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Application of HFACS to the Nighttime Aviation Accidents and Incidents

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Abstract

Commercial aviation accidents and incidents are more prevalent at the certain times of the day. Operational problems (e.g., night vision, flash blindness, black hole illusion, and reflection) faced by pilots while performing nighttime flights pose threats to flight safety. The present paper aims to examine the contributing factors to commercial aviation accidents occurred at night. In this paper, accident reports of 30 commercial airplane crashes occurred over the past five years were analyzed. The contributing factors of those accidents were examined by using HFACS (Human Factors Analysis and Classification System). The relative importance of the causal factors was determined. Literature reviews have indicated that no study has examined the causality of nighttime commercial aircraft accidents by using HFACS as a framework. It was found that physical environment was the most significant causal factor. Skill-based errors were second-highest contributing factors. Perceptual errors and decision errors were ranked as third-highest causal factors. We believe that our results may be useful for reducing the chances of human error and raising safety standards of commercial airline operations.

Keywords: HFACS, Human Factors, Night Flight, Accident Investigation, Commercial Aviation

1. Introduction

Commercial aviation industry has undergone a tremendous growth after the first jet airliner British de Havilland Comet started to operate in 1952 [1]. The last two decades has seen the rapid development of the commercial jetliner area. In 2007, the largest jetliner in the World, Airbus A380 entered into service which is capable of carrying more than 800 passengers [2][3]. In 2011, the first Boeing 787 was delivered to All Nippon Airways (ANA) [4]. In parallel with these recent developments in aviation, the safety records for commercial aviation have not shown an improvement. The number of commercial aircraft

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crashes remains stubbornly high. A large and growing body of literature has investigated the causality of commercial aircraft accidents.

A number of studies have revealed that there are several contributing factors affecting nighttime flight operations such as stress, anxiety, night vision, and flash blindness [5][6]. However, to the best of authors knowledge, there have been no report so far examining the causality of commercial airplane accidents occurred at night by using HFACS as an analytical framework.

1.1. Commercial Air Carrier Accidents

Investigating commercial air carrier accidents is a major area of interest within aviation industry. Recent catastrophic events in commercial aviation have heightened the need for the comprehensive analysis of past events (e.g., mishaps, incidents, and accidents) [7][8]. Recent evidence suggest that accident statistics recorded an increase in the number of accidents over the previous five years [9].

It has been reported that several contributing factors including weather, system/equipment malfunction, human error, and organizational factors give rise to accidents and incidents in commercial aviation [10] as well as in general aviation [11]. Among these contributing factors, human error is associated with the largest portion of commercial air carrier accidents (more than 75%) [12][13][14]. Upon closer examination of human factors, pilots are subject to several external conditions such as stress, hypoxia, circadian rhythm disruptions, venous thromboembolism which impede their performance and may give rise to errors, violations made by pilots and unwanted occurrences (e.g., near-miss, accidents and hull-loss) [15][16][17].

Among the above-mentioned preconditions which result in errors and violations, operational problems experienced by pilots while performing flight operation at night are at the heart of our understanding of causality of nighttime operations. According to the NTSB aviation accident database, 16 of the 1013 commercial air accidents occurred at night (Table-1).

Table 1. Number of nighttime accidents over the past five years [18]

Type of Operation	Accident	Incident
Part 121: Air Carrier	16	13
Part-91: General Aviation	849	10
Part 135: Air Taxi &Commuter	76	8
Part 103: Ultra-Light	0	0
Part 129: Foreign	3	2
Part-137: Agricultural	21	0
Part 125: 20+ Pax, 6000+ lbs.	1	0
Part 133: Rotorcraft Ext. Load	5	0
Non-US, Commercial	2	1
Others	40	15
All	1013	49

1.2. Night Flight

Night flying is one of the normal phases of flight. Aircraft systems (e.g., hydraulics, avionics, and bleed systems) are capable of functioning within normal parameters day and night. However, pilots are affected negatively by some challenging conditions (e.g., adverse physiological states such as night vision difficulties, spatial disorientations, circadian rhythm disruptions, and fatigue) [19][20] and environmental states such as night illusions, lack of ground aids and lighting systems [21][22].

Furthermore, it has been claimed that pilots experience heavy workload, reduced situational awareness (SA) and they have poor performance in night conditions [23][24]. Leland suggested that annually around 16% of general aviation crashes occurs due to spatial disorientation and loss of SA and he added 90% of these crashes result in fatality [25]. All these difficulties caused increased single pilot IFR nighttime accident rate by almost eight times compared to daytime accident rate [26].

In 1999, Khatwa and Helmreich analyzed all worldwide Approach and Landing Accidents between 1980-1996. They found that the accident rate at night was almost threefold of those at daytime [27]. They also found in the same study, at least 25 percent of all accidents happened due to lack of ground aids. In spite of visual ground aids (e.g. precision approach path indicator and visual approach slope indicator) pilots experience visual spatial disorientations such as black hole illusion (BHI)[23]. In 2007, Gibbs mentioned that pilots, who experienced BHI, are tend to descent deeper and fly the approach lower than normal which may result in an inadvertent flight into terrain (CFIT) [28].

In another study, it has been suggested that flight rules are different for day and night and flying under visual flight rules (VFR) at night is more dangerous than flight under the instrument flight rules (IFR) due to lack of visual performance [25]. All these studies have proved that night flight needs more concentration and attention as well as good planning.

1.3. HFACS Model

HFACS is an analytical framework to investigate accidents and incidents not only in aviation[29][30][31], but also in maritime [32], healthcare [33], and railway industries [34].

HFACS model is attracting widespread interest due to its applicability to accidents and incidents.

It is a comprehensive framework that includes four levels (Level-1: The unsafe acts, Level-2: Preconditions for unsafe acts, Level-3: The unsafe supervision, and Level-4: Organizational influences). It uses taxonomies of active (Level-1 and Level-2) and latent failures (Level-3 and Level-4). Namely, the contributing factors of accidents and incidents are classified under four levels and nineteen subgroups (Figure 1).

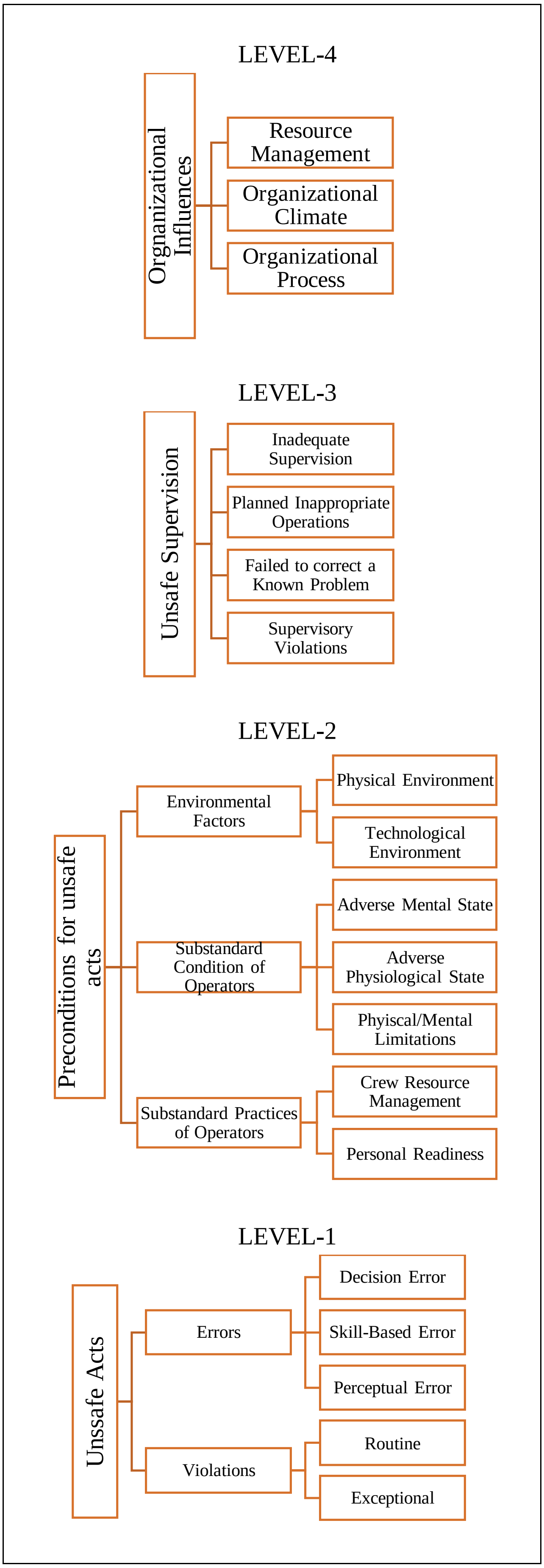

Figure 1. The HFACS Framework

2. Methodology

The data of commercial aircraft accidents occurred at night over the past decade was acquired from the NTSB accident and incident database. For the selection of accidents and incidents, the following criteria were used;

- Type of Occurrence: Accident &Incident
- Operation: Part121- Commercial Air Carrier
- Aircraft Category: Airplane
- Report Status: Probable Causes
- Injury Severity: Fatal & Non-fatal

It was decided that the best method to adopt for this study was to use codes. Coding of contributing factors was carried out by using two codes (0 was used for the absence and 1 for the presence of the subheadings of the HFACS framework). Only contributing factors identified by NTSB were used for the analysis. The data analysis was accomplished by implementing an excel spreadsheet.

3. Results and Discussion

In this study, we identified 67 contributing factors of 30 nighttime commercial air carrier accidents occurred over the past five years. Statistical results of this study are demonstrated by tables and graphics. Table 2 presents obtained statistical results.

Our findings revealed that the majority (63,33%) of the accidents and incidents are associated with physical environment (e.g., severe turbulence, clear air turbulence, and wake turbulence) which is the most significant causal factor contributing to nighttime commercial air carrier accidents. This is very much in line with previous results [29]. It was also shown that the second significant (33,33%) contributing factor is skill-based errors. This is in complete agreement with previous findings [29][30].

Contrary to expectations, we found that perceptual errors are associated with only 26,66 percent of the nighttime commercial air carrier accidents. It is the third significant causal factor of accidents and incidents analyzed in this study. However, our results lend support to support previous findings in the literature [29]. We were surprised to find that only 3,33 percent of the accidents examined in this study is associated with adverse mental state such as distraction due to degraded sensory abilities (e.g., poor vision). This finding significantly differs from previous results reported in the literature [29].

Table 2. The percentages of contributing factors by HFACS

HFACS Sub-categories	Frequency	% of all accidents
Decision Error (L1)	**8**	**26,66**
Skill-Based Error (L1)	**10**	**33,33**
Perceptual Errors (L1)	**8**	**26,66**
Routine Violations (L1)	2	6,66
Exceptional Violations (L1)	5	16,66
Physical Environment (L2)	**19**	**63,33**
Technological Environment (L2)	4	13,33
Adverse Mental State (L2)	1	3,33
Adverse Physiological State (L2)	1	3,33
Physical/ Mental Limitations (L2)	1	3,33
CRM (L2)	6	20
Personal Readiness (L2)	0	0
Inadequate Supervision (L3)	1	3,33
Planned inappropriate Operations (L3)	0	0
Failed to correct a known problem (L3)	0	0
Supervisory Violations (L3)	0	0
Resource Management (L4)	1	3,33
Organizational Climate (L4)	0	0
Organizational Process (L4)	0	0
Total	67	100,0

Note: L1, L2, L3, and L4 denote levels of subcategories in the HFACS framework.

We believe that the rate of nighttime commercial aircraft accidents due to perceptual errors is lower than those of general aviation aircraft accidents since the commercial jetliners are equipped with advanced aircraft systems (e.g., ground proximity warning systems, traffic collision avoidance systems). These advanced systems help pilots to prevent errors due to night illusions, spatial disorientations, and night vision difficulties.

Most of the accidents (*N*=16) examined in this study occurred during descent (26,7%) and ground operation (26,7%) (Figure 2). Furthermore, number of occurrences (*N*= 5, 16,6%) during the approach and landing that confirmed out findings was appreciable. This number is slightly lower than the value we expected because of the same reason as we discussed above for the low rate of perceptual errors.

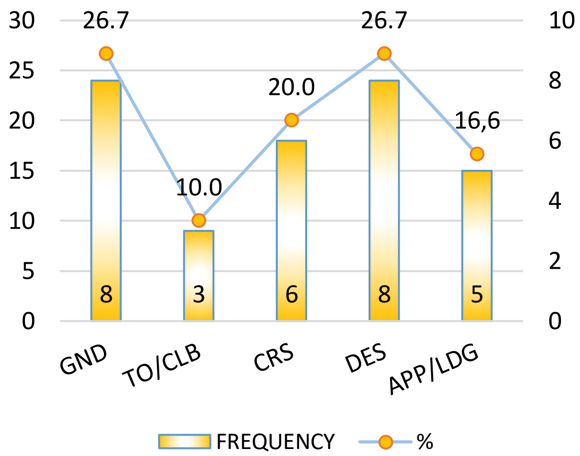

Figure 2. Phase of flight when occurrences happened

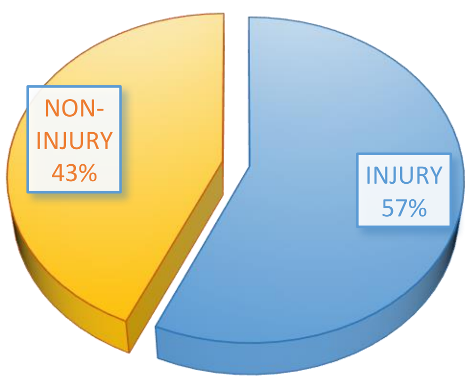

Figure 3. Nighttime Commercial Air Carrier Accidents Injury Statistics

The pie chart above shows the percentages of injuries and fatalities in accidents investigated in this study. 43 percent of accidents contributed to injuries. The most remarkable result emerge from the data is that there were no fatalities in these accidents (Figure 3).

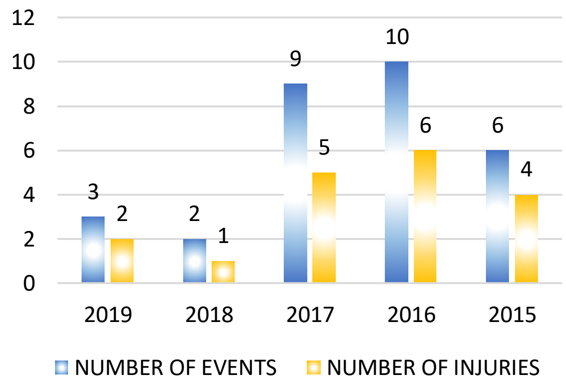

Figure 4. Number of occurrences per year and annual number of injuries

The majority of the accidents (*N*=10) and incidents occurred in 2016. The number of accidents and injuries have shown a decrease over the past five years (Figure 4).

4. Conclusion

This study set out to determine the contributing factors of nighttime commercial air carrier accidents. To the best of our knowledge, no study has examined examining the causality of commercial air carrier accidents and incidents occurred at night.

In summary, we were able to demonstrate that the most significant contributing factors of nighttime commercial air carrier accidents were physical environment, skill-based errors, and decision and perceptual errors in descending order. The results of this investigation show that there are several causal factors underlying nighttime commercial air carrier accidents and they did not occur just due to perceptual errors.

This work adds to a growing body of literature on HFACS and nighttime accidents. Further research might investigate the causality of nighttime general aviation accidents.

The present findings might help to have important implications for preventing similar occurrences in the future.

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Ethical Approval

Not applicable.

References

[1] R. Hollingham, "The British airliner that changed the world," *BBC Future*, 2017. https://www.bbc.com/future/article/20170404-the-british-airliner-that-changed-the-world. [Accessed: 23-Oct-2020].

[2] G. Norris, *Airbus A380: Superjumbo of the 21st Century*. Motorbooks International, 2005.

[3] Wikipedia, "Airbus A380," 2020. Available: https://en.wikipedia.org/wiki/Airbus_A380. [Accessed: 23-Oct-2020].

[4] The Associated Press, "Boeing delivers first 787," *2011*. http://www.cbc.ca/news/business/boeing-delivers-first-787-1.1112430. [Accessed: 23-Oct-2020].

[5] B. Kilic, "An analysis of critical factors affecting night flight training using DEMATEL," in *THE 4th INTERNATIONAL AVIATION MANAGEMENT CONFERENCE*, 2019, p. 236.

[6] V. B. Nakagawara, R. W. Montgomery, and K. J. Wood, "Aircraft accidents and incidents associated with visual effects from bright light exposures during low-light flight operations," FAA Civil Aerospace Medical Institute, Washington, D.C., 2006.

[7] R. Moura, M. Beer, E. Patelli, J. Lewis, and F. Knoll, "Learning from accidents: Interactions between human factors, technology and organisations as a central element to validate risk studies," *Saf. Sci.*, vol. 99, pp. 196–214, 2017.

[8] E. Kim and M. Rhee, "How airlines learn from airline accidents: An empirical study of how attributed errors and performance feedback affect learning from failure," *J. Air Transp. Manag.*, vol. 58, pp. 135–143, 2017.

[9] ICAO, "ICAO Safety Report 2019," 2019.

[10] A. Y. Daramola, "An investigation of air accidents in Nigeria using the Human Factors Analysis and Classi fi cation System (HFACS) framework," *J. Air Transp. Manag.*, vol. 35, pp. 39–50, 2014.

[11] B. Kilic, "HFACS Analysis for Investigating Human Errors in Flight Training Accidents," *J. Aviat.*, vol. 3, no. 1, pp. 28–37, 2019.

[12] ICAO, "Human Factors Digest: Investigation of Human Factors in Accidents and Incidents," Montreal, 1993.

[13] B. Kilic and S. Soran, "How Can an Ab-Initio Pilot Avert a Future Disaster : A Pedagogical Approach to Reduce The Likelihood of Future Failure," *J. Aviat.*, vol. 3, no. 1, pp. 1–14, 2019.

[14] B. Kilic, *Aircraft Accident Investigation: Learning from Human and Organizational Factors*, 1st ed. Istanbul: Nobel Akademik Yayıncılık, 2020.

[15] B. Kilic and S. Soran, "Awareness level of airline pilots on flight-associated venous thromboembolism," *Aerosp. Med. Hum. Perform.*, vol. 91, no. 4, pp. 1–5, 2020.

[16] D. Silverman and M. Gendreau, "Medical issues associated with commercial flights," *Lancet*, vol. 373, no. 9680, pp. 2067–2077, 2009.

[17] B. Kilic and C. Ucler, "Stress among ab-initio pilots: A model of contributing factors by AHP," *J. Air Transp. Manag.*, vol. 80, no. March, p. 101706, 2019.

[18] NTSB-National Transportation Safety Board, "Aviation Accident Database & Synopses," 2019. https://www.ntsb.gov/_layouts/ntsb.aviation/index.aspx. [Accessed: 23-Oct-2020].

[19] M. Martinussen and D. R. Hunter, *Aviation Psychology and Human Factors*, vol. 53, no. 9. London and Newyork: CRC Press, 2010.

[20] B. Kilic, "Fatigue Among Student Pilots," *Aerosp. Med. Hum. Perform.*, vol. 92, no. 1, pp. 1–5, 2021.

[21] FAA, *Airplane Flying Handbook*. U.S. Department of Transportation Federal Aviation Administration, 2016.

[22] B. BÉKÉSI, "Night flight operations introduction," in *Repüléstudományi Közlemények 2010. április 16.*, 2010.

[23] J. R. Davis, R. Johnson, J. Stepanek, and J.

A. Fogarty, *Fundamentals of Aerospace Medicine*, Fourth Edi. Lippincott Williams & Wilkins, 2008.

[24] J. Saleem and B. Kleiner, "The effects of nighttime and deteriorating visual conditions on pilot performance, workload, and situation awareness in general aviation for both VFR and IFR approaches," *Int. J. Appl. Aviat. Stud.*, vol. 5, pp. 107–120, 2005.

[25] R. Leland, "Night VFR… An Oxymoron?," *J. Aviat. Educ. Res.*, vol. 9, no. 1, p. 3, 1999.

[26] C. Bennett and M. Schwirzke, "Analysis of accidents during instrument approaches," *Aviat. Sp. Environ. Med.*, vol. 63, no. 4, pp. 253–261, 1992.

[27] R. Khatwa and R. L. Helmreich, "Flight safety foundation approach-and-landing accident reduction task force - Analysis of critical factors during approach and landing in accidents and normal flight: Data acquisition and analysis working group final report," in *1999 World Aviation Conference October 19-21, 1999 San Francisco, CA*, 1999.

[28] R. Gibb, R. Schvaneveldt, and R. Gray, "Visual misperception in aviation: Glide path performance in a black hole environment," *Hum. Factors*, vol. 50, no. 4, pp. 699–711, 2008.

[29] B. Kilic, "The Analysis of Hot-Air Balloon Accidents by Human Factor Analysis and Classification System," *J. Aeronaut. Sp. Technol.*, vol. 13, no. 1, pp. 17–24, 2020.

[30] C. A. Havle and B. Kılıç, "A hybrid approach based on the fuzzy AHP and HFACS framework for identifying and analyzing gross navigation errors during transatlantic flights," *J. Air Transp. Manag.*, vol. 76, pp. 21–30, 2019.

[31] B. Kilic and S. Gundogdu, "Human Factors in Air Cargo Operations: An Analysis Using HFACS," *J. Aviat. Res.*, vol. 2, no. 2, pp. 101–114, 2020.

[32] C. Chauvin, S. Lardjane, G. Morel, J. P. Clostermann, and B. Langard, "Human and organisational factors in maritime accidents: Analysis of collisions at sea using the HFACS," *Accid. Anal. Prev.*, vol. 59, pp. 26–37, 2013.

[33] T. Diller, G. Helmrich, S. Dunning, S. Cox, A. Buchanan, and S. Shappell, "The Human Factors Analysis Classification System (HFACS) Applied to Health Care," *Am. J. Med. Qual.*, vol. 29, no. 3, pp. 181–190, 2014.

[34] Q. Zhan, W. Zheng, and B. Zhao, "A hybrid human and organizational analysis method for railway accidents based on HFACS-Railway Accidents (HFACS-RAs)," *Saf. Sci.*, vol. 91, pp. 232–250, 2017.