Development of Smart Aircraft Logbook Based on IoT

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Abstract: This project is to develop a system that can integrate between user input and data reference stored in a cloud database. The user input is referring to the post-flight report regarding aircraft status retrieved from the Flight Management System (FMS). The data will be crosschecked subject to the reference manual which is the Master Minimum Equipment List (MMEL) and o Minimum Equipment List (MEL) that have been kept in a cloud database. This system is constructed to reduce time and response time for the post-flight check. Research exploratory had been carried out using the interview method, to obtain the information regarding the application and implementation of the Internet of Things (IoT) in the aviation industry. System reference is extracted into the cloud database. Next, the software is developed so that the user can have interaction with this system. From all the fragments from the input and data reference, this system is recommended a fast solution to determine the aircraft status; whether it is safe to fly or to be grounded for maintenance purposes. Through this methodology and IoT concept, it is believed that this system may be a beneficial idea and effort to fit the aviation industry's needs towards the rise of the Industrial Revolution 4.0.

Keywords: IoT, Aircraft Logbook

I. AIRCRAFT LOGBOOK

In every flight, standard routine for a pilot is to record in which all data concerning the aircraft after the flight completed. Refer to the Fazeel Ahmed (2017), information that include in this log basically to determine the aircraft condition, date and time of inspections on airframe, engines, and propellers. On top of that, it reflects a history of all significant events occurring to the aircraft, its components, and accessories, and also provides a place for indicating compliance with EASA/FAA airworthiness directives or manufacturers' service bulletins. Once the inspections are completed, report must be written and certified by the approve person in the aircraft logbook certifying that the aircraft is in an airworthy condition and may be returned to service.

Revised Manuscript Received on September 22, 2019.

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Current practices of standard aircraft operators are by using on paper flight report. Unfortunately with the development of digital technology, these practices seem to be old school and unpractical in term of time. Clay (2017) stated that the new generation of electronic aircraft logbook is for those requiring manual entry of the data, typos, and mistakes can be corrected. This perhaps is the most attractive feature such as arithmetic and sorting. Many logbook programs can easily tell you how many landings you've had in the past 90 days, or how many hours you've flown as cross country time under actual instrument conditions. He suggests that by having this type of logbook will make the crew have the convenience of the electronic format with the sentimentality and tactile pleasure of the paper book.

II. APPLICATION OF IOT

Referring to the statement made by Drinkwater (2017), he refer that IoT can impact both RASM (Revenue per Available Seat Mile) through differentiated customer experience and/or new revenue streams and CASM (Cost per Available Seat Mile) as result of greater efficiencies. Likewise, airports have the opportunity to increase revenues and lower operating expenses. It can be conclude that every investment towards IoT will bring a great return within times but it must be in the proper guidance and a better effort to make it into a good investment. Current application of IoT in the aviation industry have been used widely with the integration of IoT itself. The CEO of Boeing Global Services, Deal (2018) believe the connecting of ecosystem within an airline is an important part of optimizing the cost. This by mean, the revolution of using IoT in every aspect of aviation technology is a positive growth to the company to optimize their cost-saving operation and getting more simplified. The usage of fusing big data, broadband and analytics, evolving technologies helping the IoT transform every MRO company into a new concept of operation.

2.1 Data Pipes

To develop a new perspective of providing a faster service to the customers, this type of technology continues invented. They call it the trend of connected aerospace which will enable any greater capabilities such as ethernet and now they are using broadband for aircraft that will be more affordable so that there will be more bigger pipes. This can be supported by the statement that is given by Otto (2018), which is aviation will draft off of those technologies and the aviation industry will be improved by the connectivity and it will be driven by beyond aviation.

He also mention that by having this technology, more data will be receive with less money to be spent as technologies such as applications, will drive new opportunities. Good head (2018) also agree that by getting the pipe of data from the engine, as well as its context and using of cloud-computing technologies sheer the ability to crunch all of that data will produce useful outcomes. An example from this statement can be seen in every developing aviation company such as Rolls-Royce as they are planning to use full services and capabilities of data analysis on an aircraft engine.

2.2 Cloud Computing

The most advantageous of having cloud computing is time-saving. Aircraft reports are very crucial to every operator of the aircraft. When aircraft has landed, the data from the aircraft report or post-flight report is taken as the input and analyze in real- time. This is supported by the statement from Jishnu (2017), saying that once the data from the report are being merged with IoT, the data can be received in real-time by the maintenance staff on the ground rather than having to wait for the paper report from the crew.

Since each latest aircraft is currently using a high technology system, the requirement of aircraft perimeter is getting bigger. To have a manual on paper is a problem since the reference is getting more and more complicated. As General Electric's (GE) executive director, Shanbhag (2018) said in yearly report company, a system has been develop to monitor and visualize data to see the operational parameters compare to the global fleets. This will help better understand the outcome of the data.

2.3 IoT for Aviation Safety

For the application of every new technology into the industry's purpose, it must have a clear result from any safety issues. Recent research towards the implementation of IoT into the aviation industry is giving a good result towards the end of the study. Pate and Adegbija (2018) in their research said that IoT's goal is to provide new, diverse and more efficient services, spanning a wide variety of domains that promise to transform life, business, and the global economy. However, with this IoT growth, it involves billions of connected devices and also poses significant challenges. Due to the resulting exponential increase in acquired or transmitted data, overheads with respects to bandwidth bottlenecks, latency, energy consumption, and security issues are also bound to increase. So in real-time, safety-critical IoT use cases, such as in the aviation industry, devices must adhere to stringent constraints to prevent potentially fatal events.

2.3.1 Firewall

In every technology that has been developed before this, it must come with a set of security and safety prevention as it consists of sensitive data and become a major concern. So to understand the concept of this, every sensor which is the enablers for IoT, sends the sensed data to a cloud database over the internet. The communication to the cloud database may be compromised by an adversary or the database might maybe access by a curious database administrator, so it will raise security concerns. To overcome this issue, the solution is to safeguard IoT devices in a home network scenario from potential attacks. Referring to Gupta et al., (2017), in the research, they suggested that, the system that uses IoT should have a firewall to avoid any data breaches and leakage information. These factors can lead to any potential security risks that can cost the company billion-dollar loss.

2.3.2 Authority Approval

To comply with the standard approved by the authority, every design of the system that develops by using IoT integration must possess an approved design and requirement by the authority. In Malaysia, the operator must follow standard with the Civil Aviation Authority of Malaysia (CAAM) to fits every requirement that has been set up to make sure the system is safe to be used in aircraft. Vilnius (2017) stated in his research that the aircraft technical log system could be either a paper or computer system or any combination of both methods acceptable to the competent authority. In the case of a computer system, it should contain program safeguards against the ability of unauthorized personnel to alter the database.

2.3.3 Redundancy in Database

As every system in aircraft must have redundancy to avoid system failure and fatigue, every database stored in cloud computing should have the same concept of redundancy. McKeown (2017) in his research said that The Victorian Chief Investigator, Transport Safety for Australian Transport Safety Bureau (ATSB) stated that it is would recommend against using newly modified safety-critical equipment or system without redundancy.

III. METHODOLOGY

To develop an Internet of Things (IoT) database, there is a lot of data extraction, manual reference, input analyst and integration of the system that need to be done. In this project, the focus is on using a web database. By using this type of database, it is much easier to develop and also to maintain. The structure needs to be build based on aircraft manufacturer Master Minimum Equipment List (MMEL) and operator Minimum Equipment List (MEL).

3.1 Master Minimum Equipment List (Mmel) & Minimum Equipment List (Mel)

The Master Minimum Equipment List (MMEL) and the Minimum Equipment List (MEL) will deal with system failures that have an impact on the safety of the aircraft. The purpose of the MMEL is to provide operators with an efficient and reliable tool to rapidly determine if the aircraft can be dispatched without compromising the safety of the flight. The primary objective of the MMEL is to make sure, reconcile an acceptable level of safety with aircraft profitability while operating an aircraft with inoperative equipment. For this project, the manufacturer that has been used is the Airbus Company. The MMEL has the development process. The MMEL development is a process that involves many specialists within Airbus, such as MMEL specialists, system designers, safety specialists and many more. The MMEL is a legal document, required for the dispatch of an aircraft.

This document is also reviewed by the authorities before granting approval or acceptance. As a result, the safe operation of an aircraft, with one or more pieces of inoperative equipment, is safely guaranteed by the MMEL or MEL.

The different between MMEL and MEL has been explained in the table below:

Master Minimum Equipment List (MMEL)	**Minimum Equipment List (MEL)**
a) The MMEL lists all the safety-related items for which revenue flights are permitted, even if the items are inoperative at departure.	a) The MEL is a required document, which must be created for each aircraft in an Operator's fleet. It is based on the aircraft MMEL and includes the specific requirements of each National Authority.
b) The MMEL specifies the dispatch conditions: The conditions to be fulfilled and the procedures to be performed, in order to permit the revenue flights to be flown with the inoperative item for a limited period of time.	b) The MEL must be customized to take into account the specificities of each aircraft: Weight variant, options installed, software upgrades, hardware upgrades, and retrofit status.
c) The MMEL serves as a basis for Operators in developing their own MEL.	c) It is important to note that the MEL cannot be less restrictive than the MMEL.

3.2 Database Development

At the beginning of the process to develop a database, data structure needs to be done. This includes how the data will be stored, extracted and retrieved to comply with the instruction given by the user or input. The development of the process into a series of phases or steps, each of them focuses on one aspect of the development. This database will act as a brain to this project since every input has to be taken into the database to identify the status of aircraft based on the main reference, MMEL & MEL.

To design a database that can be accessed anywhere and anytime, the database must be stored in the cloud storage. The first step is to have raw data from MMEL & MEL.

Unfortunately for the majority of database languages, direct input from the user has been used. As all the current MMEL & MEL folder that can be retrieved now are in Portable Document Folder or PDF, it must be converted into web content or database records. The main reasons for converting this type of folder are:

- To make sure all type of database server can read the data
- To make data analysis easier for the system
- To make the integration between the database and system software is more reliable and faster.

To convert this MMEL & MEL, the third-party application needs to be used as the manual way to converting data into web content or database records are more complicated and it tends to the loss of data integrity.

3.3 Flow Chart of the System

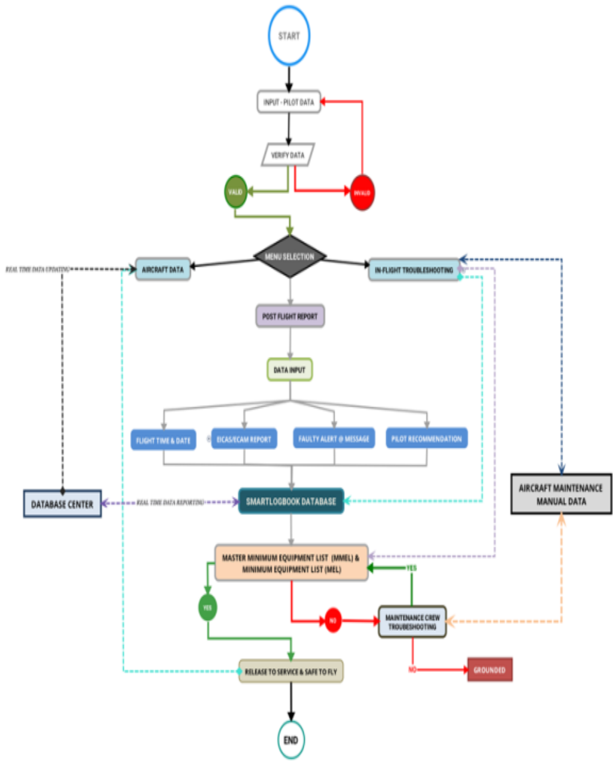

Fig. 1 Example of Flow Chart on System Operation

3.4 Database Builder

In this project, since it is an early stage of development, database builder has been used to develop its platform. The database builder that has been used is Zoho Creator. Using this platform, it is the easiest way to construct & design software to this system. It can be modified within the specifications needed as an aircraft logbook. The storage of the database also will be provided by this database builder since it can be stored until 25K data at the same time. The development of using this platform consists of two parts. The first one is to build an excel data that has been extracted from the MMEL and has been converted into this platform. The second part is to design the integration between this MMEL & the software itself.

IV. RESULT

4.1 Extraction of Mmel Data

Before the MMEL data can be used as a reference, it must be converted into the Microsoft Excel first. This is due to the software limitation on reading another format of a file. To convert MMEL data, the understanding of the document is very important. Every information extracted must be correct and follow the original data from the MMEL. The revision of this MMEL also needs to be updated due to the manufacture specification. There are 8 rows in the table that represent the original MMEL information that has been used.

System	System Number	System Details	Rectification Interval	No. Installed	No. Required for Dispatch	Remarks or Exceptions	CONDITION
AUTO FLIGHT - Autopilot/Flight Director (AP/FD)	22-10-01 (C)	Autopilot (AP)	C	2	1	(O) No change from EASA MMEL.	GO
	22-10-01 (B)		B	2	0	O) Except for ER operations, both may be inoperative provided enroute operations and approach minimums do not require their use.	GO IF
	22-10-02 (1)	Flight Director (FD)	C	2	1	(O) Except where enroute operations require its use, one may be inoperative provided: 1) Approach procedures are not dependent on its use, and 2) Associated autopilot is considered inoperative. NOTE: Any mode which operates normally may be used.	GO IF
	22-10-02 (2)		C	2	0	(O) Except where enroute operations require their use, both may be inoperative provided: 1) Approach procedures are not dependent on their use, 2) Autopilots are considered inoperative, and 3) Windshear escape guidance is considered inoperative. NOTE: Any mode which operates normally may be used.	GO IF

Fig. 2 Example of MMEL Table

4.2 Pilot Logbook

For the starting sequence of this system, the first page of the Aircraft Maintenance Programme shown as per Figure 3. All the information of the Pilot in Command must be filled in before it can proceed into the next step. Under the ECAM MESSAGE tab, the selection of the faulty will be given based on the ATA Chapter of the aircraft.

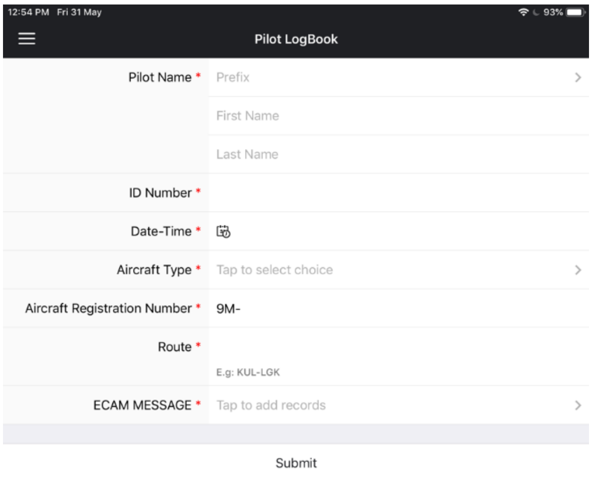

Fig. 3 Example of Pilot Logbook Page

The focus for this project is only on 3 ATA Chapter which is ATA 22: Autopilot, ATA 23: Communication & ATA 24: Electrical. Every section of this ATA Chapter is referring to the aircraft MMEL and has been simplified according to the section. This selection of faulty can be selected by the pilot based on ECAM Message at the ECAM Display (Figure 4) that they can retrieve before sign out from the cockpit.

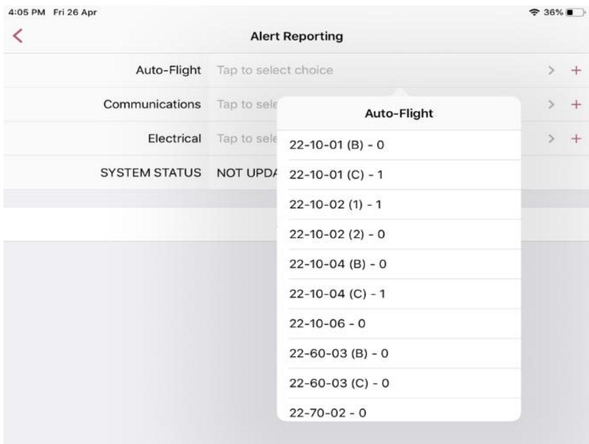

Fig. 4 List of Example for Autopilot ATA Chapter

Upon the success of the data recorded from the pilot, the further operation is taken by the Licence Aircraft Engineer (LAE) or Technician Crew. The review regarding the pilot information and details of the data logged can be retrieved back (Figure 5). The registration of the aircraft number showed the type of aircraft and the date/time added by the pilot. When any of the lists has been selected, the details showed the full information and the TROUBLESHOOT button to access the next workflow of the system (Figure 6).

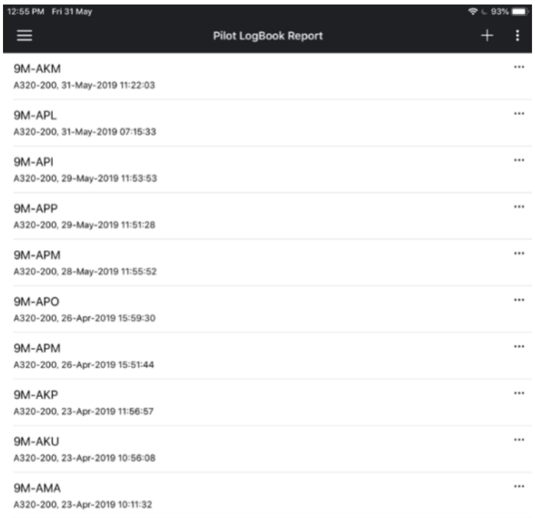

Fig. 5 List of Data Logged by Pilot in Command

Fig. 6 Details View of the Information Logged

After the troubleshoot, the workflow will redirect to the Alert Reporting Page, here the MMEL reference will be integrated with the data recorded earlier (Figure 7). The details information regarding the alert report can be seen when the list has been clicked as per Figure 8.

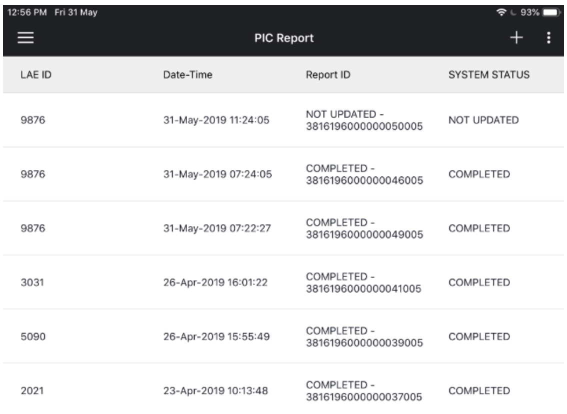

Fig. 7 List of Data Recorded by Flight Crew

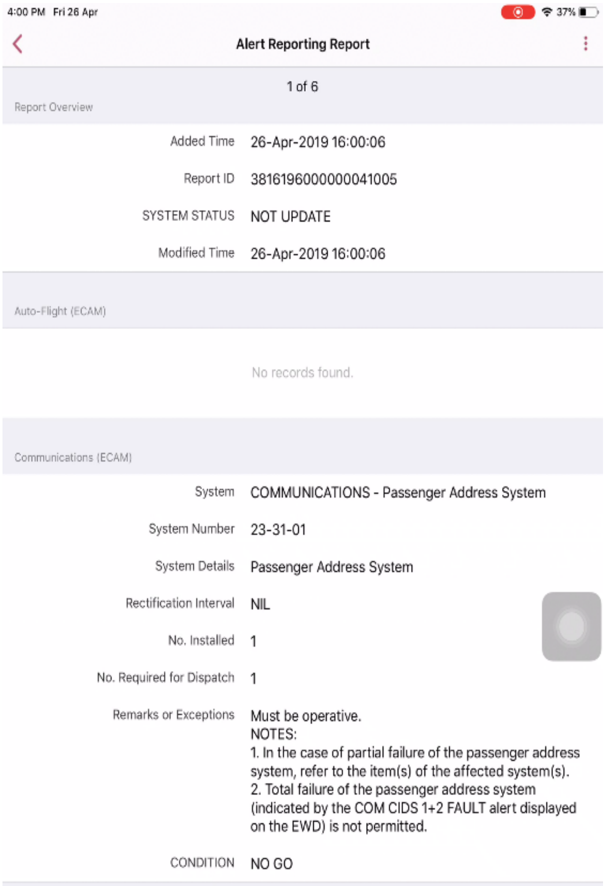

Fig. 8 Detailed View of Alert Report

Under the section of Person in Charge (PIC), the access only for the tech crew or Licence Aircraft Engineer (LAE) has been a task for the troubleshoot or responsible for releasing the aircraft to service. The information of PIC must be recorded for the safety and reference purpose to the base maintenance since it can be accessed in real-time based system. After all the details information has been submitted (Figure 9), the PIC must select which alert report needs to be updated on the status (Figure 10). If the aircraft has been declared as NO GO or grounded, the status must be identified as INCOMPLETED or AOG.

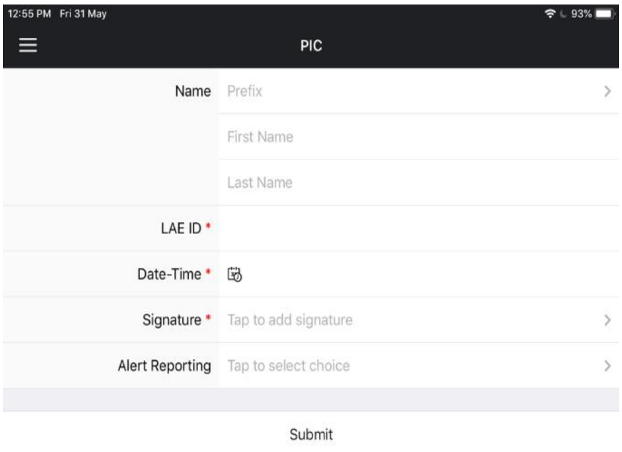

Fig. 9 Person in Charge Information Page

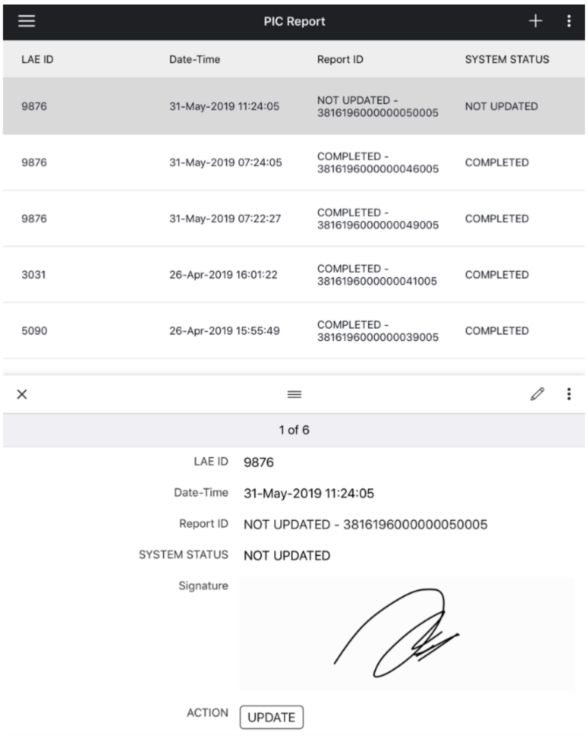

Fig. 10 Person in Charge (PIC) Action Page

After the completion of all steps above, the system will redirect back to the Alert Reporting page that showing all previous alert report's status has been COMPLETED. As shown in Figure 11, the list will generate the modified date as per the current status of information that has been done by the PIC.

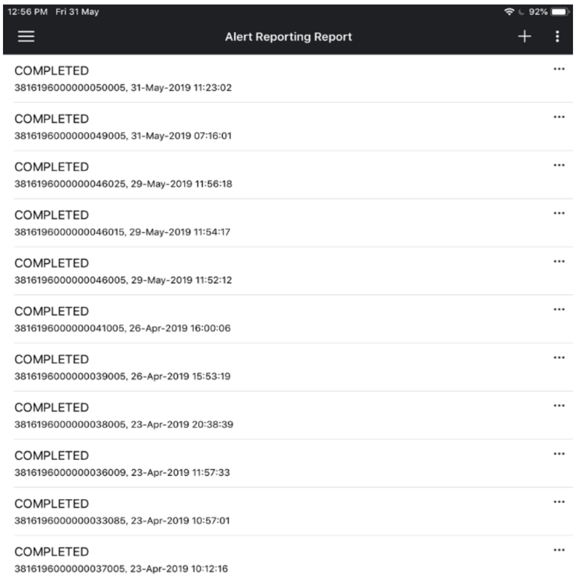

Fig. 11 List of Alert Reporting Review after Completion Status

From the result that has been done throughout the system, all the data that has been collected or stored can reach out in real-time based. After every alert report has been recorded, the notification will be directly sent to the based maintenance for direct reference. There are a few data can be compared to justify the objective of this system development. With time response that has been taken by the flight crew to react to the alert, reporting can be measured as a primary comparison, the continuity of the system will help the tech crew to make an easy way to identify the rectification for the aircraft troubleshooting.

V. CONCLUSION

After several tests had been done on this system, the objectives of this project have been achieved which includes investigating the current practice and procedures of post-flight report, developing an integrated aircraft logbook system in order to reduce operation time and improving response time for post-flight check and suggesting on improvement of the current standard operation procedure of the written aircraft logbook. Besides that, this development of this system still can be improvised with further research toward the needs of IoT in the aviation industry. During the development process of this Smart Aircraft Logbook, few limitations have been found out. Despite it can be stored up to a thousand bytes of the database after the full implementation using a real MySQL database, the memory needs to be cleaned up after it reaches the limit. But the existing data can be stored in an archive database and can be reached out when it needed.

For the future development of this system, there are a few suggestions on full-scale implementation towards this project that can be made in an earlier process. This suggestion may be the focus since the actual limitation toward this project is not the development process but it comes when the system has been fully developed but to test on real aircraft, that needs more time and approval for the authority to agree with the law and restriction. The suggestion will include:

- Paperwork on a full-scale project of the operation
- Data integrity details with cyber security authority
- Airlines company support
- Focus on full MMEL area
- Understanding on aircraft manufacture manuals & rectification

As per the above suggestion, this may be an improvement of this project in future development. With a limitation of financial, this project may be hard to achieve and success since it will require a lot of ideas and manpower to have a full ability of digitalized aircraft maintenance program. Nevertheless, it still can be made possible with great commitments that come from all parties in the aviation industry.

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