THESIS PM-147501

New Accommodation Work Barge Selection for Offshore / Swamp Lifting and Dredging Operation by Using Analytic Network Process (ANP)

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SURABAYA
2018

APPROVAL FORM

The thesis is composed to fulfill one of the requirement to obtain a degree
Magister Management Technology (M.MT)
in
Institut Teknologi Sepuluh Nopember

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Examination Date : 31 July 2018

Graduation Period : September 2018

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ACKNOWLEDGEMENT

With the name of ALLAH SWT, all praise to HIM so this research could be finalized. This thesis was made in order to fulfill one of the final tasks for graduate from Master Management of Technology in Sepuluh Nopember Institute of Technology. Furthermore, through this thesis, writer would like to convey the gratitude for people who have given their support while writing this thesis, some of them are:

1. Mr. Agus Supriyanto who encouraged and had given the writer permission to attend the Magister class in the first place.
2. My lovely Permaisuri that had been supported everytime to finish this thesis.
3. Mr. Sutan Kayo and Mrs. Cap who raised the writer to become a better person.
4. Prof. Dr. Ir. Udisubakti Ciptomulyono, MEngSc PhD as the advisor who has given his valuable time, feedbaks and guidance to finalize the thesis.
5. Prof. Dr. Ir. Mohammad Isa Irawan, M.T; Dr. Imam Baihaqi, ST., M.sc; Dr. Putu Dana Karningsih, ST., MEngSc, as examiner who have given the feedbacks to refine the thesis.
6. Dr. Ir. Hari Ginardi, who had given "a big push" to MMT-TOTAL 2015 class to finish this thesis.
7. All lectures in MMT-ITS that have shared their knowledge.
8. MMT-ITS entire academic staff which has tremandeous supported in finishing this thesis.
9. All "Comrades" in MMT-ITS 2015 that have always remind each other to keep the fighting spirit alive to finish the thesis.
10. All the person who cannot be said one by one who had given the writer variaous of support to finish the thesis.

The writer knows that this thesis is far from perfect. All suggestion are very welcome to enrich the research. Hope this thesis may useful for company and/or other researcher for further researcher.

Makassar Straits, August 4th 2018

The Writer

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ABSTRACT

CST organization is one of PHX department that is responsible for all construction support for all operation in PHX that have 4 (four) sites at swamp area and 5 (five) sites at offshore area. For 2018, there are 57 (fifty seven) new wells at 42 (fourty two) different locations that shall be drilled by PHX as operator. It is currently lack of supporting fleet to perform those planning. CST department need to decide whether the new Accommodation Work Barge (AWB) to built or not with considering all criteria within company entities and stakeholders which affecting each other in the value chain (interdependence). In order to facilitate the human decision making of CST department which involves several dependence criteria and conflicting intererest, the methodology that used for criteria definition is literature review and expert discussion. Decision Making Trial & Evaluation Laboratory (DEMATEL) method used first to verified criteria interrelation and ANP used as a multiple criteria decision making method. There are 8 (Eight) criteria that used for decision making which are Operational Safety, Operation Maintenance Cost, Fuel Cost, Availability of Supporting Fleet, Market Condition, Exchange Rates, Operating Environment, and Contract Type and Option. The selected option for the new AWB development for lifting and dredging operation is the alternative to either built new AWB or not.

Key word: Accommodation Work Barge, Offshore, Swamp, Construction, ANP, DEMATEL, Delphi

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CHAPTER 1
INTRODUCTION

1.1 Background

PHX is a subsidiary of one of multinational energy company that has been present in Indonesia for more than 45 years. PHX operates in Mahakam Delta, East Kalimantan, Indonesia producing Liquid Product (Oil and Condensate) and Gas. PHX had built numbers of platforms at offshore area to support the oil and gas production since then and became the largest gas producer in Indonesia.

Another offshore fields had opened by PHX to increase the production such as Peciko, Sisi-Nubi and South Mahakam field. These fields have more than 20 platforms operated. Between those offshore fields, PHX also expanded to swamp field, which have more than 50 Gathering & Testing Satellite (GTS) and well clusters located at Tunu, Tambora and Handil fields.

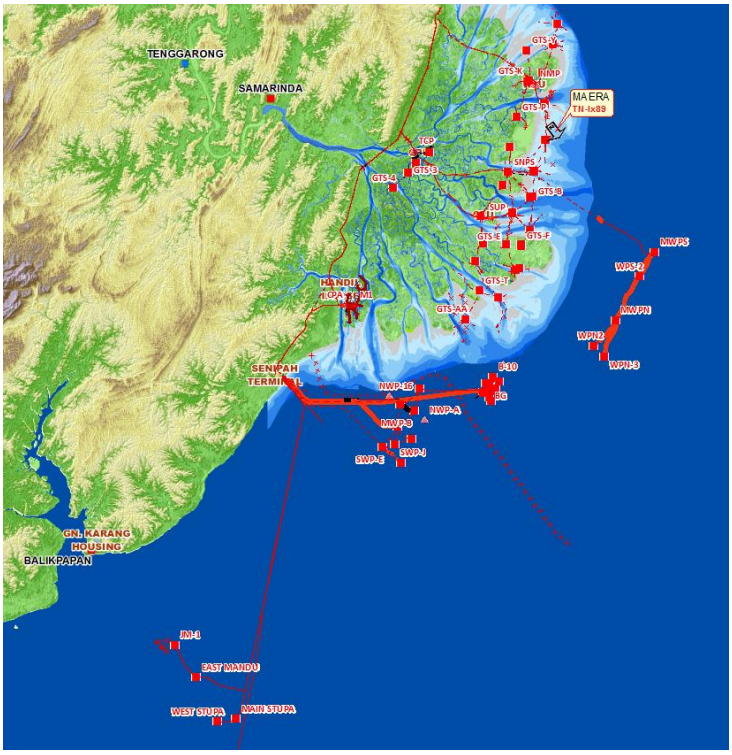

Figure 1.1 PHX Custodianship

In order to achieve maintenance and new well site preparation target, PHX need to make decisions in various entities to support detail operation. In PHX's current practice of decision making process, all annual activities proposal stated in Work Planning & Budget (WP&B) meeting with SKK MIGAS. All proposal reviewed and/or revised during the meeting, subject to justifications-both technical and non technical-that presented by PHX management team. After approved by SKK MIGAS which the bottom price of each activities, PHX begin to cascalade the WP&B to entities that will support those activities agenda along the year.

Each entities which receive the update WP&B will initiate all detail of work program and proposed to be reviewed by PHX management in Company Commitee Meeting (CCM). The CCM board are Field Operation (FO), Contract and Procurement (C&P) and the PHX's Director himself backed-up by Finance to determine which detail program that continue to executed, postoned or terminated.

CST, under Engineering Construction and Project (ECP) division, is one of department that responsible for 3 (three) main construction aspect such as; offshore construction, piping work and contruction site operation within PHX's daily operational, use accomodation work barge as main support tool beside various type of vessel such as; Landing Craft Tank (LCT), Flat Top Barge (FTB) and Sea Truck (ST). Accomodation work barge is use for small lifting, heavy lifting and dredging by using crane unit that mounted on barge. Those activities perform by many level of workers such as a barge master, a barge supervisor, 2 (two) radio operators, a nurse, a safety officer, 3 (three) crane operators and 14 (fourteen) riggers as deck crews, which stay onboard for 24 (twenty four) hours, 7 (seven) days a week for 2 (two) weeks in a row.

Currently CST have 7 (seven) accomodation work barge for construction offshore at swamp area and 5 (five) accomodation work barge to support well connection and pipe lying activities at swamp area. These accomodation work barges are spread through PHX's site area except for offshore area, there is no accomodation work barge to support CST's

offshore activities. In fact, at offshore area CST need to prepare 7 (seven) new wells. Up to present time CST ask for accomodation work barge from other entities such as Well Intervention (WLI) to support CST at offshore area. This situation, often causing some constraints in term of planning, finance and operation for both CST and WLI.

Figure 1.2 Accommodation Work Barge

In swamp area, there are 57 (fifty seven) new wells in 42 (fourty two) different location that need to be prepared by CST in 2018, which include dredging for channel and cluster site preparation, well head installation, conductor pile installation, well connection and surface facilities removal or reinstallation if the new well are in existing platform. The main concern in swamp area is site preparation dredging. It take most of the duration for new well development as other activities shall wait this site preparation to be done before they can be performed their job. Often this site preparation out of initial schedule that cause other entities have to revise their schedule that also impact in planning, finance and operation for all party. Especially Drilling entities, as main core of oil and gas entity in PHX, they demand more support for other entities including CST to make sure their drilling RIG can enter the drilling site without any delay despite how much the cost are.

Figure 1.3 Salvation Lifting Operation

Based on above concern, CST is in need for additional accomodation work barge to facilitate both new well site preparation plan and existing well maintenance plan that spread all over delta mahakam based on drilling sequence approved by Indonesian Government through Satuan Kerja Khusus Minyak dan Gas (SKK MIGAS). The new accomodation work barges expected to solve some major challenge of CST department to keep supporting activities in line with planning in drilling sequence. Since most of current accomodation work barge are more than 10 years old, CST is currently analyzing the plan to develop several new accomodation work barge completed with some supporting vessels such as Anchor Handling Tug (AHT), Tug Boat (TB), Hopper Barge (HB) and Sea Truck (ST), to ensure the smooth operation for offshore and swamp in future daily basis.

Contractual entities have concern that to process new build accomodation work barge tender will take time approximately 18 (eighteen) months for 3 (three) to 5 (five) years contract due to CST have to follow rules stated in Pedoman Tata Kerja (PTK-007) and obtain approval from SKK MIGAS regarding procurement process. They propose to launch a

bridging contract with minimum tender value allowed by SKK MIGAS without follow PTK-007 rules that expected to cover CST operation for approximately 6 (six) months by using Direct appointment (DA) method from existing contractor that have standby accomodation work barge while waiting for the new build accomodation barge tender process to be finished. Long-term contracts provide stable cash flows and guaranteed utilization, while short-term contracts increase the risk of stacking, but allow the contractor to take advantage of increasing markets and potential dayrate upswings (Moomjian, 2000). Long-term contracts exhibit higher dayrates than short-term contracts and the relationship is robust throughout the decade suggesting that E&P firms have been willing to pay more to secure drilling capacity (Kaiser et al., 2013). Above conflict will generate some criteria such as market condition, operating environment, contract type and option.

Finance entities with consideration of Capital Expenditure (CAPEX) budget in these new tenders tends to propose 1 (one) tender only instead of 2 (two) since it will cost more if CST issue both new accomodation work barge and existing unit for 6 (six) months. This is due to the decision to invest carries substantial risk because capital costs are significant and future market conditions are unknown. Factors that are known prior to undertaking a newbuild project are the capital cost of the vessel, finance terms, and the dayrate and duration of an initial contract, if applicable. Operating expenses can be estimated with a reasonable degree of certainty based on the company's historical performance, and depreciation schedules are based on current regulations. The primary unknown variables are the dayrate and utilization rate after the initial contract period and are referred to as the outyear dayrate and outyear utilization rate (Kaiser et al., 2013). Above conflict will generate some criteria such as operating maintenance cost and exchange rates.

In the other hand, since a accomodation work barge operated with some supporting vessels provide by Land Sea and Air (LSA) entities, they have some concern regarding fuel consume that used for the new

accomodation work barge activities. Recent estimates of fuel consumption in construction projects are highly variable. LSA have to recalculated the fuel budget and obtain approval also from SKK MIGAS if the new accomodation work barge tender approved. LSA intend to support DA contract and used some existing vessels rather than hire some new vessels which has to be inspected and tested which will take more time to ready the vessels. As stated by Peters and Manley (2012), that lack of standards for reporting at both the equipment and project levels make it difficult to quantify the magnitude of fuel consumption and the associated opportunities for efficiency improvements in construction projects. Above conflict will generate some criteria such as availability of supporting fleet, fuel cost, and operational safety.

The different prespective of Contractual entities, Finance entities and LSA entities are generating the conflicting objective in deciding the new accomodation work barge development.

Based on statement from Kaiser et al. (2013), Newbuild and acquiring an existing rig are based on similar decision making processes. Also, the models employed by industry are confidential but the economics of decision-making and future uncertainties governing the market are universal (Kaiser et al., 2013). Both technical and non-technical aspects shall be considered by PHX for making the decision either to build new accomodation work barge or not in order to ensure a thorough assesment as state by Mackie et al. (2010) that in the real world of oil and gas industry, a decision is rarely made by using in one measuring criteria and indeed should not be. Decision making in oil and gas industry is a complex process involving extensive analysis of multiple objective based on variety diverse criteria (Virine and Murphy, 2007).

To facilitate the human decision making of new build accomodation work barge that involve several dependence criteria and conflicting interest, this research introduces a multiple criteria decision making method of Analytic Network Process (ANP) by Saaty (2005). This research use ANP with consideration that the decision process will involves several

dependence criteria and conflicting interest in CST department. The criteria interdependence and criteria influence level firstly assesed by Decision Making Trial and Evaluation Laboratory (DEMATEL) method (Tzeng et al., 2007).

To ensure the objectivity and comprehensiveness of decision making, the list criteria from study literature validated by Enginering Construction and Project (ECP) head division as the Divison Leader. After the validation, the list of criteria was selected by respective expert in company from conflicting entities (Contractual expert, Finance expert, Marine Logistic and Fuel Monitoring expert) by using Delphi method supported with DEMATEL to verified all the criteria that had been defined which has been combined with ANP method previously by Keramatpanah (2013) to extract appropriate criteria and sub criteria in a Multi Criteria Decision Making (MCDM). In line with Mackie et al. (2010) that decision making approach relies on human is a quite usual phenomenon in most oil and gas industry.

1.2 Problems Identification

The identified problems that lead to this research are the followings:

1. What are the criteria and sub criteria to be used by CST department to decide of new build accommodation work barge selection?
2. What is the selected CST department option for the new build accommodation work barge based on identified criteria?

1.3 Research Objectives

Summarized objectives of the research are as follows:

1. To establish the criteria and sub criteria to be used by CST department to decide the selection of new build accomodation work barge.
2. To select the CST department option for selection of new build accomodation work barge based on the defined criteria.

1.4 Benefits of Research

This research hopefully will give the very best solution for academic field and to operating company within oil and gas industry, which can be elaborate as below:

1. For the academic field, this research will enrich the knowledge of multiple criteria decision making in oil and gas industry, and
2. For the company, the research become beneficial to be used as reference for multiple criteria decision-making process especially for offshore and swamp construction operation support and also could be used by other entities for additional support unit decision-making.

1.5 Scope of Research

The boundaries of this research are listed below:

1. This research is limited to offshore and swamp accomodation work barge under CST department of PHX.
2. The criteria and sub criteria from study literature was preliminary validated by ECP head division as the Divison Leader and selected by experts using Delphi method.
3. The assesments of each alternative will perform by ECP management based on the defined criteria.
4. The experts who will contribute to this research are Contractual expert, Finance expert, Marine Logistic and Fuel Monitoring expert.

1.6 Outline of Research

This thesis developed through the following chapters:

CHAPTER I INTRODUCTION

This chapter presents the background of the research, problem identification, reseach objectives, benefit of research, scope of research and outline of the reseach.

CHAPTER II LITERATURE REVIEW

This chapter draws on the various literatures on decision-making process including its application in oil and gas industry, also the theorical multi-criteria decision making which used as the basis for this research. Literatures used for this research are taken from books, journals and also related company reports.

CHAPTER III RESEARCH METHODOLOGY

This Chater explains the research stages, which cover the research program, type of data and their sources, data processing and result analysis.

CHAPTER IV RESULT DISCUSSION

This chapter describes the collection method of both primary and secondary data, the data processing and sensitivity analysis. The result is also discussed in this chapter.

CHAPTER V CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusion and recommendation following the analysis that is carried out in the previous chapter. This final chapter is expected to fulfill the objectoves of the research. Suggestion for the future reseach introduced in his chapter.

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CHAPTER 2
LITERATURE REVIEW

2.1 Multiple Criteria Decision Making (MCDM)

2.1.1 Decision Making Process

Since late 40's, Herbert Simon of Carnegie Mellon University, USA, has been well known for his works related on management and decision. His research on decision-making process within economic organization led him to receive the Noble Prize in 1978. To deal scientifically with decision, Simon began by distinguishing between facts and values or what is and what ought to be. Fact are what we can verified or falsified, while values are objective of the decision maker. He observed that decision is a matter of compromise, i.e. all decision maker have several more or less contradictory objectives in mind. Thus, Simon was the first to stress the multicriteria aspect of decision (Pomerol and Adam, 2004).

Based on these observations, Simon broke down decision making into the followings:

1. Identify all the possible alternatives;
2. Determine all the possible consequence of these alternatives;
3. Evaluate all the possible consequensces,

that means as Pomerol and Adam (2004) note, Simon consider how a decision maker evaluates all the consequences and compares them with each other. This is a central problem in any decision process that in evaluating consequences requires that managers have a complete knowledge of all future events and their probabilities.

As also stated by Ciptomulyono (2001) that decision making deals with the important stages of identifying objectives and criteria. A systematic methodology therefore is required so that the information of the decision making's objectives and the criteria could be identified and prioritized by using an appropriate weights which in turn the alternatives decisions could be allocated to the relatives importance of the objectives and how well the alternatives satisfy them.

The work of managers, scientist, engineers, lawyers, the work that streers the course of society and its economic and govermental organization--is largely

work of making decisions and solving problems. it is work of choosing issues that require attention, setting goal, finding or designing suitable course of action, and evaluating and choosing among alternative action. The first three of these activities which are fixing agendas, setting goal and designing action is usually called problem solving; and thelast, wih are evaluating and choosing, is usually called decision making (Simon,1986).

In 1977, Simon presented his famous four phase of decision making:

1. Intelligence;

   This phase consist of finding, identifying, and formulating the problem or situation that calls for a decision.

2. Design;

   In this phase, alternatives are developed and the decision's objectives are stated.

3. Choice;

   In this phase, alternatives are evaluated and the result is decision which could be carried out.

4. Review;

   Upon implementation of above decision, a review is to be made to ensure that it is the good choice.

2.1.2 Multiple Criteria Decision Making (MCDM)

Multiple criteria decision making (MCDM) is often characterized by multiple, conflicting criteria to solve a problem (chen and Chen, 2010). According Virine and Murphy (2007), MCDM is a process that can assist an individual and/or an organization to effectively incorporate and evaluate all known factors and outcomes associated with a required decision. The goal of this process is to provide the decision maker with sufficient information in order to choose an alternative that results in the most feasible and optimal outcome.

Using only numerical data in the solution of decision-making problems can cause inadequate decision-making problems. This situation also lead the criteria to conflict with each other, thus it directly affect decision-making. Therefore, with the inclusion of both quantitive and qualitative data, the nesessity of MCDM emerged (Atmaca and Basar, 2012).

There are many methodologies developed by scholars that could be used to solved multiple criteria decision problem, namely MAUT (Multi-Attributes Utility Theory), AHP and ANP, among others.

2.1.3 Decision Making Trial and Evaluation Laboratory (DEMATEL)

Decision Making Trial and Evaluation Laboratory or DEMATEL was originally developed by the Science and Human Affairs Program of the Battlelle Memorial Institute of Geneva between 1972 and 1976 to study and resolve the complicated and inertwined problem group (Tzeng et al., 2007). It is believed that DEMATEL method could improve understanding of the specific problem, the cluster of inertwined problem, and contribute to identification of workable solutions by hierarchical structure.

The procedure of DEMATEL method is summarized below refers to Lee et al. (2011):

Step 1:

Construct the scales of evaluation by using pairwise comparison. The influence scale is ranging from 0 to 4. No influence is represented by 0, while a very high influence is represented by 4.

Step 2:

Calculate the initial average matrix or direct influence matrix by scores. Sampled experts are asked to point direct effect based on their preception that each element i exerts on each other element j, as presented by a_{jj}, by utilizing a scale. An average matrix **A** is then generated.

Step 3:

Calculate the initial influence matrix by normalizing the initial average matrix **A** and becomes matrix **D**. In addition, the matrix **D** can be obtained through equation (2.1) and (2.2), in which all principal diagonal criteria are equal to zero.

$$D = s * A,\ s > 0 \qquad (2.1)$$

$$S = Min\left[\frac{1}{\max\limits_{1\le i\le n}\sum_{j=1}^{n}|a_{ij}|}\cdot\frac{1}{\max\limits_{1\le i\le n}\sum_{i=1}^{n}|a_{ij}|}\right] \qquad (2.2)$$

The following figure 2.1 (Chen and Chen, 2010) depicts a contextual relationship among the elements within a complex system including its strenght of

influence; an arrow from *d* to *g* represent the fact that *d* affects *g* with an influence score of 1.

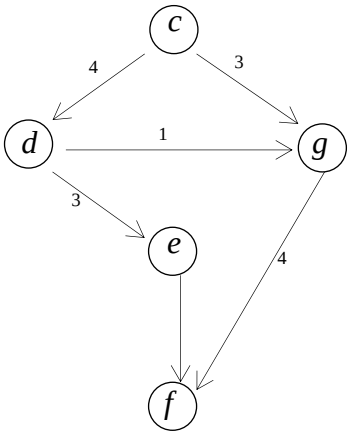


Figure 2.1 An influence map

Step 4:

Develop the total influence matrix by utilizing equation (2.3). Here, I is the indentity matrix.

$$T = D + D^2 + ... + D^m = D)I-D) ^{-1} \text{ when } m \rightarrow \infty \quad (2.3)$$

Step 5:

Obtain the prominance and relation by summing each row and column in T to yield D and R. Here, d_i is the sum of each row in T and the row sgow the degrees of direct and indirect impact over the other criteria, and r_j is the sum of each column in T where colums indicates the degree od influences from other criteria. Numeric algorithm variable d_i, represent the factors that influence others, r_j represent factors that are influenced by others, $(d_i + r_j)$ represent the strength of relationship between factors, $(d_i - r_j)$ represent the strength of influences among factors. In other word, $(d_i + r_j)$ and $(d_i - r_j)$ represent the so called prominances and relations, respectively.

Step 6:

Draw the network relation map to simplify the interpendances in an easy-to-understand structure and to clearly express relationship between factors, levels of influences, and the degree of impacts.

2.1.4 Analytic Network Process (ANP)

Similar to Analytic Hierarchy Proses (AHP), ANP is developed by Thomas L Saaty from University of Pittsburgh, USA.

The Analytic Network Process (ANP) is a general theory of relative measurement used to derived composite priority ratio scales from individual ratio scales that represent relative measurement of the influence of elements that interact with respect to conrol criteria. Through its supermatrix whose elements are themselves matrices of column priorities, the ANP captures the outcome of dependence and feedback within and between cluster of elements (Saaty, 1999). Therefore, ANP enables more accurate modeling of complex decision environment (Atmaca and Basar, 2012).

The folowing Figure 2.2 (Atmaca and Basar, 2012) depicts the structural difference between AHP and ANP.

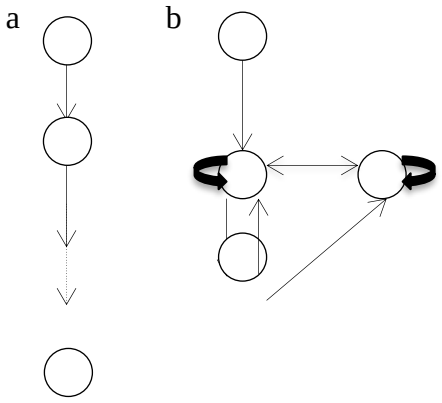


Figure 2.2 Structural Difference between AHP and ANP

According to Saaty (1999), some fundamental ideas in support of the ANP are:

1. The ANP is built on the AHP;
2. By allowing for dependence, the ANP goes beyond the AHP by including independence and hence also the AHP as a special case;
3. The ANP deals with dependence within a set of elements (inner dependence), and among different sets of elements (outer dependence);
4. The looser network structure of the ANP makes possible the representation of any decision problem with the concern for what comes first and what comes next as in hierarchy;
5. The ANP is a nonliniear strucuture that deal with sources, cycles, and sinks. A hierarchy is linear, with a goal in the top level, and the alternatives in the bottom level;

6. The ANP prioritizes not just elements but also groups or cluster of elements as in often necessary in the real worl;
7. The ANP utilize the idea of a control hierarchy or a control network to deal with different criteria, eventually leading to the analysis of benefits, opportunities, cost and risks.

The ANP process follows 4 (four) major steps (Shiue and Lin, 2012):

a. Model construction and problem structuring

The problem should be stayed clearly and decomposed into a rotational system such as a network. The structure can be obtained from the opinion of decision makers through brainstroming or other appropriate method.

b. Pair-wise comparisons matrices and priority vectors

The ANP decision elements of each component are compared pair-wise with respect to their control criterion, and the components themselves are also compared pair-wise with respect to their contribution to the goal.

Pair-wise comparison in the ANP is made in the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance asociated with the elements (or components) being compared by solving the following formula (2.4):

$$A \,.\, w = \lambda_{max \,.\, w} \qquad (2.4)$$

where A is the matrixof pair-wise comparison, w is the Eigenvector, and λ_{max} is the largest Eigenvalue of A.

c. Supermatrix formation

A supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between 2 (two) nodes (components or cluster) in a system. Let the components of a decision system be C_k, k = 1, 2, ..., N, which has nk elements denoted as e_{k1}, e_{k2}, ..., e_{knk}. The local priority vectors obtained in Step b are grouped and located in appropriate positions in a supermatrix based on the flow

of influence from a components to another component, or from a component to itself as in the loop.

A standart form of a supermatrix is ilustated by the following Figure 2.3:

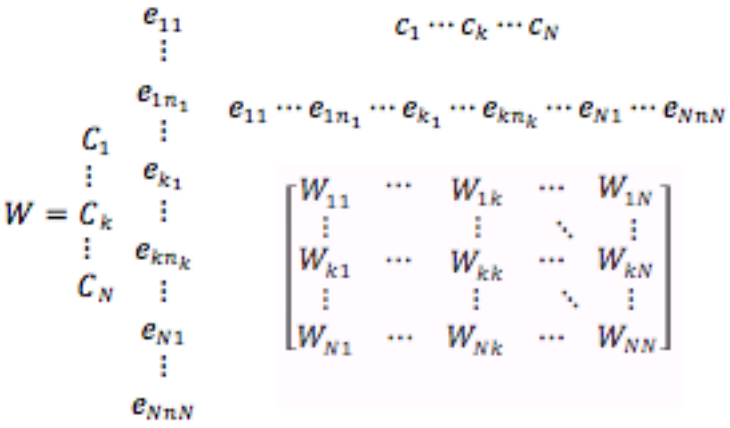


Figure 2.3 ANP Supermatric Form

To achieve a convergence on the importance weights, the weighted supermatrix is raised to the power of 2k + 1, where k is an arbitrarily large number, and this new matrix is called the limit supermatrix. The limit supermatrix has the same form as the weighted supermatrix, but all the columns of the limit supermatrix are all the same. By normalizing each block of this supermatrix, the final priorities of all elements in the matrix can be obtained.

The consistency is to be measured with Consistency Ratio (CR) which clould be obtained from Consitency Index (CI or μ) compared to Random Index (RI).

The Consistency Index could be calculated by the following formula (2.5);

$$\mu = \frac{\lambda\, max - n}{n - 1} \qquad (2.5)$$

Where λ_{max} is the maximum Eigen value.

While the Random Index could be obtained from Saaty (2005) table below;

N	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Tabel 2.1 Random Index

Consistency Ratio shall be < 10%, otherwise there are some actions to be done as suggested by Saaty (2005);

1. Find the most inconsistent judgement in the matric,
2. Determine the range of values to which the judgements can be changed corresponding to which the inconsistency would be improved,
3. Ask the decision maker to consider, if he/she can, changing his/her to a plausible value in that range.

d. Selection of best alternatives

If the supermatrix formed in Step c covers the whole network, the priority weight of alternatives can be found in the column of alternatives in the normalized supermatrix. On the other hand, if the supermatrix only comprises of components that are interrelated, additional calculation must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be the one selected.

2.2 Criteria and Sub Criteria Determination

The selection of new build accommodation work barge is to be decided based on the criteria that determined by this research by performing literature review and discussion with company experts.

Castilo and Dorao (2013) stated that in oil and gas industry, desicion making could be based on an economic analysis which involves the assesment of revenues and cost, potentially materializing in the future as a result of investment made by current time. However decision-making in oil and gas projects need to be evaluated from extensive point of view since they are influence by technichal, environmental, financial, economical, geopolitical and other issues such as the politics at the international, national and local level.

2.2.1 Criteria and Sub Criteria in Oil and Gas Industry Decision

Rabbani et al (2014) categorized the decision making criteria in Oil and Gas Company into the following:

List of Main Criteria

Main criteria	Sub-criteria
Economic (EC)	Revenue growth rate (EC1)

	Financial risk reduction (EC2)
	Diminishing the overall cost (EC3)
Environmental (EN)	Air Pollution (EN1)
	Noise (EN2)
	CO_2 emissions (EN3)
	Impacts on ecosystems (EN4)
	Animal welfare (EN5)
Social (SO)	Costumer relationship management (SO1)
	Equity (SO2)
	Job security for employees (SO3)
	Quality of life (SO4)
Internal Process (IP)	Personal rights (IP1)
	Ability to respond to emegencies (IP2)
	Improvement to efficiency (IP3)
	Employee productivity (IP4)
Growth & Learning (GL)	Employee education (GL1)
	Research & development (GL2)
	Employee knowledge sharing (GL3)
	Enhancing the labor force skill (GL4)

Tabel 2.2 Decision Making Criteria in Oil & Gas Industry by Rabbani et al (2014)

Wang et al (2009) categorized the decision making criteria in petroleum industry into the followings:

Aspects	Criteria
Technical	Efficiency
	Energy efficiency
	Primary energy ratio
	Safety
	Reliability
	Maturity
	Others
Economic	Investment cost

	Operation and maintenance cost
	Fuel cost
	Electric cost
	Net Present Value (NPV)
	Payback period
	Service life
	Equivalent Annual Cost (EAC)
	Others
Environmental	NO_x emission
	CO_2 emission
	CO emission
	SO_2 emission
	Perticles emission
	Non-methane volatile organic compounds
	Land use
	Noise
	Others
Social	Social acceptability
	Job creation
	Social benefits
	Others

Table 2.3 Decision Making Criteria in Oil & Gas Industry by Wang et al (2009)

2.2.2 Criteria and Sub Criteria of Oil and Gas Construction Support

Kaiser et al (2013) categorized the decision making factors of new offshore floating unit in oil and gas industry as follow:

Factor	Sub Factors
Market condition	
Material price	Cost distribution
	Steel
	Equipment prices
Exchange rates	
Labor	
Design class	
RIG spesification	Structural weight

	Water depth
	Operating environment
	Equipment specification
Contract type and option	
Shipyard characteristic	
Backlogs	

Table 2.4 Decision Making Criteria for Oil and Gas Construction

The criteria used as reference during discussion with expert to select and validate the criteria and sub criteria that are applicable for the company condition. This approach will perform subject to the availability and time constraints of the experts for Delphi method.

The criteria and sub criteria definition for this research are explain by the followings:

1. *Market condition.* This criterion is expected to be tools to mapping the surrounding market regarding decision to build new accommodation work barge.
2. *Operating environment.* This criterion represent PHX's offshore operating area and swamp operating area, to have better review in order to make the decision.
3. *Contract type and option.* This criterion will help the decision maker for type of contract that will be taken and kind of option that company have before making the decision.
4. *Operation maintenance cost.* Since this accommodation work barge will be operated along the contract duration, this criterion will major criterion that conflicts with all entities.
5. *Exchange rates.* This criterion represent current economic situation in Indonesia which will affect the company decision.
6. *Operational Safety.* This criterion refers to company requirement to operate all equipment safely at anytime.
7. *Fuel Cost.* This criterion in line with operation maintenance cost during contract duration.
8. *Availability of supporting fleet.* This criterion follows market condition during the decision making process.

2.3 Alternative Determination

The alternatives considered to be used for this research are limited to company reference as current decision making process. Considering the planning for build new accommodation work barge approved by SKK Migas, below are the alternatives:

1. Proceed to build new AWB for offshore and swamp area operation
2. Postponed to build new AWB for offshore and swamp area operation
3. Canceled to build new AWB for offshore and swamp area operation

2.4 The Delphi Method

Delphi technique is a group knowledge acquisition method, which is also used for qualitative issue decision-makings. Delphi technique can be used for qualitative research that is exploratory and identifying the nature and fundamental elements of a phenomenon is a basis for study. It is a structured process for collecting data during the successive rounds and group consensus (Habibi et al., 2014).

Based on Okoli & Pawlowski (2004) the Delphi method could be used for below purposes:

- Identification of the research topic
- Specification of research question(s)
- Identification of a theoretical perspective for the research
- Selection of variables of interest/generation of propositions
- Preliminary identification of causal relationships
- Definition of constructs and creation of a common language for discourse

The Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise. The technique is designed as a group communication process, which aims to achieve a convergence of opinion on a specific real-world issue. The Delphi process has been used in various fields of study such as program's planning, needs assessment, policy determination, and resource utilization to develop a full range of alternatives, explore or expose underlying assumptions, as well as correlate judgments on a topic spanning a wide range of disciplines. The Delphi technique is well suited as a method for consensus building by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects. Subject selection, time frames for conducting and completing a study, the possibility of low response rates, and unintentionally guiding feedback from the respondent group are areas which should be considered when designing and implementing a Delphi study (Hsu and Sandford, 2007).

The typical steps of Delphi method based on are (Skulmoski et al, 2007):

1. Develop the Research Question
2. Design the Research
3. Research Sample
4. Develop Delphi Round One Questionnaire
5. Delphi Pilot Study
6. Release and Analyze Round One Questionnaire
7. Develop Round Two Questionnaire
8. Release and Analyse Round Two Questionnaire
9. Develop Round Three Questionnaire
10. Release and Analyse Round Three Questionnaire
11. Verify, Generalize and Document Research Results

Ciptomulyono (2001) said that in real case study, delphi method is suggested to be applied with real responden which an expert in his/her field.

2.5 Previous Research

2.5.1 Decision Making in Petroleum Industry

Dharmantara (2015) conducted research on New Site Development Location In Offhore & Swamp Gas Field by Using Analytic Network Process (ANP) to decide where the new site organization will be established or not with considering all criteria within company entities and stake holder which affecting each other in the value chain (interdependence).

Krisnawaty (2014) had conducted research on Mature Oil Field Non-Producing Cluster Management Decision by Using Analytic Network Process (ANP).

Decision making in petroleum industry is a complex process involving extensive analysis of multiple objectives based on variety of diverse criteria. As part of the decision making process, companies often convert non-monetary criteria to common monetary equivalents, i.e assigning costs allocations regarding public response to a proposed project. However, this approach has many limitations related to recognizing the company's true financial performance in comparison to quality, safety, environmental concerns and other factors (Virine and Murphy, 2007)

2.5.2 Research in Oil and Gas Construction Support

Kaiser et al (2013) had done research for Offshore Drilling Industry and RIG Construction Market in the Gulf of Mexico.

2.5.3 Research with Delphi Method, DEMATEL, and ANP

Analytic Network Process (ANP) is one of the world wide popular tools applied for multi criteria deccision making. Atmaca and Basar (2012) used ANP approach to evaluate power palntas alternatives in Turkey. Vujanovic et al (2012) used ANP and DEMATEL to evaluate of the vehicle fleet maintenance management indicators. ANP and DEMATEL have been used by Vujanovic et al to calculate the level of interdependences an determine the level of significance of indicators in relation to the accomplishment of a defined objective.

Ola (2014) designed a decision model for contractor selection at PT Perusahaan Gas Negara (Persero), Tbk, Indonesia to improve the effectiveness of existing decision making process. The decision model was facilitated by ANP. Amelia (2014 evaluated supplier performance of an online shop based on Dickson,svendor selection criteria adaption by DEMATEL and ANP integrated approach.

Keramatpanah (2013) has combined Delphi Method with ANP previously to extract appropriate criteria and sub criteria in a multi criteria decision making for supplier selection and evaluation.

This research uses the ANP with consideration that the decision process will involves several dependence criteria and conflicting interest in CST department. The DEMATEL method used to asess criteria interdependence. The combination between ANP and DEMATEL has been used during previous research such as Vujanovic (2012). The Delphi method will use to select and validate the criteria and sub criteria by experts in the company. This position of this research shown in the table 2.5 Research Position.

2.6 Reseach Position

This research is part of numerous multi criteria decision making problems solved by Analytic Network Process (ANP) and DEMATEL approach applied in various scientific disiplines and field applications.

Nevertheless, there are differences from previous researchs, such as:

- This research is exercised for creation of new build accomodation work barge, which the previous research was focusing in new site organization gas field.
- This research is particularly applied for CST department which covering all construction work support within PHX permises.

No	Author	Year	Institution	Research	Object	Method
1	L. Murphy Virine	2007	International Pertroleum Technology Conference	Analysis of Multi criteria Decision-Making Methodologies for the Petroleum Industry	Petroleum Industry	MCDA - AHP
2	Prasanta Kumar Dey	2011	The Management Operation	Project Risk Management Using Multiple Criteria Decision-Making Technique and Decision Tree Analysis: a Case Study of Indian Oil Refinery	Oil Refinery	Multiple Critera Decision
3	E Atmaca & H.B Basar	2012	Elsevier	Evaluation of Power Plants in Turkey using Analytic Network Process	Power Plant	ANP
4	Vujanovic, Davor Valdimir Momc'ilovic', Nebojsa Bojovic', Vladimir Papic	2012	University of Belgrade, Belgrade	Evaluation of vehicle fleet maintenance management indicators by application of DEMATEL and ANP	Vehicle Fleet Maintenance	ANP & DEMATEL
5	Keramatpanah, Mohsen, Mahmood Shirazi, Ali Rajabzadeh, Amin Keramatpanah	2013	Institute of Management and Planning, Tehran, Iran	Supplier Selection and Evaluation using Delphi Technique and Analytic Network Process	Supplier	Delphi & ANP
6	Arefeh Rabbani & Mahmood Zamani	2014	ITS Surabaya	Proposing a new integrated Model Based on Sustainability Balances Scorecard (SBSC) and MCDM	National Iran Oil and Gas Company	ANP & Fuzzy Complex

				by Using Linguistic Variables for The Performance Evaluation of Oil Producing Company		Proportional Technique
7	R Amelia	2014	ITS Surabaya	Evaluasi Kinerja Pemasok Berdasarkan Adapatasi Dari Dickson's Vendor Selection Criteria dengan Pendekatan Terintegrasi DEMATEL dan ANP (Studi Kasus: Online Shop X)	Online Shop	ANP & DEMATEL
8	K.K Ola	2014	ITS Surabaya	Perancangan Model Pemilihan Kontraktor dengan Metode Analytic Network Process (Studi Kasus PT. Perusahaan Gas Negara (Persero))	Gas Company	ANP
9	Nenny Krisnawaty	2014	ITS Surabaya	Mature Oil Field Non-Produsing Cluster Management Decision by Using Analytic Network Process (ANP)	Mature Oil Field	ANP & DEMATEL
10	Aleksandar Rikalovoc & Ilija Cosic	2015	University of Novi Sad	A Fuzzy Expert System for Industrial Location Factor Analysis	Industrial Location	Fuzzy Expert System
12	Dharmantara Nusetyo Narendra	2015	ITS Surabaya	Decision of New Site Development Location in Offshore and Swamp Gas Field by Using Analytic Network Process (ANP	Offshore & Swamp Gas Field	ANP & DEMATEL
13	Hengki Irdiansyah	2018	ITS Surabaya	New Accommodation Work Barge Development Decision for Offshore / Swamp Lifting and Dredging Operation by Using Analytic Network Process (ANP)	Offshore & Swamp AWB	ANP & DEMATEL

Table 2.5 Research Position

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Research Approach

This research is a case study of multi criteria decision-making application for pertoleum industry support. DEMATEL method used to assess the criteria interdependence and ANP methods used as the tools to solve the decision-making problem. This methodology is selected following the qualitative nature of the criteria. The list of criteria from study literature validated ECP Head Division as Division Leader. List of criteria were selected by some respective experts in company from conflicting entities such as Contractual expert, Finance expert, Marine Logistic and Fuel Monitoring expert by using Delphi method, after the validation is done.

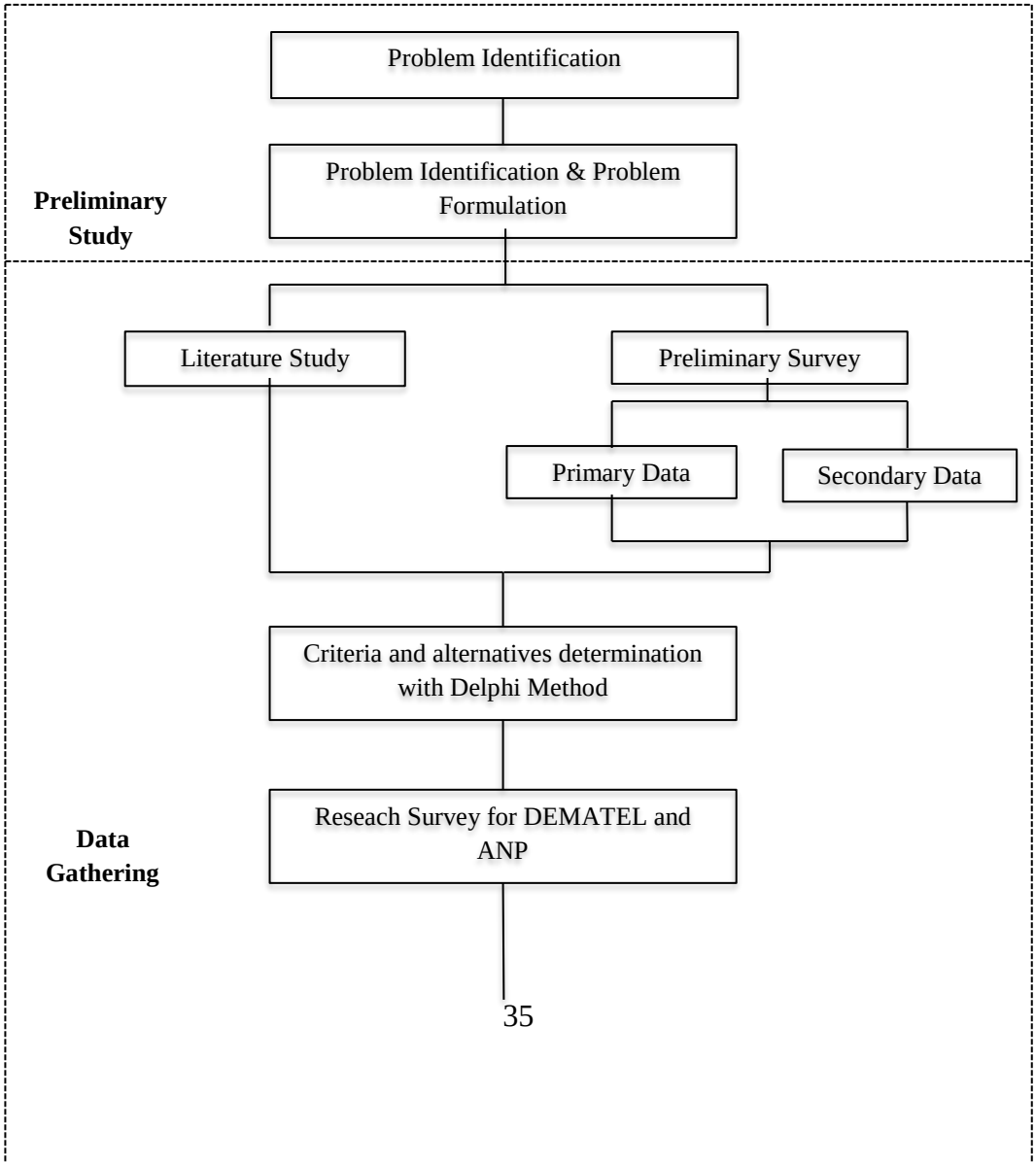
Three sets of questionnaires distributed to the expert, one is Delphi method to extract the criteria and sub criteria from the study literature, one for criteria influence level as the input for DEMATEL, and the other one for weighting the criteria governing the decision making process as the input for ANP. The planning

is to submit the questionaires directly to the experts and to do discussion before filling the questionaires to ensure that questionnaire objectives are well understood by the respondents.

3.2 Research Process

The research process is devided into four main stages, i.e. preliminary study, data gathering, data processing and the last is analysis and conclusion.

Figure 3.1 will illustrates the step by step detail which followed by more explainantion.



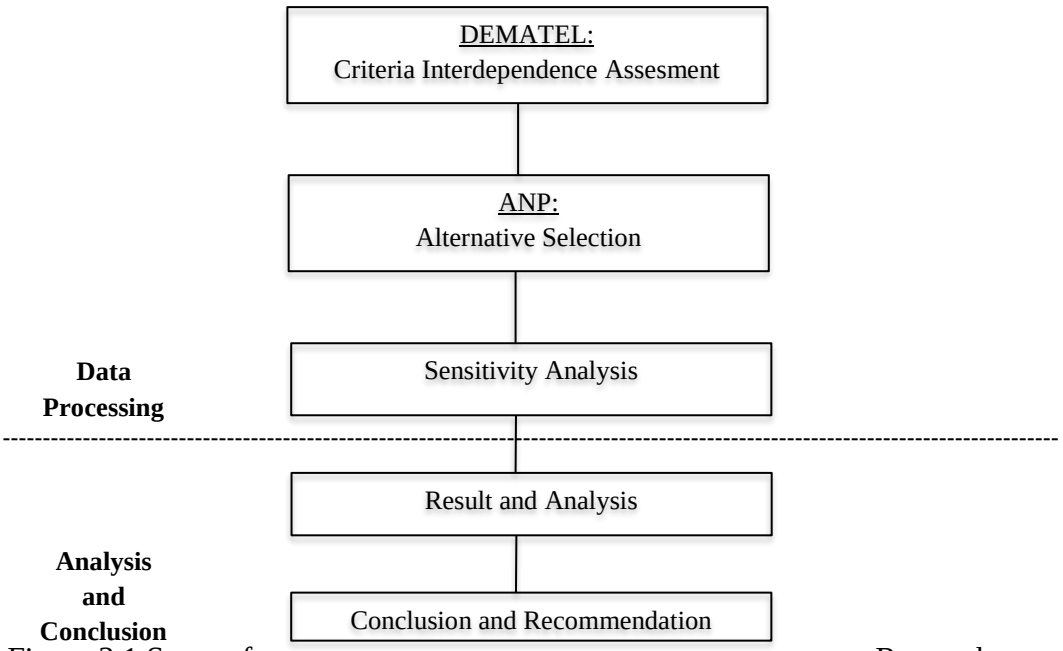


Figure 3.1 Stage of Research

3.2.1 Preliminary Study

The preliminary study is crucial to define the objectives of the research following the problem identification and formulation steps. The problem is idetified from PHX actual challenge that is not clearly resolved. Preliminary study is conducted by study literature and having dicussion with CST Management.

3.2.2 Data Gathering

The data gathering is initiated with literature study and preliminary survey. There are several type of literatures used for this research such as books, papers, journals, and also PHX internal document. Preliminary survey is performed by discussion with PHX experts as respondents concerning the research subject and the criteria to be applied based on literature review and also company specific requirement.

There are two types of data collected in this stage:

- Primary Data

  The primary data is aquired directly from the sources by means of the questionnaire to the expert of PHX. As mentioned in Section 1.5, the considered expert for this research is the ECP management.

- Secondary Data

The secondary data is obtained from existing sources in the form of reports, data or other information from PHX.

The results of above steps were used to define the criteria required to support the decision-making process as stated in Section 2.2 and the alternatives of new build accomodation work barge decision as stated in Section 2.3. Having completed the criteria and sub criteria definition, it is important to determine the relationship among the criteria and sub criteria in order to set up the decision network.

Three sets of questionnaire are developed for evaluation input:

- Delphi method to extract the criteria and sub criteria from the study literature.

  From this survey, experts to select which criteria and sub criteria in the list which are relevant as reference to decide the development of new accomodation work barge.

Score	1	2	3	4	5	6	7	8	9	10	Score
Less Relevant											More Relevant

Table 3.1 Delphi Scale

- DEMATEL method to assess the interdependence among the criteria.

  From this survey, experts are expected to give the feedback on the influence level of each criterion by the following scale referred to Lee at al. (2011):

Scale	Description
0	No influence
1	Low influence
2	Medium influence
3	High influence
4	Extremely high influence

Table 3.2 DEMATEL Influence Scale

- ANP method for the multiple criteria decision-making.

  The questionnaire for ANP was developed in pairwise comparison for both criteria and sub criteria. The questionnaire scale were referred to Saaty (2005) as presented by the following Table 3.3:

Intensity of Importance	Definition	Explanation

1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate importance	Experience & judgement slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience & judgement strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another, its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is f the highest possible order of affirmation
Reciprocals of above	if activity *i* has one of the above nozero numbers assigned to it when compared with activity *j*, then *j* has has the reciprocal value when compared with *i*	A reasonable assumption
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix

Table 3.3 The Fundamental Scale of Absolute Numbers

There are three experts from conflicting entities who were taking part as respondent, which are:

1. Contractual Head of Department
2. Finance Head of Department
3. Marine Logistic and Fuel Monitoring expert

Ideally, the feedbacks for ANP are to be given from a Focused Group Discussion (FGD) result. However, due to the timing and respondents availibility contraints, the approach for this research is explained here below:

- The three experts will give their input separately. To be noted that the questionnaire is given directly to the respondents and the criteria/sub criteria are explained prior filling the form. Naturally, experts will give opinion based on their entity's interest.
- The define criteria and sub criteria were discussed with the ECP management (Head of division, Head of Department), Contractual Management and LSA Management.

By involving the hierarchy of the ECP Management, Contractual Management and LSA Management into decision-making model, the result from the above approach is expect to be accepted by all concerned parties. After all, upon completion of this research, the result and its analysis are to be presented to the respondents to obatain their validation.

3.2.3 Data Processing

This stage is basically performing DEMATEL and ANP calculation.

From DEMATEL method, the calculation steps has been explained in Section 2.1.4, the data from the questionnaire is used to build the matrix to calculate the interdependence degree of each criterion. A the network relation map could be built to simplify the interdependences in an easy-to-undaerstand structure and to clearly express relationship between factors, levels of influences, and the degree of impacts (Lee et al., 2011).

For ANP, there are three steps to be performed within this stage, i.e.

a. Network modeling based on the interdependence result from DEMATEL.
b. Criteria Weight Determination and Pairwise Comparison Matrices

Weight determination, could be done by the following steps (Shiue and Lin, 2012);

(a). Sum the values in each column of the pairwise comparison matrix

(b). Divide each element in a column by the sum of its respective column. The result matrix is referred to as the normalized pairwise comparison matrix.

(c). Sum the elements in each row of the normalized pairwise comparison matrix, and divide sum by the *n* elements in the row. These final numbers provide an estimate of the relative priorities for the elements being compared with respect to its upper level criterion. Priority vectors must be derived for all comparison matrices.

c. Supermatrix Formation

Upon completion of the supermatix formation by using the previous stage output, there are several steps to be carried out within this stage, i.e. normalizing the unweighted supermatrix into weighted supermatrix, defining the limit supermatrix and calculating the Considtency Ratio (CR). The process within this stage was facilitated by SuperDecision® software feature.

The last step in this stage is performing sensitivity analysis in order to capture the dynamic environment of the decision makin process, The sensitivity analysis was performed also by SuperDecision® software feature.

3.2.4 Sensitivity Analysis

Sensitivity analysis is defined as study of how uncertainty in the output of a model (numerical or atherwise) can be apportioned to different sources of uncertainty in the model. The aim of sensitivity analyses is to investigate the impacts of uncertainties to the model (Simanaviciene and Ustinovhicius, 2010). Therefore, sensitivity is required to capture the decision making dynamic circumtances.

Results from the analysis for real life problem related to petroleoum industry can be very sensitive to uncertainty in weights assigned to different attributes, utility functions, value associated with pairwise comparison and other parameter solicited from decision- makers (Virine and Murphy, 2007).

3.2.5 Analysis and Conclusion

There are two steps involved in this stage, i.e

a. Result Analysis

   The Analysis and discussion was performed on the result obtained from DEMATEL calculation for the criteria interdependence and the software SuperDecision® simulation for ANP for the decision-making. This step also includes the sensitivity analysis.

b. Conclusion and Recommendation

   The final step of this stage is establishing conclusions based on the result of the research. This step is important to ascertain that the research objectives are answered by the conclusions.

   In addition to the above, suggestion to future research will propose to be carried out.

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CHAPTER 4
RESULT AND DISCUSSION

4.1 General Information of PHX Related to ECP Organization

PHX is a subsidiary of one of multinational energy company that has been present in Indonesia for more than 45 years. PHX operates in Mahakam Delta, East Kalimantan, Indonesia producing Liquid Product (Oil and Condensate) and Gas. PHX had built numbers of platforms at offshore area to support the oil and gas production since then and became the largest gas producer in Indonesia.

Construction, under Engineering Construction and Project (ECP) division, is one of department, known as ECP/CST, supported by several other department such as ECP/QSE for quality-safety-environment, ECP/PRO for liquid and process, ECP/STD for engineering study, ECP/PJC for new project development and ECP/SVC for various services, responsible for 3 (three) main construction aspect such as; offshore construction, piping work and contruction site operation within PHX's daily operational, use accomodation work barge as main support tool beside various type of vessel such as; Landing Craft Tank (LCT), Flat Top Barge (FTB) and Sea Truck (ST). Accomodation work barge is use for small lifting, heavy lifting and dredging by using crane unit that mounted on barge. Those activities perform by many level of workers such as a barge master, a barge supervisor, 2 (two) radio

operators, a nurse, a safety officer, 3 (three) crane operators and 14 (fourteen) riggers as deck crews, which stay onboard for 24 (twenty four) hours, 7 (seven) days a week for 2 (two) weeks in a row.

Contractual service, under ECP/SVC department, support all pre and post contract issues regarding tender process, internal/external audit, and issues during contract duration. Currently, ECP/SVC handle 53 ongoing contracts and 36 tender preparation. this service supported by C&P (Contract & Procurement) and Legal team of PHX.

PHX's Finance division, established representative for other each division to monitoring and assist them regarding financial issue and decision making process. In ECP, known as FIN/ECP, this representative team always involved in every decision making discussion wether technical and non-technical to ensure all decision meet with the budget planning.

4.2 Data Collection

For this research, the primary data is collected through questionnaire. Three sets of questionnaires were distributed to the respondents; the first one is for Delphi, the second one is for DEMATEL and the third one is for ANP.

Preliminary validation of the list of criteria has been conducted by having deep interview with ECP head division as division leader (red highlight). The ECP has been selected CST head department as first single respondent with the consideration of his responsibility as sole leader in CST and his chopper-view ability in describing internal decision making within CST.

The validated criteria then has been selected and assessed Method in the sequences of Delphi, DEMATEL and ANP processes by Experts from respective entities (green highlight) which are Contractual, Finance, Fuel Monitoring, Marine Logistic. The experts are the PHX personnel who are in charge in their respective entities / department with good understanding and experience of their field.

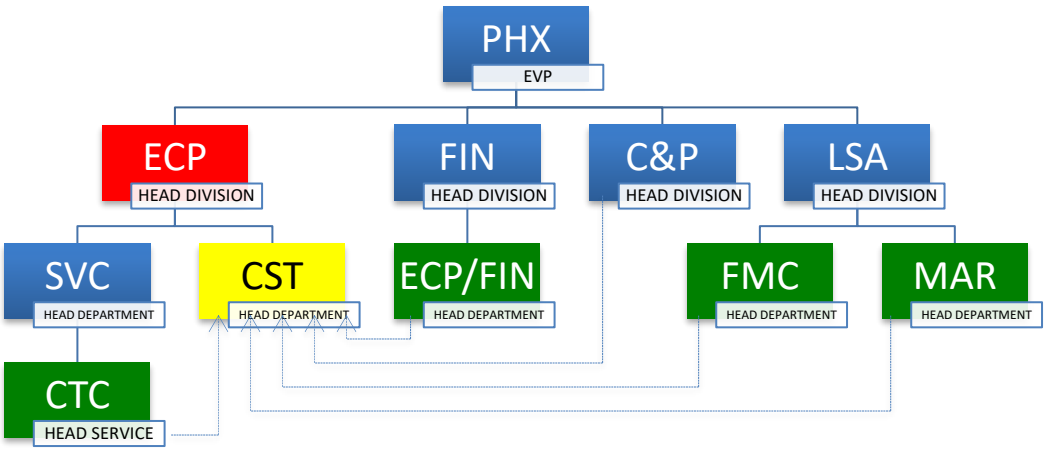

Figure 4.1 ECP's Decision Expert Simplified Organization Chart

The questionnaires are presented on Appendix 1, 3 and 5, while the result of the questionnaire is presented on Appendix 2, 4 and 6.

4.3 Data Processing

The data gathered from the deep interview and three sets of questionnaires as mentioned on Section 4.2 is then processed in two stages;

1. Interview for preliminary validation of the criteria from study literature. The result of interview used for Delphi input.
2. Delphi to select the criteria by 4 experts. The selected criteria used for DEMATEL input.
3. DEMATEL to assess the interrelation among the criteria. The interrelation resulted from this assessment used for ANP input.
4. Analytic Network Process (ANP) simulation by SuperDecisions® software for the decision making and the sensitivity analysis.

4.3.1 Preliminary Validation of Criteria

The preliminary validation has been conducted by having deep interview with ECP head division. Study literature related to New Accommodation Work Barge for Offshore/Swamp Lifting and Dredging Operation has been reviewed by CST head department to have the list criteria for next phase input. The list has been also added by 3 sub criteria by CST, agreed by ECP as shown in Table 4.1.

Aspect / Group Factor	Criteria	Source
Economic	Investment cost	Wang et al (2009)
Economic	Operation and maintenance cost	Wang et al (2009)
Economic	Fuel cost	Wang et al (2009)
Economic	Payback period	Wang et al (2009)
Economic	Service life	Wang et al (2009)
Economic	Exchange rates	Wang et al (2009)
Internal process	Personnel rights	Rabbani et al (2014)
Internal process	Ability to respond to emergencies	Rabbani et al (2014)
Internal process	Improvement of efficiency	Rabbani et al (2014)
Internal process	Employee productivity	Rabbani et al (2014)
Internal process	Contract type and option	Kaiser et al (2013)
Internal process	Market condition	Kaiser et al (2013)
Internal process	***Availability of supporting fleet***	***Additional from CST***
Environmental	Impact on ecosystem	Rabbani et al (2014)
Environmental	CO_2 emission	Rabbani et al (2014)
Environmental	Animal welfare	Rabbani et al (2014)
Environmental	Land use	Wang et al (2009)
Environmental	Noise	Wang et al (2009)
Environmental	***Operating environment***	***Additional from CST***
Environmental	***Operational safety***	***Additional from CST***

Table 4.1 The Validation Criteria by ECP

4.3.2 Delphi Method Evaluation and Analysis

The Delphi method has been used to select the list of criteria that has been preliminary validated by ECP. The questionnaires have been distributed to 4 experts in 3 rounds. The threshold average score has been set by ECP that the criteria with average score 6 in Delphi round eliminated.

During the first round, 20 criteria have been reviewed by experts with the result below:

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Investment cost	7	8	8	8	7,75
Economic	Operation and maintenance cost	9	8	8	8	8,25
Economic	Fuel cost	9	10	9	9	9,25
Economic	Payback period	6	5	5	5	5,25
Economic	Service life	8	8	8	9	8,25
Economic	Exchange rates	8	8	8	9	8,25
Internal process	Personnel rights (IP1)	5	5	5	5	5
Internal process	Ability to respond to emergencies (IP2)	5	6	5	5	5,25
Internal process	Improvement of efficiency (IP3)	9	8	8	8	8,25
Internal process	Employee productivity (IP4)	5	5	5	6	5,25
Internal process	Contract type and option	9	8	8	8	8,25
Internal process	Market condition	8	8	8	9	8,25
Internal process	*Availability of supporting fleet*	9	8	8	8	8,25
Environmental	Impact on ecosystem	7	8	8	7	7,5
Environmental	CO2 emission	5	5	5	5	5
Environmental	Animal welfare	5	5	5	5	5
Environmental	Land use	4	4	4	4	4
Environmental	Noise	4	5	4	4	4,25
Environmental	*Operating Environment*	8	8	8	9	8,25
Environmental	*Operational safety*	8	10	8	8	8,5

Table 4.2 Delphi Round 1

After the first round, 8 criteria with average score below 6 have been eliminated. This round, view criteria of Economic and Internal Process had been removed. Most of the environmental issue impacts within alternatives relatively the same which are normally handled by Enviroment and Societal Division.

During the second round, 12 criteria have been reviewed by experts with the result below:

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Investment cost	6	6	6	6	6
Economic	Operation and maintenance cost	9	8	8	8	8,25
Economic	Fuel cost	9	10	9	9	9,25
Economic	Service life	6	5	5	6	5,5
Economic	Exchange rates	8	8	8	9	8,25
Internal process	Improvement of efficiency (IP3)	5	5	5	5	5
Internal process	Contract type and option	9	8	8	8	8,25
Internal process	Market condition	8	8	8	9	8,25
Internal process	*Availability of supporting fleet*	9	8	8	8	8,25
Environmental	Impact on ecosystem	5	6	6	5	5,5
Environmental	*Operating Environment*	8	8	8	9	8,25
Environmental	*Operational safety*	8	10	8	8	8,5

Table 4.3 Delphi Round 2

After second round, 4 criteria with average score below 6 have been eliminated. Criteria have been eliminated from each aspect. Investment cost had been taken out from the list of criteria due to PHX priority to perform all new wells

for current year must be done since it was directly instructed from higher level of government in order to maintain national gas lifting capacity.

During the third round, 8 criteria have been reviewed by experts with the result in Table 4.4 Delphi Round 3.

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Sum	Average
Economic	Operation and maintenance cost	9	8	8	8	33	8,25
Economic	Fuel cost	9	10	9	9	37	9,25
Economic	Exchange rates	8	8	8	9	33	8,25
Internal process	Contract type and option	9	8	8	8	33	8,25
Internal process	Market condition	8	8	8	9	33	8,25
Internal process	*Availability of supporting fleet*	9	8	8	8	33	8,25
Environmental	*Operating Environment*	8	8	8	9	33	8,25
Environmental	*Operational safety*	8	10	8	8	34	8,5

Table 4.4 Delphi Round 3

Based on table 4.4 all criteria have average score more than 6. Before deciding the Delphi could be concluded in Round 3, the Standard Deviation analysis of the average score in 8 criteria has been conducted with result below:

Round	Sd	Quartile 1	Quartile 2	Quartile 3	Quartile Range	Quartile Deviation
Round 1	0,3018	7,40	7,80	8,00	0,60	0,04
Round 2	0,2236	7,80	7,80	8,00	0,20	0,01
Round 3	0,1000	8,00	8,00	8,20	0,20	0,01

Table 4.5 Statistics Calculation of Delphi Questionnaire

Based on table 4.5 the Standard Deviation and Quartile Range of round 3 is the lowest which indicates low variance and the response are convergent with tendency of collegial. The 8 selected-criteria used for DEMATEL input.

4.3.3 DEMATEL Method Evaluation and Analysis

The evaluation for DEMATEL method is performed using Microsoft Excel software with the following step:

Step 1: Construct the scales of evaluation by using pairwise comparison.

This step is performed during DEMATEL questionnaires development. Appendix 1 describes this step result in more detail.

Step 2: Calculate the initial average matrix by scores.

The average DEMATEL questionnaires result in the form of matrix which is called as initial average matrix or direct-influence matrix is presented on the Appendix 3.

Step 3: Calculate the initial influence matrix by normalizing initial average matrix.

To normalize the initial average matrix, needs to find the minimum k value. K value is calculated by dividing 1 to the maximum sum from each column and row. The maximum sum from column and row is 21.25 and 20.25 respectively. The k value is min (1/21.25, 1/20.25). The selected k value is 0.049 as the result of (1/20.25).

All numbers within the matrix are then multiplied by k value and resulted to a normalized initial direct-matrix as presented in appendix 3.

Step 4: Develop the total influence matrix.

The total influence matrix development is done by reducing the normalized direct-influence matrix with identity matrix (I). The result is then inversed using MINVERSE function of the Microsoft Excel®. The last action is multiplying the normalized direct-influence matrix with the inversed matrix using MMULT function of the Microsoft Excel®. The result is presented in the appendix 3

Step 5: Obtain the prominence and relation by summing each row and column to yield D and R.

In this step each row values are summed (so called D) and each row values are also summed (so called D). The strength of relationships between criteria is represented by (D+R), while the strength of influences among criteria is represented by (D-R). The value of D, R, (D+R) and (D-R) are summarized by the following Table 4.4;

Aspects / Group Factor	Criteria	D+R	D-R
Economic	Operation and maintenance cost	5,12	-1,26
Economic	Fuel cost	5,24	-0,82
Economic	Exchange rates	4,88	-1,11
Internal process	Contract type and option	5,00	0,18
Internal process	Market condition	6,61	0,17
Internal process	*Availability of supporting fleet*	2,04	0,84
Environmental	*Operating Environment*	2,14	1,21
Environmental	*Operational safety*	2,60	0,80

Table 4.6 Tabel of D, R, (D+R) and (D-R)

In addition, the difference (D-R) shows the net effect of criterion contributing to the system. When (D-R) is positive, the criterion is a net causer, and

when (D-R) is negative, the criterion is a net receiver. From the above table, there are 3 criteria considers as net receiver, namely Operation Maintenance Cost, Fuel Cost, and Exchange Rates.

Step 6: Draw the network relation map

Prior to drawing the network relation map, a threshold value needs to be defined. During this research, the threshold value in NRM has been set in 0.00 based on discussion with ECP. The NRM is presented in picture 4.1 below:

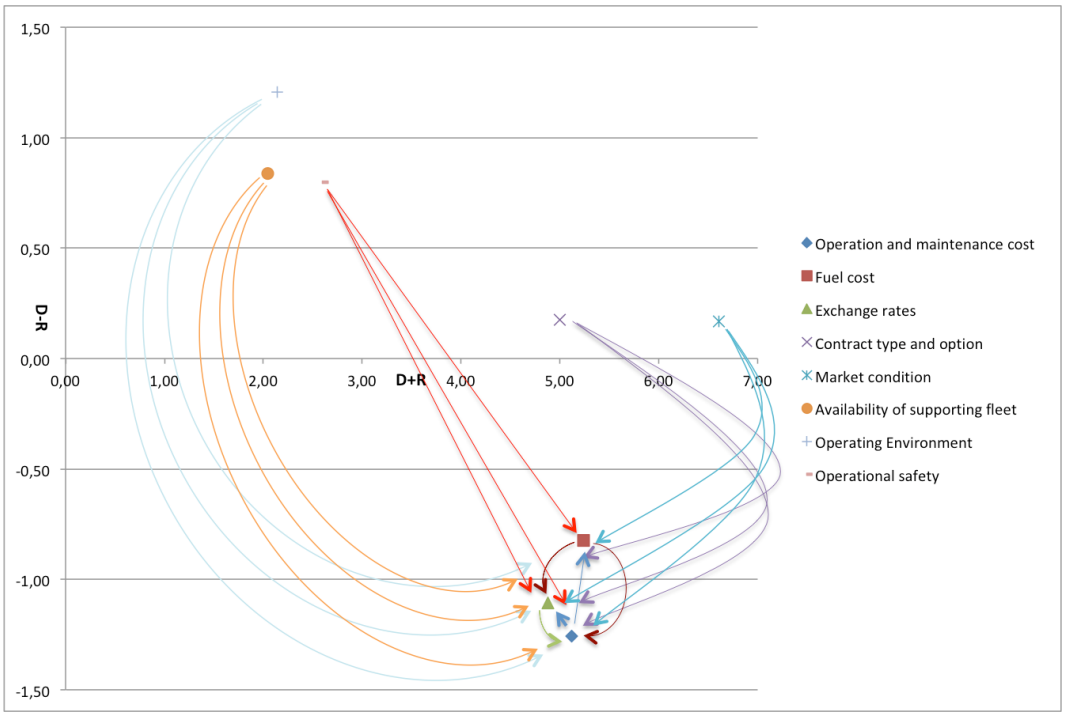

Figure 4.2 Network Relation Map (NRM)

The above DEMATEL evaluation results confirms the interrelation among criteria, which could be summarized as follows:

- Operation and Maintenance Cost criterion influences Exchange Rates, Fuel Cost criterion.
- Exchange Rates criterion influences Operation and Maintenance Cost criterion.
- Fuel Cost criterion influences Operation and Maintenance Cost, Exchange Rates criterion.
- Operating Environment criterion influences Operation and Maintenance Cost, Exchange Rates, Fuel Cost criterion.
- Availibility of Supporting Fleet criterion influences Operation and Maintenance Cost, Exchange Rates, Fuel Cost criterion.

- Operational Safety criterion influences Operation and Maintenance Cost, Exchange Rates, Fuel Cost criterion.
- Contract Type and Option criterion influences Operation and Maintenance Cost, Exchange Rates, Fuel Cost criterion.
- Market Condition criterion influences Operation and Maintenance Cost, Exchange Rates, Fuel Cost criterion.

Based on the DEMATEL result, there are 3 Net-Receiver Criteria with threshold less than 0.00 will not be analyzed in the next ANP phase. The 3 Net-Receiver Criteria are Operation and Maintenance Cost, Exchange Rates, Fuel Cost criterion. The rest 5 criteria used as input for next ANP phase.

4.3.4 ANP Method Evaluation and Analysis

The Analytic Process (ANP) as the decision making tools is performed by SuperDecisions® software.

The ANP simple network model for this research decision making is shown by the following Figure 4.2. The criteria interrelation scheme from DEMATEL evaluation is adapted to the model as shown by arrows linking from one cluster to another.

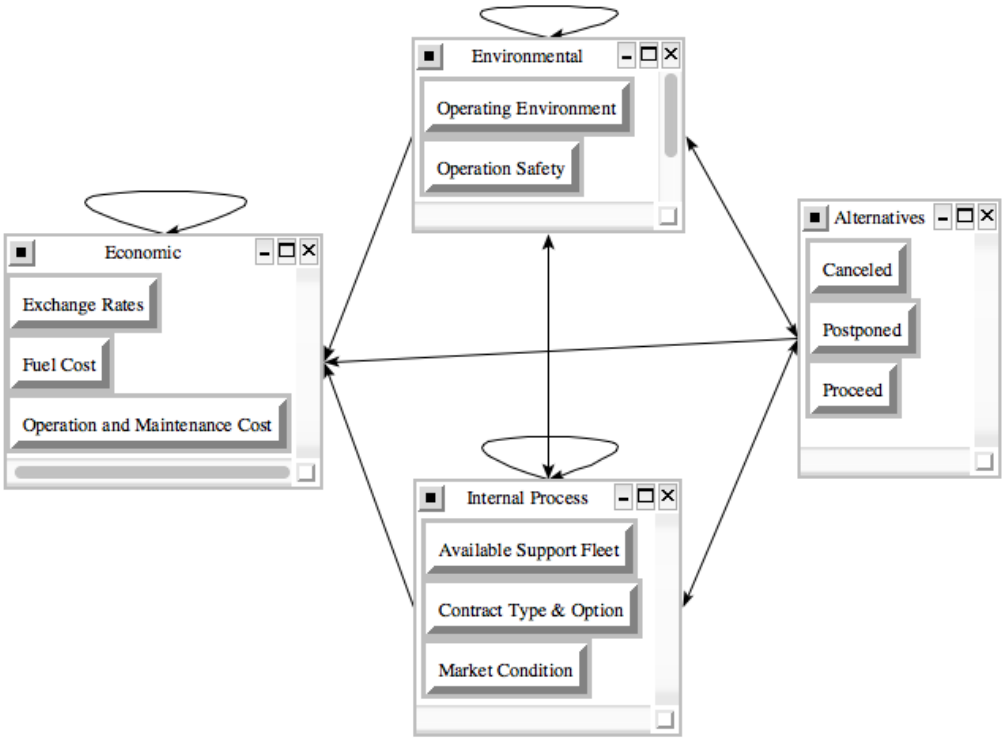

Figure 4.3 ANP Model

The simulation resulted shows that alternative to proceed to build new accomodation work barge with the weight of 59,45% instead of alternative to

canceled with the weight of 31,31% or alternative to postponed with the weight only amount of 9,25% as shown by Figure 4.3.

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: SP 2.sdmod

Canceled		0.526694	0.313095	0.000000
Postponed		0.155526	0.092453	0.000000
Proceed		1.000000	0.594453	0.000000

Figure 4.4 ANP Simulation Result

4.3.5 Sensitivity Analysis

Sensitivity analysis is performed by utilizing Super-Decisions feature and applied to all. Below are the explaination of each net-causer criteria:

1. Sensitivity to Operating Environment

   This criterion sensitivity chart shows the trend that alternative to proceed will always be the 1st , even more solid when the parameter is more than 0.5. This could be explained that operating environment will be the main criteria in order to select alternative in build new accommodation work barge since there will be different area which as offshore and swamp area.

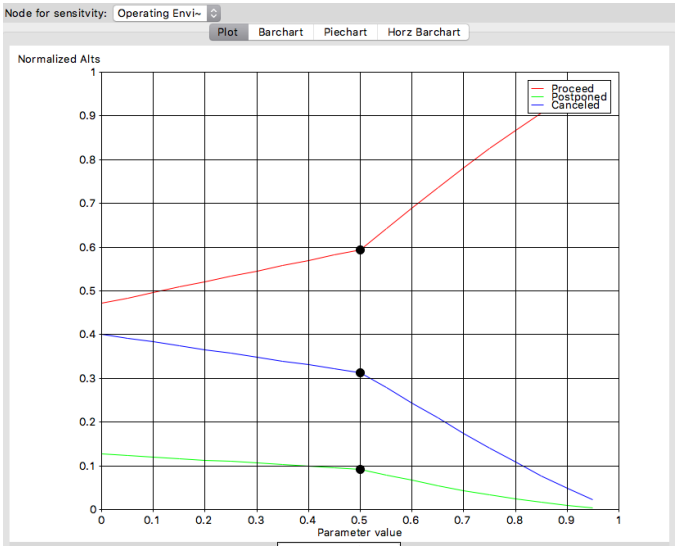

Figure 4.5 Operating Environment Criteria Sensitivity Chart

2. Sensitivity to Operation Safety

   This criterion sensitivity chart shows the trend that alternative to proceed will still be in 1st priority with the changes of criteria. This could be

explained that operation safety is a must in all activity and all decision making in PHX.

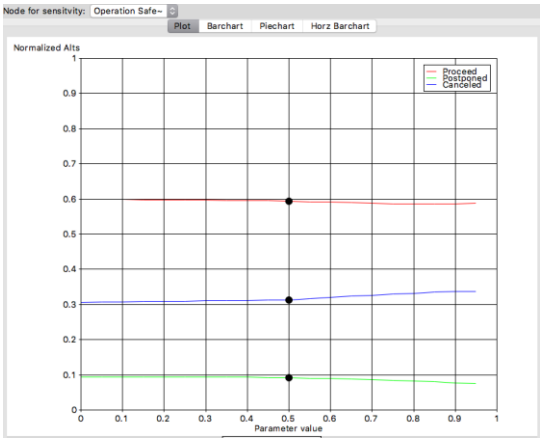

Figure 4.6 Operation Safety Criteria Sensitivity Chart

3. Sensitivity to Availibility of Supporting Fleet

This criterion sensitivity chart shows the trend that alternative to postponed could replace alternative to proceed as the 1st when the parameter is more than 0.6 and also could be replaced by alternative to canceled if the parameter is more than 0.9. This could be explained that the decisision to build new accommodation work barge will be proceed as long as sufficient supporting fleets are available. If not sufficient enough, the decision will be postponed. Futhermore, it will be canceled if there are no supporting fleet available.

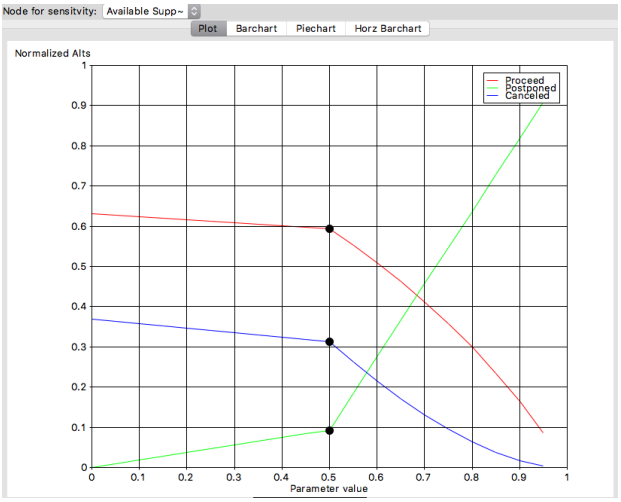

Figure 4.7 Avalibility of Supporting Fleet Criteria Sensitivity Chart

4. Sensitivity to Contract Type and Option

This criterion sensitivity chart shows the trend that alternative to proceed will be replace by alternative to canceled if parameter is more than 0.6. This could be explained that if the decision to build new accommodation work

barge is not having option to preparing the contract type, the decision will be canceled.

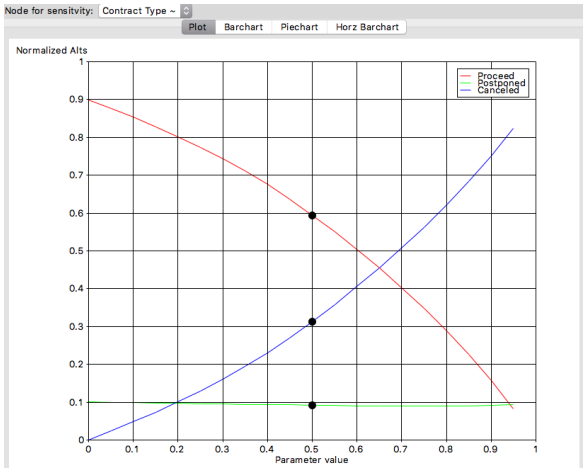

Figure 4.8 Contract Type and Option Criteria Sensitivity Chart

5. Sensitivity to Market Condition

This criterion sensitivity chart shows the trend that alternative to proceed will still be in 1st priority with the changes of criteria. This could be explained that the CST will need to always consider this criteria as main criteria in order to make decision to build new accommodation work barge since the dredging and lifting market environment are not wide as others.

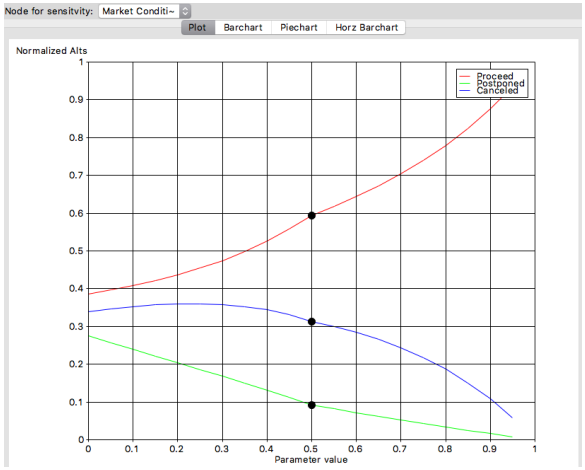

Figure 4.8 Market Condition Criteria Sensitivity Chart

4.4 Discussion

The ANP simulation is confirmed to be suitable tools for this research desicion making following their criteria interdependence. However, the result of the simulation is pretty much depending on the input of pairwise comparison criterias.

The decision making within PHX is still highly influence by Top Management direction that is responsible for the implementation of Company's

policy. In this research, the feed back from PHX's Top Management delivered the priority to ECP division's consideration to decide the new accommodation work barge. The approach of taking into consideration the feedback from Top Management in this research accommodates the decision making process within PHX.

On sensitivity part, it was shown at section 4.3.5 that the selected option is quite sensitive since it shows current condition of decision making process in PHX. This might be explained by the fact that the input data for ANP is obtained from ECP only who prefers the build of new accommodation work barge to proceeded instead of continue with existing one. Other possibility to have more wide-range sensitivity is by performing Focused Group Discussion (FGD) in selecting the importance of the criteria pairwise comparison. By doing so, the interest of each divisions could be incorporated and accepted by the concerned parties. Indeed it is not easy to gather the four experts in one place and spend some time for discussing the above subject.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the evaluation and simulation performed using Analytic Network Process (ANP) as the decision making tools, this research concluded the following points:

1. The criteria used to decide the new accommodation work barge for offshore/swamp dredging and lifting are Operating Environment, Operation Safety, Availibility of Supporting Fleet, Contract Type and Option, Market Condition.
2. The selected alternative for build new accommodation work barge for offshore/swamp dredging and lifting is Proceed with the weight of 59,45%.

5.2 Recommendation

The recommendation for the future researches is among others;

1. To define the criteria for decision making of New Build Accommodation Work Barge for Offshore/Swamp Dredging and Lifting or other marine fleet in general using more comprehensive method such as Focused Group Discussion (FGD).

2. To perform decision making of New Build Accommodation Work Barge for Offshore/Swamp Dredging and Lifting or other marine fleet in general by means of ANP model Benefit, Opportunity, Cost, Risk (BOCR) to capture the different view of this research.
3. To have detail discussion and documentation as reference in deciding criteria ratings not only with ECP Mangement but also with other Top Management as they can see the business picture of company more widely.
4. To be an option supporting tool for PHX before taking a decision in order to mapping all possible criteria that may have conflict interest toward the best alternative.

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APPENDIX 1 – DELPHI QUESTIONNAIRE

A. INTRODUCTION

Dear Sir,

I am studying Master of Management Technology with Industrial Management concentration at Sepuluh Nopember Institute of Technology (ITS) Surabaya, East Java, Indonesia, and I am currently distributing questionnaire for research purpose with title New Accommodation Work Barge Selection for Offshore / Swamp Lifting and Dredging Operation by Using Analytic Network Process (ANP).

The attached questionnaire is made to select criteria by using Delphi method, the purpose is to have your **judgment whether the criteria in the list from literature are relevant as reference** regarding the Decision of 3 alternatives to decide to build new AWB as follow:

1. Proceed to build new AWB for offshore and swamp area operation
2. Postponed to build new AWB for offshore and swamp area operation
3. Canceled to build new AWB for offshore and swamp area operation

B. DESCRIPTION

This assessment is performed by scoring the influence level of one criterion to another by referring to the scale below;

Score	1	2	3	4	5	6	7	8	9	10	Score
Less Relevant											More Relevant

There are eight criteria which compared, i.e. Operation and Maintenance Cost, Fuel Cost, Exchange Rates, Contrat Type and Option, Market Condition, Availibility of Supporting Fleet, Operating Environment, Operational Safety

Example:

C. QUESTIONNAIRE

Round 1

Aspects / Group Factor	Criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Investment cost					
Economic	Operation and maintenance cost					
Economic	Fuel cost					
Economic	Payback period					
Economic	Service life					
Economic	Exchange rates					
Internal process	Personnel rights (IP1)					
Internal process	Ability to respond to emergencies (IP2)					
Internal process	Improvement of efficiency (IP3)					
Internal process	Employee productivity (IP4)					
Internal process	Contract type and option					
Internal process	Market condition					
Internal process	*Availability of supporting fleet*					
Environmental	Impact on ecosystem					
Environmental	CO2 emission					
Environmental	Animal welfare					
Environmental	Land use					
Environmental	Noise					
Environmental	*Operating Environment*					
Environmental	*Operational safety*					

Round 2

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Investment cost					
Economic	Operation and maintenance cost					
Economic	Fuel cost					
Economic	Service life					
Economic	Exchange rates					
Internal process	Improvement of efficiency (IP3)					
Internal process	Contract type and option					
Internal process	Market condition					
Internal process	*Availability of supporting fleet*					
Environmental	Impact on ecosystem					
Environmental	*Operating Environment*					
Environmental	*Operational safety*					

Round 3

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Operation and maintenance cost					
Economic	Fuel cost					
Economic	Exchange rates					
Internal process	Contract type and option					
Internal process	Market condition					
Internal process	*Availability of supporting fleet*					
Environmental	*Operating Environment*					
Environmental	*Operational safety*					

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APPENDIX 2 – DELPHI RESULT

Round 1

Aspects / Group Factor	Criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Investment cost	7	8	8	8	7,75
Economic	Operation and maintenance cost	9	8	8	8	8,25
Economic	Fuel cost	9	10	9	9	9,25
Economic	Payback period	6	5	5	5	5,25
Economic	Service life	8	8	8	9	8,25
Economic	Exchange rates	8	8	8	9	8,25
Internal process	Personnel rights (IP1)	5	5	5	5	5
Internal process	Ability to respond to emergencies (IP2)	5	6	5	5	5,25
Internal process	Improvement of efficiency (IP3)	9	8	8	8	8,25
Internal process	Employee productivity (IP4)	5	5	5	6	5,25
Internal process	Contract type and option	9	8	8	8	8,25
Internal process	Market condition	8	8	8	9	8,25
Internal process	*Availability of supporting fleet*	9	8	8	8	8,25
Environmental	Impact on ecosystem	7	8	8	7	7,5
Environmental	CO2 emission	5	5	5	5	5
Environmental	Animal welfare	5	5	5	5	5
Environmental	Land use	4	4	4	4	4
Environmental	Noise	4	5	4	4	4,25
Environmental	*Operating Environment*	8	8	8	9	8,25
Environmental	*Operational safety*	8	10	8	8	8,5

Round 2

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Investment cost	6	6	6	6	6
Economic	Operation and maintenance cost	9	8	8	8	8,25
Economic	Fuel cost	9	10	9	9	9,25
Economic	Service life	6	5	5	6	5,5
Economic	Exchange rates	8	8	8	9	8,25
Internal process	Improvement of efficiency (IP3)	5	5	5	5	5
Internal process	Contract type and option	9	8	8	8	8,25
Internal process	Market condition	8	8	8	9	8,25
Internal process	*Availability of supporting fleet*	9	8	8	8	8,25
Environmental	Impact on ecosystem	5	6	6	5	5,5
Environmental	*Operating Environment*	8	8	8	9	8,25
Environmental	*Operational safety*	8	10	8	8	8,5

Round 3

Aspects / Group Factor	Sub-criteria	FINANCE	MARINE	FMC	CTC	Average
Economic	Operation and maintenance cost	9	8	8	8	8,25
Economic	Fuel cost	9	10	9	9	9,25
Economic	Exchange rates	8	8	8	9	8,25
Internal process	Contract type and option	9	8	8	8	8,25
Internal process	Market condition	8	8	8	9	8,25
Internal process	*Availability of supporting fleet*	9	8	8	8	8,25
Environmental	*Operating Environment*	8	8	8	9	8,25
Environmental	*Operational safety*	8	10	8	8	8,5

Note:

Respondent Finance : Head of Finance Service

Respondent Marine : Head of Marine Logistic Service

Respondent FMC : Head of Fuel Monitoring & Comsumption Service

Respondent CTC : Head of Contract & Complaiance Service

APPENDIX 3 – DEMATEL QUESTIONNAIRE

A. INTRODUCTION

Dear Sir,

I am studying Master of Management Technology with Industrial Management concentration at Sepuluh Nopember Institute of Technology (ITS) Surabaya, East Java, Indonesia, and I am currently distributing questionnaire for research purpose with title New Accommodation Work Barge Selection for Offshore / Swamp Lifting and Dredging Operation by Using Analytic Network Process (ANP) to decide the selection of new New accommodation work barge as follow:

1. Proceed to build new AWB for offshore and swamp area operation
2. Postponed to build new AWB for offshore and swamp area operation
3. Canceled to build new AWB for offshore and swamp area operation

The questionnaire feedback used as input to evaluate the criteria interdependence by DEMATEL (Decision Making Trial and Evaluation Laboratory) method.

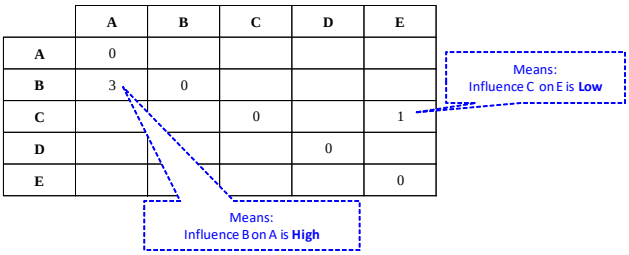
B. DESCRIPTION

This assessment is performed by scoring the influence level of one criterion to another by referring to the scale below;

Scale	Description
0	No influence
1	Low influence
2	Medium influence
3	High influence
4	Extremely high influence

There are five citeria which compared, i.e. Economic Performance, Operational Safety, Public Relation & Organization, Technology and Security.

Example:



C. QUESTIONAIRE

AVERAGE	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost								
Fuel cost								
Exchange rates								
Contract type and option								
Market condition								
Availability of supporting fleet								
Operating Environment								
Operational safety								

APPENDIX 4 – DEMATEL RESULT

A. RESULT FROM RESPONDENT

FINANCE	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	0	2	1	4	4	0	0	0
Fuel cost	1	0	2	1	3	0	0	0
Exchange rates	1	3	0	1	3	0	0	1
Contract type and option	2	2	2	0	1	1	1	0
Market condition	3	3	3	3	0	1	1	2
Availability of supporting fleet	3	0	0	1	4	0	0	0
Operating Environment	3	0	2	1	4	0	0	0
Operational safety	2	4	2	0	0	0	0	0

MARINE	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	0	2	1	3	3	0	0	0
Fuel cost	3	0	3	2	3	0	0	0
Exchange rates	1	3	0	1	3	0	0	1
Contract type and option	2	3	2	0	1	1	1	0
Market condition	3	3	3	3	0	1	1	1
Availability of supporting fleet	3	0	0	1	3	0	0	0
Operating Environment	3	0	2	1	3	0	0	0
Operational safety	3	5	3	0	0	0	0	0

FMC	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	0	1	1	4	4	0	0	0
Fuel cost	3	0	3	2	2	0	0	0
Exchange rates	2	3	0	1	4	0	0	1
Contract type and option	2	3	4	0	2	1	1	0
Market condition	3	3	4	3	0	1	1	1
Availability of supporting fleet	3	0	0	1	3	0	0	0
Operating Environment	2	0	2	1	2	0	0	0
Operational safety	3	3	3	0	0	0	0	0

CTC	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	0	2	2	4	4	0	0	0
Fuel cost	3	0	3	3	3	0	0	0
Exchange rates	3	3	0	3	4	0	0	1
Contract type and option	3	3	4	0	3	1	1	0
Market condition	4	3	4	3	0	1	1	2
Availability of supporting fleet	3	0	0	1	3	0	0	0
Operating Environment	3	0	3	1	3	0	0	0
Operational safety	3	3	3	0	0	0	0	0

Note:

Respondent Finance : Head of Finance Service

Respondent Marine : Head of Marine Logistic Service

Respondent FMC : Head of Fuel Monitoring & Comsumption Service

Respondent CTC : Head of Contract & Complaiance Service

B. DEMATEL CALCULATION

Initial average matrix or direct-influence matrix

Average	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	0	1,75	1,25	3,75	3,75	0	0	0
Fuel cost	2,5	0	2,75	2	2,75	0	0	0
Exchange rates	1,75	3	0	1,5	3,5	0	0	1
Contract type and option	2,25	2,75	3	0	1,75	1	1	0
Market condition	3,25	3	3,5	3	0	1	1	1,5
Availability of supporting fleet	3	0	0	1	3,25	0	0	0
Operating Environment	2,75	0	2,25	1	3	0	0	0
Operational safety	2,75	3,75	2,75	0	0	0	0	0

Normalized initial direct-matrix

Average	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	0,00	0,09	0,06	0,19	0,19	0,00	0,00	0,00
Fuel cost	0,12	0,00	0,14	0,10	0,14	0,00	0,00	0,00
Exchange rates	0,09	0,15	0,00	0,07	0,17	0,00	0,00	0,05
Contract type and option	0,11	0,14	0,15	0,00	0,09	0,05	0,05	0,00
Market condition	0,16	0,15	0,17	0,15	0,00	0,05	0,05	0,07
Availability of supporting fleet	0,15	0,00	0,00	0,05	0,16	0,00	0,00	0,00
Operating Environment	0,14	0,00	0,11	0,05	0,15	0,00	0,00	0,00
Operational safety	0,14	0,19	0,14	0,00	0,00	0,00	0,00	0,00

Total influence matrix

Average	Operation and maintenance cost	Fuel cost	Exchange rates	Contract type and option	Market condition	*Availability of supporting fleet*	*Operating Environment*	*Operational safety*
Operation and maintenance cost	1,26	0,35	0,32	0,38	0,43	0,06	0,05	0,08
Fuel cost	0,43	1,34	0,43	0,33	0,44	0,07	0,05	0,11
Exchange rates	0,34	0,39	1,25	0,27	0,41	0,05	0,04	0,13
Contract type and option	0,48	0,49	0,49	1,30	0,47	0,13	0,10	0,13
Market condition	0,64	0,62	0,62	0,50	1,50	0,15	0,12	0,23
Availability of supporting fleet	0,34	0,20	0,19	0,21	0,35	1,05	0,04	0,07
Operating Environment	0,35	0,23	0,32	0,23	0,37	0,05	1,04	0,08
Operational safety	0,36	0,41	0,35	0,18	0,25	0,04	0,03	1,07

APPENDIX 5 – ANP QUESTIONNAIRE

A. INTRODUCTION

Dear Sir,

I am studying Master of Management Technology with Industrial Management concentration at Sepuluh Nopember Institute of Technology (ITS) Surabaya, East Java, Indonesia, and I am currently distributing questionnaire for research purpose with title New Accommodation Work Barge Selection for Offshore / Swamp Lifting and Dredging Operation by Using Analytic Network Process (ANP). Highly appreciate for your time and feedback to support this research.

B. DESCRIPTION

Description	Comparison																	Description
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Room comfort													x					Location (city center)

Means that location is more important for me than the room comfort and I will choose the hotel located at city center.

C. QUESTIONNAIRE

Variable (Aspect) Pairwise Comparison

Which criteria give more significant impact to "Environmental Cluster"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Alternative																		Economic
Alternative																		Environmental
Alternative																		Internal Process
Economic																		Environmental
Economic																		Internal Process
Environmental																		Internal Process

Which criteria give more significant impact to "Internal Process Cluster"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Alternative																		Economic
Alternative																		Environmental
Alternative																		Internal Process
Economic																		Environmental
Economic																		Internal Process
Environmental																		Internal Process

Criteria Pairwise Comparison (Inner-Dependence – Outer-Dependence)

Which criteria give more significant impact to "Availibility of Supporting Fleet"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Fuel cost
Exchange rates																		Operation and maintenance cost
Fuel Cost																		Operation and maintenance cost

Which criteria give more significant impact to "Canceled Alternative"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Market Condition

Which criteria give more significant impact to "Postponed Alternative"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Market Condition

Which criteria give more significant impact to "Proceed Alternative"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Contract Type & Option
Availibility of Supporting Fleet																		Market Condition
Contract Type & Option																		Market Condition

Which criteria give more significant impact to "Proceed Alternative"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Operating Environmental																		Operation Safety

Which criteria give more significant impact to "Contract Type & Option"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Market Condition

Which criteria give more significant impact to "Contract Type & Option"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Fuel cost
Exchange rates																		Operation and maintenance cost
Fuel Cost																		Operation and maintenance cost

Which criteria give more significant impact to "Exchange Rates"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Operation and maintenance cost

Which criteria give more significant impact to "Fuel Cost"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Operation and maintenance cost

Which criteria give more significant impact to "Market Condition"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Contract Type & Option

Which criteria give more significant impact to "Market Condition"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Fuel cost
Exchange rates																		Operation and maintenance cost
Fuel Cost																		Operation and maintenance cost

Which criteria give more significant impact to "Environmental"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Contract Type & Option
Availibility of Supporting Fleet																		Market Condition
Contract Type & Option																		Market Condition

Which criteria give more significant impact to "Environmental"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Operating Environmental																		Operation Safety

Which criteria give more significant impact to "Environmental"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Fuel cost
Exchange rates																		Operation and maintenance cost
Fuel Cost																		Operation and maintenance cost

Which criteria give more significant impact to "Operational & Maintenance Cost"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Fuel cost

Which criteria give more significant impact to "Operation Safety"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Availibility of Supporting Fleet																		Contract Type & Option
Availibility of Supporting Fleet																		Market Condition
Contract Type & Option																		Market Condition

Which criteria give more significant impact to "Operation Safety"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Operating Environmental																		Operation Safety

Which criteria give more significant impact to "Operation Safety"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Exchange rates																		Fuel cost
Exchange rates																		Operation and maintenance cost
Fuel Cost																		Operation and maintenance cost

Criteria Pairwise Comparison (Internal Cluster)

Which criteria give more significant impact to "Environmental Cluster"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Alternative																		Economic
Alternative																		Environmental
Alternative																		Internal Process
Economic																		Environmental
Economic																		Internal Process
Environmental																		Internal Process

Which criteria give more significant impact to "Internal Process Cluster"

Aspects/Group Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Aspects/Group Factor
Alternative																		Economic
Alternative																		Environmental
Alternative																		Internal Process
Economic																		Environmental
Economic																		Internal Process
Environmental																		Internal Process

Note:

Respondent Finance : Head of Finance Service

Respondent Marine : Head of Marine Logistic Service

Respondent FMC : Head of Fuel Monitoring & Comsumption Service

Respondent CTC : Head of Contract & Complaiance Service

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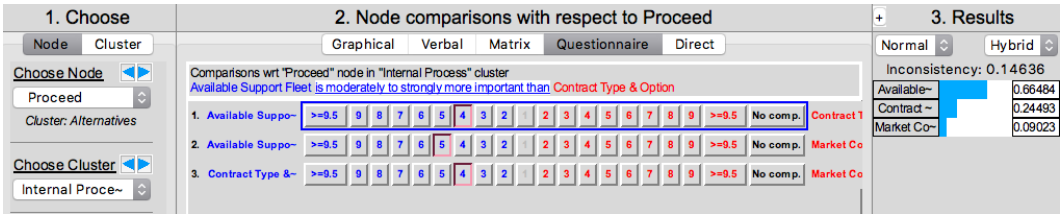
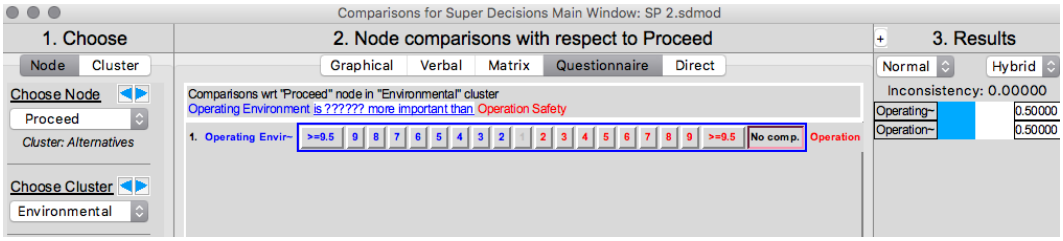
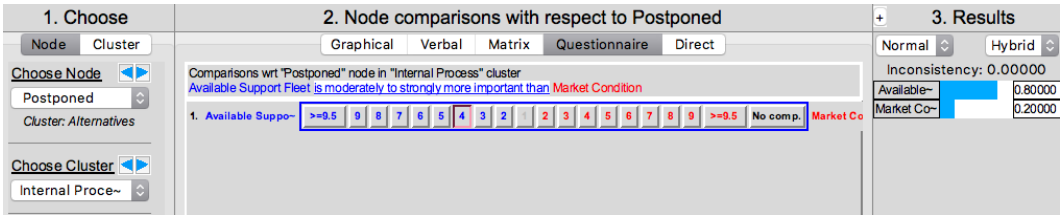
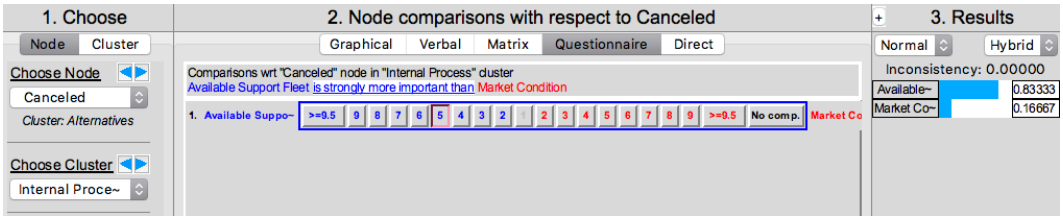
APPENDIX 6 – ANP INPUT & ANALYSIS

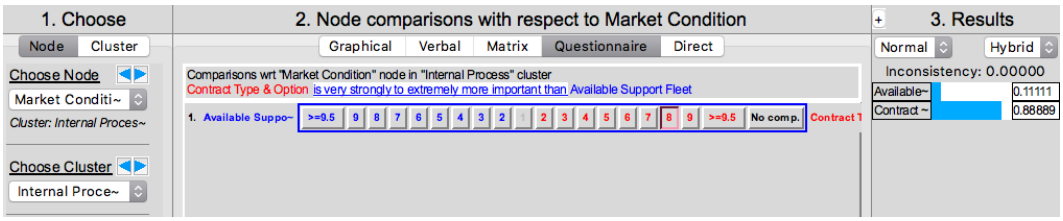
Input Pairwise Comparison to Super-Decision

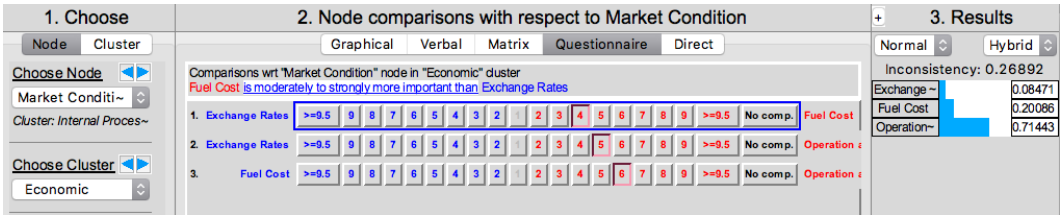


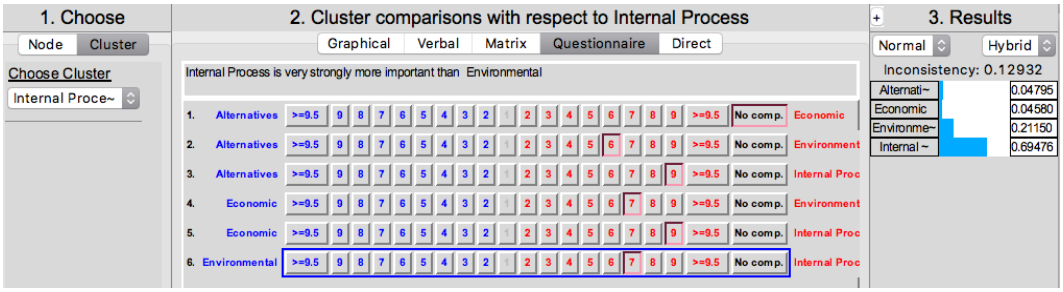


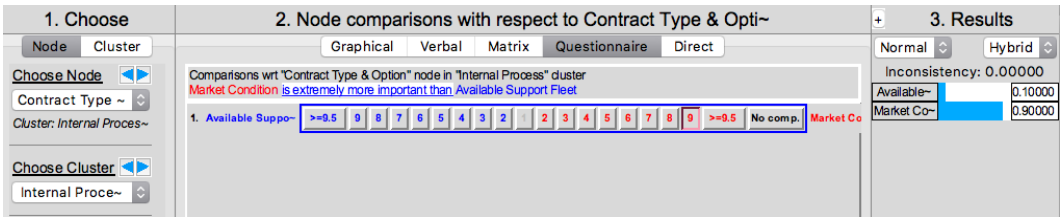


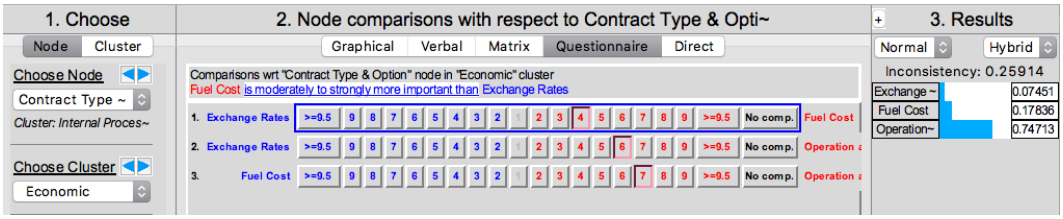


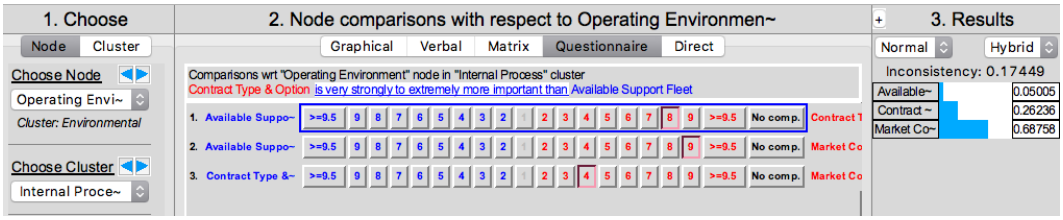


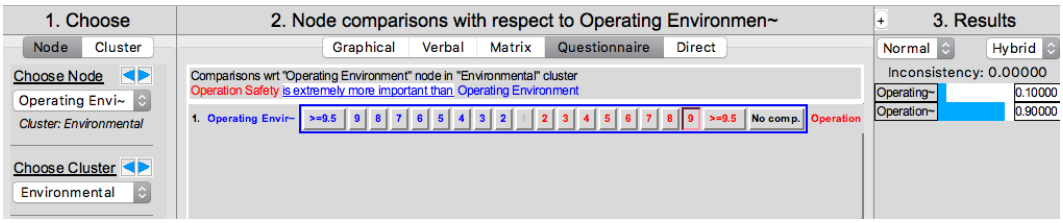


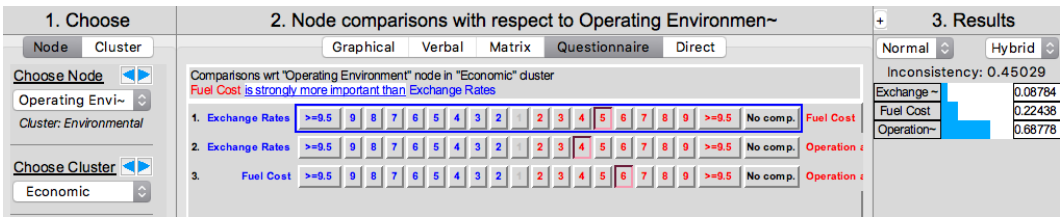

1. Choose
Node
Cluster
Choose Cluster
Internal Proce~
2. Cluster comparisons with respect to Internal Process
Graphical
Verbal
Matrix
Questionnaire
Direct
Internal Process is very strongly more important than Environmental
1. Alternatives
2. Alternatives
3. Alternatives
4. Economic
5. Economic
6. Environmental
No comp.
Economic
Environment
Internal Proc
3. Results
Normal
Hybrid
Inconsistency: 0.12932
Alternati~ 0.04795
Economic 0.04580
Environme~ 0.21150
Internal ~ 0.69476

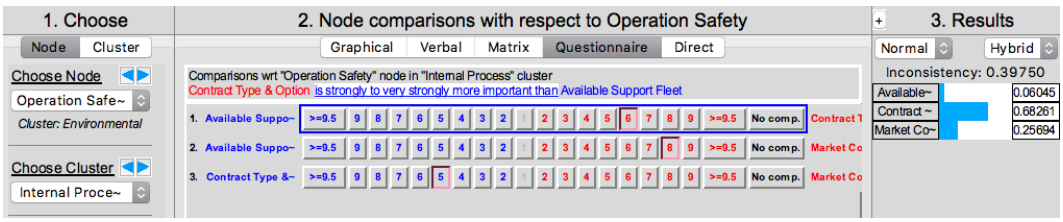

1. Choose
Node
Cluster
Choose Node
Contract Type ~
Cluster: Internal Proces~
Choose Cluster
Internal Proce~
2. Node comparisons with respect to Contract Type & Opti~
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Contract Type & Option" node in "Internal Process" cluster
Market Condition is extremely more important than Available Support Fleet
1. Available Suppo~
No comp.
Market Co
3. Results
Normal
Hybrid
Inconsistency: 0.00000
Available~ 0.10000
Market Co~ 0.90000

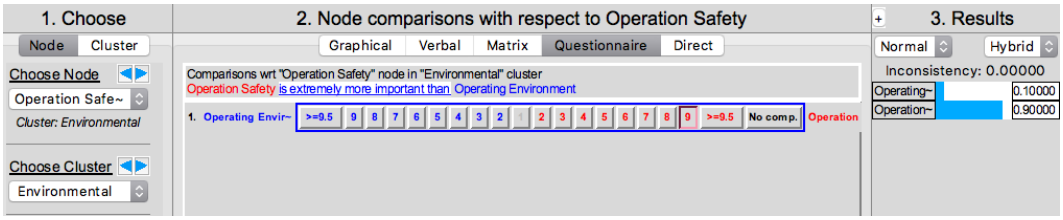

1. Choose
Node
Cluster
Choose Node
Contract Type ~
Cluster: Internal Proces~
Choose Cluster
Economic
2. Node comparisons with respect to Contract Type & Opti~
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Contract Type & Option" node in "Economic" cluster
Fuel Cost is moderately to strongly more important than Exchange Rates
1. Exchange Rates
2. Exchange Rates
3. Fuel Cost
No comp.
Fuel Cost
Operation
3. Results
Normal
Hybrid
Inconsistency: 0.25914
Exchange ~ 0.07451
Fuel Cost 0.17836
Operation~ 0.74713

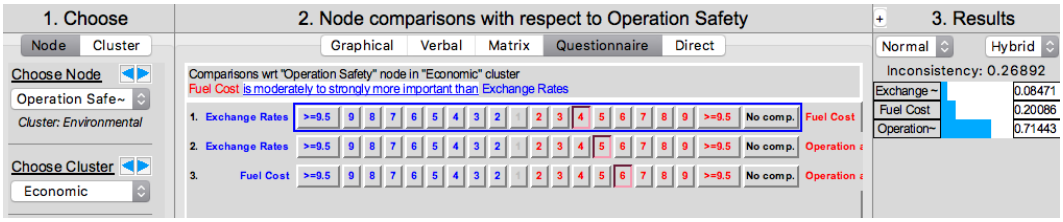

1. Choose
Node
Cluster
Choose Node
Operating Envi~
Cluster: Environmental
Choose Cluster
Internal Proce~
2. Node comparisons with respect to Operating Environmen~
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Operating Environment" node in "Internal Process" cluster
Contract Type & Option is very strongly to extremely more important than Available Support Fleet
1. Available Suppo~
2. Available Suppo~
3. Contract Type &~
No comp.
Contract T
Market Co
3. Results
Normal
Hybrid
Inconsistency: 0.17449
Available~ 0.05005
Contract ~ 0.26236
Market Co~ 0.68758


1. Choose
Node
Cluster
Choose Node
Operating Envi~
Cluster: Environmental
Choose Cluster
Environmental
2. Node comparisons with respect to Operating Environmen~
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Operating Environment" node in "Environmental" cluster
Operation Safety is extremely more important than Operating Environment
1. Operating Envir~
No comp.
Operation
3. Results
Normal
Hybrid
Inconsistency: 0.00000
Operating~ 0.10000
Operation~ 0.90000


1. Choose
Node
Cluster
Choose Node
Operating Envi~
Cluster: Environmental
Choose Cluster
Economic
2. Node comparisons with respect to Operating Environmen~
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Operating Environment" node in "Economic" cluster
Fuel Cost is strongly more important than Exchange Rates
1. Exchange Rates
2. Exchange Rates
3. Fuel Cost
No comp.
Fuel Cost
Operation
3. Results
Normal
Hybrid
Inconsistency: 0.45029
Exchange ~ 0.08784
Fuel Cost 0.22438
Operation~ 0.68778


1. Choose
Node
Cluster
Choose Node
Operation Safe~
Cluster: Environmental
Choose Cluster
Internal Proce~
2. Node comparisons with respect to Operation Safety
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Operation Safety" node in "Internal Process" cluster
Contract Type & Option is strongly to very strongly more important than Available Support Fleet
1. Available Suppo~
2. Available Suppo~
3. Contract Type &~
No comp.
Contract T
Market Co
3. Results
Normal
Hybrid
Inconsistency: 0.39750
Available~ 0.06045
Contract ~ 0.68261
Market Co~ 0.25694


1. Choose
Node
Cluster
Choose Node
Operation Safe~
Cluster: Environmental
Choose Cluster
Environmental
2. Node comparisons with respect to Operation Safety
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Operation Safety" node in "Environmental" cluster
Operation Safety is extremely more important than Operating Environment
1. Operating Envir~
>=9.5 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 >=9.5
No comp.
Operation
3. Results
Normal
Hybrid
Inconsistency: 0.00000
Operating~ 0.10000
Operation~ 0.90000


1. Choose
Node
Cluster
Choose Node
Operation Safe~
Cluster: Environmental
Choose Cluster
Economic
2. Node comparisons with respect to Operation Safety
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "Operation Safety" node in "Economic" cluster
Fuel Cost is moderately to strongly more important than Exchange Rates
1. Exchange Rates
2. Exchange Rates
3. Fuel Cost
>=9.5 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 >=9.5
No comp.
Fuel Cost
Operation
3. Results
Normal
Hybrid
Inconsistency: 0.26892
Exchange ~ 0.08471
Fuel Cost 0.20086
Operation~ 0.71443