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## PROPOSED RISK MITIGATION IN ASSET MANAGEMENT SYSTEM BASED ON SELF ASSESSMENT METHODOLOGY PLUS (SAM+) FOR ISO 55001: 2014 AND RISK MANAGEMENT APPROACH

### USULAN MITIGASI RISIKO PADA SISTEM MANAJEMEN ASET BERDASARKAN SELF ASSESSMENT METODOLOGI PLUS (SAM+) UNTUK ISO 55001:2014 DAN PENDEKATAN MANAJEMEN RISIKO

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#### Abstrak

Artikel ini membahas tentang gabungan *Self Assessment Methodology Plus* untuk ISO 55001: 2014 dan manajemen risiko dalam rangka meningkatkan kinerja dari sistem manajemen aset. Kedua pendekatan ini diimplementasikan di sebuah perusahaan yang fokus pada perawatan berat lokomotif dan variannya. Studi pendahuluan telah dilakukan menggunakan wawancara terhadap beberapa sumber daya manusia yang bekerja di perusahaan ini dan hasilnya menunjukkan bahwa terdapat kerugian yang hingga ratusan juta rupiah akibat implementasi manajemen aset yang kurang matang. Isu lain lain yang menjadi fokus penelitian ini adalah belum pernah dilakukannya pengukuran tingkat kematangan manajemen aset sehingga organisasi belum mempunyai suatu tolak ukur untuk dapat meningkatkan kematangan manajemen asetnya. sehingga perlu dilakukan analisis penerapan *asset management maturity model* untuk mengetahui bagaimana kondisi manajemen aset di organisasi tersebut sehingga dapat dilakukan penyusunan usulan strategi dan mitigasi risiko. Pada penelitian ini dilakukan pada tiga departemen di perusahaan ini. Pengukuran dilakukan menggunakan *software Self-Assessment Methodology Plus* (SAM+) berbasis ISO 55001:2014 yang dikembangkan oleh The IAM. Manajemen risiko dalam manajemen aset juga dilakukan untuk penyusunan mitigasi risiko sesuai dengan *benefit of asset management*. Setelah dilakukan penilaian, golongan perangkat tukar menjadi golongan yang diprioritaskan untuk mendapatkan usulan strategi perbaikan peningkatan tingkat manajemen aset karena memiliki nilai kematangan rendah yaitu 1,9. Usulan mitigasi risiko juga diberikan terhadap golongan ini dengan dilakukannya pemetaan risiko berdasarkan nilai *severity* dan *likelihood* terlebih dahulu. Mitigasi risiko dilakukan terhadap tujuh *risk event* yang setelah *root cause analysis* menggunakan FTA. Hasil analisis strategi mitigasi yang bisa diimplementasikan oleh organisasi untuk meningkatkan kinerja dari sistem manajemen aset.

**Keywords:** Asset Management Maturity Model (AMMM), ISO 55000: 2014 series, Manajemen Risiko, kinerja manajemen aset

#### Abstract

The combination of Self-Assessment Methodology Plus for ISO 55001: 2014 and risk management to improve the performance of an asset management system is discussed and applied in a company which handles heavy maintenance of locomotives and its variants. The result of the preliminary study showed that the company lost up to hundreds of millions due to a poor practice of asset management. The company never assessed the maturity level of asset management either. From these problems, it is necessary to apply the asset management maturity model to find out how the condition of the organization's asset management can be improved by proposing risk mitigation strategies. This research was conducted in three departments at the company. The maturity assessment was performed using the Self-Assessment Methodology Plus (SAM +) software on ISO 55001: 2014 developed by The IAM. Risk Analysis in asset management was also carried out for the risk mitigation process in accordance with the benefits of asset management. The result showed that the exchanger group was selected as the priority group observed to improve the level of asset management because it had a low maturity value of 1.9. Proposed risk mitigation was also given to this group by conducting risk mapping based on severity and likelihood values. Risk mitigation was carried out on seven risk events after a root cause analysis using FTA. The analysis resulted in a mitigation strategy that can be implemented by organizations to improve the performance of their asset management system.

**Keywords:** Asset Management Maturity Model (AMMM), ISO 55000: 2014 series, risk management, Asset Management performance.

## 1. INTRODUCTION

Organizations often experience problems related to the ability to meet the market demand and good corporate integrity as well as to maintain the performance of a service product. One of the alternatives to deal with these issues is a mature practice of asset management (Chemweno, Pintelon, Horenbeek, & Muchiri, 2015). Asset management is a group of coordinated activities of an organization to realize the value of its assets (ISO, 2014a). Basically, asset management does not focus on the asset but on how the asset can assist the organization to achieve its goal. Assets are one of the main factors that affect organizational performance so assets must be inventoried, identified, audited, and properly assessed. Asset management can be applied through a management process for gaining profits and reducing costs as efficiently and effectively as possible.

Asset management maturity model is one of the models developed by The Institute of Asset Management. It is used to measure the level of maturity in the implementation of the asset management system in an organization. The assessment is done based on ISO 550001: 2014 and contains 39 questions. Self-Assessment Methodology Plus (SAM +) is a tool that can be used independently by an organization to predict the maturity level of its asset management system. The Institute of Asset Management (2015b) in the guidebook of the SAM+ mentions that there are three basic methods used in the SAM+, namely BSI PAS 55: 2008, ISO 55001: 2014, and AM Landscape. In SAM + for ISO 55001: 2014, 27 subjects or clauses with 39 main questions and 87 additional questions are presented.

Based on our preliminary interview to the employees in PT "ABC", an assessment to measuring the level of maturity of asset management, either using BSI PAS 55: 2008, ISO 55000: 2014, or using the Asset Management Landscape has never been done. This is not the only issue; the company also experiences losses up to hundreds of million per year because of an immature practice of asset management. Based on this circumstance, the maturity of the asset management practice of this organization should be observed. In this research, the gap between the required score of The Self-Assessment Methodology Plus and the actual score was then considered as "risk" and analyzed based on a risk management process. This resulted in mitigation strategies to reduce the risk or to improve the performance of the asset management system. The importance of the research is, at this point of

time, there has been no research combining the approach of risk management to improve the performance of asset management system based on ISO 55001: 2014.

On the hand, PT. "ABC" is a capital-intensive organization. It has valuable assets that require a mature asset management system. Thus, an assessment of the maturity level of its asset management is useful to provide an overview of the organization and to offer strategies to increase the efficiency and effectiveness of its asset management process. Due to these circumstances, it is necessary to measure the level of the asset management maturity at PT. "ABC" with the Self-Assessment Maturity Plus based on ISO 55000: 2014. After measuring the maturity level of the asset management, the gap of the assessment result with the desired level of maturity was then considered as risk and analyzed based on a risk management approach. The mitigation strategies generated from the mitigation process were the strategies to fill in the gaps or to improve the maturity level of the asset management. Therefore, it was hypothesized that the combination of SAM+ and risk management approach is capable to generate mitigation strategies proposed to improve the performance of an asset management system.

## 2. LITERATURE REVIEW

Research on the implementation of SAM+ to assess the maturity of an asset management system is very limited, especially the combination of SAM+ with a risk management approach. However, research in the maturity model in other area such as carbon capability, supply chain, agile system, and data analytics capability was found in Wei, Chen, Long, and Zhao (2019); Sanae, Faycal, and Ahmed (2019); Nurdiani, Börstler, Fricker, Petersen, and Chatzipetrou (2019); and Carvalho, Rocha, Vasconcelos, and Abreu (2019). Among the limited, research on measuring the level of asset management was conducted by Godau and McGeoch (2016) in Melbourne Metro Trains Melbourne. The Metro Train company had received BSI PAS 55: 2008 certification and faced another certification at the end of 2013 so they had to assess their level of asset management maturity. It was done based on the Global Forum on Maintenance and Asset Management based on ISO 55001: 2014. Godau and McGeoch (2016) aimed to provide detailed knowledge of the differences between ISO 55001: 2014 and BSI PAS 55: 2008. Between 2013 to 2015, there was a significant improvement on the demand of the maturity level assessment of asset

management measured using AM-Landscape. The difference between this version of maturity assessment and the BSI PAS 55: 2008 is that the first contains 24 perspectives while the second contains 39 different perspectives. In addition, AM-Landscape focuses on the level of global maturity, while BSI PAS 55: 2008 focuses on physical assets.

Research by Lima and Costa (2019) focused on determining criteria that should be considered in measuring the performance of asset management. However, the study did not provide a design or the implementation of asset management maturity model. The method used in the article was Oriented Model for Asset Management (AM-RoM). The data were taken from organizational experts to determine the critical factors in organizational asset management. There are several things that must be considered in increasing the level of asset management maturity, namely the awareness of the organization's professionals, the organization's regulations, the allocation of its resources, and the collaboration between decision making related to risk management.

In Abdelhamid, Beshara, and Ghoneim (2015), the Strategic Asset Management Framework (SAMF) for education buildings in Egypt was applied. The method used was the implementation of SAMF with primary data derived from company experts based on guidance from Asset Management (AM). There are various criteria for this measurement. The first is the people and organization requirements which consist of asset management related to regulations, strategies, and arrangements with a value of 72. The second is a strategic planning recommendation which consists of plans for developing asset management and defining service levels and risk management with a value of 52. The third is the processes and practice requirements which consist of management and maintenance development plans with a value of 57. The last is the data and information system requirements with a value of 74. The results with the lowest value were obtained from the four assessments, then a strategic plan can be drawn up to improve the value. From the literature review, research combining risk management with SAM Plus has not yet been found. Thus, the novelty of this paper is combining SAM Plus based on ISO 55001:2014 and risk management approach to improve the performance of an asset management system.

#### A. Asset Management

Asset management is a series of activities from an organization that aims to realize the value of an asset. The Institute of Asset Management (2015a) states that the set of activities intended is an asset management system in an organization, the intended value of asset management is how assets can relate to balancing costs, possible risks, opportunities, and benefits to improve the organizational performance, while the intended activities are the approach, planning, and implementation in an organization.

Schneider et al. (2006) revealed that asset management is the operation of a system that consists of various assets in a life cycle that can produce sustainable value from an organization and ensure that the specified standards can be achieved.

#### B. Asset Management Standardization

ISO 55000 series has three documents. In ISO 55000 (2014a), the benefits of implementing asset management are elaborated. These benefits can be integrated with related sub-clauses (Britton et al., 2017). According to ISO (2014b) in ISO 55001 (2014), ISO 55001 is a continuation of ISO 55000 providing universal frameworks for asset management in a company. ISO 55001 explains the requirements for organizations to implement asset management based on six aspects of the organization. ISO 55001 consists of seven clauses and 39 sub-clauses. ISO 55002 contains the application of asset management based on the standards that have been issued (ISO, 2014c). ISO 55002 explains further clauses in 55001 and contains the criteria and description needed to clarify the clauses of ISO 55001.

#### C. Asset Management Maturity Model

Maturity models are descriptive models that explain important criteria of an organization to describe the characteristics in a scope of the organization (Wendler, 2012). The purpose of the maturity model is to describe business processes to determine the organization's strategic steps in a simple model (Becker, Knackstedt, & Poeppelbuss, 2009). Maturity model can also be applied to asset management, which is known as asset management maturity model, to be able to meet the current and future needs as seen from several criteria and to guarantee the continuity of the organization (The Global Forum on Maintenance and Asset Management, 2015). Data processing results in the final value of the assessment for each sub-clause. The measurement has been standardized by ISO

55001: 2014, namely maturity level 0, maturity level 1, maturity level 2, maturity level 3, and beyond.

D. Risk Management

Based on AS / NZS 4360:(2004) standard, risk is an opportunity for an event to occur that can have an effect on an object. Risk management can be defined as a comprehensive approach to handle all events that cause harm. The AS / NZS 4360: 2004 standard defines risk management as a process that involves systematic steps or methods that can reduce or minimize losses in managing impacts and risks that help in decision making. Table 1 shows the risk analysis matrix based on likelihood and consequence.

Table 1 Risk Map.

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	High	High	Extreme	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Possible	Low	Medium	High	Extreme	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Medium	High	High

E. Fault Tree Analysis

Fault Tree Analysis (FTA) is a tool for analyzing or translating failures of a system in the form of a combination of graphs of errors made. This tool is very useful in the topic of assessing and describing all types of events in a system (Foster, 2004). This tool is very effective in trying to find the source or core problem because it can identify the relationship between the causative factors in the form of a tree by involving several logic gates. In making an FTA, several important symbols are required. According to Vesely, Goldberg, Roberts, and Haasl (1981) these symbols are as shown in Table 2.

Table 2 Symbols in Fault Tree Analysis.

Symbols	Name	Information
○	Basic Event	Root of a problem that cannot be developed anymore
□	Intermediate Event	Problems that occur because one or more causes
◇	Undeveloped Event	Events that cannot be developed due to lack of information
⌒	And	Errors that occur due to several causes
⌞	Or	Errors that occur due to one mistake

3. RESEARCH METHODS

The research method contains steps taken by researchers in conducting research that starts from determining the object of research to the conclusions. In this section, the method of this research is discussed.

A. Research Flowchart

The detailed research flowchart is shown in Figure 1. It presents the stages of the research from determining the object of the research to developing the conclusions and recommendations based on the research analysis.

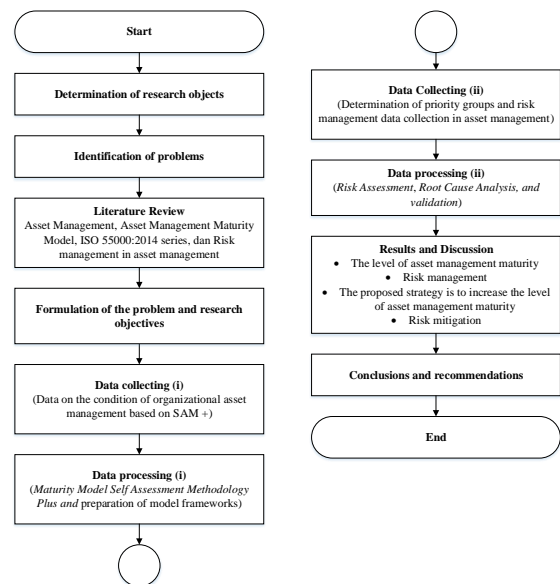


Figure 1 Research Flowchart.

B. Research Object

The implementation of Asset Management Maturity Model based on ISO 55000: 2014 and the proposed risk mitigation strategies in Asset Management in the perspectives of three departments was observed. The research focused on three different departments consisting of seven groups. The first department consists of the component group and the exchanger group. The second department is the production department consisting of metal groups, auxiliaries, and electricity traction. The third department is the planning department, which consists of work sustainability group and work facility group. These three departments have duties and obligations in managing the assets of the facilities and the infrastructure owned by the company.

### C. Data Acquisition Method

The primary data for this study were collected through interviews with the heads of groups or their representatives. Seven face-to-face interviews were conducted at the seven groups in the three departments. The interviews were performed based on the questionnaires in the Self-Assessment Methodology Plus tools. The result of the interview was then recorded directly to the SAM+ application to get direct results. The secondary data were obtained through intermediaries or from organizational documents, articles, and books. The secondary data served to strengthen the qualitative description in the research. The secondary data used in this study included a list of facility assets, namely locomotives in Java Island and a list of facility assets at PT. "ABC" in the form of machinery.

### D. Data Processing

Data processing is the procedure of processing or reviewing information in the form of methods from the interviewees so it can be used for the following steps in research. In this study the data processing stages were carried out as follows:

#### 1. Self-Assessment Methodology Plus (SAM+)

The Self-Assessment Methodology Plus (SAM+) software contains questionnaire developed directly by The Institute of Asset Management based on ISO 55001: 2014. The software is based on Microsoft Excel which consists of seven clauses and 39 questions regarding the maturity level of asset management. After conducting an assessment process, the result is presented in the form of a radar chart of each sub-clause. The radar chart shows the information related to the score of each sub-clause.

#### 2. Risk Identification and Risk Assessment

After assessing the maturity level of asset management to determine the priority of the group with the lowest value, risk identification and risk assessment were then carried out to develop a risk mitigation strategy to improve the performance of the asset management system. Risk assessment in this study used a likelihood and consequence scale adjusted to the conditions at PT. "ABC". In this process, rubrics for each level of likelihood dan consequences were developed, presented, and agreed upon by the interviewees. These rubrics were the basis of determining the likelihood dan consequence level.

### E. Analysis and Discussion

The results of the analysis and discussion were the final data processing carried out based on the data obtained through the interview method based on 39 questions from the SAM+. The results of the analysis and discussion provided information about the condition of asset management along with the assessment of its clauses so it could provide information about clauses that had not been maximized. Furthermore, analysis and discussion on risk mitigation were also carried out at the group with the lowest maturity level to propose a risk mitigation strategy integrated with asset management.

### F. Recommendations for the Proposed Improvement Strategy

Based on the results of the analysis and discussion, recommendations had been made in the form of risk mitigation based on the benefits of asset management in ISO 55001: 2014. The risks from each asset management clause can be integrated with the benefits of asset management so risk mitigation measures can be identified based on ISO 55002: 2014 as a guide for compiling recommendations on risk mitigation strategies to increase asset value.

## 4. RESULTS AND DISCUSSION

After the data processing, the results of the assessment of the maturity of asset management and risk management in asset management were obtained. The result of the interviews was the maturity level of each observed groups at PT. "ABC" as presented in Table 3. The maturity level ranged from 0 to 4 where 0 is immature and 4 is mature, with maturity level 3 as the required level for ISO 55001:2014.

### A. Analysis of Assessment Results

The exchanger group was selected as the group to be prioritized because it had the lowest score of asset management maturity of 1.9, which was reviewed from 27 valuation sub-clauses. This score was plotted in level 1 or at the level of awareness in asset management maturity level. At this level, the organization has identified the needs and requirements for asset management. The organization is also required to be able to provide evidence of the application of management. In addition to having the lowest score, based on the assessment results, this group also had the highest number of clauses whose value was less than 3. In fact, 3 is the target score for each clause in SAM+. Table 3

shows the assessment results of the maturity level of the asset management in the exchanger group along with its associated risks.

Table 3 Correlation of asset management maturity level with risk.

No.	Advantages of	Sub-Clauses Related to	Maturity Level	Code
1	Improved Financial Performance	9.1, 9.2, 9.3	2.3	-
2	Informed Asset Investment Decision	7.5, 7.6.1, 7.6.2, 9.1	2.0	AI3
3	Managed Risk	6.1, 10.1, 10.2	1.2	RM1, RM2
4	Improved Services and Outputs	7.2, 7.3, 7.4, 8.3	2.0	SO2
5	Demonstrated Social Responsibility	6.2.2, 10.1, 10.2	1.6	-
6	Demonstrated Compliance	6.2.2, 7.4	2.5	AM1, AM2, AM3
7	Enhanced Reputation	5.1, 5.3, 7.4	2	-
8	Improved Organizational Sustainability	7.1, 8.2, 10.3	1.5	-
9	Improved Efficiency and Effectiveness	4.4, 5.2, 7.1	2	-

Table 4 shows the result of the level of risk calculated from the multiplication of the severity and likelihood of each identified risk event.

Table 4 Risk Event Rating.

No	Risk Code	Risk Event	Level of Risk
1	FP1	Ineffective financial control on the asset management system	8
2	FP2	Unavailability of baseline for financial use in class	2
3	FP3	Ineffective Measurement of Key Performance Indicators	3
4	AI1	Unavailability of effective data management	8
5	AI2	Inappropriate decision making	5
6	AI3	Difficulty to find required information or poor-quality required information	16
7	RM1	Inability to identify risks to classes in the asset management system	20

No	Risk Code	Risk Event	Level of Risk
8	RM2	Incompatibility of results with what is expected by groups and organizations	10
9	RM3	Increased costs needed	9
10	SO1	Occurrence of communication errors between human resources	9
11	SO2	Inability to produce products that meet the expectations of stakeholder	10
12	SR1	Negative effects on the environment such as pollution	1
13	SR2	Incompatibility of purpose of asset management system with social or environmental goals	1
14	AM1	Tendency of policies to change quickly in a short period of time	10
15	AM2	No interest in groups and organizations in ISO 55001 certification	12
16	AM3	Unavailability of continuous training of external or internal auditors	15
17	RE1	Decreased organizational reputation for stakeholders	3
18	RE2	Insufficient leadership and communication within the organization	4
19	OS1	Inability of groups to cope with rapid changes to the needs of customers	2
20	OS2	Changes are not made at all the organizational levels including groups and implementers.	9
21	EE1	Unavailability of proper measurement of work effectiveness and efficiency	6
22	EE2	No certification of ISO 9001, 14001, 11000, 8000, 55001	6

After the level of risk had been calculated, it was then plotted into a risk map as shown in Table 5.

Table 5 Risk management risk map.

Likeli-hood	Consequence				
	Insignifi-cant	Mi-nor	Mode-rate	Ma-jor	Catashro-pic
Almost Certain				RM 1	
Likely				AI3	



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Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Possible		EE 1, EE 2	RM3, SO1, OS2	AM 2	AM3
Unlikely				FP 1, AI1	RM2, SO2, AM1
Rare	SR1, SR2	FP 2, OS 1	FP3, RE1	RE 2, RE 2	AI2

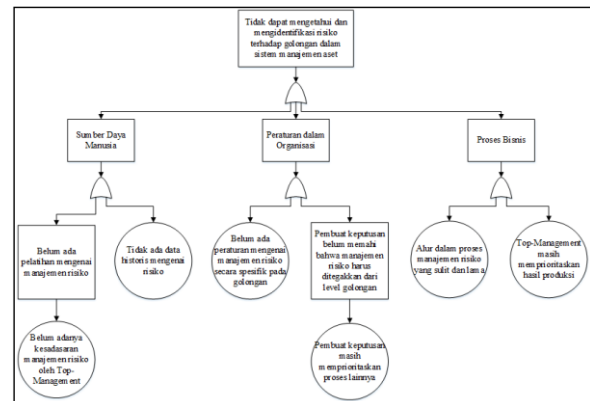


Figure 2 Fault Tree Analysis of RM1.

The risk map indicates that in the exchanger group, there were 22 risk events with the highest value shown in risk RM1. RM1 represents the inability of the group to identify the risks related to the asset management system in its area. This risk obtained a rating of 5 in likelihood and rating of 4 in severity. In the next step, this risk was analyzed by finding the root cause of the risk event to determine the mitigation strategy. The root cause analysis in this paper and that for RM1 employed Fault Tree Analysis as presented in Figure 2.

In developing the proposed improvement strategy, a framework was needed for each clause in accordance with existing assessments. This is the systematic process to improve the maturity level. An example of the result of the proposed strategy can be found in Table 6 dan Table 7. The strategy development was based on the results of the assessment on clause 10 as the most critical clause because the score of this clause was only 1.23.

**B. Proposed Strategy for Improving the Maturity Level of Asset Management**

The mitigation strategy was analyzed on the clauses and sub-clauses which obtained a score less than 3 from the result of the SAM+. The development of the proposed strategy was based on ISO 55002: 2014. ISO 55002: 2014 contains guidance for implementing ISO 55001: 2014. According to a book published by CEDR (2017), to increase the maturity level of an asset management system, there are three main steps: (1) gap analysis, it is a process to determine the gap between the actual level of maturity with the target, (2) development of plan to improve the maturity level, and (3) management of changes as part of the effort to achieve ISO 55001: 2014 certification.

Table 6 Proposed Strategy for Improvement in Maturity Level of Asset Management Level 2.

Sub-Clauses	Proposed Improvement Strategies
10.1	a. The organization should have complete and chronological historical data on issues related to the assets that are owned. b. The organization should prepare every process to identify risks and mitigate risks to the assets owned and have a long-term plan for the treatment of the assets.
10.2	a. The organization should understand every failure of their assets and document properly and consistently. b. There should be a good mechanism in analyzing each failure so damaged assets can be reduced by using predictive maintenance.
10.3	a. The groups should have a mechanism as an effort to make continuous changes because the conditions of the organization change periodically. b. The groups should have criteria or KPIs that are appropriate to the conditions of the organization to have a proper and correct evaluation.

Table 7. Proposed Improvement Strategies for Asset Management Maturity Level 3.

Sub-clauses	Proposed Improvement Strategies
10.1	a. The organization should have valid criteria for asset maintenance including the types of failures to prevent and overcome problems regarding assets properly. b. To prevent corrective actions, an effective process is needed so all failures can be minimized using preventive actions.
10.2	The organization should have a long-term planning in predictive maintenance and preventive maintenance systems that consider the resources they have. The groups should demonstrate and make changes continuously consistently. These changes should refer to sub-clauses 10.1 and 10.2 which provide criteria and identify the types of failure.
10.3	

C. Proposed Risk Mitigation Strategies

As aforementioned, the process to determine the root cause of the risks was done using a Fault Tree Analysis (FTA). The process started with the highest-level risk in the risk map. The development of the mitigation strategy was based on the basic events in the FTA results. A risk mitigation was carried out for RM1 risk event as shown in Table 8.

Table 8. Risk Mitigation for RM1

No	Risk Roots	Mitigation Strategy
1	There is no risk management awareness by the Top-management	Evaluation should start from the level of the implementer so the implementer can provide a definite evaluation of the conditions in the workforce. From the evaluation that starts from the executor, supervisor, assistant manager, and manager, the leader should analyze the problem properly using a bottom-up approach. Meanwhile, upgrading from the leadership at all the organizational levels should be done using a top-down approach.
2	There is no specific regulation on risk management for groups.	Rules should be made by the leadership in the form of work instructions for all groups, including exchanger regarding risk management. Risk management should start from the identification

No	Risk Roots	Mitigation Strategy
3	There is no historical data on risks.	of potential risks to risk mitigation. Each group is required to identify and properly document every problem along with the date of its occurrence to be a basic reference in determining the risk in the next period.
4	The top-management prioritizes production results.	The top management should consider the suggestions given by both internal and external auditors to make continuous improvement to the management system, instead of being in a stagnant management conditions as in the previous period. Auditors from the central office are also required to consider all the management aspects, instead of focusing only on the production.
5	The decision-makers prioritize other business processes.	Given that an audit by the headquarters of the organization is only done once a year, it is necessary to have an internal audit conducted every month by the top-management at PT. "ABC" to overcome the root of the problems periodically so the risk management process does not require a long mechanism.
6	lanes in the risk management process difficult and long	

The result of this research is a strong indication that the combination of SAM+ for ISO 55001:2014 and risk management as the novelty of this research is capable of generating strategies to improve the performance of the asset management system in the observed departments.

5. CONCLUSION

In this research, a combination of an approach based on SAM+ for ISO 55001:2014 and Risk Management was conducted. The purpose of combining the approaches was to improve the performance of an asset management system. This approach combination was then applied to PT. "ABC". The result of the SAM+ was the maturity level of the observed departments. Then, the gap between the required maturity score and the actual maturity score was considered as the risk and mitigated based on the risk management approach. The mitigation process resulted in strategies to improve the performance of the asset



management system at PT. "ABC. Briefly, the proposed approach combination is capable of generating strategies to improve the performance of the asset management system in the observed departments. The strategies proposed in this research are practical strategies because they were constructed based on the interviews with the heads of the groups or their representatives. However, the strategies presented in this paper are only the strategies to improve the lowest maturity level in the clause of ISO 55001: 2014. It is important for the company or other researchers to observe or duplicate the process in this article to improve all clauses whose score is less than 3 in the SAM+.

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