

# **Designing Project Risk Contingency using Tornado Diagram**

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## **Abstract**

Company X is a service and production company in telecommunications and information technology (IT). At the end of 2021, Company X has a collaborative project, which is a refurbished project. During the execution of the project in previous terms, Company X often experienced delays in project completion or the deliverable in the contract was not achieved. One of the factors that caused delays due to several risks that occurred and had a large cost impact for handling them, so Company X could not handle risks immediately because they did not have a budget for risk mitigation. The purpose of this paper aims to estimate the value of contingency reserves for identified risk so it can anticipate the priority risks and prepare for the required budget if it happened. The method that will be used in this paper is Expected Monetary Value (EMV) and Tornado Diagram. EVM is statistical calculation to determine the cost that will be used in the future to overcome the risk that happens in a project. Based on this research, the results show that there are 34 risks that can be inserted to the contingency risk cost. The total cost required is US\$5071.09 out of 0,1% of the total project budget. In addition, there are 5 risks that have the highest cost impact based on tornado diagram, including negative and positive risk. The top negative risks include delay in product delivery, defect product during delivery, additional request for product delivery, expired software license. However positive risk is also identified such as additional fund that may enhance for taking the opportunity.

## **Keywords**

Expected Monetary Value, Contingency Reserves, Risk, Cost Impact, Project.

## **1. Introduction**

According to Sufa (2012), the key success of a project is always associated with time and cost as completion. In addition, one of the success factors in a project is whether the project achieves its goals or not (Project Management Institute, 2017). In project implementation, a discrepancy often occurs both in terms of the quality of the deliverables that are not achieved, the scope of work carried out is not appropriate, or implementation of project activities that are not according to schedule. Based on Project Management Institute (2017), one of the causes of

delays is some companies currently ignore the risks that occur during project execution, and do not handle these risks effectively.

In general, risk is a hazard or consequence that may occur as a result of an ongoing process (Hasbi, 2021). Based on ISO 31000 risk is uncertainty that has an impact on goals. If an organization can carry out risk management well, then the uncertainty in a project can be handled properly (Rumimper, 2015). In project implementation, a different risk mitigation strategy is needed for each project (Ahmed, 2017). Currently, the company that is conducting one of the information and communication technology service projects is Company X.

Company X is a service and production company in telecommunications equipment and information technology (IT). At the beginning, the main business of Company X was the provision of fiber cables to the home. However, at the end of 2021, Company X have a collaboration project with Company Y, namely a refurbished project. This project has total budget which is \$3.000.000 and also categorized as medium to high risky project with a lot of uncertainty. The purpose of this project is correcting the damaged hardware so that they can be reused by customers from Company Y. Company X has been carried out the similar multiple project orders. After several projects that have been carried out, there are several obstacles that cause delays. The following is one of the project progress curves in 3<sup>rd</sup> term that has been carried out by Company X (Figure 1).

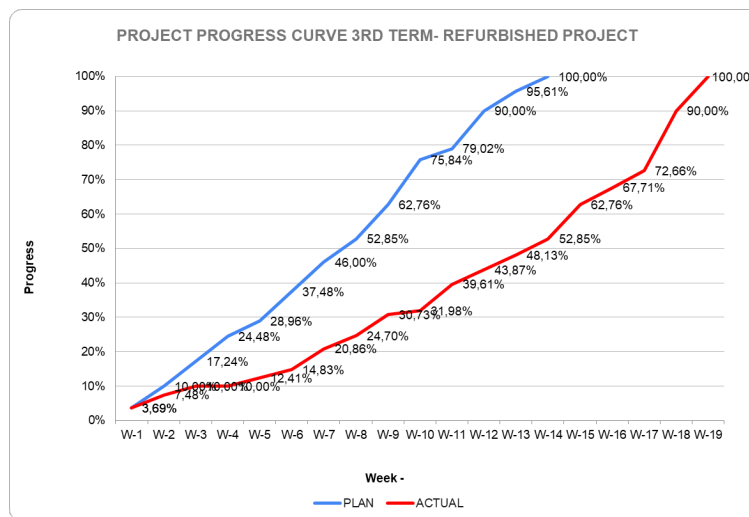


Figure 1. Project Progress Curve

Based on the progress of the refurbished project 3<sup>rd</sup> term there was a gap between the completion of the work as planned. In schedule planning, the 3<sup>rd</sup> term is planned to be completed on Week-13, but in actual data, Company X has extended the contract for six weeks. The late completion of the refurbished project will affect Company X not being able to proceed to the next term because Company Y will not re-order again. This issue will affect to the next project term as well.

Based on the problems, one of the causes of delays in refurbished project is there are possible risks that were not previously identified in the last project term, so the project team does not know what to do and how to anticipate them. According to the project manager, the risk mitigation that has been identified in refurbished project is currently only at the execution phase, while in other phases there is no risk identification and mitigation. In addition, there is no cost calculation for each risk, so if the risk occurs, Company X cannot handle the risk immediately due to the inadequate budget for handling the risk. The cost factor in determining risk priority is certainly the main thing in risk mitigation. If there is a cost factor, the project team can prioritize these risks and can optimize the risk with the highest cost so that it doesn't happen (Griffiths, 2012).

One of the ways to solve this problem is calculating the cost factor for each risk. The cost factor is included in quantitative risk analysis. Quantitative Risk Analysis is a numerical analysis technique on the results of the identification of a risk. This technique is used to measure risk in the cost aspect and provide additional information

to the project team during the risk response planning (Project Management Institute, 2017). Quantitative Risk Analysis is also more accurate because the results depend on numerical results and less subjective because we need to calculate the value (Gladysz et al, 2015). In quantitative risk analysis, there are two aspects that can be studied, namely contingency reserves for each risk and sensitivity analysis.

Based on England (2012), the contingency in risk aspect is amount of funds or budget to cover risk exposures that have been measured cumulatively and have the potential to occur. It is easier to track risk occurrence by forecasting risk contingency, so that the cost of any risk occurrence may be absorbed. Without the contingency reserve, those extra days and money are deducted from the real schedule and budget, creating delays and cost overruns (Shrivastava, 2014). If this occurs, the project will be derailed. It is also easy to understand where threats come from using this calculation. In addition, using contingency reserves can assist project managers to communicate with the stakeholders about the reason of a certain risk that may become a priority risk or due to the value of the cost impact it has. By using these aspects, problems in the project can be overcome. In contingency reserves, to obtain a value on the cost aspect, the Expected Monetary Value (EMV) method can be used. This method can forecast the costs needed to handle a risk.

Currently, the 6<sup>th</sup> term of the refurbished project is in the planning stage. So, to prevent these factors do not occur and affecting the refurbished project again, it is necessary to design contingency reserves for identifying risks. The purpose of this study is finding the contingency reserves for identified risks using the Expected Monetary Value (EMV) method and tornado diagram. This method allows companies to determine priority risks and prepare the required budget.

## 2. Methods

The project that will be the object of this research is located in Bandung, West Java, Indonesia at one Refurbished Centre in Company X. In this refurbished project, the current phase that being implemented by Company X is planning phase. There are several main sub-activities, namely planning, IGI & Sorting activities, ONT Function Test, STB Function Test, Cleansing Activities, Packing and Labelling Activities and Closing. Each main sub-activities have different risks with different categories.

Based on Project Management Institute (2017), there are several steps from data collection to research conclusions. These steps will be carried out to aim the value of contingency reserves using the EMV method and visualization by Tornado Diagram. The reason for using EMV is that by using this method, the overall cost value of all risks, both threat and opportunity risks can be investigated. In addition, according to (Project Management Institute, 2017), the use of EMV can assist in making decisions during the planning process in projects. Also, the reason of using Tornado Diagram for visualization is it can help project managers and project teams in identifying the priority risks based on required contingency reserves value.

There are two inputs needed in this calculation, such as project budget and risk assessment that has risk probability and the impact value for each aspect (scope, schedule, quality, safety, and scope). Both inputs are obtained based on assessment by expert judgement and data analysis.

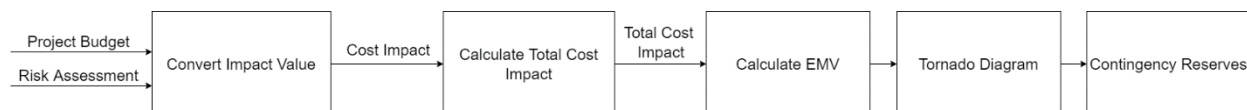


Figure 2. Research Steps

After all the data has been collected, there are several steps to get the value of Expected Monetary Value (EMV) (Figure 2). First, the impact value on each aspect (schedule, scope, security, cost, and quality) from the risk assessment will be converted into cost unit by multiplying the impact value and impact cost that have been obtained based on the cost budget of refurbished project in each activity. After all impact value has been converted into cost unit, it can be continued by calculating the total cost impact using the total impact formula according to Vargas (2013).

Expected Monetary Value can be calculated if the total impact in cost unit and probability value has been obtained. The following is formula that will be used in calculating Expected Monetary Value according to the Shrivastava (2014)

$$\text{EMV} = \text{Probability} \times \text{Impact (Cost)}$$

The probability value in the formula will be obtained based on expert judgment on this refurbished project or Project Manager. The probability value is the value that will be predicted if the risk occurs in the implementation of the project. For the impact (cost) will be obtained based on total impact that has been done before. At the expected monetary value, all possible outcomes and their probabilities of each alternative strategy (decision) will be considered (Stefanovic, 2005). After all Expected Monetary Value (EMV) has been calculated, then all of risk will be arranged from highest to lowest cost using a tornado diagram to find out the potentially high risk. The visualization will use a horizontal bar chart called a tornado diagram. According to Zhen-hai et al (2019), tornado diagrams are useful for sensitivity analysis, identifying critical variables and considering interactions between variables. In addition, the value of EVM will be an input in contingency reserves for risk register of this refurbished project. The information will contain the costs that will be required by the project team if a risk happens.

### 3. Results and Discussion

#### 3.1 Numerical Results

According to the Shivastava (2014), there are variables to calculate Expected Monetary Value (EMV), for example Risk Identification, probability value, impact value for each aspect, and cost value if risk happen. Risk identification will be used as identity code for each risk that will happen in the refurbished project.

On each risk, there are five basic aspects which affect the total cost of impact such as scope, schedule, safety, cost, and quality based on research from Vargas (2013). According to Vargas (2013), these aspect are important so it can separate the analysis based on each impact that will affect each aspect. Both values have been obtained based on data collection.

In this study, the risk that will be calculated using Expected Monetary Value is in the urgent risk category. Because it has a greater possibility to happen and the impact is also greater than watchlist risk. So, they will take a cost calculation to handle these risks. The result of calculation using EMV method is the cost value that will have an impact on the refurbished project budget if a risk occurs (Table 1).

Table 1. Result using Expected Monetary Value (EMV)

No	Risk ID	Proba bility	Impact Aspect					Impact Cost	EMV
			Scope	Schedule	Safety	Cost	Scope		
Planning									
1	R1.1	0,7	US\$ 219,12	US\$ 202,26	US\$ 151,70	US\$ 117,99	US\$ 202,26	US\$ 182,63	US\$ 118,71
2	R1.2	0,7	US\$ 219,12	US\$ 185,41	US\$ 134,84	US\$ 84,28	US\$ 202,26	US\$ 172,38	US\$ 112,05
3	R1.3	0,6	US\$ 707,91	US\$ 556,22	US\$ 505,65	US\$ 303,39	US\$ 707,91	US\$ 576,09	US\$ 345,65
4	R1.4	0,6	US\$ 92,70	US\$ 143,27	US\$ 67,42	US\$ 67,42	US\$ 92,70	US\$ 96,75	US\$ 58,05
5	R1.5	0,6	US\$ 455,09	US\$ 556,22	US\$ 606,78	US\$ 353,96	US\$ 707,91	US\$ 549,74	US\$ 329,85
6	R1.6	0,6	US\$ 202,26	US\$ 219,12	US\$ 168,55	US\$ 151,70	US\$ 185,41	US\$ 186,93	US\$ 102,81
7	R1.7	0,7	US\$ 202,26	US\$ 134,84	US\$ 151,70	US\$ 286,54	US\$ 202,26	US\$ 202,54	US\$ 131,65
8	R1.8	0,6	US\$ 168,55	US\$ 168,55	US\$ 219,12	US\$ 151,70	US\$ 202,26	US\$ 183,71	US\$ 101,04
9	R1.9	0,8	US\$ 2.224,86	US\$ 2.781,08	US\$1.668,65	US\$2.039,46	US\$ 2.224,86	US\$ 2.217,12	US\$1.773,70
10	R1.10	0,7	US\$ 1.618,08	US\$ 1.348,40	US\$1.348,40	US\$1.213,56	US\$ 1.213,56	US\$ 1.356,47	US\$ 881,70
11	R1.11	0,4	US\$ 91,02	US\$ 53,10	US\$ 98,61	US\$ 75,85	US\$ 83,44	US\$ 81,90	US\$ 32,76

No	Risk ID	Proba bility	Impact Aspect					Impact Cost	EMV
			Scope	Schedule	Safety	Cost	Scope		
12	R1.12	0,5	US\$ 84,28	US\$ 67,42	US\$ 92,70	US\$ 75,85	US\$ 92,70	US\$ 83,17	US\$ 41,59
<b>IGI &amp; Sorting Activities</b>									
13	R2.1	0,7	US\$ 101,13	US\$ 101,13	US\$ 84,28	US\$ 58,99	US\$ 84,28	US\$ 87,34	US\$ 61,14
14	R2.2	0,6	US\$ 1.179,85	US\$ 1.179,85	US\$ 758,48	US\$ 758,48	US\$ 927,03	US\$ 979,19	US\$ 587,51
15	R2.3	0,6	US\$ 101,13	US\$ 109,56	US\$ 67,42	US\$ 58,99	US\$ 67,42	US\$ 83,43	US\$ 50,06
<b>ONT Functional Test</b>									
16	R3.1	0,6	US\$ 927,03	US\$ 1.095,58	US\$ 589,93	US\$ 758,48	US\$ 1.179,85	US\$ 935,41	US\$ 561,25
17	R3.2	0,7	US\$ 168,55	US\$ 185,41	US\$ 151,70	US\$ 151,70	US\$ 202,26	US\$ 173,04	US\$ 112,48
18	R3.3	0,7	US\$ 43,81	US\$ 33,70	US\$ 33,70	US\$ 30,33	US\$ 50,55	US\$ 39,16	US\$ 27,41
19	R3.4	0,6	US\$ 1.854,05	US\$ 1.854,05	US\$ 1.685,50	US\$ 1.854,05	US\$ 2.359,70	US\$ 1.935,02	US\$ 1.064,26
20	R3.5	0,8	US\$ 47,18	US\$ 37,07	US\$ 30,33	US\$ 20,22	US\$ 50,55	US\$ 38,69	US\$ 30,95
21	R3.6	0,5	US\$ 303,39	US\$ 303,39	US\$ 278,11	US\$ 278,11	US\$ 328,67	US\$ 298,93	US\$ 134,52
<b>STB Functional Test</b>									
22	R4.1	0,7	US\$ 353,96	US\$ 353,96	US\$ 202,26	US\$ 278,11	US\$ 353,96	US\$ 314,36	US\$ 220,05
23	R4.2	0,9	US\$ 235,97	US\$ 219,12	US\$ 101,13	US\$ 185,41	US\$ 252,83	US\$ 206,02	US\$ 175,11
24	R4.3	0,5	US\$ 30,33	US\$ 33,70	US\$ 26,96	US\$ 30,33	US\$ 43,81	US\$ 33,53	US\$ 16,77
<b>Cleansing Activities</b>									
25	R5.1	0,7	US\$ 50,57	US\$ 58,99	US\$ 126,41	US\$ 92,70	US\$ 67,42	US\$ 83,85	US\$ 58,70
26	R5.2	0,7	US\$ 109,56	US\$ 134,84	US\$ 67,42	US\$ 75,85	US\$ 92,70	US\$ 99,07	US\$ 69,35
27	R5.3	0,6	US\$ 92,70	US\$ 101,13	US\$ 75,85	US\$ 75,85	US\$ 92,70	US\$ 88,23	US\$ 52,94
<b>Packing &amp; Labelling Activities</b>									
28	R6.1	0,5	US\$ 30,33	US\$ 37,07	US\$ 26,96	US\$ 30,33	US\$ 43,81	US\$ 34,23	US\$ 15,41
29	R6.2	0,6	US\$ 37,07	US\$ 37,07	US\$ 26,96	US\$ 23,59	US\$ 40,44	US\$ 33,67	US\$ 20,20
30	R6.3	0,6	US\$ 758,48	US\$ 927,03	US\$ 589,93	US\$ 674,20	US\$ 1.095,58	US\$ 829,16	US\$ 497,49
31	R6.4	0,6	US\$ 606,78	US\$ 353,96	US\$ 303,39	US\$ 404,52	US\$ 758,48	US\$ 514,67	US\$ 283,07
<b>Closing</b>									
32	R7.1	0,6	US\$ 117,99	US\$ 84,28	US\$ 84,28	US\$ 92,70	US\$ 109,56	US\$ 98,71	US\$ 59,23
33	R7.2	0,6	US\$ 84,28	US\$ 117,99	US\$ 75,85	US\$ 67,42	US\$ 101,13	US\$ 91,16	US\$ 50,14
34	R7.3	0,6	US\$ 92,70	US\$ 92,70	US\$ 84,28	US\$ 92,70	US\$ 92,70	US\$ 91,08	US\$ 50,09
<b>Total Estimated Cost (Threat Risk)</b>									US\$6.649,38
<b>Total Estimated Cost (Opportunity Risk)</b>									US\$1.578,29
<b>Total Impact Cost</b>									US\$5.071,09

Based on Table 1, there are 34 risks of urgent risk category that have been calculated for the value of impact cost. From 34 risks, there are six risk opportunity or six costs which are marked in black color. In addition, there are 28 risks in threat risk which are marked in red color. After calculation, the EMV value can be sorted based on the highest impact value and become input for the contingency reserves component in the risk register.

In addition based on Table 2, it is known that the total estimated cost impact of the project if the threat risk occurs is US\$ 6.649,38, while the cost impact on the opportunity category has a total of US\$ 1.578,29. This means that if the threat risk happens, the company must spend a total cost of contingency reserves for the threat risk, and if the opportunity risk happen, the company will get an additional budget especially for the remaining repaired product.

The company must allocate the total cost for contingency reserves approximately US\$ 5.071,09. This indicates that the refurbished project team must prepare a cost reserve, so if a risk happens and requires a budget, the project team can immediately act without using the direct project budget. In addition, there are 5 risks that have the highest cost impact, namely risks R1.9, R3.4, R1.10, R2.2, and R3.1. These results can assist the project team in avoiding risks if it happens. The following are the details of 5 risks with the highest costs based on EMV calculation.

Table 2. Details 5 Highest Cost Impact

No	Risk ID	Risk Identification	Risk Type	Contingency Reserves
9	R1.9	Delayed shipping of material from each RC	<i>Threat</i>	US\$ 1.773,70
19	R3.4	There are additional funds from clients	<i>Opportunity</i>	US\$ 1.064,26
10	R1.10	Product crash during shipping process	<i>Threat</i>	US\$ 881,70
14	R2.2	There is an additional request for the number of devices	<i>Threat</i>	US\$ 587,51
16	R3.1	The license on the ONT test system has expired	<i>Threat</i>	US\$ 561,25

### 3.1 Graphical Results

Besides numerical results, visualization is also obtained based on calculations using a tornado diagram. Tornado diagram is a visualization diagram that is useful for sensitivity analysis, identifying critical variables and considering interactions between variables. With this diagram, companies can visually see the risks that have the highest cost impact. According to Barreras (2011) the tornado diagram also serves to identify the risks that have the most influence on the project budget. Usually, the tornado diagram is used as a tool for the project team in deciding which risks need to be the priority and the main focus in project execution. The following is a tornado diagram for the refurbished project based on the calculation of contingency reserves using the EMV method.

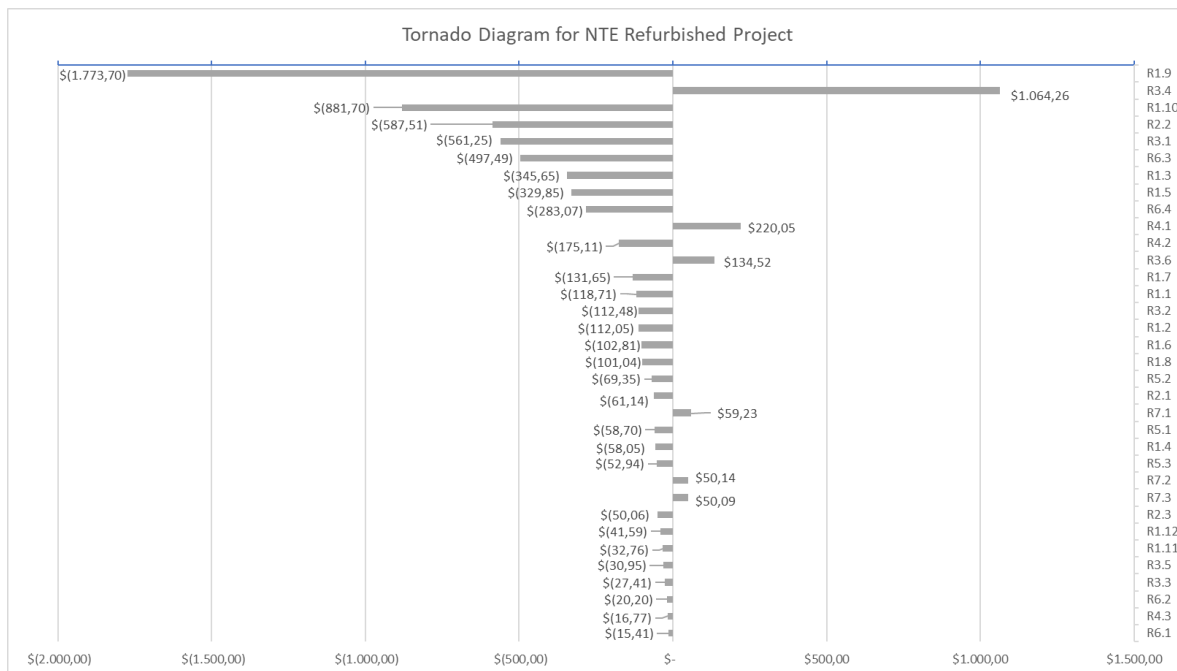


Figure 3. Tornado Diagram

Based on Figure 3, there is some information that can be obtained. There are five highest risks with four threats and one positive risk. The threat risk value will point to the left or a minus value, this indicates that the company will incur costs accordance with the value obtained. In addition, the positive risk value will point to the right or a positive

value, this indicates that the company will get funds for the value obtained. Information related to these five risks will be explained in more detail in the following diagram of the top 5 contingency reserves.

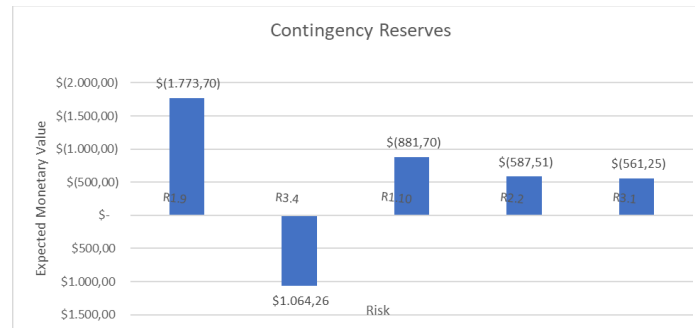


Figure 3. Top 5 of Contingency Reserves

Based on the Figure 3, there are five highest risks that will be the main priority and focus for the project team. These risks are risk ID R1.9 with contingency reserves of US\$ 1.773,70, risk ID R3.4 with contingency reserves of US\$1.064,26, risk ID R1.10 with contingency reserves of US\$881,70, risk ID R2.2 with contingency reserves of US\$587,51, and risk ID R3.1 with contingency reserves of US\$561,25. The five risks are described in a bar chart, so that the project team can monitor these risks so if that risk happens and project team can prepare a budget for the 5 highest risks.

So based on the results of the explanation of the three results, it can be seen how important contingency reserves are for companies in dealing with a risk. Contingency reserves are a quantitative aspect of a risk that can assist companies in preparing the required cost reserves if a risk happens. With contingency reserves, it will prevent schedules and costs at any risk from causing projects to get delayed or cost overrun. However, if this risk does not happen, then contingency reserves will not be used and will be stored for the next term. According to Shrivastava (2014), the purpose of a contingency reserve is to help the project team to increase project outcomes. Contingency reserves also assist project managers in optimizing risk management and preparing the project budget needed in the next term and communicating these results to stakeholders and sponsors. As for some limitations on the use of contingency reserves using the EMV method, the calculation results on the EMV can be different from the costs incurred in actual conditions. The EMV results are only used as a cost reference. If all contingency reserves occur, it will also have an impact on the budget (overbudget), and contingency reserves must be renewed if the risk register is updated. In addition, based on the England (2012) the contingency reserves that has been calculated cannot be used if there are major changes in scope of project.

## 5. Conclusion

Contingency reserves is a quantitative aspect of a risk that is important to do because it can help companies prepare the contingency reserves needed if a risk occurs. With contingency reserves, it will prevent schedules and costs at any risk from causing projects to experience delays and cost overruns. Based on the results of calculations using the EMV method, the results obtained are that there are 34 risks that are prepared for cost reserves if these risks occur. The total cost required for any risk which may occur and also handle is US\$ 5.071,09 which is only 0,1% from the total project budget. This indicates that the refurbished project team must prepare cost reserves, so that if a risk occurs and requires a budget, the project team can immediately act without need to use the main project budget. For the next research, the risk assessment can use more integrated data for example project performance integration so all the stakeholders can monitor the risk movement and also more responsible for any risk that may threat to the project objectives.

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