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Research paper

Potential Aircraft Design Improvement and Sustainability Through Feedback Information

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Abstract

Reflecting on previous case studies, events, research data, and experiences have always been crucial in ensuring the betterment of any working procedure and environment – aircraft maintenance industry included. This paper aims to highlight the importance of having feedback information being constantly disseminated in a swift and effective manner, particularly throughout all levels within the aircraft maintenance industry worldwide – which has been acknowledged by Boeing and subsequently, a few distinguished initiatives such as In Service Data Program (ISDP) and Flight Recorder Data Service (FRDS) have been introduced. In terms of fulfilling aircraft technicians' needs in their current working environments, such initiatives are crucial for more detailed inspections and supervisions to promote the possibility of enhancement and higher revenues in impending project framework. The trends and behaviour of the previous and/or existing products are analysed and the obtained information will assist appropriate decision-making for future improvements. Commonly, some specific types of information will be collected and thoroughly assessed; these information types include failure types, failure modes and frequencies of failure, and/or replacement and maintenance trends. Overall, feedback information is found to be a major contributor to the sustainability of the aircraft industry.

Keywords: *aircraft maintenance; feedback information; maintainability prediction.*

1. Introduction

Auditing bodies within aviation industry worldwide have always been striving to ensure total safety of aircrafts, the personnel involved and passengers or cargo that they carry. Particularly for aircraft maintenance, renowned safety precaution models such as Maintenance Error Decision Aid (MEDA), Swiss Cheese and not to forget, Maintenance Error Management Systems (MEMS), have long been regarded as pioneer references to be adapted and modified accordingly [1-5]. With that in mind, these have continuously been researched and analysed to upgrade the present established Standard Operating Procedures for in-depth paperwork involved in aircraft maintenances, mainly concerning maintenance reports and logs.

Although there have been questions internally as these processes involved extensive financial budget and additional working staffs and hours, related top brass of the aviation companies have clarified that maximum amount of information needs to be recorded as in time, evolutions occur and modernizations take place – hence, many aspects of maintenance procedures can be improved to generate not only higher efficiency in terms of time and personnel needed to finish certain tasks but also higher financial savings [9].

Feedback loops best describes the information collection process; feedback would naturally be a product, generated by some sort of machinery or device, while loop refers to the repeating action – just like any typical work in maintaining any aircraft part, where after a defect aircraft part has been repaired, another similar item from
another aircraft comes in and the same process begins again.

2. Systems and Documents

Audits regarding compliances and quality assurances done by authorities exist not just as another SOP to ensure total safety, but also a refresher for companies to consistently update on their paperwork. Federal Aviation Administration for instance, constantly regulate and update maintenance-related paperwork such as Service Bulletins and Airworthiness Notices. Combined with their database of the most updated and recent case studies, timely statistical reports, etc. the entire process flow would be utmost necessary for feedback information – especially when it can prevent any similar aircraft incident that has occurred within their research timeline. Even though basic information like a typical
aircraft part's general information has been duly provided by Original Equipment Manufacturers in the possible forms of sticker, guide book, manuals, etc. aviation companies and airports would still need to liaise diligently with them as every aviation company may have different industrial needs and modifications for their respective aircraft parts. This would also be important in competing in terms of work performance and industrial rankings to be the best in their respective categories and thus attracting potential investors [7].

While the process flow itself may give the impression that it would be in-depth and technical, safety models have been created to ensure total comprehension y all personnel working at all levels; from the top management until the levels of non-executives and hired external contractors whom may not be familiar with aircraft maintenance jargons. Feedback information processes are supposed to be comprehensible and convenient for all to warrant personnel's active participation and necessary responses. For this reason, a number of specific, standard aviation safety models and documents will be briefly introduced and further explained on how they are crucial to feedback information.

2.1. "Maintenance Error Decision Aid (MEDA)"

According to FAA, MEDA is what aviation authority inspectors would utilize to examine occurrences which have been presumably initiated from human errors or actions – in this case, aircraft technicians [8]. However, FAA has reiterated continuously that previous aircraft incidents caused by performance errors can always happen because of the possible unique integration of both maintenance personnel errors and errors of the aircraft components which would have not followed or complied with the respective

regulations and audits. With the production of MEDA, it would be professionally expected that similar incidents or errors would not be repeated by anyone in any possible form [3] as being normal human beings, it is natural for anyone not to cause even the slightest injuries, let alone casualties and catastrophes with aircrafts. The widely-known MEDA's five sections and their respective processes would then become one of the primary fundamental knowledge that every aircraft maintenance personnel must memorize by heart and comprehend to the fullest.

As for focusing on aircraft design improvements, two Sections; 3rd for Maintenance Error and 4th for Contributing Factors Checklist, are particularly vital because these would tailor specifically to aircraft designing. An obvious problem would be aircraft designers would not be able to study the massive amount of information regarding the intended aircraft parts gathered through MEDA in the amount of time they would normally get, especially with the constant pressure by aircraft buyers to have their aircrafts ready within the stipulated deadlines. Hence, certain parties need to cooperate in reducing the complexity of many elements in MEDA sections. Civil Aviation Authority (CAA) for instance, did introduce feedback information initiatives for MEDA sections related to making aircraft designing procedures effective. The initiatives were:

i. Consolidate aircraft repair data in a way that it would also assess technicians' performance aspects of maintenance
ii. Integrate maintenance community with psychological elements
iii. In respect to ii., the concern of assessing human errors must be done in a more analytical approach; which is why relevant management personnel must develop proper assessment methods and tools – not just some paper-based forms

2.2. "Maintenance Error Management Systems (MEMS)"

Another familiar system regulated by CAA is MEMS which has been explained thoroughly in their database [5]. With the primary structures of answering questions "*What happened?*", and "*Why did it happen?*", it would significantly diminish any hopes of repeating the same errors, especially with countermeasures and preventive measures that would have been immediately placed with the results from their study. The actual basis of MEMS is human elements tops the cause for aircraft incidents; this is the ultimate reason why it is popularly adopted by major airline companies' maintenance

departments – to upgrade and enhance their maintenance SOPs in eliminating any possible errors that may occur within their work environments and personnel.

2.3. "Aviation Safety Reporting Systems (ASRS)"

Although the origins of ASRS initiatives have been discussed since as early as 1958, it was only in 1976 that a systematic reporting database was launched. NASA has been proactive in fighting for the justice cause of preventing future aircraft incidents. Being a neutral organization without any authority to enforce any kind of punishments, NASA has been and still provide various forms of assistance for aircraft personnel, ground or air crews alike, to report any incidents or near-incident moments in the name of aviation safety. With the conditions of submissions of information and feedback being absolutely voluntary and confidential at the same time, ASRS is also another widespread platform for feedback information.

ASRS database provides more than sufficient fields and coding to indicate the types of errors, anomalies, components, and even abbreviations for places and times for voluntary submissions to be as detailed as possible [6]. For aircraft designers to enhance their progresses, they can focus on several categories in the reporting database, for instance *AIRCRAFT* (*cabin lighting*, *component*, *problem (581 for design)*, etc.) and *PERSON* (*Function. Flight Crew*, *Function. Maintenance*, etc.). Coming from NASA, every detail submitted would be reviewed and checked vigorously for authenticity before being published for the public viewing in their respective websites. Hence, every data is credible and plays an important role in designing future aircrafts.

2.4. "Air Accident Investigations Branch (AAIB) accident reports"

AAIB made their objectives of "*to determine the circumstances and causes of the accident and to make safety recommendations, if necessary, with a view to the preservation of life and the avoidance of accidents in the future*" and "*it is not to apportion blame or liability*" quite clear in their publications [12] and UK government's

crown-copyrighted website [20]. Aside from fulfilling the compliance with "International Civil Aviation Organizations (ICAO)" standard requirements, it is also another medium for not just aircraft personnel but also the public to view and study on what are the updates of the huge network of aviation-related updates and information. Specifically, AAIB complies on what has been stated in ICAO's Annex 13 – which presents sufficient data on not only worldwide standards, but also relevant SOPs to avoid flight

incidents and of course, updates on how to improvise on upgrading on-board flight crew and passengers to depart and arrive safely. Like any typical assessment by government authorities, AAIB reports audits numerous areas of pre-and-post flight maintenance, piloting and engineering measures taken whilst in-charge of flights, and number of personnel involved at every stage of flight checks. The normally rigorous part would systematically include complete information of aircraft and background of pilots, e.g. previous experience or injuries, recorded number of flying hours, licence and age; for the aircraft, SOP includes knowledge of aircraft type, engines, registration and year of manufacture, airports or countries flown, passenger manifest, etc.

As mentioned, all these information is up and ready for anyone with the means to connect to the Internet. The only problem with these report is these reports are normally huge as they are very detailed; hence the common occurrences of a typical aircraft incident report having a few hundred pages in; usually in printable Document

Format (PDF). Concerning about this particular matter, a researcher managed to develop a calculated answer for simplifying findings of any incident reports, to which he was quoted mentioning, "*the techniques enable analysts to formally demonstrate that a particular conclusion is justified given the evidence in a report. In doing so, it is possible to identify missing pieces of evidence, identify ambiguities and determine which items of evidence are critical to particular lines of argument*" [13].

With "Computer Aided Engineering (CAE)", Johnson supported the required designs of safety-critical implementations which had claimed that the process itself "*helps to ensure that findings about previous failures are propagated into the subsequent development of future systems*". Several years after that in 2004, another researcher has not just studied, but also confirmed that aircraft personnel and people in general do have some sort of faith and belief that AAIB is competent in investigating with not just professionalism but also being neutral in their reports without any form of bias elements. For that, Smart clarified the fact of in order to gain the public's confidence towards AAIB, two significant values must be clearly indicated throughout the entire investigation process: "*quality*" and "*culture*" of the government agency [14].

2.5. "Service Difficulty Reporting Systems (SDRS)"

After many distinguished models introduced by several government-based authorities, it can be seen that most of them had the basis of prioritizing human errors as the primary cause. With that in mind, FAA did another in-depth research before coming up with SDRS. This time, the main area for the database is aircraft service difficulties and not potential human errors or performances. Under FAA's guidance and supervision, all the data submitted would have to be using Form 8070-1 that has specified three separate domains of identification of the equipment affected, describing of the difficulties faced during servicing, and background profile of the personnel submitting all the necessary data [15,16]. Today in 2018, a quick glance through the FAA's website will indicate that the online, query-based system has been significantly updated with every information imaginable regarding any aircraft and part. From the Operator Control number, a submission must fulfil every criteria according to the order (starting with the "*Joint Aircraft Components and Systems (JASC) Code*")before the query can even be run by the online system. Following query requirements show Aircraft make and model, engine make and model, propeller make and model, part name and number, etc. before "P*roblem Description*" can even be filled in.

2.6. "Service Bulletin/Service Letter (SB/SL)"

An additional form of maintenance report in the aircraft maintenance world is "Service Bulletin/Service Letter (SB/SL)" which pinpoints details about adjustment, repair, and alteration of original, factory parts on any aircraft for the sole purpose of betterment of the aircraft's worthiness. SBs can come in different formats and templates according to the respective companies, but several criteria have been shared by many. European Aviation Safety Agency (EASA), for example, has made it official for SBs to be user-friendly, standardized, and prohibit overlapping / conflicting actions [21]. Pertaining to aircraft designs, aircraft companies tend to keep things private and confidential as per stated by aviation authorities, e.g. EASA Part 145 because public exposure of these kinds of documents may instigate negative consequences, for instance possible counterfeit crimes, stealing designs, safety risks, and patent rights. An SL would be produced only if the intended repair work does not require any alteration on the aircraft but only written description; hence a letter would be a sufficient reference for technicians to perform their tasks provided

2.7. "Airworthiness Directive (AD)"

For this particular document, it is more of a notification rather than a feedback information-based query. Being mandatory as it is, aircraft owners, personal or company, must adhere to ADs as they will only be produced after substantiated documents have been studied indicate that certain aircraft is not airworthy, hence strictly prohibited from flying. With that, only certain national civil aviation authorities can issue ADs to whoever's concerned. According to FAA, there are three types of ADs that can be possibly issued to aircraft owners [22]:

i. "*Notice of proposed Rulemaking (NPRM)*"
ii. "*Final Rule*"
iii. "*Emergency ADs*"

Being airworthy or not, it all depends on the physical structures of the aircraft after it has gone through a comprehensive check by regulatory bodies. Usually, ADs are issued after a certain incident and this will initiate more research should the incident affected the aircraft n a unique manner that it has never been recorded before. Hence, newer designs will cater not only for the actual function and efficiency for the aircraft, but also in terms of sustainability and toughness quality to resist possible damages from certain types of incidents, e.g. extreme weather conditions or pollutions. One potential problem from the perspective of an aircraft designer would be the difficulties in gaining more information about aircrafts being handed with ADs as they are directly issued to aircraft owners and thus, private and confidential policies are in place.

2.8. "Other sources of feedback"

Besides the abovementioned systems and documents, there are indeed more valid and reliable options in retrieving specific information for improving aircraft design purposes. Designers first need to consider opting for "*Monitoring Systems (MS)*", which are readily available even in less-developed countries. While the term MS is more often associated with medical technology, casual conversations in aircraft hangars or workshops would always be lauded with aircraft technicians always being jokingly called "*aircraft doctors*" or "*plane's nurses*" as they are fully responsible for the aircraft's health – or airworthiness, in a proper term.

Typically, MS would consist of two familiar domains; electronic and computer parts. During the actual monitoring processes, one could observe that MS conveniently indicate many comprehensive information in the forms of coding and signs which would notify aircraft personnel whether the aircraft monitored is ready for take-off or not, together with all the necessary statistics and indexes which will determine othr preventive measures, e.g. number of personnel needed to repair, what kind of tools required, timeline of repair according to maintenance / repair urgency level, etc. not only it will remove any possibility of potential human error, but also improves on work schedules and performances as a whole. MS has now become a fundamental system in any aircraft hangar as it is the wisest choice in ensuring smooth flow in maintaining sustainability and aircraft worthiness besides being indirectly and directly beneficial towards aircraft design research, lowering maintenance cost without disrupting efficiency [18] and minimizing maintenance work scheduling time [19]. However, the extent to which the information is used and its contribution to future product development is still not clear. This information has to be channelled or transformed into better information for the designers to make adjustments and also future improvements. Currently in 2018, modern globalization and technology have contributed to the plethora of aircraft MS types, ranging from the major-sized to the smallest aircraft parts e.g. "*Wearable Bio Signal Monitoring Sys-*

tem" [23], "*Non-Dispersive Infrared System*" [24], and many more – all of which were developed and initiated based on the countless, previous studies of aircraft designs.

3. Conclusion

This paper attempts to persuade the importance of utilising feedback information for aviation sustainability. Based on some of the information sources stated and briefly described above, it is hoped that more research in aircraft maintenance will be done to improvise not just in the aspect of designing future aircrafts and betterment of aircraft repair procedures, but also designing new parts to preserve the current aircrafts being used – which will benefit many airlines with their current aircraft fleets and financial standings.

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