STUDY ON THE IMPACT OF AIRCRAFT AGE ON FLIGHT SAFETY FOR A MEDIUM COURIER TURBOPROP AIRPLANE

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Abstract: *This paper introduces the connection between old aircraft and flight safety as well as the present state and potential futures for managing old aircraft. Age can be managed in two ways: retiring the aircraft and buying a newer one, or properly sustaining aging aircraft through additional and targeted maintenance. To do this, manufacturers, maintainers, operators, and owners must work together with regulators. A good way to guarantee proper maintenance is through continuing airworthiness programs and supplemental inspection programs. While the effects of aging on an aircraft can be detrimental to safety, they can be reduced with proper maintenance. If the operators follow the maintenance programs, current and future maintenance programs will operate as a preventative strategy to lessen the safety risk associated with aging aircraft.*

Keywords: *aviation, critical parts, flight safety, turboprop aircraft, maintenance, reliability*

1. INTRODUCTION

This study looked at present and potential strategies for guaranteeing the flight safety in front of aging aircraft as well as to reveal the relationship between aging aircraft and flight safety. Existing research on aircraft age was analyzed in light of safety, reliability, and statistical information. [1]

The age of an airplane cannot be determined by a single factor. The chronological age, the number of flight cycles and the number of flying hours all affect how old is an aircraft. The fact that different aircraft components age differently based on these factors makes figuring out the aircraft's age much more difficult. Certain aging processes, including fatigue, are brought on by cyclic or recurrent loading. Aircraft wings, pressurized sections, and other structural components will become fatigued as a result of flight cycles. Other processes, such degradation, corrosion, and wear, will take place over time. [2] These aging mechanisms pose a serious safety risk if they are not controlled.

Given the aforementioned factors, it is challenging to compare transport aircraft between each other. To determine if an aircraft is old, all of these variables must be taken into account. Other elements may also have an impact on how quickly aircraft age. These include the type of the aircraft operations, like the tactical flights with high maneuverability requirements, the operating environment and the maintenance on the entire system life-cycle. [3]

2. HYSTORICAL ACCIDENT RELATED TO AIRCRAFT AGE

Since the age and operating histories of the aircraft became available, MIT International Center for Air Transportation (ICAT) did a historical analysis of aircraft accidents occurring between 1959 and 2012 for transport aircraft with an MTOW larger than 60,000 lbs. According to the data, there is no relationship between the likelihood of fatal accidents and aircraft age up to 27 years old. The fatal accident rate did somewhat increase above this age, but due to the older aircraft generations' short operational lifespan, the accident rate data is not statistically significant. [4]

Worries about the safety of aging air transport aircraft due to corrosion, fatigue, or Widespread Fatigue Damage (WFD) increased following the dramatic in-flight catastrophic decompression of Aloha Airlines Flight 243 in 1988. As it approached cruise altitude, the Boeing 737-200 aircraft experienced an explosive decompression. The cabin skin and supporting structure of the cabin separated from the airplane by around 5.5 meters, which caused the decompression. Despite suffering severe structural damage, the aircraft made a safe landing. One flight attendant, however, was fatally hurt during the decompression when she was swept from the aircraft. [5]

FIG. 1 Aloha Airlines flight 243 [5]

The aircraft which was involved in the disaster, was 19 years old and made 89,680 takeoffs and landings with an average flying length of 25 minutes. The majority of the aircraft's operational life had been spent flying between the Hawaiian Islands, subjecting it to an extremely corrosive environment. The design of one particular joint (or skin splice) utilized in the fuselage's construction was another factor. In addition to riveting, the junction was cold-bonded with an epoxy-impregnated scrim fabric. Instead of passing the pressure loads through the rivets, the cold bonding was intended to distribute them uniformly over the joint.

Due to this tragic catastrophe, industry became aware of the dangerous interaction between corrosion and fatigue and were launched a series of researches and regulations with the aim of diminishing the possibility of a new case.

3. ANALYSIS OF THE RELATIONSHIP BETWEEN FAILURES AND AGE FOR A MEDIUM COURIER TURBOPROP AIRPLANE

It is required to separate the aircraft into its systems in order to assess its overall reliability. The systems of an aircraft can then be divided into subsystems and then components. As an airplane ages, its various parts perform in a different way. As a result, each of these components' dependability needs to be evaluated separately. [8]

Component reliability can be predicted during design or determined from in-service failure data. It is vital to ascertain how the components interact to construct the system after each component's reliability has been proven. Knowing the system and the component failure rates is necessary for this process, which can be highly complicated. The wear-out phase begins as an aircraft reaches the end of its useful life. As components will have variable failure rates throughout this period, establishing reliability will be significantly more difficult. [9]

The components of an airplane are also regularly upgraded and replaced when they become worn out. Another component will now have the chance to reach the end of its useful life. This component will thereafter be changed or have its lifespan increased. When further extending the aircraft's life becomes uneconomical, the cycle of upgrading and replacing components will stop.

Fatigue and corrosion are the two main mechanisms that cause aircraft to age. In addition to the wiring, flight controls, powerplants, and other components, these operations typically have an impact on the structure of the aircraft. It is possible for corrosion and fatigue to operate separately or in tandem. In comparison to either process acting alone, the combination between corrosion and fatigue can accelerate aging.

Corrosion is a way that metal breaks down over time. Corrosion usually hurts the structure of an airplane, but it can also hurt electrical connectors and wires that control flight. [10]

A small fracture that appears at a site of high stress, such as a hole, notch, or flaw in the material, usually serves as the starting point for fatigue, also known as wear out. The crack will then deepen when further loads are applied. If the crack is not found and fixed, it will gradually enlarge to a critical size and fail at loads far below the material's initial strength.

The number of flight cycles, the number of flying hours, and the relationship between repetitive loading and fatigue crack propagation are all related to fatigue-induced aging. The majority of structural components, including the wings, fuselage, and engine(s), are among the aircraft parts that are prone to fatigue. [11]

For pressurized aircraft, flying sector length affects fatigue. Due to pressurisation, an aircraft structure expands as it climbs and contracts as it descends, causing fatigue. Thus, pressurisation cycles matter more than pressurisation time.

In order to find out the connection between failures and age for the subject turboprop medium courier aircraft, I analysed during two years of operating, 2018 and 2019, two airplanes, generically named as Aircraft A and Aircraft B. In this period, each aircraft flew about 1400 hours.

I prepared a centralized situation and I noticed a total number of 308 defects, of which 170 for aircraft A and 138 for aircraft B. During the study it was found that most of the defects were observed by the pilots during the flight, namely 190, of which 94 on aircraft A and 96 on B, while on the ground, the technical team of the aircraft found 118, 76 at aircraft A and 42 at aircraft B.

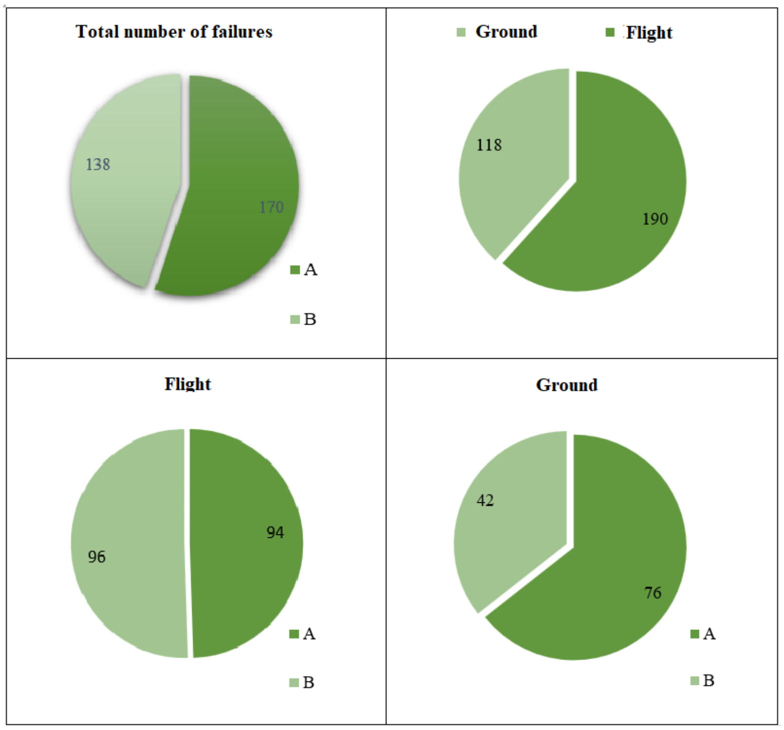

FIG. 2 Classification of defects

Out of the total of failures, were identified 21 system malfunctions, found mainly in the fuel correction and control system (TD), the negative torque detection system (NTS), but also in auxiliary equipment installed on the aircraft (lighting systems , door locks, etc.), 15 defects caused by open circuits or imperfect contacts, 15 defects due to clogging of filters or systems, 10 situations of pressure loss due to loss of tightness in the case of shock absorbers on the landing gear, parts of the entire hydraulic installation, or the parking brake, 10 situations of pressure loss due to loss of tightness in the case of shock absorbers on the landing gear, parts of the entire hydraulic installation, or the parking brake, 9 situations in which the deposits of impurities caused defects in the brake blocks, the air conditioning system and in the transmitter of the quantity of oil from the engine.

And, the most crucial information to be observed is that material failure, probably because of fatigue, accounts for 235 out of 308 incidents of faults, which suggests that the age of the aircraft may be a contributing factor. [12]

In the following paragraphs, I will classify the defects by system categories and explain the causes of their occurrence, the effectiveness of the failure detection methods and the possible ways to reduce the failure rate.

3.1. Failures of aircraft structure components

Out of a total of 54 incidents, 26 of the structure's components failures were discovered during the preliminary flight preparation (Fig. 3, a). It should be emphasized how effective are the preventive maintenance and monitoring system.

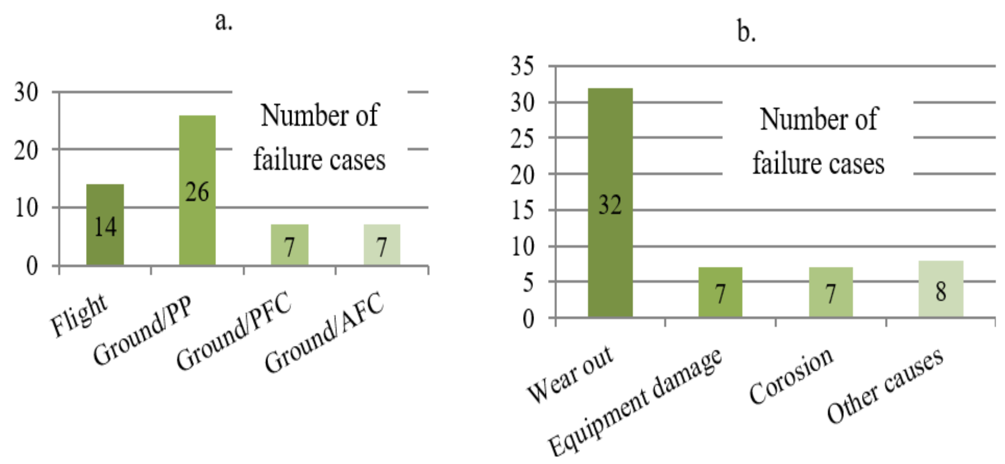

FIG. 3 Data associated to structure components failures – place/ type of preparation where these were discovered (a), causes (b)

According to 32 out of 54 cases (Fig. 3, b), fatigue is the primary cause of problems, most likely as a result of aging and vibrations that impact the cell and its aggregates. In most circumstances, the system monitoring techniques currently in use are adequate to identify errors before they materialize. In some cases, the defects are caused by the relatively low reliability of the parts, but this can be increased by replacing them with other components more reliable and lead to a decrease in the frequency of defects, even involves additional costs.

3.2. Failures of aircraft engine components

The charts (Fig. 4, a, b) show that the majority of failures happened during the flight and were primarily brought on by clogging of the injectors and filters (from the lubrication system, fuel, and hydraulics), which supports the idea that preventive maintenance and monitoring systems in technical systems of the engine type are not carried out to their full potential. Another crucial element is component wear, which is partly expected given their age and the stress of strong vibrations and temperatures inside/outside the engine, which have a significant impact on them.

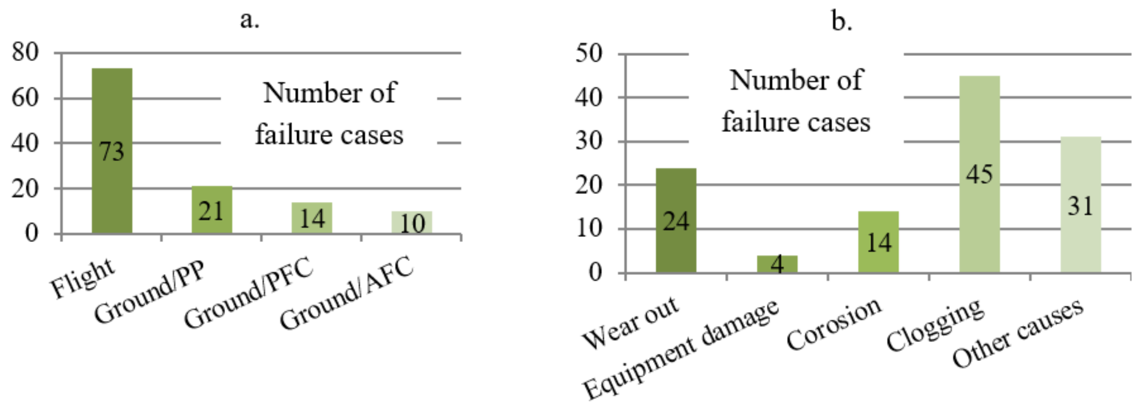

FIG. 4 Data associated to engine components failures – place/ type of preparation where these were discovered (a), causes (b)

Similar to the analysis for structural technical systems, the analysis for engine-type systems necessitates the identification of components with a high risk of failure and their replacement with others more reliable in order to assure adequate maintenance.

By applying predictive and statistical detection techniques, creating databases with flaws detected in the operation and highlighting the development of new defects, preventative measures will be simplified in order to lower the likelihood of failure.

3.3. Failures of aircraft radio components

When examining the factors that contribute to failures, it can be seen in Fig. 5 that wear accounts for the vast majority of issues, accounting for a higher percentage than other specializations. Given their age, radio parts are susceptible to vibrations with large amplitudes and prolonged exposure.

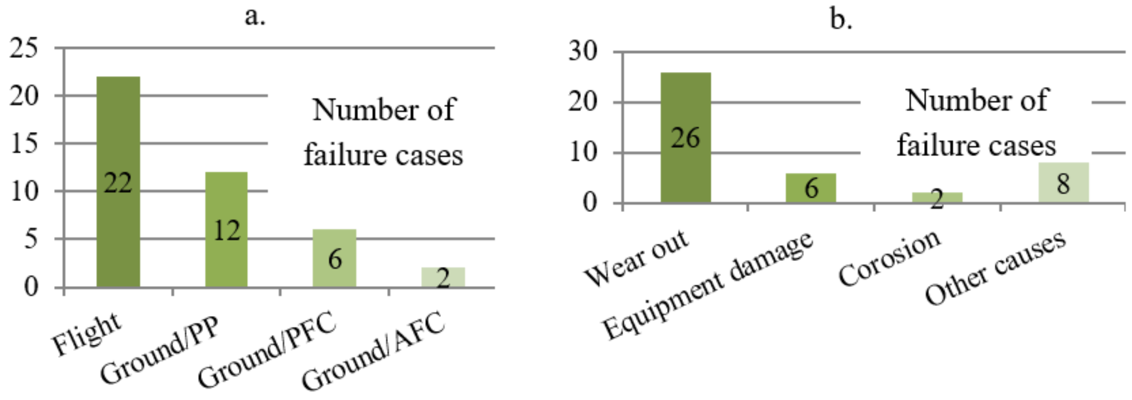

FIG. 5 Data associated to radio components failures – place/ type of preparation where these were discovered (a), causes (b)

The rule of improvement is upheld for the aircraft radio components as well, optimizing them by lowering the frequency of failures in most circumstances. This can be affected by locating the aggregates that are vulnerable to damage, wear, corrosion, moisture, etc. and by replacing them with others that have higher reliability. In order to be able to recognize the components with poorer dependability in the structure of the aggregates, detection methods can also be improved by specializing maintenance personnel.

3.4. Failures of aircraft special systems

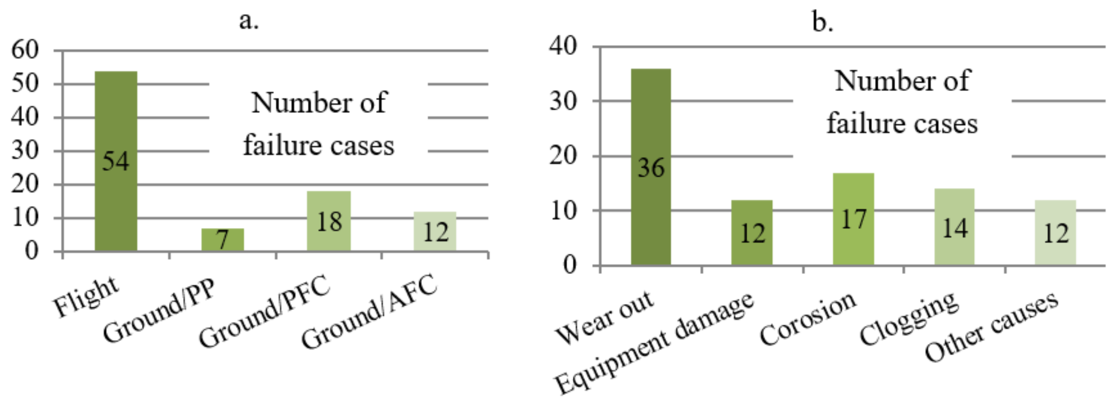

FIG. 6 Data associated to special systems failures – place/ type of preparation where these were discovered (a), causes (b)

The chart (Figure 6) shows that approximately 60% of the problems were discovered during flight, which is similar to the outcome for radio-type systems since some aggregates, like the wing and empennage deicing installation, don't begin operating until the aircraft is in the air. Preventive maintenance and the monitoring system are effective, as about a third of the faults were found during initial setup and pre-flight inspection. Therefore, streamlining preventive measures is required to lower the incidence of inflight failures.

Once more, wear is the primary cause of failures, especially given the age of the aircraft and its aggregates. Appropriate actions can be taken to impact this by identifying the aggregates that are most susceptible to wear or corrosion and replacing them with more current ones and more advanced technically.

CONCLUSIONS

At the beginning, aircraft were made to meet structural airworthiness standards for an indefinite amount of time. But at the end of the 20th century, several accidents led to an international effort to deal with problems caused by old airplane structures. The reviews that followed found a number of places where structural maintenance programs needed to be improved to make sure that older planes could still fly.

Ensuring that an aircraft's structural integrity is maintained throughout its service life is fundamental in controlling aviation safety. Maintaining an aircraft requires, beside the corrective unscheduled maintenance necessary to restore the original state of a defective system, also regularly scheduled maintenance. This type of maintenance involves investigating the structure for fatigue and corrosion, replacing life-limited components, and fixing general wear and tear. Depending on national or international requirements for a specific aircraft, maintenance schedules will vary.

Also, because age increases the complexity of an aircraft's maintenance, additional maintenance will be required in areas where fatigue or environmental deterioration has been observed to be greater than anticipated. This extra maintenance can be included in Supplementary Inspection Programmes, that should be implemented once an aircraft reaches a predetermined number of flights or hours. This programmes include additional maintenance duties and are a component of the manufacturer's maintenance guide, that specifies where to check for cracks, the equipment to be used, and the frequency of inspections.

Finally, managing aging aircraft can be accomplished in two ways: additional maintenance programmers or retirement. If maintenance programs are selected, they must be comprehensive and take into account the effects of aging on the specific aircraft model. As presented in the main part of the article, the existing preventive and corrective maintenance methods used for the subject aircraft, were sufficient to detect faults before they occur, in most of the situations. But it is important to remember that as an aircraft ages, the danger of a catastrophe rises alongside the increasing costs of maintenance.

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