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TECHNOLOGY AUDITING MODEL USING MULTI-HIERARCHICAL FRAMEWORK – FUZZY ENTROPY WEIGHT APPROACH IN PT DOK DAN PERKAPALAN SURABAYA

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ABSTRACT

PT Dok Dan Pekapalan Surabaya is an Indonesia leading company in ship repair field. With the growth of shipyard industries in Indonesia, company is expected to compete within tight competition. Problems arise when the reparation processes can't be finished on schedule. Respect to high vessel repairing demands, it can be a serious problem for company as they have many of ships waiting to be repaired. Technology management is expected to become a solution. Repair process within company is supported due to good management of technology policies. That's why technology assessment is necessary in this company. This research is proposed to be used as recommendation to PT Dok Dan Perkapalan Surabaya on how to measure and assess the technological capabilities of company. Technology Audit Model (TAM) is used as basic technology assessment model. While multi-hierarchical framework - Fuzzy Entropy Weight Approach (FEWA) are tools used to process the multi-criteria of assessment model. Based on the assessment, it can be known the weight and rank of all criteria, by which are be utilized as input for SWOT analysis. Based on this process, the the improvement strategies could be generated. The proposed strategies are knowledge sharing program, environmental impact evaluation, and project network.

Keywords : Technology Assessment, Technology Audit Model, MCDM, FEWA, SWOT, Multi-hierarchical Framework.

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PREFACE

Praise the Mighty Lord, Allah SWT, for His Blessing and Guidance, in helping the authors to successfully accomplish this final project entitled "Technology Auditing Model using Multi-hierarchical Framework - Fuzzy Entropy Weight Approach in PT Dok Dan Perkapalan Surabaya" just in time. This final project is composed as a requisite to achieve a Bachelor degree in Industrial Engineering Department of Institut Teknologi Sepuluh Nopember. Along the study processes, author receives help, motivation, and support from many parties. Therefore, author would like to express the sincerest gratitude to those who have supported and helped in finishing this final project. They are as following:

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Surabaya, January 2018

Author

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CHAPTER I
INTRODUCTION

This chapter will discusses the background in doing research, problem identification, research objectives, scope of research including limitations and assumptions, benefits gained through this research, and writing report system.

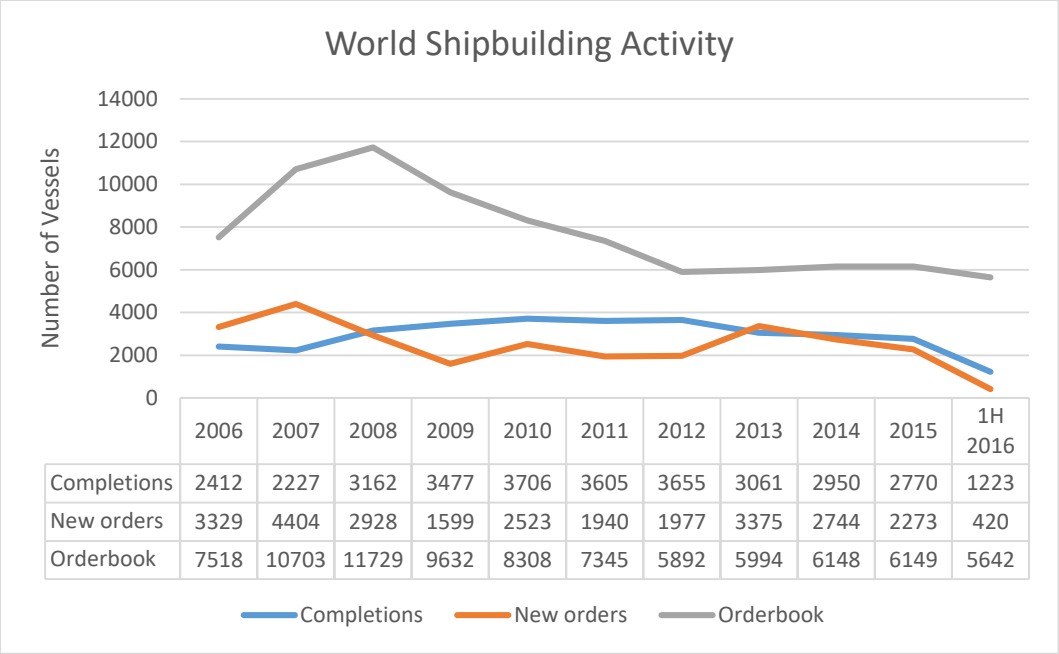
1.1 Background

Indonesia is the world's largest archipelago, with its 17,000 or so islands and span more than 5,000 km eastward from Sabang to Merauke. The territory of Indonesia stretches from 6°08' north latitude to 11°15' south latitude, and from 94°45' to 141°05' east longitude. Although in terms of area it is also considered as the largest country in Southeast Asia, only 30% (1,919,440 km²) is land, the rest is water. With the wealth and large coverage of sea, the investment and optimal exploitation of maritime sector in Indonesia can bring full advantages and support the country's economic growth.

According to Peraturan Presiden (Perpres) Nomor 16/2017 about Indonesian maritime policies, Indonesia has aim to set the country as a maritime power in the world. One of five pillars of developing Indonesian maritime power is infrastructure and maritime connectivity development (maritim.go.id, 2017). Indonesian National Shipowners Association (INSA) stated that national shipyard industries have significant correlation toward maritime connectivity development in Indonesia, since shipyard industries give full support to sea transportation activity, with the power of vessel building and repair.

Shipyard industry basically runs in ship building and ship repair business. Most shipyards are concentrated along the coasts, like Surabaya, Jakarta, and Batam in Indonesia. New ship building process includes parts fabrication and preassembling operations such as cutting, shaping, bending, machining, blasting, and painting. While ship repair process includes blasting, repainting, rebuilding and installation of machinery, system replacement and overhauls, maintenance and installation, structural reconfiguration, and major remodeling of ship interiors or

exteriors (EPA, 2001). Companies that build ships usually also have the ability to repair ships, including merchant vessels, warships, barges, cargo, and others. Based on Ministry of Industry report, shipyard industries contribute to 39.1% of PDB with sector growth of 6.6% in 2013. Hence the role of shipyard industry is very essential especially a country with large coverage of sea like Indonesia.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	1H 2016
Completions	2412	2227	3162	3477	3706	3605	3655	3061	2950	2770	1223
New orders	3329	4404	2928	1599	2523	1940	1977	3375	2744	2273	420
Orderbook	7518	10703	11729	9632	8308	7345	5892	5994	6148	6149	5642

Figure 1. 1 World Shipbuilding Activity (IHS Fairplay, 2016)

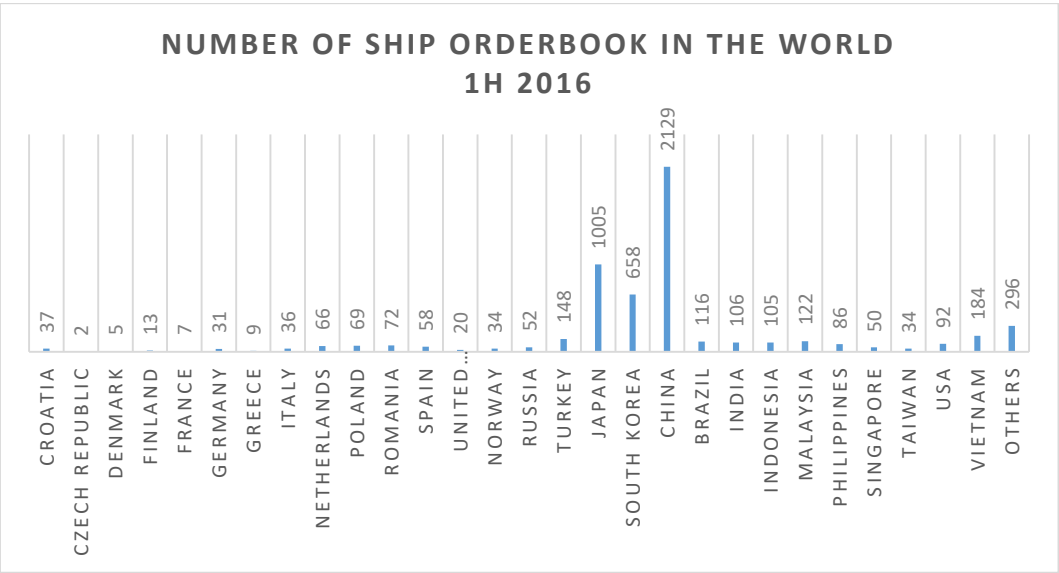


Figure 1. 2 Number of World Ship Orderbook in First Half of 2016 (IHS Fairplay, 2016)

In fact, shipyard industry has fluctuating trend in the last ten years. According to IHS Fairplay report (Figure 1.1), in first half of 2016 (January – June) there are new 420 vessel orders and 1223 vessel completions in the world. In total there are 5642 vessel orderbooks, a stage when the vessels on the shipyards' books between the new order and delivery stages. Indonesia contributes 0,0186 % of total orderbooks with 105 vessels worked in year of 2016 (Figure 1.2). That's more than most of the European countries and top three highest orderbooks in Southeast Asia. In addition there are 3 new orders and 42 completion of vessels in 2016. Therefore Indonesia's potential to become a major player in the global shipping industry is still considerable.

Those fact concludes that the shipyard market has high potential in Indonesia since there are many ship demands with various types from local and global markets over years. Vessel has a purpose as a means of transport linking economic activities between islands in Indonesia provides transportation and working facilities of mining, fisheries, tourism, and defense system. So the need for the ship will continue to increase, so does the need of maintenance. Moreover Indonesian government is intensively boosting the maritime sector. With many maritime policies included in country vision of becoming a maritime power in the world, the need of new vessels and its maintenance is very high. With high demand in Indonesia, there are many shipyard companies can be found. Nowadays there are about 250 shipyard companies in different locations in Indonesia, up to 1 million of DWT per year for ship building and 12 million DWT per year for ship repair. Most of them located at Batam, Riau, and Java Island. They have been recognized as having good ship building technology capability and reliable ship repair process. However the exploitation and utilization of shipyard industry in Indonesia is not optimal yet. According to data from the Ministry of Industry, there are 15,000 units of fleets in Indonesia, but only 10 % of them are made in Indonesian shipyard, the rest are imported. To overcome this problem, Indonesian government encourages the maritime stakeholders to use Indonesian vessels instead of importing them. It supported by restitution of PPn for Indonesian shipyard companies as well as the reduction / removal of customs duty of some raw materials / spare parts for ship building and ship repair (INDEC, 2015). It shows government's desire to boost the

country's domestic shipyard industry as part of a broader effort to strengthen the country's maritime capabilities. So the growth of shipyard industries in Indonesia is expected to increase thus making related sector become more competitive.

The reality is one of the challenges for Indonesia's shipyard is low level of ship building and repair technology and its management. The development of ship building technology will also foster the development of shipyard industry, but the use of technology is still not maximized in Indonesia. Compared to market leader like South Korea or Japan, Indonesia is still far away in term of shipyard technology. Building 10,000 DWT tanker takes 18 months in Indonesia. Whereas at Hyundai, South Korea, a 260,000 DWT tanker can be completed in just nine months (Marintec Indonesia, 2015). The competitiveness level of shipyard industry are expected to genereate technology development in Indonesia. Vice versa, management of technology can be a critical factor for a company to survive in the shipyard industry market, since the competition is very tight.

PT Dok Dan Pekapalan Surabaya (Persero) is an Indonesia leading company in ship repair and ship building field, with various types and sizes of ship ordered by clients around the world with certification of ISO 9001 international standard for ship design and construction certified by LR (Lloyd's Register). The production area of PT Dok Dan Perkapalan as a shipyard vary greatly, including ship building, ship repair, ship conversion, offshore construction, steel structure fabrication, design and engineering.

Table 1. 1 Number of Vessel Processed in 2017

Type of Vessel	Vessel Repaired	Vessel Constructed
KM	21	0
SV	5	0
CB	5	0
KMP	18	0
BG	10	0
KRI	4	0
MT	5	0
AHTS	3	0
AWB	1	0

Type of Vessel	Vessel Repaired	Vessel Constructed
AHT	5	0
MV	1	0
TB	9	0
LCT	3	0
SPOB	1	0
Total	91	0

Source: Internal Company

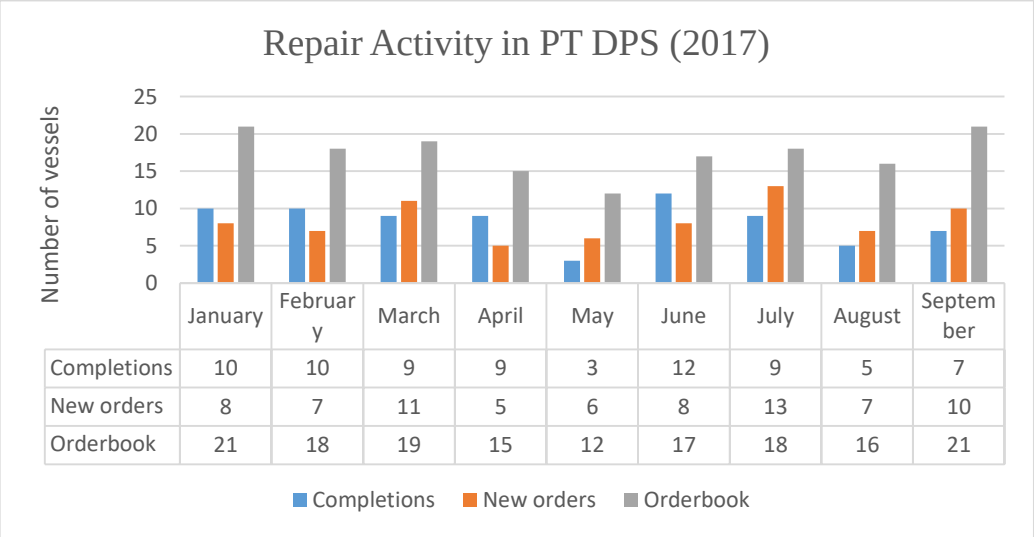


Figure 1. 3 Repair Activty in PT DPS (Internal Company, 2017)

PT Dok Dan Perkapalan experts in ship repair sector, with 4 floating dock in the shipyard. They are used together with other facilities and machines useful for repairing various type of vessels up to 10,000 DWT, such as passenger ships, tanker, cargo vessels, tug boats, supply vessels, ferry boats, navy vessel, and many more. Can be seen that PT DPS focuses on ship repair activity rather than ship construction. In January until September 2017, there are 91 different vessels repaired in PT DPS, compared to 0 ship built (Table 1.1). This happens because according to the company, the repair activity bring more economic profit than building activity. The repair demand trend itself is quite stable for every month (Figure 1.3). Moreover those number of vessel repair demand are considered quite high for a shipyard company.

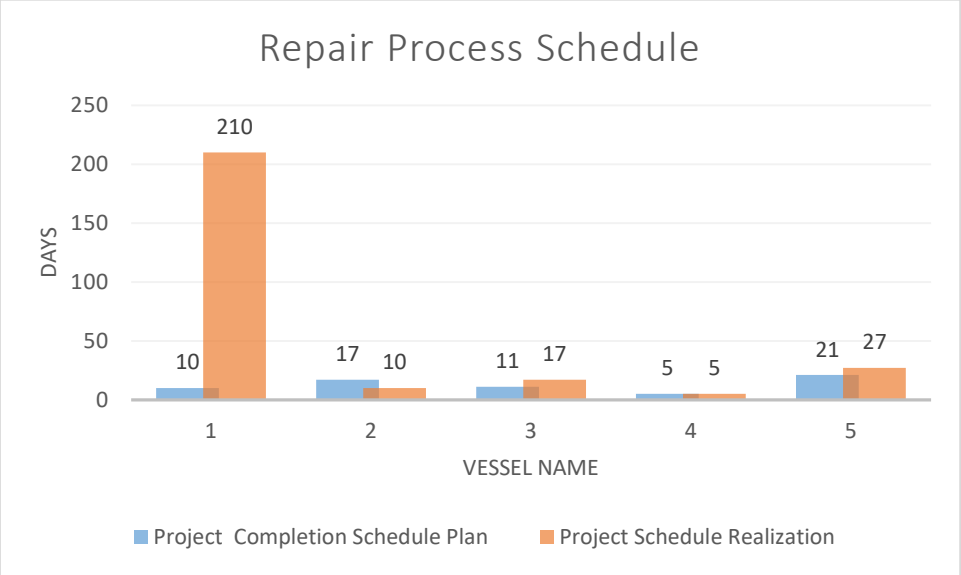


Figure 1. 4 Repair Process Schedule (Internal Company, 2017)

Problems arise when the reparation processes are expected to be completed on schedule. In fact, some of the reparation orders can't be finished on time. Based on five sample of repair processes (Figure 1.4), can be seen that most of orderbooks are late on completion. With high vessel repair demands, it can be a serious problem for company as they have many of ships waiting to be repaired. Research conducted by Abdul Rahman and Heri Supomo (2012) stated that schedule accuracy are included in very important attribute for customer satisfaction. Since time of completion is one of the important attribute to attract customers, company must find a way to overcome this difficulty especially for surviving the tight shipyard market competition in Indonesia.

Technology management is expected to become a solution. Technology here embraces more than just machines since there are several technological entities besides hardware, including software, methods, systems, and human abilities employed in the creation of goods / services (Khalil, 2000). Management of technology needed as a tool used to manage the systems that enable creation, acquisition and exploitation of technology in a company, including shipyard industry. With a good management of technology policies in a company, it can accelerates the repair time of vessels. In reality, PT Dok Dan Perkapalan Surabaya still doesn't implement the proper management of technology policies yet. They

don’t know the right action to exploit and manage their various technologies as a way to meet their demand and run the business. Moreover they still can’t identify their technological position relative toward other competitors. What they know is that the technology owned by shipyard company all must be the same. The truth is if company can’t measure their technology, they can’t manage their technology properly. So, technology assessment is necessary in this company. Assessment provides a gap determination between the existing and the desired technological situation and, respectively, offers an evaluation about possibilities for upgrading technological capabilities.

Technology Audit Model (TAM) can be used as technology assessment model. It is a technology assessment framework proposed by Garcia-Arreola (1996). It is one of internal technology audit methods used in management of technology to identify and assess the strength and company’s technology position in business competition to take advantage and seek for opportunities from company’s capabilities. TAM model was already performed and implemented by Dolinšek (2007) for the Slovenian service and manufacturing companies. Actually there are several technology audit framework beside TAM. One of the commonly used method is technometric approach. Unlike technometric method which is based on only four components: technoware, humanware, infoware, and orgaware according to ESCAP classification (1998), TAM model is more complete because of its comprehensive and thorough area categorizations like Technological Environment, Technologies Categorization, Competitors and Market, Innovation Process, Value Added Functions, and Technology Acquisition and Exploitation. So basically TAM focuses more in functionality of company in thoroughly not only in the technological hardware scope. Therefore it is suitable with the selected object since in this business, the critical things in doing reparation processes are not only related to technological scope but the interaction between the functional organization to support the activity. Moreover based on research conducted by Shirazi (2009), the six areas of evaluation in the Technology Audit Model is suitable with manufacturing and service engineering industries. However, adjustment of this model is conducted to have better assessment model which is suitable with PT Dok Dan Perkapalan Surabaya business process, especially in ship repair process.

To support the implementation of many assessment criteria like that, can be used a multi-criteria decision making approach as the weighting or assessment tools. The assessment will be conducted internally with the help of internal experts from company. They will apply scale assessment for each criteria. The experts are came from different work unit to increase the possibility of various input for assessment, so good and more objective decision making supporting tool is obtained.

Fuzzy Entropy Weight Approach (FEWA) as MCDM tool is suitable for this kind of problem. This method is selected over other methods because of its simplified structure ease decision maker from complex analysis that are experienced using other weighting method, such as AHP or ANP (Ighravwe, 2017). Fuzzy set theory is designed to deal with the extraction of the primary possible outcome from multiplicity of information that is expressed in vague and imprecise terms (Zadeh, 1965). Fuzzy set theory threats vague data as probability distributions in terms of set membership, thus can be used in logical reasoning. Meanwhile, entropy has a superiority for accommodating instability in attribute and decision makers as it terms as a measurement tools of the system disorder in thermodynamic. With the combination of both method, FEWA is very powerful in facilitating many imprecise information and thought from expert judgements that come from different backgrounds of function to strengthen the assessment.

Since there are so many criteria and hierarchies, multi-hierarchical framework analysis can be used as technology assessment framework because it can identify many criteria and categories based on their hierarchy level. Instead of common single framework, this framework can facilitates multi assessment level. Each level will generates different model of weighting depends on the number of category it has. Therefore this framework can give multi-preference to support detailed analysis in decision making process since it consider multiple level of hierarchy. It has been proven to be suitable with FEWA method with research conducted by Ighravwe (2017) for ranking maintenance sustainability strategies implemented in cement production plant.

Based on the assessment result, the position and appropriate strategies for company can be generated using SWOT analysis method. This method will

consider not only the assessment result but also the external factors affecting company. Therefore this research combining TAM criteria and multi-hierarchical framework - FEWA is conducted to give a recommendation to PT Dok Dan Perkapalan Surabaya as a shipyard company on how to measure and assess the technological capabilities of company.

1.2 Problem Formulation

Based on research background, the discussed problem for this research is how to measure technologies and propose technology improvement strategy which will be used as recommendation to support repair activities in PT Dok Dan Perkapalan Surabaya (Persero).

1.3 Research Objectives

The objectives to be achieved in this research are as follow:

1. Identify criteria of technology auditing model which are suitable for company.
2. Measure criteria of assessment using multi-hierarchical framework - Fuzzy Entropy Weight Approach (FEWA).
3. Identify the position of company using SWOT analysis.
4. Provide technology impovement strategy as recommendation based on the assessment result.

1.4 Research Benefits

This research is expected to provide benefits for company, which are as follows:

1. Company can measure and identify their technology position related to ship repair activities.
2. Company obtain recommendation of technology improvement strategy based on assessment conducted.
3. Company can consider the implementation of this research to survive and compete in Indonesian shipyard industry market.

1.5 Research Scope

The scope for this research consists of limitations and assumptions used in doing this research. Limitations' purpose is to limit the scope of research, while assumptions' purpose is to simplify the real condition within company as an object.

1.5.1 Limitations

Limitations used for this research are as follow:

1. Company experts are employees with great experience, high education, and considered as an old hand in the company.
2. The term technology used for this research focuses on company's ship repair technology and its supporting sectors.

1.5.2 Assumptions

Assumptions used for this research are as follow:

1. Technologies in company remain the same during this research time period.
2. Company's vision, mission, organization structure, and strategies remain the same during this research time period.

1.6 Report Writing Structure

The report writing structure used for the research is as follow:

CHAPTER I INTRODUCTION

This chapter discusses about background in doing research, problem identification, objectives of the research, benefits of the research for both company and author, research scope including limitations and assumptions used, and report writing structure for this research.

CHAPTER II LITERATURE REVIEW

This chapter discusses about the various compilation of literatures from several resources, consist of theories and methods used as guidelines in this

research. All of the theories and methods used will be explained in this chapter and divided into systematic critical discussion.

CHAPTER III RESEARCH METHODOLOGY

This chapter discusses about research methodology consist of systematical work flow, start from initial step until the last. All of the explanation of how the research is conducted from the beginning to the end can be found in this chapter.

CHAPTER IV DATA COLLECTING AND PROCESSING

This chapter discusses about the data gathering related to the research and how the data are processed to obtain the solution for this research problem. It consist of systematical explanation about the method used until the final result. The result will be analyzed later in next chapter.

CHAPTER V DATA ANALYSIS AND INTERPRETATION

This chapter discusses about the analysis and interpretation of the processes and result from previous chapter. Analysis and interpretation are conducted according to the research objectives.

CHAPTER VI CONCLUSION AND RECOMMENDATION

This chapter discusses about the detailed information of the research final result. Conclusions must answer the problem formulation and research objectives to ensure the work of this research are appropriate as expected before. While recommendation given to further researchers.

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CHAPTER II
LITERATURE REVIEW

This chapter will discuss various compilation of literatures from several resources such as books, articles, scientific journals, previous studies, and other sources. Literature review will be used as the guidelines in doing the research and can provide answers to the questions raised in the problem formulation. The literatures that will be explained are divided into critical discussion of Technology, Technology Assessment, Multi Criteria Decision Making (MCDM) approach, and SWOT analysis.

2.1 Technology

This sub-chapter will give explanation about technology definition, Management of Technology (MOT), and technology planning.

2.1.1 Technology Definition

According to Khalil (2000), technology can be defined as all of knowledge, products, processes, tools, methods, and systems employed in the creation of goods. Judet & Perrin (1971) add some definition to technology, which is a collection of scientific knowledges, machineries, tools, and the abilities of organizations managed systematically and effectively. Basically technology can be known as the way we do everything to achieve any specified target. Technology is a practical implementation of knowledge, a means to assist human activities.

Generally technology is always associated with hardware entity such as machine, computer, or highly advanced electronic gadget. However, technology embraces more than just machines. There are several technological entities besides hardware, including software and human abilities. Zeleny (1986) stated that technology consists of three interdependent, codetermining, and equally important components which are hardware, software, and brainware. Here are the explanation of those three components:

1. Hardware : the physical structure and logical layout of the equipment or machinery that is to be used to perform the required tasks.
2. Software: the knowledge of how to use the hardware in order to perform the required tasks.
3. Brainware: the reasons for using the technology in a particular way. Can be referred as the know-why.

In addition to three components above, Khalil (2000) proposed a fourth component which must be considered independently, for it cover all levels of technological achievements. That component is know-how, the learned or acquired knowledge of or technical skill regarding how to do things well. Know-how may be a result of experience, transfer of knowledge, or hands-on practice. This component can be acquired by receiving formal or informal education (training), working closely with an expert in a certain field, or perform recognized method of technology transfer.

Technology also can be classified in several ways. Here are the classification of technology according to its types (Khalil, 2000):

1. New technology: any newly introduced or implemented technology that has an explicit impact on the way a company produces products or provides services.
2. Emerging technology: any technology that is not yet fully commercialized but will become so within several years.
3. High technology: advanced or sophisticated technologies which involve many variables.
4. Low technology: technologies that have permeated large segments of human society.
5. Medium technology: technologies that fall between high and low technologies, usually refers to mature technologies that are more amenable than others to technology transfer.
6. Appropriate technology: technology which is utilized for optimal use.
7. Codified technology: technology which is easier to transfer and undertand.

8. Tacit technology: nonarticulated knowledge/technology which is usually based on experiences of developers.

2.1.2 Management of Technology

Actually until this day there is no unanimous agreement on the definition and scope of Management of Technology. The concept of technology management continuously grow and difficult to formulate because its multidisciplinary characteristic. Interest in MOT made the revolutionary concept became popular amongst people from three very different stratum of society, which are organizational management, scientists/researchers and academicians (Shenhar, 1990). Management of Technology (MOT) can be defined as a discipline connecting the field of engineering and science with the field of management devoted to planning, development, and implementation of technology in order to achieve strategic and operational target in an organization (Nazaruddin, 2008).

While Khalil (2000) had broader definition of MOT, which is an interdisciplinary field that integrates science, engineering, and management knowledge and practice. This Interdisciplinary nature of MOT includes engineering, social science, natural science, business theory, and industrial practice with technology focused as primary factor in wealth creation. Wealth creation embraces more than just money, but any factors like enhancement of knowledge, intellectual capital, effective exploitation of resources, preservation of the natural environment, and other factors that can contribute to raising the standard of living and quality of life.

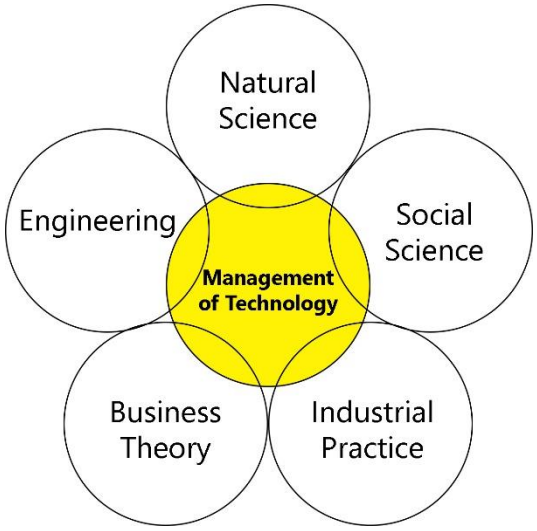

Figure 2. 1 The Interdisciplinary Nature of MOT (Khalil, 2000)

The whole focus of MOT is shifting towards technological awareness its incorporation into the academic circles, exposure of related industry and formulation of an all encompassing model for the evaluation as technology audit, planning and forecasting procedures and models (Cetindamar, et al., 2006).

MOT can be said as managing the systems that enable creation, acquisition and exploitation of technologies. It involves assuming responsibility for creating, acquiring, and convert technology to help human endeavors and satisfy customers' needs. However, more essential things for the wealth creation in MOT is the exploitation or commercialization of technology. The benefits are obtained if only when technology is connected with a customer. A customer can be defined as a beneficiary and could be an individual, a corporation, or a government entity. An innovation made and put on a shelf is not contributing to wealth and does not bring monetary returns. Technology generates wealth when it is commercialized or used to achieve a desired strategic or operational objective for a company.

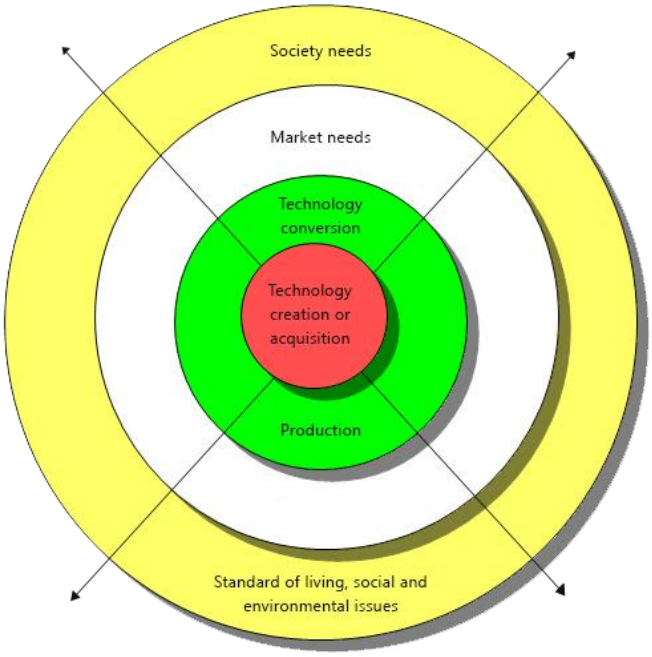

Figure 2. 2 The Connection of Technology to Satisfy Customer (Khalil, 2000)

MOT also can be defined according to its dimensions, like national, organizational, and individual dimensions. At individual level, tehcnology is a tool or method used to support the enhancement of one's worth in society. At firm level (micro-level), as we know MOT is defined as an interdisciplinary field of technological capabilities to shape and accomplish the operational and strategic objectives of an organization. It contributes to the creation and sustainability of competitive enterprises. At national/government level (macro-level), MOT is defined as a field of knowledge concerned with the setting and implementation of policies to deal with technological development and utilization, and the impact of technology on society, organizations, individuals and nature. It contributes to shaping public policy.

2.1.3 Technology Planning

Business planning is a central managerial function integrated with other important management functions of organizing, staffing, motivating, and controlling activities of a corporate. Technology planning plays important role in business planning. It is needed both at the corporate level and at the strategic

business unit level (Steele, 1989). Technology planning is a part of corporate ability to give customers superior value based on superior technology. Planning must be systematic and follows established methodologies, unlike strategizing which need more creativity (Hamel, 1996). Therefore planning is important for successful strategy implementation and evaluation.

Khalil (2000) determined the processes of planning, which are important as the plan developed. Here are the processes:

1. Examining all points of view in the organization.
2. Setting clear, realistic objectives.
3. Charting a path or paths toward achieving those objectives.
4. Obtaining commitment for execution.
5. Executing and following up on the plan.

While Porter et al. (1991) stated a technology planning framework which consist of general process of strategic planning used by many company. The framework focus on forecasting the technology and the market, to assess several aspect such us opportunities and needs, company's strengths and weaknesses, and strategy to achieve the company's goals. Here are the processes from the framework:

1. Forecast the technology.
2. Analyze and forecast the environment.
3. Analyze and forecast the market/user.
4. Analyze the organization.
5. Develop the mission.
6. Design organizational actions.
7. Put the plan into operation.

B-TECH is a comprehensive approach to technology planning. It was proposed by Stacey and described by Bhalla (1987). It shows the essentials functions that should be performed in a comprehensive planning effort. Not only that, B-TECH also consider the importance of integrating technology strategy with business strategy. In order to integrate both of technology and business strategy, B-TECH proposed 11 steps as shown in Figure 2.3.

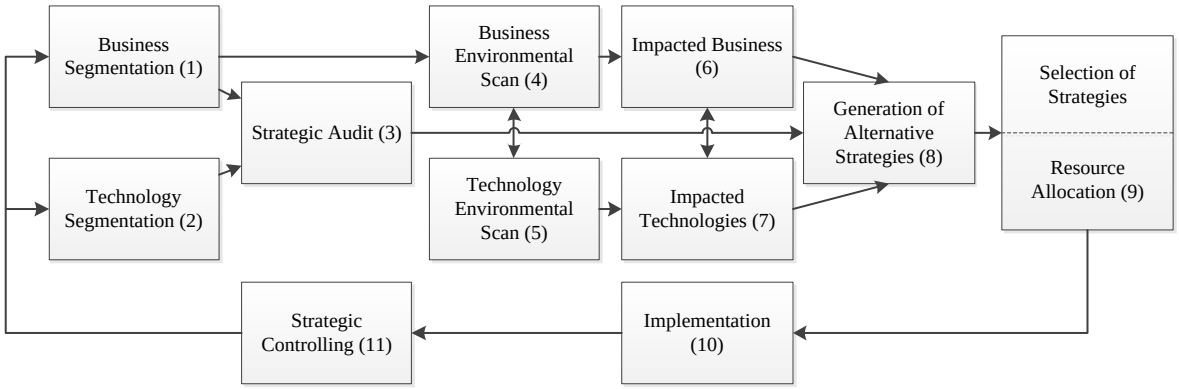

Figure 2. 3 B-TECH approach (Bhalla, 1987)

2.2 Technology Assessment

This sub-chapter will give explanation about technology audit and Technology Audit Model (TAM) as the technology assessment method.

2.2.1 Technology Audit

Technology audit is an analysis performed to identify the strengths and weakness of the technological assets of an organization (Khalil, 2000). Technology audit is used as the technology assessment to know the firm's position in technology in relation to its business competitors and the state of the art. The audit applied to all aspect of technologies in the firm, such as production technology, service technology, and marketing technology. The purpose is to develop a technology strategy, policy, or plan based on the assessment.

Martino (1994) stated that technology audit is intended to evaluate the state of the organizations technology resources. He classifies the technology audit or technological evaluation on the basis of base, key and pacing technologies and the key of success. In order to address difficulty of evaluation of the technological state, Martino uses four different taxonomies for various technologies namely technical discipline, function performed product category and underlying science.

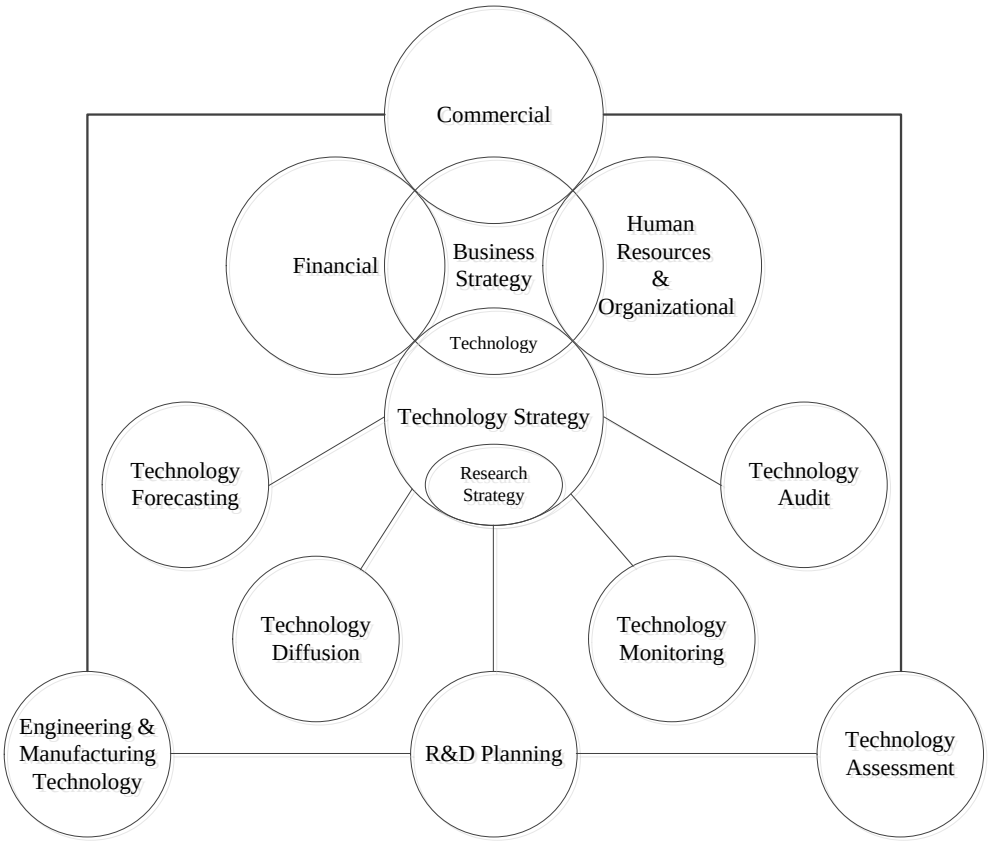

Figure 2. 4 Comprehensive Technology Planning B-TECH (Bhalla, 1987)

Both technology audit and technology assessment are important activities in technological planning based on B-TECH (Bhalla, 1987). This approach views technology planning as a major set of activities, not only R&D but more than that. It showed in the interaction of business and technology strategies in Figure 2.4. Can be seen that according to B-TECH, technology audit plays an essential factor in technology strategy in term of planning. It shows how related the audit of technology is with business planning.

Ford (1988) stated that a technology audit should provide answers to the following questions:

1. What are the technologies and know-how on which the business depends?
2. How does the company's technology position compare to its competitors? Is it a leader, a follower, or a laggard?
3. What is the life-cycle position on which the company depends?

4. Where is the company's strenght? Is it in product or production technologies or a combination of technologies?
5. Is the company effectively protecting its distinctive core technologies?
6. What emerging or developing technologies, inside or outside the company, could affect its technological position?
7. What is the value of the company's technology to its customers? Is there a big technology gap that gives the company an advantage in knowledge as well as in pricing its products?
8. Does the company have a systematic procedure and a supporting organizational structure that allows optimal exploitation of its technologies internally and externally?
9. Does the company have technological assets that it can share with other companies? Some of the ideas that need to be explored include selling technology that is no longer of use to the company, creating joint ventures to exploit the company's areas of strength, and transfering technology to another company or country.
10. What emerging or developing technologies, both inside and outside the company, could influence customers or affect the company's market position?
11. What social, political, or environmental factors might impede the natural progress of the company's technological plans?

According to Kelessidis (2000) there is general procedure in doing technology audit for a company. It consist of ten steps which are:

1. Desire / wish of firm to carry out technology audit.
2. Selection of intermediary organization / expert to carry out the technology audit.
3. First contact / visit of expert to firm to discuss on procedure / benefits of technology audit and the audit steps.
4. Preparatory work by expert on collecting basic information on the firm and the sector.
5. General short diagnosis and identifying technological areas for further analysis.

6. Data analysis by expert - report on first diagnosis.
7. Presentation of first diagnosis report to General Manager and company management.
8. Additional visits / interviews to chosen department heads. These visits may be done either by the generalist, the specialist or jointly.
9. Final report of the technology audit, compiled by the experts, which should cover subjects analysed, methodology used, problem areas identified, and solutions proposed by the experts.
10. Presentation of report by experts to company management aiming at discussing issues identified, discussing solutions proposed / identifying alternative solutions, discussing / finalizing action plan, setting up a monitoring system for plan implementation with / without the aid of the experts.

The truth is there is no standard requirements about evaluating technological capabilities like quality audits that are one of the integral requirements of the ISO 9000 series, thus making technology audit in company often based on experience. Therefore there are several technology audit method developed, such as technometric method and technology audit model (TAM). In technometric method, the assessment is based on four components: technoware, humanware, infoware, and orgaware. Said components will later determining transformation facility characteristics and facilities development based on sophistication level of used components. State-of-the-art assessment, with all its qualitative criteria, first and foremost as a quantitative metod is used. Then to assess company's technology contribution, technometric approach propose Technology Contribution Coefficient method. The result will be plotted in a THIO diagram for easier analyses.

2.2.2 Technology Audit Model (TAM)

Garcia-Arreola (1996) proposed a technology audit tool called Technology Audit Model (TAM) which includes lot of areas to be considered in technology audit. The purposes of TAM are to determine current technological status, to stress areas of opportunity, and to take advantage of the firm's strong capabilities. This model is very helpful for technology mapping support and portfolio of technology

developing projects. TAM is also helpful for the review of existing as well as evolving company competencies.

TAM is a model consists of three level, with each level going deeper into more specific functions. There are six categories in the upper level, 20 categories in second level, and 46 assessment elements in the third level. Lot of assessment level and component indicates how complete this assessment is for measuring firm's complex processes. The company's assessment result should be the criteria used to evaluate the effectiveness of its technology management capability.

TAM scores using five-point scale for each assessment elements in third level. 5 is outstanding, 4 is very good, 3 is good, 2 is fair, and 1 is poor (Shirazi, 2009). The ideal score is 5 and the avoided score is 1. Here is a TAM model structure proposed by Garcia-Arreola.

Table 2. 1 TAM Structure by Garcia-Arreola

Technology Audit Model (TAM)					
No	Criteria	No	Sub-criteria	No	Sub sub-criteria
1	Technological Environment	1.1	Senior executive leadership and orientation	1.1.1	Technology as a top priority
				1.1.2	Involvement and participation
		1.2	Technology strategy	1.2.1	Corporate strategy
				1.2.2	Goals
				1.2.3	Deployment
		1.3	Organization structure	1.3.1	Organizational chart
				1.3.2	Teamwork
		1.4	Technology culture advancement	1.4.1	Culture
				1.4.2	Learning organization
				1.4.3	Communication
				1.4.4	Management of change
		1.5	People	1.5.1	Recruiting policies
				1.5.2	Training
				1.5.3	Empowerment
				1.5.4	Reward system

Technology Audit Model (TAM)					
No	Criteria	No	Sub-criteria	No	Sub sub-criteria
2	Technologies Categorization	2.1	Service/product technologies	2.1.1	Internal technologies
				2.1.2	External technologies
				2.1.3	Basic technologies
				2.1.4	Technology trends
		2.2	Back office/process technologies	2.2.1	Internal technologies
				2.2.2	External technologies
				2.2.3	Basic technologies assessment
				2.2.4	Technology trends
		2.3	Technology in marketing	2.3.1	Innovation in marketing
				2.3.2	The product-service concept
3	Markets and Competitors	3.1	Market needs	3.1.1	Market assessment system
				3.1.2	Marketing of technology
		3.2	Competitors' status	3.2.1	Competitor assessment
				3.2.2	Benchmarking
4	Innovation Process	4.1	Idea generation	4.1.1	Intrapreneurship
				4.1.2	Entrepreneurship
		4.2	Technology generators	4.2.1	Science push
				4.2.2	Market pull
		4.3	From concept to market	4.3.1	Break-even time and break-even cost
5	Value-added Functions	5.1	Research & Development	5.1.1	Cross-functional teams
				5.1.2	Portfolio justification
				5.1.3	Sucess/failure analysis
		5.2	Operations	5.2.1	Improvement

Technology Audit Model (TAM)					
No	Criteria	No	Sub-criteria	No	Sub sub-criteria
		5.3	Environment-conscious technology	5.3.1	Green products and processes
				5.3.2	After-life analysis
6	Acquisition and Exploitation of Technology	6.1	Acquisition of technologies	6.1.1	Method of acquisition
				6.1.2	Capital investment
		6.2	Transfer of technology	6.2.1	Transfer procedures
				6.2.2	People transfer
		6.3	Exploitation for profit	6.3.1	Exploitation for profit
		6.4	Protection	6.4.1	Protection

Source: (Khalil, 2000)

Unlike technometric method which is based on only four components: technoware, humanware, infoware, and orgaware according to ESCAP classification (1998), TAM model is more complete because of its comprehensive and thorough area categorizations. TAM values attributes like management, leadership, innovation, strategy, organization structure, employees, technology, process, market, environment, and knowledge. TAM result can also assesses spesific criteria not absolutely depend with category unlike technometric approach. Moreover, basically TAM focuses more in various aspect of technology of company in thoroughly not only in the technological hardware scope. Therefore it is suitable with service industry like shipyard company since in this business, the critical things in doing reparation processes are not only related to technological scope but the interaction between all of the functional organization to support the activity.

2.3 Multi Criteria Decision Making Approach

This sub-chapter will give explanation about Multi Criteria Decision Making (MCDM) and Fuzzy Entropy Weight Approach (FEWA) as the decision making tool.

2.3.1 Multi Criteria Decision Making (MCDM) Definition

Decision is a moment in a process which evaluating the alternative courses to achieve the objective where the expectation of the related process can make the decision maker choose the alternative with the best (Harrison & Pelletier, 2000). Decision is an essential things when there is defined problem or some objective with several alternative of criteria and attributes.

Decision making proccess is a process of selecting alternatives courses to achieve some objective (Turban, 1995). It is the core process in any organization or company. With good decision making process, the company will be guaranteed to achieve the related goal. There are several function and stages of decision making process (Harrison & Pelletier, 2000). First is determine the managerial objective. Decision making process started by determining the objective and decision cycle. Second is finding alternatives. Finding alternatives done by observe the internal and external aspect to obtain the related information in finding the alternatives which can achieve the objective. Third is compare and evaluate alternatives. Alternatives then compared and evaluated using method of selecting alternatives to make a decision. Fourth is selecting process. Decision maker will select an alternatives. Fifth is implementation of decision. Decision then will be implemented in operational strategy. Sixth is follow-up and control. Implemented decision must be controlled and followed up so it ensure the process of achieving objective.

Multi Criteria Decision Making is one of the most used methods to makes decision. The purpose of MCDM is to select the best alternative from several set of alternative that consist of criteria which conflicting with each other. MCDM is used for complex problem because the criteria involved in the problem are plural (Tabucanon, 1988). The degree of difficulty of decision making is far more sensitive with the number of criteria. Criteria is the measurement, rules or standards in decision making process. Decision making process done by selecting or formulating different attributes, objectives, and goals, then they are set and considered as criteria. Criteria is built on the basic human needs and values it desires.

In MCDM, there are several elements which must be considered. First is attribute. It explains and gives a characteristic toward object. For example: height,

weight, length, etc. Second is Objective. It discusses about the direction of improvement or preference for attribute. For example: maximizing the age, minimizing cost, etc. Third is goal. It must defined at the start. For example for "to maximize the profit" objective, the goal is to achieve 10 million profit/ month.

Characteristic of MCDM problem are:

1. There are two or more attributes and criteria which are conflicting with each other.
2. There are more than two alternatives solution of decision.
3. The conflictiual character are intrapersonal and interpersonal.

According to Hwang & Yoon (1981) there are 2 types of MCDM, which are Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM). Multiple Objective Decision Making (MODM) discussing about the designing process where mathematical opimation method is used for big number of alternatives (to unlimited alternatives) to answer the question of what and how much. While Multiple Attribute Decision Making (MADM), discussing about selection problem, where mathematical analysis is less important and can be used for other alternatives with small number of alternatives. The detailed differences of both method can be seen in Table 2.2 according to Ciptomulyono (2010).

Table 2. 2 MCDM Technique

Decision Element	MADM	MODM
Criteria	Attribute	Objective
Objective	Implicit	Explicit
Attribute	Explicit	Implicit
Alternative	limited	unlimited and continuous
Interaction	Infrequent	Frequent
Usage	Problem and alternative selection	Conception and engineering problem
Method example	AHP, ANP, ELECTRE, PROMETHEE, entropy, TOPSIS	Global citeria, compromise programming, goal programming, GPSTEM

Source: (Ciptomulyono, 2010)

2.3.2 Fuzzy Entropy Weight Approach (FEWA)

Fuzzy Entropy Weight Approach (FEWA) is a tool used for evaluating and weighting the criteria. It simplified structure ease decision maker from complex analysis that are experienced using other weight method, such as AHP or ANP (Ighravwe, 2017). The speciality of this approach is the use of entropy weighting method together with fuzzy number.

Fuzzy set theory is designed to deal with the extraction of the primary possible outcome from multiplicity of information that is expressed in vague and imprecise terms (Zadeh, 1965). Fuzzy set theory threats vague data as probability distributions in terms of set membership, thus can be used in logical reasoning. Fuzzy number set shape is vary, the common shape used is triangular fuzzy number. Triangular fuzzy numbers are utilized to consider the vagueness in human thoughts. In triangular fuzzy number, each element x in X to a real number in the interval [0,1] is mapped into function $f_A(x)$ which represents the grade of membership of x in A. Then a fuzzy number A in real line R is a triangular fuzzy number if its membership function f_A: R → [0,1] is:

$$f_A(x)\begin{cases}\dfrac{x-c}{a-c}, c \le x \le a \\ \dfrac{x-b}{a-b}, a \le x \le b \\ 0, \quad otherwise\end{cases} \tag{2.1}$$

The graphical representation of this function can be seen in Figure 2.3.

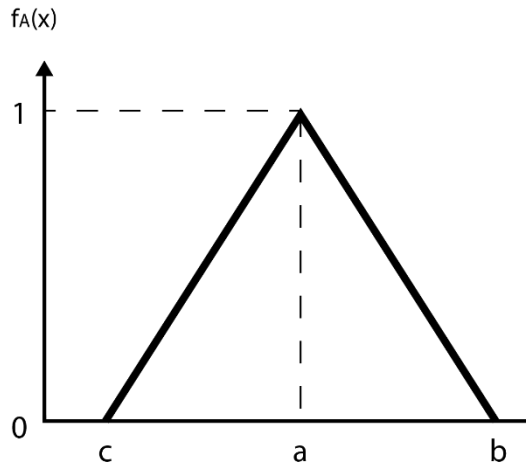

Figure 2. 5 A Triangular Fuzzy Number of (c,a,b)

With $-\infty < c \leq a \leq b < \infty$, the triangular fuzzy number can be denoted by (c,a,b). The application of triangular fuzzy number has already used by Ding (2011) in the research about ranking alternatives case. Can be seen that this approach is effective for linguistic value with 5 scale scoring.

While entropy concept was proposed by Shannon & Weaver in 1949. Since that, this method become well suited approach for measuring the relative contrast intensities of criteria to represent the average intrinsic information transmitted to the decision maker (Zeleny, 1986). In thermodynamical systems entropy is the extensive property of heat or energy change per degree Kelvin temperature. The entropy of the system is measured in terms of the changes the system has undergone from the previous state to the final state. So basically it is a measure of the disorder of a system. Therefore entropy weight method as a multi criteria tool is suitable for accommodating instability in attribute and decision makers. The basic idea of the structure entropy weight method is to analyze the indexes of the assessment system and the interrelationship between them, and then to classify the indexes into independent hierarchical grades. With score of hesitant fuzzy number, can be calculated the entropy value to obtain the weight of attributes. This combination approach can be called Fuzzy Entropy Weight Approach (FEWA).

FEWA first proposed by Sun Qiaoping and Ouyang Jiewen in a research about energy police selection problem (2015). Here Sun and Ouyang use Hesitant Fuzzy Entropy Weighted Method term instead of FEWA, while the name was proposed by Ighravwe (2017) later. FEWA method consist of three important steps which are design of decision matrix, determination of entropy values and estimation of criterion weight. The procedures for FEWA are explained as follows:

- Step 1: Design of decision matrix.

  Decision matrix is designed using linguistic terms. The five-scale linguistic expressions are employed to evaluate the criteria. They are characterized by triangular fuzzy numbers.

Table 2. 3 Linguistic Expression and Triangular Fuzzy Numbers

Linguistic values	Fuzzy number
Poor	(0, 0, 0.25)
Fair	(0, 0.25, 0.5)
Good	(0.25, 0.5, 0.75)
Very Good	(0.5, 0.75, 1)
Outstanding	(0.75, 1, 1)

The triangular fuzzy number above are translated into crisp values using Graded Mean Integration Representation (GMIR) method, used to solving the problem of defuzzification (Chen & Hsieh, 2000).

Let $X_{ij} = (c_{ij}, a_{ij}, b_{ij})$; i = 1, 2, ..., n; j = 1, 2, ..., m; to be the triangular fuzzy number. By the GMIR method, the GMIR $R(X_{ij})$ of X_{ij} is

$$R(X_{ij}) = \frac{c_{ij} + 4a_{ij} + b_{ij}}{6} \tag{2.2}$$

After that, normalization of initial crisp values is conducted. The $R(X_{ij})$ value is substracted with the maximum value given for each decision maker (Wardhani, et al., 2012). The formula is:

$$S(X_{ij}) = R(X_{ij}) - R(X_i)_{max} \tag{2.3}$$

Then the entropy values for the sub-criteria are determined by first normalising the information a hesitant decision to obtain the normalized score matrix $\hat{s}$ using formula of:

$$\tilde{s}_{ij} = \frac{s(X_{ij})}{\sum_j^m s(X_{ij})} \quad ; \; where \; 0 \leq \tilde{s}_{ij} \leq 1 \tag{2.4}$$

- Step 2: Determination of entropy values.

The normalized values are used to determine the entropy values for the various criteria using calculation of:

$$E_j = -\frac{1}{\ln n} \sum_{i=1}^{n} \tilde{s}_{ij} \ln \tilde{s}_{ij} \; ; where \; 0 \leq E_j \leq 1 \tag{2.5}$$

- Step 3: Estimation of criterion weight.

  First the total entropy value can be computed as:

$$E = \sum_{j=1}^{m} E_j \tag{2.6}$$

  Based on the entropy values for criteria, the weight for each criteria is estimated by:

$$W_{ij} = \frac{1 - E_{ij}}{n - E} \tag{2.7}$$

$$where\ 0 \leq W_{ij} \leq 1\ and \sum_{j=1}^{n} W_{ij} = 1$$

FEWA method fits with multi-hierarchical framework. This framework enables thorough analysis for the defined criteria. Weight resulted from FEWA method can be evaluated through its hieararchy level, so the worst criteria can be found not only in overall level, but also for every sector in other hieararchy levels. Thus the improvement method alternative can be vary depends on which sector needed to be improved. This combination approach was already implemented by Ighravwe (2017) in ranking maintenance strategies case in cement production plant. In that research, there are four different maintenance strategies alternatives. There are many criteria considered, devided into four main dimension of environmental, social and safety, technical, and economic. Four of those sector are important for maintenance strategies selection thus the multi-hierarchy framework was used to evaluating the importance of criteria. Therefore the hierarchy divided into two different hierarchy. First hierarchy generates four option for decision making. While second hierarchy generates one option for selecting the strategy. To support the weighting method, FEWA was used for both hierarchy assessment. Basically the purpose is to generate more options for the company using the advantages of multi-hierarchical framework. There would be another method to replace FEWA for assessment process. One of them is using group decision making proposed by Herowati (2017).

2.4 SWOT Analysis

Strengths, weaknesses, opportunities, and threats (SWOT) analysis is a method used by a firm to evaluate their strengths, weaknesses, opportunities, and threats involved in business process. With this framework of SWOT, company can analyze their business process, identify the potential or existing problems then develop improvement strategies. SWOT is a basic model for assesses what a business can and can't do, as well as its potential opportunities and threats. With SWOT method, the obtained information separated into internal factor (strengths and weaknesses) and external factors (opportunities and threats).

Strengths are the internal positive attributes to the company which are controllable, differs the company to the competitors, and gives them advantages. Weaknesses are factors within control yet detract from the company's ability to obtain or maintain a competitive advantages. Weaknesses consist of the negative internal aspects to the business that decrease the overall value that the products or services provide. Opportunities are external factors that represent the motivation for the business to exist and prosper within the marketplace. These factors include the specific opportunities existing within market that provide an advantages to the company. Threats are external factors beyond the control of the company that have the potential to place the business at risk.

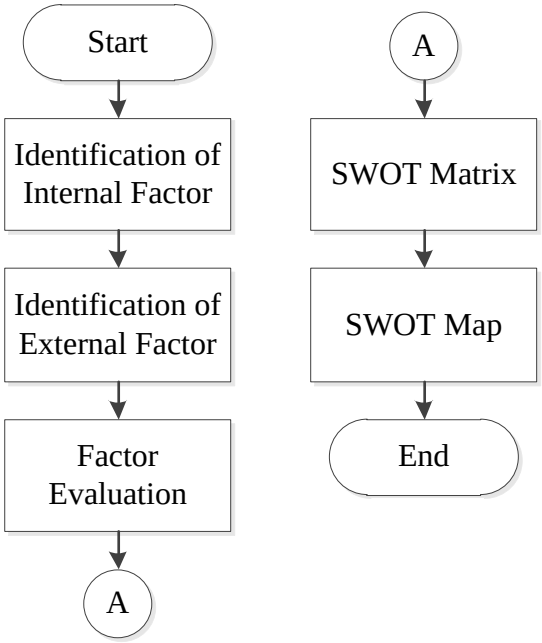

Figure 2. 6 Procedures of SWOT Analysis

The commonly used method to identify and analyze internal factor and external factor of business process is SWOT matrix and SWOT map method. The procedures can be seen in Figure 2.6. The first step is identification of internal factors which are strengths and weakness, and external factors which are threats and opportunities. Then the factor evaluation process is conducted by weighting and scoring method to know position of company. The suitable tool for weighting method is Expert Choice software. Expert Choice is used because of its reliability in assessing the rate of influence among internal factors and among the external. While for scoring method, likert scale (1-4) is used. Thus the Internal Factor Evaluation (IFE) and External Factor Evaluation (EFE) value can be obtained and presented into SWOT map table. It is formulated by result position. SO strategy uses strength to maximize opportunities, ST strategy uses strength to minimize threats, WO strategy minimizes weaknesses by taking advantages of opportunities, and WT strategy minimizes weaknesses and avoid threats. The SWOT can be further be analyzed using SWOT Matrix. The SWOT matrix is a two-cell by two-cell matrix that assists companies in determining strategic alternatives by examining external opportunities and threats and how they compare to a company's existing strengths and weaknesses. The output is improvement strategies according to existing assessment of the company.

2.5 Related Research

There are several related researches that have been done before. Those previous researches are quite similar in the term of topic, model, method or objective. They are used as references for this research and can be seen in Table 2.4 below.

Table 2. 4 Related Research and Research Position

No	Research	Model	Method	Objective
1	(Kusumaningtyas, D., 2010) Implementation of Technology Assessment in Air Traffic Control System at Juanda International Airport using Technometric and MCDM Approach	Technometric	Electre and AHP	Technology Assessment
2	(Pradana, A. H., 2011) Analisis Kandungan Teknologi Sentra Industri Kerajinan Kuningan Dengan Pendekatan Teknometrik untuk Penyusunan Prioritas Pembinaan Teknologi di Desa Bejijong Kecamatan Trowulan Kabupaten Mojokerto	Technometric	Electre and AHP	Technology Assessment
3	(Adityaputra, M. M., 2011) Analisis Kandungan Teknologi dengan Pendekatan Teknometerik dan Metode Analytic Network Process (ANP) pada Surabaya Plaza Hotel	Technometric	ANP	Technology Assessment
4	(Ighravwe, D. E., 2017) A Multi-hierarchical Framework for Ranking Maintenance Sustainability Strategies using PROMETHEE and Fuzzy Entropy Methods	Multi-hierarchical framework	Fuzzy Entropy and PROMETHEE	Ranking Strategies

No	Research	Model	Method	Objective
5	Technology Auditing Model using Multi-hierarchical Framework - Fuzzy Entropy Weight Approach in PT Dok Dan Perkapalan Surabaya	Technology Audit Model (TAM)	Fuzzy Entropy Weight Approach	Technology Assessment

The technology assessment research has already conducted by three different researcher which are Kusumaningtyas (2010), Pradana (2011), and Adityaputra (2011). They are similar with this research in the term of objective which is technology assessment. But all of them using technometric model for the assessment instead of Technology Audit Model (TAM). Technometric model is more focuses on four aspect of technology. While for the weighting method, all of them using different combination of MCDM tools such as AHP, Electre, and ANP. Other research conducted by Ighravwe (2017) is quite similar in term of method. He used Fuzzy Entropy and PROMETHEE with the framework of multi-hierarchy level. The different is the objective which is not about assessment but ranking strategies.

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CHAPTER III
RESEARCH METHODOLOGY

This chapter will discusses the methodology of this research including research workflow in the form of flowchart and the explanation of the workflow, consist of preliminary stage, data collection stage, data processing stage, data analysis and interpretation stage, and conclussion and suggestion stage.

3.1 Research Workflow

In this subchapter will be discussed about the research flowchart used as the workflow in doing the research (Figure 3.1).

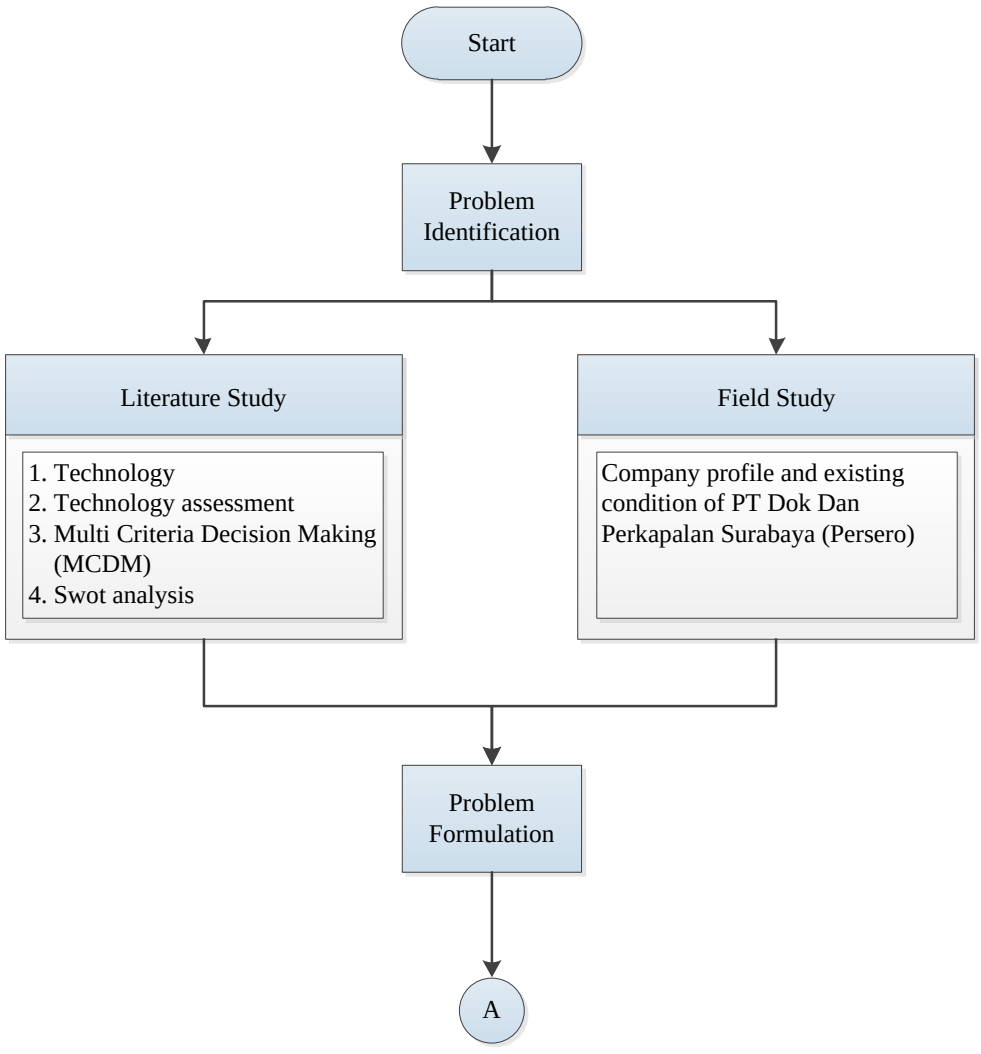

Figure 3. 1 Flowchart of Methodology

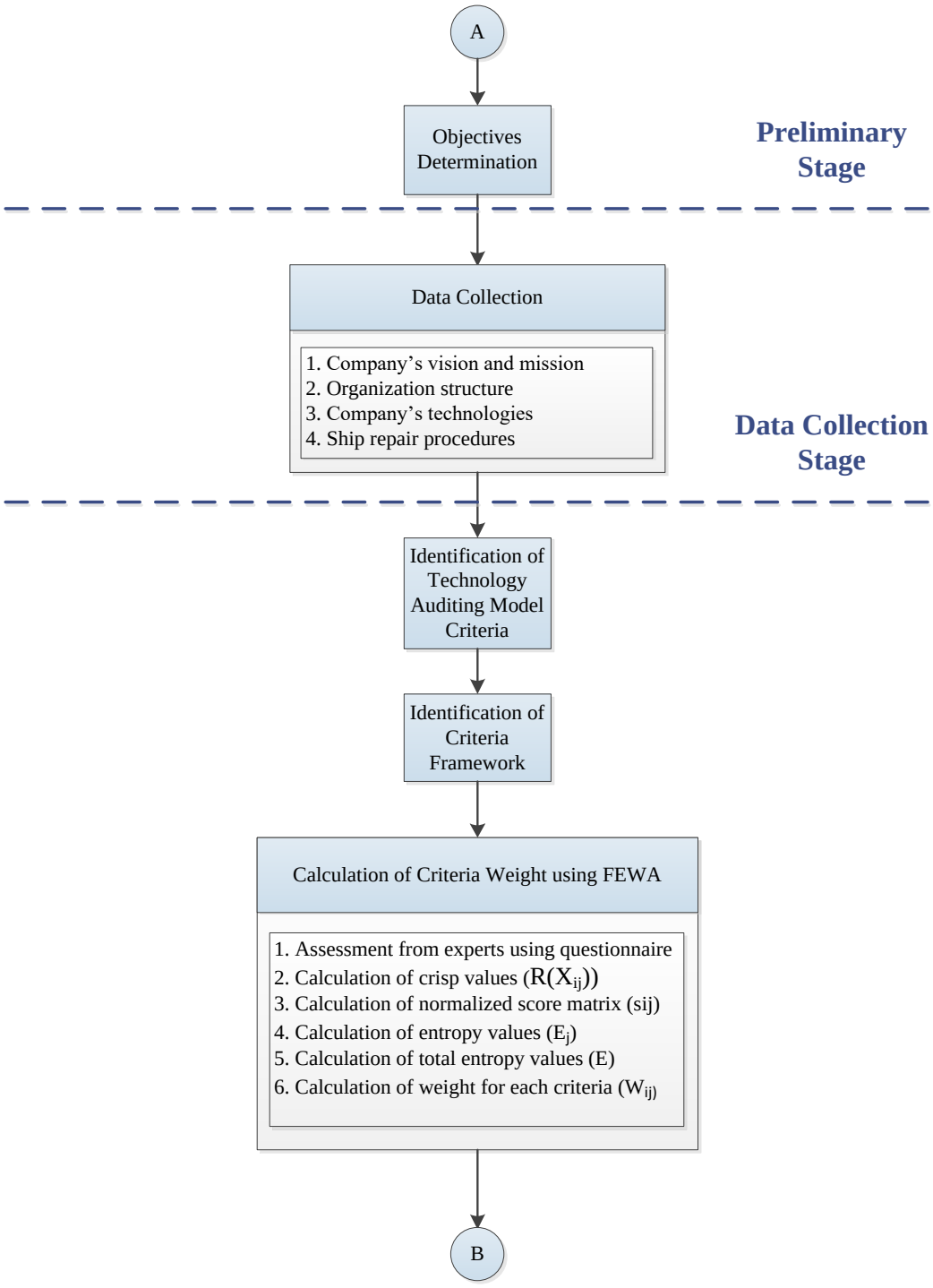

Figure 3. 1 Flowchart of methodology (continued)

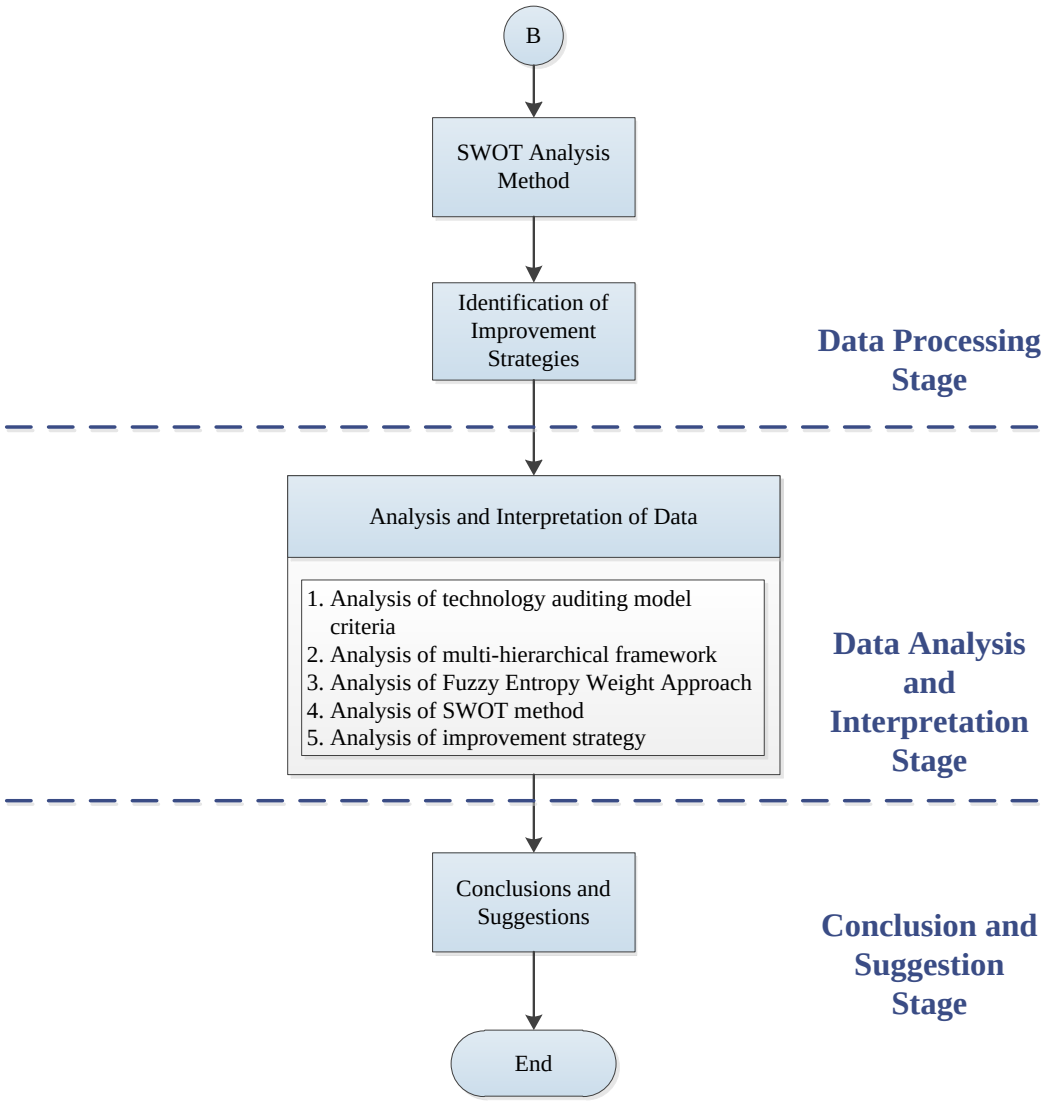

Figure 3. 1 Flowchart of methodology (continued)

3.2 Explanation of Research Flowchart

This subchapter will discusses about the explanation of flowchart above, consist of five main stages which are preliminary stage, data collection stage, data processing stage, data analysis and interpretation stage, and conclussion and suggestion stage.

3.2.1 Preliminary Stage

This is the first stage in doing the research. In this stage, the problem identification is conducted related to research topic. The chosen object is PT Dok Dan Perkapalan Surabaya (Persero). Thus the initial hypothesis is obtained related to the problem in research object. It will be supported with literature study and field study as evidence wether the hypothesis is correct or not. If the hypothesis is incorrect, actual condition must be identified. Then the problem identification refers to actual condition and compared to ideal condition. If the hypothesis is correct, the recommendation is given to company to overcome the existing problem.

Literature study in this research used as strong and relevant theoretical guidelines in doing the research. It comes from compilation of literatures and several resources such as books, articles, scientific journals, previous studies, and other sources. The literatures are divided into critical discussion of Technology, Technology Assessment, Multi Criteria Decision Making (MCDM) approach, and SWOT analysis. While field study used to know the company profile and existing condition of PT Dok dan Perkapalan Surabaya. Informations are obtained from direct observations and discussions with company.

After conducting the studies, research problem can be formulated. The discussed problem for this research is how to measure technologies and propose technology improvement strategy which will be used as recommendation to support repair activities in PT Dok Dan Perkapalan Surabaya (Persero). Last in the preliminary stage is determining research objectives. They are identify criteria of technology auditing model which are suitable for company, measure criteria of assessment using multi-hierarchical framework - Fuzzy Entropy Weight Approach (FEWA), identify the position of company using SWOT analysis, and provide technology impovement strategy as recommendation based on the assessment result.

3.2.2 Data Collection Stage

In this stage, processes of data collection related to the research are conducted. Data collection's purpose is to obtain data which will be used to support data processing of this research. In data collection, company's business processes

are identified. This step is important because to do a research, a process of business in related company must be identified as detail as possible so can be seen the connection between research problem and business process in company. This also will support the criteria selection of TAM model in data processing, by choosing the suitable TAM criteria related to company supported with disussion and brainstorming. The initial criteria of TAM and its explanations are as follow:

Table 3. 1 TAM Criteria

Technology Audit Model (TAM) Criteria		
No	Criteria	Description
1.1.1	Technology as a top priority	Technology is appreciated and managed as a key factor in the overall business strategy. There is a chief technology officer, whose judgment has a considerable influence in the decision-making process. The management style is consistent with the maturity of the enterprise.
1.1.2	Involvement and participation	Managers are active members of the technology culture within the corporation. They have close relationships with the chief technology officer and with technology gatekeepers.
1.2.1	Corporate strategy	There exist a corporate strategy aimed to achieve the corporation's vision. One aspect of this strategy is aimed toward the technologies within the corporation. The technology strategy is a significant contributor to the corporate strategy.
1.2.2	Goals	There are specific goals directed at establishing technology standards and positioning the company as the industry leader.
1.2.3	Deployment	The technical strategy is effectively communicated and deployed throughout all levels in the organization.
1.3.1	Organizational chart	The organization has a structure that enables agility. It facilitates the decision-making process. Technology is explicitly represented by a chief officer, whose judgment influences the decision-making process. There exists evidence of organizational structure around technologies, not around products.

Technology Audit Model (TAM) Criteria		
No	Criteria	Description
1.3.2	Teamwork	The roles and jobs are designed to facilitate teamwork. The teams are self-managed, with only occasional reviews from the manager. The teams can establish their own objectives and measures to support the overall technology strategy.
1.4.1	Culture	There are values within the corporation that highlight the importance of technology as a strategic factor. The corporate culture supports and encourages technology.
1.4.2	Learning organization	The organization is skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights. The organization has established methods for systematic problem solving, experimentation with new approaches, learning from its own experiences (both successes and failures) and most successul practices of others, and transferring knowledge quickly and efficiently throughout the organization. Lessons are documented and distributed throughout the organization.
1.4.3	Communication	There are no organizational barriers threatening the communication top-down, bottom-up, and horizontally. Ideas and concerns can be freely expressed. Information is made available to whoever might need it. The organizational structure is not a barrier when trying to communicate with top management levels.
1.4.4	Management of change	The organization is effective in dealing with change. People perceive change as an opportunity, rather than a threat. Teams can be easily reorganized to adapt quickly to new corporate needs.
1.5.1	Recruiting policies	Human resources is in continuous contact with the operative departments to be aware of their needs regarding new employees. Candidates are identified and selected by taking into account their initiative, leadership, and technical skills.
1.5.2	Training	A process is in place to ensure that the employees are high-skilled, knowledge resources, customer-driven, trainers, and problem solvers.

Technology Audit Model (TAM) Criteria		
No	Criteria	Description
1.5.3	Empowerment	Employees are empowered to take direct action when a problem occurs or an opportunity exists. Managers are perceived as facilitators. Data are accessible to the person / team that requires information.
1.5.4	Reward system	The reward system takes into account the different motivation factors for managers, engineers, scientists, and entrepreneurs, as well as the flexible nature of the organization.
2.1.1	Internal technologies	The corporation has clearly identified its core competencies and core services/products. Managers make sure that efforts are focused on strengthening and exploiting them.
2.1.2	External technologies	Technology gatekeepers have identified the external technologies inluded in the products, and make sure that none of them are of strategic importance. The system must be able to identify any important technology and develop it in-house before it becomes a competitiveness factor. There are established systems to forecast future developments.
2.1.3	Basic technologies	The basic technologies of the industry are clearly identified and maintained in good competitive position. There are established systems to forecast future development
2.1.4	Technology trends	Technology gatekeepers know the current standing and trends of the technologies behind the core competencies. There are established systems to forecast the future development.
2.2.1	Internal technologies	The organization values the development of process technologies as much as the development of product technologies. Managers make sure that efforts are focused on strengthening and exploiting them.
2.2.2	External technologies	Technology gatekeepers have identified the external technologies inluded in the processes. They make sure that the latest developments are included in the processes. There are established systems to forecast future developments.
2.2.3	Basic technologies assessment	The basic technologies of the industry are clearly identified and maintained in good competitive position. There are established systems to forecast future development

Technology Audit Model (TAM) Criteria		
No	Criteria	Description
2.2.4	Technology trends	Technology gatekeepers know the current standing and trends of the key process technologies that support the manufacturing process of the core products. There are established systems to forecast future developments.
2.3.1	Innovation in marketing	The company develops sound and aggressive marketing plans to better capitalize on the characteristics of the products, making them more accessible to customers.
2.3.2	The product-service concept	The company is able to identify the service customers require from the products and to look for alternative ways to satisfy that need. Products are customized solutions. The boundary between product and service becomes less obvious.
3.1.1	Market assessment system	There are systems which effectively identify the market's needs and its future possible trends. This information is available to R&D leaders, and people within the organization are encouraged to understand it. Market trends are included in the overall corporate strategy. Technology gatekeepers are active participants in this process.
3.1.2	Marketing of technology	The marketing department has developed systems to exploit not only products but technologies. Plans must be consistent with exploitation policies and with the overall technology strategy.
3.2.1	Competitor assessment	Crossfunctional teams are in charge of periodically assessing the core competencies, technological status, and possible future capabilities of competitors.
3.2.2	Benchmarking	The company periodically looks for the best practices related with its business, wherever they can be found. Internal processes and policies are compared with the benchmarks, and plans are developed to reduce the gaps.
4.1.1	Intrapreneurship	Policies exist to permit innovation at all organizational levels. Employees are encouraged to suggest new ideas for products, services, or processes. Reward systems are in place to motivate innovation within the company. Employees know the market needs and build on them in order to create new products or services. There exists a system that enables intrapreneurs to communicate and develop new ideas.

Technology Audit Model (TAM) Criteria		
No	Criteria	Description
4.1.2	Entrepreneurship	Entrepreneurs are motivated to develop their ideas within the organization if the ideas are consistent with the strategy. Otherwise, the system allows the entrepreneur to go elsewhere to develop the idea.
4.2.1	Science push	Technology gatekeepers have the resources to be experts within their fields and are empowered to suggest new directions and trend. They are aware of the latest scientific discoveries within their specific fields.
4.2.2	Market pull	Marketing is able to relate current products to market needs, identifying gaps and opportunities. The information regarding market needs is available to all interested persons/teams.
4.3.1	Break-even time and break-even cost	There is evidence of continuous improvement on the time-to-market variable. The teams are able to provide follow-up on their expenses throughout the entire time-to-market period.
5.1.1	Cross-functional teams	Crossfunctional and autonomous teams are used to plan, develop, and implement new products, processes, and/or services. Design for manufacturability is achieved through early involvement of all departments in the company. Every new venture has a champion leading the effort.
5.1.2	Portfolio justification	The R&D portfolio is fully consistent with the corporate and technology strategies, with the maturity of the industry, and with the core competencies of the corporation. There is a process to select new projects that will support the overall strategy and its congruency with technology priorities, acquisition, and exploitation.
5.1.3	Sucess/failure analysis	Projects are analyzed to identify and understand causes of success or of failure; learning is documented and distributed within the company.
5.2.1	Improvement	There are measures related to all the important variables of the processes. There is evidence of continuous improvement in those measures. The organization is able to reach economies of scale and economies of scope to satisfy market needs.

Technology Audit Model (TAM) Criteria		
No	Criteria	Description
5.3.1	Green products and processes	The company is concerned about designing and producing environment-friendly products. The processes are equipped with filters or appropriate nonpollution devices.
5.3.2	After-life analysis	The design of the product takes into account the fact that the product will be discharged at the end of its lifetime; its recycling is already considered.
6.1.1	Method of acquisition	The technology acquisition options (internal R&D, joint ventures, licensed in, or purchase) support the technology strategy. The decisions are based on the life-cycle position of the specific technology. Decisions take into account factors such as the company's standing, urgency of acquisition, investment, life-cycle position, and technology category.
6.1.2	Capital investment	Capital appropriations are analyzed and approved based not only on financial statements but also on the competitive advantage they may create.
6.2.1	Transfer procedures	The company has transfer procedures, which allow it to sucessfully transfer technologies from other insititutions, i.e., companies, laboratories, universities.
6.2.2	People transfer	When a new technology is acquired, people are also transferred to support the transfer process.
6.3.1	Exploitation for profit	Procedures exist to ensure the optimal exploitation of technologies, whether in product or processes, contracting out manufacturing, joint venture, or licensing out. The decisions are consistent with the overall technology strategy and the technology classification.
6.4.1	Protection	The innovation process is a closed loop requiring that the knowledge be protected either by patenting, secrecy, or other methods.

Source: (Khalil, 2000)

The detailed data needed in data collection can be seperated into four main data. The first data needed is company's vision and mission statement. It reflects the guidelines of company's business process. Second data is organization structure of company, to see this business functionally. Third data is technologies of company, especially in ship repair field. Technology here refers to machines and facilities of company used to support repair activity. Fourth data is ship repair

procedures within company as the core competences of PT Dok Dan Perkapalan Surabaya.

3.2.3 Data Processing Stage

In this stage, data processing is conducted based on obtained data from previous stage. The first is process is identifying the related criteria of technological capabilities assessment of company. From Technology Audit Model (TAM), will be generated the appropriate assessment point to be used as criteria in weighting process. The initial criteria can be modified adjusted with the business process. The identification process is based on the previous observation, discussion, and brainstorming with the company.

Then the framework of assessment criteria are identified. It embraces multi-level hierarchy due to application of multi-hierarchy framework. It will generates different assessment processes. The expected number of hierarchy is 3 level, which are first hierarchy, second hierarchy, and third hierarchy.

After that the assessment process is conducted. The first step is an assessment of company technological capabilities related to ship repair process using questionnaire and discussions. The questionnaire used to measure and capture respondents though. It will includes selected criteria of TAM and the scoring option for each criteria with five-scale assessment uses set of S={P,F,G,VG,O}; where P=Poor (1), F=Fair (2), G=Good (3), VG=Very Good (4), and O=Outstanding (5). The questionnaire will be in bahasa in order to avoid misunderstanding and it will be accompanied with discussion. While the number of respondent is 7 experts from company in the sector of production, project manager, production planning & control, technology officer, quality control, marketing, and human resource. Company expert are employees with great experience, high education, and considered as an old hand in the company.

After that the weighting process is conducted through FEWA method. The input for this method are assessment score from questionnaires and criteria from identification of related TAM criteria before. There are three main steps in FEWA methdod. They are:

1. Design of decision matrix. The first process is transforming the score into triangular fuzzy number defined as P=(0, 0, 0.25), F=(0, 0,.25, 0.5), G=(0.25, 0.5, 0.75), VG=(0.5, 0.75, 1), and O=(0.75, 1, 1). Then those numbers are translated into crisp values of $R(X_{ij})$. Thus normalzed score $S(X_{ij})$ and $\tilde{s}_{ij}$can be obtained.
2. Determination of entropy values. The calculation process is conducted to obtain the entropy values of E_j.
3. Estimation of criterion weight. First must be calculated the total entropy value E, then the weight for each criteria W_{ij} can be obtained.

Those steps are repeated for each hierarchy level assessment. Output from the method is the criteria weight of each hierarchy level. It will be used as inputs for next step which is SWOT analysis method. The criteria with small weight will be set as weakness, while the criteria with bigger weight will be set as strength. For the external factor will be obtained from discussion with internal company. The output of SWOT analysis are factor evaluation score, SWOT matrix strategies, and SWOT map of company's position. Finally, improvement strategies are proposed based on previous steps result.

3.2.4 Data Analysis and Interpretation Stage

In this stage, analyses and interpretation of data are conducted based on the result of data processing. There are several analyses, which are the analysis of technology auditing model criteria, analysis of multi-hierarchical framework, analysis of calculation of criteria weight using FEWA, analysis of SWOT method, and analysis of improvement strategy.

3.2.5 Conclusion and Suggestion Stage

In this stage the process of drawing conclusions from all of previous stages before is conducted. These conclusions will be the answer to the research objectives. Several suggestions will be given as references for further research.

CHAPTER IV
DATA COLLECTING AND PROCESSING

This chapter discusses about the data gathering and the result of data processing. Data are gathered based on internal company which are from discussion, interview, direct observation; and other supporting literatures.

4.1 Company Overview

PT Dok Dan Pekapalan Surabaya (Persero) is an Indonesian shipyard company, experts in ship repair and shipbuilding field. It is located at Jalan Tanjung Perak Barat 433-435 Surabaya, Indonesia. This company has repaired and built more than 600 various types of ship, ordered by both local and foreign customers.

Figure 4. 1 Logo of PT DPS (Internal Company, 2017)

PT Dok Dan Perkapalan Surabaya is established in September 22nd 1910 with the name of N.V. Droogdok Matschappij Soerabaja and originally intended to service the Dutch's ship. Between 1942 until 1945, it was managed by Japanese Government under the name of Harima Zosen. After its nationalization on January 1st 1961, this company became a state-owned company named P.N Dok dan Perkapalan Surabaya. Then since January 8th 1976, the company has assumed a new legal status as PT Dok Dan Perkapalan Surabaya, acronym DPS.

Nowadays PT DPS is included as leading company in ship repair and shipbuilding field and become one of the four shipyard State-Owned Enterprises (SOE) in Indonesia. DPS has more than 450 employees and has several certification. It has site area of 57,000 m^2 (land surface) and 70,000 m^2 (water surface). The production area of PT DPS vary greatly, including shipbuilding (up

to 10,000 DWT), ship repair (up to 8,000 DWT), ship conversion, offshore construction, streel structure fabrication, design and engineering.

4.1.1 Company's Vision and Mission

As a business company, PT Dok Dan Pekapalan Surabaya has target used as guidelines in doing the business process and progressed for the better outcome. It is reflected in vision and mission statement of the company. Vision and mission representing what company want to achieve and how to achieve it. The following are the vision and mission of PT Dok Dan Perkapalan Surabaya.

Vision

"Becoming the leading ship maintenance and repair service company in Indonesia".

Leading:

- Excel in quality, punctuality, and profitability (zero % penalty and late delivery).
- Trusted in satisfying customer needs.
- Outstanding in providing solutions.

Mission

In order to achieve the vision, PT DPS is supported by several mission. The followings are mission of the company.

1. Providing repair and maintenance service for ships and other floating equipment in a continuous and profitable manner.
2. Capable of building ships and other floating equipment with added values.
3. Implementing a working culture of punctuality, quality, and cost effectivity geared towards customer satisfaction.
4. Having a competent and reliable human resources management in providing the best solution in line with the principles of good corporate governance.
5. Professionally conducts business and prioritizing work health and safety and environmental awareness.

4.1.2 Organization Structure

PT Dok Dan Perkapalan Surabaya is supported by employees in structured funtional division. The organization structure of PT DPS updated for January 10th 2017 can be seen in Figure 4.2 to Figure 4.3.

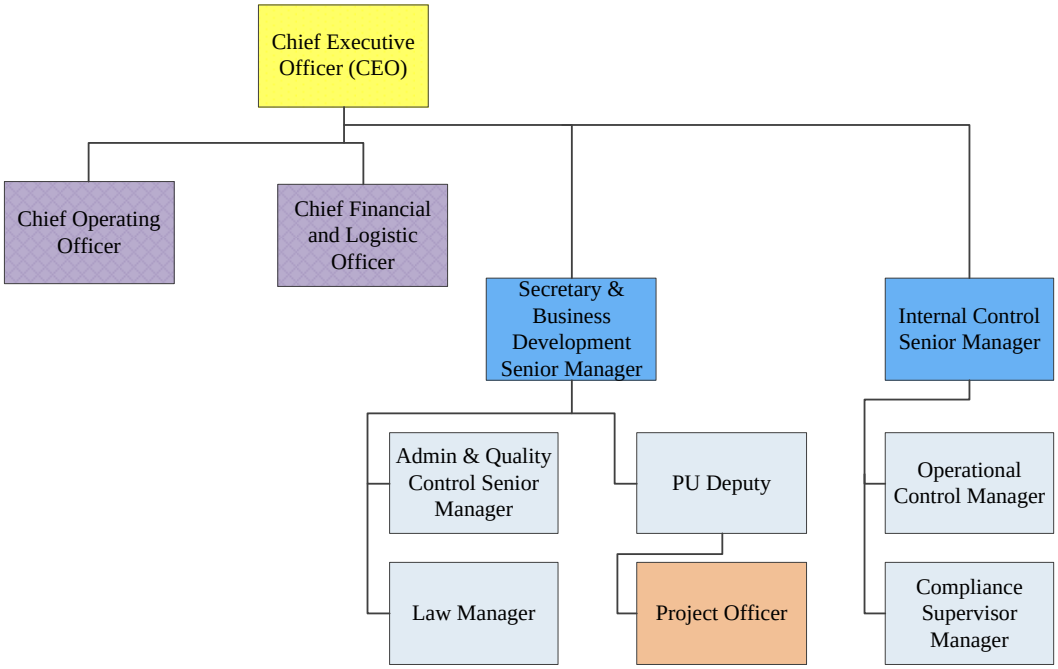

Figure 4. 2 Main Organization Structure (Internal Company, 2017)

Based on Figure 4.2, top management function of this company is Chief Executive Officer (CEO) which is responsible to two different specific chief officer which are chief operating officer and chief financial and logistic officer, and also two senior manager directly. Secretary & Business Development Senior Manager oversees Admin & Quality Control Senior Manager, Law Manager, and PU Deputy. While Internal Control Senior Manager oversees Operational Control Manager and Compliance Supervisor Manager. The job description for each position can be seen in following table.

Table 4. 1 Main Organization Structure Job Description

No	Position	Job Description
1	Secretary & Business Development SM	Inform in detail and implement company policies in the field of public relations, law, business development, corporate planning and corporate administration

No	Position	Job Description
2	Law Manager	Elaborate and implement the work program from corporate secretary in the field of law to provide legal protection for company business
3	Internal Control SM	Assist CEO in carrying out the company's financial and operational audit and assess the control, management, and implementation
4	Operational Control Manager	Manages task of collecting and grouping data based on utility for material productivity analysis from the smallest organizational level until work unit level
5	Compliance Supervisor Manager	Manages task of collecting and grouping data based on usability for improvement analysis of compliance from the smallest organizational level until division level

Source: Internal Company

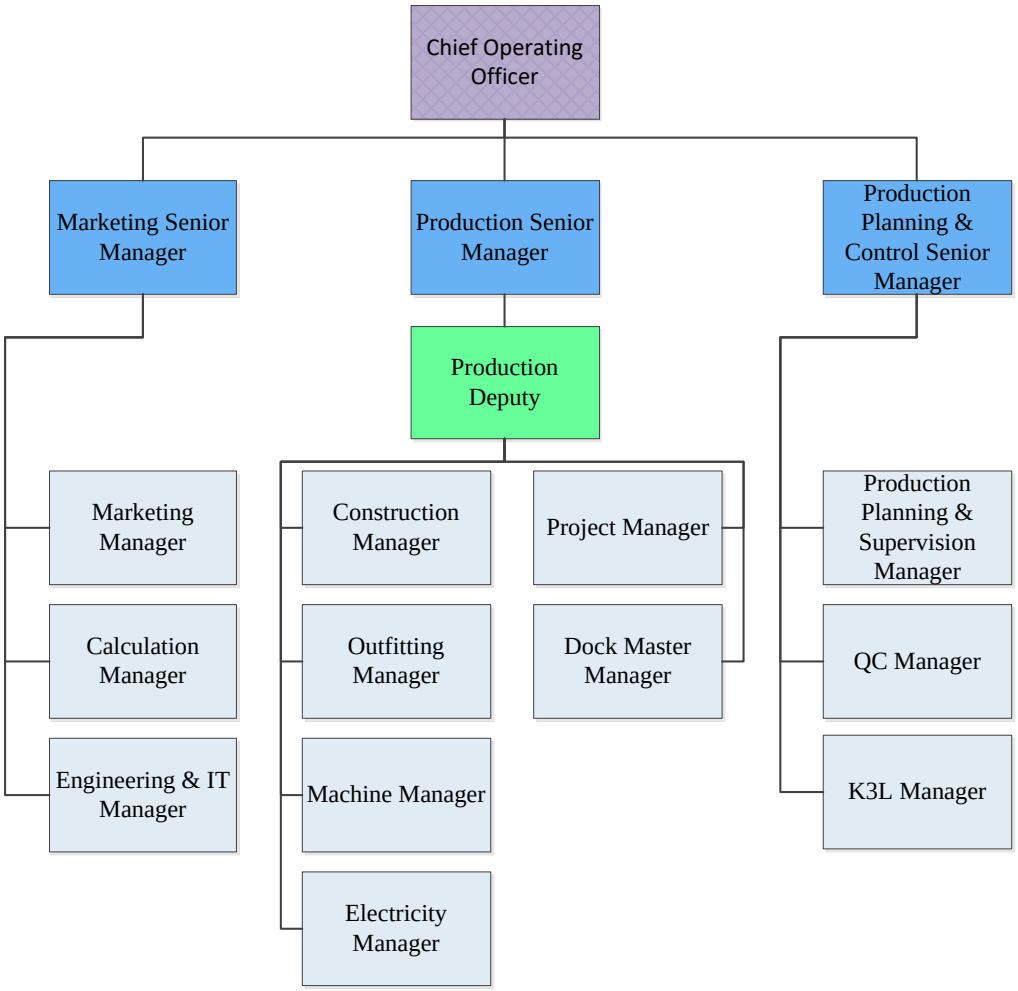

Figure 4. 3 Operational Organization Structure (Internal Company, 2017)

In Figure 4.3, can be seen that Chief Operating Officer is responsible to three operational Senior Manager. Marketing Senior Manager oversees Marketing

Manager, Calculation Manager, and Engineering & IT Manager. Production Senior Manager supported by Production Deputy oversees Construction Manager, Outfitting Manager, Machine Manager, Electricity Manager, Project Manager, and Dock Master Manager. While Production Planning & Control Senior Manager oversees Production Planning & Supervision Manager, QC Manager, and K3L Manager. The job description for each position can be seen in following table.

Table 4. 2 Operational Organization Structure Job Description

No	Position	Job Description
1	Marketing SM	Controlling activities of marketing, calculation, after-sales, engineering, and information technology to support the achievement of company's business growth targets
2	Marketing Manager	Make sales targets, conduct promotion, obtain inquiry demand, obtain profitable order considering aspect of engineering, commercial, and legality, also conduct the contract evaluation from commercial aspect
3	Calculation Manager	Manages selling price calculation price and evaluation of the result for development purpose, and report them according to company's policies
4	Engineering & IT Manager	Manage activities of engineering and implementation of information technologies corresponding to company's policies and objectives
5	Production SM	Explain and implement the Production Department program within production process covering the construction, machinery, electricity, and outfitting area optimally
6	Construction Manager	Manage the execution of project and resources management including manpower, machinery, material, and method
7	Outfitting Manager	Manage project implementation activities of outfitting, piping & ducting, waterjet & blasting, painting, and interior work by managing the resources
8	Machine Manager	Managing the implementation activities of machine, maintenance, repair, and spare part replacement
9	Electricity Manager	Controlling the implementation of projects related to electricity work
10	Dock Master Manager	Manages the operational activities of dock master section including process of launching, docking, and transport of vessels
11	Project Manager	Doing project activities from definitive contract to completion of after-sales by using all of available resources
12	Production Planning & Control SM	Manage and implement the activities of planning & controlling, SMK3 system and quality control function

No	Position	Job Description
13	Production Planning & Supervision Manager	Manage the planning (master schedule and resource planning) function activities and supervise the work based on business contract (on time and on quality)
14	Quality Control Manager	Managing activities of product quality control through controlling the projects realization result quality and their progress also report them
15	K3L Manager	Manage and implement operational activities of K3L, including application of K3 and environment to prevent work accidents

Source: Internal Company

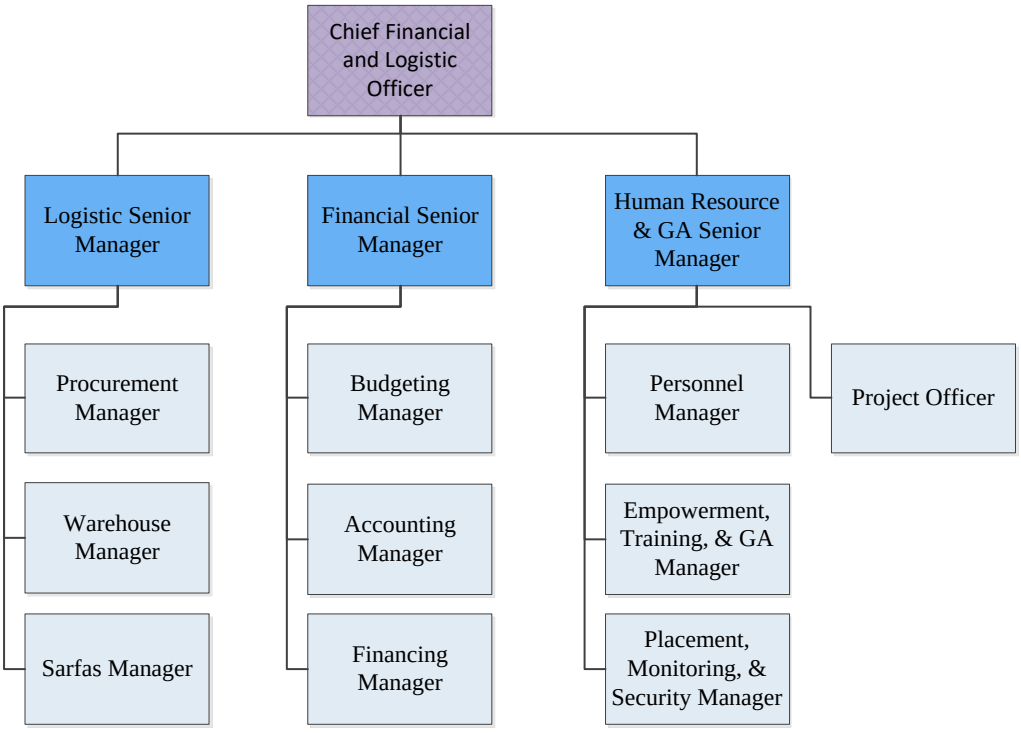

Figure 4. 4 Financial Logistic Organization Structure (Internal Company, 2017)

In Figure 4.4, can be seen that Chief Financial Officer is responsible to three different Senior Manager. Logistic Senior Manager oversees Procurement Manager, Warehouse Manager, and Sarfas Manager. Financial Senior Manager oversees Budgeting Manager, Accounting Manager, and Financing Manager. While Human Resource & General Affair Senior Manager oversees Personnel Manager; Empowerment, Training & GA Manager; Placement, Monitoring, &

Security Manager; and Project Officer. The job description for each position can be seen in following table.

Table 4. 3 Financial Logistic Organization Structure Job Description

No	Position	Job Description
1	Logistic SM	Manage and implement company policy in the field of material and tools procurement and warehousing, and also the maintenance of facilities
2	Procurement Manager	Manage and implement the work of goods and service procurement for project or operational of company
3	Warehouse Manager	Manage and implement work of management of warehouse, residual materials, palletization and transporation of material
4	Sarfas Manager	Manage the operational activities of Facilities Unit includes the availability of facilities to support production process and maintenance of facilities
5	Financial SM	Controll activities related to process of financing and accounting
6	Budgeting Manager	Manage the execution of cash outflow and cash inflows of company, budget planning and verification process
7	Accounting Manager	Manage and implement the work of financial reporting, tax reporting, and financial analysis
8	Financing Manager	Manage and implement the work of calculation and financing process
9	Human Resource & General Affair SM	Control and manage the work of personnel management, HR training, placement & security, and management of office equipment
10	Personnel Manager	Manage the human resource and welfare unit also the industrial relation effectively and efficiently to support the achievement of high productivity and the development of personnel system also the creation of conductive working culture to support all existing unit
11	Empowerment, Training & GA Manager	Manage and evaluate the work of human resource empowerment and training to prepare competentand certified human resource

Source: Internal Company

4.1.3 Company's Technology

As a shipyard company, PT Dok Dan Perkapalan Surabaya is expected to expert in manufacturing (shipbuilding) and service (ship repair) sector. Moreover the product and process within company are considered as complex. So the dependency on good technologies is very high. Aside from manpower, other crucial

aspect of technologies are company's hardwares such as machines and facilities. It is including technologies supporting ship repair process like docks and berths, workshop and installation, and transportation and material handling tools.

1. Docks and berths.

PT DPS uses floating dock for docking and berth activities. There are four main floating docks which are floating dock surabaya I, floating dock surabaya II, floating dock surabaya IV, and floating dock surabaya V. The description and capacity for each facilities can be seen in the following table.

Table 4. 4 Dock and Berths Facilities

Docks and Berths			
No	Facilities	Description	Capacity
1	South Slipway	Slipping facilities	2x2000 DWT
2	North Slipway	Slipping facilities	10,000 DWT
3	Airbag	Slipping facilities	-
4	Floating Dock Surabaya I	Dock facilities (99,24m x 22,4m x 9,9m)	3500 TLC
5	Floating Dock Surabaya II	Dock facilities (99,24m x 22,4m x 9,9m)	3500 TLC
6	Floating Dock Surabaya IV	Dock facilities (94,3m x 27m x 9,9m)	3000 TLC
7	Floating Dock Surabaya V	Dock facilities (138,52m x 26,4m x 14m)	6000 TLC

Source: Internal Company

Each floating dock is facilitated with tools such as crane and electrical system controlled from control house. The biggest dock is floating dock surabaya V with capacity of 6000 TLC. While for slipping facilities they have south slipway, north slipway, and airbag.

2. Workshops and installations.

To support production and repair activites, PT DPS has six main workshops. They are mechanical workshop, north Hull Construction (HC) workshop, south HC workshop, electricity workshop, outfitting workshop, and sarfas (facilities) workshop. Each workshop has different functions that are integrated to support

business activities. Machines and tools provided for each workshop can be seen in the following table.

Table 4. 5 Workshops and Installations Facilities

Workshops and installations		
No	Workshop	Machines and tools
1	Mechanical	CNC Lathe, drilling machine, fraise machine, milling machine, horizontal crane, sawing machine
2	North hull construction	Press machine, bending machine, CNC cutting machine, overhead travelling crane, plate rolling machine
3	South hull construction	
4	Electricity	Compressor, drilling machine, load bank electric
5	Outfitting	Pipe bending machine, lathe, drilling machine, sawing machine, milling machine, rolling machine, welding machine, blasting equipment, overhead crane
6	Sarfas	Compressor diesel, compressor electric, forklift, lathe, water jet, portal crane, drilling machine, welding machine FCAW-SAW, pump

Source: Internal Company

Basically the machines and tools are adjusted to the function of each workshop. Some of the workshop also provided with crane to support material handling activities. Outfitting workshop has many machines because of complex activities there, including pipe outfitting, wood outfitting, and blasting/painting. While sarfas is workshop for general facilities in PT DPS. Therefore most of the machines and tools there are supporting tools which are different with other workshop.

3. Transportation and material handling.

For transportation and material handling facilities are the responsibility of sarfas (facilities) department. They are supporting facilities with the purpose of moving and transporting any product or materials. Facilities of transportation and MH with its capacity can be seen in the following table.

Table 4. 6 Transportation and MH Facilities

Transportation and Material Handling		
No	Facilities	Capacity
1	Fork Lift	3000kg/5000kg
2	Railway crane	7T/60T
3	Floating crane	37,5T
4	Overhead crane	5T/10T/16T
5	Portal crane	3T/5T/10T/12T/15T
6	Tower crane	32T/50T
7	Tugboat	Up to 400HP
8	Barge	-

Source: Internal Company

The transportation facilities are divided into land surface facility and water surface facility. For the land, it is including forklift, railway crane, overhead crane, portal crane, and tower crane. For water supporting facilities, they has floating crane, tugboat, and barge.

4.1.4 Ship Repair Procedures

The core competence in PT Dok Dan Perkapalan Surabaya is ship repair activities. Ship repair is more preferable than shipbuilding in this company. In January until September 2017, there are 91 different vessels repaired in PT DPS, compared to 0 ship built. This happens because according to the company, the repair activity bring more economic profit than building activity (around Rp 100 billion of ship repair revenue in Rp100-150 billion of company revenue according to company).

Basically the ship repair procedures for all kind of ship order are the same. When there is a new ship repair order, company orders a team consist of marketing, calculation, and technical person to survey the ship. They analayze and calculate the ship specification and its cost.

Repair list then constructed. It consist of all of detailed repair activities needed by the ship. It can be constructed internally or given from the ship owner. After that PPC department constructs job order list which consist of repair activities based on repair list, description of activities, workshop responsibility, schedule and manpower. It useful for project manager team and production department. When

the ship has already docked, arrival meeting is conducted. The participants are owner, project manager team, management, and ppc team. Here the additional orders are obtained.

The main process of repair are supported by six different workshop (mechanical, south HC, north HC, electricity, outfitting, and sarfas). They do the repair according to “for working list” in job order. Sarfas act as technology officer, which provides and manages all of hardware technologies needed for repair process. Project manager act as a coordinator. They control, supervise, and reporting the progress. Aside from production departments, other departments play important role in repair process. QC department manages quality control activities, K3L department controls safety and environment activities, logistic departments manage the resources, and marketing department act as connector between customer and company in repair period. Within repair activities, sometimes new repair order are found (developed order). Last, the final price is negotiated then the ship is finally ready to be launched. The following is the repair procedures in the form of flowchart graphic.

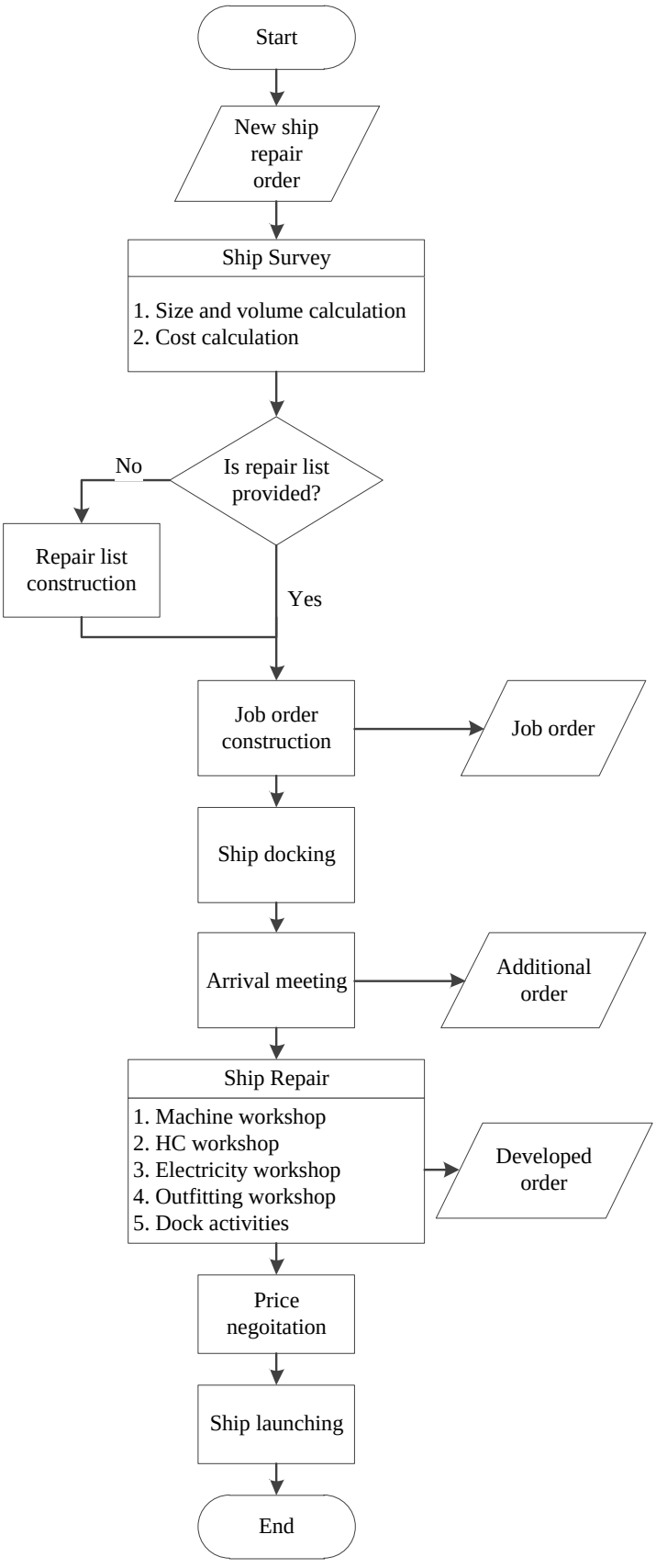

Figure 4. 5 Flowchart of Ship Repair Procedure

4.2 TAM Criteria Identification

Technology Audit Model (TAM) is used as the basic auditing model for this research. It embraces six main comprehensive aspect of technology consist of several sub-components which will be used as criteria in assessment process using multi criteria approach. TAM model is already proved to be match with PT DPS business process in general. However detail adjustment is needed because not all of the sub-component is suitable with this company. Therefore further development of the model is conducted to obtain the best appropriate model for assessing the technological capabilities in PT DPS. The following will be elaborated about the final technology auditing model criteria divided into six main categories of TAM.

4.2.1 Technological Environment Criteria

This first category of TAM mainly talk about technological environment within company. It discusses the culture of technology, how management react to technology, coorporate strategy, management of organization within company, and the human resources. In detail, there are five sub-categories in this aspect.

Senior executive leadership and orientation is the first sub-category. The existing sub-category is already appropriate since in PT DPS technology is critical factor in running business process. There are management team which their participation and appreciation in technology are interesting to measure. Not only that, DPS has chief technology officer (Sarfas division), whose judgment has an influence for company.

Second sub-category is about technology strategy. It is also already appropriate to be used as auditing model because there exist a corporate strategy, goals, and effort to deploy the strategies within company. For organization structure sub-category, organization structure has been established in the company. So it is suitable to be used and measured.

Technology culture advancement is next sub-category. It talks about the company's abilities to maintain and improve the social culture within company related to technology. All of the criteria here can be used as measurement criteria. The last sub-category is people. It discusses about the human resource and its facilities. PT DPS has recruitment of labor and reward system facilitated by human

resource department. For training program and empowerment policies are facilitated by empowerment, training, & GA division (*diklat*). However, in shipyard company which run in ship services business, the expertise of worker is included in one of the critical factors of service qualities. Based on technometric model - humanware category, there is worker expertise criteria. It is also suitable for auditing model consideration in this research. So worker expertise is added as new criteria model. The following table is the identified technology auditing model of technological environment criteria.

Table 4. 7 Criteria of Technological Environment

Technological Environment			
No	Sub-category	No	Criteria
1.1	Senior Executive Leadership and Orientation	1.1.1	Appreciation and priority of technology
		1.1.2	Involvement and participation
1.2	Technology Strategy	1.2.1	Corporate strategy
		1.2.2	Corporate goals
		1.2.3	Strategy deployment
1.3	Organization structure	1.3.1	Organizational chart
		1.3.2	Teamwork
1.4	Technology culture advancement	1.4.1	Technology culture
		1.4.2	Learning organization
		1.4.3	Communication
		1.4.4	Management of change
1.5	People	1.5.1	Recruiting policies
		1.5.2	Training
		1.5.3	Empowerment
		1.5.4	Reward system
		1.5.5	Worker expertise

4.2.2 Technologies Categorization Criteria

Technologies categorization encompasses main technological hardwares within company and their categorization either it is internal technology, external technology, basic technology, product technology or process technology. In original TAM model, it is divided into three sub-categories which are

product/service technologies, back office/process technologies, and technology in marketing.

PT DPS has several production activities so its management of core competences can be identified. Technologies play essential role in production activities and known that there is no external technologies are needed. PT DPS's ship repair activities is included in service business, so boundary between product/servicess technology and process technology is vague. Based on those identifications, the sub-cartegories model can be modified.

First sub-category identification is production technology. It talks about core technologies identification or named as internal technologies in the original model, basic technologies which embraces internal technologies used for repair activities, and technical operator as labor technology. Technical operator expertise very important in ship repair business and it is included as auditing criteria model used in technometric model - humanware category. Second sub-category is others technology. It talks about technology trends (all technology within company in general) which is a current standing and trends of the technologies in shipyard company, non-operational technology that embraces technology of back office, administration, and other non-related to production technologies, and information system which is obtained from technometric model – infoware category.

Project sub-category is added since in shipyard industry, project management is a key factor. The operational procedure from beginning of order until ship launching process must be considered and can be assessed. It is also included in technometric model – infoware category. Moreover, the schedulling management is important too for management of project. It is obtained from technometric model – orgaware category.

Last sub-category is technology in marketing. Innovation in marketing criteria which is about inovation in marketing plan can be measured. But for product-service concept criteria is not suitable for this kind of company because PT DPS runs in service activities, there is no boundary between product and service. So the sub-category is modified. Marketing expertise criteria is added from technometric model – humanware category so the expertise of marketing labor can be measured. Last, image management criteria is added since there is tight

competition in shipyard industries. The following table is the identified technology auditing model of technologies categorization criteria.

Table 4. 8 Criteria of Technologies Categorization

Technologies Categorization			
No	Sub-category	No	Criteria
2.1	Production Technology	2.1.1	Core technologies identification
		2.1.2	Basic technologies
		2.1.3	Operator
2.2	Others Technology	2.2.1	Technology trends
		2.2.2	Non-operational technology
		2.2.3	Information system
2.3	Project	2.3.1	Procedure
		2.3.2	Schedule management
2.4	Technology in Marketing	2.4.1	Innovation in marketing
		2.4.2	Marketing expertise
		2.4.3	Image management

4.2.3 Markets and Competitors Criteria

Third category of TAM model is markets and competitors. It includes market needs and competitors' status sub-categories. For market needs sub-category, company already has market assessment system provided by marketing division, so it can be measured. The technology of company is also marketed as the marketing strategy in PT DPS, since it is one of key factor in customer consideration to use company's service. For competitors' status sub-category, PT DPS already has competitor assessment system for better understanding of status, core competencies, and future capabilities of customer. The benchmarking is also conducted because it is important to reduce the gaps between the best practices related to the business. So in overall, all of original criteria in markets and competitors TAM model are suitable for measurement criteria in PT DPS. The following table is the identified technology auditing model of markets and competitors criteria.

Table 4. 9 Criteria of Markets and Competitors

Markets and Competitors			
No	Sub-category	No	Criteria
3.1	Market Needs	3.1.1	Market assessment system
		3.1.2	Marketing of technology
3.2	Competitors' Status	3.2.1	Competitor assessment
		3.2.2	Benchmarking management

4.2.4 Innovation Process Criteria

Fourth category of TAM model is innovation process. In original model, it includes idea generation, technology generators, and from concept to market sub-categories. For idea generation sub-category, the intrapreneurship and entrepreneurship aspect are provided within company. Idea generation and development from employees are permitted and facilitated, either internally or externally, so it can be measured. For technology generators sub-category, there are science push and market pull criteria. In PT DPS, technology gatekeepers and other employees have resource to be experts to support the idea generation related to business process. While marketing division is able to relate current products to market needs, identifying gaps and opportunities.

In the original model, there is from concept to market sub-category. It is not suitable for the company since it is not manufacturing company which product need to be delivered to customer. The following table is the identified technology auditing model of innovation process criteria.

Table 4. 10 Criteria of Innovation Process

Innovation Process			
No	Sub-category	No	Criteria
4.1	Idea Generation	4.1.1	Intrapreneurship
		4.1.2	Entrepreneurship
4.2	Technology Generators	4.2.1	Science push
		4.2.2	Market pull

4.2.5 Value-added Functions Criteria

Fifth category of TAM model is value-added functions. It includes research & development, operations, and environment-conscious technology sub-categories. For R&D sub-category, in existing condition there is no spesific R&D division. Although the research program is the responsibility of empowerment, training, & GA division, it is focused on external students that are interested in conducting research in DPS rather than internal research. But the innovation and R&D management in the company is interesting to assess since innovation is still needed. So the R&D criteria here is changed to measurement of innovation system to boost research and development culture within company.

For operations sub-category, the improvement criteria can be assessed. Technology maintenance criteria is added refers to technometric model – orgaware category, since it is important to support main activity as one of the job description of technology gatekeeper. For environment-conscious technology sub-category, green process criteria can be assessed since green production is considered in PT DPS facilitated by K3L division. The after-life analysis criteria from original model is removed because in this research the focus is repair activities. But company awareness and impact management are added as criteria to complete the criteria of environment-conscious model. The following table is the identified technology auditing model of value-added functions criteria.

Table 4. 11 Criteria of Value-added Functions

Value-added Functions			
No	Sub-category	No	Criteria
5.1	Research & Development	5.1.1	Innovation and R&D management
5.2	Operations	5.2.1	Improvement
		5.2.2	Technology maintenance
5.3	Environment-conscious Technology	5.3.1	Awareness
		5.3.2	Green process
		5.3.3	Impact management

4.2.6 Acquisition and Exploitation of Technology Criteria

Last category of TAM model is acquisition and exploitation of technology. In the original model, it includes acquisition of technologies, transfer of technology, exploitation for profit, and protection sub-categories. The protection sub-category is removed since there is no technology protection policies in this company. For acquisition of technologies sub-category, there are method of acquisition and capital investment criteria. PT DPS as shipyard company also conducts the acquisition method (either in the form of innovation, purchasing, leasing, or other methods) and its investment cost analysis to obtain the desired technology.

For transfer of technology sub-category, there are transfer procedures and people transfer criteria. All of those are suitable to be used as auditing model in this company. For exploitation for profit sub-category, there is technology exploitation criteria which is about the procedures to ensure optimal explotation of technologies within company. Here management of technology is added as criteria since the role of company to manage their technology is necessary so it should be assessed. The following table is the identified technology auditing model of acquisition and exploitation of technology criteria.

Table 4. 12 Criteria of Acquisition and Exploitation of Technology

Acquisition and Exploitation of Technology			
No	Sub-category	No	Criteria
6.1	Acquisition of Technologies	6.1.1	Method of acquisition
		6.1.2	Capital investment
6.2	Transfer of Technology	6.2.1	Transfer procedures
		6.2.2	People transfer
6.3	Exploitation for profit	6.3.1	Technology exploitation
		6.3.2	Management of technology

All of the proposed criteria of final technology auditing model can be seen in the following table.

Table 4. 13 Technology Auditing Model Criteria

Model			
No	Sub-category	No	Criteria
1.1	Senior Executive Leadership and Orientation	C 1.1.1	Appreciation and priority of technology
		C 1.1.2	Involvement and participation
1.2	Technology Strategy	C 1.2.1	Corporate strategy
		C 1.2.2	Corporate goals
		C 1.2.3	Strategy deployment
1.3	Organization structure	C 1.3.1	Organizational chart
		C 1.3.2	Teamwork
1.4	Technology culture advancement	C 1.4.1	Technology culture
		C 1.4.2	Learning organization
		C 1.4.3	Communication
		C 1.4.4	Management of change
1.5	People	C 1.5.1	Recruiting policies
		C 1.5.2	Training
		C 1.5.3	Empowerment
		C 1.5.4	Reward system
		C 1.5.5	Worker expertise
2.1	Production Technology	C 2.1.1	Core technologies identification
		C 2.1.2	Basic technologies
		C 2.1.3	Operator
2.2	Others Technology	C 2.2.1	Technology trends
		C 2.2.2	Non-operational technology
		C 2.2.3	Information system
2.3	Project	C 2.3.1	Procedure
		C 2.3.2	Schedule management
2.4	Technology in Marketing	C 2.4.1	Innovation in marketing
		C 2.4.2	Marketing expertise
		C 2.4.3	Image management
3.1	Market Needs	C 3.1.1	Market assessment system
		C 3.1.2	Marketing of technology
3.2	Competitor' Status	C 3.2.1	Competitor assessment

Model			
No	Sub-category	No	Criteria
		C 3.2.2	Benchmarking management
4.1	Idea Generation	C 4.1.1	Intrapreneurship
		C 4.1.2	Entrepreneurship
4.2	Technology Generators	C 4.2.1	Science push
		C 4.2.2	Market pull
5.1	Research & Development	C 5.1.1	Innovation and R&D management
5.2	Operations	C 5.2.1	Improvement
		C 5.2.2	Technology maintenance
5.3	Environment-conscious Technology	C 5.3.1	Awareness
		C 5.3.2	Green process
		C 5.3.3	Impact management
6.1	Acquisition of Technologies	C 6.1.1	Method of acquisition
		C 6.1.2	Capital investment
6.2	Transfer of Technology	C 6.2.1	Transfer procedures
		C 6.2.2	People transfer
6.3	Exploitation for profit	C 6.3.1	Technology exploitation
		C 6.3.2	Management of technology

4.3 Framework of Criteria Identification

Previously, the assesment criteria model are identified. There are six main categories proposed. They are technological environment with five sub-categories, technologies categorization with four sub-categories, markets and competitors with two sub-categories, innovation process with two sub-categories, value-added functions with three sub-categories, and acquisition and exploitation of technology with three sub-categories. In total there are 47 criteria of assessment from the proposed technology auditing model.

Multi-hierarchical framework approach is suitable for model with multiple criteria and hierarchy level. It can be used as basic framework for thorough analysis of specific criteria within desired hierarchy. For this auditing model, there are 3 level of hierarchy. First level is using all of the 47 criteria as one weighting model. Here can be identified the company's strength and weakness related to technology

in general without considering the model category boundaries. Beside the assessment of criteria, the most dominant and weakest auditing model category also can be known from this assessment level.

Second level is using all of criteria within each categories to generate weight score. Here there will be six different weight score models, according to different categories. The strength and weakness for each category can be identified. Beside that, the most dominant and weakest sub-category also can be identified from this assessment level.

Third level of hiearchy framework is using all of criteria within each sub-categories to generate weight score. So there will be 19 different weight score models according to number of sub-categories in the auditing model. Here the purpose is to identify the detailed strength and weakness of criteria within each categoy by assessing the deeper level which is for each sub-category. All of three level of assessment can be described using multi-hierarchical framework that can be seen in Figure 4.6.

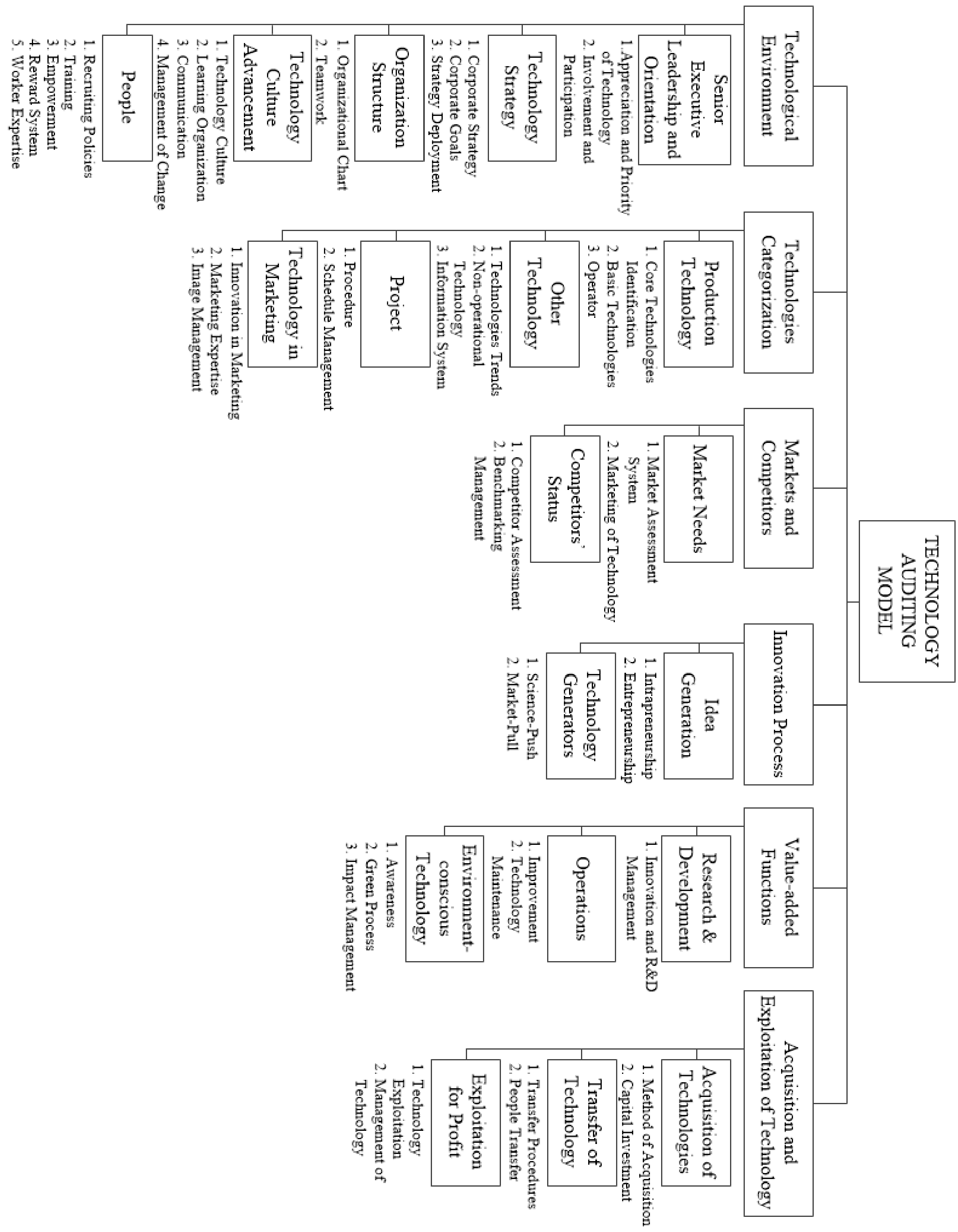

Figure 4. 6 Technology Auditing Model Criteria Framework

4.4 Fuzzy Entropy Weight Approach (FEWA)

The purpose of multi ctiteria approach method is to obtain decision maker (expert) preferences on desired criteria and generate the weighted score. Here, FEWA method is used to weight 47 different criteria from proposed technology auditing model to generate technology assessment score. There are 7 experts from internal company in the sector of production, project manager, production planning & control, technology officer, quality control, marketing, and human resource. List of experts and their capabilities are explained in Table 4.14.

Table 4. 14 Data of Expert

Expert	Name	Position	Work Experience	Last Education	Job Description
E1	Gatot Winarto	Sarfas (Facilities) Manager	20 years	S1	Manage the operational activities of Facilities Unit includes the availability of facilities to support production process and maintenance of facilities corresponding to company's policies and objectives.
E2	Hery Santoso	Production Senior Manager	20 years	D3	Explain and implement the Production Department program within production process covering the construction, machinery, electricity, and outfitting area optimally by consider aspect of quality, cost, delivery, health, safety, and environment.

Expert	Name	Position	Work Experience	Last Education	Job Description
E3	Aliansyah	Quality Control Manager	20 years	D3	Managing activities of product quality control through controlling the projects realization result quality and their progress also report them corresponding to company's policies and objectives.
E4	Dheni Bagus Kusuma	Project Officer	7 years	S2	Doing project activities from definitive contract to completion of after-sales by using all of available resources with the aim of achieving quality, cost, delivery, health, safety, and environment target.
E5	Suyitno	Renwas (PPC) Manager	13 years	S1	Manage the planning (master schedule and resource planning) function activities and supervise the work based on business contract (on time and on quality) corresponding to company's policies and objectives.
E6	Aditya Chrismawanto	Personnel Manager	13 years	S2	Manage the human resource and welfare unit also the industrial relation effectively and efficiently to support the achievement of high productivity and the development of personnel system also the creation of

Expert	Name	Position	Work Experience	Last Education	Job Description
					conductive working culture to support all existing unit corresponding to company's policies.
E7	Junaedy	Marketing Manager	11 years	S1	Make sales targets, conduct promotion, obtain inquiry demand, obtain profitable order considering aspect of engineering, commercial, and legality, also conduct the contract evaluation from commercial aspect.

A structured questionnaire is administered to all of seven internal experts listed before. It uses five-scale assessment (1-5), where Poor=1, Fair=2, Good=3, Very Good=4, and Outstanding=5. The answer of all respondents are referred as linguistic response. There are 7 different experts (E1-E7), and the linguistic response for all of 47 criteria (C 1.1.1 to C 6.3.2) can be seen in Appendix 2.

After that, those linguistic responses from experts are converted into triangular fuzzy number. The value of triangular fuzzy number can be seen in Appendix 2. Triangular fuzzy numbers then are translated into crisp values by applying Equation (2.2) of GMIR defuzzification. Then $R(X_{ij})$ are obtained for each criteria and can be seen in Appendix 2.

Next process of FEWA method start from design of decision matrix of initial crisp values normalization until estimation of criterion weight will be separated for each hierarchy level.

4.4.1 First Level Hierarchy

In first level hierarchy, all of the 47 criteria are weighted as one weighting model. It is the common weighted method with simple framework when there is no

boundary between categories. The first process is normalization of initial crisp values. From previous crisp values matrix for each criteria, can be obtained the maximum value for each expert crisp values. Then normalization is conducted using Equation (2.3). Second normalization is used for hesitant information decision conducted using Equation (2.4). The result of $S(X_{ij})$ and $\tilde{s}_{ij}$ for one normalization model can be seen in the Appendix 2.

Finally, determination of entropy values and criterion weight are conducted using Equation (2.5)-(2.7). The result can be seen in Appendix 2 and has already validated. Entropy values for each criteria are represented by E_j. While weight for each criteria are represented by W_j. Based on weight values, can be seen the best criteria of technology auditing model with the high rank and worst criteria with the low rank. All of them cover the first hierarchy level since they are compared to each others. The following is the representation of the assessment result of first level hierarchy framework using FEWA method.

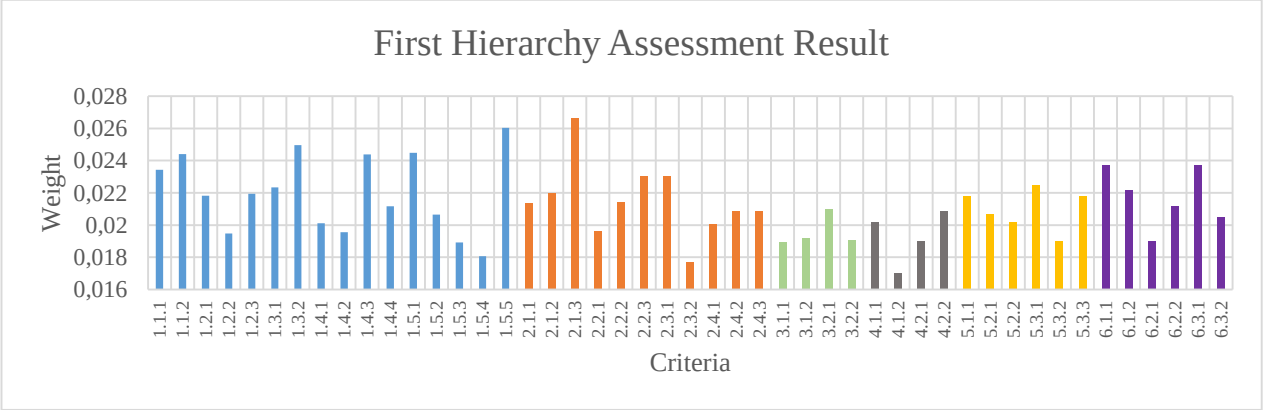

Figure 4. 7 Weight Assessment of First Hierarchy Criteria

From the result, can be seen that the criteria with highest rank is operator criteria (weight of 0.0266) included in second category. While the lowest rank is entrepreneurship criteria (weight of 0.017) included in fourth category. Beside the assessment of each criteria, can be known the strongest and weakest auditing model category from the assessment result. The following is the representation of each category's weight, obtained by calculating the average of criteria weight within each category.

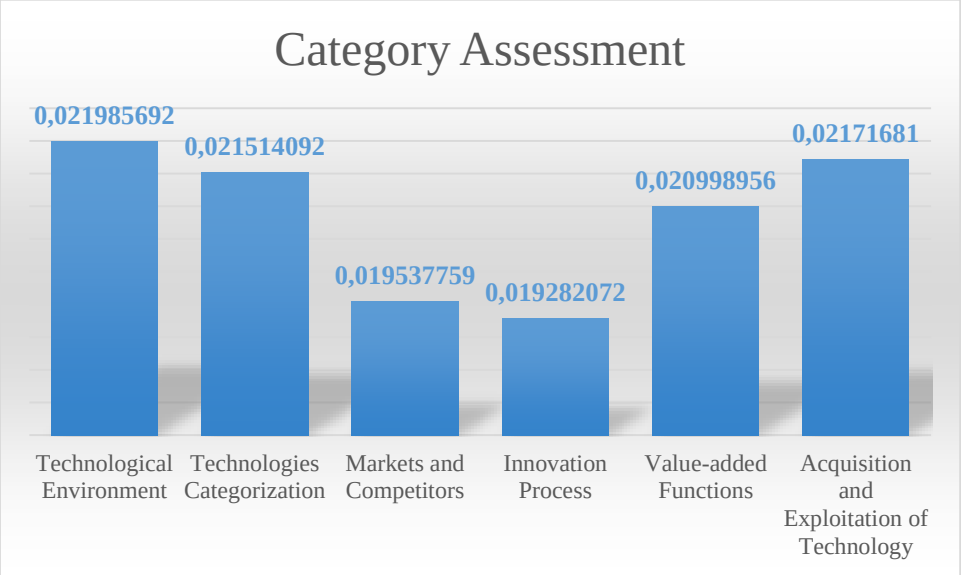

Figure 4. 8 Weight Assessment of Each Category

From the result, can be seen that the category with highest rank (biggest average weight) is technological environment category. While the lowest rank is innovation process category. Technologies categorization is the third highest rank although one of its criteria meets the highest rank against all criteria.

4.4.2 Second Level Hierarchy

In second level hierarchy, all of the 47 criteria are weighted according to each categories. So there will be six different weight score models since there are six different categories. The processes are similar with before which is start with normalization of initial crisp values. From previous crisp values matrix for each criteria, can be obtained the maximum value for each expert crisp values corresponding for each category. Then normalization is conducted. The result of $S(X_{ij})$ and $\tilde{s}_{ij}$ can be seen in the Appendix 2.

Finally, determination of entropy values and criterion weight are conducted using Equation (2.5)-(2.7) and the result can be seen in Appendix 2 and has already validated. Entropy values for each criteria are represented by E_j. While weight for each criteria are represented by W_j. Based on weight values, can be seen the best criteria of technology auditing model with the high rank and worst criteria with the low rank. All of them cover the second hierarchy level so there will be six category

of weight assessment. The following is the representation of the assessment result of first category using FEWA method.

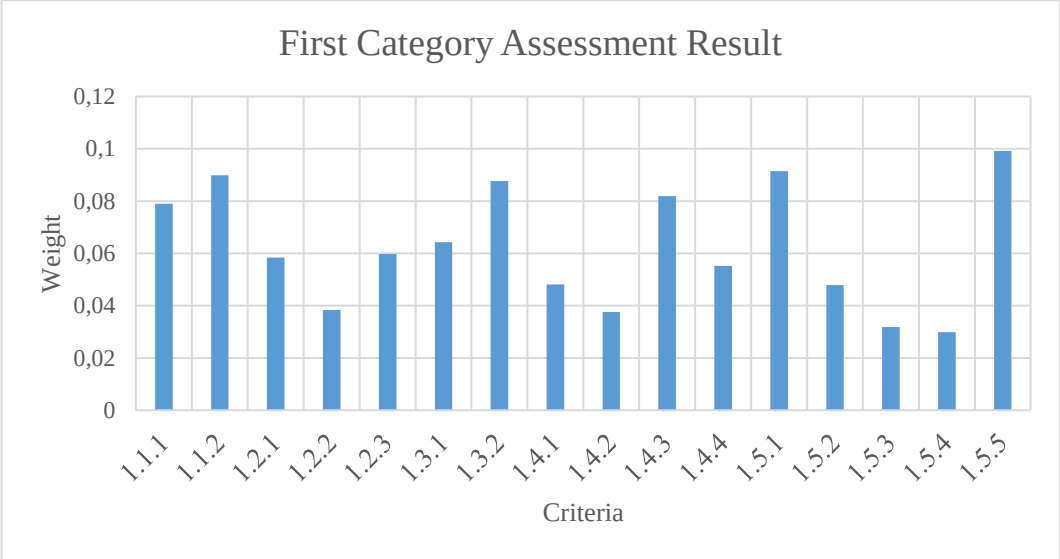

Figure 4. 9 Weight Assessment of First Category Criteria

From the result, can be seen that the criteria with highest rank is worker expertise criteria (weight of 0.0991) included in fifth sub-category. While the lowest rank is reward system criteria (weight of 0.0298), also included in fifth sub-category. Beside the assessment of each criteria, can be known the strongest and weakest auditing model sub-category from the assessment result. The following is the representation of each sub-category's weight, obtained by calculating the average of criteria weight within each sub-category.

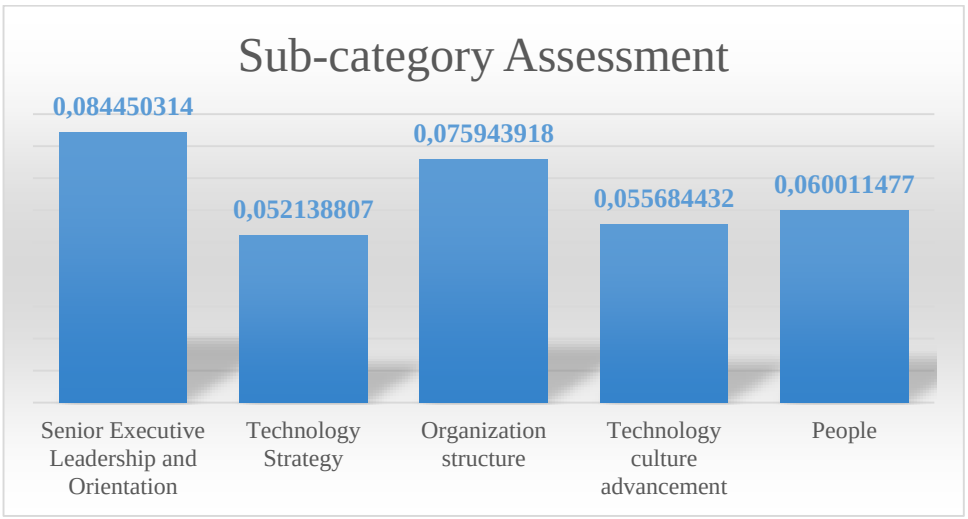

Figure 4. 10 Sub-Category Weight Assessment in First Category

From the result, can be seen that the sub-category with highest rank (biggest average weight) is senior executive leadership and orientation sub-category. While the lowest rank is technology strategy sub-category. People is the third highest rank although two of its criteria meet the highest and lowest rank against all criteria in first category assessment.

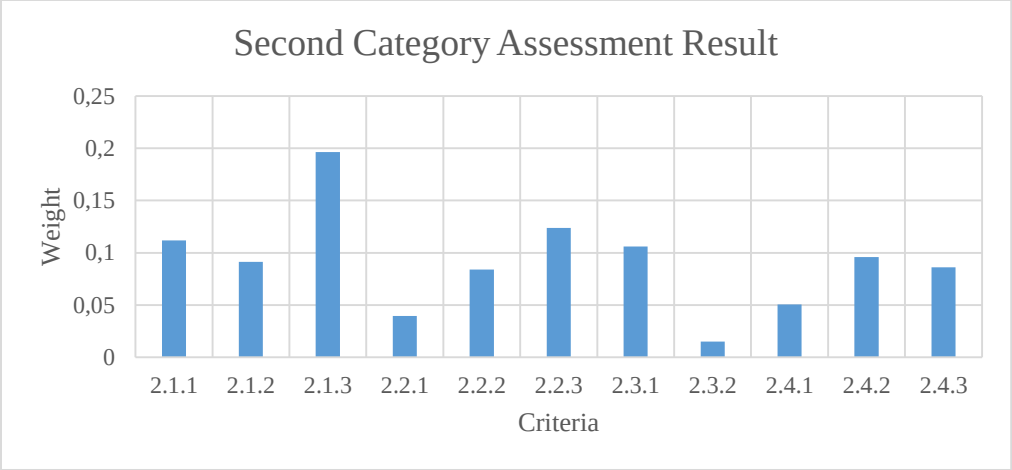

Figure 4. 11 Weight Assessment of Second Category Criteria

From the second category assessment result, can be seen that the criteria with highest rank is operator criteria (weight of 0.1965) included in first sub-category. While the lowest rank is schedule management criteria (weight of 0.015) included in third sub-category. The following is the representation of each sub-category's weight in second category.

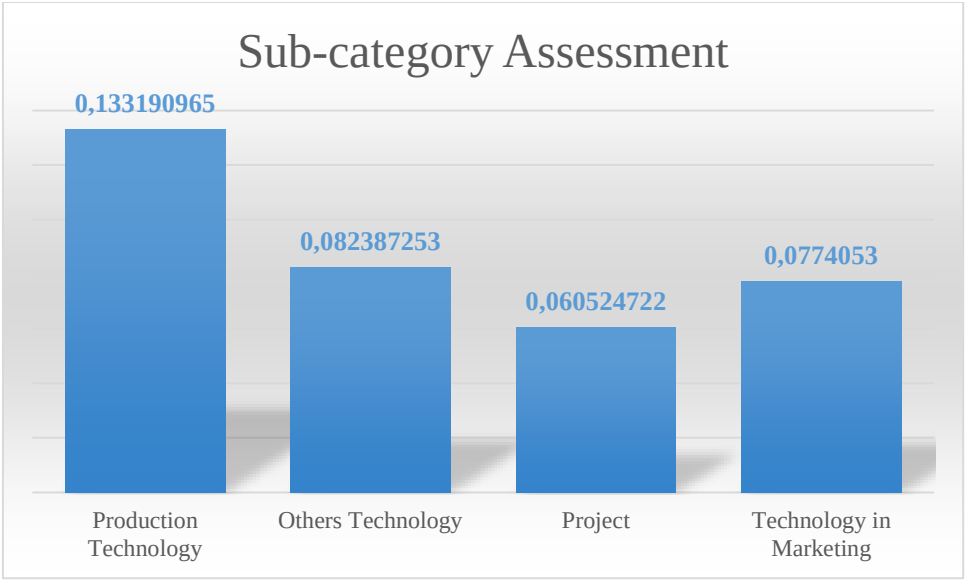

Figure 4. 12 Sub-Category Weight Assessment in Second Category

From the result, can be seen that the sub-category with highest rank is production technology sub-category. While the lowest rank is project sub-category.

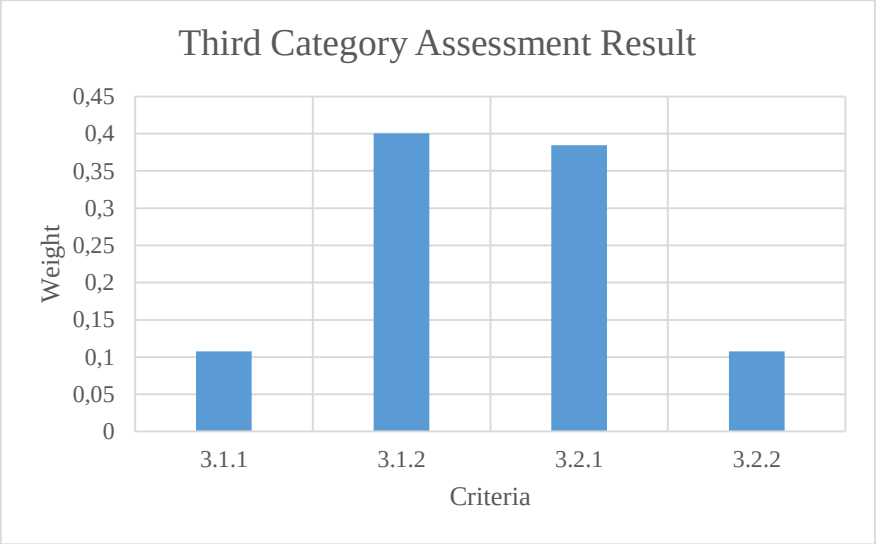

Figure 4. 13 Weight Assessment of Third Category Criteria

From the third category assessment result, can be seen that the criteria with highest rank is marketing of technology criteria (weight of 0.4003) included in first sub-category. While the lowest rank are benchmarking management and market assessment system criteria (weight of 0.1075). The following is the representation of each sub-category's weight in third category.

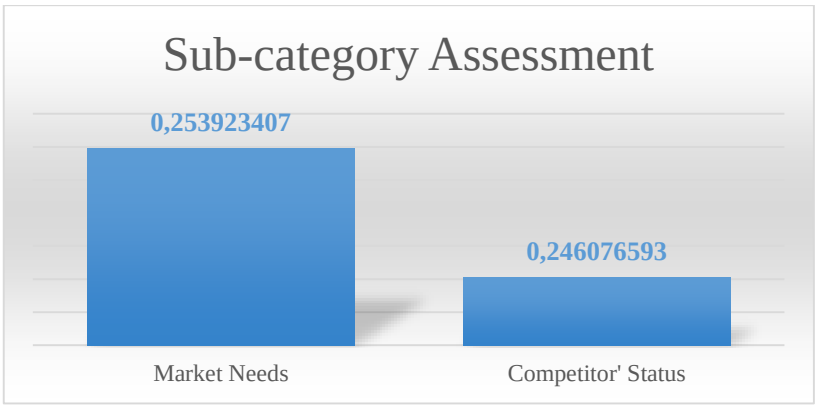

Figure 4. 14 Sub-Category Weight Assessment in Third Category

From the result, can be seen that market needs sub-category has higher weight than competitor' status sub-category in average.

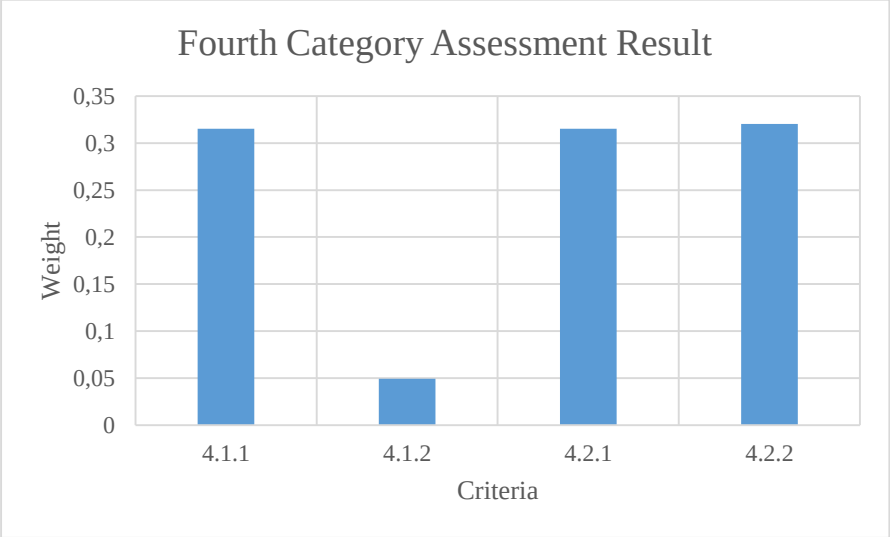

Figure 4. 15 Weight Assessment of Fourth Category Criteria

From the fourth category assessment result, can be seen that the criteria with highest rank is market pull criteria (weight of 0.3201) included in second sub-category. While the lowest rank is entrepreneurship criteria (weight of 0.0494) included in first sub-category. The following is the representation of each sub-category's weight in fourth category.

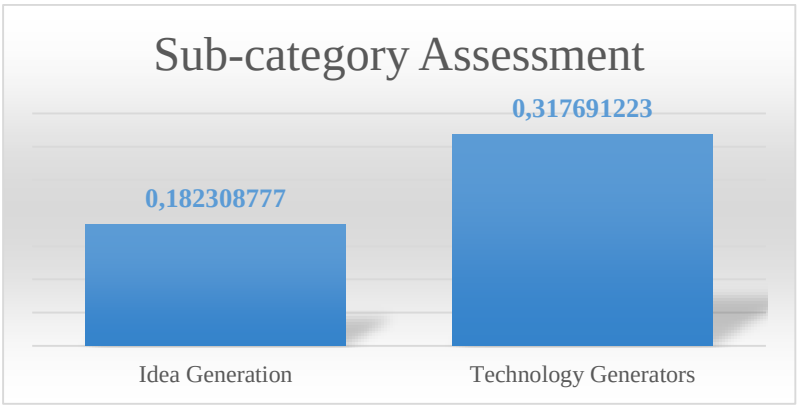

Figure 4. 16 Sub-Category Weight Assessment in Fourth Category

From the result, can be seen that technology generators sub-category has higher weight than idea generation sub-category in average.

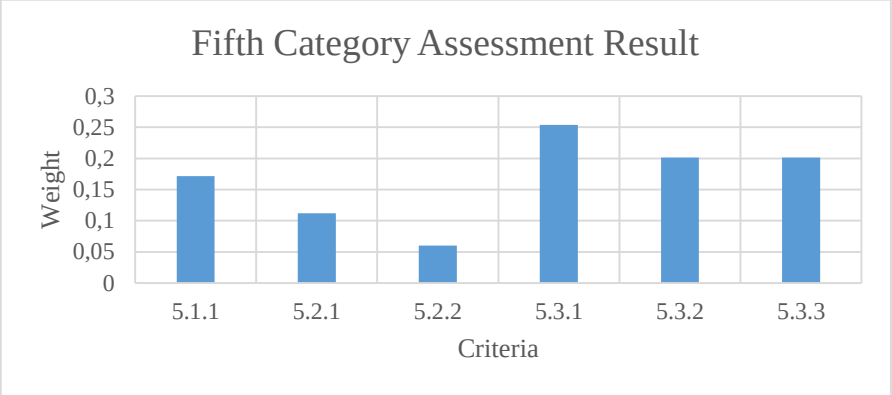

Figure 4. 17 Weight Assessment of Fifth Category Criteria

From the fifth category assessment result, can be seen that the criteria with highest rank is awareness criteria (weight of 0.2536) included in third sub-category. While the lowest rank is technology maintenance criteria (weight of 0.0599) included in second sub-category. The following is the representation of each sub-category's weight in fifth category.

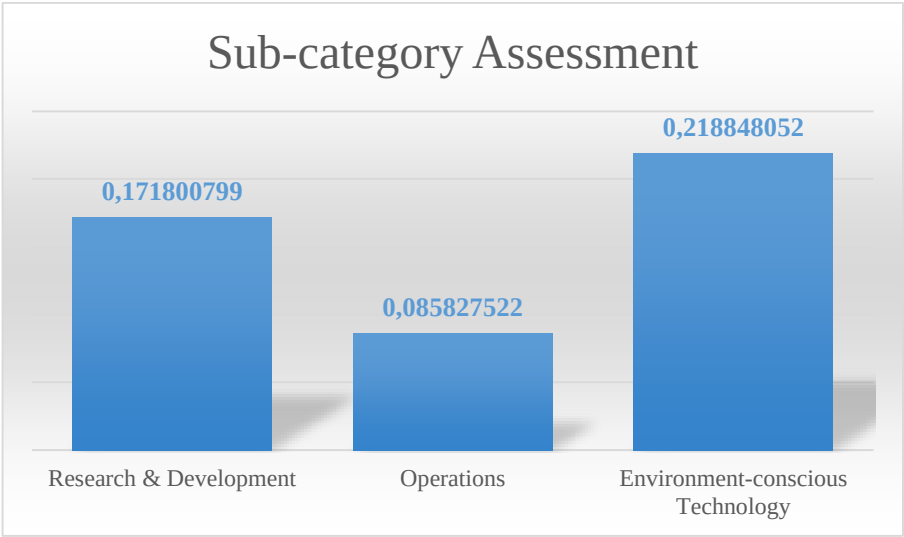

Figure 4. 18 Sub-Category Weight Assessment in Fifth Category

From the result, can be seen that the sub-category with highest rank is environment-conscious sub-category. While the lowest rank is operations sub-category.

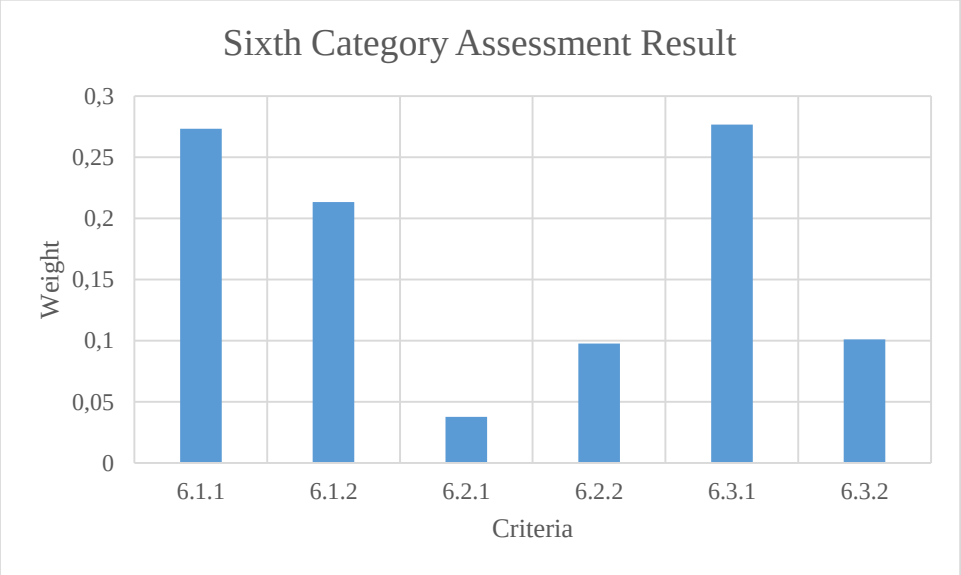

Figure 4. 19 Weight Assessment of Sixth Category Criteria

From the sixth category assessment result, can be seen that the criteria with highest rank is technology exploitation criteria (weight of 0.2767) included in third sub-category. While the lowest rank is transfer procedures criteria (weight of 0.0377) included in second sub-category. The following is the representation of each sub-category's weight in sixth category.

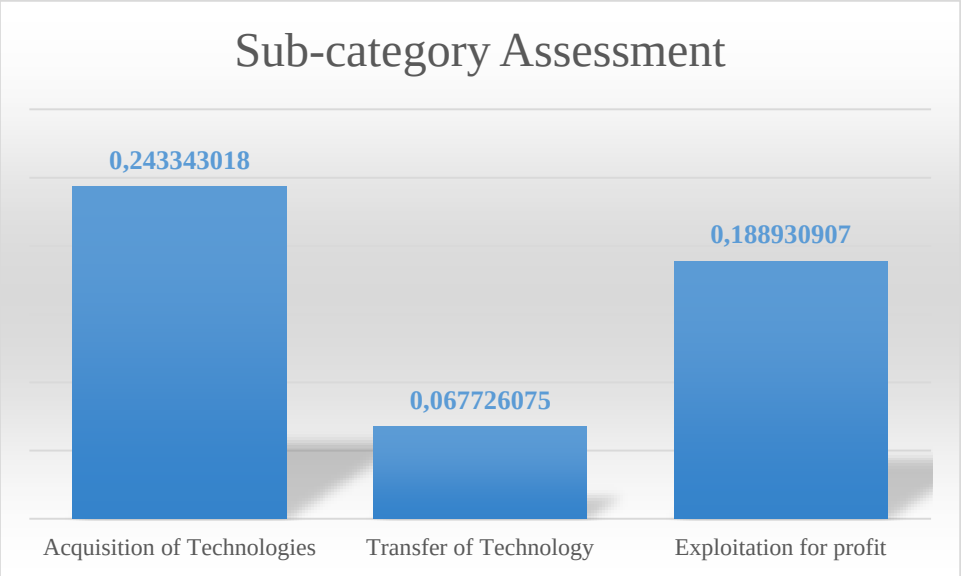

Figure 4. 20 Sub-Category Weight Assessment in Fifth Category

From the result, can be seen that the sub-category with highest rank is acquisition of technology sub-category. While the lowest rank is exploitation for profit sub-category.

4.4.3 Third Level Hierarchy

In third level hierarchy, all of the 47 criteria are weighted according to each sub-categories. So there will be 19 different weight score models since there are 19 different sub-categories. The processes are similar with before which is start with normalization of initial crisp values. From previous crisp values matrix for each criteria, can be obtained the maximum value for each expert crisp values corresponding for each category. Then normalization is conducted. The result of $S(X_{ij})$ and $\tilde{s}_{ij}$ can be seen in the Appendix 2.

Finally, determination of entropy values and criterion weight are conducted using Equation (2.5)-(2.7) and the result can be seen in Appendix 2 and has already validated. Entropy values for each criteria are represented by E_j. While weight for each criteria are represented by W_j. Based on weight values, can be seen the best criteria of technology auditing model with the high rank and worst criteria with the low rank. All of them cover the third hierarchy level so there will be 19 different model of weight assessment. The following is the representation of the assessment result of five sub-category criteria within first category using FEWA method.

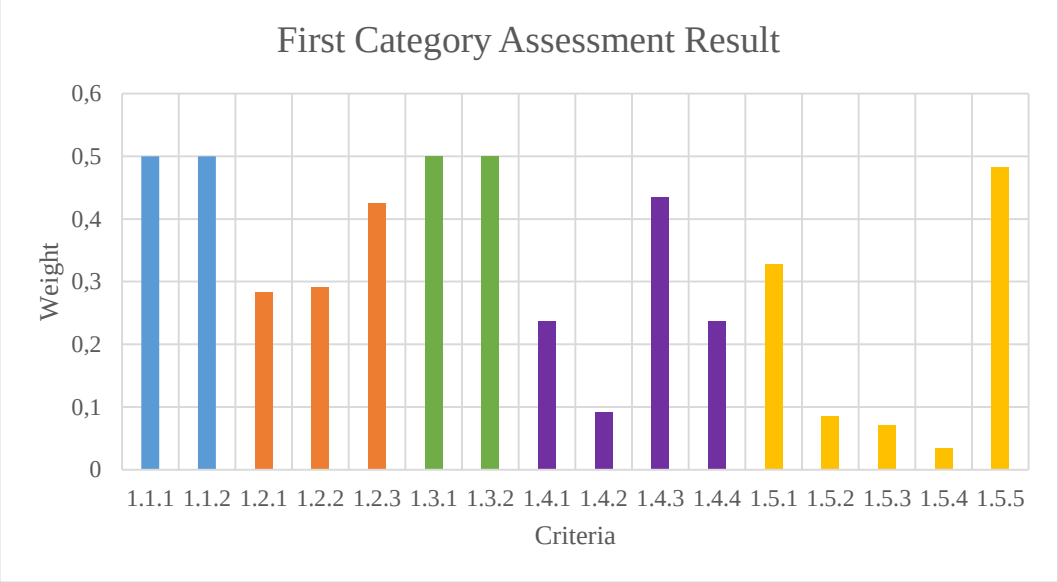

Figure 4. 21 Sub-category Assessment of First Category Criteria

From the first category assessment result, can be seen that in the first sub-category, the weight is equal for both of criteria (0.5). In the second sub-category, the criteria with highest rank is strategy deployment criteria while the lowest rank is corporate strategy criteria. In the third sub-category, the weight is also equal for

both of criteria. In the fourth sub-category, the highest rank is communication criteria, while the lowest rank is learning organization criteria. In the fifth category, the highest rank is worker expertise criteria, while the lowest rank is reward system criteria.

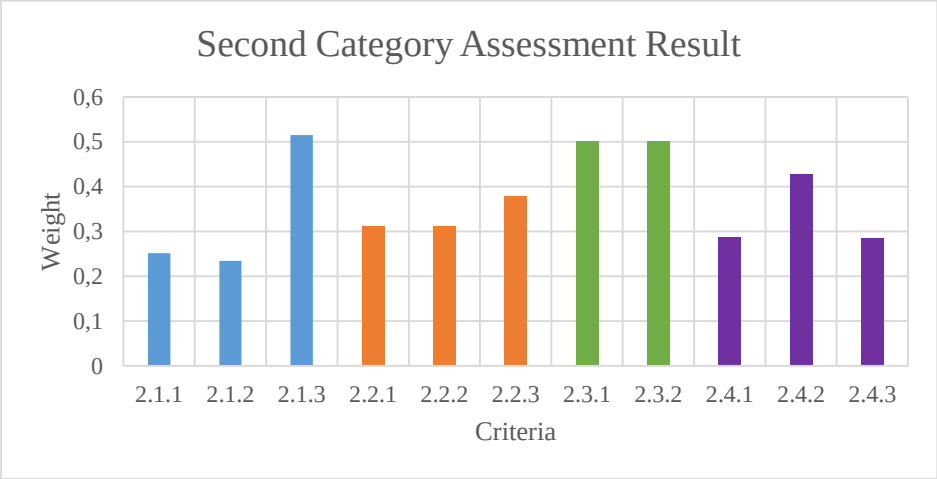

Figure 4. 22 Sub-category Assessment of Second Category Criteria

From the second category assessment result, can be seen that in the first sub-category, the highest rank is operator, while the lowest rank is basic technologies criteria. In the second sub-category, the highest rank is information system criteria while the others are equal weighted. In the third sub-category, the weight is equal for both of criteria. In the fourth sub-category, the highest rank is marketing expertise criteria, while the lowest rank is image management criteria.

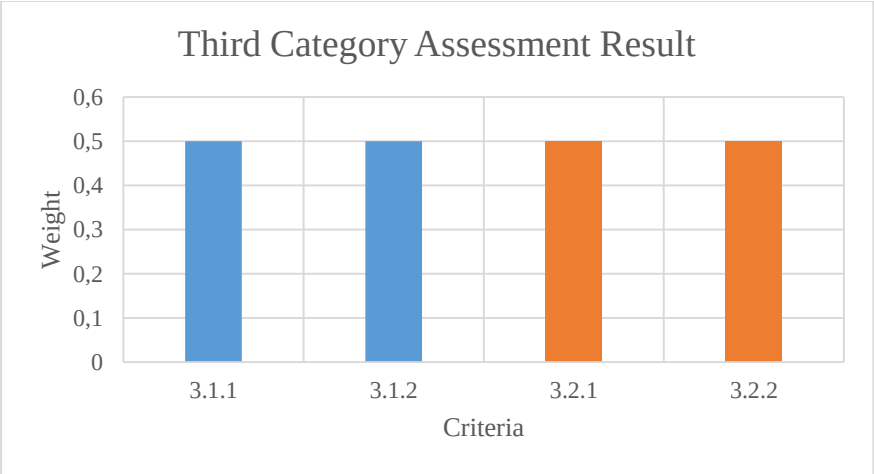

Figure 4. 23 Sub-category Assessment of Third Category Criteria

From the third category assessment result, can be seen that both first sub-category and second sub-category have equally weight size for all of criteria.

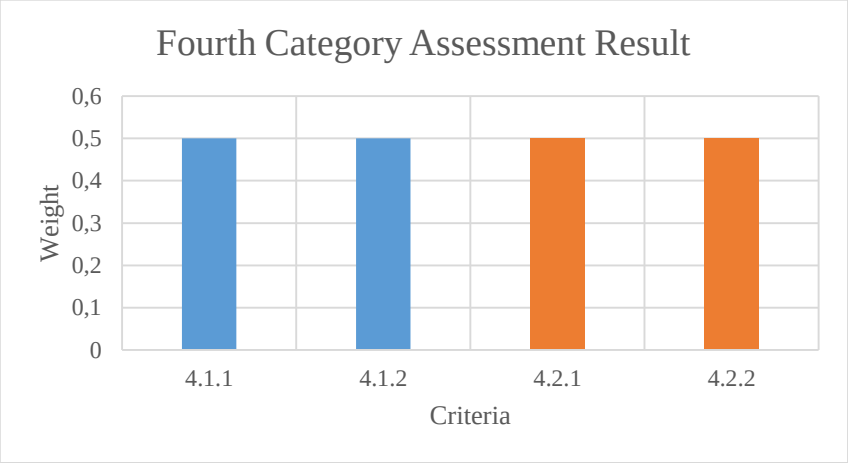

Figure 4. 24 Sub-category Assessment of Fourth Category Criteria

From the fourth category assessment result, can be seen that both first sub-category and second sub-category have equally weight size for all of criteria.

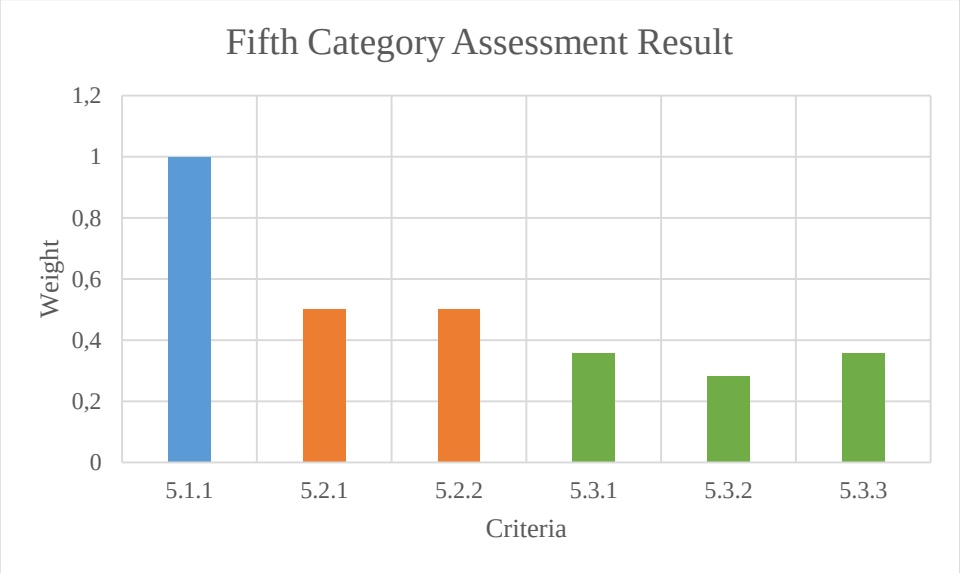

Figure 4. 25 Sub-category Assessment of Fifth Category Criteria

From the fifth category assessment result, can be seen that in the first sub-category, only one criteria here so the weight is maximum. In the second sub-category, the weight is equal for both of criteria. In the third sub-category, the highest rank are awareness and impact management with equal weight.

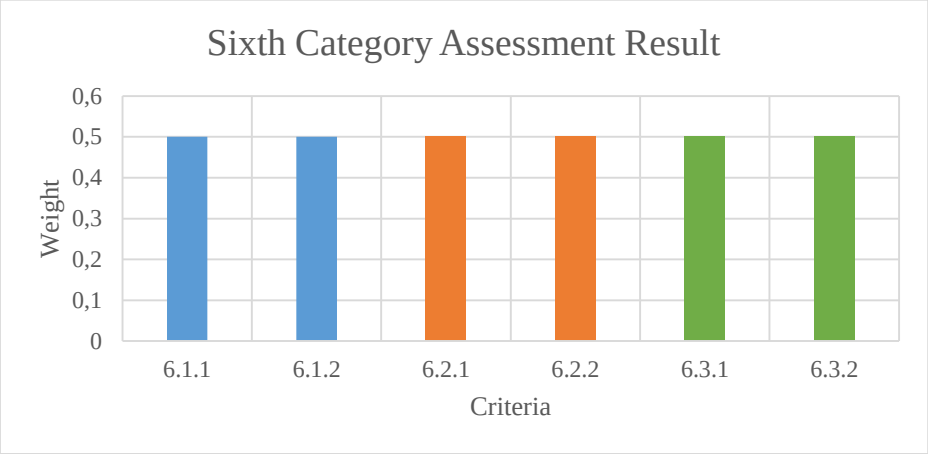

Figure 4. 26 Sub-category Assessment of Sixth Category Criteria

From the sixth category assessment result, can be seen that all first sub-category, second sub-category, and third sub-category have equally weight size for all of criteria within.

4.5 SWOT Analysis

This approach is used to assess the business process and identify the potential opportunities and threats. From this approach, will be obtained the position and suitable strategy related to the company. It will be separated into four main steps, which are identification of internal and external factors, factor evaluation, SWOT Matrix, and SWOT Map.

4.5.1. Identification of Internal and External Factors

The first step of SWOT Analysis is determining the factors affecting the company business process. There are internal factors which are about strengths and weaknesses of the firm, and external factors which are threats and opportunities.

The internal factors of SWOT are obtained from the previous assessment using FEWA method on technology auditing model criteria. For the strength factor, from the first level hierarchy assessment can be known that operator and worker expertise have highest rank among others criteria. Can be said that the expertise of employee is already good in this company. Teamwork and recruiting policies criteria also have high weight in the assessment. While from second category can be known that information system and procedure criteria have highest weight and

relatively high compared to all criteria. From the fifth and sixth category, the highest weight compared to all criteria are marketing technology and awareness criteria. While for third and fourth category, there is no criteria considered as strenght since those category have the lowest weight average compared to others.

For the weakness factor, from the first level hierarchy assessment can be known that innovation process category is the worst category with the lowest rank of average weight. Not only that, empowernment criteria become the lowest rank criteria compared to others. The second lowest rank criteria is schedule management from second category. While from first category, reward system and empowerment are the lowest. From the third, fifth, and sixth category, the lowest weight compared to all criteria for each category are market assessment system, transfer procedures, and green process.

The external factors of SWOT are obtained from the interview and discussion with internal expert of company. It is separated into opportunities and threats. For opportunity, there is government policies that support and boost shipyard industries in Indonesia. The current president is heavily improving the maritime sector in Indonesia, including shipyard industries. There is also ship regulation from Biro Klasifikasi Indonesia (BKI) that obligates ship to dock periodically. The inter-island sea transportation demand is growing which bring advantages to shipyard company. PT DPS as SOE company has advantages since there is cooperation program between SOEs company in Indonesia. Macroeconomic stability with relatively good inflation rate is also considered as opportunity.

For threat factor, the raw material of shipyard industries costs tend to rise and considered as threat for the company. There is also a high competition for shipyard industry in Indonesia. Weak domestic industries supporting the supply of materials and components, different tax incentives for the shipyard industries outside Batam, and limited access to capital investment and working capital are also considered as the threats of company. The following is the recapitulation table of identified internal factors (strengths and weaknesses) and external factors (opportunities and threats) of PT Dok Dan Perkapalan Surabaya.

Table 4. 15 SWOT of Company

STRENGTH		WEAKNESS	
S1	Good expertise of worker on ship repair process	W1	The ship repair process is often late from schedule
S2	Teamwork culture within company is high	W2	Lack of innovation management for employees
S3	Good recruiting policies	W3	Bad reward system for employees
S4	Good information system to support business process	W4	Market assessment system is not good enough
S5	Good SOP of company and its actualization	W5	Empowerment management is not good enough
S6	The company has good awareness of the environment	W6	The technology transfer procedure has not done well
S7	The technology in the company has been optimally exploited	W7	Bad environment management system in ship repair process
OPPORTUNITY		THREAT	
O1	Government policies that support and boost shipyard industries in Indonesia	T1	Raw material costs tend to rise
O2	The ship regulation for docking periodically	T2	High competition for shipyard industry
O3	Growth of inter-island sea transportation demand	T3	Weak domestic industries supporting the supply of materials and components
O4	Cooperation program between SOEs	T4	Different tax incentives for the shipyard industries outside Batam
O5	Macroeconomic stability with relatively good inflation rate	T5	Limited access to capital investment and working capital

4.5.2. Factor Evaluation

After the identification of internal and external factors, the calculation of IFE (Internal Factor Evaluation) and EFE (External Factor Evaluation) are conducted. The purpose is to know the position of the firm so they can decide the appropriate strategy. This evaluation process are done by internal expert of company. For the weight importance calculation of each factor, Expert Choice software is applicated. This software uses AHP approach to determine the weight importance level for each factor. The factors are weighted for each factor

categorization, which are internal and external factor. The consistency ratio must be smaller or equal to 10% so it is acceptable. The process and result can be seen in Appendix 3. Then all of factors are assessed using likert scale (1-4), where one is the lowest score and four is the highest score. The following is the table of internal factor evaluation result.

Table 4. 16 Internal Factor Evaluation

INTERNAL FACTOR EVALUATION					
Attributes		Weight	Rating	Score	Total
STRENGTH					
S1	Good expertise of worker on ship repair process	0.156	4	0.624	1.877
S2	Teamwork culture within company is high	0.11	3	0.33	
S3	Good recruiting policies	0.065	3	0.195	
S4	Good information system to support business process	0.074	3	0.222	
S5	Good SOP of company and its actualization	0.108	3	0.324	
S6	The company has good awareness of the environment	0.032	3	0.096	
S7	The technology in the company has been optimally exploited	0.043	2	0.086	
WEAKNESS					
W1	The ship repair process is often late from schedule	0.132	2	0.264	0.891
W2	Lack of innovation management for employees	0.028	2	0.056	
W3	Bad reward system for employees	0.048	3	0.144	
W4	Market assessment system is not good enough	0.088	2	0.176	
W5	Empowerment management is not good enough	0.06	2	0.12	
W6	The technology transfer procedure has not done well	0.034	2	0.068	
W7	Bad environment management system in ship repair process	0.021	3	0.063	
TOTAL		**1**	**Differences**		**0.986**

Can be seen that the internal factors score from company strength is 1.877, while for weakness the score is 0.891. The differences is 0.986 and it will be used as the input for SWOT map process. The following is the table of external factor evaluation result.

Table 4. 17 External Factor Evaluation

EXTERNAL FACTOR EVALUATION					
Attributes		Weight	Rating	Score	Total
OPPORTUNITY					
O1	Government policies that support and boost shipyard industries in Indonesia	0,211	3	0,633	1,914
O2	The ship regulation for docking periodically	0,037	4	0,148	
O3	Growth of inter-island sea transportation demand	0,03	4	0,12	
O4	Cooperation program between SOEs	0,091	3	0,273	
O5	Macroeconomic stability with relatively good inflation rate	0,185	4	0,74	
THREAT					
T1	Raw material costs tend to rise	0,07	3	0,21	1,381
T2	High competition for shipyard industry	0,046	4	0,184	
T3	Weak domestic industries supporting the supply of materials and components	0,058	3	0,174	
T4	Different tax incentives for the shipyard industries outside Batam	0,148	3	0,444	
T5	Limited access to capital investment and working capital	0,123	3	0,369	
TOTAL		**1**	**Differences**		**0,533**

Can be seen that the external factors score from opportunity is 1.914, while for threat factor, the score is 1.381. The differences is 0.533 and it will be used as the input for SWOT map process.

4.5.3. SWOT Matrix

The SWOT can be further analyzed using SWOT Matrix, which is a matrix that assists companies in determining strategic alternatives by examining external opportunities and threats and how they compare to a company's existing strengths and weaknesses. The matrix will be separated to four matrix strategy which are S-O strategy, S-T strategy, W-O strategy, and W-T strategy.

S-O strategies (maxi-maxi strategy) are strategies which using strengths to maximize opportunities. It also can be called as aggressive strategy. The S-O matrix can be seen in the following table.

Table 4. 18 S-O Strategy Matrix

S-O Strategy		O1	O2	O3	O4	O5
		Government policies that support and boost shipyard industries in Indonesia	The ship regulation for docking periodically	Growth of inter-island sea transportation demand	Cooperation program between SOEs	Macroeconomic stability with relatively good inflation rate
S1	Good expertise of worker on ship repair process	Develop new production competences	Improve the schedule activity	Develop knowledge management system	Conduct program with other SOEs	Develop program to optimize employee
S2	Teamwork culture within company is high		Improve compliance within company	Improve the knowledge sharing between employee		
S3	Good recruiting policies			Recruite new employees to fill the worker shortage		Recruite new employees to fill the worker shortage
S4	Good information system to support business process		Using good information system for scheduling	Improve the knowledge sharing between employee		
S5	Good SOP of company and its actualization		Develop procedure of maintenance		Increase the cooperation with SOEs	Make training program for employee
S6	The company has good awareness of the environment	Try to apply for environment certification	Develop green image strategy	Develop green process within company	Corporate with other SOEs for waste management	Develop green process within company
S7	The technology in the company has been optimally exploited		Develop good maintenance strategy	Develop good maintenance strategy		Invest new technology

Based on the strategy matrix, there are many strategies in common. Thus it can be summarized to have better S-O strategies. The final S-O strategies can be seen in the following table.

Table 4. 19 S-O Strategies

S-O Strategy		
Factor	Strategy in common	Summary of strategy
S1-O3	Develop knowledge management system	Develop knowledge management strategy to manage and optimizing the employees (S1-S2-S4-S5-O3-O5)
S1-O5	Develop program to optimize employee	
S2-S4-O3	Improve the knowledge sharing between employee	
S5-O5	Make training program for employee	
S1-O1	Develop new production competences	Develop new production competences of company (S1-S7-O1-O5)
S7-O5	Invest new technology	
S6-O1	Try to apply for environment certification	Develop environment management system within company (S6-O1-O2-O3-O4)
S6-O2	Develop green image strategy	
S6-O3	Develop green process within company	
S6-O4	Corporate with other SOEs for waste management	
S6-O5	Develop green process within company	
S1-O2	Improve the schedule activity	Develop good schedule management strategy to minimize late on schedule (S1-S2-S4-O2)
S2-O2	Improve compliance within company	
S4-O2	Using good information system for scheduling	
S1-O4	Conduct program with other SOEs	Increase the cooperation with SOEs as value-added for company (S1-S5-O4)
S5-O4	Increase the cooperation with SOEs	
S3-O3-O5	Recruite new employees to fill the worker shortage	Develop good maintenance strategy (S3-S5-S7-O2-O3-O5)
S5-O2	Develop procedure of maintenance	
S7-O2-O3	Develop good maintenance strategy	

S-T strategies (maxi-mini strategy) are strategies which using strengths to minimize threats. It also can be called as diversification strategy. The S-T matrix can be seen in the following table.

Table 4. 20 S-T Strategy Matrix

S-T Strategy		T1	T2	T3	T4	T5
		Raw material costs tend to rise	High competition for shipyard industry	Weak domestic industries supporting the supply of materials and components	Different tax incentives for the shipyard industries outside Batam	Limited access to capital investment and working capital
S1	Good expertise of worker on ship repair process		Increase QCDHSE performance		Develop lean manufacturing	Develop lean manufacturing
S2	Teamwork culture within company is high			Develop good relationship with supplier		
S3	Good recruiting policies		Develop good criteria of recruitment			Develop optimal recruiting policies
S4	Good information system to support business process	Develop good information system for supplier management		Develop good information system for supplier selection		
S5	Good SOP of company and its actualization	Implement just in time concept	Develop benchmarking system	Develop procedure for supplier selection	Implement just in time concept	Develop procedure to minimize waste
S6	The company has good awareness of the environment		Increase environment quality		Use environment program as added value	Minimize energy consumption
S7	The technology in the company has been optimally exploited		Develop technology trend analysis system			Increase the utilization of technology

Based on the strategy matrix, there are many strategies in common. Thus it can be summarized to have better S-T strategies. The final S-T strategies can be seen in the following table.

Table 4. 21 S-T Strategies

S-T Strategy		
Factor	Strategy in common	Summary of strategy
S1-T2	Increase QCDHSE performance	Develop QCDHSE performance management of company as the critical factor (S1-S3-S6-S7-T2-T5)
S3-T2	Develop good criteria of recruitment	
S6-T2	Increase environment quality	
S7-T5	Increase the utilization of technology	
S1-T4-T5	Develop lean manufacturing	Develop lean manufacturing strategy (S1-S3-S5-T1-T4-T5)
S3-T5	Develop optimal recruiting policies	
S5-T1-T4	Implement just in time concept	
S5-T5	Develop procedure to minimize waste	
S2-T3	Develop good relationship with supplier	Develop JIT partnership strategy (S2-S3-S4-T1-T3
S3-T1	Develop good information system for supplier management	
S4-T3	Develop good information system for supplier selection	
S5-T3	Develop procedure for supplier selection	
S5-T2	Develop benchmarking system	Develop trend analysis system to fill gaps with competitors (S5-S7-T2)
S7-T2	Develop technology trend analysis system	
S6-T4	Use environment program as added value	Develop economic environment approach for business process (S6-T4-T5)
S6-T5	Minimize energy consumption	

W-O strategies (mini-maxi strategy) are strategies which minimizing weaknesses by taking advantages of opportunities. It also can be called as turn around strategy. The W-O matrix can be seen in the following table.

Table 4. 22 W-O Strategy Matrix

W-O Strategy		O1	O2	O3	O4	O5
		Government policies that support and boost shipyard industries in Indonesia	The ship regulation for docking periodically	Growth of inter-island sea transportation demand	Cooperation program between SOEs	Macroeconomic stability with relatively good inflation rate
W1	The ship repair process is often late from schedule		Improve the repair time of vessel	Improve the repair time of vessel		
W2	Lack of innovation management for employees	Improve new competence related to ship business		Improve the innovation of new technology	Conduct innovation program with SOEs	Invest for new research
W3	Bad reward system for employees	Good reward system for employee innovation				
W4	Market assessment system is not good enough		Use historical record as assessment system	Develop market assessment system		
W5	Empowerment management is not good enough	Develop good job description model	Empower employee related to schedule			Develop empowernment program within company
W6	The technology transfer procedure has not done well				Develop cooperation with SOEs	Develop cooperation with academic institution
W7	Bad environment management system in ship repair process		Develop green process within repair	Improve environment management		

Based on the strategy matrix, there are many strategies in common. Thus it can be summarized to have better W-O strategies. The final W-O strategies can be seen in the following table.

Table 4. 23 W-O Strategies

W-O Strategy		
Factor	Strategy in common	Summary of strategy
W2-O1	Improve new competence related to ship business	Develop RnD unit to increase innovation culture within employee (W2-W3-W6-O1-O3-O4-O5)
W2-O3	Improve the innovation of new technology	
W2-O4	Conduct innovation program with SOEs	
W2-O5	Invest for new research	
W3-O1	Good reward system for employee innovation	
W6-O4	Develop cooperation with SOEs	
W6-O5	Develop cooperation with academic institution	
W1-O2-O3	Improve the repair time of vessel	Improve time of ship repair (W1-W5-O2-O3)
W5-O2	Empower employee related to schedule	
W4-O2	Use historical record as assessment system	Develop good market assessment system to optimize high demand (W4-O2-O3)
W4-O3	Develop market assessment system	
W5-O1	Develop good job description model	Improve empowernment of employee (W5-O1-O5)
W5-O5	Develop empowernment program within company	
W7-O2	Develop green process within repair	Develop green ship repair (W7-O2-O3)
W7-O3	Improve environment management	

W-T strategies (mini-mini strategy) are strategies which minimizing weaknesses and avoid threats. It also can be called as defensive strategy. The W-T matrix can be seen in the following table.

Table 4. 24 W-T Strategy Matrix

W-T Strategy		T1	T2	T3	T4	T5
		Raw material costs tend to rise	High competition for shipyard industry	Weak domestic industries supporting the supply of materials and components	Different tax incentives for the shipyard industries outside Batam	Limited access to capital investment and working capital
W1	The ship repair process is often late from schedule	Optimize existing material		Highly consider budget for supplier selection	Use nearest supplier for material	
W2	Lack of innovation management for employees		Develop benchmarking system to bigger competitor			
W3	Bad reward system for employees					Embrace the employees
W4	Market assessment system is not good enough		Study the customer preference related to company position			
W5	Empowerment management is not good enough		Develop people focus strategy			Develop job description for employee
W6	The technology transfer procedure has not done well		Conduct cooperation program with other company			Optimize leasing system for technology
W7	Bad environment management system in ship repair process			Minimize the waste within supply chain		Minimize the energy consumption within process

Based on the strategy matrix, there are many strategies in common. Thus it can be summarized to have better W-T strategies. The final W-T strategies can be seen in the following table.

Table 4. 25 W-T Strategies

W-T Strategy		
Factor	Strategy in common	Summary of strategy
W1-T1	Optimize existing material	Retrenchment strategy to minimize company expense (W1-W6-T1-T3-T4-T5)
W1-T3	Highly consider budget for supplier selection	
W1-T4	Use nearest supplier for material	
W6-T5	Optimize leasing system for technology	
W2-T2	Develop benchmarking system to bigger competitor	Study from competitor strategy to fill the gaps (W2-W4-W6-T2)
W4-T2	Study the customer preference related to company position	
W6-T2	Conduct cooperation program with other company	
W3-T5	Embrace the employees	Develop good employee retention management (W3-W5-T2-T5)
W5-T2	Develop people focus strategy	
W5-T5	Develop job description for employee	
W7-T3	Minimize the waste within supply chain	Minimize energy consumption (W3-W5-W7-T2-T3-T5)
W7-T5	Minimize the energy consumption within process	

4.5.4. SWOT Map

From the result of IFI and EFE calculation, can be known the position of company. It formulated using SWOT Map, where there are four different quadrant according to strength, weakness, opportunity, and threat position. It will generates decision, wether company should apply aggresive strategy (S-O), turn arround strategy (W-O), defensive strategy (W-T), or diversification strategy (S-T). The following figure is the SWOT map of the company from the previous result.

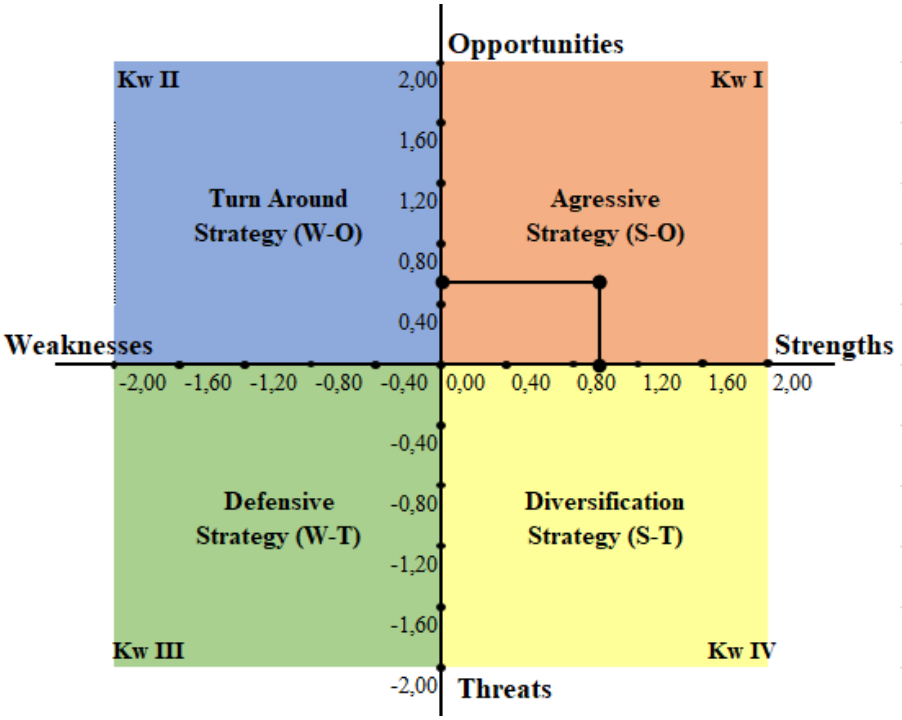

Figure 4. 27 SWOT Map

From the SWOT map, can be seen that the position is located at first quadrant. The strength's score is more dominant than weakness, while the opportunity's score is more dominant than threat. So the appropriate strategy for company according to the SWOT result is aggresive strategy, which is using firm's internal strengths to take advantage of external opportunities (use strengths to maximize opportunities). So the strategies based on SWOT approach are develop knowledge management strategy, develop new production competences of company, develop environment management system within company, develop good schedule management strategy, increase the cooperation with SOEs as value-added for company, and develop good maintenance strategy.

4.6 Improvement Strategy

This sub chapter will discusses the improvement strategies related to technology obtained from previous process as recommendations for PT Dok Dan Perkapalan Surabaya. From previous discussion about SWOT map analysis, can be known that the firm's position is located at first quadrant, therefore S-O strategies will be implemented. The proposed strategy can be seen in S-O matrix (Table 4.19).

But not all of the strategies are discussed here. Based on the discussion with company, only three strategy are proposed in this research. Those strategies are selected after considering the priority, possibility, and cost of implementing each strategy. The strategies are develop knowledge management strategy, develop environment management system, and develop good schedule management strategy. Those strategies are still general, so detailed work program can be generated to support the strategy implementation. So the whole strategy implementation is not discussed here but only the detailed work program for each strategy. The following will be discussed about the proposed detailed work program to support improvement strategies based on SWOT analysis result.

4.6.1. Knowledge Sharing Program

Knowledge sharing can be defined as an exchange of knowledge between two individuals, one who communicates knowledge and one who assimilates it (Schwartz, 2006). It is one of the strategy in knowledge management. The proposed strategy here is a knowledge sharing program, where one or more PT DPS employees act as the knowledge sharer for other employees. It is proposed since some of the company employees have good expertise, either in term of technical, managerial, or others. Usually some employees acquire the knowledge in the first by taking specific training from external institutions. The number of training taken by company's employees can be seen in the following table of external training recapitulation in 2016.

Table 4. 26 Employees Training in 2016

No	Training	Number of Training	Number of Employee	Hours
1	Competence / Technical	24	45	408
2	Managerial	4	6	32
Total		28	51	440

Source: Internal Company

There are 28 number of training where 24 are technical training and 4 are managerial training. 51 employees participated there with average hours is 8.63 hours/employe. So there are 11% of total employees who trained in 2016. In existing condition, the sharing processes in the company are not good so the

knowledge is not deployed well for all employees and the training become not useful. Therefore optimization of the knowledge must be conducted. Knowledge sharing program is expected to become a solution where company facilitate a program that ease the knowledge sharing process between employees. The program can be in the form of training, workshop, discussion, or others. Here the employee who has better knowledge will be a trainer for other employees. It is quite useful to optimize the knowledge potential of internal employees instead of conducting external training. It help facilitates any unit that need knowledge sharing for their employees.

Diklat is proposed to be facilitator unit that handle the knowledge sharing program start from the pre-program until the program is conducted. Pre-program process can be challenging because it integrates all of department/unit in the company. To ease the process, a Standard Operating Procedure (SOP) is proposed. This SOP consist of step-by-step process on how to conduct a knowledge sharing program that covers all stakeholder program. Proposed SOP can be seen in the following figure.

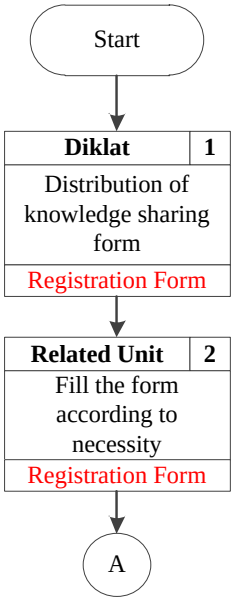

Figure 4. 28 SOP of Conducting Knowledge Sharing Program

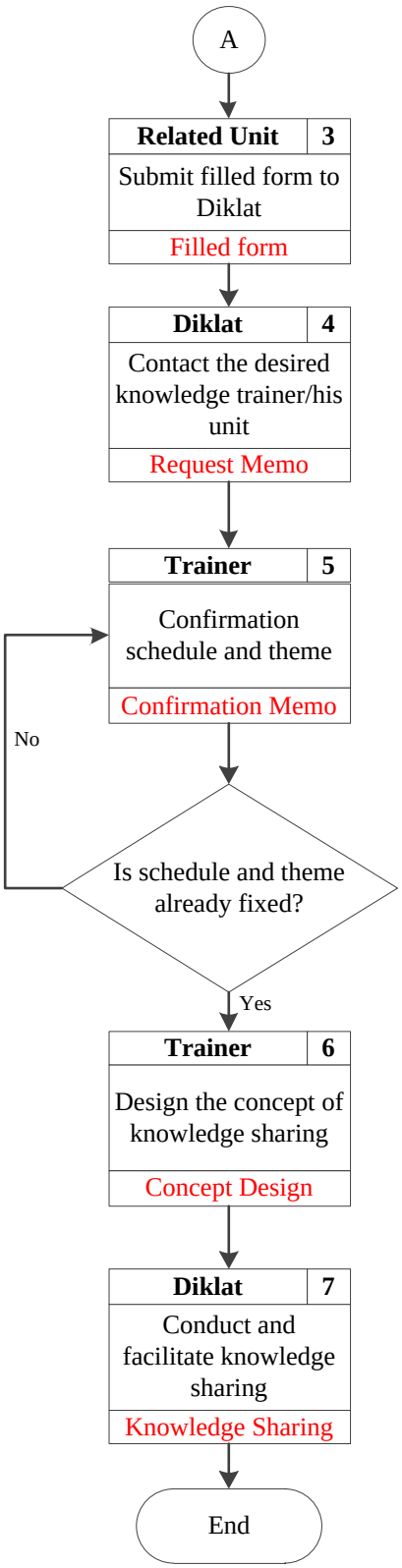

Figure 4. 28 SOP in Conducting Knowledge Sharing Program (continued)

The first process is distribution of knowledge sharing registration form by Diklat to all of unit in PT DPS. The form consist of unit identity, theme, desired

trainer, list of participants. It will triggers all unit to participate in this program. Any unit that need knowledge sharing for their employees can fill the form according to necessity, before submit it back to Diklat. Then, Diklat will processes it and contacts the related employee who expected to become a trainer. After the schedule and theme are confirmed, trainer will design the knowledge sharing program. Finally, knowledge sharing program can be conducted and facilitated by Diklat.

DFD shows how data flows through a system which is processed as well. It also includes the functionality of a system. The benefit of DFD is it can help the understanding between users and analyst about data processing and communication. The proposed DFD level zero for knowledge sharing program can be seen in Figure 4.29. There are 3 entity systems with 20 data flow for system of conducting knowledge sharing program. Detailed level can be seen in Appendix 4.

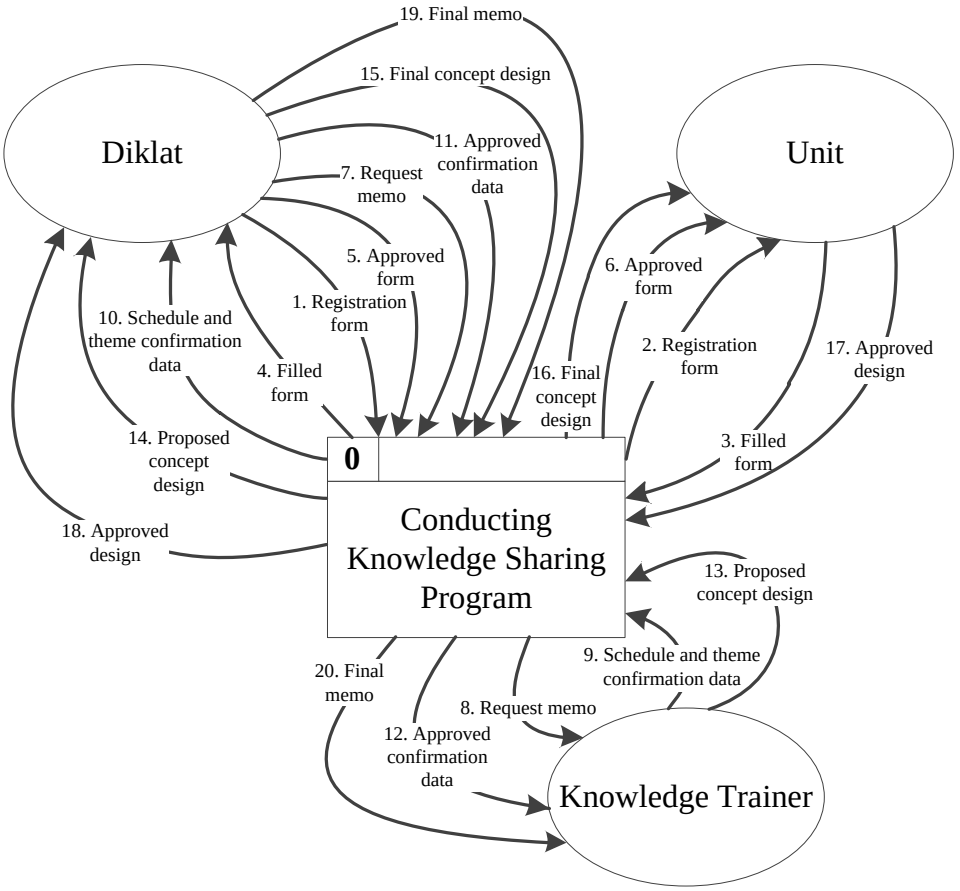

Figure 4. 29 DFD of Knowledge Sharing Program

The program is expected to become solution in exploiting the expertise of company's employees. The program will be conducted like common training

program where Diklat act as facilitator. But the difference is the trainer is from internal company and the location is expected to be conducted in the company. So besides optimizing the exploitation of internal expertise, the benefit of this program is that it can reduce the training cost (accomodation, transportation, salary, and other cost), not only for trainer but also trainees training cost. According to Peraturan Menteri Keuangan No.117/2016 about fee standard, this program can save Rp. 308,000/person for transportation and allowance cost for each training. It excludes the saving from accomodation cost, other facilitation cost, and different incentives for trainer. The weakness of this program is an adaptation is needed to trigger any unit to conduct knowledge sharing program. Moreover, the quality of training won't be like the professional training from other institutions.

4.6.2. Environmental Impact Evaluation

Evaluation of environmental impact is one of the process of Environmental Management System (EMS). It is conducted to know the environmental impact for each business process within company. From the evaluation, can be generated the suitable strategy to manage the environmental impact.

In existing condition, there is no evaluation method for environmental impact in the company. So there is no clear management of impact related to business process. Although company is already aware with environment, they still don't know the right action on environment management. In fact, environmental management can brings benefit for company in term of economic and strategic benefit. Therefore the evaluation is neccessary for PT DPS.

One of the method in evaluating the environmental impact is BAPEDAL (Badan Pengendalian Lingkungan) criteria assessment. The criteria are divided into environment factor and business factor. It can be seen in the following table.

Table 4. 27 Criteria of BAPEDAL

No	A. Area of Impact	Score
1	Influence related working unit	1
2	Influence plant area	3
3	Influence area of company	5
4	Influence community	7

No	B. Seriousness of impact	Score
1	There is no risk for flora, fauna, facility, and health	1
2	There is risk for flora, fauna, facility, and health	3
3	Cause damage for flora, fauna, facility, and health but can't be recovered	5
4	Cause permanent damage	7
No	C. Probability of Impact	Score
1	Very small (unexpected accident)	1
2	Occasionally (unplanned)	3
3	High (planned)	5
4	Can't be avoided (must be happen)	7
No	D. Time of Exposure	Score
1	Less than a day	1
2	Less than a week	3
3	Less than a month	5
4	More than a month	7
No	E. Regulation (Peraturan Perundangan)	Score
1	Unregulated in PP	1
2	Regulated in PP and already fulfilled	3
3	Regulated in PP and not fulfilled yet	7
No	F. Controlling Method	Score
1	There is controlling procedure and conducted	1
2	There is no written controlling procedure	3
3	There is controlling procedure but not conducted	5
4	There is no controlling procedure and activity	7
No	G. People Image	Score
1	Good	1
2	Fair	3
3	Bad	5

The proposed evaluation will be focused on sand blasing activity. Sand blasting is a dry abrasive blasting which is a method of surface cleaning by spitting out sand (dry abrasive material). It is a common requirement process before coating activity. Sand blasting is selected because in the company, this activity exists for all of ship repair project (100%). Although it is very useful, the wastes resulted from the activity are quite problematic. Therefore further evaluation is necessary here.

The environmental aspect and its impact to environment from sand blasting activity have already identified and can be seen in the following table.

Table 4. 28 Impact Identification in Sand Blasting

Activity	Environmental Aspect	Impact
Sand Blasting	Dust	Air quality reduction
		Health problem
	Noise	Health problem
		Disruption of comfort
	Sand	Disruption of comfort
		Water pollution
	Energy	Natural resources depletion

The BAPEDAL criteria assessment is conducted. The evaluation is done by internal expert which is K3L manager. After that criteria score is multiplied with each other to generate total score. Impact with total score equal or more than 6750 will considered as significant impact. The assessment result is presented in the following table.

Table 4. 29 Evaluation of Impact

Environmental Aspect	Impact	Evaluation Criteria							Total Score	Description
		A	B	C	D	E	F	G		
Dust	Air quality reduction	7	3	7	1	3	7	5	15435	Significant
	Health problem	7	5	7	7	3	7	5	180075	Significant
Noise	Health problem	1	7	1	7	3	1	3	441	Insignificant
	Disruption of comfort	1	5	1	1	3	1	3	45	Insignificant
Sand	Disruption of comfort	3	3	5	1	3	3	5	2025	Insignificant
	Water pollution	3	3	5	7	3	3	5	14175	Significant
Energy	Natural resources depletion	1	7	7	7	3	1	1	1029	Insignificant

The significat impact are air quality reduction and health problem from dust aspect, and water pollution from sand aspect. The mitigation strategy can be implemented to reduce those issues. The following are the proposed mitigation strategies with the benefit and the downside.

Table 4. 30 Mitigation Strategies

Aspect	Environmental Impact	Existing condition	Mitigation Strategy	Benefit	Downside
Dust	Air quality reduction	There is no strategy to control dust contaminants	Use cartridge dust collector to collect contaminants	Removes harmful pollutants	High investment cost (13-100 million idr)
Dust	Health problem	Silica sand is harmful material and forbidden for some industry	Use more environment friendly material like steel grit instead of silica sand	It can be used again for several times and has less impact	The cost is 4-5 times higher than silica sand
		Some worker don't obey safety procedure	Increase the worker compliance of sand blasting procedure	Increase safety and healt rate of operator	Reduce the conform of some worker
		Process is conducted close to other activities	Create boundaries from other activities when sand blasting is conducted	Increase health rate in working unit	Increase the project time of repair
Sand	Water pollution	Sand wastes are thrown away as trash	Use sand wastes as economic advantage by selling them to other companies	Waste generate revenue to company instead disposal cost	Need appropriate waste collector company selection

4.6.3. Project Network

Project network is a visual flow diagram of the sequence, interrelationships, and dependencies of all the activities that must be accomplished to complete the project (Larson & Gray, 2011). This is a helpful tool in project scheduling management, including ship repair schedules. The breakdowned work are arranged to make processes of project completion. The common approach to develop project network is activity-on-node (AON). Using this approach the structure of each activity is represented by a node (box) that can be seen in following figure.

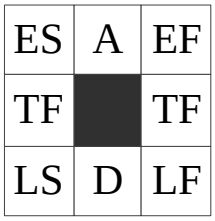

Figure 4. 30 Node of Activity (Larson & Gray, 2011)

Where (SQA, 2007):

- Earliest Start Time (ES): the earliest time at which the activity can start, given that any predecessor activity must be completed first.
- Earliest Finish Time (EF): the earliest start time for the activity plus the time required to complete the activity.
- Latest Finish Time (LF): the latest time at which the activity can be completed without delaying the project.
- Latest Start Time (LS): the latest finish time minus the time required to complete the activity.
- Total Float (TF): the amount of time that an activity can be delayed past its earliest start or earliest finish without delaying the project

It is very useful for company especially for scheduling process since late on schedule is a common thing. One of the reason is the scheduling is not detailed for all of activities. Company only makes master schedule for general activities. Moreover there is no clear sequences between all of activities.

Therefore the implementation of project network is suitable. The uses will be discussed further. In a barge vessel X project in PT DPS can be proposed the

project network. The master schedule for this project can be seen in Table 4.30 including only six activities.

Table 4. 31 Example of Master Schedule

No	Activity	Month	August-17													
		Date	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		Days	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Vessel docking															
2	General Service															
3	Outfitting Work															
4	Steel Work															
5	Mechanical Work															
6	Finishing															

The duration of this project is 13 days. The activities are general activities and can be breakdowned to more detail activities. It will focus only on outfitting and steel work for production activities to ease the process. The activities, their predecessor, and duration can be seen in the following network information.

Table 4. 32 Network Information

Activity	Code	Predecessor	Duration (days)
Vessel docking	A	-	1
External cargo hopper area	B	A	10
Forecastle deck	C	A	2
Poop deck	D	C	3
Under cabin	E	C	1
To renew gate plate	F	A(SS1)	5
Handrail forecastle/walkway	G	A	3
Base frame anchor winch	H	D	2
Anchor gipsy groove	I	D	4
Watertight doors front and rear	J	G	6
Finishing	K	B,D,E,F,I,J	1

The project network can be made based on those information. It can be seen in Figure 4.31. The node and network with red color represent the critical path of this project which is activity A, G, H, J and K. It is the path of activities that are important for the project and should not be delayed if the project is to be completed as planned.

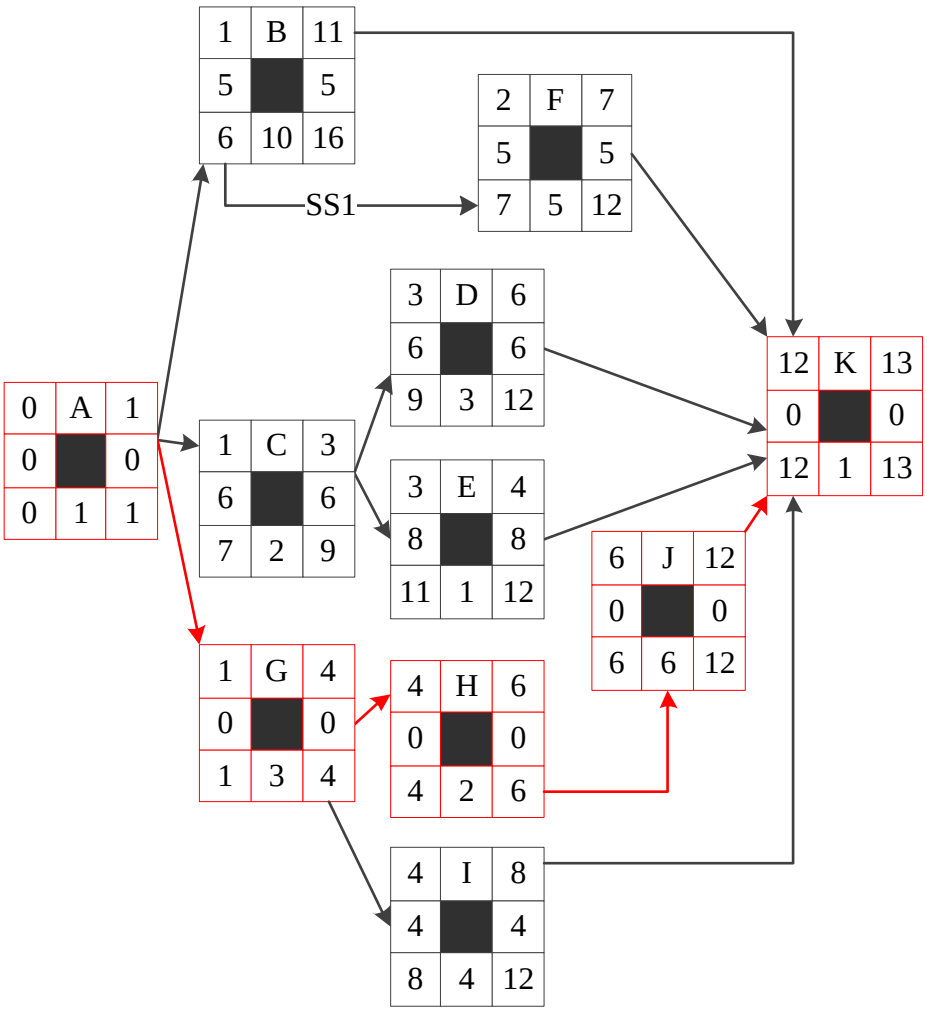

Figure 4. 31 Project Network

In conclusion, the implementation of project network is possible in PT DPS. It is an upgrade that can ease the scheduling management so it will minimize the late on schedule. This network is supporting tools for project managers to make decisions concerning project time, cost, and performance. It is also easy to be modified when unexpected things happen. Other benefits is that this method is easily understood by others since it presents a graphic display of the flow and sequence of work through the project. The uses of this project is not limited in ship repair business process. It also can be used for other project-based production process in PT DPS like shipbuilding, ship conversion, and others. But developing network path takes time. It consumes extra resource and effort from schedule maker when there are many activities in different workshop. Therefore it is not recommended for project with short duration time only.

CHAPTER V
DATA ANALYSIS AND INTERPRETATION

This chapter discusses about the data analysis and interpretation from the previous chapter result. The analysis consist of analysis of technology auditing model, multi-hierarchical framework, fuzzy entropy weight approach, SWOT method, and improvement strategy.

5.1. Technology Auditing Model Criteria Analysis

Basically this model is suitable with any kind of business process. It encompasses both manufacture and service industry since TAM is an auditing model of technology and most of businesses have technology to be managed. But doesn't mean all of the criteria in TAM is appropriate for all of company. Although one of the benefit of TAM is that the model already has exact criteria of assessment, an adjustment must be conducted to have better assessment model. So the removal of unfit criteria is permitted, so does the addition of new criteria which are more appropriate. Therefore in this research TAM model is adjusted to fit with business process of PT Dok Dan Perkapalan Surabaya, especially in ship repair process.

5.1.1. Technological Environment

Tabel 5. 1 Comparison of Technological Environment Criteria

No	Original Criteria	No	New Criteria
1.1.1	Technology as a top priority	1.1.1	Appreciation and priority of technology
1.1.2	Involvement and participation	1.1.2	Involvement and participation
1.2.1	Corporate strategy	1.2.1	Corporate strategy
1.2.2	Goals	1.2.2	Corporate goals
1.2.3	Deployment	1.2.3	Strategy deployment
1.3.1	Organizational chart	1.3.1	Organizational chart
1.3.2	Teamwork	1.3.2	Teamwork
1.4.1	Culture	1.4.1	Technology culture

No	Original Criteria	No	New Criteria
1.4.2	Learning organization	1.4.2	Learning organization
1.4.3	Communication	1.4.3	Communication
1.4.4	Management of change	1.4.4	Management of change
1.5.1	Recruiting policies	1.5.1	Recruiting policies
1.5.2	Training	1.5.2	Training
1.5.3	Empowerment	1.5.3	Empowerment
1.5.4	Reward system	1.5.4	Reward system
		1.5.5	Worker expertise

In new technological environment category, basically there is only a minor change. There are no removed criteria since this category talk about the organization technology management criteria which is certainly suitable for most of company that has management of organization within. The new worker criteria is added because it is the critical factor in the company. How the company can manage the skill of their employees is interesting to measured, moreover it is included in the technometric model – humanware category. Despite that, the first category already has very good model. This category has the biggest number of criteria, therefore the assessment can be detailed as possible, especially the organization assessment. From this model, can be known which are the best and worst criteria to support organization technology.

5.1.2. Technologies Categorization

Tabel 5. 2 Comparison of Technologies Categorization Criteria

No	Original Criteria	No	New Criteria
2.1.1	Internal technologies	2.1.1	Core technologies identification
2.1.2	External technologies	2.1.2	Basic technologies
2.1.3	Basic technologies	2.1.3	Operator
2.1.4	Technology trends	2.2.1	Technology trends
2.2.1	Internal technologies	2.2.2	Non-operational technology

No	Original Criteria	No	New Criteria
2.2.2	External technologies	2.2.3	Information system
2.2.3	Basic technologies assessment	2.3.1	Procedure
2.2.4	Technology trends	2.3.2	Schedule management
2.3.1	Innovation in marketing	2.4.1	Innovation in marketing
2.3.2	The product-service concept	2.4.2	Marketing expertise
		2.4.3	Image management

In new technologies categorization category, there are major changes. This second category mainly talk about the hardware technology categorization. But there are unfit criteria and sub-categorizations here since the boundary of product/servicesss technology and process technology criteria according to company business process is vague, so major adjustment is conducted.

The production technology sub-category focuses on the basic technical technologies of repair activities. Since all of the technologies are owned by the company, external technologies criteria is removed. Moreover, operator criteria is added. Technology trends and back office trends are included in others technology sub-category. The project sub-category is added because it is very critical to company. They are included as technology which is not embodied by the existing model. While for last sub-categories, the model is also changed due to adjustment.

In conclusion, this second category has several changes in the form of modification for inappropriate factor and addition for factors that are less considered. But the modification of this category is a normal things because it talks about categorization of technology which is tend to be different for different companies. If viewed as number of criteria, there is minor change from original model (from 10 to 11 criteria). But basically this category has already rich criteria, similar with first category. From this model, can be known which technology aspect is dominant and weak. Therefore can be said it is a critical category for TAM assessment model.

5.1.3. Markets and Competitors

Tabel 5. 3 Comparison of Markets and Competitors Criteria

No	Original Criteria	No	New Criteria
3.1.1	Market assessment system	3.1.1	Market assessment system
3.1.2	Marketing of technology	3.1.2	Marketing of technology
3.2.1	Competitor assessment	3.2.1	Competitor assessment
3.2.2	Benchmarking	3.2.2	Benchmarking management

In markets and competitors criteria, there is no change. The company has already meets the requirements to put all of the criteria to assessment model. Markets and competitors management is very essential in any business, including in shipyard company. The tight competition encourages shipyard company to have better understanding of market and competitors. Unlike previous category, four criteria are enough to measure the aspect of market and competitor technology. This model is good to measure wether the market and competitor system in PT DPS already ideal or not.

5.1.4. Innovation Process

Tabel 5. 4 Comparison of Innovation Process Criteria

No	Original Criteria	No	New Criteria
4.1.1	Intrapreneurship	4.1.1	Intrapreneurship
4.1.2	Entrepreneurship	4.1.2	Entrepreneurship
4.2.1	Science push	4.2.1	Science push
4.2.2	Market pull	4.2.2	Market pull
4.3.1	Break-even time and break-even cost		

In new innovation process category, there is a minor change. From concept to market sub-category is removed because this sub-category talks about time-to-market improvement which is irrelevant with ship repair business process. Basically this category encompasses the basic principle of technology management which is

innovation aspect. The procces to innovate technologies can be known here, wether it has already ideal or not. For shipyard company, innovation is still necessary, especially with the upcoming of market challenges and competition any company must improve their business, using innovation as an approach. The innovation generators can come from different element. So this model is expected to describe the best and worst element of innovation in PT DPS.

5.1.5. Value-added Functions

Tabel 5. 5 Comparison of Value-added Functions Criteria

No	Original Criteria	No	New Criteria
5.1.1	Cross-functional teams	5.1.1	Innovation and R&D management
5.1.2	Portfolio justification	5.2.1	Improvement
5.1.3	Sucess/failure analysis	5.2.2	Technology maintenance
5.2.1	Improvement	5.3.1	Awareness
5.3.1	Green products and processes	5.3.2	Green process
5.3.2	After-life analysis	5.3.3	Impact management

In new value-added functions category, several modification occur. The first sub-category is modified since there is no R&D unit in PT DPS. But innovation and R&D management is still interesting to assess as value-added functions. The second sub-category has little addition of new criteria which is technology maintenance because one of the job description of technology gatekeeper here is to maintenance the all of the technology. While the last sub-category is modified to adjust the model with business process. This category mainly talk about the value-added functions within company. This is the unique model since it encompasses aspect like environment, improvement, and maintenance. From the assessment, can be known what best and worst company's VAF aspect are.

5.1.6. Acquisition and Exploitation of Technology

Tabel 5. 6 Comparison of Technology Acquisition and Exploitation Criteria

No	Original Criteria	No	New Criteria
6.1.1	Method of acquisition	6.1.1	Method of acquisition
6.1.2	Capital investment	6.1.2	Capital investment
6.2.1	Transfer procedures	6.2.1	Transfer procedures
6.2.2	People transfer	6.2.2	People transfer
6.3.1	Exploitation for profit	6.3.1	Technology exploitation
6.4.1	Protection	6.3.2	Management of technology

In acquisition and exploitation of technology category, there are also several changes. Third sub-category is added with new criteria of technology management because it affects the exploitation management. Protection sub-category is removed because it isn't urgent for company, especially for ship repair process. This model talks about how company acquire, transfer, and exploit their technologies. The technologies of the company already discussed in 4.1 subchapter. How company acquire, transfer, and exploit those technologies can be assessed using this model.

5.1.7. TAM Conclusions

The new TAM model has 47 assessment criteria, 19 sub-categories, and 6 main categories. To ease the understanding, each of criteria is labeled by some code. The code aims to make the criteria more organized and systematic since the actual name of criteria are various. It consist of three different number which describe each hierarchy level of criteria. The first number is describing category, second number is describing sub-category, third number is describing criteria itself. For example, the teamwork criteria is described by 1.3.2 code which means it is the second criteria of third sub-category of first category. This model is expected to become appropriate assessment model for PT DPS. With multi criteria like this, the

assessment from experts will generate detail measurement of company technology capabilities.

In conclusions, this method is suitable to assess technology capabailities in PT DPS. The benefits and disadvantages of using TAM can be identified. The benefit of TAM as assessment criteria is that TAM has so many (multi) criteria inside three different hierarchy level. The number of assessment category and criteria is bigger compared to other similar assessment, such as technometric approach. Not only that, it embraces different aspect of criteria which tend to be conflicting. For example, the market assessment system in market and competitors category is very different with green product criteria in value-added functions.

But the weakness is that this model is not 100% "exact" model since adjustment is necessary. The original TAM model category already fit with company but the criteria inside must be modified to have better correlation with business process. Auditing team or expert must fit the model into object's business process by removing unecessary criteria, adding new criteria, or modifying the criteria.

5.2. Multi-hierarchical Framework Analysis

The common framework used for multi-criteria decision making approach is single hierarchy framework. In this framework, all of the criteria are weighted and compared to other criteria in one weighting model. The result then will be used as the preference in determining a decision for alternative selection case or assessment case. While in multi-hierarchical framework, it embraces different level of criteria weighting. The weighting not only conducted for one model of criteria like in single framework, but different model according to the level of hierarchy. Moreover, each level will generates more different model of weighting depends on the number of category it has. Therefore, in this framework multi options are generated to give different preference for decision making process. The discussion will be seperated into several analyses to have better understanding.

5.2.1. First Level Analysis

In first level, all of the 47 criteria are weighted as one weighting model. The result generates one preference for decision making process. Basically TAM criteria rank is obtained here. Which criteria is the most dominant/weakest are known using this level assessment. Moreover, the best/weakest technology aspect are also obtained here, indicated by the rank of TAM category. So this assessment level can be used to assess technology capabilities of PT DPS in general.

5.2.2. Second Level Analysis

In second level, since TAM has six main categories, there are six different weighting model here. The result generates six preferences for decision making process. The rank of criteria for each category are obtained here. Moreover, the rank of TAM sub-category for each category are also obtained. So this assessment level can be used to assess technology capabilities for each business process aspect in PT DPS. Technological environment category has the most criteria which is 16 different criteria in six sub-categories. While markets & competitors and innovation process has the lowest criteria with only four criteria in two sub-categories.

5.2.3. Third Level Analysis

In third level, since TAM has 19 sub-categories, there are 19 different weighting model here. The result generates 19 preferences for decision making process. The rank for each sub-category are obtained here. But unlike two previous level, poor assessment will be obtained here. The cause is the number of criteria in weighting model that are so small. Most of sub-category only has 2 criteria, even in research and development sub-category, its only has one criteria (can't be assessed). The best assessment is obtained in people sub-category since it has five criteria. However, although some of the weighting model in this level may not give good assessment, the technology capabilities in sub-category are still interesting to measured and can add another preference for decision making.

5.2.4. Multi-hierarchical Framework Conclusions

The advantages and disadvantages of this method can be seen in the following table.

Tabel 5. 7 Advantages and Disadvantages of Multi-hierarchical Framework

No	Advantages	Disadvantages
1	It can assess thoroughly the model with multi-criteria especially the one with multi level of hierarchy	Data processing will be more complex and resource consuming
2	It gives multiple options, preferences, and viewpoints to support detailed analysis in decision making process	It is not suitable with model that have no hierarchy which means all of criteria are independent and can not be categorized

5.3. Fuzzy Entropy Weight Approach Analysis

FEWA method as a multi-criteria tools fits with TAM multi-hierarchical framework assessment. Basically the assessment for different level is similar. But the value of a criteria can be different for different assessment level. For example, image management criteria is powerful in first level assessment, but weak in third level assessment. That happens since it is compared to different criteria. When this criteria is seen as whole model, it can be powerful. But when it seen as smaller model, it generate weaker value. The assessment result have already validated by the experts so it is appropriate. The discussion will be seperated into several analyses to have better understanding.

5.3.1. Experts Analysis

Since this method can facilitates many judgement for decision making, seven decision makers (expert) are proposed in this research to strengthen the assessment. Experts here will apply scale assessment for each criteria as an input for FEWA method. The limitation criteria of company internal expert are employee who has good experience (indicated by position in company), high education

(university graduate), and old hand in company (indicated by length of work). In addition, the experts are came from different work unit to increase the possibility of various input for assessment, so good and more objective decision making supporting tool is obtained.

The list of experts can be seen in Table 4.14. To ease the understanding, each of expert is labeled by some code (E1-E7). All of experts are manager in his position, except E2 which is senior manager of production department and E4 which is reasonable since project officer unit don't have any manager. Most of experts have work experience more than 10 years. E4 only has 7 years of work experience but his last education is master degree. Only E6 who has similar education degree. Most of experts have bachelor's degree, while E2 and E3 only have associate's degree. In conclusion, all of experts meet the criteria of the decision maker.

Expert judgements are obtained using structured questionnaire since it is the appropriate method to capture human thought. It is supported by interview and discussion with expert to minimize the misunderstanding in assessment. The linguistic response indicates the variation of assessment. E3 tend to give good assessment to the criteria. Otherwise, E5 tend to give bad assessment. Those linguistic responses from experts will be used as input for FEWA method.

5.3.2. First Level Hierarchy Analysis

The process result of first level hierarchy can be seen in the following recapitulation table.

Tabel 5. 8 First Level Result

Weights				
Criteria	Ej	1-Ej	Wj	Rank
C 1.1.1	0,19887	0,80113	0,02343	9
C 1.1.2	0,16528	0,83472	0,02441	5
C 1.2.1	0,254	0,746	0,02182	18
C 1.2.2	0,33377	0,66623	0,01948	37
C 1.2.3	0,2498	0,7502	0,02194	16
C 1.3.1	0,2364	0,7636	0,02233	13
C 1.3.2	0,14613	0,85387	0,02497	3
C 1.4.1	0,31209	0,68791	0,02012	33

Weights				
Criteria	Ej	1-Ej	Wj	Rank
C 1.4.2	0,33123	0,66877	0,01956	36
C 1.4.3	0,16646	0,83354	0,02438	6
C 1.4.4	0,2764	0,7236	0,02116	23
C 1.5.1	0,16275	0,83725	0,02449	4
C 1.5.2	0,29366	0,70634	0,02066	29
C 1.5.3	0,35299	0,64701	0,01892	43
C 1.5.4	0,38229	0,61771	0,01807	45
C 1.5.5	0,10985	0,89015	0,02603	2
C 2.1.1	0,26865	0,73135	0,02139	21
C 2.1.2	0,24874	0,75126	0,02197	15
C 2.1.3	0,08944	0,91056	0,02663	1
C 2.2.1	0,32819	0,67181	0,01965	35
C 2.2.2	0,2672	0,7328	0,02143	20
C 2.2.3	0,21141	0,78859	0,02306	10
C 2.3.1	0,21251	0,78749	0,02303	11
C 2.3.2	0,39431	0,60569	0,01771	46
C 2.4.1	0,31441	0,68559	0,02005	34
C 2.4.2	0,28591	0,71409	0,02088	25
C 2.4.3	0,28734	0,71266	0,02084	27
C 3.1.1	0,35299	0,64701	0,01892	44
C 3.1.2	0,34393	0,65607	0,01919	38
C 3.2.1	0,28278	0,71722	0,02098	24
C 3.2.2	0,3481	0,6519	0,01907	39
C 4.1.1	0,30979	0,69021	0,02019	31
C 4.1.2	0,41657	0,58343	0,01706	47
C 4.2.1	0,35045	0,64955	0,019	41
C 4.2.2	0,28596	0,71404	0,02088	26
C 5.1.1	0,25444	0,74556	0,0218	19
C 5.2.1	0,29169	0,70831	0,02072	28
C 5.2.2	0,3102	0,6898	0,02017	32
C 5.3.1	0,23185	0,76815	0,02247	12
C 5.3.2	0,35007	0,64993	0,01901	40
C 5.3.3	0,25369	0,74631	0,02183	17
C 6.1.1	0,18872	0,81128	0,02373	8
C 6.1.2	0,24245	0,75755	0,02216	14
C 6.2.1	0,35045	0,64955	0,019	41
C 6.2.2	0,27595	0,72405	0,02118	22
C 6.3.1	0,18841	0,81159	0,02374	7
C 6.3.2	0,29868	0,70132	0,02051	30
Total	**12,807**	**34,193**	**1**	

In this assessment, there is only one weighting model. The result indicates the rank of each criteria. Only criteria 4.2.1 and 6.2.1 has same rank (same weight), while others have different weight. The range of weight is start from 0.017 until 0.0266 with mean of 0.021 and standard deviation of 0.002.

- Best Criteria

The highest rank is operator (2.1.3), followed by worker expertise (1.5.5) and teamwork (1.3.2). It indicates that PT DPS has good quality of worker, especially the operator skill. According to company, One of the main advantage of this company is the operator expertise, especially the mechanical workshop. PT DPS has good worker expertise which can compete with foreign worker. It is a good advantage since quality of worker affecting the quality of service. It can attracts customer to use this company's service.

- Worst Criteria

While the lowest rank is entrepreneurship (4.1.2), followed by schedule management (2.3.2) and reward system (1.5.4). Entrepreneurship talks about innovation facilities for employee, especially the development of the idea either internally or externally. In existing condition, the innovation in PT DPS is not facilitated well. There is no unit responsible for that strategy. This fact supported by bad reward system criteria assessment which exist to motivate innovation of employees.

Schedule management criteria talks about the on time schedule realization in ship repair. In existing condition, most of repair are late on schedule because of many factors such as schedule planning, material procurement, owner characteristic, schedule compliance, and others. The schedule management problem is actually a common things in Indonesian shipyard company, not only this company.

- Category Assessment

Category assessment is obtained from each category weight average calculation. The best category is first category which is technological environment. Although the highest criteria rank is not included in first category, in the 10 highest criteria rank, 6 of them are first category criteria. This company is dominant in

technological environment which mostly talks about organization management. The superiority of this company happens especially in expertise of worker, teamwork & communication, recruiting policies, and technology participation. While the worst category is innovation process. It is suitable with the result where the lowest criteria rank is included in fourth category. Moreover, all four innovation process criteria located in below criteria rank average. Basically, the reason is similar with previous discussion which is the innovation is not facilitated well in this company. Therefore, PT DPS is recommended to give extra focus on those technologies issues since it has bad assessment.

5.3.3. Second Level Hierarchy Analysis

The process result of second level hierarchy can be seen in the following recapitulation table.

Tabel 5. 9 Second Level Result

Weights					
Category	Criteria	Ej	1-Ej	Wj	Rank
1	C 1.1.1	0,42103	0,57897	0,079	6
	C 1.1.2	0,34115	0,65885	0,0899	3
	C 1.2.1	0,57235	0,42765	0,05835	9
	C 1.2.2	0,71953	0,28047	0,03827	13
	C 1.2.3	0,56179	0,43821	0,05979	8
	C 1.3.1	0,52908	0,47092	0,06426	7
	C 1.3.2	0,35779	0,64221	0,08763	4
	C 1.4.1	0,64743	0,35257	0,04811	11
	C 1.4.2	0,7248	0,2752	0,03755	14
	C 1.4.3	0,40005	0,59995	0,08186	5
	C 1.4.4	0,59535	0,40465	0,05521	10
	C 1.5.1	0,32974	0,67026	0,09146	2
	C 1.5.2	0,64898	0,35102	0,0479	12
	C 1.5.3	0,76716	0,23284	0,03177	15
	C 1.5.4	0,78146	0,21854	0,02982	16
	C 1.5.5	0,27363	0,72637	0,09911	1
2	C 2.1.1	0,43145	0,56855	0,11176	3
	C 2.1.2	0,53583	0,46417	0,09124	6
	C 2.1.3	0	1	0,19657	1
	C 2.2.1	0,79961	0,20039	0,03939	10
	C 2.2.2	0,5733	0,4267	0,08388	8

Weights					
Category	Criteria	Ej	1-Ej	Wj	Rank
	C 2.2.3	0,36972	0,63028	0,1239	2
	C 2.3.1	0,46074	0,53926	0,106	4
	C 2.3.2	0,92345	0,07655	0,01505	11
	C 2.4.1	0,74313	0,25687	0,05049	9
	C 2.4.2	0,51257	0,48743	0,09581	5
	C 2.4.3	0,56296	0,43704	0,08591	7
3	C 3.1.1	0,93087	0,06913	0,10754	3
	C 3.1.2	0,74268	0,25732	0,4003	1
	C 3.2.1	0,75277	0,24723	0,38461	2
	C 3.2.2	0,93087	0,06913	0,10754	3
4	C 4.1.1	0,3663	0,6337	0,31518	2
	C 4.1.2	0,90061	0,09939	0,04944	4
	C 4.2.1	0,3663	0,6337	0,31518	2
	C 4.2.2	0,35621	0,64379	0,3202	1
5	C 5.1.1	0,55532	0,44468	0,1718	4
	C 5.2.1	0,71084	0,28916	0,11172	5
	C 5.2.2	0,84485	0,15515	0,05994	6
	C 5.3.1	0,34352	0,65648	0,25363	1
	C 5.3.2	0,47856	0,52144	0,20146	2
	C 5.3.3	0,47856	0,52144	0,20146	2
6	C 6.1.1	0,18819	0,81181	0,27336	2
	C 6.1.2	0,36646	0,63354	0,21333	3
	C 6.2.1	0,88792	0,11208	0,03774	6
	C 6.2.2	0,70982	0,29018	0,09771	5
	C 6.3.1	0,1781	0,8219	0,27675	1
	C 6.3.2	0,69973	0,30027	0,10111	4

In this assessment, there are six different weighting model. The difference is the normalization happens based on each category. The rest process is the same with before. The result indicates the rank of criteria in each category. Basically in this level, specific and detailed analysis can be obtained from the result. For example, if company want to focus on management aspect, they can just do this assessment level focus on technology environment category and find the strength and weakness acording to assessment result. From that result, improvement related to management can be generated without assessing other category. The further discussions will be separated into each categories to have better understanding.

- Technological Environment Category

In this category, the highest criteria rank is worker expertise (1.5.5), followed by recruiting policies (1.5.1) and involvement and participation (1.1.2). Basically the result are similar with previous hierarchy best criteria since technological environment category's weight is superior than others. While for lowest criteria rank is reward system (1.5.4), followed by empowerment (1.5.3) and learning organization (1.4.2). In PT DPS there is reward management of employee but it is not optimal yet. The reward as a tool is not effective to motivate employees especially in innovation term. Employees think innovation is not necessary since the reward is not worth the effort.

For sub-category assessment, the best is senior executive leadership and orientation sub-category and the worst is technology strategy sub-category. Management already has good priority and participation related to company technologies. But the strategy, objectives, and its deployment is not well enough compared to other management environment aspect.

- Technologies Categorization Category

In this category, the highest criteria rank is operator (2.1.3), followed by information system (2.2.3) and core technologies identification (2.1.1). Information system in PT DPS already conducted well. PT DPS has its own information system managing the employees activities. It supports the business process activity, especially for management of employee. Company also already known the core competence which is ship repair and tried to optimize that field. While for lowest criteria rank is schedule management (2.3.2), followed by technology trends (2.2.1) and innovation in marketing (2.4.1). The ability to forecast the trend of technology and company technology position is not good yet There is no specific method to measure the technology position within company and the trends. The marketing system is also has bad innovation. There is no facility such as training for marketing yet in PT DPS.

For sub-category assessment, the best is production technology sub-category and the worst is project sub-category. Production technology in PT DPS is already good with decent basic technology for ship repair process and great operator skills. But the actualisation of schedule is still considered as bad.

- Markets and Competitors Category

In this category, the highest criteria rank is marketing of technology (3.1.2). Not only the product/service, technologies in PT DPS are already marketed for customer. Technologies are used as a tool to attract customer. While for lowest criteria rank is market assessment system (3.1.1) and benchmarking management (3.2.2). There are already a system within marketing to assess market needs and benchmarking, but they aren't optimal yet. Moreover, the connection between marketing and technology management is still not good enough.

For sub-category assessment market needs sub-category is better than competitor' status sub-category. In overall, the marketing performance is bad compared to other aspect of technologies. In addition, although the competition in shipyard industry is very tight, company still lack of system to study competitor's status.

- Innovation Process Category

In innovation process category, the highest criteria rank is market pull (4.2.2). PT DPS is able to relate current products to customer needs. It is very important for customer satisfaction. Moreover, company thinks customer is the main key factor of business process. While for lowest criteria rank is entrepreneurship (4.1.2). It has already discussed before.

For sub-category assessment, technology generators sub-category is better than idea generation sub-category. In overall, innovation category is the worst category according to assessment. The best criteria here can't represent the best capabilities of company in general. The innovation process within PT DPS is still bad. Can be said that all of criteria here are urgent for special attention.

- Value-added Functions Category

In this category, the highest criteria rank is awareness (5.3.1). PT DPS already has good awareness related to environment. They consider environment as an essential things in business process. Moreover, the commitment can be seen in the company's mission statement. While for lowest criteria rank is technology maintenance (5.2.2). In existing condition, there are preventive maintenance implemented for all machine and tools. But it doesn't work like expected. The

schedule of maintenance are not realised well because of many factors. The main reason is human resource shortage.

For sub-category assessment, the best is environment-conscious technology sub-category and the worst is operations sub-category. Company still focus on present condition without realizing the benefit of continous improvement within company. Without improvement, company will lose its position to other competitors.

- Acquisition and Exploitation of Technology Category

In this category, the highest criteria rank is technology exploitation (6.3.1). The technology exploitation in PT DPS are conducted very well. Machine is rare to be found idle. All of machine and tools already utilized very well. While for lowest criteria rank is transfer procedures (6.2.1). There is no management of transfer technologies from other insititutions yet. Technologies are transfered when company is in dire need, but there is no exact procedure.

For sub-category assessment, the best is acquisition of technologies sub-category and the worst is transfer of technology sub-category. Technology acquisition in PT DPS is well conducted. There are good procedures to obtain technologies and good capital investment. But for transfer technology, it still needs improvement to support the process of transfer of technology from other institution.

5.3.4. Third Level Hierarchy Analysis

The process result of third level hierarchy can be seen in the following recapitulation table.

Tabel 5. 10 Third Level Result

Weights					
Sub-category	Criteria	Ej	1-Ej	Wj	Rank
1.1	C 1.1.1	0	1	0,5	1
	C 1.1.2	0	1	0,5	1
1.2	C 1.2.1	0,5444	0,4556	0,28399	3
	C 1.2.2	0,53431	0,46569	0,29028	2
	C 1.2.3	0,31702	0,68298	0,42573	1
1.3	C 1.3.1	0	1	0,5	1
	C 1.3.2	0	1	0,5	1
1.4	C 1.4.1	0,74249	0,25751	0,23667	2

Weights					
Sub-category	Criteria	Ej	1-Ej	Wj	Rank
	C 1.4.2	0,9	0,1	0,09191	4
	C 1.4.3	0,52678	0,47322	0,43492	1
	C 1.4.4	0,74268	0,25732	0,2365	3
1.5	C 1.5.1	0,54015	0,45985	0,32733	2
	C 1.5.2	0,88044	0,11956	0,0851	3
	C 1.5.3	0,9	0,1	0,07118	4
	C 1.5.4	0,953	0,047	0,03345	5
	C 1.5.5	0,32156	0,67844	0,48293	1
2.1	C 2.1.1	0,5119	0,4881	0,25118	2
	C 2.1.2	0,54483	0,45517	0,23423	3
	C 2.1.3	0	1	0,5146	1
2.2	C 2.2.1	0,1781	0,8219	0,31088	2
	C 2.2.2	0,1781	0,8219	0,31088	2
	C 2.2.3	0	1	0,37824	1
2.3	C 2.3.1	0	1	0,5	1
	C 2.3.2	0	1	0,5	1
2.4	C 2.4.1	0,32781	0,67219	0,28735	2
	C 2.4.2	0	1	0,42749	1
	C 2.4.3	0,33294	0,66706	0,28516	3
3.1	C 3.1.1	0	1	0,5	1
	C 3.1.2	0	1	0,5	1
3.2	C 3.2.1	0	1	0,5	1
	C 3.2.2	0	1	0,5	1
4.1	C 4.1.1	0	1	0,5	1
	C 4.1.2	0	1	0,5	1
4.2	C 4.2.1	0	1	0,5	1
	C 4.2.2	0	1	0,5	1
5.1	C 5.1.1	0	1	1	1
5.2	C 5.2.1	0	1	0,5	1
	C 5.2.2	0	1	0,5	1
5.3	C 5.3.1	0,1781	0,8219	0,35929	1
	C 5.3.2	0,35621	0,64379	0,28143	3
	C 5.3.3	0,1781	0,8219	0,35929	1
6.1	C 6.1.1	0	1	0,5	1
	C 6.1.2	0	1	0,5	1
6.2	C 6.2.1	0	1	0,5	1
	C 6.2.2	0	1	0,5	1
6.3	C 6.3.1	0	1	0,5	1
	C 6.3.2	0	1	0,5	1

In this level, there are nineteen different weighting model and the normalization happens based on each sub-category. The result indicates the rank of criteria in each sub-category. From this assessment, company can have more detailed analysis if they want to focus on specific sub-category. For example, from environment-conscious technology assessment can be known the strongest and weakest criteria for further company strategy related to the environment without assessing other aspects. The further discussions will be separated into several analyses to have better understanding.

- Assessment Analysis

Basically in this level, poor assessment will be obtained for some of sub-categories. It happens since there are small number of criteria within most of sub-categories. For sub-categories with two criteria, it will generates same weight (0.5) when using FEWA method. In the first normalization method, one of the criteria will be subtracted with the same value. Since there are only two criteria, the value for both criteria will be 0 and 1 or 0 and 0 if they have same assessment value in the beginning, for each expert judgement in second normalization. Then, using Equation (2.5) will make both criteria have 0 entropy values and later will generate same weight value.

Therefore the assessment for sub-category with only two criteria is not appropriate, similar with research and development sub-category which has only one criteria. But for the rest is still applicable. So the analysis of sub-category with two criteria is not discussed further.

- Weight of Criteria Discussion

In technology strategy sub-category, the highest criteria rank is strategy deployment (1.2.3). While for lowest criteria rank is corporate strategy (1.2.1). The strategy and goals have worse value compared to deployment. Therefore company should focus on its main strategy and its target to achieve the corporation's vision before discusses about deployment procedures.

In technology culture advancement sub-category, the highest criteria rank is communication (1.4.3). While for lowest criteria rank is learning organization (1.4.2). The communication between employee is good, there is no organizational

barrier to communicate the information. But there is no knowledge learning system implemented within company.

In people sub-category, the highest criteria rank is worker expertise (1.5.5). While for lowest criteria rank is reward system (1.5.4). Company already aware of worker expertise management, realising that expertise of worker is an important key aspect. This sub-category is unique and balanced since some of the criteria here are powerful (worker expertise and recruiting policies), but some of them are weak (empowerment and reward system).

In production technology sub-category, the highest criteria rank is strategy operator (2.1.3). While for lowest criteria rank is basic technologies (2.1.2). Basically this sub-category is already good in the beginning. But the worse criteria is the basic technologies which is related to machine, tools, and equipment of company.

In other technology sub-category, the highest criteria rank is information system (2.2.3). While the rest have same weight value.

In technology in marketing sub-category, the highest criteria rank is marketing expertise (2.4.2). While for lowest criteria rank is image management (2.4.2). The expertise of marketing employee is considered good. But the management of image is need to be improved, since customer satisfaction is the important thing in this industry.

In environment-conscious technology sub-category, the lowest criteria rank is green process (5.3.2). Although the awareness of environment is good, the process itself is considered bad related to environment. There should be an improvement for generating green process within company.

5.3.5. FEWA Conclusions

From the assessment process, can be known the benefits of FEWA method which are:

1. It can consider the variety of the criteria and their conflicting characteristic. In this research, with the variety of TAM criteria and hierarchy, using multi-criteria approach can ease the preference making process, which is assessment process.

2. It can easily done by using scale-assessment of each criteria. It also facilitates multi decision maker and powerful in weighting process.

While the weaknesses of FEWA method also can be known which are:

1. It can't be used for single decision maker assessment.
2. Another tool/method is needed for further weight processing in most of cases.

5.4. SWOT Method Analysis

This method is used to generate company position and strategies based on FEWA assessment result. The discussion will be seperated into several analyses to have better understanding.

5.4.1. Identification of Factor

- Internal Factors

For internal factors, they are obtained from assessment result in first hierarchy level. The criteria with superior weighting result are considered as strengths and the criteria with weak weighting result are included in weaknesses. Each of category assign at least one criteria for strength and one for weakness factor, so the factors can represent all of company aspect (there is no dominant aspect).

- External Factors

For external factors, they are obtained from interview and discussion with internal expert. The external factor in shipyard company is quite interesting, both for opportunities and weakness. Basically the demand in ship repair industries are big since the current policies and regulation of government related to maritime sector. But it generates tight competition in the market.

While materials play significant effect to shipyard company. In the existing condition, the material cost tend to rise. Moreover, there are different tax incentives for shipyard if they want to supply material from outside country. The problem is the local suppliers still have poor quality compared to foreigner supplier. That is why it brings disadvantages to the company.

PT DPS as SOEs company also brings some effects. Based on government strategy, there is a cooperation program between SOEs in Indonesia. It helps to boost this company business process. In other side, the access to capital investment and working capital are limited, unlike private companies.

After factor identification, all of factors are labeled with code to ease understanding. The first word is indicating factor category (S/W/O/T) and the number indicates attribute number.

5.4.2. Factor Evaluation

This process is helped by internal experts to assess the importance weight for each attribute and its rating. The discussion will be separated into weighting process, rating process, and evaluation process.

- Weighting Process

For weighting process, expert choice software is used since it is a very simple and easy software to weight importance level of criteria. The consistency ratio are below 10% for both internal and external weighting process so they are acceptable.

In internal factor, the highest attribute rank is S1 with weight of 0.156. While the lowest attribute rank is W7 with weight of 0.021. Company thinks that good worker expertise is essential factor, but bad environment management system is not so important compared to others.

In external factor, the highest attribute rank is O1 with weight of 0.211. While the lowest attribute rank is O3 with weight of 0.03. Company thinks that government policy to boost the market is important factor, but the growth of inter-island is not very affecting.

- Rating Process

For rating assessment, it uses likert scale from one to four. For strength factor, the highest rating indicates that company has very good superiority for specific strength attribute. For weakness factor, the highest rating indicates that company has very bad performance for specific weakness attribute. For opportunity factor, the highest rating indicates that the advantages obtained is very high for

specific opportunity attribute. For threat factor, the highest rating indicates that the disadvantages obtained is very high for specific opportunity attribute.

- Evaluation Process

The rating will be combined with previous attributes weight to obtain final score for each attribute. In strength factor, the highest attribute score is S1 while the lowest is S7. In weakness factor, the highest attribute score is W1 while the lowest is W2. In opportunity factor, the highest attribute score is O1 while the lowest is O3. In weakness factor, the highest attribute score is T4 while the lowest is T3.

Then total score of each factor and difference between good and bad factors in both internal and external factors are obtained. In internal factor, strength generates 1.877 total score and weakness generates 0.891 total score. The differences is 0.986. Can be seen that the strength is superior to weakness factor. Weakness factor only generates less than half of strength factor. Therefore, company is considered good if viewed internally.

In external factor, opportunity generates 1.914 total score and weakness generates 1.381 total score. The differences is 0.533. Can be seen that the difference is smaller than internal factor. But opportunity has decent score which is slighty less than half of the maximum possible score. Therefore, the advantages obtained for this company is bigger than the disadvantages.

5.4.3. SWOT Matrix

For SWOT matrix, it is divided into four different matrix according to combination of strategy. The purpose is to have detailed strategy establishment because specific relation between factor can be known before they are merged into one powerful strategy. The analysis will be separated based on each strategy matrix.

- S-O Strategy

In S-O strategy, there are 6 different strategies that can be seen in Table 4.19. The strategy which embraces most factor are the first and sixth strategy. The strategies will be discussed as following.

1. Knowledge management strategy is needed to optimizing the quality of employees in the company. With this strategy the knowledge can be transfered effectively to all of employees.
2. New production competences is an option for company since there are high demand and good government policies especially in maritime sector. It is quite ambisious strategy but interesting to try since the competence requirement are not too much different with ship repair and shipbuilding. Moreover the expertise of the labors are already good.
3. Environment Management System (EMS) is the answer for the good environment awareness in company. Indonesian shipyard companies commonly don't implement specific strategy for environment. They still hardly find the correlation between their industries with environment. Good awareness can be a requirement in conducting green strategy. Therefore this company can obtain both economic benefits (revenue, minimal energy consumption, etc) or strategic benefits (public image, certification, etc) from implementing EMS.
4. Good schedule management strategy is an upgrade for the existing system. As already known, it is a common thing that shipyard industries can't fulfill the ship repair schedule on time. With good schedule management, PT DPS can takes the high demand of ship repair.
5. Cooperation program with other SOEs is the proposed strategy reflected from the fact that this company is SOE and government tend to prioritize SOE. DPS can collaborate with other SOEs to obtain added value in terms of revenue and publicity.
6. Good maintenance strategy is also an upgrade strategy for PT DPS. It improves the system of maintenance within company by making good maintenance procedures and resource allocation.

- S-T Strategy

In S-T strategy, there are 5 different strategies that can be seen in Table 4.21. The strategy which embraces most factor are the first and second strategy. The strategies will be discussed further.

1. QCDHSE management strategy is strategy to improve the performance of quality, cost, delivery, health, safety and environment within company. It is needed to face high competition of shipyard industries.
2. Lean manufacturing strategy is a method to minimizing wastes within business process. The unecessary waste must be removed in this concept strategy. Therefore it can reduce the unecessary cost.
3. JIT partneship strategy is one of the strategy in Just-In-Time concept. Basically it manage the good relation with suppliers so it can bring benefits to company. The supplier selection plays important role in this strategy.
4. Trend analysis is needed to face the high competition in the market. It will forecast the technology trends of other competitors and world shipyard industries in general.
5. Economic environment approach is how to exploit good environment awareness to generates profit for company.

- W-O Strategy

In W-O strategy, there are 5 different strategies that can be seen in Table 4.23. The strategy which embraces most factor are the first strategy. The strategies will be discussed further.

1. With the high demand company must innovate to compete in the market. RnD unit can be a sollution to facilitate the innovation process within company. Therefore continous improvement can be obtained.
2. Time of ship repair should be improved to face the high demand. It is to minimize the late on schedule of any ship repair project.
3. Company also can develop good market assessment system since the existing condition is not good enough. So they can analyse the market potential and exploit the demand effectively.
4. Empowernment of employee development is necessary. It can increase the employee exploitation performance so they can give their full potentials for company.
5. Green ship repair process are needed because in this era green company is very beneficial. It can increase the image and quality of company.

- W-T Strategy

In W-T strategy, there are 4 different strategies that can be seen in Table 4.25. The strategies will be discussed further.

1. Retrenchment strategy is a defensive strategy useful to minimize the expense. Before conducting any investment, appropriate analysis is conducted prioritizing cost over quality.
2. Study from bigger competitor is a strategy to fill the existing gaps with competitor. Therefore this company can gain the similar competences.
3. Employee retention management is a way to increase the loyalty of worker. It is very effective method to embrace the employees and increase the welfare.
4. The last strategy is about minimizing energy consumption. The low energy material is needed and effective energy management can be conducted so there is minimal cost from energy used in business process.

5.4.4. SWOT Map

Based on SWOT map result, the company is located in aggresive strategy quadrant. It is expected since the strength and opportunity value are superior than bad factors. Can be said that company has good capabilities and good external advantages so the appropriate strategy must be considered. Six different strategies have already generated. The priority selection can be conducted to select the strategy implementation priority if there are some limitations. Multi-criteria decision making tool can be used with conflicting criteria as consideration such as budget cost, urgency, resources, conformity with company's vision, or other criteria. But the strategies are not specific yet. It must be breakdowned into specific work programs so they are applicable for company.

5.4.5. SWOT Method Conclusions

The benefit of this method is that it isn't only cover the internal factors but also external factors. The relation between both internal and external factor can be analysed using evaluation and matrix analysis. So, integrated output strategies can be generated. The weakness of this method are many processes needed before

obtaining the appropriate strategies and the quality of subjective judgment is crusial things here.

5.5. Improvement Strategy Analysis

Improvement strategies are proposed since it is expected that the technology assessment in this research is not only implemented in this company but also can bring improvement for the company. Actually from the assessment result many possible improvement strategies can be generated by the company. But this research will limits it into three improvement strategies. Analysis of improvement strategy will be divided into three analyses, which are analysis of knowledge sharing program, environmental impact assessment, and project network method.

5.5.1. Knowledge Sharing Program Analysis

This program is detailed work program from the proposed strategy of developing knowledge management strategy. The discussion will be seperated into several analyses to have better understanding.

- Existing Condition

In existing condition of company, employees have good expertise. It comes from either training, discussion, experience, or other knowledge transfer method. The knowledge can be technical knowledge, managerial knowledge, or other knowledges. Unfortunately, there is no knowledge sharing management so the expertise of employees are not optimally exploited yet. With this program, employees can gain knowledge from other employee in a facilitated program without participating external training from other institutions.

- SOP of Conducting Program

The idea is good but the implementation is quite challenging. Therefore SOP to conduct the program is proposed (Figure 4.28). The SOP is already following PT DPS standard SOP design, where each process includes the related party, related file, and process sequence to ease understanding. The process flow are made as simple as possible, but still consider the culture of company that values procedures in any processes. Because of the possibility of tight schedule, the

process of time comfirmation between all related party is made as flowchart decision, so it can generates the right schedule that benefits all parties.

- DFD

For DFD level 0, there are 20 data flow. The busiest entity is Diklat since it connecting both related unit and knowledge trainer entities. While for DFD level 1, the busiest activities is in the third DFD process which is design the knowledge sharing concept. The reason is because in that process all of entities are participating. While for first process, only Diklat and Unit are participating and in second process the entities are only Diklat and knowledge trainer. The high work load of Diklat is reasonable because Diklat is the one who conducting the program.

- Implementation, Advantages, and Disadvantages

With good procedures like the proposed one in this research, this program can be easily implemented without investing high cost. The training are conducted like usual training, but with internal trainer. As already stated before, this program can brings many benefits, especially in cost saving. Company can deliver the same knowledges for all employees without making them participate in some other institutions training. For external training, the cost of participating employees for training can be minimized. For internal training, the cost of accomodation and transportation for trainer can be removed since no need to carry trainer to PT DPS's company. Not only that, the trainer will costs less than professional trainer.

For the downside, the weakness of the difference with proffesional training can be minimized with the help of training module. In every professional training, a module is obtained to ease the study after training process. That module can be useful as a supporting tool for internal knowledge sharing program.

While for the awareness of unit to conduct this program might have some time to control. Usually in some unit, they don't know that they need this program. They think it is not important for them. Therefore Diklat as facilitator must triggers them to try this program. Diklat must promotes the benefit of conducting the knowledge sharing program. Once they have tried it, the high possibility is that they will try to conduct the program again. Other strategy that can be implemented to overcome that problem is the company's management obligates all units to take this program in the beginning.

5.5.2. Environmental Impact Evaluation Analysis

This program is detailed work program from the proposed strategy of developing environment management system strategy. The discussion will be seperated into several analyses to have better understanding.

- Existing Condition

In existing condition, company has good awareness of environment facilitated by K3L unit. The commitment can also be seen in company's mission statement. But the truth is there is no progressive environmental strategy. K3L only work on the floating dock cleaning activities and environment controller. The reason is because K3L give bigger attention for safety and health rather than environment.

From the discussion with K3L manager, they still don't know what environmental strategy must be implemented. Therefore environmental impact evaluation is a great solution to overcome that problem. Not only it can assess the environment pocess, it also give suitable recommendation strategy related to managing environmental impact.

- BAPEDAL as Evaluation Method

BAPEDAL criteria assessment is an internal assessment for identifying the significant environmental impact from company activities. It is used since it is a simple assessment method with good criteria including environment and business factors. The criteria can easily be understood by auditor which is K3L manager in this research.

- Sand Blasting Identification

The evaluation is focused on sand blasting activity because from the discussion with company, this process has a lot impact to environment. Moreover, this process always occurs in any ship repair project. The identification of impact can be seen in Table 4.28. Sand blasting is very harmful activity with dust waste as a hazardous material. Dust is generated as the reaction of sand with object surface. Not only contain silica sand particle, it also consist of dangerous ship contaminants. It is very harmful for human lungs.

In addition, it also affecting the quality of air since most particle is a bad material. Sand blasting activity also generates high noise with about 100 psi pressure from compressor. Ear protector is compulsory for the operator. Extracted silica sand mixed with contaminants are the solid waste. Unlike dust, it can be seen by naked eye. If it isn't managed properly, it can go to the sea and blend with water. The solid waste is dangerous since it contains B3 wastes. For the energy, it uses compressor so it requires gas (solar) to start the machine.

- Assessment Result and Mitigation Strategies

The assessment is conducted by company with the discussion and interview. From the result, can be seen that there are three significant impact. Health problem from dust aspect is the highest impact total score, while the lowest total score is disruption of comfort impact in noise environment aspect.

The significant impact are necessary to be mitigated. There are five proposed mitigation strategies.

1. The first one is about how to control dust using cartridge dust collector. It is suitable since the size is small and effective to collect dust waste. But the cost of investment is quite high. Further cost analysis must be conducted before investing the machine.
2. For using steel grit strategy, actually it is possible to be implemented. Although the cost is high, the material can be used several times unlike silica sand that will extracts after the first use. It also more friendly than silica sand which is not popular in company with good quality of HSE.
3. Worker compliance must be considered since some of employee don't obey the safety procedure. In some cases, they don't use the right safety protection suit and the way of blasting the sand affecting other people.
4. Boundaries from other activities is needed because the sand blasting activities is not only affecting the operator but people surrounding. But it will cost the late on schedule since parallel work can't be done.
5. For sand wastes, instead throw it away, company can sell its waste to other parties that need those for their production input. Besides can remove the disposal cost, it also can generates new income for company.

Sand blasting activity evaluation is one of the example of environment impact evaluation. To have better strategies, all of activities within this company must be breakdowned to know all of their environmental impact and their assessment score. Therefore, in the future the thorough environmental impact mitigation strategy can be implemented in PT DPS.

5.5.3. Project Network Analysis

This program is detailed work program from the proposed strategy of developing good schedule management strategy. The discussion will be seperated into several analyses to have better understanding.

- Existing Condition

In existing condition, the schedule for any project are in the form of master schedule. It consist of general activities and their duration. It comes with job order list formed by Renwas unit consist of activities list, responsible unit, duration, and manpower. The work activities are general activity for each workshop. There is no specific sequence of steps to conducting process. For example painting process can be breakdowned into cleaning process, sand blasting process, and coating process. And the duration given is just a total duration for each workshop. There is no detailed duration and connection between all activities. So in conclusion there is no clear sequence order of activities.

- Project Network Implementation Case

In a barge vessesl X project can be implemented project network for better scheduling. The analyses will be seperated into several analyses as follow.

1. Identification of process and network. With project network method, all of process within project must identified as detail as possible. At least the sequence must be clear with detailed duration for each activities. In case example, it is a repair project with 13 days duration. The focuses are only for vessel docking, outfitting work, steel work, and finishing activities. Then the general activities are breakdowned into detailed activities after identification to both outfitting and steel work are conducted. All of activities are labelled with alphabetical code to ease understanding. There is a start-to-start connection between activity A and

F. It means that activity F will starts 1 day after activity A started. The rest connections are represented by finish-to-start connection which means an activity will start after its predecessor has finished. The duration already breakdowned into detailed duration unlike the original schedule. The full network information can be seen in Table 4.31.

2. Identification of critical path. The project network proposed can be seen in Figure 4.31. Using this network, critical path can be found. Critical path includes all of activities that have total float of 0. The critical path of this case are activity A, activity G, activity H, activity J, and activity K. All of those activities are important activities for this project completion. They are very sensitive with the delay which will give significant impact for project. So if any unexpected things happen to the project, project manager should give high attention and allocation to critical path activities.

- Advantages and Disadvantages

There are many benefits from implementing this method. Basically it is a supporting tools to ease the decision making of project manager concerning time, cost, and performance of project. Not only that, it also ease the work for workshop unit in PT DPS since detailed schedule is proposed for them. Additional works are common things in ship repair activity within company. Fortunately, this method is suitable for sensitive changes since it is very easy to modify. It a good tool to explain the changes for all of project teams. The other benefit are further method can be implemented since it is suitable with critical path method. The example are crash cost method to accelerate the project and Program Evaluation Review Technic (PERT) for complex project. They can be implemented since the detailed activities and duration already proposed using project network.

The downside of this project is that schedule maker must give extra efforts and resources to make the complex project network. It must embraces all of activities within all production workshop. The good integration between workshop unit and Renwas/Pimpro unit is expected to support this idea. The efforts are big but it is totally worth since there are many benefits from this concept. Other disadvantages is that this method is not suitable with simple project with small duration. But the common project in PT DPS has duration about 12 days or more

according to repair list. So it is expected to be applicable. Actually this method is not just destined for scheduling management in ship repair production activities. It also can be implemented in other production area of PT DPS like shipbulding, ship conversion, offshore construction, and steel structure fabrication.

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CHAPTER VI
CONCLUSION AND SUGGESTION

This chapter discusses about the conclusions of this research and the suggestions as additional references for further research.

6.1. Conclusions

The following are the conclusions obtained from this research.

1. The criteria model consist of three hierarchy level with 47 criteria of technology assessment in total. It is included in six main category of Technology Audit Model (TAM). Technological environment category consists of 5 different sub-categories and 16 criteria. Technologies categorization category consists of 4 different sub-categories and 11 criteria. Markets and competitors category consists of 2 different sub-categories and 4 criteria. Innovation process category consists of 2 different sub-categories and 4 criteria. Value-added functions category consists of 3 different sub-categories and 6 criteria. Acquisition and exploitation of technology category consists of 3 different sub-categories and 6 criteria. Full criteria framework can be seen in Figure 4.6. They have already adjusted to fit the company business process.
2. The assessment process is assisted by 7 internal experts of company. FEWA method is used for three different hierarchy level. In first level assessment, criteria with highest rank is operator criteria (weight of 0.0266) included in second category. While the lowest rank is entrepreneurship criteria (weight of 0.017) included in fourth category. In second level assessment, there are 6 different models according to categories. Criteria with highest rank sequentially from the first category until six category are worker expertise criteria (weight of 0.0991), operator criteria (weight of 0.1965), marketing of technology criteria (weight of 0.4003), market pull criteria (weight of 0.3201), awareness criteria (weight of 0.2536), and technology exploitation criteria (weight of 0.2767). Criteria with lowest rank sequentially from the

first category until six category are reward system criteria (weight of 0.0298), schedule management criteria (weight of 0.015), benchmarking management and market assessment system criteria (weight of 0.1075), entrepreneurship criteria (weight of 0.0494), technology maintenance criteria (weight of 0.0599), and transfer procedures criteria (weight of 0.0377). In third level assessment, there are 19 different models according to sub-categories. Most of the models, 12 of them, have two criteria only so they will generate same weight value. In technology strategy sub-category, the highest criteria rank is strategy deployment (weight of 0.4257). While for lowest criteria rank is corporate strategy (weight of 0.2839). In technology culture advancement sub-category, the highest criteria rank is communication (weight of 0.4349). While for lowest criteria rank is learning organization (weight of 0.0919). In people sub-category, the highest criteria rank is worker expertise (weight of 0.4829). While for lowest criteria rank is reward system (weight of 0.0334). In production technology sub-category, the highest criteria rank is strategy operator (weight of 0.5145). While for lowest criteria rank is basic technologies (weight of 0.2342). In other technology sub-category, the highest criteria rank is information system (weight of 0.3782). In technology in marketing sub-category, the highest criteria rank is marketing expertise (weight of 0.4274). While for lowest criteria rank is image management (weight of 0.2851). In environment-conscious technology sub-category, the lowest criteria rank is green process (weight of 0.2814), while both of the rest criteria's weight are 0.3592.

3. In SWOT analysis, the factor identification is conducted using assessment result for internal factor and discussion with company for external factor. From Internal Factor Evaluation (IFE) process, the differences between strength and weakness score is 0.986. From External Factor Evaluation (EFE) process, the differences between opportunity and threat score is 0.533. Using SWOT map, the position of company is located in first quadrant. So the appropriate strategy for company according to SWOT

result is aggresive strategy, which is using firm's internal strengths to take advantage of external opportunities.

4. There are three improvement strategies proposed for company. Three of them are generated based on assessment and SWOT result. The first strategy is knowledge sharing program. Here company facilitate a program that ease the knowledge sharing process between employees. Employee who has better knowledge will be a trainer for other employees. It is useful to optimize the knowledge potential of internal employees instead of conducting external training. The SOP and DFD are proposed to support this program implementation. Second strategy is environmental impact evaluation. It is conducted to know the environmental impact for each business process within company. From the evaluation, can be generated the suitable strategy to manage the environmental impact. In this research the evaluation is focused on sand blasting activity. The significant impact based on assessment are air quality reduction and health problem from dust aspect, and water pollution from sand aspect. Five mitigation strategy are proposed to mitigate those impacts. Third strategy is project network. It is a a helpful tool in project scheduling management, including ship repair schedules. In this research, the implementation is focused on a barge vessel project. Basically it is an upgrade that can ease the scheduling management so it will minimize the late on schedule.

6.2. Suggestions

The following are the suggestions for further research obtained based on this research.

1. The number of technology audit model criteria can be improved especially within each sub-categories, using other similar technology assessment criteria.
2. Other production area like shipbuilding, ship conversion, offshore construction, steel structure fabrication, design or engineering can be assessed using similar assessment model.

3. Further research can discuss the improvement strategies based on the identified position of the company from this research.
4. Quantitative method and tools can be used to support the analysis and decision process for further research.
5. Further research can consider the implementation of group decision making using expertise-based ranking of experts (Herowati, et al., 2017).

REFERENCES

Adityaputra, M. M., 2011. *Analisis Kandungan Teknologi dengan Pendekatan Teknometerik dan Metode Analytic Network Process (ANP) pada Surabaya Plaza Hotel,* Surabaya: Industrial Engineering Department ITS.

Bhalla, S. K., 1987. *The Effective Management of Technology.* Columbus, OH: Battelle Press.

Cetindamar, D., Can, O. & Pala, O., 2006. Technology management activities and tools: The practice in Turkey. *PICMET,* pp. 9-13.

Chen, S. H. & Hsieh, C. H., 2000. Representation, ranking, distance, and similarity of L-R type fuzzy number and application. *Australian Journal of Intelligent Information Processing Systems,* 6(4), pp. 217-229.

Ciptomulyono, U., 2010. *Paradigma Pengambilan Keputusan Multikriteria dalam Perspektif Pengembangan Projek dan industri yang Berwawasan Lingkungan.* Pidato Pengukuhan Guru Besar Jurusan Teknik Industri, ITS.

Ding, J.-F., 2011. An Integrated Fuzzy TOPSIS Method for Ranking Alternatives and its Application. *Journal of Marine Science and Technology,* 19(4), pp. 341-352.

Dolinšek, S., 2007. Development of the Technology Audit Model. *MIC,* pp. 1409-1418.

EPA, 2001. *Shipbuilding & Ship Repair,* Washington, D.C.: s.n.

Ford, D., 1988. Develop Your Technology Strategy. *Long Range Planning,* 21(5), pp. 85-94.

Garcia-Arreola, J., 1996. Technology Effectiveness Audit Model: A Framework for Technology Auditing.

Hamel, G., 1996. Strategy as Revolution. *Harvard Business Review,* pp. 69-82.

Harrison, E. F. & Pelletier, M. A., 2000. The Essence of Management Decision: Management. *Management Decision,* 38(7), p. 463.

Herowati, E., Ciptomulyono, U., Parung, J. & S., 2017. Expertise-based ranking of experts: An assessment level approach. *Fuzzy SetsandSystems,* Volume 315, pp. 44-56.

Hwang, C. L. & Yoon, K., 1981. *Multiple Attribut Decision Making: Methods and Application: A State of the Art Survey.* Berlin, Springer Verlag.

Ighravwe, D. E., 2017. A Multi-hierarchical Framework for Ranking Maintenance Sustainability Strategies using PROMETHEE and Fuzzy Entropy Methods. *Journal of Building Pathology and Rehabilitation.*

IHS Fairplay, 2016. *Shipbuilding Statistics,* s.l.: s.n.

INDEC, 2015. *Profil Perusahaan Galangan Kapal di Indonesia.* [Online] Available at: http://indec.co.id/product/show/62 [Accessed 30 September 2017].

Judet, P. & Perrin, J., 1971. *A Propos du transfert des technologies pour un programme intégre de.* s.l.:s.n.

Kelessidis, V., 2000. *Technology Audit,* s.l.: Thessaloniki Technology Park.

Khalil, T. M., 2000. *Management of Technology: The key to competitiveness and wealth creation.* New York: McGraw - Hill.

Kusumaningtyas, D., 2010. *Implementation of Technology Assessment in Air Traffic Control System at Juanda International Airport using Technometric and MCDM Approach,* Surabaya: Industrial Engineering Department ITS.

Larson, E. W. & Gray, F. C., 2011. *Project Management the Managerial Process.* 5th penyunt. New York: Mcgraw-hill.

Marintec Indonesia, 2015. *Strengthening the Potential of the Shipyard Industry as the Main Force Indonesia's Maritime Sector.* [Online] Available at: http://marintecindonesia.com/strengthening-the-potential-of-the-shipyard-industry-as-the-main-force-indoneisas-maritime-sector/ [Accessed 1 October 2017].

maritim.go.id, 2017. *Bumikan Visi Indonesia Poros Maritim Dunia.* [Online] Available at: https://maritim.go.id/bumikan-visi-indonesia-poros-maritim-dunia-kemenko-kemaritiman-gelar-rakornas/ [Accessed 29 September 2017].

Martino, J. P., 1994. A Technology Audit: Key to Technology Planning. *IEEE.*

Nazaruddin, 2008. *Manajemen Teknologi.* Yogyakarta: Graha Ilmu.

Porter, A. et al., 1991. *Forecasting and Management of Technology*. New York: Wiley.

Pradana, A. H., 2011. *Analisis Kandungan Teknologi dengan Pendekatan Teknometerik dan Metode Analytic Network Process (ANP) pada Surabaya Plaza Hotel,* Surabaya: Industrial Engineering Department ITS.

Qiaoping, S. & Jiewen, O., 2015. Hesitant Fuzzy Multi-Attribute Decision Making Based on TOPSIS with Entropy-Weighted Method. *Management Science and Engineering,* 9(3), pp. 1-6.

Rahman, A. & Supomo, H., 2012. Analisa Kepuasan Pelanggan pada Pekerjaan Reparasi Kapal dengan Metode Quality Function Deployment (QFD). *Jurnal Teknik ITS,* 1(1), pp. 297-302.

Riston, N., 2008. Strategic Management. *Neil Riston and Ventus.*

Schwartz, D. G., 2006. *Encyclopedia of Knowledge Management.* s.l.:IGI Global.

sembcorp marine, 2016. *Forging Ahead,* s.l.: s.n.

Shannon, C. E. & Weaver, W., 1949. The mathematical theory of communication.

Shenhar, A., 1990. Management of Technology: A Morphological Taxonomy. *Tel-Aviv University.*

Shirazi, S. Z., 2009. The Possibility of Industrial Management using Technology Audit Model in the Public Sector Engineering Units of Pakistan. *Journal of Information & Communication Technology,* 3(1), pp. 21-28.

SQA, 2007. *www.sqa.org.uk.* [Online]
Available at: https://www.sqa.org.uk/e-learning/ProjMan02CD/page_11.htm
[Accessed 23 December 2017].

Steele, L. W., 1989. *Managing Technology.* New York: McGraw-Hill.

Tabucanon, M. T., 1988. *Multiple Criteria Decision Making in Industry.* Amsterdam: Elsevier.

Turban, 1995. *Decision Support Systems and Expert Systems.* New Jersey: Prentice Hall International Inc..

Wardhani, I. K., Usadha, I. G. N. R. & Irawan, M. I., 2012. Seleksi Supplier Bahan Baku dengan Metode TOPSIS Fuzzy MADM (Studi Kasus PT. Giri Sekar Kedaton, Gresik). *Jurnal Sains dan Seni POMITS,* I(1), pp. 1-6.

Zadeh, L. A., 1965. Fuzzy sets. *Information and Control,* 8(3), pp. 338-353.

Zeleny, M., 1986. High Technology Management. *Human System Management,* pp. 109-120.

APPENDIX

Appendix 1: Questionnaire of assessment

PENGANTAR

Kuesioner berikut merupakan kuesioner tentang penilaian teknologi pada penelitian tugas akhir berjudul "Penilaian Teknologi berdasarkan *Technology Audit Model* menggunakan *Multi-hierarchical Framework* dan FEWA". Tujuan dari penelitian ini adalah untuk mengukur kapabilitas teknologi reparasi kapal dan memberikan rekomendasi berupa *improvement strategy* berdasarkan hasil penilaian. Teknologi disini adalah teknologi yang mendukung proses reparasi kapal di PT Dok Dan Perkapalan Surabaya. Teknologi tidak hanya mencangkup mesin saja, tetapi juga pekerja, proses, metode, strategi, *skill, knowledge,* dll.

Sedangkan kuesioner ini adalah media yang dilakukan oleh peneliti atau surveyor kepada pihak ahli internal perusahaan untuk menangkap dan mengukur nilai teknologi yang ada pada model penilaian yang sudah disesuaikan dengan perusahaan sebelumnya berdasarkan kapabilitas dari pihak ahli internal perusahaan. Pengambilan data kuesioner dilakukan dengan pendekatan wawancara kuesioner secara mendalam pada responden.

Hasil penilaian teknologi akan digunakan sebagai bahan identifikasi dan gambaran permasalahan teknologi di perusahaan. Kemudian akan diidentifikasi strategi *improvement* yang dijadikan rekomendasi untuk perusahaan. Diharapkan rekomendasi dari penilitian ini bisa dipakai untuk mengembangkan proses reparasi kapal dan dipakai sebagai penentuan posisi teknologi PT Dok Dan Perkapalan Surabaya kedepannya. Segala aktivitas wawancara dan data adalah murni digunakan untuk kepentingan pendidikan dan penelitian. Atas perhatian dan partisipasinya diucapkan terima kasih.

Peneliti

Achmad Danu Firdaus

Kuesioner Penilaian Teknologi Reparasi Kapal

Nama Responden : _____

Instansi : _____

Jabatan : _____

Lama Kerja : _____

Pendidikan Terakhir : _____

Keahlian : _____

Serifikasi/Pelatihan : _____

Mohon kesediaan bapak/ibu untuk mengisi kuesioner di bawah ini. Tujuan dari kuesioner ini adalah untuk menilai teknologi berdasarkan model penilaian teknologi yang sesuai dengan PT Dok Dan Perkapalan Surabaya.

Petunjuk Pengisian:

Pada kuesioner ini Bapak / Ibu bisa memberi nilai dari kriteria teknologi yang ada berdasarkan performansi dan kondisi nyata dari perusahaan. Terdapat 47 kriteria penilaian dengan 6 kategori teknologi. Masing-masing kriteria sangat berpengaruh kepada penilaian performansi teknologi perusahaan. Penilaian menggunakan 5 poin penilaian (1-5) sebagai berikut:

Skala Penilaian	Keterangan
5	Sangat bagus sekali
4	Sangat bagus
3	Bagus
2	Sedang
1	Jelek

Bapak / Ibu diharapkan memberikan penilaian dengan mencentang (✓) pada kolom penilaian (1-5) yang tepat. Masing-masing kriteria penilaian akan dijelaskan lebih detail terkait definisi penilaian tertinggi(5) dan terendah(1) untuk masing-masing kriteria.

1. Lingkungan Teknologi

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
A. Kepemimpinan dan orientasi eksekutif senior							
1	Apresiasi dan prioritas teknologi di perusahaan	Apresiasi manajemen kepada teknologi di perusahaan. 5= teknologi semakin diprioritaskan dan dianggap sebagai *key factor*, 1= semakin tidak diprioritaskan					
2	Partisipasi dan keterlibatan manajer dengan teknologi di perusahaan	Dukungan manajemen terhadap budaya teknologi. 5= manajer peduli terhadap budaya teknologi, 1= manajer tidak peduli					
B. Strategi teknologi							
3	Strategi perusahaan	Strategi dan *plan* perusahaan untuk mencapai visi perusahaan. 5= strategi sudah baik untuk mencapai visi, 1= strategi belum baik					
4	Target perusahaan	Target capaian perusahaan mendukung manajemen teknologi yang baik. 5= target perusahaan mendukung teknologi, 1= target tidak mendukung					
5	Penyebaran strategi perusahaan	Penyebaran dan komunikasi strategi di perusahaan. 5= strategi sudah dikomunikasikan dengan efektif, 1= belum dikomunikasikan dengan baik					
C. Manajemen organisasi							

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
6	Struktur organisasi	Kualitas struktur organisasi di perusahaan. 5= struktur organisasi dirasa sudah baik dengan *job desc* yang jelas, 1= masih belum baik					
7	Kerja sama (*teamwork*)	Budaya kerjasama di perusahaan. 5= budaya kerjasama di perusahaan tinggi dan terfasilitasi, 1= budaya kerjasama masih kurang					
D. Kemajuan budaya teknologi							
8	Budaya teknologi	Budaya perusahaan untuk mendukung teknologi. 5= budaya di perusahaan yang sudah mengapresiasi pentingnya teknologi, 1= perusahaan masih belum mengapresiasi teknologi					
9	*Knowledge learning*	Metode dan proses pembelajaran di perusahaan. 5= *learning process* di perusahaan sudah baik didukung dengan *transfer knowledge*, 1= proses pembelajaran di perusahaan belum baik					
10	Komunikasi	Komunikasi dan ketersediaan informasi di perusahaan. 5= komunikasi sudah baik dan tidak terbatasi struktur organisasi serta ketersediaan informasi yang baik, 1= komunikasi belum baik dan informasi susah didapatkan					

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
11	Manajemen perubahan	Adaptasi terhadap perubahaan. 5= perusahaan sudah baik menyikapi perubahan dan menganggap perubahan sebagai kesempatan bukan ancaman, 1= perusahaan belum baik dalam menyikapi perubahan					
E. Karyawan							
12	Kebijakan merekrut karyawan baru	Sistem rekruitmen karyawan baru di perusahaan. 5= perusahaan dalam merekrut karyawan baru mempertimbangkan kebutuhan dan ketrampilan teknis-non teknis karyawan, 1= sistem rekrutimen dan kriteria kebutuhan karyawan belum baik					
13	Pelatihan karyawan	Proses pelatihan karyawan di perusahaan. 5= ada proses untuk menjamin kualitas karyawan dengan pelatihan yang baik, 1= pelatihan di perusahaan belum berjalan dengan baik					

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
14	Keahlian karyawan	Keahlian dan *expertise* karyawan di perusahaan. 5= karyawan di perusahaan memiliki keahlian dibidangnya sesuai dengan ekspektasi, 1= karyawan di perusahaan belum memiliki keahlian yang diharapkan					
15	Pemberdayaan pekerja	Pemberdayaan karyawan di perusahaan. 5= sistem pemberdayaan karyawan di perusahaan sudah baik dan berjalan, 1= pemberdayaan belum terlaksana dengan baik					
16	Sistem penghargaan (*reward*)	Sistem penghargaan karyawan di perusahaan. 5= sistem penghargaan sudah baik dan memotivasi karyawan, 1= sistem penghargaan belum baik					

2. Kategorisasi Teknologi

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
A. Teknologi reparasi							
1	Identifikasi dan eksploitasi *core competencies* perusahaan	Manajemen kompetensi utama perusahaan. 5= perusahaan sudah mengidentifikasi kompetensi utama di perusahaan dan sudah fokus pada aktivitas tersebut, 1= perusahaan belum bisa mengidentifikasi kompetensi utama perusahaan					
2	Teknologi reparasi kapal	Teknologi yang mendukung proses reparasi kapal di perusahaan. 5= kualitas teknologi reparasi kapal sudah baik dan mendukung proses bisnis perusahaan, 1= kualitas teknologi belum baik					
3	Operator dan teknisi reparasi kapal	Keahlian dan ketrampilan teknisi reparasi kapal. 5= teknisi reparasi kapal sudah memiliki keahlian yang baik untuk mendukung proses reparasi kapal, 1= teknisi belum memiliki keahlian yang baik					
B. Teknologi lainnya							

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
4	Teknologi non operasional	Teknologi yang mendukung proses non operasional di perusahaan. 5= kualitas teknologi non operasional sudah baik dan mendukung proses bisnis perusahaan, 1= kualitas teknologi belum baik					
5	*Trend* teknologi	Kemampuan perusahaan dalam memposisikan teknologi perusahaan dan perkembangan teknologi reparasi kapal. 5= perusahaan paham posisi teknologi mereka dibandingkan pesaingnya dan paham perkembangan teknologi reparasi kapal, 1= perusahaan belum bisa memposisikan diri dan belum paham *trend* teknologi					
6	Sistem informasi di perusahaan	Sistem informasi perusahaan yang terintegrasi. 5= perusahaan memiliki sistem informasi yang baik untuk mendukung proses bisnis, 1= perusahaan belum mempunyai sistem informasi yang baik					
C. Teknologi di pemasaran							

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
7	Inovasi di pemasaran	Kemampuan dan inovasi perusahaan untuk memasarkan diri ke *customer*. 5= perusahaan sudah memiliki sistem pemasaran yang baik dan inovatif. 1= perusahaan belum memiliki sistem pemasaran yang baik dan cenderung tidak inovatif					
8	Ketrampilan karyawan untuk pemasaran	Keahlian dan ketrampilan karyawan kususnya bagian pemasaran dalam memasarkan perusahaan dan berhubungan dengan *customer*. 5= karyawan pemasaran sudah baik dalam proses pemasaran dan iteraksi dengan pembeli, 1= karyawan pemasaran belum baik dalam proses pemasaran					
9	Citra dan *brand* perusahaan	Kemampuan perusahaan untuk menjaga citra perusahaan di masyarakat dan *customer*. 5= perusahaan memiliki metode yang baik untuk menjaga citra perusahaan, 1= perusahaan belum memiliki metode yang baik untuk menjaga citra perusahaan					
D. Proyek reparasi kapal							

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
10	Prosedur operasional	SOP perusahaan dalam proses reparasi kapal yang menyangkut semua divisi yang terkait. 5= perusahaan sudah memiliki SOP yang baik dan mendukung proses reparasi kapal, 1= perusahaan belum memiliki SOP yang baik terkait proses reparasi kapal					
11	Schedulling pekerjaan	Sistem penjadwalan pada proses reparasi kapal dan aktualisasinya. 5= perusahaan memiliki sistem penjadwalan proyek yang baik dengan tingkat aktualisasi yang tinggi, 1= perusahaan belum memiliki sistem penjadwalan yang baik					

3. Pasar dan Kompetitor

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
A. Kebutuhan pasar							
1	Sistem identifikasi dan penilaian pasar	Identifikasi pasar dan *customer* pada perusahaan. 5= sistem identifikasi pasar sudah efektif dan dikomunikasikan dengan baik ke seluruh bagian perusahaan, 1= sistem identifikasi pasar belum efektif					

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
2	Pemasaran teknologi	Kemampuan perusahaan untuk mengunggulkan teknologi perusahaan dalam pemasaran. 5= Perusahaan sudah mempertimbangkan keunggulan teknologi pada proses pemasaran ke *customer*, 1= perusahaan belum mempertimbangkan teknologi pada proses pemasaran					
B. Status kompetitor							
3	Pemahaman terhadap *competitor*	Kemampuan perusahaan untuk menilai *competitor*. 5= perusahaan sudah baik dalam menilai perusahaan kompetitor dan perkembangannya, 1= perusahaan belum baik dalam menilai kompetitor					
4	Perbandingan dengan perusahaan lain (*Benchmarking*)	Kemampuan perusahaan untuk membandingkan dengan *competitor*, perusahaan sejenis, dan perusahaan lain. 5= perusahaan sudah baik dalam membandingkan diri dengan perusahaan lainnya untuk mereduksi *gap* yang ada, 1= perusahaan belum baik dalam membandingkan dengan perusahaan lain					

4. Proses Inovasi

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
A. Ide (*Idea generation*)							
1	Proses *intrapreneurship*	Kemampuan perusahaan untuk mendukung proses inovasi di perusahaan. 5= budaya inovasi di perusahaan sudah baik dan terfasilitasi, 1= budaya inovasi di perusahaan belum baik					
2	Proses *entrepreneurship*	Kemampuan perusahaaan untuk mengembangkan inovasi karyawan diluar perusahaan. 5= karyawan terfasilitasi dengan baik untuk berinovasi di luar, 1= karyawan belum terfasilitasi untuk berinovasi diluar					
B. Generator teknologi							
3	*Science push*	Kemampuan perusahaan untuk paham tentang teknologi dan perkembangannya. 5= perusahaan paham tentang perkembangan dan kebutuhan teknologi reparasi kapal, 1= perusahaan belum paham					

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
4	*Market pull*	Kemampuan perusahaan untuk menyesuaikan kompetensi perusahaan dengan kebutuhan *customer* dan pasar. 5= Perusahaan sudah baik untuk menyesuaikan kompetensi dengan kebutuhan pasar sebagai peluang, 1= perusahaan belum bisa menyesuaikan kompetensi dengan kebutuhan pasar					

5. *Value-Added Functions*

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
A. Penelitian dan pengembangan							
1	Sistem inovasi reparasi kapal	Sistem perusahaan untuk mengembangkan inovasi dan penelitian terkait reparasi kapal. 5= perusahaan memiliki sistem dan wadah yang baik terkait inovasi dan penelitian, 1= perusahaan belum memiliki wadah yang baik terkait proses inovasi					
B. Operasional							

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
2	Strategi untuk berkembang (*Improvement*)	Kemampuan perusahaan untuk proses improvisasi berkelanjutan untuk kesejahteraan perusahaan. 5= proses *improvement* di perusahaan sudah baik dan berkelanjutan, 1= proses *improvement* perusahaan belum baik					
3	Maintenance teknologi	Kemampuan perusahaan untuk memperbaiki dan memelihara teknologi perusahaan. 5= perusahaan memiliki kemampuan manajemen *maintenance* teknologi yang baik, 1= kemampuan manajemen *maintenance* belum baik					
C. Teknologi peduli lingkungan							
4	Kepedulian terhadap lingkungan	Kepedulian perusahaan terhadap lingkungan sebagai faktor dari proses bisnis. 5= perusahaan memiliki kepedulian yang tinggi terhadap lingkungan sebagai faktor dampak proses perusahaan, 1= perusahaan belum peduli terhadap lingkungan					

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
5	Proses ramah lingkungan	Sistem ramah lingkungan pada kegiatan perusahaan. 5= perusahaan memiliki sistem ramah lingkungan yang baik, 1= perusahaan belum memiliki sistem ramah lingkungan yang baik					
6	Dampak setelah reparasi	Pertimbangan *sustainability* dan dampak lingkungan pada kapal kedepannya setelah reparasi. 5= perusahaan sudah mempertimbangkan dengan baik *sustainability* dan dampak lingkungan setelah proses reparasi kapal, 1= perusahaan belum mempertimbangkan *sustainability* dan dampak lingkungan					

6. Eksploitasi Teknologi

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
A. Akuisisi teknologi							
1	Metode akuisisi teknologi	Sistem dan proses akuisisi teknologi di perusahaan (pembelian, investasi, inovasi, dll). 5= sistem akuisisi teknologi sudah baik dan mendukung proses bisnis perusahaan, 1= sistem akuisisi teknologi belum baik					

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
2	Modal investasi	Sistem analisa modal akuisisi teknologi di perusahaan. 5= sistem analisa modal sudah baik saat mengakuisisi teknologi, 1= sistem analisa modal belum baik					
B. Transfer ilmu teknologi							
3	Prosedur *transfer* teknologi	Kemampuan perusahaan untuk men*transfer* teknologi dan pengetahuannya dari intansi lain. 5= perusahaan sudah baik dalam mentransfer teknologi dari instansi lain, 1= perusahaan belum baik dalam transfer teknologi					
4	*People transfer*	Kemampuan perusahaan untuk *transfer people* ketika proses *transfer teknologi. 5=* perusahaan sudah memiliki sistem *transfer people* yang baik untuk mendukung proses *transfer*, perusahaan belum memililki sistem *transfer people* yang baik					
C. Eksploitasi teknologi untuk profit							

No	Kriteria Penilaian	Deskripsi	Nilai				
			1	2	3	4	5
5	Eksploitasi teknologi	Kemampuan perusahaan untuk mengeksploitasi teknologi yang dimiliki secara optimal. 5= eksploitasi teknologi perusahaan sudah baik dan optimal, 1= eksploitasi teknologi perusahaan belum baik dan optimal					
6	Manajemen teknologi	Kemampuan perusahaan untuk memanajemen teknologi yang dimiliki. 5= Perusahaan memiliki kemampuan yang baik dalam memanajemen teknologi yang dimiliki, 1= perusahaan belum memiliki kemampuan manajemen teknologi yang baik					

Appendix 2: Data processing using FEWA

Linguistic Expression

Five-scale Linguistic Expression							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	3	3	5	5	3	4	4
C 1.1.2	4	3	5	4	3	5	4
C 1.2.1	3	4	5	4	2	3	3
C 1.2.2	2	4	4	4	2	4	3
C 1.2.3	2	5	5	3	2	2	4
C 1.3.1	3	4	5	3	2	4	4
C 1.3.2	3	5	5	4	3	4	4
C 1.4.1	2	4	4	3	2	5	4
C 1.4.2	3	4	4	3	2	4	3
C 1.4.3	3	5	5	4	3	4	3
C 1.4.4	3	4	4	5	3	4	2
C 1.5.1	2	5	5	5	2	5	3

Five-scale Linguistic Expression							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.5.2	3	4	5	2	2	3	3
C 1.5.3	2	4	4	4	2	3	3
C 1.5.4	3	1	4	4	3	3	3
C 1.5.5	3	5	5	3	4	4	5
C 2.1.1	2	5	4	3	4	2	4
C 2.1.2	3	5	4	3	4	3	3
C 2.1.3	3	5	5	4	4	5	4
C 2.2.1	3	4	4	3	3	3	3
C 2.2.2	3	3	5	3	3	3	4
C 2.2.3	3	4	5	4	3	3	4
C 2.3.1	3	4	5	4	3	4	3
C 2.3.2	3	3	4	3	3	2	2
C 2.4.1	3	5	4	3	3	2	2
C 2.4.2	3	4	4	4	3	3	4
C 2.4.3	3	5	4	4	3	1	3
C 3.1.1	2	4	4	5	2	1	3
C 3.1.2	3	4	4	3	3	2	3
C 3.2.1	3	4	5	3	2	1	4
C 3.2.2	3	5	4	3	2	1	2
C 4.1.1	3	3	5	3	2	3	3
C 4.1.2	3	3	4	3	2	2	2
C 4.2.1	3	4	4	3	2	3	3
C 4.2.2	3	4	5	3	3	2	2
C 5.1.1	3	5	5	2	2	1	4
C 5.2.1	3	4	5	3	2	2	3
C 5.2.2	3	4	5	2	2	3	2
C 5.3.1	3	4	5	2	3	4	4
C 5.3.2	2	4	4	2	3	3	4
C 5.3.3	3	4	5	3	3	3	3
C 6.1.1	3	5	5	4	2	4	3
C 6.1.2	2	5	5	4	3	2	2
C 6.2.1	3	4	4	3	2	3	3
C 6.2.2	3	4	5	3	2	3	3
C 6.3.1	3	5	5	3	3	4	3
C 6.3.2	3	5	4	3	3	3	2

Triangular Fuzzy Number

Fuzzy Number							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)
C 1.1.2	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)
C 1.2.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 1.2.2	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
C 1.2.3	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)	(0.5, 0.75, 1)
C 1.3.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)
C 1.3.2	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)
C 1.4.1	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.5, 0.75, 1)
C 1.4.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
C 1.4.3	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
C 1.4.4	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0, 0.25, 0.5)
C 1.5.1	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.75, 1, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.25, 0.5, 0.75)
C 1.5.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 1.5.3	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 1.5.4	(0.25, 0.5, 0.75)	(0, 0, 0.25)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 1.5.5	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.75, 1, 1)
C 2.1.1	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.5, 0.75, 1)
C 2.1.2	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 2.1.3	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)
C 2.2.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 2.2.2	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)
C 2.2.3	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)
C 2.3.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
C 2.3.2	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)
C 2.4.1	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)
C 2.4.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)
C 2.4.3	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0, 0.25)	(0.25, 0.5, 0.75)
C 3.1.1	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)	(0, 0, 0.25)	(0.25, 0.5, 0.75)

Fuzzy Number							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 3.1.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)
C 3.2.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0, 0.25)	(0.5, 0.75, 1)
C 3.2.2	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0, 0.25)	(0, 0.25, 0.5)
C 4.1.1	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 4.1.2	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)	(0, 0.25, 0.5)
C 4.2.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 4.2.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)
C 5.1.1	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)	(0, 0.25, 0.5)	(0, 0, 0.25)	(0.5, 0.75, 1)
C 5.2.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)
C 5.2.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)
C 5.3.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)
C 5.3.2	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)
C 5.3.3	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 6.1.1	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
C 6.1.2	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0, 0.25, 0.5)
C 6.2.1	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 6.2.2	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)
C 6.3.1	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
C 6.3.2	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0, 0.25, 0.5)

Crisp Values

Crisp Values R(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	0,5	0,5	0,95833	0,95833	0,5	0,75	0,75
C 1.1.2	0,75	0,5	0,95833	0,75	0,5	0,95833	0,75
C 1.2.1	0,5	0,75	0,95833	0,75	0,25	0,5	0,5
C 1.2.2	0,25	0,75	0,75	0,75	0,25	0,75	0,5
C 1.2.3	0,25	0,95833	0,95833	0,5	0,25	0,25	0,75
C 1.3.1	0,5	0,75	0,95833	0,5	0,25	0,75	0,75
C 1.3.2	0,5	0,95833	0,95833	0,75	0,5	0,75	0,75
C 1.4.1	0,25	0,75	0,75	0,5	0,25	0,95833	0,75
C 1.4.2	0,5	0,75	0,75	0,5	0,25	0,75	0,5

Crisp Values R(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.4.3	0,5	0,95833	0,95833	0,75	0,5	0,75	0,5
C 1.4.4	0,5	0,75	0,75	0,95833	0,5	0,75	0,25
C 1.5.1	0,25	0,95833	0,95833	0,95833	0,25	0,95833	0,5
C 1.5.2	0,5	0,75	0,95833	0,25	0,25	0,5	0,5
C 1.5.3	0,25	0,75	0,75	0,75	0,25	0,5	0,5
C 1.5.4	0,5	0,04167	0,75	0,75	0,5	0,5	0,5
C 1.5.5	0,5	0,95833	0,95833	0,5	0,75	0,75	0,95833
C 2.1.1	0,25	0,95833	0,75	0,5	0,75	0,25	0,75
C 2.1.2	0,5	0,95833	0,75	0,5	0,75	0,5	0,5
C 2.1.3	0,5	0,95833	0,95833	0,75	0,75	0,95833	0,75
C 2.2.1	0,5	0,75	0,75	0,5	0,5	0,5	0,5
C 2.2.2	0,5	0,5	0,95833	0,5	0,5	0,5	0,75
C 2.2.3	0,5	0,75	0,95833	0,75	0,5	0,5	0,75
C 2.3.1	0,5	0,75	0,95833	0,75	0,5	0,75	0,5
C 2.3.2	0,5	0,5	0,75	0,5	0,5	0,25	0,25
C 2.4.1	0,5	0,95833	0,75	0,5	0,5	0,25	0,25
C 2.4.2	0,5	0,75	0,75	0,75	0,5	0,5	0,75
C 2.4.3	0,5	0,95833	0,75	0,75	0,5	0,04167	0,5
C 3.1.1	0,25	0,75	0,75	0,95833	0,25	0,04167	0,5
C 3.1.2	0,5	0,75	0,75	0,5	0,5	0,25	0,5
C 3.2.1	0,5	0,75	0,95833	0,5	0,25	0,04167	0,75
C 3.2.2	0,5	0,95833	0,75	0,5	0,25	0,04167	0,25
C 4.1.1	0,5	0,5	0,95833	0,5	0,25	0,5	0,5
C 4.1.2	0,5	0,5	0,75	0,5	0,25	0,25	0,25
C 4.2.1	0,5	0,75	0,75	0,5	0,25	0,5	0,5
C 4.2.2	0,5	0,75	0,95833	0,5	0,5	0,25	0,25
C 5.1.1	0,5	0,95833	0,95833	0,25	0,25	0,04167	0,75
C 5.2.1	0,5	0,75	0,95833	0,5	0,25	0,25	0,5
C 5.2.2	0,5	0,75	0,95833	0,25	0,25	0,5	0,25
C 5.3.1	0,5	0,75	0,95833	0,25	0,5	0,75	0,75
C 5.3.2	0,25	0,75	0,75	0,25	0,5	0,5	0,75
C 5.3.3	0,5	0,75	0,95833	0,5	0,5	0,5	0,5
C 6.1.1	0,5	0,95833	0,95833	0,75	0,25	0,75	0,5
C 6.1.2	0,25	0,95833	0,95833	0,75	0,5	0,25	0,25
C 6.2.1	0,5	0,75	0,75	0,5	0,25	0,5	0,5
C 6.2.2	0,5	0,75	0,95833	0,5	0,25	0,5	0,5
C 6.3.1	0,5	0,95833	0,95833	0,5	0,5	0,75	0,5
C 6.3.2	0,5	0,95833	0,75	0,5	0,5	0,5	0,25

1. First Hierarchy

Maximum Crisp Values

Max							
Category	E1	E2	E3	E4	E5	E6	E7
M1	0,75	0,95833	0,95833	0,95833	0,75	0,95833	0,95833

Normalization

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	-0,25	-0,4583	0	0	-0,25	-0,2083	-0,2083
C 1.1.2	0	-0,4583	0	-0,2083	-0,25	0	-0,2083
C 1.2.1	-0,25	-0,2083	0	-0,2083	-0,5	-0,4583	-0,4583
C 1.2.2	-0,5	-0,2083	-0,2083	-0,2083	-0,5	-0,2083	-0,4583
C 1.2.3	-0,5	0	0	-0,4583	-0,5	-0,7083	-0,2083
C 1.3.1	-0,25	-0,2083	0	-0,4583	-0,5	-0,2083	-0,2083
C 1.3.2	-0,25	0	0	-0,2083	-0,25	-0,2083	-0,2083
C 1.4.1	-0,5	-0,2083	-0,2083	-0,4583	-0,5	0	-0,2083
C 1.4.2	-0,25	-0,2083	-0,2083	-0,4583	-0,5	-0,2083	-0,4583
C 1.4.3	-0,25	0	0	-0,2083	-0,25	-0,2083	-0,4583
C 1.4.4	-0,25	-0,2083	-0,2083	0	-0,25	-0,2083	-0,7083
C 1.5.1	-0,5	0	0	0	-0,5	0	-0,4583
C 1.5.2	-0,25	-0,2083	0	-0,7083	-0,5	-0,4583	-0,4583
C 1.5.3	-0,5	-0,2083	-0,2083	-0,2083	-0,5	-0,4583	-0,4583
C 1.5.4	-0,25	-0,9167	-0,2083	-0,2083	-0,25	-0,4583	-0,4583
C 1.5.5	-0,25	0	0	-0,4583	0	-0,2083	0
C 2.1.1	-0,5	0	-0,2083	-0,4583	0	-0,7083	-0,2083
C 2.1.2	-0,25	0	-0,2083	-0,4583	0	-0,4583	-0,4583
C 2.1.3	-0,25	0	0	-0,2083	0	0	-0,2083
C 2.2.1	-0,25	-0,2083	-0,2083	-0,4583	-0,25	-0,4583	-0,4583
C 2.2.2	-0,25	-0,4583	0	-0,4583	-0,25	-0,4583	-0,2083
C 2.2.3	-0,25	-0,2083	0	-0,2083	-0,25	-0,4583	-0,2083
C 2.3.1	-0,25	-0,2083	0	-0,2083	-0,25	-0,2083	-0,4583
C 2.3.2	-0,25	-0,4583	-0,2083	-0,4583	-0,25	-0,7083	-0,7083
C 2.4.1	-0,25	0	-0,2083	-0,4583	-0,25	-0,7083	-0,7083
C 2.4.2	-0,25	-0,2083	-0,2083	-0,2083	-0,25	-0,4583	-0,2083
C 2.4.3	-0,25	0	-0,2083	-0,2083	-0,25	-0,9167	-0,4583
C 3.1.1	-0,5	-0,2083	-0,2083	0	-0,5	-0,9167	-0,4583
C 3.1.2	-0,25	-0,2083	-0,2083	-0,4583	-0,25	-0,7083	-0,4583
C 3.2.1	-0,25	-0,2083	0	-0,4583	-0,5	-0,9167	-0,2083
C 3.2.2	-0,25	0	-0,2083	-0,4583	-0,5	-0,9167	-0,7083
C 4.1.1	-0,25	-0,4583	0	-0,4583	-0,5	-0,4583	-0,4583

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 4.1.2	-0,25	-0,4583	-0,2083	-0,4583	-0,5	-0,7083	-0,7083
C 4.2.1	-0,25	-0,2083	-0,2083	-0,4583	-0,5	-0,4583	-0,4583
C 4.2.2	-0,25	-0,2083	0	-0,4583	-0,25	-0,7083	-0,7083
C 5.1.1	-0,25	0	0	-0,7083	-0,5	-0,9167	-0,2083
C 5.2.1	-0,25	-0,2083	0	-0,4583	-0,5	-0,7083	-0,4583
C 5.2.2	-0,25	-0,2083	0	-0,7083	-0,5	-0,4583	-0,7083
C 5.3.1	-0,25	-0,2083	0	-0,7083	-0,25	-0,2083	-0,2083
C 5.3.2	-0,5	-0,2083	-0,2083	-0,7083	-0,25	-0,4583	-0,2083
C 5.3.3	-0,25	-0,2083	0	-0,4583	-0,25	-0,4583	-0,4583
C 6.1.1	-0,25	0	0	-0,2083	-0,5	-0,2083	-0,4583
C 6.1.2	-0,5	0	0	-0,2083	-0,25	-0,7083	-0,7083
C 6.2.1	-0,25	-0,2083	-0,2083	-0,4583	-0,5	-0,4583	-0,4583
C 6.2.2	-0,25	-0,2083	0	-0,4583	-0,5	-0,4583	-0,4583
C 6.3.1	-0,25	0	0	-0,4583	-0,25	-0,2083	-0,4583
C 6.3.2	-0,25	0	-0,2083	-0,4583	-0,25	-0,4583	-0,7083

Second Normalization

Second Normalization (sij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	0,01818	0,05288	0	0	0,01563	0,0098	0,01064
C 1.1.2	0	0,05288	0	0,01193	0,01563	0	0,01064
C 1.2.1	0,01818	0,02404	0	0,01193	0,03125	0,02157	0,0234
C 1.2.2	0,03636	0,02404	0,04762	0,01193	0,03125	0,0098	0,0234
C 1.2.3	0,03636	0	0	0,02625	0,03125	0,03333	0,01064
C 1.3.1	0,01818	0,02404	0	0,02625	0,03125	0,0098	0,01064
C 1.3.2	0,01818	0	0	0,01193	0,01563	0,0098	0,01064
C 1.4.1	0,03636	0,02404	0,04762	0,02625	0,03125	0	0,01064
C 1.4.2	0,01818	0,02404	0,04762	0,02625	0,03125	0,0098	0,0234
C 1.4.3	0,01818	0	0	0,01193	0,01563	0,0098	0,0234
C 1.4.4	0,01818	0,02404	0,04762	0	0,01563	0,0098	0,03617
C 1.5.1	0,03636	0	0	0	0,03125	0	0,0234
C 1.5.2	0,01818	0,02404	0	0,04057	0,03125	0,02157	0,0234
C 1.5.3	0,03636	0,02404	0,04762	0,01193	0,03125	0,02157	0,0234
C 1.5.4	0,01818	0,10577	0,04762	0,01193	0,01563	0,02157	0,0234
C 1.5.5	0,01818	0	0	0,02625	0	0,0098	0
C 2.1.1	0,03636	0	0,04762	0,02625	0	0,03333	0,01064
C 2.1.2	0,01818	0	0,04762	0,02625	0	0,02157	0,0234
C 2.1.3	0,01818	0	0	0,01193	0	0	0,01064
C 2.2.1	0,01818	0,02404	0,04762	0,02625	0,01563	0,02157	0,0234

Second Normalization (sij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 2.2.2	0,01818	0,05288	0	0,02625	0,01563	0,02157	0,01064
C 2.2.3	0,01818	0,02404	0	0,01193	0,01563	0,02157	0,01064
C 2.3.1	0,01818	0,02404	0	0,01193	0,01563	0,0098	0,0234
C 2.3.2	0,01818	0,05288	0,04762	0,02625	0,01563	0,03333	0,03617
C 2.4.1	0,01818	0	0,04762	0,02625	0,01563	0,03333	0,03617
C 2.4.2	0,01818	0,02404	0,04762	0,01193	0,01563	0,02157	0,01064
C 2.4.3	0,01818	0	0,04762	0,01193	0,01563	0,04314	0,0234
C 3.1.1	0,03636	0,02404	0,04762	0	0,03125	0,04314	0,0234
C 3.1.2	0,01818	0,02404	0,04762	0,02625	0,01563	0,03333	0,0234
C 3.2.1	0,01818	0,02404	0	0,02625	0,03125	0,04314	0,01064
C 3.2.2	0,01818	0	0,04762	0,02625	0,03125	0,04314	0,03617
C 4.1.1	0,01818	0,05288	0	0,02625	0,03125	0,02157	0,0234
C 4.1.2	0,01818	0,05288	0,04762	0,02625	0,03125	0,03333	0,03617
C 4.2.1	0,01818	0,02404	0,04762	0,02625	0,03125	0,02157	0,0234
C 4.2.2	0,01818	0,02404	0	0,02625	0,01563	0,03333	0,03617
C 5.1.1	0,01818	0	0	0,04057	0,03125	0,04314	0,01064
C 5.2.1	0,01818	0,02404	0	0,02625	0,03125	0,03333	0,0234
C 5.2.2	0,01818	0,02404	0	0,04057	0,03125	0,02157	0,03617
C 5.3.1	0,01818	0,02404	0	0,04057	0,01563	0,0098	0,01064
C 5.3.2	0,03636	0,02404	0,04762	0,04057	0,01563	0,02157	0,01064
C 5.3.3	0,01818	0,02404	0	0,02625	0,01563	0,02157	0,0234
C 6.1.1	0,01818	0	0	0,01193	0,03125	0,0098	0,0234
C 6.1.2	0,03636	0	0	0,01193	0,01563	0,03333	0,03617
C 6.2.1	0,01818	0,02404	0,04762	0,02625	0,03125	0,02157	0,0234
C 6.2.2	0,01818	0,02404	0	0,02625	0,03125	0,02157	0,0234
C 6.3.1	0,01818	0	0	0,02625	0,01563	0,0098	0,0234
C 6.3.2	0,01818	0	0,04762	0,02625	0,01563	0,02157	0,03617

Weight Values

Weights				
Criteria	Ej	1-Ej	Wj	Rank
C 1.1.1	0,19887	0,80113	0,02343	9
C 1.1.2	0,16528	0,83472	0,02441	5
C 1.2.1	0,254	0,746	0,02182	18
C 1.2.2	0,33377	0,66623	0,01948	37
C 1.2.3	0,2498	0,7502	0,02194	16
C 1.3.1	0,2364	0,7636	0,02233	13
C 1.3.2	0,14613	0,85387	0,02497	3
C 1.4.1	0,31209	0,68791	0,02012	33

Weights				
Criteria	Ej	1-Ej	Wj	Rank
C 1.4.2	0,33123	0,66877	0,01956	36
C 1.4.3	0,16646	0,83354	0,02438	6
C 1.4.4	0,2764	0,7236	0,02116	23
C 1.5.1	0,16275	0,83725	0,02449	4
C 1.5.2	0,29366	0,70634	0,02066	29
C 1.5.3	0,35299	0,64701	0,01892	43
C 1.5.4	0,38229	0,61771	0,01807	45
C 1.5.5	0,10985	0,89015	0,02603	2
C 2.1.1	0,26865	0,73135	0,02139	21
C 2.1.2	0,24874	0,75126	0,02197	15
C 2.1.3	0,08944	0,91056	0,02663	1
C 2.2.1	0,32819	0,67181	0,01965	35
C 2.2.2	0,2672	0,7328	0,02143	20
C 2.2.3	0,21141	0,78859	0,02306	10
C 2.3.1	0,21251	0,78749	0,02303	11
C 2.3.2	0,39431	0,60569	0,01771	46
C 2.4.1	0,31441	0,68559	0,02005	34
C 2.4.2	0,28591	0,71409	0,02088	25
C 2.4.3	0,28734	0,71266	0,02084	27
C 3.1.1	0,35299	0,64701	0,01892	44
C 3.1.2	0,34393	0,65607	0,01919	38
C 3.2.1	0,28278	0,71722	0,02098	24
C 3.2.2	0,3481	0,6519	0,01907	39
C 4.1.1	0,30979	0,69021	0,02019	31
C 4.1.2	0,41657	0,58343	0,01706	47
C 4.2.1	0,35045	0,64955	0,019	41
C 4.2.2	0,28596	0,71404	0,02088	26
C 5.1.1	0,25444	0,74556	0,0218	19
C 5.2.1	0,29169	0,70831	0,02072	28
C 5.2.2	0,3102	0,6898	0,02017	32
C 5.3.1	0,23185	0,76815	0,02247	12
C 5.3.2	0,35007	0,64993	0,01901	40
C 5.3.3	0,25369	0,74631	0,02183	17
C 6.1.1	0,18872	0,81128	0,02373	8
C 6.1.2	0,24245	0,75755	0,02216	14
C 6.2.1	0,35045	0,64955	0,019	41
C 6.2.2	0,27595	0,72405	0,02118	22
C 6.3.1	0,18841	0,81159	0,02374	7
C 6.3.2	0,29868	0,70132	0,02051	30
Total	**12,807**	**34,193**	**1**	

2. Second Hierarchy

Maximum Crisp Values

Max							
Category	E1	E2	E3	E4	E5	E6	E7
M1	0,75	0,95833	0,95833	0,95833	0,75	0,95833	0,95833
M2	0,5	0,95833	0,95833	0,75	0,75	0,95833	0,75
M3	0,5	0,95833	0,95833	0,95833	0,5	0,25	0,75
M4	0,5	0,75	0,95833	0,5	0,5	0,5	0,5
M5	0,5	0,95833	0,95833	0,5	0,5	0,75	0,75
M6	0,5	0,95833	0,95833	0,75	0,5	0,75	0,5

Normalization

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	-0,25	-0,4583	0	0	-0,25	-0,2083	-0,2083
C 1.1.2	0	-0,4583	0	-0,2083	-0,25	0	-0,2083
C 1.2.1	-0,25	-0,2083	0	-0,2083	-0,5	-0,4583	-0,4583
C 1.2.2	-0,5	-0,2083	-0,2083	-0,2083	-0,5	-0,2083	-0,4583
C 1.2.3	-0,5	0	0	-0,4583	-0,5	-0,7083	-0,2083
C 1.3.1	-0,25	-0,2083	0	-0,4583	-0,5	-0,2083	-0,2083
C 1.3.2	-0,25	0	0	-0,2083	-0,25	-0,2083	-0,2083
C 1.4.1	-0,5	-0,2083	-0,2083	-0,4583	-0,5	0	-0,2083
C 1.4.2	-0,25	-0,2083	-0,2083	-0,4583	-0,5	-0,2083	-0,4583
C 1.4.3	-0,25	0	0	-0,2083	-0,25	-0,2083	-0,4583
C 1.4.4	-0,25	-0,2083	-0,2083	0	-0,25	-0,2083	-0,7083
C 1.5.1	-0,5	0	0	0	-0,5	0	-0,4583
C 1.5.2	-0,25	-0,2083	0	-0,7083	-0,5	-0,4583	-0,4583
C 1.5.3	-0,5	-0,2083	-0,2083	-0,2083	-0,5	-0,4583	-0,4583
C 1.5.4	-0,25	-0,9167	-0,2083	-0,2083	-0,25	-0,4583	-0,4583
C 1.5.5	-0,25	0	0	-0,4583	0	-0,2083	0
C 2.1.1	-0,25	0	-0,2083	-0,25	0	-0,7083	0
C 2.1.2	0	0	-0,2083	-0,25	0	-0,4583	-0,25
C 2.1.3	0	0	0	0	0	0	0
C 2.2.1	0	-0,2083	-0,2083	-0,25	-0,25	-0,4583	-0,25
C 2.2.2	0	-0,4583	0	-0,25	-0,25	-0,4583	0
C 2.2.3	0	-0,2083	0	0	-0,25	-0,4583	0
C 2.3.1	0	-0,2083	0	0	-0,25	-0,2083	-0,25
C 2.3.2	0	-0,4583	-0,2083	-0,25	-0,25	-0,7083	-0,5
C 2.4.1	0	0	-0,2083	-0,25	-0,25	-0,7083	-0,5

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 2.4.2	0	-0,2083	-0,2083	0	-0,25	-0,4583	0
C 2.4.3	0	0	-0,2083	0	-0,25	-0,9167	-0,25
C 3.1.1	-0,25	-0,2083	-0,2083	0	-0,25	-0,2083	-0,25
C 3.1.2	0	-0,2083	-0,2083	-0,4583	0	0	-0,25
C 3.2.1	0	-0,2083	0	-0,4583	-0,25	-0,2083	0
C 3.2.2	0	0	-0,2083	-0,4583	-0,25	-0,2083	-0,5
C 4.1.1	0	-0,25	0	0	-0,25	0	0
C 4.1.2	0	-0,25	-0,2083	0	-0,25	-0,25	-0,25
C 4.2.1	0	0	-0,2083	0	-0,25	0	0
C 4.2.2	0	0	0	0	0	-0,25	-0,25
C 5.1.1	0	0	0	-0,25	-0,25	-0,7083	0
C 5.2.1	0	-0,2083	0	0	-0,25	-0,5	-0,25
C 5.2.2	0	-0,2083	0	-0,25	-0,25	-0,25	-0,5
C 5.3.1	0	-0,2083	0	-0,25	0	0	0
C 5.3.2	-0,25	-0,2083	-0,2083	-0,25	0	-0,25	0
C 5.3.3	0	-0,2083	0	0	0	-0,25	-0,25
C 6.1.1	0	0	0	0	-0,25	0	0
C 6.1.2	-0,25	0	0	0	0	-0,5	-0,25
C 6.2.1	0	-0,2083	-0,2083	-0,25	-0,25	-0,25	0
C 6.2.2	0	-0,2083	0	-0,25	-0,25	-0,25	0
C 6.3.1	0	0	0	-0,25	0	0	0
C 6.3.2	0	0	-0,2083	-0,25	0	-0,25	-0,25

Second Normalization

Second Normalization (sij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	0,05	0,13095	0	0	0,04167	0,0495	0,03704
C 1.1.2	0	0,13095	0	0,04673	0,04167	0	0,03704
C 1.2.1	0,05	0,05952	0	0,04673	0,08333	0,10891	0,08148
C 1.2.2	0,1	0,05952	0,16667	0,04673	0,08333	0,0495	0,08148
C 1.2.3	0,1	0	0	0,1028	0,08333	0,16832	0,03704
C 1.3.1	0,05	0,05952	0	0,1028	0,08333	0,0495	0,03704
C 1.3.2	0,05	0	0	0,04673	0,04167	0,0495	0,03704
C 1.4.1	0,1	0,05952	0,16667	0,1028	0,08333	0	0,03704
C 1.4.2	0,05	0,05952	0,16667	0,1028	0,08333	0,0495	0,08148
C 1.4.3	0,05	0	0	0,04673	0,04167	0,0495	0,08148
C 1.4.4	0,05	0,05952	0,16667	0	0,04167	0,0495	0,12593
C 1.5.1	0,1	0	0	0	0,08333	0	0,08148
C 1.5.2	0,05	0,05952	0	0,15888	0,08333	0,10891	0,08148

Second Normalization (sij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.5.3	0,1	0,05952	0,16667	0,04673	0,08333	0,10891	0,08148
C 1.5.4	0,05	0,2619	0,16667	0,04673	0,04167	0,10891	0,08148
C 1.5.5	0,05	0	0	0,1028	0	0,0495	0
C 2.1.1	1	0	0,14286	0,16667	0	0,12782	0
C 2.1.2	0	0	0,14286	0,16667	0	0,08271	0,125
C 2.1.3	0	0	0	0	0	0	0
C 2.2.1	0	0,11905	0,14286	0,16667	0,125	0,08271	0,125
C 2.2.2	0	0,2619	0	0,16667	0,125	0,08271	0
C 2.2.3	0	0,11905	0	0	0,125	0,08271	0
C 2.3.1	0	0,11905	0	0	0,125	0,03759	0,125
C 2.3.2	0	0,2619	0,14286	0,16667	0,125	0,12782	0,25
C 2.4.1	0	0	0,14286	0,16667	0,125	0,12782	0,25
C 2.4.2	0	0,11905	0,14286	0	0,125	0,08271	0
C 2.4.3	0	0	0,14286	0	0,125	0,16541	0,125
C 3.1.1	1	0,33333	0,33333	0	0,33333	0,33333	0,25
C 3.1.2	0	0,33333	0,33333	0,33333	0	0	0,25
C 3.2.1	0	0,33333	0	0,33333	0,33333	0,33333	0
C 3.2.2	0	0	0,33333	0,33333	0,33333	0,33333	0,5
C 4.1.1	0	0,5	0	0	0,33333	0	0
C 4.1.2	0	0,5	0,5	0	0,33333	0,5	0,5
C 4.2.1	0	0	0,5	0	0,33333	0	0
C 4.2.2	0	0	0	0	0	0,5	0,5
C 5.1.1	0	0	0	0,25	0,33333	0,3617	0
C 5.2.1	0	0,2	0	0	0,33333	0,25532	0,25
C 5.2.2	0	0,2	0	0,25	0,33333	0,12766	0,5
C 5.3.1	0	0,2	0	0,25	0	0	0
C 5.3.2	1	0,2	1	0,25	0	0,12766	0
C 5.3.3	0	0,2	0	0	0	0,12766	0,25
C 6.1.1	0	0	0	0	0,33333	0	0
C 6.1.2	1	0	0	0	0	0,4	0,5
C 6.2.1	0	0,5	0,5	0,25	0,33333	0,2	0
C 6.2.2	0	0,5	0	0,25	0,33333	0,2	0
C 6.3.1	0	0	0	0,25	0	0	0
C 6.3.2	0	0	0,5	0,25	0	0,2	0,5

Weight Values

Weights					
Category	Criteria	Ej	1-Ej	Wj	Rank
1	C 1.1.1	0,42103	0,57897	0,079	6
	C 1.1.2	0,34115	0,65885	0,0899	3
	C 1.2.1	0,57235	0,42765	0,05835	9
	C 1.2.2	0,71953	0,28047	0,03827	13
	C 1.2.3	0,56179	0,43821	0,05979	8
	C 1.3.1	0,52908	0,47092	0,06426	7
	C 1.3.2	0,35779	0,64221	0,08763	4
	C 1.4.1	0,64743	0,35257	0,04811	11
	C 1.4.2	0,7248	0,2752	0,03755	14
	C 1.4.3	0,40005	0,59995	0,08186	5
	C 1.4.4	0,59535	0,40465	0,05521	10
	C 1.5.1	0,32974	0,67026	0,09146	2
	C 1.5.2	0,64898	0,35102	0,0479	12
	C 1.5.3	0,76716	0,23284	0,03177	15
	C 1.5.4	0,78146	0,21854	0,02982	16
	C 1.5.5	0,27363	0,72637	0,09911	1
2	C 2.1.1	0,43145	0,56855	0,11176	3
	C 2.1.2	0,53583	0,46417	0,09124	6
	C 2.1.3	0	1	0,19657	1
	C 2.2.1	0,79961	0,20039	0,03939	10
	C 2.2.2	0,5733	0,4267	0,08388	8
	C 2.2.3	0,36972	0,63028	0,1239	2
	C 2.3.1	0,46074	0,53926	0,106	4
	C 2.3.2	0,92345	0,07655	0,01505	11
	C 2.4.1	0,74313	0,25687	0,05049	9
	C 2.4.2	0,51257	0,48743	0,09581	5
	C 2.4.3	0,56296	0,43704	0,08591	7
3	C 3.1.1	0,93087	0,06913	0,10754	3
	C 3.1.2	0,74268	0,25732	0,4003	1
	C 3.2.1	0,75277	0,24723	0,38461	2
	C 3.2.2	0,93087	0,06913	0,10754	3
4	C 4.1.1	0,3663	0,6337	0,31518	2
	C 4.1.2	0,90061	0,09939	0,04944	4
	C 4.2.1	0,3663	0,6337	0,31518	2
	C 4.2.2	0,35621	0,64379	0,3202	1
5	C 5.1.1	0,55532	0,44468	0,1718	4
	C 5.2.1	0,71084	0,28916	0,11172	5
	C 5.2.2	0,84485	0,15515	0,05994	6
	C 5.3.1	0,34352	0,65648	0,25363	1
	C 5.3.2	0,47856	0,52144	0,20146	2

Weights					
Category	Criteria	Ej	1-Ej	Wj	Rank
	C 5.3.3	0,47856	0,52144	0,20146	2
6	C 6.1.1	0,18819	0,81181	0,27336	2
	C 6.1.2	0,36646	0,63354	0,21333	3
	C 6.2.1	0,88792	0,11208	0,03774	6
	C 6.2.2	0,70982	0,29018	0,09771	5
	C 6.3.1	0,1781	0,8219	0,27675	1
	C 6.3.2	0,69973	0,30027	0,10111	4

3. Third Hierarchy

Maximum Crisp Values

Max							
Category	E1	E2	E3	E4	E5	E6	E7
M1.1	0,75	0,5	0,95833	0,95833	0,5	0,95833	0,75
M 1.2	0,5	0,95833	0,95833	0,75	0,25	0,75	0,75
M 1.3	0,5	0,95833	0,95833	0,75	0,5	0,75	0,75
M 1.4	0,5	0,95833	0,95833	0,95833	0,5	0,95833	0,75
M 1.5	0,5	0,95833	0,95833	0,95833	0,75	0,95833	0,95833
M 2.1	0,5	0,95833	0,95833	0,75	0,75	0,95833	0,75
M 2.2	0,5	0,75	0,95833	0,75	0,5	0,5	0,75
M 2.3	0,5	0,75	0,95833	0,75	0,5	0,75	0,5
M 2.4	0,5	0,95833	0,75	0,75	0,5	0,5	0,75
M 3.1	0,5	0,75	0,75	0,95833	0,5	0,25	0,5
M 3.2	0,5	0,95833	0,95833	0,5	0,25	0,04167	0,75
M 4.1	0,5	0,5	0,95833	0,5	0,25	0,5	0,5
M 4.2	0,5	0,75	0,95833	0,5	0,5	0,5	0,5
M 5.1	0,5	0,95833	0,95833	0,25	0,25	0,04167	0,75
M 5.2	0,5	0,75	0,95833	0,5	0,25	0,5	0,5
M 5.3	0,5	0,75	0,95833	0,5	0,5	0,75	0,75
M 6.1	0,5	0,95833	0,95833	0,75	0,5	0,75	0,5
M 6.2	0,5	0,75	0,95833	0,5	0,25	0,5	0,5
M 6.3	0,5	0,95833	0,95833	0,5	0,5	0,75	0,5

Normalization

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	-0,25	0	0	0	0	-0,2083	0
C 1.1.2	0	0	0	-0,2083	0	0	0
C 1.2.1	0	-0,2083	0	0	0	-0,25	-0,25

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.2.2	-0,25	-0,2083	-0,2083	0	0	0	-0,25
C 1.2.3	-0,25	0	0	-0,25	0	-0,5	0
C 1.3.1	0	-0,2083	0	-0,25	-0,25	0	0
C 1.3.2	0	0	0	0	0	0	0
C 1.4.1	-0,25	-0,2083	-0,2083	-0,4583	-0,25	0	0
C 1.4.2	0	-0,2083	-0,2083	-0,4583	-0,25	-0,2083	-0,25
C 1.4.3	0	0	0	-0,2083	0	-0,2083	-0,25
C 1.4.4	0	-0,2083	-0,2083	0	0	-0,2083	-0,5
C 1.5.1	-0,25	0	0	0	-0,5	0	-0,4583
C 1.5.2	0	-0,2083	0	-0,7083	-0,5	-0,4583	-0,4583
C 1.5.3	-0,25	-0,2083	-0,2083	-0,2083	-0,5	-0,4583	-0,4583
C 1.5.4	0	-0,9167	-0,2083	-0,2083	-0,25	-0,4583	-0,4583
C 1.5.5	0	0	0	-0,4583	0	-0,2083	0
C 2.1.1	-0,25	0	-0,2083	-0,25	0	-0,7083	0
C 2.1.2	0	0	-0,2083	-0,25	0	-0,4583	-0,25
C 2.1.3	0	0	0	0	0	0	0
C 2.2.1	0	0	-0,2083	-0,25	0	0	-0,25
C 2.2.2	0	-0,25	0	-0,25	0	0	0
C 2.2.3	0	0	0	0	0	0	0
C 2.3.1	0	0	0	0	0	0	0
C 2.3.2	0	-0,25	-0,2083	-0,25	0	-0,5	-0,25
C 2.4.1	0	0	0	-0,25	0	-0,25	-0,5
C 2.4.2	0	-0,2083	0	0	0	0	0
C 2.4.3	0	0	0	0	0	-0,4583	-0,25
C 3.1.1	-0,25	0	0	0	-0,25	-0,2083	0
C 3.1.2	0	0	0	-0,4583	0	0	0
C 3.2.1	0	-0,2083	0	0	0	0	0
C 3.2.2	0	0	-0,2083	0	0	0	-0,5
C 4.1.1	0	0	0	0	0	0	0
C 4.1.2	0	0	-0,2083	0	0	-0,25	-0,25
C 4.2.1	0	0	-0,2083	0	-0,25	0	0
C 4.2.2	0	0	0	0	0	-0,25	-0,25
C 5.1.1	0	0	0	0	0	0	0
C 5.2.1	0	0	0	0	0	-0,25	0
C 5.2.2	0	0	0	-0,25	0	0	-0,25
C 5.3.1	0	0	0	-0,25	0	0	0
C 5.3.2	-0,25	0	-0,2083	-0,25	0	-0,25	0
C 5.3.3	0	0	0	0	0	-0,25	-0,25
C 6.1.1	0	0	0	0	-0,25	0	0
C 6.1.2	-0,25	0	0	0	0	-0,5	-0,25

Normalization S(Xij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 6.2.1	0	0	-0,2083	0	0	0	0
C 6.2.2	0	0	0	0	0	0	0
C 6.3.1	0	0	0	0	0	0	0
C 6.3.2	0	0	-0,2083	0	0	-0,25	-0,25

Second Normalization

Second Normalization (sij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 1.1.1	1	0	0	0	0	1	0
C 1.1.2	0	0	0	1	0	0	0
C 1.2.1	0	0,5	0	0	0	0,33333	0,5
C 1.2.2	0,5	0,5	1	0	0	0	0,5
C 1.2.3	0,5	0	0	1	0	0,66667	0
C 1.3.1	0	1	0	1	1	0	0
C 1.3.2	0	0	0	0	0	0	0
C 1.4.1	1	0,33333	0,33333	0,40741	0,5	0	0
C 1.4.2	0	0,33333	0,33333	0,40741	0,5	0,33333	0,25
C 1.4.3	0	0	0	0,18519	0	0,33333	0,25
C 1.4.4	0	0,33333	0,33333	0	0	0,33333	0,5
C 1.5.1	0,5	0	0	0	0,28571	0	0,25
C 1.5.2	0	0,15625	0	0,44737	0,28571	0,28947	0,25
C 1.5.3	0,5	0,15625	0,5	0,13158	0,28571	0,28947	0,25
C 1.5.4	0	0,6875	0,5	0,13158	0,14286	0,28947	0,25
C 1.5.5	0	0	0	0,28947	0	0,13158	0
C 2.1.1	1	0	0,5	0,5	0	0,60714	0
C 2.1.2	0	0	0,5	0,5	0	0,39286	1
C 2.1.3	0	0	0	0	0	0	0
C 2.2.1	0	0	1	0,5	0	0	1
C 2.2.2	0	1	0	0,5	0	0	0
C 2.2.3	0	0	0	0	0	0	0
C 2.3.1	0	0	0	0	0	0	0
C 2.3.2	0	1	1	1	0	1	1
C 2.4.1	0	0	0	1	0	0,35294	0,66667
C 2.4.2	0	1	0	0	0	0	0
C 2.4.3	0	0	0	0	0	0,64706	0,33333
C 3.1.1	1	0	0	0	1	1	0
C 3.1.2	0	0	0	1	0	0	0
C 3.2.1	0	1	0	0	0	0	0
C 3.2.2	0	0	1	0	0	0	1

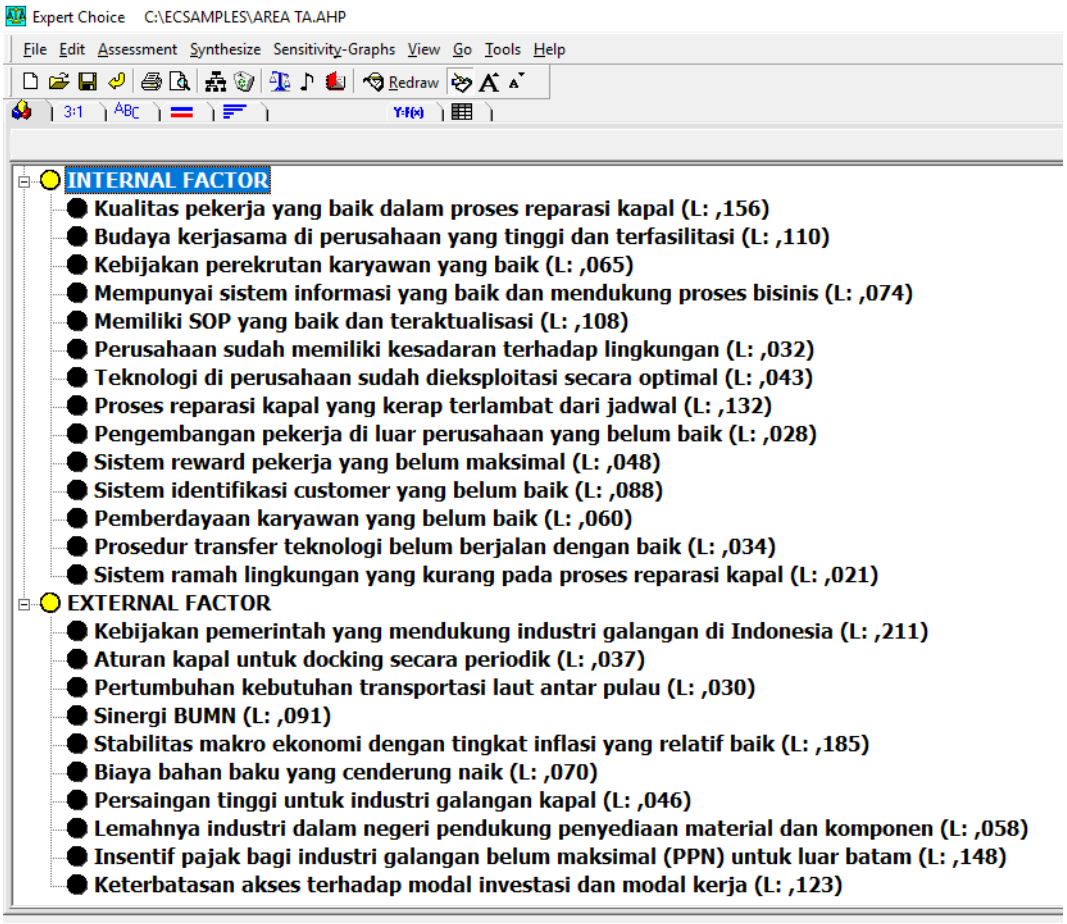
Second Normalization (sij)							
Criteria	E1	E2	E3	E4	E5	E6	E7
C 4.1.1	0	0	0	0	0	0	0
C 4.1.2	0	0	1	0	0	1	1
C 4.2.1	0	0	1	0	1	0	0
C 4.2.2	0	0	0	0	0	1	1
C 5.1.1	0	0	0	0	0	0	0
C 5.2.1	0	0	0	0	0	1	0
C 5.2.2	0	0	0	1	0	0	1
C 5.3.1	0	0	0	0,5	0	0	0
C 5.3.2	1	0	1	0,5	0	0,5	0
C 5.3.3	0	0	0	0	0	0,5	1
C 6.1.1	0	0	0	0	1	0	0
C 6.1.2	1	0	0	0	0	1	1
C 6.2.1	0	0	1	0	0	0	0
C 6.2.2	0	0	0	0	0	0	0
C 6.3.1	0	0	0	0	0	0	0
C 6.3.2	0	0	1	0	0	1	1

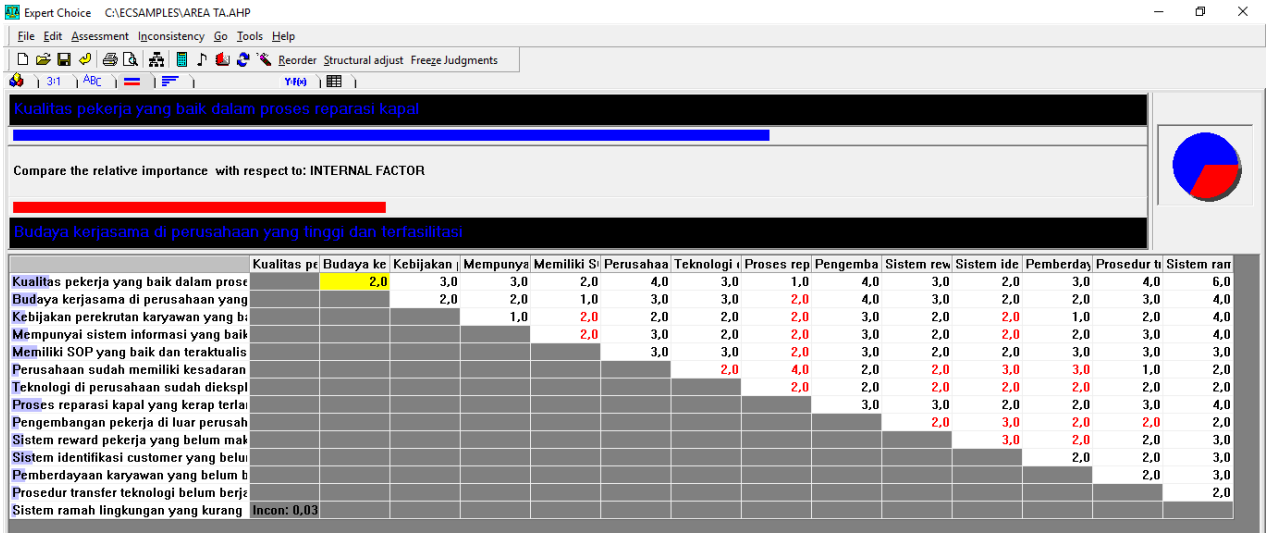
Weight Values

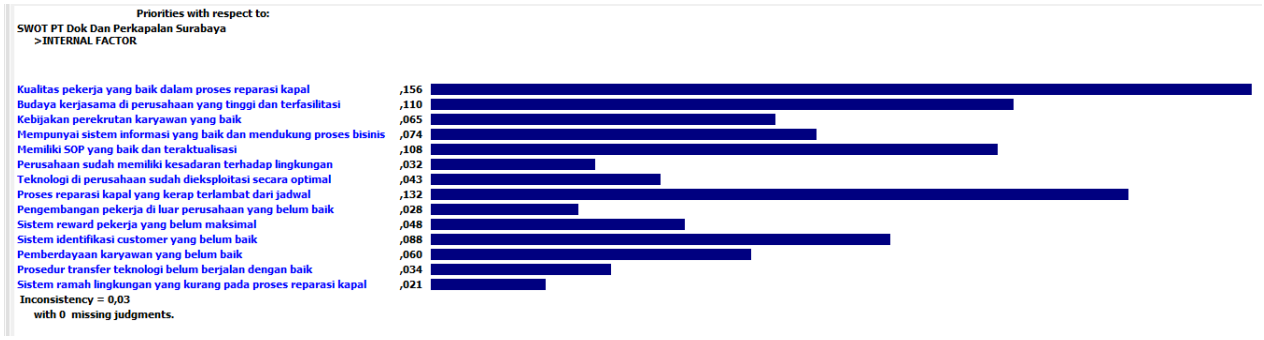
Weights					
Sub-category	Criteria	Ej	1-Ej	Wj	Rank
1.1	C 1.1.1	0	1	0,5	1
	C 1.1.2	0	1	0,5	1
1.2	C 1.2.1	0,5444	0,4556	0,28399	3
	C 1.2.2	0,53431	0,46569	0,29028	2
	C 1.2.3	0,31702	0,68298	0,42573	1
1.3	C 1.3.1	0	1	0,5	1
	C 1.3.2	0	1	0,5	1
1.4	C 1.4.1	0,74249	0,25751	0,23667	2
	C 1.4.2	0,9	0,1	0,09191	4
	C 1.4.3	0,52678	0,47322	0,43492	1
	C 1.4.4	0,74268	0,25732	0,2365	3
1.5	C 1.5.1	0,54015	0,45985	0,32733	2
	C 1.5.2	0,88044	0,11956	0,0851	3
	C 1.5.3	0,9	0,1	0,07118	4
	C 1.5.4	0,953	0,047	0,03345	5
	C 1.5.5	0,32156	0,67844	0,48293	1
2.1	C 2.1.1	0,5119	0,4881	0,25118	2
	C 2.1.2	0,54483	0,45517	0,23423	3

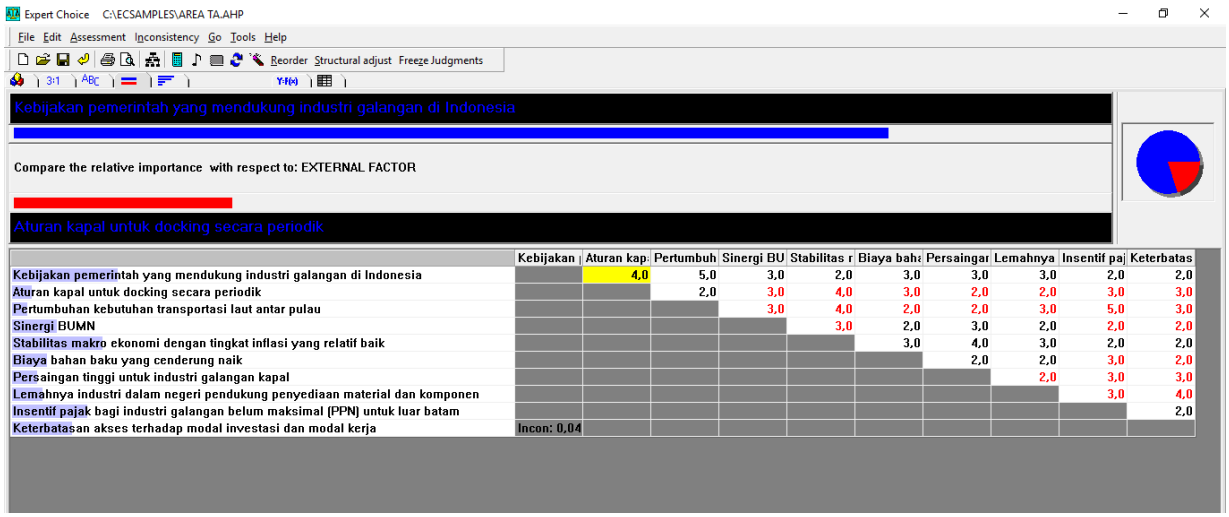
Weights					
Sub-category	Criteria	Ej	1-Ej	Wj	Rank
	C 2.1.3	0	1	0,5146	1
2.2	C 2.2.1	0,1781	0,8219	0,31088	2
	C 2.2.2	0,1781	0,8219	0,31088	2
	C 2.2.3	0	1	0,37824	1
2.3	C 2.3.1	0	1	0,5	1
	C 2.3.2	0	1	0,5	1
2.4	C 2.4.1	0,32781	0,67219	0,28735	2
	C 2.4.2	0	1	0,42749	1
	C 2.4.3	0,33294	0,66706	0,28516	3
3.1	C 3.1.1	0	1	0,5	1
	C 3.1.2	0	1	0,5	1
3.2	C 3.2.1	0	1	0,5	1
	C 3.2.2	0	1	0,5	1
4.1	C 4.1.1	0	1	0,5	1
	C 4.1.2	0	1	0,5	1
4.2	C 4.2.1	0	1	0,5	1
	C 4.2.2	0	1	0,5	1
5.1	C 5.1.1	0	1	1	1
5.2	C 5.2.1	0	1	0,5	1
	C 5.2.2	0	1	0,5	1
5.3	C 5.3.1	0,1781	0,8219	0,35929	1
	C 5.3.2	0,35621	0,64379	0,28143	3
	C 5.3.3	0,1781	0,8219	0,35929	1
6.1	C 6.1.1	0	1	0,5	1
	C 6.1.2	0	1	0,5	1
6.2	C 6.2.1	0	1	0,5	1
	C 6.2.2	0	1	0,5	1
6.3	C 6.3.1	0	1	0,5	1
	C 6.3.2	0	1	0,5	1

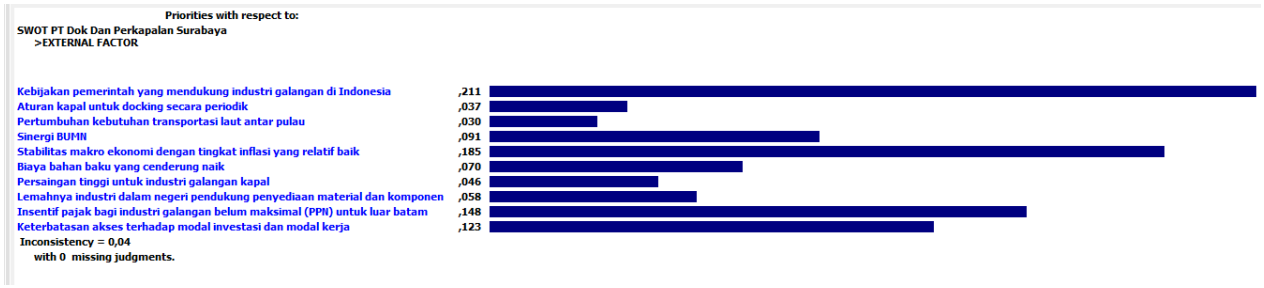
Appendix 3: Expert Choice software processing





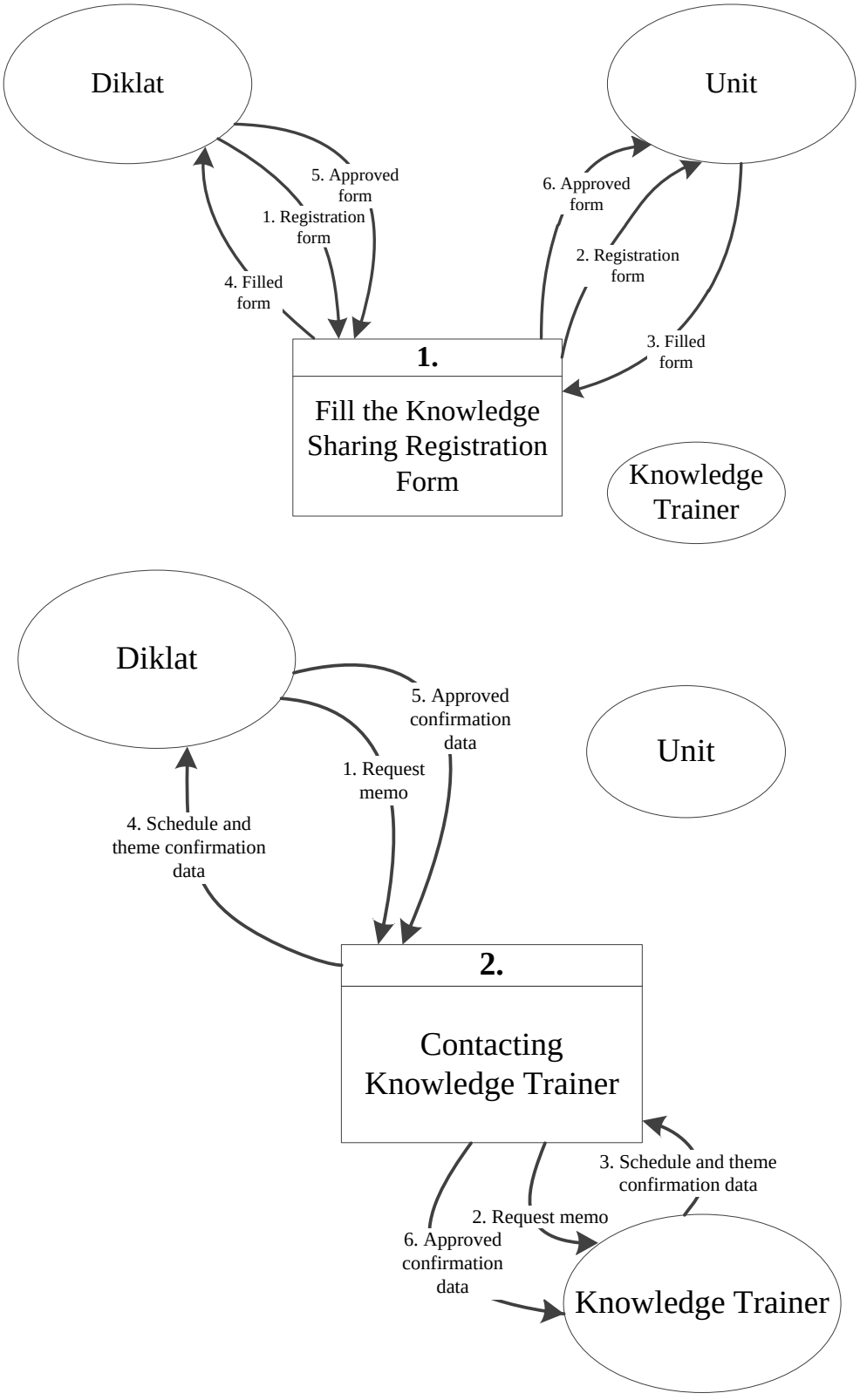

Priorities with respect to:
SWOT PT Dok Dan Perkapalan Surabaya
>INTERNAL FACTOR
Kualitas pekerja yang baik dalam proses reparasi kapal ,156
Budaya kerjasama di perusahaan yang tinggi dan terfasilitasi ,110
Kebijakan perekrutan karyawan yang baik ,065
Mempunyai sistem informasi yang baik dan mendukung proses bisinis ,074
Memiliki SOP yang baik dan teraktualisasi ,108
Perusahaan sudah memiliki kesadaran terhadap lingkungan ,032
Teknologi di perusahaan sudah dieksploitasi secara optimal ,043
Proses reparasi kapal yang kerap terlambat dari jadwal ,132
Pengembangan pekerja di luar perusahaan yang belum baik ,028
Sistem reward pekerja yang belum maksimal ,048
Sistem identifikasi customer yang belum baik ,088
Pemberdayaan karyawan yang belum baik ,060
Prosedur transfer teknologi belum berjalan dengan baik ,034
Sistem ramah lingkungan yang kurang pada proses reparasi kapal ,021
Inconsistency = 0,03
with 0 missing judgments.

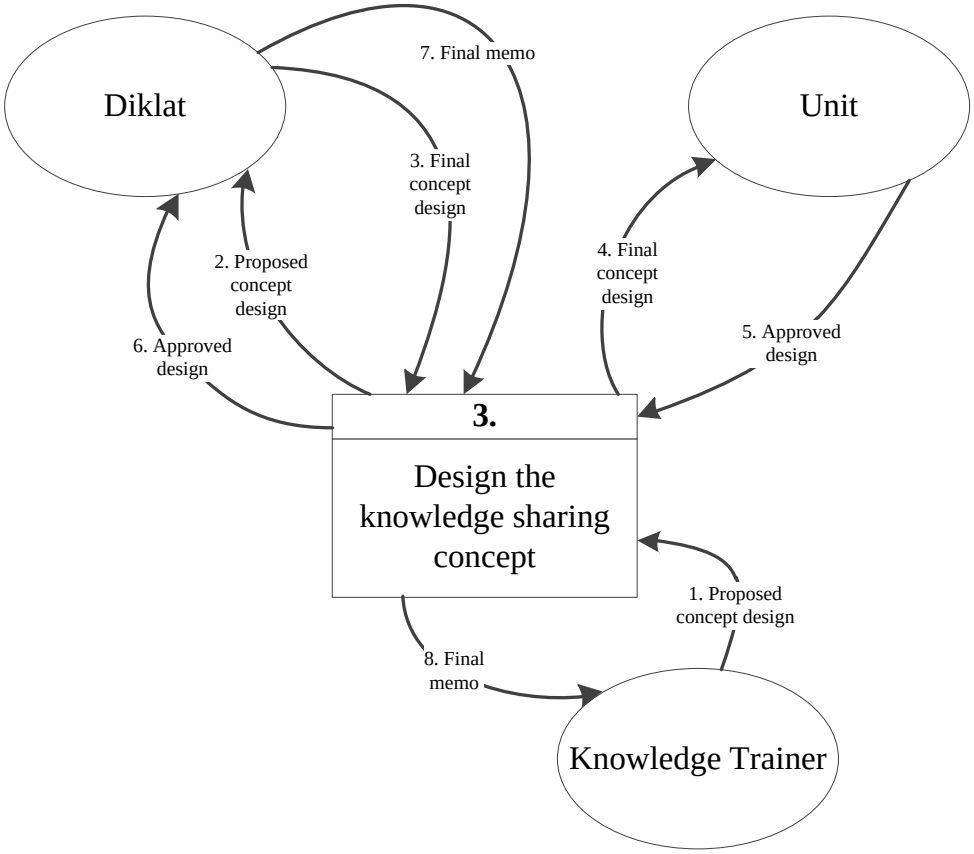

Expert Choice C:\ECSAMPLES\AREA TA.AHP
File Edit Assessment Inconsistency Go Tools Help
Reorder Structural adjust Freeze Judgments
Kebijakan pemerintah yang mendukung industri galangan di Indonesia
Compare the relative importance with respect to: EXTERNAL FACTOR
Aturan kapal untuk docking secara periodik
Kebijakan | Aturan kap | Pertumbuh | Sinergi BU | Stabilitas r | Biaya bah | Persaingar | Lemahnya | Insentif pa | Keterbatas
Kebijakan pemerintah yang mendukung industri galangan di Indonesia 4,0 5,0 3,0 2,0 3,0 3,0 3,0 2,0 2,0
Aturan kapal untuk docking secara periodik 2,0 3,0 4,0 3,0 2,0 2,0 3,0 3,0
Pertumbuhan kebutuhan transportasi laut antar pulau 3,0 4,0 2,0 2,0 3,0 5,0 3,0
Sinergi BUMN 3,0 2,0 3,0 2,0 2,0 2,0
Stabilitas makro ekonomi dengan tingkat inflasi yang relatif baik 3,0 4,0 3,0 2,0 2,0
Biaya bahan baku yang cenderung naik 2,0 2,0 3,0 2,0
Persaingan tinggi untuk industri galangan kapal 2,0 3,0 3,0
Lemahnya industri dalam negeri pendukung penyediaan material dan komponen 3,0 4,0
Insentif pajak bagi industri galangan belum maksimal (PPN) untuk luar batam 2,0
Keterbatasan akses terhadap modal investasi dan modal kerja Incon: 0,04


Priorities with respect to:
SWOT PT Dok Dan Perkapalan Surabaya
>EXTERNAL FACTOR
Kebijakan pemerintah yang mendukung industri galangan di Indonesia ,211
Aturan kapal untuk docking secara periodik ,037
Pertumbuhan kebutuhan transportasi laut antar pulau ,030
Sinergi BUMN ,091
Stabilitas makro ekonomi dengan tingkat inflasi yang relatif baik ,185
Biaya bahan baku yang cenderung naik ,070
Persaingan tinggi untuk industri galangan kapal ,046
Lemahnya industri dalam negeri pendukung penyediaan material dan komponen ,058
Insentif pajak bagi industri galangan belum maksimal (PPN) untuk luar batam ,148
Keterbatasan akses terhadap modal investasi dan modal kerja ,123
Inconsistency = 0,04
with 0 missing judgments.

Appendix 4: DFD in knowledge sharing procedure

DFD Level 1:




Diklat
Unit
7. Final memo
3. Final concept design
2. Proposed concept design
4. Final concept design
5. Approved design
6. Approved design
3.
Design the knowledge sharing concept
1. Proposed concept design
8. Final memo
Knowledge Trainer

AUTHOR'S BIOGRAPHY

The author was born in Surabaya May 27th 1996 with the full name Achmad Danu Firdaus. The author is the first child with two siblings. The author went to SDN Margorejo 1 Surabaya (2002-2008) and SMP Negeri 1 Surabaya (2008 – 2011). Then, the author completed his study at SMA Negeri 2 Surabaya (2011 – 2014). Author's interest on industrial engineering major brought him to continue his study in Industrial Engineering Department of Institut Teknologi Sepuluh Nopember (ITS) in 2014.

Beside university academic activities, the author also actively involved in student organization namely HMTI (Himpunan Mahasiswa Teknik Industri) ITS and BEM (Badan Eksekutif Mahasiswa) ITS. On the other hand, the author involved in various software trainings such as AutoCad, ARENA, and QIET, also other trainings which are scientific paper writing, business training, management training (LKMM TD), and organization training (P3MTI). Moreover, author was also actively involved in student committees such as head of P3MTI (2017), industrial engineering games committee (2015-2016), industrial challenge commitee (2016), vice chairman of Indonesian writing seminar committe (2016), GERIGI ITS commitee (2015), and PAMMITS committee (2015). The author also participated an internship program as project control staff at PT Krakatau Engineering. Finally, by completing this final project research, the author graduated from Industrial Engineering Department ITS and achieves his Bachelor degree. For detail information about this research, please contact the author by email achdanuf@gmail.com.

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