

# Aircraft Redelivery Project Risk Assessment: A Case Study in Maintenance, Repair and Overhaul (MRO) Company

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## Abstract

In the Aircraft redelivery process, MRO companies often experience delays in the completion of aircraft maintenance and repair before being handed over to the lessor (aircraft owner). A study was conducted to analyse the risk causes with a systematic risk management approach. The risk assessment study refers to ISO 31000, which consists of 4 stages: risk-cause identification, risk-cause classification, risk analysis, and evaluation, and risk treatment identification. Root-cause and Pareto analysis also used to help to strengthen the analysis and decision making. This study was conducted in one of the MRO Companies in Indonesia. From a study of 7 cases of aircraft redelivery delay in 2001-2017, it was found that the dominant cause of the risk was late in decision making on new findings of aircraft condition, bad data management, bad system planning, availability of materials and workers, and poor quality of maintenance work. After the risk assessment process, it was obtained that 6 risks causes need to be reduced, 3 risks need to be shared/transferred, and 3 risks need to be accepted.

## 1. Introduction

The aviation industry applies very high safety standards to ensure every flight is safe. Flight safety is very dependent on the aircraft condition. The aircraft condition becomes a particular concern by each airline as the lessee and lessor as the owner of the aircraft when the lease agreement ends. The lessee is obliged to redeliver the aircraft to the lessor in accordance with the redelivery provisions (International Air Transport Association 2017). In this series of redelivery processes, a Maintenance, Repair, and Overhaul (MRO) company is appointed to carry out maintenance and repairs of aircraft. One of the important issues that often occurs is the delay in aircraft maintenance and repair completion. This issue has a big impact on MRO companies related to extended work time and cost, penalty fees of late handover from the lessor, and disruption of subsequent aircraft maintenance activities. Approximately, there are 80% delay occurred in the aircraft redelivery process (Lehri 2019). Since 2010, there has been a significant increase in the aircraft leasing business, and it is estimated that this number will continue to increase, because of its ability to remove residual value risk, provide alternate financing, increase flexibility in orders, and until recently, enable off-balance-sheet debt (World of Leasing Yearbook 2018). Therefore, an effort is needed to improve these conditions so that the risk of delay in aircraft redelivery can be minimized.

All types and sizes of organizations have internal and external factors that influence the achievement of their objectives. The effect of this uncertainty has on an organization's objectives is "risk". Which can be measured by the likelihood and its impact on the organization (Wang and Hsu 2009). Efforts to systematically minimize the impact of risks are called risk management. Risk management has long been an important contributor to most types of management and is widely applied in various areas, such as manufacturing, insurance, services, and economics (Ritchie and Brindley 2007). The study was conducted in one of the MRO Companies in Indonesia. Documentation from the 2001-2017 period about aircraft redelivery delay was analysed. In the literature review process, it is known that there are still a few academic types of research that discuss about risk management in the aircraft redelivery process. Therefore, this study aims to help the MRO Company to minimize the risk of aircraft redelivery process by assessing the risks. The scope of this study includes risk assessment which consists of identifying the risk causes, classifying risk causes, analysing and evaluating the risk causes, and risk treatment categorization. Pareto analysis and root cause analysis are also used to determine the dominant factors and their causes

## 2. Literature Study

Risk assessment is hardly a new or novel undertaking: as individuals, we intuitively analyze, assess, and decide upon a risky situation or life choices with inherently uncertain outcomes as part of everyday living (Edujee 2000). With the growing number of the world's aircraft leasing industry, an effective process of aircraft redelivery has never been so important for aircraft owners as lessor, also for MRO Company who responsible for aircraft maintenance and repair completion. Many studies have been conducted to explain how to manage aircraft redelivery as smooth as possible, including risk mitigation strategies about aircraft redelivery delay (International Air Transport Association 2017; Ackert 2014).

The implementation of the risk management framework in the aviation industry has been studied for a long time, especially in the field of aviation safety (Patriarca et al. 2019; Rios et al. 2019; Guzhva et al. 2019; Lee 2006). The aviation industry has a wide scope of services and processes. There are big research opportunities in risk management related to the aircraft leasing industry due to a few types of research conducted in this area. There is an important phrase at the end of the leasing agreement - the aircraft redelivery process. Compliance with redelivery considerations causes this process to have high complexity and has a significant impact on the lessee and lessor, so that it requires good planning, including risk management. The potential risks arising from this process will increase along with the significant growth potential of world-wide aircraft leasing transactions which are predicted to be worth approximately US \$ 15.8 billion by 2030 (Anonymous 2020). The scope of this study has great potential in developing risk management in the aircraft redelivery process. To answer the research gap described previously, this study focused on risk-cause identification, analysis & evaluation, and risk-cause treatment of aircraft redelivery.

### 2.1 Risk Management

All activities of an organization involve risk. Risk can be interpreted as the possibility of adverse events that interfere with the achievement of objectives (Crane et al. 2013). Risks that arise in operational activities can cause a decrease in performance, which if not handled properly will be able to cause greater and systemic problems, such as the failure to achieve organizational goals. Therefore, a comprehensive risk management study is needed to be able to identify, analysed, map, determine priorities, and develop alternative structured and systematic risk management.

### 2.2 Based on the Research Result Conducted by

Based on the research result which was conducted by Bagian et al. (2002), it is known that ISO 31000 is a powerful framework of risk management to be applied to project management. Generally, a risk management process proposed by ISO (2018), consists of five steps: 1) communication and consultation; 2) establishing the context; 3) risk assessment, consist of risk identification, risk analysis, and evaluation; 4) risk treatment/response; 5) monitoring and review and each of the process have its purpose as described (ISO 2018):

1. The first step goal is to provide, share, or obtain information and to engage in dialogue with stakeholders regarding the management of risk.
2. The second step goal is to define the external and internal parameters to be taken into account when managing risk and setting the scope and risk criteria for the risk management policy.
3. The third step goal is to identify the potential risk and allow the organization to effectively manage the scenario and evaluate the risks identified by likelihood and impact value.
4. The fourth step goal is to decide how to treat the risks based on the risks profile.
5. The fifth step goal is to monitor risks on an ongoing basis, to reduce the likelihood of reoccurrence.

This study focuses on the risk of delays in the aircraft redelivery process, and the scope discussed is only limited to step three and four, that is risk assessment and risk treatment. In the analysis and evaluation, these steps are carried out: determination of risk likelihood and impact scale, risk profile categorization, and the type of risk cause treatment. Table 1 and Table 2 below show the consequence and likelihood scale that has already been used by the MRO Company. Both of the consequences and likelihood have a 1-5 scale, which will indicate the final risk score of each risk causes that already identified in the previous step.

Table 1. Consequence scale<sup>a</sup>.

Consequence (C)		Score
Insignificant	No effect or very little effect to the achievement of goals/objectives	1
Minor	Decreased achievement of goals/objectives	2
Moderate	Significant reduction in achievement of goals/objectives	3
Major	Low achievement of goals/objectives and can cause other severe effects	4
Catastrophic	Very high fatality effects and causes organizational goals cannot be achieved	5

<sup>a</sup>Source: MRO Company Documentation, 2019

Table 2. Likelihood scale<sup>a</sup>.

Likelihood (L)		Score
Rare	Risk occurs very rarely	1
Unlikely	Risk rarely occurs	2
Possible	Risk sometimes occurs	3
Likely	Risk occurs repeatedly	4
Certain	Risk is almost unavoidable	5

<sup>a</sup>Source: MRO Company Documentation, 2019

Table 3 shows the categorization of risk score, and it is obtained by multiply consequence and likelihood scale. The blue line shows the limit of tolerance set by the MRO Company. It was known that High and Crisis risk causes will be a priority to be treated.

Table 3. Risk score categorization<sup>a</sup>.

Risk level (RL)	Risk Score (RS)	Responsibility
Low	1 – 4	Responsibility for risk control is carried out by General Manager and informed to the Vice President
Medium	5 – 8	Responsibilities for risk control is carried out by General Manager and discussed with Vice President
High	9 – 15	The responsibility of risk control is carried out by the Vice President and discussed with the Director, management plan must be prepared immediately
Crisis	16 – 25	The responsibility for risk control carried out by the Vice President and discussed with the Directors, monitored by the Board of Directors, management plan must be prepared immediately

<sup>a</sup>Source: MRO Company Documentation, 2019

The MRO company has already set the categorization of risk treatment/response. The decision about risk treatment categorization is discussed with the project manager because the project manager is the only person who has the authority to decide before the risk causes will be taken care of by the general manager. Table 4 below shows the risk treatment/response category.

Table 4. Risk treatment/response<sup>a</sup>.

Risk Treatment/Response		
Reduce	:	This response was chosen because the risk has a high likelihood to occur and organization has the resources to control it. This risk response requires more effort in risk control, so that the risk score becomes smaller by reducing the value of its consequence or likelihood.
Share/Transfer	:	This risk response is chosen if control needed from other parties inside or outside the organization, i.e. insurance or outsourcing to third party.
Accept	:	This response is chosen if the risk is from external organization, and there is no control that can be applied to the risk. Organizations can only mitigate when the risk actually occurs. Example: Change of government regulations regarding export and import. To mitigate the risk, organization can negotiate or consolidate the solution with custom bureau.
Avoid	:	This response is chosen with the aim that the risk would never occur by eliminate the process. The risks inherent in the process will never exist because the process does not exist. Example: Companies want to avoid exchange rate risk when making transactions with customers, the company decides not to trade in foreign currencies (in Rupiah).

<sup>a</sup>Source: MRO Company Documentation, 2019

### 2.3 Aircraft Redelivery

Aircraft redelivery is a process of returning aircraft from the lessee to the lessor at the end of the leasing agreement (International Air Transport Association 2017). The condition of the aircraft must comply with the requirements specified in the redelivery conditions. A common requirement in the redelivery process is an aircraft is capable to fly without major maintenance. The requirements can be grouped into four categories, consist of (Ackert 2014):

1. Physical requirements, which focus on assessing the physical condition of the aircraft. These requirements consist of: (1) visual inspection of principal airframe units, components, systems, and cabin interior; (2) visual inspection of certified repairs and modifications; (3) engine and APU borescope.
2. Records requirements, which focus being on the satisfactory audit of all aircraft records to ensure compliance with the terms and conditions set forth by the lease and the regulatory authorities. These requirements consist of: (1) current status of the airframe, engines, APU, landing gear, components; (2) current status of applicable AD's and SB's; (3) current status of manuals; (4) current status of certificates; (5) current status of major repairs, alteration, and modifications; (6) statements
3. Performance requirements, which focus on demonstrating the satisfactory operation of the aircraft and all systems comply with the terms and conditions of the lease to the lessor. These requirements consist of: (1) engine power assurance run & condition trend monitoring; (2) check and part live minimums; (3) aircraft acceptance flight; (4) systems functional and operational tests.
4. Certification requirements, which focus to ensure compliance with local regulatory authority requirements and, where cross-border transfers are concerned, compliance with the next lessee's regulatory requirements. These requirements consist of: (1) current certificate of airworthiness and export certificate of airworthiness; (2) EASA Form 1 or FAA form 8130-3 certification on all fitted components; (4) supplemental type certificate (STCs).

Commercial aircraft lease agreements contain standard requirements of redelivery conditions that the lessee/airline operator must comply to. Coverage of contractual redelivery considerations categorized into (Ackert 2014): a.) Pre-redelivery and b.) Return Condition Considerations.

#### 1. Pre-redelivery

This stage is carried out between the lessee and the lessor with the objective to comprehensively assess and document the airplane status against lease return conditions.

This stage consists of 3 parts: 1) pre-redelivery meeting, 2) aircraft records review, 3) aircraft physical inspection.

#### 2. Return condition consideration

The main purpose of redelivery condition consideration is to ensure the interests of the lessor are protected, to determine the value of the residual assets and remarketing potential to the next lessee. The conditions

considerations consist of 1) conditions of engines, 2) conditions of APU, 3) Conditions of Part and Components, 4) Conditions of Airframe, 5) Conditions of Interior, Cockpit & Cargo Compartments, 6) Conditions of Airworthiness Directives, 7) Condition of Repairs, 8) Condition of Modifications, 9) Strip & Paint Condition, 10) Acceptance Flight Condition, and 11) Execution of Return Acceptance Certificate.

### 3. Research Methodology

Besides the literature review and analysis of the ISO 31000 risk management framework, the result of the study was obtained through other several methods to strengthen the analysis and help the decision make the process. The study begins with an analyse of the problem through documentation from the 2001-2017 period about aircraft redelivery project delays. Focus group discussion and an interview were conducted to identify the risk-cause of the aircraft redelivery project delay. The root-cause analysis was used to strengthen the analysis of the main problem, and Pareto analysis was used to capture the dominant risk-cause. A questionnaire was used to capture the perceptions of late and current aircraft redelivery project managers about the likelihood and impact of each risk-cause, and in the second phase were conducted in-depth interviews with the late and current project manager to validate questionnaire results and risk treatment categorization. The Pareto analysis is also used to support decisions related to risk treatment prioritization. The methodology used in this study is shown in Figure 1 below.

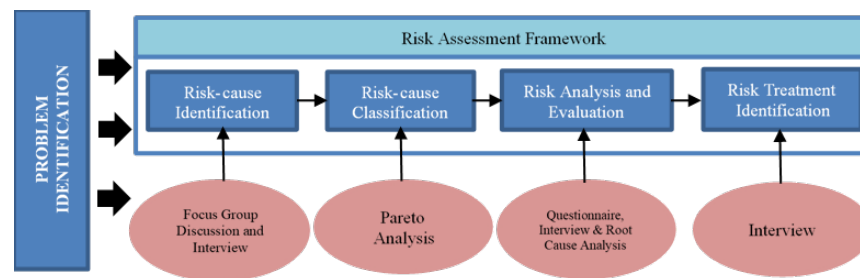


Figure 1. Research methodology

## 4. Result Discussion and Analysis

### 4.1 Risk-cause Identification and Classification

Risk assessment is a critical part of risk management because it involves risk and source of risk identification that can interfere with the achievement of the organization. It also includes an examination of the probability of the potential causes and their consequences (Santos and de Oliveira 2019). The first step of Risk Assessment was risk-cause identification. Since researchers in this area suggest that the risk assessment process has to be carried out by “expertise from the area” (Ayra et al. 2015), this step was based on the late and current project manager’s knowledge and was obtained by held focus group discussion (FGD) and interview. The result of risk-cause identification is shown in the Table 5.

Table 5. Risk-cause identification result.

No.	Risk Cause	Number of Occurrence
1	Late to make decisions on new findings	11
2	Bad data management	8
3	Bad system planning	5
4	Availability of materials and workers	4
5	Poor quality of maintenance work	4
6	Component malfunction	2
7	Poor quality inspection	2
8	Long negotiation process	2
9	Component replacement	1
10	System errors	1
11	CIA late payment	1

12	Long holiday	1
<b>Total</b>		<b>42</b>

The risk classification is carried out using the Pareto analysis approach, which aims to determine the most dominant source of risk that causes delays in the aircraft redelivery process. Pareto chart is one of the decision-making methods that is used for selecting the limited number of tasks that produce the most significant overall effect on a problem (Juran and Godfrey 1998). It is often called Pareto 80/20, which means 80% of effects arise from 20% of causes, or in another term, 20% of the effort will influence 80% of the outcomes (Russel and Taylor 2011). In this study, the Pareto concept means that 20% of the risk causes will account for 80% of aircraft redelivery delays. Based on the Pareto analysis in Figure 2, it is known that the dominant risk causes are late to decide on new problems or findings, bad data management, bad system planning, availability of materials and workers, and poor quality of maintenance work with the total percentage of 76.2%. This is strengthened by the results of research conducted by Lehri (2019), which said that the majority of lessors stated that the cause of delays in aircraft redelivery was late in decision making, bad planning, and unscheduled repairs. Besides, Lehri (2019) also states that in the aircraft redelivery process, the most challenging areas to redeliver on time and budget are data records and engines. Therefore, based on this analysis, MRO companies must begin to improve conditions by prioritizing improvements from the most dominant risk causes, to be able to make significant changes to the achievement of objectives.

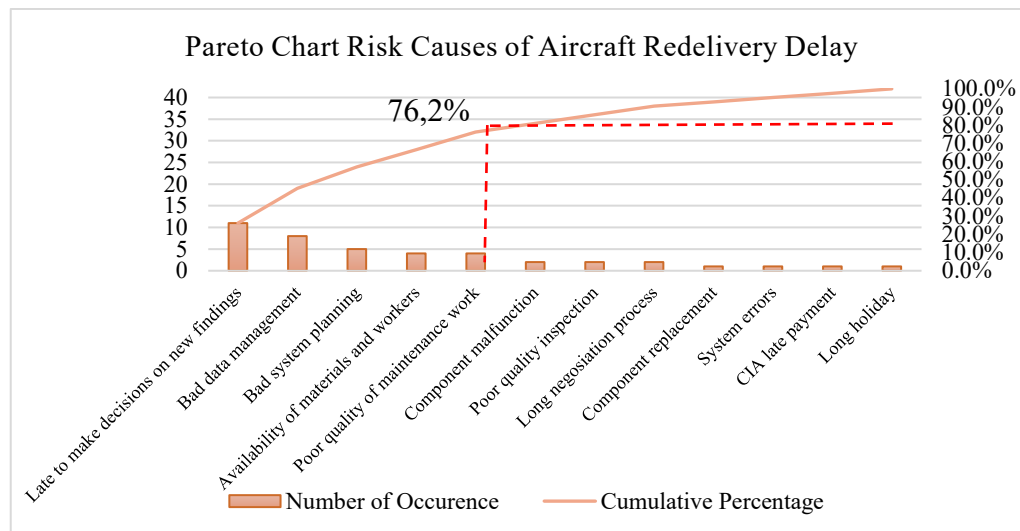


Figure 2. Pareto analysis result.

#### 4.2 Risk-cause Analysis and Evaluation

Risk analysis and evaluation is a process to determine the level of risk, and provide a picture of the causes and consequences, and aims to describe the risk both in qualitatively and quantitatively Aven (2008). This step aims to explore the risk causes of the most dominant causes of delay in the redelivery process which then compiled to the root cause analysis. Root cause analysis is a method of problem-solving that attempts to identify the most critical cause of the fault or problems that occurred (Cerniglia-Lowensen 2015). The main purpose behind root cause analysis is that future problems only can be avoided by identifying and correcting the root cause of problems (Bagian et al. 2002). The root cause analysis carried out by conducted interviews with the company's stakeholder. Figure 3 shows the root-cause analysis of one of the most dominant risk causes that is late to make decision on new findings.

Based on Figure 3, it was known that the risk causes are divided into 5 categories that are materials, methods, machines, men, and managements. One of the main causes of late to make a decision on new findings/problem was the lack of aircraft historical data. It shows that there is still ineffective communication regarding the completeness of aircraft data between MRO company and its' customer. In addition, other main causes are low workers' resource planning and workers utilities, and availability of raw materials that cause too long maintenance lead time. MRO company also need to improve their internal capabilities, especially in maintenance planning and employee scheduling, and also consider to increase the workspaces capacity. The IBA (Lehri 2019) research also shows a similar

result where the main causes of late in decision making regarding the lack of planning, lessor-involved decision making, and poor data management. It shows that these problems are global problems in many MRO companies.

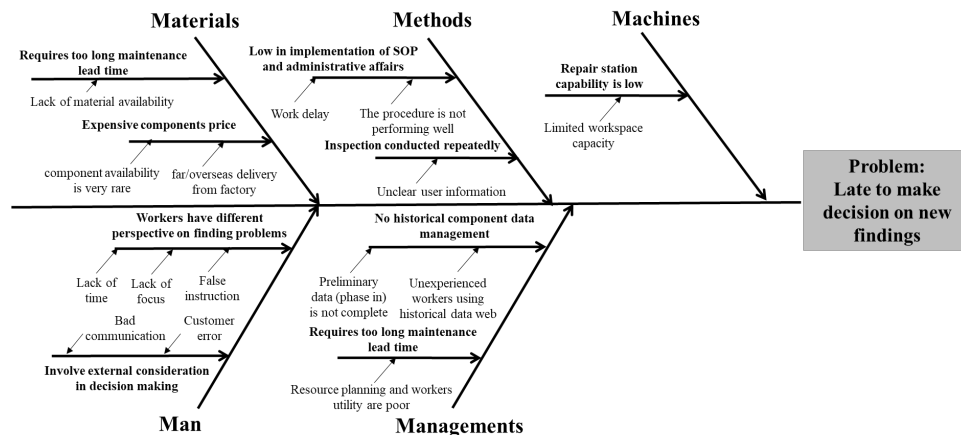


Figure 3. Root-cause analysis of late to make decision on new findings risk cause.

The risk analysis and evaluation step were conducted by distributing a questionnaire to the aircraft redelivery project manager to assess the level of impact (consequence) and frequency (likelihood) of the risk causes. The risk score is obtained by multiplying the value of consequence and risk likelihood. Table 6 shows the result of the evaluation process, which consists of risk-cause code, percentage of frequency, risk score, and risk level. Based on Table 6, it was found that there are two risk causes categorized as a crisis: late in making decisions for new findings and poor data management, one risk cause categorized as high: poor system planning, two risk causes categorized into medium and seven other risk causes categorized as low. This should be a warning sign for the company, because the risk tolerance limits set by the company are in the medium category. The total frequency percentage of risk causes that are categorized as crisis and high is 57.1%, which shows that this risk cause is quite common in the implementation of aircraft redelivery processes.

Table 6. Risk analysis and evaluation result.

No	Objective	Code	Risk Cause	Percentage	No. Of Occurrence	Inherent			Risk Level
						C	L	RS	
1	The Aircraft is redelivered on time and comply the considerations of redelivery conditions	RC 1	Component malfunction	4.8%	2	3	1	3	Low
2		RC 2	Availability of materials and workers	9.5%	4	3	2	6	Medium
3		RC 3	Component replacement	2.4%	1	2	1	2	Low
4		RC 4	Late to make decision on new findings	26.2%	11	4	5	20	Crisis
5		RC 5	System errors	2.4%	1	3	1	3	Low
6		RC 6	CIA late payment	2.4%	1	2	1	2	Low
7		RC 7	Bad data management	19.0%	8	4	4	16	Crisis
8		RC 8	Poor quality of maintenance work	9.5%	4	4	2	8	Medium
9		RC 9	Bad system planning	11.9%	5	4	3	12	High
10		RC 10	Poor quality inspection	4.8%	2	4	1	4	Low
11		RC 11	Long holiday	2.4%	1	2	1	2	Low

12		RC 12	Long negotiation process	4.8%	2	2	1	2	Low
<b>Total</b>				<b>100.0%</b>	<b>42</b>				

In addition, the consequence value for risk causes categorized as a crisis, and high shows a high value. It means that the risk cause has a significant impact on the delay in the aircraft redelivery process. International Air Transport Association, in its research stated that the redelivery of the aircraft process requires excellent system planning, considering that the implementation requires quite a long time and involves various stakeholders and complicated processes. Therefore, MRO companies must improve the existing condition to minimize the occurrence of risk causes by planning improvements according to risk treatment

### 4.3 Risk-cause Treatment

Risk-causes treatment involves selecting one or more options to conquer the likelihood, impact, and the implementation of these options (Santos and de Oliveira 2019). This step was carried out through interviews with the stakeholders, and it was decided that there were six risk causes that were reduced, three risk causes were shared/transferred, and three risk causes were accepted as shown in Table 7. Based on prioritized risk causes, the company should focus on solving them by reducing and transferring the risk causes systematically in order to reduce the delay of the aircraft redelivery process by 80%. From Table 7, it is known that risk causes that accepted, MRO Company can do nothing to solve the problems, for example, the long holiday and long negotiation process because they are related to external stakeholders/environment, so it was decided to accept the risk causes.

Table 7. Risk-cause treatment categorization.

<i>Treatment</i>				
	<i>Reduce</i>	<i>Share/Transfer</i>	<i>Accept</i>	<i>Avoid</i>
<i>Risk</i>	Component malfunction	Availability of materials and workers	Component replacement	
	Late to make decision on new findings	CIA late payment	Long holiday	
	System errors	Bad system planning	Long negotiation process	
	Bad data management			
	Poor quality of maintenance work			
	Poor quality inspection			

## 5. Conclusion

The principal objective of this study is to identify, classify, analyse, and evaluate risk causes of aircraft redelivery delay help the MRO Company to minimize the risk of aircraft redelivery process by assessing the risks and prepare risk cause treatment categorization. From the results of this study, it was known that risk causes which dominantly happen are late to make the decision about new findings, bad data management, bad system planning, availability of workers and materials, and poor quality of maintenance works. This knowledge can be information for managers in MRO Company, as well as the other researchers. There are a few limitations of the present study, along with many possibilities for future research. This study only applied several steps to form the ISO 31000 risk management framework that is related to risk assessment steps. In order to, gain more comprehensive results, future studies could apply the complete risk management framework of ISO 31000 and also enhance the risk treatment activity. Furthermore, future studies could also analyse the application of integrated risk management framework on lessor company, lessee company, and MRO company to obtain the more comprehensive results from all the process that related to aircraft redelivery process.



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