Estimation model of Jakarta MRT phase 1 project cost overrun for the risk based next phase project funding purpose

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Abstract. The preliminary estimate of Jakarta MRT project cost overrun was considered high by the Provincial Government of DKI Jakarta. Therefore, it is necessary to evaluate the value of the change to see the reasonableness of the Contractor's claim value registered until 2016 and the allocation of contingencies against the possibility of any other claim risk until the project completion in March 2019. The purpose of this study is to analyse the risks that cause cost overrun in MRT Jakarta Phase 1 project that has been allocated and not yet been allocated. In analysing the project risk contingencies, this research method uses Monte Carlo analysis using @Risk software. Survey in this research is conducted to get answers to any risks that impact to the project cost overrun by doing questionnaires or interviews to respondents experienced in MRT Jakarta project or other railway projects. The results of this study are expected to become an evaluation in estimating the final cost of MRT Jakarta phase 1 project and can be a reference for risk-based budget estimation to the next phase of MRT Jakarta project.

1. Introduction
Construction of the Jakarta Phase I MRT Project in The North-South Corridor is carried out on the line connecting from Lebak Bulus to Bundaran HI, which has a length of ± 16 kilometres. The completion of the work is targeted by March 2019. This project has become the concern of many parties and is very suitable for research because it is part of the government's National Strategic Project in 2017. MRT Jakarta is a pioneer in the rise of modern railway technology in Indonesia in general, and DKI Jakarta Province in particular (KPPIP, 2016).

With the Design and Build procurement system, PT MRT Jakarta (MRTJ) uses products issued by the Ministry of Transportation and the DKI Provincial Government which in this case, both parties coordinated for implementation purposes; where the claim issues that arise at this time cannot be separated from the planning products produced by the Ministry of Transportation and the DKI Provincial Government (Lemtek UI, 2017).

In the execution of the Work, MRTJ as the project owner is assisted by the JMCMC Consultant as the Construction Management Consulting Services (CMCS) who is appointed as the representative of PT MRTJ as the party to carry out the monitoring, control and ensure the Contractor performs the work according to the requirements stipulated in the Contract. JMCMC has conducted an initial review and evaluation of the value of claims submitted by the Contractor, or those that are still in the process of submission by the Contractor, herein are referred to as the 1st Reviewer. The estimated increase in the value of the contract was also reviewed in general by the BPKP (State Development Audit Agency) of DKI Jakarta, referred to as the 2nd Reviewer. From the results of the initial
evaluations that have been carried out, it has resulted in an approximate phenomenon of project value increase due to changes in scopes and other conditions amounting to ± Rp 4,2 trillion which was made at work progress ± 26.6% in 2015. This preliminary estimate of Jakarta MRT project cost overrun was considered high by the Provincial Government of DKI Jakarta considering the concept of a Design and Build contract with a Lump Sum Contract Value that is generally understood to be a fixed contract value (fixed price). This potential project cost overrun is required the approval of the DKI Jakarta Provincial Government to be able to apply for additional funding loans to the Japan International Cooperation Agency (JICA) as the organization that provides funding loans for the Jakarta MRT Project. Therefore, in order to obtain the estimation made is reasonable and accountable, an evaluation and justification of the estimated value of the change is needed to see the fairness of the value of the claim and the allocation of the possibility of other claim risks taking into account the technical aspects and type of contract used until the project will be completed (Lemtek UI, 2017).

Changes to project costs, or increases in costs, occur as a result of many related factors, all of which are related to some form of risk. Analysis of the reasons for charging construction project costs is an important step to improve the existing cost estimation system and can be used to determine areas where the biggest improvements can be obtained (Creedy, Skitmore, & Wong, 2010). The phenomenon of increased project costs is due to slow decision making, poor schedule management, rising material / machine prices, poor contract management, delays in providing design approvals, requested design changes from the authorities as regulators, rework due to wrong work, delays of land acquisition, wrong estimation / cost estimation method is the main cause of cost increases. The main causes identified by this study will be compared with findings from other countries and there are similarities that are quite relevant (Subramani, Sruthi, & Kavitha, 2014).

Delays in construction projects, cost overrun, and low quality have long been a common problem in the construction and engineering sectors. In particular, the increase in time and costs in large public construction projects seems to be a global phenomenon, namely without a decrease in the last 70 years and an average cost that exceeds 28% (Larsen, Shen, & Lindhard, 2016). Cost overrun is defined as actual costs that exceed the budget, can also be called cost increased, or excess the budget. The key to overcoming the cost overrun problem is to identify key of risk factors, which is also not easy. Understanding of risk can help all parties involved to reduce its negative impact on the increase in costs (Vu, Wang, Min, Mai, & Nguyen, 2016).

Further research is not only done for the factors and indicators that cause cost overrun in the Design and Build project, but also improves project performance and team management strategies. The purpose of this paper is to investigate various risk sources and to evaluate how to measure contingency in budgeting to anticipate the impact of cost overrun in future projects, especially those caused by variation works. This paper looks at the project owner's perspective.

2. Literature Review

Design and Build (D & B) is an integrated contract approach that provides design and construction services in a single contract with a single point of responsibility (Qing Chen, 2015). It is known that the project delivery method in Design and Build (D & B) can reduce the number of claims from the contractor to the owner because a designer becomes a member of the contractor's project team (Pardis Pishdad-Bozorgi, 2012). However, a project risk in this Design and build system must remain and has been defined as an uncertainty that can generate positive opportunities or negative impacts (O. E. Ogunsanmi, 2011).

2.1 Object of Research

The Mass Rapid Transit System Project Phase I of the Lebak Bulus - Bundaran HI Corridor had been prepared for a long time and through a complete study process since 2006 and finally began its construction in 2013 with a completion target in early 2019. This project length is ±16 km which is divided by two sections, ±10 km for elevated structures including depot, and ±6 km for underground structures. The project has a role in providing rail-based mass transportation modes that are able to
transport large numbers of passengers and in a short time as that in one trip, a series of trains can carry 1,950 passengers. In a day, it is targeted to transport 173,000 passengers (PT MRT Jakarta, 2017).

Furthermore, Sumitomo Corporation as the train provider for MRT services also added that the train to be used in the MRT service would use the automatic train operation (ATO) system and have the Standard Urban Railway System for Asia (STRASYA) standard. With this system, train travel will be fully controlled through Operation Control Center (OCC) located at the Lebak Bulus Depot. Whereas a machinist is only in charge of pressing the door opening button, pressing the start button when going to run the train and during an emergency. It is possible that this can be an advantage of the MRT so that residents from both inside and outside Jakarta can optimize their use so that the inefficiency of mobilization time can be significantly reduced. In addition, Jakarta MRT railway system will use the latest signaling system in Indonesia by introducing the CBTC (Communication Based Train Control) signaling system and implementing a moving block system for train travel arrangements (PT MRT Jakarta, 2017).

2.2 Cost Breakdown Structure

Cost Breakdown Structure classifies costs in the project to the unit cost / cost center and cost / type of cost elements. The formation of a cost structure helps in efficient cost planning, control, and the introduction of measures to reduce costs (Weaver, 2014).

The Cost Breakdown Structure is based on the WBS (Work Breakdown Structure). WBS is job decomposition in a hierarchical and deliverable-oriented manner carried out by the project team in order to achieve project objectives and produce a desired deliverable (Project Management Institute, 2013).

Making WBS is a process of describing deliverables and project work in the form of individual components in the form of lists that are top down and hierarchically explain the components that must be built and the work associated with them. The WBS itself is a system that divides the project into several manageable work packages, either from components, or WBS elements to provide a general framework for scheduling, costs, communication, risk assessment, supervision and control (Project Management Institute, 2013).

The table below shows details of the costs for five metro in the USA into several subsystems (Federal Transit Authority, 1992). The next table shows the same details for metro extension line projects in Madrid, Caracas, Mexico City and Santiago, which use cost breakdowns that are somewhat different from those used for metro USA (BB&J Consult, 2000). For metro in the USA, project costs can be separated for the station subsystem, while non-USA metro does not. As for Metro USA, train / rolling stock costs are not separated, in contrast to non-USA metro costs which separate the costs for rolling stock.

| Item      | San Francisco BART (%) | Atlanta MARTA Phase A (%) | Baltimore MTA Phase I (%) | Chicago CTA O’Hare (%) | Boston MBTA Red Line South (%) |
|-----------|------------------------|---------------------------|---------------------------|------------------------|-------------------------------|
| Land      | 7                      | 9                         | 2                         | 0                      | 11                            |
| Guideway  | 37                     | 37                        | 33                        | 25                     | 20                            |
| Stations  | 19                     | 20                        | 30                        | 28                     | 33                            |
| Trackwork | 3                      | 2                         | 2                         | 7                      | 7                             |
| Power     | 2                      | 1                         | 2                         | 7                      | 5                             |
| Control   | 4                      | 2                         | 4                         | 8                      | 7                             |
| Facilities| 2                      | 3                         | 2                         | 4                      | 0                             |
| Eng./Mgt./Test | 14                   | 23                        | 24                        | 8                      | 6                             |
| Vehicles  | 12                     | 7                         | 9                         | 20                     | 15                            |

| Total     | 100                    | 100                       | 100                       | 100                    | 100                           |
Table 2. Components Cost for 5 metro in Madrid, Caracas, Mexico City and Santiago.

| Item                              | Mexico City Line B (%) | Caracas Line 3 (%) | Santiago Line 5 (%) | Santiago Line 5 extension (%) | Madrid extension excl. Arganda (%) |
|-----------------------------------|------------------------|--------------------|---------------------|-------------------------------|-----------------------------------|
| Civil works for tunnels only      | 24.5                   | 32.8               | 36.4                | 40.5                          | 54.6                              |
| Equipment                        | 18.0                   | 24.2               | 16.6                | 13.9                          | 14.2                              |
| Rolling stock                     | 36.2                   | 15.7               | 24.8                | 21.4                          | 15.4                              |
| Design and supervision            | 3.4                    | 3.6                | 5.5                 | 10.3                          | 1.9                               |
| Track                            | 5.3                    | 2.8                | 6.3                 | 4.3                           | 3.5                               |
| Power                            | 5.2                    | 8.9                | 4.4                 | 2.8                           | 2.4                               |
| Signalling and communications     | 4.1                    | 6.8                | 4.3                 | 5.2                           | 2.7                               |
| Station equipment                 | 0.2                    | 2.3                | 0.7                 | 0.4                           | 1.7                               |
| Escalators and lifts              | 0.3                    | 2.1                | 0.2                 | 0.9                           | 2.7                               |
| Passenger toll equipment          | 0.5                    | 0.7                | 0.5                 | 0.2                           | 0.3                               |
| Workshop equipment                | 2.3                    | -                  | 0.3                 | -                             | 0.6                               |
| Total                             | 100                    | 100                | 100                 | 100                           | 100                               |

In the Jakarta MRT project which is consist of 8 (eight) Contract Packages, the structure or component of this project cost can be explained for each package which will be shown in the tables below. The cost structure of the Jakarta MRT project is obtained and combined from the Contract Package No.101 (CP101) up to Contract Package No.108 (CP108).

Table 3. Cost Structure of Jakarta MRT Project Phase 1

| No | Description                                                                 | %  |
|----|-----------------------------------------------------------------------------|----|
| 1  | Preliminaries and General Requirements                                      | 9.46% |
| 2  | Design                                                                      | 2.94% |
| 3  | Depot Civil and Building Works                                              | 3.11% |
|    | Depot and Workshop Equipment (not including Substation and Signal, Telecom)  |     |
| 4  | Transition Structure of Depot Entrance                                      | 3.46% |
| 5  | Viaduct Substructure                                                        | 3.48% |
| 6  | Viaduct Superstructure                                                      | 4.60% |
| 8  | Bridge Over Jakarta Outer Ring Road                                         | 0.35% |
|    | Open Cut, Transition Structure and Cut and Cover Tunnels                    |     |
| 9  | and First Pour Tracked Concrete                                             | 0.50% |
| 10 | Bored Tunnels including First Pour Concrete                                 | 6.85% |
| 11 | Cross Over Cut and Cover Structure for Scissors Crossing                    | 1.70% |
| 12 | Elevated Stations                                                           | 4.98% |
| 13 | Underground Stations                                                        | 12.58% |
| 14 | Substations (Civil)                                                         | 0.20% |
| 15 | Environmental Control System                                               | 3.85% |
| 16 | Water Supply, Plumbing and Drainage Services                                | 0.67% |
2.3 Causes of Cost Overrun

Project risk is defined as events or conditions that are uncertain, if they occur, have a positive or negative effect on one or more project objectives such as scope, schedule, cost, or quality (Project Management Institute, 2013). MRTJ has identified several conditions of Variation Order (VO) that correspond to the VO list received, including land acquisition (for depot area, for along the elevated main line, and location for Cooling Tower (CT) & Ventilation Tower (VT) in underground section) which has the potential to add a claim for prolongation cost or extension of time, utility relocation (gas pipeline) which has the potential to increase costs for uncharted utilities, design changes after bidding due to regulator requests / policies which are one of the variations (Lemtek UI, 2017).

In early of 2016, the details of the claim value or VO for each work package were submitted as the Contractor's claim as follows (Lemtek UI, 2017). This is what we called as inherent risks which calculated from the risks that have been allocated / planned (planned risks):

a) VO due to changes in earthquake regulations which have an impact on design changes;
b) VO due to regulations prohibiting the use of BJTS 50 (standard type of reinforcing steel);
c) VO due to utility relocation;
d) Compensation for the impact of the delay in land acquisition that will be calculated against the extension of time (EOT) and overhead costs of the Contractor.

According to Subramani, Sruthi, & Kavitha (2014), the main causes of project cost overruns include but are not limited to the following:

| No | Description                                | %   |
|----|--------------------------------------------|-----|
| 17 | Fire Detection and Suppression Services    | 1.07% |
| 18 | Electrical Works                           | 3.52% |
| 19 | Signage and Graphics                       | 0.18% |
| 20 | Substation System                          | 3.64% |
| 21 | Overhead Contact System                    | 1.91% |
| 22 | Power Distribution System                  | 3.00% |
| 23 | Signaling System                           | 3.33% |
| 24 | Telecommunication System                   | 1.52% |
| 25 | Facility SCADA System                      | 0.23% |
| 26 | Automatic Fare Collection System           | 2.07% |
| 27 | Platform Screen Doors System               | 1.42% |
| 28 | Escalators - Elevators                     | 1.06% |
| 29 | Track works                                | 5.07% |
| 30 | Manufacture/Procurement Motor Car          | 8.83% |
| 32 | Shipping and Delivery to Depot             | 0.77% |
|     | Spares, Special Tools, Testing Equipments  |       |
| 33 |                                           | 0.31% |
| 34 | Testing and Commissioning                  | 0.35% |
| 35 | Product Support                            | 0.06% |
| 36 | PROVISIONAL SUMS                           | 0.36% |
| 37 | PROVISIONAL SUMS for DAYWORKS              | 0.43% |
| 38 | Construction Management Consulting Services| 2.10% |
|    | Total                                      | 100% |

2.3 Causes of Cost Overrun
a) Inadequate project formulation: Poor field investigation, inadequate project information, poor cost estimates, lack of experience, project formulation and inadequate feasibility analysis, poor project appraisal leading to wrong investment decisions.

b) Poor planning implementation: Inadequate time plans, inadequate resource plans, inadequate equipment supply plans, unanticipated linkages, poor cost planning, poor organization.

c) Lack of proper contract planning and management: Improper pre-contract actions, poor post-award contract management.

d) Poor project management during execution: Inadequate and ineffective work, delays, changes in the scope of work and location, laws and regulations.

There are also contingent risks which have the probability is less than 100% and has not been allocated until the completion of the project. The purpose of contingency risk allocation for estimating this project cost overrun is to cover costs that are not known with certainty when the estimate is developed. This could be due to incomplete engineering, lack of time to get definite pricing, minor errors or omissions and a change in the scope of the project (Bouayed, 2016).

The following are the results of data collection of contingent risks from Legislative Council (2012), Ejaz (2011), and Park (2012):

Table 4. Contingency Risk that Caused Cost Overrun

| No. | Risk Category       | Risk Events for Project Owner                                                                 |
|-----|---------------------|---------------------------------------------------------------------------------------------|
| 1   | Legal risks         | Local Regulation Changes                                                                     |
| 2   | Not Gain Licensing  | for Train Operations                                                                        |
| 3   | National Regulation | Changes in the Political Situation                                                           |
| 4   | Standard / Specification Changes |                                                                 |
| 5   | Political Risks     | Changes in the Political Situation                                                           |
| 6   | Complicated in bureaurecy |                                                                 |
| 7   | Economics / Finance Risks | Delayed payment to Contractors/Consultants                                                   |
| 8   | Financial Condition of Project Owner |                                                                 |
| 9   | Changes in Currency Exchange |                                                                 |
| 10  | Financial Condition of Contractors |                                                                 |
| 11  | Inflation           |                                                                                             |
| 12  | The high of Indirect Cost |                                                                                          |
| 13  | Social Risks        | Demonstration / protest from the public                                                     |
| 14  | Natural Risks       | Unexpected geological conditions                                                             |
| 15  | Management          | Poor Control of project                                                                      |
| 16  | Risks               | Organizational change of Project Owner                                                       |
| 17  | Lack of planning and scheduling |                                                                                          |
| 18  | Lack of preparation | in the estimation of Budget                                                                 |
| 19  | Decision-making is slow |                                                                                          |
| 20  | Risk Design / Methods | Drawing/Specification while preconstruction study / initial investigation does not match with construction |
| 21  | The shallowness of the design |                                                                                          |
| 22  | Inaccurate Design   |                                                                                             |
| 23  | Interface Design Issues |                                                                                         |
| 24  | Request for change of working methods / design from client / external parties |                  |
| 25  | Low productivity from Contractors |                                                                                          |
| 26  | Delay information / lack of communication / meetings |                                                |
| 27  | Poor Safety/Security |                                                                                             |
| 28  |                                                                 |
| No. | Risk Category          | Risk Events for Project Owner                                                                 |
|-----|-----------------------|-----------------------------------------------------------------------------------------------|
| 29  | Poor Health           |                                                                                               |
| 30  | Error in Construction Method |                                                                                           |
| 31  | Delays in the inspection and testing works |                                                                                           |
| 32  | Operations and Logistic Risks | Postpone works instruction from the Client                                                        |
| 33  | The delay in land acquisition |                                                                                           |
| 34  | The delay in relocation of utilities |                                                                                           |
| 35  | Lack of resources / equipments / materials |                                                                                           |
| 36  | Defects in materials and construction equipments |                                                                                           |
| 37  | Delay in delivery of materials and equipments |                                                                                           |
| 38  | Additional for Temporary Works |                                                                                           |
| 39  | Additional for Permanent Works |                                                                                           |
| 40  | Contractual Risks     | Type of contract used is not appropriate                                                        |
| 41  | Contract duration is not appropriate |                                                                                           |
| 42  | The contract awarded to the lowest bidder |                                                                                           |
| 43  | Work Package price is unrealistic |                                                                                           |
| 44  | Poor Contract Management |                                                                                           |
| 45  | Price escalation (price adjustment) |                                                                                           |
| 46  | The contract is not clear in managing Dispute |                                                                                           |

2.4 Risk Based Model Estimation for Cost Overrun

Based on Project Management Institute (2013), when the project takes place, the project team can develop a cost estimate to project completion (Estimate at Completion / EAC) which may differ from the Budget at Completion (BAC) based on project performance. The EAC is usually based on the actual costs (AC) incurred for the work completed, plus an estimate to complete the remaining work (ETC). It is the task of the project team to predict what might be encountered in conducting an ETC, based on its experience to date. So that in this study the EAC = AC + ETC formula will be used.

According to the Department of Planning, Transportation and Infrastructure (2012) on manual estimates of estimated costs of road and rail projects from Government of Australia, estimated project costs can be defined into Project Options Estimates as can be seen below:

| Table 5. Project Options Estimates |
|-------------------------------------|
| **Base Estimate**                  | Added between client fees and original construction costs | |
| +                                   | Inherent Risks calculated from the risks that have been allocated / planned |
| Contingency Reserved                | Contingent Risks calculated from unknown risk items (unplanned risks) |
| *(Inherent & Contingent Risks)*     | =                                                                 |
| **Project Options Estimate**        | Total from Base Estimate and Contingency Reserved |

Weaknesses of methods for calculating contingencies have encouraged the search for stronger methods. Baccarini (2005) conducted a literature review of this method. Monte Carlo simulations are found as the most widely accepted method for estimating the cost contingencies needed because project cost estimators become more aware of their increased effectiveness during traditional percentage approaches.
After the data collection process is complete, a Monte Carlo simulation can be done to determine the overall risk of the combined costs of the project. Bouayed (2016) uses the @Risk and Decision Tools software from Palisade Corporation, because the number of iterations required makes this process impossible by hand. For each iteration, a Monte Carlo simulation randomly selects the cost for each item, according to the specified probability distribution, and then adds together the costs of all elements, to get the total project cost. The procedure is repeated many times. When the simulation is complete, the total project costs generated from each iteration are plotted on the histogram. Cost distribution for the total project is the basis for estimating the contingency of the costs required. (Bouayed, 2016).

3. Research Methodology
This research conducted through a series of data collection and analysis processes, it can be concluded that to produce the cost structure of the Jakarta Phase 1 MRT Project, data collection was carried out in the form of an analysis of BOQ (Bill of Quantity) data archive of Jakarta Phase 1 MRT project from Contract Package 101 - 108 for get a basis for calculating the initial Contract Value (Base Cost). Then archival analysis is also needed to identify risks that have been included in the risk of increasing project costs when the project is underway which is called inherent risk. The archive used for inherent risk cost analysis is obtained from Lemtek UI through Third Party Reviewer Consultation Service Report in 2017.

Furthermore, a literature study related to contingent risks will be analyzed to be the contingent costs which are the cost reserves to anticipate uncertainty conditions until project completion allocated to work items based on experience and implementation of previous projects (Adi & Yunwanti, 2014). Then proceed with expert validation to a number of experienced experts in the field of modern railroad construction to obtain contingent risk data which is a risk that has never been identified before. This risk needs to be anticipated to affect the increase in costs in the Jakarta MRT project until the completion of the project. So that obtained some qualitative data input from the questionnaire results from 30 respondents who assessed the magnitude of the impact and frequency of each contingent risk. After obtaining the questionnaire data, a homogeneity test was conducted for the respondent's data based on the latest educational background, position / position, work experience, and agency and also validity and reliability to ensure that the data was valid. The final step is to make a risk rating and analyze for the type of data distribution for each of the top 10 risks using goodness of fit test method.

The next step is to do a monte carlo test analysis using the @Risk software where later the percentage figure will be the amount of contingency costs that must be anticipated until the project is completed. Then, from several simulations given, it will be obtained the amount of contingency costs that will be added to the previous inherent costs that have been calculated, and finally added the base cost value of the project, then we will have the total cost of the Jakarta MRT project Phase 1 which already applied as an model estimation for the risk-based cost overrun.

4. Result and Discussion

4.1 Base Cost of Jakarta MRT Project Phase 1
The data collection process carried out by researchers to obtain various phenomena, information and research conditions in accordance with the scope of research using archival data collection. Archive data collection is used as a reference for determining the specification of the WBS form of the Jakarta MRT construction project. In its implementation, the researchers refer to the Contract Document from the Work Package “CP101”, “CP102”, “CP103”, “CP104”, “CP105”, “CP106”, “CP107”, “CP108” and “Construction Management Consultancy Service Work” to get the portion of the cost of each component which is the total cost of the Jakarta MRT phase 1 project at the beginning of construction (base cost). The said base cost can be seen in the Table 3. The initial total cost of Jakarta MRT Project Phase 1 is ± Rp 11,8 Trillion or ± USD 868 million (currency rate 1 USD = 13,580 IDR).
From the results of combining all the cost components of the CP101-CP108 Job Package, it was obtained that the 5 (five) largest sequences of each project cost structure were as follows:

1. Underground Station Works 12.58%
2. Preliminaries and General Requirements (Preparation and non-permanent work) 9.46%
3. Manufacturing and Procurement of Rolling Stock (16 MRT Train sets) 8.83%
4. Tunnel Boring Machine for tunneling works 6.85%
5. Trackworks 5.07%

4.2 Inherent Risk Cost

Inherent Risks calculated from the risks that have been allocated/planned when the project progress was 26.6% in 2015. The collection of Inherent Risk data is obtained from the analysis of the Jakarta MRT document file, namely on the report of Third Party Reviewer Consultancy services provided by Lemtek UI in 2017. The report describes the details of the claim that has been submitted by the contractor for additional work that can be approved as Variations (claimable) or which cannot be approved as Variations (unclaimable) due to consideration of the type of design and build contract.

From the table below, it can be concluded that the value of Inherent Risk (not including contingency) that has been estimated by the Consultant 3rd Party Reviewer or Lemtek UI (2017) is ± Rp 3.7 Trillion or 31.83% of the initial Contract value.

| Work Package | Percentage from Total Initial Contract Value |
|--------------|---------------------------------------------|
| Design Changes in Accordance with the Latest Earthquake Regulations | 3.09% |
| Design Changes to the BJTS-50 (standard type of reinforcing steel) Prohibition | 1.00% |
| Changes in Cooling Tower & Ventilation Tower Locations | 2.94% |
| Changes in Design upon Request by Regulators | 2.13% |
| Claim due to delay in Utility Relocation | 1.28% |
| Claim due to delay in land acquisition | 0.18% |
| Variations due to Interfaces between work packages | 2.00% |
| Other variations | 0.22% |
| **Total of Variations (VO)** | **12.83%** |
| Price Adjustment (PA) | 15.30% |
| Prolongation Cost due to Extension of Time | 1.61% |
| Additional cost for Construction Management Consulting Services | 1.09% |
| Claim due to delay payment | 1.01% |
| **Total VO + other Claims** | **31.83%** |

To validate the mapping of inherent risks with cost structure that have been obtained, the author also analyzes archives based on Third Party Reviewer Report provided by Lemtek UI (2017). So that there is an inherent risk allocation for cost structure in the following table.

| No | Description | % from total of Inherent Cost | % from total of Initial Cost |
|----|-------------|------------------------------|-----------------------------|
| 1  | Preliminaries and General Requirements | 19.4% | 6.17% |
| 2  | Design | 18.4% | 5.85% |
| 3  | Depot Civil and Building Works | 2.0% | 0.65% |
| 4  | Depot and Workshop Equipment (not including Substation and Signal, Telecom) | 0.0% | 0.00% |
| No | Description                                                                 | % from total of Inherent Cost | % from total of Initial Cost |
|----|------------------------------------------------------------------------------|-------------------------------|------------------------------|
| 5  | Transition Structure of Depot Entrance                                       | 1.0%                          | 0.32%                        |
| 6  | Viaduct Substructure                                                          | 8.2%                          | 2.60%                        |
| 7  | Viaduct Superstructure                                                        | 4.1%                          | 1.30%                        |
| 8  | Bridge Over Jakarta Outer Ring Road                                          | 2.0%                          | 0.65%                        |
| 9  | Open Cut, Transition Structure and Cut and Cover Tunnels and First Pour Tracked Concrete | 1.0%                          | 0.32%                        |
| 10 | Bored Tunnels including First Pour Concrete                                   | 0.0%                          | 0.00%                        |
| 11 | Cross Over Cut and Cover Structure for Scissors Crossing                      | 0.0%                          | 0.00%                        |
| 12 | Elevated Stations                                                            | 7.1%                          | 2.27%                        |
| 13 | Underground Stations                                                          | 13.3%                         | 4.22%                        |
| 14 | Substations (Civil)                                                           | 1.0%                          | 0.32%                        |
| 15 | Environmental Control System                                                 | 0.0%                          | 0.00%                        |
| 16 | Water Supply, Plumbing and Drainage Services                                  | 0.0%                          | 0.00%                        |
| 17 | Fire Detection and Suppression Services                                       | 0.0%                          | 0.00%                        |
| 18 | Electrical Works                                                             | 0.0%                          | 0.00%                        |
| 19 | Signage and Graphics                                                          | 0.0%                          | 0.00%                        |
| 20 | Substation System                                                             | 1.0%                          | 0.32%                        |
| 21 | Overhead Contact System                                                       | 1.0%                          | 0.32%                        |
| 22 | Power Distribution System                                                     | 1.0%                          | 0.32%                        |
| 23 | Signaling System                                                              | 1.0%                          | 0.32%                        |
| 24 | Telecommunication System                                                      | 1.0%                          | 0.32%                        |
| 25 | Facility SCADA System                                                         | 1.0%                          | 0.32%                        |
| 26 | Automatic Fare Collection System                                              | 1.0%                          | 0.32%                        |
| 27 | Platform Screen Doors System                                                  | 1.0%                          | 0.32%                        |
| 28 | Escalators - Elevators                                                        | 1.0%                          | 0.32%                        |
| 29 | Track works                                                                   | 1.0%                          | 0.32%                        |
| 30 | Manufacture/Procurement Motor Car                                             | 1.0%                          | 0.32%                        |
| 31 | Spares, Special Tools, Testing Equipment and Measuring Equipments             | 1.0%                          | 0.32%                        |
| 32 | Testing and Commissioning                                                     | 1.0%                          | 0.32%                        |
| 33 | Product Support                                                               | 0.0%                          | 0.00%                        |
| 34 | Provisional Sums For Dayworks                                                 | 2.0%                          | 0.65%                        |
| 35 | Construction Management Consulting Services                                    | 2.0%                          | 0.65%                        |

| Total | 100% | 31.83% |

### 4.3 Contingent Risk Cost

Furthermore, a literature study related to contingent risks will continue to be contingent costs which are cost reserves or cost estimates to anticipate uncertainty conditions to project completion allocated to work items based on experience and implementation of previous projects (Adi & Yunwanti, 2014). Then proceed with expert validation to a number of experienced experts in the field of modern railroad...
construction to obtain contingent risk data which is a risk that has never been identified before. This risk needs to be anticipated to affect the increase in costs in the Jakarta MRT project until the completion of the project. So that obtained some qualitative data input from the questionnaire results from 30 respondents who assessed the magnitude of the impact and frequency of each contingent risk. After obtaining the questionnaire data, a homogeneity test was conducted for the respondent's data based on the latest educational background, position, work experience, and agency. This also process with validity and reliability test to ensure that the data was valid. The final step is to make a risk rating and see the type of data distribution for each of the top 10 risks.

From the results that have been obtained, the author chooses 10 variables from the highest risk rating and then looks at the data distribution pattern using the "goodness to fit" method. This is important to be done to be the basis for contingency analysis using the @risk software later. Analysis of monte carlo using @Risk can be known about the allocation of funds needed as a contingency cost until the Jakarta Phase 1 MRT project is completed. Here are 10 of the highest ranking contingency risk events.

| Risk Category : Contract | Risk Level | Risk Ranking |
|--------------------------|------------|--------------|
| X32 The Contract Specifications explaining the Employer’s Requirement are not clear and detail | High | 5 |
| X31 The duration of the Contract is not appropriate | High | 4 |

| Risk Category : Operational and Logistic | Risk Level | Risk Ranking |
|------------------|------------|--------------|
| X26 Delay in utility relocation | High | 2 |
| X27 Delay in land acquisition | High | 1 |

| Risk Category : Design and Work Method | Risk Level | Risk Ranking |
|-----------------------------|------------|--------------|
| X18 Issue of interface design | High | 3 |
| X19 Request changes to work methods / designs from clients / external parties | Medium | 7 |

| Risk Category : Financial | Risk Level | Risk Ranking |
|--------------------------|------------|--------------|
| X6 Delay payment | High | 6 |

| Risk Category : Legal / Regulation | Risk Level | Risk Ranking |
|-----------------------------------|------------|--------------|
| X3 Changes to Central Government Regulations | Medium | 8 |
| X1 Changes to Regional Regulations | Medium | 9 |

| Risk Category : Management | Risk Level | Risk Ranking |
|----------------------------|------------|--------------|
| X13 Lack of preparation in estimated costs | Medium | 10 |

The next step is to do a monte carlo simulation analysis using the @Risk software where later the percentage figure will be the amount of contingency costs that must be anticipated until the project is completed. The following is a summary of all variables that have been converted into a percentage of the cost of each risk:

| Variable | Risk Name | Percentage of Contingency Cost from the Initial Contract Amount (%) |
|----------|-----------|---------------------------------------------------------------|
| X27      | Delay in land acquisition | 2.54%             |
| X26      | Delay in utility relocation | 2.47%            |
From the table above, it can be concluded that the estimated risk contingency for funding the Jakarta MRT Phase 1 project is 15.74% of the initial project cost or ± Rp 1.8 Trillion.

4.4 Risk-Based Project Cost Estimates At Completion (EAC)

From the results obtained in the previous section, that is getting contingency costs that will be added to the previous inherent costs that have been calculated, and finally added to the initial cost value of the project, then the total cost of the Jakarta MRT Phase 1 project has been analyzed using a risk-based project cost overrun model and can be seen in the following table:

**Table 10. Results of Estimated Project at Completion (EAC) Cost Based on Inherent and Contingency Risks**

| Code | Description                                      | % Initial Project Cost (A) | % Inherent Risk from Initial Cost (B) | % Contingency from Initial Cost (C) | % EAC from Initial Cost (A+B+C) |
|------|--------------------------------------------------|---------------------------|--------------------------------------|-----------------------------------|-------------------------------|
| W1   | Preliminaries and General Requirements            | 9.46%                     | 6.17%                                | 1.49%                             | 11.60%                        |
| W2   | Design                                           | 2.94%                     | 5.85%                                | 0.46%                             | 6.27%                         |
| W3   | Depot Civil and Building Works                   | 3.11%                     | 0.65%                                | 0.49%                             | 2.88%                         |
| W4   | Depot and Workshop Equipment (not including Substation and Signal, Telecom) | 3.46% | 0.00% | 0.54% | 2.71% |
| W5   | Transition Structure of Depot Entrance           | 0.02%                     | 0.32%                                | 0.00%                             | 0.24%                         |
| W6   | Viaduct Substructure                             | 3.48%                     | 2.60%                                | 0.55%                             | 4.49%                         |
| W7   | Viaduct Superstructure                           | 4.60%                     | 1.30%                                | 0.72%                             | 4.49%                         |
| Code | Description                                                                 | % Initial Project Cost (A) | % Inherent Risk from Initial Cost (B) | % Contingency from Initial Cost (C) | % EAC from Initial Cost (A+B+C) |
|------|-----------------------------------------------------------------------------|---------------------------|--------------------------------------|-------------------------------------|-------------------------------|
| W8   | Bridge Over Jakarta Outer Ring Road                                          | 0.35%                    | 0.65%                                | 0.06%                               | 0.71%                         |
| W9   | Open Cut, Transition Structure and Cut and First Pour Tracked Concrete       | 0.50%                    | 0.32%                                | 0.08%                               | 0.61%                         |
| W10  | Bored Tunnels including First Pour Concrete                                  | 6.85%                    | 0.00%                                | 1.08%                               | 5.37%                         |
| W11  | Cross Over Cut and Cover Structure for Scissors Crossing                     | 1.70%                    | 0.00%                                | 0.27%                               | 1.33%                         |
| W12  | Elevated Stations                                                           | 4.98%                    | 2.27%                                | 0.78%                               | 5.45%                         |
| W13  | Underground Stations                                                         | 12.58%                   | 4.22%                                | 1.98%                               | 12.72%                        |
| W14  | Substations                                                                 | 0.20%                    | 0.32%                                | 0.03%                               | 0.38%                         |
| W15  | Environmental Control System                                                | 3.85%                    | 0.00%                                | 0.61%                               | 3.02%                         |
| W16  | Water Supply, Plumbing and Drainage Services                                | 0.67%                    | 0.00%                                | 0.10%                               | 0.52%                         |
| W17  | Fire Detection and Suppression Services                                     | 1.07%                    | 0.00%                                | 0.17%                               | 0.84%                         |
| W18  | Electrical Works                                                            | 3.52%                    | 0.00%                                | 0.55%                               | 2.76%                         |
| W19  | Signage and Graphics                                                        | 0.18%                    | 0.00%                                | 0.03%                               | 0.14%                         |
| W20  | Substation System                                                           | 3.64%                    | 0.32%                                | 0.57%                               | 3.08%                         |
| W21  | Overhead Contact System                                                     | 1.91%                    | 0.32%                                | 0.30%                               | 1.72%                         |
| W22  | Power Distribution System                                                   | 3.00%                    | 0.32%                                | 0.47%                               | 2.57%                         |
| W23  | Signaling System                                                            | 3.33%                    | 0.32%                                | 0.52%                               | 2.83%                         |
| W24  | Telecommunication System                                                    | 1.52%                    | 0.32%                                | 0.24%                               | 1.41%                         |
| W25  | Facility SCADA System                                                       | 0.23%                    | 0.32%                                | 0.04%                               | 0.40%                         |
| W26  | Automatic Fare Collection System                                            | 2.07%                    | 0.32%                                | 0.33%                               | 1.85%                         |
| W27  | Platform Screen Doors System                                                | 1.42%                    | 0.32%                                | 0.22%                               | 1.34%                         |
| W28  | Escalators - Elevators                                                      | 1.06%                    | 0.32%                                | 0.17%                               | 1.05%                         |
| W29  | Track works                                                                 | 5.07%                    | 0.32%                                | 0.80%                               | 4.20%                         |
| W30  | Manufacture/Procurement Motor Car                                            | 8.83%                    | 0.32%                                | 1.39%                               | 7.15%                         |
| W31  | Shipping and Delivery to Depot                                              | 0.77%                    | 0.32%                                | 0.12%                               | 0.83%                         |
| Code | Description                                        | % Initial Project Cost (A) | % Inherent Risk from Initial Cost (B) | % Contingency from Initial Cost (C) | % EAC from Initial Cost (A+B+C) |
|------|---------------------------------------------------|----------------------------|--------------------------------------|-----------------------------------|----------------------------------|
| W32  | Spares, Special Tools, Testing Equipment and Measuring Equipments | 0.31%                     | 0.32%                                | 0.05%                             | 0.46%                            |
| W33  | Testing and Commissioning                         | 0.35%                     | 0.32%                                | 0.06%                             | 0.50%                            |
| W34  | Product Support                                   | 0.06%                     | 0.00%                                | 0.01%                             | 0.05%                            |
| W35  | Provisional Sums                                 | 0.36%                     | 0.65%                                | 0.06%                             | 0.72%                            |
| W36  | Provisional Sums For Dayworks                    | 0.43%                     | 1.30%                                | 0.07%                             | 1.22%                            |
| W37  | Construction Management Consulting Services       | 2.10%                     | 0.65%                                | 0.33%                             | 2.09%                            |
|      | **TOTAL**                                         | **100%**                  | **31.83%**                           | **15.74%**                        | **147.57%**                      |

From the Table 10, it can be concluded that the Jakarta Phase 1 MRT project is estimated to have a cost overrun estimation of 47.57% from initial contract amount or Rp 5.6 Trillion.

5. Conclusion

In the implementation of the Jakarta Phase 1 MRT Project construction, there has been an indication of the increase in contract value due to a change in the scope of work in which the Contractor has submitted several claims of additional costs to PT MRT Jakarta. There was also initial identification of claims that will be submitted by the Contractor in the future.

In order to get the estimation made it is reasonable and accountable, an evaluation and justification of the estimated value of the change is needed to see the fairness of the claim value and the allocation of the possibility of other claim risks taking into account the technical aspects and the type of contract used until the project is completed. A very big discrepancy between initial cost and risk-based cost estimation is ranging to 47.57% which consists of 31.83% inherent risks and 15.74% contingency risks.

Finally, the authors recommend that in the planning stage of any construction project, larger efforts should be exerted on the planning preparation, scheduling and cost evaluation to reduce the risk of delay and cost overrun of the project implementation. Similarly, during the construction stage of projects careful organization and management processes should be applied to fulfill the requirements of the projects’ plans. Successful management of construction projects may need to adopt procedures to avoid problems and to adopt contingency plans to reduce the effects of problems when they occurred.

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