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U.S./EUROPE COMPARISON OF ATC-RELATED ACCIDENTS AND INCIDENTS

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Abstract: Nowadays, air transportation is known as the most safety type of transportation. However, there have been a lot of airplane crashes in which a lot of people lost their lives alongside with a huge material damage and a high cost for air industry. The causes of airplane crashes are different and various. One of the causes is air traffic control errors. Research shows that 6% - 10% of all aircraft crash accidents are caused by air traffic control errors. However, this type of research is very important for the sustainability of traffic management. In this research data of airplane accidents and incidents for the period between 2008-2018 in the US caused by air traffic control errors taken from NTSB and data of airplane accidents and incidents for the same period in Europe taken from EASA were used. Both data were analyzed according to various factors such as time of the day of the occurrence, place of the occurrence, type of flight rules, the ATC unit where the error was made, weather conditions, and traffic frequency. All occurrences (accidents and incidents) were analyzed according to these factors and results have been shown in graphs for the US airspace and European airspace compared to each other. The results of the study show differences in the percentage of occurrences with ATC contribution and occurrences affected by traffic density as external factors and VFR accidents related to ATC. According to other factors, results are compatible with each other.

Keywords: air traffic control, air traffic, accidents, incidents.

1. Introduction

Since the early days of aviation, there have been many accidents and incidents. Due to the lack of equipment in the aircraft produced in the early years of aviation, safe air traffic was not provided and the number of accidents was high. As the studies and findings in the field of aviation increased, airplanes started to be safer.

As it can be seen in Figure 1, most of the accidents that occurred in the early years of air transportation were machine-related accidents. Over the time, with the development of technology and the safety of aircraft, causes of accidents changed. In the 1970's the majority of aircraft accidents were caused by human errors. In the 1990s, after the humans fulfilled their individual duties fully and human factor errors were minimized, organizational factors emerged as a number one risk factor (FAA, 2012). From the begenning of the 21st century aviation has become high safe by providing ambraced the safety approaches of the past and implementing SSP or SMSs. However there are a many occurences showing that the relations between aviation organizations have contributed to negativ results and showing the importance of the total aviation system and the complexity of the aviation safety (ICAO, 2018).

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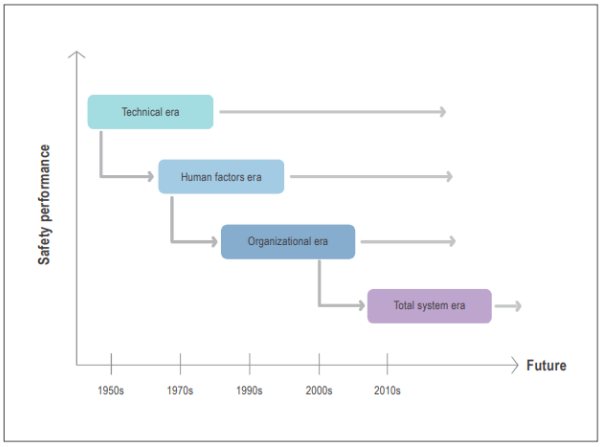

Fig. 1.
The Evolution of Safety
Source: (ICAO, 2018)

During the early years of aviation, by using simple cockpit instruments and visual landmarks on the ground aircrew were able to prevent disappearing of aircraft. However, both military and commercial demands gradually required pilots to fly in poor visibility conditions and at night. The job of air traffic controller was subsequently established to help maintain safe separation between aircraft and to ensure that pilots would not fly their planes into the ground or other obstacles (Hopkin, 1995). Many of the aviation accidents nowadays are not caused by control devices but by human errors, including errors made by air traffic controllers (Wiegmann and Shappell, 1997; Moon *et al.,* 2015). When it comes to the human factor in aviation, the most important role belongs to pilots and controllers (Reason, 1990; Wells and Rodrigues, 2004). While flight crew-related accidents have been included in many studies there has been insufficient research conducted to identify conditions in which Air Traffic Control (ATC) - related accidents and incidents occurred (Poundset *et al.,* 2000).

Example: When examining pilot-related accidents, it could be seen that factors such as flight rule (IFR vs. VFR), time of the day (day-night), location of aircraft (air vs. ground) and external factors (weather conditions, traffic density, traffic complexity) affect the accidents. These are some of the factors that can affect ATC-related accidents also. However, unlike the flight crew, ATC personnel and their responsibilities vary. ATC responsibilities may include a variety of operators (METEO, ARO, NOTAM) such as the tower, approach, and en-route control services and also management personnel (Pape and Wiegman, 2001).

Although air transportation is known as the safest type of transportation there have been still a lot of airplane crashes in which a lot of people lost their lives alongside with a huge material damage and a hefty cost for the air industry. In the period from 2008 to 2018, there were a total of 127 fatal accidents with 5098 fatalities (ICAO, 2018). Primary causes of aircraft accidents, by frequency are following: 1. Flight Crew, 2. Airplane, 3.

Weather, 4. Maintenance, 5. Airport/ATC 6. Other (Boeing, 2019). Different researches show that 6% - 10% of all the airplane crash accidents are caused by air traffic control errors. Since the percentage of these accidents is always present in approximately the same proportion, investigating accidents caused by ATC can be of great importance in eliminating those causes and reducing ATC-related accidents.

The study related to accidents and incidents caused by ATC determined that these events are infrequent (Pape and Wiegmann, 2001). However, the study has shown that these occurrences are likely to involve local controllers interacting with multiple aircraft in the air during daylight VFR conditions. An in-depth analysis of the narrative reports using the Human Factors Analysis and Classification System (HFACS) revealed that skill-based errors (attention failures and memory lapses) were the most common type of error committed by ATC personnel.

In the research about factors underlying human errors in ATC, examined the reports of accidents and incidents in civil aviation in South Africa airspace for 3 years. In the research, it has been determined that there are times in the shift that can be called risk times when ATC errors are more frequent. This research concluded that the human factor is at the root of information processing error which is the ATC-related error (De Reuck, 2014).

The purpose of this study is to examine ATC-related accidents and incidents in the US and European airspaces that occurred between 2008 and 2018, and to determine the frequency of these incidents, operational and environmental conditions, different control personnel contribution rates, and to analyze the ATC-induced factors that cause/affect those accidents. Monitoring and being aware of the current situation regarding ATC-related accidents and incidents is very important for the sustainability of air traffic management in the future.

2. Data and Methodology

The study provides a comprehensive review of all United States (US) and Europe civil aviation accidents and incidents that occurred between 2008 and 2018, using database records held by the National Transportation Safety Board - NTSB (for the US) and European Union Aviation Safety Agency - EASA (for Europe).

All accidents and incidents from these databases were analyzed according to the factors such as type of flight rules, time of day, location of the accident, contribution of ATC, ATC units, contribution of outside factors, error frequency, and all findings will be presented as comparison on following graphs. The study is a descriptive statistical study.

3. Results

Analysis of data from the NTSB and EASA showed that the accidents with the ATC contribution for the period 2008-2018 in the Europe were 163 while that number in the US was 63. Also, a much bigger number of incidents with ATC contribution have been reported in the Europe. The following figure (Fig.2.) show the percentage of ATC's direct and indirect involvements in accidents and incidents in the US and the Europe.

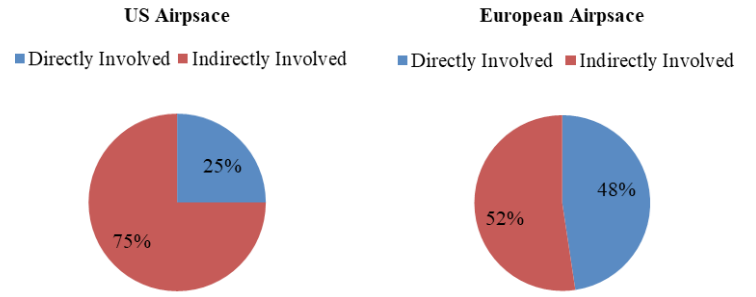

Fig. 2.
ATC's Direct and Indirect Involvement in Aircraft Accidents and Incidents US and Europe

As it is shown in the Fig. 2. in European airspace the percentage of accidents and incidents in which ATC is directly and indirectly involved is almost the same, there is just a slight difference. However, in US airspace the situation is different, the number of accidents and incidents directly caused by ATC is three times lower than the number of accidents and incidents in which ATC is indirectly involved.

If we were to analyze only the accidents caused by ATC, then the percentage of accidents in which ATC is directly involved is almost the same in both, European and US airspace (Fig. 3.).

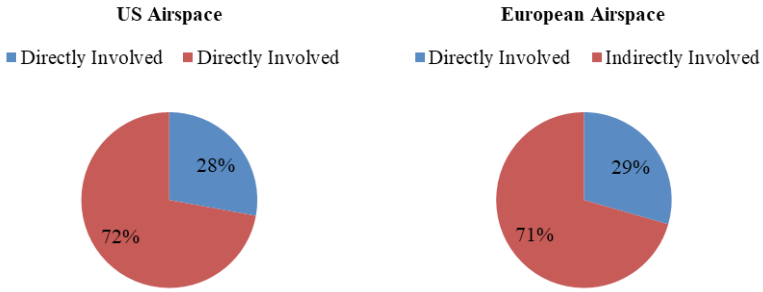

Fig. 3.
The Percentage of Accidents Directly Caused by ATC vs Accidents Indirectly Caused by ATC

When all occurrences (accidents and incidents) in the European and US airspace are analyzed according to flight rules, the results differ from each other. The results of this analysis conducted on all flight occurrences in the US and European airspace shows that there are more Instrument Flight Rules (IFR) flights

with some type of ATC error contributed to flight occurrence. The percentage of IFR flight occurrences caused by ATC in US airspace is 75, while 25 % of all flight occurrences in US airspace belong to Visual Flight Rules (VFR) flights. However in European airspace only 12% of all flight occurrences belong to VFR flights, all of the other occurrences (exactly 88%) are in IFR flights. Those results in which the number of IFR flight occurrences is higher than the number of VFR flight occurrences have been expected because of the fact that the responsibility of ATC for navigation in IFR flights is complete while in VFR flights responsibility of ATC is partial.

This difference in the percentages of VFR flight occurrence between European (12%) and US (25%) airspace is due to the different structure of airspace and differences in classes of these airspaces, as well as various regulations on VFR and the responsibilities and services that ATC provides to VFR flights. The responsibilities of ATC for VFR flights and the services that ATC provides to VFR flights in US airspace are higher than one regulated by EUROCONTROL.

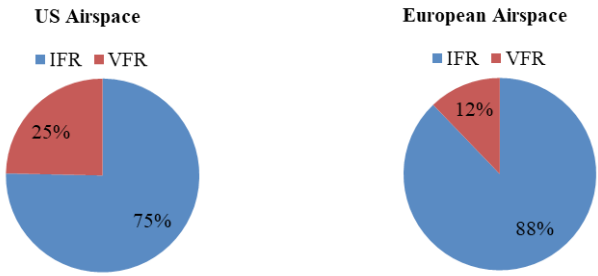

Fig. 4.
The Percentage of IFR and VFR Flight Occurrences in the US and European Airspaces

In the case when only accidents caused by ATC are observed and analyzed according to the flight rules, we can see (on the Fig. 5.) that in the US airspace accidents on IFR flights are more frequent, while in the European airspace accidents on VFR flights are more frequent. As stated in the previous paragraph, in European airspace the responsibility of ATC on VFR flights is significantly less and the provision of navigation services is only partial, which in the end led to a higher number of ATC errors contributed to VFR accidents. In these VFR accidents with ATC error contribution, the most common ATC error is lack of communication and lack of action.

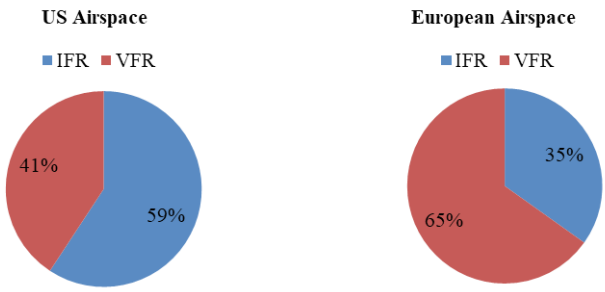

Fig. 5.
The Percent of IFR and VFR Accidents in the US and European Airspaces

The number of VFR flights in the US is significantly higher than in Europe but despite that, there is a greater number of VFR accidents in the European airspace. The reason for this may be in the organization of airspace in Europe and its division into classes, as well as the greater spontaneity of US controllers in communicating with VFR pilots and providing navigation services to them (EUROCONTROL and FAA, 2019).

Below are some basic differences in US and European airspace that relate specifically to VFR flights:

- Airport operating times: In Europe, VFR pilots must check on airport operating time while in the US airports are open 24 hours a day and 7 days a week.

- VFR procedures: In Europe, VFR pilots are requested to approach along certain routes while in the US there are no VFR approach charts or VFR approach procedures.

- Flight following: In Europe, flight following is not available 24/7 whereas it is available all the time in the US. Moreover, there are much more advisories from flight following in the US than from FIC in Europe. The kind of information in "flight following":
  - Traffic information;
  - Weather at destination;
  - The weather around airplane position, like the intensity and size of precipitation;
  - Vectors around weather and restricted areas.

The following figure (Fig. 6.) shows that a higher percentage of VFR accidents in which ATC is directly involved in the US airspace than in Europe and the reason for this is the aforementioned responsibilities of controllers for VFR flights that are higher in the US than in the EU.

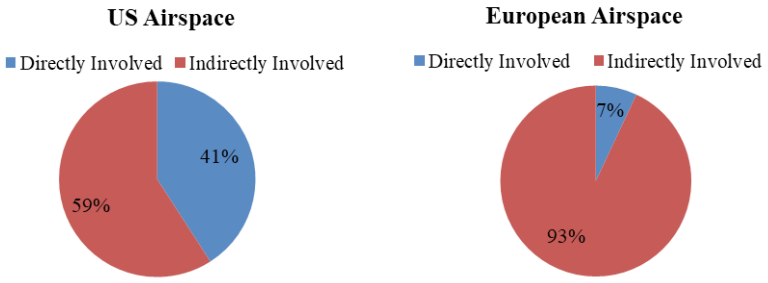

Fig. 6.
VFR Accidents ATC Contributions

The most common types of occurrences on VFR flights are presented in the following figures, US airspace (Fig. 7.) and EU airspace (Fig. 8.)

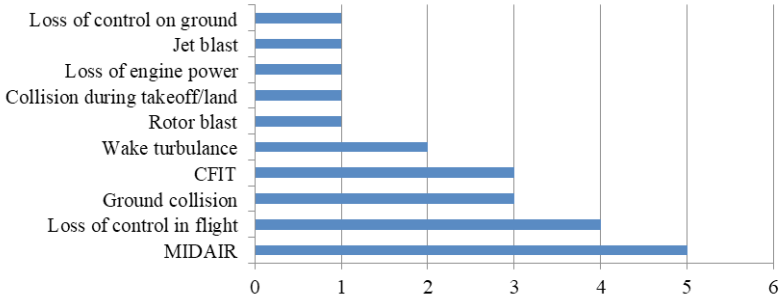

Fig. 7.
Frequency of Occurrence Types in VFR Accidents (US Airspace)

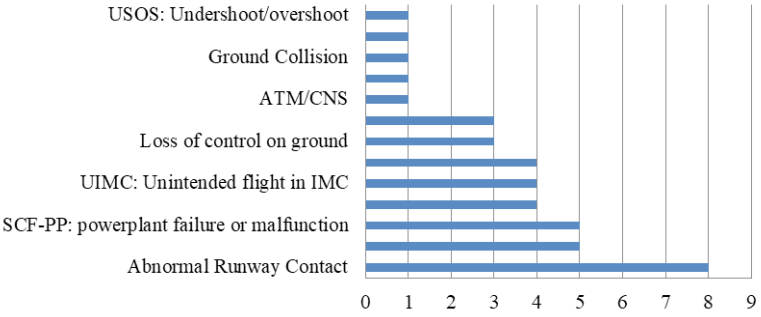

Fig. 8.
Frequency of Occurrence Types in VFR Accidents (European Airspace)

The two most common types of occurrences for both airspaces are Controlled Flight into Terrain (CFIT) and Loss of control in flight (LOC-I). CFIT is the second most common flight occurrence in both EU airspace and US airspace. As it can be seen, some of the most common occurrences for both airspaces (US and European airspaces) are related to movements on airport maneuvering surfaces. "Loss of separation" accidents on VFR flights caused by ATC are the most frequent type of occurrence in US airspace, while "loss of separation" is only seventh cause of VFR accidents in EU airspace. The next item that was taken in consideration in the analysis of occurrences caused by ATC error is external factors. The results of the analysis are shown in the next figure (Fig. 9.).

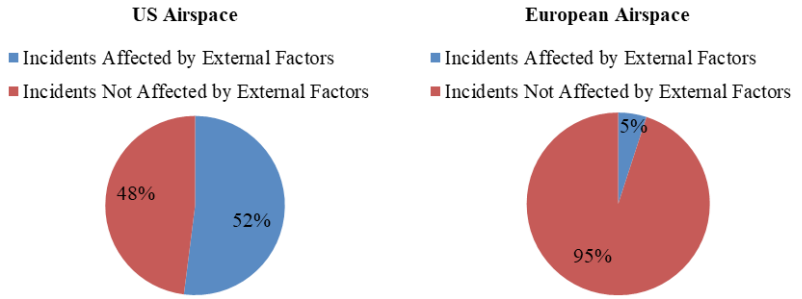

Fig. 9.
Percentage of Occurrences which were Affected by External Factors

The percentage of occurrences caused by ATC errors in US Airspace which were caused by some external factor is 52% while the percentage of these occurrences in EU airspace is only 5%. The external factors that were taken into consideration in US Airspace occurrences are low visibility, traffic density, weather conditions and navigation equipment while in EU Airspace occurrences those factors are traffic complexity, traffic density and low visibility. The percentages of each of them are shown in the Fig. 10.

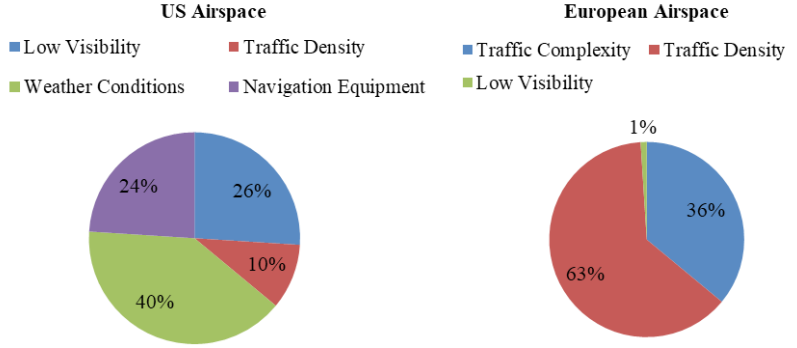

Fig. 10.
The Percentage of External Factors Affecting Occurrences

40% of all occurrences in US airspace were caused by weather conditions, while 10% of them were caused by heavy traffic in the US airspace and 63% in the EU airspace. The percentage of occurrences caused by low visibility conditions in the US airspace is 26%, while in the EU airspace is only 1%.

As shown in the following graphs (Fig. 11.) more than three-quarters of all occurrences in both airspaces occurred during the day. One-quarter of ATC-related occurrences in EU airspace occurred during the night (25%), and less than one-fifth (19%) of all occurrences that ATC contributed to in US airspace took place at night time. Taking in consideration that more flights take place during the day, higher percentage of occurrences that happened during the day comparing to those happened at night are something that can be expected. When we know that the average number of flights during the day is 3 times higher than the flights during the night and that almost all VFR flights are mostly during the day and compare it with the results of occurrence analysis according to the time of the occurrence we come to the conclusion that some 4% -10% more occurrence during the night than during the day in relation to the ratio of day and night flights.

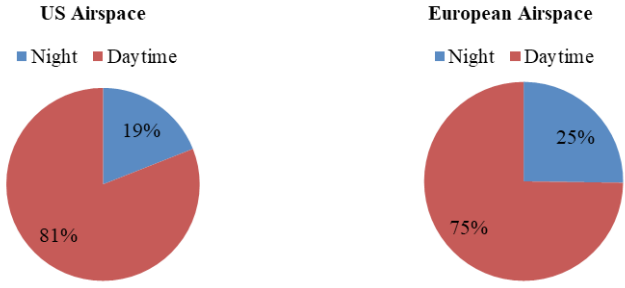

Fig. 11.
Percentage of Occurrences by Time of Day

By analyzing the airplane occurrences that ATC contributed to according to the place where they occurred we came to the results that a significantly smaller number of all occurrences, namely 28% of them in the US airspace and 25% of them in EU airspace occurred on the ground. If we take into account that the number of airplane accidents that occurred during the flight (in the air) is much higher than the number of accidents that occurred at the maneuvering areas of the airport, such results are compatible. Through history number of huge and fatal accidents occurred on the ground. The most fatal accident in history was the Tenerife accident in which two planes collided on the runway and 583 people died (NASB, 1977). The cause of this accident as it was determined latter was an air traffic control error (airport tower) (Wagner, 2017). Even though the number of plane accidents that occurred on the ground is low they carry a great risk.

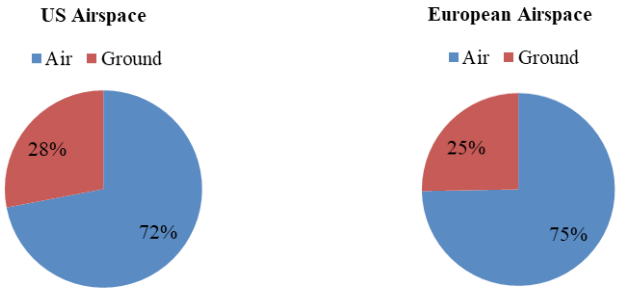

Fig. 12.
Percentage of Occurrences According to the Location

The error rate of air traffic control units is shown in the Fig. 13. As we can notice from figure, in US airspace Tower Control (TWR) has been involved in 52% of occurrences while in EU airspace the Area Control Center (ACC) has been involved in 44% of occurrences.

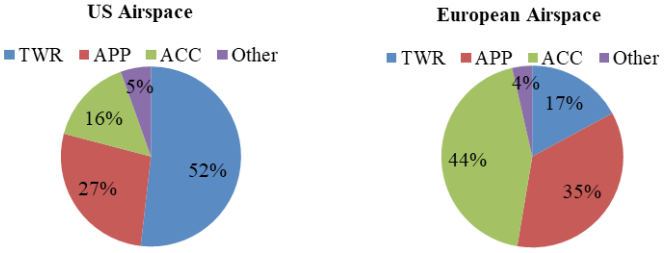

Fig. 13.
Error Rates of Air Traffic Control Units

The Fig. 14. shows that the rates of Area Control Center (ACC) contribution to airplane occurrences in the US and EU airspaces are compatible. The VFR occurrence rate is 12% in the US airspace and 10% in the EU airspace while the IFR occurrence rate is 88% in the US airspace and 90% in the EU airspace.

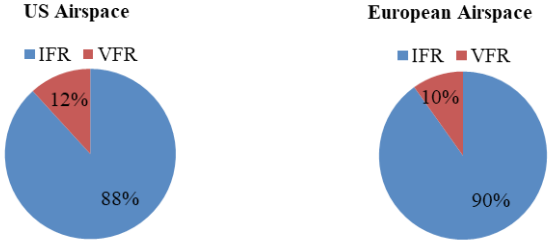

Fig. 14.
Rates of IFR and VFR Occurrences related to ACC

By analyzing the occurrence with ACC contribution, we came to the result that ACC is directly involved in 68% of occurrences in EU airspace, while this percentage for US airspace is 47%. It can be seen on the Fig. 15.

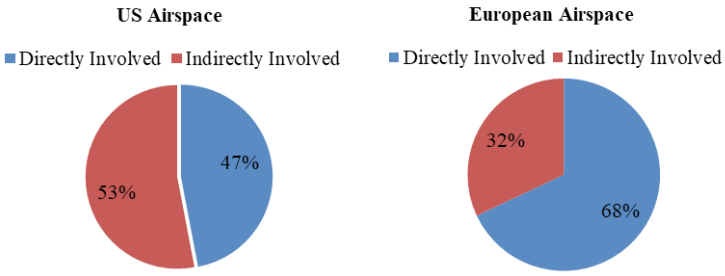

Fig. 15.
The Rates of Occurrences with ACC Contribution

Considering only the occurrences that are defined as accidents 56% of them occurred in EU Airspace and 52% in US Airspace (Fig. 16.).

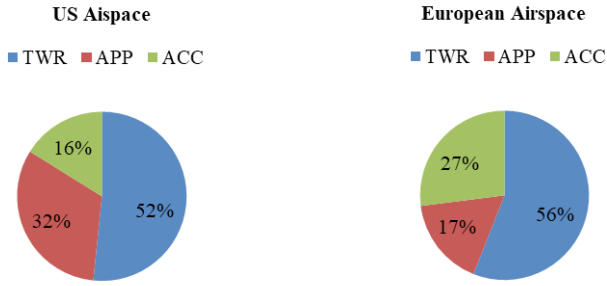

Fig. 16.
Accident Analysis according to ATC Units

Most of the all aircraft accidents in history occurred during the landing and take-off phase. According to the analysis (Boeing, 2018) 9% of the accidents that occurred in the world between 2007 and 2016 occurred in the maneuver area of the airport, 7% during take-off, 27% during the final approach, and 22% in the landing phase. In all of those four flight phases, aerodrome control (TWR) is responsible for traffic, and 65% of all accidents occurred when the responsibility for air traffic was on aerodrome control (TWR). The result of that Boeing analysis, 65% of all accidents is related to TWR is in accordance with results of this study, where is 56% (Europe) and 52% (US) of accidents is related to TWR.

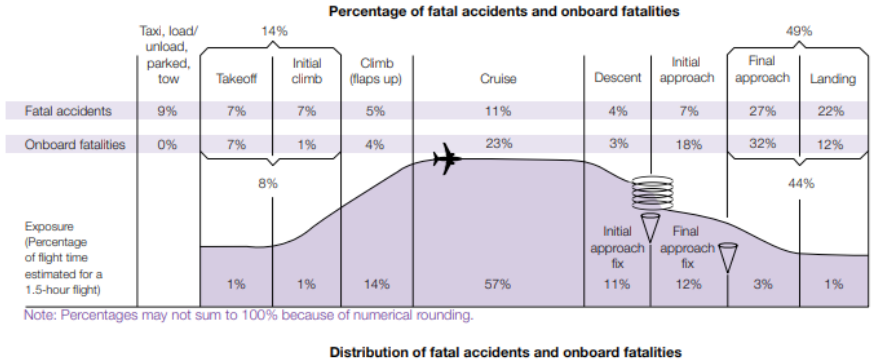

Fig. 17.
Percentage of Fatal Accidents according to the Flight Phase
Source: (Boeing, 2018)

In the analysis made in this study, it was determined that from all airplane accidents with aerodrome traffic control (TWR) contribution 52% of them in US and 56% in the Europe occurred when the responsibility was on Tower Control (TWR). Boeing's analysis included flights between 2007 and 2016 and analysis in this paper took into consideration accidents between 2008 and 2018. Therefore, it can be concluded that the results of both analyses are compatible with each other.

4. Discussion

The results of this study showed that there are more accidents and incidents with ATC contribution in the Europe than in the US and one of the reasons may be the fact that in the US all controllers are English native speakers while in the Europe most of them are not, that can be the reason for more miscommunication errors in the EU than in the US. Studies have shown that accidents that occurred due to a miscommunication error involved either a controller or a pilot who were not a native English speaker, or in some case both of them were not native English speaker (Breul, 2013; Strother, 1999). Also, the results of eighteen hours of air-ground communications at Kingsford Smith International Airport, Sydney, Australia analysis revealed that accented pilots committed more communication errors than native English-sounding pilots and more specifically that these errors were mistakes rather than omissions, and involved words rather than numbers (Wu, Molesworth & Estival, 2019). Air traffic controllers are forced to speak quickly in order to be able to provide services to all aircraft under their jurisdiction in a period when traffic frequency was increased. Accelerated communication is one of the causes that increase the likelihood of miscommunication, especially for nonnative English speakers (Alderson, 2009; Estival & Molesworth, 2016; Molesworth & Estival, 2015; Prinzo *et al.,* 2009).

When it comes to factors such as Aircraft Location type and Time of Day, similar results are presented in a study conducted by the FAA for the period 1985-1997 (Pape and Wiegmann, 2001). According to that study the largest number of accidents and incidents

are related to Tower Control. In this study we came to the same conclusion when it comes to incidents and accidents in the US airspace, while in ATC-related accidents and incidents in European airspace the Tower Control is the third cause of accidents and incidents. But when only ATC-related accidents are taken into account the results of three researches (Pape and Wiegmann, 2001; Boeing, 2018 and ICAO, 2014), as well as of this study, match to each other.

According to FAA study, the rate of accidents with TWR contribution is 60% (local controllers 41%, tower supervisors 10%, and ground controllers 9%) (Pape and Wiegmann, 2001), according to Boeing research this rate is 65% (Boeing, 2018), according to ICAO Safety Report this rate is 72% (ICAO, 2014), while according to this study the rate is 52% for US Airspace, and 56% for European.

According to FAA study in US airspace, the highest percentage of ATC-related accidents and incidents involved two airplanes colliding or coming in close proximity to each other (Pape and Wiegmann, 2001). Also the result of this study indicates the same for US airspace while that was not the case with accidents and incidents in European airspace. The highest difference in the results of this study compared to that of the FAA is in the number of ATC-related incidents and accidents that occurred in adverse weather conditions. According to this study, there have been 20% such accidents more than in the previous study.

It is generally accepted that heavy traffic volume may present an excessively heavy workload to ATC personnel (Malakis, Kontogiannis, Kirwan, 2010) and thus may result to a higher probability for errors (Rodgers, Mogford and Mogford, 1998). An analysis of the experiment made in Korea clearly showed that several types of ATC human errors are influenced by traffic volume (Moon, Yoo and Choi, 2011). However, the results of this research showed that there are more accidents and incidents in Europe than in the US, although the US controllers control more flights with fewer controllers.

5. Conclusion

The result of the study shows differences in the percentage of occurrences with ATC contribution. In European airspace, the percentage of accidents and incidents in which ATC is directly involved is double times higher than the percentage of the accidents and incidents in which ATC is directly involved in US Airspace.

The next important finding of this study is the significantly more frequency of VFR accidents related to ATC in European Airspace in regard to US Airspace. However, the higher percentage of VFR accidents in which ATC is directly involved is in the US airspace. ATC is indirectly involved in the higher number of VFR accidents (93%) related to ATC in European Airspace. The reason for this can be the different structure of airspace and differences in classes of these airspaces, as well as various regulations on VFR and the responsibilities and services that ATC provides to VFR flights. This can be a very important topic for researches in the future.

Also, the study shows that traffic density was the external factor in the 63% of occurrence related to ATC in which some of the external factors were involved. And it is a substantial finding when we know that the total surface

of continental airspace is similar in Europe and the US. However, the US controllers manage approximately 67% more flights and handle significantly more Visual Flight Rules (VFR) traffic with some 13% fewer controllers and fewer en route facilities (EUROCONTROL and FAA, 2019).

Investigation of ATC-related aircraft accidents and incidents according to the type of errors (organizational versus personal errors) and a comparison of the rates of those accidents according to the organization of airspace management in Europe and in the US can be a very important topic for some further researches.

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