

Saimaa University of Applied Sciences  
Faculty of Mechanical Engineering Lappeenranta  
Mechanical engineering and production technology

Fayçal Sadki

**Accelerated improvement workshop in WP4004  
program AIRBUS A330 by DMAIC method**

Thesis 2016

## **Abstract**

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Accelerated improvement workshop in WP4004 program AIRBUS A330 by DMAIC method, 37 pages

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Instructors: Deg. Program Manager Jukka Nisonen, Saimaa University of Applied Sciences.

Quality Assurance Manager Nihad Zamamra, Labinal Power Systems Morocco.

The objective of this accelerated improvement project was to optimize the use of the jig boards in the program Airbus330-WP4004 production lines, decrease the spending on the making and equipping the jig board templates and finally find a convenient way to store the jigs when not in use.

The main method used to resolve the different issues was DMAIC (Define Measure Analyze Control) which is a core tool used to drive Six Sigma projects mainly used for improving, optimizing and stabilizing manufacturing processes, production lines and designs.

As a result of this project an optimization solution was found then put into test, the different difficulties encountered were analysed and a solution was found to them. An optimization protocol defining the tasks of the different departments involved was established. A jig board loading tool was designed and a storing space was reserved to it.

Keywords: lean Manufacturing, production management, DMAIC and industrial management.

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# 1 Introduction

A pure and perfect higher education should not be limited to theoretical courses, but should also seek practical skills in a professional environment in order to implement all the knowledge acquired during the studying process.

It is in this context that a 12 weeks bachelor thesis project was conducted at Labinal Power Systems Morocco, SAFRAN group as a project coordinator between the different departments Quality and CAD production department. LPS is one of the jewels in the world of the manufacturing of aeronautical electric harness. Considered a pioneer in its sector LPS is a leader enjoying a high reputation and holding a large market share internationally.

Faced with an unstable market, LPS is obliged to meet the requirements dictated by his macro and micro economic environment. For that LPS has opted for a policy based on the principles of Lean manufacturing to modernize its production facilities to satisfy customers increasingly demanding and face potential competition.

It is in this context that this graduation project took place with the use of Lean management concepts and tools to improve the production line, reduce waste and maximize an intelligent use of space.

This work is carried out for this purpose, it will be distributed as follows:

1. Presentation of the host company.
2. Defining Accelerated improvement workshop and the DMAIC method.
3. Define phase.
4. Measure and analysis phase.
5. Improvement phase.
6. Control phase.
7. Summary and discussion

## **2 Labinal Power Systems**

### **2.1 Presentation**

Industrial high-tech company, Labinal SAFRAN Group, is a world-leading position in the field of electrical wiring systems and studies, engineering, and related to the aerospace and defense markets.

The company's talent is based on the know-how acquired over decades and his experience serving the world's leading aircraft manufacturers.

Industrial activities of the company, market segment and oriented primarily towards meeting the expectations of customers, are organized into three divisions:

- SAFRAN service engineering: provides engineering solutions for aerospace and transportation industries including avionics and embedded systems, aircraft structures, mechanical and electrical systems.
  
- Labinal wiring Europe and North America provides a comprehensive system of electrical wiring in the manufacture, integration and configuration management.
  
- Labinal services Europe and North America performs installations, modifications and electrical testing of the new series or ongoing programs on customer sites

- Creation:** 11 May 2005 (fusion of Snecma and Sagem)
- Legal Form:** Corporation with Executive and Supervisory Board.
- Headquarters:** France (Paris).
- Activities:** Conception and production of engines for aircrafts helicopter, rockets and aeronautical equipment for defense and security.
- Employees:** 54 900 until 31 December 2015.
- Turnover:** 10 448 Million € until 31 December 2015.
- Subsidiaries:** Snecma, Turbomeca, Snecma Propulsion Solide, Techspace Aero, Aircelle, Messier-Dowty, Messier-Bugatti, Hispano-Suiza, Labinal, Sagem, Sagem Security.
- Industries:**
- ✓ Aerospace Propulsion,
  - ✓ Aeronautical Equipment ,
  - ✓ Defense and Security,

### 2.1.1 Activities

It is within the Division Labinal Wiring Europe has developed over many years expertise to become number 1 electrical wiring systems and electrical harnesses for Present in all segments of the aviation and defense markets, this division which has 1,267 employees in Europe and Morocco, offers a comprehensive service of design and manufacturing.

### 2.1.2 Customers

The Business Division Centres are dedicated to leading European manufacturers of the aerospace and defense, including Agusta, Airbus Deutschland, Airbus France, Airbus UK, Dassault Aviation, EADS Astrium, Eurocopter and Hispano-Suiza.

### 2.1.3 Organization

The division is organized around four Business Centers:

- **Labinal Villemur** used helicopters and civil aviation customers: Agusta, Airbus Deutschland, Airbus France, Airbus UK, Eurocopter.
- **Labinal Vichy's** main Dassault Aviation, Hispano-Suiza and EADS Astrium clients.
- **Labinal Ajaccio** realizes the electrical hearts for the Airbus A330 and A340 programs.
- **Labinal Morocco** manufactures electrical wiring for Airbus and Eurocopter.

The division is also involved in the operational management of the joint venture MATIS Aerospace, based on Royal Air Morocco and Boeing in Casablanca (Morocco). MATIS Aerospace produces electrical harnesses for Airbus, Boeing, Dassault Aviation and Hispano-Suiza.

The organization of the division is consistent with an orientation closer to the customer, accountability of all stakeholders and the need to provide all the same level of service and quality.

## 2.2 Labinal Power Systems Morocco

Labinal Power Systems Morocco is located in Ain Atig near Rabat (Morocco). Founded in August 2004, it is a public company with a share capital of 400,000 dirhams. Built on a plot of 7 hectares, the production site covers an area of 10 800 m<sup>2</sup>.

It is dedicated to the assembly and marketing of electrical wiring systems for the aviation industry. The new plant, which offers its employees a work environment at the forefront of technical innovation, is the realization of an investment of 100 million dirhams.

By the Moroccan capital LPS is 100 000DH 000DH as against 300 share of foreign capital.

With this facility primarily dedicated to production of wiring for the entire Airbus family, LPS responds to increases in aircraft production rates and contributes to industrial development in the region.

Labinal Power Systems Morocco has its own training school for theoretical and practical courses on business aircraft wiring.

## 2.3 The Process of making electrical wires

### 2.3.1 Overview of Production

The final product of each production line is called "harness" it is a set of VB. Each VB is a set of plugs and bundles cables together and intended to be directly integrated into the aircraft.

The production process is organized according to the criteria of "Lean Manufacturing" which is in the process of continuous improvement implemented by the SAFRAN tool in order to optimize productivity, reduce all kind of waste and optimize ergonomics.

Production processes are poorly mechanized except cutting phases cables and testing. Thus, the equipment that Labinal Power Systems Morocco has are:

- A preparatory workshop CMP with 5 cutting machines and laser marking cables, and 2 self-cutting machines
- 3 WEETECH electrical testers used for programs A320, A330, A400M and MKII
- 1 CKT electrical tester used for the A350 program

Other equipment used by **LPS Morocco** are hand tools assigned to the operator or workstation (manual crimpers or pneumatic wire strippers, guns, self-welder).

Traceability requirements imposed by the tools customers require calibration and on-going maintenance of these tools. This is monitored by the calibration service. The quality of the maintenance of these tools is part of the points when audited certifications production process.



### 2.3.2 Description of the manufacturing process

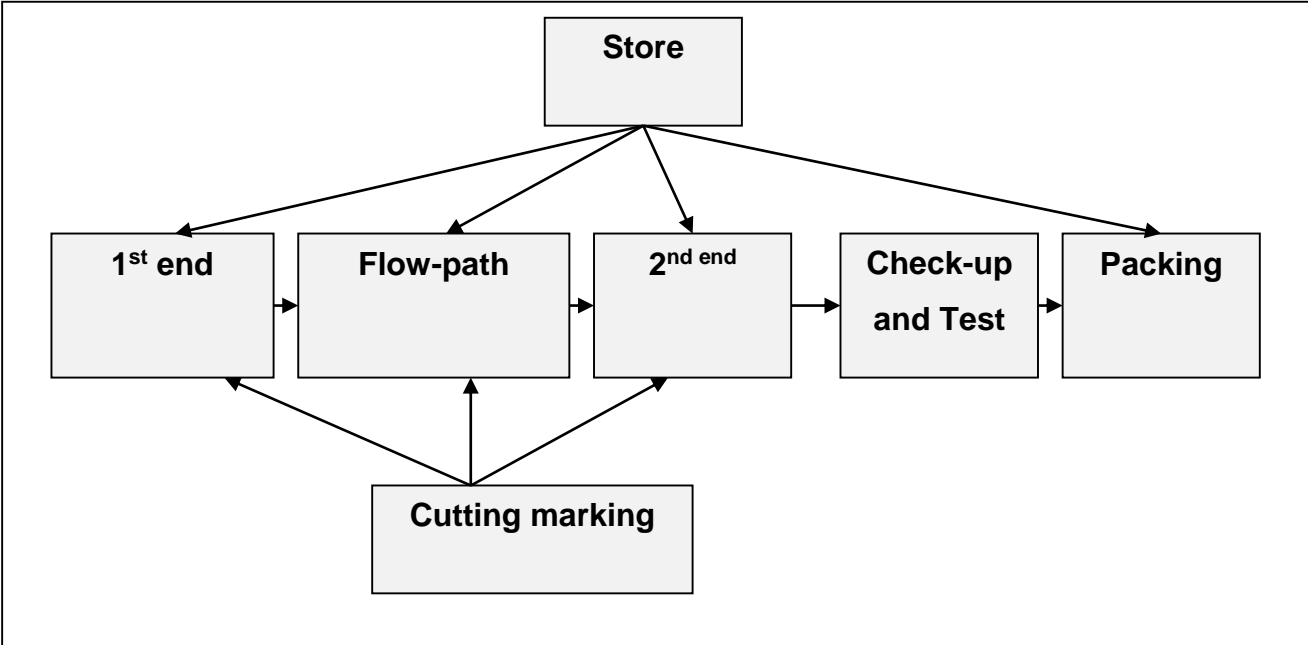
LPS Morocco is divided into Airbus and Eurocopter programs. Each of these programs has an autonomous team. At the head of each, a team leader is responsible for overseeing and balancing the work of his operators, inform his superiors on the progress of the burden of the day and coordinate with other links in the chain of production, mainly Supply / Store service and the CMP service.

The manufacturing process is shown schematically in the figure below. The operations carried in the CMP workshop are Laser cutting and marking cables, mechanical assembly and printing plates and sleeves.

Generally, the work in each manufacturing team includes the following phases: 1 end, flow-path, 2nd end, control, electrical testing and packing. In the 1st and 2nd end, three main operations are performed: self-sealing, stripping / crimping and insertion.

After the CMP workshop, the cable is moved into the first end, then it is flow-pathed on so-called "Jig-boards" templates. The last phase is to organize cables according to the instructions on the jig-board and perform the rest of the self-welding operations, and crimping in filling. We get at the end, a harness, which is the wiring in its final form.

Control is performed throughout the production line and ends with electrical testing and final inspection. Once these manufacturing steps performed, the harness is packed before being shipped.



## **Figure 1 manufacturing process description**

### **3 Accelerated improvement workshop and DMAIC method**

#### **3.1 Accelerated improvement workshop**

AIM is an intensive performance improvement program with two objectives:

- To achieve quantifiable organizational performance improvement within 8-12 weeks
- To develop organizational capability to deliver future AIM projects

AIM employs the principles of two proven improvement methodologies: Lean Thinking and Six-Sigma, both of which have been widely adopted in the private and public sectors. When implemented well they can deliver spectacular results. Lean has evolved out of the Toyota Production System (TPS) and has moved from its manufacturing roots into service organizations and the public sector. It focuses on identifying customer value streams, “implementing flow” and “eliminating waste”. Six-Sigma’s focus on reducing process variation is sometimes described as “TQM on steroids”, where there are three underpinning principles of: - understanding and meeting agreed customer requirements - identifying failures and eliminating them, to reduce costs - involving staff, at all levels in continuous improvement The reality is that you can have the best of both worlds. Both sets of tools can help you improve performance. We have deliberately used the word “tools” here. Neither approach will deliver sustainable improvement without the right leadership and facilitation support. Tools and methodologies on their own are inadequate.

#### **3.2 DMAIC method**

DMAIC refers to a data-driven quality strategy for improving processes, and is an integral part of the company’s Six Sigma Quality Initiative. DMAIC is an acronym for five interconnected phases: Define, Measure, Analyze, Improve, and Control.

Each step in the cyclical DMAIC Process is required to ensure the best possible results.

The process steps:

1. **Define** the Customer, their Critical to Quality (CTQ) issues, and the Core Business Process involved.

Define who customers are, what their requirements are for products and services, and what their expectations are. Define project boundaries the stop and start of the process. Define the process to be improved by mapping the process flow

2. **Measure** the performance of the Core Business Process involved.

Develop a data collection plan for the process  
Collect data from many sources to determine types of defects and metrics in order to compare it to customer survey results to determine shortfall

3. **Analyze** the data collected and process map to determine root causes of defects and opportunities for improvement.

Identify gaps between current performance and goal performance. Prioritize opportunities to improve and identify sources of variation

4. **Improve** the target process by designing creative solutions to fix and prevent problems.

Create innovative solutions using technology and discipline. Develop and deploy implementation plan

5. **Control** the improvements to keep the process on the new course.

Preventing the reverting back to the “old way” require the development, documentation and implementation of an ongoing monitoring plan  
Institutionalize the improvements through the modification of systems and structures (staffing, training, incentives)

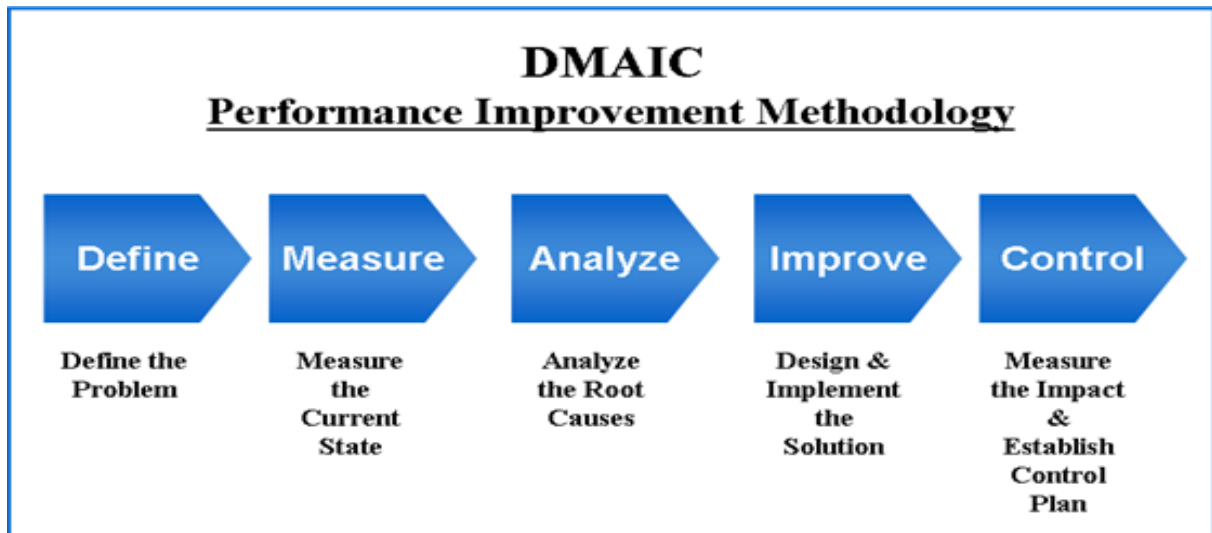


Figure 2 DMAIC process description

## 4 DEFINE phase

### 4.1 Use of 6 PACKS

The 6 PACK is a tool used in project management in order to have a clear structure of the project and the different data such as the goals, impact of the project...

Table 1 6-pack

LINK WITH THE COMPANY'S STRATEGY	NAME OF THE PROJECT
Lean manufacturing , zero waste , kai-zen: continuous improvement	AIW: WP4004 PROGRAM OPTIMIZATION
IMPACT OF THE PROJECT	DESCRIPTION OF THE ISSUE
<p><b>Financial</b> : cut or reduce unnecessary spending</p> <p><b>Operational</b>: higher productivity, better space management, less waste</p> <p><b>Client's satisfaction</b>: products delivered faster, cheaper and with a higher quality.</p>	<p>- Slow and time consuming production line with low productivity.</p> <p>-High spending for jig board equipment</p> <p>-No convenient storing method for jig-boards.</p>
OPERATIONAL GOALS	AREA OF PROJECT
<p>-Optimize the WP4004 production lines by finding a more efficient manufacturing method and standardize it.</p> <p>-Eliminate or reduce all type of waste in time, materials and money.</p> <p>-Find a convenient way to store the jig-boards.</p>	WP4004 program
PLANNING	TEAM
<ul style="list-style-type: none"> <li>● <b><u>Define</u></b></li> <li>● <b><u>Measure</u></b></li> <li>● <b><u>Analyse</u></b></li> <li>● <b><u>Improve</u></b></li> <li>● <b><u>Control</u></b></li> </ul>	<p><b><u>Projet managers</u></b>: Nihad zamamra faycal sadki</p> <p><b><u>Team</u></b>: otmane tentani,</p>

## 4.2 Understanding the issue

Airbus has different clients and each one of them has different criteria according to its needs.

For instance for the same type of aircraft A330 some airline companies have 1<sup>st</sup> class, business class and economical in it, others have only economical class; some have TV screens, the internet and music players on board others do not.

These different demands and specifications made by airline companies require a change in the structure of the plane which directly affects the length, shape and composition of the electrical wires.

Because of the different client's demands, for each type of airplane for example A350 there can be multiple versions of its electrical wiring structure. Each version represents a special request (an order) from an Airbus client.

The issue for Labinal Power Systems is that it keeps receiving from airbus different versions of the wires. Some are very different (in terms of length and shape) from the standard or original version, others are quite similar to it or similar to other versions previously received.

## 5 MEASURE AND ANALYSE phases

In this phase there will be an analysis of the effects and consequences caused by the continuous reception of a new wire version from airbus.

### 5.1 Time Consuming

Each time there is a new version or a modification in the wires, Airbus sends the 3D model of the wire to Labinal's CAD department which has to transform the 3D plan to a 2D plan flattening process adding some modification then the 2D plan is printed on a reel scale (1/1). The material to make the jig board must be ordered, then comes the selection of the worker who will install the jig board and equip it and when it is ready the quality department has to check the jig board and validate it and only then the work on the jig board can start. The making of jig board is a long process.

## 5.2 Work Space and Storage

Labinal power systems continuously receives many new versions of wires and also stores old versions but all these jig boards are not used every day some might be used only one time, others will not be used for months but LPS cannot dispose of them since Airbus may or may not ask to produce that version again in the future (it all depends on Airbus's clients).

So LPS must store all these jig boards and this occupies a lot of space. There is no established convenient way to store the jig board, they were put one over the other which damages the jigs.



**Figure 3 Damaging storage**

## 5.3 Costs and Expenses

The making and equipping of jig boards necessitates material such as wood, steel, tools, clamps... The printing of the jig 2D plan on a reel scale is also expensive. So in the making of each new version LPS has to spend a lot of money and resources which impacts negatively the company's budget.

## **6 IMPROVEMENT phase**

In this phase the different solutions found will be presented.

### **6.1 Progress by the companies ideas**

This is a lean manufacturing concept used in LPS where the company involves its employees in finding solutions to the issues. This principal is about engaging everyone to participate in the continuous improvement by suggesting each from his own perspective ideas and solutions.

We came up with a number of solutions that were analyzed and finally 3 were selected and validated.

#### **6.1.1 Combination of similar 2D wire versions**

The idea is that instead of having to make a new jig board for each new version or modification received, LPS should combine the maximum of 2D plans which are similar in one jig board.

#### **6.1.2 Superposition**

Since the jig board is made of many boards placed one next to another and since a lot of versions are alike and only have dissimilarities in certain areas. The idea was to make small jig boards of the areas of dissimilarities so that when flow pathing in a version and we arrive to an area of variance we superpose the board representing the correct 2D structure over the area of dissimilarity.

#### **6.1.3 Double Sided jig boards:**

The idea here is to use the jig boards from both sides (front and rear) meaning that each side would be used for a different version of the wire.



#### **6.1.4 Jig boards carrier**

This was another creative way to store the jig boards by designing a jig board carrier where the jigs not in use can be placed and will be safely preserved, easily movable and accessible.

#### **6.1.5 Compartments**

Since there is an issue in the way of storing the jig boards there was the idea of making “storage compartments” under the support of the jig boards. This way the jig boards will be safe and easily accessible when needed by the workers.

#### **6.1.6 Disassemble the jig boards not in use**

It was noticed that for some version even though they have not been used for more than 6 months they are still being stored which is considered as waste since it is occupying space which is a precious element for LPS. Therefore it was proposed that the jig boards of the versions that will not be used for more than 6 months should be disassembled instead of wastefully stored.

### **6.2 Solution establishment**

After suggesting the different possible solutions to the production managers they selected to proceed to the analysis and study of the following solutions:

- Combination of similar 2D wire versions
- Design a Jig boards carrier
- disassemble the jig boards not in use

#### **6.2.1 Fusion of similar versions**

##### **6.2.1.1 *Choosing the comparison tool***

The team was brought to think about a tool that will help in the comparison of the different 2D plans we have in order to identify and gather the versions that are similar

.To do so we came up with few ideas: using a software, transparent prints and visual comparison.

## **Software**

The idea here was to use a software that compares images and indicates the areas where there are differences between them. This software worked perfectly on images and photos but did not work on 2D plans. Since Airbus has a CAD department that converts the 3D models to 2D plan which is converted to pdf format then sent to LPS. This unstandardized conversion (2D to pdf) is made by different airbus technicians (when making a pdf file from the 2D plan you have to define the borders and sizes which are selected differently from technician to another). Therefore the SOFTWARE cannot use because the pdf files are not standardized into the same format.

## **2D plans printed in transparent paper**

The idea was to print the 2D plan of each version in a transparent paper and compare them by superposing them. Unfortunately this paper was not available and this procedures was judged as expensive. This solution was refused.

## **Visual-analysis**

This was the only option left where the CAD department staff will have to visually check the 2D plans and try to identify the ones that are similar and manually determine the areas of dissimilarity.

### ***6.2.1.2 Choosing the VB prototype***

To start any project you have to go through the test phase and to do so you have to choose a prototype. In this matter there were 5 VBs to choose from. It was decided that the 1501 VB will be the prototype because it was the most complex one, the idea behind this choice was that if we choose the most complex VB this would give us a more global idea about all the difficulties that might be encountered with the other VB's as well if the project succeeds and the company decides to generalize this optimization

solution to the other VB's we would already have established an optimization protocol that would most likely be effective for the other products.

### 6.2.1.3 *Selecting the versions to be optimized*

Before the comparison process we had to update the information that we have and select the versions that should be optimized. Because some versions available in the database are old ones that would not be produced in the future others are exactly similar but under different names.

After reviewing the client's demands we choose the versions that the client demanded to produce for the rest of the year.

26 versions will be produced:

**10 versions** are already in the template group "basic all versions."

**4 versions** are new creations not yet received from Airbus.

**4 versions** are available but will only be used once.

**8 versions** are available and will be used many times.

After an analysis of this data it was decided that the "prototype phase" would only include the 8 versions which are available and would be used several times should be subject to optimization. The following document was established In order to manage all this data.

**Table 2 versions to be produced**

	may	june	july	august	september	october	november	december	total uses		
CHH01			1						1	CHH01	VERSION
KAC02							1		1	KAC02	basic all versions
CPA10						1			1	CPA10	basic all versions
CEB01				1					1	CEB01	VERSION
CPA11						1			1	CPA11	VERSION
CCA07		1							1	CCA07	basic all versions
GIA03		1							1	GIA03	VERSION
DAH02					1		1		2	DAH02	NEW CREATION
ALK03	1				1				2	ALK03	VERSION
HAL01					1	1			2	HAL01	basic all versions
ARG01					1	1			2	ARG01	NEW CREATION
CRK01					1		1		2	CRK01	basic all versions
OMA03	1			1					2	OMA03	VERSION
TAR01							1	1	2	TAR01	NEW CREATION
ONE02		1			1				2	ONE02	VERSION
78V01				1	1				2	78V01	basic all versions
QTR12	1		1						2	QTR12	basic all versions
KAL06		1			1			1	3	KAL06	VERSION
SIA05			1		1		1		3	SIA05	basic all versions
DAL01			1				1	1	3	DAL01	basic all versions
CSN05			1				1	1	3	CSN05	VERSION
ETD13			2				1		3	ETD13	VERSION
AAW03			1		1	1		1	4	AAW03	VERSION
CES06		1		1		1		1	4	CES06	VERSION
THY09						3	1	2	6	THY09	NEW CREATION
XFA01	1	1	1	1	1	1			6	XFA01	basic all versions
total uses	4	6	9	5	11	10	9	8	62		

- version used once
- version available in the jig-board "basic all versions."
- new creation not yet received from Airbus.
- version to be optimized

#### 6.2.1.4 *Comparing the 2D plans of the different versions*

After deciding to make the comparison process a man made one and selecting the version that would be optimized, We started the comparison process by choosing a “Standard Version” that would be used as an origin or base of comparison, in other words we will compare all the versions that we have in respect to that “Standard version” to determine the areas of difference and what parts of the 2D plans are subject of dissimilarities.

#### 6.2.1.5 *Establishing the sorting criteria*

Since we are working in a team on this project we had to establish sorting criteria that will be standardized for all the team to follow when sorting the 2D plans.

- **Dimensional criteria**

when sorting the operator should try to group 2D plans of the versions that have the most dimensional similarities, in other words group the versions which have branches with similar lengths.

- **Morphological criteria**

Try to group the 2D plans that have the same or similar shapes together, in other words to group the versions that have a similar branches structure.

- **Grouping criteria**

When grouping the similar versions together the “Grouping Equality” should be taken into consideration, in other words the groups should contain approximately the same number of versions.

#### 6.2.1.6 *The sorting of similar versions*

After the comparison and in respect of the sorting criteria we were able to categorize the 8 versions into 2 groups as a result we will have 2 optimized jig boards “combining multiple similar versions”. The categorization was as follows

- **ALK03+OMA03**
- **CSN05-CHH01-KAL06-AAW03-CES06-ETD13**

### 6.2.1.7 *The making of an optimized jig board plan*

The making of jig board plans is made by using the software **CATIA**. LPS Morocco and all daughter companies of the French company Safran use CATIA for design of a full range of aerospace, defense and security products.

- **CATIA**

**CATIA (Computer Aided Three-dimensional Interactive Application)** is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systèmes

**Scope of application:**

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development ([CAX](#)), including conceptualization, design ([CAD](#)), manufacturing ([CAM](#)), and engineering ([CAE](#)). CATIA facilitates collaborative engineering across disciplines, including surfacing & shape design, mechanical engineering, and equipment and systems engineering.

- **The use of Catia in the project**

The first step is to draw the common elements between all the similar versions then by using the 2D pdf files of each one them the differences are added. These elements of each version must be added in a distinguished color. During this process all the norms and standards defined by Airbus must be respected in order to ensure the functionality and quality of the product. One important norm is Respecting the Radius of curvature it has direct effect on wire's quality.



#### 6.2.1.8 *The making of risks analysis form (R.A.F)*

Before actually testing the solution a risks analysis must be conducted. LPS has a standard risk analysis form that was used in this process. This form determines:

- What is the new process analyzed?
- Steps of the Product/Program Concerned
- Potential Failure Mode
- Potential Effect(s) of Failure
- Recommended Action(s) and who is responsible?

After organizing a meeting with the whole team concerned by this project, each department (Quality, CAD, Production...) made an analysis from their own perspective about all the possible failures and issues that might be encountered during the establishment of this new optimization process. Then we filled up the form as follows



**Table 4 risk analysis form**

Process Function	Step of process	Potential Failure Mode	Potential Effect(s) of Failure	Recommended Action(s)	Responsibility
NEW CREATION NEW PROCESS FOR LABINAL POWER SYSTEMS MOROCCO	the fusion of multiple wires versions in one jig board	Receiving modifications as new indices to be added in one or multiple versions grouped	Plan template overloaded : likelihood of confusion between versions by Operators	not to exceed a MAX of 6 versions grouped by template / grouping very similar versions dimensional and morphological	D.RHAOUSSI M.ELMOUTTAQI M.LAMTOUNI
		Modification in the main strand for one or multiple versions grouped	necessity of separating the modified version (s) if non possibility of modifying the plan template together	keep the template in digital format (Catia) for each version (template design currently used ) / possibility of grouping modified version with other versions	
		Errors in lengths	Assembly problem	Double control plane by (control + quality) using a list of critical items to be checked	
		Forgetting branches of a grouped version	Electrical problem / functional / assembly		
		forgetting to distinguish the version with specific colour for each version grouped	assembly problem		
	NON Respect of the Radius of curvature	functional problem \ low quality\ injury of wire			
	RISKS DURING MANUFACTURING	confusion of the operator	manufacturing of the wrong version	Sensitize about risks and raise awareness of the operators by tutoring them - Use high skilled and experienced operators	
Double control plane by (control + quality) using a list of critical items to be checked				H.ESSAMLALI M.ELMOUTTAQI	

## 6.2.2 Designing jig boards carrier

### 6.2.2.1 Design

The idea of designing a carrier came from the need of solving the jig board's storage issue. After asking for the measurements of all the boards used in the WP4004 program, a simple design was sketched, dimensioned and modeled. The result was as follows



**Figure 4 jig boards carrier**

After designing the carriers the sketch was delivered to the head of the CAD department for further analysis and approval. Indeed the CAD department introduced some modification to the initial design and approved it then it was sent to a manufacturer. After receiving the carriers from the manufacture the testing started. During this trial phase the boards were installed inside the carrier and checked if it was safe and easily movable these were our main focus because most of the workers are females.

This was the final manufactured result of the carrier



Figure 5 carrier prototype

### 6.2.2.2 Establishing a storage space for jig board carriers

After testing the carriers it was noticed that on one hand the carriers resolved storage issues but on the other hand they were occupying space in the production line. From this situation came the idea of implementing a storage space where the carriers can be parked. After analyzing the map of the whole factory an empty space was found at the corner where the carriers can be safely stored and easily accessible.

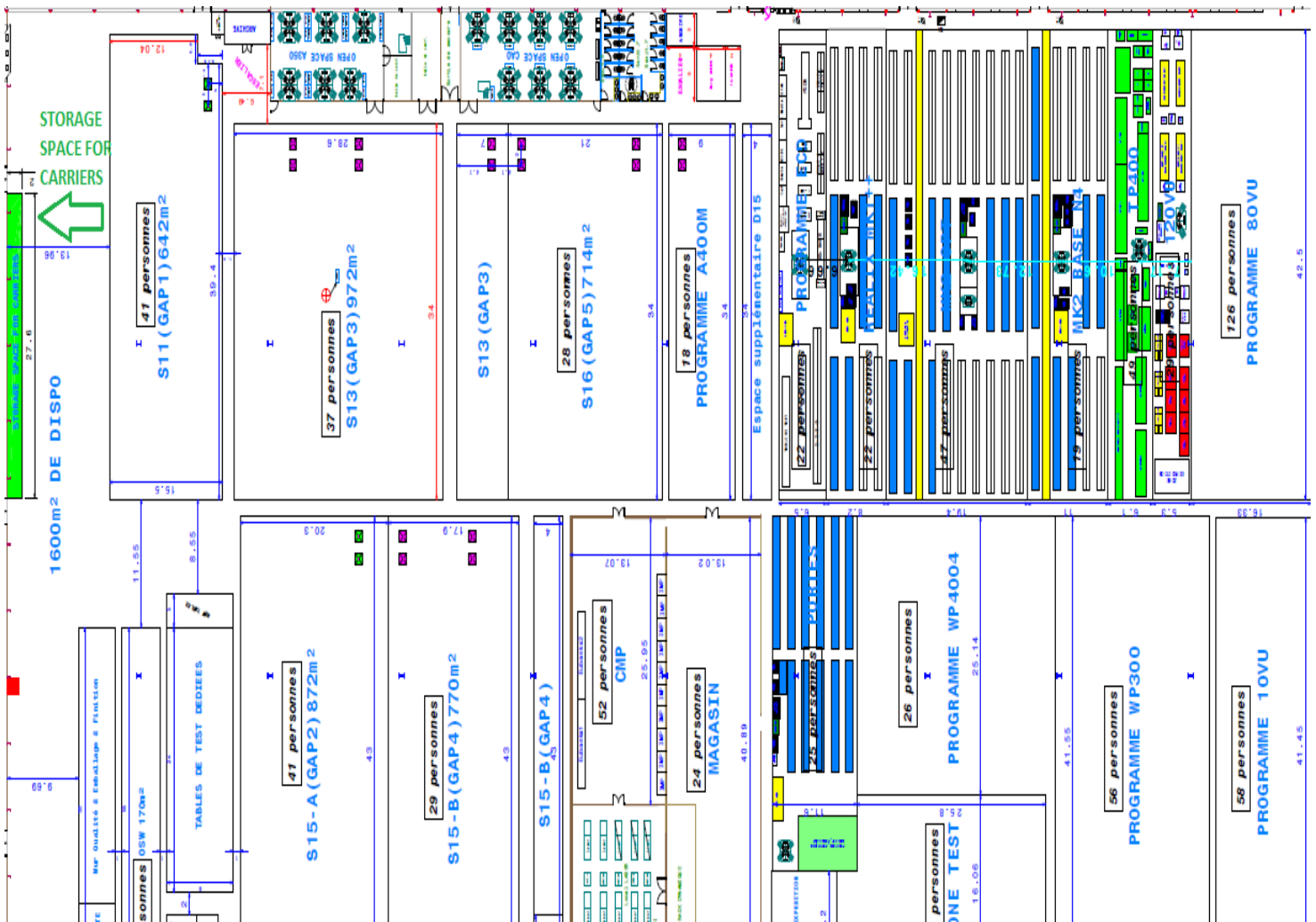


Figure 6 storage for carriers

### 6.2.3 Disassembly of the jig boards not in use

After analyzing the list of the version that will be produced for the next 6 months it was decided to disassemble the jigs of the version not in use for at least the next 6 months and use those boards gained for the making of the new jig boards for the new optimized versions.

Disassemble means removing all the equipment and the jig board plan from the board. This process is done by skilled maintenance workers in order not to damage the boards.

The disassembly is followed by an evaluation that will determine whether the board is in a good condition that will enable it to be used once again as a jig board for another version either in the WP4004 program or another one. The following versions were selected to be disassembled:

- SAV02 has not been used since 4 months
- AAW03 has not been used since 7 months
- PAL04 has not been used since 7 months
- PAL05 has not been used since 8 months

## 7 CONTROL PHASE

In this phase there will be the establishment of an optimization protocol and an evaluation of the project

### 7.1 Optimization Protocol

The establishment of an optimization protocol is necessary to make sure that the improvement that was achieved will remain in the future. The protocol defines the roles of the different departments involved in the new process.

#### 7.1.1 CAD department

- Keep the 2D plans of the versions updated by adding the new modification received from airbus
- comparing the 2D plans of the different versions
- sorting the similar versions according to the sorting criteria
- grouping the similar versions in a single jig board
- make the optimized 2D plans in **Catia** and store them in an electrical format
- make the optimized jig board plans in **Catia** and store them in an electrical format
- keep the number of grouped versions to a maximum of 6 per jig board
- When making the 2D and jig board plans respect the standards and norms set by Airbus.

#### 7.1.2 Production department

- disassemble the jigs that will not be used for the next six months
- Equip the jig boards
- Order the necessary equipment, tools and components to make the wire
- Make the electrical harnesses
- Test the functionality of the harness
- Packaging of the product
- Send for delivery

### **7.1.3 Quality department**

- Check each new created optimized jig board in terms of compatibility to the standards and norms set by Airbus.
- Check each optimized jig board that has been modified.
- Check the equipment of the jig board

### **7.1.4 Methods department**

- Send the 2D plans of the new version to be produced to CAD department
- Keep up to date a file that indicates the version to be fabricated for the next 6 months
- Immediately inform the CAD department about any modification received from AIRBUS in the structure of a version.

## 7.2 Project evaluation

After the testing of the new solution for the prototype was conducted. The gains, efficiency of the project, difficulties encountered were analyzed and recommendations were given.

### 7.2.1 The gains

The gains of the project were calculated and sorted into 2 types, real gains and provisional ones.

- The real gains are the ones actually made after the testing phase.
- The provisional gains are the achievements planned in respect to the analysis made on the other VBs.
- The real gains from fusion solution were in a total of **120 re-usable boards**.
- The estimated gains from fusion solution are in a total of **163 boards**.
- The gains from disassembly were **124 re-usable boards**.



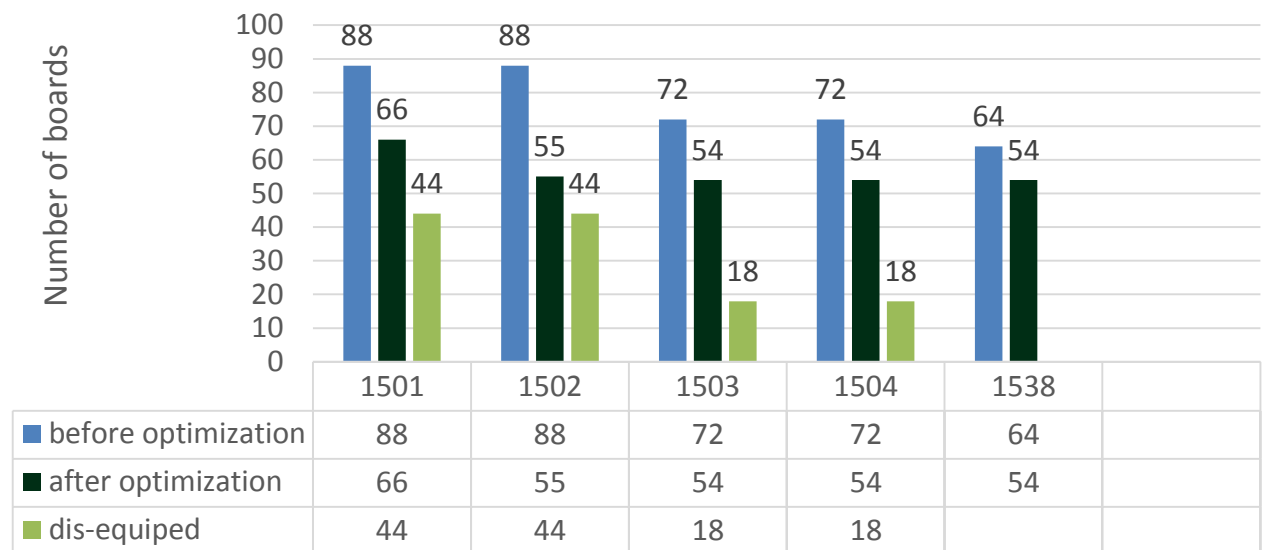
**Table 5 gains form fusion solution**

VB	VERSIONS COMBINED	boards Per jig board	number of jigs per VB	total number of boards Per VB <b>before optimization</b>	number of jigs per VB	total number of boards Per VB <b>after optimization</b>	gain%	bords gained	Comments
1501	ALK03 + OMA03	11	8	11*8 = 88	2	11*2= 22	75,00%	66	The versions ALK03 + OMA03 couldn't be combined with the other version. They had to be sperated.
	CSN05-CHH01-KAL06-AAW03-CES06-ETD13								
1502	CES06-ETD13	11	8	11*8=88	3	11*3	62,50%	55	only the comparison of 2D plans was accomplished
	ALK03 + OMA03+AAW03								
	CSN05-CHH01-KAL06								
1504	CHH01-KAL06-AAW03	9	8	9*8=72	2	9*2	75,00%	54	only the comparison of 2D plans was accomplished
	CES06+ETD13+ALK03 + OMA03+CSN05								
1503	CES07+SKY01	9	8	9*8=72	2	9*2	75,00%	54	only the comparison of 2D plans was accomplished
	KAL06 + CSN05 + CES06 + ALK03 + OMA03								
1538	KAL06 + CSN05 + CES06 + CES07+SKY01+ALK03 + OMA03	8	8	8*8=64	1	(8+2)*1=10	84,30%	54	one optimized jig board with the superposition of 2 boards

Table 6 gains from disassembly

vb	Versions to disassemble				number of boards per vb	number of versions disassembled	number of boards gained
	SAV02	AAW03	PAL04	PAL05			
<b>1501</b>	*	*	*	*	<b>11</b>	<b>4</b>	<b>44</b>
<b>1502</b>	*	*	*	*	<b>11</b>	<b>4</b>	<b>44</b>
<b>1503</b>			*	*	<b>9</b>	<b>2</b>	<b>18</b>
<b>1504</b>			*	*	<b>9</b>	<b>2</b>	<b>18</b>
						<b>Total gain from disassembly</b>	<b>124</b>

## Number of boards per VB



■ before optimization    ■ after optimization    ■ dis-equipped

### 7.2.2 Difficulties encountered

Few difficulties have been encountered in terms of:

- Respecting the limit of radius of curvature
- Equilibrium in the grouping of similar versions
- Large dissimilarities between some versions

## **8 Summary and discussion**

This thesis project has been evaluated as highly efficient since all the goals that were set have been achieved within the time frame that was defined. This accelerated Improvement workshop was successful in defining the different issues that were in the WP4004 program production lines, it was also successful in terms of results, there have been a major gain in the number of boards and a more sustainable use of jig boards have been set up, moreover a better space management and a safer jig board storage was accomplished by utilizing the newly designed jig board carriers. In addition a protocol has been established to ensure that the progress that was achieved and the solutions that were found will still be applied in the future. However there have been few difficulties that were encountered in the process of fusion between different 2D plans such as the difficulty in respecting the radius of curvature and equilibrium in the grouping of similar versions in one jig. Nevertheless some recommendations were given to counter these obstacles, for instance implementing an automated comparison software and assigning the tasks of the new optimization protocol to experienced operators to avoid amateur mistakes. All in all a major improvement has taken place in the A330-WP4004 production zone and only few details have to be subject to a further optimization.

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