The problem is that as TreND convert the Catia products and parts into CGR and this actual format do not take account of line parts. As a results the fasteners are most of the time graphically missing.

Actually it is a main concern since almost 30% of the Delivery Query Notes (notes that listed the technical problems met during assembly in the Final Assembly Line) are due to clashes between fasteners (e.g with bolt head) and parts. It is also a request from the Stress department to have a link between the parts and the fasteners impacted to inform them into the Table 1.5.2;

3.3.2 Problem Analysis

To answer to this major issue, I studied the way that are managed the fasteners. As said before there are gathered in Design Solution and stocked in line parts. The reference of such file had the particle STD, for example : the part V5391075107000-STD01 illustrated in Figure 5. For this study, I opened a Native file to see the way it was organized. In figure 5 you can see the tree product. In there you can notice that the fasteners have properties among which there is the Parts_to_tight property.

Figure 5: Example of STD file and its structure
The actual idea was to write a Catia macro able to open one by one the STD files, extract the tightened information and then build a Database which could be queried on demand. The detailed process is described on figure 6.

Figure 6: Description of the macro process

The code ran perfectly, however as the amount of fasteners is huge the macro has to be run simultaneously to reduce time execution but without overloading the capability of the computer.

Another improvement was to transfers the parts of the code which were written in Visual Basics for Catia into Perl language. Indeed Perl is a language perfectly adapted for file and data processing. The execution time is, as a consequence, reduced drastically. The green rectangle in Figure 6 represent the part of the code executed in Perl.

Finally as the fasteners are not modified everyday, the macro was changed in order to work in deltas. That is to say that only the files that have been modified since the last running of the macro will be analyzed.

Once the database built, it is easy to ask for a query. An excel file has been created in which you can enter your parts impacted. Another macro will search into the data base the fasteners references (the fastener name and the STD file in which it is stocked).

As the TreND module has a module made for searches, named the Search Wizard, we can use it to filter which fastener is actually present or not. Indeed, as the database retrieve all the fasteners impacting our part, it can happened that references of fastener change and are used for a specific range of MSN. For these, we can add lines to the code in order to create a xml (format to use for the Search Wizard) and load it in the module.

3.3.3 Example of use

Let’s have a look on how does the macro work. First you launch the TreND module in Catia and select the parts you want to study. Then copy the part numbers on the Excel in order to run the macro. This steps are described in Figure 7 : on the left the Catia selection of the part (here a Lateral Panel) and on the right the launch of the macro (Excel and the command window)

Figure 7: First step of displaying the fasteners : Catia selection and running the macro

Once the macro ends, you can launch the Search Wizard module in order to load the xml which had been generated by the macro. A search is made in the product structure to retrieve the part numbers that have been given by the program. Then, TreND has the possibility to load the native
part and so to add it in Catia. Finally, thanks to a module developed by Airbus named *Holes and Fasteners* you have the possibility to display the fasteners contained into the STD natives files you load before.

The figure 8 illustrates these steps: on the right the *Search wizard* module in which the xml generated with the macro is loaded. And on the left, a picture of the final panel with all the fasteners displayed in 3D.

![Search wizard and fasteners panel](image)

**Figure 8**: The search wizard and a panel with the fasteners displayed

### 3.3.4 Conclusion of the fasteners displaying project

Even if in surface this topic seems easy, its automation is quite hard to implement. Indeed, this process needs a person to run a batch file (containing the different macros to run in a certain order) once a day.

Moreover, technically speaking I had to learn more about coding languages. In fact, I had to go deeper the in VB Catia coding skills and also to learn the Perl language.

Nevertheless, this method depend extremely on the rigor the parameters have been written. It could happened that the parameters are missing and then all the previous methods is wrong. to counteract this issue, a permanent list could be written listing the missing parameters on fasteners inside a STD file.

### 3.4 Other minor projects

In addition to the three main previous projects, I led different little studies or code writing. Even if they were minor in content, as they were applied to all the different activities presented in chapter 2.2, it enables me to discover all the jobs of the team. The following project made are :

- a planning of the Change Request for the *Product Evolution*
- a study about the Interface Point existing in Enabling Platform for the *Interface management* and the *Cabin DMU Customization*
- a study about the possibility of automatizing a DMU building thanks to a preset Layout to pass the *DMU Quality Gates* faster
- a macro analyzing the Quality Checks that must be done for *SSCI*

It was really rewarding to learn all the different facts of the configuration management. Moreover, thanks to this minor projects I had the opportunity to use my skills, to see the work environment and to be totally part of it.
4 Conclusion

As a conclusion, I would say that, despite the fact I did not apply exactly what I have learned during my studies focused on mechanics, I have learned and widened my aeronautical culture thanks to the Airbus company itself but before everything else, thanks to the passion my colleagues have for the aircrafts.

Moreover, this internship enables me to learn and apply coding languages and software manipulation which will be really useful for the future.

I take part in team events, meetings and projects as much as I can and it brought to me a lot of experience.

I would like to thank one more time my team for this wonderful Internship.