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Delay Identification of the HVAC Project on West Madura Offshore Oil Company Using the House of Risk Method

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***Abstrak*—This research is focused on the analysis of delays or risks to the implementation of the "Procurement and Installation HVAC Installation" contract at West Madura Offshore Oil Company, which has a working area in the Offshore area. This study uses the HOR (House of Risk) method as an alternative to the ISO31000: 2009 risk management method that has been used internally by West Madura Offshore Oil Company The basis for selecting the HOR (House of Risk) method is the existence of a tool to see the impact (severity) and relations (relations) between the event of a delay and the factoring agent. In identification of the cause of the delay the method used are collecting data primary through Focus Group Discussion between Internal Expert and Secondary data which use project data for Offshore HVAC Project in the period of the year 2016-2018. The HOR (House of Risk) method in conducting this process is presented as follow review historical data and related document, Focus Group Discussion as information gathering techniques, Risk analysis and Risk Register. There are five significant risks from the results of research using the HOR (House of Risk) method, namely Poor-quality shop and coordination drawings, weather constraints, limited quantity and quality of HR (contractors and subcontractors), Absence of duct fabrication workshops at the site and lack of communication between contractor and subcontractor.**

Keywords—Risk Management, House Of Risk, HVAC, Delay Analysis, Offshore.

I. INTRODUCTION

PROJECT risk is an uncertain event or condition which, if it occurs, has a positive or negative effect on the project objectives [1]. Projects with broad complexity and strategic importance occur in oil and gas industry construction projects. Risk of conditions in the Oil and Gas field which is a hazardous area, which requires special requirements both for electrical mechanical construction and installation. In NFPA and ICEE there are HVAC (Heating Ventilation Air Conditioning) cooling system requirements as a cooling system as well as a pressurized system. and consists of several subsystems, primarily: thermodynamic processing and filtration, water separation, hot, cold, steam, or water supply for humidification, air duct installation, automatic adjustment subsystem [2].

West Madura Offshore Oil Company is one of the Indonesian Oil and Gas PSC Contractors, one of West Madura Offshore Oil Company Platforms require the work "Procurement and Installation of HVAC" which has been carried out from 2016 to 2018. In its implementation, there was a delay of 382 days. The loss resulted from the delay in the work of "Procurement and Installation of HVAC" in terms of West Madura Offshore Oil Company, namely in terms of lost opportunity cost recovery valued at IDR 9,574,600,000. This delay is caused by delays in the Manufacturing Heating Ventilation Air Conditioning (HVAC) unit, Fabrication Ducting, and Installation processes in the Offshore area.

The delay factor in the Heating Ventilation Air Conditioning (HVAC) work is not only caused by factors in construction but operational problems that hinder the completion of a project such as lack of resources, improper allocation of resources, delays in project implementation, and other problems outside the schedule. in the work plan [3].

Assaf et al. state that the causes of delays include, among others, material, labor, equipment, costs, changes in design changes, relationships with related agencies, scheduling and control, slow monitoring and testing procedures used in the project, environment, contractual issues, and the absence of consultant's professional managers [4].

Internal West Madura Offshore Oil Company has implemented a risk management approach with ISO 31000: 2009 standards as a tool or tool in risk management. The aspect of project delay risk is not reflected in the implementation of ISO31000: 2009 risk management of West Madura Offshore Oil Company Therefore in this study the authors tried to use the HOR (House of Risk) method developed as an alternative method to find the causes or risk identification [5].

II. METHOD

Risk management always begins with risk identification, which may be considered the most important phase of the risk management process. The aim of risk factor identification is to comprehensively identify all significant sources of factors affecting a certain project's objective, as well as the causes of those factors [6].

That's why this study utilized Focus Group Discussion. Focus Group Discussion were conducted by Internal Expert from West Madura Offshore Oil Company for the purpose of identifying the risk which is part of risk management process.

The risk management process begins by setting the scope of the "Procurement and Installation of HVAC Project" to be managed at risk. Furthermore, risk identification activities are carried out to determine the potential hazards that may arise

Table 1.
Profile of Respondents as Internal Experts

Stakeholder	**Number of Respondents**	**Work Experience (years)**
Engineering	1	5-10
Project Executor	3	10-15
QA&QC Project	2	5-10
Process Safety	1	5-10
Field Engineer	2	5-10
Line Manager Technical Maintenance	1	10-15

Table 2.
HOR Model 1

		Risk Agent (Aj)							
Business Process	**Risk Event (E*i*)**	A1	A2	A3	A4	A5	A6	A7	**Severity of Risk Event *i* (S*i*)**
Plan	E1	R11	R12	R13	..	..	..	..	S1
	E2	R21	R2	..	..	..	..	..	S2
Source	E3	R31	..	..	..	..	..	..	S3
	E4	R41	..	..	..	..	..	..	S4
Make	E5	..	..	..	..	..	..	..	S5
	E6	..	..	..	..	..	..	..	S6
Deliver	E7	..	..	..	..	..	..	..	S7
	E8	..	..	..	..	..	..	..	S8
Return	E9	..	..	..	..	..	..	..	S9
Occurance of Agent *j*		O1	O2	O3	O4	O5	O6	O7	
Aggregate Risk Potential *j*		ARP1	ARP2	ARP3	ARP4	ARP5	ARP6	ARP7	
Priority Rank of Agent *j*									

Table 3.
Twenty (20) significant risk factors for the HVAC Systems project., "Risks Affecting the Delivery of HVAC Systems: Identifying and Analysis

Risk Factors classification	**RFIT**	**Rank**	**RFIC**	**Rank**	**Group**
Poor selection of valves that might cause more damage	0,449	1	0,459	1	B
Lack of specialized laborers	0,417	2	0,355	5	D
Poor-quality shop and coordination drawings	0,417	3	0,371	3	D
Wrong selections that might cause future rectification	0,406	4	0,415	2	C
Poor safety regulations	0,385	5	0,344	8	D
Wrong work procedure between different disciplines	0,367	6	0,318	12	D
Equipment sizes clash with provided spaces	0,363	7	0,358	4	C
Wrong selection of dampers and plenum boxes	0,339	8	0,337	11	A
Power/Chilled/Duct connection might not match with the equipment	0,338	9	0,34	9	C
Openings missing in the concrete and wall for horizontal and vertical penetration	0,337	10	0,278	15	D
Selecting fittings that might not be compatible with the pipe thickness	0,336	11	0,352	6	B
Weak connection/ joints (threaded/ groove/ welded etc.) between two chilled water pipe pieces	0,334	12	0,347	7	B
Inappropriate storage of the duct, which might cause damage to the duct	0,329	13	0,254	22	A
Unsafe handling of the equipment	0,312	14	0,338	10	C
Installation without following the standard procedure	0,312	15	0,275	16	D
Extreme weather conditions	0,311	16	0,27	18	D
Shortage of power supply for machine's operation	0,311	17	0,252	24	D
Lack of water supply and drainage for testing	0,308	18	0,253	23	B
Abnormal floor height that might require special scaffolding	0,304	19	0,26	21	D
Inappropriate fixing methods	0,301	20	0,278	14	D

and also do historical data collection from the project in the 2016-2018 implementation period. In this stage a list of delays will be generated that can be obtained from the identification of the source of the delay, what are the factors of delay (what), where the delay factor appears / is found (where), how the delay arises in that place (how) and why the delay arises (why), which delay has an impact on the achievement of company goals and objectives within the scope of the "Procurement and Installation of HVAC" projects.

A. Data Collection

Data collection will be divided into two with detail;(1)Primary Data, starting with setting the scope of the "Procurement and Installation of HVAC Project" to be managed at risk, then conducting Focus group discussions and Internal Expert Judgments using secondary data as a basis for discussion;(2)Secondary data, the collection of similar project history data (HVAC) at West Madura Offshore Oil Company in the period of 2016-2018 as secondary data.

In determining the weighting criteria in this study will be carried out through an expert judgment process with the profile of respondents can see Table 1. Respondents in table 1 are internal stakeholders involved in the HVAC project in the 2016-2018 period and are also experts at WEST MADURA OFFSHORE OIL COMPANY has experience in fields related to the HVAC project.

After conducting a focus group discussion, the researcher does the re-recording for further re-verification so that the definition of the researcher from the results of the focus group

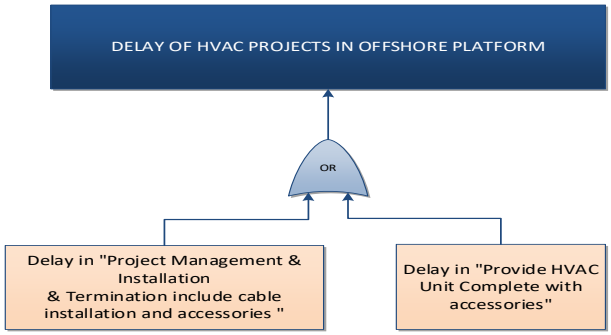

Figure 1. FTA (Fault Tree Analysis) level 1 identification of the delay in the results of the FGD (Focus Group Discussion).

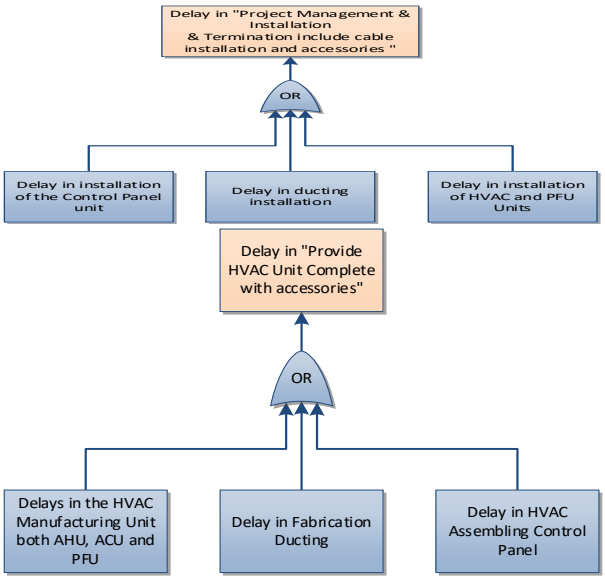

Figure 2. Level 2 FTA (Fault Tree Analysis) identification of the delay in the results of the FGD (Focus Group Discussion).

discussion can be believed to be in accordance with the objectives and research objects.

B. Risk Identification or Delay Stage

Risk identification activities carried out to determine the potential hazards that may arise. The common tools and techniques used are:

a. *Review* documents: Input documents in the pre-project stage (Pre-FS / FS documents, economic models, risk evaluation results, and other supporting documents.
b. *Information Gathering Techniques* which will be used are: Focus Group Discussion.
c. *Analysis Checklist*
d. *Root Cause Analysis,* which will be used is FTA basis from the Internal Expert Judgment of West Madura Offshore Oil Company. After getting the risk based on the risk identification process, next step is using House ofRisk (HOR) method for the identification of the delay stage. The detail step are:

a. Identification of possible delays that may occur for each stakeholder, obtained from the focus group discussion
b. Give a rating on a scale of 1 to 5 regarding the severity due to factors that occur delays
c. Identify agents of delays and assess their likelihood.
d. Develop a linkage matrix (relations) between each of the delay factor agents with each delay.

Table 4.
Likert scale for severity used in the HOR (House of Risk) approach

Scale	Remark
5	Very serious impact and cause project failure
4	Serious impact on project completion
3	Moderate impact on project completion
2	Little impact on project completion
1	The impact on the completion time target can be ignored

Table 5.
Likert scale for probability used in the HOR (House of Risk) approach

Scale	Remark
6	Probabilities inevitably occur and cause project failure
5	The probability of occurrence is very high so it is very common for projects
4	High probability of occurrence
3	Probability of moderate occurrence
2	low probability of occurrence
1	the probability of occurrence will almost certainly not occur

Table 6.
Severity rating value for delay events in the HOR (House of Risk) metho

Code	Delay Event	Severity
E1	Delay in HVAC Manufacturing Units both AHU, ACU and PFU	4
E2	Delay in Fabrication Ducting	4
E3	Delay in the HVAC Assembly Control Panel	3
E4	Delay in installation of the Control Panel unit	3
E5	Delay in ducting installation	4
E6	Delay in installation of HVAC and PFU Units	4

e. Calculate the Aggregate Delay Potential of Agent j (ADPj) which is the result of the possible emergence of the delay factor j agent and the aggregate effect of the delay caused by the delay factor agent.
ARPj = Oj∑iSiRij……...(1)
f. Rank the delay factor by the aggregate risk potential from the largest value to the smallest value.
g. Use Pareto Chart 80:20 with ARP_j as basis calculation using formula :
Pareto = (ADPj/TotalADP) x 100%……...(2)
HOR Model 1 can see Table 2.

III. RESULT AND DISCUSSIONS

A. Identification of Late Events

The primary data obtained from this identification came from focus group discussions with internal expert judgment consisting of engineering, project executors, QA & QC projects, process safety, field engineers, and Line Manager Technical Maintenance as Contract Holder in the "Procurement and HVAC Installation "Button. And secondary data obtained from the literature review and historical data of the company must be able to describe events, risk agents (include sources of risk), potential consequences, and key risk indicators.

The Literature Review that will be used is a paper entitled Risks affecting the delivery of HVAC systems: Identifying and analysis [7] which describes the risks in HVAC construction projects, a list of risks contained in this paper can be seen in Table 3. To determine the severity and probability of the risk, a Likert scale is used in the HOR

Table 7.
the probability or occurrence for delay agents in the HOR (House of Risk) method

Code	Delay Agent	Occurrence
A1	Complicated delivery and inspection procedures	2
A2	Weather Constraints	5
A3	Difficult access in "horizontal and vertical penetration" of the walls of the room	2
A4	Limited quantity and quality of human resources (contractors and subcontractors)	4
A5	Limitations of POB (Personal on Board) on PT.XYZ's Offshore Platform	3
A6	Absence of duct fabrication workshop at the site	6
A7	Lack of communication between contractor and sub-contractor	5
A8	Lack of storage space for ducts, pipes, and equipment at the site	6
A9	Logistic difficulties in shifting the ducts, pipes, and equipment to the storage area	4
A10	Poor-quality shop and coordination drawings	5
A11	Low performance / productivity of contractors	4
A12	Safety Regulations for Offshore work	2

Table 8.
Listing or listing of agents causing delays in the delay event with E1 code that will be used in the HOR (House of Risk) Method

No	Event Delay	Delay Agent
E1	Delay in HVAC Manufacturing Units both AHU, ACU, and PFU	Limited quantity and quality of human resources (contractors and subcontractors) Complicated delivery and inspection procedures Lack of communication between contractors and subcontractors Poor-quality shop and coordination drawings Logistical difficulties in shifting the ducts, pipes, and equipment to the storage area

Table 9.
Listing or listing of agents causing delays in the delay event with the E2 code that will be used in the HOR (House of Risk) Method

No	Event Delay	Delay Agent
E2	Delay in ducting Fabrication	Limited quantity and quality of human resources (contractors and subcontractors) Lack of communication between contractors and subcontractors Poor-quality shop and coordination drawings

Table 10.
Listing or listing of agents causing delays in the delay event with the E3 code that will be used in the HOR (House of Risk) Method

No	Event Delay	Delay Agent
E3	Delay in HVAC Assembling Control Panel	Lack of communication between contractors and subcontractors Poor-quality shop and coordination drawings Limited quantity and quality of human resources (contractors and subcontractors)

(House of Risk), with details as follows: (a) For the severity, the Likert scale will be used as in table 4; (b) 2. For the probability or probability number, the Likert scale will be used as in table 5.

The FGDs result that have been carried out with Fault Tree Analysis (FTA) are events and agents and sub-agents of delays related to delays from the project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)" which show in figure 1 and 2.

From Figure 1 and 2 we can know factors that cause (can be called a Delay Event) of the project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)", namely:

1) Delay "Project Management & Installation & Termination

Delay "Project Management & Installation & Termination including cable installation and accessories", which has a delay agent:

a. Delay in the installation of the Control Panel unit
b. Delay in ducting installation
c. Delay in the installation of the HVAC Unit (Heating Ventilation Air Conditioning) and PFU (Pressurize Fan Unit).

2) Delay "Provide HVAC Unit Complete with accessories

Delay "Provide HVAC Unit Complete with accessories", which has a delay agent:

a. Delay in HVAC (Heating Ventilation Air Conditioning) Manufacturing Unit both AHU (Air Handling Unit), ACU (Air Conditioning Unit) and PFU (Pressurize Fan Unit).
b. Delay in Fabrication Ducting
c. Delay in HVAC (Heating Ventilation Air Conditioning) Assembly Control Panel

Furthermore, the probability or occurrence value of delay agent and severity or impact severity of each event delay can be seen in table 6 and 7.

From the table 6 and 7 it is known that the HOR (House of Risk) method uses table 4 and 5 as a scale to determine the severity impact and that will be used to obtain risk ratings through Aggregate Delay Potential (ADP) calculations which the matrix is shown in table 2.

Table 11.
Listing or listing of agents causing delays in the delay event with the E4 code that will be used in the HOR (House of Risk) Method

No	Event Delay	Delay Agent
E4	Delay in the installation of the Control Panel unit	Limitations of POB (Personal on Board) on PT.XYZ's Offshore Platform Limited quantity and quality of human resources (contractors and subcontractors) Safety Regulations for Offshore work Weather Constraints

Table 12.
Listing or listing of agents causing delays in the delay event with the E5 code that will be used in the HOR (House of Risk) Method

No	Event Delay	Delay Agent
E5	Delay in ducting installation	Limited quantity and quality of human resources (contractors and subcontractors) Safety Regulations for Offshore work Weather Constraints Poor-quality shop and coordination drawings Absence of duct fabrication workshop at the site Difficulties in "horizontal and vertical penetration" against the walls of the room

Table 13.
Listing or listing of agents causing delays in delay events with code E6 that will be used in the HOR (House of Risk) Method

No	Event Delay	Delay Agent
E6	Delay in the installation of HVAC and PFU Units	Limitations of POB (Personal on Board) on PT.XYZ's Offshore Platform Limited quantity and quality of human resources (contractors and subcontractors) Safety Regulations for Offshore work Weather Constraints Difficult access in "horizontal and vertical penetration" of the walls of the room Lack of storage space for ducts, pipes, and equipment at the site

Table 14.
ADP (Aggregate Delay Potential) results on the HOR (House of Risk)

Business Process	Risk Event (E*i*)	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	Severity of Risk Event *i* (S*i*)
Provide HVAC unit	E1	3	0	0	3	0	0	3	0	9	9	0	4
	E2	0	0	0	3	0	0	3	0	0	9	0	4
	E3	0	0	0	3	0	0	3	0	0	9	0	3
Project Management and Installation	E4	0	9	0	3	3	0	0	0	0	0	1	3
	E5	0	9	0	3	3	9	0	0	0	9	1	4
	E6	0	9	1	3	3	0	0	3	0	0	1	4
Occurance of Agent *j*		2	5	2	4	3	6	5	6	4	5	2	
Aggregate Risk Potential *j*		24	495	8	264	99	216	165	72	144	675	22	
Priority Rank of Agent *j*		9	2	11	3	7	4	5	8	6	1	10	

Table 15.
Ranking or ranking of Pareto results from the ADP (Aggregate Delay Potential) on the HOR (House of Risk) method

Agent Code	Aggregate Risk Potential *j*	Priority Rank of Agent j	Cumulative Percen	Delay Agent
A10	675	1	31%	Poor-quality shop and coordination drawings
A2	495	2	54%	Weather Constraints
A4	264	3	66%	Limited quantity and quality of human resources (contractors and subcontractors)
A6	216	4	76%	Absence of duct fabrication workshop at the site
A7	165	5	83%	Lack of communication between contractors and subcontractors

B. Identification of Agents Causing Delays

After finding the event or event causing the delay, the next step is to find the agent and sub-agent causing the delay. With primary and secondary data obtained. Then get several agents and sub-agents causing delay using the FTA (Fault Tree An alysis) method and Focus Group Discussion (FGD),the result are shown in the following Table 8, 9, 10, 11, 12 and 13.

C. Analysis of Research Result Based on the Method Used

Based on the results of the research that has been done in the previous sub-chapter both about the significant potential

risks that cause delays in the Project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)" on the WEST MADURA OFFSHORE OIL COMPANY Offshore Platform or risk mitigation to deal with it using the Risk Management method The ISO31000: 2009 approach and HOR (House of Risk) are obtained potential significant risks that cause delays in the Project "Procurement and Installation of HVAC (Heating Ventilation Air Conditioning)" on the Offshore Platform of PT.XYZ, like seen in table 14 and 15. From table 15, we can resume:

1) Poor-quality shop and coordination drawings

"Poor-quality shop and coordination drawings" which have the largest quantitative impact of five hundred twenty-two (522) thousand USD, an RPN (Risk Priority Number) of fifteen (15) or in the category of High Impact, and a percent value of Pareto diagram of 31%. Thirty-one percent (31%) shows the largest contribution compared to other risks. The delay agent "Poor-quality shop and coordination drawings" ranks third of the twenty list of risk factors causing delays in the HVAC project [7].

2) Weather constraints

Weather constraints "which have an RPN (Risk Priority Number) of sixteen (16) or with the High Impact category, and a percent value of a pareto diagram of 23%. The value of twenty-three percent (23%) shows the second largest contribution compared with other risks. This is caused by the transportation and accommodation system in the offshore area which is very dependent on weather conditions.

3) Limitations on the quantity and quality of human resources (contractors and subcontractors

"Limitations on the quantity and quality of human resources (contractors and subcontractors)" which have an RPN (Risk Priority Number) of twenty (20) or with a High Impact category, and a percent value of a pareto diagram of 12%. The value of twelve percent (12%) shows the third largest contribution compared to other risks. This is caused "Limited quantity and quality of human resources (contractors and subcontractors)" is common or often occurs in every construction project and were identified as the factors most causing project delay [6].

4) Absence of duct fabrication workshop at the site

"Absence of duct fabrication workshop at the site" where the RPN (Risk Priority Number) value is twenty (20) or with the category of High Impact, the percent value of the pareto diagram is 10%. The value of ten percent (10%) shows the fourth largest contribution compared with other risks. Delay agent "Absence of duct fabrication workshop at the site" is the uniqueness of HVAC construction work in Oil and Gas companies located in offshore areas, in addition to limited space, hazardous area location is another factor that causes no duct fabrication workshop ".

5) The lack of communication

"The lack of communication between the contractor and the sub-contractor which has an RPN (Risk Priority Number) of nine (9) or with the Moderate Impact category, and the percent value of the Pareto diagram is 7%. A value of seven percent (7%) shows the fifth largest contribution compared with other risks, this is in the correlation between three (3) delay events with codes E1 through E3 with a correlation value of three (3) or with categories according to the Likert scale "low". This is caused "Limited quantity and quality of human resources (contractors and subcontractors)" is common or often occurs in every construction project.

IV. CONCLUSION

After numerous proses including FGD (focus group discussion), this study has identified the risk factors that affect the duration and cost of the identified activities for the purpose of high-lighting the key risks that can significantly influence the delivery of HVAC systems in offshore construction projects. The outcome of the study is a list of five (5) significant risk factor which fall to category Manufacturing or Fabrication and Installation. A summary of the specific conclusions drawn from this study is as follows:(a)The result from FGD regarding the ranking of risk factors were determined based on three indices related to the probability of occurrence, impact and the inherent quantitative impact . The experience of the respondents was taken into consideration; (b)Severity scale indices were developed based on a combination of the probability of occurrence and the impacts of risk factors on time and cost to describe the key risk factors affecting HVAC system activities; (c)"Poor-quality shop and coordination drawings" was considered the most important risk factor that affected both time and cost. With 31% shown as the largest contribution compared to other risks, this is due to the high correlation value (9, "high correlation") to the most delay events; (d)Correlation or relationship between risk agents each other are important factor that can determine the risk priority which can lead to accurately risk treatment.

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