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QUANTITATIVE RISK ASSESSMENT OF THE AH-140 SHIP-BUILDING PROJECT AT PT. PAL INDONESIA TO SUPPORT THE DUTIES OF THE INDONESIAN NAVY

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ABSTRACT

The AH-140 Shipbuilding project is a challenge for PT.PAL as part of the Indonesian Defense Industry Holding under PT. LEN Industry is under a situation of uncertainty, which will bring up both positive and negative risks. Negative risks that can cause project delays should be mitigated to prevent delays. This thesis has the aim of knowing the interaction between risks and obtaining mitigation recommendations for the implementation of the AH-140 Shipbuilding project. Bayesian Network is used to determine the level of project risk interaction, as well as to model scenarios by providing certainty on the risks that have an effect. AHP is used to assess the chance of occurrence at Independence risk and ANP is used to assess opportunities from Dependence risk. In the study, it was found that there were 22 risks. risk (E14) Quality of work, risk (E20) Cost overrun, and risk (E7) material shortage. The influence of risk variables that have the potential to occur in the AH-140 Shipbuilding project, causing potential delays in ship launching at a Low-risk level with actual conditions of 43%, Medium risk Level with actual conditions of 31%, and High-risk level with actual conditions of 26%. This is influenced by the risk (E14) of the quality of work, the risk (E20) of cost overrun, and the risk (E7) of material shortages. So that get some recommendations in response to risks that have the potential to occur.

***Keywords**: Project Risk Management, Bayesian Network, AHP, ANP.*

1. Introduction

Strategic project development is a challenge for an organization. Shipbuilding with the highest classification, namely Naval class, not all shipyards have the opportunity to carry out the project. The existence of this request is a challenge in itself from the shipyard. There is a deviation in planning and actual conditions indicating uncertainty that causes risks to arise so that if they are not responded to, they will have a wider impact. This condition is caused by weaknesses or failures in internal processes, human resources, systems, and external events, which give rise to various risks that can cause direct or indirect loss. Several definitions in the literature state that risk is exposure to lose in a project (Chapman and Ward, 1997 in Ahmed et al., 2007). Risk can also be defined as the opportunity for loss in a project (Kartam and Kartam, 2001 in Ahmed et al., 2007). So in order to assess the risk of a development project with a Naval class classification, a risk assessment model that can occur in the project is used. Uncertainty conditions in the project can be described as interacting through a Bayesian network, of course, with expert preferences due to the availability of event data. Preferences use AHP and ANP as assessment methods.

2. RESEARCH METHODS

2.1 Analytic Hierarchy Process (AHP)

The stages of decision-making in the AHP method are basically as follows:

a. Define the problem and determine the desired solution.

b. Create a hierarchical structure starting with the general objective, followed by the criteria and alternative choices to be ranked.

c. Form a pairwise comparison matrix that describes the relative contribution or influence of each element on each objective or criterion level above it. Comparisons are made based on the choice or judgment of the decision maker by assessing the level of importance of an element compared to other elements.

d. Normalizing the data is by dividing the value of each element in the paired matrix by the total value of each column.

e. Calculating the eigenvector values and testing their consistency, if they are not consistent then data collection (preferences) needs to be repeated. The eigenvector eigenvalue in question is the maximum eigenvector value obtained using Matlab or manually.

f. Repeat steps 3, 4, and 5 for all hierarchical levels.

g. Calculating the eigenvector of each pairwise comparison matrix. The eigenvalue vector is the weight of each element. This step is to synthesize the choices in prioritizing the elements at the lowest hierarchical level to achieve the goal.

h. Test the consistency of the hierarchy. If it does not meet the CR < 0.1 then the assessment must be repeated.

2.2 Analytic Network Process (ANP)

As a development of AHP, ANP is defined as a non-bayesian and non-parametric qualitative approach to the decision-making process with a general framework without making assumptions (Acharya, 2012). ANP has several advantages, including its ability to assist decision-makers in measuring and synthesizing a number of factors in a hierarchy or network. The advantage of ANP compared to AHP is that ANP is superior in terms of simplicity, connectivity, more objective comparisons, more accurate predictions, and more stable and robust results.

2.3 Risk Assessment

In general, the steps in risk measurement are as follows:

a. Identifying risks and studying the characteristics of those risks.

b. Measuring these risks, seeing how big the impact is on the company's performance, and determining the priority of these risks.

At the risk identification stage, management takes action in the form of identifying every form of risk experienced by the company, including the forms of risk that the company may experience. This identification is done by looking at and observing the potential risks that have been seen and those that will be seen.

2.4 Bayesian Networks

Bayesian Networks (BN) is a probabilistic model in the form of a Directed Acyclic Graph / DAG which is used to describe probability relationships and Probabilistic Inference between Variables. BN is defined by 2 components namely Directed Acyclic Graph / DAG and Conditional Probability Table / CPT. The first component is the DAG in the form of nodes and arrows. The second component is the Conditional Probability Table (CPT) for each variable in the network. CPT for variable B, specifies the conditional distribution P(B| Parent (B)), where the parent (B) is a node parent of B. BN combines two aspects of the decision maker, namely the qualitative aspect and the quantitative aspect. The qualitative aspect is represented by the causal relationship of the existing problems through the Directed Acyclic Graph, while the quantitative aspect is represented by the level of trust of the decision maker where the interdependence relationship is expressed in the form of a conditional probability distribution for each variable in the network.

2.5 Shipbuilding Project

The process that requires a lot of time and money is at the hull construction stage. According to (Basuki, 2012), hull construction has the greatest risk opportunity in new shipbuilding projects, namely 38.67% compared to the design, outfitting, etc. stages. The hull construction stage is one of the stages in the overall ship construction.

2.6 Research Framework

The Bayesian model is used to estimate the potential risk under uncertainty. The ANP method is used to assess weights based on Expert preferences so as to produce robust data to be used as input data in the Bayesian Network model. This is due to the uncertainty of risk data in the AH-140 shipbuilding project. Sensitivity analysis is used to see potential risks that have a strong influence on the objective variable so that risk mitigation is obtained based on expert validation.

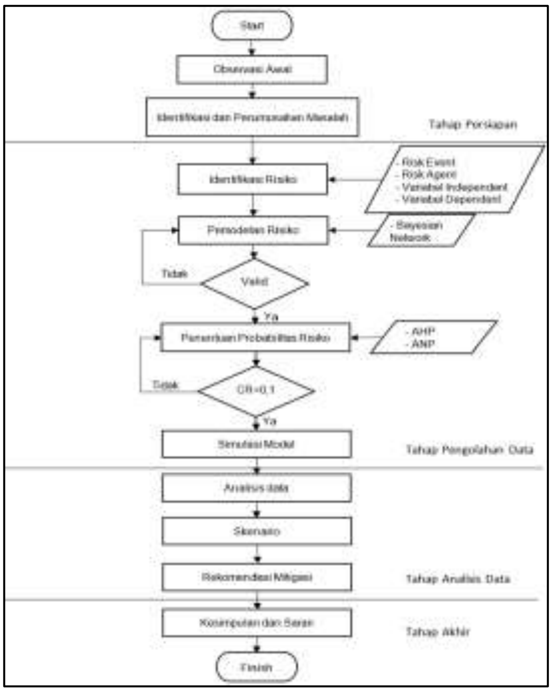

Figure 1. Flow Chart.

3. ANALYSIS AND DISCUSSION

3.1 Identification of risks

The results of interviews with experts and risk owners of the AH-140 ship-building project where RBS as a reference have identified potential risks that arise on the critical trajectory of the AH-14 ship-building project in the table

Table 1. Risk Identification

Risk Type	Description of the Risk Event	Code
Ops-1	The potential for inaccuracies in the milestone implementation schedule	E1
Ops-2	The potential for delays in design drawings	E2
Ops-3	Potentially incomplete production drawings	E3
Ops-4	The potential for obstacles to human resources	E4
Ops-5	Potential errors in purchase requisitions	E5
Ops-6	Potential damage to workshop equipment and facilities	E6
Ops-7	The potential for material shortages during project implementation	E7
Ops-8	The potential for delays in the Main Engine	E8
Ops-9	The potential for delays in the arrival of material	E9
Ops-10	Potential delays in the mobility of lifting and conveyance equipment	E10
Ops-11	Potential for errors in the launch procedure	E11
Ops-12	The potential for production defects / Defect	E12
Ops-13	Potential delays in ship launching	E13
Ops-14	The potential for the quality of work to not be up to standard	E14
Ops-15	Potential technological imbalances used in design drawings	E15
Ops-16	Potential product quality is out of specification	E16
Ops-17	The potential for problems related to bureaucracy, rules and regulations	E17
HSE-1	Potential for fire	E18
HSE-2	Potential for work accidents	E19
Fin-1	The potential for an increase in material prices	E20
Fin-2	The potential for swelling in the allocation of work costs	E21
Fin-4	Potential risks in acceptance/ benefit	E22

3.2 Bayesian Models

At this stage, the creation of a risk network interaction model is carried out using influence diagrams. The first step of this stage is to identify causal statements derived from risk data sources.

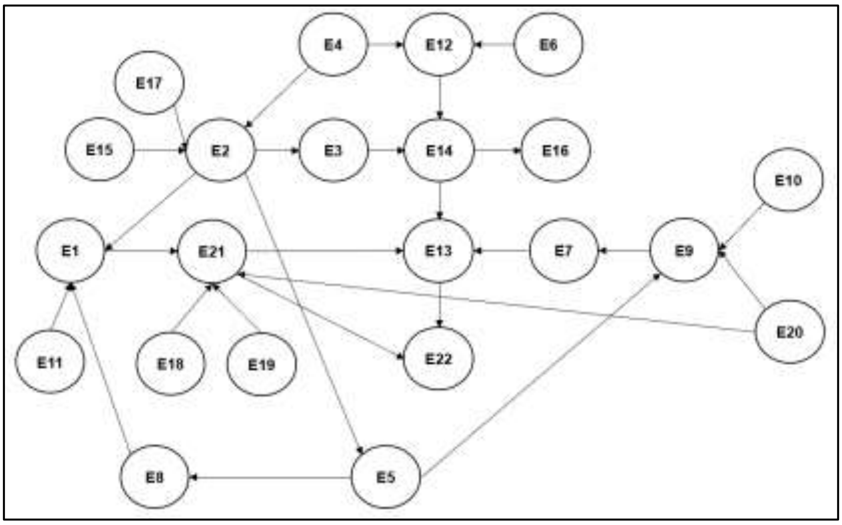

Figure 2. Interaction of the risk network.

Based on Figure 1.2, network interaction does not form a cyclic loop, so the network interaction is made into a Bayesian network model as shown in Figure 4.7.

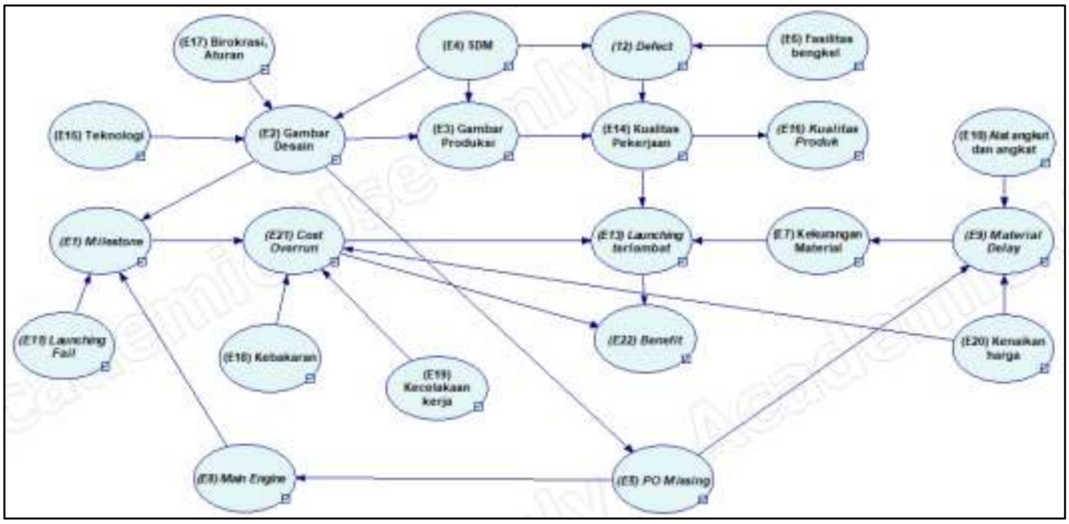

Figure 3. Models Bayesian Network.

3.3 Determination of Prior and Conditional Probability

At this stage, the prior probability is a representation of the independent risk variable in table 2. The results of the AHP questionnaire are used as input for processing risk weighting.

Table 2. Prior Probability

No	Code	*state*			Risk Factor	CR
		Low	*Medium*	*high*		
1	E4	0.81	0.11	0.07	1	0.05
2	E6	0.78	0.14	0.08	1	0.08
3	E10	0.89	0.07	0.03	1	0.09
4	E11	0.81	0.11	0.08	1	0.07
5	E15	0.82	0.11	0.07	1	0.05
6	E17	0.36	0.54	0.1	1	0.09
7	E18	0.82	0.11	0.07	1	0.05
8	E19	0.54	0.3	0.16	1	0.07
9	E21	0.16	0.65	0.19	1	0.06

The results of the ANP Questionnaire become input to the Super Decision 2.10 software. with CR<0.1. Figure 1.4. shows data processing using Genie 4.10 software.

Node properties: (E2) Gambar Desain

General | Definition | Format | User properties | Value

(E20) Birokrasi...	L								
(E4) SDM	L			M			H		
(E15) Teknologi	L	M	H	L	M	H	L	M	H
L	0.7	0.15	0.23	0.23	0.14	0.1	0.2	0.09	0.09
M	0.21	0.63	0.34	0.45	0.46	0.36	0.71	0.41	0.39
H	0.09	0.22	0.43	0.32	0.4	0.54	0.09	0.5	0.52

(E20) Birokrasi...	M								
(E4) SDM	L			M			H		
(E15) Teknologi	L	M	H	L	M	H	L	M	H
L	0.41	0.25	0.19	0.22	0.16	0.11	0.23	0.14	0.09
M	0.37	0.47	0.35	0.57	0.61	0.43	0.27	0.23	0.17
H	0.22	0.28	0.46	0.21	0.23	0.46	0.5	0.63	0.74

(E20) Birokrasi...	H								
(E4) SDM	L			M			H		
(E15) Teknologi	L	M	H	L	M	H	L	M	H
L	0.29	0.15	0.1	0.19	0.01	0.09	0.18	0.06	0.01
M	0.5	0.53	0.55	0.54	0.58	0.1	0.33	0.18	0.11
H	0.21	0.32	0.35	0.27	0.41	0.81	0.49	0.76	0.88

Figure 4. Input on Genie 4.10.

3.4 Analysis and Discussion

3.4.1 Actual Conditions

The variables contained in the Bayesian Networks model are very decisive at each level of the level where the lower variable can greatly influence or not affect the variable above it. This can be a determining factor in the main variable. After the prior probability values on the independent variable and CPT on the dependent variable are known, then data processing is carried out using the model created in Genie 4.0 software, as shown in Figure 5.

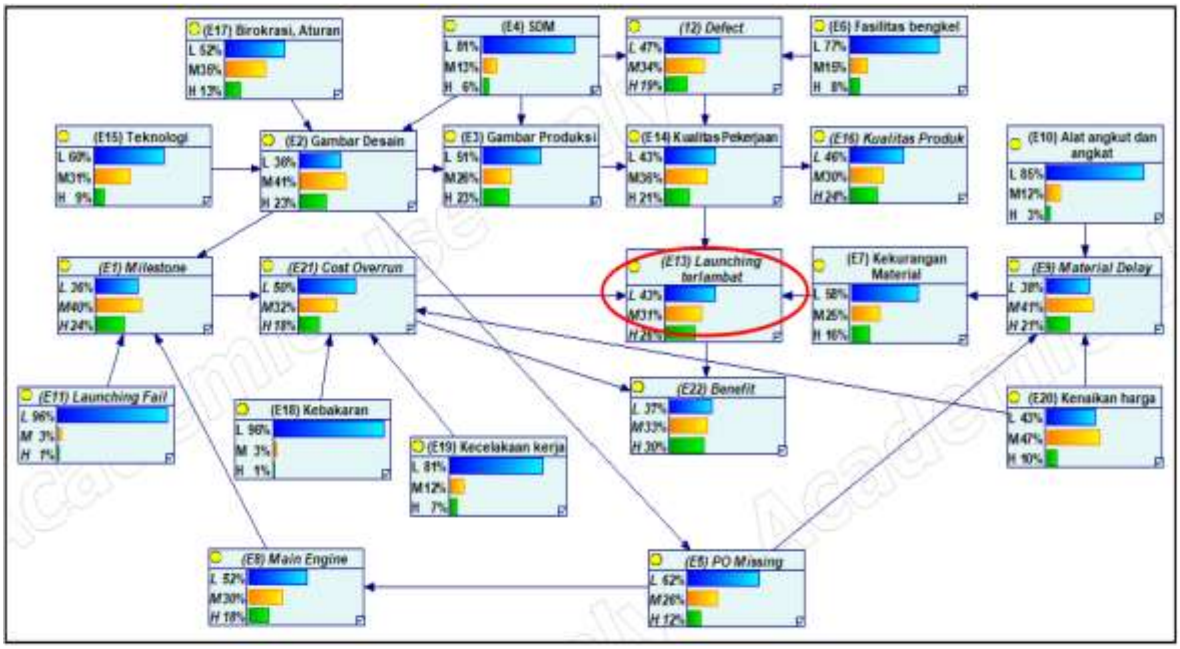

Figure 5. Actual Conditions of the Project.

Based on Figure 5, it can be concluded that the risks that have the potential to occur in the AH-140 Shipbuilding project cause potential delays in ship launching at a Low-risk level with actual conditions of 43%, a Medium risk level with actual conditions of 31%, and a High-risk level with actual conditions of 26 %.

Table 3. Joint Probability of Potential Risks

No	Code	*Joint Probability (%)*			Total (%)
		Low	*Medium*	*high*	
1	E1	36	40	24	100
2	E2	36	41	23	100
3	E3	51	26	23	100
4	E7	58	25	16	100

No	Code	*Joint Probability (%)*			Total (%)
		Low	*Medium*	*high*	
5	E9	38	41	21	100
6	E12	47	34	19	100
7	E13	43	31	26	100
8	E14	43	36	21	100
9	E20	43	47	10	100
10	E21	50	32	18	100
11	E22	37	33	30	100

3.4.2 Sensitivity analysis

Sensitivity analysis is an analysis to determine the variable with the greatest influence on the objective variable. Risk (E13) Late launching is the objective variable in the model, so the most influential variables can be identified. The results of the sensitivity test of objectives or goals and variables that affect the risk (E13) of late launching can be seen in Figure 6.

Figure 6. Sensitivity analysis.

Based on the results of the sensitivity analysis, it can be concluded that the risks that affect the risk of (E13) late launching at all risk levels are (E14) quality of work risk, (E20) cost overrun risk, and (E7) material shortage risk.

3.4.3 Modeling Scenario

At this stage, the scenario is used to provide changes to the target, namely the risk of (E13) Launching is late. Changes to targets are necessary to provide Measures so that the risk of (E13) Late Launching can be minimized. Changes will be analyzed using predictive and diagnostic reasoning. The scenario is carried out by providing certainty (evidence) on the risks that have an impact, namely the risk of (E14) Quality of work, (E7) Material shortages, (E21) Cost Overrun.

a. Scenario on Risk Variable (E14).

Diagnostic reasoning is carried out which shows that to provide risk certainty (E14) quality of work at the Low level, changes are needed in the associated risks, namely the risk of (E3) Production Drawings, (E12) Defects, (E2) Design Drawings, (E6) Workshop Facilities, (E4) HR, (E15) Technology, and risk (E21) Regulatory bureaucracy.

Table 4. Scenario of Risk Variable (E14) Quality of Work.

No	*Parent Risk*	Actual Condition (%)	Scenario Results (%)

		L	M	H	L	M	H
1	(E2) Design Drawings	36	41	23	41	42	17
2	(E3) Production Drawings	51	26	23	65	24	11
3	(E4) HR	81	13	6	88	8	4
4	(E6) Workshop facilities	77	15	8	85	11	4
5	(E12) *Defects*	47	34	19	68	22	9
6	(E15) Technology	60	31	9	61	30	8
7	(E17) Regulatory bureaucracy	52	35	13	53	34	13

b. Scenario on Risk Variable (E7).

Diagnostic reasoning is carried out which shows that certainty at risk (E7) of material shortages at a Low level requires changes at related risk levels, namely (E9) Material Delay, risk (E10) Transport and lifting equipment, risk (E20) Price increase, risk (E5) PO Missing, risks (E2) Design Drawings, risks (E4) HR, risks (E15) Technology, and risks (E17) Bureaucracy, rules and regulations. This can be done by avoiding and reducing, the potential risks that exist.

Table 5. Scenario of Risk Variable (E7) Material Shortage.

No	*Parent Risk*	Actual Condition (%)			Scenario Results (%)		
		L	M	H	L	M	H
1	(E2) Design Drawings	36	41	23	37	40	23
2	(E4) HR	81	13	6	81	13	6
3	(E5) *PO Missing*	62	26	12	65	25	10
4	(E9) *Material delays*	38	41	21	51	38	11
5	(E10) Transport and lifting equipment	85	12	3	86	12	2
6	(E15) Technology	60	31	9	60	31	9
7	(E17) Bureaucracy, rules, and regulations	52	35	13	52	35	13
8	(E20) Price increase	43	47	10	45	46	9

c. Scenario on Risk Variable (E20)

is certainty in the risk (E20) Cost overrun at the Low level gives change to the goal, namely the risk of (E13) Late launching at the Low level of 52%, Medium Level of 27%, and High Level of 20%. Where the change in the target gives a change in the risk (E21) Benefit and (E22) Product Quality. This change has increased from the previous level of Low at 57%, Medium at 30%, and High at 13% respectively, while at risk (E22) Product Quality is Low at 48%, Medium at 29%, and High at 24% respectively.

These changes are not only related to objectives but also occur in parent risk. Diagnostic reasoning is carried out which shows that certainty at risk (E21) Cost overrun at a Low level requires changes at related risk levels, namely (E20) Price increases, (E19) Work accidents, (E18) Fire, (E1) Milestone, (E2) Design drawings, (E15) Technology, (E17) Regulatory bureaucracy, (E4) HR, (E5) PO Missing, (E8) Main Engine, and (E11) Launching file. This can be done by avoiding and reducing, the potential risks that exist.

Table 6. Scenario of Risk Variable (E20) Cost overrun.

No	*Parent Risk*	Actual Condition (%)			Scenario Results (%)		
		L	M	H	L	M	H
1	(E1) *Milestones*	36	40	24	42	37	21
2	(E2) Design drawings	36	41	23	38	40	22
3	(E4) HR	81	13	6	81	13	6
4	(E5) *PO Missing*	62	26	12	64	25	11

5	(E8) *Main Engine*	52	30	18	55	28	16
6	(E11) *Launching file*	96	3	1	96	3	1
7	(E15) Technology	60	31	9	61	31	8
8	(E17) Regulatory bureaucracy	52	35	13	52	35	13
9	(E18) Fire	96	3	1	97	3	-
10	(E19) Work accident	81	12	7	83	11	7
11	(E20) Price increase	43	47	10	54	42	5

d. Simultaneous Scenario

Simultaneous scenarios are needed to see the overall changes to the related risks if the influential risks are given 100% evidence together. if there is certainty about risk (E14) Quality of work, risk (E7) Material shortages, and risk (E21) Cost overrun at a Low level then the potential risk (E13) Late launching can be minimized to a Low level with actual conditions of 81%. Where these conditions are the result of minimizing the Medium risk level from forecasting conditions by 31% to 14%, and the High-risk level from 26% to 5%. A change in the target gives a change in the risk of (E22) Benefit and (E16) Product Quality. This change has increased from the previous level of Low at 61%, Medium at 28%, and High at 11% respectively, while at risk (E16) Product Quality is Low at 81%, Medium at 12%, and High at 7% respectively.

Table 7. Simultaneous Scenarios

No	*Parent Risk*	Actual Condition (%)			Scenario Results (%)		
		L	M	H	L	M	H
1	(E1) *Milestones*	36	41	23	45	38	19
2	(E2) Design drawings	36	41	23	44	41	15
3	(E3) Production Drawings	51	26	23	66	24	10
4	(E4) HR	81	13	6	89	8	3
5	(E5) *PO Missing*	62	26	12	70	22	8
6	(E6) Workshop facilities	77	15	8	85	11	4
7	(E8) *Main Engine*	52	30	18	59	27	14
8	(E9) *Material delays*	38	41	21	55	35	10
9	(E10) Transport and lifting equipment	85	12	3	86	12	2
10	(E11) *Launching file*	96	3	1	96	3	1
11	(E12) *Defects*	47	34	19	69	22	9
12	(E15) Technology	60	31	9	62	30	8
13	(E17) Regulatory bureaucracy	52	35	13	53	34	12
14	(E18) Fire	96	3	1	97	3	-
15	(E19) Work accident	81	12	7	83	11	6
16	(E20) Price increase	43	47	10	55	40	4

4. CONCLUSION

a. The influence of risk variables that have the potential to occur in the AH-140 Shipbuilding project, causing potential delays in ship launching at a Low-risk level with actual conditions of 43%, Medium risk Level with actual conditions of 31%, and High-risk level with actual conditions of 26%.

b. The results of the sensitivity analysis can be concluded that the risks that affect the occurrence of risk (E13) Late launching at all risk levels are the risk (E14) Quality of work, risk (E20) Cost overrun and risk (E7) material shortage.

c. There are four mitigation scenarios , namely:
1) Certainty of risk (E8) Quality of work at Low level , resulting in an increase in the level of Low risk (E13) Launching to 55% and reduce the potential risk of Medium and High to 27% and 18% respectively. Changes in the objectives give changes to the risk (E21) Benefit and (E22) Product Quality respectively Low 39%, Medium 33%, and High 28% level, while at product quality risk Low level 81%, Medium 12% and High 7%.
2) Certainty of risk (E7) Lack of material at the Low-Level results in an increase in the

risk (E13) Late launching at the Low 53% level, and reduces the Medium Level to 31% and the High Level to 18%. Changes in objectives provide a change in risk (E21) Benefit and (E22) Product Quality respectively Low 57%, Medium 30%, and High 13%, while at risk (E22) Product Quality is Low 48%, Medium respectively 29% and High 24%.

3) Certainty on risk (E20) Cost overrun at a Low level gives a change in risk (E13) Late launch at Low level of 52%, Medium Level 27% and High Level of 20%. Changes to the objectives give changes to the risk (E21) Benefit and (E22) Product Quality respectively Low 57%, Medium 30%, and High 13%, while at risk (E22) Product Quality successively Low 48% level, Medium 29% and High 24%.

4) Certainty of risk (E14) Quality of work, risk (E7) Material shortages and risks (E20) Cost overrun is at Low level resulted in a potential risk (E13) of late launching at the Low level increasing to 81% and the Medium and High-risk levels respectively to 14% and 5%. Changes in objectives give changes to risk (E21) Benefit increases from the previous level Low 61%, Medium 28% and High 11% respectively, while at risk (E22) Product Quality successively Low 81%, Medium 12 %, and High 7%.

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