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The influence of implementing electronic flight bag application on aviation safety mediated by the optimization of human resources

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The unintegrated use of information technology in the cockpit of Garuda aircraft was the electronic flight bag, with the application of the Garuda electronic flight manual and the Garuda electronic airway manual. This gap would cause potential negligence and delay in distributing paper documents or manuals to the aircraft of Garuda Indonesia Airline. It was necessary to study whether the use of Garuda electronic flight manual software and Garuda electronic airway manual could ease the duties of the Pilot on board the aircraft. This research aimed to know the influence of implementing the Garuda electronic flight manual and the Garuda electronic airway manual on flight safety by optimizing human resources. The study used the Path Analysis method. The samples of this research were 30 pilots as the users and processors of the Garuda electronic flight manual and the Garuda electronic airway manual. The study found that the variable of flight safety was directly influenced by the implementation of the Garuda electronic flight manual, the Garuda electronic airway manual, and the optimization of human resources. In addition, implementing the Garuda electronic flight manual and the Garuda electronic airway manual was the variable influencing flight safety at most.

1. Introduction

Air transportation, both passenger and cargo, in the last decade before the Covid-19 pandemic, increased significantly. Regarding the number of fleets sold by the two biggest companies in the aircraft industry, namely Boeing and Airbus, it is stated that the growth of aircraft sales from 2009 to 2019 increased by up to 60 percent (Mazareanu, 2020)**.** Long-distance passenger and cargo transportation by air has faced significant challenges along with the age of flight (Benligiray & Kurt, 2016). Although air traffic has almost doubled, major accidents have not increased. Flight safety is the most important aspect of aviation.

One of the Quantum Leap application strategies of Garuda Indonesia is increasing the number of fleets up to almost 50% of the initial number in three years. The spread of Garuda Indonesia aircraft at several airports will complicate the process of updating data and has the potential for delays or not up-to-date manual data on the aircraft. This also requires the Pilot during preflight to be more thorough in ensuring that the manuals to be used in the flight are the most up-to-date documents. With minimal time, the Pilot's Workload on the aircraft can be reduced with tools that can automatically help the flight preparation process until the flight finishes, reduce the Pilot's mistakes and improve flight safety (Ayiei et al., 2020). The impacts on flight safety mostly caused by human factors being studied are not statistically strong enough to be conclusive (Solgård & Oppheim,

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2019). According to Ateş (2017a), information on flight operations is saved and presented electronically by minimizing the mistakes caused by human factors and improving the accuracy of information used by pilots. Ateş (2017b) says that operators can access information on flight operations quickly and easily, and the information needed by users is presented in a better electronic format. The tool aid used in the aircraft cockpit is Electronic Flight Bag (EFB) in the form of hardware and software, which has been extensively used by air transportation in the last several years and facilitates the Pilot in the cockpit performing flight management duties more efficiently and effectively (Kafali & Savaş, 2021).

The information technology now continuously developing and which starts to be used by many airlines is the EFB program with the application of Garuda Electronic Flight Manual (GEFM) and Garuda Electronic Airway Manual (GEAM) to facilitate Pilots to access and process navigation data. This GEFM-GEAM continues to develop software applications and hardware to generate profit for airlines. The profit will, directly and indirectly, cause potential cost savings obtained from the optimization of fuel conservation monitoring applications, improvement in the flight time accuracy from the preflight acceleration in the cockpit, improvement in the accuracy of aircraft performance calculation, reduction of manual reproduction cost, and business process simplification to optimize human resources.

According to Ateş (2017a), information on flight operations is saved and presented electronically by minimizing the mistakes caused by human factors and improving the accuracy of information used by pilots. EFB is designed to improve safety, efficiency, and the whole operation of the flight deck and the airline's operation related to giving better information to aircraft crew and improved functionality in the digital format which is easy to use (Trujillo & Ellersick, 2006). According to Solgård and Oppheim (2019), in their research in Norway, it seems that the implementation of electronic document applications by operators has been effective.

Some problems are found in the research, such as aircraft accidents caused by human factors, the unintegrated application of GEFM-GEAM used by Garuda with its aircraft avionic system, the GEFM-GEAM application, which has not been integrated into the aircraft avionic system, namely Flight Management Computer (FMC) in which its update is out of sync with GEFM-GEAM like Aeronautical Information Regulation and Control (AIRAC) cycle which is late and issued every 28 days, whether the GEFM-EAM software can facilitate the duties of Pilot on board the aircraft, potential negligence and delay in the distribution of paper manuals to aircraft, very short time of flight preparation requiring special attention for Pilots to ensure that all documents in the aircraft cockpit have been updated, and the difficulties in updating the data of aircraft manuals which are still using papers due to aircraft spread at several airports.

2. Literature Review

2.1. Flight Safety

Safety management systems, especially flight safety, according to ICAO, has been widely acknowledged as a systematic approach to managing safety, including organizational structure, accountability, policy, and necessary procedures (ICAO, 2006). ICAO (2013), Zieja et al. (2015), and Samosir et al. (2021) explain that flight safety is a condition of fulfilling safety requirements in the utilization of airspace, aircraft, airport, air transportation, flight navigation, as well as supporting facilities and other public facilities. According to Federal Aviation Administration, the safety management system is a formal, top-down, organizationally approached system to manage safety risks and assure the effectiveness of safety risk control (FAA, 2015). Safety management systems at this time, according to Gill (2004), have become a research topic about safety perception, safety violation, and flight safety development, and related to management and safety culture (Gill & Shergill, 2004). Safety culture, especially in aircraft maintenance, has a strong and positive influence (Rahmanita et al., 2023; Ricardianto et al., 2023; Gerede, 2015). Generally, the aviation industry's safety management system is developed by international authorities (Marina et al., 2023; Kurt & Gerede, 2018). Finally, the safety management system requires the aviation industry to integrate safety policy and to improve safety performance at organizational and individual levels (Majid et al., 2022; Ricardianto et al., 2022; Chen & Chen, 2011).

2.2. Electronic Flight Bag (EFB)

EFB is a tool for electronic information management, and GEFM-GEAM has been used for quite a long time by commercial flight operators as a useful tool to improve operational efficiency and flight safety (Bhardwaj & Purdy, 2019; Garuda Indonesia, 2017)**.** According to Melnichuk et al.(2019), EFB can accommodate various software applications for automating functions conventionally performed in manual ways, such as takeoff calculation, weight and balance, and landing performance. EFB has advantages compared with the computer software in laptops, that is no need for special storage when the aircraft is operated below 10,000 feet as required when using a laptop (Mecham, 2002). Initially, EFB used laptops having operational functions and flight management. In the operational flight activities in the aircraft cockpit, manual documents are accessed digitally to facilitate the Pilot to find the reference for flight operation more easily and quickly. In general, EFB is an instrument that is a digital document to be carried and used during a flight replacing information on paper.

EFB is designed to improve safety, efficiency, and the whole operation of the flight deck and airline operation related to giving better information to the aircraft crew and upgraded functionality in the easy-to-use digital format (Trujillo & Ellersick, 2006). Lupidi et al. (2015) explain that the adjusted combination of EFB and polarimetric radar can increase the Pilot's situational consciousness and support track optimization. The study by Zelazo (2012) explains that the installment of a sophisticated Class 3 EFB system in the cockpit will enable aircraft operators to utilize the technology of Automatic Dependent Surveillance-Broadcast (ADS-B) in a shorter time at a lower cost of implementation and will give additional benefits to the operator.

In the research of Chandra et al. (2003), it is proven that EFB can maximize the information provided to the Pilot as the reference in the preflight process. The use of EFB does not significantly influence the Pilot's Workload. However, research by Suppiah (2019) and Lopes et al. (2022) shows that it can significantly increase the Pilot's Workload during an unexpected situation. Different visual layouts of the EFB paper manual and chart do not significantly influence the Pilot's Workload.

This GEFM-GEAM application can be used for various functions with a high level of effectiveness compared to a conventional paper reference (Ateş, 2017b). in general, some advantages can be obtained from using GEFM-GEAM, namely improving flight safety and increasing operational efficiency. It may occur due to the ease obtained by flight crew with the EFB application and the ease of ground support in collecting and sending flight data faster with business process simplification. According to Sanderson (2011), *Electronic Flight Manual* is the data and manual information in the aircraft cockpit used in electronic form. The manuals in the aircraft cockpit include such flight documents as Flight Crew Operation Manual (FCOM), Aircraft Operation Manual (AFM), Operation Manual (OM), Route Operation Manual (ROM), Dangerous Goods Handling Manual (DGHM), Cargo Flight Operation Manual (CFOM) (Garuda Indonesia, 2017).

2.3. Human Resources Optimization

Human Resources (HR), in general, is one of the competitive advantage resources and the main variable to achieving success in a competition to reach the goal (Hapsari et al., 2021; Ivancevich, 2007; Mathis & Jackson, 2011). Human Resources Management (HRM) has a strategic function in the organizational activities effectively integrated into the HR strategy (Tiftik & Yakupoğlu, 2023; Saluy et a., 2021). Theoretically, to reach organizational goals, human resources management should establish orderly planning, organizing, directing, and supervising all the elements which are the strengths to meet the need (Ricardianto, 2018). Human Resources is one of the most important factors in a company compared with factors other than business capital (Purnomo et al., 2018). So, managing HR well is essential to improve the company's effectiveness and efficiency. HR includes each individual's intellectual and physical powers (Sa'diyah et al., 2022).

Limited HR and business processes passing through several steps to support updating manual data in the aircraft cockpit become obstacles causing delays as waiting for data updating. It needs an efficient and effective operational strategy to support flight operations to improve flight safety. This work efficiency can be increased, among others, by optimizing the use of information technology systems through automation or digitalization. With this automation, the business process, which initially takes a long time or goes through several steps, can be simplified. The initial utilization of many workforces will decrease due to technology utilization. This research aims to know the direct influence of the GEFM-GEAM application on flight safety, human resources optimization on flight safety, and the direct influence of the GEFM-GEAM application on human resources optimization.

3. Research Method

In this research, the data analysis technique uses path analysis with the flight safety (Z) variable as the exogenous variable. In contrast, the endogenous variable is the GEFM-GEAM application (X1-X2) and human resources optimization variable (Y). The population of this research is the operators of Garuda Indonesia Airlines involved in the use of GEFM-GEAM application in the aircraft cockpit of Airbus A330-200/300/900 numbering 26 aircraft of Airbus A330 series that consists of six A330-200 aircraft, seventeen A330-300 aircraft, and three A330-900 aircraft. The sample of this research is the users and processors of GEFM-GEAM, as many as 30 pilots. The questions in the questionnaire are obtained from interviews with ten officers as the administrators who manage the EFB. The questions are about the use of EFB and its relations with human resources optimization and flight safety.

GEFM as an exogenous variable (X1) uses four variable dimensions: ease in pre, in, and post-flight works, ease of accessing the flight diagram, reduction of Pilot's Workload, and speed to decide. GEAM as an exogenous variable (X2) uses four variable dimensions: ease in pre, in, and post-flight works, ease of accessing the flight diagram, reduction of the Pilot's Workload, and speed to making decisions. The intervening variable is human resources optimization (X3) using four dimensions: thinking ability, Workload, job training, and business process. The variable of flight safety (Y) as an endogenous variable uses four dimensions: supervision, employee training, awareness of flight safety, and flight safety report.

Based on the above description, a conceptual model and research hypotheses are formulated (Fig. 1).

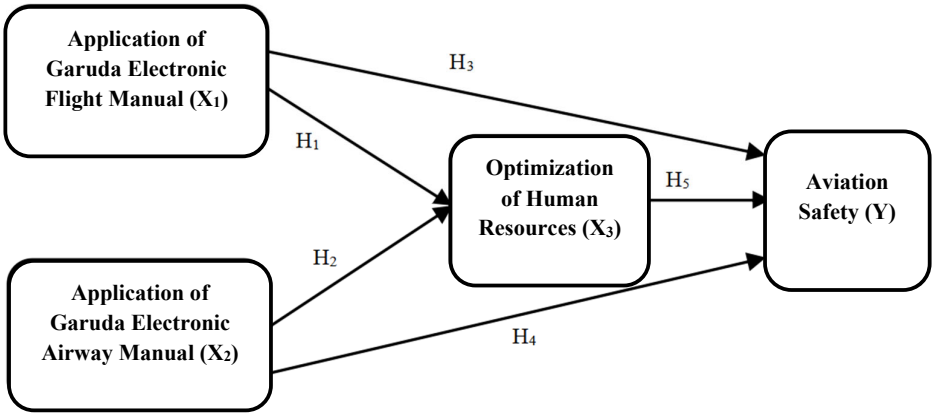


Fig. 1. Conceptual Model

H1: Garuda *electronic flight manual* application directly influences the optimization of human resources.
H2: Garuda *electronic airway manual* application directly influences the optimization of human resources.
H3: Garuda *electronic flight manual* application directly influences flight safety.
H4: Garuda *electronic airway manual* application directly influences flight safety.
H5: *The optimization of human resources directly influences flight safety.*

4. Results and Discussion

4.1. Validity dan Reliability

Validity and reliability tests are carried out on the four research variables, namely GEFM-GEAM applications (X1-X2), optimization of human resources (X3), and flight safety (Y). The validity test is carried out using 30 respondents obtained randomly from Garuda Indonesia Airlines. Based on the results of validity and reliability tests, it is found that all the above statements have significance at (α) > 0.05. So, the 12 statements are valid and reliable. In the description, the distributed questionnaire is to measure the correlation between the Garuda electronic flight manual application (X1) and Garuda electronic airway manual application (X2), optimization of human resources (X3), and flight safety (Y).

4.2. Results of Path Analysis Test

Fig. 2 is the result of estimating the path coefficient of the structural relationship model among variables. Based on the path analysis test, the values of path coefficient, correlation, and standard deviation are obtained with the statistical value of path analysis as in Table 1.

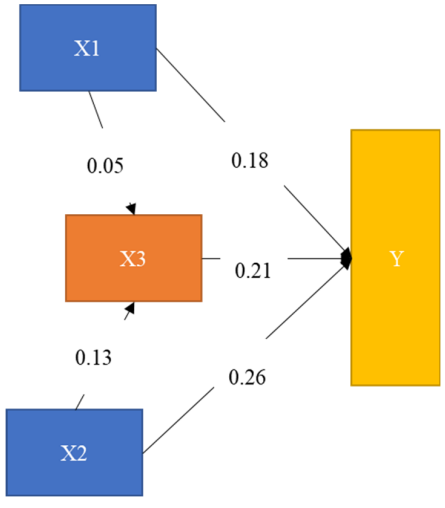


Fig. 2. Path Coefficient

Table 1
Result of Path Analysis Test

No	Hypothesis	Path Coefficient (ρ)	Coefficient of Correlation (r)	SD	statistic Value	Test Result α 0.05
H_1	Garuda electronic flight manual application and Optimization of Human Resources (X1-X3)	0.06	0.453	0.06	0.93	Not Significant
H_2	Garuda electronic airway manual application and Optimization of Human Resources (X2-X3)	0.06	0.353	0.08	0.97	Not Significant
H_3	Garuda electronic flight manual application and Flight safety (X1-Y)	0.09	0.100	0.010	8.71	Significant
H_4	Garuda electronic airway manual application and Flight safety (X2-Y)	0.05	0.118	0.021	8.50	Significant
H_5	Optimization of Human Resources and Flight safety (X3-Y)	0.07	0.126	0.037	4.62	Significant

Table 1 shows that the result (α > 0.05) with the $_{table}$ is 1.697. The result of the statistic> table shows that the correlation between the independent and dependent variables is significant. Each variable is related to different levels of significance, depending on the results of the path analysis that has been done.

4.3. Final Model Suitability Test (Goodness of Fit)

It is known that some indicators can be used to measure whether a model is fit. It can be concluded that the goodness of fit from the result of the model test is as follows; (1) H0 is accepted because, in the normal parameters using One-Sample Kolmogorov-Smirnov Test, it obtains the value of K-S = 0,185 > α = 0.05, so that the data is normally distributed. Whereas as the result of the t-test, H0 is accepted because the value of sig X1 = 0.083, X2 = 0.113, and X3 = 0.123 > α = 0.05, so the data indicates a correlation. It can be concluded that the result of this analysis proves that the GEFM application (X1) and GEAM application (X2), and optimization of human resources (X3) do influence flight safety (Y).

4.4. Results of Hypothetical Test

The result of structural model analysis among variables is used for hypothetical tests, and its size can be measured through the direct influence among variables. The result of the hypothetical test is based on the value of the path coefficient and the significance value of each path studied. The results of the hypothetical test are as follows.

H_1: *Garuda Electronic Flight Manual Application (X_1) directly influences the Optimization of Human Resources (X_3).*

Based on the result of the research, the value of the coefficient of correlation is found to be $X_1Y = 0.100$ using the value of $_{statistic} = 0.93$ and $_{table} = 1.697$ at α 0.05. Because $_{statistic}$s < $t_{able,}$ the coefficient of correlation X_1X_3 is insignificant. Thus, statement Ho is rejected. So, it is found that the direct influence of the GEFM Application (X_1) on the Optimization of Human Resources (X_3) is not significant.

H_2: *Garuda Electronic Airway Manual Application (X_2) directly influences the Optimization of Human Resources (X_3).*

Based on the result of the research, the value of the coefficient of correlation is found to be $X_2X_3 = 0.100$ using the value of $_{statistic} = 0.97$ and $t_{able} = 1.697$ at α 0.05. Because $_{statistics < table,}$ the coefficient of correlation X_2X_3 is insignificant. Thus, statement Ho is rejected. So, it is found that the direct influence of the GEAM Application (X_2) on the Optimization of Human Resources (X_3) is not significant.

H_3: *Garuda Electronic Flight Manual Application (X_1) directly influences the Flight Safety (Y).*

Based on the result of the research, the value of the coefficient of correlation is found to be $X_1Y = 0.118$ using the value of $_{statistic} = 8.71$ and $t_{able} = 1.697$ at α 0.05. Because $_{statistic}$s> $_{table,}$ then the coefficient of correlation X_1Y is significant. Thus,

statement Ho is accepted. So, it is found that the direct influence of the GEFM Application (X_1) on flight safety (Y) is significant.

H_4: *Garuda Electronic Airway Manual application (X_2) and Flight safety (Y).*

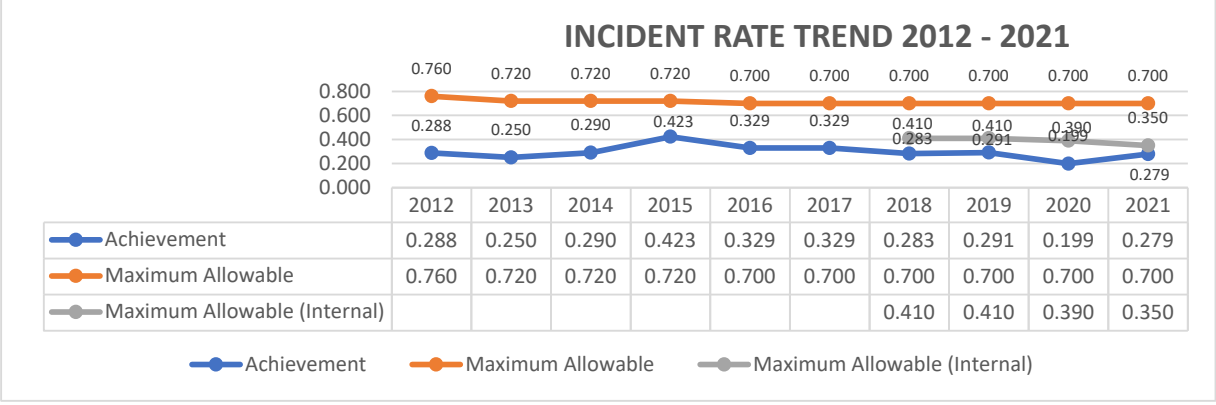
Based on the result of the research, the value of the coefficient of correlation is found to be $X_2Y = 0.453$ using the value of $_{statistic} = 8.50$ and $_{table} = 1.697$ at α 0.05. Because $_{statistic}s > _{table}$, then the coefficient of correlation X_2Y is significant. Thus, statement Ho is accepted. So, it is found that the direct influence of GFAM Application (X_1) on flight safety (Y) is significant.

H_5: *Optimization of Human Resources (Y) and Flight Safety (Z).*

From the result of the research, the value of the coefficient of correlation X_2X_1 on Y= 0.129 with the value of $_{statistic} = 4.62$ and $_{table} = 1.697$ at α 0,05. Because $_{statistic}s > _{table}$, the coefficient of correlation Y on Z is significant; thus, statement Ho is accepted. So, it is found that the direct influence of the Optimization of Human Resources (X3) on flight safety (Z) is significant.

4.5. Implication of Actual Data

Garuda Electronic Flight Manual (GEFM) and Garuda Electronic Airway Manual (GEAM) in the Electronic Flight Bag (EFB) were implemented in 2019. In Fig. 3, it is seen that there was a decreasing incident graphic from 2019 to 2021. This indicates a simplified suitability between the research results and the hypothetical test with the actual data that occurred at PT Garuda Indonesia Tbk on a macro basis.



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Achievement	0.288	0.250	0.290	0.423	0.329	0.329	0.283	0.291	0.199	0.279
Maximum Allowable	0.760	0.720	0.720	0.720	0.700	0.700	0.700	0.700	0.700	0.700
Maximum Allowable (Internal)							0.410	0.410	0.390	0.350

Fig. 3. Incident Rates Garuda Indonesia 2012-2021

5. Discussion

5.1. Electronic Flight Bag and Optimization of Human Resources

Although the hypothetical test results find an insignificant direct influence of GEFM and GEAM application in the EFB program on the Optimization of Human Resources, the EFB application provides more efficient and effective services. The results of this hypothetical test support some opinions, such as Suppiah (2019) and Suppiah et al. (2020), that using the EFB application does not significantly influence the Pilot's Workload. Pilots consider EFB an improvement in traditional aviation, gaining security that may seem lower than expected. Indeed, there is no uniform perception of flight safety for all operators. Such a different perception of flight safety is considered the function of the Pilot's duties in the cockpit. Further findings can help management allocate resources in better ways and increase potential profit due to efficiency when implementing new technologies, building a safe organization that is more effective in its process. Smart technology used in this research is in line with the opinion of Beach et al. (2014), Garuda Indonesia (2017), and Wong and Man (2023) that it improves aircraft safety through better performance in maintenance. However, it is impacted by technical problems and the human factor, especially during the recovery from the Covid-19 pandemic. They explain that in EFB, an application becomes a unity of GEFM-GEAM application which will facilitate the Pilot to navigate the flight efficiently and effectively.

According to Chandra et al. (2003), considering the human factor for EFB application is a good starting point to evaluate the concept of EFB application. However, this research also shows that the increased task demands during unexpected situations can cause a significant increase in the Pilot's Workload. This study also indicates that the influence of the Pilot's Workload due to the different visual layouts of paper and graphics in the EFB application does not significantly influence the Pilot's Workload. This study still has a direct influence on the study by Chase and Hiltunen (2021), which identifies the strengths

and weaknesses of using EFB related to the training in an airline based on EFB training; EFB reliability; EFB arrangement; electronic document; and obstruction, Workload, as well as head-down time.

5.2. Electronic Flight Bag and Flight Safety

The hypothetical test finds a significant direct influence of GEFM and GEAM application in the EFB program on optimizing Human Resources. Further findings can help management allocate resources in better ways and increase potential profits due to efficiency when implementing new technologies, building a safe organization that is more effective in its process. Smart technology used in this research is in line with the opinion of Beach et al. (2014), Garuda Indonesia (2017), and Wong and Man (2023) that it improves aircraft safety through better performance in maintenance. However, it is impacted by technical problems and human factors, especially during the recovery from the Covid-19 pandemic.

This study related to flight safety supports the study by Chandra and Kendra (2009) concerning the Pilot, who reports some factors such as chart display configuration and difficulties in using EFB when newly implemented, identification of EFB usage for calculating the landing distance as the factor causing accidents. This research supports the study by Samosir et al. (2021) stating that the effectiveness of the EFB application can have a significant impact on the flight safety aspect of Garuda Indonesia, which operates the aircraft type B777300-ER, as well as proves a positive significance in the correlation between EFB and flight safety. So, improving flight safety can be done by using the GEAM application in the aircraft cockpit during flight operation, pre, in, and post-flight.

5.3. Optimization of Human Resources and Flight Safety

The hypothetical test results find a significant direct influence of optimizing human resources on flight safety. The optimization of human resources is a process of optimizing something to be the best. Flight safety is a condition where safety requirements are fulfilled in utilizing airspace, aircraft, airport, air transportation, flight navigation, supporting facilities, and other public facilities. Theoretically, the influence of HR optimization on flight safety supports the opinions of ICAO (2018), FAA (2019), Poerwanto (2019), and Samosir et al. (2021) that flight safety management integrates the concept of the safety system with the human factor and human performance in the design and operation of a system. This research supports a study by Chan and Li (2023), explaining that safety managers and practitioners of safety management systems have an innovative ability to choose a more effective intervention approach and safety management.

This research is in line with the result of a study by Tiftik and Yakupoğlu (2023) and Adedoyin et al. (2020) concerning HR optimization and flight safety by explaining that every employee at the airport must ensure the safety and security of operations; during flight operation, it needs the direct roles of airport management in the ground handling process, ensure passenger satisfaction, take off and fly the aircraft safely. Other supportive research fully utilizes flight data from airlines in different conditions that combine the attitude characteristics of the pilots and inform the risk analysis of other insecure incidents such as hard landing on the runway and attack to the aircraft tail (Li et al., 2023).

Another research line is the study by Zhou and Zhang (2018), stating that enhancing the awareness of professional flight related to human factors must fully take advantage of the cause-effect chain among human factors. Related to training, this research is in line with the study by Tran et al. (2022), which integrates EFB into aviation training devices so that human resources become very optimal. Concerning the pilots who attend simulation training, the result shows an increase in pilots' total flight hours, experience with the EFB application, and information criticality provided in EFB that will increase the pilots' trust in the information provided by EFB. So, this research aligns with the study of Misra and Halleran (2019) and Pittorie et al. (2021). This hypothetical research aligns with the opinion of Solgård and Oppheim (2019) that the impact on flight safety caused by most of the human factors studied is not statistically strong enough to be conclusive. The result of this research has significant direct influences. However, there is a different opinion that the main instrument of flight safety for flight risk management does not fulfill the expectation due to a higher efficiency standard, which burdens human resources (Malakis et al., 2023).

6. Conclusion

The variable of flight safety has both direct and indirect impacts on various variables, such as the implementation of the Garuda Electronic Flight Manual-Garuda Electronic Airway Manual (GEFM-GEAM) application and the optimization of human resources. In addition, implementing the GEFM-GEAM application is the most influential variable in-flight safety. As a further recommendation for this limited research, it is necessary to assess the GEFM-GEAM application in factual ways and further research in actual ways. As a simulation for assessing the GEFM-GEAM program, further research can be based on this research by using the questionnaire data in Quarter I of 2021 (February-April period), using the Likert method for flight safety with support on optimizing human resources. Garuda Indonesia Tbk needs to develop an information system integrated into implementing GEFM-GEAM policy and application since it is proven to be directly correlated with flight safety.

Based on the use of the four research variables with the supporting tool aids of the Electronic Flight Bag used in Garuda

Airlines' aircraft cockpit, this research is new combined research or a research novelty, especially the implementation of the Garuda Electronic Flight Manual-Garuda Electronic Airway Manual (GEFM-GEAM) application in the flight activities. The use of some research dimensions, such as the ease of accessing flight diagrams, reduction of the Pilot's Workload, and speed in making decisions, also support the novelty of this research.

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