# IMPLEMENTATION OF THE CPM METHOD IN THE CONSTRUCTION PROJECT OF THE SURABAYA "X" HOSPITAL HEALTH CHECKUP

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**ABSTRACT**

The process of planning to project control during the execution of construction work is an important activity of a project. A project can be said to be a success or a failure caused by ineffective planning and control, so project activities fail. so there will be a delays, decreased quality, and increased implementation costs. A project is limited by a predetermined time and cost so management in the project must be able to anticipate changing conditions that occur. The Critical Path Method abbreviated CPM method can be applied to manage project completion time more efficiently and effectively. To be able to reduce the impact of project delays and cost overruns through a crash calculation mechanism with three alternative controls; additional labor or overtime work. Duration acceleration is carried out on jobs that are on the critical path and with the cheapest costs. In this study, the total project age was 277 calendar days, while the project deadline was 284 calendar days, thus the project was delayed for 7 calendar days with a total fine of Rp 25.242.944.400 and penalty cost is 1/1.000 for sum of contract. In this study the CPM method is intended to shorten the life of the project so that it can be completed in accordance with the predetermined time limit and determine the age of project in accordance with the existing contract, using CPM the project life can be shortened to 257 working days with an budget efficiency Rp. 176,700,611

**Keywords:** Scheduling, CPM, Critical Path, Crashing, Time Acceleration

## 1. INTRODUCTION

A project activity can be said to be successful if all the scope of work is met with good quality, conformity between the realization of the schedule, the costs incurred, and the agreed time limit according to the contract. Therefore, it is necessary to control time efficiently and effectively. Sufficient knowledge and skills in using tools commonly used in project management such as Microsoft project, excel, primavera, etc. A project manager especially beginners. This capability will be more complete if a project manager is assisted with project management support applications. This capability makes it easier for project managers to manage and document, be it small or large-scale projects, it can also cut monitoring time because it is enough to see from the system.

So far, companies in determining time are only based on experience so several problems often arise in project planning and control, namely the lack of project managers in mapping the critical path of activity. The critical path is critical to project implementation. At PT. XYZ projects often occur due to delays in the completion of critical activities and the impact on project costs is getting bigger. Sometimes found more than one critical path in project work activities.

XYZ Corporate is a company working in the construction of the Indonesian National Construction Implementing Association (GAPENSI) so PT XYZ has standardization and classification to provide national construction services. In addition, PT XYZ's qualifications and classifications have been registered nationally based on the National Business Entity Certification Agency (LSBU) (Ministry of Public Works and Public Housing, 2022). Problems that often arise in there is a difference between the target time and the implementation of building construction by XYZ corporate and the realization of completion so that the impact on the costs incurred is increasing, affecting the company's profits, even the company can suffer losses due to penalties that must be met if the building construction project does not comply with the agreed time.

Inadequate production equipment, procurement of required materials, procurement and quality of human resources, as well as costs are some of the factors that can affect project completion time, delays will impact not only costs but also consumer views on the credibility of the company itself which will have an impact on the survival of the company. In project planning and control, one of the methods used is the CPM method. This method is quite widely used in planning and controlling building construction projects. This method has the advantage of analyzing projects in terms of estimating the project finishing time by finding the critical path, identify the start and end times of each activity to determine the project schedule, and calculating the amount of slack time for each activity so as to minimize project delays.

The shortcoming that exists in previous studies, including those stated in the references review, is that the calculation of the CPM method is not detiled and has not been applied to health care a building construction project especially medical chekup building. In the CPM (Critical Path Method) method there are stages of determining the critical path, where the critical path is the activity in the project that has the longest total execution time and shows the fastest project completion time span compared to other activity paths..

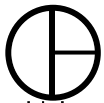
Applying the CPM method to applications, especially in health care building projects, can help and facilitate project managers in mapping problems in project work so that the time and costs needed in project work can be estimated properly and critical paths in project work can be mapped properly. Project managers also easy to find out critical activities in project work so these activities need to be controlled so that related activities do there is no delay in project completion and the project can be completed on time.

## 2. LITERATURE REVIEW

### 2.1. Project Schedule

Schedule is elaboration of planning project into a sequence of steps for implementing work to achieve goals. The time factor has been included in the schedule. A well-known method of compiling a schedule is network analysis, which depicts in a graph the relationship sequences of project work. Network Planning Notations and Symbols include:

a. → : Arrows/arrows indicate an activity/activity, namely an activity or work whose completion requires a duration (a certain period of time) and a resort (labor, tools, materials, and costs). The arrows guide the direction of each activity, where length and slope have no effect.

b.  Node / Event, which is a round circle which means if an event or event is a meeting of the beginning and end of the activity.

c. – – → Dummy / discontinuous arrows that represent pseudo activities, namely activities that do not require duration and resources.

d. ↔ Double Arrow / Arrow model that shows the critical path activities (critical path).

The factors that influence Network Planning according to (Siswojo, 2000) include (1) the plan that will be used by the company in implementing the project, determining the activities that must be carried out, and the logic of dependence on each other; (2) The length of time used in the project is usually measured in standard time units: days, hours, minutes, that time.

Jobs that must precede or be preceded by other jobs are identified in terms of time. This network is very useful for project planning and control. Scheduling is an activity to determine the time required and arrange the sequence of activities while determining when the project can be completed. Project scheduling is something more specific and becomes part of project planning. Project scheduling includes timing and stages of implementing activities as originally planned.

### 2.2. Network Planning

Network planning is literally an interrelated dependency relationship between the parts of the work as outlined in the network diagram so that it is known which parts of the work must take precedence and which jobs must wait for the completion of other work (Soeharto, 1997). Overall (Gray and Erik, 2007). The following are some of the terms used to build a project network:

a. Activities are activities within the project that take time to be implemented according to the project plan.

b. A combined activity is an activity or activities that have more than one activity that precedes it (more than one dependency arrow).

c. A path is a sequence of related activities.

d. Predecessor is a predecessor activity.

e. A successor is a substitute activity or activity that follows another activity.

f. The Critical Path is the longest path on the network of a project, if the activity on that path is delayed, the project will experience delays due to the delay at the same time.

### 2.3. Critical Path Method (CPM)

CPM known as the critical path, was created by (Kelley, Walker, & Sayer, 1989) of the company Remington Rand and M.R Walker of Du Pont in order to develop a management control systemThis system is intended to plan and control a large number of activities that have complex dependencies on a project activity in terms of design and construction. Through the critical path method, implementers can find out which jobs are vulnerable and influential in the overall work process.

If there is a delay and by knowing the location of the delay, in its implementation, anticipatory actions can be taken for the time inefficiency that occurred previously, so that delays in one part do not propagate to other jobs. In the analyzes of identifying the critical path there are several terms or definitions, namely as follows:

a. Earliest Start Time (ES) is the earliest time (fastest) a project activity can start, taking into account the time to be achieved from the activity and the requirements that must be met according to the sequence of work.

b. Latest Start Time (LS) is the longest time to be able to start a project activity without experiencing a delay in the entire project.

c. Early Finish Time (EF) is the earliest time an activity in the project can be completed, or equal to ES + Desired activity time.

d. Latest Finish Time (LF) is the slowest time to be able to complete an activity in a development project without delaying the completion of the entire project, or equal for LS + expected time activity.

### 2.4. ES, EF, LS, dan LF

According to Heizer and Render (2014: 105-109) in conducting critical path analysis, the use of a two-pass process consisting of a forward pass and a backward pass to determine the time schedule of activities in the project. ES and EF are determined during the feed-forward activity. LS and LF are determined during the back pass activity. ES (earliest start) is the earliest time a project activity can start assuming all its predecessors have been completed. EF (earliest finish) is the earliest time a project activity can be completed. LS (late start) is the last time an activity can be started so as not to delay the completion of the entire project. LF (late finish) is the last time an activity can be completed so as not to delay the completion time of the entire development project.

a. Forward Pass is an Early Start Time rule. Before an activity project could start, all of its predecessors must be completed after any activities. The earliest finish time (EF) of an activity is the calculate of the earliest start time (ES) and the time of the activity itself, that is EF = ES + Activity time.

1) If an activity have only one direct predecessor, ES is the same as the EF of the predecessor activity.

2) If an activity have more than one of direct predecessors, it's ES is the maximum value of all predecessor EFs, i.e.: ES = Maximum {EF all direct predecessors }.

b. Backward Pass is the Slowest Finish Time Rule activity project. Again, This rule is based on the fact that before a project activity can be started, all its predecessors must be completed within the given activity time. The rule for the slowest start time or also known as the slowest start time (LS) of a project activity is the difference between the latest completion time (LF) and the existing project activity time, namely: LS = LF - Activity time.

After calculating the earliest time and the slowest time of all activities, it becomes easy to find the amount of float time each activity project has. Slack is the free time that activity has so that its implementation can be postponed without causing delays in the overall project.

1) If an activity is a direct predecessor of only one activity, its LF equals the LS of the activity project that has immediately follows it.

2) If an activity project has a directing predecessor of more than one activity, then LF is the min of all LS values of the activity. activities that directly follow it, namely: LF = Min {LS of all activity that immediately follow it}.

3) Slack or Float is a critical activity with an activity value of zero which is on the critical path, namely Float = LS – ES or Float = LF – EF.

## 2.5. Research Methodology

The methodology used in this research is to do the work in a directed and systematic way so that there are clear sequences in the implementation of this research, by using a clear method, the research plan is carried out until the completion of the final stage of the research. The stages of work are made with a diagram according to Figure 1.

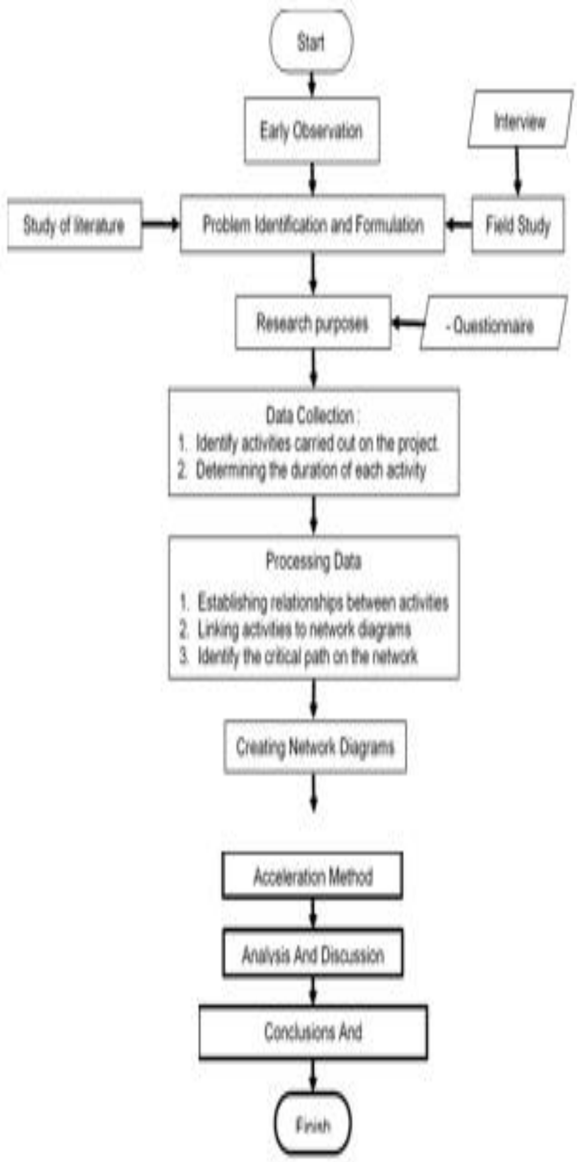



**Figure 1.** Research Flow Chart

The stages in this research begin with initial observation of the problem, identification and problem formulation through literature review and direct field observation through interviews, determining research objectives, collecting data through project identification and determining project duration, data processing through preparing activities, and linking activities and determining critical path, compiling a Gantt Chart, calculating the time and cost of acceleration, Analysis of Results, and ending with the Final Stage, while the explanation of these stages includes the preparation stage, modeling stage, data processing stage, data processing stage, results from the analysis stage and the end.

## 3. Result and Discussion

This research initially describes the activities, namely the assessment and identification of the project scope by describing and breaking it down into activities or groups of activities that are project components. This preparation is based on experience and/or data in past projects. Each activity has an estimated time in the process or duration which is arranged in the master schedule.

Determine the relationship between activities, that is, activities are rearranged into a chain, where the sequence of activities is in accordance with the logic of dependency in network planning so that the sequence of activities can be known from the beginning of the development process of a project until the completion of the project as a whole.

a. Input Activities Project

Activity determination begins by defining project activities and entering the duration of each activity followed by defining its predecessor. That each activity on the project has a predecessor activity as the basis for implementing and calculating the completion time of activities in Table 1 and create network planning Figure 1 according to project data.

**Table 1.** Description of Activities, Duration, and Predecessors Activities

| NO | Activity | Description of activities | Duration (Day) | Predecessor |
|---|---|---|---|---|
| 1. | A | Mobilization | 4 | - |
| 2. | B | Worker Barracks Loading | 7 | A |
| 3. | C | Land Clearing | 7 | A |
| 4. | D | Backfill and Compaction | 14 | C |
| 5. | E | Stake Fabrication and Mobilization | 11 | A |
| 6. | F | Erection | 20 | E |
| 7. | G | Stake Head Cutting | 7 | F |
| 8. | H | Reinforcing | 17 | G |
| 9. | I | Formwork | 19 | H |
| 10. | J | Casting | 14 | I |
| 11. | K | Roof Frame Work | 7 | J |
| 12. | L | Roof Closure | 3 | K |
| 13. | M | Water Installation Sparring | 7 | F |
| 14. | N | Genset Room | 30 | D |
| 15. | O | Septic Tank Fabrication | 14 | A |
| 16. | P | Making infiltration and septic tanks | 2 | O |
| 17. | Q | Mobilization | 3 | P, N, B, L, M |
| 18. | R | Making Keet Directors, Work Barracks, Work Losses During the Implementation Period | 3 | Q |
| 19. | S | Practical Column Work | 21 | R |
| 20. | T | Lightweight Brick Wall Pair | 14 | R |
| 21. | U | Plaster and Acian | 30 | AP, S |
| 22. | V | Install GRC Partition wall | 30 | Z |
| 23. | W | Travertine and Conwood wall mount | 20 | U |
| 24. | X | Ceiling Work | 20 | U |
| 25. | Y | Door and Window Works | 15 | Z |
| 26. | Z | Floor job | 45 | X |
| 27. | AA | Painting Job | 20 | U |
| 28. | AB | Glass Canopy Roof Work | 7 | X |
| 29. | AC | Storage Works | 1 | T |
| 30. | AD | Submission of New Electrical Installation | 45 | R |
| 31. | AE | Incoming and Outgoing Cubicle Jobs | 14 | AM |
| 32. | AF | Transformer Work | 4 | AM |

| NO | Activity | Description of activities | Duration (Day) | Predecessor |
|---|---|---|---|---|
| 33. | AG | Bed Lift Jobs | 120 | R |
| 34. | AH | Electrical Installation Installation | 30 | T |
| 35. | AI | Internal telephone jobs | 7 | T |
| 36. | AJ | Sound System Jobs | 7 | T |
| 37. | AK | CCTV Jobs | 7 | T |
| 38. | AL | AC jobs | 14 | AH |
| 39. | AM | Feeder Cable Work | 7 | T |
| 40. | AN | Electrical Panel Work | 5 | AH |
| 41. | AO | Lightning Protection Job | 2 | AF, AE |
| 42. | AP | Plumbing Job | 21 | R |
| 43. | AQ | Sanitary Work | 7 | AP |
| 44. | AR | Hydrant Job | 14 | U |

Source: Processed Author's Data

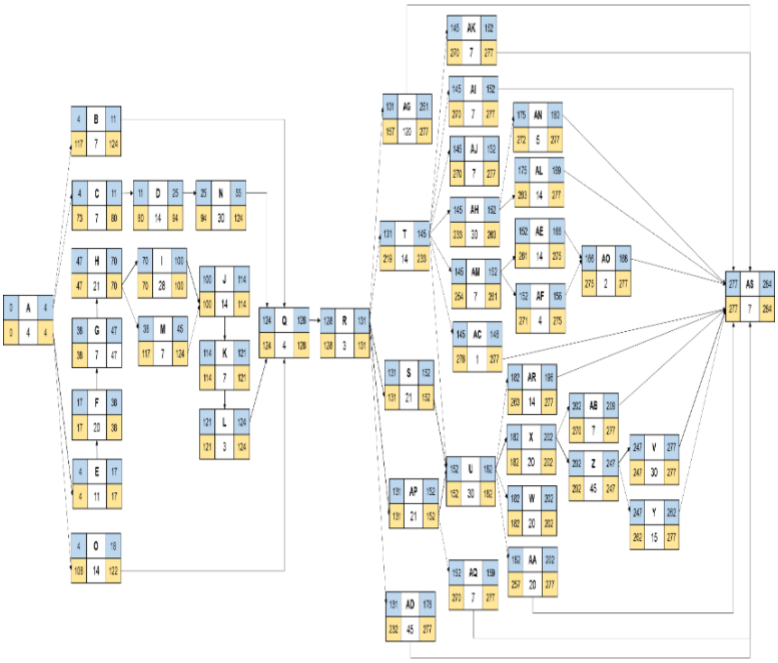


**Figure 2.** Network Planning

**Table 2.** CPM Calculation

| No | Activity | Predessor | Durasi | Early Start | Early Finish | Late Start | Late Finish | Slack |
|---|---|---|---|---|---|---|---|---|
| 1 | A | - | 4 | 0 | 4 | 0 | 4 | 0 |
| 2 | B | A | 7 | 4 | 11 | 117 | 124 | 113 |
| 3 | C | A | 7 | 4 | 11 | 73 | 80 | 69 |
| 4 | D | C | 14 | 11 | 25 | 80 | 94 | 69 |
| 5 | E | A | 13 | 4 | 17 | 4 | 17 | 0 |
| 6 | F | E | 21 | 17 | 38 | 17 | 38 | 0 |
| 7 | G | F | 9 | 38 | 47 | 38 | 47 | 0 |
| 8 | H | G | 23 | 47 | 70 | 47 | 70 | 0 |
| 9 | I | H | 30 | 70 | 100 | 70 | 100 | 0 |
| 10 | J | I | 14 | 100 | 114 | 100 | 114 | 0 |

| No | Activity | Predessor | Durasi | Early Start | Early Finish | Late Start | Late Finish | Slack |
|---|---|---|---|---|---|---|---|---|
| 11 | K | J | 7 | 114 | 121 | 114 | 121 | 0 |
| 12 | L | K | 3 | 121 | 124 | 121 | 124 | 0 |
| 13 | M | F | 7 | 38 | 45 | 117 | 124 | 79 |
| 14 | N | D | 30 | 25 | 55 | 94 | 124 | 69 |
| 15 | O | A | 14 | 4 | 18 | 108 | 122 | 104 |
| 16 | P | O | 2 | 18 | 20 | 122 | 124 | 104 |
| 17 | Q | P, N, B, L, M | 4 | 124 | 128 | 124 | 128 | 0 |
| 18 | R | Q | 3 | 128 | 131 | 128 | 131 | 0 |
| 19 | S | R | 21 | 131 | 152 | 131 | 152 | 0 |
| 20 | T | R | 14 | 131 | 145 | 219 | 233 | 88 |
| 21 | U | AP, S | 30 | 152 | 182 | 152 | 182 | 0 |
| 22 | V | Z | 30 | 247 | 277 | 247 | 277 | 0 |
| 23 | W | U | 20 | 182 | 202 | 257 | 277 | 75 |
| 24 | X | U | 20 | 182 | 202 | 182 | 202 | 0 |
| 25 | Y | Z | 15 | 247 | 262 | 262 | 277 | 15 |
| 26 | Z | X | 45 | 202 | 247 | 202 | 247 | 0 |
| 27 | AA | U | 20 | 182 | 202 | 257 | 277 | 75 |
| 28 | AB | X | 7 | 202 | 209 | 270 | 277 | 68 |
| 29 | AC | T | 1 | 145 | 146 | 276 | 277 | 131 |
| 30 | AD | R | 45 | 131 | 176 | 232 | 277 | 101 |
| 31 | AE | AM | 14 | 152 | 166 | 261 | 275 | 109 |
| 32 | AF | AM | 4 | 152 | 156 | 271 | 275 | 119 |
| 33 | AG | R | 120 | 131 | 251 | 157 | 277 | 26 |
| 34 | AH | T | 30 | 145 | 175 | 233 | 263 | 88 |
| 35 | AI | T | 7 | 145 | 152 | 270 | 277 | 125 |
| 36 | AJ | T | 7 | 145 | 152 | 270 | 277 | 125 |
| 37 | AK | T | 7 | 145 | 152 | 270 | 277 | 125 |
| 38 | AL | AH | 14 | 175 | 189 | 263 | 277 | 88 |
| 39 | AM | T | 7 | 145 | 152 | 254 | 261 | 109 |
| 40 | AN | AH | 5 | 175 | 180 | 272 | 277 | 97 |
| 41 | AO | AF, AE | 2 | 166 | 168 | 275 | 277 | 109 |
| 42 | AP | R | 21 | 131 | 152 | 131 | 152 | 0 |
| 43 | AQ | AP | 7 | 152 | 159 | 270 | 277 | 118 |
| 44 | AR | U | 14 | 182 | 196 | 263 | 277 | 81 |
| 45 | AS | AN, AG, Y, AA, W, AD, AB AR, | 7 | 277 | 284 | 277 | 284 | 0 |

Description : Critical Path

Source: Processed Author's Data

Based on the results of the CPM calculation in Table 2, then it is described in the form of a network diagram that has been adjusted to the results obtained. The following can be seen in Figure 3 network diagram using the CPM method. A series of activities that fall into the critical of path using the CPM method is a critical of path that is on the path A, E, F, G, H, I, J, K, L, Q, R, S, U, V, X, Z, AP, and AS.

Based on Figure 3, the project of completion time by using the CPM method is 101 days. With the analysis that Paths A, E, F, G, H, I, J, K, L, Q, R, S, U, V, X, Z, AP, and AS are paths that do not have work time between the completion of one activity stage with other activities with the start stage of the next activity.

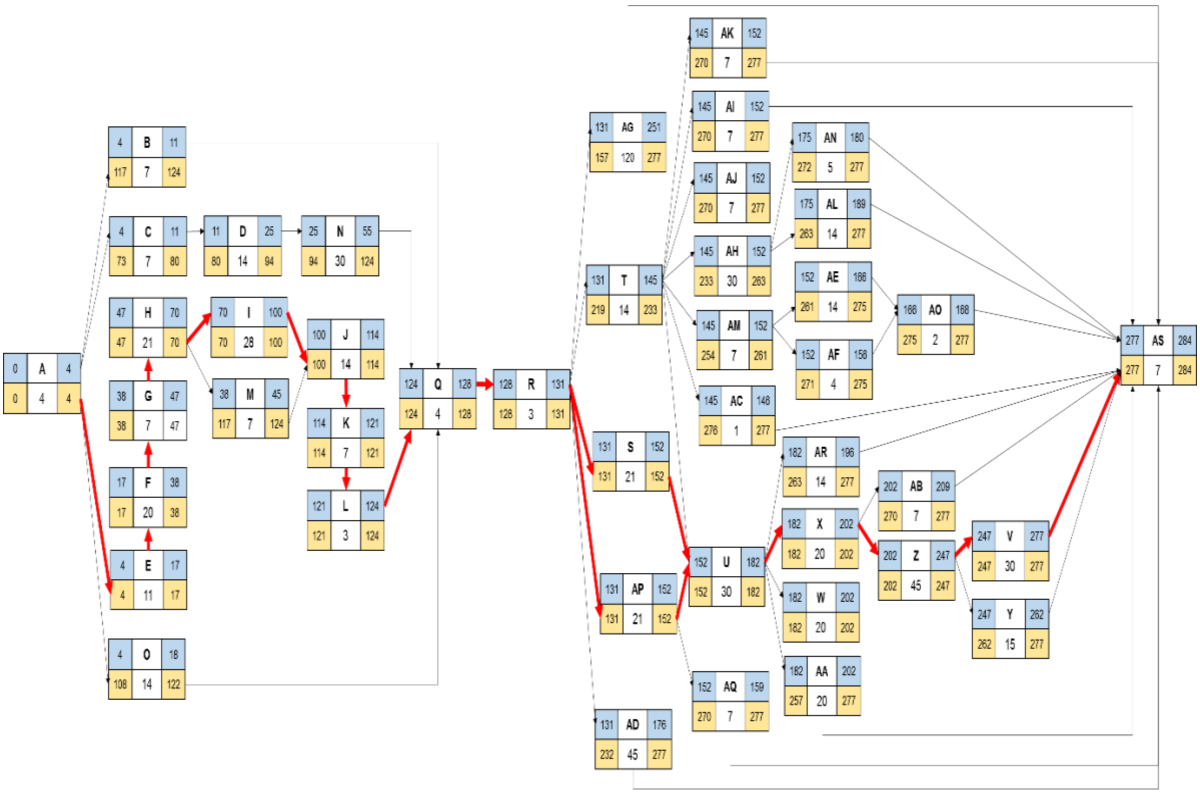



**Figure 3.** Critical Path

b. Acceleration Time

Calculating crash duration look in Table 3 :

$$\text{Crash Duration} = \frac{\text{Working hours}}{\text{Working hours} + (a \times b)} \times \text{Initial Duration}$$

Working hours + (a x b)

Where :

a = Number of overtime hours

b = Coefficient of decrease in work productivity

= 0.9 for 1 hour overtime

= 0.8 for 2 hours of overtime

= 0.7 for 3 hours of overtime

Initial Duration of Activity A = 4 days

$$\text{Crash Duration} = \frac{8 \text{ Hours}}{8 \text{ hours} + (1 \times 0.9)} \times 4 \text{ days} = 3.59 \text{ rounded to 4 days}$$

**Table 3.** Acceleration Time

| No | Activity | Predessor | Durasi | Accelerate | No | Activity | Predessor | Durasi | Accelerate |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | - | 4 | 0 | 24 | X | U | 20 | 182 |
| 2 | B | A | 7 | 4 | 25 | Y | Z | 15 | 247 |

| No | Activity | Predessor | Durasi | Accelerate | No | Activity | Predessor | Durasi | Accelerate |
|---|---|---|---|---|---|---|---|---|---|
| 3 | C | A | 7 | 4 | 26 | Z | X | 45 | 202 |
| 4 | D | C | 14 | 11 | 27 | AA | U | 20 | 182 |
| 5 | E | A | 13 | 4 | 28 | AB | X | 7 | 202 |
| 6 | F | E | 21 | 17 | 29 | AC | T | 1 | 145 |
| 7 | G | F | 9 | 38 | 30 | AD | R | 45 | 131 |
| 8 | H | G | 23 | 47 | 31 | AE | AM | 14 | 152 |
| 9 | I | H | 30 | 70 | 32 | AF | AM | 4 | 152 |
| 10 | J | I | 14 | 100 | 33 | AG | R | 120 | 131 |
| 11 | K | J | 7 | 114 | 34 | AH | T | 30 | 145 |
| 12 | L | K | 3 | 121 | 35 | AI | T | 7 | 145 |
| 13 | M | F | 7 | 38 | 36 | AJ | T | 7 | 145 |
| 14 | N | D | 30 | 25 | 37 | AK | T | 7 | 145 |
| 15 | O | A | 14 | 4 | 38 | AL | AH | 14 | 175 |
| 16 | P | O | 2 | 18 | 39 | AM | T | 7 | 145 |
| 17 | Q | P, N, B, L, M | 4 | 124 | 40 | AN | AH | 5 | 175 |
| 18 | R | Q | 3 | 128 | 41 | AO | AF, AE | 2 | 166 |
| 19 | S | R | 21 | 131 | 42 | AP | R | 21 | 131 |
| 20 | T | R | 14 | 131 | 43 | AQ | AP | 7 | 152 |
| 21 | U | AP, S | 30 | 152 | 44 | AR | U | 14 | 182 |
| 22 | V | Z | 30 | 247 | 45 | AS | AN, AG, Y, AA, W, AD, AB AR, | 7 | 277 |
| 23 | W | U | 20 | 182 | | | | | |

c. Cost

The calculation of project costs in terms of workers' wages is divided into 2, namely the wages of workers in normal conditions and accelerated conditions, in normal conditions workers are paid according to normal wages while in accelerated conditions they are paid 1.5 times the normal wage so that the details of wages can be seen from the table 4.

**Table 4.** Comparison of Normal Cost and Accelerate Cost

| Aktivity | Duration | Foreman | Craftsman | Labourer | Accelerate Cost | | Normal Cost | |
|---|---|---|---|---|---|---|---|---|
| A | 4 | 1 | 1 | 4 | Rp | 3.322.992 | Rp | 2.798.000 |
| B | 7 | 1 | 2 | 4 | Rp | 6.833.512 | Rp | 5.754.000 |
| C | 7 | 1 | 6 | 6 | Rp | 12.693.800 | Rp | 10.689.000 |
| D | 14 | 1 | 1 | 1 | Rp | 6.268.920 | Rp | 5.278.000 |
| E | 11 | 1 | 3 | 4 | Rp | 12.338.524 | Rp | 10.389.500 |
| F | 20 | 1 | 2 | 4 | Rp | 19.524.320 | Rp | 16.440.000 |
| G | 7 | 1 | 4 | 4 | Rp | 8.870.064 | Rp | 7.469.000 |
| H | 17 | 1 | 2 | 4 | Rp | 16.595.672 | Rp | 13.974.000 |
| I | 19 | 1 | 6 | 6 | Rp | 34.454.600 | Rp | 29.013.000 |
| J | 14 | 1 | 1 | 4 | Rp | 11.630.472 | Rp | 9.793.000 |
| K | 7 | 1 | 4 | 3 | Rp | 7.976.472 | Rp | 6.716.500 |
| L | 3 | 1 | 2 | 2 | Rp | 2.162.712 | Rp | 1.821.000 |

| Aktivity | Duration | Foreman | Craftsman | Labourer | Accelerate Cost | Normal Cost |
|---|---|---|---|---|---|---|
| M | 7 | 1 | 2 | 1 | Rp 4.152.736 | Rp 3.496.500 |
| N | 30 | 1 | 4 | 6 | Rp 45.673.920 | Rp 38.460.000 |
| O | 14 | 1 | 2 | 4 | Rp 13.667.024 | Rp 11.508.000 |
| P | 2 | 1 | 2 | 4 | Rp 1.952.432 | Rp 1.644.000 |
| Q | 3 | 1 | 1 | 4 | Rp 2.492.244 | Rp 2.098.500 |
| R | 3 | 1 | 2 | 2 | Rp 2.162.712 | Rp 1.821.000 |
| S | 21 | 1 | 2 | 1 | Rp 12.458.208 | Rp 10.489.500 |
| T | 14 | 1 | 2 | 1 | Rp 8.305.472 | Rp 6.993.000 |
| U | 30 | 1 | 2 | 1 | Rp 17.797.440 | Rp 14.985.000 |
| V | 30 | 1 | 9 | 6 | Rp 67.494.120 | Rp 56.835.000 |
| W | 20 | 1 | 9 | 6 | Rp 44.996.080 | Rp 37.890.000 |
| X | 20 | 1 | 2 | 2 | Rp 14.418.080 | Rp 12.140.000 |
| Y | 15 | 1 | 6 | 6 | Rp 27.201.000 | Rp 22.905.000 |
| Z | 45 | 1 | 6 | 6 | Rp 81.603.000 | Rp 68.715.000 |
| AA | 20 | 1 | 4 | 24 | Rp 76.405.440 | Rp 64.340.000 |
| AB | 7 | 1 | 6 | 3 | Rp 10.013.024 | Rp 8.431.500 |
| AC | 1 | 1 | 1 | 2 | Rp 575.436 | Rp 484.500 |
| AD | 45 | | 1 | | Rp 6.546.060 | Rp 5.512.500 |
| AE | 14 | 1 | 4 | | Rp 10.591.392 | Rp 8.918.000 |
| AF | 4 | 1 | 4 | | Rp 3.026.112 | Rp 2.548.000 |
| AG | 120 | 1 | 6 | | Rp 125.695.680 | Rp 105.840.000 |
| AH | 30 | 1 | 3 | 3 | Rp 29.820.840 | Rp 25.110.000 |
| AI | 7 | 1 | 4 | 2 | Rp 7.082.880 | Rp 5.964.000 |
| AJ | 7 | 1 | 4 | 2 | Rp 7.082.880 | Rp 5.964.000 |
| AK | 7 | 1 | 3 | | Rp 4.277.420 | Rp 3.601.500 |
| AL | 14 | 1 | 6 | | Rp 14.664.496 | Rp 12.348.000 |
| AM | 7 | 1 | 2 | 2 | Rp 5.046.328 | Rp 4.249.000 |
| AN | 5 | 1 | 2 | | Rp 2.327.960 | Rp 1.960.000 |
| AO | 2 | 1 | 2 | | Rp 931.184 | Rp 784.000 |
| AP | 21 | 1 | 3 | 3 | Rp 20.874.588 | Rp 17.577.000 |
| AQ | 7 | 1 | 1 | 1 | Rp 3.134.460 | Rp 2.639.000 |
| AR | 14 | 1 | 6 | 2 | Rp 18.238.864 | Rp 15.358.000 |
| AS | 4 | 1 | 1 | 4 | Rp 3.322.992 | Rp 2.798.000 |
| | | **Total** | | | **Rp 807.738.337** | **Rp.733.914.500** |

d. Equipment Cost

Namely the cost of equipment to carry out construction work. In calculating this cost, It is also necessary to pay attention to several things in calculating project costs such as direct and indirect costs of the warehouse, operating labor costs, and operating costs if the equipment is leased as well as investment, depreciation, repair, maintenance, and mobilization costs if the equipment is not leased.

The calculation of equipment costs is adjusted to the activities carried out by acceleration, namely project activities E (1 Day), F (2 Days), G (1 Day), H (2 Days), I (3 Days), J (1 Day), K (1 Day), S, (2 Days), U (3 Days), V (3 days), X (2 Days), Z (5 Days), AP (2 Days) and AS (1 Day) namely the cost of equipment to carry out construction work. In calculating this cost, In addition, it is necessary to pay attention to several factors and regarding the costs of entering and leaving the warehouse, operational labor costs, and operational costs if the equipment is leased as well as investment, depreciation, repair, and maintenance, and mobilization costs if the equipment is not leased, including table :

**Table 5.** Additional Activity Cost without Accelerate Time

| Activity | Accelerate (Day) | Equipment | Cost (Per Day) | Total Cost |
|---|---|---|---|---|
| E | 1 | Rent Truck Trailer | Rp. 42.000.000 | Rp. 42.000.000 |
| F | 2 | Rent Mobile Crane | Rp. 390.000 | Rp. 780.000 |
| G | 1 | Rent Mobile Crane | Rp. 145.000 | Rp. 145.000 |
| H | 2 | Rent Scafolding | Rp. 1.440.000 | Rp. 2.880.000 |
| I | 3 | Rent Scafolding | Rp. 1.440.000 | Rp. 4.320.000 |
| J | 1 | Rent Scafolding | Rp. 1.440.000 | Rp. 1.440.000 |
| K | 1 | Rent Mobile Crane | Rp. 390.000 | Rp. 390.000 |
| S | 2 | Rent Mobile Crane | Rp. 390.000 | Rp. 780.000 |
| U | 3 | Rent Scafolding | Rp. 1.440.000 | Rp. 4.320.000 |
| V | 3 | Rent Scafolding | Rp. 1.440.000 | Rp. 4.320.000 |
| X | 2 | Rent Scafolding | Rp. 1.440.000 | Rp. 2.880.000 |
| AP | 2 | Rent Scafolding | Rp. 1.440.000 | Rp. 2.880.000 |
| AS | 1 | Rent Truck Trailer | Rp. 42.000.000 | Rp. 42.000.000 |
| Electricity | 27 | PLN | Rp. 120.000 | Rp. 3.240.000 |
| Water | 27 | PDAM | Rp. 90.000 | Rp. 2.430.000 |
| | | **Total** | | **Rp.114.805.000** |

Comparison of the total cost of normal time with acceleration time:

a. Normal Time in 284 days :
   1) Workers' Wages : Rp. 733.914.500
   2) Equipment Cost : Rp. 114.805.000
   3) Penalty Cost 7 days : Rp. 176.700.611
   4) Total : Rp.1.025.420.111

b. Accelerate Time in 257 days :
   1) Workers' Wages : Rp. 848.719.000
   2) Equipment Cost : Rp. 0
   3) Penalty Cost : Rp. 0
   4) Total : Rp. 848.719.500

## 4. Conclusion

Based on the data analysis and discussion that has been carried out in this study, the conclusion that can be drawn in this study is the number of days that can be completed in this project using the CPM scheduling method is 257 days. However, without using this method, the project completion time would take 284 days. In addition, the company can save costs of Rp. 176,700,611 while avoiding penalty fees due to project delays.

So that by applying the calculation to the CPM method, the company can perform project efficiency for 7 days while simultaneously being able to streamline the budget by using network planning. By using Network Planning using the CPM (Critical Path Method) method as a tool, companies can find out which activities need to be prioritized so as not to experience project completion delays. Initial planning in scheduling techniques must be more mature in order to facilitate the implementation of the project schedule.

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# WORK SAFETY RISK MANAGEMENT TOWARDS ZERO ACCIDENT IN FASHARKAN SURABAYA

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**ABSTRACT**

Occupational health is an element of health related to the work environment and work, which can directly or indirectly affect work efficiency and productivity. Meanwhile, work safety is the main means to prevent work accidents that can cause harm in the form of injury or injury, disability or death, property loss, damage to equipment or machinery and environmental damage widely. In essence, Occupational Safety and Health (K3) is an effort to create protection and security from various risks of accidents and hazards, both physical, mental and emotional to workers, companies, communities and the environment. In addition, occupational safety and health is expected to create work comfort and high work safety as stated in PerKasal Number 26 of 2018 concerning Occupational Safety and Health in the Indonesian navy. This study aims to find out what types of accidents have a high risk in Fasharkan Surabaya, find out what impacts can be caused by high risk accidents and obtain steps that can be taken to reduce work accidents at Fasharkan Surabaya by using the Formal Safety Assessment (FSA) Method. There are four types of accidents that occur in Fasharkan Surabaya with the highest starting risk ranking, namely human accidents with work equipment, human accidents with property, human accidents with work systems and human accidents with the environment. The impact of the four accidents caused substantial material losses. To reduce the risk of the three types of accidents, the lowest Implied Cost of Averting a Risk (ICAR) measurement is carried out for each risk reduction option. The risk mitigation carried out is providing training for General K3 Experts, Electricity & Generators who have an ICAR of 92 million rupiahs, training of Fire K3 Officers who have an ICAR of 15.75 million rupiahs, Implementation of Work SOPs and Tightening of Supervision which has an ICAR of 12.5 million rupiah, and Procurement of Work Safety Equipment in the work area of workshops and ships as well as Personal Protective Equipment for each worker who has an ICAR of 53.5 million rupiah.

**Keywords:** Formal Safety Assessment (FSA), Risk Assessment, Work Accident.

## 1. INTRODUCTION.

The number of work accidents in Fasharkan Surabaya is very worrying. In the preliminary survey, in the last 10 years from 2010 to 2021, 20 incidents have been identified. This figure is still minimal when compared to actual events which are almost entirely not properly recorded through the workshop activity journal at Fasharkan Surabaya. Starting from scratching work accidents, falling materials, electrocuted, slipping, inhaling toxic gases, to the dangers of radiation of radioactive substances. So, based on these data, all are required to be more serious in implementing the OHS (Occupational Health and Safety) culture. Accidents not only cause death, material loss, and damage to the environment but also affect the productivity and welfare of the crew members of Fasharkan Surabaya. With a good K3 culture, the number of work accidents can be reduced, which in turn will increase work productivity. Work accidents also affect the human development index and the employment development index. (Menakertrans, Ida Fauziayah 2020).

Fasharkan Surabaya as one of The Work Unit in The Fifth Naval Main Base in particular and in the Navy in general which is loaded with high-risk construction work so there is a high potential for work accidents. Until now there is no SOP that specifically discusses Occupational Safety and Health as a derivative of Perkasal number 34 of 2020 concerning Guidelines for the Implementation of Occupational Health and Safety Management Systems (SMK3). Apart from the Jukker as an elaboration of the DSP, there are only ways to deal with fire hazards in the event of a fire disaster. The research that has been carried out at Fasharkan Surabaya, especially regarding Risk Management, is to discuss global risks regarding the operations of Fasharkan Surabaya, both onshore and onboard operations. In this study, it will be discussed about risk management on work safety which is devoted to discussing the incidence of work accidents at Fasharkan Surabaya. What are the causes and how are risk mitigation efforts to overcome them. It is hoped that the final goal of this research is to be able to formulate a draft SOP regarding work safety standardization and minimize the occurrence of work accidents so that the goal of zero accident according to the Kasal Telegram Number 147/Basegram/0308 twu.0311.1538 can also be realized.

## 2. LITERATURE REVIEW

Risk management in this paper is using the FSA (Formal Safety Assessment) method. The steps carried out in implementing risk management are to identify the risks that may be experienced by the work unit, in this case Fasharkan Surabaya, after identifying them, an evaluation is carried out on each -each risk is reviewed from the risk value (severity) and frequency (IMO, 2002). The last stage is risk control. In the risk control stage, it is divided into 2, namely physical control (risk is eliminated, risk is minimized) and financial control (risk is retained, risk is transferred). Risk management consists of three components, namely:

a. Risk Identification & Analysis
b. Risk evaluation
c. Risk reduction & risk control (Risk Treatment)

### 2.1. Step 1 Hazard Identification:

Problem Definition. The purpose of the problem definition is to describe the problem correctly based on the analysis related to the regulation being reviewed or being developed. Problem definition must be in accordance with operational experience and applicable requirements by considering all relevant aspects.

Risk distinguishing proof, within the shape of a list of all important mishap scenarios with potential causes and results, as a reply to the address of what blunders might happen (IMO, 2002). The point is to distinguish a risk list and a set of scenarios whose need is decided by the level of hazard of the issue beneath the talk. This objective can be accomplished by utilizing standard strategies to distinguish dangers that contribute to mishaps, by screening these risks through a combination of existing information and conclusions, and by checking on the common show that was created amid the issue definition. The approach utilized for danger-distinguishing proof, for the most part, a combination of inventive and explanatory strategies, points to determining all significant risks. A harsh examination of the causes and impacts of each mischance category utilizing specific procedures, such as blame tree investigation, occasion tree examination, disappointment mode and impact investigation (FMEA), risk and operability thinks about (HAZOP), what on the off chance that investigation strategy, and chance commitment tree (RCT), which was chosen concurring to the issue being talked about.

### 2.2. Step 2 Risk Assessment:

This objective can be accomplished by utilizing methods that are fitting to the hazard show made and consideration is centred on the dangers that are surveyed as tall. The esteem in address is the level of hazard, which can be isolated into:

a. Risks that cannot be justified or accepted, except in exceptional circumstances (intolerable).
b. The dangers that have been made are so little that there's no requirement for advanced (insignificant) safeguards.
c. A hazard whose level is between an unfortunate and an irrelevant level (as low as reasonably practicable = ALARP).

### 2.3. Step 3 Selection of Risk Controls:

The point of step 3 is to propose successful and down-to-earth RCOs, by taking after four rule steps:

a. Centering on the dangers that require control, to channel the yield of the 2nd step, so that the centre is as it were on the zones that most require change control.

b. Distinguish activities to control potential dangers (risk control measures = RCMs).

c. Assess the adequacy of RCMs in decreasing chance by re-evaluating step 2.

d. Grouping RCMs into basic options.

### 2.4. Step 4 (Cost and Benefit Assessment):

The objective of step 4 is to recognize and compare the benefits and costs of actualizing each of the RCOs recognized in step 3. Costs must be expressed in life cycle costs, which incorporate a beginning, working, preparing, assessment, certification, decommissioning, etc. In the meantime, benefits may include diminishments in terms of passings (fatalities), injuries/losses (wounds), mischances (casualties), natural harm and cleaning (natural harm & clean-up), and reimbursements by third parties who are mindful. The yield of step 4 comprises of:

a. Costs and benefits for each RCO recognized in step 3.

b. The costs and benefits for the RCO of concern (which are most influenced by the issue).

c. Financial utility communicated within the suitable file.

d. The equation used to solve this problem is the Cost of Averting a Risk Index (ICAR) as given in Equation 2.1 below:

$$\text{ICAR} = \frac{(\Delta C - \Delta B)}{\text{Risk Reduction}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

ICAR = *Implied cost of averting a risk* (Risk reduction cost index)

$\Delta C$ = Risk control costs

$\Delta B$ = economic benefits of implementing risk control

Risk Reduction = Reducing risk after controlling

### 2.4. Step 5 (Recommendations for Decision Making):

The purpose of step 5 is to define the recommendations that should be provided to the decision-maker, in an auditable and traceable manner. Recommendations are based on:

a. Comparison and ranking of all hazards and their causes.

b. Comparison and ranking of risk control options as a function of combined costs and benefits.

c. Identification of risk control options that keep risk as low as possible so that it makes sense to implement.

Proposals ought to be given in an organization that can be caught on by all parties, not withstanding involvement. Accommodation of suggestions as a result of an FSA handle must be given instantly and get to pertinent supporting archives by a component that incorporates comments. The yield of step 5 comprises:

a. An objective comparison of alternative options, based on potential risk reduction and cost-effectiveness, according to legislation or regulations that are being reviewed or developed.

b. Feedback information to review the results given in the previous steps.

**Table 1.** Severity Index

| Skala | Human | Property | Environment | Stakeholder |
|---|---|---|---|---|
| C0 | Not significant (very small chance of injury) (0-1 million) | Not significant (0 - 10 million) | Insignificant (meaningless damage) (0 - 10 million) | Not significant (0 - 10 million) |
| C1 | Minor (One minor injury) (1 million – 5 million) | Small (10 - 100 million) | Minor (Controlled short term damage) (10 – 50 million) | Small (Temporary project stop or work restrictions) (10 – 100 million) |
| C2 | Medium (a lot minor injuries or one serious injury) (5 Million-10 million) | Currently / Middle (100 - 200 million) | Moderate (Major Damage) (50 - 100 million) | Medium (National scope, the project is temporarily closed for a few days. There are no KRI maintenance and repair activities) (100 - 200 million) |
| C3 | Severe (Many serious injuries or one death) (10 million – 25 million) | Big (200 - 500 million) | Major (widespread damage with potential environmental damage) (100 - 200 million) | Large (National scope, Fasharkan temporarily closed from maintenance and repair projects for a few days) (200 - 500 million) |
| C4 | Catastrophic / major disaster (Many cause death (25 Million and more) | Big disaster (500million+) | Disaster (Damage is extensive to neighboring countries) (200million+) | Disaster (international scope, Fasharkan closed, work was interrupted and maintenance and repair activities did not occur for a long period of time) (500million+) |

(Table's Legend : *Port & Harbour Risk Assessment & Safety Management System*)

**Table 2.** Risk Possibility Assessment

| **Scale** | **Concecuency** | **Definition** |
|---|---|---|
| F1 | *Almost Certain* | Can happen any time<br>Happens almost every day |
| F2 | *Likely* | Happens once a week |
| F3 | *Possible* | Can happen every now and then<br>Happens 1 time in 1 month |
| F4 | *Unlikely* | Can happen 1 time in 1 year |
| F5 | *Rare* | Almost never, very rarely<br>Happened once in more than 1 year |

(Table's Legend: Australian Standard / New Zealand Standard 4360, 2004)

**Table 3.** Risk Matrix

| | | | | | | |
|---|---|---|---|---|---|---|
| Consequence | C4 | 5 | 6 | 7 | 8 | 10 |
| | C3 | 4 | 5 | 6 | 7 | 9 |
| | C2 | 3 | 3 | 4 | 6 | 8 |
| | C1 | 1 | 2 | 2 | 3 | 6 |
| | C0 | 0 | 0 | 0 | 0 | 0 |
| Frequency | | F5 | F4 | F3 | F2 | F1 |

Information:

0 & 1 = Negligible risk

2 & 3 = Low risk

4 & 5 = Area of As low as Reasonably Practicable Area (ALARP)

6 = The risk is getting higher

7 & 8 = Significant risk

9 & 10 = Risiko tinggi

### 2.5. Formal Safety Assessment

Formal Safety Assessment (FSA) could be a judicious, organized, and orderly technique or process for evaluating dangers related to exercises within the oceanic division (shipping) and assessing the costs and benefits of a few hazard control alternatives, utilizing chance investigation and cost-benefit appraisal (International Maritime Organization, 2002). FSA points to diminishing existing dangers, as well as moving forward with shipping security (marine security), which incorporates assurance of life, well-being, marine environment, and property rights.

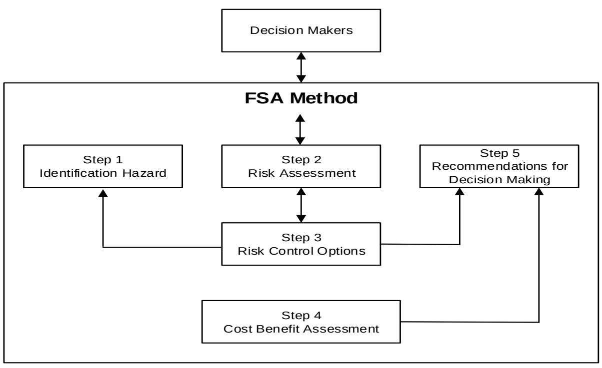


**Figure 1.** *Framework Formal Safety Assessment* (FSA)

### 2.6. Zero Accident

The Indonesian navy has a zero accident program as outlined in the Kasal Telegram Number 147/Basegram/0308 twu.0311.1538 which states that zero accidents means that there are no more accidents at work sites that can cause temporary or permanent injury, even fatal or death, as well as material loss. . Creating a zero accident work environment is not easy. This requires a long process even years and requires a continuous process. The zero accident campaign is one method to reduce the potential for work accidents caused by human error. The zero accident campaign is a campaign that supports the trinity of principles, methods and practices. If one of them is removed, the zero-accident campaign will not be achieved. The zero accident campaign consists of 3 (three) main principles, namely zero, anticipation and participation. These three are called 3 (three) basic image principles, namely:

a. Zero principle

It is a principle to eliminate all accidents to zero, including occupational accidents, occupational diseases and traffic accidents, by finding, understanding and solving hazards or problems that are hidden in everyone's daily life or hidden in the workplace and work.

b. Anticipation principle

Preventing the emergence of accidents before activities, by discovering, understanding and solving the hidden dangers and problems in their daily lives and of course the hidden dangers in the workplace and work, and to create a happier workplace, zero accidents and illnesses.

c. Prinsip partisipasi

Practicing problem solving activities in the spirit of self-initiative in their respective positions and workplaces with the integration and cooperation of leaders, managers, staff, and employees, to find, understand and solve hidden hazards or problems in the workplace and work.

## 3. RESULT AND DISCUSSION.

At the beginning of data collection, one thing that is needed is how many work orders there are in Fasharkan Surabaya in the period 2010 to 2021 including Hardepo and Harmen / Hardar. The Fasharkan Surabaya 2010-2021 Job Data Table provides an overview of this.

**Table 4.** Fasharkan Surabaya Job Data (SPK unit)

| No. | Year | Type of work | |
|---|---|---|---|
| | | Hardepo | Harmen / Hardar |
| 1 | 2010 | 156 SPK | 157 SPK |
| 2 | 2011 | 179 SPK | 217 SPK |
| 3 | 2012 | 102 SPK | 127 SPK |
| 4 | 2013 | 141 SPK | 165 SPK |
| 5 | 2014 | 139 SPK | 203 SPK |
| 6 | 2015 | 113 SPK | 177 SPK |
| 7 | 2016 | 99 SPK | 182 SPK |
| 8 | 2017 | 77 SPK | 166 SPK |
| 9 | 2018 | 121 SPK | 154 SPK |
| 10 | 2019 | 135 SPK | 133 SPK |
| 11 | 2020 | 165 SPK | 199 SPK |
| 12 | 2021 | 125 SPK | 145 SPK |

After knowing the common depiction of the conditions at Fasharkan Surabaya, the other most vital thing is to display information on mishaps that have happened. The Work Mishap Information table underneath appears mishap information that happened at Fasharkan Surabaya which appears the number of episodes recorded from 2010 to 2021.

**Table. 5** Work Accident Frequency at Fasharkan Surabaya Year 2010 – 2021

| No | Type of Accident | Number of Frequency | | | | | | | | | | | | Jumlah |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| 1 | Human with Work System | | | | | | | | | | | | 1 | 1 |
| 2 | Human with Environment | | 1 | | 1 | | 1 | | | | | | | 3 |
| 3 | Human with Property | | | 1 | | | | | 1 | 1 | 1 | 2 | | 6 |
| 4 | Humans with Work Tools | 1 | | | | 2 | 2 | 1 | | 1 | 3 | | | 10 |
| | Summary | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | 2 | 4 | 2 | 1 | 20 |

(Table's Legend : Production Dept. of Fasharkan Surabaya and Author's processed results)

### 3.1. Determining Consequence Criteria Value

In determining a consequence criterion, an interview with an expert on work accidents that occurred at Fasharkan Surabaya was carried out, which later on the results of the interview will be assessed based on existing criteria standards, such as AS/NZS Standard 4360:2004, IMO, and others.

a. Humans: incidents on work safety that are the recipient of the direct impact of workplace accidents. The risks accepted by humans from mild to death.

b. Property: any work accident can cause property loss. For example, a fire in a workshop or other facility that causes damage to the asset.

c. Environment: work accidents can cause environmental damage, for example fires in the work area due to plate welding and others. The environmental damage includes those that have an impact on plants around the work area.

Fasharkan Surabaya stakeholders will also accept the risks caused by work accidents. For example, if there is a work accident at Fasharkan Surabaya, it will automatically concentrate on completing the work on time according to the schedule and production targets will be late and also production costs will swell due to the completion of the accident. The following table shows the initial risk level for this type of accident.

**Table. 7** Hazard List with Frequency Scores and Consequences and Score Scores for Each Event

| | | | | | The Most Likely Consequences | | | | | | Worst Possible Consequence | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Hazard Impact Assessment | | | | | | Hazard Impact Assessment | | | | |
| Danger Number | Hazard Type | Workshop Type | Danger Details | Possible Cause | Hazard Type | Human | Property | Environment | Stakeholer | Frequency | Hazard Type | Human | Property | Environment | Stakeholer | Frequency |
| 1 | (A)<br>Human Accident with Work System | All Workshop | Accidents that occur when there is missed communication between 1 work team and another work team, including not complying with Standard Operating Procedures | - Communication tools that don't work normally<br>- Errors in reading & understanding the SOP of a job<br>- There is no backup communication (messenger) who is in charge of conveying messages when the communication tool is constrained | - Electrocution weak current<br>- Bruises on the body<br>- Irritation to the skin<br>- Shock & fall<br>- Sprained / slipped / bruised ankle | C1<br>2 | C0<br>0 | C0<br>0 | C1<br>2 | F3 | - Electrocuted strong current<br>- Severe bruises and even broken bones<br>- Severe irritation to the skin<br>- Shocked & Fallen even died | C2<br>6 | C1<br>3 | C1<br>3 | C2<br>6 | F2 |
| 2 | (B)<br>Human Accident with Property | All Workshop | Accidents that occur between humans and property that cause damage to property and humans | - The physical condition of the property / infrastructure is fragile due to the age factor<br>- Lots of electric current leakage in buildings / ships<br>- Lots of oil spills on the ship/workshop<br>- Limited working space conditions | - Electrocution weak current<br>- Bruises on the body<br>- Shock & fall<br>- Sprained / slipped / bruised ankle<br>- Minor damage to buildings | C2<br>4 | C1<br>2 | C0<br>0 | C1<br>2 | F3 | - Electrocuted strong current<br>- Severe bruises and even broken bones<br>- Shocked & Fallen even died<br>- Severe damage to buildings | C3<br>7 | C2<br>6 | C1<br>3 | C2<br>6 | F2 |
| 3 | (C)<br>Human Accident with Environment | All Workshop | Accidents that occur between humans and the environment that cause damage to the environment and humans | - Unhealthy / stuffy work environment<br>- Insufficient/excessive lighting in the workspace<br>- The condition of a messy workspace with used materials & equipment that are not used / haven't been cleaned up | - Minor visual disturbances<br>- Mild respiratory distress<br>- Mild irritation to the body<br>- Light pollution to the environment | C0<br>0 | C0<br>0 | C0<br>0 | C0<br>0 | F5 | - Severe visual impairment<br>- Severe respiratory distress<br>- Severe irritation to the body<br>- Severe pollution to the environment | C1<br>2 | C1<br>2 | C1<br>2 | C1<br>2 | F4 |
| 4 | (D)<br>Human Accident with Work Equipment | All Workshop | Accidents that occur between humans and work equipment that cause damage to work equipment and humans | - Only 50% ready-to-use work equipment<br>- Lack of operator knowledge about work equipment<br>- Operators do not understand the SOP for the use of work tools used<br>- Unstable electrical voltage & imperfect lubrication on work tools | - Minor injuries to the body<br>- Electrocution weak current<br>- Shocked & fell<br>- Minor damage to work tools | C2<br>6 | C1<br>3 | C0<br>0 | C1<br>3 | F2 | - Severe injuries to the body<br>- Electrocuted by a strong current<br>- Shocked & fell<br>- Severe damage to work tools | C3<br>9 | C2<br>8 | C1<br>6 | C2<br>8 | F1 |

(Source: Result of interview with expert and crew of Fasharkan)

**Table 9.** Results Obtained After Giving Weight

| Incident | Most Likely Consequences | | | | Worst Possible Consequence | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Human | Property | Environme | Stakeholde | Human | Property | Environme | Stakeholde | **Summary** | **Order** |
| Human Accident with Work System | 0,8 | 0 | 0 | 0,6 | 2,4 | 0,6 | 0,3 | 1,8 | 6,5 | **3** |
| Human Accident with Property | 1,6 | 0,4 | 0 | 0,6 | 2,8 | 1,2 | 0,3 | 1,8 | 8,7 | **2** |
| Human Accident with Environment | 0 | 0 | 0 | 0 | 0,8 | 0,4 | 0,2 | 0,6 | 2 | **4** |
| Human Accident with Work Equipment | 2,4 | 0,6 | 0 | 0,9 | 2,7 | 1,6 | 0,6 | 2,4 | 11,2 | **1** |

From the calculation the table above shows that human accidents with work equipment are the events that have the highest risk then the second is human accidents with property, the third is human accidents with the environment and the last is human accidents with work systems.

### *3.2. Weighting Sensitivity*

On this occasion it will be shown how the sensitivity of this weighting value if it is varied to values that are considered realistic. In this study, the weighting values for humans varied,

namely 0.3, 0.4, 0.5, 0.6, 0.7 with the weighting values for Meteri given in the table below:

**Table 10.** Weight Variation

| No | Human | Property | Environment | Stakeholders |
|---|---|---|---|---|
| 1 | 0,7 | 0,1 | 0,1 | 0,1 |
| 2 | 0,6 | 0,1 | 0,1 | 0,2 |
| 3 | 0,5 | 0,15 | 0,05 | 0,3 |
| 4 | 0,4 | 0,2 | 0,1 | 0,3 |
| 5 | 0,3 | 0,2 | 0,2 | 0,3 |

**Table 11.** Variations in Weighting of Human Victims

| Type of Accident | Risk Rating Per Weighted | | | | |
|---|---|---|---|---|---|
| | 0,7 | 0,6 | 0,5 | 0,4 | 0,3 |
| Human Accident with Work Equipment | 1 | 1 | 1 | 1 | 1 |
| Human Accident with Property | 2 | 2 | 2 | 2 | 2 |
| Human Accident with Work System | 3 | 3 | 3 | 3 | 3 |
| Human Accident with Environment | 4 | 4 | 4 | 4 | 4 |

The table above shows that by giving weighting variations, it does not provide a significant risk rating change from the types of accidents that exist. What is more important in risk mitigation here is how we reduce the high risk value that occurs to an acceptable risk value

**Table 12.** Risk Reduction

| Incident | Initial Risk | | | | General, Electrical & GenSet OHS Expert Training | | | | Fire K3 Officer Training | | | | Enforcement of Standard Operational Work Procedures & Tighter Supervision | | | | Procurement of Personal Protective Equipment (PPE) in accordance with The List of Personnel Composition (DSP) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Human | Property | Environment | Stakeholder | Human | Property | Environment | Stakeholder | Human | Property | Environment | Stakeholder | Human | Property | Environment | Stakeholder | Human | Property | Environment | Stakeholder |
| Human Accident with Work Equipment | 9 | 8 | 6 | 8 | 6 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Human Accident with Property | 7 | 6 | 3 | 6 | 6 | 4 | 2 | 4 | 6 | 4 | 2 | 4 | 5 | 3 | 2 | 3 | 6 | 4 | 2 | 4 |
| Human Accident with Work System | 6 | 3 | 3 | 6 | 4 | 2 | 2 | 4 | - | - | - | - | 3 | 2 | 2 | 3 | - | - | - | - |
| Human Accident with Environment | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | - | - | - | - | 0 | 0 | 0 | 0 | - | - | - | - |

**Table 13.** Risk Reduction Cost (in Rupiah)

| Countermeasures | Countermeasures Cost (∆C) | Benefit (∆B) | | | |
|---|---|---|---|---|---|
| | | Human Accident with Work Equipment | Human Accident with Property | Human Accident with Work System | Human Accident with Environment |
| General, Electrical & GenSet OHS Expert Training | 242 million | 150 million | 100 million | 50 million | 10 million |
| Fire K3 Officer Training | 81,5 million | 50 million | 25 million | - | - |
| Enforcement of Standard Operational Work Procedures & Tighter Supervision | 105 million | 80 million | 50 million | 25 million | 10 million |
| Procurement of Personal Protective Equipment (PPE) in accordance with The List of Personnel Composition (DSP) (238) | 607 million | 500 million | 350 million | - | - |

**Table 14.** ICAR Calculation (in Rupiah)

| Countermeasures | Risk Reduction | | | | ICAR | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D |
| General, Electrical & GenSet OHS Expert Training | 2 | 2 | 2 | 1 | 92 million | 142 million | 192 million | 232 million |
| Fire K3 Officer Training | 2 | 1 | | | 15,75 million | 56,5 million | | |
| Enforcement of Standard Operational Work Procedures & Tighter Supervision | 2 | 2 | 2 | 2 | 12,5 million | 27,5 million | 40 million | 47,5 million |
| Procurement of Personal Protective Equipment (PPE) in accordance with The List of Personnel Composition (DSP) (238) | 2 | 1 | | | 53,5 million | 257 million | | |

Information: A = Human Accident with Work Equipment
B = Human Accident with Property
C = Human Accident with Work System
D = Human Accident with Environment

## 4. CONCLUSION.

From the results of the analysis carried out, the following conclusions are obtained:

a. The number of work mischances in Fasharkan Surabaya is very stressful. This may be seen from the overall rate of work mischances for 11 a long time (2010 to 2021) as numerous as 20 cases that can be recorded, not counting work mischances that are not well recorded within the everyday movement diary and work unit minutes. After the calculations are carried out, they can be positioned consecutively beginning from the most noteworthy hazard esteem, specifically:

1) Human Accident with Work Equipment, with risk value 9

2) Human Accident with Property, with risk value 7

3) Human Accident with Work System, with risk value 6

4) Human Accident with Environment, with risk value 2

For these four types of accidents, risk reduction measures are carried out by knowing in advance the main causes of the four types of accidents.

b. The main cause of the four types of work accidents with high risk is due to a very minimal understanding of K3 (Occupational Health and Safety) by Fasharkan Surabaya crew members. The most likely damage is injuries to the workers' bodies, damage to property buildings (infrastructure) and environmental pollution around the Fasharkan Surabaya workshop. Human Accidents with Work Equipment, Property, Work Systems, and Environment, are often motivated by work equipment that is not ready to use or only 50% of its technical condition and also the work space and work atmosphere that is not conducive so that there is a chance for work accidents to occur in humans and also result in accidents. damage to the physical building (infrastructure) of Fasharkan Surabaya.

c. The actions to reduce the risk of the four types of work accidents at Fasharkan Surabaya are as follows:

1) Human Accidents with Work Equipment, namely by holding training for General K3 Experts, Electricians & Generators who have an ICAR of 92 million rupiah so that workers understand K3 culture and avoid the risk of work accidents, as well as training for Fire K3 Officers who have an ICAR of 15.75 million rupiah so that workers are ready and alert within the occasion of a fire in the workshop or ship work area. Next is the implementation of work SOPs and tightening supervision which has an ICAR of 12.5 million rupiah so that workers understand and comply with all good and safe work procedures. Then the last one is the Procurement of Work Safety Equipment in the work area of workshops and ships as well as Personal Protective Equipment for each worker who has an ICAR of 53.5 million rupiah so that workers feel safe while working..

2) Human Work Accidents with Property, namely by holding training for General K3 Experts, Electricians & Generators who have an ICAR of 142 million rupiah so that workers understand K3 culture and avoid the risk of work accidents, as well as training for Fire K3 Officers who have an ICAR of 56.5 million rupiah so that workers are ready and alert within the occasion of a fire in the workshop or ship work area. Next is the implementation of work SOPs and tightening supervision which has an ICAR of 27.5 million rupiah so that workers understand and comply with all good and safe work procedures. Then the last one is the Procurement of Work Safety Equipment in the work area of workshops and ships as well as Personal Protective Equipment for each worker who has an ICAR of 257 million rupiah so that workers feel safe while working.

3) Human Accidents with Work Systems, namely by holding training for General K3 Experts, Electricians & Generators who have an ICAR of 192 million rupiah so that workers understand K3 culture and avoid the risk of work accidents and the application of work SOPs and tighten supervision which has an ICAR of 40 million rupiah so that workers understand and comply with all good and safe work procedures.

4) Human Accidents with the Environment, namely by holding training for General K3, Electricity & Genzet Experts who have an ICAR of 232 million rupiah so that workers understand K3 culture and avoid the risk of work accidents and the application of work SOPs and tighten supervision which has an ICAR of 47.5 million rupiah so that workers understand and comply with all good and safe work procedures.

From the results of this final project, we suggest reducing the occurrence of work accidents that can have a major impact on both human and material casualties, namely risk mitigation to reduce the occurrence of work accidents between humans and work equipment, property, work systems and the environment in Fasharkan Surabaya is to provide an understanding maximum about Occupational Safety and Health (K3) through training of General K3, Electricity and Genzet Experts as well as fire prevention training. Then enforce professional and safe work SOPs and tighten supervision in the field. The next step is to equip work safety equipment both in the Fasharkan workshop and on the ship and equip workers with personal protective equipment that is comfortable to wear while working and provides security for the wearer.

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