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

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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 occurrence. 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 highest 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 transportation 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 occurrence [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.

| No | Risk Factors                                      | Reference                        |
|----|--------------------------------------------------|----------------------------------|
| 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                |
| 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]       |
| 9  | Girder                                           | Research Proposal                |
| 10 | Low equipment maintaining                        | Sarkar and Singh, 2019 [10]     |
| 11 | Unscheduled material delivery                    | Husin et al., 2017 [11]         |
| 12 | Inflation                                        | Mubarak et al., 2017 [8]        |
| 13 | Unexpected Cost                                  | Research Proposal                |
| 14 | Late Payment                                     | Vidivelli et al., 2017 [12]     |
| 15 | Unskilled labor                                  | Mubarak et al., 2017 [8]        |
| 16 | Low productivity                                 | Firdaus et al, 2017 [13]        |
| 17 | Subcontractor failure                            | Perera et al., 2014 [9]         |
| 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 |
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

| No | Risk Factors | Reference |
|----|--------------|-----------|
| 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 |

| Level 0 | Level 1 | Level 2 | Level 3 |
|---------|---------|---------|---------|
| 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 respondents. 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 influences the APMS project.

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

| Probability | Impact |
|-------------|--------|
| 0.90 | Low Moderate High |
| 0.70 | Low Moderate High |
| 0.50 | Low Moderate High |
| 0.30 | Low Moderate High |
| 0.10 | Low Moderate Moderate |

Table 3 shows the combination of probability and the impact. The probability scale consists of values of 0.1 to 0.9 which shows the probability of occurrence is almost never to almost certain. While the impact scale consists 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, i.e., high risk, moderate risk, and low risk. The risk rating can be calculated using equation 1.

\[ \text{Risk Level} = \text{Probability} \times \text{Impact} \quad \text{..... (1)} \]

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 does 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 the 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 |
|----------|-------------------------------|-----------------|------------|--------------------|---------------|-----------------------|
| X1       | Design 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 | 0.5 | 0.2 | 0.1 | Moderate | Mitigation |
| X5       | Change in girder type | 0.5 | 0.2 | 0.1 | Moderate | Mitigation |
|          | Time | 0.3 | 0.4 | 0.12 | Moderate | Mitigation |
| X6       | Tight project schedule | 0.5 | 0.2 | 0.1 | High | Avoiding |
| X7       | Late owner approval | 0.7 | 0.4 | 0.28 | High | Avoiding |
| X8       | Delay in relocating existing facilities | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
|          | Material and Equipment | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
| 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 | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
| X12      | Inflation | 0.5 | 0.4 | 0.1 | High | Avoiding |
| X13      | Unexpected Cost | 0.5 | 0.2 | 0.1 | Moderate | Mitigation |
| X14      | Late Payment | 0.3 | 0.4 | 0.12 | Moderate | Mitigation |
|          | Resources | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
| X15      | Unskilled labor | 0.5 | 0.4 | 0.1 | High | Avoiding |
| X16      | Low productivity | 0.3 | 0.4 | 0.12 | Moderate | Mitigation |
| X17      | Subcontractor failure | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
|          | Managerial | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
| X18      | Error in choosing construction method | 0.3 | 0.4 | 0.12 | Moderate | Mitigation |
| X19      | Lack of communication and coordination | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
| X20      | Poor project information (soil test and survey report) | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
|          | External | 0.1 | 0.4 | 0.04 | Moderate | Mitigation |
| 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, plotting 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
[1] E. Science. 2009 Time integration analysis of Soekarno-Hatta International Airport (SHIA) Train with Skytrain. [2] Samantra C, Datta S, and Sankar S 2017 Engineering Applications of Artificial Intelligence Fuzzy based risk assessment module for metropolitan construction project : An empirical study 65 pp 449–464. [3] Pai P S K, Singh A K, Mittal A, and Anand N 2018 Analysis of time overruns in roads and highways sector in India using AHP ranking technique 7 pp 259–262. [4] Project Management Institute 2017 PMBOK: A guide to the project management body of knowledge Fourth: Pennsylvania. [5] Rodney E, Ducq Y, Breysse D, Ledoux Y, Rodney E, and Ducq Y 2015 IFAC-PapersOnLine 48(3) pp 535–540. [6] Kock A and Darmstadt T U 2014 Risk management in project portfolios Is More Than Managing Project Risks : A Contingency Perspective on Risk A Contingency Perspective on Risk Management. [7] Kerzner H 2001 Project Management 7 New York: John Wiley & Sons, Inc. [8] Mubarak, Husin S, and Oktaviati M 2017 AIP Conf. Proc 1903. [9] Perera B A K S, Rameezdeen R, Chileshe N, and Reza Hosseini 2014 Int. J. Constr. Manag 14(1) pp 1–14.
[10] Sarkar D and Singh M 2019 *Int. J. Constr. Manag.* 0(0) pp 1–12.

[11] Husin S, Abdullah, Riza M, and Afifuddin M 2017 *AIP Conf. Pro* 1903.

[12] Vidivelli B, Vidhyasagar E, and Jayasudha E 2017 *Risk Analysis in Bridge Construction Projects* pp 8271–8284.

[13] Firdaus A, Setiawan T, and Sitepu E 2017 The Risk Rating of Delay Risk Factor of Road Construction Project in Papua *Malaysian J. Civ. Eng.* 29(3) pp 345–352.

[14] Kendrick T 2015 *Identifying Project Scope Risk. Identifying and Managing Project Risk* 3 New York: Amacompp.

[15] Cunningham T 2015 *Risk Allocation under the Principal ‘ Traditional ’ Irish Forms of Building Contract* pp 0–16.

[16] Abas A A, Arshad R A, and Ismail Z 2017 *Challenges of Accurate Estimation in Preliminaries of Construction Projects* 23(4) pp 2970–2973.