Evaluating and mitigating risk of an automated people mover system project: a case study

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***Shifa Fauziyah, Fardzanela Suwarto, Rudolf Tobing, and Fajar Nurjihad**
Diponegoro University

*Corresponding author email: shifa.fauziyah@live.undip.ac.id

Abstract. Risks describe as the situation of uncertainty. Risks will appear on every construction project, including an Automated People Mover System (APMS) project. The length of APMS track is 3.05 kilometres to connect Soekarno-Hatta Airport terminals 1, 2 and 3. Track APMS is a bridge structure with a simple concept span. Girder was designed with the PC-V concept. More complex project causes various risks. Therefore, to deliver complex projects to success, the risks should be managed. It is important to handle the risk by applying risk management. Risk management has 3 stages: risk identification, risk analysis and risk response strategy. This research was organized through questionnaire and interview with contractor in APMS project. Risk identification using Risk Breakdown Structure (RBS) method. Then the result of risk identification will analyze using probability and impact matrix. The matrix were aimed to earn the risk category and classified into 3 groups i.e. high, moderate, and low. Risk response strategy is to minimize the impact of risk occurence. This research identified 25 risk factors that consist of 7 category: design risks, time risks, material and equipment risks, financial risks, resources risks, managerial risks and external risks. Delay in relocating existing facilities and girder damage risks are the higest risk, both risk should be avoidance. This study purposed to identification and mitigate risks. These findings were valuable for contractor to mitigate risks especially with the same project characteristics.

1. Introduction

Automated People Mover System (APMS) is a new trasnportation mode at Soekarno-Hatta Airport, this mode will be integrated directly with the Commuter Line Station (integrated building) which is a mode of transportation from Manggarai Station to Soekarno-Hatta Airport. Automated People Mover System (APMS) is planned to connect the terminals 1,2,3 at Soekarno-Hatta Airport. Automated People Mover System (APMS) used Girder as the main beam to accommodate total load. The APMS project is classified as a new project in Indonesia and has high complexity [1], so it is important to analyze the risks and manage the risks.

Risks in APMS project are classified into 7 (seven) risk category i.e design, time, material and equipment, financial, resources, managerial and external [2]. Risk management aims to help stakeholder choosing the best action to mitigate the risk using various approaches. Therefore, risk management should be applied and monitored periodically to the probability of impact [3].

This study goals to identify and analyze the potential risks in APMS project. This research organized will be known the risk factors that affect to the project, value of probability and impact, risk category, and risk response strategy of each risk. Besides, this analysis also gives a recommendation for the risk response strategy of the highest risk level.

2. Literature Review

2.1. Risk

Risks describe as the situation of uncertainty [4]. The situation can be an advantage or disadvantage to the project goals, which has a positive impact called opportunities while negative impact called threats [4]. Risk consist of two major elements: (i) the probability of an event occurring, and (ii) the impact due to consequences [3]. The risks in the construction project are permananent, but their impacts can be minimized. Risk is handled independently of the project therefore need an effort to minimize the impact when the risk occurence [5].

2.2. Risk Management

Risk management is an organization to minimize the impact of uncertain situation and/or to reduce the probability of the negative events [6]. According to [7] describes 3 (three) stages of risk management activity: (i) Risk Identification; The risk identification desribes the risks (what, how, when, where and why the risks can happen to the project), (ii) Risk Analysis; calculate the value of probability and impact of the risks. Then the level of each risk is determined, (iii) Risk Response Strategy: risk response is the stage to apply the best actions or strategies to minimize the impact of the risks. When implemented on every project, risk management is directly correlated with project success [6].

The risk factors in this study are acquired from several previous research. Hereafter, the risk factors are validated using questionnaires and interviews methods. The variable of risk factors in this study can be seen in table 1.

Table 1. Related literatures for APMS Project Risk

No	Risk Factors	Reference
	Design	
1	Conflict on work items	Samantra et al., 2017 [2]
2	Poor site surveys	Samantra et al., 2017 [2]
3	Poor constructability of construction	Mubarak et al., 2017 [8]
4	Error in work drawings and specifications	Perera et al., 2014 [9]
5	Change in girder type	Research Proposal
	Time	
6	Tight project schedule	Sarkar and Singh, 2019 [10]
7	Late owner approval	Sarkar and Singh, 2019 [10]
8	Delay in relocating existing facilities	Samantra et al., 2017 [2]
	Material and Equipment	
9	Girder	Research Proposal
10	Low equipment maintaining	Sarkar and Singh, 2019 [10]
11	Unscheduled material delivery	Husin et al., 2017 [11]
	Financial	
12	Inflation	Mubarak et al., 2017 [8]
13	Unexpected Cost	Research Proposal
14	Late Payment	Vidivelli et al., 2017 [12]
	Resources	
15	Unskilled labor	Mubarak et al., 2017 [8]
16	Low productivity	Firdaus et al, 2017 [13]
17	Subcontractor failure	Perera et al., 2014 [9]
	Managerial	
18	Error in choosing construction method	Sarkar and Singh, 2019 [10]
19	Lack of communication and coordination	Vidivelli et al., 2017 [12]
20	Poor project information (soil test and survey report)	Research Proposal

No	Risk Factors	Reference
	External	
21	Poor management of traffic	Sarkar and Singh, 2019 [10]
22	Inadequate labor safety	Samantra et al., 2017 [2]
23	Heavy rainfall	Samantra et al., 2017 [2]
24	Earthquake	Firdaus et al, 2017 [2]
25	Government policy	Research Proposal

3. Research Methodology

Risk management can be classified into three stages, i.e. risk identification, risk analysis, and risk response strategy [7]. Risk identification stage using the Risk Breakdown Structure (RBS) method. RBS is a tool to identifying and grouping the project risks. RBS aims to help the project manager concern on specific risks. RBS output is risk response strategy that will be useful for project manager to mitigate risks.

RBS will be gruped into 4 (four) levels, namely level 0 states a risk identification, Level 1 is a general grouping on a APMS project risk, Level 2 is a category of level 1 and divided into 7 (seven) risk factors such as time, design, material and equipment, financial, resources, managerial and external. Level 3 is a sub-category of level 2 and provide specific risk description (see table 2).

Table 2. Risk Breakdown Structure for APMS project

Level 0	Level 1	Level 2		Level 3	
Risk Identification	Risk of an Automated People Mover System Project	1	Design	X1	Conflict on work items
				X2	Poor site surveys
				X3	Poor constructability of construction
				X4	Error in work drawings and specifications
				X5	Change in girder type
		2	Time	X6	Tight project schedule
				X7	Late owner approval
				X8	Delay in relocating existing facilities
		3	Material and Equipment	X9	Girder damage
				X10	Low equipment maintaining
				X11	Unscheduled material delivery
		4	Financial	X12	Inflation
				X13	Unexpected Cost
				X14	Late Payment
		5	Resources	X15	Unskilled labor
				X16	Low productivity
				X17	Subcontractor failure
		6	Managerial	X18	Error in choosing construction method
				X19	Lack of communication and coordination
				X20	Poor project information (soil test and survey report)
		7	External	X21	Poor management of traffic
				X22	Inadequate labor safety
				X23	Heavy rainfall
				X24	Earthquake
				X25	Government policy

Risk analysis based on questionnaire survey, total data was gathered from 10 respondent. The respondents consisted of project manager, manager engineering, site engineer, consultant. This method is applied to find out the frequency and impact of the risk by presenting a number that shows the risk level [14]. The risk analysis aimed to find the highest risk level that influence to the APMS project.

Table 3. Probability and Impact Matrix (PMBOK, 2017)

Probability	Impact				
	0,05 *very low*	0,10 *low*	0,20 *moderate*	0,40 *high*	0,80 *very high*
0,90 *almost certain*	0,05 Low	0,09 Moderate	0,18 High	0,36 High	0,72 High
0,70 *likely*	0,04 Low	0,07 Moderate	0,14 Moderate	0,28 High	0,56 High
0,50 *possible*	0,03 Low	0,05 Low	0,10 Moderate	0,20 High	0,40 High
0,30 *unlikely*	0,02 Low	0,03 Low	0,06 Moderate	0,12 Moderate	0,24 High
0,10 *almost never*	0,01 Low	0,01 Low	0,02 Low	0,04 Moderate	0,08 Moderate

Table 3 shows combination of probability and the impact. The probability scale consist of values of 0.1 to 0.9 which shows the probability of occurrence is almost never to almost certain. While the impact scale consist of values of 0.05 to 0.8 which shows the impact level from very low risk to very high. The combination of probability and the impact result of the risk rating, which then can be categorized into 3 groups, ie high risk, moderate risk and low risk. The risk rating can be calculated using equation 1.

$$\text{Risk Level} = \text{Probability} \times \text{Impact} \quad \ldots\ldots \quad (1)$$

Risk response strategy, describes the way how to control the project risk. Risk response is classified into 4 (four) types i.e. (i) risk avoidance: the project team acts to relieve risks, (ii) risk transfer: the project team transfers the impact of risk to other party such as subcontractor, (iii) risk mitigation: the project team takes action to minimize the impact of a risk, (iv) risk acceptance: the project team do nothing when the risk occurs [4].

4. Result and Discussion

This study has identified a total number of 25 risk factors, which classified into 7 categories, i.e. design, time, material and equipment, financial, resource, managerial, and external. Recapitulation of respondent's answer to probability (P) and impact (I) is analyzed to find the risk level. Based on these values specified the risk category and response strategies required.

Table 4. Risk Analysis for APMS Project

Variable	Risk Factors	Probability (P)	Impact (I)	Risk Level (P x I)	Risk Category	Risk Response Strategy
	Design					
X1	Conflict on work items	0.7	0.1	0.07	Moderate	Mitigation
X2	Poor site surveys	0.3	0.2	0.06	Moderate	Mitigation
X3	Poor constructability of construction	0.1	0.05	0.01	Low	Monitoring
X4	Error in work drawings	0.3	0.4	0.12	Moderate	Mitigation

Variable	Risk Factors	Probability (P)	Impact (I)	Risk Level (P x I)	Risk Category	Risk Response Strategy
	and specifications					
X5	Change in girder type	0.5	0.2	0.1	Moderate	Mitigation
	Time					
X6	Tight project schedule	0.3	0.4	0.12	Moderate	Mitigation
X7	Late owner approval	0.5	0.2	0.1	Moderate	Mitigation
X8	Delay in relocating existing facilities	0.7	0.4	0.28	High	Avoiding
	Material and Equipment					
X9	Girder damage	0.5	0.4	0.2	High	Avoiding
X10	Low equipment maintaining	0.3	0.4	0.12	Moderate	Mitigation
X11	Unscheduled material delivery	0.1	0.4	0.04	Moderate	Mitigation
	Financial					
X12	Inflation	0.5	0.1	0.05	Low	Monitoring
X13	Unexpected Cost	0.5	0.2	0.1	Moderate	Mitigation
X14	Late Payment	0.3	0.4	0.12	Moderate	Mitigation
	Resources					
X15	Unskilled labor	0.5	0.2	0.1	Moderate	Mitigation
X16	Low productivity	0.3	0.4	0.12	Moderate	Mitigation
X17	Subcontractor failure	0.1	0.4	0.04	Moderate	Mitigation
	Managerial					
X18	Error in choosing construction method	0.3	0.1	0.03	Low	Monitoring
X19	Lack of communication and coordination	0.3	0.2	0.06	Moderate	Mitigation
X20	Poor project information (soil test and survey report)	0.1	0.4	0.04	Moderate	Mitigation
	External					
X21	Poor management of traffic	0.5	0.2	0.1	Moderate	Mitigation
X22	Inadequate labor safety	0.3	0.2	0.06	Moderate	Mitigation
X23	Heavy rainfall	0.3	0.4	0.12	Moderate	Mitigation
X24	Earthquake	0.1	0.4	0.04	Moderate	Mitigation
X25	Government policy	0.3	0.2	0.06	Moderate	Mitigation

Based on the analysis above and shown in table 4, there are 2 (two) risk in high category that is delay in relocating existing facilities (X8) and girder damage (X9) with avoidance strategy response, 20 risks in moderate category with mitigation strategy response and 3 (three) low category risk which are poor constructability of construction (X3), inflation (X12) and error in choosing construction method (X18) with monitoring strategy response.

Delay in relocating existing facilities (X8) is the highest risk on APMS project. Relocating existing facilities such as pipeline, drainage system, electricity system. and other facilities that provide service to the public directly or indirectly. Construction progress would be late if there was existing facilities

on construction plan. Coordinating existing facilities relocation is one of the first project agenda before the construction is taken place to avoid the risk. Engineering manager assigned coordinator to identify existing infrastructure in project or request information about any existing facilities from responsible party [15]. Furthermore, ploting the information about existing infrastructure to the project drawing. By using the legal background to relocate existing facilities, engineering team assessed conflict between existing infrastructure and project plan. Contractor reported alternative choices and schedule of utility relocation. The result of existing facilities relocation plan would be updated on shop drawing. Sometimes most of contractor used third party i.e. subcontractor to handle existing facilities relocation and also to avoid this risk.

Facilities relocation also has impact to increase project cost. Therefore, contractors need price to avoid unexpected condition. The price is called provisional sum [16]. Because of complexity of the works, provisional sum is used to do work that may not be required or scope of work is undefined. An example of an undefined work might be an existing facilities or the ground conditions. The project cannot be started until the existing facilities is demolished and the ground opened up.

Another highest risk is girder damage (X9). When girder arrived on site, the procurement should ensure the girder quality by checked visually. Then the procurement team coordinate with supplier party when dropping and laying the girders on the padd. The padd should have a same size. Besides, give enough space between girders to prevent damage.

5. Conclusion

This research presented the risk management of an Automated People Mover System Project (APMS). Seven risk categories and twenty-five risk sub-categories were identified. Gained 2 (two) high risks that is delay in relocating existing facilities (X8) and girder damage (X9), 20 moderate risks and 3 (three) low risks that is poor constructability of construction (X3), inflation (X12) and error in choosing construction method (X18). The risk of delay in relocating existing facilities and girder damage are the highest risk level. Risk response strategy to avoid the risk of delay in relocating existing facilities delegated coordinator from engineering team to identify existing infrastructure in project and request information about any existing facilities from responsible party. While to avoid the risk of girder damage is coordinate procurement and supplier party when dropping and laying the girders on the pedestal to prevent damage to the girders.

This research is arranged on the first APMS project in Indonesia that using girder as the main beam. Therefore, the study is supposed to convey recommendations to project managers about risk management and risk response strategy on other APMS project.

6. References

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