Quotation for Customer Proposal and Performance Analysis for aircraft maintenance

KTH Thesis Report

Antoine BEZIER
Authors
Antoine BEZIER <bezier@kth.se>
Double degree student in Aerospace Engineering
KTH Royal Institute of Technology - ENSAM Arts et Métiers ParisTech

Place for Project
Sabena Technics Nîmes
Nîmes-Garons Airport
Saint-Gilles, France

Examiner and Supervisor for KTH
Raffaello Mariani <rmariani@kth.se>
Teknikringen 8
KTH Royal Institute of Technology

Supervisor for the company
Nidal Kochrad <nidal.kochrad@sabenatechnics.com>
Quotation Officer
Nîmes-Garons Airport
Saint-Gilles, France
Abstract

By working as an intern with the Quotation Officer of Sabena Technics Nîmes facility, an aircraft maintenance company, this degree project highlights the different factors to take into account in a quotation of civil planes (B737/B767/A320/A330) by analysing work packages from airline company, applying a process to estimate the important data as the man hours or tools, and using my technical knowledge to understand maintenance tasks. Management knowledge for commercial sale reviews was useful as well, this job is in the middle of the commercial team and and the technical team. Finally, a critical opinion of the process has been made in order to propose an improvement of the next quotations.

Keywords

Maintenance, aircraft, quotation, performance analysis, internship, aerospace engineering, databases, feedback, customer support, request for proposal, repair, technical work preparation, commercial offer, continuous improvement.
Abstract

Genom att arbeta som praktikant hos offerterbetaren på Sabena Technics anläggning i Nimes, ett underhållsföretag för flygplan, belyser detta examensarbete de olika faktorer som ska beaktas i en underhållsoffert för civila flygplan (B737/B767/A320/A330). Detta gjordes genom att analysera arbetspaket från flygbolag, tillämpa en process för att uppskatta viktiga uppgifter som arbetstimmar eller verktyg, och använda mina tekniska kunskaper för att förstå underhållsuppgifter. Kunskaper om förvaltning av kommersiella försäljningsöversikter var också användbara, eftersom det här jobbet ligger mitt emellan det kommersiella teamet och det tekniska teamet. Slutligen har jag gjort en kritisk bedömning av processen för att föreslå en förbättring av framtida offerter.

Nyckelord

Flygplansunderhåll, prestandaanalys, flygteknik, databaser, kommersiellt erbjudande, kontinuerlig förbättring.
Acknowledgements

I would mainly like to thank my supervisor Raffaello Mariani who has been a precious help for accepting to take time and energy for me, confirm me the rightness of my working in accordance with academic requests and give his expert point of view on aeronautic subjects. He had already trusted me during a previous project on Green Raven (a student-focused research project of a technological demonstrator platform for a hybrid/electric unmanned aerial vehicle at KTH [2]) and I am grateful for his support and his teachings. I would also like to thank my supervisor for the company, Nidal Kochrad, firstly for choosing me and trusting me to perform this job, and secondly for teaching me and allowing me to become more competent. Moreover, I would like to thank some others persons in the company : Jérôme Alamo who gave me excellent technical advice, saved me a lot of time and guided me in some decisions ; Simon Moreau and Julien Granados, who advice me as well for quotes ; Jean-François Hochenauer, my superior who gave my a good framework and supports, as well as the other members of the Airframe operation department ; Philippe Fournadet, Sabena Technics Nîmes facility CEO to welcome me in the company and to listen to me in sale review meetings ; and finally, Laure Rouquayrol, Diane Houpeau, Stéphanie Roquelaure, Cédric Pouzadoux, Aurélien Charre, Mélina Remal and Julie Costa for their sympathy and kindness.
# Nomenclature

**Latin Letters**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Airworthiness Directive</td>
</tr>
<tr>
<td>ADW</td>
<td>Additional work</td>
</tr>
<tr>
<td>AMM</td>
<td>Aircraft Maintenance Manual</td>
</tr>
<tr>
<td>AOG</td>
<td>Aircraft On Ground</td>
</tr>
<tr>
<td>ATA</td>
<td>Air Transport Association</td>
</tr>
<tr>
<td>DCM</td>
<td>Direct Cost Margit</td>
</tr>
<tr>
<td>EBIT</td>
<td>Earnings Before Interest and Taxes</td>
</tr>
<tr>
<td>EO</td>
<td>Engineering Order</td>
</tr>
<tr>
<td>IPC</td>
<td>Illustrated Parts Catalog</td>
</tr>
<tr>
<td>LOPA</td>
<td>Layout of Passenger Accommodations</td>
</tr>
<tr>
<td>MH</td>
<td>Man Hour(s)</td>
</tr>
<tr>
<td>MPD</td>
<td>Maintenance Planning Document</td>
</tr>
<tr>
<td>MRO</td>
<td>Maintenance, Repairs and Operations</td>
</tr>
<tr>
<td>NDT</td>
<td>Non Destructive Test</td>
</tr>
<tr>
<td>RFP</td>
<td>Request For Proposal</td>
</tr>
<tr>
<td>SB</td>
<td>Service Bulletin</td>
</tr>
<tr>
<td>SEDS or FSE</td>
<td>Social and Economic Data Sheet</td>
</tr>
<tr>
<td>TAT</td>
<td>Turnaround Time</td>
</tr>
<tr>
<td>WP</td>
<td>Workpackage</td>
</tr>
</tbody>
</table>
# Contents

1 Introduction

1.1 Presentation of the company ........................................... 9
1.2 Problem ................................................................. 11
1.3 Purpose ................................................................. 12
1.4 Goal ....................................................................... 12
1.5 Methodology ............................................................ 13
1.6 Delimitations ............................................................ 13
1.7 Stakeholders: Internal organisation for Sabena Technics Nîmes facility 14
1.8 Benefits, Ethics and Sustainability .................................. 15
1.9 Outline ................................................................. 16

2 <Theoretical Background> ................................................. 17

2.1 Hard skills ............................................................... 17
2.2 Soft skills ............................................................... 18
2.3 Related Work in the company ...................................... 18

3 <Methodologies and Methods: Quotation and Preparation> .......... 20

3.1 Input data ............................................................. 20
   3.1.1 Protocol/MPD tasks ............................................. 21
   3.1.2 AD and SB tasks ................................................ 23
   3.1.3 EO tasks and other Additional Works ..................... 24
3.2 Special treatment of input data ..................................... 24
   3.2.1 Excluded tasks .................................................. 24
   3.2.2 Rectification rate ................................................ 25
   3.2.3 Capping .......................................................... 26
   3.2.4 Subcontracting .................................................. 27
   3.2.5 Tooling .......................................................... 28
3.3 Social and Economic Data Sheet ........................................ 28
  3.3.1 Reserve of time for material and tool handling ............... 29
  3.3.2 Towing, hangaring, performing daily, weekly check, incoming and
       outgoing inspections (aircraft arrival, departure, and run-up) .. 30
  3.3.3 Material cost .................................................. 30
  3.3.4 Transport Cost ................................................. 31
  3.3.5 Planning ....................................................... 31
  3.3.6 Cost of framing ................................................ 31
  3.3.7 Direct Cost ..................................................... 32
  3.3.8 Indirect Cost .................................................. 32
  3.3.9 Global Turnover and Direct Cost Margin ....................... 33
  3.4 Approval of the quotation and commercial offer redaction ........ 33
  3.5 Preparation ...................................................... 35

4 <The work> .................................................................. 37

5 <Result : Work performance analysis> ................................. 38
  5.1 Collecting feedback .................................................. 38
    5.1.1 Man hours analysis ............................................ 38
    5.1.2 Supply chain ..................................................... 40
    5.1.3 Other collected feedback ...................................... 40
  5.2 Case of Nîmes Facility : Feedback analysis ....................... 41
    5.2.1 Man hours ....................................................... 41
    5.2.2 Supply chain ..................................................... 43
    5.2.3 TAT and Direct Cost Margin .................................. 43

6 <Conclusions> ................................................................ 44
  6.1 How to improve the performance as a Quotation Officer ........ 44
    6.1.1 A shared Database ............................................. 44
    6.1.2 Increasing the way of communication of data ................. 45
  6.2 Opening : unpredictable factors in aircraft maintenance ........ 46
    6.2.1 Future Work ..................................................... 47
    6.2.2 Final Words ...................................................... 48

References ..................................................................... 49
Chapter 1

Introduction

1.1 Presentation of the company

Sabena Technics is a French leading Independant MRO Customer-oriented solutions and modification services for the civil and military aircraft business with:

- 500M€ Turnover
- 3000 employees
- +500 customers worldwide
- 16 sites worldwide
- 250 heavy maintenance check

The company was created in 1968 and was named Touraine Air Transport (TAT). By expanding its activities, it has acquired other companies (ex: AOM) and was called TAT Group. In 2006, TAT Group acquires Sabena technics Brussels. Sabena technics becomes the sole MRO brand of TAT Group. It has been continuing to acquire and create peripherals structures. By developing several types of activities, Sabena Technics can provide a better answer for different customers requests. [13]
The degree project has been carried on Nîmes airport. This place has been chosen because the air traffic is minimal, and the site is secured by military rules and infrastructure (control tower, barbed wires ...).

Sporadically before October 2020 and continuously since then, the Nîmes center’s activity is focused on commercial aviation and government contracts, in particular the maintenance of the Civil Security Directorate’s firefighting fleet (Canadair CL-415, Beechcraft B200, DHC8 Q400) and the cargo and refueling aircraft of the French Air Forces (KC-135 and C-135FR).

There is more about the stories of these aircrafts that I have read and learnt through this internship in Appendix A.1.

However, the framework of this degree project is focused on commercial aircraft (A320/A330/B737/B767), see Section Delimitations 1.2 and Problem 1.2.
1.2 Problem

Sabena Technics Nîmes had won an offer from French Army for 12 years of KC-135 maintenance. However, this plane has slowly been replaced by the A330 M.R.T.T. So far, the MRTT maintenance is carried on by Airbus. Consequently, arriving at the end of the 12-year-contract for the KC-135, there is a bigger need for civil commercial aviation contracts.

During this period, there has been a small number of deep commercial aviation checks (as C-Check for example). Thus, the need for quotes was small. Now, the increase of commercial contracts has required to set back the job of quotation officer.

The problem is: KC-135 checks were quite repetitive, so no need to study in detail the requirements for each item. Moreover, the customer (French Army) was relatively flexible for the time interval from the submission date to the completion of the maintenance (also called TAT, Turnaround Time [6]).

These two statements are not at all the case for commercial aircraft: each day of TAT represents money for an airline company, and the work packages are all different. This fact requires to study all the items and give a specific quote of it. Indeed, there is a need to study every single item to identify specific tools or specific work as Sabena does not hold all the tools, or possess the expertise to accomplish the tasks (ex: NDT for engine as borescope). However, since there was no need to build one during years, there is not a clear database between an item and its requirements (man hours (MH), tools, subcontracting... the quote’s details will be given in Chapter 3). How to define as accurate as possible the general needs of a maintenance check? How to get the customer prise under control? How to capitalize on work already done to have a better
CHAPTER 1. INTRODUCTION

performance next time?

1.3 Purpose

This report first presents the work done for the company by understanding how to process the customer information.

Then, it illustrates how the performance on aeronautic maintenance has been analyzed to make new tools to improve the next performance.

Finally, the project discusses on the difficulty to predict with accuracy an aircraft maintenance due to a too important number of unpredictable factors.

1.4 Goal

The first goal is to reply Customers’ Request For Proposal (RFP) by analyzing a work package to make a quotation of it in an Excel file. Then a Social and Economic Data Sheet SEDS [8] (called FSE in French for "Fiche Sociale et Economique") sum up in one Excel sheet the important data to make the proposal. Finally, a commercial offer in accordance with commercial data is written based on a Word template.

If the contract is signed by the customer, the second goal is to prepare the check in detail by the preparation team. Indeed, the Quotation Officer does not work on this part. Although, to have a better view on the whole phase before the technical work, one month of this internship has been done with the preparation team. First, verifying if all the documentation was sent by the customer or accessible by company’s tools, and second, reading it to order all required materials. This information are written in a shared excel file. Then, the documentation is printed and upgraded : adding on it necessary additional information for a good work quality and sorting it to make it easier for team leader to split the work. Moreover, access panels and major panels to be removed are printed to make the job of opening access easier.

Then, during the technical work, the third goal is to collect information to be able to compare the quotation/preparation and reality, either by looking at the time notified on the company software spending on each task which can have some accuracy troubles or by speaking with the mechanical team and understand where are the major trouble.
At the end, a table to compare between prediction and reality is made to analyze which prediction was good or not and try to understand why.

Finally, all of this work should be used for the next proposal to be more and more efficient. To do that, the last goal is to assure an enrichment of a database by using a feedback at each step of the project.

### 1.5 Methodology

The method is based on current internal Sabena process and is going to be detailed as :

- Process for making a work package quotation,
- Process for making a Social and Economic Data Sheet,
- Process for having the approval to send the commercial offer,
- Process for preparing the technical work,
- Process for collecting feedback,

and how to use different tools to achieve this goal : Database as Airbus World [3], MyBoeingFleet [5], Internal Database and software (ex : AMASIS).

### 1.6 Delimitations

The framework of this degree project is focused on commercial aircraft (A320/ A330/ B737/ B767), because the department I worked in was dedicated to this activity, because military and government contracts are less easy to have access and to speak about it, and because commercial contracts are slowly becoming the largest part of the company’s revenue, for reasons explained in Section 1.2 ”Problem”.

In this department, the job is delimited by inputs and outputs : the commercial team and the customer support give the work packages, and when the proposal is signed, the folder is forwarded to the preparation team leaded by the Planification officer (See Section 1.7).

In this thesis project, to have a better view of the whole pre-technical work process, the quotation is the main subject, but observations and works have been performed with
the preparation team as well. However, it was not an option to continue further and to work as a technical worker on the plane, although a frequent communication with the technical team is important to perform feedback.

Therefore, the delimitations are from the commercial data to the whole technical work preparation.

1.7 Stakeholders: Internal organisation for Sabena Technics Nîmes facility

As it has been said in Section 1.1, this thesis has been focused on commercial aircraft contract of the company. So, it would be pointless to present all details of the company organisation. It seems better to present a general organisation and give more details to stakeholder in the same department as the quotation officer: the Airframe Operations department for civil commercial contract. These are the persons that I have had to daily exchange with them.

![General organization chart of Sabena Technics Nîmes](image)

Figure 1.7.1: General organization chart of Sabena Technics Nîmes
CHAPTER 1. INTRODUCTION

1.8 Benefits, Ethics and Sustainability

Maintenance is a key point in the aircraft lifecycle, it requires to have access to the different parts of the plane, how it is possible to take care of them and how to do it in a more efficient way. So, this project has illustrated in details the organs inside an aircraft, the link between the different elements and how the time and the external environment can affect it. This is really useful to improve technical knowledge, especially on B737/B767 and A320/A330. In another hand, the job is in connection with the commercial team which deal with market reality by having attractive prices and aiming to customer satisfaction. The right balance between letting enough time to the technical team to do the job and not too much to be cost-effective is a tough equilibrium to find.

In addition, by analysis process in maintenance aircraft field, it is possible to find an equilibrium point between safety and sustainability, in order to change part at the right frequency (too often: wasting oil, grease, part... and too rarely : a crack or a corrosion can damage the aircraft and cause a crash [7]). Consequently, this is a good example of an ethic/sustainable balance due to this compromise between safety and saving earth.
resources.

1.9 Outline

After having introduce thesis' framework, the second chapter deals with background knowledge used along the project. It was useful to had acquired them during my studies and experiences. Hard skills as software, aeronautic vocabularies and physical flying concepts's knowledge have been obviously requested, and soft skills as communications was needed to present the work performed as clear as possible.
Chapter 2

<Theoretical Background>

2.1 Hard skills

The main hard skill used in this thesis has been my knowledge from MS Office software: Excel has been daily used to receive work packages, treat the data on it, filter the information needed for the study, throwing out the unnecessary ones, and search in the sheets using formula to extract the right data.

Moreover, to perform a technical analysis of several maintenance tasks and commercial data, it has been used:

- Vocabulary learnt during my studies and previous work experience,
- How to look for the right information in an important amount of documentation (ex: in Airbus World [3], MyBoeingFleet [5], or Airfleet [10]),
- How to use maintenance manuals (as AMM, MPD, IPC) by using my aircraft knowledge to estimate the resources needed to perform the task and the severity of the task (which data are you looking for and in which manual you find it?),
- how to use ATA classification and fuselage station to analyse maintenance tasks
- Financial analysis: dealing with several mathematical operations to optimize spreadsheet’s computation.

Moreover, the planes were just beside the desk. Consequently, by simply watching the different maintenance operations or asking to go in the aircraft, it was possible to see a "naked" machine: where the control cables are, how difficult it is to access to some
part of the plane (ex: behind the toilets), what are the tests to perform after during a task... It was interesting to continuously increase my technical knowledge.

### 2.2 Soft skills

During an internship, one of the main insight is to notice how soft skills are important in a workplace. Especially, this internship allows to highlight:

- The capability to adapt yourself in many different situations,
- How to organise and schedule the work,
- How to analyse in detail what it has been asked to do by choosing a right methodology,
- Making a synthesis of several analysis to be clear about what are the conclusions classified in the order of priority information,
- Asking for guidance or listen to advice.

These skills have been acquired during several projects throughout my studies, in particular by communicating during the last year in KTH with projects from 2 to 6 months and from 2 to 20 members.

### 2.3 Related Work in the company

Related work is made by stakeholders presented in Subsection 1.7. To be more accurate, a quotation officer is daily in contact with the commercial team and the customer support to receive input commercial data (work package, customer details, Layout of Passenger Accommodations (LOPA), etc) and to ask for additional or missing documentations. He is also strongly linked to the Planification officer to give quotation data and to receive available and not available spot. This last information is important to avoid useless work and to decide about quotation priorities. For example, if an airline would like a check during June 2022 but Sabena Nîmes facility has no slot available during this period (because hangars are already full of planes, or because there is already a booked check which will mobilize full manpower, or because the input date is to short to prepare the check), there is no need to make a quote of the check. Then, the quotation work is sent to the preparation team, which prepare technical work
for the aircraft manager team. From this point, receiving a feedback from these two teams is related to the work perform for quotation because it helps to realise a better performance next time. For example, the one of the teams might find a required tool that the quotation officer did not notice it earlier. Indeed, the preparation team goes deeper into the analysis than the quotation officer. The database can be upgraded by using this feedback.
Chapter 3

<Methodologies and Methods: Quotation and Preparation>

In this Chapter, each step of the quotation will be slowly detailed to explain in detail how to a quote is currently made in Sabena Technics Nîmes facility.

3.1 Input data

As explained in Section 2.3, the commercial team and customer support are giving input data through RFP. To model the job to perform, an Excel file is divided by
different type of tasks:

- Protocol tasks, also called MPD tasks or routine tasks
- AD and SB tasks, for Airworthiness Directive and Service Bulletin
- EO tasks, for Engineering Order, and other Additional Works.

In the next subsections, it is explained each type of tasks and how to quote it.

3.1.1 Protocol/MPD tasks

These tasks are listed by the manufacturer (Ex: Airbus or Boeing), with an associated time to perform each task. The manufacturer database can be found on Airbus World [3] or My Boeing fleet [5] and extracted as a Excel file. Each type of aircraft (A320, A330, B737, B767) has its own MPD database.

To go into further detail, Airbus database splits the total time in 3 parts: Preparation / Access / Task. The aim is to avoid a duplication of time. For example, if two operations require to open the fan cowld doors, it is useless to do it twice, so to sell twice the time. Otherwise, Sabena will be less competitive on the market, and this is not a big effort to make. What Airbus calls "Preparation" is repetitive pre-operations to accomplish before the operator can do the task which are not covered by an access panel number (toilet or galley removal to inspect the floor structure). At the opposite, the time to remove and install an access panel which has a number can be found in the "Access" category. Consequently, "Task" time only represents the duration of the operation. In the same logic, it is better to do it once and to gather all the operations under a jacking in the same time in the schedule.

- Example of access: 831FZ (access panel on A330)
- Example of Preparation task: Airplane Jacking (procedure to level the aircraft with jacks in order to perform landing gears extension and extraction)
- Example of operation: flight control mechanism lubrication
CHAPTER 3. <METHODOLOGIES AND METHODS : QUOTATION AND PREPARATION>

Note: the Quotation Officer does not make a complete planning of the visit, however it is better to have an idea of a "macro-planning" to help the quotation officer.

These tasks mainly are "basic" maintenance operations, and maintenance cost for a brand-new aircraft is computed according to this data. In other words, it is a sell argument to roughly estimate maintenance cost of an aircraft for a airline company, so it might be a reason why an airline would choose a plane against another.

This selling point is the reason why this data does not represent the reality of the time spend in a MRO on the aircraft, it is under-estimated to make the cost lower "on paper" (detailed about what is taken into account according to manufacturer can be found in Appendix B.1). So, a ratio must be found between these time indications and the MRO productivity. What is the MRO performance compared to the manufacturer standard? That is why a good feedback from the production team is important for the quotation officer. Indeed, a ratio between the time spent to perform the task and the indicated time in the manufacturer database might give this ratio. In practical terms, this ratio is not representative for each task. This point will be treated in more detail in Chapter 4 (Work). Consequently, an average ratio is easier to compute, and it is used to convert indicated time in database into estimated time for quotation.

So, to estimated the time for MPD task:

- From manufacturer data, the Quotation Officer selects the tasks in accordance with the customer MPD work package by using the tool "vlookup" on Excel, which
gives which items are presents in the work package,

- By filtering the database in these present items, he can have a first rough time estimation for all MPD tasks,

- Then he deletes the duplication of access and preparation time, read the "longest” tasks/access/preparation, globally check if there is a special need as tools, jacking, fueling, or subcontracting... to have a better view of the important jobs to perform,

- By applying a global MPD coefficient, the quotation officer can estimate the time to perform MPD tasks in the MRO. This coefficient is between 2.5 and 5 in function of the manufacturer and the task complexity.

Note: Another solution would be to have enough data from MRO performance to estimate time not in function of a manufacturer database but only in function of MRO performance, by making a statistical study on each maintenance task to predict the time to spend for each task. However, as it has been said in the Introduction, there is not enough data for civil aircraft to make this study. Consequently, it is impossible to do that so far. Moreover, there is a lot of interference between tasks. A global coefficient on a group of task is more practical. Furthermore, an efficient planning of resources and material will increase maintenance efficiency.

### 3.1.2 AD and SB tasks

By studying what is happening in real time on a type of aircraft, a manufacturer can decide to add mandatory of recommended tasks into Airworthiness Directives. For example, if several airlines have noticed that a pump systematically fails before its due date, the manufacturer can order to inspect the pump more frequently to make sure that the aircraft will be not stopped on the ground (called AOG ) because of that element. To make it official, the manufacturer writes a Service Bulletin to detail why this task is to be performed and how to do it.

More importantly for the quotation officer, it is often possible to find the time to perform the task, the tools and parts required, the accesses and the preparations. By analysing it, the data are classified into a database, one per each type of aircraft (A320,A330,B737,B767). Sometimes, calling a subcontractor is required (example : special cabin cleaning, NDT operation, etc).
Theses documents are quite long to read and it needs to be performed one by one. Treating AD/SB tasks really is time-consuming, that is why it is crucial to capitalize on the work done and to collect as much useful information as possible in the database.

According to the technical team and feedback, time indicating in AD/SB files is rather accurate. A security coefficient between 1.5 and 2 is still used to ensure the technical team that they will have enough time to perform the operation.

### 3.1.3 EO tasks and other Additional Works

These tasks are special orders for the company specific for each aircraft. While a maintenance check is performed, it is a right opportunity to check part of the plane in function of its cycle of life: checking old repairs, performing a temporary or permanent one, changing cabin configuration (carpet and/or NTF), or refurbishing seats. These special customer requests must be studied one by one. Depending on the airline company, it is more or less easy to analyse them. Indeed, if pictures, subtasks to do, material requested, etc, is given and well defined, it can be easy. Otherwise, additional data is frequently requested.

Often, these tasks requires to speak with several persons in the company to have an expert point of view. The most common ones are: NDT managers, members of Engineering team, or chief of technical teams.

By discussing with them, the quotation officer can roughly estimate the time needed to perform the task.

### 3.2 Special treatment of input data

In the work package, some tasks needs to be clarified, other cannot be performed in Nîmes facility because a too important investment must be done or because they will not fit in the agreed TAT, and some are added during the technical work.

#### 3.2.1 Excluded tasks

In particular cases, a MRO cannot perform a task. There are several cases for that.

If:
• Not enough information is provided from the customer about a task
• A document is missing to perform the task or to identify a tool
• Without studying the task to perform the aircraft (ex: a defect), the MRO cannot affirm that it will be able to realise the task

The task is excluded from the commercial offer, but it might be performed during the technical work. Treatment of these tasks will be done through a "Time and Material" basis. The Aircraft Manager assisted by the account manager will compute the labour and the material cost and provide a quote to the customer representative. The quote may lead to negotiations between the parties.

If:

• the task is known as not possible to be performed in the MRO (because a tool is missing and too expensive to buy, the infrastructure does not allowed to perform it, lack of competences...)
• the task is making an important impact on TAT by its significant duration or by its special requirement (turning off the power supply) and it is not possible to fit the task in the slot

The task is excluded from the check and will be performed only if the customer pays a high price for the tool or service (ex: adding a lot of workers by doing a subcontract with an interim agency).

Note: When the MRO competences are limited, it is possible to ask a subcontractor, more specialized, to realise the task. It can reduce the TAT because the performance is better, but it might increase the price as well. Example: Borescope inspection for new engines, or installing wires in the cabin.

3.2.2 Rectification rate

After performing an inspection, there is a risk of finding a defect. It is called a rectification. The quotation officer has to estimate the proportion of time of the entire check that will be used to solve findings. This figure is the most blurry part of the quote. Indeed, it is impossible to predict the amount of findings during a check without performing the inspection tasks. However, some criteria can help:

• age of aircraft: the older it is, the higher the risk is to find defects
• type of check: the most inspections there are, the higher the risk is to find defects. Moreover, if a zone to inspect is under a humid area (toilet or galley), because these zones are prone to corrosion development, the risk of increasing rectification time is high.

• aircraft history: if the last maintenance was made in an cheap foreign country or if an aircraft is badly treated by the company, the risk of findings is higher

From this analysis, the rectification rate can go from 10% from a young and well-treated aircraft performing a small check with no structural inspection, to 50% for an old and badly-treated aircraft performing a big check with structural inspection. This percentage is not accurate and can weigh heavily in the financial balance and the total time of the check (in other word, the TAT).

This rectifications only concern protocol tasks. All defects found for AD/SB/EO tasks will be treated in Time and Material Basis (with the aircraft manager and the account manager).

3.2.3 Capping

Inside this amount of rectification, a capping can be defined by the customer. This means that until a defined amount of hour, the customer cannot be invoiced. Let’s take an example: The customer would like a capping of 10 hours per task card. If the time spent on a defect is 11 hours, 1 hour will be invoiced to the customer. If the time spent on a defect is lower than 10 hours, the customer will be not invoiced.

Consequently, a “reserve” of hours has to be taken into account in the first commercial offer. Let’s continue the example: if the check represents 1000 hours of work, and the estimate rectification rate is 10%, there is a total of 100 hours of estimated rectification in total. Due to the capping, a proportion from this 100 hours has to be added in the commercial offer, to cover the rectifications which will not be able to be invoiced later, ie the rectifications hours that will fall below the 10 hours threshold. From a database of previous checks, it is possible to determinate this ratio. For example, 10 hours per task card represents 30% of total estimated rectification (100H) to take into reserve, which represents in the example 30H. Obviously, the bigger is the capping, the higher the percentage is. For another example, a capping of 100H per task card avoids any invoice from the aircraft manager to the customer, so all estimated rectifications
must be taken into reserve. A high capping (50h, 100h) reduces workload over the A/C manager and the customer representative during the work event (less paper, and less time consuming negotiations). Heavy checks are treated with high capping (>50h) to fluidize check whereas smaller checks are monitored by a small capping (<25 MH).

With the same logic, it is possible to define a capping for spare parts concerning rectifications arising from routine items. For example, the customer would like a capping of 1000 EUR per line item. If a pump of 1500 EUR must be replaced, 500 EUR will be invoiced to the customer. Consequently, 1000 EUR will be paid by the MRO, so a money provision must be taken. From the database of previous checks, it also is possible to define the reserve to do and the ratio between the total amount of estimated money spent in rectification.

Moreover, the type of capping has to be defined. Indeed, if the same part has to be purchased several times (ex : 4 pumps), it has to be clear whether the capping applies only one time for all the pumps to be purchased or repeated 4 times. To continue the example of the pumps (one pump cost 1500 EUR, capping 1000 EUR), if 4 pumps must be replaced, will the customer be invoiced of 5000 EUR \((1500 \times 4 - 1000)\) or 2000 EUR \((1500 \times 4 - 1000 \times 4)\) ? The first case is called "per Line items" (same Part Number are grouped together and capping applies only on time) and the second one is called "per Single Item". In the second case, the reserve of money has to be even more important. To be honest, this case is highly risky for the MRO, it is not the preferred option. Without a specific request from the client, this type of capping will not be used, as it increases the price and uncertainty about the "financial" success of the check. It has to be avoid as far as possible.

### 3.2.4 Subcontracting

Subcontractors are requested when the MRO is missing special competences for a special task, or to perform a task more efficiently.

Classic subcontracting contracts are :

- Internal or external commercial cleaning
- Fueling or defueling the aircraft
- Special NDT tasks (ex: special borescope inspections)
• Removal/installation of cabin equipment (seats, toilets, galleys, carpets, NTF)

• Special wiring operations

### 3.2.5 Tooling

An important tool to buy or to rent can impact a lot the price of the commercial offer. Obviously, if the tool is useful for later, it might be a good investment. The tool department has to be aware of that to check if it is a good idea to invest on it, or not.

To be aware if the company owns a tool required for the accomplishment of a task card, the MRO intern can look after software AMASIS [1] includes an inventory of all the tools managed by the company. (and a lot of other functionality not used in this internship). By seeking for the tool there, it is possible to check if the MRO has already the tool or not.

Note : MRO shall cover classic tools to perform routines tasks. Special tools can be re-invoiced to customer.

### 3.3 Social and Economic Data Sheet

Once all cost drivers have been identified and calculated (manhours, material, rectifications, tools, subcontracts...), a sheet is created to sum up all this data.

Moreover, it includes additional data which should be taken into consideration :

• Reserve of time for material and tool handling

• Time for towing, hangaring, performing daily and weekly check

• Incoming and Outcoming inspections (Aircraft arrival, run-up, etc)"

• Material cost

• Transport cost

• Planning data

• Cost of framing
• Cost of administrative work (aircraft file update, parts ordering, check preparation and planning, work order creations)

• Direct cost

• Indirect cost (including hangar cost)

• Global Turnover and Direct Cost Margin

Every Work Time are listed in this bar chart. They have been explained earlier or they will be explained below:

![Bar Chart: Social and Economic Data Sheet Work Time](image)

Figure 3.3.1: Bar Chart: Social and Economic Data Sheet Work Time

Note: here, "All Rectification" means "All expected rectification" during the quotation process.

### 3.3.1 Reserve of time for material and tool handling

This figure represents the amount of time spent to move material or heavy tools like jacks in the hangar or on the runway to do a task later on. It is a margin of hour to...
be sure that technical teams will have enough time to perform the job and to store tools and other material in a proper way. Usually, 10% is added to the total amount of production time.

However, the quotation officer knows that he can reduce this parameter to be more competitive. The communication with the commercial team needs to be clear enough.

### 3.3.2 Towing, hangaring, performing daily, weekly check, incoming and outcoming inspections (aircraft arrival, departure, and run-up)

These are classic jobs to realise during an aircraft maintenance technical work. Depending on aircraft’s size, it is more or less long. For example, for a A320 or a B737 (called "narrowbody aircrafts"), it is estimated 60 hours, than for a A330 and B767 (called "widebody aircraft"), it is more around 110 hours. In intern, there is a table to find equivalence between these classic jobs and the estimated times.

### 3.3.3 Material cost

First, there is a distinction to make: the total material cost is the sum between the protocol material cost and the reserve for rectifications that will fall under capping:

\[
Tot_{\text{material cost}} = Protocol_{\text{material cost}} + Rectif_{\text{material cost}} \cdot \%\text{capping}
\]  

where \(\%\text{capping}\) is the ratio found by using the database of capping from previous check (Example: 500 EUR per Line Items (see 3.2.3): requires to take in provision: 50% of the total estimated material cost for rectification.

To compute material cost, a linear approximation is used between the amount of hours and the material cost:

\[
Protocol_{\text{material cost}} = C_{\text{protocol}} \cdot Hours_{\text{protocol}}
\]  

\[
Rectif_{\text{material cost}} = C_{\text{rectif}} \cdot Hours_{\text{rectif}}
\]
where $C_{\text{protocol}}$ and $C_{\text{rectif}}$ are two coefficients defined by using previous experiences.

### 3.3.4 Transport Cost

There is two methods possible:

- using a fixed price
- applying a coefficient on the amount of hours as Equation 3.2 for material cost

### 3.3.5 Planning

By dividing the total amount of hour (including all estimated rectifications) by the capacity of production per day of the MRO, it simply gives the number of required working days:

$$Working.Days = \frac{\text{inspections.hours} + \text{rectifications.hours}}{\text{production.capacity}}$$

By adding the right amount if non-working days (Sundays, holidays, etc), the quotation officer finds an estimation of the TAT.

Important note : this is an estimated TAT. Beware of the incompressible task in time, limits must be given. Everything cannot be done in one day even if there are an unlimited number of technicians. Some tasks cannot be parallelized (e.g.: reassembling the cabin before launching tests). It is the notion of critical path that must be taken into account. On a narrowbody, because of the space, more than 30-40 people per day is not an option (50-60 for a widebody). In general, a cabin removal on an A330, takes 1-2 weeks, and installation takes 2-3 weeks in Nîmes facility.

### 3.3.6 Cost of framing

It is an estimation in hours of the time spent by the preparation, team leaders, etc... for the check. By using the examples of previous checks, this amount of hours is a percentage of the technical time spent on the aircraft to perform tasks:
CHAPTER 3. <METHODOLOGIES AND METHODS : QUOTATION AND PREPARATION>

\[ \text{Hours}_{\text{framing}} = \text{Technical.Hours} \cdot \%\text{Framing} \]  \hspace{1cm} (3.4)

where \( \%\text{Framing} \) is a percentage based on previous checks.

Note: Cost of administrative work is computed by using the same formula but by replacing \( \%\text{Framing} \) with \( \%\text{Admin.Work} \). To make this report easier, \( \text{Hours}_{\text{framing}} \) will include \( \text{Hours}_{\text{Admin.Work}} \). It is an internal distinction non-useful for the quotation work.

3.3.7 Direct Cost

By multiplying the production time by the hourly production rate (which has the unit of €/h), the result is the direct cost of the check.

\[ \text{Direct.cost} = \text{Production.time} \cdot \text{Rate}_{\text{hourly.production}} \] \hspace{1cm} (3.5a)

\[ \text{Production.time} = \text{Technical.time} + \text{rectification}_{\text{under.capping}} + \text{Hours}_{\text{framing}} \] \hspace{1cm} (3.5b)

3.3.8 Indirect Cost

Based on data given by the financial department, indirect cost can be computed. It is due to the production (including the overhead cost which is composed of the salaries of executives and managers), subcontracting, supply chain, and hangar or parking fees. The quotation officer applies these different coefficients:

\[ \text{Indirect.cost}_{\text{production}} = \text{Production.time} \cdot C_{\text{ind.prod}} \] \hspace{1cm} (3.6a)

\[ \text{Indirect.cost}_{\text{subcontract}} = \text{Cost}_{\text{subcontract}} \cdot \%\text{Ind}_{\text{subcontract}} \] \hspace{1cm} (3.6b)

\[ \text{Indirect.cost}_{\text{supply.chain}} = \text{Cost}_{\text{material}} \cdot \%\text{Ind}_{\text{supply.chain}} \] \hspace{1cm} (3.6c)

where the coefficient \( C_{\text{ind.prod}} \) has the unit €/h.
3.3.9 Global Turnover and Direct Cost Margin

These are the linked formulas to find the Global Turnover:

\[
\text{Global.Turnover} = \text{Direct.cost} + \text{Indirect.cost} + \text{EBIT.Margin} \quad (3.7a)
\]

\[
\text{EBIT.Margin} = (\text{Financial.Cost} + \text{Net.result}) \cdot \text{Global.Turnover} \quad (3.7b)
\]

\[
\Rightarrow \text{Global.Turnover} = \frac{\text{Direct.cost} + \text{Indirect.cost}}{1 - \text{Financial.Cost} - \text{Net.result}} \quad (3.7c)
\]

where \(\text{Financial.Cost}\) and \(\text{Net.Result}\) are financial parameters expressed as percentages of Global Turnover. For the Quotation officer in Sabena Nîmes, the financial cost stays fixed, but the Net Result can evolve to modify the Direct Cost Margin DCM:

\[
\text{DCM} = \text{Global.Turnover} - \text{Direct.Cost} = \text{Indirect.Cost} + \text{EBIT} \quad (3.8a)
\]

\[
\%\text{DCM} = \frac{(\text{Global.Turnover} - \text{Direct.Cost})/\text{Global.Turnover}} \quad (3.8b)
\]

Finally, all parameters required to present the quote to the managers are ready, from production to financial data.

3.4 Approval of the quotation and commercial offer redaction

When the quotation is ready, a meeting is held with the VP Airframe Operations, Customer Support, Planification Officer, and sometimes the CEO of Sabena Technics Nîmes facility. Indeed, if a slot is targeted by several airlines, it is a commercial and strategic choice to accept one against the other in order to have a longer collaboration that may follow.

During this meeting, the Quotation Officer exposes the key figures of the check: man hours with their different proportions, important tasks and accesses, key points to be careful, price, TAT, specific tools to rent, sub-contacting, customer requests potentially
unsatisfied, potential margin to be able to negotiate the price later on without giving too much pain to the production team. All this requirements have to fit in the right slot, and with enough human resources to deal with it. Otherwise, the group defines a new slot to propose, or ask for more human resources by subcontracting or using temporary worker contracts.

When the managers agree on the quote, a commercial offer is written and contains all important information to clearly define as far as possible that is include or exclude of the price. It is a crucial step because switching an exclusion in a inclusion can cost a non-schedule amount of money to spend without being included in the commercial price.

Globally, the contract includes:

- Scope of work with a reminder of used work packages
- Work Schedule / Milestones / TAT
- Place of work
- Documentation to provide by the customer
- Material Supply*
- Financial conditions**
- Warranty periods

*Indeed, all material for AD/SB/EO and material for non routine works above capping has to be paid or sent by the customer

** This is the most important part : it gives the price of the check with all inclusions (Manpower for which tasks, capping, classic operations as aircraft arrival, run-up, etc) and exclusions (any important works which can be extremely costly, special material, equipment, etc)

Note : the commercial offer does not include the amount of hours predicted, this information is obviously kept secret. Nevertheless, the airline has the Airbus database to estimate global HMO. Then, they can compare MRO(s) rate and their competitiveness.

Once it is written, the Customer Support and the VP Airframe Operations review it again, send it to the commercial team which ask questions and can make small
modifications on financial conditions to be more attractive. However, they cannot change the inclusion/exclusion conditions.

Hopefully, the customer will sign this offer.

### 3.5 Preparation

For the Quotation Officer, there are many quotes to make, and not all of them will be signed. Therefore, spending too much time on one quote might be useless and create the risk to miss time for another one. However, if the customer signs the offer, the request has to be studied in more detail. Indeed, the preparation team should rely on the quote as a starting point, but they must go further.

First, the team studies each work package’s items and determine:

- Access
- Tools
- Consumables, parts, expendables
- Global understanding of the main operations in a task
- Control levels

Therefore, they obviously need the documentation that the quotation officer has used earlier (included missing documentations that he has obtained from the customer) to work on the same basis. Moreover, some tools and accesses have been noticed during the quotation (hopefully, the majority of them). Indeed, new engine and new aircraft expose the MRO to new type of tools, which are not in his possession. For engine and aircraft known by the MRO, there are low chance to miss a tool. In this way, some elements to determinate are common between the quote and the preparation needs.

However, "Control levels" and "Consumables, parts, expendables" are specific analysis for the preparation team, depending on the type of task (General inspection, detailed inspection, operational test, etc) and the ATA chapter (Air Transport Association).

Then, each task documents need to be printed, with the control levels written on it, and without a mistake or something unclear in it. A sticker is stuck on it to track the
task through the check. Printing them before is necessary to save time, to be sure that the technicians have all documents they need to perform the tasks, and to have the right signature of the qualified technical worker at the right place. Quality of work is important in a MRO to keep the aircraft maintenance agreements.

The preparation team do not hesitate to ask question to the technical team to prepare as good as possible the job for them.

A good preparation is a key point for a technical work with a minimum of trouble. On the opposite, missing something during this work phase will create a waste of time in the production, or it can cost a lot of money because urgent move are always expensive (for example, bring in a part from another country in less than 24 hours). Therefore, it is a stressful job.

All documents are forwarded to the technical team: the technical work can begin.
Chapter 4

<The work>

During this degree project, I actually apply the methods described in the Chapter 3 to more than 20 work packages for B737/B767/A320/A321/A330, freight or passenger, sent by the commercial teams concerning airlines from the world. To quote some names, IBERIA, LATAM, or TRANSAVIA requested quotations for one or several of their aircraft checks. I have actively participated to two check C of IBERIA A330. I had been able to make the quote approved, contribute to the preparation and see the planes being checked. Therefore, I had the chance to compare my own quote compared to the real work.

Unfortunately, for confidential reasons, I cannot present real figures of a quotation. It would be commercially unfair. However, the most important part to understand is the method, because the quote does not matter, the process is still the same. The activity which was taking the majority of the time was to analyse EO and Additional task one by one by using my background described in Chapter 2 and by increasing in knowledge through the time.

Moreover, it can be interesting to make a judgement on this method and try to improve it. To do that, a comparison between the technical work performance and the quote should be the starting point to check where are the bigger gaps in man hours, lack of resources or communication... Therefore, the next step is to analyse the performance of the MRO during a check compared to the quote.
Chapter 5

<Result : Work performance analysis>

5.1 Collecting feedback

There will be a gap between what it has been predicted and what it will happen. To try to quantify these gaps, a maximum of usable data are required about:

- Man hours
- Material, tools and supply chain
- Expenditure on materials
- Expenditure on subcontracting
- Main troubles during the check
- Respect of TAT

During the technical work, the Planification Officer is sending every day a state of progress of the check, which is useful to evaluate to what extent the job goes as planned. At the end, the final progress report can be used as a feedback.

5.1.1 Man hours analysis

Man hours spent is the main concern of the Quotation officer because it is the main cost driver (then comes the material cost). First, he has a general look on the check. If the
final amount of hour is close to the one quoted, the main goal is reached. Indeed, there obviously is gaps between each quotation of each item in reality. Globally, over the check, the total manhours spent should be close to predictions. Sometimes a technician can perform better on a task because conditions are optimum and can last longer on another one due to non-productivity factors (as parallelization of non-compatible tasks, lack of supplies or tools). However, if all gaps are overlapped and they cancel each other out, the commercial offer is still right so the overall plan is respected.

Although this first point can be satisfying, it is needed to go deeper. if all gaps cancel each other out during this check, it might be not true next time if some gaps are not corrected. Here it comes the main trouble from a proper feedback: for a task, the time written in the progress report might be not the one spend on aircraft. The reason is the production organisation: a team leader will give a pack of job cards to perform, and the technician is frequently starting the job by tracking the fist one, performing all jobs in the pack, and finally indicate the end of the first task. Therefore, the time written on the software for the first card is over-estimated whereas the other cards will have no associated time. Therefore, it is not possible to just pick up the time for the progress report as a reference for a unique task. However, pack of cards are always given for a specific zone. By adding all times from this zone (in quotation and in the progress report), the result is more interesting to compare. Moreover, it gives an order of magnitude for next checks. For example, if the time to remove and install all the cabin equipment in a B767 took 2000H to perform (figure as an example), it is useful to know for the next cabin removal plane to quote.

Therefore, adding man hours per zone and compare it to the quotation per zone is one of the method to overcome inaccurate task card labour record. Another interesting sum to make is the man hours per type of task: MPD, AD/SB, EO. Indeed, ratios have been chosen to compute the quotation (See Section 3.1). Especially, by dividing the time spent during the check by the announced manufacturer time (for MPD or AD/SB tasks), the result is a ratio that we can compare to the one used for making the quote. It gives an objective idea of the MRO efficiency. Sometimes, doing the same computation with all accesses is interesting because the ratio might be different.

In a second time, the other time parameters can be checked, such as total rectifications hours (ie Unscheduled/Scheduled Manhours ratio) or hours of framing and administrative works.
5.1.2 Supply chain

Here, it will be included tools and materials used during a check.

The most frequent and also problematic mistake is to miss a tool to perform an operation. In this case, the procurement team makes an urgent request to a supplier to provide us the tool as soon as possible. Since time is money, making come a tool by this path is really expensive and can fall-off the profits.

For AD/SB/EO, the customer is supposed to bring in materials and tools. However, depending on the client’s rigour, the MRO sometimes has to ask a specific list of material. If something is missing, the customer should do the maximum to bring it on time. In this case, it is a customer mistake, so if the TAT increases, there will be no penalties for the MRO because it was not his fault if the job is not performed on time. On the contrary, it is possible that the customer receives some penalties to let his aircraft longer than planned in the hangar, so it can take the spot of another scheduled aircraft.

So, being really careful with the tools and notice when one was missing to update the database can make a huge difference in the future. It can block the check and create a lot of stress around this trouble.

5.1.3 Other collected feedback

The price of subcontracting paid is to be compared to the one quoted to check if the subcontract has been useful, if the price was the one indicated in the quotation, and if there has been a subcontract done that the quotation had not taken into account.

If the TAT is not respected, it is important to check if the mistake is coming from an under-estimation of work from the quotation officer, a lack of human resources developed on this check, or a bad estimation of the critical path. Indeed, the possibility to perform tasks in the same time on the aircraft might be over-estimated.

The main troubles during the check can occurs because of reasons mentioned earlier, or for other various reasons. In many cases, the contract might be sources of disagreements between the customer and the MRO, either because of a possible interpretation of an unclear sentence, or because a mistake when it has been written.
In any case, the most important is to capitalize on the experience, bad or good, to perform better next times.

5.2 Case of Nîmes Facility: Feedback analysis

In this Section, figures will not be given for confidentiality reasons. However, trends are explained.

5.2.1 Man hours

In these following tables, ratios based on the amount of time spend or estimated compared to the amount of time according to manufacturer are compared to highlight MRO Performance:

Table 5.2.1: A330 3-week check

<table>
<thead>
<tr>
<th>MPD Task</th>
<th>MRO Performance/Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>1.23</td>
</tr>
<tr>
<td>Preparation (with cabin removal)</td>
<td>2</td>
</tr>
<tr>
<td>Access</td>
<td>0.56</td>
</tr>
<tr>
<td>Global MPD</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Table 5.2.2: B767 8-week check

<table>
<thead>
<tr>
<th>MPD Task</th>
<th>MRO Performance/Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>1.8</td>
</tr>
<tr>
<td>Preparation (with cabin removal)</td>
<td>1.1</td>
</tr>
<tr>
<td>Access</td>
<td>1.3</td>
</tr>
<tr>
<td>Global MPD</td>
<td>1.4</td>
</tr>
<tr>
<td>AD/SB/EO</td>
<td>0.75</td>
</tr>
</tbody>
</table>
CHAPTER 5.  <RESULT : WORK PERFORMANCE ANALYSIS> 

Table 5.2.3: A330 2-week check

<table>
<thead>
<tr>
<th>MPD Task</th>
<th>MRO Performance/Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>0.2</td>
</tr>
<tr>
<td>Task + Prepa</td>
<td>0.97</td>
</tr>
<tr>
<td>Access</td>
<td>0.625</td>
</tr>
<tr>
<td>Global MPD</td>
<td>0.8</td>
</tr>
<tr>
<td>AD/SB/EO</td>
<td>0.93</td>
</tr>
</tbody>
</table>

By analysing several feedback, the comparison "per zone" shows that some part of the place was frequently under-estimated, as the cabin removal for example. Indeed, this is also due to MRO experience on this type of task. This is clearly true for the first example (3-week check): the preparation time explodes because of this factor.

In the case of the comparison of item grouped by type of task (MPD, SB...), the longer the check requiring a high level of A/C parts disassembling, the greater the deviations from the MPD. This is what happened on the a check that lasted 8 weeks. The reasons for this increase can be:

- Long rework, long structural rectification work
- Interference between tasks (e.g. waiting for floor panel refurbishment in backshops (unscheduled event). This task was a bottleneck, preventing galley re-installation and tests to be conducted.

As a result, the increase in the critical path is more affected on long checks and on which extent the A/C is disassembled. For small checks (2, 3 weeks), the MPD ratio is fairly respected because the non-productivity phenomena becomes less significant and because the level of disassembling is low, but still slightly higher than the one estimated. So, the quotation time for MPD is frequently underestimate.

When there are too many human resources developed in the same time without enough leaders and managers, some workers are missing information about what they have to do and how they have to do it, so either they do it without being supervised, or they do nothing. In both case, the non-productivity increases. It was the case during the 8-week check.

Issues of findings the right amount of time spend on a task is highlighted by the last
This 2-week check has been well done. It does not make sense that the MPD task ratio is so big and the preparation ratio so low. However, by adding all the hours, a more reasonable performance ratio is found: 1.3. It is really close to the one used to make the quote. How to improve the way of recording the time? It will be discussed in the Conclusion chapter (6.1.2).

Note: There is also a difference between Airbus and Boeing. As a reminder, it is a commercial argument to make maintenance time lower, to cut off the cost of a plane for an airline.

5.2.2 Supply chain

For the studied cases, the real material cost was always close to the quotation. The ratios are good, there is no need to change them if there is not an inflation on part prices. However, inflation does exist, the company may have to adapt the ratio next year depending on this factor.

For tooling, it is not the same. A tool is missing in every check. The database might be carefully filled up about this subject, and it must be studied more carefully by the preparation team.

5.2.3 TAT and Direct Cost Margin

The TAT is obviously the most watched item by airlines even before money, with the exception of the case where customer supply has been delayed. Sometimes, it can create a lot of stress, but aircraft goes out in time.

The Direct Cost Margin depends on the mistakes made. A mistake in one line of the contract can be extremely difficult to fight against (especially concerning what is included and/or excluded from the offer), as well as a tool missing or the deviation from the estimated MPD time which can cost a lot. Globally, the Margin was fine.
Chapter 6

<Conclusions>

6.1 How to improve the performance as a Quotation Officer

6.1.1 A shared Database

First, by continuously being aware of production and technical problem, the Quotation Officer continues to learn and to modify the database for being closer to the reality. He also has the role to give advise to maintain or improve MRO performance.

However, this feedback must be available for the preparation team as well. Indeed, even though they should do it on their side too, they are missing time to do it. Moreover it is not useful to do it twice. In addition to that, some elements to determinate by the preparation team are common with the quote. Making a shared database would allow a better communication between the service. It will show to the preparation team the first analysis of the quotation officer and the feedback collected, and on the other way around, it will indicate to the quotation officer a deeper analysis of a tasks, with can be useful for a check later on. It allows a primordial communication between services, in an efficient way. However, the database structure has to be exhaustive, but still clear. The goal is to save time by knowing where to look at to have the right information.

Therefore, a shared database between quotation officer and preparation team can improve the performance to do the job one time with rightness. Moreover, the procurement team knows when a tool is urgently order. They could increase the same
database to avoid the quotation officer to run after the information, and to avoid to do it again.

To go even further, aircraft managers will understand better how a task has been analysed, they just have to look it up in the database.

### 6.1.2 Increasing the way of communication of data

However, a database is not the only solution. Other way of communication should be used.

First, a standardize sheet between the quotation desk and the preparation desk might be useful to highlight the important points of the check. In this way, they would start a preparation by knowing the main tasks, the special requirement as jacking, defueling, tooling, if subcontractors have been contacted, etc. Moreover, this sheet might be connected to previous document made or used by the Quotation Officer using hyperlink. In this way, a customer documentation cannot be lost.

Second, to have a better view on the technical work, a way to control the time spent for each task would be better, to increase the database task by task and to be able to do statistical treatment on it later. To do so, there are two solutions;

- Using the same system of tracking but intensify the control by team leaders and managers. In other words, each team leader should indicate when a task is done to be sure to have the right time, or he should put more pressure on his team to do it. This method gives even more work to team leaders who have already enough to do.

- Another idea can be to change the system of tracking the card. A QR code at the beginning and at the end of the job card can be added. In this way, the time between the 2 scans are the actual time for the task. If there is removal/installation, it is possible to put intermediate QR code to scan to also have the time of sub-tasks. Moreover, the final QR might redirect toward a small survey to ask if every went well, if a tool was missing, any comment for later.. and it will go directly on the database.

The second solution requires more materials, as one phone or tablet to scan the QR codes. It might annoy the technical team and they can have the feeling to loose their time. However, if managers make them understand the reason of why they are doing it,
the scans can be done properly (due to a developed team spirit). Moreover, compared to a system where they have to go back and forth to scan the job card, they are saving time, so managers can use this argument to further encourage the technical team to do so.

As the imagination has no limit, if each team had his documentations on a tablet, there would be many possibilities. The application would recognize when the task has started by simply pressing a button, the technician would be free to navigate and click on a sub-task to have more documentations and schemes, he would report a defect directly online and he would be able to sign and finish the task all on the tablet. The data available with that method would open to another way of doing the job. Furthermore, the maintenance field is ready for this transition which has already started in some facilities as the one in Bordeaux (Sabena BOD), the biggest and the more evolved facility in Sabena Technics groups (see Appendix B.2).

6.2 Opening : unpredictable factors in aircraft maintenance

Although there are solutions to improve accuracy in the quotation of a maintenance check, some factors will stay extremely difficult to predict without technological help. Indeed, rectifications have been presented in the Chapter 3 as something highly unpredictable. Although the age of plane, the type of check and the aircraft maintenance history can help us, depending on aircraft operating conditions, the quality of daily maintenance, airworthiness event, the health status of the aircraft can be radically changed. Indeed, if these events create damages on critical or fragile parts, long rework will have to be done and will increase the TAT, even on a small check.

Therefore, here it comes back the dilemma exposed in Section 1.8 Benefits, Ethics and Sustainability, about the right moment to inspect, to operate (ex: lubrication) or to change a part. To be more accurate on this point, there is two ways to deal with the problem:

- Reliability study : by studying the the usefulness of a maintenance operation, an engineer team can advice Airworthiness Directive that is is useful to increase inspection on a part or at the opposite, useless and that the company can save money and resources. To do so, the engineer team needs data from the airplane,
through maintenance report

• predictive maintenance: for key part on the aircraft, sensors can help to check the health of a part and indicate when it is the right moment to change it. This is called condition monitoring. This is the most effective way to doing maintenance because no time and resources are lost, technology is telling when the part needs maintenance. Unfortunately, it is expensive to have sensors everywhere, therefore the company will choose carefully where to put some. [9] This exists for engines where the engine parameters are monitored in real time to detect any deviations. There is also the ACARS system which sends data (failures) to the ground before the aircraft lands.

The two ways are complementary: by having more information, engineers can work on it and can define where it is more useful to put sensors.

6.2.1 Future Work

To sum up what it has been advised in the previous sections:

• A shared database between the Quotation Officer and the Preparation Team that can be used and upgraded by other colleagues. The first objectives is to clearly define how to build it, which are the necessary information, maybe create a color chart for certainty of information, and a space of comments and technical work feedback. It will be a long but pay-off work.

• Create a communication sheet between the Quotation Officer and the preparation team to not loose any information of customer files.

• having a better view on the technical work time for each task card by modifying the way of controlling it (e.g. : QR code explained in Subsection 6.1.2)

• starting a discussion with the reliability engineering team to have advice about rectifications rate

And finally, since Sabena has several facilities in France, more data and knowledge exchanges inside the group will be beneficial to have another eye on the process.
6.2.2 Final Words

In case of someone would like to continue this work, the advice would be to not hesitate to ask questions about what is important and what is less a priority. Focusing on the essential and communication are important qualities for the quotation officer.

Personally, I think that I have improved these skills. Through this first experience in a company, I learn my strengths, as my capacity to socialise with other colleagues, my determination which pays off because I help to sign contracts, but also where I can be better: synthesise shortly what I want to say, keep the essential. Finally, I am glad that my company supervisor was satisfied of my work, and I hope Sabena will find someone to finish the work.
Bibliography


# Appendix - Contents

## A First Appendix : story of airplanes

A.1 History of aircraft and Sabena Technics Nîmes’relationship .......................... 52
   A.1.1 Beechcraft B200 ......................................................................................... 52
   A.1.2 Canadair CL-415 ...................................................................................... 52
   A.1.3 C-135F and KC-135 .................................................................................. 53

## B Second Appendix : additional information collected during this internship

B.1 Manufacturer man-hours does not take into account : ................................. 55
   B.1.1 Extracted from Airbus documentation ....................................................... 55
   B.1.2 Extracted from Boeing documentation ..................................................... 56
   B.2 Connected mechanical team in Bordeaux .................................................... 57
Appendix A

First Appendix : story of airplanes

A.1 History of aircraft and Sabena Technics

Nîmes’relationship

If you want to learn more about the aircraft quoted in 1.1:

A.1.1 Beechcraft B200

The Beechcraft B200 is a business aircraft with 6 to 8 seats, 2 of which are reserved for crew members. The company has three Beechcraft B200s. The Beechcraft B200s are powered by two Pratt&Whitney PT6A42 turboprop engines and Hartzell and MCCauley propellers. Two of the three Civil Security Beechcraft B200s have been modified in terms of propeller configuration, from three-blade to four-blade propellers, to meet better flight performance requirements.

A.1.2 Canadair CL-415

The Civil Security fleet also includes twelve Canadairs. The Canadair CL-415 replaces the older CL-215 models. Although it is very similar to its predecessor, the Canadair CL-415 has some notable differences. First, it offers a new engine. The star engines have been replaced by two Pratt & Whitney 123AF turboprop engines rated at 2,404 horsepower. The result is a power gain that allows the CL-415 to fly faster and carry more water. The speed gain is 40 knots (75Km/h) and the water weight is increased from 5 to 6 tons. The manufacturer has equipped it with modern avionics, a cockpit
with screens, air conditioning and a computer capable of managing the drop diagram, which considerably improves the efficiency of the aircraft. In addition, it is equipped with winglets on the wingtips and stabilizers on the ailerons, which differentiates it externally from its predecessor. The presence of these winglets and stabilizers made the aircraft more unstable in strong crosswinds.

Like all amphibious aircraft, the CL-415 requires heavy maintenance to reduce the effects of seawater corrosion, a phenomenon underestimated by the aircraft manufacturer. After returning from a mission or a scooping training over the sea, the aircraft must undergo a complete rinsing of the payload bay, the engines and the hull with demineralized water. This operation requires three hours of work.

The CL-415 has a range of four hours and a cruising speed of 370 Km/h. [11]

A.1.3 C-135F and KC-135

Designed in the early 1950s by Boeing, the KC-135 Stratotanker was the first jet refueling aircraft. More than 700 aircraft of this type were delivered to the U.S.A.F. between 1957 and 1965. Its revolutionary design for the time (underwing pods and two-lobe fuselage) inspired Boeing for its B707 and other manufacturers for their commercial jets produced since then.[4] As part of its nuclear deterrence policy, France took delivery of the last twelve aircraft produced. They were assigned to the strategic air force in support of the Mirage IV, the nuclear weapons carrier. With specific French avionics, in addition to the refuelling configuration thanks to the boom located under the tail, these aircraft were to allow the transport of freight, personnel or medical evacuation (Morphée system). A plane crashed in the Pacific during take-off from Hao atoll in 1972 (n° 473) during the French nuclear test campaign. Originally, all KC-135s were equipped with Pratt and Whitney J57-P-59W turbojet engines, In 1986, France re-engined the eleven remaining C-135Fs with Franco-American CFM-56 2B engines, renamed C-135FR (Reengine). In 1995, the eleven aircraft were fitted with wingtip pods to allow the refueling of several fighters simultaneously; a drogue is attached to the end of a hose on which the fighter aligns itself to engage its boom. The boom itself can be equipped with the hose and drogue, or with a rigid telescopic boom with a nozzle at the end for refueling the Boeing E-3 Sentry ”AWACS” or allied fighters. In 1997, three KC-135Rs were purchased from the U.S.A.F. (five purchased, two of which were sold to Turkey). The remaining three were to be modified to C-135FR standards, but this
upgrade has not yet taken place. They keep their original avionics, have no pods, and no cargo capability. The replacement by A330 multi role transport and tanker (M.R.T.T.) in France, and by KC-45A (A330 modified according to the Canadian and German A310 M.R.T.T.) in the United States of America should take place progressively from 2030 onwards, i.e. nearly 70 years after their production, these aircraft having passed through the hands of four generations of pilots and mechanics. [14]
Appendix B

Second Appendix: additional information collected during this internship

B.1 Manufacturer man-hours does not take into account:

B.1.1 Extracted from Airbus documentation

[3]

"Man-hours quoted in the MPD do not take into account:

• 1. Non-routine work, e.g. repair, troubleshooting, shop overhaul.
• 2. Preparatory work such as aircraft cleaning, positioning work stands, connecting ground power carts.
• 3. One-time actions, e.g. de-greasing, stripping, painting.
• 4. Embodiment of modifications, cabin (galley, lavatory, furnishings) refurbishment.
• 5. Non-productive time, e.g. shift-change, set-up of tools, waiting for sealant or paint drying.
• 6. Planning and establishment of procedures."
APPENDIX B. SECOND APPENDIX: ADDITIONAL INFORMATION COLLECTED DURING THIS INTERNSHIP

The task man-hours quoted in the MPD are provided for guidance only and should be adjusted to the specific operator conditions and efficiency.”

B.1.2 Extracted from Boeing documentation

”Estimated manhours required to perform the task. [5] These manhours do not include the time required to open/close access doors, panels, position work stands, troubleshoot, nor correct discrepancies found while performing the task. The estimated manhours are based on the use of skilled personnel and ready availability of the required tools and equipment.”

56
B.2 Connected mechanical team in Bordeaux

Figure B.2.1: Connected mechanical team in Bordeaux (Translation below)

En ligne avec la stratégie du Groupe, le plan ambitieux de digitalisation de nos activités franchit une étape majeure avec le lancement du premier chantier de maintenance connecté.

Sur notre site Bordelais, nous réalisons une visite d'entretien de type C2 de 3 semaines totalement digitalisée sur un Airbus A330. Notre client, Corsair, pourra suivre le chantier et interagir avec l'équipe Sabena technics en temps réel à travers un portail permettant l'accès à l'avancement des cartes de travail, la validation des travaux supplémentaires, la gestion des délais d'approvisionnement pièces...
CONNECTED MECHANIC : LAUNCH OF THE FIRST DIGITAL PROJECT

In line with the Group’s strategy, the ambitious plan to digitalise our activities has reached a major milestone with the launch of the first connected maintenance site. At our Bordeaux site, we are carrying out a 3-week C2 type maintenance visit that is totally on an Airbus A330. Our customer, Corsair, will be able to follow the work and interact with Sabena technics team in real time through a portal allowing access to the progress of the work cards, the validation of additional work, the management of supply deadlines parts...

Since Monday, our technicians use an iPad from which they can view their maintenance tasks, consult the aircraft’s technical manuals, record defects on the aircraft or declare the removal /equipment removal/reinstallation. - Share in real time their activities with the other functions of the site: steering, planning, supply-chain, technical technical office...

WHAT NEXT? The construction site will last 3 weeks. It will allow us to test in real situation all the processes from preparation to execution, including planning, the supply chain and invoicing. It will be rich in lessons that will allow us to further enrich our tool and our and our vision of digital before deploying it more widely.

François Doré, Deputy Managing Director in charge of Strategy and Innovation