A STUDY OF ACCIDENTS AND INCIDENTS OF LANDING ON WRONG RUNWAYS AND WRONG AIRPORTS

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This paper addresses the landings on wrong runways/ at wrong airports happened between 03/26/1992 and 05/08/2012. The visibility, intended landing runway heading, accident landing runway heading, pilots' flight hours, and the ages of those pilots are studied to test whether they have correlations with the number of personnel injury, the number of personnel death, and the degrees of aircraft damage. Some significant findings are: the most likely angular difference between the supposed landing runway headings and wrong runway headings among wrong runway/airport landings is 180 degrees, and there is a weak negative correlation between aircraft damage and pilot flight hours. All the data used in the paper was collected from the National Transportation Safety Board (NTSB) database.

Introduction

Ever since first manned flight, the people have been enjoying the freedom of flight, and they must land back on earth. However, landing is not always so easy. The legendary pilot Chuck Yeager once said, "If you can walk away from a landing, it's a good landing. If you use the airplane the next day, it's an outstanding landing (Yeager, 2016, p.1)." The researchers of this research analyzed total of 84 accidents and incidents due to landings on wrong runways or wrong airports between 1992 and 2012 in the States. There are many studies that have been focused on landings at wrong airports regarding spatial disorientation and aviation physiology, but few existing research studies available based on empirical data based on the perspectives of pilots. In the study, the researchers reviewed the accident and incident reports from the NTSB database to conclude what pilot-related factors may cause landings on wrong runways or wrong airports. After a series of search and discussions, the researchers narrowed down these variables in this study: visibility, supposed landing runway heading, accident/incident landing runway heading, pilot in command flight hours, the age of the pilots, the degree of aircraft damage, andthe numbers of injuries or deathes and their injury conditions.

Literature Review

Mismatches between external world reality and the "internal world" aircrew mental picture relative to the real world would cause landings at wrong airports. In other words, the pilots misjudged the time, speed and distance, finally misidentified the wrong airport as the correct ones through the distortion of the facts of the reality (Antuano & Mohler, 1989). Landings on wrong runways or at wrong airports can be considered as the instances of disorientation on the part of the pilot. The pilots who become disoriented, are inadequately informed by the the external visual environment, deceived by the force environment, or both effects (Stott, 2012). The main cause of such accidents or incidents can be listed as perceptual error under errors under unsafe acts of pilots by Human Factors Analysis and Classification System (HFACS) (Shappell & Wiegmann, 2000). It is noteworthy that the NTSB is calling on the FAA to issue new rules requiring controllers to withhold a landing clearance until after an aircraft has passed all other airports that may be confused with the destination airport (Croft, 2015). This terse news shows that the aviation safety investigation body come to realize that other than pilot errors, there are more things can be done outside the cockpit. From renowned researcher Dr. Douglas Wiegmann, it has been learn that aviation accidents; especially general aviation accidents, usually happen when pilots fly VFR (Visual Flight Rules) into instrument meteorological conditions (IMC), and the reason behind that can be from the pilots don't realize the dangerous transition between VFR and IMC during the flights, or they are overconfident in their piloting skills and don't fully appreciate the risks of flying into the adverse weather (Wiegmann & Goh, 2002). According to the

Aircraft Owners and Pilots Association (AOPA), "since 2002, more than 86% of all fixed-wing VFR-into-IMC accidents have been fatal" (AOPA, 2016). Even before this alarming number found in 2016, there was a research paper suggested ground all VFR (Visual Flight Rules) flights when there are Marginal VFR weather conditions because it had shown that restricted visibility was the leading cause or a contributing factor in the fatal accidents when those accidents materialized in Marginal Visual Flight Rule (MVFR) or Instrument Flight Rule (IFR) (Pearson, 2002).

On average, there are more than ten incidents of commercial operations involved with landings on the wrong runways every decade domestically and internationally combined since 1960s (Silversmith, 2016). Even though commercial pilots are better trained compared with general aviation counterparts; however, they would land on the wrong runways, and even wrong airports in perfect weather conditions. A research team from Purdue University found that runway incursions occur at a more frequent rate for airports with intersecting runways compared to airports with no intersecting runways after they analyzed the data from the 30 busiest airports with intersecting runways and the 30 busiest airports without intersecting runways were compared in USA between 2009 and 2013 (Johnson, Zhao, Faulkner, & Young, 2016). In the research, two independent variables: the flight hours of the pilots in command, and the age of pilot, which could be counted as liveware in the SHELL (Software, Hardware, Liveware, Liveware) model proposed by the International Civil Aviation Organization (ICAO) in ICAO Circular 216-AN31. The model put emphasis on the connection between liveware and either one of rest four components, and it shows that any breakdown of two or more components can lead to human performance problem (Australian Government, 2014).

Mr. Voogt and Mr. Doorn recommended comparison of airports near the destination airport and the use of GPS to the identification procedure to prevent landing at wrong airports after they did an analysis of 54 incidents and 11 incidents happened between 1981 and 2004 (De Voogt & Van Doorn, 2007).

Research Questions

The researchers of this study addressed the following questions:

What is the most likely angular difference between the supposed landing runway headings and wrong runway headings among wrong runway/airport landings? (descriptive statistics)

What is the flight hour distribution of the pilots in command from the wrong runway/airport landing?

What is the most likely visibility when the wrong runway/airport landing? (descriptive statistics)

What is the correlation between the degree of aircraft damage and the flight hours of the pilot, age of the pilot? (MLR)

What is the correlation between the degree of personnel injury and the flight hours of the pilot, age of the pilot? (MLR)

What is the correlation between the number of personnel loss and the flight hours of the pilot, age of the pilot? (MLR)

Methodology

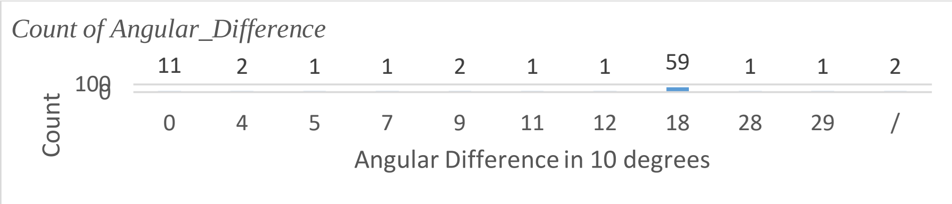
The data is from NTSB (National Transportation Safety Board) aviation accident database, and the database is accessible to the public. The query is constrained to wrong runway or wrong airport, broad phase of flight: landing, and Injury Severity: all. There are entirely 82 NTSB accident or incident reports generated. In other words, there is a total valid sample size of 82 (n=82). The accidents/incidents happened between March 26th, 1992 and May 8th, 2012.

Most of the independent variables in the research are directly from the NTSB report, the visibility, the mislanded runway heading, and the flight hours of the pilot, and the age of pilot.

For the dependent variables in the research, there are aircraft damage, the number of people injured, and the fatality number directly from the NTSB report. And the researchers can either determine the supposed runway the pilot should land at from reading the description of accident or incident in the NTSB reports or get it directly from the description from the NTSB report. In order to do a multilinear regression, the degrees of aircraft damage have been converted to numerical variables like 0, 1, 2, 3 in respect to none, minor, substantial destroyed. And for the same reason, the researchers combined the degree and the number of personnel injury together, and the new indications are 0, 1, 2 in respect to nobody injured, one person with minor injury, one person with serious injury.

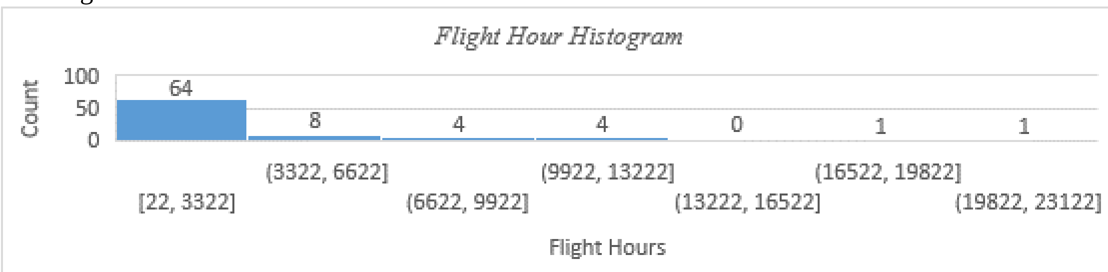
Results

The angular difference between supposed landing runway heading and mislanded landing runway heading distribution is shown below:



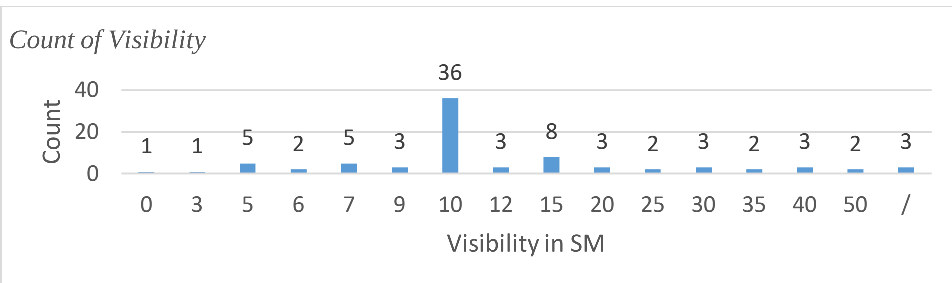
The graph shows that the most frequent (59/82) angular difference between the supposed landing runway headings and wrong runway headings among wrong runway/airport landings is 180 degrees.

The flight hour distribution of the pilots in command having the wrong runway/airport landing is presented in histogram shown below:



The histogram indicates that the absolute majority of the pilots in command from wrong airport/runway landings are in low flight hour range.

The visibilities of accidents and incidents are recorded below:



From the graph, the researchers found out the most likely visibility in the wrong runway/airport landings are 10 statute miles (SM). And the average visibility in the wrong runway/airport landing is 14 SM.

The Multilinear Linear Regression (MLR) is used to test the correlation between the degree of aircraft damage and the flight hours of the pilot, age of the pilot.

By using MLR, the researcher found out that there is a correlation between the degree of aircraft damage and the flight hours of the pilot, age of the pilot because the whole model Pr value is 0.002, which is smaller than the alpha value 0.05. However, after a further examination, it has been found out that Pr value of age of pilot is greater than 0.05, hence the researchers used Bonferroni method to remove the independent variable age of pilot, and made a new single linear regression (SLR) to show the correlation between the degree of aircraft damage and hours of flight.

By using the SLR analysis, it shows that there is a correlation between the degree of aircraft damage and the flight hours of the pilot. And it can be expressed as the following equation:

$$Y = -0.00003330 X + 2.13139$$

Y: Degree of aircraft damage, and X: Hours of Flight.

The MLR is again used to test the correlation between the degree of personnel injury and the flight hours of the pilot, age of the pilot. By using the MLR, the researchers found out that there is no correlation established between the degree of personnel injury and the flight hours of the pilot, age of the pilot because Pr value of the model is 0.3963 and it is bigger than the alpha value.

Finally, the MLR is used to test the correlation between the number of personnel loss and the flight hours of the pilot, age of the pilot. The researchers found out that there is no correlation established between the degree of personnel injury and the flight hours of the pilot, age of the pilot because Pr value of the model is 0.2639, and it is greater than the alpha value 0.05.

Discussion

There were total 82 observations of the angular difference between mislanded runway heading and supposed runway heading, but there are only 80 valid observations because two observations are lack of supposed landing runway headings and mislanded runway headings. The absolute majority of the angular difference is 180 degrees. In other words, most of the pilots in the wrong runway/airport landing accidents landed in the tail wind. They were either unware of tail wind situations or making the risky landings with the knowledge of the tailwind, all of those corresponded with the fact that most of the pilots were low-flight-time pilots in the research. And the next most frequent angular difference is 0 degree. It entails the following situations: landings on the parallel runways in the same airports, landings on the parallel runways in different airports, or landings on the same runways in the same airports.

Against the findings of many previous spatial disorientation studies, the accidents/ incidents in this research happened on excellent weather condition in terms of visibility (average visibility 14 SM). One possible reason is that the accidents/incidents pilots are low hour pilots and they were apt to flying in Visual for Reference (VFR) weather.

There is only one weak negative correlation existed between the degree of aircraft damage and the flight hours of the pilots in command, which makes sense because more experienced pilots can make better judgments so that minimize the damage to aircraft in accidents/incidents.

There is no correlation between the degree of personnel injury and the flight hours of the pilot, age of the pilot. And there is no correlation between the number of personnel loss and the flight hours of the pilot, age of the pilot. One reason is that there were not enough samples with the personnel injury or loss so that it is impossible to establish statistical significance.

According to the NTSB, most of the accidents are attributed as “WRONG RUNWAY - SELECTED - PILOT IN COMMAND”. However, this study tends to find out what has caused these pilots, even the more experienced ones to commit such error? It is deemed that to choose a right runway regarding wind condition is the basics of pilotage skills. As stated by Wiegmann and Shappell (Wiegmann & Shappell, 2001), various human factors could play a role in these accidents and NTSB’s report may not be comprehensive enough for covering these factors behind.

Human Factors Analysis and Classification System (HFACS) is a framework developed by Dr. Weigmann and Dr. Shappell based on Reason’s Swiss cheese model in 1990. HFACS framework allows investigators to identify Human causes in aviation accidents. Developed from the Swiss cheese model, HFACS has gone further from just identifying latent and active failures. The framework was initially developed for the U.S. military use, but it has also now been applied outside the military. HFACS categorized human error into four levels of failure, namely I) Unsafe Acts of operators, II) Preconditions for unsafe acts, III) unsafe supervision and IV) organizational influences.

From studying the final report of each case in the NTSB’s database, it revealed that rarely did NTSB indicate how the pilots achieve weather information. Most of the information is factual and does not disclose why and how the pilots make such mistake in selecting the wrong runway. According to HFACS classification, selecting the wrong runway is probably a decision error or a skill-based error, if not a violation. Regrettably, the factual information in NTSB’s report is too scarce to deduce what are the human factors that caused pilots errors, as all of the 78 cases showed no mechanical failures in the aircraft.

The results of the regression analysis revealed that there is a correlation between flight hours of pilot and aircraft damage: the higher the flight hours obtained by the pilot, the lesser damage is to a plane. Such result is in line with previous similar research on crash rate (Li, et al., 2003). Although the rate of wrong runway landings does not change significantly across pilots’ age, flight experience as measured by total flying hours does have a correlation with wrong runway landings. Li, et al. (2003) in a similar study found that flight experience has a protective effect against the risk of crash decreases as flight experience increases until a certain threshold, which is 5000 hours of flight. It can be regarded that as pilots built their flight experience, they are exposed to a variety of risks and probably have learned how to handle different risk through experiencing them. Such risk handling skills enable pilots with more flight experience to choose the runway correctly when wind information is presented.

On the other hand, the age of pilots may not necessary be associated with the degree of aircraft damage. Although pilots are more vulnerable to health problems through aging, FAA’s rigorous health standards on the pilost are not interrelated with applicants’ age. If a pilot can obtain FAA’s airman medical certificate, it denotes that his/her health is up to an airman standard and are deemed fit to fly and not jeopardizing flight safety. If a pilot’s health function is disqualifying, he/she would be declined in the issuance of airman medical certificate, leaving only those who are medically fit in the skies. Our research, in fact, reflects that a wrong runway landing is more related to the pilots' ability to make a right decision rather than aircraft maneuvering skills. Such ability is part pf the pilots's situaton awareness which is not correlated with age, but experience.

From the study statistics, most accidents being studied happened at day time rather than night time. In fact, only 5 cases (6.7%) and 1 case happened at night and dusk respectively. It is suggested that it is because pilots are more vigilant at night and more likely to verify information in a meticulous manner. At night, windsocks can hardly be identified and may cause pilots to stay cautious to weather information. This results are in line with FAA's (Lee, 2012) findings in 2011. Pilot's attitude toward risk and their risk perception should not be overlooked. This research shows that pilots committing wrong runway landing varied drastically in terms of flight experience, ranging from student pilots to airline transport pilot. The least experienced student pilot clocked 22 hours, while the most experienced pilot had 19306 hours of flight. This suggested that with ample of flight experience, a pilot can still make basic mistakes if they are not vigilant enough.

Based on NTSB data for U.S. rotorcraft accidents from 2001-2010, over 88% of the accidents occurred in daylight conditions and over 95% occurred in visual meteorological conditions. Interestingly, 60 of all 78 (77%) accidents happened in between 1992-2002, and only 18 (23%) of them happened in between 2002-2012. Such huge difference in accident rate has aroused our attention. One probable reason for such discrepancy may be attributed to the technology advancement and a deeper understanding on aviation human factors. Glass cockpit on light aircraft wasn't something new. In 2003, Cirrus Design Corporation began to use glass cockpits in Federal Aviation Administration (FAA)-certified light aircraft as electronic primary flight displays (PFD). The company quickly standardized electronic PFDs on their SR20 and SR22 models subsequently. These electronic PFDs also as known as glass cockpit displays, are integrated with a lot of functions which are necessary to pilots, such as terrain and traffic avoidance, synthetic vision, and autopilots and global positioning systems(GPS) (National Transportation Safety Board, 2010). Glass cockpit has proven very useful in commercial aviation by relieving pilot's workload. It is thus deduced that the glass cockpit when coupled with integrated weather update service, have greatly reduced the chances of wrong runway landing, particularly the 180 degree ones (i.e. landing on the opposite direction) either by directly navigating or giving cues to pilots to land on the right runway.

The other reason for less accidents reported during 2002-2012 perhaps may be the deeper understanding and emphasizes of human factors and safety in aviation. The airlines started to look into human factors and employed crew resources (CRM) training after the 1977 Tenerife airport disaster after two Boeing 747 collided. Human factors have been studied greatly. In 1980, several authorities including the European Joint Aviation Authority (now EASA) have incorporated quality assurance program in their management system, and FAA quickly followed them as well.

10-15 years later, in the 1995 aviation safety summit which comprises of about a thousand representatives from the aviation sector, FAA's administrator David Hinson advocated to work towards a goal of zero accidents in a large, international scale. In the summit meeting, FAA formed a new office of system safety and issued an aviation safety action plan with 173 initiatives. These are regarded as stepping stone of the current safety management system(SMS) which is required by ICAO to be implemented by aviation service providers in 2006 (Britton, 2016).

The introduction of the notion of safety in human factors and implementation of SMS in general aviation have been raised the pilots' concern for safety training. Now, it is an order from FAA (FAA, 2016) to develop and implement SMS in certain providers, such as flight schools in the United States. Under the implementation of SMS on flight schools, training organizations and airline operators, it is thought that pilots' attitude and understanding towards aviation safety have been improved. Pilots may have been benefited by going through a more rigorous training and thus lowered the chance by committing errors.

In Weigmann and Shappell's study (2001), it revealed that skill based and decision errors have accounted for over forty percent of all the accidents which associated with human errors. In this study, 62 out of 75 (83%) cases have landed on the opposite runway. Presume these errors are made by pilots out of decision error by wrongfully selected the opposite runway, it is believed that decision errors and skill-based error are easily being made in the landing phrase. In fact, according to FAA, there are more than 250 accidents happened during the landing phase in 2014 and were accounted for the largest portion of accidents by flight phases. Decision errors denote when an operator implements a plan which is unsatisfactory in achieving the desired outcome and results in an unsafe situation and skill-based error entails an error which occurs in the execution of a routine procedure by an operator (Wiegmann & Shappell, 2001).

In our study, most pilots select the wrong runway under daylight with good visibility and weather conditions. Although NTSB did not provide sufficient factual information, we suspected that the pilots committed these errors either by not understanding wind components and intentionally chose the wrong runway (decision error) or simply mixed up the runway and landed wrongly (skill-based error). Landing phase is the busiest phase of a flight and pilots would be busy setting up an aircraft for landing configuration. Such high workload could distract pilots' concentration on their decision-making process and makes them feel tired and disorientated, especially when the pilots are landing at somewhere with which they are not familiar. We, therefore, advocate that pilots are easier to commit skill based and decision error during the landing phase.

It must be stressed that HFCAS is much more than just skilled-based and decision errors. There are also other latent factors, such as environmental factors and physical conditions of operators and supervision factors. However, because of not having enough the factual information from the NTSB, we propose the most probable reason for wrong runway landing by cross referencing Weigmann and Shappell's data.

Conclusion

Wrong runway landings can be lethal if not handled properly. When pilots are flying into an uncontrolled airport, it is pilots' duty to ensure flight safety by choosing the most suitable runway based on factors inside and outside cockpits. This paper studies the correlation between flight experience, the age of pilots, personnel injury, aircraft damage and visibility and the results are tabulated and presented. Findings show that there is a correlation between flight experience and degree of personal injury and aircraft damage, and the possible cause of such correlation is discussed. It is hoped that through such study, more attention would be given to pilots' training in Aeronautical Decision-Making(ADM) and wrong runway landing awareness in the future.

References

Antuano, M. J., & Mohler, S. R. (1989). Geographical disorientation: Landing at Wrong Airport. *Aviation, space, and environmental medicine*, 996-1004.

AOPA. (2016). *VFR INTO IMC ACCIDENTS 08/14/2015 - 08/14/2016*. Retrieved from AOPA Organization Web site: https://www.aopa.org/asf/ntsb/vfrintoimc.cfm?window=1

Australian Government. (2014). *SMS 6 SMS For Aviation- A Practical Guide 2nd Edition*. Retrieved from Australian Government Civil Aviation Safety Authority: https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/sms/download/2014-sms-book6-human-factors.pdf

Croft, J. (2015, November 15). NTSB: Controllers, Software Complicit In Wrong - Runway Landings. *Aviation Daily*. Washington, United States of America: Penton Media, Inc., Penton Business Media, Inc.

De Voogt, A. J., & Van Doorn, R. R. (2007). Approach and Landings at Wrong Airports: Analysis of 54 Incidents and 11 Accidents, 1981-2004. *Aviation, Space, and Environmental Medicine*, 117-120.

Johnson, M. E., Zhao, X., Faulkner, B., & Young, J. P. (2016). Statistical Models of Runway Incursions Based on Runway Intersections and Taxiways. *The Journal of Aviation Technology & Engineering*, 15-26.

Lee, R. (2012, Jan). *U.S. Rotorcraft Accident Data and Statistics*. Retrieved from Aircraft Electronics Association: https://www.aea.net/events/rotorcraft/files/US_Rotorcraft_Accident_Data_And_Statistics.pdf

Pearson, D. C. (2002). *"VFR Flight Not Recommended" A Study of Weather-Related Fatal Aviation Accidents.*

Shappell, S. A., & Wiegmann, D. A. (2000). *The Human Factors Analysis and Classification System–HFACS.* Springfield, MO: National Technical Information Service.

Silversmith, J. A. (2016, July 10). *The Legacy of Douglas Corrigan: "Wrong Way" Landings by Commercial Airliners*. Retrieved from Third Amendment: http://www.thirdamendment.com/WrongWay.pdf

Stott, J. R. (2012). Orientation and Disorientation in Aviation. *Extreme Physiology and Medicine*.

Wiegmann, D., & Goh, J. (2002). Human Factors Analysis of Accidents Involving Visual Flight Rules Flight into Adverse Weather. *Aviation, Space, and Environmental Medicine* , 817-822.

Yeager, C. (2016, August 27). *Chuck Yeager Quotes*. Retrieved from Brainy Quote: http://www.brainyquote.com/quotes/quotes/c/chuckyeage598656.html