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Monte Carlo Simulation Application for Project Scheduling Improvements in The Shipping Industry

N Nazaruddin[1], Arini Anestesia Purba[2], I Putu Deny Arthawan Sugih Prabowo[3]

[1]Department of Industrial Engineering, Universitas Islam Negeri Sultan Syarif Kasim, Riau, Indonesia
[2] Department of Industrial Engineering, Institut Teknologi Kalimantan, Balikpapan, Indonesia
[3] Department of Information Systems, Institut Teknologi Kalimantan, Balikpapan, Indonesia

Author Email: nazar.sutan@uin-suska.ac.id[1], arini.anestesia@lecturer.itk.ac.id[2], putudeny.asp@lecturer.itk.ac.id[3]

Abstract. This research was carried out at PT. X is a shipping yard that produces one of them, namely ship blocks. In the implementation of ship block building projects, there is uncertainty in the project's duration, so it needs to be completed by applying the Monte Carlo simulation method. Monte Carlo Simulation is a method used to model and analyze systems with risks and uncertainties. The basis of the Monte Carlo simulation is to conduct experiments on probabilistic elements through random sampling. This study aims to identify the probability of duration and percentage of possibility of the period in a project so that scheduling using Microsoft Project software is more measurable and optimal. Based on the Monte Carlo simulation results in ball software, the fastest duration for the H402 ship block project was obtained, namely 64 days, with a 0% probability of success. The longest time was 83 days with a chance of 100%, and the average duration for 73 days with a possibility of 65%, while the plan duration was 80 days with a probability of 94.7%. Then for the H501A block work, the fastest time produced is 74 days with a chance of 0%, the longest most extended is 82 days with a probability of 100%, and the average duration for 79 days with a possibility of 60-70% while the time of the plan is for 75 days with a probability of 9.8%.

Keywords: Monte Carlo Simulation, Project, Ship products, Uncertainty

1 Introduction

Scheduling activities are part of project activities in the planning process[1]. With scheduling, a company can determine when an activity or project work will start and when it will end and can adjust resources related to the implementation of project activities[2][3]. Project work does not only sometimes go to a predetermined schedule because of the need to consider resources and other factors that effectively and efficiently affect project activities e duration of the project is uncertain due to several factors, namely the quality and quantity of resources, environmental and weather conditions, technology and equipment,[4][5][6].

PT.X is a company currently holding a project to manufacture ship block parts ordered from Japan, totalling nine ship blocks working on this project. Some problems indicate a delay in project work. The contributing factor is an imbalance between the amount of mass produced in units of tons/week from the initial planning and the realization of this project. In the first week, it was planned to make a total mass of 22 tons/week, but the completion produced a total mass of 9.6 tons/week. Then another problem was the imbalance between the initial planning of the number of workers needed and the realization in the field in the first week; it was planned as many as 35 people, but the completion in the area was only seven people. Table 1 shows the progress of the project undertaken by PT X.

Table 1. Project Progress

Ship block name	Mass weight estimation (ton)	Actual start	Actual duration	(%) Progress	Block fabrication status
H402M	99.180	10-January-2022	69 days	87%	Assembly
H401U	87.310	13-January-2022	66 days	100%	Complete

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H402U	122.54	15-January-2022	64 days	100%	Complete
H501A	140.22	14-January-2022	65 days	83%	Assembly
H502A	61.23	17-February-2022	31 days	40%	Sub Assembly
H503A	50.18	14-February-2022	34 days	28%	Sub Assembly
H504A	35.74	17-February-2022	31 days	30%	Sub Assembly
H505A	24.81	14-February-2022	34 days	38%	Sub Assembly
H506A	27.31	03-February-2022	45 days	53%	Assembly

Based on table 1, the work on the ship block with the name H402M was carried out on January 13, while the realization was carried out three days earlier. The H401U block was carried out on January 11, but in reality, it was carried out two days after the specified date and on other ship blocks. Not appropriate due to the acceleration and delay in the work of this project. In addition, in terms of the planned duration, it is not by its realization. For example, the yield on block H402M is designed to be completed within 65 days, but in the development of this block, it has taken 69 days and is still in the assembly stage, while completing one block still requires three working processes again.

Based on the problems that have been described, it can be concluded that the occurrence of delays in project work, this problem has a significant impact on the company, one of which is the level of client confidence to work together again with the company in future projects. For this reason, the problem needs to be solved using probabilistic scheduling, known as the Monte Carlo simulation. This simulation is used because of the various durations of a project and the factors that cause uncertainty[7][8][9]. The monte Carlo simulation is a probability calculation simulation that discusses risk aspects in project management[10]. This method is used to understand the potential effects of project uncertainty. Besides that, with this method, the confidence level in the results of acceleration or delay of a project can be seen ed on the probability of project completion more efficiently by considering risk aspects in project work[11][12][13].

In the field of project management, Monte Carlo simulation is used to calculate or iterate over the cost and time of a project using randomly selected values from the probability distribution of costs and times that may occur to estimate the distribution of possible prices and a total time of a project[14][15].

Three-time estimates are used to perform the Monte Carlo simulation, namely the optimistic, pessimistic, and most probable time obtained based on questionnaires distributed to several workers in this field. With different duration variations from the Monte Carlo simulation results[16][17][18], scheduling using the Microsoft project can be used as a reference in the project schedule that is more optimal. It is hoped that this simulation can provide an alternative in project scheduling, especially on project duration, that can be used in decision-making for the next project in the future[19][20][21].

The limitation of this research problem is only to measure two ship blocks studied from 9 blocks in the project, namely the H402U ship block and the H501 ship block. This is because the two blocks inspected are the blocks that have the largest mass number of the total blocks to be produced and have entered the production stage at the time of field observation.

2 Methodology

This research methodology is an explanation of the research steps from beginning to end for this research. The actions that will be carried out in this research are as follows[22–28]:

2.1 Preliminary Studies

This preliminary study is the first step in observation and data collection, interviews, and field surveys. Then the main problem of the object of this research is formulated to design the method of completion of the shipbuilding project.

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2.2 Formulate the Problem

Problem identification is a stage in finding problems or factors that cause uncertainty in the ship block building project. The situation in this research is the uncertainty of project completion duration based on several factors that affect scheduling, namely workforce, material, and other external factors.

2.3. Data collection

Table 2 shows the data collection methods, analytical methods, and the desired results of this study.

Table 2..Data Collection

Goals	Dimension	Collected data	Collection method data	Data analysis method	Output
Knowing the probability	Duration	Optimistic, pessimistic, and most likely time duration	Field surveys, literature studies, and questionnaires	Monte Carlo method	Probability duration
Scheduling	Duration	Work duration simulation project	Study of literature	Project scheduling using Microsoft project	New Scheduling Proposal

Table 2 is the data collected to achieve each goal of improving project schedules to produce the expected outputs as follows:

a. Knowing the probability and probability percentage is part of the Monte Carlo simulation process obtained based on field surveys, literature studies, and distributing questionnaires so that a result is received in time duration.
b. Scheduling, for scheduling the data collected in the form of the duration of the Monte Carlo simulation results collected based on the study of literature. The method used is scheduling using the Microsoft Project application.

3 Results and Discussion

3.1 Monte Carlo Method

The monte Carlo method is carried out using the Crystal Ball application so that the fastest, longest, and average simulation results on each work item in each ship block are studied. Several steps must be carried out to run the Monte Carlo simulation, namely the following reasons[29,30,39,31–38].

a. Average duration on block H402U
   Mean = (R1+R2+R3+R4+R5)/N (1)
   R = Respondent
   Mean = (70+60+55+65+60)/5 = 62 days
b. Calculating Standard deviation
   Standard deviation = (min time, max time) (2)
c. Calculating the standard error is by using an absolute error of 2%.
   absolute error = 0,02 x mean (3)
d. Counting the number of iterations
   Iterate = (3* standard deviation/absolute error)^2 (4)

Table 3 and Table 4 show the recapitulation of the calculation results to determine the number of iterations[40,41,50,42–49].

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Table 3. Recapitulation of the number of iterations in the H402U ship block

Number	Job name	Fastest average duration (days)	Longest average duration (days)	Standard deviation	Average duration	Absolute error	Iteration
1	Block H402U	62	69	4.95	66	1.31	128
2	Panel Fabrication	38	40	1.41	39	0.78	30
3	SQ1 MD1	25	28	2.12	27	0.53	144
4	SQ2 Z10B	4	5	0.71	5	0.09	556
5	SQ3 F8B	16	18	1.41	17	0.34	156
6	SQ4 F12BA	9	11	1.41	10	0.20	450
7	SQ5 F9B	4	6	1.41	5	0.10	1800
8	SQ6 F34B	4	5	0.71	5	0.09	556
9	SQ7 LM9BB	13	14	0.71	14	0.27	62
10	SQ8 L9BB	14	16	1.41	15	0.30	200
11	SQ9 L11B	5	7	1.41	6	0.12	1250
12	SQ10 LM7BB	7	8	0.71	8	0.15	200
13	SQ11 SSP	6	9	2.12	8	0.15	1800
14	SQ12 SSS	6	9	2.12	8	0.15	1800
15	Block assembly	22	26	2.83	24	0.48	313
16	Install lifting lug	3	4	1.41	4	0.08	2813
17	Block final NDT	5	6	1.41	6	0.12	1250
18	Inspection	4	5	1.41	5	0.10	1800

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Table 4. Recapitulation of the Number of Iterations on the H402U Ship Block

Number	Job name	Fastest average duration (days)	Longest average duration (days	Standard deviation	Average duration	Absolute error	Iteration
1	Block H501A	73	80	4.95	77	1.53	94
2	Panel fabrication	32	37	3.54	35	0.69	236
3	SQ1 Z1BA	28	31	2.12	30	0.59	116
4	SQ2 L11CG-H	15	17	1.41	16	0.32	176
5	SQ3 L07BA	5	6	0.71	6	0.11	372
6	SQ4 F17BA	6	8	1.41	7	0.14	918
7	SQ5 F24BA	4	5	0.71	5	0.09	556
8	SQ6 F27BA	5	6	0.71	6	0.11	372
9	SQ7 L02BA	3	4	0.71	4	0.07	918
10	SQ8 L09BA	5	7	1.41	6	0.12	1250
11	SQ9 L01BB	4	6	1.41	5	0.1	1800
12	SQ10L09BB/L11BA	6	7	0.71	7	0.13	266
13	SQ11 L13BA	4	6	1.41	5	0.1	1800
14	SQ12F11BA/F16BA	5	7	1.41	6	0.12	1250
15	SQ13 F30BA	5	6	0.71	6	0.11	372
16	SQ14 F30BB	5	7	1.41	6	0.12	1250
17	SQ15 L03BA	3	4	0.71	4	0.07	918
18	SQ16 F32BA	3	4	0.71	4	0.07	918
19	SQ17 L0BA	2	3	0.71	3	0.05	1800
20	SQ18 F8BA	6	7	0.71	7	0.13	266
21	SQ19 F8BB	5	7	1.41	6	0.12	1250
22	SQ20 F7BA	3	4	0.71	4	0.07	918
23	SQ21 Z2BA	3	4	0.71	4	0.07	918
24	SQ22 SS1BA/B	10	12	1.41	11	0.22	372
25	SQ23 SS1BC/D	10	12	1.41	11	0.22	372
26	SQ24 F24HA	2	4	1.41	3	0.06	5000
27	Block assembly	28	33	3.54	31	0.61	302
28	Install lifting lug	3	5	1.41	4	0.08	2813
29	Block final NDT	5	7	1.41	6	0.12	1250
30	Inspection	5	8	2.12	7	0.13	2396

Table 3 and Table 4 are recapitulation tables in the form of calculation results before running the simulation to determine each work item's iteration. Iteration in the Monte Carlo simulation is useful for knowing how many iterations to solve mathematical problems based on each work item on each ship block.

3.2 Run Monte Carlo Simulation

Figures 1 and 2 are the results of the Monte Carlo simulation run using Crystal Ball software by entering the number of iterations for each job.

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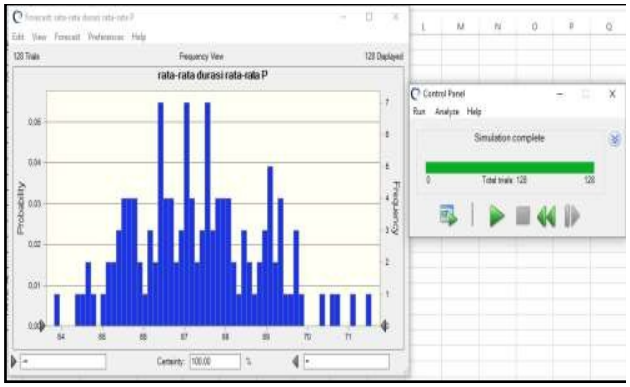
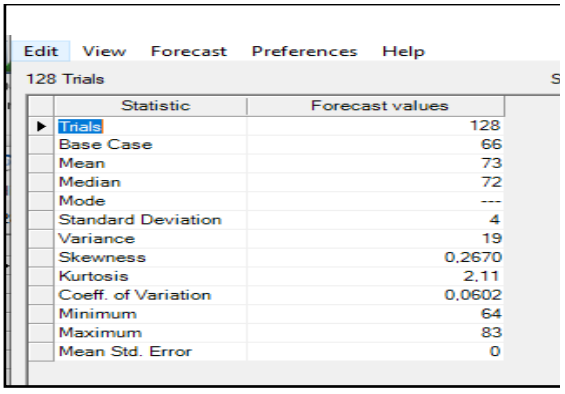


Figure 1. The Results of the Simulation of the Monte Carlo Block Item H402U



Statistic	Forecast values
Trials	128
Base Case	66
Mean	73
Median	72
Mode	---
Standard Deviation	4
Variance	19
Skewness	0,2670
Kurtosis	2,11
Coeff. of Variation	0,0602
Minimum	64
Maximum	83
Mean Std. Error	0

Figure 2. H402U block Item Statistics

Based on Figure 1 and Figure 2, it can be concluded that for a work item, the fastest duration generated after running the simulation is 64 days, and the longest time is 83 days. In comparison, the most likely course is 73 days.

3.3 Determine Assumptions on the Fastest and Longest Duration

Figure 3 and Figure 4 show determining the reference mean duration assumption for the Monte Carlo simulation to select the average time.

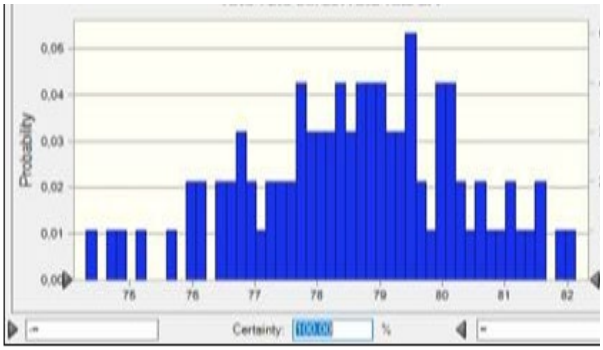
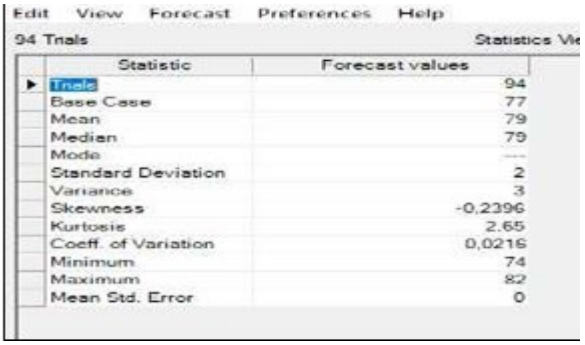


Figure 3. Monte carlo simulation results in block item H501A



Statistic	Forecast values
Trials	94
Base Case	77
Mean	79
Median	79
Mode	---
Standard Deviation	2
Variance	3
Skewness	-0,2396
Kurtosis	2,65
Coeff. of Variation	0,0216
Minimum	74
Maximum	82
Mean Std. Error	0

Figure 4. H501A . block item statistics

Based on Figure 3 and Figure 4, it can be concluded that for work item P in block H501A, the fastest duration generated after running the simulation is 74 days, the longest time is 82 days, and the average duration is 79 days. After carrying out a series of stages to run the simulation, it is necessary to recapitulate the overall simulation results from the fastest time, longest duration, and average work items in each block studied.

3.4 Simulation results

Tables 5 and 6 recapitulate simulation results for the H402U and H501A ship blocks.

Table 5. Recapitulation of Simulation Results for Block H402U

Number	Job name	Fastest average duration (day)	Longest Average duration (day)	Average duration (day)
		Hasil simulasi		
1	Block H402U	64	83	73
2	Panel Fabrication	37	42	39
3	SQ1 MD1	26	29	27

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4	SQ2 Z10B	4	5	4
5	SQ3 F8B	17	18	18
6	SQ4 F12BA	10	11	10
7	SQ5 F9B	5	6	6
8	SQ6 F34B	4	5	5
9	SQ7 LM9BB	13	15	14
10	SQ8 L9BB	15	17	15
11	SQ9 L11B	6	7	7
12	SQ10 LM7BB	7	8	8
13	SQ11 SSP	7	9	8
14	SQ12 SSS	7	9	8
15	Block assembly	23	27	24
16	Install lifting lug	6	7	6
17	Block final NDT	6	7	6
18	Inspection	5	6	6

Table 6. Recapitulation of Simulation Results for Block H501A

Number	Job name	Fastest average duration (day)	Longest Average duration (day)	Average duration (day)
		Simulation results		
1	Block H501A	74	82	79
2	Panel fabrication	33	38	36
3	SQ1 Z1BA	28	32	30
4	SQ2 L11CG-H	15	18	16
9	SQ7 L02BA	3	4	4
10	SQ8 L09BA	6	7	7
11	SQ9 L01BB	5	6	6
12	SQ10L09BB/L11BA	6	7	7
13	SQ11 L13BA	5	6	6
14	SQ12F11BA/F16BA	6	7	7
15	SQ13 F30BA	5	6	6
16	SQ14 F30BB	6	7	6
17	SQ15 L03BA	3	4	4
18	SQ16 F32BA	3	4	4
19	SQ17 L0BA	2	3	3
20	SQ18 F8BA	6	7	7
21	SQ19 F8BB	6	7	7
22	SQ20 F7BA	3	4	4
23	SQ21 Z2BA	3	4	4
24	SQ22 SS1BA/B	11	12	12
25	SQ23 SS1BC/D	11	12	11
26	SQ24 F24HA	3	4	4
27	Block assembly	30	34	32
28	Install lifting lug	4	5	5
29	Block final NDT	6	6	7
30	Inspection	6	8	7

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Based on the recapitulation results in Table 5 and Table 6, then design a schedule using Microsoft Project software. In the preparation of the scheduling of each vessel block studied, it is designed based on the simulation results for each fastest duration, longest duration, and average duration. Then compared with the time of the plan. Figure 5, Figure 6, and Figure 7 show the scheduling results for the H402U block. Figure 8, Figure 9, and Figure 10 show the scheduling results for block H501A.

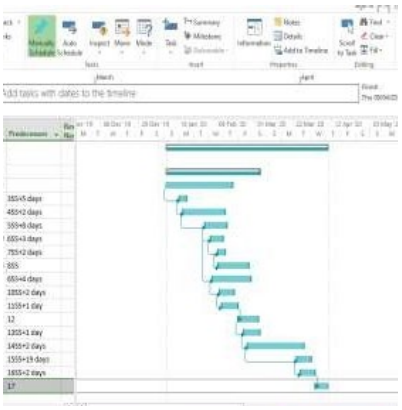

Figure 5. Scheduling the Fastest Duration of the H402U Block

Figure 6. Scheduling the Longest Duration of the H402U Block

Figure 7. Scheduling the Average Duration of the H402U Block

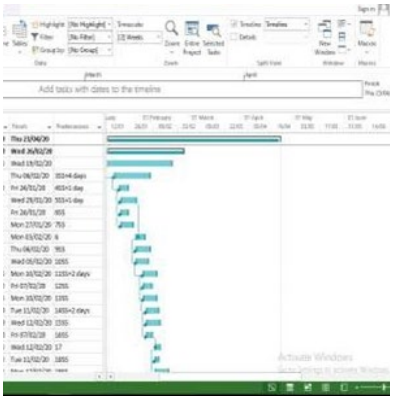

Figure 8. Scheduling the Fastest Duration of Block H501A

Figure 9. Scheduling the Longest Duration of the Block H501A

Figure 10. Scheduling the Average Duration of Block H501A

3.5 Scheduling Probability

Table 6. Percentage Chance of Success of H402U and H501A Blocks

.Block H402U	%	0	10	20	30	40	50	60	70	80	90	100
	Durasi	64	66	68	69	70	71	72	74	75	76	83
Block H501A	%	0	10	20	30	40	50	60	70	80	90	100
	Durasi	74	76	77	77	78	78	79	79	80	80	82

Based on the results of the simulation, it can be seen that the probability of the work in question is for the entire job on block H402U, which produces an average duration of 73 days with a chance of 65%, while for block H501A, it has an average time of 79 days with a probability of 70%.

4 Conclusions

The total scheduling duration generated based on the simulation results has the fastest and longest. The average time for the H402U block with the quickest course produces 64 days with a percentage of 0% probability of success, and the most extended duration is 83 days with a 100% probability of success. The average period resulted in 73 days with a 65% chance of success. Furthermore, the H501A block with the fastest duration resulted in 74 days, with the percentage probability of success equal to the probability of success of the quickest duration H402U. The longest period was 82 days, with a 100% probability of success. The average duration resulted in 79 days with a percentage probability of success. Meanwhile, compared with the percentage of the plan duration for block H402U is 94.7%, and for block, H501A is 9.8%. 60% and 70%.

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