Airlines Maintenance Management System

Phase I: Maintenance Planning System

System Requirements Specification

Version 1.3

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Table of Contents

Figures Index

Index of Tables

List of Revised Pages

Revision	Title	Subtitle	Pages
1.1	Figure Index		3-3
1.1	Table Index		4-4
1.2	1. General Background		6-6
1.3	5.2 Use Cases	5.2.1 User Login Use Cases	7-7
1.3	5.2 Use Cases	5.2.2 Planner Use Cases	9-9
1.3	5.2 Use Cases	5.2.3 Technician Use Cases	11-11
1.3	5.2 Use Cases	5.2.4 Inspector Use Cases	13-13
1.3	5.2 Use Cases	5.2.5 Management/Authority Use Cases	15-15
1.3	5.3 Non-Functional Req	5.3.10 Normalization Analysis	20-21

1 General Background:

Automated Civil Aviation Maintenance Systems (ACAMS) can ease the maintenance process profoundly and can also mitigate the chances of disasters occurrence. On one hand it can eliminate the paper work and the human effort to file and organize it and by that it saves valuable resources and more valuable time. On the other hand it might protect the system from the human factor errors.

A complicated system as the civil aviation maintenance system with all its requirements, records and supervision would get much more easier when utilizing a computer system to manage it. Benefits from utilizing such a system can be briefed in[1]:

- Optimization of maintenance processes:
  - Possibility to exhaust maintenance limits to its full due to accurate calculations
  - Careful planning of all maintenance events including manpower/material
  - Scheduling of maintenance activities against the flight schedule
  - Analysis of trends of components/airframe) = pro-active maintenance rather than reactive
  - Additional functions for multi-operator contexts
  - Workflow settings allow the automation of maintenance processes
- Cost Reduction
  - Avoidance of AOG due to careful planning of required material availability
  - Reduced inventory due to optimization of consumables' / rotables' stock levels
  - Identification of surplus material
  - Comprehensive warranty tool to optimize cost recovery
  - Customers will benefit from enhanced Cost Control functions (new Quotation Manager, Budget Management etc.)

In addition, the outcomes from utilizing this system will cover other concerns that have always distressed the civil aviation community, that is the human factor errors. A disaster like the notorious accident of Air France FL4590 Concorde accident might have been avoided if the maintenance staff had a rigorous maintenance system to insure not forget about a spacer between the main landing gear wheels[2].

1 http://www.swiss-as.com/modules.do

2 The official report stated that the accident was a result of a metal strip that was on the runway the Concorde used for take off but an investigation held by British 'The Observer" by Davide Rose stated that there might be another reason uncovering the information about that the aircraft came out from a maintenance procedure missing a component in its MLG that might lead to the accident. http://www.theguardian.com/world/2001/may/13/davidrose.focus/print

2 Technical Background

This section is a background about the maintenance work in the commercial civil aviation industry. The following flow chart illustrates the general process.

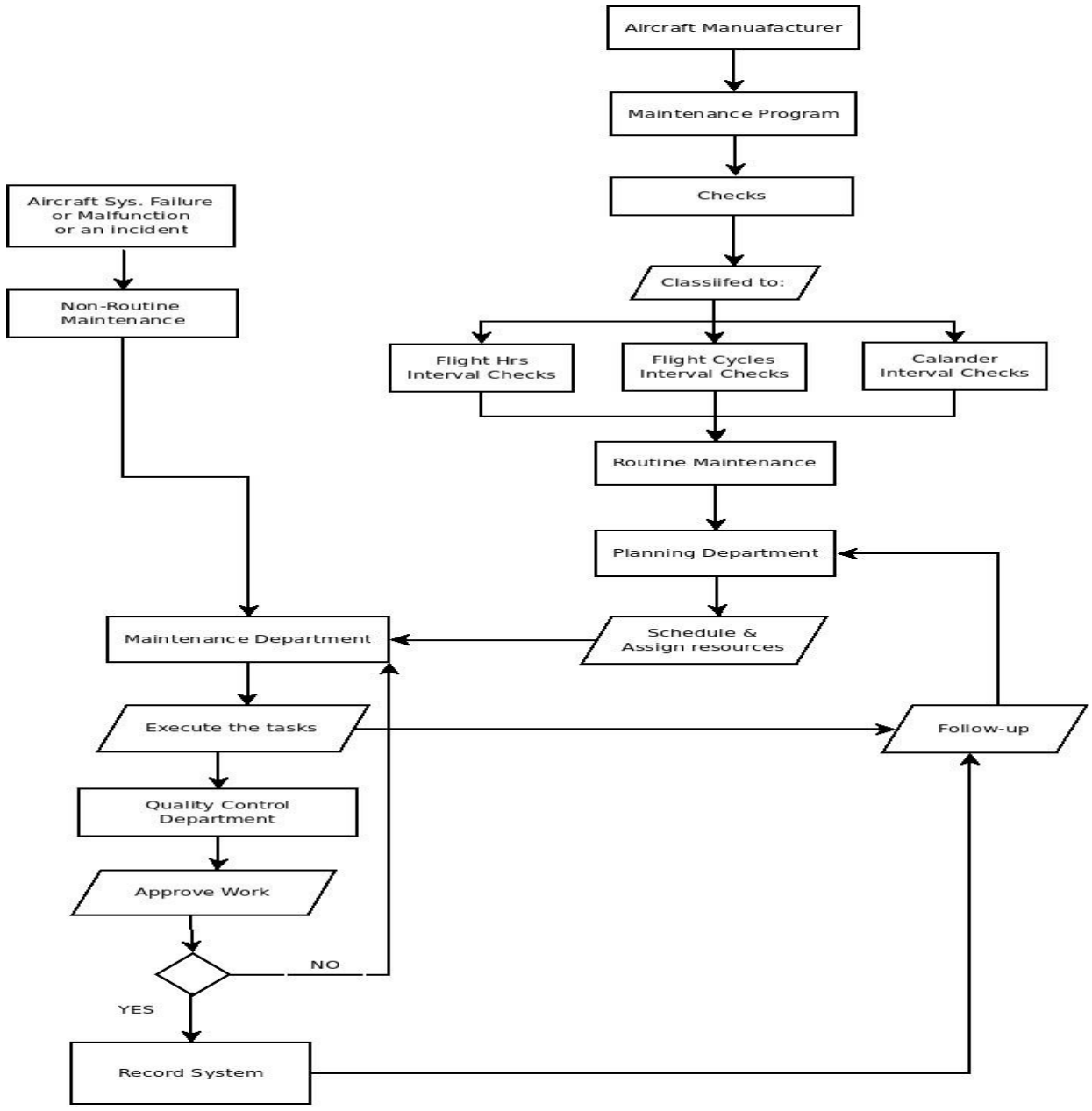

Fig 1: Commercial civil aviation maintenance general process

Maintenance is classified into Routine Maintenance and Non-routine Maintenance.

1 Routine Maintenance

The routine maintenance is about a maintenance schedule or plan the aircraft manufacture plotted for his product. The plan is arranged in certain checks that have certain intervals. The checks intervals can either be:

a) Flight Hours intervals

b) Flight Cycle intervals

c) Calender intervals

The checks are maintenance packages that holds maintenance tasks within. Each task is for dedicated a certain maintenance action (inspection/testing a system or a replacement of a component,...). Maintenance checks are performed by executing the tasks and signing it off.

When a task is signed of by maintenance staff it should be also signed off by the quality control inspectors to assure the quality of work done.

This process is followed-up by the planning department to insure the conformity with the check plan.

The check with its tasks is then recorded.

2 Non-routine Maintenance

When a technical problem is reported by pilots or maintenance staff and it requires some action then the maintenance department responds. It initiates a non-routine work order and handle the maintenance procedures and then closes the work order by signing it of by one of its certificated staff.

When the work order is signed off by the maintenance department it should be approved by the quality control department by signing it off by one of its inspectors. The work order is then recorded.

Some times the maintenance procedure needed to solve the technical problem does not need the aircraft to enter the hanger and it solved on the apron. In such a case the problem and the maintenance action is logged in the technical log book (TLB) of the aircraft but then should be recorded in the record system and signed off by the certificated maintenance staff.

3 Introduction

Although large companies, as Swiss AviationSoftware (http://www.swiss- as.com) with its AMOS application, respond to the market's needs for MRO's which serve huge fleets[3], there is a need for software that offers an alternative for small/medium and growing MRO's with competitive costs.

The Airline Maintenance Management System (ALMMS) gives a solution for a rigorous management to the maintenance processes in the civil aviation field. ALMMS has many aspects to cover as shown in figure 2.

Planning in the civil aviation aircraft maintenance is of great concern because most of the maintenance operations will submit to a very strict maintenance program which the aircraft manufacturer delivers with the aircraft. This maintenance operations are also subject to supervision from authoritarian firms like the civil aviation authorities (CAA) or other audit organizations, such as IATA Operational Safety Audit (IOSA), to assure the conformity with the maintenance program.

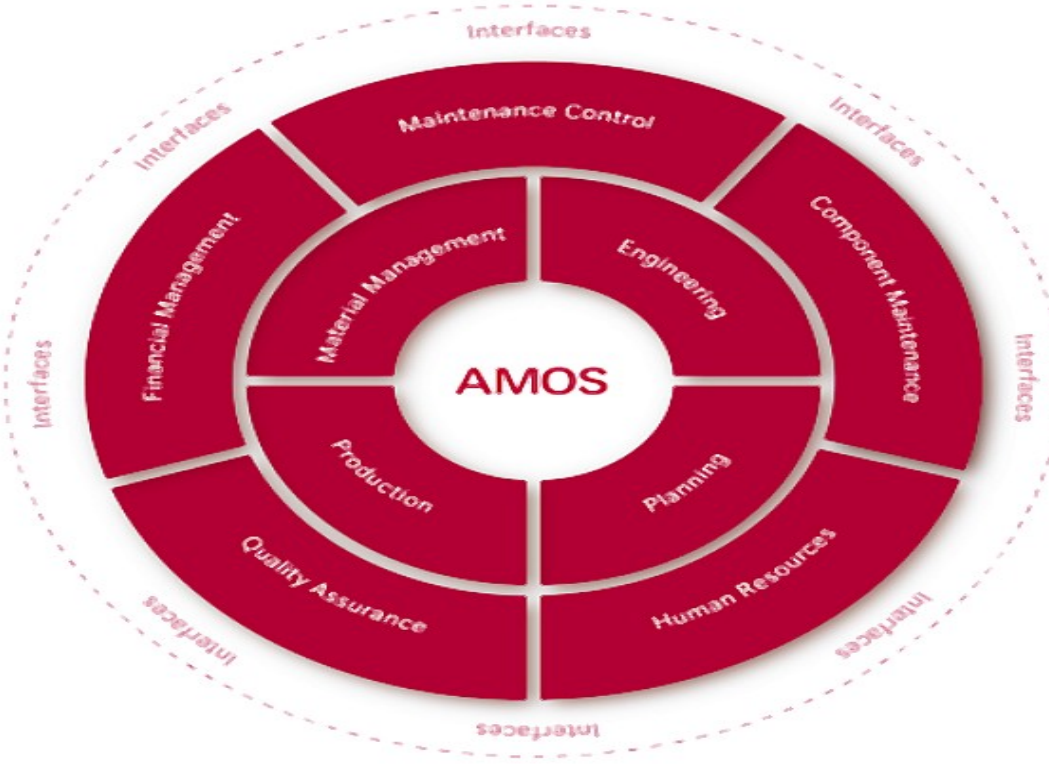

Fig 2: Maintenance Management System Modules[4]

Planning and follow-up of the maintenance operations might be challenging as the maintenance program classify maintenance checks on intervals that counts:

3 AMOS official website also mentions that it serves the growing MRO's.
4 http://www.swiss-as.com/modules.do

1. Flight hours
2. Flight Cycles
3. Calender months

that is beside the on-condition maintenance in which maintenance actions should be taken in case of aircraft systems' failure or malfunction.

Also the time that maintenance operations take is of great concern in the civil aviation industry as the fleet should always be in operations rather than being on-ground to maximize the revenue for the airlines.

3.1 Purpose

This requirements specification document contains complete and accurate information on the ALMMS Phase I: Maintenance Planning System, its features and capabilities. It will outline the functional requirements, non-functional requirements, system-level requirements and operational constraints.

The intended audience of stakeholders includes, but is not limited to:

• Software Engineers

• Software Quality Analysts,

• Project Contractor,

• Technical/Document Writers,

• System Administrators, and

• End Users

3.2 Scope

This project is an attempt to offer an effort to present a solution for aviation Maintenance Repair and Overhaul (MRO) organizations. However, because it is a big system to plan and build, this project will handle the civil aviation maintenance management aspects in the aircraft maintenance planning field as we may call it phase I of the whole ALMMS project.

This system will provide:

1. A record for the maintenance operations on the fleet.
2. An index for the maintenance program schedule for the planners to assign work orders.
3. Access for the maintenance staff to the view maintenance assignments and the option to close it when finished.
4. Access for the maintenance staff to open a non-routine work order and close it when finished.

5. Access for quality control staff to approve the work done.
6. Access for authoritarian firms to check the conformity with manufacturer maintenance program.
7. Access for the airline management to follow-up the fleet on-ground for maintenance operations.

A complete description of the prescription drug monitoring system will be defined; this will include use case diagram(s), dataflow diagram(s), and a list of functional and nonfunctional requirements.

3.3 Definitions, Acronyms, and Abbreviations

- ALMMS – Airline Maintenance Management System
- ACAMS – Automated Civil Aviation Maintenance Management Systems
- MRO – Maintenance, Repair and Overhaul Organizations
- IATA – International Air Transport Association
- IOSA – IATA Operational Safety Audit
- ATA – Air Transport Association
- ATA 100 Chapter numbers – common referencing standard for all commercial aircraft documentation.
- QC – Quality Control
- MSN – Aircraft Manufacturer Serial Number

3.4 References

1. Elmasri,R., Navathe, S.B. 2011. Fundamentals of Database Systems (6th Edition). Addison - Wesley Longman Publishing Co., Inc., Boston, MA, USA.
2. Federal Aviation Regulations, Part 43: Maintenance, Preventive Maintenance, Rebuilding, And Alteration
3. Egyptian Civil Aviation Regulations, Part 43: Maintenance, Preventive Maintenance, Rebuilding, And Alteration

4 System Description

4.1 Product Perspective

The purpose of the system is to allow:

1. **Maintenance planners** to follow-up the maintenance checks that are due for execution and issue work orders for it. This is done by the checking the list of check and decide which checks are due and prepare for them and then issue a work order it the maintenance record system. Also to follow-up the maintenance work processing carried out by the maintenance department to assure that the work is going according to the check plan.
2. **Maintenance Staff** to view the work orders assigned by the maintenance planning department and to close it when its finished. It also allows the maintenance staff to open work orders for the non-routine maintenance and close it when it is finished.
3. **Quality control staff** to sign off the work done by the maintenance staff or reject it and order rework.
4. **The authoritarian firms** and airlines management. to check the work processing and check the maintenance records.

The system will record the maintenance operations as soon as it finish its cycle and signed off by the certified staff.

The system will focus on the planning process from the work to done or actually done on the aircraft and its recording system prospective rather than the planning for the work process prospective (i.e. the time allocation for the process, human resources allocation, tools, materials, parts and equipments allocation).

4.2 Product Functions

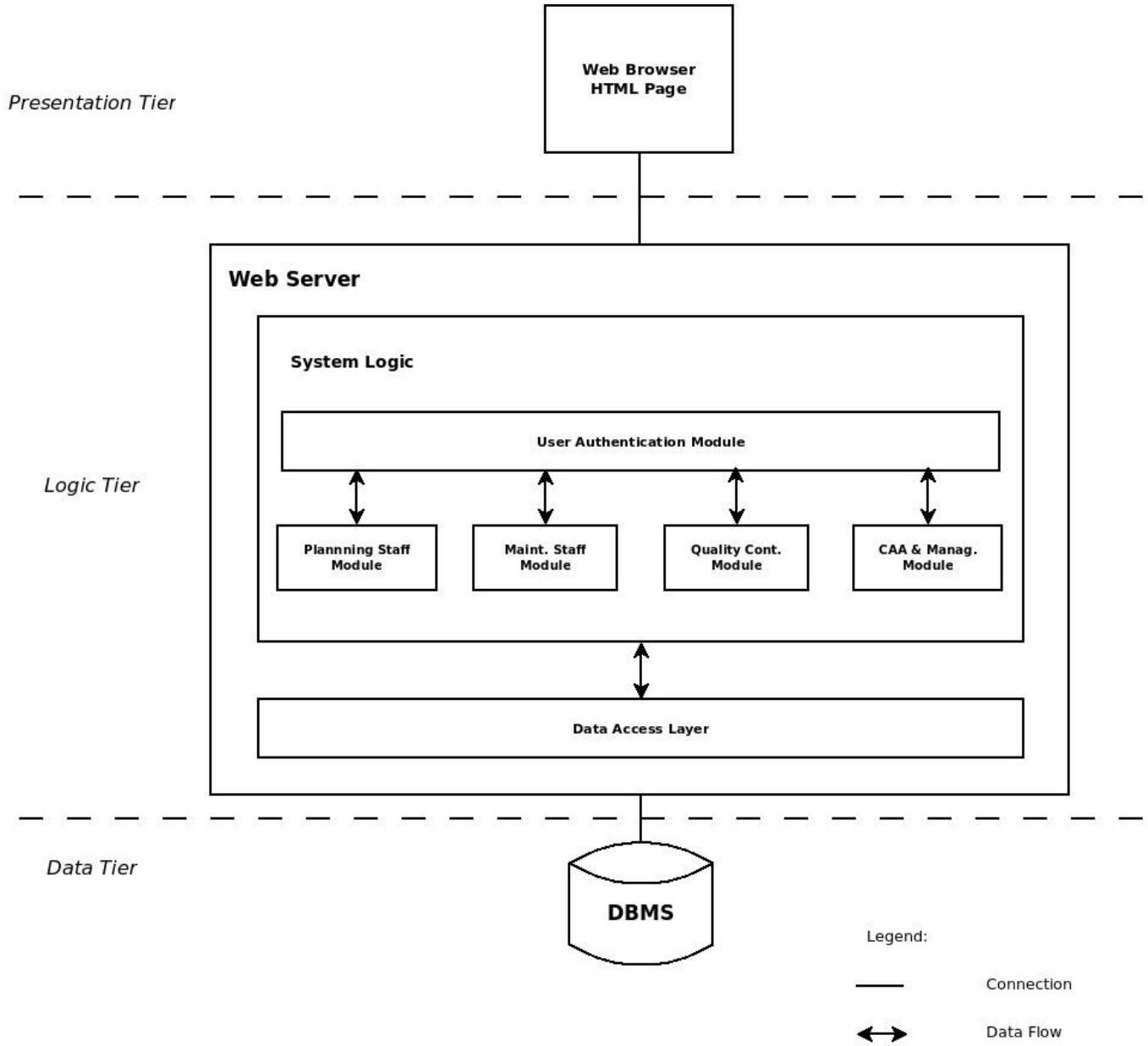

Fig 3: ALMMS Architecture Design

The system is designed to ease the maintenance planning process by offering an easy access to information and to terminate the paper work. This to allow users with different concerns to get there data from the same database and prohibit redundancy. It also lower the chances of poor recording system. For safety reasons in the civil aviation industry, the maintenance process should be very rigorous or the operator (airline) might lose its operation license if a maintenance task was not performed in the exact time it was due; this system should mitigate this. The database would be access through a web-based system for convenience of accessing it from any location and to avoid any different computer operating systems obstacles.

The modules for the application program will be;

1. **Authentication Module:**

   This module will verifies the individual that attempts to access the system. After the users successfully authenticated, they will be redirected to the corresponding module pertains to them.

2. **Planning Staff Module:**

   This Module will give the planning staff the access to view the checks list and the option to issue a work order for it. In addition to that they can view the maintenance record to follow up the maintenance process.

3. **Maintenance Staff Module:**

   This module will give the certified maintenance personnel the access to view the scheduled checks issued by the planning department and sign off its tasks as they finish it.

   The module will also allow them to issue a non-routine work orders and sign them as they finish it

4. **Quality Control Module:**

   This module will give the quality control inspectors the access the signed off work by the certificated maintenance personnel and sign it themselves if they are satisfied by the work. If they are not satisfied, the module will give them the option to reject the task and send it back to be viewed in the maintenance module.

5. **Authoritarian Firms and Management Modules:**

   This module will give access to a view for the work done and closed work orders.

   In the figure above, there are three tiers: the presentation tier, logic tier and data tier. In the presentation tier, each user will interact with the system through their web browser. This will send PHP requests to the web server that holds the application program.

   The logic tier contains the inner-workings of the ALMMS system. There are various modules stored on the server. The purpose of adopting this modular architectural design is to have a high level of cohesion and overcome coupling,

   Each user request will be passed through the authentication module which will then forward their requests to a corresponding module - based on the type of user. Each module will have different features/functionality that the user can manipulate. Requests from each module will be routed through the data access layer. The purpose of the data access layer is to transform user requests into a representative notation that the DBMS can understand (i.e, using SQL). Each SQL query will obtain data from the database. All data routed from the database, through the data access

layer, will be redirected to the user - and presented in a manner that they will understand.

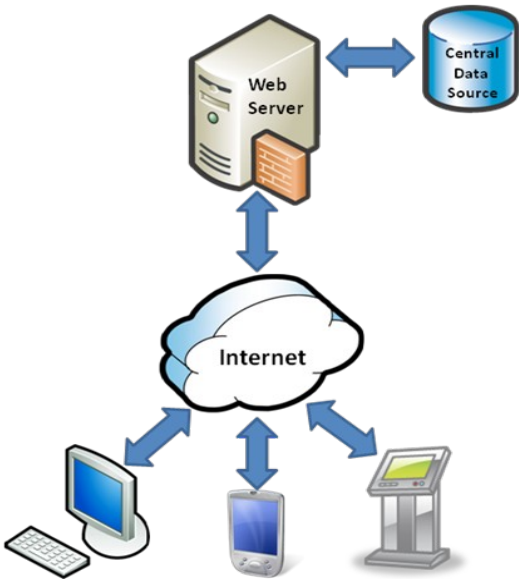

Fig 4: Client Perspective of the ALMMS

[5]

Figure 4 shows that several clients can access the ALMMS web application via the internet. Their requests will be served by a web application - which resides on a web server. The web application will then query the database server to obtain relevant information for each client.

5 https://msdn.microsoft.com/en-us/sync/bb887608.aspx

5 Specification Requirements

5.1 User Interface Requirements

5.1.1 Request access to use the ALMMS

Requesting access will be quite simple; users privileges are granted from the the group the user belongs to. The process will go as following:

5.1.1.1 Inputs

In the main page of the application program, each user will have to choose the group he/she belongs to and then will be allowed to enter his/her user name and password.

5.1.1.2 Processing

The system will validate the user's user name and password before granting access to the page of the group.

5.1.1.3 Outputs

The system will display the page of the group the user belong to.

5.1.1.4 Error Handling

he system shall guard against multiple attempts, made by the same individual, to request access to the system.

5.1.2 Allow users to make changes

5.1.2.1 Planning Staff

The system will allow the planning department staff through their group page to view the near due checks. It will also allow them to issue a work order for the due checks to be performed by the maintenance department and record the personnel who issued the work order through their access account. In addition to that the they will have the capability to follow-up the work process and the maintenance record.

5.1.2.2 Maintenance Staff

The system will allow the certificated maintenance department staff through their page to view the issued checks from the planning department and to sign of its tasks as they are executed.

The system will also allow the certificated maintenance staff to open work words from there page and sign it off when it is finished.

The System will record the signature of the certificated maintenance personnel when they sign off the work through their access account.

5.1.2.3 Quality Control Staff

The system will allow the quality control inspectors through their page to view the signed off work by the maintenance department. It will allow them to signed of the work done by maintenance department as “approved” or it will reject he work and send it back to the maintenance department page to re-execute

the work and sign it off again.

The System will record the signature of the quality control inspectors when they sign off the work through their access account.

5.1.2.4 Error Handling

The system will ensure that there is no redundancy in the data; 1) it will not allow planners to issue more than a work order for the due check, 2) it will not allow maintenance staff to issue more than a work order for the same non-routine task.

5.2 Use Cases

5.2.1 User Login Use Cases

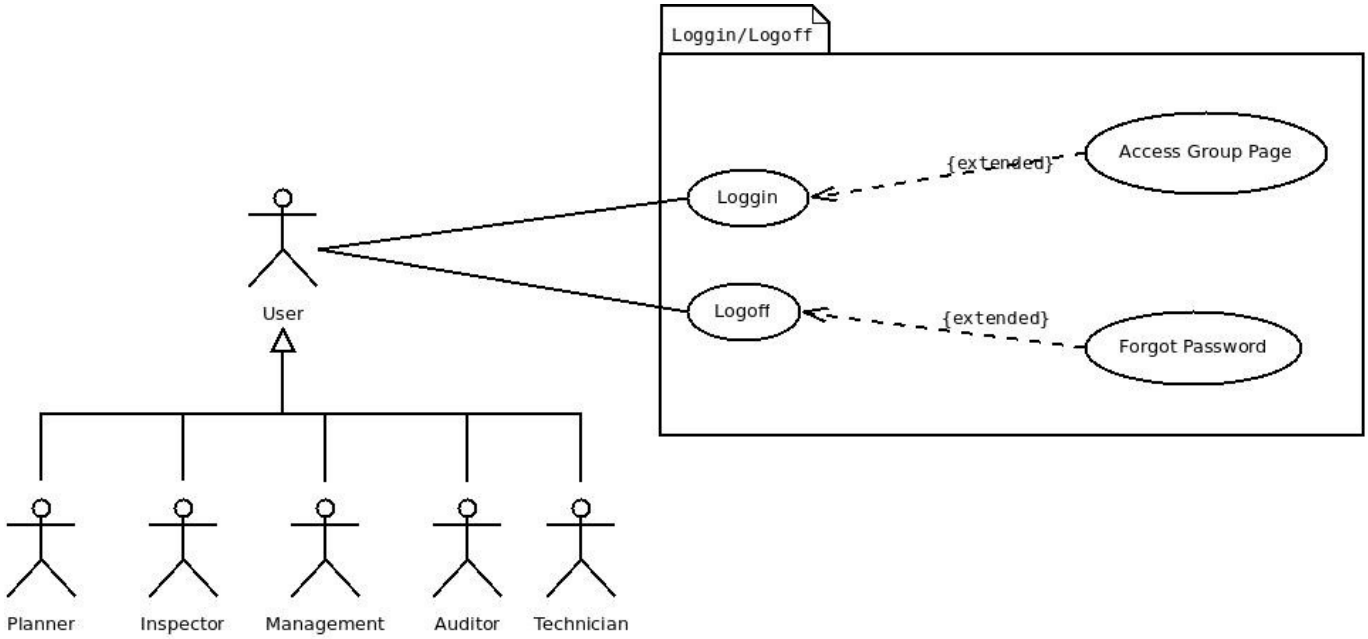

Fig 5: Login Use Cases

The use case diagram in figure 5 states that there are five intended users of the system. All five users have similar login features such as log on, register, forgot password and log off. Each a group of users can access its group web page specified for the accessing user.

Use case name	Login
Use case purpose	The purpose of this use case is to allow a user to log into the online system
Precondition	User is authorized
Post conditions	User will be able to see (read) and/or change (write) the information stored onto the system
Constraints	The user must have a valid login user name and password i.e. he/she must be an existing user
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 1: Login Use Case

Use case name	Logoff
Use case purpose	The purpose of this use case is to allow a user to log out of the system
Precondition	The user must be logged into the system
Post conditions	User will be out of the online system
Constraints	None
Assumptions	User is done with his/her work

Table 2: Logoff Use Case

Use case name	Forgot password
Use case purpose	The purpose of this use case is to allow a user to recover his/her forgotten password.
Precondition	User is authorized
Post conditions	Retrieved password shall be by sending him a new password to his email by the system administrator.
Constraints	The user must have a valid login user name and password i.e. he/she must be an existing user
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 3: Forgot Password Use Case

Use case name	Access group's page
Use case purpose	The purpose of this use case is to allow to allow a user to access his/her group's page
Precondition	User is authorized
Post conditions	User will be able to access data he is allowed to view/change
Constraints	The user must have a valid login user name and password i.e. he/she must be an existing user
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 4: Access Group's Page Use Case

5.2.2 Planner Use Cases

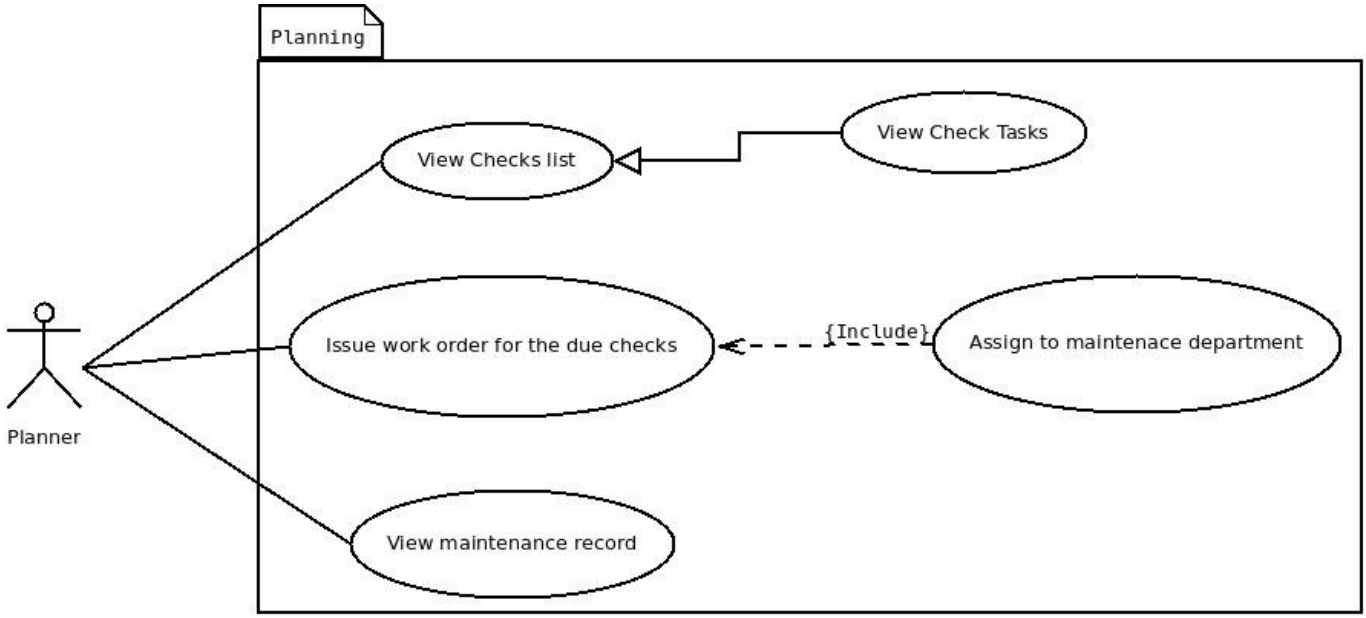

Fig 6: Planner Use Cases

As shown in figure 6, planners can access checks lists and their tasks to assign the due checks for routine work for maintenance. They can also have an access to maintenance records to monitor the work done on the aircraft.

Use case name	View Check Lists
Use case purpose	The purpose of this use case is to allow a planners to view the list of the checks to find if there is due checks
Precondition	User is authorized
Post conditions	Planners issue work orders to for the due checks
Constraints	Only planners can see the the checks list
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 5: View Check List Use Case

Use case name	View Check tasks
Use case purpose	The purpose of this use case is to allow a planners to view the list of the tasks of the due checks
Precondition	User is authorized
Post conditions	Planners will issue the work orders for the sue tasks and plan for the issue according to the tasks
Constraints	Only planners can see the the check tasks list before the issuance of work orders
Assumptions	None

Table 6: View Check Tasks Use Case

Use case name	Issue Work Orders For The Due Checks
Use case purpose	The purpose of this use case is to allow a planners issue work orders for the due checks
Precondition	User is authorized
Post conditions	The issued work order will be viewable to the technicians to start work. The subject check and tasks will be accessible to the technicians.
Constraints	Only planners can issue routine maintenance work orders
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 7: Issue Work Orders For Due Checks Use Case

Use case name	View Maintenance Record
Use case purpose	The purpose of this use case is to allow a planners to view maintenance records
Precondition	User is authorized
Post conditions	The planners will be able to follow-up the maintenance process
Constraints	Planners can not modify records
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 8: View Maintenance Record Use Case

5.2.3 Technician Use Cases

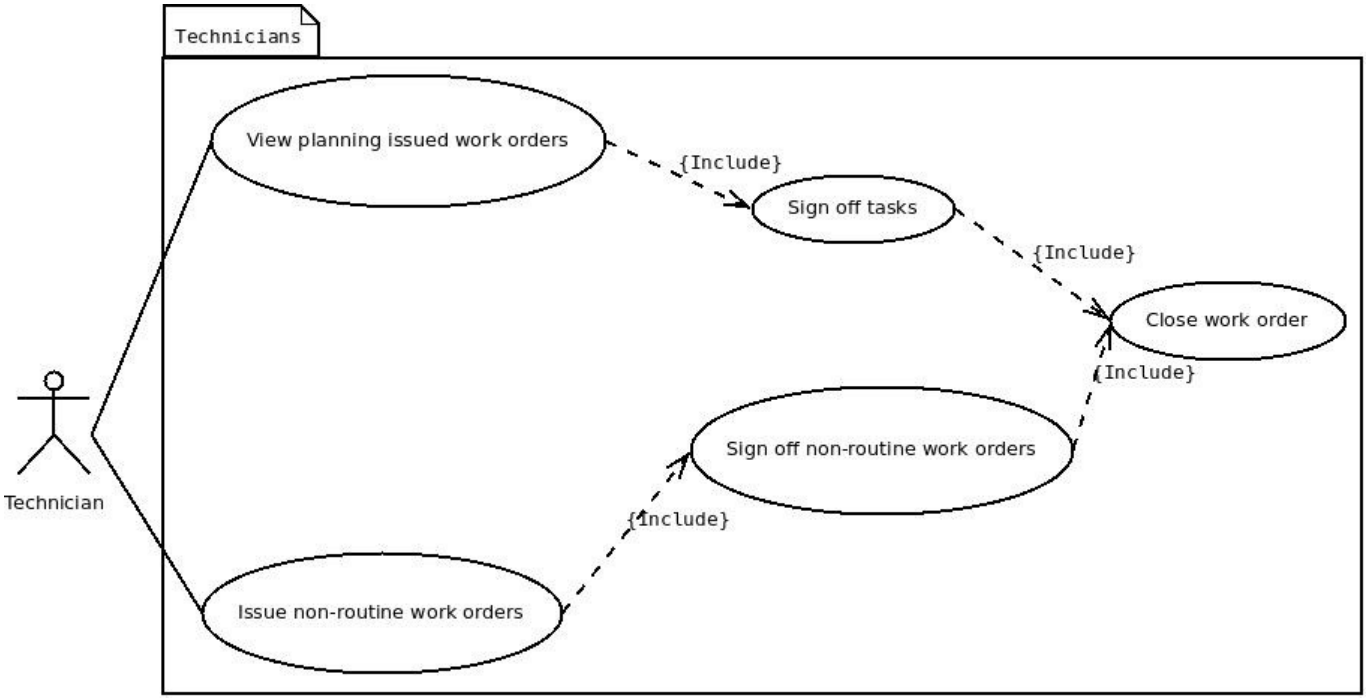

Fig 7: Technician Use Cases

As shown in figure 6, technicians can view the issued work orders assigned by planners and sign them off they finish them. They can as well open the non-routine work orders for fault repaired outside the maintenance program and sign them of when they finish the work.

Use case name	View Planning Issued Work Orders
Use case purpose	The purpose of this use case is to allow technicians to view the routine work orders issued by planners
Precondition	User is authorized
Post conditions	The certified technicians will be able to sign off the due check tasks
Constraints	Technicians can not modify check or check tasks
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 9: View Planning Issued Work Orders Use Case

Use case name	Sign Off tasks
Use case purpose	The purpose of this use case is to allow technicians to sign off every task they finish in the due check
Precondition	User is authorized
Post conditions	The certified quality control inspectors shall approve or disapprove the work done by technicians
Constraints	Technicians can not modify check or check tasks
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 10: Sign Off Tasks Use Case

Use case name	Issue non-routine work order
Use case purpose	The purpose of this use case is to allow certified technicians to issue work orders for the non-routine maintenance work.
Precondition	User is authorized
Post conditions	The certified technicians will be able to sign off the due non-routine work orders when the work is done
Constraints	none
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 11: Issue Non-routine Work Order Use Case

Use case name	Sign off non-routine work order
Use case purpose	The purpose of this use case is to allow certified technicians to sign off non-routine work orders when the work is done
Precondition	User is authorized
Post conditions	The certified quality control inspectors shall approve or disapprove the work done by technicians
Constraints	none
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 12: Sign Off Non-routine Work Order Use Case

Use case name	Close work order
Use case purpose	The purpose of this use case is to allow technicians to close the work orders when the work is done
Precondition	User is authorized
Post conditions	The certified quality control inspectors shall approve or disapprove the work done by technicians
Constraints	Technicians can not modify check or check tasks
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 13: Close Work Order Use Case

5.2.4 Quality Control Inspector Use Cases

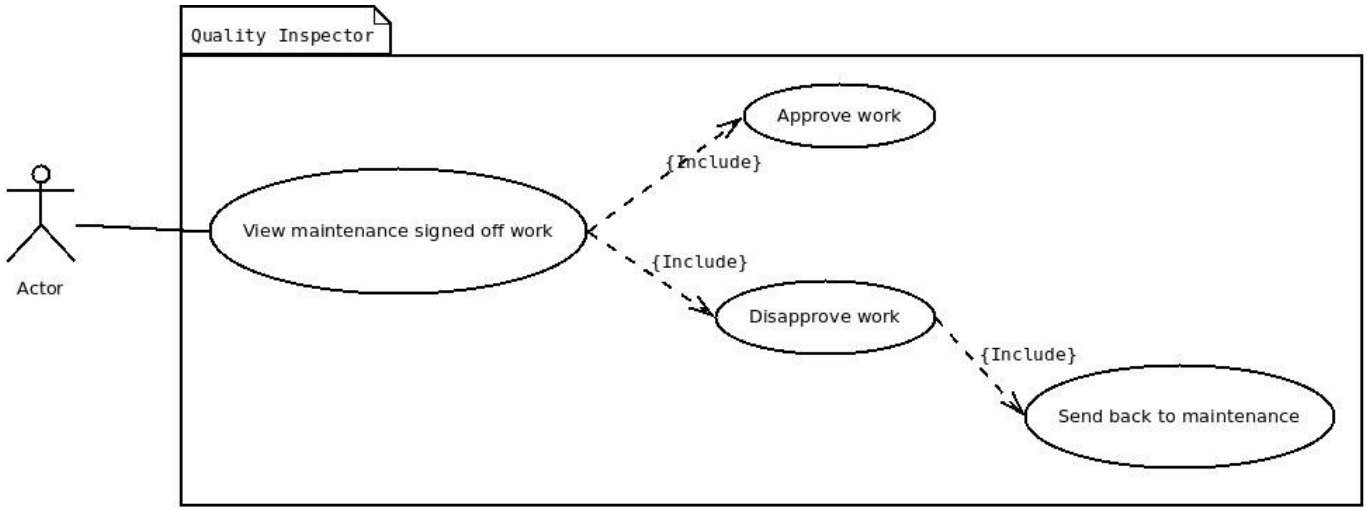

Fig 8: Quality Control Inspector Use Cases

As shown in figure 8, quality inspector can access the sign-off work performed by maintenance to approve or disapprove it. Disapproved work shall be sent back to maintenance for rework.

Use case name	View maintenance signed off work
Use case purpose	The purpose of this use case is to allow inspectors to view the signed off tasks and work orders
Precondition	User is authorized - The work is signed off by a certified technician
Post conditions	The work is approved or the work is disapproved
Constraints	Inspectors can not modify the work orders
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 14: View Maintenance Signed Off Work Use Case

Use case name	Approve work order
Use case purpose	The purpose of this use case is to allow inspectors to approve and sign off the work tasks and work orders
Precondition	User is authorized
Post conditions	The tasks and work orders shall be closed and recorded
Constraints	Inspectors can not modify the work orders
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 15: Approve Work Order Use Case

Use case name	Disapprove work order
Use case purpose	The purpose of this use case is to allow inspectors to disapprove the work tasks and work orders
Precondition	User is authorized
Post conditions	The tasks and work orders shall be sent it back to maintenance
Constraints	Inspectors can not modify the work orders
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 16: Disapprove Work Order Use Case

5.2.5 Authoritarian Firms and Management Uses Cases

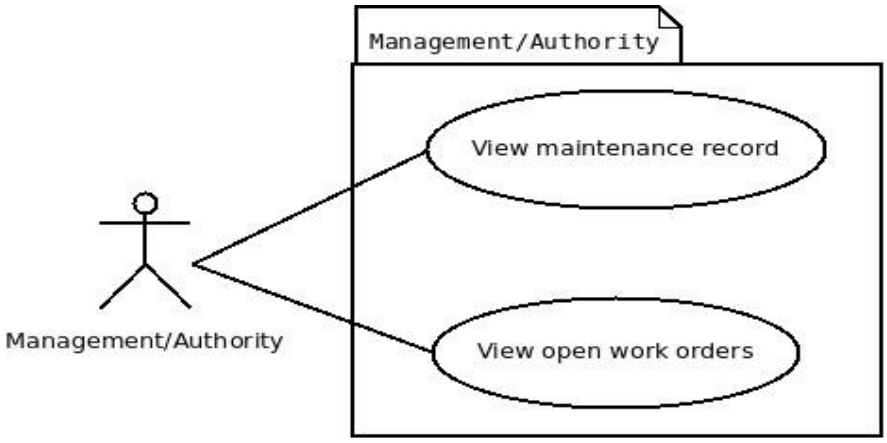

Fig 9: Management/Authority Use Cases

As shown in figure 9, management personnel and auditors can have access to maintenance records to evaluate work progress and check work done on aircrafts.

Use case name	View maintenance record
Use case purpose	The purpose of this use case is to allow Management and Authoritarians to view the maintenance records for follow-up
Precondition	User is authorized
Post conditions	none
Constraints	User can not modify records
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 17: View Maintenance Recored Use Case

Use case name	View open work orders
Use case purpose	The purpose of this use case is to allow Management and Authoritarians to view open work orders for follow-up
Precondition	User is authorized
Post conditions	none
Constraints	User can not modify records
Assumptions	Information identifying the user has already been entered into the system before the use case is started

Table 18: View Open Work Orders Use Case

5.3 Non-Functional Requirements

5.3.1 User Interfaces

The system will have four main types of stakeholders: planners, technicians, quality inspectors and managers/auditors. Accordingly, each will have different web user interface designs. However, there are general design principles that will be followed to ensure that the system is user friendly.

The user interface will:

- Have a simplistic design to minimize training and enable ease of use and understanding.

  Simple design strategies include:

  - Restricting the use of textboxes unless absolutely necessary (e.g. only use textboxes for data entry).
  - Using point-and-click operations: i.e. presenting the user with a list of options by way of hyperlinks, radio buttons, list boxes, checkboxes etc.
- Minimize the use of colors and animations in order to be unobtrusive and minimize distractions.
- Provide short and descriptive error messages to each user; e.g. "passwords must be between 6 and 12 characters".
- Maintain consistent user interface design to facilitate user friendliness; e.g. the location of buttons and menu items should remain consistent throughout the application.
- Present data to user in a manner that they will understand and suppress underlying SQL code. E.g. All data should be presented in natural language and eliminate formal syntax and semantics.
- Perform data cleaning techniques to guard against SQL injection attacks.

5.3.2 Hardware Interfaces

It will more convenient for the users to use their mobile hand-held devices and tablets (personal or supplied by the company) to access ALMMS. Providing a web based design will enable users to access the information from their portable hand-held devices, as well as their personal computers. Also, many hand-held devices have built-in features such as voice recognition, touch screen and hand-writing recognition. Therefore, they will integrate seamlessly with a web based design and each user can choose their preferred input methods.

Each use (employee) should have an ID card. Therefore, it would ease the accessing process by swiping his card on a card reader to access his/her account and start a session.

5.3.3 Software Interfaces

The system will be designed using open source software solutions such as PHP, JavaScript and MySQL.

All application logic shall be hosted on an Apache Server.

It is recommended that the database reside on a separate server from the application program. The database shall then be connected to the network, at the server site, using conventional Ethernet connections. The details of this configuration are left to the network administrators as they will have knowledge of appropriate design choices that will reduce network latency.

5.3.4 Performance

The system shall have a response time of less than 5 seconds for each query performed against the database.

5.3.5 Reliability

The system should present accurate and efficient information to each user. Planner need up to date information about the checks that are due on each aircraft in the fleet to assign the work needed to be carried out. They also need to see run-time progress in the maintenance operation to be able to plot plans for the maintenance processes. Technicians also need run-time updates in the assigned work orders issued by the planning department to start their work as soon as possible to avoid any delay. Management and personnel auditors shall need also to have a solid view about the work done on the aircrafts that is under maintenance work.

The database shall have a backup database to secure the information from being lost in case of damage of the running database.

5.3.6 Security

Security is if great importance in the aviation industry considering the safety concerns and also the competitive aspects concerns. Therefore, the system shall require the use of passwords, as an authentication mechanism, which will guard against unauthorized use. Also, users will be advised about the confidentiality of the material they are in contact with.

5.3.7 Miss Use Handling

The database shall log the transactions that made the changes to the database and the user who made the change for accounting the responsibility of the action taken. That means that the system shall log the planners' ID when they issue work orders. The system shall log the the technicians ID when they issue work orders or sign it off. The system shall log the quality control inspectors when they sign off the work orders or reject them.

5.3.8 Logical Database Requirements

The database shall be designed using a relational database management system. It is important that ACID (Atomicity, Consistency, Isolation and Durability) properties be enforced for all transactions.

5.3.9 Schema Definition

The rational tables schema and its attributes domain and range of values for ALMMS is as follows:

5.3.9.1 Employee Entity

Field	Type	Null	Key
ID	int(11)	NO	PRI
DEP	varchar(3)	NO	
F_Name	varchar(45)	NO	
L_Name	varchar(45)	NO	
PW	varchar(45)	YES	

Fig 10: Employee Entity

5.3.9.2 Fleet Type Entity Entity

Field	Type	Null	Key
Type_ID	int(11)	NO	PRI
Type	varchar(45)	YES	
Manf	varchar(45)	YES	

Fig 11: Fleet Type Entity

5.3.9.3 Fleet Entity

Field	Type	Null	Key
MSN	int(11)	NO	PRI
MnfDate	varchar(45)	YES	
Reg	varchar(6)	YES	
Type_ID	int(11)	YES	MUL
LstCHK_FH	int(11)	YES	
LstCHK_FC	int(11)	YES	
LstCHK_Date	date	YES	

Fig 12: Fleet Entity

5.3.9.4 Check Entity

ID	int(11)	NO	PRI
MSN	int(11)	YES	MUL
CHK_Type	varchar(45)	YES	
Intvl_FH	int(11)	YES	
Intvl_FC	int(11)	YES	
Intvl_CAL	int(11)	YES	

Fig 13: Check Entity

5.3.9.5 Task Entity

Field	Type	Null	Key
ID	int(11)	NO	PRI
CHK_ID	int(11)	NO	MUL
TskCrdNo	int(11)	NO	
DocFile	varchar(45)	NO	

Fig 14: Task Entity

5.3.9.6 Maintenance Record

Field	Type	Null	Key
ID	int(11)	NO	PRI
MSN	int(11)	NO	MUL
EngSN	int(11)	YES	
APU_SN	int(11)	YES	
SrtDate	date	YES	
EndDate	date	YES	
MaintType	char(3)	NO	
CHK_ID	int(11)	YES	MUL
NRC	int(11)	YES	
TLB	int(11)	YES	
Tech_ID	int(11)	YES	MUL
Ins_ID	int(11)	YES	MUL
Pln_ID	int(11)	YES	

Fig 15: Maintenance Record

5.3.10 Normalization Analysis

Given a set of functional dependencies for each relation, and that each relation has a designated primary key; this information combined with the tests (conditions) for normal forms drives the normalization process for relational schema design.

The normalization analysis for the project's schema is as follows:

5.3.10.1 Employee Entity

This schema satisfies:

- First normal form as each attribute has atomic values.
- Second normal form as each attribute depends on the key attribute, the whole attribute and nothing but the attribute.
- Third normal form as every non-key attribute is non-transitively dependents on the PK.

5.3.10.2 Fleet Type Entity Entity

This schema satisfies:

- First normal form as each attribute has atomic values.
- Second normal form as each attribute depends on the key attribute, the whole attribute and nothing but the attribute.
- Third normal form as every non-key attribute is non-transitively dependents on the PK.

5.3.10.3 Fleet Entity

This schema satisfies:

- First normal form as each attribute has atomic values.
- Second normal form as each attribute depends on the key attribute, the whole attribute and nothing but the attribute.
- Third normal form as every non-key attribute is non-transitively dependents on the PK.

5.3.10.4 Check Entity

This schema satisfies:

- First normal form as each attribute has atomic values.
- Second normal form as each attribute depends on the key attribute, the whole attribute and nothing but the attribute.
- Third normal form as every non-key attribute is non-transitively dependents on the PK.

5.3.10.5 Task Entity

This schema satisfies:

- First normal form as each attribute has atomic values.
- Second normal form as each attribute depends on the key attribute, the whole attribute and nothing but the attribute.
- Third normal form as every non-key attribute is non-transitively dependents on the PK.

5.3.10.6 Maintenance Record

This schema satisfies:

- First normal form as each attribute has atomic values.
- Second normal form as each attribute depends on the key attribute, the whole attribute and nothing but the attribute.
- Third normal form as every non-key attribute is non-transitively dependents on the PK.

5.3.11 Integrity Constraints

5.3.11.1 Entity Integrity Constraints

All ID numbers are unique.

All primary keys cannot be null.

All IDs are alphanumeric values.

5.3.11.2 Domain Constraints

- Range of values:

  Please see section 5.4.6.1

- Default value:

  For attributes that are not specified in section 5.4.6.1 as Not Null values, the default value is Null.

  ID's in tables tbl_TSK_REC, tbl_TSK, tbl_MAINT_REC, tbl_CHK and tbl_AC_TYPE are automatically incremented.

- Values that should not be null

  Aircraft Type ID, Type, Manufacturer

  Aircraft Manufacturer Serial Number, Registration Marks, Type_ID

  Maintenance Record ID, MSN, Start Date, Maintenance Type

  Check ID, Check Type, Flight Hours Interval, Flight Cycles Interval, Calender Interval

  Employee ID, Department, Last Name, Password

  Task ID, Check ID, Task Card Number

  Task Record ID, Check ID, Record ID, Technician ID, Time/Date

5.3.11.3 Referential Integrity Constraints

Referential constraints are shown on the ERD (Figure 17)

5.3.11.4 User Defined Constraints (Business Rules)

- When users register to use the system, the system will first check if their information is already present in the system. If the user exists, they will be presented with password reset options.
- Planners can not assign new work orders for checks before 5 calender days from the due date of the check.
- Technicians can not access the check tasks before they are assigned by the planning department in a work order.
- Quality control inspectors can not sign off the work done before the certified maintenance personnel sign it off.
- Work orders can not be recorded before it is signed of from both certified maintenance personnel and quality control personnel.
- Management personnel and auditors can not change data in database.

6 Analysis Models

6.1 Sequence Diagrams

6.1.1 User Interaction Scenario

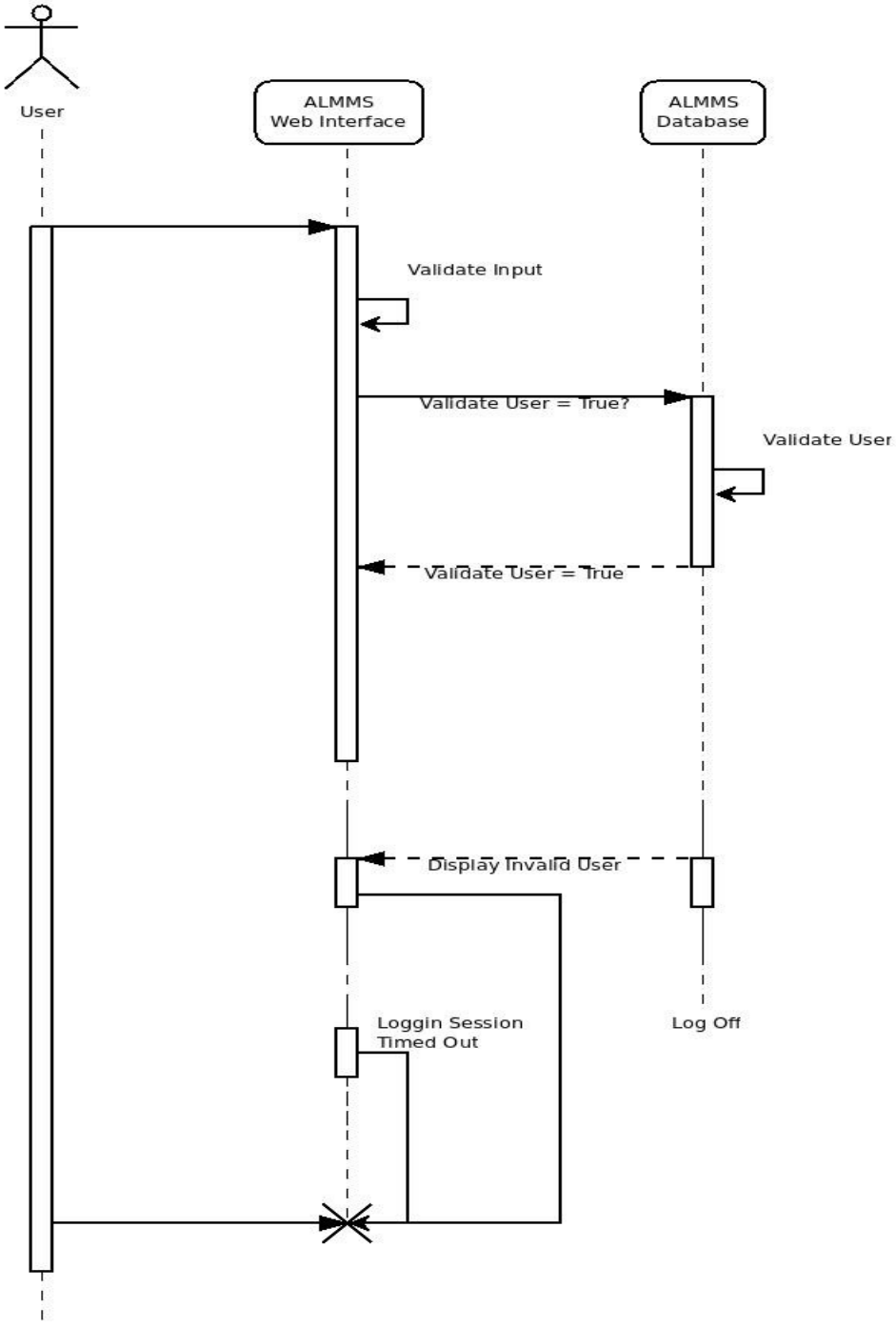

Fig 16: Scenario diagram: User Interaction Scenario

The diagram in figure 12 shows the sequence of actions that occurs when logging into the system.

The user is required to enter their login credentials. This information will be validated for completeness and the database will verify if the user exists. If the user provided accurate information, a welcome message will be displayed. If not, an error message will be displayed .

If the user choose to logout the session will be terminated.

6.1.2 Planner Interaction Scenario

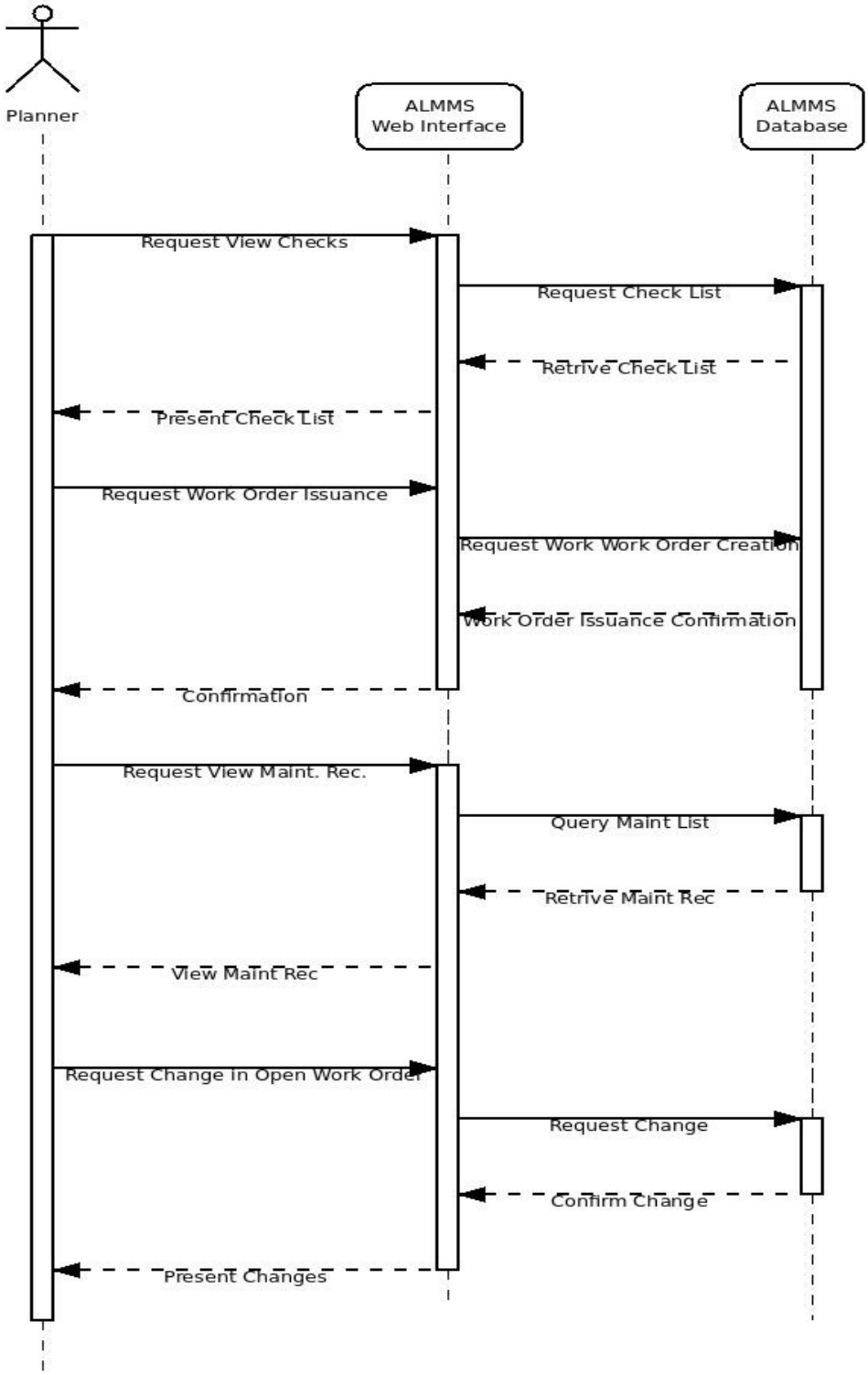

Fig 17: Scenario diagram: Planner Interaction Scenario

The diagram in figure 17 shows the sequence of actions that occurs when a planner views the check list and see if there are due checks. If there are due checks the planner will issue a work order. If the planner

wants to change in the work order he/she issued, the system will display the maintenance record for update mode.

6.1.3 Technician Interaction Scenario

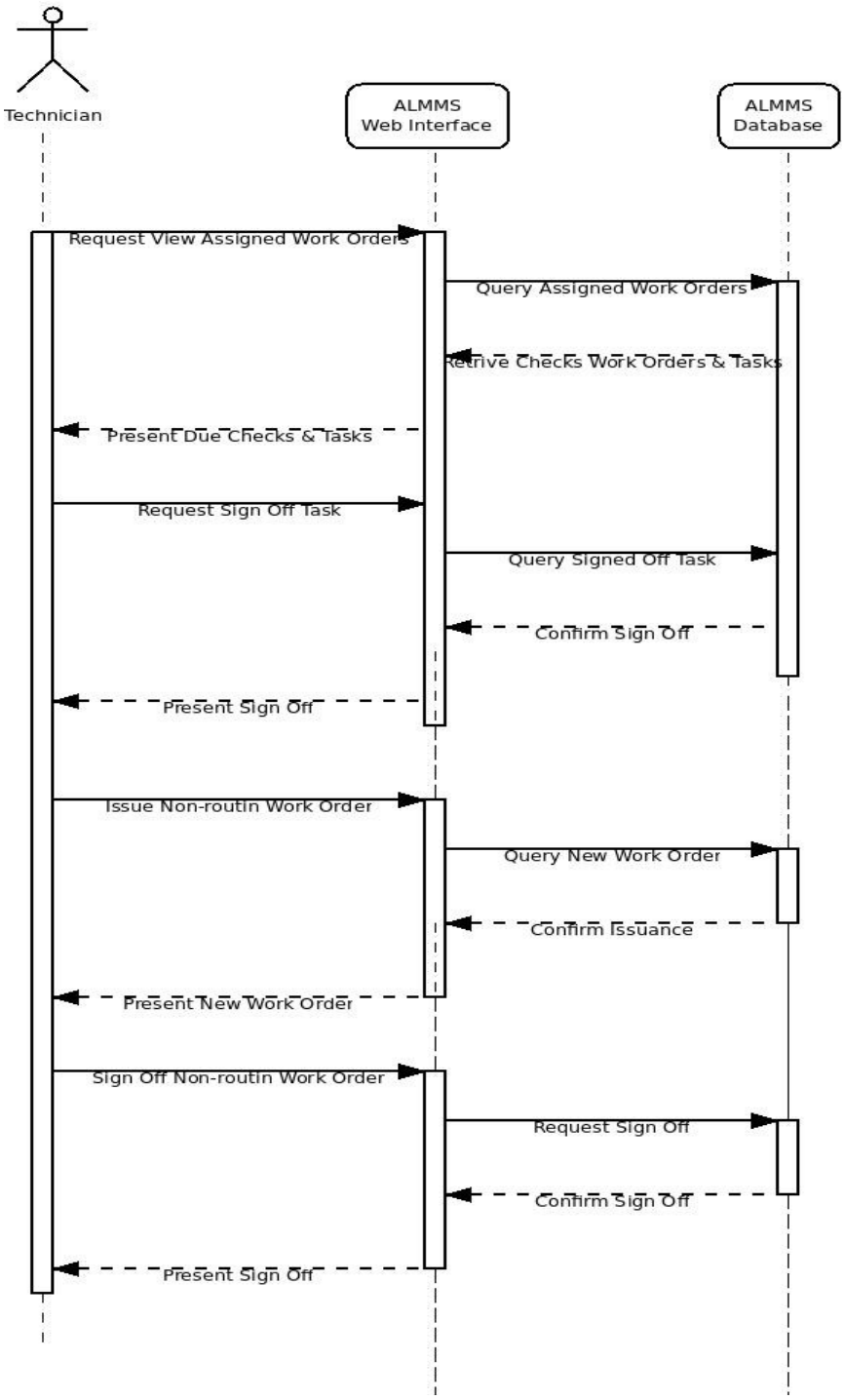

Fig 18: Scenario diagram: Technician Interaction Scenario

The diagram in figure 18shows the sequence of actions that occurs when a technician want to view

assigned work orders to start working on it. The system will retrive the date and allow him/her to sign them off if he/she want to.

If the technician wants to issue a non-routine work order, the system will allow him to update the maintenance record and issue the new work order. When he/she is finished from the maintenance work, the system will allow him/her to sign off the work order the maintenance staff issued earlier.

6.1.4 QC Inspector Interaction Scenario

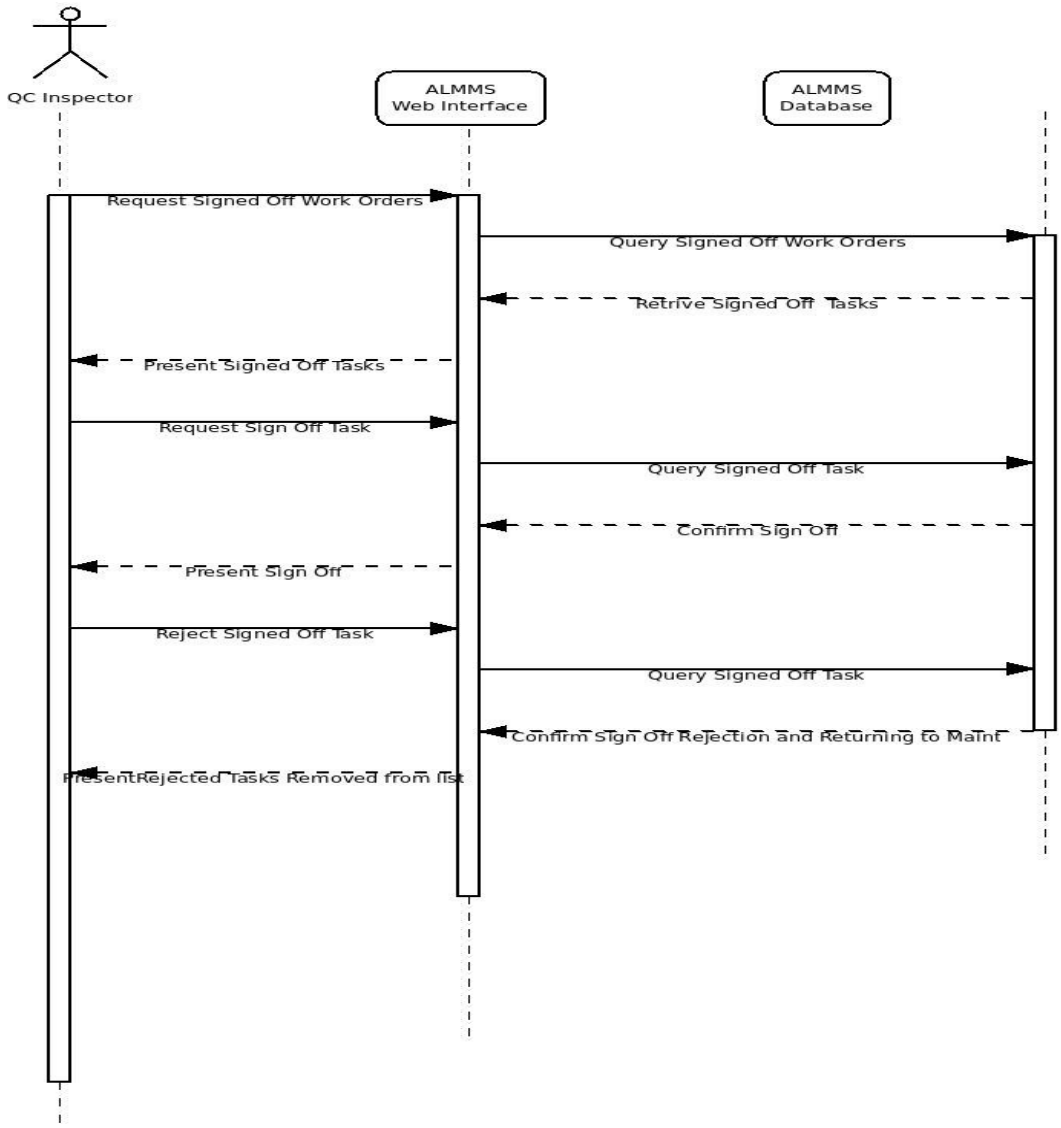

Fig 19: Scenario diagram: QC Inspector Interaction Scenario

The diagram in figure 19 shows the sequence of actions that occurs when a quality control inspector wants to view the maintenance takes or work orders signed-off be technicians and it allows him to approve and close it or to reject the work and cancel the sign-off by the technicians to send it for rework process.

6.1.5 Management Personnel/Auditors Interaction Scenario

The

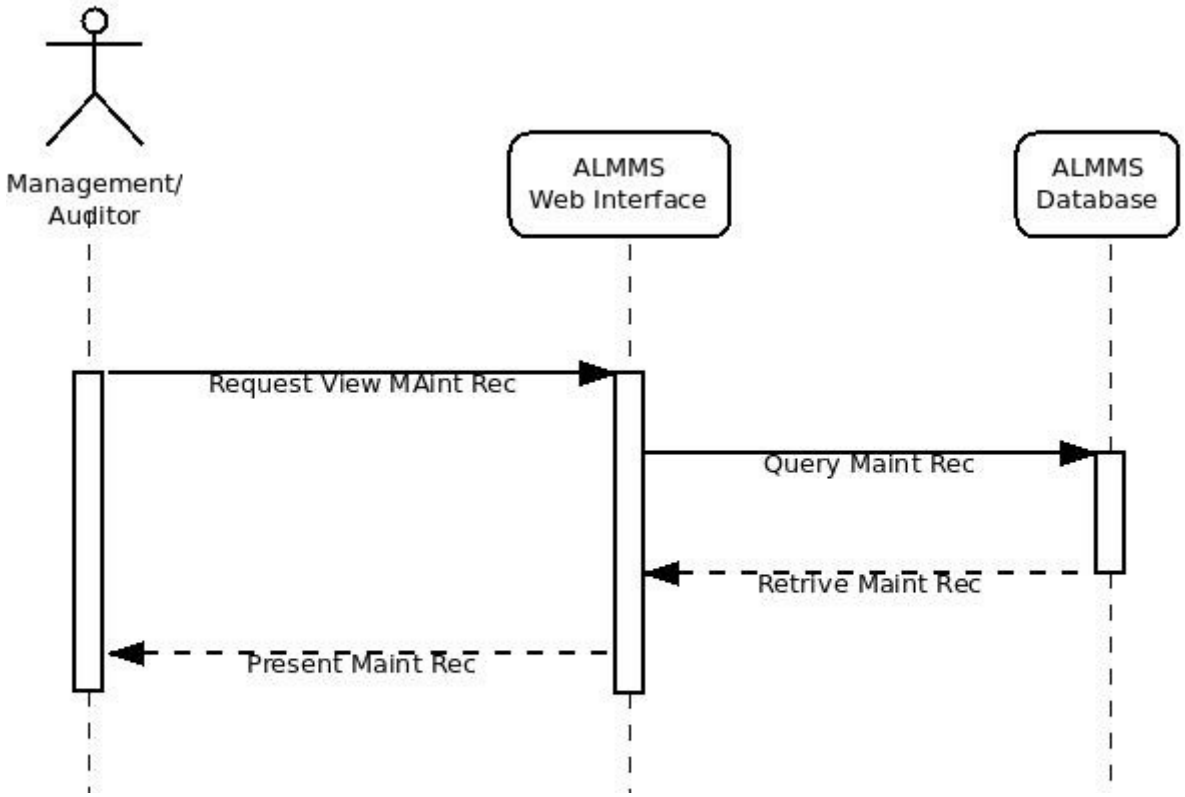

Fig 20: Scenario diagram: Management/Auditor Interaction Scenario

diagram in figure 20 shows the sequence of actions that occurs when a management personnel or an auditor wants to view the maintenance record.

6.2 ER Diagram

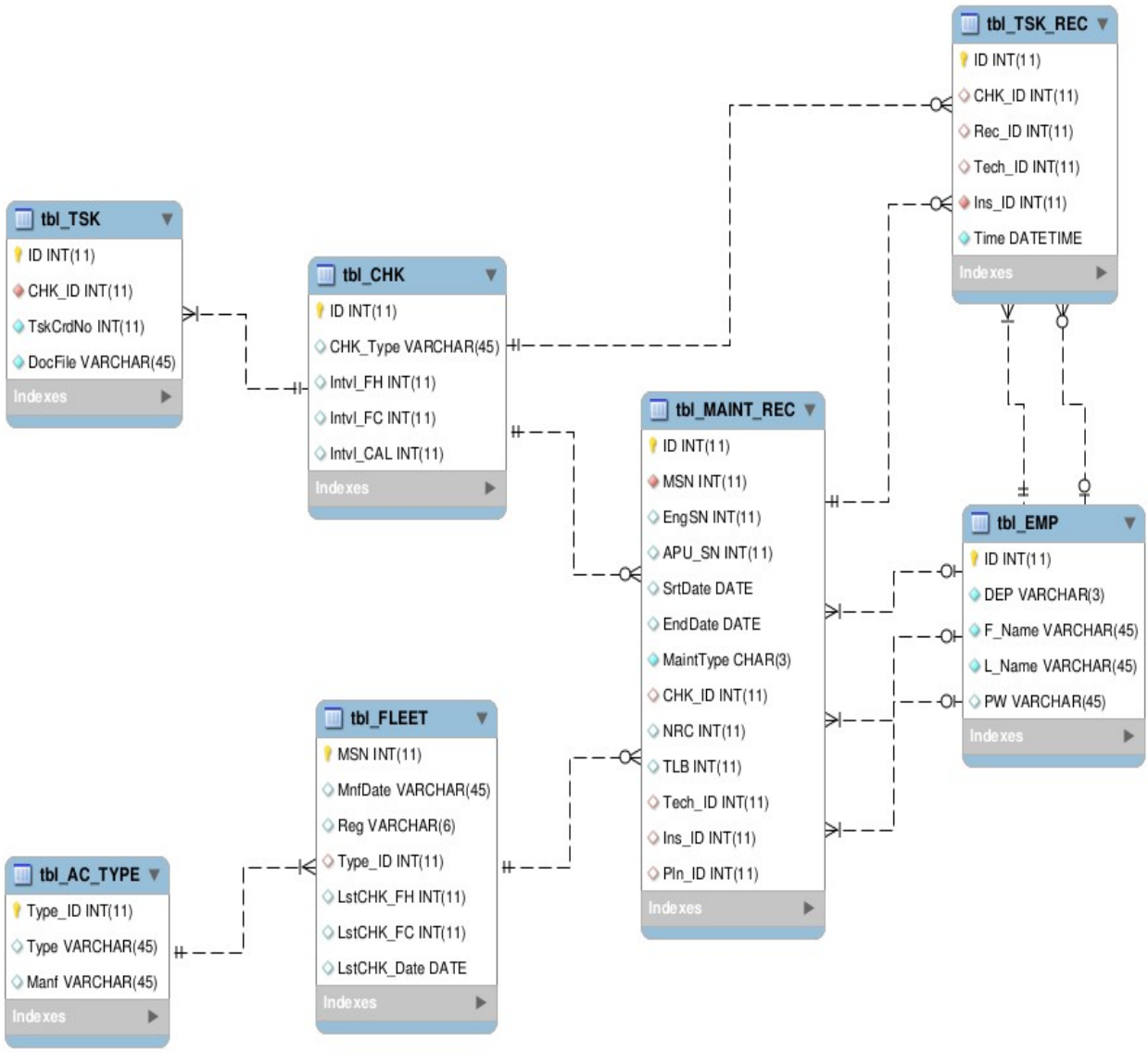

Fig 21: ALMMS ERD

An aircraft in the fleet might have maintenance record and it might not if it is a new one with now maintenance work performed on it. Every aircraft have a type and the airlines might have more than an aircraft of the same type.

Every aircraft type has its own maintenance program having its own checks each having its specific tasks. Every aircraft tuple will be holding information about the the flight hours the aircraft went through a FH type check. It will also hold information about the flight cycles the aircraft went through a FC type check. Similarly, It will hold information about the date the aircraft went through a Calender type check. Using this information the planner will be able to decide which check will be next due.

When the planner decide that a check is due he will open a work order in the maintenance record table

and his/her ID will be recorded in the opened record. Maintenance then will respond to that and start accessing the check's record. The certificated technician will be able to sign-off the tasks one by one till it is finished, his/her ID will be recorded on every task he/she signs-off. The Quality control inspector will access the signed-off tasks and approve or disapprove the work. If the work is approved the tasks will be closed one by one till the whole check is closed. The Inspector ID will be recorded in the closed tasks. If the work is disapproved the sign-off the the technician will be canceled and the task will be issued for rework. Recorded tasks are stored in a separate table which is related to the record table and the checks table.

When all the tasks of the check is signed of by the technicians and inspectors, the work order is then closed automatically.

Technicians can open the work order in the maintenance record table for the non-routine work and then sign it off. The inspectors shall be able then to approve the work and sign it of and close the work order or reject it to return for maintenance for rework. When an inspector reject the work, he/she cancels the maintenance sign-off.

6.2.1 Description of entities and relationships

Relationship	Entities	Cardinality	Participation
Belongs to	Aircraft, Type	Many:One	Mandatory, Mandatory
Have maintenance record/work order	Aircraft, Record	Many:One	Optional, Mandatory
Belongs to	Check Record, Check	Many:One	Optional, Mandatory
Belongs to	Task, Check	Many:One	Mandatory, Mandatory
Belongs to	Task Rec, Check	Many:One	Optional, Mandatory
Issue Work Order	Planner, Check Issuance	One:Many	Mandatory, Optional
Sign-Off Tasks	Technician, Task	One:Many	Mandatory, Optional
Sign-Off Tasks	Inspector, Task	One:Many	Mandatory, Optional
Sign-Off Work Order	Technician, Work Order	One:Many	Mandatory, Optional
Sign-Off Tasks	Inspector, Work Order	One:Many	Mandatory, Optional

Table 19: Description of Entities and Relationship