A Human Factors Analysis and Classification System of Unsafe Acts in Philippine General Aviation Accidents

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Abstract- A Human Factors Analysis and Classification System (HFACS) framework was applied to investigate human error in Philippine General Aviation (GA) accidents from 2019 to 2024. This study focuses specifically on Tier 1: Unsafe Acts, including skill-based errors, decision errors, perceptual errors, routine violations, and exceptional violations. Twenty-six accident reports from the Civil Aviation Authority of the Philippines (CAAP) were analyzed. Frequency distributions, Fisher's Exact Test, and Cohen's Kappa for inter-rater reliability were used. Results show Skill-Based Errors as the most recurrent unsafe act, particularly in-flight training and agricultural spraying. No statistically significant association was found between unsafe act type and accident outcome. Trends indicate reduced accident frequency in years with stronger regulatory oversight. The study recommends enhancements in pilot proficiency, regulatory compliance, and HFACS-based safety programs.

Index Terms- Aviation Safety, HFACS, Human Error, General Aviation, Unsafe Acts

I. INTRODUCTION

Aviation safety in developing nations often intersects with systemic and structural limitations, including constrained regulatory resources, challenging operating environments, and limited access to advanced safety technologies. General Aviation (GA) sectors within these regions—often used for training, agricultural operations, private flights, and air taxi services—may exhibit higher accident rates due to variability in organizational safety culture, aircraft maintenance standards, and pilot experience levels.

A significant challenge in the Philippines is the scarcity and varying quality of available aviation safety data, particularly within General Aviation. Despite the efforts of the Civil Aviation Authority of the Philippines (CAAP), several accident reports lack consistent detail, and many investigations emphasize mechanical findings over human factors. This disparity limits the nation's capacity to develop targeted safety interventions that address behavioral and systemic contributors to accidents.

This gap in localized research underscores the importance of analyzing Philippine GA accidents through structured human factors models. The Human Factors Analysis and Classification System (HFACS) offers a means to systematically categorize unsafe acts and latent conditions contributing to aviation mishaps, providing insight into underlying patterns and potential areas for safety improvement

II. STATEMENT OF THE PROBLEM

1)   What subtypes of Unsafe Acts and Outcomes are most frequently implicated in Philippine GA accidents during 2019-2024?
2)   How has the prevalence of these Unsafe Acts and Outcomes changed annually from 2019 to 2024, particularly in relation to CAAP regulatory updates?
3)   What significant relationship between specific Unsafe Acts and Outcomes?
4)   What policy improvement can be proposed to minimize general aviation accidents?

III. RESEARCH METHODOLOGY

1) Methods of Research
In order to gather data and information on general aviation accidents that happened in the years 2019 to 2024, a letter was sent to CAAP's Aircraft Accident/Incident Investigation Board (AAIIB) asking for a copy of the reports made during the relevant years stated in the study. A description of each causal factor associated with Unsafe Acts were also provided as a base reference during the lecture and when answering the questionnaire.

Selection of the reports was done after the AAIIB's report had been made available. The reports that were not taken into consideration are based on the defined scope and limitations.

Every accident report was classified and segmented based on the HFACS framework. The coding process involved assigning each accident to the appropriate HFACS- Unsafe Acts Tier 1:Unsafe Acts subtypes:

(1) skill-based errors (e.g., mishandling crosswind landings), (2) decision errors (e.g., VFR flight into Instrument Meteorological Conditions), (3) perceptual errors (e.g., misjudging altitude due to visual illusions), (4) routine violations (habitual non-compliance like skipping checklists), and (5) exceptional violations (rare, high-risk actions such as unauthorized low-altitude flying). Case-study analysis (Crowe et al., 2011) supplements this by examining contextual narratives (e.g., weather conditions, organizational pressures) behind recurring errors. The case study approach is suitable for thoroughly examining intricate occurrences in their authentic setting (Crowe et.al, 2011), like human error in aviation accidents. Descriptive statistics identify the most prevalent Unsafe Acts and Outcomes and will be calculated through Google Sheets.

This methodical classification will enable the detection of patterns and trends within the data. To ensure operational validity, a subset of 20% of the reviewed cases were independently assessed by the participants. If discrepancies arise, it is resolved through consensus.

2) Respondents
The respondents of the study involved 2 active and CAAP licensed pilots with a minimum of 1,000 flight hours at the time of answering the questionnaire and 1 CAAP AAIIB employee. Each participant had a 30-minute lecture on the HFACS framework.

3) Research Instrument
The study used questionnaires, either through online modalities such as Google Forms or traditional pen-and-paper, to gather data from the participants. The respondents categorized each accident using HFACS, with the help of narrative and tabular data of AAIIB reports. The data collected from the questionnaires were subsequently assessed to provide a critical inference on the research questions.

4) Statistical Treatment
This study employed both quantitative and qualitative methods to investigate the relationship between specific Unsafe Acts and their associated Outcomes (e.g., fatal or non-fatal incidents). The quantitative component utilized Fisher's Exact Test to determine the presence of a statistically significant association between the categorized variables. This test allowed for precise analysis of the relationship between Unsafe Acts and Outcomes, particularly in cases involving small sample sizes and categorical data.

To ensure the reliability of the data classification, Cohen's Kappa coefficient was calculated to assess inter-rater agreement. The resulting Kappa value indicated a substantial level of agreement between raters, affirming the consistency and dependability of the classification process used in the study.

The qualitative aspect of the study involved the categorization and interpretation of incident records based on the HFACS Tier 1 Unsafe Acts to determine the most prevalent unsafe act and outcomes per year; this structured classification provided a meaningful basis for statistical analysis and interpretation.

IV. RESULTS AND FINDINGS

A total of 54 accident reports were used in the study with 46 or 85.19% categorized as GA accidents and the remaining 8 or 14.81 as commercial aviation. Each of the CAAP accident reports are then assessed based on the defined scope and limitations, leaving 26 reports or 56.52% to be assessed.

The accidents were segregated based on the year it was reported by CAAP. It was determined that in 2019, there were 10 reported accidents; in 2020, there were 2 reported accidents; in 2021, there were 4 reported accidents; in 2022, there were also 4 reported accidents; in 2023, there were 6 reported accidents; and in 2024, there was 1 reported accident.

To ensure the consistency and reliability of the coding process, inter-rater reliability was assessed using Cohen's Kappa coefficient, a widely accepted statistical measure for evaluating agreement between raters beyond chance. In this study, pairwise comparisons were conducted between the researcher and three other trained coders to assess the reliability of classifications applied to aviation accident reports.

For the classification of Unsafe Acts based on the HFACS framework, the analysis yielded a kappa value of $\kappa = 0.6806$, which falls within the range of substantial agreement according to the interpretative scale proposed by Landis and Koch (1977). This suggests that the coding or assessment process used in the study is highly reliable, and that the observed agreement is not due to chance. As such, the data may be considered dependable for further statistical analysis and interpretation. The substantial agreement further supports the consistency and objectivity of the raters' judgments.

In contrast, the classification of Outcomes resulted in a Cohen's Kappa of κ = 1.000, indicating perfect agreement among all raters. This result suggests that the categorization of accident outcomes was interpreted with complete consistency. Overall, these kappa values provide strong evidence that the coding procedures employed in this study were carried out with a high level of consistency, thereby reinforcing the credibility and dependability of the data used for analysis.

A. Common Unsafe Act

In 2019, it was found that there were a total of 10 accidents with 30.00% attributed to Flight Training and the remaining 70.00% to Agriculture Spraying. It has been found that the most common unsafe act in the year 2019 was Decision Errors and is attributed to Agricultural Spraying and Flight Training. Decision Errors were the most frequent unsafe act in both Flight Training and Agriculture Spraying due to the high cognitive demands and dynamic nature of aviation operations. In 2020, it was found that there were a total of 2 accidents with 100% of them being attributed to Flight Training. It has been found that there is an equal distribution in Decision Errors and Perceptual Errors making the two of them the most common unsafe act. These findings suggest that both incidents in this category involved a breakdown in judgment and perception, key indicators of inadequate situational awareness or misinterpretation of environmental cues (e.g., instrument readings or visual references). Additionally, no skill-based errors or violations were reported. The equal distribution between decision and perceptual errors points to possible cognitive overload, distraction, or inadequate training protocols, particularly under pandemic-adjusted instruction environments. In 2021, there were a total of four reported accidents, and all were attributed to Skill Based Errors, accounting for 100% of the unsafe acts recorded that year. No incidents were classified under Decision Errors, Perceptual Errors, Routine Violations, or Exceptional Violations. This pattern highlights a specific trend toward execution-based performance failures rather than issues in judgment, perception, or rule compliance. In 2022, a total of four reported accidents were recorded, with incidents attributed to both Flight Training and General Aviation operations. Flight Training accounted for two unsafe acts: one Decision Error and one Skill-Based Error, each contributing 25% of the total incidents. The Decision Error likely reflects a lapse in judgment, planning, or pilot choice that compromised the safety of flight operations. This is a notable development, as it indicates that beyond technical ability, cognitive and judgment-based shortcomings are beginning to emerge within the training environment. In 2023, a total of 6 reported accidents were recorded, representing the highest number of unsafe acts since 2019. Skill Based Errors were the most common type, accounting for 3 incidents or 50% of the total. This reflects a continued pattern of difficulty in executing basic flight procedures, which remains a persistent challenge across different types of operations. In 2024, there was a single reported accident across all monitored aviation operations, highlighting a relatively low incident rate for the year. This lone event occurred within the Agriculture Spraying sector and was classified as a Skill-Based Error, accounting for 100% of the unsafe acts recorded.

B. Outcomes

From 2019 to 2024, Philippine general aviation (GA) accident outcomes exhibited fluctuating trends in fatalities and non-fatal incidents. In 2019, the industry recorded 10 total accidents, with 3 fatalities or 30.00% and 7 non-fatal cases or 70.00%. By contrast, 2020 saw only 2 accidents, both non-fatal, likely due to reduced flight operations during COVID-19 lockdowns. The following years revealed inconsistent safety improvements. In 2021, fatalities resurged to 50.00 % of total accidents of 2 out of 4, possibly due to post-lockdown rustiness and extension of airmen's licenses validity. Whereas, in 2022, it was found that out of 4 reported accidents, there was only 1 that resulted in fatalities and the remaining 3 having none. However, 2023 experienced another peak, with 3 fatalities out of 6 accidents or 50%, suggesting regulatory lapses, particularly in agricultural aviation Lastly, in 2024, there was only 1 reported accident and it resulted in no fatalities.

C. Regulatory Update

In 2019, Unsafe acts were widespread and diverse, including Decision errors and Skills-based errors, many of which led to fatal accidents. These incidents prompted CAAP to begin reactive enforcement measures such as grounding non-compliant operators and initiating fleet audits. These immediate actions were the initial steps toward the adoption of more proactive risk-based regulation. However, these occurred before significant CAAP reform actions were in place aside from the SSP that was enacted in March 2014, 5 years before. In 2020, due to the COVID-19 pandemic, general aviation activity declined significantly, leading to fewer reported incidents; only 2 unsafe acts were recorded, both classified as cognitive errors (i.e. decision and perceptual) within Flight Training operations. These

accidents may have been caused by CAAP's MC-18-2020, wherein operations of Approved Training Organizations (ATOs) were resumed during the pandemic. Additionally, the extension of airmen licenses and certificates validity through CAAP's MC-10-2020 may also be attributed to the accidents due to proficiency checks not being done to pilots. The non-fatal outcomes that were recorded highlighted the importance of maintaining pilot proficiency during prolonged periods of operational downtime. CAAP's focus this year was on aligning internal procedures with ICAO recommendations rather than issuing new safety circulars, setting the groundwork for future reforms. In 2021, all 4 unsafe acts were Skill-based Errors distributed across all operations. CAAP responded with targeted regulations, including MC-24-2021, which mandated operator compliance with ICAO safety standards to address systemic risks. MC-23-2021 and MC-06-2021 updated aerodrome safety protocols by incorporating ICAO Annex 14 amendments, focusing on runway design and lighting to prevent night-flight accidents. Additionally, MC-18-2021 revised weather reporting standards (ICAO Annex 3) to mitigate perceptual errors, while MC-04-2021 modernized radio navigation aids to reduce communication-related incidents. The year also saw pandemic-related extensions of licenses and certificates (e.g., MC-08-2021, MC-09-2021), which may have delayed recurrent training, contributing to skill degradation. In 2022, Philippine General Aviation recorded 4 accidents (1 fatal, 3 non-fatal), reflecting a decline in fatalities but persistent safety challenges. In response, CAAP issued several Memorandum Circulars (MCs) targeting these risks. MC-032-2022 strengthened aerodrome safety by adopting ICAO Annex 14 standards, mandating runway safety assessment. MC-019-2022 introduced digital wildlife strike reporting to improve data tracking. Additionally, MC-014-2022 reinstated mandatory pilot skill tests post-COVID, addressing proficiency gaps from the lockdown period. Despite these measures, non-fatal training accidents persisted, suggesting partial compliance gaps. In 2023, Philippine General Aviation experienced a concerning resurgence in fatal accidents (3 fatal, 3 non-fatal). CAAP responded with a series of targeted regulations, including MC-013-2023 introduced updated guidelines for aircraft operations during inclement weather, addressing poor decision-making in bad conditions. In 2024, it was found that there was only 1 non-fatal accident (engine failure), reflecting potential improvements from CAAP's aggressive regulatory reforms. The authority has shifted focus toward preventive measures and digital modernization with MC-024-2024 and MC-033-2024 adopting ICAO Annex 10

amendments, upgrading digital data communication and ATC procedures to reduce human errors. Operational oversight has also been tightened through measures like MC-011-2024, which reinforced airport clearance requirements for all CAAP-operated airports, ensuring stricter compliance checks before flight operations. Additionally, MC-036-2024 laid the groundwork for the TOCID surveillance plan (2025–2026), which will implement real-time monitoring of regulatory compliance, signaling CAAP's shift toward more dynamic safety oversight.

D. Significant Relationship of Unsafe Acts and Outcomes

In evaluating whether a significant relationship exists between specific types of Unsafe Acts and Outcomes, a Generalized Fisher Exact Test was through the R.4.5.1 application software. This treatment is more reliable for data with small sizes. The data consisted of a 2×5 contingency table including five types of unsafe acts: Decision Errors, Perceptual Errors, Skills Errors, Routine Violations, and Exceptional Violations, across two outcomes: Fatal and Non-Fatal accidents.

The results of the Fisher's Exact Test indicated that there was no statistically significant relationship between the type of Unsafe Act and the outcome of the accident. The *p*-value derived through Monte Carlo simulation was 0.1149, exceeding the conventional threshold of 0.05. According to Principle 3 of the American Statistical Association (ASA) Statement on *p*-Values, it is essential to avoid dichotomous thinking in interpreting such results; that is, declaring results simply as "significant" or "not significant" based solely on arbitrary thresholds like $p < 0.05$. Doing so risks oversimplifying complex relationships and may lead to inaccurate or misleading conclusions (Wasserstein & Lazar, 2016).

Moreover, as Salway and Wakefield (2005) point out, the interpretation of statistical relationships in ecological studies can be complicated by within-area variability in both exposures and confounders. In the context of this study, which examines the relationship between categories of unsafe acts and outcomes (fatal vs. non-fatal), the ecological nature of the dataset introduces the potential for ecological bias. This type of bias occurs when relationships observed at the group level fail to reflect the true relationships at the individual level, particularly when the distribution of individual characteristics within groups is heterogeneous.

For example, if certain types of unsafe acts (e.g., decision errors) are more prevalent among less experienced pilots or under specific environmental conditions, and these variables are not uniformly distributed across the dataset, the aggregated analysis might obscure true associations. This means that although the statistical test does not detect a significant relationship overall, subgroup-specific or context-dependent effects may still exist. Therefore, the result should not be interpreted as definitive evidence of independence between unsafe acts and accident severity, but rather as an indication of insufficient power or data resolution to uncover more nuanced interactions.

IV. CONCLUSION

1. In 2019, the most common Unsafe Act was Decision Errors. While, the most common Outcome resulted in no fatalities. In 2020, the most common Unsafe Act was a tie in both Decision Errors and Perceptual Errors. While, the most common Outcome resulted in no fatalities. In 2021, the most common Unsafe Act was Skill-based Errors. While, the most common Outcome was a tie between both outcomes. In 2022, the most common Unsafe Act was spread amongst four Unsafe Acts: Decision Errors, Skill-based Errors, Routine Violations, and Exceptional Violations. While, the most common Outcome resulted in no fatalities. In 2023, the most common Unsafe Act was Skill-based Errors. While, the most common Outcome was a tie between both outcomes. In 2024, the most common Unsafe Act was Skill-based Errors. While, the most common Outcome resulted in no fatalities.
2. Regulatory updates such as CAAP's State Safety Programme (CAAP, 2014) and the Management Services Agreement with ICAO in 2023 (CAAP, 2023) introduced reforms like mandatory skill checks and expanded audits that are credited for the progressive drop in total accident outcomes by 2024.
3. The Fisher's Exact Test resulted in no significant relationship between Unsafe Acts and Outcomes.

V. RECOMMENDATIONS

In light of the findings discussed in this study, several recommendations are proposed to enhance the understanding of human factors in Philippine general aviation and address key challenges related to oversight, pilot competency, training quality, and safety reporting. After a thorough analysis of the data, the following recommendations are hereby made:

1. Future researchers are encouraged to conduct more operation-specific studies by disaggregating accident data by operational environment and company supervision. Doing so can reveal deeper patterns behind the prevalence of unsafe act subtypes. As well as to include the other tiers (Tier 2-4) of the HFACS framework.
2. Regulatory bodies, such as CAAP, and future researchers are encouraged to collaborate in creating a digital safety dashboard that integrates annual trends in outcomes and unsafe acts with corresponding policy implementations. This system would help CAAP evaluate the effectiveness of each regulatory memorandum circular in reducing fatalities and mitigating error types. Researchers, on the other hand, should perform time-series and policy impact analyses to establish evidence-based feedback loops for regulatory refinement.
3. It is recommended that future studies expand the scope of analysis by including the higher tiers of the HFACS framework such as preconditions for unsafe acts, supervisory failures, and organizational influences. This broader application would help reveal system-level factors that may influence the frequency and severity of unsafe acts, which were not captured in this study's focus on active failures.
4. This study recommends the implementation of a General Aviation Safety Competency and Compliance Program (GASCCP). This policy should require all general aviation pilots to undergo standardized competency-based recurrent training every two years, including technical skills assessments and human factors modules. A non-punitive safety reporting system should also be established to encourage pilots and personnel to report near-misses or procedural lapses without fear of sanctions. To ensure accountability, CAAP should conduct annual random audits of general aviation operators, flight schools, and maintenance providers. The GASCCP aims to strengthen oversight, improve pilot proficiency, and promote a culture of continuous safety improvement across the general aviation sector.

ACKNOWLEDGMENT

REFERENCES

[1] Abesamis, P. P. R., De Dios Bulos, R., & Ching, M. (2020). Improving Aviation Incidents using Association Rule Mining Algorithm and Time Series Analysis. *IOP Conference Series Materials Science and Engineering*, *946*(1), 012005. https://doi.org/10.1088/1757-899x/946/1/012005

[2] Barnett, A. (2020). Aviation safety: a whole new world? *Transportation Science*, *54*(1), 84–96. https://doi.org/10.1287/trsc.2019.0937

[3] Civil Aviation Authority of the Philippines. (2014). *STATE SAFETY PROGRAMME*. https://caap.gov.ph/wp-content/uploads/2023/09/state_safety_programme_edition_1.00.pdf

[4] Civil Aviation Authority of the Philippines. (2023, October 17). *Philippines signs Management Service Agreement with ICAO*. https://caap.gov.ph/philippines-signs-management-service-agreement-with-icao/

[5] Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*, *11*(1). https://doi.org/10.1186/1471-2288-11-100

[6] Cruz, G. S., & Sigua, R. (2017). Philippine Air Transport Safety: Analysis of Accidents and Incidents over the Last Two Decades. *Journal of the Eastern Asia Society for Transportation Studies*, *12*. https://sci-hub.se/https://doi.org/10.11175/easts.12.1974

[7] Dekker, S. (2001). THE RE-INVENTION OF HUMAN ERROR. *Human Factors and Aerospace Safety*, *1*(3). https://trid.trb.org/view.aspx?id=717654

[8] Dekker, S. (2002). *The Field Guide to Human Error Investigations*. https://www.humanfactors.lth.se/fileadmin/lusa/Sidney_Dekker/books/DekkersFieldGuide.pdf

[9] Dela Peña, A. (2025). Reducing human error in aviation: The impact of advanced training programs. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.5054523

[10] Detwiler, C., Hackworth, C., Holcomb, K., & Shappell, S. (2007). Beneath the tip of the iceberg: A human factors analysis of general aviation accidents in Alaska versus. . . *ResearchGate*. https://www.researchgate.net/publication/237328084_Beneath_the_Tip_of_the_Iceberg_A_Human_Factors_Analysis_of_General_Aviation_Accidents_in_Alaska_Versus_the_Rest_of_the_United_States

[11] Dumapias, I., & Avergonzado, J. (2021). Pilot Sensing Device Simulator. *IASPER Interdisciplinary Research Journal*, *14*. https://aseanresearch.org/downloads/iasper/publication/14/1_IRVIN%20B%20DUMAPIAS.pdf

[12] Gaur, D. (2005). Human factors analysis and classification system applied to civil aircraft accidents in India. *PubMed*, *76*(5), 501–505. https://pubmed.ncbi.nlm.nih.gov/15892552

[13] Griffin, T. G. C. (2008). The Limits of Expertise: Rethinking Pilot Error and the Causes of Airline Accidents. Ergonomics, 51(7), 1119–1120. doi:10.1080/00140130701680445

[14] Harris, D., & Li, W.-C. (2005). HFACS Analysis of ROC Air Force Aviation Accidents: Reliability analysis and cross-cultural comparison. *International Journal of Applied Aviation Studies*, *5*, 65–81. https://www.researchgate.net/publication/255728827_HFACS_Analysis_of_ROC_Air_Force_Aviation_Accidents_reliability_analysis_and_cross-cultural_comparison

[16] *Human Factors Analysis and Classification System (HFACS)*. (2024, March 19). SKYbrary Aviation Safety. https://skybrary.aero/articles/human-factors-analysis-and-classification-system-hfacs

[17] *ICAO Universal Safety Oversight Audit Programme (USOAP)*. (2022, June 19). SKYbrary Aviation Safety. https://skybrary.aero/articles/icao-universal-safety-oversight-audit-programme-usoap

[18] Iglesias, M. (2025, January 28). *CAAP reports fewer aviation accidents in 2024 - Malaya Business Insight*. Malaya Business Insight. https://malaya.com.ph/business/corporate/caap-reports-fewer-aviation-accidents-in-2024/

[19] Landis, J. R., & Koch, G. G. (1977). *The Measurement of Observer Agreement for Categorical Data. Biometrics, 33(1), 159.* doi:10.2307/2529310

[20] Merriti, A. C., & Helmreich, R. L. (1996). Human factors on the flight deck. *Journal of Cross-cultural Psychology*, *27*(1), 5–24. https://doi.org/10.1177/0022022196271001

[21] Nogueira, R. P. R., Melicio, R., Valério, D., & Santos, L. F. F. M. (2023). Learning methods and predictive modeling to identify failure by human factors in the aviation industry. *Applied Sciences*, *13*(6), 4069. https://doi.org/10.3390/app13064069

[22] *Number of aircraft in the United States 1990-2022 | Statista*. (2024, April 16). Statista. https://www.statista.com/statistics/183513/number-of-aircraft-in-the-united-states-since-1990/

[23] Oster, C. V., Strong, J. S., & Zorn, C. K. (2013). Analyzing aviation safety: Problems, challenges, opportunities. *Research in Transportation Economics*, *43*(1), 148–164. https://doi.org/10.1016/j.retrec.2012.12.001

[24] Reason, J. (1990). *Human error*. https://doi.org/10.1017/cbo9781139062367

[26] Salcedo, D. A. (2024a, September 8). CAAP enforces security screening for private aircraft passengers. *Aviation Updates Philippines*. https://aviationupdatesph.com/2024/09/caap-enforces-security-screening-for-private-aircraft-passengers/

[27] Salcedo, D. A. (2024b, September 30). CAAP completes Air Traffic Management System upgrade. *Aviation Updates Philippines*. https://aviationupdatesph.com/2024/09/caap-completes-air-traffic-management-system-upgrade/

[28] Salway, Ruth & Wakefield, Jon. (2005). Sources of bias in ecological studiesof non-rare events. Environmental and Ecological Statistics. 12. 321-347. 10.1007/s10651-005-1516-5.

[29] Seva, R., Gutierrez, A. M. J., & Duh, H. B. L. (2007). Culture and communication in the Philippine aviation industry. In *Lecture notes in computer science* (pp. 806–813). https://doi.org/10.1007/978-3-540-73331-7_88

[30] Seva, R. R., Gutierrez, A. M. J. A., Duh, H. B. L., & Chong, J. (2007). An evaluation of CRM attitudes of Filipino pilots in four Philippine aviation companies. *the International Journal of Aviation Psychology/the International Journal of Aviation Psychology*, *17*(3), 285–298. https://doi.org/10.1080/10508410701343532

[31] Shappell, S., Detwiler, C., Holcomb, K., Hackworth, C., Boquet, A., & Wiegmann, D. (2006). *Human Error and Commercial Aviation Accidents: A Comprehensive, Fine-Grained Analysis using HFACS*. Scholarly Commons. https://commons.erau.edu/publication/1218

[32] Shappell, S., Detwiler, C., Holcomb, K., Hackworth, C., Boquet, A., & Wiegmann, D. A. (2007a). Human Error and Commercial Aviation Accidents: An analysis using the Human Factors Analysis and Classification System. *Human Factors*, *49*(2), 227–242. https://doi.org/10.1518/001872007x312469

[33] Shappell, S., & Wiegmann, D. (2003a). A Human Error Analysis of General Aviation Controlled Flight Into the Terrain Accidents Occurring Between 1990-1998. *Embry Riddle Scholarly Commons*. https://commons.erau.edu/cgi/viewcontent.cgi?article=2314&context=publication