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Enhancing Aircraft Maintenance: Safety Management Systems and Capability Building for Optimal MRO Business Performance

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Abstrak

The aeronautics sector, including aircraft construction, parts supply or maintenance of aircraft parts, and repair and modification services, is currently one of the most dynamic industries in the world. The business performance of aircraft maintenance companies is highly dependent on the Safety Management System (SMS) and Capability Building (CB). This research is a synthesis formed integrative based on various previous research literature modified by researchers. The population in this study were company leaders or parties representing them in private and state-owned Maintenance, Repair, and Operations (MRO) companies, totaling 119, with a sample of 91 respondents. This research was verification research with an explanatory survey. Data analysis used the Structural Equation Model (SEM) with the Partial Least Square (PLS) approach through the SmartPLS software. We found that MRO business performance is influenced by SMS and CB in aircraft maintenance service companies in Indonesia. CB mediated the effect of SMS on Business Performance in aircraft maintenance service companies in Indonesia. MRO business performance can be further improved with intervention from CB based on SMS integration. SMS was so integrated with CB that SMS could not develop without CB, and vice versa. One aspect that needed to continue to develop here was an assessment related to identifying accident risks in the SMS, which was integrated with various maintenance and overhauls in the CB.

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1. INTRODUCTION

The aeronautics sector, including aircraft construction, spare parts supply or maintenance of aircraft parts, and repair and modification services, is currently one of the most dynamic industries in the world (Romero et al., 2016). This industry creates several enormous opportunities for economic activities and financial benefits in various parts of the world.

One of the determining factors for the progress of the aviation industry is the support of aircraft maintenance companies or Aircraft Maintenance and Overhaul (AMO). Aviation companies place high hopes on management, facilities of Maintenance, Repair, and Operations (MRO) services to extend the life of their company assets to ensure the availability of transportation services in the future. MRO services are complex because they

involve various processes whose performance depends on the aircraft design and maintenance reliability, regulations, spare parts availability, and certified human resources (Vieira & Loures, 2016). Meanwhile, airlines need efficiency, quality, and safety at the best cost (Romero et al., 2016).

The phenomenon that occurs is that there are many major or minor accidents in the world of aviation, which lead to MRO performance that is not yet optimal due to low Capability Building (CB) and a Safety Management System (SMS) that is not yet integrated and comprehensive (Fajariansyah et al., 2021). Civil aviation accidents have become a big issue for the entire aviation community, both nationally and internationally. Four main organizational sections are operational actors in the world of aviation, namely: Aircraft Operator Certified, Air Traffic Control Organization, Maintenance Center, and Aerodrome Operation (Aviation & Regulation, 2017). One organization that plays an essential role in the aviation safety system is AMO. This organization is responsible for care, maintenance, and overhaul. The most significant percentage of airplane accidents are caused by human error in carrying out maintenance (Kvalheim & Dahl, 2016).

A guarantee of product safety is one of the conditions for developing an MRO company to guarantee product safety and minimum failures in the maintenance process. The term incident or accident in SMS is related to product failure, which includes reduced or lost construction capabilities/components, including aircraft engines, resulting in an incident or catastrophic impact (Aviation & Regulation, 2017). The incidents do not stop there. Delays in work time, disruption to workflow, and pressure from top management can lead to irregularities and violations. Tight business competition leads to an unhealthy competitive situation where the dominance of large companies can freely make unilateral policies.

Most of the research on Aircraft MRO performance directly links strategy formulation with company performance and does not link strategy formulation in SMS and its implementation in improving CB (Fajariansyah et al., 2021). The problems of MRO companies in Indonesia are similar to problems in other countries, namely their performance. Only 4 out of 119 MRO companies in Indonesia have very high performance, while the others are classified as high, relatively high, or even less (Ridwan, 2018). Safety factors, human resource factors, regulatory compliance, technology, costs, and supply chain management can cause these problems (Nam et al., 2023). Some of the research results show the existence of an empirical gap. For this reason, researchers are trying to fill this gap by researching MRO companies in Indonesia.

This research aims to confirm business performance, which is influenced by SMS and CB in MRO companies in Indonesia. Another objective is to confirm the mediating effect of CB in the influence of SMS on the business performance of MRO companies in Indonesia.

Literature Review

This research's state-of-the-art points to MRO business performance, which is highly dependent on SMS and CB. In the strategic management model, this SMS can function as a strategy in the strategy formulation phase, which in turn is implemented in the strategy implementation phase in CB. Ultimately, it all leads to the output or final result, namely performance. This model is based on the external and internal environment, such as regulations and standards (external environment) and MRO Support and Human Factors (internal environment).

The concept of business performance has different meanings in various industries. This concept can be viewed from various perspectives, such as macro and micro. From a micro perspective, performance is limited to individual or employee performance in an organization, or unit or group performance, to organizational performance. The concept of performance is often juxtaposed with productivity and competitiveness concerning quality, speed, reliability, and innovation.

In the service industry, performance can be seen from three aspects, namely (1) operational performance, (2) financial performance, and service performance (Zhang et al., 2015). Operation performance is related to "the effectiveness of the use of every resource

the company uses, such as capital, raw materials, technology, and others. The extent to which it is used optimally to achieve profits or its vision and mission" (Moeheriono, 2014). This operational performance is closely related to reduced management costs, lead time, reduced order time, reduced levels of damaged raw materials, and reduced production process delays (Truong et al., 2017).

In this perspective, several factors that describe the importance of performance (individual to organizational level) in an organization are related to (1) cost and resource efficiency; (2) greater employee engagement; (3) better customer outcomes; dan (4) impact on bottom line (Kataria et al., 2012).

Capability development or Capability Building (often also called capability development) in MRO is a critical component in determining the performance of MRO itself. The meaning of CB itself is increasing the facilities of an individual or organization to produce, do, or carry out something. *Capacity development* is developing and strengthening the skills, instincts, abilities, processes, and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world (United Nations, 2022). An essential element in capacity building is the transformation that is generated and sustained over time from within. This kind of transformation goes beyond doing tasks to changing thought patterns and attitudes. (Nelson, 2021).

In this research, CB in MRO can be characterized by four components, namely (1) line maintenance, (2) heavy maintenance, (3) component maintenance, and (4) engine overhaul (Katnam et al., 2013). In this case, line maintenance, heavy maintenance, and component maintenance relate to the capabilities of employees or companies in the type of aircraft category, the number of incoming aircraft, and the number of failures, damage, or even fatalities due to negligence in one year, as well as engine overhauls.

Safety Management System (SMS) is a set of concepts and decision-making stages for holders of all work operations to handle and manage safety to create a safe atmosphere with minimum risks. Effective SMS is a tool for identifying hazards and mitigating risks before job operational threats occur (Gill & Shergill, 2004). A Safety Management System (SMS) is a systematic approach to managing safety, including the required organizational structure, accountability, policies, and (Liou et al., 2008). Specifically, SMS is divided into 4 main components, namely (Standards et al., 2013): safety policy, safety risk management, safety assurance, and safety promotion.

The basic framework for implementing SMS in improving the business performance of MRO companies in Indonesia is based on a review of previous research. This review includes several main variables studied previously, namely MRO business performance as an output that the existence of CB and SMS can determine.

2. METHODS

The research object refers to information regarding the variables studied, the research subject (analysis unit and observation unit), the locus, and the time the research was carried out. The variables modeled in this research consist of one exogenous variable (SMS), one mediating or intervening variable (CB), and one endogenous variable (MRO business performance). So, in this research, the object that is the focus of concentration is the influence of SMS and CB, which have implications for Business Performance and the relationship, both correlational and causality, between variables. The subject or unit of research analysis that is the primary source is state-owned and private MRO companies with job titles mechanic, engineering, quality control, specialist, and department and division leaders. The focus of the research was carried out in selected companies, with an implementation time of 10 (ten) months.

Based on its objectives, this type of research is descriptive and verification. Descriptive research aims to describe or carry out the current state of the research object or subject based on visible facts or as they are. Meanwhile, verification shows that research looks for

the influence of the independent variable on the dependent variable. Descriptive research design describes and develops conditions and relationships between variables, including SMS, Capability Building, and Business Performance.

A verification research design is used to test research hypotheses and determine the influence between exogenous, mediating, and endogenous variables through statistical tests relevant to data obtained through online surveys. The research method used is quantitative research with an explanatory survey approach. The quantitative research method is a process of finding knowledge that uses numbers to find information about what to know. Explanatory research is to test hypotheses between hypothesized variables.

This research uses a survey method based on the data collection and collection methods above. Next, data collection uses a scale 1 to 9 questionnaire, using web-based information technology. All responses obtained from the online questionnaire are then processed using the following software: (1) Spreadsheet software (MS Excel) to carry out data scanning and descriptive analysis, and (2) PLS software, Partial Least Square, namely a multivariate statistical technique for handling many variables response and explanatory variables at the same time. The framework model in this study can be depict in Figure 1.

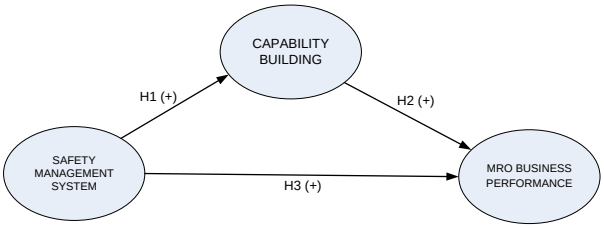

Figure 1. Research Framework
Source: Researcher Development (2023)

Based on the problem formulation and research framework, the main hypotheses in the model are:

1. Safety Management System positively influences MRO Business Performance.
2. Capability Building positively influences MRO Business Performance.
3. Capability Building mediates the influence of Safety Management System on MRO Business Performance.

3. RESULTS AND DISCUSSION

Average scores from dimensions (1) cost and resource efficiency, (2) greater employee engagement, (3) better customer outcomes, and (4) impact on the bottom line in MRO Business Performance are high, ranging from 7.203 to 7.335 (compared to ideal 7 to 9). On average, MRO companies perform well in these four dimensions of business performance. The scores for these dimensions are above average, suggesting that MRO businesses are generally efficient in managing costs and resources, have engaged employees, deliver positive outcomes for customers, and positively impact their financial bottom line.

The dimensions of CB are (1) line maintenance training development, (2) heavy maintenance training development, (3) component maintenance training development, and (4) engine overhaul training development. The average scores of the dimensions are high, ranging from 6.355 (relatively high) to 7.201 (high). These dimensions represent different aspects of training and development within the context of the CB program. The average scores are generally high, with some dimensions performing exceptionally well (three first dimensions) and others performing at a relatively high level (engine overhaul training development), but all are considered favorable.

Overall, the achievement of this SMS construct is 6.873, which is included in the moderately implemented category (in the range of 5,001 – 7,000). This condition shows that

SMS at MRO companies in Indonesia is still not optimal. The safety risk management dimension has been implemented, but the other three dimensions are still in the sufficiently implemented range.

Before analyzing the structural model, Figure 2 depicts the overall model from the PLS calculation results.

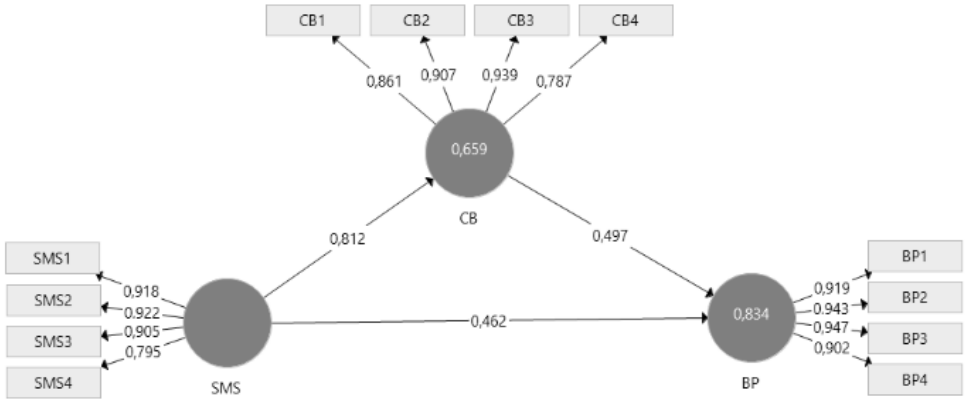

Figure 2. Overall Model
Source: Data Processed (2023)

Standardized Root Mean Square Residual (SRMR) is used to test model fit in PLS, defined as the difference between the observed correlation and the model in the correlation matrix. Thus, the criterion assess the average magnitude of the difference between the observed and expected correlations as an absolute measure of the model fit criterion. The SRMR value is expected to be less than 0.10 or 0.08, considered a good fit. This SRMR value can be used as a goodness of fit (GoF) measurement for PLS-SEM to avoid model misspecification. Referring to the Smart-PLS output results, the overall model fit calculation can be seen in Table 1.

Based on the provided fit indices, the estimated model fits the data well and is comparable to the saturated model in terms of model fit. The fit indices generally indicate a good fit between the model and the observed data.

Table 1. Model Fit

	Saturated Model	Estimated Model
SRMR	0.052	0.052
d_ULS	0.208	0.208
d_G	0.337	0.337
Chi-Square	159.946	159.946
NFI	0.869	0.869
rms Theta	-	0.226

Source: Data Processed (2023)

The structural equation of the model can be formulated into two equations:
CB = 0.812 SMS + e, with R^2 = 0.659
BP = 0.462 SMS + 0.497 CB, with R^2 = 0.834

Referring to the PLS calculation results, a summary of acceptance and rejection of the hypothesis, including direct effects, indirect effects, total effects, and mediation effects, can be explained in Table 2.

Table 2. Hypothesis Testing Summary

	Coef.	T-stat	P-values	Hypo-thesis
CB -> BP	0.497	4.857	0.000	Accepted
SMS -> BP	0.462	4.874	0.000	Accepted
SMS -> CB	0.812	21.76	0.000	Accepted
SMS -> CB -> BP	0.404	4.593	0.000	Accepted

Source: Data Processed (2023)

Table 2 contains path coefficients and their associated statistical information from a structural equation modeling (SEM) analysis. Path coefficients represent the strength and direction of the relationships between variables in a structural equation model, and the associated statistics help assess the significance of these effects.

This coefficient (0.497) suggests that there is a positive and significant relationship between Capability Building (CB) and Business Performance (BP). The T-statistic (4.857) and the associated p-value (0.000) indicate that this relationship is statistically significant, meaning that the effect of CB on BP is unlikely to have occurred by chance. As the hypothesis is accepted, this implies that there is a meaningful and positive impact of Capability Building on MRO Business Performance.

Next, the coefficient (0.462) indicates a positive and statistically significant relationship between the Safety Management System (SMS) and Business Performance (BP). The T-statistic (4.874) and the low p-value (0.000) prove that this relationship is not due to chance. The accepted hypothesis suggests that improving the Safety Management System can positively impact MRO Business Performance.

In the path of SMS -> CB, the coefficient (0.812) represents a strong, positive, and highly significant relationship between the Safety Management System (SMS) and Capability Building (CB). The exceptionally high T-statistic (21.76) and the very low p-value (0.000) indicate a robust and meaningful relationship. The accepted hypothesis suggests that improving the Safety Management System is associated with increased Capability Building within the MRO.

Finally, the coefficient (0.404) signifies a positive and statistically significant relationship between Safety Management System (SMS), Capability Building (CB), and Business Performance (BP). The T-statistic (4.593) and the low p-value (0.000) indicate that this complex relationship is not due to chance. The accepted hypothesis implies that there is a meaningful sequential mediation effect where improvements in SMS lead to increased CB, which in turn positively affects BP in the MRO companies.

As explained in previous studies, there is a close correlation between the Safety Management System and MRO business performance. In this case, the effectiveness of SMS is critical in maintaining safe operations in the MRO business, and here, effective SMS needs to go hand in hand with the development and maintenance of Capability Building (Eickemeyer et al., 2014).

MRO businesses that invest in developing capabilities for safety management can establish a safety culture and implement proactive safety measures that reduce the likelihood of safety incidents or accidents. Improving capabilities in safety management can involve training employees on safety procedures, establishing safety reporting and investigation protocols, and implementing aspects of safety performance to track and improve safety performance (Schneider et al., 2013).

A well-designed SMS can help MRO businesses identify and manage risks, improving safety performance and reducing incidents. By investing in developing capabilities for SMS, MRO businesses can build more robust safety management systems tailored to their unique needs and operations. This SMS may include developing policies and procedures to ensure compliance with regulatory requirements, implementing risk assessments and management practices, and establishing safety monitoring and reporting systems (Rajee Olaganathan et al., 2020).

The research results reveal the mediating effect of Capability Building in the influence of SMS on Business Performance. The research results show that Capability Building can mediate this construct, influencing MRO business performance. The mediation effect for SMS is partial. These findings also show that capability can explain the strengthening influence of the independent variable on the dependent variable, namely MRO business performance.

Developing skills, knowledge, and resources are necessary to build and maintain effective MRO operations and improve business performance. First, increasing capabilities in MRO can lead to increased efficiency and productivity (Sarkar & Mohapatra, 2006). By investing in the training and development of personnel involved in MRO operations, businesses can ensure that their employees have the skills necessary to do their jobs effectively. This development can lead to reduced turnaround times, improved work quality, and increased output, which can help improve business performance and profitability.

Second, increasing capabilities can improve safety performance (Nam et al., 2023). By investing in safety training and education for MRO personnel, businesses can establish a safety culture and a proactive approach to safety management. This SMS can help reduce the likelihood of safety incidents and accidents, which can have significant financial and reputational consequences.

Third, increasing capabilities can help MRO businesses adapt to industry changes and technological advances (Goritiyal et al., 2021). By keeping up with the latest developments in MRO technology, techniques, and regulations, businesses can stay competitive and offer high-quality services to their customers. This development can increase customer satisfaction and loyalty, improving MRO business performance.

Comprehensive capability building is critical to the success of an MRO business. Businesses can improve efficiency, safety performance, and adaptability by investing in developing the skills, knowledge, and resources necessary to establish and maintain effective MRO operations. This operation can improve business performance and sustainable success in the highly competitive aviation industry (Schneider et al., 2013).

The Safety Management System (SMS) can be implemented effectively based on compliance with regulations and standards, reliable MRO Support, and adequate Human Factors. Capability Building can be formed and maintained well by strengthening regulations and standards, reliable MRO Support, and alignment of Human Factors and integration with SMS. However, MRO Support cannot fully support training and development in Capability Building because there are slight differences between the training and development curriculum and conditions in the field. MRO Business Performance can be implemented and achieved effectively and efficiently through increasing Capability Building and implementing SMS based on regulations and standards, MRO Support, and Human Factors. SMS and Capability Building must go hand in hand in improving MRO Business Performance. SMS can contribute to business performance through Capability Building, and conversely, Capability Building can contribute more to business performance through SMS.

4. CONCLUSION

Business performance in aircraft maintenance service companies in Indonesia is considered high, while the Safety Management System and Capability Building are still relatively high. It is confirmed that the Safety Management System and Capability Building can influence MRO business performance in Indonesia. Overall, MRO business performance can achieve the expected effectiveness and efficiency with adequate SMS integration and Capability Building. Capability Building mediates the effect of the Safety Management Systems on Business Performance in aircraft maintenance service companies in Indonesia. MRO business performance can be further improved with intervention from Capability Building based on SMS integration.

The Safety Management System is highly integrated with Capability Building so that SMS cannot develop without Capability Building, and vice versa. One aspect that needs to continue to be developed here is an assessment related to identifying accident risks in the SMS which is integrated with various maintenance and overhauls in the Capability Building. In Capability Building, MRO companies are proposed to pay more attention to the engine overhaul training and development aspect because its contribution still needs to be higher in the development of Capability Building compared to other aspects. Therefore, developing this capability can be focused on understanding training and developing engine overhaul technology.

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