CONTRIBUTING FACTORS IN AIRCRAFT ACCIDENTS TRIGGERING FATALITIES

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ปัจจัยที่ส่งผลต่ออุบัติเหตุทางอากาศที่ก่อให้เกิดการเสียชีวิต

น.ส.ประกายเพชร ชลายนนาวิน

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ประกายเพชร ชลายนนาวิน : ปัจจัยที่ส่งผลต่ออุบัติเหตุทางอากาศที่ก่อให้เกิดการเสียชีวิต. (CONTRIBUTING FACTORS IN AIRCRAFT ACCIDENTS TRIGGERING FATALITIES) อ.ที่ปรึกษาหลัก : ศ. ดร.กมลชนก สุทธิวาทนฤพุฒิ, อ.ที่ปรึกษาร่วม : รศ. ดรพงศา พรชัยวิเศษกุล,ดร.จุฬา สุขมานพ

การคมนาคมทางอากาศถือได้ว่าเป็นวิธีการเดินทางที่ปลอดภัยที่สุด พร้อมทั้งสร้างประโยชน์ทางเศรฐกิจและสังคม โดยการเชื่อมต่อการขนส่งต่อเนื่องในหลายรูปแบบ การเพิ่มการจ้างงาน การขับเคลื่อนกิจกรรมทางเศรษฐกิจทั่วโลกและระดับท้องถิ่น การลดเวลาการเดินทางและสร้างการค้า การส่งเสริมการท่องเที่ยวและบริการ การเชื่อมโยงผู้คนและประเทศต่างๆ ตลอดจนการสนับสนุนกิจกรรมด้านมนุษยธรรมในพื้นที่ชนบทห่างไกล จากสถิติเมื่อเทียบอัตราผู้เสียชีวิตจากอุบัติเหตุทางอากาศนั้น พบว่าการคมนาคมทางอากาศมีแนวโน้มที่จะเกิดอุบัติเหตุที่มีผู้เสียชีวิตมากกว่าการคมนาคมในด้านอื่น อาทิ ทางน้ำ ทางบก และทางราง ดังนั้น เมื่ออุบัติเหตุทางอากาศเกิดขึ้น จึงส่งผลกระทบเป็นแนวกว้าง การศึกษานี้มีวัตถุประสงค์หลัก เพื่อศึกษาวิเคราะห์อุบัติเหตุทางอากาศทั่วโลกที่มีผู้เสียชีวิต ระหว่างปีพ.ศ. 2557-2561 โดย (1) การระบุปัจจัยที่ส่งผลต่ออุบัติเหตุทางอากาศที่ก่อให้เกิดการเสียชีวิต และ (2) การค้นหาแนวทางมาตรการบรรเทาและป้องกันอุบัติเหตุทางอากาศที่จะเกิดขึ้นในอนาคต งานวิจัยนี้ดำเนินการในรูปแบบของงานวิจัยแบบผสมผสานระหว่างการวิจัยเชิงปริมาณและคุณภาพ โดยการสัมภาษณ์ผู้เชี่ยวชาญด้านความปลอดภัยทางการบิน และรวบรวมข้อมูลอุบัติเหตุของอากาศยานพาณิชย์จากทั่วโลกจากฐานข้อมูลอุบัติเหตุ รายงานฉบับสุดท้ายของการสอบสวนอุบัติเหตุ และหน่วยงานการบินต่างๆ เพื่อสังเคราะห์ปัจจัยที่สำคัญและส่งผลต่อการเกิดอุบัติเหตุทางอากาศที่มีผู้เสียชีวิต เมื่อนำปัจจัยมาวิเคราะห์ด้วยการถดถอยลอจิสติกทวิภาค การวิเคราะห์ด้วยแบบจำลองโทบิตโดยใช้แบบจำลองถดถอยแบบเซนเซอร์ และการถดถอยโลจิสติกแบบเรียงลำดับ ผลการวิจัยพบว่าช่วงเวลาทำการบิน ขนาดของอากาศยาน และระดับประสิทธิผลของระบบการกำกับดูแลความปลอดภัยการบินพลเรือนของรัฐที่อากาศยานเกิดอุบัติเหตุ เป็นปัจจัยที่ส่งผลต่อการเกิดอุบัติเหตุที่มีการเสียชีวิต โดยปรากฏผลว่าเที่ยวบินที่ทำการในระหว่างเวลา 00:00-05:59 น. โดยอากาศยานขนาดเล็กที่มีน้ำหนักบรรทุกสูงสุดของเครื่องบินขณะบินขึ้นระหว่าง 5,701-27,000 กิโลกรัม และการบินในเส้นทาง ไป/กลับจาก/เหนือ รัฐที่มีระดับประสิทธิผลของระบบการกำกับดูแลความปลอดภัยการบินพลเรือนน้อย บ่งบอกถึงแนวโน้มที่จะเกิดอุบัติเหตุที่มีผู้เสียชีวิต โดยเฉพาะระดับประสิทธิผลของระบบการกำกับดูแลความปลอดภัยการบินพลเรือนของรัฐที่อากาศยานเกิดอุบัติเหตุนั้น ถูกค้นพบว่าส่งผลกระทบต่อจำนวนผู้เสียชีวิตและระดับความเสียหายของอากาศยาน ทั้งนี้ ระดับประสิทธิผลของระบบการกำกับดูแลความปลอดภัยการบินพลเรือนของรัฐ ยังเป็นกุญแจสำคัญในการพัฒนาเพื่อบรรเทาและป้องกันอุบัติเหตุในอนาคต จึงนำไปสู่การเสนอแนะแนวทางมาตรการบรรเทาและป้องกันอุบัติเหตุ โดยแบ่งออกเป็น 7 ด้าน คือ (1) การบัญญัติกฎหมาย กำหนดระเบียบข้อบังคับ คู่มือแนวทางปฏิบัติ และแบบแผนโดยรัฐ (2) การจัดการด้านนิรภัย การตรวจสอบและการกำกับดูแลด้านความปลอดภัย (3) การรับรองและการอนุญาตของรัฐ (4) โครงสร้างพื้นฐาน เครื่องมือและอุปกรณ์ (5) การกำหนดกระบวนการขั้นตอนและวิธีปฏิบัติ (6) การปฏิบัติการและการบริการ และ (7) คุณสมบัติและความสามารถของบุคลากร และการฝึกอบรม โดยมีเป้าประสงค์พัฒนาระบบการกำกับดูแลด้านความปลอดภัยของรัฐ เพื่อนำไปสู่การบรรเทาและป้องกันการเกิดอุบัติเหตุที่มีผู้เสียชีวิต

สาขาวิชา	การจัดการโลจิสติกส์และโซ่อุปทาน (สหสาขาวิชา)	ลายมือชื่อนิสิต ....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม ....
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Prakayphet Chalayonnawin : CONTRIBUTING FACTORS IN AIRCRAFT ACCIDENTS TRIGGERING FATALITIES. Advisor: Prof. KAMONCHANOK SUTHIWARTNARUEPUT, Ph.D. Co-advisor: Assoc. Prof. PONGSA PORNCHAIWISESKUL, Ph.D., Chula Sukmanop, Ph.D.

Air transport has always been considered the safest way to travel. It has contributed numerous economic and social benefits, for instance, connecting multimodal modes of transportation, increasing employment, driving global and local economic activities, reducing travel time and generating trade, tourism, and services, connecting people and countries, and supporting humanitarian activities in a remote rural area. Historical records on the fatality ratio suggested that air transportation has the highest likelihood of accidents (occurrences with fatalities) when compared to all other transportation modes, including highway, railroad, and water. Then, when an accident occurs, it largely affects various stakeholders. This study aims to re-analyze the worldwide aircraft accidents from 2014 to 2017, by (1) identifying the contributing factors that trigger accidents (occurrences with fatalities) and (2) providing the countermeasures accounting for all high-risk accidents and significant contributing factors, for the mitigation/prevention of the future occurrences. A mixed method of quantitative and qualitative approaches was conducted. Ten aviation safety experts were recruited for an interview. Worldwide commercial aircraft accidents were collected from accident databases, final investigation reports, and various aviation communities. Factors derived from the expert interview and the precedent aircraft accidents were analyzed by adopting binary, censored, and ordered logistic regressions. Results revealed that time of day, aircraft size, and the effective implementation of State of occurrence has an impact on accidents. The predicted model suggested that flights during 00:00-05:59, operating on a small-sized aircraft with an MTOW of 5,701-27,000 kg, and flying on the route to/from/over a State of occurrence with a low effective implementation signify the likelihood of an accident occurring. Remarkably, the effective implementation of the State of occurrence was discovered that it has an impact on the number of fatalities, and the level of aircraft damage. As a result, it is the key to mitigating and preventing future mishaps. Considering the improvement of the State of occurrence effective implementation, countermeasures were proposed and classified into 7 dimensions: State legislation, regulations, guidance, and plan; safety management, oversight, and audit; State certification, authorization, and approval; infrastructure and equipment; protocols and procedures; operation and services; and qualification, competency, training of personnel. Ultimately, advancing the State's safety oversight system will lead to the mitigation and prevention of future accidents.

Field of Study:	Logistics and Supply Chain Management	Student's Signature ....
Academic Year:	2021	Advisor's Signature ....
		Co-advisor's Signature ....
		Co-advisor's Signature ....

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More importantly, I would like to dedicate this achievement to my family. I wish to thank my Chalayonnawin family, especially my parents and my sister for their endless patience, sacrifices, enthusiastic support, and word encouragement throughout my study. My special thanks are extended to my friends, and colleagues for their words of encouragement and continuous support. Lastly, my appreciation goes out to my classmates for the incredible year of studying together.

Prakayphet Chalayonnawin

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CHAPTER I INTRODUCTION

1.1. Background/Overview

Air transport has always been considered the safest way to travel (Koo et al., 2019; Molin et al., 2017). In all available modes of transportation, the United States Department of Transport reported 6,774,520 accidents in 2019, including air, highway, railroad, and water (Bureau of Transportation Statistics, 2021). Air transportation was found to have the lowest record in the number of accidents and the number of fatalities, as shown in Figure 1 (Bureau of Transportation Statistics, 2021) and Figure 2 (Bureau of Transportation Statistics, 2022). It accounts for approximately 0.02% of accidents and 1.20% of fatalities in all modes. However, the statistics on fatality ratio shows that air has the highest likelihood of accidents (occurrences with fatalities) when compared to all other modes (Figure 3).

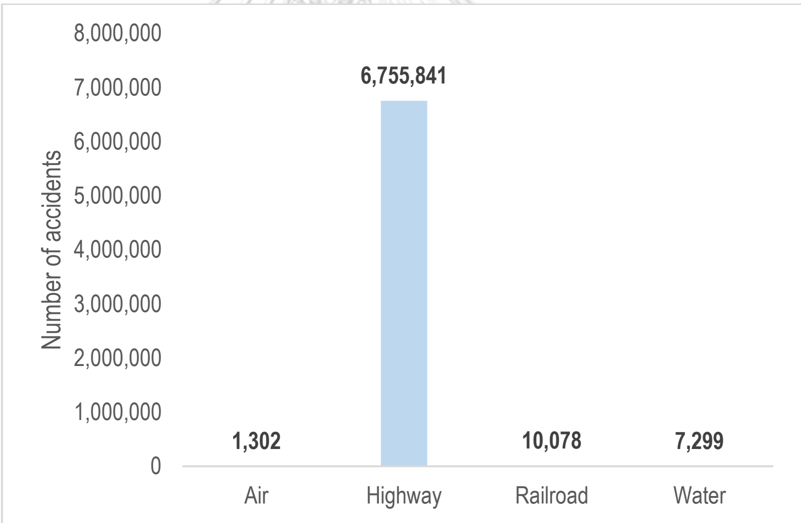

Figure 1 Historical Transportation Accidents by Mode in 2019 (Bureau of Transportation Statistics, 2021)

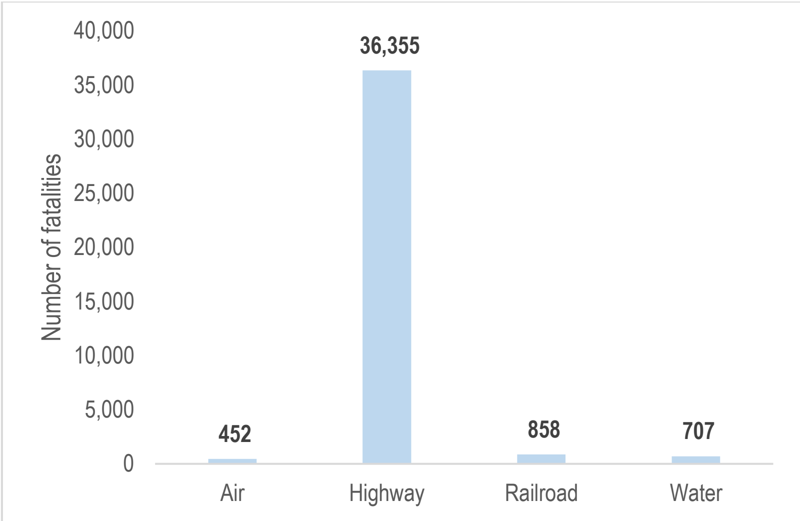

Figure 2 Historical Transportation Fatalities by Mode in 2019 (Bureau of Transportation Statistics, 2022)

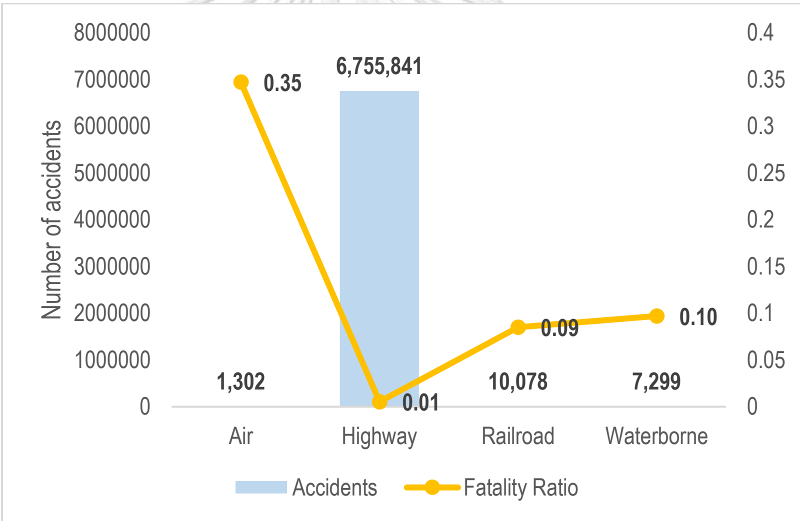

Figure 3 Historical Transportation Accidents and Fatalities Ratio by Mode in 2019 (Bureau of Transportation Statistics, 2021, 2022)

1.1.1. Commercial Air Transport Operations

In recent years, the volume of air traffic has grown tremendously to 4.5 billion passengers and 46.8 million scheduled commercial flights globally (Air Transport Action Group, 2020). It has contributed numerous economic and social benefits, for instance, connecting multimodal modes of transportation, increasing employment, driving global and local economic activities, reducing travel time and generating trade, tourism, and services, connecting people and countries, and supporting humanitarian activities in a remote rural area (Industry High Level Group, 2017).

During pre-COVID 19 situation, it contributed $3.5 trillion (equivalent to 4.1% of the world's gross domestic product (GDP)), created more than 87 million jobs supported by aviation, and linked 48,044 routes globally (Air Transport Action Group, 2020). In 2038, the passenger traffic volume, demand for passenger and freighter aircraft, GDP, and jobs are forecasted to approximately double in 20 years with 8.2 billion passengers, 39,210 aircraft, $6.3 trillion in GDP, and 143 million jobs supported by Aviation (Air Transport Action Group, 2020; Airbus, 2019). Therefore, improving safety in aviation and continuous efforts in reducing aircraft accident rate is vital to support future economic growth locally and globally.

1.1.2. Commercial Air Transport Accidents

The United Nations Sustainable Development Goal to which aviation safety contributes is "to make cities and human settlements inclusive, safe, resilient, and sustainable" by reducing the number of deaths and people affected by disasters, which is consistent with the International Civil Aviation Organization (ICAO) Global Aviation Safety Plan 2020–2022 aspirational goal of accomplishing zero fatalities in commercial operations by 2030 (ICAO, 2020c, n.d.-a). In the past, there were unforgettable aircraft accidents that made the headlines and shocked the World, such as the Tenerife airport disaster causing, 583 fatalities from the crash between KLM and Pan Am, Japan Airlines Flight 123, causing 520 fatalities from faulty maintenance, Charkhi Dadri mid-air collision causing 349 fatalities from Kazakhstan Airlines crashed with Saudia Flight and Malaysia Airlines Flight 17 that was shot down near the Russian border, likely by pro-Russian forces in control of the region during the War in Donbass between separatist insurgents and the Ukrainian Government Forces (Morris, 2017).

Moreover, during the past decade, the reoccurrences of fatal accidents were still happening and had taken more than a hundred lives. Those ill-fated flights are Malaysia airlines MH17 with 298 fatalities; Malaysia Airlines MH370 in 2014 with 239 fatalities; Metrojet 7K9268 in 2015 with 224 fatalities; Lion Air JT610 in 2018 with 189 fatalities; Ukraine International Airlines PS752 in 2020 with 176 fatalities; Indonesia AirAsia QZ8501 in 2014 with 162 fatalities; Air India Express IX812 in 2010 with 158 fatalities;

Ethiopian Airlines ET302 in 2019 with 157 fatalities; Dana Air 9J992 in 2012 with 153 fatalities; Airblue ED202 in 2010 with 152 fatalities; and Germanwings 4U9525 in 2015 with 150 fatalities (ASN, 2022; BBC News, 2021). Some have discovered causes, some investigations are still ongoing, and some are still missing and remain unresolved. According to the Swiss Cheese Model of accident causation (Reason, 2016), "bad events happen when these holes or weaknesses line up to permit a trajectory of accident opportunity to bring hazards into damaging contact with people and/or assets", and the gap of defenses appear due to active failures and latent conditions.

1.1.3. Aviation Occurrence Categories

In general, after the accident investigation, the State conducting investigation shall send the Preliminary Report and Accident Data Report to other stakeholders and/or ICAO such as the State of Registry or State of Occurrence, State of Operator, State of Design, and State of Manufacturer (ICAO, 2020a). The ICAO Accident/Incident Data Reporting (ADREP) system is maintained by ICAO and it receives data from States (ICAO, 2020b). During the occurrence (accident/incident) collection and reporting process, the ADREP occurrence category taxonomy, which is a set of terminology and definitions for aviation accident and incident reporting systems, is applied (ICAO, 2020b, n.d.-b). According to ICAO (2020b), "occurrence refers to accidents, serious incidents and incidents". The ADREP taxonomy is commonly used with the European Coordination Centre for Accident and Incident Reporting System (ECCAIRS). The taxonomy includes Aerodrome (ADRM), Abrupt maneuvre (AMAN), Abnormal runway contact (ARC), Air Traffic Management/Communication, Navigation and Surveillance (ATM/CNS), Bird strike (BIRD), Cabin safety events (CABIN), Controlled flight into or toward terrain (CFIT), Collision with obstacle(s) during take-off and landing (CTOL), Evacuation (EVAC), External load related occurrences (EXTL), Fire/smoke (non-impact) (F-NI), Fire/smoke (post-impact) (F-POST), Fuel related (FUEL), Ground Collision (GCOL), Glider towing related events (GTOW), Icing (ICE), Low altitude operations (LALT), Loss of control - ground (LOC-G), Loss of control - inflight (LOC-I), Loss of lifting conditions en-route (LOLI), Airprox/ ACAS alert/ loss of separation/ (near) midair collisions (MAC), Ground Handling (RAMP), Runway excursion (RE), Runway incursion - vehicle, aircraft or person (RI), Runway incursion - other (RI-O), Runway incursion-vehicle or aircraft (RI-VA), System/component failure or malfunction [non-powerplant] (SCF-NP), powerplant failure or malfunction (SCF-PP), Security related (SEC), Turbulence encounter (TURB), Unintended flight in instrument meteorological conditions (UIMC), Undershoot/overshoot (USOS), Collision Wildlife (WILD), Windshear or thunderstorm (WSTRW), Other (OTHR), and Unknown or undetermined (UNK) (ECCAIRS, 2013). ICAO remains focused on their safety priorities of high-risk categories of occurrence (HRCs) Controlled Flight into Terrain (CFIT), Loss of Control-inflight (LOC-I), Mid-air collision (MAC), Runway excursion (RE), Runway incursion (RI) (ICAO, 2020d). The HRCs were chosen considering the historical records of actual fatalities, high fatality risk per accident, or the number of accidents and incidents (ICAO, 2019b). Likewise, the International Air Transport Association (IATA) concentrates on Runway Excursions, Controlled Flight into Terrain, Loss of Control-In-flight, and Mid-air Collision (IATA, 2021).

1.1.4. Impact of Air Transport Accident

When an accident occurs, it largely affects various stakeholders, including insurer, aircraft manufacturer, and airline company (Kaplanski & Levy, 2010); passengers, public, media, economy and society (Li et al., 2015). Many studies found that the consequences of aviation accidents and incidents come with medical costs, rehabilitation/long-term care, workplace costs, productivity losses, property (aircraft) damage, loss of quality of life, emergency services, insurance administration, legal expenses, and accident investigation costs (shown in Figure 4) (BTE, 1999), changes in stock price (Kaplanski & Levy, 2010; Wang, 2013), negative airline reputation and image, consumer trust (Yang et al., 2018); and public perception (Li et al., 2015).

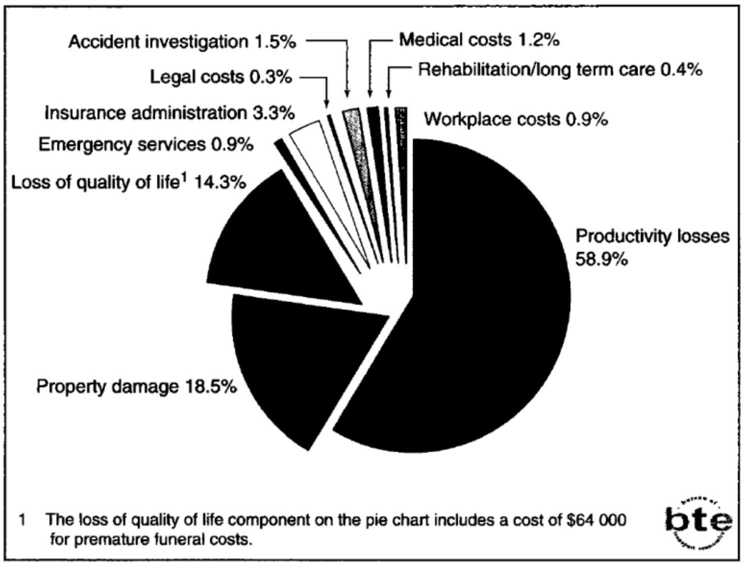

Figure 4 Component Cost of Aviation Accident (BTE, 1999)

As a result, many institutions have been working together seamlessly to prevent the accident. For example, ICAO has established Annex 13 Aircraft Accident and Incident Investigation, Annex 19 Safety Management, and Doc 9859 Safety Management Manual for the compliance of Safety Standard, established by the 193-member States; and the IATA which is a trade association representing 295 airlines. Both organizations place safety as their top priority (IATA, 2021; ICAO, 2019b). Though the goal for aviation safety is to achieve zero accident rate, there are risks in aviation operation. Risk can only be a positive number; hence, risk can only be decreased close to zero but cannot be zero (Tiamtiabrat, 2007). Consequently, the best solution is to improve aviation safety so that the fatalities can be reduced to close to zero.

Even though International organizations, aviation-related organizations, civil aviation authorities, airports, airlines, and air traffic service providers have been putting their great effort into working together in setting Safety Standards, Regulations, and Guidelines targeted to protecting lives and the system. However, these catastrophic events are still occurring. Moreover, passengers, who are trusted by the aviation system and its safety record, chose what they thought was the best and safest way to travel. Still, they lost their lives in this tragic event. For that reason, it can be indicated that there could be latent failures existing in the system waiting to cause a mishap. Therefore, these failures need to be identified and fixed to reduce the number of accidents resulting the fatality to close to zero.

According to the ICAO's historical fatality record from 2008 to 2019 (Figure 5), the volume of the passengers shows the upward trend and increasing every year. Meanwhile, the rate of fatalities is intended to be declines, however fluctuated. It is questionable whether the passengers are flying in a safe environment, where the likelihood of the plane crashes is low. From the observation, the historical records (Figure 5 and Figure 6) from 2008 to 2019, there are similar pattern of accidents every three to four years. In 2010, there were 768 fatalities which increased from the previous year; however, in the latter years, it started to reduce and slightly showed a safer sign for three years. Unexpectedly, the number of fatalities in 2014 skyrocketed to 911 fatalities, higher than in 2010. The pattern was the same from 2015-2017, where the number of fatalities gradually decreased showing a safer sign. Nevertheless, in 2018, there were 514 fatalities accounted for more than a 900% increase of fatalities compared to the previous year.

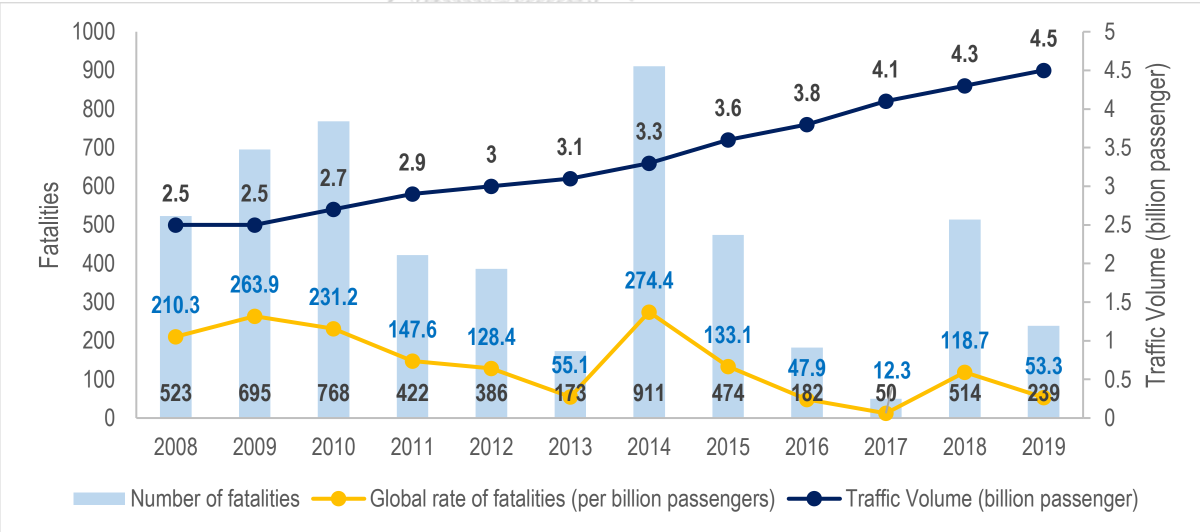

Figure 5 Historical records on passenger traffic, number of fatalities and the global rate of fatalities (ICAO, 2013, 2014, 2015a, 2015b, 2016, 2017, 2018, 2019a, 2019c, 2020d)

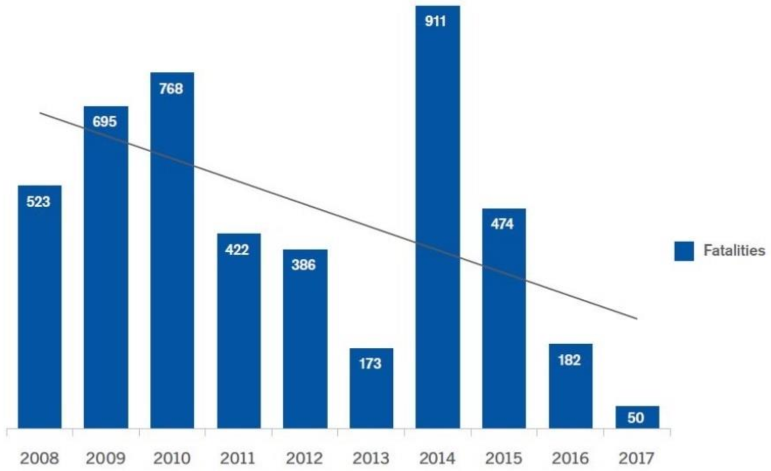

Figure 6 Historical Fatality Records for Scheduled Commercial Flights (ICAO, 2018)

1.2. Significance of the Problem

Air transport has the lowest mortality risk and is trusted by passengers for its safety procedure and record. However, every 3-4 years, when the rate of accidents has decreased to its lowest record, there was a dramatic increase in accidents in a later year. Despite the layers of safety defenses in the aviation system, the industry is still experiencing catastrophic events from latent failures existing in the system. Therefore, this study aims to re-analyze the worldwide aircraft accidents from 2014 to 2017, using multiple statistical techniques by (1) identifying the contributing factors that trigger accidents (occurrences with fatalities) and (2) providing the countermeasures accounting all high-risk accidents and significant contributing factors, for the mitigation/prevention of the future occurrences.

It is essential that these accidents shall be thoroughly investigated to explore any underlying factors, indeed, not to place the blame or liability on anyone. However, it would be valuable for all aviation professionals to learn from the past, stimulate the improvement of international aviation safety, and prevent future occurrences.

1.3. Research Objectives

The primary goal of this research is to re-analyze the worldwide aircraft (occurrences) (accident/incident) from the 2014 to 2017, which the objectives are specified as follows:

a) To identify contributing factors that triggered accidents (occurrences with fatalities) and;

b) To provide the countermeasures accounting all high-risk accidents and significant contributing factors, for the mitigation/prevention of future occurrences.

1.4. Research Questions

a) What are contributing factors in the analyzed accidents which triggered fatalities?

b) How can safety be improved to prevent the reoccurrence and provide early protection that would lead to similar accidents?

1.5. Scope of Study

The mixed method of quantitative and qualitative approaches was conducted to explore critical contributing factors and countermeasures for an accident (occurrence with fatalities). In terms of the quantitative approach, the study focuses on the worldwide aircraft occurrences (accident/incident) from commercial operations, in which the English final reports between 2014–2017 are publicly available. The scheduled commercial operations of aircraft with a maximum take-off weight (MTOW) of more than 5,700 kg were included in this study. It is to be consistent with the official accidents published in the ICAO Safety Report. On the other hand, the expert interviews were carried out for a qualitative method. Ten experts from five different disciplines (airport operator, air navigation service provider, airline operator, aircraft accident investigation agency, and academician) were recruited for an interview. The experts were selected based on their field of expertise and minimum experience of 10 years related to aviation safety or aviation accident investigation.

1.6. Research Contribution

a) This study focuses on identifying the critical contributing factors and additional factors (if any) from the expert interview and the precedent aviation accidents from 2014-2017 through binary, censored, and ordered logistic regressions. Moreover, ten experts from five different disciplines with local and international experience were recruited to further provide countermeasures to mitigate and prevent future accidents.

b) It is intended that the study build upon the existing principles and findings from reputable institutions and practitioners in the academician perspective in seeking alternatives in preventing future occurrences.

Previous studies regarding the analysis of aviation accidents focused on accidents in general aviation; with only human factors; with specific accident occurrence type/situation/duty (Aguiar et al., 2017; Boyd, 2015; Erjavac et al., 2018; Gong et al., 2014; Kelly & Efthymiou, 2019; Nakagawara et al., 2004; Xue & Fu, 2018), however, they did not focus on accidents (occurrences with fatalities) in commercial operation by applying multiple statistical techniques.

To the best of my knowledge, one study has similarly explored the past aviation accidents (Ekman & Debacker, 2018). However, this research focuses on only the effect of MTOW, flight phase, and aircraft damage on survivability of passengers. Moreover, the qualitative examination was not performed to explore countermeasures from experts. The findings in this research could provide a further exploration into the critical contributing factors affecting fatal accidents and provide countermeasures for prevention and protection from accidents (occurrences with fatalities). Moreover, it could deliver incremental knowledge on the existing findings and principles from reputable institutions and additional factors (if any).

1.7. Expected Outcomes/Benefits

a) Critical contributing factors that influenced the aircraft mishaps with fatalities; and

b) Countermeasures for preventing and protecting from the reoccurrence of a similar catastrophic event.

CHAPTER II LITERATURE REVIEW

2.1. Definition and Terminology

Refers to the ICAO Annex 13 – Aircraft Accident and Incident Investigation (ICAO, 2020) provides the meaning of the terms used in the Standards and Recommended Practices as follows:

Accident is an occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

a) a person is fatally or seriously injured as a result of:

— being in the aircraft, or

— direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or

— direct exposure to jet blast,

*excep*t when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or b) the aircraft sustains damage or structural failure which:

— adversely affects the structural strength, performance or flight characteristics of the aircraft, and

— would normally require major repair or replacement of the affected component,

except for engine failure or damage, when the damage is limited to a single engine (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), or for minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or c) the aircraft is missing or is completely inaccessible.

Note 1.— For statistical uniformity only, an injury resulting in death within thirty days of the date of the accident is classified, by ICAO, as a fatal injury.

Note 2.— An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

Note 3.— The type of unmanned aircraft system to be investigated is addressed in 5.1.

Note 4.— Guidance for the determination of aircraft damage can be found in Attachment E.

Causes are Actions, omissions, events, conditions, or a combination thereof, which led to the accident or incident. The identification of causes does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

Contributing factors are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

Incident is an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

Occurrences are accidents, serious incidents and incidents.

Serious incident is an incident involving circumstances indicating that there was a high probability of an accident and associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down.

Other definitions and terminology are also provided in **Appendix A.**

2.2. Accident Occurrence Categories

When reporting an incident and accident to ICAO, it is consolidated and reported in a specific taxonomy called the European Co-ordination Centre for Accident and Incident Reporting Systems (ECCAIRS) Occurrence Category (ECCAIRS, 2013; ICAO, n.d.-b)

Table 1 shows the ECCAIRS 36-type of occurrences and provides definitions and descriptions. This ECCAIRS is a common reporting taxonomy that is widely used in many countries, including Thailand.

Table 1 ADREP Taxonomy ECCAIRS Occurrence Category

OCCURRENCE CATEGORY	DESCRIPTION
ADRM: Aerodrome	Occurrences involving aerodrome design, service, or functionality issues.
AMAN: Abrupt maneuvre	The intentional abrupt maneuvering of the aircraft by the flight crew.
ARC: Abnormal runway contact	Occurrences involving Air traffic management (ATM) or communications, navigation, or surveillance (CNS) service issues.
Air Traffic Management /Communication, Navigation and Surveillance (ATM/CNS)	Occurrences involving Air traffic management (ATM) or communications, navigation, or surveillance (CNS) service issues. (ATM: ATM/CNS)
BIRD: Bird strike	Occurrences involving collisions / near collisions with birds
CABIN: Cabin safety events	Miscellaneous occurrences in the passenger cabin of transport category aircraft
CFIT: Controlled flight into or toward terrain	Inflight collision or near collision with terrain, water, or obstacle without indication of loss of control
CTOL: Collision with obstacle(s)	Collision with obstacle(s), during take-off or

OCCURRENCE CATEGORY	DESCRIPTION
during take-off and landing	landing whilst airborne.
EVAC: Evacuation	Occurrence where either; (a) person(s) are injured during an evacuation; (b) an unnecessary evacuation was performed; (c) evacuation equipment failed to perform as required; or (d) the evacuation contributed to the severity of the occurrence.
EXTL: External load related occurrences	Occurrences during or as a result of external load or external cargo operations.
F-NI: Fire/smoke (non-impact)	Fire or smoke in or on the aircraft, in flight or on the ground, which is not the result of impact.
F-POST: Fire/smoke (post-impact)	Fire/Smoke resulting from impact.
FUEL: Fuel related	One or more powerplants experienced reduced or no power output due to fuel exhaustion, fuel starvation/mismanagement, fuel contamination/wrong fuel, or carburetor and/or induction icing.
GCOL: Ground Collision	Collision while taxiing to or from a runway in use.
GTOW: Glider towing related events	Premature release, inadvertent release or non-release during towing, entangling with towing, cable, loss of control, or impact into towing aircraft / winch.
ICE: Icing	Accumulation of snow, ice, freezing rain, or frost on aircraft surfaces that adversely affects aircraft control or performance.
LALT: Low altitude operations	Collision or near collision with obstacles/objects/terrain while intentionally operating near the surface (excludes takeoff or

OCCURRENCE CATEGORY	DESCRIPTION
	landing phases).
LOC-G: Loss of control - ground	Loss of aircraft control while the aircraft is on the ground
LOC-I: Loss of control - inflight	Loss of aircraft control while or deviation from intended flightpath inflight.
LOLI: Loss of lifting conditions en-route	Landing en-route due to loss of lifting conditions.
MAC: Airprox/ ACAS alert/ loss of separation/ (near) midair collisions	Airprox, ACAS alerts, loss of separation as well as near collisions or collisions between aircraft in flight.
RAMP: Ground Handling	Occurrences during (or as a result of) ground handling operations.
RE: Runway excursion	A veer off or overrun off the runway surface.
RI: Runway incursion - vehicle, aircraft or person	Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft.
RI-O: Runway incursion - other	Collision with, risk of collision, or evasive action taken by an aircraft to avoid, a person or animal on a runway in use.
RI-VA: Rwy incursion-vehicle or a/c	Collision with, risk of collision, or evasive action taken by an aircraft to avoid, a vehicle or other aircraft on a runway in use.
SCF-NP: System/component failure or malfunction [non-powerplant]	Failure or malfunction of an aircraft system or component - other than the powerplant.
SCF-PP: powerplant failure or malfunction	Failure or malfunction of an aircraft system or component - related to the powerplant.

OCCURRENCE CATEGORY	DESCRIPTION
SEC: Security related	Criminal/Security acts which result in accidents or incidents (per International Civil Aviation Organization [ICAO] Annex 13).
TURB: Turbulence encounter	In-flight turbulence encounter
UIMC: Unintended flight in IMC	Unintended flight in Instrument Meteorological Conditions (IMC)
USOS: Undershoot/overshoot	A touchdown off the runway surface.
WILD: Collision Wildlife	Collision with, risk of collision, or evasive action taken by an aircraft to avoid wildlife on a runway or on a helipad/helideck in use.
WSTRW: Windshear or thunderstorm	Flight into windshear or thunderstorm.
OTHR: Other	Any occurrence not covered under another category.
UNK: Unknown or undetermined	Insufficient information exists to categorize the occurrence.

2.3. Contributing Factors/Circumstantial Factors

Factors that are likely to contribute to fatal accidents were studied in a literature review (see Table 2).

Flight schedule – Day, Month, and Time

In general, flight schedule in commercial air transport are not solely depended on airline decision, however, they are driven by external factors such as market demand, competition, slot shortages, and incentives (Givoni & Rietveld, 2009). Regarding day and month, accidents were found to occur on weekends (Saturday and Sunday) more than on weekdays; moreover, the most mishaps happened during the flying season from April to September (summer period) (Dambier & Hinkelbein, 2006). Time of flight is crucial for aviation personnel, particularly duty time. Duty time is the main indicator of fatigue, which is one of the key safety issues leading to accidents (Bourgeois-Bougrine et al., 2003; U.S. Department of Transportation, 2017; Williamson et al., 2011). A company's inadequate time allocation for task was one of the top ten circumstantial factors contributing to fatal accidents (U.K. CAA, 2013). Night operations, jet lag, schedules on consecutive days with multiple legs, early wake-ups, early starts, and long working hours during the window of circadian low (02:00-06:00) carried risks of fatal flights and were associated with pilot and air traffic controller fatigue (Bourgeois-Bougrine et al., 2003; Boyd, 2015; Caldwell, 2005; Chang et al., 2019; Coombes et al., 2020; Roach et al., 2012). Notably, more pilot errors are generated during early morning (00:00-05:59) flights than morning flights (06:00-11:59) (Mello et al., 2008).

Aircraft

Aircraft age has been a contributing factor in several accidents in the past. Aging aircraft generates risk of corrosion over time and fatigue in structural components including aircraft wings and pressurized sections (Australian Transport Safety Bureau, 2007). It can be defined by chronological age, flight cycles, and a number of flight hours. Accidents involving aging aircraft have highlighted the safety issue over aging aircraft, such as Comet DH-106 in 1954 fuselage fatigue failures, B707 Lusaka tailplane failure in 1977, particularly Aloha 243 in 1988 explosive decompression of a 19-year-old aircraft, with 35,496 airframe flight hours, and 89,680 flight cycles (Australian Transport Safety Bureau, 2007; EASA, 2021b).

Aircraft manufacturer was found to be a factor that led to accidents. Airworthiness, including maintenance issues, system/component failures, engine failures, and problems with aircraft design, were involved in fatal accidents according to some studies (Kinnersley & Roelen, 2007; U.K. CAA, 2013). Boeing's design and production phase issues with the battery in the B787 aircraft overheating and, in multiple cases, catching fire led to the aircraft being grounded by airlines and the U.S. Federal Aviation Administration (Song et al., 2014). Recently, two accidents from Lion Air and Ethiopian Airlines involving B737 Max design flaws contributed to 346 fatalities when a significant change and installation of new software called the Maneuvering Characteristics Augmentation System was conducted without informing the pilots and airlines of the changes to the B737 Max and that the changes required simulation training (Herkert et al., 2020; Sgobba, 2019). Other studies found Russian manufacturers to have poor safety records and are frequently involved in maintenance accidents (Khan et al., 2020; Kharoufah et al., 2018).

Regarding aircraft models, Boeing 737 and Airbus A320 were frequently discovered to be involved in avionics-related accidents, in which Boeing 737 had the highest proportion (Baidzawi et al., 2019). Moreover, the design of aircraft, air traffic management, and the airport was identified as causal or contributing factors to the accident (Eurocontrol, 2004). Furthermore, the recent Boeing 737 Max accidents with Lion Air in 2018 and Ethiopian Airlines in 2019 presented the issue surrounding aircraft design and software that led to two fatal crashes which grounded these aircraft models globally (Rhee et al., 2020; Topham, 2021)

For aircraft size, one study found that the most significant proportion of accidents occurred in medium-sized aircraft with a maximum takeoff weight (MTOW) of 27,001-272,000 kg, while the highest average fatality rate was from small-sized aircrafts with an MTOW of 5,701-27,000 kg (Ekman & Debacker, 2018). The same study found that the lowest proportions of fatal and serious injuries were in larger aircrafts (Ekman & Debacker, 2018). Similarly, larger airplanes resulted in fewer impact injuries and had a higher probability of survival than smaller airplanes according to another study (RGW Cherry & Associates Limited, 2016). Fatal accidents involving large airplanes mainly involved air cargo flights (Savage, 2013). In contrast, other studies found that more incidents and accidents occur with jet-engine aircrafts than with turboprops, whereas another study suggested that more accidents occur in turboprops, and large jets have the highest average number of fatalities per accident (Oster et al., 2013; Pramono et al., 2020).

Flight Phase

Previous studies found that the phase of flight had a significant effect on fatality ratios and the survivability of the aircraft's occupants (Ekman & Debacker, 2018; Tiabtiamrat & Wiriyacosol, 2010). Approach and landing were most common phases in fatal accidents, while most human-caused factors occurred en route or during takeoff and initial climb (Airbus, 2022; Boeing, 2021; EASA, 2019, 2021a; Kharoufah et al., 2018; Williams, 2011) . Maintenance accidents contributed during the initial climb phase, along with sleep deprivation, high workloads, and verbal exchanges that generated fatigue during descent and climb (Bourgeois-Bougrine et al., 2003; Khan et al., 2020).

Pilot total flight experience

The pilot flight experience by total flight time is perceived as an indicator associated with incident (Ji et al., 2018). Moreover, pilot with high experience and qualification has a likelihood to evaluate and view the risk lower than normal and can accept to operate the aircraft in a challenging weather condition (Makarowski et al., 2016). Also, the pilot with a high degree of mindfulness tend to be more cautious during their early stage of experience-building and becoming more confident at the later stage in which that confidence could lead to the deviation from the Standard Operating Procedures (SOPs) (Ji et al., 2018).

State Safety Oversight

The ICAO's Universal Safety Oversight Audit Programme (USOAP) effective implementation (EI) is generally used as a metric representing States' safety oversight systems (ICAO, 2019b). Importantly, it is one of the Global Aviation Safety Plan's targets to be achieved by 2022, 2036, and 2030 (ICAO, 2019a). According to the ICAO (n.d.-a) regarding the USOAP effective implementation (EI), "it is a measure of the State's safety oversight capability and an indication of a State's degree of compliance with ICAO provisions. It is measured through USOAP and calculated for each critical element, audit area, or as an overall measure. It is expressed as a percentage" and the rationale is "compliance to ICAO's international standards is the key to safe aviation activities in States." Inadequate regulatory oversight is a factor that has frequently contributed to fatal accidents worldwide (U.K. CAA, 2013). There are past incidents and accidents that were suspected to be related to the State of Registry, State of Occurrence, and the State of Operator because safety recommendations were made directly to the Civil Aviation Authority in terms of safety oversight, aircraft worthiness, air operator certification, personnel, training, and emergency and rescue operation (Skybrary, 2010, 2012a, 2012b, 2013, 2014). Africa had the highest number of human factor-related accidents and incidents from 2000 to 2014 (Kharoufah et al., 2018). Therefore, EI on State of registry, State of occurrence, and State of operator are another interesting factors for this research.

Air Navigation Service

According to the European Union Aviation Safety Agency EASA (2018), air navigation service (ANS) refers to "air traffic services; communication, navigation and surveillance services; meteorological services for air navigation; and aeronautical information services". Air traffic management system design, air traffic control, fatigue due to working schedules, miscommunication between pilots and air traffic controllers, and memory errors were causal and contributing factors in fatal accidents (Chang et al., 2019; EASA, 2019; Kinnersley & Roelen, 2007; Shorrock, 2005; Tajima, 2004; U.K. CAA, 2013). EASA has identified airborne, and runway collisions as crucial risk areas in air traffic management (ATM) and ANS, and most ATM accidents were collisions with obstacles (EASA, 2019, 2021a; van Es, 2001). Deadliest accidents related to ANS in the past include the Douglas DC-7 and Lockheed L-1049 collision over the Grand Canyon in 1956, the midair collision of a TU154 and a B752 over Überlingen in 2002; and the runway collision of KLM 4805 and Pan Am 1736, in Tenerife in 2002 (ASN, n.d.; Kwang-Eui et al., 2011). Globally, ANS is one of the areas with low effective implementation (EI) of the ICAO's Universal Safety Oversight Audit Programme (USOAP), which measures a State's safety oversight capability (ICAO, 2019b). EI was correlated with fatalities, and regulatory oversight was one of the top factors contributing to fatal accidents (Spence et al., 2015; U.K. CAA, 2013). Thus, this study considered the ANS EI of the accident location.

Table 2 Factors that are likely to contribute to fatal accidents

Variables	Literature Review
Flight schedule including day,	(Bourgeois-Bougrine et al., 2003; Boyd, 2015; Caldwell, 2005; Chang et al., 2019; Coombes et al., 2020; Dambier & Hinkelbein,

Variables	Literature Review
month, and time	2006; Givoni & Rietveld, 2009; Mello et al., 2008; Roach et al., 2012; U.K. CAA, 2013; U.S. Department of Transportation, 2017; Williamson et al., 2011)
Aircraft Age	(Australian Transport Safety Bureau, 2007; EASA, 2021b)
Aircraft manufacturer	(Herkert et al., 2020; Khan et al., 2020; Kharoufah et al., 2018; Kinnersley & Roelen, 2007; Sgobba, 2019; Song et al., 2014; U.K. CAA, 2013)
Aircraft model	(Baidzawi et al., 2019; Eurocontrol, 2004; Rhee et al., 2020; Topham, 2021)
Aircraft size	(Ekman & Debacker, 2018; Oster et al., 2013; Pramono et al., 2020; RGW Cherry & Associates Limited, 2016; Savage, 2013)
Phase of flight	(Airbus, 2022; Boeing, 2021; Bourgeois-Bougrine et al., 2003; EASA, 2019, 2021a; Ekman & Debacker, 2018; Khan et al., 2020; Kharoufah et al., 2018; Tiabtiamrat & Wiriyacosol, 2010; Williams, 2011)
Pilot – total flight experience	(Ji et al., 2018; Makarowski et al., 2016)
State safety oversight - effective implementation	(ASN, n.d.; Chang et al., 2019; EASA, 2018, 2019, 2021a; ICAO, 2019b; Kinnersley & Roelen, 2007; Kwang-Eui et al., 2011; Shorrock, 2005; Spence et al., 2015; Tajima, 2004; U.K. CAA, 2013; van Es, 2001)

CHAPTER III METHODOLOGY

3.1. Research Questions

a) What are contributing factors in the analyzed accidents which triggered fatalities?

b) How can safety be improved to prevent the reoccurrence and provide early protection that would lead to similar accidents?

3.2. Research Process Framework

The research framework is shown in Figure 7 and 8.

Figure 7 Research Process Framework

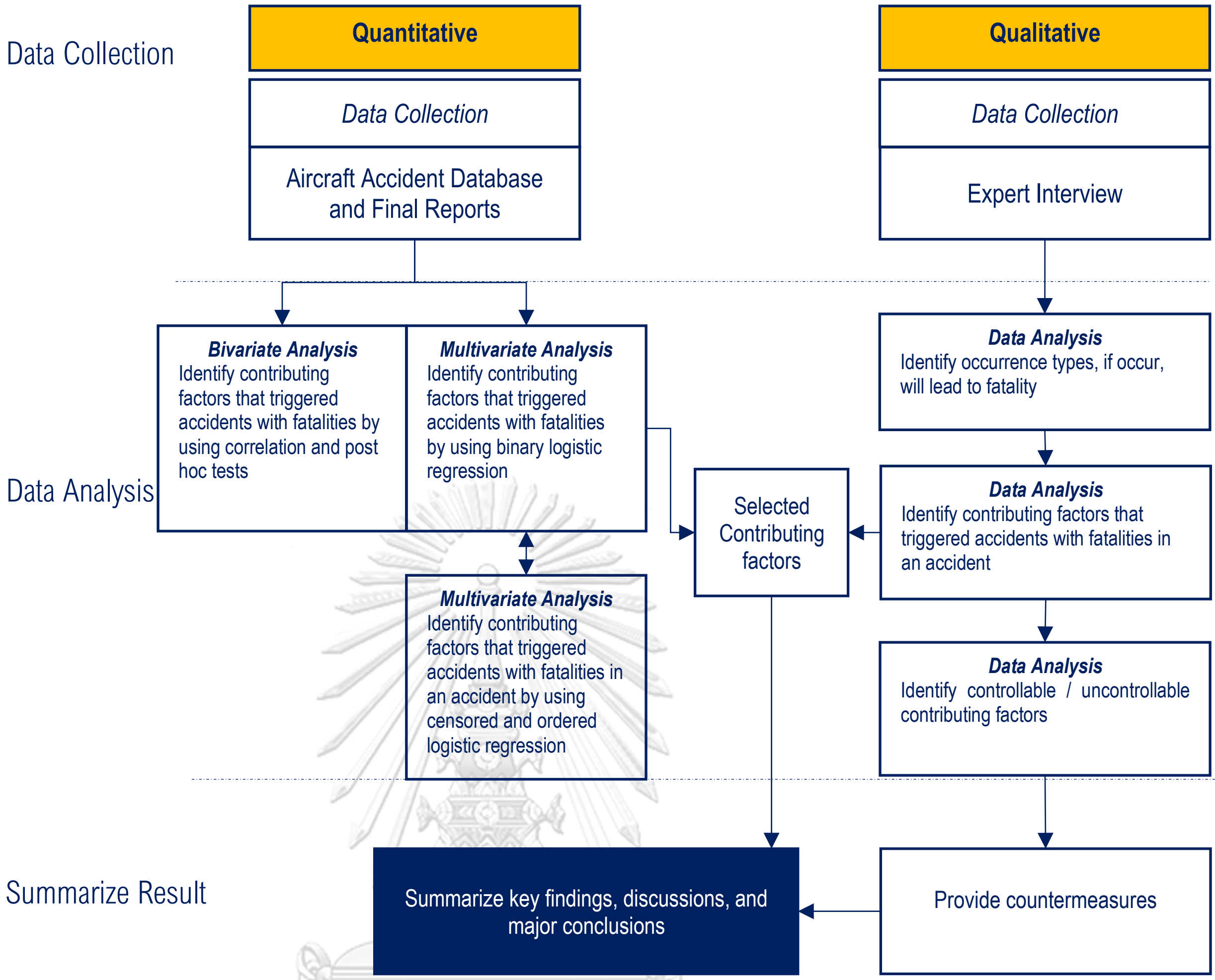

Figure 8 Research Process Design Step 5-8

3.3. Research Design

Qualitative approach

A qualitative approach was adopted to explore factors contributing to commercial air transport accidents from the perspectives of ten experts from five different disciplines and professional experience. The factors in interview questions were constructed based on previous studies in the literature review. Also, some factors were originated from the aircraft accident final report of the U.S. National Transport Safety Board that the researchers consider could trigger accidents. The nine semi-structured interviews were conducted online through Microsoft Teams, and one interview was conducted via a Line call (an application). In each interview, the author informed the interviewees of an overview of the research study, research objectives, benefits of the research, interview structure, and questions. Prior to the interview, consent was obtained from interviewees for taking part in the study and permission to audio or video record for transcription purposes. The sessions were interviewed in Thai and English language and transcribed.

Quantitative approach

This observational quantitative research study is based on the official accidents from the annual ICAO Safety Reports, in which selected accidents are those publicly available final investigation reports in English. The data focused on the aviation occurrences from commercial operations during a 4-year period ranging from 2014 to 2017 prior to the pandemic outbreak, COVID-19, when the traffic was normal. They were consolidated from public sources, which include, authoritative air accident investigation agencies, civil aviation authorities, government-related agencies, international organizations, aircraft manufacturers, and accident database/aviation-related web pages (see Table 3). The study variables were recorded in a Microsoft Excel spreadsheet and were then transferred to and analyzed in SPSS program version 28.0.0.0 (190) and Stata 17.0.

Table 3 Sources of data (see ***Appendix B****)*

Accident Investigation Agencies, Civil Aviation Authorities, and Government related agencies	
Australia	Australian Transport Safety Bureau (ATSB)
Bahamas	Air Accident Investigation Department of the Bahamas
Bangladesh	Aircraft Accident Investigation Group of Bangladesh (AAIC-BD)
Brazil	Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA) – Center for Investigation and Prevention of Aeonautical Accidents, Brazilian Air Force
Canada	Transportation Safety Board of Canada (TSB)
Denmark	Accident Investigation Board Denmark (Havarikommissionen for Civil Luftfart og Jernbane)
France	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA)

Germany	German Federal Bureau of Aircraft Accident Investigation, Germany
Ghana	Ministry of Aviation, Ghana
Greece	Air Accident Investigation and Aviation Safety Board (AAIASB) – Ministry of Infrastructure and Transport, Hellenic Republic
India	Aircraft Accident Investigation Bureau (AAIB), Ministry of Civil Aviation, Government of India
Indonesia	Komite Nasional Keselamatan Transportasi (KNKT) – National Transportation Safety Committee, Republic of Indonesia
Iran	Aircraft Accident Investigation Board, Civil Aviation Organization, Islamic Republic of Iran
Ireland	Air Accident Investigation Unit (AAIU) Ireland, Department of Transport Tourism and Sport
Italy	Agenzia Nationale per la Sicurezza del Volo (ANSV) – Italian civil aviation safety investigation authority
Japan	Japan Transport Safety Board (JTSB), Ministry of Land, Infrastructure, Transport and Tourism
Malaysia	Biro Siasatan Kemalangan Udara – Air Accident Investigation Bureau (AAIB), Ministry of Transport Malaysia
Malaysia	The Malaysian ICAO Annex 13 Safety Investigation Team for MH370
Mali	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC), Republique du Mali
Myanmar	Myanmar Aircraft Investigation Bureau (MAIB)
Nepal	Aircraft Accident Investigation Commission, Government of Nepal
Netherlands	Dutch Safety Board, Netherlands
New Zealand	Civil Aviation Authority of New Zealand
Pakistan	Aircraft Accident Investigation Board of Pakistan (AAIB), Civil Aviation Authority of Pakistan
Portugal	Gabinete de Prevenção e Investigação de Acidentes com Aeronaves

	e de Acidentes Ferroviários (GPIAAF), Portugal
South Africa	Accident and Incident Investigations Division, South African Civil Aviation Authority
Spain	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC), Spain
Sweden	Statens haverikommission (SHK) – Swedish Accident Investigation Authority
Switzerland	Swiss Transportation Safety Investigation Board (STSB), Switzerland
Taiwan	Aviation Safety Council
Taiwan	Taiwan Transportation Safety Board (TTSB)
United Arab Emirates	Air Accident Investigation Sector, General Civil Aviation Authority, United Arab Emirates
United Kingdom	Air Accidents Investigation Branch (AAIB), United Kingdom
United States	Federal Aviation Administration (FAA)
United States	National Transportation Safety Board (NTSB), United States of America
	Banjul Accord Group Accident Investigation Agency (BAGAIA)
	The Interstate Aviation Committee (IAC)
International Organizations	
ICAO	
EASA	
EUROCONTROL	
Aircraft manufacturers	
ATR	
Bombardier	
Embraer	
Lockheed-Georgia company	

Database/Aviation-related web pages
Aviation Safety Network Database
CAPA
Planespotter.net

3.4. Population/Sample

Qualitative approach

Purposive sampling was implemented to generate the sample. The sample is varied from different fields in aviation. The interview aims to capture the experts' knowledge, expertise, opinion, and experience of the key stakeholders in the accident investigation, namely, airport, airline, air navigation service provider, accident investigation, and aviation related international organization. The ten interviewees were recruited based on their field of expertise and minimum experience of 10 years related to aviation safety or aviation accident investigation. The author also took into consideration of diversity in experience by recruiting both local and international participants.

Quantitative approach

The target population of the scheduled commercial air accidents included 352 cases of the ICAO official accidents that occurred in 2014-2017 (ICAO, 2015, 2016, 2017, 2018). The 2014-2017 period was chosen as the study period. Most final investigation reports were publicly available, and the traffic was normal before the COVID-19 pandemic. All occurrences reported are of those aircraft with above a 5,700 kg MTOW. 238 cases were eliminated: 218 cases had not reached the final report stage, 14 cases did not publish a final report in English, and seven final reports could not be found (see Figure 9). Therefore, the sample size was 114 occurrences, which consisted of accidents and incidents (occurrences).

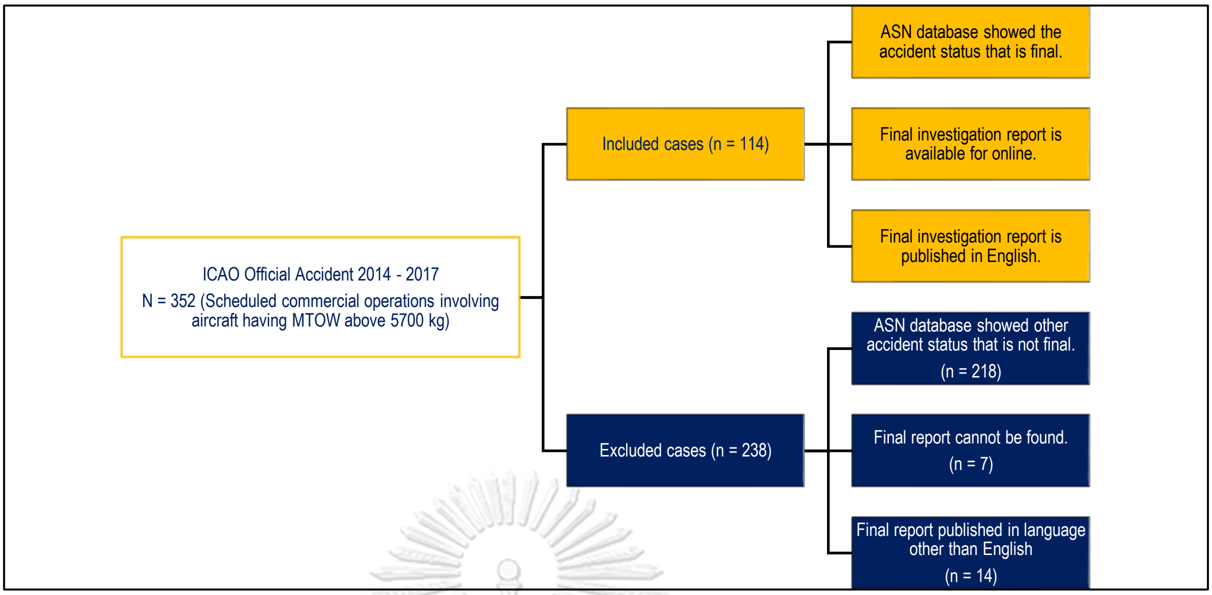

Figure 9 Study Cases Criteria

3.5. Data Collection and Procedures

Qualitative

The selected qualitative data collection method is a semi-structured interview. The research requires expert opinion, which is limited in terms of specialists. The interview questions are classified into four parts: occurrence types that would lead and not lead to fatalities, factors contributing to accident (occurrence with fatalities), countermeasures, and expert demographic information. The interviews were arranged through individual sessions due to the pandemic of COVID-19, and the experts were in different countries and time zone. The sessions were held depending on the preferred time of the participants. The experts were contacted and scheduled through phone call and email. This research is subject to sensitivity as the majority of experts are working in government and international agencies; therefore, the interview questions were circulated to the respondents in advance. It allows the respondents to review the set of questions prior to accepting the invitation for an interview. The questions were reviewed by three aviation experts before launching.

In the first part, the interviewees were asked based on their experience, to give a score for the 36-type of occurrences from the Accident/Incident Data Reporting (ADREP) taxonomy called European Co-ordination Centre for Accident and Incident

Reporting Systems (ECCAIRS) Occurrence Category (version dated 23 April 2013). ECCAIRS were used during the gathering and reporting accident/incident data (ECCAIRS, 2013). Interviewees were provided with a set of definitions and descriptions. The 9 points Likert scale were applied from 1 = extremely likely to not lead to fatalities, 2 = likely to not lead to fatalities, 3 = not lead to fatalities, 4 = slightly to not lead to fatalities, 5 = neither lead nor not lead to fatalities, 6 = slightly lead to fatalities, 7 = lead to fatalities, 8 = likely to lead to fatalities, and 9 = extremely likely to lead to fatalities. After all 36 occurrences were rated, the interviewees were asked to select five occurrence types that, if they occur, will lead to the highest fatalities and severity.

In the second part, the five selected occurrences were used for the experts to apply to the given set of factors. The interviewees were asked to provide rating scores on a set of the factors if it contributes to or can trigger accident (occurrences with fatalities) using a 9-point Likert scale 1 = extremely likely to not lead to fatalities, 2 = likely to not lead to fatalities, 3 = not lead to fatalities, 4 = slightly to not lead to fatalities, 5 = neither lead nor not lead to fatalities, 6 = slightly lead to fatalities, 7 = lead to fatalities, 8 = likely to lead to fatalities, and 9 = extremely likely to lead to fatalities. Also, the interviewees were given the opportunity to select if the factor is controllable, meaning can be improved or adjusted, and uncontrollable, meaning cannot be improved or adjusted to mitigate and prevent future accidents.

In the third part, after deriving the contributing factors from the quantitative approach, the experts were asked to provide countermeasures for mitigating and preventing future accidents with fatalities. The experts were asked to select two occurrence types from the top five occurrence types with the highest fatality and severity in part one, and also to choose the derived contributing factor(s) that they think is controllable (can be improved or adjusted). Then, they were asked to consider two high risk scenarios and how the selected contributing factor could mitigate and prevent the future accidents.

In the demographic part, the questions aim to seek the experts' background and professional experience, including position, area of expertise, type of organization, years of experience, and professional license (if any) from the experts. These are screening and confirmatory questions to ensure that the targeted key experts were chosen for the interview.

The interview questions were classified into four parts: occurrence type, contributing factors, countermeasures, and demographic information (see Table 4).

Table 4 Expert Interview Questions

Main Interview Questions	
Part 1	Based on your experience, please give a score of 1 - 9 for the level of significance of occurrence that you consider leading to fatalities.
	Please select five occurrence types, if they occur, they will lead to the highest fatality and severity.
Part 2	Based on your experience, 1) please give a score of 1 - 9 for the level of factors that can trigger fatalities in this type of occurrence. Select whether this factor is controllable (may be improved/adjusted) or uncontrollable (may not be improved/adjusted)
Part 3	Please provide the countermeasures for mitigating and preventing accidents based on the significant contributing factors.
Part 4	Demographic Information of the study participants: Position, field of expertise, organization, and years of experience

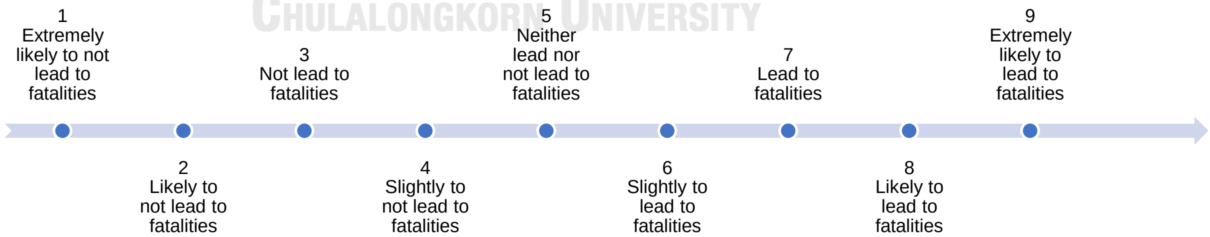

Figure 10 9-point Likert scale

Quantitative

The study occurrences were initiated from the ICAO Official Accidents published in the ICAO Annual Safety Report. The status of each occurrence was reviewed against the ASN aviation safety database to select occurrences that had concluded and for which a final investigation report was published. The characteristics of each occurrence were observed and recorded. Most reports provided all the information required for this research study. However, certain information, such as personnel, medical examination, and aircraft information, in some reports were not given. Moreover, additional information was collected from other external sources (see Table 3).

During the data analysis, the correlation tests were performed on independent variables. Subsequently, Bonferroni's post hoc test was conducted on the statistically significant independent variables correlated with dependent variables. Then, the independent variable that had a statistically significant correlation with the dependent variable was studied in other literature, or was recognized as one of the important contributing factors was selected for regression.

The data were input into an Excel spreadsheet and transferred to the SPSS program and Stata for analysis. There were 34 study variables: 31 independent variables and three dependent variables, (described in Table 5). Most variables originated mainly from the NTSB final report. The independent variables were day of operation, month of operation, time of day (time of the occurrence), aircraft age (year), aircraft manufacturer, aircraft model (family), engine manufacturer, aircraft size (MTOW), airline (business type), nature of operation, flight phases, air navigation service, airport, State of registry, State of occurrence, State of operator, meteorological condition at accident site, meteorological condition of light, meteorological type of airspace, meteorological type of clearance, meteorological type of flight plan filed, captain/pilot in command – age, captain / pilot in command – total flight experience (hours), captain / pilot in command – aircraft type rating, captain / pilot in command – ability to operate other aircraft type, captain / pilot in command – medical certification, co-pilot / first officer – age, co - pilot / first officer – total flight experience (hours), co - pilot / first officer – aircraft type rating, co - pilot / first officer – ability to operate other aircraft type, and co - pilot / first officer – medical certification. The dependent variables were occurrences (categorical), number of fatalities (continuous), and aircraft damage (categorical). The number of fatalities and aircraft damage were used as a proxy for fatal accidents to analyze and re-confirm the contributing factors applying other statistical techniques. The Kolmogorov-Smirnov test showed a *p* value below .05; therefore, this study used a nonparametric test because the data were not normally distributed. The correlations between independent and dependent variables were identified using Spearman Rho, Pearson Chi-square, and Fisher's Exact Tests. The binary logistic regression assessed the impact on accident (occurrence with fatalities) to derive the primary outcome. Censored and ordered logistic regressions were applied to study the impact on the number of fatalities and aircraft damage.

Table 5 Definition of variables

Variable(s)	Variable Type(s)	Description
Dependent		
Occurrences	Categorical	Accidents, serious incidents and incidents. Yes – Occurrence with fatalities (Accident) No – Occurrence with no fatalities (Incident)
Number of fatalities	Continuous	Total fatalities of passengers and crews
Aircraft Damage	Categorical	Level of damages resulting from the occurrence: Minor Substantial Damaged beyond repair and destroyed
Independent		
Day of operation	Categorical	The day that the occurrence happened: - Weekend - Weekday
Month of operation	Categorical	The quarter that the occurrence happened: - Quarter 1 – January – March - Quarter 2 – April – June

Variable(s)	Variable Type(s)	Description	
Dependent			
		- Quarter 3 – July – September - Quarter 4 – October - December	
Time of day	Categorical	Time of the occurrence: - 00:00 – 05:59 (Early morning) 06:00 – 11:59 (Morning) 12:00 – 17:59 (Afternoon) 18:00 – 23:59 (Night)	
Aircraft Age (year)	Continuous	The difference between the first year of flight and to a year of the occurrence	
Aircraft manufacturer	Categorical	Aircraft manufacturer of an aircraft involving in the occurrence:	
		Airbus Antonov ATR Beechcraft Boeing Bombardier British Aerospace de Havilland Canada	Embraer Fairchild / Swearingen Fokker HESA Let L Lockheed McDonnell Douglas Saab
Aircraft model (family)	Categorical	Aircraft model of an aircraft involving in the occurrence:	
		Airbus A300 Airbus A320 Family Airbus A330 Airbus A380	CRJ-100 Series CRJ-900 DC-9 / MD-80 Series DHC-8 Dash 8

Variable(s)	Variable Type(s)	Description	
Dependent			
		An-26 / 140 An-74 ATR 42 / 72 Beechcraft 99 / 1900 Boeing 737 Classic Boeing 737 Next Generation Boeing 747 Boeing 757 Boeing 767 Boeing 777	ERJ-145 Family ERJ-170 ERJ-190 Fokker 100 Fokker 50 Jetstream 31 / 41 L-410 Lockheed L-100 Hercules SA226 / 227 Saab 340 / 2000
Engine (manufacturer)	Categorical	Engine manufacturer of an aircraft involving in the occurrence:	
		CFM International Engine Alliance Garrett Airesearch General Electric (GE) International Aero Engines (IAE)	Kilmov Motor Sich Pratt & Whitney Rolls-Royce/Allison
Aircraft size (MTOW)	Categorical	Maximum Take-Off Weight of an aircraft involving in the occurrence: 5701 – 27,000 kg (Small) 27,001 – 272,000 kg (Medium) More than 272,000 kg (Large)	

<table>
<tr><th>Variable(s)</th><th>Variable Type(s)</th><th colspan="2">Description</th></tr>
<tr><td>Dependent</td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Airline (business type)</td><td rowspan="2">Categorical</td><td colspan="2">Airline business type of an aircraft involving in the occurrence:</td></tr>
<tr><td>Full-service carrier
Low-Cost carrier
Cargo</td><td>Charter
Regional/Commuter
Other</td></tr>
<tr><td rowspan="2">Nature of operation</td><td rowspan="2">Categorical</td><td colspan="2">Nature of operation (flight) of an aircraft involving in the occurrence:</td></tr>
<tr><td>International Scheduled Passenger
International Non-Scheduled Passenger</td><td>Domestic Scheduled Passenger
Cargo
Ferry/positioning</td></tr>
<tr><td rowspan="2">Flight Phase</td><td rowspan="2">Categorical</td><td colspan="2">Phase of flight of an aircraft involving in the occurrence:</td></tr>
<tr><td>Standing
Pushback / towing
Taxi
Take-off
Initial climb</td><td>En route
Maneuvering
Approach
Landing</td></tr>
<tr><td>Air Navigation Service (ANS)</td><td>Continuous</td><td colspan="2">It represents the State’s safety oversight system of ICAO USOAP Effective implementation (express as a percentage) in the ANS area at the occurrence year of the State in the territory of which an accident or incident occurs.</td></tr>
</table>

Variable(s)	Variable Type(s)	Description
Dependent		
Airport (Aerodromes and Ground Aids: AGA)	Continuous	It represents the State's safety oversight system of ICAO USOAP Effective implementation (express as a percentage) in the AGA area at the occurrence year of the State in the territory of which an accident or incident occurs. (applicable only to accident/incident that occur at the airport)
State of registry	Continuous	It represents the State's safety oversight system of ICAO USOAP Effective implementation (express as a percentage) at the occurrence year of the State on whose register the aircraft is entered.
State of occurrence	Continuous	It represents the State's safety oversight system of ICAO USOAP Effective implementation (express as a percentage) at the occurrence year of the State in the territory of which an accident or incident occurs.
State of operator	Continuous	It represents the State's safety oversight system of ICAO USOAP Effective implementation (express as a percentage) at the occurrence year of the State in which the operator's principal place of business is located or, if there is no such place of

Variable(s)	Variable Type(s)	Description
Dependent		
		business, the operator's permanent residence.
Meteorological condition at the accident site	Categorical	Meteorological condition at the occurrence: - Visual Meteorological Conditions (VMC) - Instrument Meteorological Conditions (IMC)
Meteorological condition of light	Categorical	Meteorological condition of light at the occurrence: - Dawn - Day - Dusk - Night/Dark
Meteorological type of airspace	Categorical	Class of airspace of an aircraft involving in the occurrence: - Class A, B, C, D, E, F, G
Meteorological type of clearance	Categorical	Designated type of clearance of an aircraft involving in the occurrence: - Unknown - None - Visual Flight Rules (VFR) - Instrument Flight Rules (IFR)
Meteorological type of flight plan filed	Categorical	Type of flight plan filed of an aircraft involving in the occurrence: - Visual Flight Rules (VFR) - Instrument Flight Rules (IFR)

<table>
<tr><th>Variable(s)</th><th>Variable Type(s)</th><th colspan="2">Description</th></tr>
<tr><td>Dependent</td><td></td><td colspan="2"></td></tr>
<tr><td>Captain/Pilot in command – Age</td><td>Continuous</td><td colspan="2">Age</td></tr>
<tr><td>Captain / Pilot in command – Total Flight Experience (hours)</td><td>Continuous</td><td colspan="2">Total flying hours</td></tr>
<tr><td rowspan="2">Captain / Pilot in Command – Aircraft Type Rating</td><td rowspan="2">Categorical</td><td colspan="2">Authorized aircraft type rating associated with the license of the pilot operating the aircraft involving in the occurrence:</td></tr>
<tr><td>Single-engine land
Multi-engine land
Single-engine land and Multi-engine land</td><td>Single-engine land,
Multi-engine land,
Single-engine sea
Single-engine land;
Single-engine sea</td></tr>
<tr><td>Captain / Pilot in command - Other Aircraft Type</td><td>Categorical</td><td colspan="2">Pilot’s ability to operate another aircraft type, other than the aircraft type involving in the occurrence:
- None
- Yes</td></tr>
<tr><td>Captain / Pilot in command – Medical Certification</td><td>Categorical</td><td colspan="2">Pilot medical certification specification:
- With limitations
- Without limitations</td></tr>
<tr><td>Co-Pilot / First officer - Age</td><td>Continuous</td><td colspan="2">Age</td></tr>
<tr><td>Co-Pilot / First officer – Total Flight Experience (hours)</td><td>Continuous</td><td colspan="2">Total flying hours</td></tr>
</table>

<table>
<tr><th>Variable(s)</th><th>Variable Type(s)</th><th colspan="2">Description</th></tr>
<tr><td>Dependent</td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Co-Pilot / First officer – Aircraft Type Rating</td><td rowspan="2">Categorical</td><td colspan="2">Authorized aircraft type rating associated with the license of the pilot operating the aircraft involving in the occurrence:</td></tr>
<tr><td>Single-engine land
Multi-engine land
Single-engine land and Multi-engine land</td><td>Single-engine land, Multi-engine land, Single-engine sea
Single-engine land; Single-engine sea</td></tr>
<tr><td>Co-Pilot / First officer - Other Aircraft Type</td><td>Categorical</td><td colspan="2">Pilot’s ability to operate another aircraft type, other than the aircraft type involving in the occurrence:
- None
- Yes</td></tr>
<tr><td>Co-Pilot / First officer – Medical Certification</td><td>Categorical</td><td colspan="2">Pilot medical certification specification:
- With limitations
- Without limitations</td></tr>
</table>

CHAPTER IV RESULTS

4.1. Demographic Results of experts

In this research study, a total of 10 experts were recruited for an interview comprising practitioners and academicians from five different disciplines: airport operator, air navigation service provider, airline operator, aircraft accident investigation agency, and academician (see Table 6). Both local and international experts met the criteria of having at least ten years of experience in the respected field. The majority of experts have more than 20 years of experience, 40% of experts have experience between 15-20 years, and 10% have 10-15 years of experience. The most common fields of expertise are aviation safety, aircraft accident, and aerodrome.

Table 6 Demographic of study participants

Position	Field of expertise		Organizations	Years of experience
Executive Vice President	- Aircraft Accident - Aerodrome - Aviation Safety - Aviation Security and Facilitation	- Performance-based Navigation - Remotely Piloted Aircraft System - USOAP	Airport	15-20
Division Director	- Aerodrome - Aviation Safety - Legal		- Airport - Airline - University	15-20
Senior Co-Pilot	- Aerodrome - Aviation Safety - Aviation Security and Facilitation - Dangerous Goods	- Communication, Navigation, and Surveillance - Meteorology - Performance-based Navigation	Airline	10-15

Position	Field of expertise		Organizations	Years of experience
Captain Pilot	- Aircraft Accident - Aviation Safety	- Dangerous Goods - USOAP	Airline	>20
Regional Officer	- Air Traffic Management - Aviation Safety	- Communication, Navigation, and Surveillance	- Air Navigation Service Provider - International Organization	>20
Regional Executive Vice President and Master Officer	- Aerodrome - Air Traffic Management - Aviation Safety - Communication, Navigation, and Surveillance	- Performance-Based Navigation - Remotely Piloted Aircraft System - Environment	- Civil Aviation Authority - Air Navigation Service Provider - International Organization	15-20
Agency and Department Director	- Air Traffic Management - Aviation Safety - Safety Management System		Air Navigation Service Provider	>20
Commission Member	- Aircraft Accident - Airworthiness - Aviation Safety	- Dangerous Goods - USOAP - Legal	Accident Investigation Agency	>20
Advisor	- Aircraft Accident		Accident Investigation Agency	>20
Safety Manager, Aviation Safety and Security Lecturer, Internal auditor, consultant	- Aircraft Accident - Airport Management - Aerodrome	- Aviation Safety - Aviation Security and Facilitation - USOAP	- Airport - University	15-20

4.2. Research Question 1: What are contributing factors in the analyzed accidents which triggered fatalities?

4.2.1. Expert Interviews

4.2.1.1. Occurrence Types

Q1.1: Based on your experience, please give a score of 1 - 9 for the level of significance of occurrence that you consider leading to fatalities.

During the data analysis, the score of 1-9 was categorized into four groups which are (1) not related/not applicable (no score given), (2) not lead to fatalities (score 1-4), (3) lead to fatalities (score 6-9), and (4) neither lead nor not lead to fatalities (score 5). Rating not provided because the experts had no experience, not enough information, or no comment were excluded. Table 7 shows the frequency of expert ratings on occurrence types that would lead to fatalities if they occur.

ADRM

The distribution of occurrences by ADRM was 55.6% lead to fatalities, 33.3% neither lead nor not lead to fatalities, and 11.1% not lead to fatalities.

AMAN

The distribution of occurrences by AMAN was 55.6% lead to fatalities and 22.2% not lead to fatalities, and 22.2% neither lead nor not lead to fatalities.

ARC

The distribution of occurrences by ARC was 55.6% lead to fatalities, 33.3% not lead to fatalities, and 11.1% neither lead nor not lead to fatalities.

ARC

The distribution of occurrences by ATM was 66.7% lead to fatalities, 22.2% not lead to fatalities, and 11.1% neither lead nor not lead to fatalities.

BIRD

The distribution of occurrences by BIRD was 55.6% not lead to fatalities, 33.3% neither lead nor not lead to fatalities, and 11.1% lead to fatalities.

CABIN

The distribution of occurrences by CABIN was 55.6% not lead to fatalities, 22.2% not related/not applicable, 11.1% lead to fatalities, and 11.1% neither lead nor not lead to fatalities.

CFIT

The distribution of occurrences by CFIT was 100% lead to fatalities.

CTOL

The distribution of occurrences by CTOL was 70% lead to fatalities, 20% not lead to fatalities, and 10% neither lead nor not lead to fatalities.

EVAC

The distribution of occurrences by EVAC was 50% not lead to fatalities, 30% lead to fatalities, 10% not related/not applicable, and 10% neither lead nor not lead to fatalities.

EXTL

The distribution of occurrences by EXTL was 50% not lead to fatalities, 30% not related/not applicable, 10% lead to fatalities, and 10% neither lead nor not lead to fatalities.

F-NI

The distribution of occurrences by F-NI was 40% not lead to fatalities, 30% lead to fatalities, 20% not related/not applicable, and 10% neither lead nor not lead to fatalities.

F-POST

The distribution of occurrences by F-POST was 90% lead to fatalities and 10% not related/not applicable.

FUEL

The distribution of occurrences by FUEL was 66.7% lead to fatalities, 22.2% not lead to fatalities, and 11.1% neither lead nor not lead to fatalities.

GCOL

The distribution of occurrences by GCOL was 50% not lead to fatalities, 30% lead to fatalities, and 20% neither lead nor not lead to fatalities.

GTOW

The distribution of occurrences by GTOW was 87.5% not related/not applicable, and 12.5% neither lead nor not lead to fatalities.

ICE

The distribution of occurrences by ICE was 75% lead to fatalities and 25% neither lead nor not lead to fatalities.

LALT

The distribution of occurrences by LALT was 44.4% not related/not applicable, 44.4% lead to fatalities, and 11.1% not lead to fatalities.

LOC-G

The distribution of occurrences by LOC-G was 55.6% lead to fatalities, 33.3% not lead to fatalities, and 11.1% neither lead nor not lead to fatalities.

LOC-I

The distribution of occurrences by LOC-I was 100% lead to fatalities.

LOLI

The distribution of occurrences by LOLI was 55.6% not related/not applicable, 22.2% not lead to fatalities, and 22.2% lead to fatalities.

MAC

The distribution of occurrences by MAC was 100% lead to fatalities.

RAMP

The distribution of occurrences by RAMP was 55.6% not related/not applicable, 33.3% not lead to fatalities, and 11.1% neither lead nor not lead to fatalities.

RE

The distribution of occurrences by RE was 70% lead to fatalities and 30% not lead to fatalities.

RI

The distribution of occurrences by RI was 70% lead to fatalities, 20% not lead to fatalities, and 10% neither lead nor not lead to fatalities.

RI-O

The distribution of occurrences by RI-O was 50% lead to fatalities, 30% not lead to fatalities, and 20% neither lead nor not lead to fatalities.

RI-VA

The distribution of occurrences by RI-VA was 70% lead to fatalities, 20% not lead to fatalities, and 10% neither lead nor not lead to fatalities.

SCF-NP

The distribution of occurrences by SCF-NP was 44.4% lead to fatalities, 22.2% not lead to fatalities, 22.2% neither lead nor not lead to fatalities, and 11.1% not related/not applicable.

SCF-PP

The distribution of occurrences by SCF-PP was 50% lead to fatalities, 25% not lead to fatalities, 12.5% not related/not applicable, and 12.5% neither lead nor not lead to fatalities.

SEC

The distribution of occurrences by SEC was 62.5% lead to fatalities, 25% not lead to fatalities, and 12.5% not related/not applicable.

TURB

The distribution of occurrences by TURB was 50% lead to fatalities, 40% not lead to fatalities, and 10% neither lead nor not lead to fatalities.

UIMC

The distribution of occurrences by UIMC was 42.9% not related/not applicable, 28.6% not lead to fatalities, 14.3% lead to fatalities, and 14.3% neither lead nor not lead to fatalities.

USOS

The distribution of occurrences by USOS was 60% lead to fatalities, 20% not lead to fatalities, 10% not related/not applicable, and 10% neither lead nor not lead to fatalities.

WILD

The distribution of occurrences by WILD was 40% not lead to fatalities, 30% lead to fatalities, 20% neither lead nor not lead to fatalities, and 10% not related/not applicable.

WSTRW

The distribution of occurrences by WSTRW was 70% lead to fatalities, 20% not lead to fatalities, and 10% not related/not applicable.

OTHR

The distribution of occurrences by OTHR was 66.7% not related/not applicable and 33.3% not lead to fatalities.

UNK

The distribution of occurrences by UNK was 66.7% not related/not applicable and 33.3% lead to fatalities.

The majority of experts' selections of occurrences that would lead to fatalities were CFIT (100%), MAC (100%), LOC-I (100%), F-POST (90%), ICE (75%), CTOL (70%), RE (70%), RI (70%), RI-VA (70%), WSTRW (70%), ATM (66.7%), FUEL (66.7%), SEC (62.5%), USOS (60%), ADRM (55.6%), AMAN (55.6%), ARC (55.6%), LOC-G (55.6%), RI-O (50%), SCF-PP (50%), TURB (50%), and SCF-NP (44.4%). Notably, all ten experts chose CFIT (100%) and MAC (100%) if occur would lead to fatalities.

On the contrary, BIRD (55.6%), CABIN (55.6%), EVAC (50%), EXTL (50%), F-NI (40%), GCOL (50%), and WILD (40%) were mostly selected as not lead to fatalities. Moreover, most experts gave GTOW (87.5%), OTHR (66.7%), UNK (66.7%), LOLI (55.6%), RAMP (55.6%), and UIMC (42.9%) were not related or applicable. LALT cannot be categorized as 44.4% not related/not applicable and 44.4% lead to fatalities.

In addition, the expert also suggested that crew resource management should be highlighted as another occurrence that would lead to fatalities. The expert explained that in the past accident, there was a quarrel in the cockpit that generated stress and carelessness, then caused the aircraft to stall and go down. Therefore, coordination issue within the cockpit between flight crews was recommended to be highlighted as a separate occurrence type.

Table 7 Frequency of Experts' ratings (score 1-9) on occurrence type that would lead to fatalities if they occur

OCCURRENCE	Frequency	%
ADRM		
Not lead to fatalities	1	11.1
Lead to fatalities	5	55.6
Neither lead nor not lead to fatalities	3	33.3
Total	9	100
ARC		
Not lead to fatalities	3	33.3
Lead to fatalities	5	55.6
Neither lead nor not lead to fatalities	1	11.1
Total	9	100
BIRD		
Not lead to fatalities	5	55.6
Lead to fatalities	1	11.1
Neither lead nor not lead to fatalities	3	33.3
Total	9	100

OCCURRENCE	Frequency	%
AMAN		
Not lead to fatalities	2	22.2
Lead to fatalities	5	55.6
Neither lead nor not lead to fatalities	2	22.2
Total	9	100
ATM		
Not lead to fatalities	2	22.2
Lead to fatalities	6	66.7
Neither lead nor not lead to fatalities	1	11.1
Total	9	100
CABIN		
Not related/Not applicable	2	22.2
Not lead to fatalities	5	55.6
Lead to fatalities	1	11.1
Neither lead nor not lead to fatalities	1	11.1

OCCURRENCE	Frequency	%
Total	9	100
CFIT		
Lead to fatalities	10	100
CTOL		
Not lead to fatalities	2	20
Lead to fatalities	7	70
Neither lead nor not lead to fatalities	1	10
Total	10	100
EVAC		
Not related/Not applicable	1	10
Not lead to fatalities	5	50
Lead to fatalities	3	30
Neither lead nor not lead to fatalities	1	10
Total	10	100
EXTL		
Not related/Not applicable	3	30
Not lead to fatalities	5	50
Lead to fatalities	1	10
Neither lead nor not lead to fatalities	1	10
Total	10	100
F-NI		
Not related/Not applicable	2	20
Not lead to fatalities	4	40
Lead to fatalities	3	30
Neither lead nor not lead to fatalities	1	10
Total	10	100
F-POST		
Not related/Not applicable	1	10
Lead to fatalities	9	90
Total	10	100
FUEL		
Not lead to fatalities	2	22.2
Lead to fatalities	6	66.7
Neither lead nor not lead to fatalities	1	11.1
G-COL		
Not lead to fatalities	5	50
Lead to fatalities	3	30
Neither lead nor not lead to fatalities	2	20

OCCURRENCE	Frequency	%
Total	9	100

OCCURRENCE	Frequency	%
Total	10	100

GTOW		
Not related/Not applicable	7	87.5
Neither lead nor not lead to fatalities	1	12.5
Total	8	100

ICE		
Lead to fatalities	6	75
Neither lead nor not lead to fatalities	2	25
Total	8	100

LALT		
Not related/Not applicable	4	44.4
Not lead to fatalities	1	11.1
Lead to fatalities	4	44.4
Total	9	100

LOC-G		
Not lead to fatalities	3	33.3
Lead to fatalities	5	55.6
Neither lead nor not lead to fatalities	1	11.1
Total	9	100

LOC-I		
Lead to fatalities	9	100

LOLI		
Not related/Not applicable	5	55.6
Not lead to fatalities	2	22.2
Lead to fatalities	2	22.2
Total	9	100

MAC		
Lead to fatalities	10	100

RAMP		
Not related/Not applicable	5	55.6
Not lead to fatalities	3	33.3
Neither lead nor not lead to fatalities	1	11.1
Total	9	100

OCCURRENCE	Frequency	%
RE		
Not lead to fatalities	3	30
Lead to fatalities	7	70
Total	10	100

OCCURRENCE	Frequency	%
RI		
Not lead to fatalities	2	20
Lead to fatalities	7	70
Neither lead nor not lead to fatalities	1	10
Total	10	100

RI-O		
Not lead to fatalities	3	30
Lead to fatalities	5	50
Neither lead nor not lead to fatalities	2	20
Total	10	100

RI-VA		
Not lead to fatalities	2	20
Lead to fatalities	7	70
Neither lead nor not lead to fatalities	1	10
Total	10	100

SCF-NP		
Not related/Not applicable	1	11.1
Not lead to fatalities	2	22.2
Lead to fatalities	4	44.4
Neither lead nor not lead to fatalities	2	22.2
Total	9	100

SCF-PP		
Not related/Not applicable	1	12.5
Not lead to fatalities	2	25
Lead to fatalities	4	50
Neither lead nor not lead to fatalities	1	12.5
Total	8	100

SEC		
Not related/Not applicable	1	12.5
Not lead to fatalities	2	25
Lead to fatalities	5	62.5
Total	8	100

TURB		
Not lead to fatalities	4	40
Lead to fatalities	5	50
Neither lead nor not lead to fatalities	1	10
Total	10	100

OCCURRENCE	Frequency	%
UIMC		
Not related/Not applicable	3	42.9
Not lead to fatalities	2	28.6
Lead to fatalities	1	14.3
Neither lead nor not lead to fatalities	1	14.3
Total	7	100

OCCURRENCE	Frequency	%
USOS		
Not related/Not applicable	1	10
Not lead to fatalities	2	20
Lead to fatalities	6	60
Neither lead nor not lead to fatalities	1	10
Total	10	100

WILD		
Not related/Not applicable	1	10
Not lead to fatalities	4	40
Lead to fatalities	3	30
Neither lead nor not lead to fatalities	2	20
Total	10	100

WSTRW		
Not related/Not applicable	1	10
Not lead to fatalities	2	20
Lead to fatalities	7	70
Total	10	100

OTHR		
Not related/Not applicable	2	66.7
Not lead to fatalities	1	33.3
Total	3	100

UNK		
Not related/Not applicable	2	66.7
Lead to fatalities	1	33.3
Total	3	100

Q1.2: Please select five occurrence types, if they occur, they will lead to the highest fatality and severity.

After an analysis of each occurrence published in ECCAIRS, the experts were requested to select five occurrences if occur would lead to the highest fatalities and severity. Figure 11 shows the most selected occurrences were CFIT (90%), MAC (80%), LOC-I (60%), F-POST (50%), and CTOL (40%).

The experts perceived a similar view on the occurrence with high fatality risk if it occurred. The five highest-rated occurrences if happen would trigger fatalities by most experts are CFIT, MAC, LOC-I, F-POST, and ICE. All ten experts chose CFIT and MAC, which could indicate the high safety priority given to both categories. Also, another confirmatory question for experts to select the occurrence type with the highest severity and fatality, also confirmed that CFIT, MAC, LOC-I, F-POST, and CTOL were occurrence types; if they occur would lead to the highest fatality and severity.

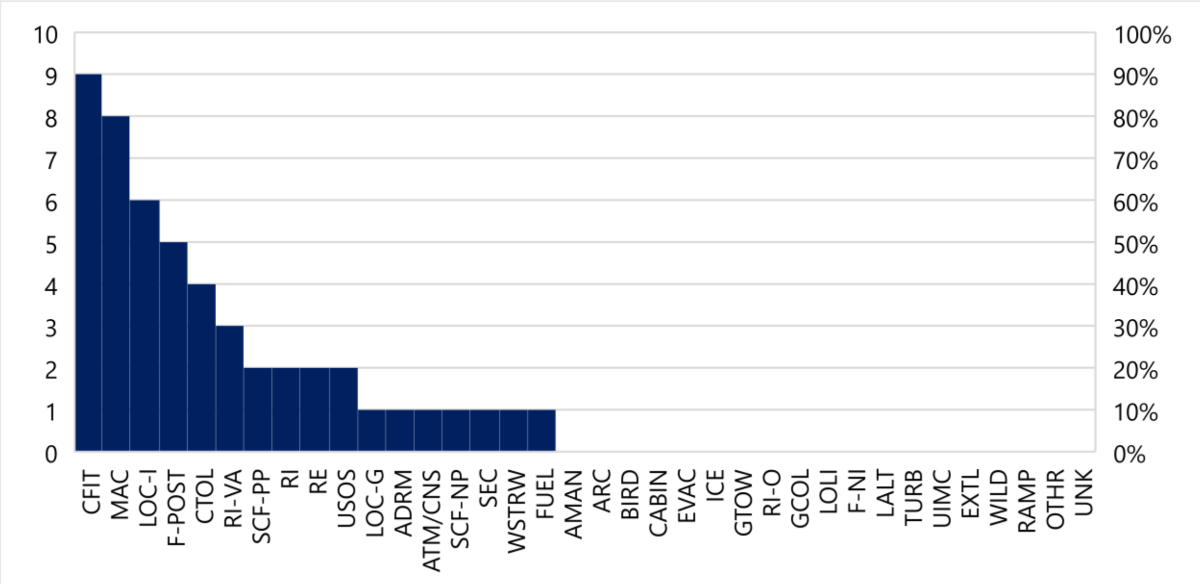

Figure 11 Experts' selections on which occurrence, if occurred, would lead to the highest fatalities and severity.

4.2.1.2. Factors contributing to an aircraft accident (occurrence with fatalities)

Q2 Based on your experience, 1) please give a score of 1 - 9 for the level of factors that can trigger fatalities in this type of occurrence. Select whether this factor is controllable (may be improved/adjusted) or uncontrollable (may not be improved/adjusted)

In part two, the selected occurrences in part one were used as case studies for the experts to analyze the factors contributing to accidents (see Table 8).

Day of operation

The distribution of factors by day of operation was 78% not related, 10% not lead to fatalities, 10% lead to fatalities, and 2% neither lead nor not lead to fatalities.

Month of operation

The distribution of factors by month of operation was 60% not related, 26% lead to fatalities, 12% not lead to fatalities, and 2% neither lead nor not lead to fatalities.

Time of day

The distribution of factors by the time of day was 48% lead to fatalities, 36% not related, 14% not lead to fatalities, and 2% neither lead nor not lead to fatalities.

Aircraft age (year)

The distribution of factors by aircraft age (year) was 74% not related, 16% lead to fatalities, and 10% not lead to fatalities.

Aircraft manufacturer

The distribution of factors by aircraft manufacturer was 86% not related, 8% not lead to fatalities, and 6% lead to fatalities.

Aircraft model (family)

The distribution of factors by aircraft model (family) was 76% not related, 16% lead to fatalities, 6% not lead to fatalities, and 2% neither lead nor not lead to fatalities.

Engine (manufacturer)

The distribution of factors by the engine (manufacturer) was 92% not related, 4% not lead to fatalities, and 4% lead to fatalities.

Aircraft size (MTOW)

The distribution of factors by aircraft size (MTOW) was 68% not related, 16% lead to fatalities, 12% not lead to fatalities, and 4% neither lead nor not lead to fatalities.

Airline (business type)

The distribution of factors by the airline (business type) was 40% lead to fatalities, 30% not related, 24% neither lead nor not lead to fatalities, and 6% not lead to fatalities.

Nature of the operation

The distribution of factors by nature of the operation was 70% not related, 20% lead to fatalities, 6% not lead to fatalities, and 4% neither lead nor not lead to fatalities.

Flight phase

The distribution of factors by flight phase was 72% lead to fatalities, 16% not related, 10% neither lead nor not lead to fatalities, and 2% not lead to fatalities.

Air navigation service

The distribution of factors by air navigation service was 58% lead to fatalities, 24% not related, 12% neither lead nor not lead to fatalities, and 6% not lead to fatalities.

Airport

The distribution of factors by the airport was 50% lead to fatalities, 38% not related, 8% neither lead nor not lead to fatalities, and 4% not lead to fatalities.

State of registry

The distribution of factors by State of registry was 76% not related, 20% lead to fatalities, 2% neither lead nor not lead to fatalities, and 2% not lead to fatalities.

State of occurrence

The distribution of factors by State of occurrence was 74% not related, 20% lead to fatalities, 4% neither lead nor not lead to fatalities, and 2% not lead to fatalities.

State of the operator (EI)

The distribution of factors by State of the operator (EI) was 70% not related, 22% lead to fatalities, 6% not lead to fatalities, and 2% neither lead nor not lead to fatalities.

Meteorological condition at the accident site

The distribution of factors by the meteorological condition at the accident site was 54% lead to fatalities, 34% not related, 6% neither lead nor not lead to fatalities, and 6% not lead to fatalities.

Meteorological condition of light

The distribution of factors by the meteorological condition of light was 44% lead to fatalities, 32% not related, 14% neither lead nor not lead to fatalities, and 10% not lead to fatalities.

Meteorological - type of airspace

The distribution of factors by the meteorological - type of airspace was 78% not related, 12% lead to fatalities, 8% not lead to fatalities, and 2% neither lead nor not lead to fatalities.

Meteorological - type of clearance

The distribution of factors by meteorological - type of clearance was 80% not related, 12% lead to fatalities, 4% neither lead nor not lead to fatalities, and 4% not lead to fatalities.

Meteorological - type of flight plan filed

The distribution of factors by meteorological - type of flight plan filed was 86% not related, 8% lead to fatalities, 4% not lead to fatalities, and 2% neither lead nor not lead to fatalities.

Pilot age

The distribution of factors by pilot age was 70% not related, 16% lead to fatalities, 8% not lead to fatalities, and 6% neither lead nor not lead to fatalities.

Pilot – total flight experience (hour)

The distribution of factors by pilot total flight experience (hour) was 56% lead to fatalities, 24% not related, 14% neither lead nor not lead to fatalities, and 6% not lead to fatalities.

Pilot - aircraft type rating

The distribution of factors by pilot aircraft type rating was 88% not related, 10% lead to fatalities, and 2% not lead to fatalities.

Pilot - medical certification

The distribution of factors by pilot medical certification was 84% not related, 8% not lead to fatalities, 4% neither lead nor not lead to fatalities, and 4% lead to fatalities.

The most selected factors that can trigger accidents were flight phase (72%), air navigation service (58%), pilot total flight experience (56%), meteorological condition at the accident site (54%), airport (50%), time of day (48%), meteorological condition of light (44%), and airline (40%).

The factors that most experts selected as not related to accidents were engine (manufacturer) (92%), pilot aircraft type rating (88%), aircraft manufacturer (86%), meteorological - type of flight plan filed (86%), pilot medical certification (84%), meteorological - type of clearance (80%), day of operation (78%), meteorological - type of airspace (78%), aircraft model (76%), State of registry (76%), aircraft age (74%), State of occurrence (74%), nature of operation (70%), State of operator (70%), pilot age (70%), aircraft size (68%), and month of operation (60%).

Table 8 Frequency of Experts' ratings (score 1-9) on factors that can trigger accident (occurrence with fatalities)

FACTOR	Frequency	%	FACTOR	Frequency	%
Day of operation			Month of operation		
Not related	39	78	Not related	30	60
Neither lead nor not lead to fatalities	1	2	Neither lead nor not lead to fatalities	1	2
Not lead to fatalities	5	10	Not lead to fatalities	6	12
Lead to fatalities	5	10	Lead to fatalities	13	26
Total	50	100	Total	50	100
Time of day			Aircraft age (year)		
Not related	18	36	Not related	37	74
Neither lead nor not lead to fatalities	1	2	Not lead to fatalities	5	10
Not lead to fatalities	7	14	Lead to fatalities	8	16
Lead to fatalities	24	48	Total	50	100
Total	50	100			
Aircraft manufacturer			Aircraft model (family)		
Not related	43	86	Not related	38	76
Not lead to fatalities	4	8	Neither lead nor not lead to fatalities	1	2

FACTOR	Frequency	%
Lead to fatalities	3	6
Total	50	100

FACTOR	Frequency	%
Not lead to fatalities	3	6
Lead to fatalities	8	16
Total	50	100

Engine (manufacturer)		
Not related	46	92
Not lead to fatalities	2	4
Lead to fatalities	2	4
Total	50	100

Aircraft size (MTOW)		
Not related	34	68
Neither lead nor not lead to fatalities	2	4
Not lead to fatalities	6	12
Lead to fatalities	8	16
Total	50	100

Airline (business type)		
Not related	15	30
Neither lead nor not lead to fatalities	12	24
Not lead to fatalities	3	6
Lead to fatalities	20	40
Total	50	100

Nature of operation		
Not related	35	70
Neither lead nor not lead to fatalities	2	4
Not lead to fatalities	3	6
Lead to fatalities	10	20
Total	50	100

Flight phase		
Not related	8	16
Neither lead nor not lead to fatalities	5	10
Not lead to fatalities	1	2
Lead to fatalities	36	72
Total	50	100

Air navigation service		
Not related	12	24
Neither lead nor not lead to fatalities	6	12
Not lead to fatalities	3	6
Lead to fatalities	29	58
Total	50	100

Airport		

State of registery (EI)		

FACTOR	Frequency	%
Not related	19	38
Neither lead nor not lead to fatalities	4	8
Not lead to fatalities	2	4
Lead to fatalities	25	50
Total	50	100

FACTOR	Frequency	%
Not related	38	76
Neither lead nor not lead to fatalities	1	2
Not lead to fatalities	1	2
Lead to fatalities	10	20
Total	50	100

State of occurrence		
Not related	37	74
Neither lead nor not lead to fatalities	2	4
Not lead to fatalities	1	2
Lead to fatalities	10	20
Total	50	100

State of operator		
Not related	35	70
Neither lead nor not lead to fatalities	1	2
Not lead to fatalities	3	6
Lead to fatalities	11	22
Total	50	100

Meteorological condition at the accident site		
Not related	17	34
Neither lead nor not lead to fatalities	3	6
Not lead to fatalities	3	6
Lead to fatalities	27	54
Total	50	100

Meteorological condition of light		
Not related	16	32
Neither lead nor not lead to fatalities	7	14
Not lead to fatalities	5	10
Lead to fatalities	22	44
Total	50	100

Meteorological - type of airspace		
Not related	39	78
Neither lead nor not lead to fatalities	1	2
Not lead to fatalities	4	8

Meteorological - type of clearance		
Not related	40	80
Neither lead nor not lead to fatalities	2	4
Not lead to fatalities	2	4

FACTOR	Frequency	%
Lead to fatalities	6	12
Total	50	100

Meteorological - type of flight plan filed		
Not related	43	86
Neither lead nor not lead to fatalities	1	2
Not lead to fatalities	2	4
Lead to fatalities	4	8
Total	50	100

Pilot – total flight experience (hour)		
Not related	12	24
Neither lead nor not lead to fatalities	7	14
Not lead to fatalities	3	6
Lead to fatalities	28	56
Total	50	100

Pilot – medical certification		
Not related	42	84
Neither lead nor not lead to fatalities	2	4
Not lead to fatalities	4	8
Lead to fatalities	2	4
Total	50	100

FACTOR	Frequency	%
Lead to fatalities	6	12
Total	50	100

Pilot age		
Not related	35	70
Neither lead nor not lead to fatalities	3	6
Not lead to fatalities	4	8
Lead to fatalities	8	16
Total	50	100

Pilot – aircraft type rating		
Not related	44	88
Not lead to fatalities	1	2
Lead to fatalities	5	10
Total	50	100

4.2.1.3. Controllable/Uncontrollable Factor

Q2: Based on your experience, 1) please give a score of 1 - 9 for the level of factors that can trigger fatalities in this type of occurrence. Select whether this factor is controllable (may be improved/adjusted) or uncontrollable (may not be improved/adjusted)

Table 9 presented the descriptive statistics on the experts' opinions on which factors can be improved or adjusted to mitigate or prevent accidents (occurrences with fatalities).

Day of operation

The distribution of factors by day of operation was 78% not related, 12% controllable, and 10% uncontrollable.

Month of operation

The distribution of factors by month of operation was 60% not related, 26% uncontrollable, and 14% controllable.

Time of day

The distribution of factors by time of day was 36% not related, 34% controllable, and 30% uncontrollable.

Aircraft age (year)

The distribution of factors by aircraft age (year) was 74% not related, 24% controllable, and 2% uncontrollable.

Aircraft manufacturer

The distribution of factors by aircraft manufacturer was 86% not related, 10% controllable, and 4% uncontrollable.

Aircraft model (family)

The distribution of factors by aircraft model (family) was 76% not related, 16% controllable, and 8% uncontrollable.

Engine (manufacturer)

The distribution of factors by engine (manufacturer) was 92% not related, 6% controllable, and 2% uncontrollable.

Aircraft size (MTOW)

The distribution of factors by aircraft size (MTOW) was 68% not related, 18% controllable, and 14% uncontrollable.

Airline (business type)

The distribution of factors by airline (business type) was 70% controllable and 30% not related.

Nature of operation

The distribution of factors by nature of operation was 70% not related and 30% controllable.

Flight phase

The distribution of factors by flight phase was 60% controllable, 24% uncontrollable, and 16% not related.

Air navigation service

The distribution of factors by air navigation service was 72% controllable, 24% not related, and 4% uncontrollable.

Airport

The distribution of factors by the airport was 48% controllable, 38% not related, 12% uncontrollable, and 2% both uncontrollable and controllable.

State of registry

The distribution of factors by State of registry was 76% not related and 24% controllable.

State of occurrence

The distribution of factors by State of occurrence was 74% not related, 24% controllable, and 2% uncontrollable.

State of operator

The distribution of factors by State of operator was 70% not related, 28% controllable, and 2% uncontrollable.

Meteorological condition at the accident site

The distribution of factors by the meteorological condition at the accident site was 38% uncontrollable, 34% not related, and 28% controllable.

Meteorological condition of light

The distribution of factors by the meteorological condition of light was 36% controllable, 32% uncontrollable, and 32% not related.

Meteorological - type of airspace

The distribution of factors by the meteorological - type of airspace was 78% not related and 22% controllable.

Meteorological – type of clearance

The distribution of factors by the meteorological - type of clearance by 80% not related, 18% controllable, and 2% uncontrollable.

Meteorological - type of flight plan filed

The distribution of factors by the meteorological - type of flight plan filed was 86% not related and 14% controllable.

Pilot age

The distribution of factors by pilot age was 70% not related, 28% controllable, and 2% uncontrollable.

Pilot - total flight experience (hours)

The distribution of factors by pilot - total flight experience (hours) was 74% controllable, 24% not related, and 2% uncontrollable.

Pilot aircraft type rating

The distribution of factors by pilot aircraft type rating was 88% not related and 12% controllable.

Pilot medical certification

The distribution of factors by pilot medical certification was 84% not related and 16% controllable.

The most factors that experts chose as controllable factors were pilot total flight experience (74%), air navigation service (72%), airline (business type) (70%), flight phases (60%), airport (48%), and meteorological condition of light (36%).

Other factors were described as not related which are engine (manufacturer) (92%), pilot aircraft type rating (88%), aircraft manufacturer (86%), meteorological - type of flight plan filed (86%), pilot medical certification (84%), meteorological - type of clearance (80%), day of operation (78%), meteorological - type of airspace (78%), aircraft model (family) (76%), State of registry (76%), aircraft age (year) (74%), State of occurrence (74%), nature of operation (70%), State of operator (70%), pilot age (70%), aircraft size (MTOW) (68%), month of operation (60%), meteorological condition at accident site (38%), and time of day (36%).

Table 9 Frequency of Experts' selections on controllable and uncontrollable factors

FACTOR	Frequency	%	FACTOR	Frequency	%
Day of operation			Month of operation		
Not related	39	78	Not related	30	60
Uncontrollable	5	10	Uncontrollable	13	26
Controllable	6	12	Controllable	7	14
Total	50	100	Total	50	100
Time of day			Aircraft age (year)		
Not related	18	36	Not related	37	74
Uncontrollable	15	30	Uncontrollable	1	2
Controllable	17	34	Controllable	12	24
Total	50	100	Total	50	100
Aircraft manufacturer			Aircraft model (family)		
Not related	43	86	Not related	38	76
Uncontrollable	2	4	Uncontrollable	4	8
Controllable	5	10	Controllable	8	16
Total	50	100	Total	50	100
Engine (manufacturer)			Aircraft size (MTOW)		
Not related	46	92	Not related	34	68

FACTOR	Frequency	%
Uncontrollable	1	2
Controllable	3	6
Total	50	100
Airline (business type)		
Not related	15	30
Controllable	35	70
Total	50	100
Flight phase		
Not related	8	16
Uncontrollable	12	24
Controllable	30	60
Total	50	100
Airport		
Not related	19	38
Uncontrollable	6	12
Both uncontrollable and controllable	1	2
Controllable	24	48
Total	50	100
State of occurrence		
Not related	37	74
Uncontrollable	1	2
Controllable	12	24
Total	50	100

FACTOR	Frequency	%
Uncontrollable	7	14
Controllable	9	18
Total	50	100
Nature of operation		
Not related	35	70
Controllable	15	30
Total	50	100
Air navigation service		
Not related	12	24
Uncontrollable	2	4
Controllable	36	72
Total	50	100
State of registery (EI)		
Not related	38	76
Controllable	12	24
Total	50	100
State of operator		
Not related	35	70
Uncontrollable	1	2
Controllable	14	28
Total	50	100

FACTOR	Frequency	%
Meteorological condition at the accident site		
Not related	17	34
Uncontrollable	19	38
Controllable	14	28
Total	50	100

FACTOR	Frequency	%
Meteorological condition of light		
Not related	16	32
Uncontrollable	16	32
Controllable	18	36
Total	50	100

Meteorological - type of airspace		
Not related	39	78
Controllable	11	22
Total	50	100

Meteorological - type of clearance		
Not related	40	80
Uncontrollable	1	2
Controllable	9	18
Total	50	100

Meteorological - type of flight plan filed		
Not related	43	86
Controllable	7	14
Total	50	100

Pilot age		
Not related	35	70
Uncontrollable	1	2
Controllable	14	28
Total	50	100

Pilot – total flight experience (hour)		
Not related	12	24
Uncontrollable	1	2
Controllable	37	74
Total	50	100

Pilot – aircraft type rating		
Not related	44	88
Controllable	6	12
Total	50	100

Pilot – medical certification		

FACTOR	Frequency	%
Not related	42	84
Controllable	8	16
Total	50	100

FACTOR	Frequency	%

4.2.1.4. Additional factors that can trigger fatalities in an accident suggested by experts

Pilot and Air Traffic Controller Physical and Psychological condition

Fatigue is one of the main issues concerning the physical condition of the personnel that can lead to decision error. It could cause a long-haul flight to lead to stress, low visibility due to the weather, and a high workload. Likewise, personnel could also not fit to fly due to intoxication from alcohol or illegal substances when attending work.

The psychological condition of the personnel is also another critical issue. The personnel could be experiencing depression from work or family pressure, or from skilled fade during COVID-19. An example of an accident resulting from the psychological condition of the flight crew is a Germanwings crash in 2015.

Pilot and Air Traffic Controller Competency and Practical drift

The competency of the personnel, including knowledge, skills, experience, and attitude, is the factor that could amplify how the personnel make a decision and take an action in resolving problem in a different situation. Also, practical drift is another interesting factor that should be emphasized. In certain workplace, the personnel could often perform task/duty that is not a standard practice from the organization, and later they could misunderstand to which is an appropriate and correct action.

Flight time/Duty time

There is a strong linkage between flight time/duty time to the personnel physical condition. The flight time/duty time requirement can cause fatigue. The airline may not control or monitor the flight time/duty time or the resting time of the pilot.

Crew Resource management

Crew coordination between flight crew and cabin crew is important when operate a flight. It is essential that the flight crew communicate to the cabin crew to provide the update of the situation, and inform the important message such as decision to evacuate.

Aircraft design and maintenance

Aircraft design is directly related to the aircraft manufacturer. The selection of material for designing an aircraft could affect the crashworthiness, and the flame speed. Moreover, the issues relating to aircraft maintainance could be from non-adherence to maintainance checklist, no risk assessment performed, or improper planning for parts purchase and replacement. It could result an event such as engine failure or explosion.

Air traffic services

The design of crossing routes could lead to a collision.

Airport – design, signages, and runway condition

Airport design, such as multiple crossed runways, can cause runway incursion. Moreover, non-standard signages can cause the pilot to misinterpret of the situation. It happened in the past to Singapore airlines flight 006 in 2000. The pilot was not aware that they were on the wrong runway due to the non-standard signages, resulting a deadliest accident. In addition, runway condition issues, such as contaminated runway and improper maintenance of runway surface, could affect to the loss of aircraft control.

Ground operation

Ground personnel could operate nearby the runway and enter the unauthorized area outside the markers. For example, the ground personnel could be drving across the runway, while the aircraft is taking off.

Environment and extreme weather

Environmental and extreme weather condition could be from volcano eruption, rainstorm or thunderstorm or typhoon season, crosswind, turbulence, snow, dust, and temperature. The volcano ashes can lower the visibility of the personnel. Extreme weather condition with thunderstorm, particularly in mountainous area, is also very dangerous. All of these can affect the personnel which could result human error.

Nation culture

Personnel from a country with control and command culture and power distance could lead to various incident/accident. For example: Captain did not listen to co-pilot warning and co-pilot was to frighten to inform the Captain of the situation.

Transparency of accident investigation authority

Accident investigation regulation could be the factor to illustrate the transparency of the investigation authority. In certain circumstances, some incidents were not investigated by the accident investigaton authority. Therefore, the root cause of the incident were not known to prevent the future incident/accident.

Carry on items and Cargo

Passenger carry-on items such as battery, lighter, matchbox, alcohol or perfume contain inflammable substances that could lead to fire. Furthermore, the inflammable parcel, parcel packaging, and placement of parcel in the cargo are factors to consider as it could also lead to fire on the aircraft.

4.2.2. Aircraft Accident Database and Final Reports

4.2.2.1. Descriptive Statistics

Test of normality

The Kolmogorov-Smirnov was performed on interval/ratio variables whether they are normally distributed. The test showed aircraft age (year) ($p = .031$), air navigation service ($p < .001$), airport ($p < .001$), State of registry ($p < .001$), State of occurrence ($p < .001$), State of operator ($p < .001$), Captain/Pilot in command - total flight experience ($p = .007$), and Co-Pilot/First officer - total flight experience ($p < .001$), which indicated that majority of variables were not normally distributed (see Table 10). Therefore, non-parametric tests were used.

Table 10 Test of Normality on independent variables

Tests of Normality			
	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Aircraft Age (year)	.121	59	.031
Air navigation service	.286	59	<.001
Airport	.208	59	<.001
State of registry	.273	59	<.001
State of occurrence	.220	59	<.001
State of operator	.273	59	<.001
Captain/Pilot in command – age	.078	59	.200*
Captain/Pilot in command – total flight experience (hour)	.138	59	.007
Co-Pilot/First officer - age	.102	59	.197
Co-Pilot/First officer – total flight experience (hours)	.158	59	<.001

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 11 shows the summary statistics of the interval/ratio variables.

Aircraft age (year)

The median (Q1-Q3) of aircraft age (year) was 13 (5-23). The minimum and the maximum of aircraft age (year) were 1 and 48.

Air navigation service

The median (Q1-Q3) of air navigation service was 86.7 (63.2-87.2). The minimum and the maximum of air navigation service were 15.3 and 99.4.

Airport

The median (Q1-Q3) of airport was 93.2 (71.8-97.3). The minimum and the maximum of airport were 6.7 and 98.7.

State of registry

The median (Q1-Q3) of State of registry was 92.2 (80.7-92.6). The minimum and the maximum of State of registry were 32.2 and 98.9.

State of occurrence

The median (Q1-Q3) of State of occurrence was 92.2 (72.9-92.2). The minimum and the maximum of State of occurrence were 18.5 and 98.9.

State of operator

The median (Q1-Q3) of State of operator was 92.2 (80.7-92.5). The minimum and the maximum of State of operator were 32.2 and 98.9.

Captain/Pilot in command – age

The median (Q1-Q3) of Captain/Pilot in command – age was 47 (41.5-55). The minimum and the maximum of Captain/Pilot in command – age were 25 and 64.

Captain/Pilot in command – total flight experience (hours)

The median (Q1-Q3) of Captain/Pilot in command – total flight experience (hours) was 9478:00 (6403:00-14200:20). The minimum and the maximum of Captain/Pilot in command – total flight experience (hours) were 1458:00 and 36000:00.

Co–Pilot / First officer – age

The median (Q1-Q3) of Co – Pilot / First officer – age was 37 (28-45). The minimum and the maximum of Co – Pilot / First officer – age were 22 and 62.

Co-Pilot/First officer – total flight experience (hours)

The median (Q1-Q3) of Co-Pilot / First officer – total flight experience (hours) was 2997:00 (1438:00-6400:00). The minimum and the maximum of Co-Pilot/First officer – total flight experience (hours) were 26:00 and 29440:00.

Table 11 Interval/Ratio Variables Summary Statistics

Interval Variable Summary Statistics (*n* = 114)						
Variable	n	Missing	Median	Min	Max	Q1-Q3
Aircraft age (year)	114	0	13	1	48	5-23
Air navigation service	110	4	86.7	15.3	99.4	63.2-87.2
Airport	91	23	93.2	6.7	98.7	71.8-97.3
State of registry	114	0	92.2	32.2	98.9	80.7-92.6
State of occurrence	110	4	92.2	18.5	98.9	72.9-92.2
State of operator	111	3	92.2	32.2	98.9	80.7-92.5
Captain/Pilot in command – age	95	19	47	25	64	41.5-55

Interval Variable Summary Statistics (*n* = 114)

Variable	n	Missing	Median	Min	Max	Q1-Q3
Captain/Pilot in command – total flight experience (hour)	105	9	9487:00	1458:00	36000:00	6403:00-14200:20
Co-Pilot/First officer - age	78	36	37	22	62	28-45
Co-Pilot/First officer – total flight experience (hour)	89	25	2997:00	26:00	29440:00	1438:00-6400:00

Table 12 shows the summary statistics of categorical variables.

Day of operation

The distribution of occurrences by day of operation was a weekday (71.1%) and a weekend (28.9%).

Month of operation

The distribution of occurrences by month of operation (quarter) was quarter 1 (28.9%), quarter 4 (28.1%), quarter 3 (24.6%), and quarter 2 (18.4%).

Time of day

The distribution of occurrences by time of day was 06:00-11:59 (39.5%), 18:00-23:59 (31.6%), 12:00-17:59 (21.9%), and 00:00-05:59 (7%).

Aircraft manufacturer

The distribution of occurrences by aircraft manufacturer was Boeing (35.1%), ATR (13.2%), Airbus (12.3%), de Havilland Canada (8.8%), Embraer (5.3%), Bombardier (4.4%), McDonnell Douglas (4.4%), and other - Fairchild/Swearingen, Fokker, Saab, Antonov, Beechcraft, British Aerospace, Let L, HESA, and Lockheed (16.7%).

Aircraft model (family)

The distribution of occurrences by aircraft model (family) was Boeing 737 Next Generation (20.2%), ATR 42/72 (13.2%), Airbus 320 family (8.8%), de Havilland Canada DHC-8 Dash 8 (8.8%), Boeing 737 Classic (7%), McDonnell Douglas DC-9/MD-80 series (4.4%), Boeing 777 (3.5%), Bombardier CRJ-100 series (2.6%), Embraer ERJ-145 family (2.6%), Fairchild/Swearingen SA226/227 (2.6%), Saab 340/2000 (2.6%), and other - Airbus A300, A330, A380; Antonov – An 26/140, An 74; Beechcraft 99/1900; Boeing

747,757,767; Bombardier CRJ-900; Embraer – ERJ-170, 190; Fokker 50, 100; British Aerospace Jetstream 31/41; Let L-410; Lockheed L-100 Hercules (23.7%).

Engine (manufacturer)

The distribution of occurrences by engine (manufacturer) was Pratt and Whitney (32.5%), CFM International (31.6%), General Electric (14%), Rolls-Royce/Allison (8.8%), IAE (4.4%), Garrett Airesearch (3.5%), Motor Sich (1.8%), Engine Alliance (0.9%), Kilmov (0.9%) and missing data (1.8%).

Aircraft size (MTOW)

The distribution of occurrences by aircraft size (MTOW) was aircraft with an MTOW of 27,001–272,000 kg (59.6%), aircraft with an MTOW of 5,701-27,000 kg (34.2%), and aircraft with an MTOW over 272,000 kg (6.1%).

Airline (business type)

The distribution of occurrences by airline (business type) was full-service carrier (32.5%), low-cost carrier (25.4%), regional/commuter (22.8%), cargo (10.5%), charter (7.9%), and other (0.9%).

Nature of operation

The distribution of occurrences by nature of operation was domestic scheduled passenger (58.8%), International schedule passenger (24.6%), cargo (14%), International non-scheduled passenger (0.9%), ferry/positioning (0.9%), and missing data (0.9%).

Flight phase

The distribution of occurrences by flight phase was landing (43%), en route (12.3%), taxi (10.5%), take-off (9.6%), standing (8.8%), approach (7%), pushback/towing (4.4%), and initial climb (4.4%).

Meteorological condition at the accident site

The distribution of occurrences by the meteorological condition at the accident site was VMC (37.7%), IMC (5.3%), and missing data (57%).

Meteorological condition of light

The distribution of occurrences by the meteorological condition of light was night/dark (21.1%), day (19.3%), dawn (6.1%), dusk (1.8%), and missing data (51.8%).

Meteorological - type of airspace

The distribution of occurrences by the meteorological - type of airspace was class B (8.8%), class C (3.5%), other - class A, D, E, G (3.5%), and missing data (84.2%).

Meteorological - type of clearance

The distribution of occurrences by the meteorological – type of clearance was IFR (34.2%), other – VFR and Unknown/None (3.5%), and missing data (62.3%).

Meteorological - type of flight plan filed

The distribution of occurrences by the meteorological - type of flight plan filed was IFR (35.1%) and missing data (64.9%).

Captain/Pilot in command - aircraft type rating

The distribution of occurrences by Captain/Pilot in command - aircraft type rating was only multi-engine land (17.5%); single-engine land and multi-engine land (14%); single-ending land, multi-engine land, and single-engine sea (1.8%); single-engine land (0.9%), and missing data (65.8%).

Captain/Pilot in command - other aircraft type

The distribution of occurrences by Captain/Pilot in command - other aircraft type was none (24.6%), able to operate other aircraft type (15.8%), and missing data (59.6%).

Captain/Pilot in command medical certification

The distribution of occurrences by Captain/Pilot in command - medical certification was with limitations (23.7%), without limitations (9.6%), and missing data (66.7%).

Co-pilot/first officer - aircraft type rating

The distribution of occurrences by co-pilot/first officer - aircraft type rating was single and multi-engine land (14.9%); multi-engine land (14%); other - single-engine land only, single and multi-engine land and single-engine sea, and single-engine land and sea (2.6%); and missing data (68.4%).

Co-pilot/first officer - other aircraft type

The distribution of occurrences by co-pilot/first officer - other aircraft type was none (15.8%), able to operate other aircraft type (15.8%), and missing data (68.4%).

Co-pilot/first officer medical certification

The distribution of occurrences by co-pilot/first officer - medical certification was without limitations (14.9%), with limitations (14%), and missing data (71.1%).

Most occurrences happened on weekday (71.1%); during January – March or quarter 1 (28.9%); during 06:00-11:59 (morning) (39.5%); with Boeing aircraft (35.1%); with Boeing 737 next generation (20.2%); on an aircraft with Pratt and Whitney engine (32.5%); on an aircraft size of a 27,001-272,000 kg MTOW (59.6%); on a full-service carrier (32.5%); in a domestic scheduled passenger flight (58.8%); during landing phase (43%); in VMC (visual meteorological condition) (37.7%); in the dark/night light (21.1%); class B airspace (8.8%); in IFR clearance (34.2%); in IFR flight plan (35.1%); with Captain/Pilot in Command of multi-engine land rating (17.5%); with Captain/Pilot in Command that unable to operate other aircraft type (24.6%); with Captain/Pilot in command having medical certification with limitations (23.7%), with Co-Pilot/First officer with single-engine land and multi-engine land rating (14.9%), and with Co-Pilot/First officer having medical certification without limitations. The ability to operate other aircraft type for Co-Pilot/First officer cannot be concluded because there are equal percentages between able and unable to operate.

Table 12 Categorical Variable Summary Statistics

FACTOR	Frequency	%
Day of operation		
Weekday	81	71.1
Weekend	33	28.9
Total	114	100

FACTOR	Frequency	%
Month of operation		
Quarter 1	33	28.9
Quarter 2	21	18.4
Quarter 3	28	24.6
Quarter 4	32	28.1
Total	114	100

FACTOR	Frequency	%
Time of day		
00.00-05.59	8	7
06.00-11.59	45	39.5
12.00-17.59	25	21.9
18.00-23.59	36	31.6
Total	114	100
Aircraft model (family)		
Airbus A300	1	0.9
Airbus A320 family	10	8.8
Airbus A330	2	1.8
Airbus A380	1	0.9
An-26 / 140	2	1.8
An-74	1	0.9
ATR42 / 72	15	13.2
Beechcraft 99 / 1900	2	1.8
Boeing 737 Classic	8	7.0
Boeing 737 Next Generation	23	20.2
Boeing 747	2	1.8
Boeing 757	1	0.9
Boeing 767	2	1.8
Boeing 777	4	3.5
CRJ-100 Series	3	2.6
CRJ-900	2	1.8
DC-9 / MD-80 Series	5	4.4
DHC-8 Dash 8	10	8.8
ERJ-145 Family	3	2.6
ERJ-170	1	0.9
ERJ-190	2	1.8
Fokker 100	2	1.8
Fokker 50	1	0.9

FACTOR	Frequency	%
Aircraft manufacturer		
Airbus	14	12.3
Antonov	2	1.8
ATR	15	13.2
Beechcraft	2	1.8
Boeing	40	35.1
Bombardier	5	4.4
British Aerospace	2	1.8
de Havilland Canada	10	8.8
Embraer	6	5.3
Fairchild / Swearingen	3	2.6
Fokker	3	2.6
HESA	1	0.9
Let L	2	1.8
Lockheed	1	0.9
McDonnell Douglas	5	4.4
Saab	3	2.6
Total	114	100
Engine (manufacturer)		
CFM International	36	31.6
Engine Alliance	1	0.9
Garrett Airesearch	4	3.5
General Electric	16	14
IAE	5	4.4
Kilmov	1	0.9
Motor Sich	2	1.8
Pratt & Whitney	37	32.5
Rolls-Royce/Allison	10	8.8
Total	112	98.2
Missing	2	1.8

FACTOR	Frequency	%
Jetstream 31 / 41	2	1.8
L-410	2	1.8
Lockheed L-100 Hercules	1	0.9
SA226 / 227	3	2.6
Saab 340 / 2000	3	2.6
Total	114	100

FACTOR	Frequency	%
Aircraft size (MTOW)		
5,701-27,000 kg	39	34.2
27,001-272,000 kg	68	59.6
>272,000 kg	7	6.1
Total	114	100

FACTOR	Frequency	%
Airline (business type)		
Full-service carrier	37	32.5
Low-cost carrier	29	25.4
Cargo	12	10.5
Charter	9	7.9
Regional/Commuter	26	22.8
Other	1	0.9
Total	114	100

FACTOR	Frequency	%
Nature of operation		
International Scheduled Passenger	28	24.6
International Non-scheduled Passenger	1	0.9
Domestic Scheduled Passenger	67	58.8
Cargo	16	14
Ferry/Positioning	1	0.9
Total	113	99.1
Missing	1	0.9

FACTOR	Frequency	%
Flight phase		
Standing	10	8.8
Pushback / Towing	5	4.4
Taxi	12	10.5
Take-off	11	9.6
Initial climb	5	4.4
En Route	14	12.3
Approach	8	7
Landing	49	43
Total	114	100

FACTOR	Frequency	%
Meteorological condition at the accident site		
Visual (VMC)	43	37.7
Instrument (IMC)	6	5.3

FACTOR	Frequency	%
Meteorological condition of light		
Dawn	7	6.1
Day	22	19.3

FACTOR	Frequency	%
Total	49	43
Missing	65	57

FACTOR	Frequency	%
Dusk	2	1.8
Night/Dark	24	21.1
Total	55	48.2
Missing	59	51.8

Meteorological - type of airspace		
Class A	1	0.9
Class B	10	8.8
Class C	4	3.5
Class D	1	0.9
Class E	1	0.9
Class G	1	0.9
Total	18	15.8
Missing	96	84.2

Meteorological - type of clearance		
Unknown / None	2	1.8
VFR	2	1.8
IFR	39	34.2
Total	43	37.7
Missing	71	62.3

Meteorological - type of flight plan filed		
IFR	40	35.1
Missing	74	64.9

Captain/Pilot in command – aircraft type rating		
Single-engine land	1	0.9
Multi-engine land	20	17.5
Single-engine land; Multi-engine land	16	14
Single-engine land; Multi-engine land; Single-engine sea	2	1.8
Total	39	34.2
Missing	75	65.8

Captain/Pilot in command - other aircraft type rating		

Captain/Pilot in command – Medical Certification		

FACTOR	Frequency	%
None	28	24.6
Yes	18	15.8
Total	46	40.4
Missing	68	59.6
Co-Pilot/First officer – aircraft type rating		
Single-engine land	1	0.9
Multi-engine land	16	14
Single-engine land; Multi-engine land	17	14.9
Single-engine land; Multi-engine land; Single-engine sea	1	0.9
Single-engine land; Single-engine sea	1	0.9
Total	36	31.6
Missing	78	68.4
Co-Pilot/First officer – Medical Certification		
With limitations	16	14
Without limitations	17	14.9
Total	33	28.9
Missing	81	71.1

FACTOR	Frequency	%
With limitations	27	23.7
Without limitations	11	9.6
Total	38	33.3
Missing	76	66.7
Co-Pilot/First officer - other aircraft type rating		
None	18	15.8
Yes	18	15.8
Total	36	31.6
Missing	78	68.4

4.2.2.2. Occurrences (Accidents/Incidents)

During 2014–2017, 114 accident cases met the criteria and were included in this study; of these, 17 (14.9%) were accidents (Occurrences with fatalities). Table 13-16 exhibit the descriptive statistics and correlations between the occurrences (accident/incident) and independent variables.

Time

Day of operation

The distribution of accidents (occurrences with fatalities) by day of operation was 11 (64.7%) weekday and 6 (35.3%) weekend. There was no statistically significant association between occurrences (accident/incident) and day of operation (p = .568). Most occurrences (accident/incident) happened on weekday; however, 6 of 33 occurrences (18.2%) were accidents (occurrences with fatalities) that occurred on weekend.

Month of operation

The distribution of accidents (occurrences with fatalities) by month of operation (quarter) was 7 (41.2%) quarter 1, 4 (23.5%) quarter 3, 4 (23.5%) quarter 4, and 2 (11.8%) quarter 2. There is no statistically significant association between occurrences (accident/incident) and month (p = .702). However, 7 of 33 occurrences (21.21%) were accidents (occurrences with fatalities) that occurred in quarter 1.

Time of day

The distribution of accidents (occurrences with fatalities) by time of day was 8 (47.1%) during 06:00–11:59, 4 (23.5%) during 12:00–17:59, 3 (17.6%) during 00:00–05:59, and 2 (11.8%) during 18:00–23:59. There is no statistically significant association between occurrences (accident/incident) and time of day (p = .094). Most occurrences (accident/incident) happened during 06:00-11:59 (morning); however, 3 of 8 occurrences (37.5%) were accidents (occurrences with fatalities) that occurred during 00:00 – 05:59.

Aircraft

Aircraft manufacturer

The distribution of accidents (occurrences with fatalities) by aircraft manufacturer was 5 (29.4%) ATR, 3 (17.6%) Boeing, 2 (11.8%) Airbus, 2 (11.8%) Let L, 1 (5.9%) Antonov, 1 (5.9%) Bombardier, 1 (5.9%) Fairchild/Swearingen, 1 (5.9%) HESA, and 1 (5.9%) McDonnell Douglas. There was a statistically significant association between occurrences (accident/incident) and aircraft manufacturer (p = .018). Most occurrences (accident/incident) happened to Boeing aircraft; however, 1 of 1 occurrence (100%) and 2 of 2 occurrences (100%) were accidents (occurrences with fatalities) that occurred to HESA and Let L aircraft respectively.

Aircraft model (family)

The distribution of accidents (occurrences with fatalities) by aircraft model (family) was 5 (29.4%) ATR 42/72, 2 (11.8%) Airbus 320 family, 2 (11.8%) Antonov An-26/140, 2 (11.8%) Let L-410, 1 (5.9%) Boeing 737 Next Generation, 1 (5.9%) Boeing 747, 1 (5.9%) Boeing 777, 1 (5.9%) Bombardier CRJ-100 series, 1 (5.9%) McDonnell Douglas DC-9/MD-80 series, and 1 (5.9%) Fairchild/Swearingen SA226/227. There was a statistically significant association between occurrences (accident/incident) and aircraft model (p = .046). Most occurrences (accident/incident) happened to Boeing 737 Next Generation; however, 2 of 2 occurrences (100%) and 2 of 2 occurrences (100%) were accidents (occurrences with fatalities) that occurred to Antonov An-26/140 and Let L-410.

Engine (manufacturer)

The distribution of accidents (occurrences with fatalities) by engine (manufacturer) was 7 (41.2%) Pratt and Whitney, 3 (17.6%) CFM International, 3 (17.6%) General Electric, 1 (5.9%) Garrett Airesearch, 1 (5.9%) Kilmov, 1 (5.9%) Motor Sich, and 1 (5.9%) Rolls-Royce/Allison. There was no statistically significant association between occurrences (accident/incidan ent) and engine (p = .221). Most occurrences (accident/incident) happened to aircraft with Pratt and Whitney engine; however, 1 of 1 occurrence (100%) was an accident (occurrence with fatalities) that occurred in aircraft with Kilmov engine.

Aircraft size (MTOW)

The distribution of accidents (occurrences with fatalities) by aircraft size (MTOW) was 11 (64.7%) aircraft with an MTOW of 5,701-27,000 kg, 4 (23.5%) aircraft with an MTOW of 27,001-272,000 kg, and 2 (11.8%) aircraft with an MTOW over 272,000 kg. There was a statistically significant association between occurrences (accident/incident) and aircraft size (MTOW) (p = .007). Most occurrences (accident/incident) happened to medium-sized aircraft with a MTOW 27,001-272,000 kg; however, 2 of 7 occurrences

(28.6%) were accidents (occurrences with fatalities) that occurred to large aircraft with a MTOW above 270,000 kg.

Airline business model and operation

Airline (business type)

The distribution of accidents (occurrences with fatalities) by airline (business type) was 5 (29.4%) full-service carrier, 3 (17.6%) low-cost carrier, 3 (17.6%) cargo, 3 (17.6%) regional/commuter, 2 (11.8%) charter, and 1 (5.9%) other. There was no statistically significant association between occurrences (accident/incident) and airline (business type) ($p = .252$). Most occurrences (accident/incident) happened to full service carriers; however, 3 of 12 occurrences (25%) were accidents (occurrences with fatalities) that occurred in cargo carriers.

Nature of operations

The distribution of accidents (occurrences with fatalities) by nature of operations was 7 (41.2%) domestic scheduled passenger, 5 (29.4%) international scheduled passenger, and 5 (29.4%) cargo. There was no statistically significant association between occurrences (accident/incident) and nature of operations ($p = .249$). Most occurrences (accident/incident) happened to domestic scheduled passenger flights; however, 5 of 16 occurrences (31.3%) were accidents (occurrences with fatalities) that occurred in cargo flights.

Flight Phase

The distribution of accidents (occurrences with fatalities) by flight phase was 8 (47.1%) en route, 6 (35.3%) approach, and 3 (17.6%) initial climb. There was a statistically significant association between occurrences (accident/incident) and flight phases ($p < .001$). Most occurrences (accident/incident) happened during landing phase; however, 6 of 8 occurrences (75%) were accidents (occurrences with fatalities) that occurred during approach phase.

Meteorology

Meteorological condition at the accident site

The distribution of accidents (occurrences with fatalities) by the meteorological condition at the accident site was 5 (71.4%) visual (VMC) and 2 (28.6%) instrument

(IMC). There was no statistically significant association between occurrences (accident/incident) and meteorological condition at accident site (p = .199). Most occurrences (accident/incident) happened in visual (VMC); however, 2 out of 6 occurrences (33.3%) were accidents (occurrences with fatalities) that occurred in instrument (IMC).

Meteorological condition of light

The distribution of accidents (occurrences with fatalities) by the meteorological condition of light was 3 (50%) Day and 2 (50%) Night/Dark. There was no statistically significant association between occurrences (accident/incident) and meteorological condition of light (p = .887). Most occurrences (accident/incident) happened during night/dark light; however, 3 out of 22 occurrences (13.6%) were accidents (occurrences with fatalities) that occurred during daylight.

Meteorological – type of airspace

There were no accidents (occurrences with fatalities) in the data collected for the meteorological – type of airspace. There was no statistically significant association between occurrences (accident/incident) and meteorological - type of airspace (p = .222).

Meteorological - type of clearance

The distribution of accidents (occurrences with fatalities) by the meteorological - type of clearance was 3 (75%) IFR and 1 (25%) VFR. There was no statistically significant association between occurrences (accident/incident) and meteorological - type of clearance (p = .334). Most occurrences (accident/incident) happened to an aircraft with IFR clearance; however, 1 of 2 occurrences (50%) were accidents (occurrences with fatalities) having VFR clearance.

Meteorological - type of flight plan filed

The distribution of accidents (occurrences with fatalities) by meteorological - type of flight plan filed was 5 (100%) IFR. There was no result in correlation test.

Flight crew

Captain/Pilot in command - aircraft type rating

The distribution of accidents (occurrences with fatalities) by Captain/Pilot in command - aircraft type rating was 3 (100%) multi-engine land. There was no statistically significant association between occurrences (accident/incident) and Captain/Pilot in command – aircraft type rating (p = .405).

Captain/Pilot in command - other aircraft type

The distribution of accidents (occurrences with fatalities) by Captain/Pilot in command -other aircraft type was 4 (100%) able to operate other aircraft type. There was a statistically significant association between occurrences (accident/incident) and Captain/Pilot in command -other aircraft type (p = .019). Most occurrences (accident/incident) happened to Captain/Pilot in command that are unable to operate other aircraft type; however, 4 of 18 occurrences (22.2%) were accidents (occurrences with fatalities) to Captain/Pilot in command that are able to operate other aircraft type.

Captain/Pilot in command - medical certification

The distribution of accidents (occurrences with fatalities) by Captain/Pilot in command medical certification was 5 (83.3%) certified with limitations and 1 (16.7%) certified without limitations. There was no statistically significant association between occurrences (accident/incident) and Captain/Pilot in-command medical certification (p = .650). However, 5 of 27 occurrences (18.5%) were accidents (occurrences with fatalities) with Captain/Pilot in command's certified with limitations in medical certification.

Co-pilot/first officer - aircraft type rating

The distribution of accidents (occurrences with fatalities) by co-pilot/first officer - aircraft type rating was 2 (66.7%) multi-engine land and 1 (33.3%) single-engine and multi-engine land. There was no statistically significant association between occurrences (accident/incident) and co-pilot/first officer type rating (p = .695). Most occurrences (accident/incident) happened to Co-Pilot/First officer hold a single-engine land and multi-engine land type rating; however, 2 of 16 occurrences (12.5%) were accidents (occurrences with fatalities) with Co-Pilot/First officer hold a multi-engine land type rating.

Co-pilot/first officer - other aircraft type

The distribution of accidents (occurrences with fatalities) by co-pilot/first officer - other aircraft type was 5 (100%) able to operate other aircraft type. There was a statistically significant association between occurrences (accident/incident) and co-pilot/first officer - other aircraft type (p = .045). In the overall occurrences, there are equal percentage between co-pilot/first officer able to operate and unable to operate other aircraft type.

Co-pilot/first officer - medical certification

The distribution of accidents (occurrences with fatalities) by co-pilot/first officer - medical certification was 2 (50%) certified with limitations and 2 (50%) certified without limitations. There was no statistically significant association between occurrences (accident/incident) and Captain/Pilot in-command medical certification (p = 1). Most occurrences (accident/incident) happened to Co-pilot/First officer certified without limitations in medical certification; however, 2 of 16 occurrences (12.5%) were accidents (occurrences with fatalities) with Co-pilot/First officer certified with limitations in medical certification.

Most accidents (occurrences with fatalities) occurred on weekday (64.7%); during January – March or quarter 1 (41.2%); during 06:00–11:59 (morning) (47.1%); with ATR aircraft (29.4%); with ATR 42/72 (29.4%); on an aircraft with Pratt and Whitney engine (41.2%); on an aircraft size of a 5,701-27,000 kg MTOW (64.7%), on full-service carriers (29.4%); in a domestic scheduled passenger flights (41.2%); during en route phase (47.1%); in visual (VMC) (71.4%); in the daylight (50%); in IFR clearance (75%); IFR flight plan (100%); with Captain/Pilot in Command of multi-engine land rating (100%); with Captain/Pilot in Command that able to operate other aircraft type (100%); %); with Captain/Pilot in command having medical certification with limitations (83.3%); with Co-Pilot/First officer with multi-engine land rating (66.7%); with Co-Pilot/First officer able to operate other aircraft type (100%); and Co-Pilot/First officer having medical certification with limitations (50%). There were no accidents (occurrences with fatalities) in the data collected for the meteorological – type of airspace.

The distributions of between most occurrences and most accidents that are consistent are day of operation (weekday), month of operation (quarter 1), time of day, engine (manufacturer), airline (business type), nature of operation, meteorological condition at the accident site, meteorological – type of clearance, meteorological – type of flight plan flied, Captain/Pilot in command - aircraft type rating, and Captain/Pilot in command – medical certification.

However, the higher likelihood for the accident to happen considering overall occurrences are on weekend, during quarter 1, during 00:00 – 05:59 (early morning), with HESA and Let L aircraft, with Antonov An-26/140 and Let L-410, on an aircraft with Kilmov engine, on an aircraft size of above 270,000 kg MTOW, on cargo carriers, in cargo flights, during approach phase, in instrument (IMC), in the daylight, in VFR clearance, with Captain/Pilot in Command that able to operate other aircraft type, Captain/Pilot in Command having medical certification with limitations, with Co-Pilot/First officer with multi-engine land type rating, and Co-Pilot/First officer having medical certification with limitations. Meteorological - type of flight plan filed, Captain/Pilot in command - aircraft type rating, and Co-pilot/first officer - other aircraft type cannot be compared because it has only one category.

Table 13 Descriptive Statistics between occurrences (accident/incident) and independent variables (categorical)

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Count	%	Count	%	Count	%
Day of operation						
Weekday	70	72.2	11	64.7	81	71.1
Weekend	27	27.8	6	35.3	33	28.9
Month of operation						
Quarter 1	26	26.8	7	41.2	33	28.9
Quarter 2	19	19.6	2	11.8	21	18.4
Quarter 3	24	24.7	4	23.5	28	24.6
Quarter 4	28	28.9	4	23.5	32	28.1
Time of day						
00:00-05:59	5	5.2	3	17.6	8	7
06:00-11:59	37	38.1	8	47.1	45	39.5
12:00-17:59	21	21.6	4	23.5	25	21.9
18:00-23:59	34	35.1	2	11.8	36	31.6
Aircraft manufacturer						
Airbus	12	12.4	2	11.8	14	12.3
Antonov	1	1	1	5.9	2	1.8
ATR	10	10.3	5	29.4	15	13.2
Beechcraft	2	2.1	0	0	2	1.8
Boeing	37	38.1	3	17.6	40	35.1

	No fatalities n = 97		Fatalities n = 17		Sample n = 114	
	Count	%	Count	%	Count	%
Bombardier	4	4.1	1	5.9	5	4.4
British Aerospace	2	2.1	0	0	2	1.8
de Havilland Canada	10	10.3	0	0	10	8.8
Embraer	6	6.2	0	0	6	5.3
Fairchild / Swearingen	2	2.1	1	5.9	3	2.6
Fokker	3	3.1	0	0	3	2.6
HESA	0	0	1	5.9	1	0.9
Let L	0	0	2	11.8	2	1.8
Lockheed	1	1	0	0	1	0.9
McDonnell Douglas	4	4.1	1	5.9	5	4.4
Saab	3	3.1	0	0	3	2.6
Aircraft model						
Airbus A300	1	1	0	0	1	0.9
Airbus A320 Family	8	8.2	2	11.8	10	8.8
Airbus A330	2	2.1	0	0	2	1.8
Airbus A380	1	1	0	0	1	0.9
An-26 / 140	0	0	2	11.8	2	1.8
An-74	1	1	0	0	1	0.9
ATR42 / 72	10	10.3	5	29.4	15	13.2
Beechcraft 99 / 1900	2	2.1	0	0	2	1.8
Boeing 737 Classic	8	8.2	0	0	8	7

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Count	%	Count	%	Count	%
Boeing 737 Next Generation	22	22.7	1	5.9	23	20.2
Boeing 747	1	1	1	5.9	2	1.8
Boeing 757	1	1	0	0	1	0.9
Boeing 767	2	2.1	0	0	2	1.8
Boeing 777	3	3.1	1	5.9	4	3.5
CRJ-100 Series	2	2.1	1	5.9	3	2.6
CRJ-900	2	2.1	0	0	2	1.8
DC-9 / MD-80 Series	4	4.1	1	5.9	5	4.4
DHC-8 Dash 8	10	10.3	0	0	10	8.8
ERJ-145 Family	3	3.1	0	0	3	2.6
ERJ-170	1	1	0	0	1	0.9
ERJ-190	2	2.1	0	0	2	1.8
Fokker 100	2	2.1	0	0	2	1.8
Fokker 50	1	1	0	0	1	0.9
Jetstream 31 / 41	2	2.1	0	0	2	1.8
L-410	0	0	2	11.8	2	1.8
Lockheed L-100 Hercules	1	1	0	0	1	0.9
SA226 / 227	2	2.1	1	5.9	3	2.6
Saab 340 / 2000	3	3.1	0	0	3	2.6
Engine (manufacturer)						
CFM International	33	34.7	3	17.6	36	32.1

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Count	%	Count	%	Count	%
Engine Alliance	1	1.1	0	0	1	0.9
Garrett Airesearch	3	3.2	1	5.9	4	3.6
General Electric	13	13.7	3	17.6	16	14.3
IAE	5	5.3	0	0	5	4.5
Kilmov	0	0	1	5.9	1	0.9
Motor Sich	1	1.1	1	5.9	2	1.8
Pratt & Whitney	30	31.6	7	41.2	37	33
Rolls-Royce/Allison	9	9.5	1	5.9	10	8.9
Aircraft size (MTOW)						
5,701 – 27,000 kg	28	28.9	11	64.7	39	34.2
27,001 - 272,000 kg	64	66	4	23.5	68	59.6
More than 272,000 kg	5	5.2	2	11.8	7	6.1
Airline (business type)						
Full-service carrier	32	33	5	29.4	37	32.5
Low-cost carrier	26	26.8	3	17.6	29	25.4
Cargo	9	9.3	3	17.6	12	10.5
Charter	7	7.2	2	11.8	9	7.9
Regional/Commuter	23	23.7	3	17.6	26	22.8
Other	0	0	1	5.9	1	0.9
Nature of operation						

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Count	%	Count	%	Count	%
International Scheduled Passenger	23	24	5	29.4	28	24.8
International Non-scheduled Passenger	1	1	0	0	1	0.9
Domestic Scheduled Passenger	60	62.5	7	41.2	67	59.3
Cargo	11	11.5	5	29.4	16	14.2
Ferry/Positioning	1	1	0	0	1	0.9
Flight phase						
Standing	10	10.3	0	0	10	8.8
Pushback / towing	5	5.2	0	0	5	4.4
Taxi	12	12.4	0	0	12	10.5
Take-off	11	11.3	0	0	11	9.6
Initial climb	2	2.1	3	17.6	5	4.4
En route	6	6.2	8	47.1	14	12.3
Maneuvering	-	-	-	-	-	-
Approach	2	2.1	6	35.3	8	7
Landing	49	50.5	0	0	49	43
Meteorological condition at the accident site						
Visual (VMC)	38	90.5	5	71.4	43	87.8
Instrument (IMC)	4	9.5	2	28.6	6	12.2
Meteorological – condition of light						
Dawn	7	14.3	0	0	7	12.7

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Count	%	Count	%	Count	%
Day	19	38.8	3	50	22	40
Dusk	2	4.1	0	0	2	3.6
Night/Dark	21	42.9	3	50	24	43.6
Meteorological – type of airspace						
Class A	1	5.9	0	0	1	5.6
Class B	10	58.8	0	0	10	55.6
Class C	4	23.5	0	0	4	22.2
Class D	1	5.9	0	0	1	5.6
Class E	1	5.9	0	0	1	5.6
Class G	0	0	1	100	1	5.6
Meteorological – type of clearance						
Unknown / None	2	5.1	0	0	2	4.7
VFR	1	2.6	1	25	2	4.7
IFR	36	92.3	3	75	39	90.7
Meteorological – type of flight plan filed						
IFR	35	100	5	100	40	100
Captain/Pilot in command – aircraft type rating						
Single-engine land	1	2.8	0	0	1	2.6
Multi-engine land	17	47.2	3	100	20	51.3
Single-engine land; Multi-engine land	16	44.4	0	0	16	41

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Count	%	Count	%	Count	%
Single-engine land; Multi-engine land; Single-engine sea	2	5.6	0	0	2	5.1
Captain/Pilot in command - other aircraft type						
None	28	66.7	0	0	28	60.9
Yes	14	33.3	4	100	18	39.1
Captain/Pilot in command – medical certification						
With limitations	22	68.8	5	83.3	27	71.1
Without limitations	10	31.3	1	16.7	11	28.9
Co-pilot / first officer – aircraft type rating						
Single-engine land	1	3	0	0	1	2.8
Multi-engine land	14	42.4	2	66.7	16	44.4
Single-engine land; Multi-engine land	16	48.5	1	33.3	17	47.2
Single-engine land; Multi-engine land; Single-engine sea	1	3	0	0	1	2.8
Single-engine land; Single-engine sea	1	3	0	0	1	2.8
Co-pilot / first officer - other aircraft type rating						
None	18	58.1	0	0	18	50
Yes	13	41.9	5	100	18	50
Co - pilot / first officer – medical certification						
With limitations	14	48.3	2	50	16	48.5
Without limitations	15	51.7	2	50	17	51.5

Table 14 Correlations between occurrences (accident/incident) and independent variables (categorical)

	Pearson Chi-square	Fisher's exact		Pearson Chi-square	Fisher's exact
	p	*p*		*p*	*p*
Day of operation		.568	Meteorological condition at accident site		.199
Month of operation		.702	Meteorological condition of light		.887
Time of day		.094	Meteorological - type of airspace		.222
Aircraft manufacturer		.018*	Meteorological - type of clearance		.334
Aircraft model (family)		.046*	Meteorological - type of flight plan filed		-
Engine (manufacturer)		.221	Captain/pilot in command - aircraft type rating		.405
Aircraft size (MTOW)	.007*		Captain/pilot in command - other aircraft type		.019*
Airline (business type)		.252	Captain/pilot in command - medical certification		.650
Nature of operation		.249	Co - pilot/first officer - aircraft type rating		.695
Flight phase		<.001**	Co - pilot/first officer - other aircraft type		.045*
			Co - pilot/first officer - medical certification		1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Aircraft

Aircraft age (year)

The median (Quartile 1–Quartile 3) aircraft age (year) of overall occurrences was 13 (4-20), of which 13 (4-20) were incidents (occurrences with no fatalities) and 4.5 (3-6) accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and aircraft age (year) (p = .794).

Effective Implementation

Air navigation service

The median (Quartile 1–Quartile 3) air navigation service of overall occurrences was 86.4 (59.6-86.7), of which 86.4 (63.2-86.7) were incidents (occurrences with no fatalities) and 59.2 (56.3-62.1) accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and air navigation service (p = .069).

Airport

The median (Quartile 1–Quartile 3) airport of overall occurrences was 88 (57.5-97.3), of which 88 (57.5-97.3) were incidents (occurrences with no fatalities) and 71.6 (70.8-72.4) accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and airport (p = .206).

State of registry

The median (Quartile 1–Quartile 3) State of registry of overall occurrences was 92.2 (67.9-92.2), of which 92.2 (69.1-92.2) were incidents (occurrences with no fatalities) and 82.8 (66.8-98.9) accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and State of registry (p = .073).

State of occurrence

The median (Quartile 1–Quartile 3) State of occurrence of overall occurrences was 87.9 (66.3-92.2), of which 89.5 (65.9–92.2) were incidents (occurrences with no fatalities) and 69.2 (66.8–71.7) were accidents (occurrences with fatalities). There was a statistically significant association between occurrences (accident/incident) and State of occurrence (p = .045).

State of operator

The median (Quartile 1–Quartile 3) State of operator of overall occurrences was 92.2 (67.9-92.2), of which 92.2 (69.1-92.2) were incidents (occurrences with no fatalities) and 82.8 (66.8-98.9) were accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and State of operator (p = .102).

Flight crew

Captain/Pilot in command – age

The median (Quartile 1–Quartile 3) captain / pilot in command – age of overall occurrences was 48 (42.5-55.5), of which 48 (43-56) were incidents (occurrences with no fatalities) and 43 (38-48) were accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and Captain/Pilot in command – age (p = .490).

Captain/Pilot in command – total flight experience (hours)

The median (Quartile 1–Quartile 3) Captain/Pilot in command – total flight experience (hours) of overall occurrences was 9487:02 (6834:30-14347:50:30), of which 9800:00 (6850:00-14495:21) were incidents (occurrences with no fatalities) and 7826:01 (5965:00-9687:02) were accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and Captain/Pilot in command – total flight experience (hours) (p = .829).

Co-Pilot/First officer – age

The median (Quartile 1–Quartile 3) Co-Pilot/First officer - age of overall occurrences was 36 (28-42.5), of which 36 (28-43) were incidents (occurrences with no fatalities) and 32 (27-37) were accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and Co-Pilot/First officer – age (p = .546).

Co-Pilot/First officer – total flight experience (hours)

The median (Quartile 1–Quartile 3) Co-Pilot/First officer – total flight experience (hours) of overall occurrences was 2970:00 (1508:50-6000:39), of which 2970:00

(1588:00-6178:18) were incidents (occurrences with no fatalities) and 3539:00 (1311:00-5767:00) were accidents (occurrences with fatalities). There was no statistically significant association between occurrences (accident/incident) and Co-Pilot/First officer – total flight experience (hours) (p = .314).

Table 15 Descriptive Statistics between occurrences (accident/incident) and independent variables (continuous)

	No fatalities *n* = 97		Fatalities *n* = 17		Sample *n* = 114	
	Median	Q1-Q3	Median	Q1-Q3	Median	Q1-Q3
Aircraft age (year)	13	4-20	4.5	3-6	13	4-20
Air navigation service	86.4	63.2-86.7	59.2	56.3-62.1	86.4	59.6-86.7
Airport	88	57.5-97.3	71.6	70.8-72.4	88	57.5-97.3
State of registry	92.2	69.1-92.2	82.8	66.8-98.9	92.2	67.9-92.2
State of occurrence	89.5	65.9-92.2	69.2	66.8-71.7	87.9	66.3-92.2
State of operator	92.2	69.1-92.2	82.8	66.8-98.9	92.2	67.9-92.2
Captain/Pilot in command – age	48	43-56	43	38-48	48	42.5-55.5
Captain/Pilot in command – total flight experience (hours)	9800:00	6850:00-14495:21	7826:01	5965:00-9687:02	9487:02	6834:30-14347:50:30
Co-pilot / first officer - age	36	28-43	32	27-37	36	28-42.5
Co-pilot / first officer – total flight experience (hours)	2970:00	1588:00-6178:18	3539:00	1311:00-5767:00	2970:00	1508:50-6000:39

Table 16 Correlations between occurrences (accident/incident) and independent variables (continuous)

	Spearman's rho
	p
Aircraft Age (year)	.794
Air navigation service	.069
Airport	.206
State of registry	.073
State of occurrence	.045*
State of operator	.102
Captain/Pilot in command – age	.490
Captain/Pilot in command – total flight experience (hours)	.829
Co-Pilot / first officer - age	.546
Co-Pilot / first officer – total flight experience (hours)	.314

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Bonferroni post hoc tests (Table 17-22) were conducted on significant factors and showed that the proportion of accidents (occurrences with fatalities) in ATR; ATR 42/72; small-sized aircraft with an MTOW between 5,701–27,000 kg; and during initial climb, en route, and approach phases were greater than the proportion of incidents (occurrences with no fatalities) ($p < .05$). However, the proportion of incidents (occurrences with no fatalities) in medium-sized aircraft with an MTOW between 27,001 and 272,000 kg was larger than the proportion of accidents (occurrences with fatalities) ($p < .05$).

Table 17 Bonferroni post hoc test – Aircraft manufacturer

Comparisons of Column Proportions[b]			
		Occurrences	
		No fatalities (Incident)	Fatalities (Accident)
		(A)	(B)
Aircraft manufacturer	Airbus		
	Antonov		
	ATR		A
	Beechcraft		.[a]
	Boeing		
	Bombardier		
	British Aerospace		.[a]
	de Havilland Canada		.[a]
	Embraer		.[a]
	Fairchild / Swearingen		
	Fokker		.[a]
	HESA	.[a]	
	Let L	.[a]	
	Lockheed		.[a]
	McDonell Douglas		
	Saab		.[a]

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

Significance level for upper case letters (A, B, C): .05

a. This category is not used in comparisons because its column proportion is equal to zero or one.

b. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Table 18 Bonferroni post hoc test – Aircraft model (family)

Comparisons of Column Proportions[b]			
		Occurrences	
		No fatalities (Incident)	Fatalities (Accident)
		(A)	(B)
Aircraft model (family)	Airbus A300		.[a]
	Airbus A320 family		
	Airbus A330		.[a]
	Airbus A380		.[a]
	An-26 / 140	.[a]	
	An-74		.[a]
	ATR42 / 72		A
	Beechcraft 99 / 1900		.[a]
	Boeing 737 Classic		.[a]
	Boeing 737 Next Generation		
	Boeing 747		
	Boeing 757		.[a]
	Boeing 767		.[a]
	Boeing 777		
	CRJ-100 Series		
	CRJ-900		.[a]
	DC-9 / MD-80 Series		
	DHC-8 Dash 8		.[a]
	ERJ-145 Family		.[a]
	ERJ-170		.[a]
	ERJ-190		.[a]
	Fokker 100		.[a]
	Fokker 50		.[a]
	Jetstream 31 / 41		.[a]
	L-410	.[a]	
	Lockheed L-100 Hercules		.[a]

Comparisons of Column Proportions[b]		
	Occurrences	
	No fatalities (Incident)	Fatalities (Accident)
	(A)	(B)
SA226 / 227		
Saab 340 / 2000		.[a]

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

Significance level for upper case letters (A, B, C): .05

a. This category is not used in comparisons because its column proportion is equal to zero or one.

b. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Table 19 Bonferroni post hoc test – Aircraft size (MTOW)

Comparisons of Column Proportions[a]			
		Occurrences	
		No fatalities (Incident)	Fatalities (Accident)
		(A)	(B)
Aircraft size (MTOW)	5,701-27,000 kg		A
	27,001-272,000 kg	B	
	>272,000 kg		

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

Significance level for upper case letters (A, B, C): .05

a. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Table 20 Bonferroni post hoc test – Flight phase

Comparisons of Column Proportions[b]			
		Occurrences	
		No fatalities (Incident)	Fatalities (Accident)
		(A)	(B)
Flight phase	Standing		.[a]
	Pushback / Towing		.[a]
	Taxi		.[a]
	Take-off		.[a]
	Initial climb		A
	En Route		A
	Maneuvering	.[a]	.[a]
	Approach		A
	Landing		.[a]

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

Significance level for upper case letters (A, B, C): .05

a. This category is not used in comparisons because its column proportion is equal to zero or one.

b. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Table 21 Bonferroni post hoc test – Captain/Pilot in command – other aircraft type

Comparisons of Column Proportions[b]			
		Occurrences	
		No fatalities (Incident)	Fatalities (Accident)
		(A)	(B)
Captain / Pilot in command – other aircraft type	None		.[a]
	Able to operate other aircraft type		.[a]

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

Significance level for upper case letters (A, B, C): .05

a. This category is not used in comparisons because its column proportion is equal to zero or one.

b. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the

Bonferroni correction.

Table 22 Bonferroni post hoc test – Co – Pilot / First officer – other aircraft type

Comparisons of Column Proportions[b]			
		Occurrences	
		No fatalities (Incident)	Fatalities (Accident)
		(A)	(B)
Co – Pilot / First officer – other aircraft type	None		.[a]
	Able to operate other aircraft type		.[a]

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion.

Significance level for upper case letters (A, B, C): .05

a. This category is not used in comparisons because its column proportion is equal to zero or one.

b. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

4.2.2.3. *Number of fatalities*

Table 23-24 displays the descriptive statistics and correlations between number of fatalities and independent variables (time of day, aircraft manufacturer, aircraft model (family), aircraft size (MTOW), flight phase, Captain/Pilot in command – other aircraft type, Co-pilot/Pilot in command other aircraft type, and State of occurrence), for which 17 cases with fatalities are presented (*n* = 981). The descriptive statistics of time of day was exhibited in this section because it has *p* value close to .05 and previous study suggested that time of day is a contributing factor to accident.

Time

Time of day

The median (Quartile 1–Quartile 3) number of fatalities by time of day was 62 (32–89) for 00:00–05:09, 41.5 (3.5–156) for 06:00–11:59, 26.5 (4–50.5) for 12:00–17:59 and 24.5 (1–48) for 18:00–23:59. The minimum and maximum number of fatalities during each period were 2 and 116 for 00:00–05:59, 2 and 239 for 06:00–11:59, 2 and 54 for 12:00–17:59, and 1 and 48 for 18:00–23:59. There was no statistically significant association between number of fatalities and time of day (*p* = .338).

Aircraft

Aircraft manufacturer

The median (Quartile 1–Quartile 3) number of fatalities by aircraft manufacturer was 156 (150-162) for Airbus, 47 (43-48) for ATR, 62 (33-150.5) Boeing, and 4 (2-6) Let L. The minimum and maximum number of fatalities by aircraft manufacturer were 150 and 162 for Airbus, 1 and 54 for ATR, 4 and 239 for Boeing, and 2 and 6 for Let L. There was no statistically significant association between number of fatalities and aircraft manufacturer (*p* = .253).

Aircraft model (family)

The median (Quartile 1–Quartile 3) number of fatalities by aircraft model (family) was 156 (150-162) for Airbus 320 family, 21.5 (3-40) for Antonov An-26/140, 47 (43-48) ATR 42/72, and 4 (2-6) Let L-410. The minimum and maximum number of fatalities by aircraft model (family) were 150 and 162 for Airbus 320, 3 and 40 for Antonov An-26/140, 1 and 54 for ATR 42/72, and 2 and 6 for Let L-410. There was no statistically significant association between number of fatalities and aircraft model (family) (*p* = .160).

Aircraft size (MTOW)

The median (Quartile 1–Quartile 3) number of fatalities by aircraft size (MTOW) was 133 (89–156) for aircraft with a 27,001–272,000 kg MTOW, 121.5 (4–239) for aircraft with MTOW over 272,000 kg, and 6 (2–45) for aircraft with a 5,701 – 27,000 kg MTOW. The minimum and maximum number of fatalities by aircraft size (MTOW) were 62 and 162 for aircraft with a 27,001–272,000 kg MTOW, 4 and 239 for aircraft with MTOW over 272,000 kg, and 1 and 54 for aircraft with a 5,701–270,000 kg MTOW. There is significant evidence of an association between number of fatalities and aircraft size (MTOW) (*p* = .007).

Flight phase

The median (Quartile 1–Quartile 3) number of fatalities by flight phase was 85 (24.5-156) for en route, 40 (20.5-41.5) for initial climb, and 5 (3-48) approach. The minimum and maximum number of fatalities by flight phase were 2 and 239 for en route, 1 and 43 for initial climb, and 2 and 62 for approach. There was no statistically significant association between number of fatalities and flight phase (*p* = .891).

Effective implementation

State of occurrence

The median (Quartile 1–Quartile 3) of State of occurrence (*n* = 17) was 71.7 (62-90.5). The State of occurrence minimum and maximum (EI) were 46.1 and 95.1. There was no statistically significant association between number of fatalities and State of occurrence (*p* = .203).

Flight crew

Captain/Pilot in command – other aircraft type

The median (Quartile 1–Quartile 3) number of fatalities by Captain/Pilot in command – other aircraft type was 156 (78-200.5) able to operate other aircraft type. The minimum and maximum number of fatalities by Captain/Pilot in command – other aircraft type were 6 and 239 for able to operate other aircraft type. The correlation test cannot be computed.

Co-Pilot/First officer – other aircraft type

The median (Quartile 1–Quartile 3) number of fatalities by Co-Pilot/First officer other aircraft type was 54 (6-62) able to operate other aircraft type. The minimum and maximum number of fatalities by Co-Pilot/First officer – other aircraft type were 1 and 239 for able to operate other aircraft type. The correlation test cannot be computed.

Table 23 Descriptive Statistics between number of fatalities and independent variables

	Number of fatalities n = 981			
	Median	Q1-Q3	Min	Max
Time of day				
00:00-05:59	62	32-89	2	116
06:00-11:59	41.5	3.5-156	2	239
12:00-17:59	26.5	4-50.5	2	54
18:00-23:59	24.5	1-48	1	48
Aircraft manufacturer				
Airbus	156	150-162	150	162
ATR	47	43-48	1	54
Boeing	62	33-150.5	4	239
Let L	4	2-6	2	6
Aircraft model (family)				
Airbus A320 family	156	150-162	150	162
An-26 / 140	21.5	3-40	3	40
ATR42 / 72	47	43-48	1	54
L-410	4	2-6	2	6
Aircraft size (MTOW)				
5,701 – 27,000 kg	6	2-45	1	54
27,001 – 272,000 kg	133	89-156	62	162
More than 272,000 kg	121.5	4-239	4	239
Flight phase				
Initial climb	40	20.5-41.5	1	43
En Route	85	24.5-156	2	239
Approach	5	3-48	2	62

	Number of fatalities *n* = 981			
	Median	Q1-Q3	Min	Max
State of occurrence	71.7	62-90.5	46.1	95.1
Captain/Pilot in command – other aircraft type				
None	-	-	-	-
Able to operate other aircraft type	156	78-200.5	6	239
Co-pilot / first officer – other aircraft type				
None	-	-	-	-
Able to operate other aircraft type	54	6-62	1	239

Table 24 Correlations of significant independent variables derived from correlation tests of between occurrences and all 31 independent variables

	Spearman's rho
	p
Time of day	.338
Aircraft manufacturer	.253
Aircraft model (family)	.160
Aircraft size (MTOW)	.007*
Flight phase	.891
State of occurrence	.203
Captain/Pilot in command – other aircraft type	-
Co-pilot / first officer – other aircraft type	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.2.2.4. Aircraft Damage

Table 25-27 illustrates the descriptive statistics between aircraft damage and independent variables (time of day, aircraft manufacturer, aircraft model (family), aircraft size (MTOW), flight phases, Captain/Pilot in command – other aircraft type, Co-pilot/Pilot in command other aircraft type, and State of occurrence; *n* = 113). There is one missing datum. The descriptive statistics of time of day was exhibited in this section because it has *p* value close to .05 and previous study suggested that time of day is a contributing factor to accident.

Time

Time of day

The distribution of aircraft damaged beyond repair and destroyed by time of day was 10 (47.6%) during 06:00–11:59, 5 (23.8%) during 12:00–17:59, 3 (14.3%) during 00:00–05:59, and 3 (14.3%) during 18:00–23:59. There was no statistically significant association between aircraft damage and time of day (p = .367). However, 3 of 8 aircraft (37.5%) were damaged beyond repair and destroyed occurred during 00:00–05:59.

Aircraft

Aircraft manufacturer

The distribution of aircraft damaged beyond repair and destroyed by aircraft manufacturer was 6 (28.6%) ATR, 4 (19%) Boeing, 2 (9.5%) Airbus, 2 (9.5%) Antonov, 2 (9.5%) Let L, 1 (4.8%) Bombardier, 1 (4.8%) de Havilland Canada, 1 (4.8%) Fairchild/Swearingen, 1 (4.8%) HESA, and 1 (4.8%) McDonnell Douglas. There was no statistically significant association between aircraft damage and aircraft manufacturer (p = .172). However, 2 of 2 aircraft (100%), 1 of 1 aircraft (100%), and 2 of 2 aircraft (100%) were damaged beyond repair and destroyed occurred to Antonov, HESA, and Let-L aircraft.

Aircraft model (family)

The distribution of aircraft damaged beyond repair and destroyed by aircraft model (family) was 6 (28.6%) ATR 42/72, 2 (9.5%) Airbus A320 family, 2 (9.5%) Antonov An-26/140, 2 (9.5%) Boeing 777, 2 (9.5%) Let L L-410, 1 (4.8%) Antonov An-74, 1 (4.8%) Boeing 737 Next Generation, 1 (4.8%) Boeing 747, 1 (4.8%) Bombardier CRJ-100 Series, 1 (4.8%) McDonnell Douglas DC-9/MD-80 Series, 1 (4.8%) de Havilland Canada DHC-8 Dash 8, and 1 (4.8%) Fairchild/Swearingen SA226/227. There was no statistically significant association between aircraft damage and aircraft model (family) (p = .282). However, 2 of 2 aircraft (100%), 1 of 1 aircraft (100%), and 2 of 2 aircraft (100%) were damaged beyond repair and destroyed occurred to Antonov An-74, ATR 42/72, and Let L-410 model.

Aircraft size (MTOW)

The distribution of aircraft damaged beyond repair and destroyed by aircraft size (MTOW) was 13 (61.9%) for aircraft with a 5,701–27,000 kg MTOW, 5 (23.8%) for aircraft with a 27,001–272,000 kg MTOW, and 3 (14.3%) for aircraft with an MTOW over 272,000 kg. There was significant evidence of an association between aircraft damage and size of aircraft ($p < .001$). However, 3 of 7 aircraft (42.9%) were aircraft damaged beyond repair and destroyed to an aircraft with MTOW over 272,000 kg.

Flight phase

The distribution of aircraft damaged beyond repair and destroyed by flight phase was 8 (38.1%) en route, 6 (28.6%) approach, 3 (14.3%) initial climb, 2 (9.5%) landing, 1 (4.8%) pushback/towing, and 1 (4.8%) take-off. There was significant evidence of an association between aircraft damage and flight phase ($p < .001$). However, 6 of 8 aircraft (75%) were aircraft damaged beyond repair and destroyed during approach.

Flight crew

Captain/Pilot in command – other aircraft type

The distribution of aircraft damaged beyond repair and destroyed by Captain/Pilot in command – other aircraft type was 5 (83.3%) able to operate other aircraft type and 1 (16.7%) none. There was significant evidence of an association between aircraft damage and Captain/Pilot in command – other aircraft type ($p = .024$). However, 5 of 18 aircraft (27.8%) were aircraft damaged beyond repair and destroyed with Captain/Pilot in command able to operate other aircraft type.

Co-Pilot/First officer – other aircraft type

The distribution of aircraft damaged beyond repair and destroyed by Co-Pilot/First officer – other aircraft type was 5 (100%) able to operate other aircraft. There was significant evidence of an association between aircraft damage and Co-Pilot/First officer – other aircraft type ($p = .023$). However, 5 of 18 aircraft (27.8%) were aircraft damaged beyond repair and destroyed with Co-Pilot/First officer able to operate other aircraft type.

Effective Implementation

State of occurrence

The median (Quartile 1–Quartile 3) of State of occurrence on aircraft damaged beyond repair and destroyed was 71.7 (52.1-90.7). There was significant evidence of an association between aircraft damage and State of occurrence (p = .002).

Most aircraft damage beyond repaired and destroyed occurred during 06:00–11:59 (morning), with ATR aircraft, with ATR 42/72 model, on an aircraft with a 5,701–27,000 kg MTOW, during en route phase, with Captain/Pilot in command that able to operate other aircraft type, and Co-pilot/First officer that able to operate other aircraft. The results are the same to the primary dependent variable.

However, the higher likelihood for the aircraft damage beyond repaired and destroyed considering overall aircraft that damage are during 00:00–05:59 (early morning), with Antonov, HESA, and Let-L aircraft, with Antonov An-74, ATR 42/72, and Let L-410 model, on an aircraft with MTOW over 272,000 kg, during approach phase, with Captain/Pilot in command that able to operate other aircraft type, and with Co-Pilot/First officer that able to operate other aircraft type.

Table 25 Descriptive Statistics between aircraft damage and independent variables (categorical)

	Minor *n* =10		Substantial *n* = 82		Damaged beyond repair and destroyed *n* = 21		Sample *n* = 113	
	Count	%	Count	%	Count	%	Count	%
Time of day								
00:00-05:59	1	10	4	4.9	3	14.3	8	7.1
06:00-11:59	4	40	30	36.6	10	47.6	44	38.9
12:00-17:59	2	20	18	22.0	5	23.8	25	22.1
18:00-23:59	3	30	30	36.6	3	14.3	36	31.9
Aircraft manufacturer								
Airbus	2	20	10	12.2	2	9.5	14	12.4
Antonov	0	0	0	0	2	9.5	2	1.8
ATR	0	0	9	11	6	28.6	15	13.3
Beechcraft	0	0	2	2.4	0	0	2	1.8
Boeing	7	70	29	35.4	4	19.0	40	35.4
Bombardier	0	0	4	4.9	1	4.8	5	4.4
British Aerospace	0	0	2	2.4	0	0	2	1.8
de Havilland Canada	1	10	8	9.8	1	4.8	10	8.8
Embraer	0	0	5	6.1	0	0	5	4.4
Fairchild / Swearingen	0	0	2	2.4	1	4.8	3	2.7
Fokker	0	0	3	3.7	0	0	3	2.7

	Minor		Substantial		Damaged beyond repair and destroyed		Sample	
	n =10		*n* = 82		*n* = 21		*n* = 113	
	Count	%	Count	%	Count	%	Count	%
HESA	0	0	0	0	1	4.8	1	0.9
Let L	0	0	0	0	2	9.5	2	1.8
Lockheed	0	0	1	1.2	0	0	1	0.9
McDonnell Douglas	0	0	4	4.9	1	4.8	5	4.4
Saab	0	0	3	3.7	0	0	3	2.7
Aircraft model								
Airbus A300	0	0	1	1.2	0	0	1	0.9
Airbus A320 Family	2	20	6	7.3	2	9.5	10	8.8
Airbus A330	0	0	2	2.4	0	0	2	1.8
Airbus A380	0	0	1	1.2	0	0	1	0.9
An-26 / 140	0	0	0	0	2	9.5	2	1.8
An-74	0	0	0	0	1	4.8	1	0.9
ATR42 / 72	0	0	9	11.0	6	28.6	15	13.3
Beechcraft 99 / 1900	0	0	2	2.4	0	0	2	1.8
Boeing 737 Classic	1	10	7	8.5	0	0	8	7.1
Boeing 737 Next Generation	5	50	17	20.7	1	4.8	23	20.4
Boeing 747	0	0	1	1.2	1	4.8	2	1.8
Boeing 757	0	0	1	1.2	0	0	1	0.9
Boeing 767	0	0	2	2.4	0	0	2	1.8

	Minor *n* =10		Substantial *n* = 82		Damaged beyond repair and destroyed *n* = 21		Sample *n* = 113	
	Count	%	Count	%	Count	%	Count	%
Boeing 777	1	10	1	1.2	2	9.5	4	3.5
CRJ-100 Series	0	0	2	2.4	1	4.8	3	2.7
CRJ-900	0	0	2	2.4	0	0	2	1.8
DC-9 / MD-80 Series	0	0	4	4.9	1	4.8	5	4.4
DHC-8 Dash 8	1	10	8	9.8	1	4.8	10	8.8
ERJ-145 Family	0	0	3	3.7	0	0	3	2.7
ERJ-170	0	0	1	1.2	0	0	1	0.9
ERJ-190	0	0	1	1.2	0	0	1	0.9
Fokker 100	0	0	2	2.4	0	0	2	1.8
Fokker 50	0	0	1	1.2	0	0	1	0.9
Jetstream 31 / 41	0	0	2	2.4	0	0	2	1.8
L-410	0	0	0	0	2	9.5	2	1.8
Lockheed L-100 Hercules	0	0	1	1.2	0	0	1	0.9
SA226 / 227	0	0	2	2.4	1	4.8	3	2.7
Saab 340 / 2000	0	0	3	3.7	0	0	3	2.7
Aircraft size (MTOW)								
5,701 – 27,000 kg	0	0	26	31.7	13	61.9	39	34.5
27,001 – 272,000 kg	9	90	53	64.6	5	23.8	67	59.3
More than 272,000 kg	1	10	3	3.7	3	14.3	7	6.2

	Minor		Substantial		Damaged beyond repair and destroyed		Sample	
	n =10		*n* = 82		*n* = 21		*n* = 113	
	Count	%	Count	%	Count	%	Count	%
Flight phase								
Standing	0	0	10	12.2	0	0.0	10	8.8
Pushback / towing	0	0	3	3.7	1	4.8	4	3.5
Taxi	7	70	5	6.1	0	0.0	12	10.6
Take-off	2	20	8	9.8	1	4.8	11	9.7
Initial climb	0	0	2	2.4	3	14.3	5	4.4
En route	0	0	6	7.3	8	38.1	14	12.4
Maneuvering	-	-	-	-	-	-	-	-
Approach	0	0	2	2.4	6	28.6	8	7.1
Landing	1	10	46	56.1	2	9.5	49	43.4
Captain/Pilot in command – other aircraft type								
None	4	100	23	63.9	1	16.7	28	60.9
Yes	0	0	13	36.1	5	83.3	18	39.1
Co-pilot / first officer – other aircraft type rating								
None	2	100	16	55.2	0	0	18	50
Yes	0	0	13	44.8	5	100	18	50

Table 26 Descriptive Statistics between aircraft damage and independent variables (continuous)

	Minor *n* =10		Substantial *n* = 82		Damaged beyond repair and destroyed *n* = 21		Sample *n* = 113	
	Median	Q1-Q3	Median	Q1-Q3	Median	Q1-Q3	Median	Q1-Q3
State of occurrence	92.5	92.2-93.7	92.2	80.3-92.2	71.7	52.1-90.7	92.2	72.9-92.2

Table 27 Correlations between aircraft damage and independent variables

	Fisher's exact	Spearman's rho
	p	*p*
Time of day	.367	
Aircraft manufacturer	.172	
Aircraft model (family)	.282	
Aircraft size (MTOW)	<.001**	
Flight phase	<.001**	
State of occurrence		.002*
Captain/Pilot in command - other aircraft type	.024**	
Co-pilot / first officer - other aircraft type	.023**	

4.2.2.5. Binary Logistic Regression

Binary logistic regression was performed on 114 accident cases. The purpose of adopting this statistical approach was to examine the impact of factors contributing to accidents (occurrences with fatalities). The dependent variable was occurrences (accident/incident); and significant independent variables were aircraft manufacturer, aircraft model (family), aircraft size (MTOW), flight phase, State of occurrence, Captain/Pilot in command – other aircraft type and Co-pilot/First officer - other aircraft type. The time of day did not have a *p* value less than 0.05. However, they were included in the regression because the *p* value was close to 0.05. Moreover, several studies found that time of day contributed to fatigue and pilot errors.

The binary logistic regression was implemented to assess the impact on the likelihood of significant factors contributing to accidents (occurrence with fatalities) occurring. The primary outcome was achieved as the results show that the model was statistically significant when compared with the null model, $\chi^2(6) = 23.786$, $p = .001$. The time of day, aircraft size (MTOW), and State of occurrence explained 35.4% (Nagelkerke R^2) of variance in the accidents (occurrences with fatalities), and 88.2% of cases were predicted correctly (see Table 28).

Table 29 demonstrates that time of day 00:00–05:59 ($p = .006$), medium-sized aircraft with an MTOW of 27,000 – 272,000 kg ($p = .004$), and State of occurrence ($p = .031$) are significant independent variables that contributed to the model. However, flights operated during 06:00–11:59 and 12:00–17:59 and large-sized aircraft with an MTOW more than 272,000 kg were not significant and therefore do not have an impact on accidents (occurrences with fatalities).

The odds ratio (OR) indicates that accidents (occurrences with fatalities) are 48.769 times (95% CI 3.081–772.090) more likely to occur during 00:00–05:59 (time of day) than during 18:00–23:59. Additionally, the OR indicates accidents (occurrences with fatalities) are 0.102 (95% CI 0.022-0.475) less likely to occur when flying a medium-sized aircraft with an MTOW of 27,000–272,000 kg than when flying a small-sized aircraft with an MTOW of 5,701–28,000 kg. Finally, the OR of 0.964 (95% CI 0.932-0.997) explains that every increase in State of occurrence EI means the likelihood of accidents (occurrences with fatalities) occurring is 0.964 times lower.

Table 28 Binary Logistics Regression (1)

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	23.786	6	<.001
	Block	23.786	6	<.001
	Model	23.786	6	<.001

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	63.842[a]	.194	.354

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	11.664	7	.112

Classification Table[a]

			Predicted		
			Fatalities in an accident		Percentage Correct
Observed			No	Yes	
Step 1	Fatalities in an accident	No	93	2	97.9
		Yes	11	4	26.7
	Overall Percentage				88.2

a. The cut value is .500

Table 29 Binary Logistic Regression (2)

Variables in the Equation									
		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	18:00-23:59			8.236	3	.041			
	00:00-05:59	3.887	1.409	7.609	1	.006*	48.769	3.081	772.090
	06:00-11:59	2.279	1.174	3.769	1	.052	9.764	.978	97.447
	12:00-17:59	1.544	1.220	1.603	1	.205	4.685	.429	51.154
	5701-27000 kg			9.336	2	.009			
	27001-272000 kg	-2.281	.783	8.476	1	.004*	.102	.022	.475
	>272000 kg	.323	1.036	.097	1	.755	1.382	.181	10.530
	State of Occurrence	-.037	.017	4.662	1	.031*	.964	.932	.997
	Constant	.207	1.652	.016	1	.900	1.229		

a. Variable(s) entered on step 1: Time, Aircraft Size by MTOW, State of Occurrence

4.2.2.6. Censored (Tobit) Regression

The impact of time of day, aircraft size (MTOW) and State of occurrence on the number of fatalities was explored using censored regression. The minimum left-censored of 0 was assigned and the upper limit was infinity.

The outcome (see Table 30), achieved by adopting censored regression, suggested that time of day 00:00–05:59 (p = .018) and State of occurrence (p = .047) have a significant impact on number of fatalities. All sizes of aircraft by MTOW were not significant independent variables in the model. The predicted value of number of fatalities was 199.60 times higher during 00:00–05:59 (time of day) than during 18:00–23:59. A 1% decrease in State of occurrence was associated with increase of about 3 fatalities in the predicted value of number of fatalities.

Table 30 Censored Regression

		Number of obs	= 110
		Uncensored	= 15
Limits: Lower	= 0	Left-censored	= 95
Upper	= inf	Right-censored	= 0
		LR chi2(6)	= 20.46
		Prob > chi2	= 0.0023
Log likelihood	= -110.86037	Pseudo R2	= 0.0845

Number of fatalities	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
Time						
00:00-05:59	199.600	83.306	2.400	.018*	34.400	364.799
06:00-11:59	126.534	65.607	1.930	.056	-3.566	256.634
12:00-17:59	65.807	67.195	0.980	.33	-67.443	199.056
Aircraft Size						
MTOW 27,001-272,000 kg	-94.119	47.996	-1.960	.053	-189.297	1.060
MTOW >272,000 kg	58.759	64.159	0.920	.362	-68.471	185.988
State of Occurrence	-2.138	1.064	-2.010	.047*	-4.248	-0.028
Constant	-10.301	97.750	-0.110	.916	-204.142	183.541
var(e.Fatal)	12556.440	5318.738			5420.810	29084.970

4.2.2.7. Ordered Logistic Regression

Finally, ordered logistic regression was carried out to investigate the effect of time of day, aircraft size (MTOW) and State of occurrence on aircraft damage. The outcome (see Table 31) obtained using ordered logistic regression, indicates that aircraft size (MTOW) (p = .001) and State of occurrence (p < .001) have a significant impact on aircraft damage. No time categories were statistically significant; hence time category cannot explain the level of aircraft damage.

The odds of higher severity of aircraft damage for aircraft with an MTOW of 27,001–272,000 kg (medium-sized) was 0.138 lower than for aircraft with an MTOW of 5,701 – 27,000 kg (small-sized). Likewise, the OR of 0.946, suggested that, for a 1% increase in State of occurrence, the severity of aircraft damage is expected to be 0.946 times lower.

Table 31 Ordered Logistic Regression

		Number of obs	= 109
		LR chi2(6)	= 31.29
		Prob > chi2	= 0.000
Log likelihood =	-64.706843	Pseudo R2	= 0.1947

Aircraft Damage	Odds ratio	Std. err.	z	P>z	[95% conf. interval]	
Time						
00:00-05:59	5.654	5.398	1.810	.070	0.871	36.723
06:00-11:59	2.003	1.147	1.210	.225	0.652	6.152
12:00-17:59	1.275	0.824	0.380	.707	0.359	4.524
Aircraft Size						
MTOW 27,001-272,000 kg	0.138	0.083	-3.280	.001*	0.043	0.451
MTOW >272,000 kg	2.116	2.250	0.710	.481	0.263	16.999
State of Occurrence	0.946	0.015	-3.550	.000*	0.918	0.976

* Significance level = 0.05

** Significance level = 0.01

4.3. Research Question 2: How can safety be improved to prevent reoccurrence and provide early protection that would lead to similar accidents?

4.3.1. Expert Interview

Q.3 Please provide the countermeasures for mitigating and preventing accidents based on the significant contributing factors.

The experts selected the following occurrences in which they would like to provide the countermeasures: CFIT, MAC, CTOL, LOC-I, RE, and RI. The majority of experts selected the occurrence from the top-five most selected events if occurred would lead to the highest fatality and severity. However, a certain expert selected runway safety related events which are runway excursion and incursion reflecting the ICAO's High-Risk Accident Occurrence Categories.

Regarding contributing factors, most experts chose State of occurrence as the controllable factor to improve for the purpose of mitigation and prevention of future accidents, however, some chose aircraft size. The reasons that aircraft size was chosen was because the expert wanted to highlight the safety issue for small aircraft. The purpose was not to ban or reduce the operation of small-sized aircraft. However, it is to find the stricter countermeasures in uplifting the safety level for this type of operation.
The countermeasures that were proposed to mitigate and prevent the future accidents are classified into 7 dimensions.

a) State Legislation, Regulations, Guidance, and Plan
b) Safety Management, Oversight, and Audit
c) State certification, authorization, and approval
d) Infrastructure and Equipment
e) Protocols and Procedures
f) Operation and Services
g) Qualification, Competency, Trainings of Personnel

Figure 12 7 Dimensions of mitigative/preventive countermeasures

State Legislation, Regulations, Guidance, and Plan

Prior to any accident, it is advised that the regulator shall ensure the provision of legislation, specific operating regulations, technical guidance, and plan are available and accessible. It shall describe the service standards of all operators and could be issued in the form of acts, ministerial regulations, or civil aviation authority regulations. Importantly, the document should be compliant in accordance with international standards; moreover, should be periodically updated. Therefore, it could be promptly applied to a certain situation when required, for example, safety management system, State safety programme, State search and rescue plan, national disaster prevention plan, and airport emergency plan.

Additionally, recommendations on assuring the availability of certain regulations were proposed.

a) Specific regulation for aeronautical information such as standard air navigation service (ANS) chart, and correct publication of terrain data.

b) Specific licensing and certification regulations for flights operating at night and/or in IMC requiring certain instruments and equipment on the aircraft to avoid CFIT.

c) Regulation on certification requirement for aircraft equipment to avoid MAC. State should require the installation of an Airborne Collision Avoidance System (ACAS), Traffic Alert and Collision Avoidance System (TCAS), or anti-collision light.

d) Regulation on airspace, ATS routes, and flight procedure design to keep aircraft away from each other to avoid MAC.

e) Regulation on certification for airspace and instrument flight procedure design to avoid MAC.

f) Regulation for air navigation service provider relating to minimum safe altitude and safety net alerts to avoid CFIT,

g) Regulation on design and quality management of instrument flight procedures and charts, IFR, and VFR procedures to avoid CFIT.

h) Regulation on licensing and training for pilot and air traffic controller to avoid MAC should concentrate on response to loss separation and maneuvering to avoid collision including visual detection and ACAS alerts, and air traffic control system alerts. It is essential to have regulations for maintaining licensing and training standards.

i) Regulation on licensing and training particularly for pilots to avoid MAC should be related to compliance with air traffic controller clearances; maintaining a lookout conforming to aerodrome circuit traffic pattern, conforming to a standard table of cruising level, and response to ACAS alert.

j) Regulation on licensing and training particularly for air traffic controllers to avoid MAC should be related to conflict detection and resolution, and clearances.

k) Regulation on personnel recurrent and refresher training regulation for flight crew and air traffic controllers. Air traffic controllers should be mandated to receive training relating to aerodrome control, approach control, clearances, and radar vectoring, and minimum safe altitude.

l) Regulation on standard and sufficient marking, light, and obstacles during low visibility to avoid CFIT.

Lastly, an expert suggested that regulation of penalty action should be considered for the intended action resulting in a mishap.

Safety Management, Oversight, and Audit

It is suggested that safety management, oversight, and audit should be strengthened at the regulator and operator levels, in particular, the synchronization between the two levels. The inspector/auditor should have the ability to identify, manage hazards, resolve safety issues, and provide procedures. The system should support constant monitoring and periodic follow-up on the issue reported. The organization should encourage and regularly promote a safety management system, safety culture, safety reporting, safety sharing practice, investigation, and audit. The promotion of safety issues and positive safety culture could emphasize that safety is a public concern; subsequently, it could lead to systematic safety sharing practices and an efficient reporting system such as database sharing of root causes between regulator and operator to prevent reoccurrence.

At the regulator level, some States may lack of resources and adequate safety oversight. They should ensure to assign a dedicated unit to carry out audits, inspections, and oversight of the operators to ensure regulatory compliance and standard practices. Oversight of training and licensing organization is recommended, especially recurrent training for recovering in the high-risk situation, such as from loss of separation. Furthermore, the unit should construct a plan to actively monitor operators and execute periodic safety oversight in accordance with the schedule including surprise checks, spot checks, and ramp checks. Importantly, their proficiency in operator's service and responsibility is compulsory to conduct stricter oversight and supervision. Then, qualified inspectors should be able to provide accurate recommendations and gain the trust of the operators.

Likewise, the operator should ensure the availability of a designated unit, such as a quality assurance department, to provide the internal audit function within the organization, and the implementation of the operator safety management system. The department should conduct safety oversight and an audit routinely, particularly in the area concerning aircraft condition, schedule for maintenance, and schedule for parts replacement to align with the master maintenance planning document. In terms of personnel, the audit should be extended to cover the personnel qualification ensuring the personnel meet the standards, and personnel performance-based audit ensuring no practical drift occurs during operation.

Lastly, State regulators shall seek cooperation and urge operators to weigh and give high priority in the following safety policy rather than concerning financial aspects.

State certification, authorization, and approval

The experts highlight the importance of certification, licensing, authorization, and approval obligations. State must ensure that operators, including air operators, air navigation service providers, and aerodrome operators, are certified, authorized, and licensed for their services, operations, and personnel. The certification of public and private airports is essential for aerodrome operators. Air operators should be certified and licensed for the aircraft airworthiness, and moreover, the authorization to fly performance-based navigation which would reduce the risk of CFIT. The personnel, especially air traffic controllers, pilots, and airport vehicle drivers, must go through an appropriate certification and licensing process so that the operators are proficient to provide safe service.

During the certification process, there are other elements to consider such as understanding the application of the procedures, composure, communication skills, and decision making (included in the ICAO CBT). These elements are necessary during training and certification. Therefore, it should be incorporated into the required training of the personnel. All of these elements aim for all operators and personnel to meet the minimum requirement.

Infrastructure and equipment

Air operators, air navigation service providers, aerodrome operators, and aviation-related service providers such as meteorology, are advocated to provide standard and sufficient infrastructure and equipment to accommodate the operation. Furthermore, it should also concern with the regular system maintenance of the infrastructure and equipment to ensure that they are functional.

Air operators are obliged to install special equipment on the aircraft to reduce the risk of CFIT and LOC-I, such as a Ground proximity warning system (GPWS) which gives a warning/alert to the flight crew with respect to the aircraft's proximity to the terrain, flight envelope protection, and in-flight upset warning. These installations should be feedback to the aircraft manufacturer/design.

Air navigation service providers should provide and maintain adequate air traffic management (ATM) and communication, navigation, and surveillance (CNS) systems, infrastructure, and equipment. It is suggested that air navigation service providers should install an air traffic control radar system (minimum safe altitude warning) in all airports for monitoring the aircraft, in the circumstance when flying near terrain, the air traffic control radar can warn the pilot. In terms of improving the system, they should improve radar monitoring by leveraging new radar technology in increasing radar coverage to enhance air traffic controller awareness.

Aerodrome operators should focus on providing functional physical infrastructures such as runway, visual aids, and surface radar. At the beginning of operating an aerodrome, the traffic was still low, and later large aircraft started to operate, the aerodrome is required to have a longer runway to accommodate large aircraft. Moreover, it is advised that the aerodrome should construct or extend a longer runway to increase the margin of safety in the case of abort take-off or landing, in regard to the concern over CTOL. Visual aids are the vital element that is expected to provide high performance in an operation. The aerodrome operator needs to make sure sufficient and clear lighting, marking, and signage, especially during low visibility; also it should be well-maintained and standard. Notably, in a large aerodrome or aerodrome where the air traffic control tower is not sufficiently high to see the aircraft, the aerodrome operator should adopt surface radar. The radar will detect the location of the aircraft on the ground which helps to increase overall awareness between the pilot and air traffic controller. In addition, the aerodrome operator should implement the new global reporting format for runway surface conditions and efficiently utilize the system, not limited to during rain.

Finally, the organization that provides aviation-related services such as meteorology, they obliged to ensure an effective weather forecasting system in the controlled airspace to reduce the risk of LOC-I.

Protocols and Procedures

Protocols and procedures are critical components to smoothly operating in a safe environment. They should not be limited to a single service provider; however, cooperation between entities could create a safety climate. State, if not already have, should establish a standardized operational procedure with international standard compliance, for aviation personnel to understand, follow, and universally employ the same procedures. All operators, if not already have, develop the standard of procedures, complying with the regulator, to ensure that operational safety issues are resolved and reported to the regulator. Furthermore, operators are urged to perform operational risk assessment procedures to control operational risk. Apart from the standard of procedures, operators are encouraged to continually update the manual of operations (MOOs) such as air navigation service providers, air operators, and aerodromes. In case, there are discrepancies between the State and operator's standard of procedures, they should be highlighted and resolved to be aligned.

Air operators should reinforce the high level of safety. Standard of procedures is the main factor for preventing incident/accident. Therefore, the standard of procedures and manual for specific duty should be accessible and strictly followed by the personnel, such as for flight crew to abort landing during low visibility, licensed aircraft engineer or licensed aircraft mechanic to inspect and guarantee that the aircraft is fit-to-fly before releasing.

Similarly, air navigation service providers should ensure the availability and reinforcement of procedures for air traffic controllers in communicating/informing the pilot. It could help in reducing accident/incident occurring such as CFIT. It is essential that the protocol should be clear to the personnel, in case of an abnormal or irregular situation, it could help the situation to recover. In terms of interactive operation, flight crew and air traffic controllers should be using standard phraseology when communicating. This would help to lower the risk of accidents, in particular MAC and CTOL. Additionally, when performing air navigation service tasks, it is beneficial for air traffic controllers to share a common protocol with the neighboring countries.

Likewise, aerodrome operators should establish procedures approved by the regulator. They should be practical and able to accommodate on irregular circumstances, such as an airport emergency plan or special engine failure procedure during take-off. This would reduce the risk of CTOL.

Operation and services

Apart from strictly pursuing standard practices, operators should ensure communication efficiency, collaboration between related entities, and execution of plans, services, and exercises. Operators should share information and advisory that improve better collaboration between neighboring countries in terms of communication between air traffic controllers and pilots. It is advised that there should be consistent communication between the air traffic controller, flight crew, and vehicle driver to avoid RI. For example, they should tune into the same radio channel used for communication with the airport vehicle driver. Also, hotspots should be clearly addressed in Aeronautical Information Publication. Therefore, even the pilot who has not flown to this airport can acknowledge and carefully operate. In regard to the national disaster prevention plan, the operator shall ensure that emergency, rescue, and evacuation services and exercises should be promptly prepared and carried out for a high-risk situation. This situation also involves the rescue and firefighting service of the aerodrome operator. Aerodrome operators should also focus on implementing bird control management to reduce the risk of CTOL. It is proposed that the Runway Safety Team

meeting, if not already exist, should be established and regularly arranged at the national and operational level to resolve and seek mitigation measures for all airports.
In addition, the aeronautical meteorological office should provide accurate and on-time information for pilot situational awareness and assessment. Also, it is suggested that innovation or technology should be introduced to the operators to ensure real-time information is reported to the pilot.

Qualification, Competency, Training of personnel

Qualified and competent personnel is the key driving force to organizations. Prior to assigning duty or during recruitment, regulators and operators should ensure that the selected personnel is qualified and specialized to perform specific tasks and duties, such as State inspector is qualified to perform audit and safety oversight for air navigation service. Regarding human resource development, the regulator and operators should ensure all personnel received the required training. Moreover, the organizations should maintain and keep current the skills of the personnel through adequate and standard training and simulation to prevent skill fade. It is recommended to reinforce the recurrent, examination, annual refresher, and a performance check for air traffic controllers, pilots, engineers, airport vehicle drivers, and search and rescue including firefighting and medical service personnel. All required training should be taken place in accordance with the established syllabus. Importantly, the trainer should ensure that personnel understand the application of the procedures, composure, communication skills, and decision-making (included in the ICAO CBT) during training to reach the minimum requirement.

Air operators should focus on providing training to flight crew and maintenance engineers. The operator should ensure the availability of the airline's training assessment. Generally, the flight crew should receive appropriate training to fly certain aircraft and routes. Also, they should ensure that the flight crew performed all required training including initial, recurrent, pilot proficiency check training, crew resource management (CRM), flight management system (FMS), and upset recovery and situational awareness to be attentive in following procedures for LOC-I. In some cases, the operators should add a special requirement in flight crew training such as pilot on self-study booklet and video, simulator training, supervision flight for a pilot flying into countries with high terrain such as Nepal, Bhutan. The training could help reduce the likelihood of human error and high-risk accidents.

Similarly, the air navigation service provider should ensure that their air traffic controllers are generally trained to use the radar system. Moreover, personnel should be monitored on their air traffic controller recurrent and training.

Furthermore, collaborative knowledge sharing and training between organizations are advocated, such as knowledge sharing and training between aerodrome personnel, air traffic controllers, pilots, search and rescue units, firefighting, and medical service, or neighboring countries to promptly prepare for the accident/incident that occurs outside the airport.

CHAPTER V DISCUSSIONS, RECOMMENDATIONS, LIMITATIONS, FURTHER STUDY, AND CONCLUSIONS

5.1 Discussions

Occurrence types

The experts' interview perceived a similar view on the occurrence with high fatality risk if it occurred. The five highest-rated occurrences if happen would trigger fatalities by most experts are CFIT, MAC, LOC-I, F-POST, and ICE. Also, an additional question for experts to select the occurrence type with the highest severity and fatality, also confirmed that CFIT, MAC, LOC-I, F-POST, and CTOL were occurrence types; if they occur would lead to the highest fatality and severity. The experts' opinion is consistent with the ICAO and IATA safety concerns. ICAO's high-risk categories of occurrences are CFIT, LOC-I, MAC, RE, and RI (ICAO, 2019), whereas IATA top's safety priority risks are RE, CFIT, LOC-I, and MAC (IATA, 2022). RE and RI did not receive the highest score from the experts. However, they were still selected mainly by 70% of experts as occurrences that would lead to fatalities. The selected occurrence types were adopted by experts as scenarios to identify significant factors which the study was able to successfully derive with 8 contributing factors (flight phase, air navigation service, pilot – total flight experience (hour), meteorological condition at the accident site, airport, time of day, meteorological - condition of light, and airline) and 7 controllable factors (airline, pilot – total flight experience (hour), air navigation service, flight phase, time of day, and meteorological condition of light).

In addition, the expert made a suggestion that crew resource management should be recognized as an occurrence type that would lead to accidents (occurrence with fatalities). The coordination and communication within the cockpit are also serious matters to be taken into consideration as they could cause stress and carelessness to the flight crew. Therefore, it should be discussed for a recommendation for regulators to establish as an official occurrence category.

Contributing factors

The comparison between the findings from the expert interview and accident reports suggested that contributing factors can be described into three groups: similar contributing factor identified from both approaches, different contributing factors identified from both approaches, and contributing factors that impact the accidents (occurrences with fatalities).

Similar contributing factor identified from qualitative and quantitative approaches

Flight phase received the highest response from the experts as the factor that would trigger an accident (occurrence with fatalities). Likewise, it had a significant association with the occurrences (accident/incident). However, flight phase was excluded from the regression model because it does not have an impact on accidents (occurrence with fatalities). Also, time of day was a factor most selected by nearly half of the experts. Though, there was no statistically association between time of day and occurrences, time of day was studied in other literature and a p value close to .05. Therefore, it was able be included during the model generating process.

Different contributing factors identified from qualitative and quantitative approaches

Furthermore, different factors identified from the expert interview were State's effective implementation of the safety oversight system in the area of air navigation service area, pilot total flight experience (hour), meteorological condition at the accident site, State's effective implementation of the safety oversight system in the area of aerodrome and ground aids (airport), time of day, meteorological condition of light, and airline business type. However, these contributing factors had no association with the occurrences (accident/incident). Therefore, they were not further explored in the regression models. On the other hand, the contributing factors, including aircraft manufacturer, aircraft model, aircraft size, State of occurrence's effective implementation of the safety oversight system, Captain/Pilot in command ability to operate other aircraft type, and Co-pilot/First officer ability to operate other aircraft type, were derived from the accident reports. Even though, these factors were statistically associated with the occurrences (accident/incident), only aircraft size and State of occurrence's effective implementation of the safety oversight system had an impact on accidents (occurrence with fatalities). It should be noted that the derived factors that were not examined should be further explore in future study.

Contributing factors that impact the accidents (occurrences with fatalities)

Lastly, time of day, aircraft size, and State of occurrence's effective implementation of the safety oversight system were contributing factors that impact the accidents (occurrences with fatalities). The past accidents revealed that flights operating between 06:00 and 11:59 had the most occurrences (accident/incident). The proportion of accidents (occurrences with fatalities) was highest for flights operating between 00:00 – 05:59 (early morning). The odds of accidents occurring during 00:00-05:59 are greater than during 18:00-23:59 by approximately 49 times. Likewise, the number of fatalities during 00:00-05:59 is greater than during 18:00-23:59 by approximately 200 times. The results supported the previous literature indicating that pilots were exposed to a higher risk of attention issues and fatigue during early morning 00:00–05:59. Therefore, the flights operating in early morning (00:00–05:59) are at high risk for accidents.

Small-sized aircraft with an MTOW of 5,701–27,000 kg have the highest contribution to accidents (occurrences with fatalities) and aircraft being damaged beyond repair and destroyed, as well as a higher proportion of accidents (occurrences with fatalities) than the proportion of incident (occurrences without fatalities). Despite contributing to a large proportion of overall occurrences, it was found that medium-sized aircraft with an MTOW of 27,000–272,000 kg represent the highest proportion of incident (occurrences without fatalities). This is consistent with the previous literature, which reported that a medium-sized aircraft of MTOW 27,001–272,000 kg had the most frequent accidents, whereas a small-sized aircraft of MTOW 5,701–27,000 kg had highest fatality rate (Ekman & Debacker, 2018). Furthermore, it was discovered that flying in a medium-sized aircraft represents a lower risk of being in accidents (occurrences with fatalities) and experiencing higher severity of aircraft damage than flying in a small-sized aircraft, respectively. Also, previous studies suggested that larger aircraft have a lower percentage of fatal injuries and a higher possibility of survival (Ekman & Debacker, 2018; RGW Cherry & Associates Limited, 2016). The results indicate that large-sized aircraft with an MTOW over 272,000 kg have the most fatal accidents among overall accidents (2 of 7; 28.6%) and the second highest median (121.5) in the number of fatalities; notably, this is significantly associated with several fatalities. However, the censored regression illustrated that the number of fatalities is not affected by the aircraft size. This could be due to the low number of fatalities in large-sized aircraft, as one of two accidents involved only four passenger fatalities.

State of occurrence's effective implementation of the safety oversight system had an impact to accidents (occurrences with fatalities), number of fatalities, and aircraft damage. The median of State of occurrence's effective implementation was lower in the accidents (occurrences with fatalities) (69.2) than in the incident (occurrences without fatalities) (89.5). Likewise, median of State of occurrence's effective implementation was lowest for aircraft being damaged beyond repaired and destroyed. Moreover, the likelihood of accidents (occurrences with fatalities) and a higher severity of aircraft damage to occur is decreasing when the State of occurrence's effective implementation increases. Correspondingly, a 1% decrease in the State of occurrence effective implementation will increase the number of fatalities by approximately 3. Therefore, a higher State's effective implementation, also meaning improving State safety oversight system, would signify a reduction in the likelihood of accidents (occurrences with fatalities), number of fatalities, and more significant severity of aircraft damage.

Mitigative/Preventive Countermeasures

The mitigative/preventive countermeasures were suggested considering the improvement of State of occurrence's effective implementation of the safety oversight system. The measures were discovered and categorized into 7 dimensions: State legislation, regulations, guidance, plan; safety management, oversight, and audit; State certification, authorization, and approval; infrastructure and equipment; protocols and procedures; operation and services; and qualification, competency, trainings of personnel. The identified dimensions similarly reflect the eight critical elements (CE) of an ICAO Universal Safety Oversight Audit Programme that ICAO conduct the audit to assess State's capability in providing safety oversight (ICAO, 2020). There are two dimensions that associated with the CE in the State regulator level.

The countermeasures in the State legislation, regulations, guidance, and plan are linked, to the CE-2 Specific operating regulations. The measures emphasized on the availability, accessibility, compliance, and up-to-date of the legislation and specific operating regulations. Likewise, CE-2 urged the State to "promulgate regulations to address, at a minimum, national, requirements emanating from the primary aviation legislation, for standardized operational procedures, products, services, equipment and infrastructures in conformity with the Annexes to the Convention on International Civil Aviation" and the "Specific operating regulations should be comprehensive, clear, consistent and up to date" (ICAO, 2017; Khoury, 2019). In terms of Safety management, oversight, and audit, the measure suggested on the qualification and ability of the inspector to be able to provide recommendations. Also, CE-4 Qualified Technical Personnel stated that "a civil aviation inspector should be fully qualified, with specific regulatory skills, and demonstrate a minimum appropriate level of technical knowledge".

The seven dimensions were not newly introduced to the industry. However, it indicates the lack of implementation from the State regulator and operator. Therefore, it should be noted that the countermeasures provided by the experts should be consider reinforcing through the safety oversight and audit system.

5.2 Recommendations

As described in the discussions, significant findings of contributing factors and countermeasures were emphasized. In order to take a safety enhancement initiative in eliminating the risks of future accidents, the recommendations are provided as follows:

Operational level

Time of day, aircraft size, and State safety oversight system were identified as a key risk in the air transportation. State regulators and operators should regularly update the risk profile considering for the operation during 00:00-05:59 (early morning), flight operating a small-sized aircraft with an MTOW of 5701 – 27,000 kg, and flying in the route (to/from/over) the State with low effective implementation of the safety oversight system. Moreover, the monitoring of the specific flight/operation will facilitate the State regulator and operator to promptly identify and actively manage high risk operation.

National level

The effective implementation of the State safety oversight system can be improved through a safety oversight and audit systems. Therefore, it is recommended that the government body of the State that should take an initiative and submit an official request to ICAO to conduct an audit, despite the audit cycle. The proactive movement will allow the State to expedite the process in re-investigating their aviation safety system, resolving the issues in each audit area, and ultimately improve the effective implementation of the State.

International level:

Crew resource management was raised by the expert as an additional occurrence type to be incorporated into the accident/incident reporting taxonomy. The crew resource management is directly related to human factor which is the common cause to most fatal accident. It is proposed that aviation safety organization should consider human factor related occurrence type, including crew resource management to be established as an occurrence category for reporting accident/incident.

In this research study, the access to the final investigation reports is the drawback in this research study. The researchers collected information from various sources from both private and public sector, which consumed certain amount of time. Some reports were issued in local language and some reports could not be found. Some information in the report were not given such as personnel information or medical information. It is recommended that there should be a centralized organization which provide an aircraft accident database service that could be accessible by the public and is user friendly. The State regulator shall reveal the full information to the public. The purpose of the disclosure was for transparency and could be further examined by academician.

5.3 Limitations

The sample included in this study was reduced by more than half due to the unavailability of finalized investigation reports. Moreover, there are different formats of investigation reports between investigating agencies/committees in which some information was not provided, such as personnel, medical examination, and aircraft information. Hence, a large amount of missing data is excluded from the analysis.

Due to the pandemic, it is challenging to conduct an online interview. The disruption from internet connection and sound affects the amount time taken to complete a session.

5.4 Further Study

A set of contributing factors were considerably identified through specialized practitioners and academician, and historical accidents. Nonetheless, they were not able to further examine in this research study. Therefore, it is proposed for academician to consider investigating the following contributing factors: aircraft manufacturer, aircraft model, airline business type, pilot total flight experience, ability to operate other aircraft type by Captain/Pilot in command and Co-pilot/First officer. meteorological condition at the accident site, meteorological condition of light, State's effective implementation of safety oversight system in the area of air navigation service area, and aerodrome and ground aids.

Correspondingly, additional factors that could be contributing to accidents were suggested during the expert interview. Therefore, it is recommended that the following factors be analyzed in future research: pilot and air traffic controller physical and psychological condition; pilot and air traffic controller competency and practical drift; flight time/duty time; crew resource management; aircraft design and maintenance; air traffic services; airport – design, signages, and runway condition; ground operation; environment and extreme weather; nation culture; transparency of accident investigation authority; and carry on items and cargo.

5.5 Conclusions

The primary objective of this research study was to re-analyze the worldwide aircraft accidents from 2014 to 2017, using multiple statistical techniques by (1) identifying the contributing factors that trigger accidents (occurrences with fatalities) and (2) providing the countermeasures accounting all high-risk accidents and significant contributing factors, for the mitigation/prevention of the future occurrences.

The current study achieved the research objectives and discovered critical contributing factors in the aircraft accident that trigger fatalities using expert interviews, and binary, censored, and ordered logistic regression for data analysis. Moreover, mitigative and preventive measures were recommended by aviation practitioners and academician who had more than 10 years of domestic/international experience in aviation safety and aircraft accident.

In this research, the contributing factors that trigger accidents (occurrences with fatalities) were identified: time of day, aircraft size, and State of occurrence's effective implementation of the safety oversight system. The most critical contributing factors that has a significant impact on the accidents (occurrences with fatalities), number of fatalities, and level of aircraft damage is State of occurrence's effective implementation of the safety oversight system. Notably, it was revealed that flying in the early morning between 00:00-06:59; flying on a small-sized aircraft with a MTOW of 5,701-27,000 kg; and flying in the route to/from/above the State that has lower effective implementation of the safety oversight system increased the likelihood of the accident (occurrence with fatality) to occur. Furthermore, almost all experts suggested that improving State of occurrence safety oversight system could prevent the aviation mishaps. Therefore, the countermeasures for mitigating and preventing future accidents were proposed, which can be classified into 7 dimensions: State legislation, regulations, guidance, plan; safety management, oversight, and audit; State certification, authorization, and approval; infrastructure and equipment; protocols and procedures; operation and services; and qualification, competency, trainings of personnel.

REFERENCES

APPENDICES

Appendix A

Definitions and Terminology

Definitions

Terminology	Definition
Accident	an occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which: a) a person is fatally or seriously injured as a result of: — being in the aircraft, or — direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or — direct exposure to jet blast, *except* when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or b) the aircraft sustains damage or structural failure which: — adversely affects the structural strength, performance or flight characteristics of the aircraft, and — would normally require major repair or replacement of the affected component, *except* for engine failure or damage, when the damage is limited to a single engine (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture

Terminology	Definition
	holes), or for minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or c) the aircraft is missing or is completely inaccessible. *Note 1.— For statistical uniformity only, an injury resulting in death within thirty days of the date of the accident is classified, by ICAO, as a fatal injury.* *Note 2.— An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.* *Note 3.— The type of unmanned aircraft system to be investigated is addressed in 5.1.* *Note 4.— Guidance for the determination of aircraft damage can be found in Attachment E.*
Causes	Actions, omissions, events, conditions, or a combination thereof, which led to the accident or incident. The identification of causes does not imply the assignment of fault or the determination of administrative, civil or criminal liability.
Contributing factors	actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.
Effective Implementation (EI)	.A measure of the State’s safety oversight capability, calculated for each critical element, each audit area or as an overall measure. The EI is expressed as a percentage (ICAO, 2019).
Instrument	Meteorological conditions expressed in terms of visibility,

Terminology	Definition
metrological condition (IMC)	distance from cloud, and ceiling, less than the minima specified for visual meteorological conditions.
Incident	An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.
Occurrences	Accidents, serious incidents and incidents.
Serious incident	An incident involving circumstances indicating that there was a high probability of an accident and associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down.
State of design	The State having jurisdiction over the organization responsible for the type design.
State of occurrence	The State in the territory of which an accident or incident occurs
State of operator	The State in which the operator’s principal place of business is located or, if there is no such place of business, the operator’s permanent residence
State of registry	The State on whose register the aircraft is entered.
Visual Meteorological Condition (VMC)	Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, equal to or better than specified minima.

Appendix B

Sources of Data

Accident Investigation Agencies, Civil Aviation Authorities, and Government related agencies
Accident and Incident Investigations Division, South African Civil Aviation Authority (Accident and Incident Investigations Division - South African Civil Aviation Authority, 2017);
Accident Investigation Board Denmark (Havarikommissionen for Civil Luftfart og Jernbane) (Accident Investigation Board Denmark (Havarikommissionen for Civil Luftfart og Jernbane), n.d.-a, n.d.-b);
Agenzia Nationale per la Sicurezza del Volo (ANSV) – Italian civil aviation safety investigation authority (Agenzia Nazionale per la Sicurezza del Volo (ANSV), 2021);
Air Accident Investigation and Aviation Safety Board (AAIASB) – Ministry of Infrastructure and Transport, Hellenic Republic (Air Accident Investigation and Aviation Safety Board (AAIASB), 2018);
Air Accident Investigation Department of the Bahamas (Air Accident Investigation Department of the Bahamas, 2018);
Air Accident Investigation Sector, General Civil Aviation Authority, United Arab Emirates (Air Accident Investigation Sector of the United Arab Emirates, 2020);
Air Accident Investigation Unit (AAIU) Ireland, Department of Transport Tourism and Sport (Air Accident Investigation Unit Ireland, 2015);
Air Accidents Investigation Branch (AAIB), United Kingdom (Air Accidents Investigation Branch, 2014, 2015a, 2015b, 2015c, 2015d, 2016, 2017a, 2017b);
Aircraft Accident Investigation Board of Pakistan (AAIB), Civil Aviation Authority of Pakistan (Aircraft Accident Investigation Board of Pakistan, 2020; Safety Investigation Board (SIB) Pakistan, 2017);
Aircraft Accident Investigation Board, Civil Aviation Organization, Islamic Republic of Iran (Islamic Republic of Iran. Civil Aviation Organization. Aircraft Accident Investigation Board, 2016, 2017);
Aircraft Accident Investigation Bureau (AAIB), Ministry of Civil Aviation, Government of India (Aircraft Accident Investigation Bureau - Ministry of Civil Aviation - Government of

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India, 2016, 2017a, 2017b; Committee of Inquiry - VT-JCX, 2018; Committee of Inquiry - VT-JGA, 2017; Committee of Inquiry - VT-JGD, 2017; Committee of Inquiry - VT-SUC, 2017; Investigators - VT-AYB, 2019);
Aircraft Accident Investigation Commission, Government of Nepal (Aircraft Accident Investigation Commission - Government of Nepal, 2015, n.d.);
Aircraft Accident Investigation Group of Bangladesh (Aircraft Accident Investigation Group of Bangladesh, 2021);
Australian Transport Safety Bureau (ATSB) (Australian Transport Safety Bureau, 2015, 2017, 2019a, 2019b);
Aviation Safety Council (Aviation Safety Council, 2016a, 2016b);
Banjul Accord Group Accident Investigation Agency (BAGAIA) (Banjul Accord Group Accident Investigation Agency (BAGAIA), 2018);
Biro Siasatan Kemalangan Udara – Air Accident Investigation Bureau (AAIB), Ministry of Transport Malaysia (Biro Siasatan Kemalangan Udara - Ministry of Transport Malaysia, n.d.);
Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile, 2016a, 2016b, 2017, 2020);
Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA) – Center for Investigation and Prevention of Aeonautical Accidents, Brazilian Air Force (Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA), 2019, 2021);
Civil Aviation Authority of New Zealand (Civil Aviation Authority of New Zealand, 2000, 2012);
Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC), Republique du Mali (Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC) Republique du Mali, 2016);
Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC), Spain

Accident Investigation Agencies, Civil Aviation Authorities, and Government related agencies
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