The study to evaluate the factors that influence on aviation accidents in USA

Ayat, Muhammad; Raza, Tahir; Ahmad, Ozair; Azmatullah

Published in:
First International Conference on Industrial Engineering and Management Applications

Published: 28/02/2017

Document Version
Peer reviewed version

THE STUDY TO EVALUATE THE FACTORS THAT INFLUENCE ON AVIATION ACCIDENTS IN USA

Mohammad Ayat[1], Tahir Raza[2], and Ozair Ahmed Syed[2]

[1]Lecturer at Department of Industrial Engineering and Management
Dawood University of Engineering & Technology
Karachi, Sindh 74800, Pakistan
Corresponding author's e-mail: ayat@sabanciuniv.edu

[2]Student at Department of Industrial Engineering and Management
Dawood University of Engineering & Technology
Karachi, Sindh 74800, Pakistan

Abstract: In today world, people became more time conscious and luxury loving, which resulted in the diversion of people's attention from ancient means of transportation to the modern ways i.e. aviation. The transition not only facilitated people but increased the air traffic and the number of accident as well.
The purpose of this study is to find out the major causes of the aviation accidents in United States because accidents cannot be completely eliminated but can be reduced.
We obtained the data for a period of 24 years from Jan 1992 to Dec 2015, from two data bases; NASA maintained database "Aviation safety reporting system" (ASRS) [1] and National transportation safety board (NTSB) maintained database "Aviation accident and incident data system"(AIDS) [2]. Correlation and other descriptive statistical tools have been used in the study to show the relationship between the factors effecting the accidents. Minitab statistical package is used for the statistical analysis. To see the accidents more closely, we grouped the accidents into three segments of aviation operations: General Aviation (GA), CFR 14 Part 135 and CFR 14 Part 121.
We found that the size of the flight, terrain, and seasonal effects have significant influence on the number of aviation accidents in United States. The General Aviation, which is the smallest segment of aviation operation dominates over other segments' accident (CFR 14 Parts 121 and 135). It caused for 98% of all aviation accidents. The data also shows the significance of seasonal trend that 44% of all aviation accidents took place between the months of May and August. At the end of the study we present recommendations for policy makers to reduce the accidents in aviation industry to a certain level.

1. INTRODUCTION

In this fast growing, scientifically facilitated and abundantly mechanized world accidents are inevitable in every walk of life. People suffer huge losses and many of them even lose their lives. Steps have been taken for the retardation but still lot need to be done in this field.
Taking all types of accidents is beyond the scope of the paper, therefore we are taking the aviation accidents into consideration so that, if not all the factor, some of them are exposed and remedies should be suggested to avoid them. There are many factors which are responsible and need to be considered in the aviation industry to ensure the safety of the crew members as well as the passengers.
An aviation accident is defined under 49 Code of Federal Regulations (CFR) 830.2 as an occurrence when the operation of an aircraft, with the intent of flight, results in substantial damage to the aircraft, death or serious injury to any person.
The purpose of this paper is to diagnose the causes and effects of various factors in General aviation, CFR 14 Part 121 and CFR 14 Part 135, which are responsible for the accidents and to find out the relationship between the cause and effect. Technological as well as human errors and environmental conditions are responsible in some way or the other. To go into the brief details the accidents are categorized into sub groups (i.e.: Destroyed, Substantial, Minor and None.) while injuries are categorized according to the severity of the injuries into Fatal and Serious injuries.

The paper focuses on the five major factors of the accident i.e.: size factor, seasonal factor, regional factor, human error, and the bird strikes. To go into the depth of the above factors, data of 24 years have been collected from NASA maintained database "Aviation safety reporting system" (ASRS) [1] and National transportation safety board (NTSB) maintained data based "Aviation accident and incident data system"(AIDS) [2] for Jan 1992 to Dec 2015

After reviewing the literature of the impact of aviation accidents (i.e.: bird strike, seasonal and segmental categories) we came at the conclusion that the number of accidents may be retarded by diagnosing and forecasting weather phenomena well ahead of its occurrence and passing information to the air traffic control (ATC). We suggest that the affected air space (where accidents occur frequently) may refrained. Ineffective use of air space produces huge costs that could be reduced by in-time identification of hazardous weather phenomena.

In this paper, we discussed various factors effecting the aviation accidents and their causes. Related data is obtained mainly from two sources as given in the references [1, 2]. Analytical results and the findings are compiled in way to facilitate the reader, which progress systematically and in an interlinked fashion.

2. LITERATURE REVIEW

Many factors play their role in the air craft accidents i.e.: Aircraft Design, Environment, Human Factor, Management, Manufacturing, Seasonal Factors, Size of Flight, Maintenance, and Bird Strike etc. Dealing with all the above stated factors is beyond the scope of the paper, to discuss these factors each requires separate attention and paper. Majority of the authors have made the Human Factor responsible contributing 45% of the accident while the contribution of the Environmental Factor is 3-5% remaining other factors are responsible for the rest of the 50% (Johnson, Holloway) [3]. The given data shows that the contribution of Environmental factor in the aviation accident is indirectly proportional to the rate of accidents.

"To error is to men" human by its nature cannot avoid mistakes and its implications are drastic in many occupational accidents, the involvement of civil and military aviation accidents is 70% to 80% (Wiegmann, Shappell 2001) [4]. Minor detail related to human factor should be collected with the assistance of well trained staff and appropriate instruments in order to minimize the effect.

Another factor that poses dangers to the aviation is the bird, of all species, strike which also varies from region to region. The strike rate is higher in those areas which are near to the greenery and water. The factor has direct relation with rate of accidents and the type of damage caused depends upon the mean body mass (Dolbeer, Wright, Cleary) [5].

The analysis shows that the major portion of the accident is caused while landing. Due to the miss understanding between the control room and the crew members, and due to the unfavorable weather condition (i.e.: Thunderstorms, Air Turbulence, Ceiling and Visibility, In-flight Icing). Birds (red-tail hawk, Gull, Scoter, Cormorant) collision is the factor, ranked as third major cause of the accidents below 3000 ft. altitude (Wang, Herricks) [6].

There are various factors which are responsible for the high risks rate with small planes. Firstly, they are driven by non-professional people. The rules are relaxed for amateur pilots, who don't have to log as many flight hours to be certified. Another reason is mini planes, which land at small airports that may not even have paved and well equipped runways (Sullivan 2014) [7].

The influence of geographic factor on the aviation accidents varies from region to region and the rate is different for different regions. It is found that United States is the major victim, suffering 788 accidents and 10,625 fatalities. Through proper training and sound knowledge of the locality to the pilot accidents of this nature can easily be minimized (Calderone and Gould 2015). [8]

3. RESEARCH METHODOLOGY

1.1 Method of Data collection

Data used for this study obtained from two data bases; NASA maintained database "Aviation safety reporting system" (ASRS) [1] and National transportation safety board (NTSB) maintained data based "Aviation accident and incident data system"(AIDS) [2] for a period of Jan 1992 to Dec 2015. The data consist of Aviation accidents happened to CFR 14 Part 135, CFR 14 Part 121 and General Aviation (GA). Most of the General Aviation (GA) flights are used for personal and recreational purposes. However some flights are conducted for revenue generating purposes too. CFR 14 Part 135 is commuter airlines (Part 135 scheduled) and air taxis (part 135 unscheduled) and CFR 14 Part 121 are

generally referred to major airlines and cargo carriers. Before March 1997, Scheduled aircraft with 30 seats fell under CFR 14 Part 121, while those with less than 30 seats were considered CFR 14 Part 135. Because of regulatory changes, CFR 14 Part 121 now includes all aircraft with 10 or more than 10 seats; thus some commuters once regarded as CFR 14 Part 135 are now considered CFR 14 Part 121.

NASA Aviation safety reporting system (ASRS) receives, processes, and analyze reports of unsafe and hazardous situation that are voluntarily submitted by pilots, air traffic controllers, dispatchers, flight attendants, and maintenance technicians. They submit their reports on a specific designed report format, which describe both unsafe occurrences and hazardous situation. The filled out form can be submitted either by posting on ASRS address or electronically by using Report Submission Form (RSF) procedure.

The national transportation safety board (NTSB) and aviation accident and incident data system (AIDS) contains information collected during NTSB investigation of an accident or incident involving aircraft within the United States, its territories and possessions and international water.

Aviation accident and incident data system (AIDS) is mainly composed of accidents. It contains many fields for each accident record, including the information regarding the aircraft, environment, location of the accident, flight phase, injury level and the date at which the accident recorded.

1.2 Data Analysis

Correlation study and descriptive statistical tools are used to show the relationship between the factors affecting the accidents. Correlation study helped us in finding out the relation between numbers of accidents and flying hours. Descriptive statistics tells us about the distribution of accidents. The distribution of the aviation accidents have been shown with detail description.

Minitab statistical package is used for the statistical analysis of data to determine the variance, range and deviation of the accidents with respect to the months and years.

4. RESULT AND DISCUSSION

The accidents have been grouped into three segments of aviation operations as we discussed in the introduction section i.e. General Aviation (GA), CFR 14 Part 135, and CFR 14 Part 121. The analysis of the accidents data show that General Aviation accidents dominate over other segments' accident (CFR 14 Parts 121 and 135). It is also evident from the Figure 01 which shows GA, and CFR 14 Parts 121 and 135 annual accidents data separately for the period of 1992 to 2015. General Aviation accidents are responsible for 98% of all aviation accidents (The great majority of accident-involved aircraft across all purposes of flight in General Aviation (GA) were fixed-wing airplanes (86%), with helicopters accounting for 9% of the accident aircraft and all other types of aircraft accounting for less than 5%.) took place, while CFR 14 Part 121 for 2% and CFR 14 Part 135 for 0.46% of all aviation accidents took place during the period.

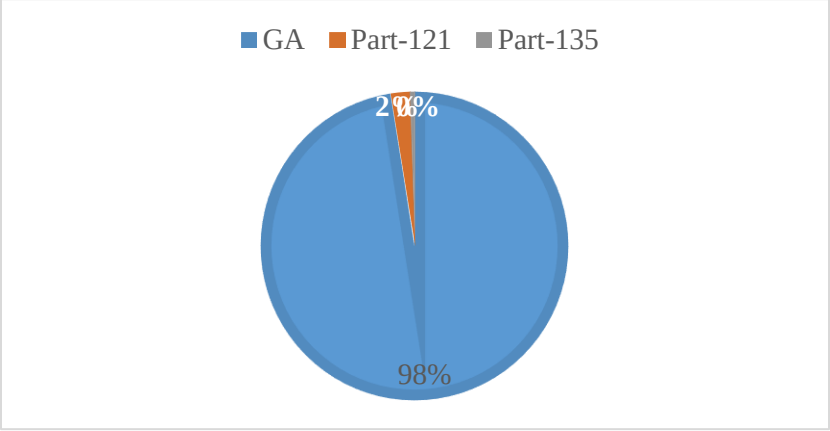

Figure 01. Aviation Accidents' ratio of three segments of Aviation operations for 1992 to 2015

However, the rate of General Aviation (GA) accidents have significantly decreased from 8.5 to 6.5 accidents per 100,000 flight Hours, during the period of 1992 to 2012 and 5.8 in 2015. The number of GA aviation accidents has dropped from 1908 to 1209 during the last two decades. As figure 02 shows that there is a consistent downward trend over the time span in General Aviation (GA) accidents. There are 36.6% decrease happened in the number of General Aviation accidents in the last two decades i.e. from 1992 to 2015 in US aviation Accidents.

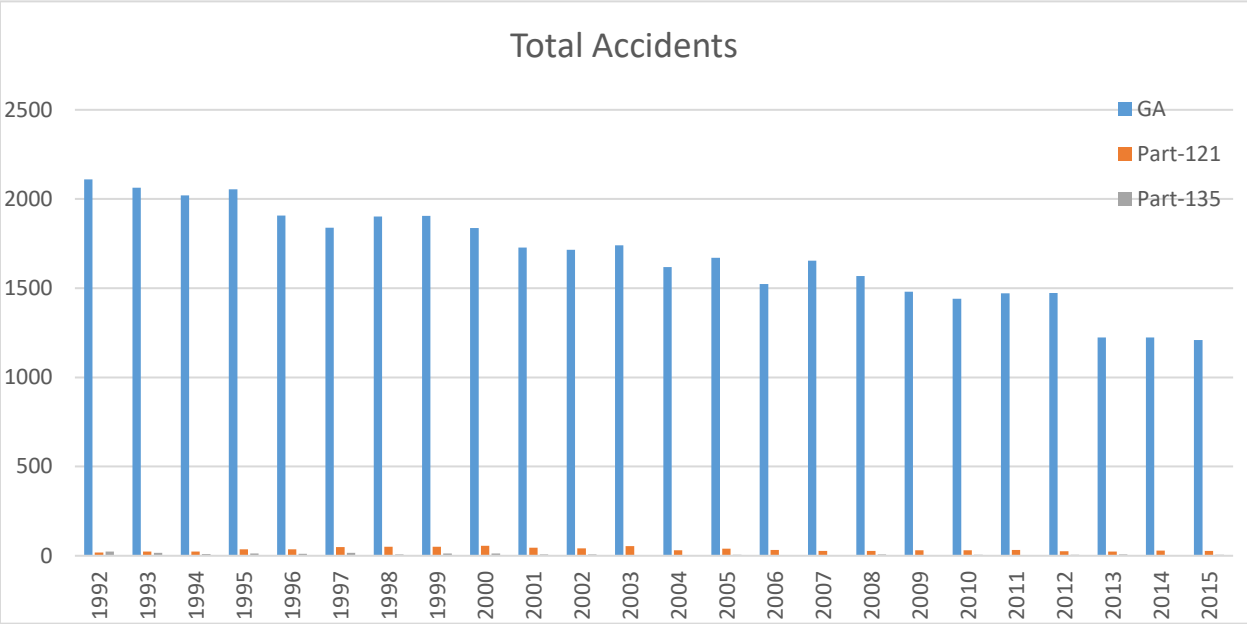

Figure 02. Annual Aviation Accidents of three segments of Aviation Operations for 1992 to 2015

Although in the rate of CFR 14 Part 121 accidents, no significant changes have been observed during the period, which have changed from 0.146 to 0.157 accidents per 100,000 flight hours in the last two decades.
There is a consistent decrease happened in the rate of General aviation accidents but it is still much higher than rate of accidents in CFR 14 Parts 121 and 135. [See Figure 02].
The rate of accident from 2001 to 2015 is almost flat. The flatness of the rate of accident curve across the decade suggests that the modestly decreasing trend in annual accidents number was primarily due to reduction in General Aviation (GA) Operations.
Figure 03 show the behavior of General aviation, 14 CFR Part 121 and 14 CFR Part 135 accidents rate. The rate of accidents for 14 CFR Part 121 which remain stable in a range 0.129-0.309. Unusual fluctuation (in term of rapid increase) has been observed in accidents rate for 14 CFR Part 135 after 1997. The fluctuation in the rate of accidents is only due to 14 CFR Part 135 scheduled services. It became prominent due to the legislation according to which since March 20, 1997, aircraft with 10 or more seats used in scheduled passenger service have been operated under 14 CFR 121. The increase in rate of accidents in scheduled 14 CFR Part 135 is because of shifting a safer operation group to 14 CFR Part 121. When scheduled flights were categorized by the number of passengers seat, it become evident that begining in 1994, three years before the rule change, crash rates of flight with 10-30 seats were even more lower than the crash rate of flights with more than 30 passenger seats (Baker et al. 2009) [9]. This (10-30 passengers seats commuters) was the safest operation group among all.

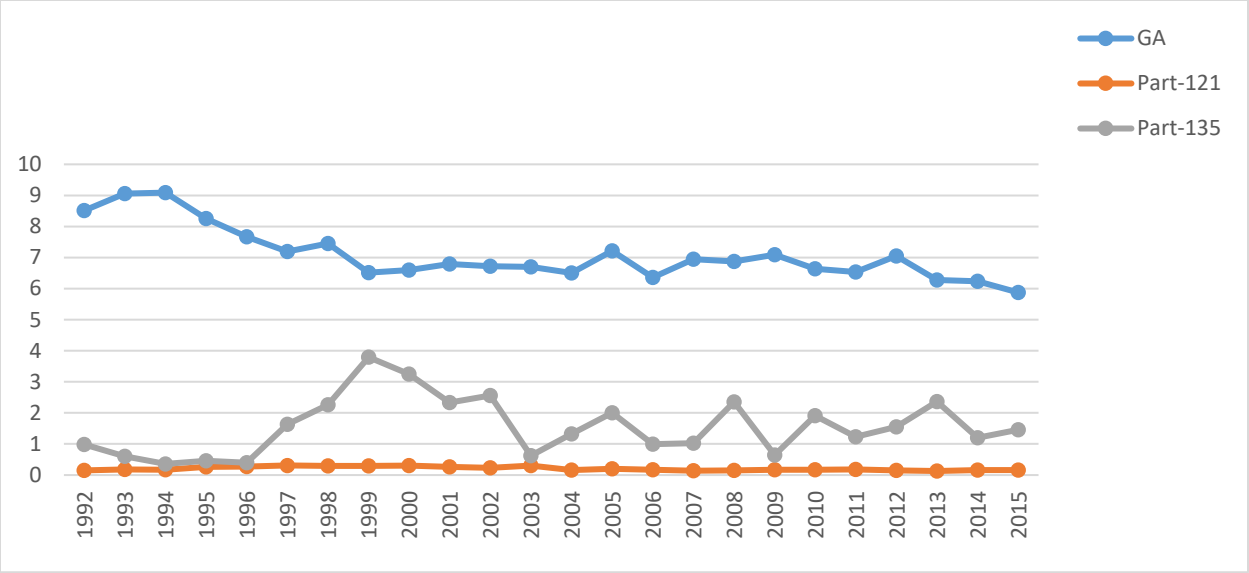

Figure 03. Annual Aviation Accidents per 100,000 flight hours of three segments of Aviation operations for 1992 to 2015

Reasons for the improved safety of 10-30 seat scheduled commuters probably include the 1992 requirement that all turbine-powered aircraft with 10 or more seats must be equipped with approved ground proximity warning system to prevent their all-too prevalent controlled-flight-into-terrain crashed (Thomas, Benzyl, Mainwaring, Conway) [10].
The crash rate of scheduled commuter with less than 10 seats was much higher than the scheuled commuter having 10-30 passenger seats (Baker et al. 2009) [9].
After 2000, the accident rate of Scheduled 14 CFR Part 135 operations declined dramaticlly (Figure 04). The decline was happend as a result of the efforts made to reduce crashes in Alaska where 91% of the scheduled 14 CFR Part 135 commuter crashes were occured. Among such efforts by the FAA is the Alaska Capstone project, which provides information to the pilot about weather, terrain, and air traffic and permits trained pilots to fly safely at lower altitudes using GPS [11].

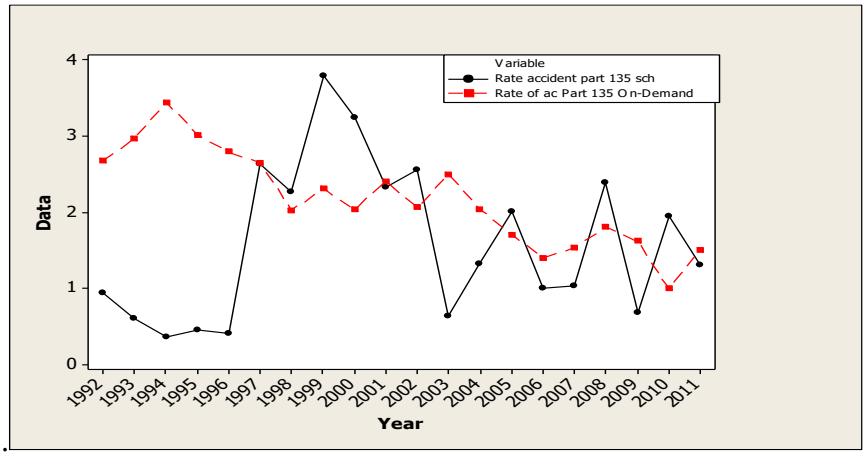

Figure 04. Rate of accidents 14 CFR Part 135 Scheduled and On-Demand services

Rate of accidents for 14 CFR Part 135 On-demand services are steadily decreasing as shown in Figure 04. This decline in the annual part 135 On-demand services could be the result of a number of factors, including the general decline in aviation activity after September 11, 2001; a fluctuation in overall U.S. aviation accidents; and other factor.

4.1 Alaska Factor

The air carriers operated under the regulation of 14 CFR Part 135 scheduled operations, 47 accidents occurred in Alaska out of total 56 accident by the period of 2001 to 2012. It shows 83% accidents in 14 CFR Part 135 Scheduled operations occurred in Alaska State. In 14 CFR Part 135 unscheduled services, 30% accidents in US occurred in Alaska State.

4.2 Seasonal Distribution of Accidents

There is a stronger seasonal trend exists in the data, a regular repeating pattern of highs and lows related to quarter of the year as well as a downward trend as evident from the figure 04. There is more Aviation accidents happened in summer in the United States of America than other months (Figure 05).
As the weather gets warmer in USA, more families start planning their getaways. During the summer, there are more occasions to have a great time in great weather, but with increase in aviation activity level, there is a potentially greater chance for more accidents to happen (101 critical days in summer).
The eleven years data (From 2002 to 2012) of United States accidents, show that the United States Aviation, on average, suffers 124 accidents per month during the first four months; average per month increase in accidents is 200 in summer and again decreases to 133 accidents per month in the last four months of the year. The data also shows that 44% of all aviation accidents took place between the months of May and August. While 27% aviation accidents took place in the first fourth months and 29% in the last four months of the year. It shows the largest percentage of accidents took place in the months of June, July and August. It reaches its peak in the month of July.
The monthly distribution is positive correlated with the aviation activities, as the aviation activity level increases; there are potentially greater chances of the accidents to happen. The exact relationship between activities and accidents may change over time, but the number of accidents or mishaps will always be dependant on the number of aviation activities (Current Procedure for Collecting and Reporting U.S General Avaition Accident and Activity Data 2005).

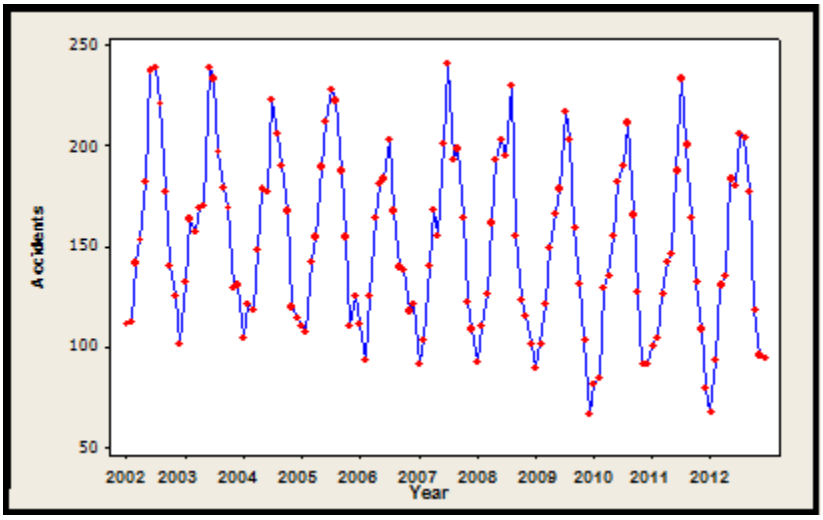

Figure 05. Monthly Aviation Accidents data for the period of 2002 to 2012 which show the seasonal and downward trend in the data.

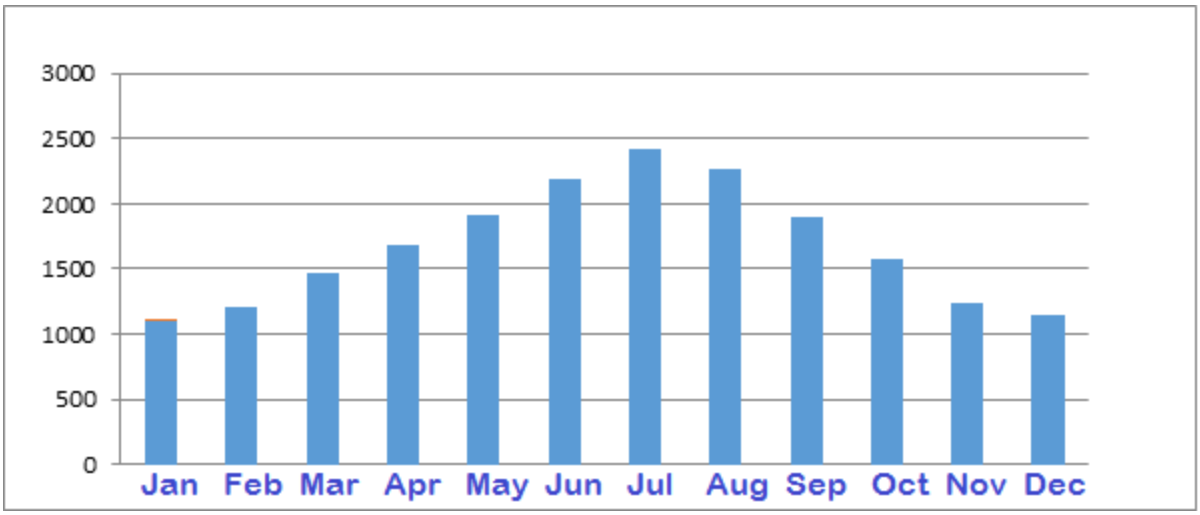

Figure 06. Average Monthly Aviation Accidents for the period 2002 to 2012

4.3 Classification of the Accidents

Aviation accidents have been grouped into four events i.e Destroyed, Substantial , Minor and None. The classification is expressed in terms of Aircraft damage resulted in accident. The objective is to give an indication of the severity of the accident in term of the Aircraft damage. The groups proposed by International Civil Aviation Organization (ICAO) for the purposes of international comparison of the aviation accidents.

Destroyed means the damage sustained makes it inadvisable to restore the aircraft to an airworthy condition. Substantial damage adversely affects the structural strength performance, or flight characteristics of the aircraft. İt normally requires major repair or replacement of the affected component. In minor damage the aricraft can be renderd airworthy by simple repairs or repalcement. İt doesn't need any extensive inspection. In None, the aircraft sustained no damage in the occurence [12].

The statistics of the Aviation accidents data for the period of 2009 to 2012 show that substantial event dominate over other events. The aviation accidents are caused for 3% destroyed event, 95% substantial, and 1% for each Minor and None events. However the distributions of these events are different for different segments of aviation operations (Table 01). It is also evident from the Table 01 that all accidents events are dominated by General aviation accidents except None which is by Part 121.

Table 01. Event wise grouped data of GA, Parts 121 and 135 for the period of 2009 to 2012

	General Aviation (GA)		Part 121		Part 135	
	No: of events	%age	No: of events	%age	No: of events	%age
Destroyed	143	2	3	3	2	1
Substantial	5618	96	45	43	160	97
Minor	48	1	11	10	1	1
None	36	1	46	44	2	1

4.4 Autocorrelation Study

The series appears to slowly wander up and down as shown in the Figure 07. The figure show the autocorrelation Function for monthly accident data with 5% significant limits. The significance of Modified Box-Pierce Q statistic "LBQ" Test (Q>Chi-square) and the very small value of P implies that one or more of the autocorrelations up to lag 30 can be judged as significantly (different from zero at any level). The figure 07 shows a distinct seasonal pattern for autocorrelation. The ACF decreases from a positive value p=0.8 toward 0 as the lag increase, then from 0 toward negative reaching to its extremes p=-0.8 and again decaying toward 0 and so on. It has an alternating pattern of positive and negative lags. It is clear from the auto-correlation pattern that the accident data have strong similarities

with each other. So the data is not independent, it is depended on one another in a specific pattern. Analysis of the data from the current study showed that there is a seasonal plus downward trend along a random component.
So the suitable model for the data may be
X (t) =T (t) +S (t) +R (t)
Where X (t) = time series under investigation
T(t) = trend,
S(t) = seasonal term, and
R(t) = random component
A Mathematical model can be determined for this data by using Fourier series to model the periodic component and substracting this fourier term from the original time series to get the random component. Then a low order Gaussian AR process is used for modelling the remaining random part.

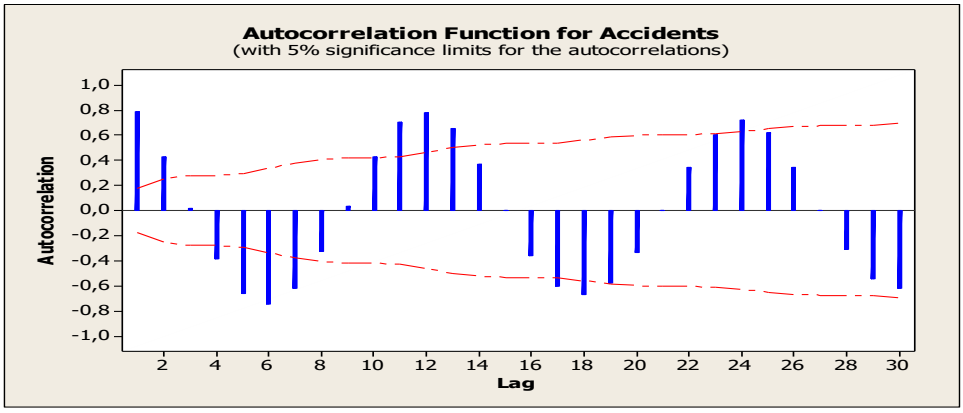

Figure 07: Autocorrelation Function of the monthly aviation accident data

The analysis also shows that the random component is not so prominent in the data.

5. CONCLUSION

Accidents cannot be completely eliminated but efforts can be made to reduce its effects or the number of accidents can be minimized using different corrective and preventive ways and means. In order to up-root the factors causing various types of accidents in all types of aviation the accident reporting system should be refined and made friendly enough so that all the causes are brought in the knowledge of the safety board. It is found that crew members do not report the factor which cause a near miss in the aviation considering it minor and in this way it goes unattended. Complexity of the formal way of reporting the near-miss, forms, is one of the primary cause, forms should be made simple and crew members should be encouraged enough so that may not hesitate to report even minor causes.
Confusions and contact barriers created between the crew members and the control room due to the ill-functioning of the radar system and other technologies used in the aviation should also be considered and refined. Because of the above said two factors either the crew member obtain delayed information or do not get the appropriate information.
Whatever the type of accident is, our target is to minimize aviation accidents by using a primarily non-regulatory, proactive, and data-driven strategy to get effective results for that purpose. The aviation safety board need to revise its policies and frame them such that it should be easy to follow and comprehensive enough to cover all even minor details.

6. REFERENCES

1. NASA maintained database "Aviation safety reporting system" (ASRS) http://akama.arc.nasa.gov/ASRSDBOnline/QueryWizard_Filter.aspx

2. National Transportation Safety Board Aviation Accident and incident data system (NTSB): http://www.asias.faa.gov/pls/apex/f?p=100:24:0::NO:

3. C.W. Johnson, C.M. Holloway "On the Over-Emphasis of Human 'Error' As A Cause of Aviation Accidents: 'Systemic Failures' and 'Human Error' in US NTSB and Canadian TSB Aviation Reports" USA, NASA Langley Research Center, Hampton, VA 23681-2199, pp.1-34.

4. Douglas A. Wiegmann and Scott A. Shappell (2001) "Human Error Analysis of Commercial Aviation Accidents: Application of the Human Factors Analysis and Classification System (HFACS)"Aviation, Space, and Environmental Medicine, Vol. 72. pp. 1006-16.

5. Richard A Dolbeer, Sandra E Wright, Edward C Cleary "Ranking the Hazard of Wildlife Species to the aviation" Wildlife society, Vol.28, pp.372-378

6. Jinfeng Wang and Edwin E. Herricks "Bird-aircarft strike threat assessment using avian radar information" Center of Excellence for Air Technology, Department of Civil and Environmental Engineering, University of Illinois, Urbana, IL 61801

7. Gail Sullivan (2014) "The many reasons small planes crash" Morning Mix, Washington Post Online. [Accessed November 22, 2016] URL: https://www.washingtonpost.com/news/morning-mix/wp/2014/12/09/why-small-planes-crash-more-often/?utm_term=.185a3170f46d

8. Julia Calderone and Skye Gould (2015) "The 25 countries with the most airline accidents and fatalities" Tech News Online. [Accessed November 22, 2016] URL: http://www.businessinsider.com/airplane-accident-statistics-by-region-2015-11

9. Baker et al. (2009) "Crash rates of scheduled commuter and air carrier flights before and after a regulatory change" Aviate Space Environ Med., Vol. 80(4): pp. 381-385.

10. Thomas TK, Benzyl DM, Mainwaring JC, Conway GA. (2000) "Controlled flights into terrain accidents among commuter and air taxi operators in Alaska" Aviate Space Environ Med., Vol. 71: pp. 1098-1103.

11. FAA. "Capstone comes to Southeast Alaska" 2003. Mar 31 [Accessed September 12, 2008]. From http://www.faa.gov/news/press_release/news_story.cfm?newsId=6375

12. International Civil Aviation Organization, Homepage Retrieved November 22, 2016 from http://www.icao.int