Project Scheduling Based on Risk of Gas Transmission Pipe

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Abstract. The planning of a project has a time limit on which must be completed before or right at a predetermined time. Thus, in a project planning, it is necessary to have scheduling management that is useful for completing a project to achieve maximum results by considering the constraints that will exist. Scheduling management is undertaken to deal with uncertainties and negative impacts of time and cost in project completion. This paper explains about scheduling management in gas transmission pipeline project Gresik-Semarang to find out which scheduling plan is most effectively used in accordance with its risk value.

Scheduling management in this paper is assisted by Microsoft Project software to find the critical path of existing project scheduling planning data. Critical path is the longest scheduling path with the fastest completion time. The result is found a critical path on project scheduling with completion time is 152 days. Furthermore, the calculation of risk is done by using House of Risk (HOR) method and it is found that the critical path has a share of 40.98 percent of all causes of the occurrence of risk events that will be experienced.

1. Introduction

Project has a time limit on which the project should be completed before or right at the designated time. However, in reality on the ground, a project does not always run according to the time set since there are factors that hinder the course of project work. Thus, it is necessary to have good project planning so as not to disrupt the project activity.

The function of planning is to reduce uncertainty \cite{1}. By doing good planning, like what to do, the timing, resources, etc., it will make the activity run more clear, sure, and efficient. Improving the efficiency of operations, one with good planning, will make the project run smoothly. Therefore, planning is an important factor in the execution of a project. Planning a project starts from the scheduling or time of project work.

Scheduling is the allocation of time available to carry out each job in order to complete a project until the maximum results are achieved taking into account the constraints. To avoid various obstacles in the process of project work, good scheduling management is required. Scheduling management is done to deal with uncertainty and negative impact on project completion time.

The gas transmission pipeline project is a major project that is expected to supply gas to the areas of East and Central Java. This project certainly requires an optimal scheduling and control planning in order to avoid any deviation in project work. The first objective of this paper is to identify the critical path of gas transmission pipeline project. The second objective is to identify the priority agency of risk agents using the House Of Risk (HOR) method and determines which critical path has the smallest value of the risk agent, thereby reducing the risk that occurs during the course of the project. The advantage of the House of Risk (HOR) method knows what factors can cause the occurrence of risk events. In addition, with this method can be determined priority risk agents and risk percentage, so that can be done appropriate risk handling.
2. Project Scheduling

2.1 Scheduling Management

Scheduling management consists of two words of management and scheduling. Management is a science of the art of organizational leadership that consists of planning, organizing, implementing and controlling of limited resources in order to achieve effective and efficient goals and objectives [2]. Management is an integrated process in which individuals as part of an organization are involved in maintaining, developing, controlling, and running programs that are all directed towards a set goal and are ongoing over time [3].

Scheduling is the coordination of time in production activities, so that the allocation of raw materials and auxiliary materials and equipment to the facility or part of processing within the factory can be made at a given time [4]. In scheduling planning there has been provided specific guidelines for completing a project activity more quickly and efficiently [5]. Efficient scheduling management criteria that achieve the greatest reduction in the time required to complete a project in question while maintaining the economic feasibility of the use of available resources [6].

Thus, scheduling management is planning, organizing, implementing, and controlling activities on production activities schedules and limited resources, so as to achieve goals and objectives more quickly and efficiently.

Scheduling management is used to control project activity every day. The aspects of scheduling management are determining project scheduling, measuring and reporting on project progress, comparing scheduling with actual project progress in the field, determining the consequences of comparisons of schedules with progress in the field at the end of project completion, planning for handling to address those outcomes, and renew project scheduling. Management continues to seek new and better control techniques to address the complexity, mass data, and narrow time that characterize many of today's highly competitive industries and environments, and look for better methods to provide technical data and costs to customers [7].

There are various software to support the optimization of project scheduling management. One of the most popular software is Microsoft Project (Ms Project). Ms Project developed since 1984 with Ms-DOS base. Later, the software was developed on a Windows basis and known as Microsoft Project [8]. Meanwhile, Ms Project is a software project management program developed and sold by Microsoft designed to assist project managers in developing plans, assigning resources for tasks, tracking progress, managing budgets, and analyzing workloads [9].

2.2 Risk

The definition of risk is the probability of an event that will cause a loss or failure or potential failure [10]. Risk is a decision-making condition in which the probability of a certain alternative will be known to lead to a desired goal or outcome [11]. The general formula used to perform the calculation of risk values is [12]:

\[ \text{Risk} = \text{Consequence} \times \text{Likelihood} \]

A project is an effort that mobilizes available resources, organized to achieve certain important goals, objectives, and expectations and must be completed within a limited time in accordance with the agreement.

2.3 House of Risk (HOR)

Risk Analysis to be used in this research is by using House of Risk (HOR) method. This method has the advantage of knowing which risk agents have an effect in the course of a project, so that risk management can be done accordingly.

House Of Risk Method (HOR) to identify, analyze, measure and mitigate potential risks in a project.
The application of House Of Risk (HOR) consists of two stages as follows [13]:

a. House Of Risk (HOR) 1, is used to identify potential risk events and risk agents. Results of House Of Risk (HOR) 1 are grouping of risk agents into priority risk agents in accordance with Aggregate Risk Potential (ARP) and Pareto Diagrams.

b. House Of Risk (HOR) 2, is used for the design of mitigation strategies undertaken for the handling of priority risk agents. Results of House Of Risk (HOR) 1 will be used as initial data on House Of Risk (HOR) 2.

And also House Of Risk (HOR) 2 gives priority proactive step effective financial ability and other resources. The steps of House Of Risk (HOR) 2, among others:

- Determine some of the top ranking risk agents to be the cause of the risks that will be prioritized for handling.
- Identify relevant Proactive Action (PA) steps to prevent risk agents.
- Determine the level of relationship between each PA and the risk agent.
- Calculates the total effectiveness of each proactive action.
- Assess difficulty level (Dk) in implementing PA.
- Calculates the total effectiveness ratio with difficulty level.
- Priority ranking on proactive action is most effective at reducing risk occurrence according to company capability.

In this study, the risk analysis will only be done until the House Of Risk (HOR) stage. Steps in House Of Risk (HOR) 1 are as follows:

a. Identify the occurrence of risk events (Risk Event, Ei).
   These risks are all possible events of project implementation.

b. Assess the level of impact or severity (Severity, Si).
   This severity value states how much of a disruption caused by an event risk to the implementation of the project.
   The severity value consists of 1, 2, 3, and 4. Where 1) shows that the impact is very small (negligible value), 2) illustrates that impacts have little effect on the project (no injuries, low financial loss), 3) means impacts in the medium category on the sustainability of the project (first aid treatment, medium financial loss), and 4) indicate that the impacts are included in the medical treatment requires, high financial loss category.

c. Identify the risk-causing agent (Risk Agent, Aj), ie any factor that can lead to occurrence of identified risk events.

d. Determining the probability of occurrence (Occurance, Oj) of a risk agent.
   This occupation represents the probability of occurrence of a risk agent, resulting in the emergence of one or more risk effects. The occurrence value of 1, 2, and 3. 1) means only occurring once a month, 2) means occurring once a week, and 3) means occurring once a day.

e. Measure the correlation (Correlation, Rij) between a risk event and the risk-causing agent.
   If a risk agent causes an occurrence of a risk event, then there can be a correlation. Correlation value consists of 0, 1, 3, 9, where 0) indicates no correlation relationship, 1) describes the correlation relationship is small, 3) represents medium correlation, and 9) describes the high correlation.

f. Calculates the value of the risk priority index or Aggregate Risk Potential (ARPj).
   This priority index will be used as a consideration for determining the priority of risk handling in data entry on House Of Risk (HOR) 2 and determining which agents or causes of risk are most influential in the sustainability of a project. Calculation of ARP value is as follows:
ARPj = Oj ΣSi.Rij  \hspace{1cm} (2)

Where,
ARPj: Aggregate Risk Potential (Risk Priority Index)
Oj : Occurrence (Opportunity Emergence Risk Agent)
Si : Severity (Impact of Risk Events)
Rij : Correlation Between Risk Agent and Risk Event

3. Analysis and Discussion

3.1 Project Scheduling Data
Project scheduling data was obtained from PT. X who contributed as sub-contractor to the ongoing project. This scheduling data includes data on the name of the activity, the duration of the activity (in the day), the start date and its completion of an activity, and the sequence of interdependencies between the project activities.

3.2 Critical Path Determination
After knowing and writing the relationship between activities into Microsoft Project, the next step is to find a critical path. The critical path is the path with the longest path with the fastest completion time. To obtain a critical path, forward calculations are required to obtain ES and EF values as well as backward calculations to obtain LS and LF values. Afterwards, the total float values obtained from the calculation of LF - ES or LS - ES values. The critical path can be determined by looking at activities that have a total value of float = 0 (LF - EF = 0 or LS - ES = 0).

In accordance with the results obtained from the Microsoft Project program, two critical paths are obtained from the scheduling of this project:

a. Critical path with duration of 194 days.
   It consists of activities numbered 1-2-3-7-10-30-32-43-44-45-46-47-48.

b. A critical path with duration of 152 days.
   It consists of activities numbered 1-2-3-7-11-12-13-19-32-43-44-45-46-48

It is known that the critical path is the longest path with the completion of the fastest time, so it can be concluded that the critical path used in this paper is a critical path with a duration of 152 days consisting of Mobility and Survey activities - ROW Clearing - Load and Unload Pipe - Stringing - Line Up Welding - NDT - FJC - Holiday Test - Lowering - Backfill - Pigging - Hydrotest - Aerial Marker, Warning Sign, Marker Sign - Re-Instatement.

3.3 Risk Analysis with House of Risk (HOR) Method
Risk Analysis to be used in this paper is to use House of Risk (HOR) method. Reference [13] uses the HOR method to identify, analyze, measure and mitigate potential risks in a project.

Application of HOR consists of two stages, namely:

a. HOR 1 is used to identify potential risk events and risk agents. The result of HOR 1 is grouping of risk agents into priority risk agents in accordance with the results of Aggregate Risk Potential (ARP) calculations.

b. HOR 2 is used for the design of mitigation strategies undertaken for the handling of priority risk agents. The result of this HOR 1 will be used as initial data on HOR 2.

In this paper, risk analysis will only be done until stage HOR 1. This is because there is no data about risk mitigation. The steps in HOR 1 are as follows:
a. Identify the occurrence of risk events (Risk Event, Ej). These risks are all possible events of project implementation.
b. Assess the level of impact or severity (Severity, Sj). This severity value states how much of a disruption caused by an event risk to the implementation of the project. The severity value consists of 1, 2, 3, and 4. Where 1 indicates that the impact is very small (negligible value), 2 illustrates that the impacts have little effect on the project (no injuries, low financial loss), 3 means impacts in the moderate category on the sustainability of the project (first aid treatment, medium financial loss), and 4 indicates that the impacts are in the category of medical treatment requires, high financial loss.
c. Identify the risk-causing agent (Risk Agent, Aj), ie any factor that can lead to occurrence of identified risk events.
d. Determining the probability of occurrence (Occurance, Oj) of a risk agent. This Occurance states the probability of occurrence of an occurrence of a risk agent, resulting in the emergence of one or more risk effects. The occurance value of 1, 2, and 3. 1 means that it only happens once a month, 2 means it occurs once a week, and 3 means occurs once a day.
e. Measure the correlation (Correlation, Rij) between a risk event and the risk-causing agent. If a risk agent causes a risk to occur, then there can be a correlation. The correlation value consists of 0, 1, 3, 9, where 0 indicates no correlation relationship, 1 represents a small correlation relationship, 3 represents a moderate correlation, and 9 represents a high correlation.
f. Calculates the value of the risk priority index or Aggregate Risk Potential (ARPj). This priority index will be used as a consideration for determining priority risk handling in data entry in HOR 2 and determining which agents or causes of risk are most influential in the sustainability of a project. Calculation of ARP value is as follows:

\[
ARP_j = O_j \Sigma S_j R_{ij}
\]

Where Oj is the occurence value of the risk agent, Si is the severity value of the risk event, and Rij is the correlation value between the risk events and the risk agent.

The risk analysis in this paper uses the HOR phase 1 method that includes the stage of identification and measurement of risk. Risk identification includes the risk events and its severity, risk agents and chance occurrence opportunities, as well as correlations between risk events and risk agents (correlations).

1. Identify Risk Events and Value of Severity
Risk events are the risks that will occur in the project and the impact on the sustainability (severity) of the project itself. This severity value can be seen in Table 1.

| Severity Value | Description |
|----------------|-------------|
| 1              | the impact is very small (negligible value) |
| 2              | the impacts have little effect on the project (no injuries, low financial loss) |
| 3              | the impacts in the moderate category on the sustainability of the project (first aid treatment, medium financial loss) |
| 4              | the impacts are in the category of medical treatment requires, high financial loss. |
The results of identification of risk events and severity values are as follows:
It is known that there are 10 risk events that have scores of two that indicate that the impact of the risk event has little effect on the sustainability of the project activity, 12 scores of three that indicating that the risk event has a moderate impact on the sustainability of the project activity, and Two four-point scores indicating that such risk events have a serious impact on the course of the project activity.

2. **Identify Risk Agent and Occurrence Value**
Risk agents are what factors are responsible for the occurrence of risk events. The value of occurrence is the probability of occurrence of risk agents. The value of this occurrence can be seen in Table 2.

| Occurrence Value | Description     |
|------------------|-----------------|
| 1                | Once a month    |
| 2                | Once a week     |
| 3                | Once a day      |

The results of identification of risk agents and occurrence values are consist of 33 risk agents that potentially trigger the occurrence of risk events. Based on the value of the probability scale, the risk agent is divided into 20 risk agents with occurrence value of one which indicates that the possibility of the risk agent occurs only once in a month. 11 risk agents that have a two occurrence value that suggests that the possibility of a risk agent appears only once in a week of operation and there are two risk agents that have a three occurrence value indicating that the agent occurs once in a single day of operation.

3. **Calculation of Aggregate Risk Potential Value (ARP)**
Prior to calculating the value of Aggregate Risk Potential (ARP), first create a House of Risk table (HOR) phase 1. In this HOR table there is the value of occurrence and risk agents, severity and risk events, and correlation values between risk agents and risk events. These values will then be used in calculating the ARP value. Through the results of risk analysis, obtained ARP value which is the result of HOR output phase 1.

 Aggregate Risk Potential (ARP) calculation aims to determine the priority level in the process of handling a risk agent. The risk agent will then be sorted by the highest to lowest ARP values. The ARP calculation process involves several elements, ie the level of impact of a risk event ($S_i$), the chance level of the occurrence of the risk agent ($O_j$), and the level of connectedness between the risk agent and the risk event ($R_{ij}$). The calculation of ARP is obtained by using the following calculation:

$$ARP_j = O_j \sum S_i \cdot R_{ij}$$

Where,
- $ARP_j$: Aggregate Risk Potential (Risk Priority Index)
- $O_j$: Occurrence (Opportunity Emergence Risk Agent)
- $S_i$: Severity (Impact of Risk Events)
- $R_{ij}$: Correlation Between Risk Agent and Risk Event.

In Table 3 there is an ARP calculation result and a priority risk ranking agent. These ratings are arranged based on ARP values from the largest to the smallest. The greater the value of ARP, the smaller the ratings and risk agents are also increasingly prioritized. The ARP calculation results and the 10 ranking priority risk agents can be seen in Table 3.
Based on Table 3 the highest ARP value is found in risk agents with code A7 with ARP value is 172 and ranking 1. This indicates that the risk agent has the highest priority in handling it compared to the others. This is because, the higher the ARP value of a risk agent, it will be directly proportional to the level of impact that will be generated in the process of completion of a project.

4. **Grouping of Priority Risk Agent With Pareto Calculation**

In handling risk not all risk agents get a handling. This is caused by several factors, such as the cost of the handling process and the level of impact is considered too small. Thus, not all risk agents are handled by the project owner, unless the risk agent is considered a priority.

The Pareto diagram is a diagram developed by an Italian economist named Vilfredo Pareto in the XIX Century [14]. Determination of the category of risk agents is done by using Pareto law or known as 80 : 20 law. The application of Pareto law at risk is that 80% of project owner losses are attributable to a crucial 20% risk. By focusing 20% of crucial risks, the impact of project owner risk by 80% can be overcome.

The process of constructing a pareto diagram consists of six steps, namely [15], [16]:

a. Determine the method or meaning of data classification, eg based on problem, cause, type of mismatch, and so on.

b. Determine the units used to sequence these characteristics, such as dollars, frequency, units, and so forth.

c. Collect data according to predetermined time interval.

d. Summarizes the data and ranks the categories of data from the largest to the smallest.

e. Calculates the cumulative frequency or cumulative percentage used.

Draw a bar chart showing the relative importance of each issue. Identify some things that are important to get attention.

In Table 4 we can see seven risk agents that included in the priority category in accordance with the Pareto calculations.

| Risk Agent | Ranking | ARP | ARP Cumulative | % ARP | % ARP Cumulative | Category |
|------------|---------|-----|----------------|-------|------------------|----------|
| A7         | 1       | 172 | 172            | 8.62  | 8.62             | Priority |
| A25        | 2       | 146 | 318            | 7.31  | 15.93            |          |
| A4         | 3       | 117 | 435            | 5.86  | 21.79            |          |
| A1         | 4       | 102 | 537            | 5.11  | 26.90            |          |
| A11        | 5       | 99  | 636            | 4.96  | 31.86            |          |
| A29        | 6       | 94  | 730            | 4.71  | 36.57            |          |
| A12        | 7       | 88  | 818            | 4.41  | 40.98            |          |
In Figure 1 it can be seen that getting to the right, the ARP value of a risk agent is getting smaller and the % cumulative ARP is getting bigger. In Figure 1 it is also known which risks are included in the priority category, i.e. with an allusion between the ARP value and its % cumulative ARP. It is known in Figure 1 that the priority risk agent ends at a risk agent with code A12. Subsequently, the risk agent is incorporated into the grouping of non-priority risk agents.

4. Conclusion
Based on the results of the analysis conducted, can be drawn some conclusions as follows:
1. The critical path on project scheduling consist of activities Mobility and Survey - ROW Clearing - Load and Unload Pipes - Stringing - Line Up Welding - NDT - FJC - Holiday Test - Lowering - Backfill - Pigging - Hydrotest - Aerial Marker, Warning Sign, Marker Sign - Re-Instatement with a duration of completion of 152 days.
2. There are seven category fall into the priority agency of 33 identified risk agents. The seven risk agents are limited to human resources, miscommunication between project executor and owner, seasonal change factor, sudden material damage, non compliance with employee safety standards, transport / transportation equipment is damaged, employee accidents is occur. The category of priority risk agents indicates that these seven risk agents account for 40.98 percent of all causes of the risk occurrence experienced in accordance with the results obtained from the Pareto calculations.

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