INCIDENT ANALYSIS AND STANDARDIZATION OF MOUNTAINOUS FLIGHT COMPETENCY FOR IMPROVING FLIGHT SAFETY IN INDONESIA

Capt. Megi H. Helmiadi¹, Wisnu Aji Nugroho², Mileniawan Januar Ramadhani³

¹Politeknik Penerbangan Indonesia Curug, ²Ikatan Komite Audit Indonesia, ³Kantor Otoritas Bandar Udara Wilayah VI – Padang.

e-mail: ¹<u>megihudihelmiadi@ppicurug.ac.id</u>, ²<u>mileniawanramadhani@gmail.com</u>, ³mileniawanramadhani@gmail.com coresponding: mileniawanramadhani@gmail.com

Received :	Revised :	Accepted :
31 January 2025	01 May 2025	12 June 2025

- Abstract: Safety aspect of mountain flight in Indonesia has become main concern in recent decades, specifically as it caused several casualties each year. To mitigate this risk, in-depth understanding is required, especially related to factors that contributes to flight safety in mountainous area. Despite its urgency, to the best of authors' knowledge, there is lack of study related to flight safety and standardisation for training program and flight crew for mountainous flight in Indonesia, even in Southeast Asia. Therefore, this work discusses the analysis of mountain flight incident occurred in Indonesia, especially in Papua. The objective of this research is to analyze the incidents and evaluate possible improvements to be conducted to increase mountain flight safety in Indonesia. Literature study method is used for this work based on past investigation reports conducted by Indonesian National Transportation Safety Board. Based on the conducted analysis, human factor is the most significant affect that contributes to mountain flight safety incidents. Therefore, as a conclusion the initiation and development of the first mountainous flight training in Indonesia is proposed to solve this issue, which will be established in Aviation Polytechnic of Jayapura, a government-based training organization for aviation personnel that could represent the mountainous flight environment for training purpose.
- **Keywords:** Flight Safety, Flight Training, Incident Analysis, Mountain Flying, Personnel Competency Standardisation

Introduction

Indonesia is an archipelagic country with diverse geographical condition. This characteristic, henceforth, known to causes air transport crucial for transportation and logistics supply chain (Ramadhani et al., 2024). Moreover, this especially true for remote and hardly accessible area in mountainous region such as in Papua. (Kameswara & Suryani, 2021). Nevertheless, this mountain flying activities are also prone to accidents and incidents (Pramono et al., 2020). Mountain flying itself is a flight conducted in a mountainous region, where the terrain elevation changes more than 3000 feet in 10 Nautical Mile Distance. (European Union, 2016). This challenging topological condition is indeed more susceptible to incidents and accidents for aircraft (Wilkes et al., 2022). Furthermore, it is even stated that the mountain flying activities are 3 times more probable to accidents compared to normal flight condition (Joseph T. Nall, 2014). This is caused by terrain with diverse elevation in mountainous area which consequently yields to more challenging wind and weather condition, especially for pilot (Aguiar et al., 2017).

Langit Biru: Jurnal Ilmiah Aviasi Vol.18 No.2 June 2025 ISSN (p) 1979-1534 ISSN (e) 2745-8695

In Indonesia, recent mountain flying accident occurred in Malinau in 2024, causing 1 fatality and 1 person seriously injured (Komite Nasional Keselamatan Transportasi Republik Indonesia, 2024). In addition, one of the most fatal mountains flying accident occurred in Okisibil, Papua resulting to all 54 passengers and crews died (Komite Nasional Keselamatan Transportasi Republik Indonesia, 2015). Papua, as one of active region for mountain flying, is susceptible to incidents and accidents. Investigation data from Indonesian National Transportation Safety Committee (NTSC) is used to summarize the incidents and accidents from mountain flying in Papua. Incidents related to mountain flying in Papua during 2019 – 2024 is provided in Figure 1.



Figure 1. Summary of Mountain Flying Incident in Papua Year 2019 – 2024

Based on Figure 1, it is evident that on average 8 incidents occurred every year, causing damage, serious injuries, and fatalities. Albeit their severe impacts, there is lack of study that specifically concerns the factors that cause of accidents, safety analysis, and policies that can be implemented to improve the safety of mountain flying activities in the Papua region. Thus, these aspects are still unknown and needs to be studied thoroughly. Therefore, this study addresses this issue by analyzing the incidents data and policies that can be implemented to increase the safety aspect of mountain flying, especially in terms of increasing and standardizing mountain flying flight crew competencies. The contribution of this work to society is to improve the overall mountain flight safety in Indonesia through the analysis related to mountain safety incidents and policy also the recommendation based on the conducted incident report analysis. Therefore, the research problems addressed in this study are:

- 1. What is the most frequent and most severe mountain flight incidents especially in Papua?
- 2. What factors that contribute to mountain flight incidents especially in Papua?
- 3. What recommendations that can be given to improve the mountain flight safety in Indonesia?

Method

This work implemented Literature review method. Incident investigations report and national and international civil aviation authority regulations and guidelines are extensively utilised to retrieve and analyze the data. Descriptive analysis approach with quantitative method is used to evaluate the mountain flying incidents and their root-cause in Papua ranging from 2019 to 2024. Procedurally speaking, the first step of this research is by collecting relevant flight incident investigation final reports from Komite Nasional Keselamatan Transportasi. The evaluated incident data include but not limited to number of occurences, factor affecting incidents, and impacts of incidents. After the investigation data has been collected, the type of incidents for each occurence is categorized. After that, the Frequency-impact matrix is constructed to determine

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the risk priority for risk assessment from each type of incidents based on the number of occurences and severity of the incidents (Rios Insua et al., 2018). The severity of incidents is determined from damage to aircraft and environment, number of injuries and fatalities, and classification of serious incidents and accidents terminologies stated by International Civil Aviation Organization (ICAO). Accident is a type of incident that causes serious injuries, fatalities, or severe aircraft damage. On the other hand, serious incident is a type of incident that involving circumstances that indicate high probability of accidents (International Civil Aviation Organization, 2020). After the analysis has been conducted, the root causes of mountain flight incidents are categorized into four categories namely Aircraft, Terrain, Weather, and Personnel. After the root cause of each incident has been categorized, the most frequent contributing factor is determined. Finally, the safety recommendation is given based on the mountain flight incident contributing factors that have been determined.

Discussion

I. Analysis of Mountain Flying Incidents

From conducted analyses, 49 mountain flying incidents occurred from 2019 to 2024. These incidents could be divided into 11 incident categories with its number of occurence percentage relative to total occurences can be seen on Figure 2. Based on Figure 2, runway excursion is the most frequent incident with 57% occurent percentage. Runway excursion is an incident that occurs when an aircraft veers off or overruns the runway surface during takeoff or landing (International Civil Aviation Organization, 2022) (Wang et al., 2024). This results agrees with International Air Transport Association (IATA) report which stated that runway excursions is the most frequent incidents in airport(IATA, 2022). From these 11 incident types that have been analysed, 4 them lead to fatalities. Summary of incidents that result to fatalities are provided in Figure 3.



Figure 2. Number of Occurence Percentage for Various Mountain Flying Incident Types on Year 2019 – 2024



Figure 3. Summary of Accidents Resulting to Fatalities Year 2019 – 2024

Figure 3 reemphasizes results from Figure 2 that shows runway excursion as the most frequent incident. Nevertheless, there are accidents that less frequent yet caused more severe impacts which are Controlled Flight Into Terrain (CFIT), Loss of Control In Flight, and Abnormal Runway Contact. Controlled Flight Into Terrain contributes most of deaths, with recorded number of 21 fatalities, which are 88 percents of total fatalities. CFIT itself is defined as In-flight collision with terrain, water, or obstacle without indication of loss of control (Kelly & Efthymiou, 2019) (Chamsou Andjorin & Boeing Commercial Airplanes, 2015). On the other hand, from Figure 3 it is seen that Loss of Control In Flight and Abnormal Runway Contact are other types of accident which caused deaths in mountain flying activities. Loss of Control In Flight is a condition accidents in which the flight crew was unable to maintain control of the aircraft in flight, resulting in an unrecoverable deviation from the intended flight path (Bromfield & Landry, 2019). Meanwhile, any landing or takeoff that involves abnormal contact with the runway or landing surface such as nose landing and belly landing conditions (International Civil Aviation Organization, 2024). If the probability and impact of each incident types are evaluated, the probability-severity matrix can be constructed as seen on Figure 4. From Figure 4, as the number of injuries per incident for runway excursion is smaller than CFIT and LOC-I, the severity index is lower albeit the probability is higher.

Safety Risk	Severity				
Probability	Catastrophic	Hazardous	Major	Minor	Negligible
Frequent			Runway Excursion		
Occasional	Controlled Flight into Terrain				
Remote			Abnormal Runway Contact		
Improbable		Loss of Control In Flight		Ground Collision	Collision with Obstacle System/Component Failure or Malfunction (Powerplant)
Extremely Improbable			Fuel Related		System/Component Failure or Malfunction Non Powerplant Undershoot/ Overshoot Wildlife

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Figure 4. Probability-severity Matrix of Flight Incident Types in Mountain Flying

II. Causes of Mountain Flying Incidents

In general, there are four main factors which affect the safety aspect of mountain flying. These factors are terrain, weather, aircraft, and personnel (human factor). These four factors are intertwined, thus one flight incident could be resulting from one or more of these four factors (FAA Aviation Safety, 2022) (Federal Aviation Administration, 1999). Terrain factor relates to geographical and topological condition during flight. Therefore, route familiarization and situational awareness to environment should be emphasized to prevent dangerous circumstances, which could lead to incident such as Controlled Flight Into Terrain and Loss of Control due to updraft and downdraft from mountain waves. Weather factor related to meteorological condition such as turbulence, visibility and wind speed during flight (Storer et al., 2019). On the other hand, aircraft factor concerns the aircraft performance and technical limitation, such as maximum flight altitude and engine power. In addition, personnel (human factor) discusses the sufficient competency, coordination, and awareness to conduct mountain flying. Based on these four factors and their correlation to analyzed incident data, the summary of root-cause for mountain flying incident is provided in Figure 5.



Figure 5. Contribution Percentage of Mountain Flight Incidents Year 2019-2024

From Figure 5, it is evident that personnel factor has highest contribution to mountain incidents. From the keywords are lack of awareness to flight environment, incompliance to operational guideline such as Company Operation Manual (OM) and Quick Reference Handbook (QRH), also lack of coordination with other personnel on ground. This factor is mainly found in controlled flight into terrain accidents.

Besides, aircraft technical factor contribution is fairly high in 28%. This relates to technical problems affecting tire, braking system, engine power control, and structural vibration. In addition, implemented aircraft maintenance that was incompliant to aircraft maintenance manual also affect this issue. This factor mainly faced in runway excursion incidents.

Terrain factor mainly related to ground elevation and tree which can be considered as obstacle during flight. Besides, it also makes approach and landing more challenging, especially in short runway length condition. In addition, fluctuative runway elevation and slippery condition on runway also discussed in several reports, especially related to runway excursion incidents.

Meanwhile, weather factor discussed in investigation reports mainly concerns about low accuracy of weather report due to lack of competent observer personnel and measuring instruments in certain airports and airstrips, thus making it harder to predict weather condition in destination. Besides, low visibility especially in cloudy condition also is reported.

III. Existing Policy Implementations

In order to improve mountain flying safety in Indonesia, Indonesian Directorate General of Civil Aviation already published several rules for air operator to be implemented. In terms of aircraft aspect, Director Decree Number KP 40 2020 and KP 47 2020 have been published to improve effectivity and personnel capability in using Terrain Awareness and Warning System (TAWS) instrument in aircraft which could prevent terrain collision during flight.

On the other hand, for human factor aspect, Director Decree Number KP 63 2020 has been published which provide guidelines for air operator in constructing training program curriculum for Controlled Flight Into Terrain (CFIT) and Approach and Landing Accident Reduction (ALAR) training program.

IV. Proposed Mountain Flying Training Program and Standardisation Policies

Currently, implemented policies to improve mountain flying safety aspect only facilitate ground class and flight simulator teaching methods to improve personnel understanding. Furthermore, the training responsibilities are given to each airline, making it possible for various airlines to have discrepancy in their training curriculum and competency standards. In addition, there is lack of established mountain flying training organization in Indonesia, even in Southeast Asia region. Therefore, it is proposed to establish mountain flying training institution in Indonesia as a place to improve and standardize personnel competencies. To represent mountainous terrain accurately for real flying experience, the institution is planned to be constituted in Jayapura Aviation Polytechnic, a government-based training institution for aviation personnel which already has established supporting facilities. Several milestones are required to realize this proposed mountain flying training institution and flight crew competency standardization. These milestones are summarized in Figure 6.



Figure 6. Contribution Percentage of Mountain Flight Incidents Year 2019-2024

The first milestone is sending initiator personnel from the Directorate General of Civil Aviation consisting of the Airport Authority Office and the Directorate of Airworthiness and Aircraft Operation as regulators and Aviation Polytechnic to take part in mountain flying training program abroad. This phase is intended to improve insights and competence of trainees through a standardized training program which has already been proven to produce international mountain flying pilots with prominent qualifications.

The second milestone corresponds to On Job Training (OJT) program in national mountain flying air operator for mountain flying alumni that has been graduated from previous milestone. This phase purpose is to increase their flying hours and understanding real flight conditions of mountain flying in Indonesia by implementing the training that has previously been followed.

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The third phase is the initiation of a domestic mountain flying training program by alumni trainees from aviation polytechnics who have been sent on training abroad and conducted OJT at domestic mountain flying airlines. With provision of insights, competencies and experience gained from training and OJT, the goal of this phase is to encourage alumni in constructing curriculum and becoming instructors of mountain flying education programs with prominent educational quality while still remain relevant for mountain flying conditions in Indonesia.

The final phase is the national standardization of mountain flying competencies in Indonesia. Through the national mountain flying training program at the Aviation Polytechnic that has been built by training and OJT alumni, it is possible to establish mountain flying competency requirements that apply nationally. The existence of these competency requirements can be proven by the competency certificates that need to be owned by aviators before carrying out mountain flying activities.

Conclusion

From the conducted analysis of mountain flying serious incidents and accidents in the Papua region, it is known that Runway Excursion is the most common type of occurences. However, Controlled Flight into Terrain (CFIT) has the greatest impact in terms of casualties caused. From in-depth analysis, the human factor contributes the most to the safety aspects of mountain flying in Papua. To solve this issue, a policy is proposed in the form of the establishment of an integrated mountain flying training ground at Jayapura Aviation Polytechnic which in the future will become an insitution for standardising national flying competencies. The proposed milestones to establish this training center consist of sending personnel from the Directorate General of Civil Aviation and Aviation Polytechnic to domestic mountain flying training, followed by an On Job Training (OJT) program at domestic mountain flying airlines, followed by the formation of a mountain flying training curriculum by personnel who have been educated and passed OJT, and finally the establishment of national mountain flying standardisation with proof of training certificates.

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