UNIVERSIDADE DA BEIRA INTERIOR

Engenharia

Sofinare - workflow management, a case study

A Web Database Application development

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Dissertação para obtenção do Grau de Mestre em

Engenharia Aeronáutica

(2º ciclo de estudos)

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Covilhã, Outubro de 2012

"*Quality is never an accident; it is always the result of intelligent effort*" by John Ruskin.

ACKNOWLEDGEMENTS

I would like to begin by thanking my advisor Professor José Manuel Mota Lourenço da Saúde and all the Grupo7Air staff working in Tires Aerodrome. Firstly for the opportunity of working with them, giving me the possibility to develop my dissertation in such a prestigious aeronautical organization; and secondly for their availability, patience, kindness, support, and understanding while advising me in my project.

I would also like to express my gratitude to my entire Family, whose undivided support, love, and everlasting patience have carried me throughout my Masters degree, and will undoubtedly continue to do so throughout the rest of my life.

Finally to my colleagues and my close friends, whose companionship is a necessary premise to the conclusion of my Masters degree, I thank you all.

RESUMO

Esta dissertação reflete a pesquisa levada a cabo nas instalações das empresas de manutenção aeronáutica Sofinare e Aerotécnica. Ambas empresas fazem parte do Grupo7Air, um grupo que incide totalmente na área da aeronáutica.

A Aerotécnica está interessada em iniciar um grande projeto, que incide na criação de um software que contemple todas as empresas do Grupo7Air, tendo sobretudo em conta que este grupo é constituído por empresas certificadas EASA-Part 145 (manutenção), Part-M (gestão da aeronavegabilidade), Part-21 (projeto/design) e Part-147 (formação de Técnicos de Manutenção Aeronáutica). Pretende-se criar uma aplicação que possa gerir toda a informação com que as empresas do grupo trabalham diariamente, ou seja, gerir toda a informação relativa à manutenção aeronáutica (programas de manutenção, componentes, sub-componentes e o seu rastreio, diretivas, ferramentas, material em armazém, etc.), de tal modo que haverá a necessidade da existência de uma grande base de dados alojada num servidor, sendo constituída por inúmeras tabelas que terão toda a informação armazenada.

Atualmente a Aerotécnica (juntamente com a Aerovip), dado o seu âmbito na indústria de manutenção aeronáutica, possui uma aplicação designada por C.A.L.M.: um poderoso *software* que lhes permite inúmeras vantagens, tornando-se uma ferramenta essencial para o trabalho do seu dia-a-dia. No entanto, para além do seu elevado custo, apresenta algumas limitações que se pretendem eliminar, tais como: haver a necessidade de instalar o *software* em todos os computadores da empresa onde é necessário usá-lo. Por isso, concluiu-se que uma ferramenta que funcionasse através da web (aplicação-web) seria o ideal, estando cada trabalhador da empresa à distância de um simples *browser* para gerir ou consultar qualquer informação que lhe fosse necessária, sem haver a necessidade de ter que instalar a aplicação em todos os computadores da empresa. Além disso, é pretendido uma aplicação que desempenhe todas as funções do CALM e mais outras funções que surgirão do interesse da empresa, sendo que o código do *Software* poderá ser alterado, visto que será *open-source*, e constantemente atualizado, de maneira a cobrir os interesses da empresa.

Nesta dissertação, estudou-se um possível começo do desenvolvimento deste *software* e da sua base de dados, que já pudesse ajudar o pessoal da Sofinare a registar informaticamente a abertura e fecho de Ordens de Trabalho.

PALAVRAS-CHAVE

C.A.L.M., Software de gestão de manutenção aeronáutica.

RESUMO ALARGADO

Esta dissertação reflete a pesquisa levada a cabo nas instalações das empresas de manutenção aeronáutica Sofinare e Aerotécnica. Ambas empresas fazem parte do Grupo7Air, um grupo que incide totalmente na indústria da aeronáutica. Neste grupo fazem parte as seguintes empresas: Leávia (Escola de Aviação Civil), Aerovip (Empresa certificada Part-M Subpart G e aprovada para serviços de transporte aéreo (regular, executivo e carga)), Aerotécnica (Empresa certificada EASA - Part 145, certificada para efectuar *Overhaul* de motores de pistão, reparações estruturais, pintura e ensaios não destrutivos), Sofinare (Certificada EASA Part -145 e Part -21 para a manutenção de e planificação de equipamentos de electrónica), Tecnam Portugal(que representa a empresa Tecnam com sede em Itália que fabrica aeronaves de alta qualidade), a VipClean (empresa de limpeza de aeronaves e embarcações), a Cenfortec (centro dedicado à formação de técnicos de manutenção aeronáutica em formação Básica e formação Tipo. EASA Part-147 certificada), a Pilot WIngs Aviation Store (loja que comercializa material aeronáutico e produtos relacionados com a aviação em geral, tais como cartas aeronáuticas, *headsets*, acessórios para voo, material de simulação)o e a Crucial Sky Technology (empresa dedicada à investigação e desenvolvimento de hardware/software para produção de sistemas de automação e controlo para fins aeroespaciais).

A Aerotécnica está interessada em iniciar um grande projeto, que incide na criação de um Software que contemple todas as empresas do Grupo7Air, tendo sobretudo em conta que este grupo é constituído por empresas certificadas EASA-Part 145 (manutenção), Part-M (gestão da aeronavegabilidade), Part-21 (projeto/design) e Part-147 (formação de Técnicos). Pretende-se criar uma aplicação que possa gerir toda a informação com que as empresas do grupo trabalham diariamente, ou seja, gerir toda a informação relativa à manutenção aeronáutica (programas de manutenção, componentes, sub-componentes e o seu rastreio, diretivas, ferramentas, material em armazém, etc.) de tal modo que toda a informação necessitará de uma grande base de dados alojada num servidor, sendo constituída por inúmeras tabelas que terão toda a informação armazenada e ligada entre si.

Atualmente a Aerotécnica, como empresa de manutenção aeronáutica, possui uma aplicação designada por C.A.L.M.: um *software* poderoso que lhes garante inúmeras vantagens, sendo uma ferramenta essencial para desempenhar as funções da empresa no dia-a-dia. No entanto, para além do seu elevado custo, apresenta algumas limitações no trabalho, que se pretendem eliminar através do desenvolvimento do futuro *software*, tais como: haver a necessidade de instalar o *software* em todos os computadores da empresa onde é necessário usá-lo. Por isso, concluiu-se que uma ferramenta que funcionasse através da web (aplicação-web) seria o ideal, estando cada trabalhador da empresa à distância de um simples *browser*

para gerir ou consultar qualquer informação que fosse necessária. Além disso, o CALM, tal como qualquer outro *software* normal de gestão aeronáutica, implica que se tenha que estar constantemente a registar o número de horas que cada avião fez, ou por exemplo o número de horas que cada técnico trabalhou numa determinada tarefa de manutenção, havendo sempre a obrigação de estar sempre alguém a atualizar os dados no computador, o que implica a necessidade constante de várias pessoas no circuito da gestão da manutenção. O ideal seria que a futura aplicação a desenvolver fosse mais autónoma no controlo e registo das tarefas de manutenção, não havendo necessidade de estar alguém continuamente a gerir no computador, tornando o circuito de gestão mais autónomo e menos fastidioso por parte dos trabalhadores.

Pretende-se desenvolver este *software* através das linguagens de programação PHP e MySQL que, para além da enorme vantagem de serem *open-source,* são bastante poderosas para desenvolver aplicações para a Web, completando-se mutuamente, ou seja, as funções do software serão programadas em linguagem PHP e a recolha e/ou leitura de dados através de MySQL, estando a base-de-dados alojada num servidor.

Nesta dissertação, estudou-se um possível começo do desenvolvimento deste *software* e da sua base de dados, que já pudesse ajudar o pessoal da Sofinare a registar informaticamente a abertura e fecho de obras de manutenção.

ABSTRACT

A web-based application has been developed to ensure recording of all details of maintenance works carried out at SOFINARE (a Portuguese aeronautical company meeting EASA PART 145 standards). The main objective is to have a safe and easy-to-use system to control and retain maintenance work records. This application is just the beginning of a future software that later will be developed by Grupo7Air engineers to be used in their organisation covering specific aspects such as having all maintenance information (aircrafts, technicians, manuals, maintenance programmes, works, inventory, component tracking, etc.) stored in a vast group of tables, which will form the database, in a way that, any data one wants to know can be picked up in those tables through the Software.

This research was carried out at AEROTÉCNICA and SOFINARE, both Portuguese aeronautical organisations, with the purpose of analysing the maintenance process and also to study how a software implementation can be done to controlling the maintenance process in the aeronautical maintenance industry. Later on, this software can be continuously developed and upgraded to be widely used in the entire Grupo7Air organisation, to help through the maintenance management while complying with the existent aeronautical legislation requirements, while ensuring aircraft maintenance planning is efficient and accurate, and, at the same time, helping the needs of the company to survive, that is, being able to keep making money in the present crisis.

This work begun by planning how the database should be created in order to save maintenance organisation data safely and correctly, so it can be used later to future software tasks.

This application has been developed (and it will continue to be) using *PHP* open source language and *MySQL* database resource. The use of *PHP* and *MySQL* as the developing programming languages allow this software to be a multiple platform software in a time saving way, since the source code is recognized by the different browsers, that is, it works on Internet Explorer, or Mozilla Firefox for example, being these, the favorite browsers of the company's staff, running under Windows, OS X or Linux. Implementing and learning the software through one's favorite browser is thus simplified, it doesn't have to be installed in each employee PC and also reduces implementation costs. The PC has only to be able to connect to the internal server and have access to internal database where all data are safely stored through this application.

KEYWORDS

C.A.L.M., Maintenance Management Software.

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LIST OF ACRONYMS

A/C	Aircraft
AD	Airworthiness Directive
AMC	Acceptable Means of Compliance
AMO	Approved maintenance organisation
ATA	Air Transport Association
ATC	Air Traffic Control
CALM	"Computerized Aircraft Log Manager"
CAS	*Certificado de Aptidão para o Serviço*
CAT	*Certificado de Aprovação Técnica*
CRS	Certificate Release to Service (= *CAS in Portuguese*)
DN	*Directiva de Navegabilidade*
DOA	Design Organisation Approval
EASA	European Aviation Safety Agency
EC	European Commission
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
GM	Guidance Material
ICAO	International Civil Aviation Organisation
INAC	*Instituto Nacional de Aviação Civil*
IRs	Implementing Rules
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
MEL	Minimum equipment list

MOA	Maintenanc Organisation Approval
MOE	Maintenance Organisation Exposition
MOM	*Manual de Organização de Manutenção*
MP	Maintenance Programme
MRO	Maintenance Repair and Overhaul
OTE	*Ordem Técnica de Engenharia*
RTS	Release to Service
SB	Service Bulletin
TMA	*Técnico de Manutenção Aeronáutica*
WO	Work Order (in *Portuguese OT – Ordem de Trabalho, ou simplesmente Obra*)

CHAPTER 1

INTRODUCTION

Owning an aircraft today can be a complicated venture. The majority of aircraft owners just want to enjoy their aircraft and not be tied down with the bureaucracy of regulations. Anyone who has never been, somehow, related to aeronautical maintenance has no idea of the quantity of paperwork and regulations any aeronautical maintenance organisation must comply with.

This research has been conducted in the context of the reliability programme activity of the Grupo7Air Maintenance organisations, which are AEROTÉCNICA and SOFINARE. Both organisations comply with the Quality policy stated on EASA Part-145 regulations, ensuring that all activities and services carried out are fulfilled according to the accepted procedures by INAC.

The present document is the report of the research work carried out for 9 months in the aforesaid EASA Part-145 organisations to fulfill the degree of MSc in Aeronautical Engineering.

Nowadays with the financial crisis, an organisation with a well-known reputation as Grupo7Air, has to strive between achieving sufficient returns for the continuity of its companies and to keep improving the organisation processes to offer its customers the high quality services they must comply with.

This research is believed to have contributed to the understanding and mastering of some regulations, mainly EASA Part-145, and procedures affecting the practical work that certification engineers have to undertake in regulatory, authorities and in aircraft engineering companies.

1.1 BACKGROUND

1.1.1 GRUPO7AIR

Grupo7Air is a Portuguese aeronautical group of companies composed by:

- ✓ AeroVip:

Regional Airline offering Air Transportation (Airline, charters, flight baptisms, tourists flights) and Air Work (Publicity, Photography and Film/Video). It's a qualified EASA Part-M Subpart G continuing airworthiness management organisation (CAMO) and it's managed in parallel with the other companies within the group, promoting the exchange of work among them. So, AeroVip is responsible for the management of all the Grupo7Air's aircrafts continuing airworthiness and also for outside customers, while Grupo7Air's EASA Part-145 maintenance organisations (that is, SOFINARE and AEROTÉCNICA) are responsible for all the technical maintenance of the Grupo7Air's aircrafts (AeroVip's included).

- ✓ AEROTÉCNICA:

  Certified Part-145 maintenance organization, with more than 30 years of aeronautical experience in the field of aircraft maintenance. Maintains more than 80 aircrafts, including multiple turbine and piston engines, with more than 60 000 flying hours per year.

- ✓ SOFINARE:

  An EASA Part 21 Design Approved Organization (DOA) certified for project design and implementation on structures and avionics. It is also EASA Part-145 certified for avionics repair, to carry out repairs on various type of Aircraft Communications and Navigation equipments installed on light and heavy aircraft, covering a significant number of manufacturers.

- ✓ Cenfortec:

  EASA Part 147 Certified School for Aircraft Maintenance Engineers (in Portuguese: TMA-Técnico de Manutenção Aeronáutica). Its main purposes are: educate Aircraft Maintenance Engineers, through theoretical and practical teaching; type-rating instruction; and EASA training courses (Part-M, Part-145, and Fuel Tank Safety courses).

- ✓ Leavia:

  A certified flight school that graduates commercial and airline pilots for more than 10 years.

- ✓ Crucial Sky Technology:

  Systems development and Engineering solutions for industrial and aeronautical markets;

- ✓ TECNAM Portugal:

Supplier of Light Sport Aircrafts and CS-23 Twin Rotax aircraft up to 4 persons;

- ✓ VipClean:

  Specialized cleaning services for aircrafts and luxury ships.

- ✓ Pilot Wings:

  Pilot equipment supplier and aeronautic merchandising.

1.1.2 AEROTÉCNICA GENERAL INFORMATION

AEROTÉCNICA is an EASA PART-145 certified organization that performs aeronautical maintenance on aircrafts lighter or heavier than 5700kg. Its headquarters and main hangars are located in Tires, but it also has facilities in Portimão (where occasional line maintenance is done) and in Bragança (to cover line maintenance needs).

In its headquarters, AEROTÉCNICA disposes the human resources, infrastructures, technical publications, standard and special tools, equipments, stores and the materials needed in order to proceed to its maintenance actions, in accordance with the technical approved certificate.

In terms of structures maintenance, AEROTÉCNICA is certified to perform heavy structural repair in almost all type of light aircraft. It is also able to paint light and medium aircraft, with certified quality, customized skin fuselage repair, and specialized treatments. In general terms, the capabilities are: painting of general aviation aircraft and helicopters, engines, landing gears, wheels, brakes and structural components; preparation of components and surface treatment with blasting facilities.

Besides structure maintenance, AEROTÉCNICA is experienced in engine overhaul, due to more than 20 years working with piston engines (reciprocating engines). The maintenance work is performed in accordance with the manufacturer instructions. After performing the maintenance work, the engines are tested on a Test Bench and certified with EASA Form 1. So, in this context AEROTÉCNICA is qualified for the following capacities: All TCM and Lycoming reciprocating engines; overhaul and rebuilt of engines performing up to 400HP; shock-load (complete inspection to the engine in case for example of a bird strike, propeller strike on the runway, and so on) and top overhaul inspection; Cylinder overhaul; Carburetors, injection systems and fuel pumps.

It is also certified to act on the electrical engine accessories: maintenance, repair and overhaul of magnetos, ignition harnesses, starters, and alternators; and turbocharger systems: inspection, repair and overhaul of turbocharger systems and its components. Non-destructive tests can also be carried out to crankshafts, camshafts, and gears.

1.1.3 SOFINARE GENERAL INFORMATION

SOFINARE (*Sociedade de Financiamentos e Representações, Lda.)* is an Aircraft Maintenance Organisation dedicated exclusively to the repair/maintenance of avionics and also to the execution of repairs and implementing modifications on avionics installations, being certified under Part 145 PT145.026 SOFINARE certified Maintenance Organisation. It also holds an EASA Part-21 Subpart J Design Approved Organization (DOA), enabling to provide EASA approved Supplemental Type Certificates (STC) & Major repairs in accordance with Part 21 Subparts E and M respectively.

It is qualified for: to embody changes and repairs on aeroplanes, related to installation of avionic equipments, radios, electrical systems, cabin interiors, galleys or other interiors equipments; providing, under its DOA privileges, minor or major changes and repairs to small aircraft, related to the installation of avionics equipment, structure, electrical systems, cabin interiors, galleys or other interiors equipments.

SOFINARE has the ability to carry out inspection work and upgrading the installed wiring as needed, thus making the aircraft more reliable, reducing the likelihood of faults in electrical system and electronic equipments.

It also has a commercial department able to supply avionic equipments, since it holds representation of manufacturers of acknowledged reputation and quality such as Garmin, Avidyne, Honeywell, among others. SOFINARE is the only authorized Dealer and Service Center in Portugal to Garmin and Honeywell aviation products.

SOFINARE approved capability list can be seen in table 1.

TABEL 1 - List of ratings approved at SOFINARE

Class	Rating
Components other than complete engines or APUs	€2 (auto flight)¤
	C3 (Comms and Nav)

1.2 DEFINITIONS

Here are given general definitions of the items listed below that are referred in this dissertation. (This information came from [1], [2]).

- Aircraft
- Airworthiness

- Base Maintenance
- Certifying Staff
- Component
- Continuing airworthiness
- Human Factors
- Line Maintenance
- Maintenance
- Maintenance programme
- Member State
- Organisation
- Pre-flight Inspection
- Repair
- Repairable
- Rotable
- Scheduled Maintenance
- Service Bulletin
- Unscheduled Maintenance
- Work Order

Aircraft

Any machine that can derive support in the atmosphere from the reactions of the air other than reactions of the air against the earth's surface;

Airworthiness

The condition of an item (aircraft, aircraft system or part) that meets its type design in that the item operates in a safe manner to accomplish its intended purpose.

Base Maintenance

The combination of technical and administrative handling needed to inspect, rectify, repair, overhaul or modify the aircraft to an approved standard, to be carried out during a planned period of time for which the aircraft will be out of service.

Certifying staff

Personnel responsible for the release of an aircraft or a component after maintenance.

Component

Any engine, propeller, part or appliance.

Continuing airworthiness

All the processes ensuring that, at any time in its operating life, the aircraft complies with the airworthiness requirements in force and is in condition for safe operation.

Human Factors

Body of scientific facts concerning the human characteristics (the term includes all psychosocial and biomedical considerations).

Line Maintenance

The combination of technical and administrative handling, needed to keep or to restore the aircraft in a serviceable, airworthy and to the customers satisfactory condition, in order t have the aircraft operational for the purpose of its next flight.

Maintenance

Any combination of overhaul, repair, inspection, replacement, modification or defect rectification of an aircraft or component, with the exception of pre-flight inspection.

Maintenance programme

The Maintenance programme (MP) contains the complete set of taskcards for a specific aircraft type. The initial maintenance programme for an aircraft type is issued by the aircraft manufacturers. These Maintenance Review Board (MRB) reports contain the minimal requirements to operate the aircraft safely. Each operator can then adapt the MRB reports to meet the requirements of the national authorities.

Member State

A member state is a state that is a member of an international organisation. A member state of the European Union is a state that is party to treaties of the European Union (EU) and thereby subject to the privileges and obligations of EU membership.

Organisation

A natural person, a legal person or part of a legal person. Such an organisation may be established at more than one location whether or not within the territory of the Member States.

Pre-flight inspection

The inspection carried out before flight to ensure that the aircraft is fit for the intended flight.

Repair

The restoration of an aircraft/aircraft component to a serviceable condition in conformity with an approved standard.

Repairable

Material with a part number, but no registered serial number and no registered maintenance history. A repairable is a consumable that can be repaired based on economical limits.

Rotable

Material with a part number and serial number. Rotable parts have a (computer) registered maintenance history and can be repaired as long as repair costs do not exceed economical limits.

Scheduled Maintenance

Maintenance performed to retain an item in a serviceable condition by systematic inspection, detection, prevention of failures, replacement of wear-out items, adjustment, calibration, cleaning, etc. (A, B, C checks, weekly's, 150 hours, etc., modification programs, aircraft painting and major scheduled component changes such as landing gears or engines).

Service Bulletin

Document that contains information issued by the manufacturer of an aircraft, aircraft engine or component that details maintenance procedures that will enhance safety or improve the performance of the product.

Unscheduled Maintenance

Maintenance performed to restore an item to a satisfactory condition by correction of a known or suspected malfunction and/or defect outside of the normal maintenance programming.

Work Order (Maintenance Work order)

For all maintenance events which are carried out on an aircraft, a work order has to be issued in the recording system. No matter whether the technical staff has to perform a check, a time removal or to rectify a snag, the document which proves that a certain action has been completed is always the work order.

1.3 RESEARCH PROBLEM

Once at the AEROTÉCNICA and SOFINARE facilities, some EASA regulation was fundamental to read in order to better understand how maintenance must be carried out and how much information is needed to work with. Moreover, it was fundamental to make a deep research at SOFINARE and AEROTÉCNICA facilities to clearly understand how all maintenance data flows and how every task must be processed and recorded. It's all about aeronautical maintenance legislation. In appendix B, some mandatory procedures are mentioned.

To assist private aircraft owners and pilots in achieving the ability to enjoy their aircraft, there is a software called CALM being used in AEROTÉCNICA which consists of a complex system, helping maintenance companies in their responsibility of ensuring their aircraft are airworthy and compliant with aeronautical authorities' regulations. This software was designed to save time and hassle required to keep up with the bureaucracy surrounding the maintenance of aircrafts, freeing up their time to do what owners want most: flying safely their aircraft.

AEROTÉCNICA is preparing the beginning of a big project, concerning the development of a software covering all organisations of Grupo7Air. For this full development all EASA regulation must be known as this software will focus on all EASA regulations that Grupo7air companies comply with: Part-145, Part-21, Part-M, Part-147, Flight Operations, and so on. Nowadays there're many software to manage aeronautical maintenance, but there's none complete software able to manage all aeronautical data the way Grupo7air wants. That is, Grupo7Air is aspiring to an innovative application that can do even more than the one in use at AEROTÉCNICA which is CALM. This future software shall have further technical capabilities such as helping technicians while checking their maintenance tasks individually and reduce the number of workers being responsible for managing the mandatory paperwork. Besides, a future software developed by their own imposed requirements should also be useful if later on aspire for further functions on the software. Being developed through open source programming languages (mainly *PHP* and *MySQL* open source script languages) the company will save lots of money, since all aircraft maintenance management software in the market are very expensive (costing thousands of dollars!), and further the company will always have access to the software programming source code, modifying it whenever is wanted or required.

The present work represents the beginning development of the software to responding the need of an IT resource capable of analyzing some the important aeronautical data of the company (work orders related), as a support to the aircraft maintenance staff.

It is foreseen that the future complete software requires only a browser installed. The CPU shall have a frequency speed of at least 500MHz, which is the recommended for using the Mozilla Firefox browser, otherwise it may run slowly, but that won't be a problem as most of the people who use browsers to surf on the internet, may have a not so "stone age" pc.

This software covers a wide range of features and can perform a cast list of things, aiming to become a valuable and cheaper help to most everyone in the company.

CHAPTER 2

STATE OF THE ART

2.1 INTRODUCTION

This chapter presents the literature review concerning the subject described above, and further, the research carried out at AEROTÉCNICA and SOFINARE facilities.

As this work was carried out at EASA Part-145 approved organisations, it is fundamental to understand some of the regulations their workers are required to follow in order to keep up with EASA certifications (see Appendix).

2.2 GRUPO7AIR AERONAUTICAL MAINTENANCE MANAGEMENT RESEARCH

How maintenance data flows in AEROTÉCNICA Part-145, AeroVip Part-M, and SOFINARE and how they are related to each other?

The most useful software the organisation uses is the C.A.L.M. 6.0 software. C.A.L.M. stands for Computerized Aircraft Log Manager, and it's an almost indispensable aviation maintenance management software that Grupo7Air's maintenance and airworthiness sections use. It's proven for: rotables, inspections, and bulletin tracking; reliability reporting; maintenance and budget forecasts, inventory management, work orders and purchase orders; technical data and publication distribution; and flexible reporting. [6]

Given the C.A.L.M. range of potentialities it provides, it's easily understood that it uses a considerable big database where all maintenance data is stored and queried. Another very important service is client server configuration, enabling the software to be run on many computer seats in the Grupo7Air organisation and, thus, facilitating every engineer on his maintenance management work.

Every day a specific worker from the AEROTÉCNICA's maintenance management section has to update the total number of hours that each airplane has flown. That's done through the C.A.L.M. software. Every starting day, Part 145 stuff must consult every *Aircraft Journey & Technical Log book*, locally (in Portuguese) known as the *"RTB"* that stands for *Relatório Técnico de Bordo* (or also known as *"CTB"* which means *Caderneta Técnica de Bordo*). As the name states, it's a logbook every aerorplane must own, and where pilots must register the time flown on it. Thus, the staff in AEROTÉCNICA Part-145 responsible for this update must log in and add flight time in the C.A.L.M software. Then, it is given a list of all

the aircraft the organisation is responsible for, and it is updated every aircraft total time flown in the database. Later, one can verify flight time of any aircraft through the help of the C.A.L.M. software.

Through this procedure, one is able to track the total time each aeroplane of the organisation has flown so far. And this is also useful to monitor the time flown since last inspection, maintenance, or count time since, for example, its engine last overhaul or assembly. Thus, daily registration of hours flown is fundamental and extremely important for the maintenance management. It has an important role on tracking every component of any aeroplane as long as inspections and all kind of maintenance tasks are registered too. When talking about registering these kind of tasks, it's all about registering the work done, the work deferred, modifications embodiment, date and time when they were carried out and further, the software will be able to calculate all kind of time and time duration since maintenances, flights, inspections, assembly of components, and so on…

2.3 STATE OF THE ART OF EXISTING SOFTWARE FOR AERONAUTICAL MAINTENANCE

C.A.L.M. SOFTWARE

Introduction

C.A.L.M. is a user-friendly application that integrates with the organisation's daily business processes and provides a complete suite of operational functions to handle day-to-day aviation maintenance operations. C.A.L.M. gives the maintenance manager critical information that is needed to manage aircraft fleets, whether a person has one or more aircraft. The inventory management gets easier and more efficient with C.A.L.M. This is one of the very few areas of operations in which a person can easily, quickly, and without risk, lower the organisation total operational costs. Lowering inventories because one knows exactly what is on hand and what one will need, giving a valuable tool to manage the inventories of spare parts more efficiently. [7]

C.A.L.M. has the following main modules, which may or may not be licensed to use depending upon the company license: [7]

- ✓ Maintenance Tracking;
- ✓ Inventory Tracking – Purchase Orders / Repair Orders;
- ✓ Work Orders;

- ✓ CAS (Continuous Aircraft Surveillance);
- ✓ Bar Coding;
- ✓ CARTS (Computerized Aircraft Reliability Tracking System).

The C.A.L.M. module contains all maintenance tracking functions. This maintenance allows keeping track of all maintenance functions on airframes, engines, and auxiliary systems for the company's fleet. The maintenance module tracks bulletin compliance information along with detailed record cards and electronic log management capabilities.

The Inventory Tracking function allows to maintain part (both serialized and non-serialized) information, track tool calibrations, maintain customer and supplier file information, and maintenance publications inventories.

The Purchase Order module is contained within the Inventory Module and allows to create purchase orders for parts based upon analysis of what and when is needed. Receipts against the purchase orders as well as historical analysis are also part of the Purchase Order module.

The Work Order module allows to keep a detailed tracking system of all worked performed on the company's fleet along with labor costs, parts used and all information in order to maintain accurate records and provides with valuable analysis.

The Continuous Aircraft Surveillance monitors discrepancies and reports mechanical reliability and corrective action module or deferrals. The software is integrated with work orders to create automatic MEL tasks to be completed.

The Bar Code module gives the data accuracy needed to be able to perform superior inventory management. The Bar Code module allows to quickly, easily and efficiently enter inventory transactions into C.A.L.M. and it is an add-on to the Inventory Tracking features of C.A.L.M.

C.A.L.M. automates the tracking of component life cycles and inspections on aircraft and airframe components. The system was designed to create a user-friendly environment for managing a large amount of data easily, accurately, and effectively.

System requirements

C.A.L.M. 6.0 requires the following Hardware/Software configuration [7]:

For the workstations:

- ✓ Processor Type: Pentium class PIII or higher or AMD K7 or higher
- ✓ Processor Cycle Speed: 500 MHz or higher

- ✓ Memory: 128MB or higher
- ✓ Network Card: 100MBPS Minimum (Usually auto-sensing for 10/100 MBPS).
- ✓ Operating System: Win98 or higher. Use with all Win98, or all XP, or all Win 2000 for the workstations.
- ✓ Hard Drive: ATA66 or ATA100 EDI type drives that have 7200 RPM and at least 20 GB o total space. CALM only requires a small portion (20 MB) of hard drive space for a workstation or client version.

For the Server:

- ✓ Processor Type: Pentium class PIII or higher or AMD K7 or higher (A dual processor is really nice);
- ✓ Processor Cycle Speed: 500 MHz or higher
- ✓ Memory: 256 MB or higher
- ✓ Network Card: 100 MBPS Minimum (Usually auto-sensing for 10/100 MBPS)
- ✓ Operating System: WinNT 4.0 or higher Windows 2000 Professional Server is very acceptable
- ✓ Hard Drive: Preferable SCSI type drives that have at least 7200 RPM and at least 40 GB of total space. CALM data requires a large portion (200 MB+) of hard drive space for a server version.
- ✓ If RAID is available, that is nice for speed and reliability.
- ✓ Backup System: Tapes are fine, but no preferred for CALM. Tapes are recycled over time and this can be unacceptable at times because problems may not be discovered in the cycle overlap. Preferable to use a compression utility that runs daily that compresses the datafiles into a zip file that has the name of the day I.E. May 23, 2002 would be 'B020523.zip'. That is just an example.
- ✓ Preferred: CDRW to burn copies of the backup files so they can be removed from the hard drive.

Network

- ✓ All cables must be able to transfer speeds of at least 100 MBPS.
- ✓ All hubs, switches, and routers must also handle at least 100 MBPS.

Main C.A.L.M. menu and functions

The C.A.L.M. main screen has a group of main menu options and then has sub options and sub-menu. The main menu line contains the following items:

- ✓ Maintenance – for all maintenance tracking functions including airframe, engine, and auxiliary systems, component tracking, the addition of flight time to the components and the verification of flight time.
- ✓ Bulletins – for all airframe, engine, and auxiliary system.
- ✓ Inventory – for parts, publications, and tool inventory tracking as well as the basic inventory reports (only if the company is licensed for this module).
- ✓ Work Order -(only if the company is licensed for this module).
- ✓ Purchase Order - (only if the company is licensed for this module).
- ✓ Reports – allows the user to access system reports other than basic inventory reports.
- ✓ Forecast – allows the user to input information on the costs tracked components for budget forecasting within C.A.L.M.
- ✓ Bar Code Scanning – modules (only if the company is licensed for this module).
- ✓ Utilities – system Setup and configuration as well as certain system wide functions such as the fleet-wide parts search.

C.A.L.M. FIRST STEPS AFTER INSTALLATION

Functions to be completed before utilizing C.A.L.M. to its fullest extent:

- ✓ Set up the airframes of the organisation within the system with their components to track (Maintenance function);
- ✓ Set up engines and their components to track (Maintenance function);
- ✓ Set up auxiliary systems and their components to track (Maintenance function);
- ✓ Add current inventory into C.A.L.M. (Inventory function);
- ✓ Set up the basic costs for inspections, overhauls, and other actions, which are required by the operations (Forecast function);
- ✓ Set up the System Warning Times for the maintenance due reporting functions (Utilities menu);

- ✓ Set up basic work order header information (Work Order function);
- ✓ Setup basic purchase order header information (Purchase Order);

Warning times

The C.A.L.M. Maintenance Due, Budget Forecast Report, and Forecast Report are based on a set of warning limits, which were initially set up for the system. The warning times set in the utilities are the permanent warning times for all functions in C.A.L.M. until/unless they are changed.

Warning times are set for all life limit measurements. These limits determine how far in advance the user is notified that components have maintenance coming, for 500 cycles (on items whose life is measured in cycles), 500 is entered in the limits for cycles.

Warning times can be set up to reflect an average usage for the time period liked to reflect in the maintenance reporting. For example, if flight time is added to an aircraft and that flight time added to current flight time will exceed the set warning times for hours flown, will be seen that the component requires a specific action (Example: overhaul).

For the maintenance due report, this can be generated on a weekly basis see what is coming due over the next week. If the warning times are set to reflect typical weekly times (Example: hours, cycles, days, etc) then the Maintenance Due report will reflect those maintenance items due within that average weekly usage.

As an example, a component currently has 245 cycles. The overhaul limit is 275 cycles. The overhaul cycle limit is 275 cycles. If the set warning cycles limit is set 25, this item would not shown up on the generated Maintenance due report since the 245 current +25 warning limit is still less than the 275 limit the component. If the warning cycle limit was set to 50, a Maintenance Due report generated would include this component with the overhaul maintenance due since the current 245 cycle count plus the warning limit of 50 cycles exceeds the overhaul limit of 275 cycles.

The setting of the warning times for the system is done through the selection of the utilities menu. A window named "*Warning Limits*" will require the following limits:

- ✓ Cycle limits – the number of cycles for warning of maintenance due tasks. The average cycles flown for the company's fleet for the period of time the company is concerned with the reporting shall be inserted.
- ✓ Hour limits – the number of hours for warning of maintenance due tasks. The average hours flown for the company's fleet for the period of time the company is concerned with for reporting shall be inserted.

- ✓ RIN limits – retirement index number, a recent Bell Helicopter innovation, the RIN is a value connected with heavy lift events and will be the measure for assessing the need for torque events and overhaul/retirement. The average RIN counts for the company's fleet for the period of time the company is concerned with for reporting shall be inserted. This feature can be turned off if it is not required.
- ✓ Date Limits – To a specific calendar date.
- ✓ No. of Days – for component life limits in number of days, the number of days in the reporting period the company is concerned with, is inserted. For example, the Maintenance Due report is generated every Monday, 7 is inserted as the number of days to report. This will give a report on Monday morning of all the maintenance due components within the next 7 days.
- ✓ No. of Months – This shows either Exact day due or the end of the calendar month.
- ✓ LCF1 Limits.
- ✓ GP/NG/N1 Engine Cycle Limits.
- ✓ PT/NP/N2 Engine Cycle Limits

Maintenance tracking

At the heart of the C.A.L.M. system is the maintenance tracking function. This allows the user to maintain both serialized and non-serialized components with warnings for the service life limits. In addition, the system will track scheduled inspections. Airframes, engines and auxiliary can be created and attached/detached from the airframes. Each of the three main areas of control, airframes, engines, and auxiliary systems can have components, which apply to those sub-systems, which are tracked with the main system. C.A.L.M. allows inputting flight time and having all time flown accumulated on the components, which are currently attached to that airframe.

Times flown and cycles can be applied to all airframes, engines, auxiliary systems and their components. If the time flown is different for the engine(s) and/or the auxiliary system(s) from the airframe, those times can be inputted independently, but easily.

The first steps in implementing C.A.L.M. for Maintenance Tracking are the following:

- ✓ Create airframes and their components to track;
- ✓ Create engines and their components to track;
- ✓ Create auxiliary systems and their components to track;
- ✓ Attach engines and auxiliary systems to the appropriate airframe.

In C.A.L.M. Maintenance Tracking each of the Airframe, Engines, and Auxiliary Systems can have multiple components to track. The components may also have sub-components to track. The Airframes, Engines, and Auxiliary Systems may also have Inspections as specified. Once these steps are completed, the on-going Maintenance Tracking functions of C.A.L.M. are ready which include times to perform, or specific inspections which will be routinely required (e.g. a 100 hour inspection every 100 hours) can be input and tracked by C.A.L.M.

For airframes, there is a special button for setting up and tracking inspections separately from part components. For engines and auxiliary systems, an inspection can be created as a component of the engine or auxiliary system.

Airframe and airframe component on-going maintenance

Once the components are added to the airframe to be tracked, they will be able to be maintained for tracking purposes by:

- ✓ Adding flight time to an airframe, its components, sub-components and all attached subsystems (engines and auxiliary systems);
- ✓ Removing a component from an airframe. The component can be selected to be placed on another airframe, into serviceable or non-serviceable inventory, or completely delete the component from the system.
- ✓ Adding a different component to the airframe, whether entered as an airframe component or moved from inventory to the airframe;
- ✓ Editing the component information such as description, life limits, etc.

All components taken off of an airframe retain their most current time flown statistics in inventory. When attached to an airframe the current time. When attached to an airframe, the current time flown history is retained for the component.

The maintenance of the components on the airframe is essential to maintain the integrity of the data for maintenance report and for the ability to forecast maintenance due for the fleet.

Airframe description

The basic Aircraft description information needed in CALM consists in:

- ✓ Registration Number of the aircraft. Example: CS-ABC, N4763B.
- ✓ Name of the manufacturer of the airframe. Example: Cessna, Dornier, Boeing, etc.
- ✓ Model Number of the aircraft. Example: C152A, A320, B737-400, etc.

- ✓ The Serial Number provided by the manufacturer of the airframe. Example: JJ89999870.
- ✓ Description (data that would be used to describe the airframe).
- ✓ The location of the airframe or the base where the aircraft operates out of.
- ✓ The Total Hours accumulated on the airframe.
- ✓ The total cycles/landings accumulated on the airframe.
- ✓ The total number of engines.
- ✓ The total number of auxiliary systems.
- ✓ Status (this field describes whether the airframe is in service or out of service).

Components tracked

For tracking components, CALM software needs the following information to be entered in their respective fields:

- ✓ Airframe – the airframe to which the components are attached;
- ✓ Component x of y – the total number of components attached to the airframe ("y") and the number of the component ("x");
- ✓ Attached subs – the total number of attached sub components of the component displayed;
- ✓ Component Name;
- ✓ Serial Number – the serial number provided by the manufacturer of the component;
- ✓ The Date of installation of the component to the airframe, engine, aux. or to the master component;
- ✓ Part Number – the Part Number of the component on the airframe;
- ✓ ATA Code – The Airline Transportation Association Code of the components;
- ✓ Description of the item, which can display either the position of the part on the airframe or the number of the part. Example, first or second part of the same kind;
- ✓ Comments attached to the component;
- ✓ Record card information to the component;
- ✓ History- The attachment history of the component;

- ✓ Cycles - The Service life of the components in terms of cycles;
- ✓ Inspection – The service life of the component in terms of the number of hours before an inspection is due;
- ✓ Overhaul – The service life of the component in terms of the number of hours before an overhaul is scheduled;
- ✓ Retirement – The Service life of a component in terms of the number of hours before a retirement is foreseen;
- ✓ On Condition – The service life of a component, which have to be checked depending on the condition is activated in the software (through a check box checked) ;
- ✓ Months – The Service life of a component in terms of the calendar number of months before the completion of its lifetime;
- ✓ Days – The Service life of a component in terms of the number of days before the completion of its lifetime;
- ✓ RINS – The Service life of a component in terms of the Retirement Index Numbers before the completion of its lifetime;
- ✓ RHL – The Service of a component in terms of Repetitive Havy Lifts before the completion of its lifetime;
- ✓ Condition Monitored (TSN – Time Since New) – The Service life of a component in terms of the Condition monitored before the completion of its lifetime.

Bulletins

The CALM System allows entering and tracking various types of bulletins. Bulletin information can be inputted and compliance information can be tracked including inspection information. A bulletin for an airframe, engine, or auxiliary system can be added to CALM. Once added, the bulletin can be updated, complied with, printed, and accessed for future reference.

Bulletin categories

The Bulletins can be categorized into the following types of bulletins:

- ✓ AD – Airworthiness Directives;
- ✓ SB – Service Bulletins;
- ✓ TB – Technical Bulletins;
- ✓ User Defined Bulletin Codes – (Set up user defined Bulletin Coding Types).

Reports

CALM contains a series of reports for use in analyizing the company's fleet and fleet readiness. The reports are accessible through the Reports Main Menu option.

Inventory

The Inventory section of CALM contains information on all items in stock.

Most of the information in this section (information above, that is, 2.3 sub-chapter) came from [7] and also from practical presentations given to me at the AEROTÉCNICA facilities.

2.4 OVERVIEW ON PRODUCTION CONCEPT

"Production is the process by which goods and services are created. Production systems combine materials, labours, and capital resources in an organised way with the objective of producing some goods or service. Production system may occur in factories, banks, stores, hospitals etc. In all instances, some input to the system is being processed within the system to produce a goods or services as an output; we are in fact dealing with the operations phases of any enterprise. 'Creation' of goods and services of production, to perform this function, the production system require inputs from other subsystems of the organization, such as service inputs (e.g. maintenance, supervision, plant layout, design etc.) and control inputs (e.g. measurement, data processing, planning, control, order and sales information processing, forecasting etc.)." [8]

2.5 SOFINARE EASA PART-145 MAINTENANCE ORGANISATION RESEARCH

Whenever AEROTÉCNICA staff carries out maintenance on any aircraft and comes across with some electronic equipment failure, or there is some kind of electronic inspection needed (for example, a radio, a GPS inspection, an aircraft wire, etc.), this maintenance task must be requested to SOFINARE, as SOFINARE is the only organisation of Grupo7Air that is eligible to proceed to these maintenance tasks (electronic related). Thus, a work order is requested from AEROTÉCNICA to SOFINARE. This is lke an internal request inside the whole organisation, that is, AEROTÉCNICA is going to request maintenance work to SOFINARE, given its electronic capacities. Conventionally, whenever AEROTÉCNICA requests a maintenance work order to SOFINARE, the requisition number of this work order to be opened in SOFINARE will have the same number of the work order opened in AEROTÉCNICA where the given task is inserted.

The present development of this software application for SOFINARE EASA Part-145 maintenance organisation focuses on the production scope. So, it was also fundamental to make a research about production planning and its compliance with EASA Part-145 (refer to Appendix B).

At SOFINARE when a Work order is opened a document called Work sheet needs to be filled in with all the details of the maintenance work required through the requisition document. The requisition document is always the first paper to be filled in, in order to proceed to opening a Work Order. The Work sheet consists of a single sheet of paper, both sides printed, and its design was set at SOFINARE, being authorized by INAC. A print of this document can be seen in Figures 1 [front side] and 2 [back side].

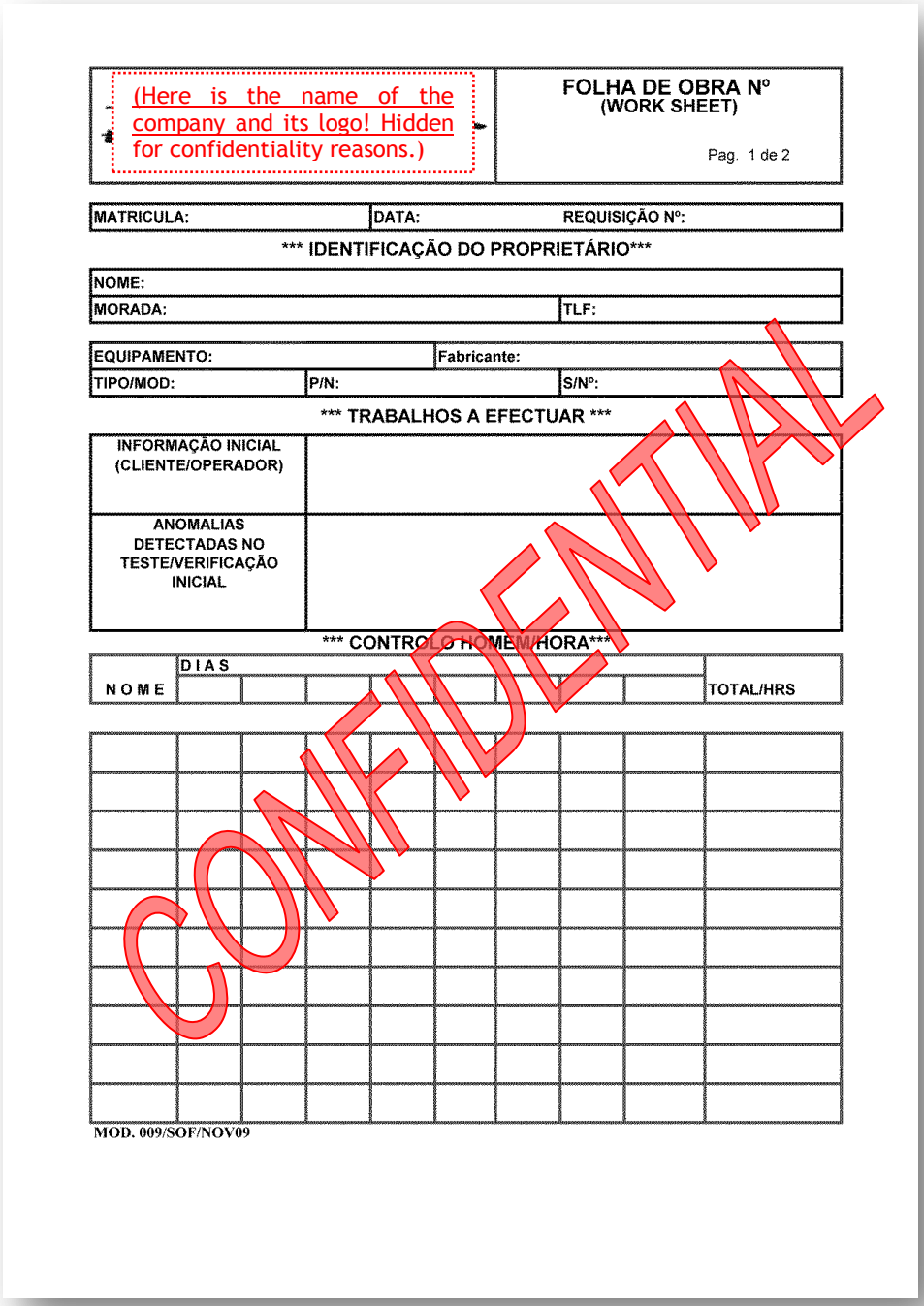
The Work Order sheet was a paper needed to begin developing the software, since it shows the fields required to fill in, in order to officially open a Work Order. Later, in the application developed so far, those fields can be seen through a form programmed through PHP.

After the maintenance work is done, approved and certified by the Certifying Staff an EASA Form1* must be issued by SOFINARE, along with the component repaired. This document is an Authorised Release Certificate which guarantees the component airworthiness. According to EASA Part 21A.307, Release of parts and appliances for installation:

"No part or appliance (except a standard part), shall be eligible for installation in a type-certificated product unless it is: (a) Accompanied by an authorized release certificate (EASA Form 1) certifying airworthiness; and (b) Marked in accordance with Subpart Q."

A print of an EASA Form 1 used at SOFINARE can be seen in Figure 3.

* The certificate is to be used for import purposes, as well as for domestic and intra-Community purposes, and serves as an official certificate for the delivery of items from the manufacturer to users. Appendix I of EASA Part 21 includes a facsimile of the document and the completion instructions.



(Here is the name of the company and its logo! Hidden for confidentiality reasons.)

FOLHA DE OBRA Nº
(WORK SHEET)

Pag. 1 de 2

MATRICULA:	DATA:	REQUISIÇÃO Nº:

*** IDENTIFICAÇÃO DO PROPRIETÁRIO***

NOME:	
MORADA:	TLF:

EQUIPAMENTO:	Fabricante:	
TIPO/MOD:	P/N:	S/Nº:

*** TRABALHOS A EFECTUAR ***

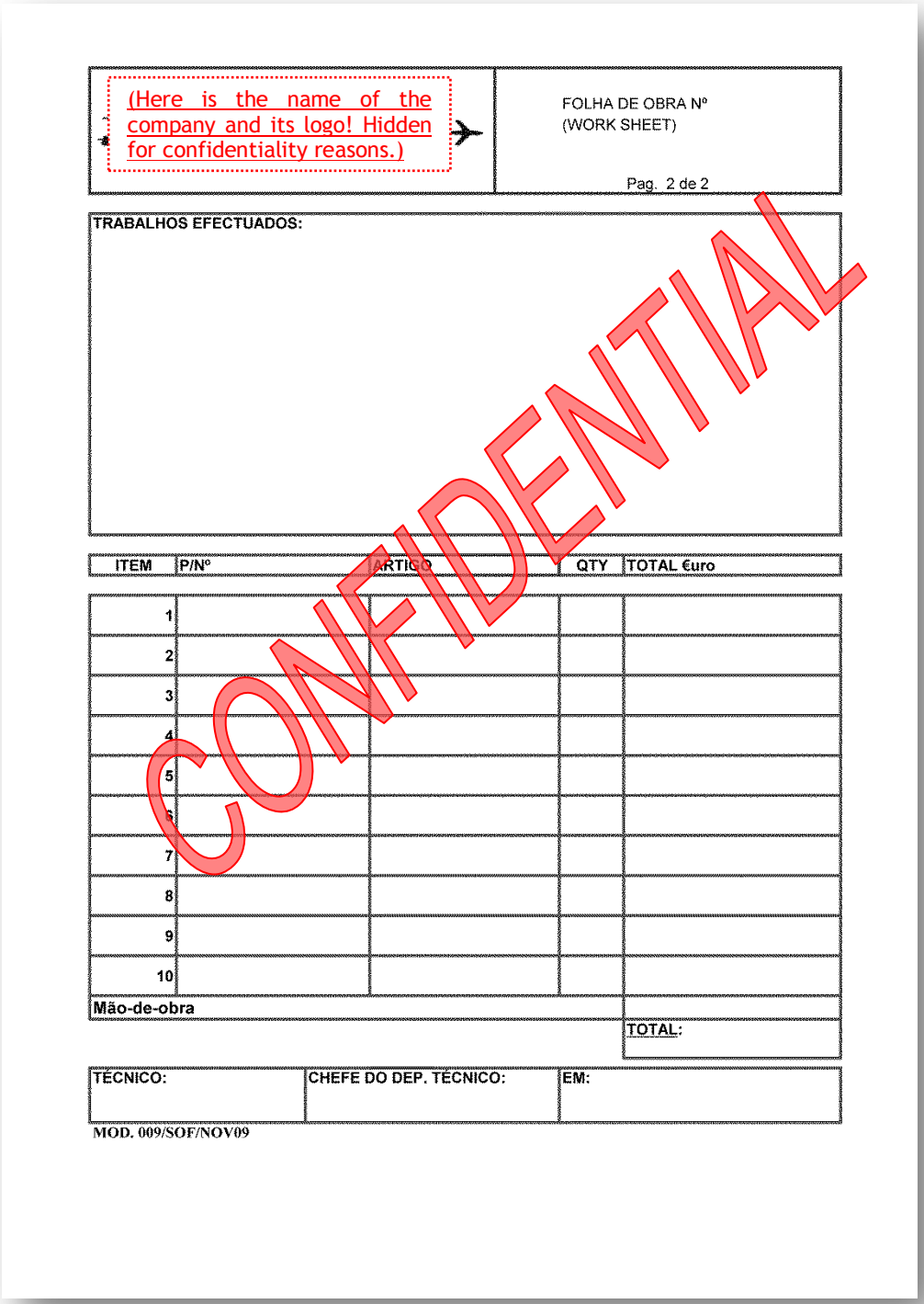
INFORMAÇÃO INICIAL (CLIENTE/OPERADOR)	
ANOMALIAS DETECTADAS NO TESTE/VERIFICAÇÃO INICIAL	

*** CONTROLO HOMEM/HORA***

NOME	DIAS							TOTAL/HRS

MOD. 009/SOF/NOV09

FIGURE 1- FRONT VIEW OF THE WORK SHEET USED AT SOFINARE.



(Here is the name of the company and its logo! Hidden for confidentiality reasons.)

FOLHA DE OBRA Nº
(WORK SHEET)

Pag. 2 de 2

TRABALHOS EFECTUADOS:

ITEM	P/Nº	ARTIGO	QTY	TOTAL €uro
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Mão-de-obra				
				TOTAL:

TÉCNICO:	CHEFE DO DEP. TÉCNICO:	EM:

MOD. 009/SOF/NOV09

FIGURE 2 – BACK VIEW OF THE WORK SHEET USED AT SOFINARE.

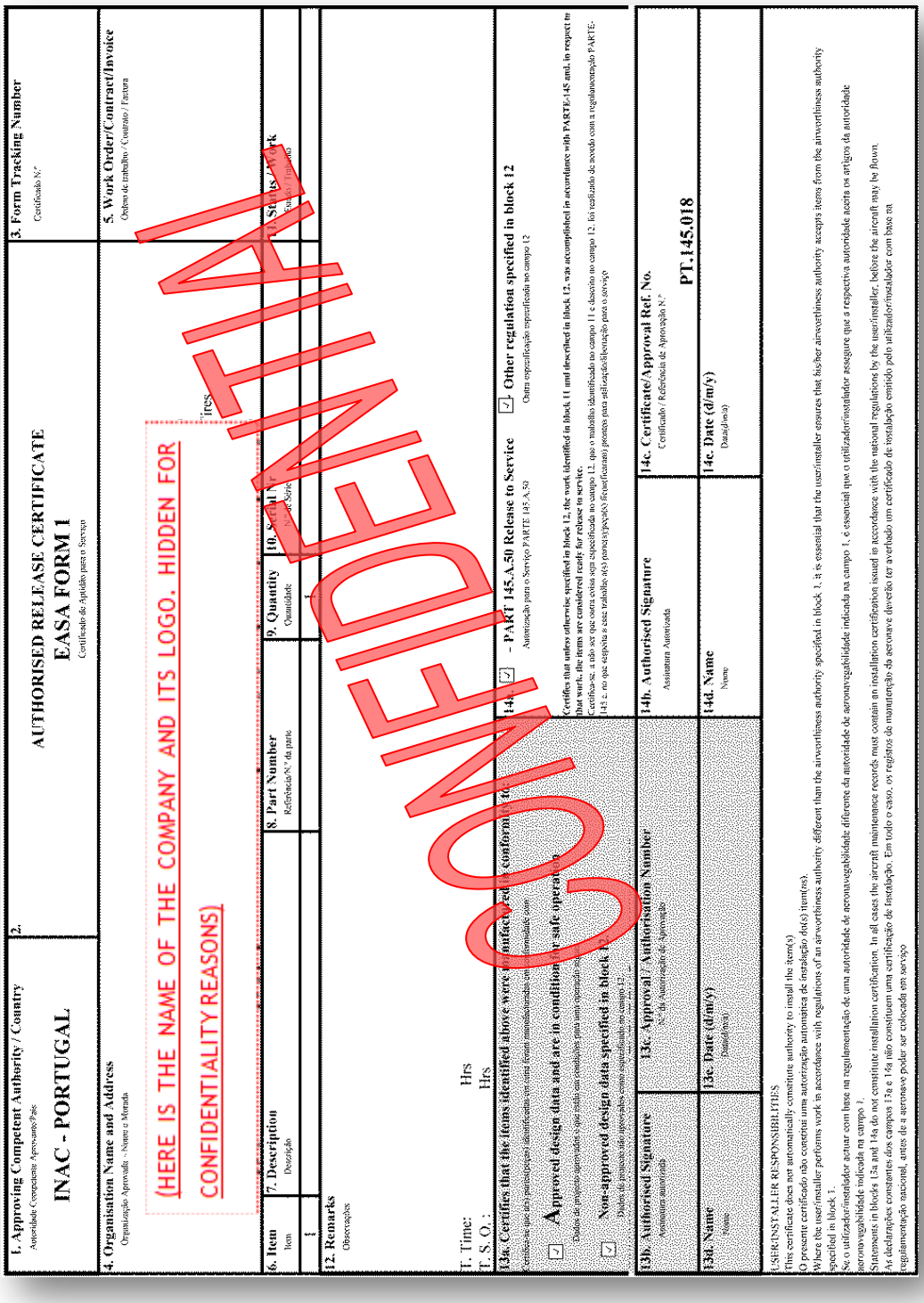


FIGURE 3– COPY OF A SOFINARE EASA FORM 1.

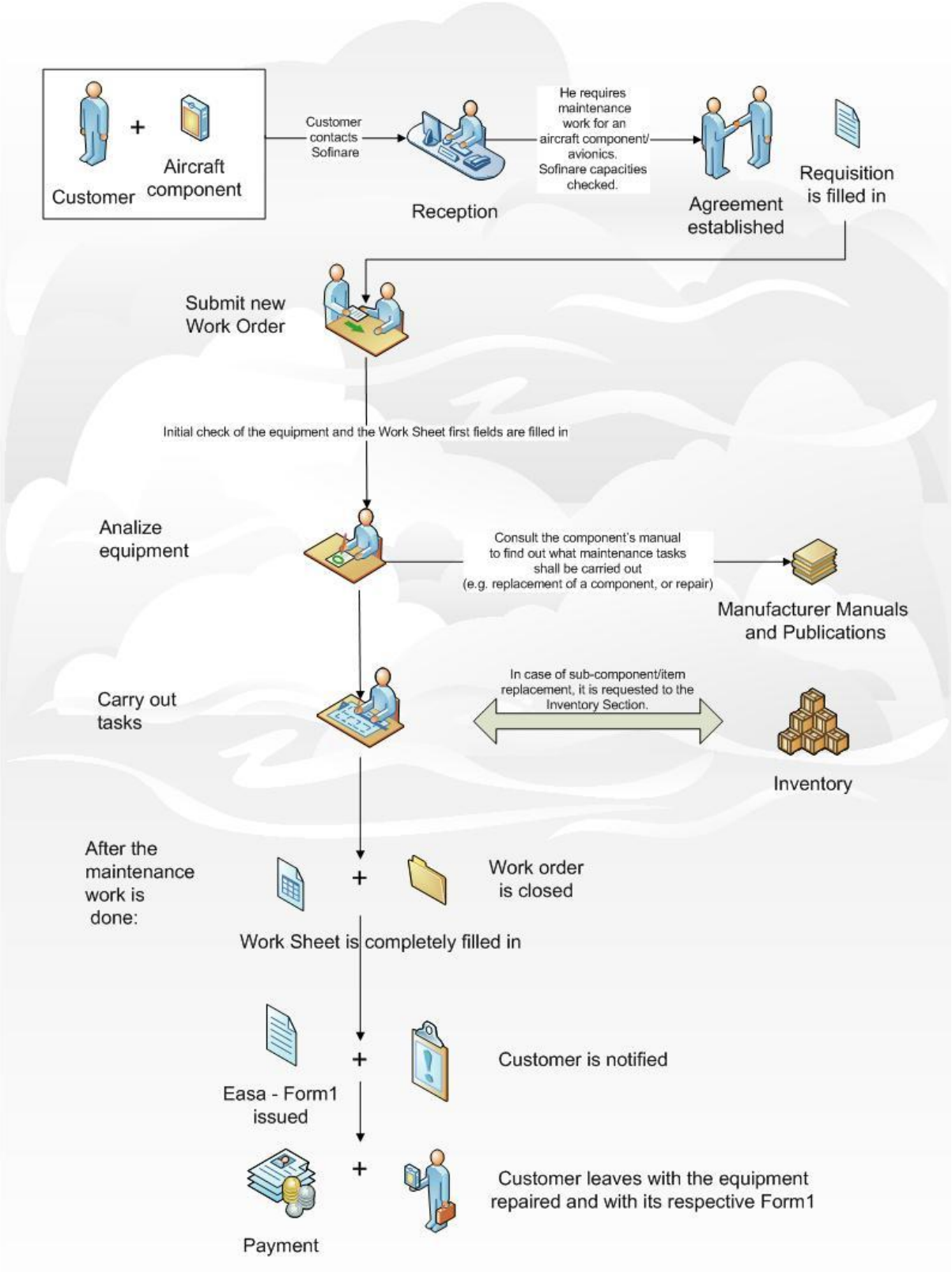


FIGURE 4 – SOFINARE MAINTENANCE WORKFLOW CHART

Presently, SOFINARE doesn't have any computerized maintenance recording system, thus the application resulting from the present work is considered important for the company to allow to systematize and to upgrade the work planning and control. Thus, a Work flow was created in order to clearly understand how data flows in a work order. See figure 4. This will represent the beginning of the software development, which AEROTÉCNICA is willing to create.

CHAPTER 3

RESULTS AND ANALYSIS

APPLICATION DEVELOPMENT

SOFINARE SCOPE

First of all, this application requires initially to be configured according to the SOFINARE Production data. Every Aeronautical Maintenance Organisation has its customers. So, it is necessary to populate the information about the customers of the organisation, that is, personnel data and airplane registrations: customers' details: name, address, phone numbers, e-mails, and airplane registrations. Besides, regarding SOFINARE's capacities (C2 and C3 ratings), those were considered to be chosen once a Work Order is open, according to its scope.

It was also fundamental to consider that not all SOFINARE technicians have the same rating capacities. Thus, when using the Software, once the scope of the work is chosen, the user can only choose the technicians who carried out the work from a list with the ones authorized for, that is, the ones having the capacity required.

DATABASE PLANNING: IMPORTANCE

Before writing a *PHP* program, the Web database application needs to be planned. This is possibly the most important step in developing an application. As the author of the book «*PHP* and *MySQL* for Dummies» says: "*It's painful to discover, especially just after finishing the last program for the application, that it was left something out and have to start over from the beginning*". "Good *planning prevents such painful backtracking*". In addition, it keeps one focused on the functionality of the application, thus preventing one from writing pieces for the application that do ease things but turn out to have no real purpose in the finished application. And if more than one person is working on the application, that is the case for future continuation of this software development, planning ensures that all the pieces will fit together in the end.

"The first step in the planning phase is to identify exactly why this application is developed and what is wanted from it." [O'Reilly - *Web Database Applications with PHP and MySQL, 2nd* ed. (2004)]

Relationships

Database relationships refer to how the data in one table relates to the data in another.

There are three types of relationships between any two tables: *one-to-one*, *one-to-many*, or *many-to-many*.

A relationship is one-to-one if one and only one item in Table A applies to one and only one item in Table B. For example each Work Order at SOFINARE has only one Requisition, and each Requisition applies to only one Work Order; no Work Order can have two Requisition numbers, and no Requisition can refer to two Work Orders.

A relationship is one-to-many if one item in Table A can apply to multiple items in Table B. An aircraft model will apply to many aircraft registrations, but each aircraft itself (so each aircraft registration) can only be only one aircraft model. A one-to-many relationship is the most common one between tables in normalized databases, so it will also be the most common in this software.

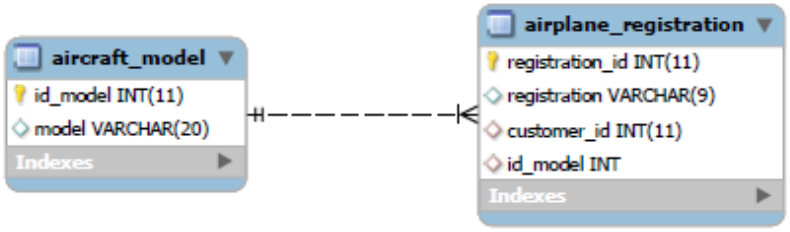


FIGURE 5 – A ONE TO MANY RELATIONSHIP IN THE DATABASE

Finally, a relationship is many-to-many if multiple items in Table A can apply to multiple items in Table B. A Work Order can contain tasks done by multiple technicians, and technicians can work in multiple work orders.

Many-to-many relationships in the database design should be avoided because the lead to data redundancy and integrity problems. Instead of having *many-to-many* relationships, properly designed databases use intermediary tables that break down one *many-to-many* relationship into two *one-to-many* relationships.

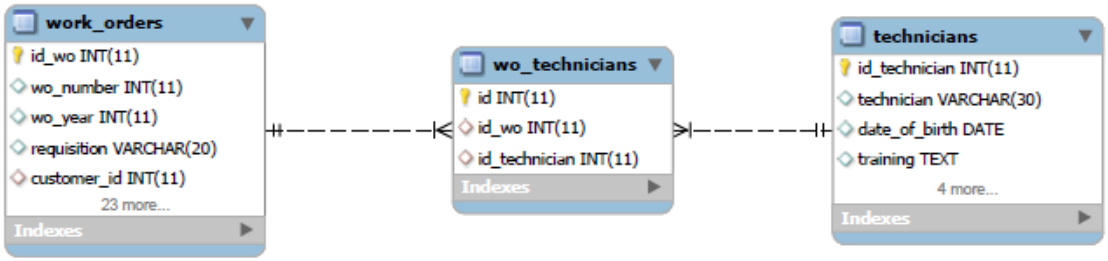


FIGURE 6 - A MANY TO MANY RELATIONSHIP TRANSFORMED INTO TWO ONE-TWO MANY RELATIONSHIP IN THE DATABASE

Relationships and keys work together in that a key in one table will normally relate to a key in another. That can also be seen in Figures 5 [*id_model*] and 6 [*id_wo*].

Entity-relationship diagram

The process of database design results in an *ERD* (entity-relationship diagram) or *ERM* (entity-relationship model). This graphical representation of a database uses boxes for tables, ovals for columns and line symbols to represent the relationships (see Figures 7 and 8). So, Entity-relationship modeling is a simple and clear method of expressing the design of database.

There are many programs available to help create a database schema, including MySQL Workbench (www.mysql.com), which was used at the time of this database development.

Figure 7 shows a partial model of the application database developed so far in this dissertation. In the diagram, relationships can be seen between customers, technicians, and work orders. Each customer has attributes such as a name, address, phone number, and e-mail. A technician, given its responsibility in the aeronautical maintenance business, has a larger list of attributes such as name, date of birth, basic training information, type training, experience, and date of first issue of authorisation that should be kept on record. [see Part-M, AMC 607 (C) Certifying Staff]

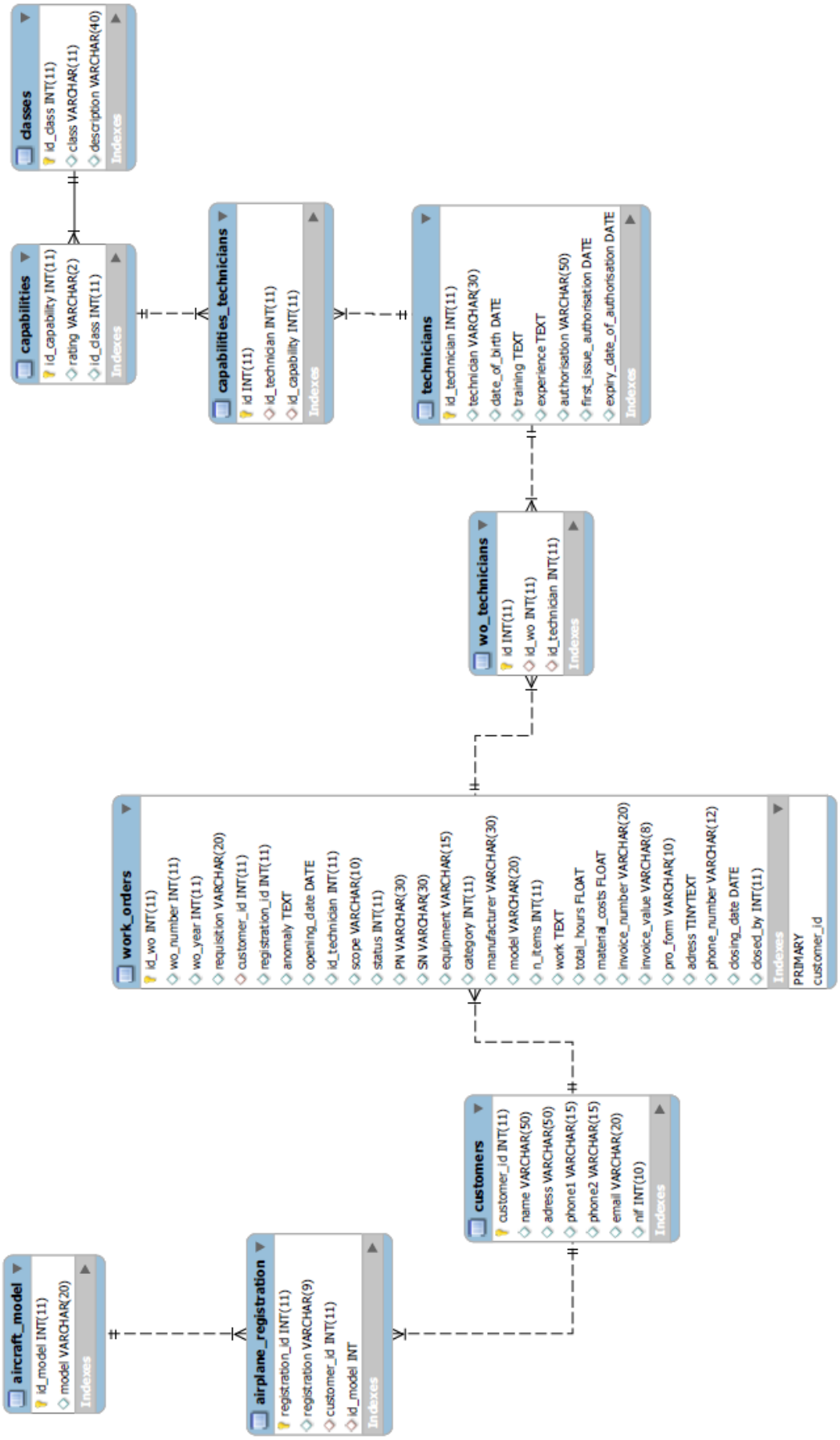


FIGURE 7- AN ALMOST-COMPLETE ER MODEL FOR THE SOFTWARE DATABASE CREATED SO FAR

By incorporating a database into a Web application, some of the data generated by PHP can be retrieved from MySQL. This further moves the site's content from a static (hard-coded) basis to a flexible one, flexibility being the key to a dynamic Web site.

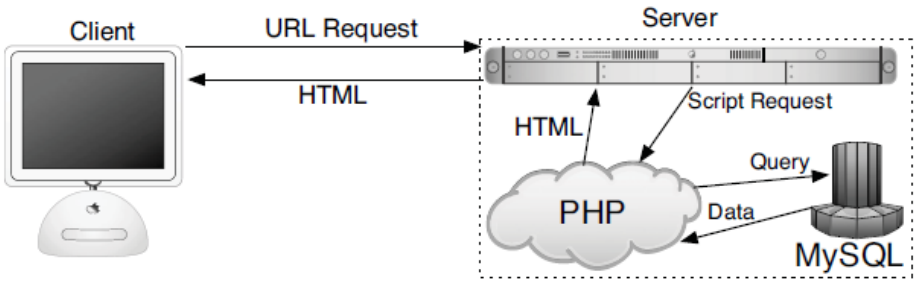


FIGURE 8 - HOW MOST OF THE DYNAMIC WEB APPLICATIONS IN THIS SOFTWARE WILL WORK, USING BOTH PHP AND MYSQL.

APPLICATION TASKS

Firstly, the main purposes of this application are:

- ✓ To collect SOFINARE orders' details: opening date, closing date, id number, type of work applied, costs, and workers involved, so that we can develop an order list;
- ✓ To collect the time spent on every order, by asking the workers at what time they opened a given order and at what time they closed it;
- ✓ To deliver information about orders, invoices and workers to the company administrators in a catalog fashion;
- ✓ To store all maintenance data in a solid and reliable internal database.

Opening a work order in sofinare

All work orders numbers shall be auto-incremented. For example, if last work order opened is number, let's say, 88, the new work order shall have number 89. So, what this application does is to firstly check the number of the last work order created and stored in the database, and it automatically inserts the number of the new work order, printing it in the "Work order number" field of the form. Anyway, if the Software user decides to give a different number to the Work Order being opened, he can just do it.

Same happens to the order year, that is, the year when the order was created. The year of the work order corresponds to the last two digits of the complete work order number. Once again, the application will suggest these last two digits of the work order number. So if a work order belongs to the current year (by the time this was developed was 2012), the application will automatically insert on the "Order year" field the number 12. In figure 9 is shown an example of a work order whose number 8-12 is being opened. After choosing the customer of this work, its airplane registrations stored in the database are picked up from the form and the user needs to select which airplane registration is considered, regarding the present work order being opened.

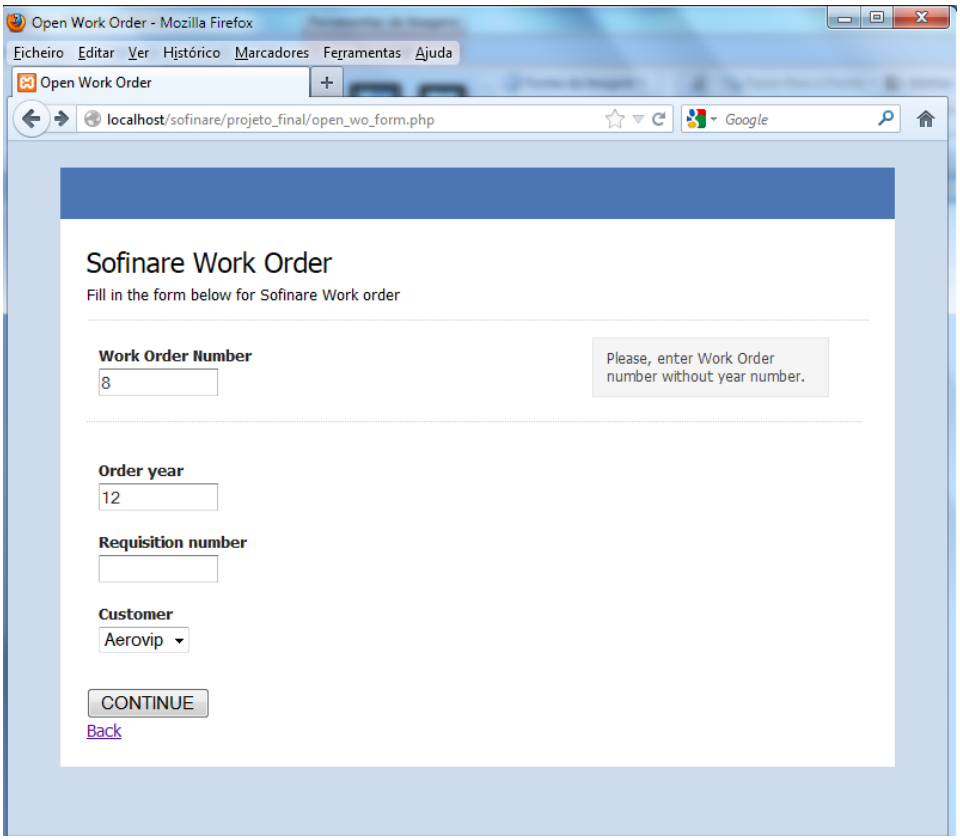


FIGURE 9 - A WORK ORDER BEING OPENED: FIRST FIELDS TO BE FILLED IN.

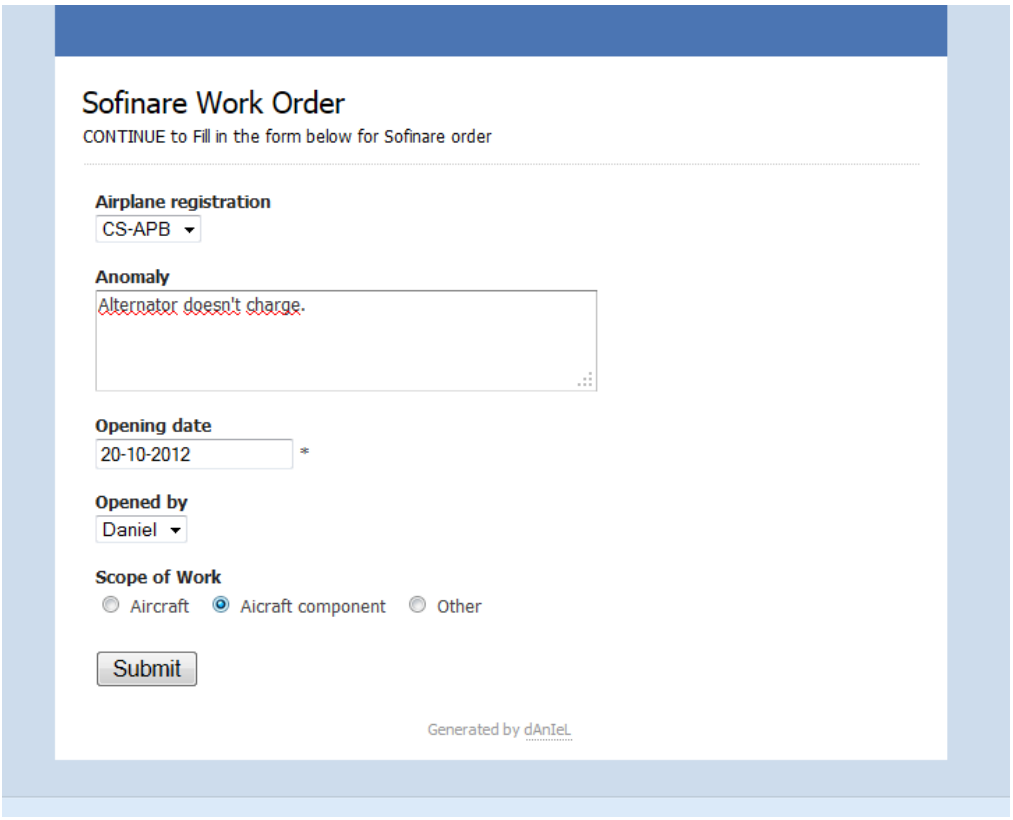


FIGURE 10 – SELECTION OF THE AIRCRAFT REGISTRATION RELATED TO THIS WORK ORDER, INSERTION OF THE ANOMALY, OPENING DATE AND SCOPE OF WORK.

In Figure 10 an airplane registration is picked up. Anomaly detected in the component is described, opening date automatically is inserted, the worker/technician who opens the Work order is selected and the scope of work is chosen. Being a component repair, Aircraft component shall be selected.

When closing a Work Order the application will only let close Work Orders that are still open. Figure 11 shows the initial form that starts to close a Work Order. Note that the scope of the work carried out is always asked. For example, if it was a Radio repair, option C3 should be selected. If it was an Autopilot repair, option C2 should be selected. Neither being a Radio, nor an Autopilot or a Navigation System there is still option “Not Applicable”, which can be selected. All these data is going to be correctly stored in the SOFINARE’s database created.

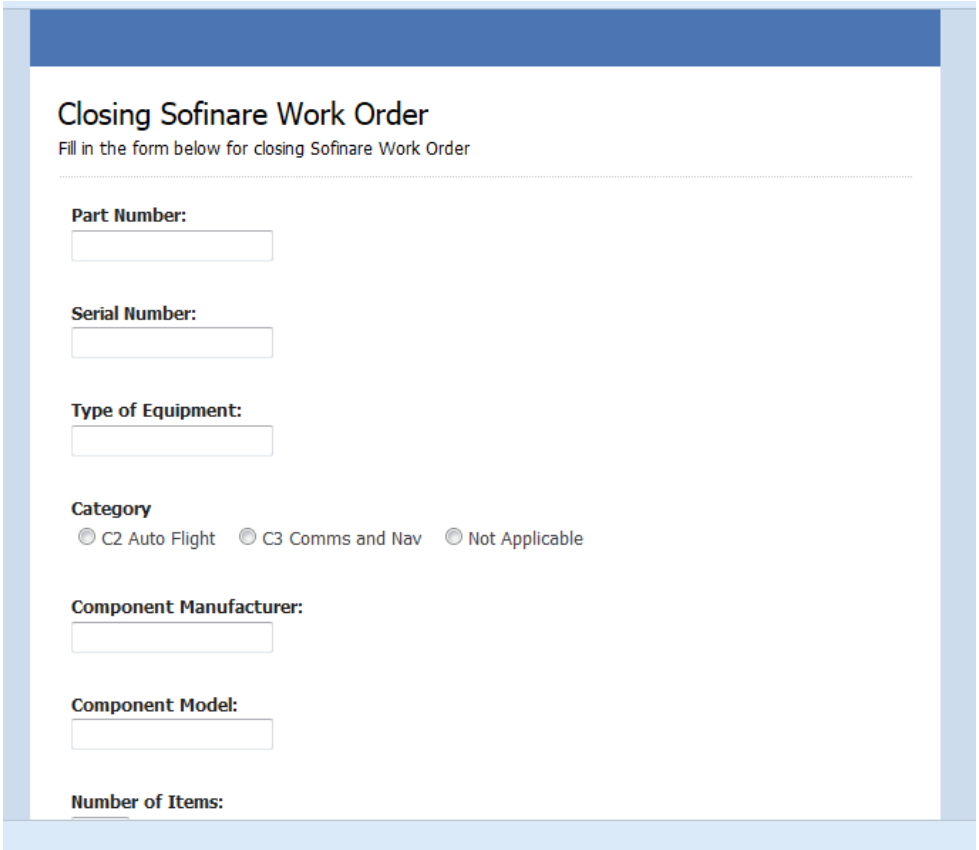


FIGURE 11 - FORM TO BEGINNING TO CLOSE A WORK ORDER PREVIOUSLY CHOSEN

More detailed description is presented in the video recorded, showing the interaction between the software and the database. It will also be presented during the oral exposition.

Another purpose of this application is to be continuously developed in order to be used in maintenance tracking and planning. This service is designed to benefit by reducing the administrative work load for tracking and planning fleet maintenance. A systematic procedure to ensure aircraft task tracking and planning is efficient and accurate.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH WORK

The main purpose of this research was the development of the beginning of software procedures to control and manage the entire maintenance data, starting at SOFINARE. In order to achieve this main objective, it was needed to find out where this application should start to be created. Then, it was decided to start at SOFINARE, by starting to develop an application to manage work orders, that is, registering its work order details in a web application way, so it can later be consulted whenever is wanted, as long as one is connected to the server. It was also needed to understand how PHP and MySQL languages work, how they query and record data and how important is to create a well organized and structured database. A so widely project being developed will undoubtedly require a lot of patience for planning, searching and interaction. Moreover, the programming languages must be very well managed and known from the people who are going to develop this software. Lots of comparisons with C.A.L.M. shall be carried out in order to have really greater software.

RESEARCH OUTPUT – FUTURE REQUIREMENTS

The main purpose of this application after its complete development is to provide the management tools that will allow the user to explore, track, and study the data of anything related of a certain aircraft registration, type; technician, tool, component, maintenance services, bulletins, ideally being independent from CALM.

The future developments must be able to respond to the following needs in terms of analyses:

- ✓ The relations between several parameters of a given aircraft, technician, component or internal directive, calculating, for instance how many hours a given technician has been working so far today on a given order, for how long a certain order was open;
- ✓ The relations between components and airplanes;
- ✓ The relations between technicians and orders;

- ✓ The relations between internal directives and airplanes;

To fulfill these needs, the future application must recognize the different elements in a given aeronautical company, be able to access to their properties, staff, material, papers, and establish the necessary relation between them. Due to the large amount of possible scenarios, with different types of users and properties, the software shall need to calculate numerous parameters to be able to provide the necessary information on any company task.

Aeroplanes need to be maintained according to prescribed standards. The owners and maintenance organisations need to be able to show to the aeronautical authorities that they have maintained their aeroplanes in the prescribed way ("compliance"). It is indispensable a system which optimizes the scheduling of maintenance and records when it is completed.

Before planning a maintenance management system, it is important to take into account that:

- ✓ An aeroplane is an assembly of components, and each component shall be tracked and maintained.
- ✓ Components can move from one plane to another (eg. an engine).
- ✓ Components wear out at different rates. Some are impacted by calendar utilization or hours flown; others by number of landings (cycles), etc.
- ✓ Planes are on the ground multiple times per day and each time presents an opportunity to do maintenance.
- ✓ Planes require a team of qualified mechanics, each with various skills. No one person can do all the work on a plane.
- ✓ The record keeping needs to be to be accurate and traceable at all time to originator.

Core Features of an advanced MRO Solution:

- ✓ Web based (Mainly *PHP* and *MySQL* web-programming languages): for ease of use and integration with other systems. Having no geographic boundaries, being ease-of-use and having much reduced IT costs.
- ✓ Integrated: to be able to share data real time with other systems that the customer is running.
- ✓ Intelligent: more than just a "data capture" system.

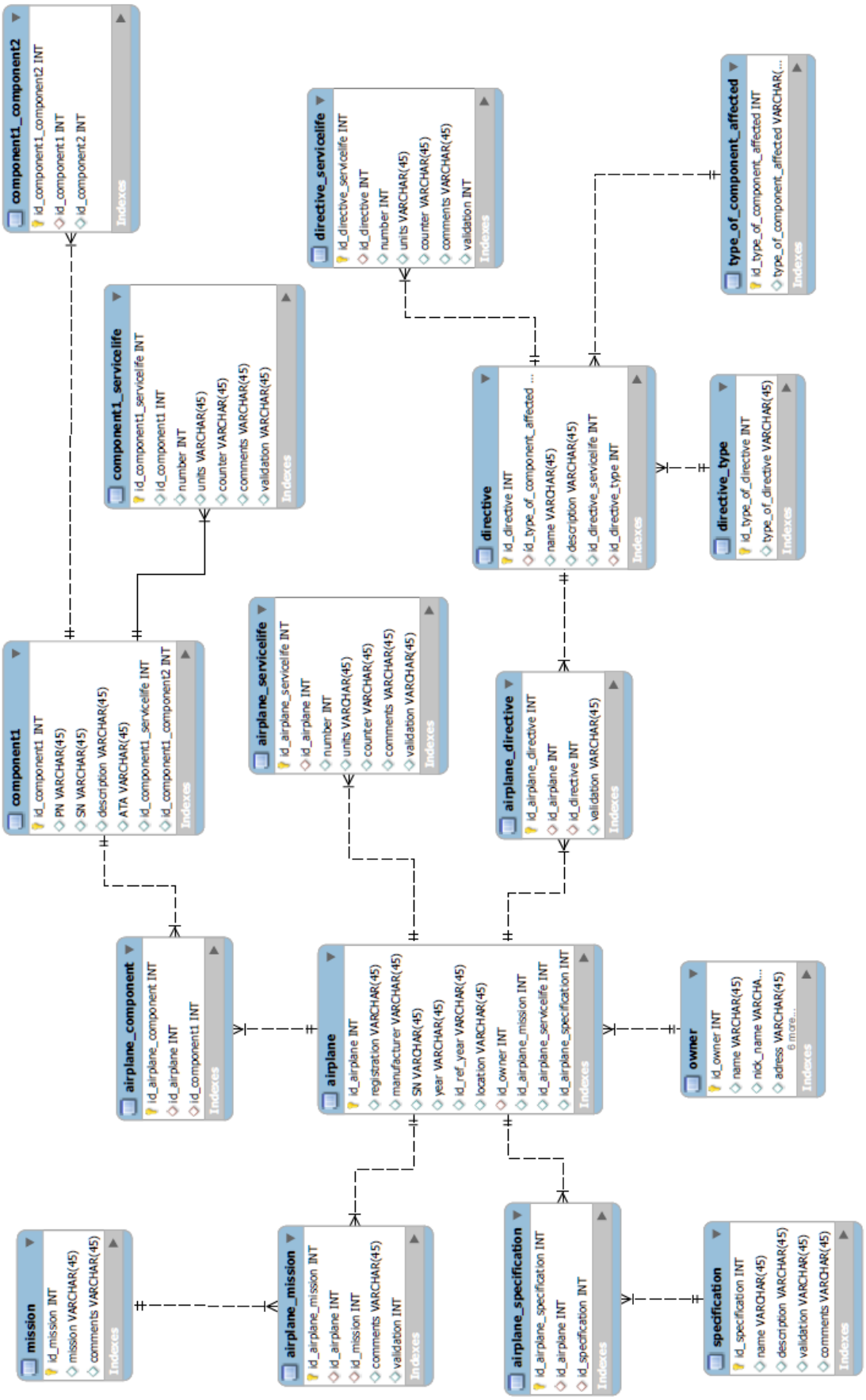


FIGURE 12 - FUTURE DATABASE SUGGESTION

Figure 12 represents a database diagram model suggestion for future reference in the development of the future software.

CHAPTER 5

BIBLIOGRAPHY

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APPENDIX A

AIRWORTHINESS AUTHORITIES

AIRWORTHINESS AUTHORITIES PURPOSES

From a general point of view, an airworthiness authority has the following tasks [4]:

- ✓ To prescribe airworthiness requirements and procedures, ranging from aircraft type certification, construction, and operation to the relevant organizations.
- ✓ To inform the interested parties regarding the above-mentioned prescriptions. This is performed in different ways. The authority publishes, among various types, technical regulations and technical standards. At present, much information can be found on the Internet.
- ✓ To control aeronautical material, design, manufacturing organisations, and aircraft operators. This is to ensure that all pertinent prescriptions are complied with. Control operations can be performed in different ways, with the appropriate involvement of the relevant authority.
- ✓ To certify aeronautical material and organisations. This is to declare in a legal form compliance with the applicable requirements of an aircraft or part of it, or a change to a type certificate, the capability of an organisation to perform specific aeronautical tasks.

THE EUROPEAN AVIATION SAFETY AGENCY -EASA

The establishment of the European Aviation Safety Agency (EASA) was the most important event for the European airworthiness regulation. It is an independent European Community body with a legal identity and autonomy in legal, administrative, and financial matters. This single authority has been created by the adoption of a European Parliament and Council

Regulation (EC) No. 1592/2002 of 15 July 2002 to put in place a Community system of air safety and environmental regulation. Meanwhile, on 20 February 2008, the European Parliament and the Council have adopted Regulation 216/2008 repealing Regulation 1592/2002, which extends the scope of EASA to operations, to flight crew licensing, and to third-country operators. EASA now has the mandate to work on Implementing Rules concerning the aforementioned areas. The activity of the EASA started, as planned, on 28 September 2003 and, after a transitory period in Brussels, the Agency moved to Cologne (Germany). [1]

Figure 13 depicts the EASA's regulation organizational structure.

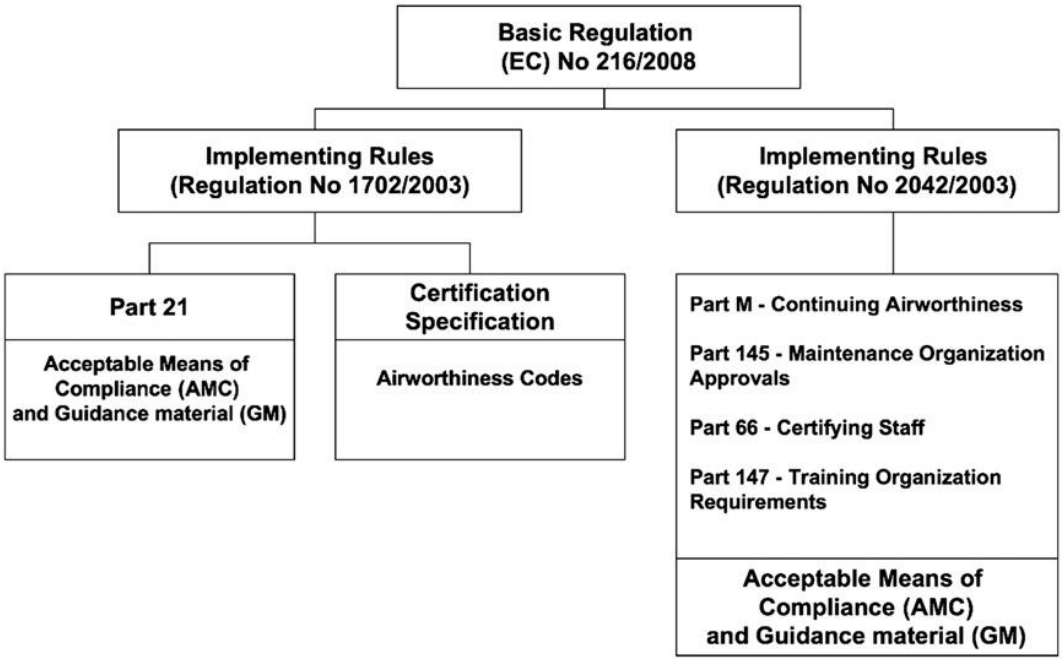

FIGURE 13 - EASA REGULATION STRUCTURE

Easa implementing rules (IR)

These IRs contain documents defined as Parts, which are divided into two sections: Section A, detailing the requirements to be satisfied by aeronautical subjects; and Section B, containing the procedures to be followed by the national authorities.

The IRs (EC) No. 1702/2003 for the airworthiness and environmental certification of aircraft and related products, parts, and appliances, as well as for the certification of design and production organizations, specify:

- ✓ The issuing of type certificates, restricted type certificates, and changes to those certificates.
- ✓ The issuing of certificates of airworthiness, restricted certificate of airworthiness, permit to fly, and authorized release certificates.
- ✓ The issuing of repair design approval.
- ✓ The showing of compliance with environmental protection requirements.
- ✓ The issuing of noise certificates.
- ✓ The identifying of products, parts, and appliances.
- ✓ The certifying of certain parts and appliances.
- ✓ The certifying of design and product organizations.
- ✓ The issuing of Airworthiness Directives.

Annex to this document is Part 21, "Certification of aircraft and related products, parts and appliances, and design and production organizations."

The IRs (EC) No. 2042/2003 specify the continuing airworthiness of aircraft and aeronautical products, parts, and appliances, and the approval of organizations and personnel involved in these tasks.

The following are Annexes to this document:

- ✓ Annex I, Part M establishes the measures to be taken to ensure that airworthiness is maintained, including maintenance. It also specifies the conditions to be met by persons and organisations involved in such continuing airworthiness management.
- ✓ Annex II, Part 145 establishes the requirements to be met by an organization to qualify for the issue or continuation of an approval for the maintenance of aircraft and components.
- ✓ Annex III, Part 66 establishes the requirements for the issue of an aircraft maintenance license and conditions of its validity and use, for aeroplanes and helicopters.
- ✓ Annex IV, Part 147 establishes the requirements to be met by organisations seeking approval to conduct training and examination as specified in Part 66.

Acceptable means of compliance (AMC) and guidance material (GM)

Some rules can be interpreted in different ways. This is the reason why the authorities issue advisory material for the explanation of the rule or suggest suitable procedures to perform a demonstration of compliance to the same rule. EASA Certification Standards contain AMCs and GMs. As Florio, author of the book « *Airworthiness: An Introduction to Aircraft Certification* » says, ACMs provide "a means, but not the only means, by which a requirement can be met". Whereas the GM "helps to illustrate the meaning of a specification or requirements".

Executive and regulatory tasks

The main tasks of the Agency currently include:

- ✓ Rulemaking: drafting aviation safety legislation and providing technical advice to the European Commission and to the Member States;
- ✓ Inspections, training, and standardization programs to ensure uniform implementation of European aviation safety legislation in all Member States;
- ✓ Safety and environmental type certification of aircraft, engines, and parts;
- ✓ Approval of aircraft design organizations worldwide and of production and maintenance organisations outside the EU;
- ✓ Authorization of third-country (non-EU) operators;
- ✓ Coordination of the European Community program Safety Assessment of Foreign Aircraft regarding the safety of foreign aircraft using Community airports;
- ✓ Data collection, analysis, and research to improve aviation safety.

EASA PART 145 repair station certification

EASA Part 145 applies to the aircraft maintenance sector. It is the standards for the certification and operation of an aircraft maintenance organization, such as a repair station, and its employees.

EASA Part 145 regulates the standards for qualifying as a repair station and the maintenance requirements for aircraft and aircraft articles.

Once a repair station has a Part-145 certification, they will be a recognized maintenance organization worldwide. However, the applicable rules must be adhered to.

EASA will accept some non-EASA Member state based maintenance organizations and repair stations as long as a recognized Authority certifies them. For an agency to be considered an Authority by EASA, their standards must meet standards equivalent to EASA 145.

The FAA is a recognized Authority by EASA, due to a bilateral aviation safety agreement. This means that U.S. repair stations that are certified by the FAA under FAR 145 can also be accepted by the EASA.

The FAA certified repair stations still have to comply with any maintenance special conditions that are contained in EASA 145 that are not in FAR 145.

To make the differences between EASA 145 and FAR 145 transparent, they are outlined in Maintenance Implementation Procedures (MIPs) agreed between the EASA and the FAA.

They can also be found in the Appendix to EASA 145, as well as in EASA Administrative & Guidance Materials Part Two: Maintenance, Section Three: Temporary Guidance Leaflet (TGL) 22.

APPENDIX B

SOME EASA REGULATION RELEVANT TO THIS DISSERTATION

EASA PART-145 PRODUCTION PLANNING

For AMO production means work completion of work such as inspection, modification, repair, servicing etc. Man hrs planning is an important factor of production planning.

Reviewing Consolidated version of Part 145 (Annex II) to Comission Regulation EC No. 2042/2003, issued on November 2010, it was found the following Technical Requirements (Section A) about Production planning:

145. A.47 Production planning

(a) The organisation shall have a system appropriate to the amount and complexity of work to plan the availability of all necessary personnel, tools, equipment, material, maintenance data and facilities in order to ensure the safe completion of the maintenance work.

(b) The planning of maintenance tasks, and the organising of shifts, shall take into account human performance limitations.

AMC 145.A.47 (a) Production planning

Depending on the amount and complexity of work generally performed by the maintenance organisation, the planning system may range from a very simple procedure to a complex organisational set-up including a dedicated planning function in support of the production function.

For the purpose of Part-145, the production planning function includes two complementary elements:

- ✓ scheduling the maintenance work ahead, to ensure that it will not adversely interfere with other work as regards the availability of all necessary personnel, tools, equipment, material, maintenance data and facilities.
- ✓ during maintenance work, organising maintenance teams and shifts and provide all necessary support to ensure the completion of maintenance without undue time pressure.

When establishing the production planning procedure, consideration should be given to the following:

- ✓ Logistics,
- ✓ Inventory control,
- ✓ Square meters of accommodation,
- ✓ Man-hours estimation,
- ✓ Man-hours availability,
- ✓ Preparation of work,
- ✓ Hangar availability,
- ✓ Environmental conditions (access, lighting standards and cleanliness),
- ✓ Co-ordination with internal and external suppliers, etc.
- ✓ Scheduling of safety-critical tasks during periods when staff are likely to be most alert.

AMC145.A.47 (b) Production planning

Limitations of human performance, in the context of planning safety related tasks, refers to the upper and lower limits, and variations, of certain aspects of human performance (Circadian rhythm / 24 hours body cycle) which personnel should be aware of when planning work and shifts.

145. A.30 Personnel requirements

(d) The organisation shall have a maintenance man-hour plan showing that the organisation has sufficient staff to plan, perform, supervise, inspect and quality monitor the organisation in accordance with the approval. In addition the organisation shall have a procedure to

reassess work intended to be carried out when actual staff availability is less than the planned staffing level for any particular work shift or period.

AMC 145.A.30 (d) Personnel requirements

Has sufficient staff means that the organisation employs or contracts such staff of which at least half the staff that perform maintenance in each workshop, hangar or flight line on any shift should be employed to ensure organisational stability. Contract staff, being part time or full time should be made aware that when working for the organisation they are subjected to compliance with the organisation's procedures specified in the maintenance organisation exposition relevant to their duties. For the purpose of this sub-paragraph, employed means the person is directly employed as an individual by the maintenance organisation approved under Part-145 whereas contracted means the person is by another organisation and contracted by that organisation to the maintenance organisation approved under Part-145.

The maintenance man-hour plan should take into account any maintenance carried out on aircraft / aircraft components from outside the Member State and should also take into account all work carried out outside the scope of the Part-145 approval.

The maintenance man-hour plan should relate to the anticipated maintenance work load except that when the organisation cannot predict such workload, due to the short term nature of its contracts, then such plan should be based upon the minimum maintenance workload needed for commercial viability. Maintenance work load includes all necessary work such as, but not limited to, planning, maintenance record checks, production of worksheets/cards in paper or electronic form, accomplishment of maintenance, inspection and the completion of maintenance records.

In the case of aircraft base maintenance, the maintenance man-hour plan should relate to the aircraft hangar visit plan as specified in AMC 145.A.25 (a).

In the case of aircraft component maintenance, the maintenance man-hour plan should relate to the aircraft component planned maintenance as specified in 145.A.25(a)(2).

The quality monitoring compliance function man-hours should be sufficient to meet the requirement of 145.A.65(c) which means taking into account AMC 145.A.65(c). Where quality monitoring staff perform other functions, the time allocated to such functions needs to be taken into account in determining quality monitoring staff numbers.

The maintenance man-hour plan should be reviewed at least every 3 months and updated when necessary.

Significant deviation from the maintenance man-hour plan should be reported through the departmental manager to the quality manager and the accountable manager for review. Significant deviation means more than a 25% shortfall in available man-hours during a calendar month for any one of the functions specified in 145.A.30 (d).

APPENDIX C

MAIN WEB-APPLICATION SOURCE CODE FILES DEVELOPED SO FAR [*PHP* AND *MYSQL* SCRIPT LANGUAGES]

Many code programming files were created. Each file has a unique name. All these files need to be stored at the corresponding folder where all code programming files are kept. Using XAAMP, the folder address should be something like this: C:\xampp\htdocs. All these files were created and tested in *localhost* server, using XAAMP application. Besides these files, a database must be created in *localhost* server. This can be achieved through a file called *sofinare.sql* , which was created with the help of Workbench. This file is provided in the CD.

All the programming source code created so far is available on the CD with further instructions.

OPEN_WO_FORM.PHP

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<?php include "functions.php" ?>

<?php ligarBD(); ?>

<head>

<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">

<title>Open Work Order</title>


<link rel="stylesheet" type="text/css" href="view.css" media="all">

<script type="text/javascript" src="view.js"></script>

<script type="text/javascript" src="calendar.js"></script>

</head>

<body id="main_body" >
```

```
<img id="top" src="top.png" alt="">
<div id="form_container">

<h1><a>Sofinare Working Order</a></h1>

<!---------------------------------- FORM com method=POST ---------------------------------------->
<form id="form_sofinare" class="appnitro" method="post" action="open_wo_form_cont.php">
<div class="form_description">
<h2>Sofinare Work Order</h2>
<p>Fill in the form below for Sofinare Work order</p>
</div>
<ul>
<!-----An unordered list starts with the <ul>tag.Each list item starts with the <li> tag--------->
<li id="li_1" >
<label class="description" for="order_number">Work Order Number </label>
<?php
$wo_set = get_all_wo();
$wo_count = mysql_num_rows($wo_set);

if( $wo_count == 0){
$wo_number = 1;

}else{
```

```
                                $query = "SELECT * FROM work_orders ORDER BY id_wo
DESC LIMIT 1";

                                $last_order_set = mysql_query($query);

                                $last_order = mysql_fetch_array($last_order_set);

                                $wo_number = $last_order["wo_number"] + 1;

                                }

        ?>

        <div>

                <input id="wo_number" name="wo_number" class="element text small"
type="text" maxlength="9" value="<?php echo ($wo_number); ?>"/>


        </div><p class="guidelines" id="guide_1"><small>Please, enter Work Order
number without year number.</small></p>

        </li>


        <li class="section_break">

<!--    <h3>-----------Section break------------------</h3>                    -->

                <p></p>

        </li>


        <li id="li_2" >

        <label class="description" for="order_year">Order year </label>


        <?php           $year = date("y");

                                //echo $year."<br/>";

        ?>
```

```
<div>

<input id="order_year" name="order_year" class="element text small" type="text" maxlength="2" value="<?php echo $year; ?>"/>

</div><p class="guidelines" id="guide_2"><small>If 2012, then it's 12</small></p>

</li>

<li id="li_3" >

<label class="description" for="requisition">Requisition number </label>

<div>

<input id="requisition" name="requisition" class="element text small" type="text" maxlength="20" value=""/>

</div>

</li>

<!----------------------------------------------------------------------------------------------------->

<li id="li_4" >

<label class="description" for="customer_id">Customer </label>

<div>


<?php

$customer_set = get_all_customers();

$menu='<select name="customer">';

//$menu .='<option value="" selected="selected"></option>';

while($customer = mysql_fetch_array($customer_set)){

$menu .='<option value="' .$customer['customer_id']. '">' .$customer['name'].'</option>';

};
```

```
        $menu .= '</select>';

        echo $menu;

?>

        </div><p class="guidelines" id="guide_4"><small>Vai buscar lista de clientes à DB.</small></p>

        </li>

<!------------------------------------------------------------------------------------------------------------>


        <br>

                <div align="center"><input type ="submit" name="submit" value="CONTINUE" /></div>

        </form>

<!------------------------------------------------------------------------------------------------------------>

        <br />

                <a href="staff_new_order.php">Back</a>

<?php

//        5. Close connection

        mysql_close();

?>

</body>
```

OPEN_WO_FORM_CONT.PHP

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<?php require_once("functions.php"); ?>

<?php ligarBD() ?>

<head>

<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">

<title>Sofinare Work Order Form</title>

<link rel="stylesheet" type="text/css" href="view.css" media="all">

<script type="text/javascript" src="view.js"></script>

<script type="text/javascript" src="calendar.js"></script>

</head>

<body id="main_body" >

        <img id="top" src="top.png" alt="">

        <div id="form_container">

        <h1><a>Sofinare Work Order</a></h1>

<!------------------------------------------------------------------------------------------------------------------>

<?php

        $order_number = $_POST['wo_number'];

        $order_year = $_POST['order_year'];

        $requisition = $_POST['requisition'];

        $customer= $_POST['customer'];

        $query = "INSERT INTO work_orders(

        wo_number, wo_year, requisition, customer_id) VALUES (

                '{$order_number}', {$order_year}, '{$requisition}', {$customer}

                        )";

        //faltava a seguinte linha de código, pq estava a deixar de dar.
```

```
                mysql_query($query);
?>
<!-------------------------------------------------------------------------------------------------------------->
        <form id="form_sofinare" class="appnitro"  method="post" action="create_wo.php">
                <div class="form_description">
                <h2>Sofinare Work Order</h2>
                <p>CONTINUE to Fill in the form below for Sofinare order</p>
                </div>
        <ul>

        <li id="line1" >
                <label class="description" for="airplane_registration">Airplane registration </label>
                <div>
        <!--tenho que tirar isto para passar as matriculas para dentro da caixa....
        <select class="element select small" id="airplane_registration" name="airplane_registration"> -->
        <?php
//$sel_customer = get_customer_by_id($customer_id);
        $registration_set = get_registrations_for_customer($customer);
        $menu_reg='<select name="registration">';
        //$menu .='<option value="" selected="selected"></option>';
        while($registration = mysql_fetch_array($registration_set)){
        $menu_reg .= '<option value="" .$registration['registration_id']. '">' .$registration['registration'].'</option>';
        };
        $menu_reg .= '</select>';
```

```
echo $menu_reg;

?>

</div><p class="guidelines" id="guide_5"><small>These are the aircraft registrations of the previously selected customer. Please, choose the corresponding aircraft registration for this work order.</small></p>

                </li>

                <li id="line2" >

                <label class="description" for="element_2">Anomaly </label>

                <div>

                        <textarea id="element_2" name="anomaly" class="element textarea small"></textarea>

                </div>

                </li>

<!------------------------------------------------------------------------------------------------------------>

                <li id="line3" >

                <label class="description" for="element_3">Opening date </label>

                <?php

                                $today = date("d-m-Y");                 // d-m-y=25-09-12

                                //echo $today."<br/>";

                ?>

                <div>

        <input type="text" name="opening_date" size="20" value="<?php echo $today; ?>" /> *

                </div>

                </li>


<!------------------------------------------------------------------------------------------------------------>

                <li id="li_4" >
```

```
<label class="description" for="element_4">Opened by </label>
<div>
<?php
$technicians_set = get_all_technicians();
$menu_types = '<select name="opener">';
while($technician = mysql_fetch_array($technicians_set)){
$menu_types .='<option value="' .$technician['id_technician']. '" >'
.$technician['technician'].'</option>';
};
$menu_types .='</select>';
echo $menu_types;
?>
</div>
</li>
<li id="line5" >
<label class="description" for="element_5">Scope of Work</label>
<div>
<input type="radio" name="scope" value="aircraft"/> Aircraft
 
<input type="radio" name="scope" value="component"/> Aicraft component
 
<input type="radio" name="scope" value="other"/> Other
</div>
</li>
<!----------------------------------------------------------------------------------------------------->
```

```
                <li class="buttons">
                        <input type="hidden" name="form_id" value="356210" />

                                <input id="saveForm" class="button_text" type="submit"
name="submit" value="Submit" />
                </li>
        </ul>
        </form>
                <div id="footer">
                        Generated by <a href="www.sofinare.com">dAnIeL</a>
                </div>
        </div>
        <img id="bottom" src="bottom.png" alt="">
        </body>
</html>
```

CREATE_WO.PHP

```
<?php require_once("functions.php"); ?>
<?php
        ligarBD();
        $errors = array();
        //empty array
?>
<?php
        //Form Validation
        $required_fields = array('registration', 'anomaly', 'opening_date', 'opener');
        foreach($required_fields as $fieldname){
```

```
            if(!isset($_POST[$fieldname]) || empty($_POST[$fieldname])){
            //if we do have an error, then:
            $errors[]=$fieldname;
            //in the end of the array the last error: usar []
            }
        }
        if(!empty($errors)) {
            header("Location: open_wo_form_cont.php");
            exit;
        }
?>
<?php
        $registration = ($_POST['registration']);
        $anomaly = ($_POST['anomaly']);
        $opening_date= ($_POST['opening_date']);
        $opener= ($_POST['opener']);
        $scope = ($_POST['scope']);
            $opening_date = converte_data_mysql($opening_date);
            $query = "SELECT * FROM work_orders ORDER BY id_wo DESC LIMIT 1";
            $last_order_set = mysql_query($query);
            $last_order = mysql_fetch_array($last_order_set);
            $id = $last_order["id_wo"];
?>
<?php

        $query = "UPDATE work_orders SET
```

```
        registration_id = {$registration},

        anomaly = '{$anomaly}',

opening_date = '$opening_date',

        id_technician = $opener,

scope = '$scope',

status = 1

WHERE id_wo = $id"; //no fim de criada a obra dizer que o status dela é realmente aberta

//acima tinha $opening_date entre chavetas, era por isso que nao guardava a data na db corretamente...

                                        //tirei as chavetas e pus single quotes (como está no exemplo da formabase)

                                $result=mysql_query($query);

                                //test if the update succeeded or not

                                if(mysql_affected_rows() == 1){

                                        //Success

                                        header("Location: index.php");

                                }else {

                                        //Failed

                                        echo "<p>Work Order creation failed.</p>";

                                        echo "<p>" . mysql_error() . "</p>";

                                                //to see what the error was and why it didn't succeed

                                                //should succeed unless there's a problem with the db

                                }

?>

<?php mysql_close(); ?>
```

FUNCTIONS.PHP

```
<?php require_once("functions.php"); ?>


<?php
	ligarBD();
	$errors = array();
	//empty array
?>
<?php
	//Form Validation
	$required_fields = array('registration', 'anomaly', 'opening_date', 'opener');
	foreach($required_fields as $fieldname){
		if(!isset($_POST[$fieldname]) || empty($_POST[$fieldname])){
		//if we do have an error, then:
		$errors[]=$fieldname;
		//in the end of the array the last error: usar []
		}
	}

	if(!empty($errors)) {
		header("Location: open_wo_form_cont.php");
		exit;
	}

?>
<?php
```

```
$registration = ($_POST['registration']);

$anomaly = ($_POST['anomaly']);

$opening_date= ($_POST['opening_date']);

$opener= ($_POST['opener']);

$scope = ($_POST['scope']);


$opening_date = converte_data_mysql($opening_date);


        $query = "SELECT * FROM work_orders ORDER BY id_wo DESC LIMIT 1";

        $last_order_set = mysql_query($query);

        $last_order = mysql_fetch_array($last_order_set);

        $id = $last_order["id_wo"];
?>

<?php

        $query = "UPDATE work_orders SET

        registration_id = {$registration},

        anomaly = '{$anomaly}',

        opening_date = '$opening_date',

        id_technician = $opener,

        scope = '$scope',

        status = 1

        WHERE id_wo = $id"; //no fim de criada a obra dizer que o status dela é realmente aberta

//acima tinha $opening_date entre chavetas, era por isso que nao guardava a data na db corretamente...
```

```
            $result=mysql_query($query);
            //test if the update succeeded or not
            if(mysql_affected_rows() == 1){
            //Success
            header("Location: index.php");

        }else {
            //Failed
            echo "<p>Work Order creation failed.</p>";
            echo "<p>" . mysql_error() . "</p>";
            //to see what the error was and why it didn't succeed
            //should succeed unless there's a problem with the db
        }
?>
<?php mysql_close(); ?>
```

CLOSE_WO_FORM.PHP

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<?php include "functions.php" ?>
<?php ligarBD(); ?>
<?php

if($_GET["id"]!=""){
        $id = $_GET["id"];
}
if($_POST){
```

```
$id = $_POST["id"];                    //nao esquecer passar id
$pn = $_POST['PN'];
$sn = $_POST['SN'];
$equipment= $_POST['equipment'];
$category = $_POST['category'];
if($category==0){
//caso nao se trate de nenhuma categoria
        $category=0;
}
$manufacturer = $_POST['manufacturer'];
$model = $_POST['model'];
$n_items = $_POST['n_items'];

if($id==""){

        echo "falta id";
}

else{
        $query ="UPDATE work_orders SET
                        PN ='$pn',
                        SN ='$sn',
                        equipment = '$equipment',
                        category = {$category},
                        manufacturer ='{$manufacturer}' ,
```

```
                        model='$model',
                        n_items = $n_items
                        WHERE id_wo = $id";
        }

        if(mysql_query($query)){
                //sucess!
                header("Location:
close_wo_form_cont.php?id_wo=$id&category=$category&n_items=$n_items");
                exit;
        }
        else{
                //display error message.
                echo "<p>Closing work order failed. </p>";
                echo "<p>" . mysql_error() . "</p>";
        }
}
?>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
<title>Closing Work Order</title>
<link rel="stylesheet" type="text/css" href="view.css" media="all">
</head>
<body id="main_body" >

        <img id="top" src="top.png" alt="">
```

```
<div id="form_container">

<h1><a>Closing Working Order</a></h1>

        <form method="post" class="appnitro" action="close_wo_form.php">

        <!--class="appnitro" ficar melhor formatado, centrado-->


        <div class="form_description">

        <h2>Closing Sofinare Work Order</h2>

        <p>Fill in the form below for closing Sofinare Work Order</p>

        </div>

<ul>

<li id="line1" >

        <label class="description" for="element_1">Part Number: </label>

        <div>

                <input type="text" name="PN" value="<?php //echo $sel_page['menu_name']; ?>" id="PN" /></p>

        </div>

</li>

<li id="line2" >

        <label class="description" for="element_2">Serial Number: </label>

        <div>

                <input type="text" name="SN" value="<?php //echo $sel_page['menu_name']; ?>" id="SN" /></p>

        </div>

</li>

<li id="line_equi" >

        <label class="description" for="element_equi">Type of Equipment: </label>
```

```
<div>
<input type="text" name="equipment" value="<?php //echo $sel_page['menu_name']; ?>" id="equipment" /></p>
</div>
</li>

<li id="line3" >
<label class="description" for="element_3">Category </label>
<span>
<input type="radio" name="category" value="9" />C2 Auto Flight
 
<input type="radio" name="category" value="10" />C3 Comms and Nav
 
<input type="radio" name="category" value="0" />Not Applicable
 
</span>
</li>
<li id="line4" >
<label class="description" for="element_4">Component Manufacturer: </label>
<div>
<input type="text" name="manufacturer" value="<?php //echo $sel_page['menu_name']; ?>" id="manufacturer" /></p>
</div>
</li>
<li id="line5" >
<label class="description" for="element_5">Component Model: </label>
```

```
                <div>
                        <input type="text" name="model" value="<?php //echo
$sel_page['menu_name']; ?>" id="model" /></p>
                </div>
        </li>

        <li id="line6" >
                <label class="description" for="element_6">Number of Items:</label>
                <div>
                        <select name="n_items">
                <?php
                        for($count=0; $count <= 10; $count++) {
                                echo "<option value=\"{$count}\"";
                                //if($sel_subject['position']==$count){ echo " selected"; }
                                echo ">{$count}</option>";
                }
                ?>
        </select></p>
        </div>
        </li>
</ul>
        <ul>
                <li class="section_break">
                        <p></p>
                </li>
        <br>
```

```
                    <!--Passar valor do id da wo por hidden-->
        <div align="center"><input type="hidden" value="<?php echo $id; ?>" name="id" />
        <input type ="submit" name="submit" value="CONTINUE" /></div>

</form>

        <br />
                    <a href="staff_new_order.php">Cancel</a>
<?php
        mysql_close();
?>
</body>
```

CLOSE_WO_FORM_CONT.PHP

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<?php include "functions.php" ?>
<?php ligarBD(); ?>
<?php
if($_GET["id_wo"]!=""){
                    $id_wo = $_GET["id_wo"];
                    $category = $_GET["category"];
                    $n_items = $_GET["n_items"];
}
if(isset($_POST["id_wo"]) && isset ($_POST["wo_technicians"])){
```

```
$id_wo = $_POST["id_wo"];
$wo_technicians = $_POST["wo_technicians"];
$work = $_POST["work"];                    //texto de trabalhos efetuados
        $num_wo_technicians = count($wo_technicians);
        echo("$num_wo_technicians");
        echo("WO id numero: $id_wo<br/>");
        echo("First Technician $wo_technicians[0]");
        for($i=1; $i<=$num_wo_technicians; $i++){
                $id_technician = $wo_technicians[$i-1];
                        $SQL = "INSERT INTO wo_technicians
                                        (id_wo, id_technician)
                                        VALUES
                                        ($id_wo, $id_technician)";

                mysql_query($SQL) or die(mysql_error());
                        $flag=1;
        }
        if(isset($flag)){ //se nao der erro ao gravar em wo_technicians
                        $query = "UPDATE work_orders SET
                                                work ='{$work}'
                                                WHERE id_wo = {$id_wo}";
                                mysql_query($query) or die(mysql_error());
                        header("Location:
close_wo_form_handlabour.php?id_wo=$id_wo&num_wo_technicians=$num_wo_technicians");
                        //para passsar valores para outro form so dara por ?
(com get no form sguinte) ou por session
                        exit;
```

```
                }
                else{
                        //display error message.
                        echo "<p>Closing work order failed. </p>";
                        echo "<p>" . mysql_error() . "</p>";
                }
}
?>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
<title>Closing Work Order</title>
<link rel="stylesheet" type="text/css" href="view.css" media="all">
</head>
<body id="main_body" >
<img id="top" src="top.png" alt="">
<div id="form_container">
<h1><a>Closing Working Order</a></h1>
<form method="post" class="appnitro" action="close_wo_form_cont.php">
<!--class="appnitro" ficar melhor formatado, centrado-->
<div class="form_description">
<h2>Closing Sofinare Work Order (continue)</h2>
<p>Continue to Fill in the form below for closing Sofinare Work Order <?php //echo "$id_wo"?> </p>
</div>
<ul>
<li id="line1" >
```

```
<label class="description" for="element_1">Technicians Certified for this Work: </label>
<br/>
<?php

        if($category==0){       //caso nao se trate de nenhuma categoria
                $category=0;
                $technicians_set=get_all_technicians();
        }else{                  //caso haja categoria, escolher apenas tecnicos com rating
                $id_category = $category;
                $technicians_set=get_technicians_for_category($id_category);
        }
                while($technician=mysql_fetch_array($technicians_set)){
                //imprimir cada tecnico:  com checkbox
?>
<input type="checkbox" name="wo_technicians[]" value= "<?php echo $technician["id_technician"] ?>"/><?php echo $technician["technician"] ?> <br/><br/>
<?php
}
?>
</li>
<br/>
<li class="section_break">
<p></p>
</li>
<?php
        if($n_items!=0){
```

```
?>
<li id="line_n_items" >
<label class="description" for="element_items">NEW ITEMS APPLIED:</label>
<div>
        <table align="center" class="lista" width="100%" cellspacing="0" cellpadding="5">

                <tr>
                        <th>Item</th>
                        <th>          PN</th>
                        <th>   Description</th>
                        <th>  Qty</th>
                        <th>Cost</th>
                        <th>Comments</th>
                        <th width="80"> </th>
                </tr>
<?php
        $i = 1;
        while ($i <= $n_items ):
?>
                <tr>
                <td class="item" align="center"><?php echo ($i);?></td>
                <td class="item" align="center">  <input name="item_pn[]" size= "16" type=text></td>
                <td class="item" align="center">  <input name="item_description[]" size= "13" type=text></td>
                <td class="item" align="center">  <input name="item_qty[]" size= "3" type=text></td>
```

```
                <td class="item" align="center">    <input name="item_cost[]" size= "4" type=text></td>

                <td class="item" align="center">  <input name="item_oomments[]" size= "20" type=text></td>

                </tr>


<?php

        ++$i;

        endwhile;

?>

</table>

<br/>

</div>

</li>

<?php

        }

        else{

                echo "<h5>No new items appplied.</h5>";

        }

?>

<li id="line_work_carried_out" >

<div>

        <label class="description" for="element_work_carried_out">Work carried out: </label>

        <!--    <p>Work carried out:<br/>                -->

                <textarea name="work" rows="8" cols="63"><?php //echo ;?></textarea>

        <!--    </p>    -->
```

```
</div>

</li>

</ul>

<ul>


<li class="section_break">

<p></p>

</li>

<br>

<div align="center"><input type="hidden" value="<?php echo $id_wo; ?>" name="id_wo" />

<input type ="submit" name="submit" value="CONTINUE" /></div>

</form>

<br />

<a href="staff_new_order.php">Cancel</a>

<?php

//        5. Close connection

          mysql_close();

?>

</body>
```

CLOSE_WO_FORM_HANDLABOUR.PHP

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<?php include "functions.php" ?>

<?php ligarBD(); ?>

<?php
```

```
if($_GET["id_wo"]!=""){

                $id_wo = $_GET["id_wo"];

                $num_wo_technicians=$_GET["num_wo_technicians"];

}


if(isset($_POST["id_wo"]) && isset ($_POST["submit"])){

                $id_wo = $_POST["id_wo"];

                $hours_array=$_POST["hours"];

                /*calculo do tempo total em horas gasto na obra*/

                $minutes_array=$_POST["minutes"];

                $total_hours=array_sum($hours_array);

                        echo("Soma dos numeros das caixas horas = $total_hours<br/>");
//check if it is correct. Yes!

                foreach ($minutes_array as $value) {

                        $minutes_in_hours[] = $value * (1/60);

                }

                $total_minutes_in_hours=array_sum($minutes_in_hours);

                $total_hand_labour = $total_hours+$total_minutes_in_hours;


                                        echo("Total handlabour: $total_hand_labour");

                                                $SQL = "UPDATE work_orders SET

                                                total_hours ={$total_hand_labour}

                                                WHERE id_wo = {$id_wo}";
```

```
                                        mysql_query($SQL) or die(mysql_error());

                                        header("Location:
close_wo_form_invoice.php?id_wo=$id_wo");

                                        //para passsar valores para outro form so dara por ?
(com get no form sguinte) ou por session

                                        exit;

}

?>

<head>

<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">

<title>Closing Work Order</title>

<link rel="stylesheet" type="text/css" href="view.css" media="all">

</head>

<body id="main_body" >

<img id="top" src="top.png" alt="">

<div id="form_container">

<h1><a>Closing Working Order</a></h1>

<form method="post" class="appnitro" action="close_wo_form_handlabour.php">

<div class="form_description">

<h2>Closing Sofinare Work Order (continue)</h2>

<p>Continue to Fill in the form below for closing Sofinare Work Order <?php //echo
"$id_wo"?> </p>

</div>

<ul>

<li id="line_handlabour" >

<label class="description" for="element_handlabour">HAND LABOUR:</label>

<p>Man Hours Control<br/>
```

```
<div>
<table align="right" class="lista" width="100%" cellspacing="0" cellpadding="5">
		<tr>
			<th>Technician</th>
			<th>  Hours</th>
			<th>   Minutes</th>

			<th width="80"> </th>
		</tr>
<?php
		$wo_technicians_set=get_technicians_for_work_order($id_wo);
		while($technician = mysql_fetch_array($wo_technicians_set)){
?>
		<tr>
			<td class="item" align="center"><?php echo $technician["technician"]
;?></td>
			<td class="item" align="center">  <input name="hours[]" size= "2"
type=text></td>
			<td class="item" align="center">  <input name="minutes[]" size= "2"
type=text></td>
		</tr>
<?php
		}
?>
</table>
</div>
</li>
```

```
<li class="section_break">

<p></p>

</li>
```

Next, total hours will be automatically calculated and printed in the next form for invoice issues.

```
</ul>

<ul>

<li class="section_break">

<p></p>

</li>

<br>

<div align="center"><input type="hidden" value="<?php echo $id_wo; ?>" name="id_wo" />

<input type ="submit" name="submit" value="CONTINUE" /></div>

</form>

<br />

<a href="staff_new_order.php">Cancel</a>

<?php

        mysql_close();

?>

</body>
```

CLOSE_WO_FORM_INVOICE.PHP

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<?php include "functions.php" ?>

<?php ligarBD(); ?>
```

```
<?php
if($_GET["id_wo"]!=""){
                $id_wo = $_GET["id_wo"];
}
if(isset($_POST['submit'])){
                $id_wo = $_POST["id_wo"];
                $total_hours = $_POST["total_hours"];
                $material = $_POST["material"];
                $invoice_number=$_POST["invoice_number"];
                $invoice_value=$_POST["invoice_value"];
                $pro_form=$_POST["pro_form"];
                $adress=$_POST["adress"];
                $phone=$_POST["phone"];
                $closing_date=$_POST["closing_date"];
                $closed_by=$_POST["closed_by"];
                $closing_date=converte_data_mysql($closing_date);
                $query = "UPDATE work_orders SET
                                                status=0,
                                                total_hours = {$total_hours},
                                                material_costs ={$material},
                                                invoice_number ='{$invoice_number}',
                                                invoice_value ={$invoice_value},
                                                pro_form = '{$pro_form}',
                                                adress = '{$adress}',
                                                phone_number = '{$phone}',
                                                closing_date = '{$closing_date}',
```

```
                                        closed_by = {$closed_by}
                                WHERE id_wo = $id_wo"; //we need to tell what to
update
                                $result=mysql_query($query);
                                //test if the update succeeded or not
                                if(mysql_affected_rows() == 1){
                                        //Success
                                        header("Location: index.php");
                                        exit;
                                }else {
                                        //Failed
                                        echo "<p>Work Order closing failed.</p>";
                                        echo "<p>" . mysql_error() . "</p>";
                                                //to see what the error was and why it
didn't succeed
                                                //should succeed unless there's a
problem with the db
                                }
}
?>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
<title>Closing Work Order</title>
<link rel="stylesheet" type="text/css" href="view.css" media="all">
</head>
<body id="main_body" >
<img id="top" src="top.png" alt="">
```

```
<div id="form_container">

<h1><a>Closing Working Order</a></h1>

<form method="post" class="appnitro" action="close_wo_form_invoice.php">

<div class="form_description">

<h2>Closing Sofinare Work Order (continue)</h2>

<p>Continue to Fill in the form below for closing Sofinare Work Order. <?php  echo "Finally, this is the last one :)"?> </p>

</div>

<ul>

<li id="li_total_hours" >

<label class="description" for="total_hours">Total Hand Labour charged:</label>

        <?php

                $query = "SELECT customers.*, work_orders.id_wo, work_orders.customer_id, work_orders.total_hours

                        FROM customers, work_orders

                        WHERE work_orders.customer_id=customers.customer_id

                        AND id_wo={$id_wo}";

                $result = mysql_query($query);

                if($result === FALSE) {  //se der erro quero que me diga o que é.

                        die(mysql_error());

                }

                $work_order = mysql_fetch_array($result);

                $total_hand_labour = $work_order["total_hours"];

        ?>

<div>
```

<input id="total_hours" name="total_hours" class="element text small" type="text" maxlength="6" value="<?php echo ($total_hand_labour); ?>"/>

<small>Here is inserted the total hand labour charged. Check total hand labour calculated.</small>

<li id="li_2" >

<label class="description" for="material">Material (Total material costs charged):</label>

<input id="material" name="material" class="element text small" type="text" maxlength="6" value=""/>

<small>Please, insert here total material applied costs.</small>

<li id="li_3" >

<label class="description" for="invoice_number">Invoice number </label>

<input id="invoice_number" name="invoice_number" class="element text small" type="text" maxlength="10" value=""/>

<li id="li_4" >

<label class="description" for="invoice_value">Invoice value </label>

<input id="invoice_value" name="invoice_value" class="element text small" type="text" maxlength="8" value=""/>


```
<li id="li_5" >

<label class="description" for="pro_form">Pro form N. </label>

<div>

<input id="pro_form" name="pro_form" class="element text small" type="text" maxlength="8" value=""/>

</div>

</li>

<li class="section_break">

<p></p>

</li>

<li id="li_adress" >

<label class="description" for="adress">Customer's Adress:</label>

                <?php

                                $adress = $work_order["adress"];

                ?>

<div>

        <textarea name="adress" rows="2" cols="63"><?php echo("$adress") ;?></textarea>

</div><p class="guidelines" id="guide_adress"><small>Check customer's adress.</small></p>

</li>

<li id="li_phone" >

<label class="description" for="phone">Customer's Phone Number:</label>

                <?php

                                $phone1 = $work_order["phone1"];

                ?>

<div>
```

```
<input id="phone" name="phone" class="element text small" type="text" maxlength="11" value="<?php echo "$phone1"; ?>"/>

</div><p class="guidelines" id="guide_phone"><small>Check customer's phone number.</small></p>

</li>

<li id="line_closing_date" >

<label class="description" for="element_3">Closing date </label>

<?php

                $today = date("d-m-Y");                    // d-m-y=25-09-12

?>

<div>

<input type="text" name="closing_date" size="20" value="<?php echo $today; ?>" />

</div><p class="guidelines" id="guide_phone"><small>Today's date automatically displayed.</small></p>

</li>

<li id="li_5" >

<label class="description" for="element_5">Closed by </label>

<div>

<?php

$technicians_set = get_all_technicians();

$menu_types = '<select name="closed_by">';

while($technician = mysql_fetch_array($technicians_set)){

$menu_types .='<option value="' .$technician['id_technician']. '" >'

.$technician['technician'].'</option>';

};

$menu_types .='</select>';

echo $menu_types;
```

```
        ?>
</div>
</li>
<li class="section_break">
<p></p>
</li>
Thank you!
</ul>
<li class="section_break">
</li>
<br>
<div align="center"><input type="hidden" value="<?php echo $id_wo; ?>" name="id_wo" />
<input type ="submit" name="submit" value="FINISH!" /></div>
<a href="wo_list.php">Cancel</a>
</form>
</body>
<img id="bottom" src="bottom.png" alt="">
</body>
<?php mysql_close(); ?>
</html>
```