

# Monte Carlo Method Application in Airport Investment

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**Abstract**— PT Angkasa Pura 1 El Tari Kupang International Airport carried out the development of the Kupang El Tari airport in 2018, the total area of the airport was 7,462 meters<sup>2</sup> to 15,462 meters<sup>2</sup> for the construction of El Tari Kupang International Airport, of course the development requires a large amount of money, so the purpose of this study was to use the Monte Carlo method to determine the probability analysis of the successful development of the El Tari Kupang International Airport. The project risk analysis v2.1 program was used in this study to run the Monte Carlo simulation. This program calculates the capital risk of the evaluated project as well as the financial contingencies required to cover these risks. The Monte Carlo simulation results show that the probability of success is 50.14 percent. If the project owner desires an 80 percent probability level, the budget that must be prepared must not be less than \$118,355,439, or \$6,030,868 plus a 5.37 percent contingency. However, if the owner wishes to be more cautious, the funds that must be prepared are \$128,695,389 or \$16,334,201 plus a 14.54 percent contingency to achieve a probability of 99 percent. Alternatively, this investment development project can be said to be successful.

**Keywords**— Monte Carlo, Probability, Project Risk Analysis.

## I. INTRODUCTION

East Nusa Tenggara Province is made up of 1192 islands divided into 21 regencies and one municipality. According to 2019 BPS data, the total population of NTT Province was 5,466,203 people, with a 1.66 percent population growth rate (BPS NTT.2019). Of course, this must be balanced with the provision of adequate infrastructure or transportation provider services such as airports, ports, terminals, and roads to support the movement of people and goods to and from the province.

The increasing rate of movement of people and goods into and out of NTT Province, which increases year after year, necessitates an increase in facilities. As a result, the government developed facilities in 2018 through PT Angkasa Pura 1 El Tari Kupang International Airport, including the addition of aerobridge facilities, the expansion of parking areas, and the expansion of the terminal building's capacity. As a result, the total airport area development, which was originally 7,462 m<sup>2</sup>, has increased to 15,462 m<sup>2</sup>. The implementation of the construction of the El Tari Kupang International Airport necessitates a large sum of money; thus, an analysis of the investment made in the El Tari Kupang International Airport construction work is required. In this study, investment analysis is carried out using the Monte Carlo simulation method, with the goal of analyzing this risky and uncertain investment.

## II. LITERATURE REVIEW

All statistical sampling techniques used to estimate solutions to quantitative problems are referred to as Monte Carlo simulations (Monte Carlo Method, 2008). A model is built based on the actual system in a Monte Carlo simulation. Each variable in the model has a different probability value, which is indicated by the probability distribution, also known as the probability distribution function (pdf).

A Monte Carlo simulation is used in project management to calculate or iterate over the cost and time of a project using values drawn at random from the probability distributions of

costs and times that may occur. The goal of this simulation is to compute the distribution of project costs and total time (Project Management Institute, 2004). In general, Monte Carlo simulations are classified as risk management, time management, or cost management in the project management literature.

## III. RESEARCH METHODOLOGY

The researcher in this study used the project risk analysis v2.1 program to simulate the Monte Carlo simulation. The program's goal is to allow the capital risks of the project to be assessed and the financial contingencies required to cover those risks to be calculated rationally and sustainably. The procedures used in project risk analysis encourage disciplined assessment and calculate the required contingencies using a proven statistical method known as Monte Carlo Simulation. The project risk analysis results can be displayed in an easy-to-read graphic format, providing the assessor with an overall risk assessment quickly and effectively. The results can also be viewed in a detailed table format.

The project risk analysis will select and highlight areas that are vulnerable to risk while calculating the required contingency. In this study, researchers used 100,000 iterations (simulations) with 50 intervals to obtain more specific results than the probability of the results generated by this application.

## IV. RESULTS AND DISCUSSION

The simulation in the El Tari Kupang International Airport development project begins with determining the subjects to be simulated, such as cash in, cash out, and investment. Then compute the highest (high) and lowest (low) costs, as well as the actual cost (likely cost).

TABLE 1. project cost data

Project Cost Data						
Item	Description	Distribution	Likely Cost	Low Cost	High Cost	Exp. Cost
1	Cash In	Triangular	\$ 50,507,904	\$ 38,464,149	\$ 62,551,659	\$ 50,507,904
2	Cash Out	Normal	\$ 50,265,056	\$ 38,295,382	\$ 62,234,730	\$ 50,265,056
3	Investment	Normal	\$ 11,551,116	\$ 10,155,519	\$ 12,946,713	\$ 11,551,116
Total			\$ 112,324,076	\$ 86,915,050	\$ 137,733,102	\$112,324,076

Source: Calculation

After running 100,000 simulations with 50 intervals, an error rate of 0.95 percent is obtained, indicating that the results obtained have very good success accuracy. The following are the basic results of the Monte Carlo analysis performed with the Project Risk Analysis v2.1 application:

TABLE 2. basic statistic

Basic Statistics	
Mean Cost:	\$ 112,301,114
Lowest Cost:	\$ 84,094,909
Highest Cost:	\$ 140,862,410
Standard Deviation:	\$ 7,152,305
Real error	67853
% Real error	0.95%
Kurtosis:	2.862
Skewness:	-0.008
Iterations Run:	100,000
Median cost:	\$112,242,829
The difference between the median and the true mean	0.0519%

Source: Calculation Result

The researchers obtained kurtosis and skewness values from the table above. Kurtosis is the curve's relative size in comparison to the shape of the normal distribution curve. The kurtosis value for the normal distribution is 0, whereas the kurtosis value for the Monte Carlo simulation is 2.862. A positive kurtosis value indicates that the Monte Carlo simulation's distribution curve, as shown in the image above, has a flat and regular shape (platykurtic). Meanwhile, skewness is a measure of the symmetrical shape of the curve, with a value of 0 in the normal distribution and -0.008 in the Monte Carlo simulation. This negative result indicates that the tail of this curve is leaning more to the left, as illustrated in the figure below:



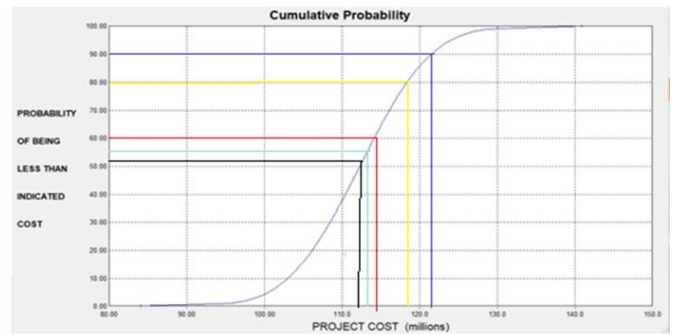
Fig. 1. Probability Distribution Cost

The highest bar in the histogram above is found to be in the position of \$112,301,114, with a probability of 6.3 percent, obtained with 100,000 iterations and 6300 events in this simulation.

TABLE 3. Probability Percentage

Probability	Project Cost	Project cost
0%	\$84,094,909	Rp 1,213,741,821,597
5%	\$100,549,213	Rp 1,451,226,791,229
10%	\$103,015,571	Rp 1,486,823,736,243
15%	\$104,730,572	Rp 1,511,576,345,676
20%	\$106,152,081	Rp 1,532,092,985,073
25%	\$107,374,528	Rp 1,549,736,562,624
30%	\$108,482,793	Rp 1,565,732,151,369
35%	\$109,478,498	Rp 1,580,103,161,634
40%	\$110,445,549	Rp 1,594,060,608,717
45%	\$111,379,053	Rp 1,607,533,871,949
50%	\$112,301,114	Rp 1,620,841,978,362
55%	\$113,226,830	Rp 1,634,202,837,390
60%	\$114,161,393	Rp 1,647,691,385,169
65%	\$115,096,045	Rp 1,661,181,217,485
70%	\$116,084,566	Rp 1,675,448,541,078
80%	\$118,877,162	Rp 1,715,754,079,146
85%	\$119,131,534	Rp 1,719,425,430,222
90%	\$121,131,534	Rp 1,748,291,430,222
95%	\$124,031,534	Rp 1,790,147,130,222
100%	\$140,862,410	Rp 2,033,067,163,530

Source: Calculation Result



Graph 1. Probability Cost

Based on the results of the Monte Carlo simulation, which were obtained with an average budget of 112,301,114, the probability that this project will be successful is approximately 50.14 percent. Considering the cash flow and investment provided with various risks and uncertainties of success, the El Tari Kupang International Airport development project already has a fairly high probability.

TABLE 4. Contingency Analysis

Contingency Analysis			
Sum of Likely Costs (SLC):		\$112,301,114	
Probability of being less than SLC:		50.14%	
Confidence Level	Total Project Cost	Required Contingency Value	
Desired	Cost	Value	Percent of SLC
100%	\$140,862,410	\$28,538,334	25,41%
99%	\$128,695,389	\$16,334,201	14,54%
95%	\$124,031,534	\$11,707,192	10,42%
90%	\$121,516,937	\$9,192,722	8,18%
80%	\$118,355,439	\$6,030,868	5,37%

Source: Calculation Result

As previously stated, the El Tari Kupang International Airport development project has a probability level with an average cost of success of 50.14 percent. However, if the project owner, in this case, PT Angkasa Pura, is moderate and wants an 80 percent probability level, the budget that must be prepared must not be less than \$118,355,439, or an additional \$6,030,868 or a 5.37 percent contingency is required. However, if the owner wishes to be more cautious, the funds that must be prepared are \$128,695,389 or \$16,334,201 plus a 14.54 percent contingency to achieve a probability of 99 percent.

#### V. CONCLUSION

The Monte Carlo simulation method can be used to conclude an investment analysis for the El Tari Kupang International Airport development project. The lowest

probability of success for this project is 50.14 percent, and the highest probability is 99 percent. As a result, the El Tari Kupang International Airport development project can be described as a success with high optimism.

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