Causes of Aviation Accidents and Incidents Especially with Engine Failure

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Abstract

Air transport is the safest and the most dynamic mode of transport but there are errors that can lead to aviation accidents or incidents. This paper deals with explanations of basic concepts in the field of aviation safety, states organizations that are involved in ensuring the safety of the aviation industry, including Safety management system. The main idea of this article is to analyze the causes of air accidents and incidents during the ten-year period, especially focusing on the causes of aircraft engine failure. Based on the identified primary causes of aircraft engine failure, authors propose measures that ultimately lead to increased safety in aviation.
KEY WORDS: *air transport, safety, aviation accidents, aviation incidents, engine failure*

1. Introduction

Air transport is the youngest and fastest growing transport sector in the world. In recent years, air traffic has seen a significant increase in transport performance, as safety and short transport times are generally known advantages of air transport. Large investments in the aviation industry have spent on discovering new technologies or innovating older technologies to improve aviation safety but there are still new air accidents and incidents that need to be eliminated in the future. To avoid the occurrence of aviation disasters, it is first and foremost necessary to thoroughly analyze the primary causes of aviation disasters that have already occurred and subsequently introduce different safety measures.

2. Safety in air transport

Safety is the main indicator of air transport quality. Several governmental and non-governmental organizations are involved in the operation of air transport. In general, these organizations seek to increase reliability and, above all, aviation safety. However, they also deal with other activities that are necessary for the efficient operation of air transport, including aeronautical regulations and standards, advocating the interests of airlines worldwide, the economic and environmental sustainability of the whole aviation sector, aircraft and staff certification. The main organizations include ICAO, EASA, EUROCONTROL, IATA.

In aviation legislation are listed two concepts of terminology of air transport safety. Security is the protection of air traffic from unlawful acts, for example before terrorist attacks [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].

Efforts to continually improve the level of aviation safety resulted in the creation of a Safety management system in 2013. All aspects of the Safety management system are defined in Annex 19 (guidance is available in the Safety management manual) issued by ICAO [2].

For all civil aviation subjects the deployment of the Safety management system is mandatory and should be integrated into an organization's entire management system to describe its structure and scope, available resources, employee responsibility and decision-making across the organization [3]. For all operators and organizations are essentially identical basic principles of the Safety management system, as well as its structure and content. Differences in Safety management system arise about the size and complexity of organization and the risks unique to the operation [4].

To maintain an acceptable level of civil aviation safety, each State is required to establish a State safety programme, under which it is for each service provider to establish a Safety management system under the jurisdiction of that State. The State safety programme includes the following chapters:

- state safety policy and objectives,
- state safety risk management,
- state safety assurance,
- state safety promotion [2].

In the context of air safety, most people speak at a time when an air accident or an air incident occurs, notably in air passenger transport. Here, aviation terminology also distinguishes between air accident and incident. Air accident is „an occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

- a person is fatally or seriously injured,
- the aircraft sustains damage or structural failure,
- the aircraft is missing or is completely inaccessible“ [5].

Air incident may impair the safety of air traffic operations and is associated with the operation of an aircraft [5].

3. Aviation accidents and incidents

In aviation is dedicated great attention of air accidents and incidents to increase safety. If such an event occurs, it is imperative that air accident investigators remove the primary cause in the shortest possible time to prevent these causes in the future. For investigation of air disasters, ICAO issued an Annex 13 – Aircraft Accident and Incident Investigation.

All data on air accidents and incidents are carefully recorded by aviation organizations but everyone records these data for their specific purposes. The ICAO records data in general for aviation and therefore it is possible objectively to monitor the development of serious air accidents and the number of related injuries for all.

Figure 1 shows the development of air accidents and the number of fatalities registered by ICAO [6,7]. Figure 1 shows that the number of air accidents variate each year, including the number of injuries, but in 2007 values are more higher than in 2016 [6,7]. The exception is the year 2014 where there was a large increase in deaths relative to death in other years, but this was mainly due to the disappearance of Boeing 777 by Malaysia Airlines 8 of March 2014, where 239 passengers were on board and Boeing 777 Malaysia Airlines 17 of July 2014, where 298 passengers were killed. It is clear that only two air accidents out of 98 will caused two-thirds of total passenger deaths in 2014.

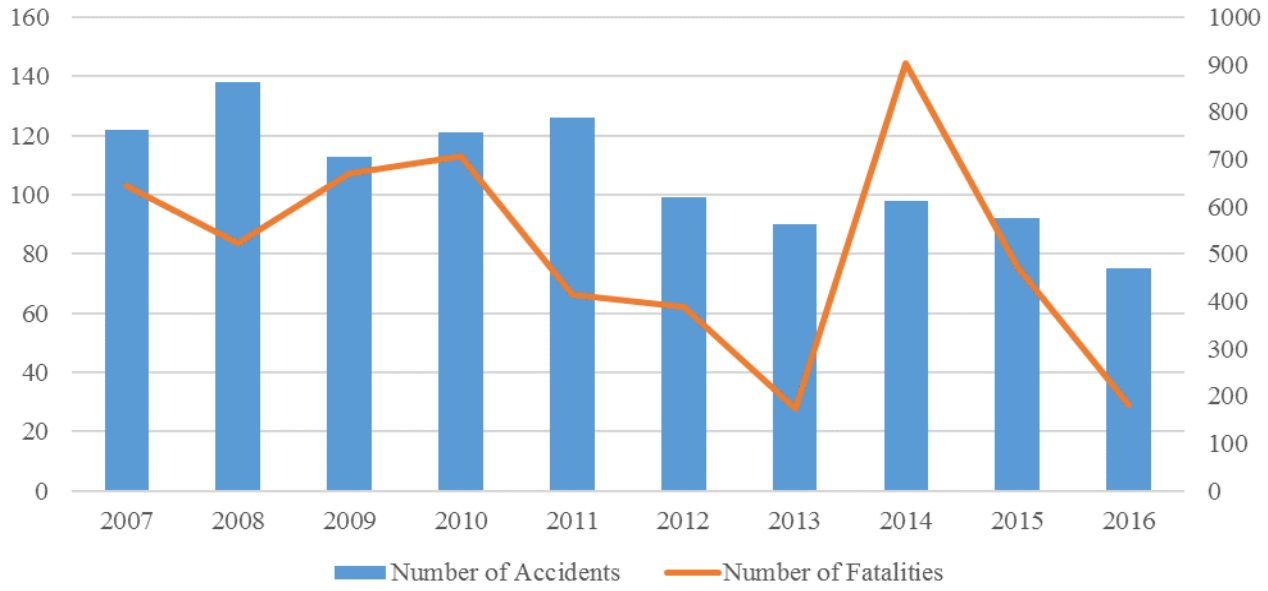

Fig. 1 Trend in aviation accidents and fatalities within ICAO

In connection with air accidents and fatalities, it is important to note that the development of passengers transported is constantly increasing, as can be seen in table 1 [8]. It is necessary to determine whether dependence exists or not between air accidents and fatalities and the number of transported passengers. For confirmation the dependence, the authors made a correlation based on the values show in table 1.

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)
2007	122	645	2,209
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

Based on the correlation, the correlation coefficient between the number of transported passengers and the number of air accidents is **-0,867**, this means that there probably is an indirect dependence. For the number of transported passengers and the number of fatalities, the correlation coefficient is **-0,410**, there is no dependence. To confirm these results, it is important to use the test statistic namely the t-test according to the following formula [9].

$$t = \frac{r_{yx}}{\sqrt{1 - r_{yx}^2}} \times \sqrt{n-2} \tag{1}$$

here R_{yx} – correlation coefficient; n – range of data.

Critical field is given by inequality $| t | > t1\text{-}a / 2$, according to statistical tables it is 2,306 at the most commonly used 5% permissible error. It can be argued that between the number of transported passengers and the number of air accidents the t value is **-4.910** and is in the critical field. For the number of transported passengers and the number of fatalities the result of the test is **-1,272** and this value is outside the critical field. [9], [10]. The test statistic thus proven the indirect dependence between the number of transported passengers and the number of fatalities.

3.1 The James Reason Swiss Cheese Failure Model

The occurrence of aviation accidents or incidents can be caused by a variety of causes. To prevent the occurrence of the causes of aviation disasters in future, it is necessary to identify these causes. James Reason developed the Swiss-Cheese model, which illustrates that accidents usually involve successive breaches of multiple system defences. These breaches can be triggered by a few various factors such as equipment failures or operational errors [11]. The James Reason Swiss Cheese Failure Model is shown at the figure 2 [11].

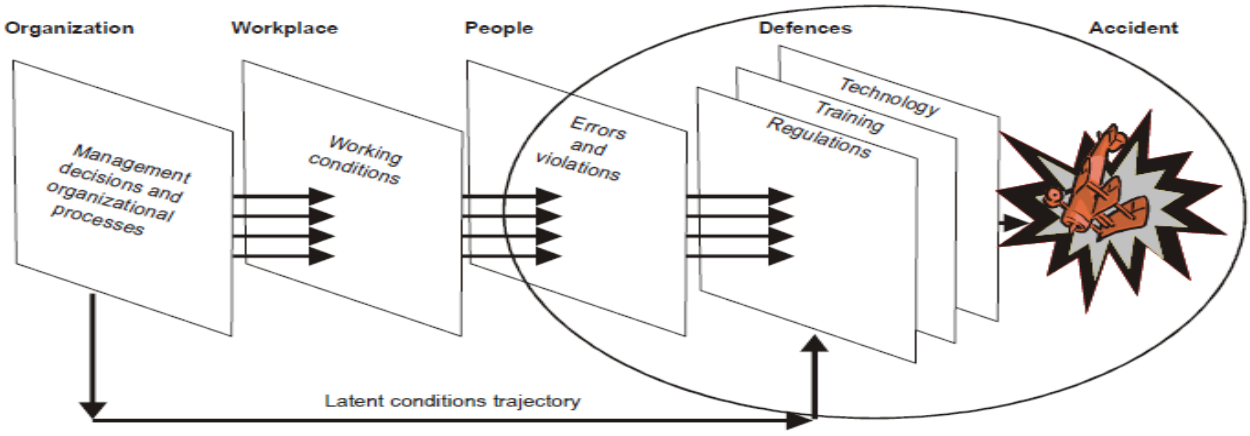

Fig. 2 The James Reason Swiss Cheese Failure Model

The model proposes that all accidents include a combination of active failures and latent conditions. Active failures are actions or inactions, including errors and violations, which have an immediate adverse effect and are

generally associated with front-line personnel (pilots, air traffic controllers, aircraft mechanical engineers, etc.). Latent conditions are those that exist in the aviation system before a damaging outcome has happened. The consequences of latent conditions may remain dormant for a long time. Initially, these latent conditions are not perceived as harmful, but will become evident once the system's defences have been breached (lack of safety culture, poor equipment or procedural design, conflicting organizational goals, defective organizational systems or management decisions) [11].

3.2 Common causes of aviation accidents and incidents

Air accident statistics began to be recorded around the middle of the 20th century. It was important to record the primary cause of an air crash. Since several primary causes of air accidents can be recorded, they are divided into groups. As mentioned above, each organization records data and then breaks it into groups primarily for its needs. The authors of the article drew statistical data from the aviation safety website, as there is a very clear arrangement of groups. There are recorded all accidents including incidents from all airlines, including smaller aircraft carrying fewer passengers.

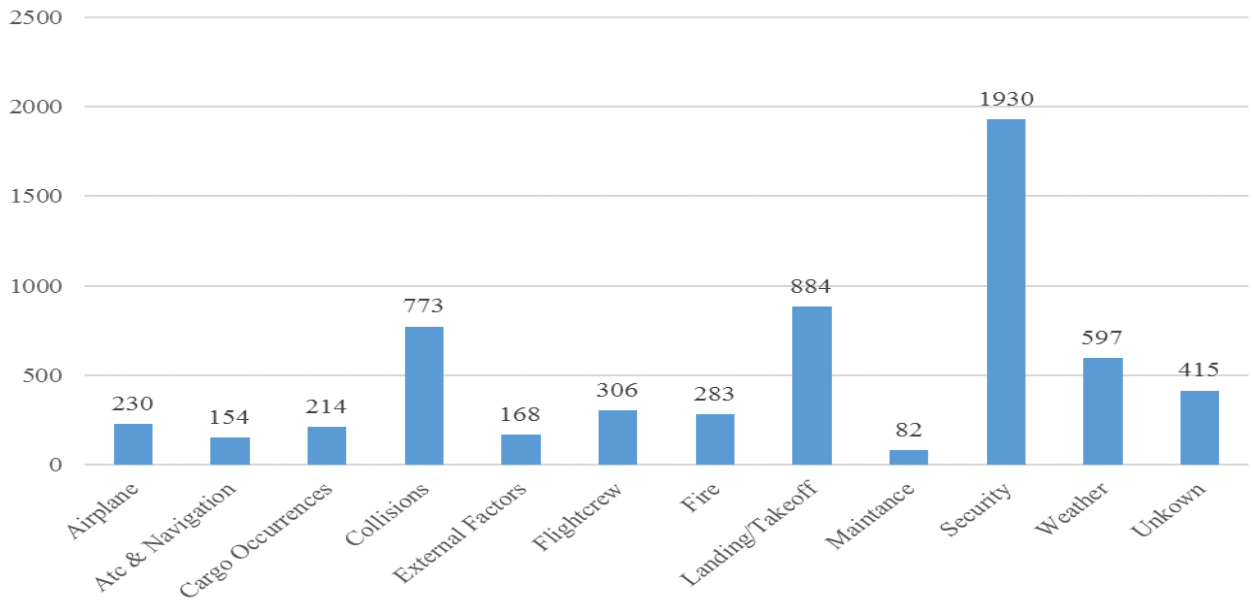

Fig. 3 Common causes of aviation accidents and incidents

Figure 3 shows that there are 12 groups of causes of air accidents and incidents, but 11 of these groups are part of safety and only one part of security [12]. It can be argued that part of the security caused accidents and incidents considerably less than the rest of the safety groups. There were 1 930 special events in the security area, but the safety had 4 106 special events. The authors mainly deal with the causes of engine failure of the aircraft. These are causes belonging to the Airplane group (safety).

3.3 Engine failure as a cause of aviation accidents and incidents

Engine development is not over because airlines produce a lot of pressure on engine manufacturers not only because of their reliability in operation but also because of the economic aspect. The engine can save a large proportion of aviation fuel and each flight made with these engines saves a significant portion of the cost of an airlines, particularly large Boeing and Airbus commercial aircraft. It could be reasons why engines still can cause a problem with safety in aviation.

From a safety perspective, it can be seen in figure 4 that the engine is the second most common causes of airplane accidents and incidents, these data are for the period 2008-2017. Airframe failure recorded higher values than engines, but the air crashes caused by the engine will have higher financial consequences for the airlines than the airframe failure [13].

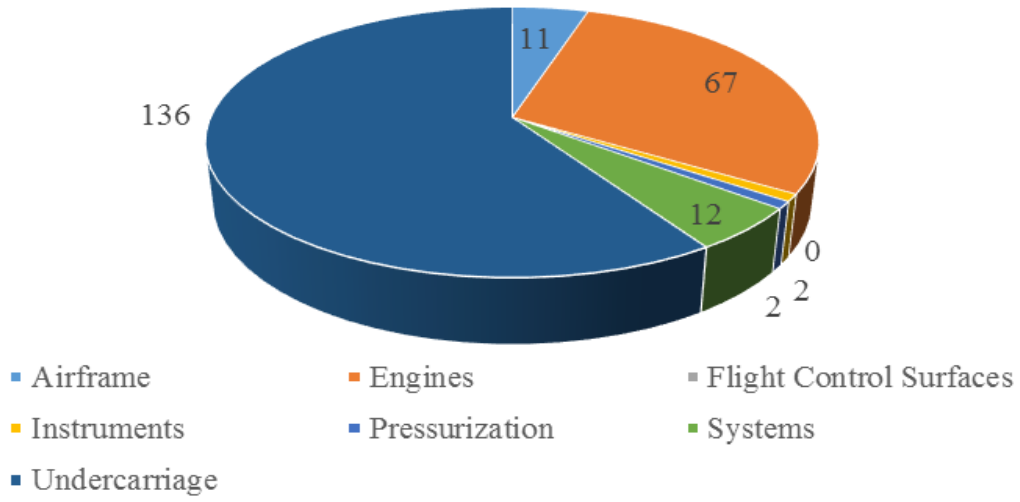

Fig. 4 Airplane causes of aviation accidents and incidents

During the last ten years (2008-2017), 67 air accidents and incidents caused by an aircraft engine can be recorded. The statistics in figure 5 show that failure of all engines is main of the engine causes [13]. For multi-engine aircraft, it is not a big problem to fly with one inoperable engine and then do emergency landing on close airport but in case of a failure of all engines the aircraft becomes very difficult to pilot so it is necessary to avoid this cause. Of course, this problem concerns rather smaller aircrafts that fly commonly with one engine, in large transport aircraft that have two or four engines this occurrence is very exceptional.

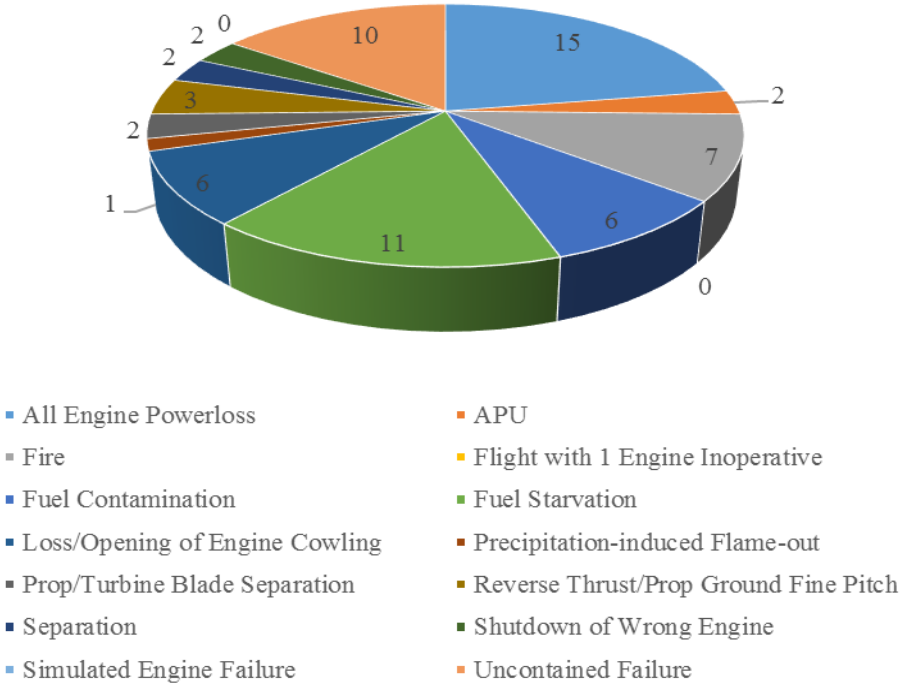

Fig. 5 Engine failure causes of aviation accidents and incidents

Fuel starvation and Uncontained failure are other very important causes, which have high number in the occurrence and they can assure the failure of the aircraft engine. Fuel starvation should eliminate the safety practices of airlines and engine manufacturers who accurately define when it is safe to fly or when it is necessary landing or refueling, which could be deplete from the tank faster (such as a strong head wind) during a flight. However, if a critical condition occurs when fuel levels are low in aircraft tanks, sophisticated computer (build in aircraft) warn crew of an aircraft, especially in large aircraft. If the fuel is depleted and the engines stopped, it is a mistake caused especially by

the crew of an aircraft that does not follow the safety procedures. Therefore, it can be argued that stopping engines due to fuel starvation occurs after overcoming several safety systems (The James Reason Model).

Uncontained failure has been more detected than previous causes, but this statistic has not yet been able to record an increase in the last few months of 2018. Although this cause does not ensure usually a direct stop engine, for example, component separation may damage other parts of the aircraft (including engines) and therefore other important parts that are necessary to control the aircraft. This cause can be eliminated by performing a reliable inspection of the technical competence of the aircraft by trained personnel.

4. Conclusions

Within the identified causes of air accidents and incidents especially with engine failure, it can be argued that for increasing the safety in aviation it is needed to focus on all engine powerloss, fuel starvation and uncontained failure. These causes in the last 10 years most often caused a failure of the aircraft engine. Since the very sophisticated safety procedures and safety features of each component of the aircraft or engine are at a very high level, it is necessary to focus on what the aircraft crew should do when the engine shuts down.

If the engine is switched off on an aircraft, it is imperative that the pilot can continue to pilot the aircraft, even with limited stability. Even though pilots have practicing on flight simulators to pilot an aircraft with an inoperable one or all engine, this training is performed so that these engines are not completely switched off on the simulator but only the thrust of engines pulls down to a minimum. Authors of this article believe that training is not sufficient for pilots, as the complete disengagement of the engines will cause a much bigger problem when piloting the aircraft than just the reduced thrust of all engines (all engines are still running). Recommendations for improving safety in aviation when all engines are turned off would be if the pilots take a fly hours and practicing (for example landing) on an airplane without a motor, in a glider. Only this practical simulation will fully show the pilot how is it possible to pilot aircraft without engines.

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References

1. Nařízení Evropského parlamentu a rady (ES) č. 300/2008 ze dne 11. března 2008 o společných pravidlech v oblasti ochrany civilního letectví před protiprávními činy a o zrušení nařízení (ES) č. 2320/2002 [online cit.: 2018-02-13]. Available from: http://eur-lex.europa.eu/legal-content/CS/TXT/PDF/?uri=CELEX:32008R0300&qid=1518263873061&from=EN (in Czech)
2. Annex 19 [online cit.: 2018-02-13]. Available from: https://www.skybrary.aero/index.php/ICAO_Annex_19,_Safety_Management
3. **Civil Aviation Authority.** 2010. Safety Management Systems – Guidance to Organizations. Safety Regulation Group. Version 3.
4. **Civil Aviation Safety Authority.** 2014. Safety Management System Basics. In Safety management system kit – Booklet 1. 2nd edition.
5. Annex 13 [online cit.: 2018-02-13]. Available from: http://www.emsa.europa.eu/retro/Docs/marine_casualties/annex_13.pdf
6. The International Civil Aviation Organization – Safety Report 2012 [online cit.: 2018-02-23]. Available from: https://www.icao.int/safety/Documents/ICAO_SGAS_2012_final.pdf
7. The International Civil Aviation Organization – Safety Report 2017 [online cit.: 2018-02-23]. Available from: https://www.icao.int/safety/Documents/ICAO_SR_2017_18072017.pdf
8. The World Bank – Air transport passengers carried [online cit.: 2018-02-26]. Available from: https://data.worldbank.org/indicator/IS.AIR.PSGR
9. **Hindls, R. et al.** 2007. Statistika pro ekonomy, Praha: Professional Publishing. ISBN: 978-80-86946-43-6 (in Czech).
10. Statistika - tabulky [online cit.: 2018-03-08]. Available from: http://statistika.vse.cz/download/materialy/tabulky.pdf (in Czech)
11. **The International Civil Aviation Organization.** 2013. *Safety Management Manual.* Doc 9859 AN/474. 3rd edition. ICAO: Montreal, Canada.
12. Aviation Safety Network [online cit.: 2018-03-08]. Available from: https://aviation-safety.net/database/events/
13. Aviation Safety Network – Airplane Engines [online cit.: 2018-03-08]. Available from: https://aviation-safety.net/database/events/event.php?code=AC