Use of Aircraft Engine Type and Quantity and their Impact on Air Transport Safety

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Abstract

Air transport is the safest way to transport people and goods in the world. Aviation has gone through many years of technological development to ensure that transport takes place not only quickly but also safely while maintaining the highest safety criteria. Over the past 50 years, jet engines have replaced older piston and turboprop engines in passenger and cargo air transport. At the same time mostly, aircraft starting began to be produced with two engines compared to previous older models that had three or more engines. This paper deals with the analysis and investigation of the influence of the use of the engine type and its number on aircraft in relation to air disasters (air safety).
KEY WORDS: *air transport, engines, safety, air disaster*

1. Introduction

Air transport is a very fast developing transport industry, which is also considered to be the safest. More and more passengers are transported every year, resulting in an increase in aircraft movements, which puts a heavy burden on maintaining a high level of aviation safety. However, there are air accidents or air incidents that will negatively affect of all aviation safety statistics. If a large aircraft, such as a Boeing 737 or Airbus 320 part of air catastrophe is always very closely monitored by the media and there is a big pressure on investigators to explain the causes of the accident and incident.

In general, identifying the causes of air accidents and air incidents contributes to increased air safety. Based on the identified causes procedures and manuals are created (modified) and pilots, aircraft maintenance and air traffic control must use these safety measure.

2. Safety in air transport

Safety is an essential aspect for assessing air traffic [1]. Aviation has two concepts of safety and security [1]. Safety is „the state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level" [2]. Security is the protection of air transport from unlawful acts (terrorist attacks) [3]. In this article, attention is focused on the safety section.

Government and non-governmental organizations address the issue of safety regulations and manuals and each of these organizations takes care of a certain component of safety. Below are the basic organizations operating in aviation.

- ICAO – The International Civil Aviation Organization.
- EASA – The European Aviation Safety Agency.
- EUROCONTROL – The European Organization for the Safety of Air Navigation.
- IATA – The International Air Transport Association.

Table 1 shows the number of air accidents and the number of fatalities over the last 10 years registered by ICAO. Table 1 shows that the number of accidents in the last 10 years has dropped almost to half, but in 2017 there were still 88 accidents that is a large number in aviation [4,5]. What is positive is that the number of fatalities from these accidents has dropped significantly [4,5]. At the same time, table 1 shows that the number of passengers carried has doubled over the last 10 years [6], and so there is increasing pressure for aviation safety.

Table 1

Influence of air accidents and fatalities on carried air passengers

Years	Number of Accidents	Number of Fatalities	Air Transport Passengers Transported (in trillion)
2008	138	524	2,208
2009	113	670	2,250
2010	121	707	2,628
2011	126	414	2,787
2012	99	388	2,894
2013	90	173	3,048
2014	98	904	3,227
2015	92	474	3,464
2016	75	182	3,696
2017	88	50	4,100

Based on the statistics presented in Table 1, a correlation was made to show whether the number of air accidents and the number of fatalities affected the demand for air transport. The correlation coefficient is calculated based on the formula below [7]:

$$r_{12} = \frac{\sum x_{1i}x_{2i} - \sum x_{1i} \sum x_{2i}}{\sqrt{[n\sum x_{1i}^2 - (\sum x_{1i})^2] \times [n\sum x_{2i}^2 - (\sum x_{2i})^2]}} \quad (1)$$

where *n* – number of pairs of data; x_1, x_2 – examined variables.

Correlation coefficient is used to measure the tightness of dependence between variables. Direct linear relationship exists between variables if the value of the coefficient equals to 1. Value minus 1 indicates the exact opposite, indirect linear relationship. Linear independence of variables exists if the correlation coefficient is zero [7]. The correlation coefficient between air accidents and the number of passengers carried is **-0,827**, this is probably indirect dependence. No dependence exists between the number of fatalities and the number of passengers carried, because the correlation coefficient is **-0.568**.

The test statistic that will finally confirm causal relationship between the variables is given by the following formula [7]:

$$t = \frac{r_{12}}{\sqrt{1 - r_{12}^2}} \times \sqrt{n-2} \quad (2)$$

where r_{12} – correlation coefficient; *n* – number of pairs of data.

After calculating the t value, it is necessary to know the critical field for dependency. Statistical tables state that the value of 2,306 is a value that indicates this critical field at 5% error tolerance [8]. The *t* value is **-4,166** between the number of transported passengers and the number of air accidents and is in the critical field. The result is **-1,951** and this value is outside the critical field between the number of transported passengers and the number of fatalities. The test statistic thus proven the indirect dependence between the number of transported passengers and the number of fatalities.

3. Engines in air transport

In air transport, airplanes with piston, turboprop and jet engines are used. The oldest engines are piston engines, which are not used much at present. The use of piston engines was mainly in the first half of the 20th century, where these engines were used for military aircraft.

Turboprop engines are on airplanes that use airliners for the transportation of passengers and cargo, especially for short distances due to lower operating costs than jet engines. The most used aircraft with two turboprop engines is the ATR 72, which has a capacity of 78 passengers, to develop an average speed of 509 km/h with a range of up to 1 528 km [9].

The most commonly used in commercial aviation are jet engines, which are primarily produced by three leading manufacturers of Pratt & Whitney, General Electric and Rolls-Royce. Jet engines have higher operating costs compared to turboprop engines, but they can produce higher air speeds. They are used on larger aircraft with more passengers or cargo and for long distance. The most commonly used Boeing 737, which uses jet engines, transports up to 189 passengers at a travel speed of 842 km/h with a range of up to 5 665 km [10]. The largest airlines have a fleet of aircrafts primarily powered by jet engines, which are complemented by a few types of turboprop aircrafts, as already mentioned to ensure transportation primarily to short lines.

Aviation engines have a major impact on aviation safety and the highest safety requirements are placed on their manufacture and subsequent regular maintenance. It is imperative that engine maintenance is performed correctly and at predetermined operating intervals as specified by the manufacturer. Every airline seeks to minimize its costs, but this should not affect the quality and scope of maintenance work on aircraft engine maintenance [11]. To improve aviation safety, modern jet engines are designed so that, even if one engine fails during a flight, the aircraft can flight of no major changes, but must land at the nearest (suitable) airport for maintaining high level of safety in air transport. However, if all engines fail, it is imperative that pilots be able to land without thrust, all pilots are trained for these situations. The aircraft engine is the second most common cause of air disasters after the airframe [12].

Figure 1 shows the number of air accidents over the last 50 years by engine type [13]. Aircrafts powered by turboprop engines accounted more air accidents until 90's of the 20th Century than jet-powered aircrafts. This fact is, of course, influenced by the fact that, since the 80's of the 20th Century, jet-powered aircraft have been increasingly being produced. These aircraft were immediately put into commercial operation and were used not only to carry passengers but also cargo. From 90's of the 20th Century until now jet-powered aircrafts were included of air accidents more than turboprop engines aircrafts.

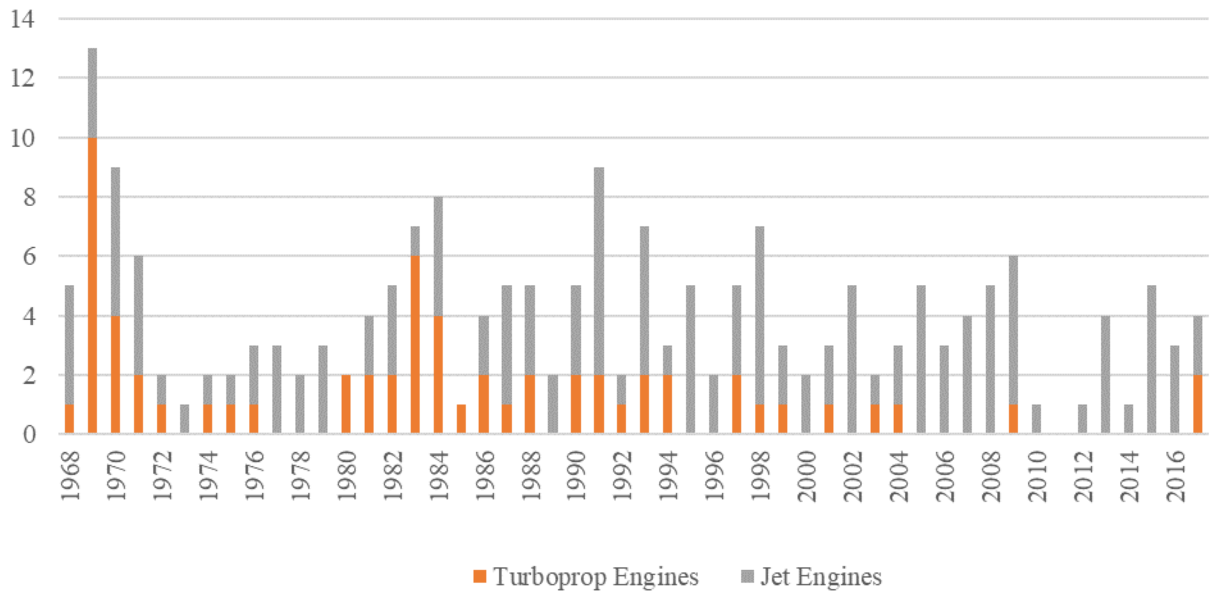

Fig. 1 Trend in air accidents by type of engines for last 50 years

After following figure 1, it is necessary to analysis a more in-depth of these air disasters and focus on the number of aircraft engine. Then the impact of the type used and the number of engines on the aircraft on safety in the air transport can certainly be seen in this analysis.

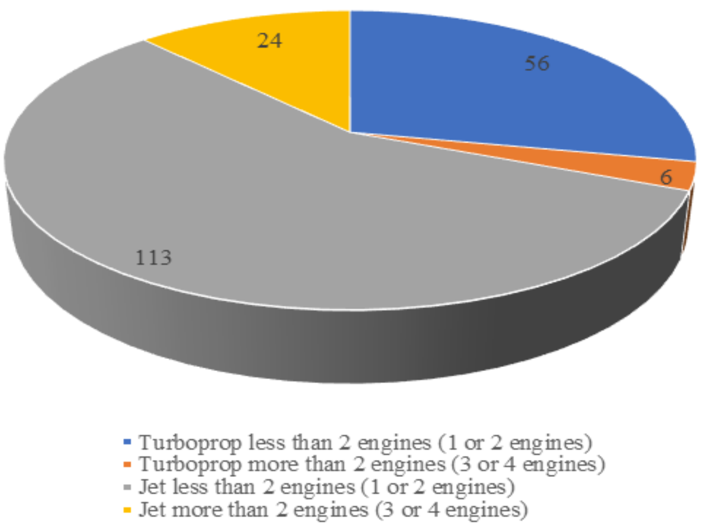

Fig. 2 Number of air accidents by engine types and quantity for last 50 years

Figure 2 shows the analysis of air accidents over the last 50 years [13]. The authors chose two criteria, according to the type of engine and at the same time as the second criterion used the number of engines used on the aircraft. Most airlines use twin-engine aircraft because two jet engines can power big commercial aircrafts (such as the Boeing 777) and for airlines represent lower operating costs than four-engine aircrafts such as Airbus 340, Airbus 380 or older Boeing 747.

It follows from figure 2 that aircraft powered by two jet engines are most often involved in an air disaster. The second group consists of aircraft with two or one turboprop engine, but it is almost half of air disasters than in the first group. The four-engine turboprop and jet aircrafts have less impact on aviation safety than two engines aircrafts. Four-engine included in only 30 of the 199 air disasters.

4. Conclusions

Within analysis of the air accidents over the last 50 years, the authors have focused especially on the number of engines and their kind used on a given aircraft that was part of a given flight disaster. The investigation revealed that over the last 50 years, aircrafts powered by twin jet or twin turboprop engines were in 169 of the 199 air disasters. While the proportion of four-engine, turboprop and jet engines, does not record higher occurrences in these air disasters. It is thus clear that, based on statistical data, four-engine aircraft are more safe than twin-engine aircraft, but the maintenance and operation of four-engine aircraft represents a higher cost for airlines.

Depending on the correlation calculation, which shows that demand for air transport is indirectly dependent on the number of fatalities in air disasters, it is indispensable to constantly increase aviation safety and avoid air disasters completely, especially on jet-powered aircrafts because they can transport more passengers than turboprop aircrafts.

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