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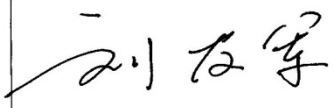
Author: Liu Youjun	Signature: 
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Cost-efficiency Analyses of Offshore 3D Seismic Survey

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Preface

This Master's thesis is my final project for receiving the Master's degree in Industrial Economics at the University of Stavanger. The selected title-- Cost-efficiency analyses of offshore 3D seismic survey of the thesis is closely related to my working background and specialization in industrial Economics. The intention of this research is to analyze the reasons and the methods to make our seismic survey more efficiently, and to find some better solutions to survive especially in the competition during the oil price crisis period for the service companies.

Drilling offshore is an expensive activity, all the companies want to get oil or gas from the borehole when they drilling. How to drill more accurately? Usually, a 3D seismic survey is quite essential, only with this can we know where the potential reservoir lies. And we can drill the hole to the reservoir as close as possible. But now the crude oil barrel price has been going down and at about 50$ which is the half price of the year 2013;No company wants to spend a big sum of money on seismic survey at the risk of finding no reservoir especially when the oil price is pretty low, so we have to face the problem of how to save more money. How to earn more money with limited cost? There will be a lot we need to do. Here we will get the question of how to be more Cost- efficiency for 3D seismic survey offshore? The motivation is mainly to analyze the reasons or methods on how to lower the cost and improve the efficiency for the GEO service companies.

At this time, due to the low crude oil price, oil service companies are quite struggling to survive, they try to work through this tough period, The method commonly adopted are cutting the headcount, such as the biggest oil service company Schlumberger (SLB) announced to reduce about 9000 employees at the beginning of 2015 and focus on control their costs in 2015, following its step Weatherford decided to reduce 5000

employees in April; besides, at the end of 2014, Baker Hughes was purchased by Halliburton which used to be the second biggest service company, the purchase was also rooted in the low oil price, I believe.

As one of the oil service companies China Offshore Service Limited company (COSL), we didn't reduce the number of employees, but we have our own strategy to reduce costs and make all the endeavor to spend less and be profit more, Last year we had bid on the external market at very low price intended to win more contracts even at the risk of lose money, but it seems that the market shrink far beyond our imagine, till now we didn't get any contract. So we begin to focus on the job of cost decreasing and benefit increasing program, how to save more money with limited resource is the main goal this year, and this is also the motivation for focusing on this topic and title of this master theses.

Abstract

The main objective of this project is to analyses the factors that affect the cost and efficiency during the offshore 3D seismic survey.

Four parts will be discussed to support the main objective--the equipment, environment, decision making on the investment and human factors. These parts will analyze how those elements affect the cost and efficiency in 3D seismic surveys and how to optimize these effects during production. The study focus on examples from South China Sea working area to back up the argument.

The first part introduces the equipment, which as the executive element employed in almost all offshore activities we want them to run without problem as long as possible and to be as efficient as possible. So the problem with the equipment usually cause down time for long hours. The root causes are identified as below: lack of maintenance or lack of spare parts or lack the knowledge to handle it. If we have proper maintenance plan/strategy, the equipment would probably be in service for longer period before break down.

As to the maintenance and spare parts for the equipment, we would elaborate within the field of equipment Operations and maintenance management. And condition monitoring and management would be probably used as well if necessary, such as Thermography, Vibration monitoring, Thermodynamic monitoring, Wear and oil monitoring, Nondestructive testing. As to the critical spare parts, the economic spare part will be discussed.

Part two, the environment. In this chapter, mostly we would talk about the environment that affect the vessel efficiency, for example, the sea state, wind, typhoon, sea current etc. As ergonomics for human working condition is a critical factor, we would single this out in the human performance part which is part three.

When we mentioned the weather in South China Sea, there always Typhoon during summer, the rough sea state cause the data we acquired very noisy and this kind of data may not be preferred and may need be acquired again, that would cost time and waste money, what's worse is we should pick up streamers for the shelter to avoid the

Typhoon, this would cost even more. This part will be supported by history statistic data of typhoon effect. The harsh weather in winter in BoHai bay or North Sea would not be included in the project although it affects seismic activity a lot.

Part three, since the equipment investment will cost much, when we make decision for the new investment, we shall consider how could we use our limited money to get the most benefit. A practical example from COSL would be listed to illustrate how to make reasonable decisions and investment based on the calculation of excel.

Part four, human factors, as the most important character in all the programs or projects, will be analyzed from the prospective of how would it affect the cost and efficiency in the seismic survey. The human resource, human performance, project management as well as ergonomics have great influence on the cost and efficiency.

How many employees we need now? How they should be trained to suit the job? How their efficiency will be improved? And shall we follow the principle of job design to fit the workers. This may refer to several aspects with respect to project management and Human factors, technology and organizational issues. As a project, optimize the project management strategy and do proper risk assessment to minimize the cost and save more time would be discussed.

Acknowledgement

When the deadline for this thesis comes around the corner, it would probablymeans the master's program between COSL and UIS for this term has mostly been finished. At this time I would like to send my sincere thanks to those who have made their endeavor to help us both in Norway and China.

Especially, I would like to send my sincere thanks to my thesis supervisor—professor Tore Markeset. During the period of writing thesis, he had given me professional support and valuable advices on the chosen of the topic and the content of the thesis, as well as modification. I also want to extend my appreciations to my company for the most resource and convenience they had provided to me during this time. As well I would like to thank my family for the spiritual support which they had spared no effort to give.

And it is very grateful for the colleagues who had helped me with data gathering at the beginning of this thesis; especially I want to express the help from the Manager of Human Resource division Mr Li Jianmin, he shared with me some valuable experiences and useful suggestion not only one the thesis but also on how to learn more; as well I should send my thanks to the Party chief on board HYSY720 Mr. ZhaiHuijie, and Mr. Wu Tao on HYSY721 for the huge historical data they had supplied.

Liu Youjun

June 10th 2015

Methodology

In this thesis, the method is mainly to discuss the factors that affect the cost and efficiency in marine 3D seismic operations. I would like to discuss these factors based on a huge number of historical statistic data obtained during on board the vessel, and use the basic knowledge of maintenance and operation to calculate the critical spare parts and also the decision making when relate to the investment. Probability calculations and decision making with excel as well the sensitive analysis will be used here.

The last part would be the human operation. The human ergonomics, risk assessment to minimize the cost and strengthen the efficiency and the other traditional operations such as bunking at sea with towing would be discussed with practical examples. Mainly in this thesis I would rely on the historical data and practical examples combined with the basic knowledge from project management, risk analysis and management, investment and decision making, as well as human resource aspects etc to illustrate how and the extent of those factors affect the cost and efficiency of the 3D seismic operation.

1 Introduction of seismic vessel

In order to know well of this thesis, for those who are not really familiar with seismic vessels, I would like to give a brief introduction of the seismic vessel. The working flow and the equipment we use under water.

1.1 Equipment brief introduction

Normally, a seismic vessel consists of a vessel and the seismic equipment. The vessel should have strong power force and be well designed for both the working and living conditions and fit all kinds of requirements of the ship classes such as DNV ABS or CCS etc. As well the seismic equipment should be fitted to improve the data quality and increase its efficiency; besides well trained and organized crew members are quite essential.

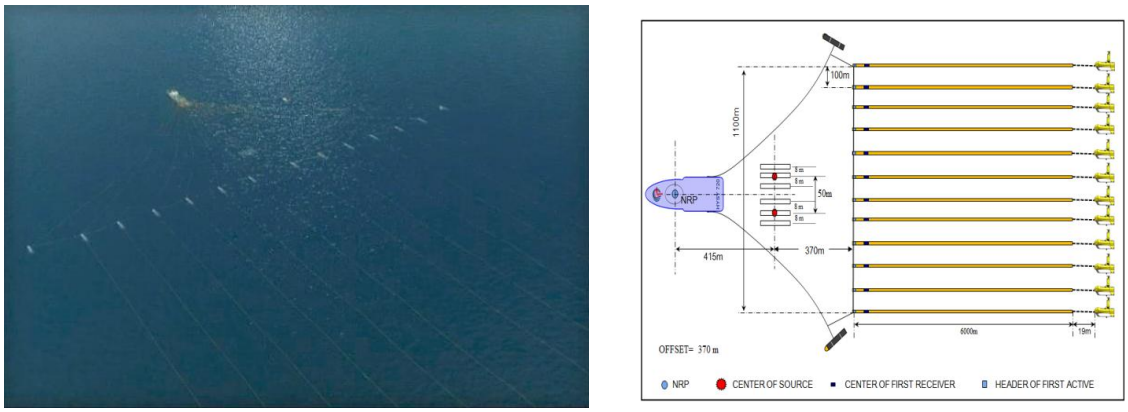

Figure 112 Streamer Seismic vessel diagram

Due to the equipment fixed on the streamers and its characteristic when designed，the streamers can be suspended in sea water with towing force. These equipment consists of compass bird, acoustic bird, lateral birds, floats, tail/front buoys etc.

The vessel supply continuously power force for the towing streamers since it has been deployed. Once the vessel had stopped, with the towing force the streamers suspended in the sea water normally will sink quickly and cause disasters to the seismic vessel. so we do all kinds of assessments and prevention measures to prevent this from

happening .

Figure 2 Compass Bird Acoustic Bird Lateral Bird

Source:(ION 2013)

Besides the streamer, the seismic source is one of the most important equipment, only with the source can we get the useful reflect signals from the formation.

Figure 3Source arrays and streamer winches

Source:(Sercel 2013)

What we talk about are what included in sea equipment, another important and essential part is the on board equipment and the vessel itself. The data acquired from the formation transferred to the recording room was processed and finally recorded on the tapes. The bridge which is the head of the vessel can never be ignored and as well the engine which is the heart of the vessel should never be stopped when we are shooting.

1.2 The seismic working flow

When we are shooting a line, first we should have the positioning data from the GPS system. When the vessel get to the precise position, the source was triggered automatically and strong acoustic wave pass through the sea water to the sea bed and to the deeper formation and then reflected to the sea water again and the signal captured by the hydrophones located in the streamer, and the signal transferred to the digital format and was transported to the recording room; in the recording room, after a series procedure data stored on the magnetic tape. Then the vessel goes to the next shot position, and continuously to the next loop.

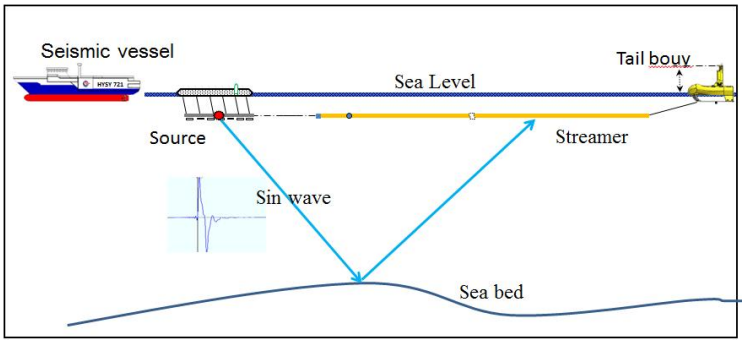

Figure 4The seismic data acquisition chain

All equipment have their designed work life and need proper maintenance all the time , and the operator may have minor faculties due to long time work hours or bad working environments and all the procedure assessment may have flaws, and so on so forth.

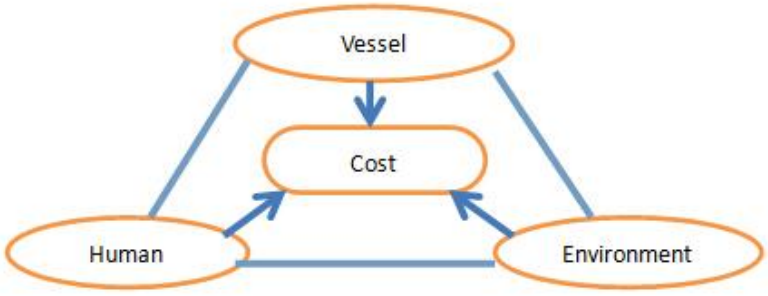

Figure 5Cost efficiency affect factors diagram

All these uncertainties lies in equipment, human and environment make up of the reasons and factors that may lead to high cost or lower our efficiency during seismic operation. Some problems can be avoided while other can only be improved. Then it comes to us the main topic that how to strengthen the efficiency with controlled ideal costs.

2 Equipment

Equipment is the critical executive part when we carry out our job, we want them function as long as possible, and we don't want intermittent failure or down time; down time means money lose, every company want to earn money. How to earn as much as possible with what we have? What we need is not only a long-lasting and well-performed equipment all the time but also the ones with low cost and high efficiency.

For example, last few years before, we usually use very simple cell phones which we can only do some limited things like short message, telephone call, and other simple functions we need, this kind of cell phone is quite stable and usually last really long, we can use this kind of cell phone up to ten years if we want. But later we find that the capacity and function of this kind of cell phone is no longer suite for the present daily needs. We need it function as a camera then we can take more high solution pictures when we are travelling, and function as a computer we can view internet and sent Emails as well, and so on. So we need to update our cell phone. So it is the same theory with our production equipment, we need them to be more advanced and more efficient.

2.1 The application of latest technology and products

Seismic survey is a kind of intensive technique concentrated operation, also a high risk associated activity, in order to carry out the seismic survey more efficiently and safely, we need the assistance of the most advanced technology now and the refined risk assessment methods to lower the possibility of hazard. So when built a seismic vessel it is very important to make full use of the most advanced technology and the most cost-efficient equipment which can strengthen our efficiency. But due to some limitations, not all of the equipment or devices used on board are as efficient as we want. In the following pages I would give some practical examples to illustrate this

2.1.1 Vessel designed for the future use.

Vessel equipment designed for Geo service usually can supply service in good condition for at least 15 years or more. But when we design a vessel at the beginning, we may equip with the latest equipment at present, or purchase the newest product we can use today. How could we know what will happen in the later 10 years? what kind of new technology will be used in this field? And does any related regulations in this field will be modified that would probably affect our usage of the equipment?

If equipment installed on the vessel is not well designed for the future use, it may have problems in the later years. Companies should take the responsibility to make continuous updates for the equipment or vessel to suit to the needs, and in this condition, it would cost even more time and money to make modification since all the other equipment adjacent to it would probably be affected. The cost and efficiency of the fleet off course will be impacted.

Take one of our 6 streamer vessel as an example. Built in 2001，it was a vessel designed for a towing vessel and was converted to a geophysics service vessel at 2008. Since it was not built for geophysics survey purpose~~ly,~~ when rebuilt the vessel, the design may be constrained due to the former constructions. And focusing on the cost~~s~~, the engineer only installed the traditional popular equipment to that day but not the latest new technologies. Actually the application of the solid sentinel streamers was introduced in 2005. Sentinel has become the system of choice for streamer seismic survey acquisition already at that moment(Sercel 2013). It equipped with six streamer winch with capacity of 6000 meters oil filled streamer and two 2000Psi compressor whose capacity is 31 cubic meters per minute.

The capacity of this vessel is quite good that day, and performs very well except some minor flaws such as the noise in the recording room and the living quarter is a little tiny and may be some other equipment is not well designed for ergonomics

But at that moment, this vessel is quite a big success, carrying out many difficult 3D seismic surveys and earns a lot of money. It always have full schedule all the year round. But in later years, when the solid streamer which is filled with special foam as filling media becomes the basic requirements, the oil filled streamers which may cause oil leakage and cause environment pollution are forbidden to use due to the

publish of the world wide environment protection policy. Another problem arise also：the oil based streamer outer diameter is only 55mm, but the solid streamer outer diameter is 75mm, this means the streamer winch which used to be carry 6000 meters oil based streamers can only fulfill about 4500 meters solid streamers, not companies wants to do 3D seismic survey with only 4500 meters streamers. So to update the streamers and the winches are become the urgent requirement for that vessel.

So the vessel going to the dock in 2012 and cut the hull to add two more winches in order to carry the streamers that the exits 6 winches cannot carry. This problem had been solved with the easiest way even though it consume about 1 month dock time and about 4 million Yuan. This problem seems be solved while it is not the case. Actually every time we deploy or retrieve the streamers we need to disconnect the 1500 meters streamer that the former winches can't carry and connect it to the newly installed 2 winches. In this condition we may waste 5 or more hours every time we deploy or retrieve the streamers. Actually according to the new statistic, the time this vessel used ~~it~~is almost the same or even more than the new built 12 streamers vessel.

2.1.2 Cost and efficiency analysis for the design flaw

According to the daily rate we can get the cost of the 5 wasted hours. If we have 12 times retrieve per year that means we have 12 times deploy and retrieve, which adds up to 120 extra hours for a single boat. If the hour rate is 30000 RMB， this would aggregated to nearly 4 million per year per vessel, we lose even more every year due to our design flaws.

Besides, it cost more time and more operators, when retrieve or deploy streamers more tasks get involved, the more working hours we exposed to, the high risk we are(AVEN 2008).

According to the definition that is the expected number of fatalities over a year and the relationship between PLL and FAR. The exposed hour on this vessel increased by 120 or more, and the FAR(Fatal Accident rate) value will be increased also, suppose that we had 1000 worker working all the year round in the last 20 years. Based on this,

we can get the FAR value with the following equation.

FAR=[PLL] 10^8/nt(AVEN 2008) Equation (2.1)

FAR=1*10^8/(1000*120*20)=42

The big value means that this activity is high-risk associated, and risk assessment should be taken to minimize the number of fatal accidents or tremendous property loss.

So companies should take risk assessment and other measures to minimize the FAR value and extra money would probably needed for the measures to eliminate hazards. For Example, if the ICAF is 200million, due to the increase of the FAR we may have to inject more money in order to save one life.

2.1.3 Costs caused by region constrains for the most advanced technology and products

At the beginning of the most advanced technology, due to the patent they owned, the owner may only want to sell their products to some specific regions, so different regions may have different products, some regions may have constrained products or technology. Take an easy example here, the same type of cars in Europe may be quite different from cars in Asian. Some are only sold in Europe or America; some are only sold in Asia.

But in the oil and gas industry, it is a worldwide market, we provide service for the whole world, if our products are limited due to this reason, so we may out of the competition or we may have to spend more money on the products updates.

Let's take the depth controller—the compass bird which we used on board as I had mentioned in the previous chapter as an example. It has some kinds of categories. Now what we use is the most popular type5011, made in USA and designed by an UK company. But for the product exported to other countries out of America and Europe, it will be labeled as 5011E.The difference is not so obviously at the beginning, but now as the streamer working depth is much deeper than before, we used to keep the streamer working depth at the range from 0-30 meters. The most advanced practice will expected to reach 60 meters or more. The maximum working depth for 5011E

type is only 30 meters, but the 5011 type can working at the maximum depth of 120 meters.

Last year we had a newly built vessel HYSY721, equipped with 600 5011E type compass bird, but later in 2014, we got the chance to bid for some new projects which required to keep the streamer at the range of 0-60 meters. We want to get the contract; under the condition of the low crude oil price, to get an external contract is one of the essential tasks. But what we reluctant to do is, we have to update the 600 pieces of 5011E compass bird, which was bought just a few months before. We had to spend some extra money to negotiate with the UK company whether they can exchange their 5011 type to us. Finally we get the price of about 80 hundred dollars to update one compass bird (as we know the regular price for a new compass bird is about 100 hundred dollars) .So it is really costly for us considering that the vessel had only been built for only about 3 months.

Besides, we had to pack all these 600 pieces of compass bird and transfer them to the US where their factory lies, and it takes about at least 1 month for the transportation and during this time we have nothing to use, we cannot carry out any seismic survey. So if we take this period of lose in to consideration, we may at least lose 50 million if in normal production season. That is a huge number of money. Fortunately we carry out the update process in the winter season and at the time we only prepare for the next seismic survey and only the maintenance for the equipment were carrying on, so we are spared from big sum of loss.

2.2 Equipment Operations and maintenance

Maintenance is defined as a combination of all technical, administrative and managerial actions, including supervision actions, during life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function(Moubray and Lanthier 1991). In order to make the system last longer, and to make for use of the lifecycle of any part, we could do all kinds of maintenance to the system. And normally The maintenance of any system can be categorized in to two

types: corrective maintenance and preventive maintenance(Chitra 2003).

As we know, we should input not only manpower but also materials as well as documentations and information to the system, and we may get higher availability, higher reliability as well as low risks. However, all these input tangible or intangible materials are very expensive but it is really indeed, if lack of maintenance there would be more failure happen and would cause more down time. Downtime cause more money and may need long time to retrieve to normal production. So do predictive maintenance as well as corrective maintenance is always essential. But together with maintenance, condition monitoring is one of the most important part can't be ignored.

2.2.1 Condition monitoring while maintenance

During the whole process of maintenance, we need to know the status of the equipment all the time, so condition monitoring is quite important. With condition monitoring we could make degradation estimation(Carden and Fanning 2004) and do specific Planning of maintenance; also we can perform some fault detection to avoid dangerous situations, shut down of equipment before total failure(Ma 2007).

With the intensive high technologies, engineers and researchers, particularly in the aerospace and offshore oil industries, find to detect faulty are more and more difficult. So during the late 1970s and early 1980s, vibration based damage detection was began to be utilized during (Farrar, Doebling et al. 2001).

Most of the equipment are rotating with high speed, and it is proved to be the most effective and mature also the successful way to be detected by the vibration based detection(Farrar, Doebling et al. 2001).

With the help of the vibration monitoring device we can easily get the acceleration, velocity and displacement through integration a derivation formula. As well, these parameters can also be calculated each one or all together on Real Time. We not only need these normal speed parameters but also some Spectrogram in real time is quire essential, this is usually a Time based FFT Graphic. This means the device can calculate the FFT of each second of your recorded signal and place it in a graphic, and other format you wanted(INSTRUMENTS)). Which we can see the picture below is

one of the vibration monitor we used on board.

Figure 6Vibration monitoring device and display

Source:(INSTRUMENTS)

Besides vibration monitoring, we had other methods to monitor the status of our equipment, such as Oil analysis which will reveal abnormal wear or unfavorable operation conditions(Rao 1996); Visual inspection, using for example stroboscope inspection which is the most common way for the operators. And thermodynamic condition monitoring (TCM) is preferably used for performance monitoring at thermal fluid flow.(Markeset 2014) often we need a combination of 1 or 2 methods together to determine the defective parts.

Condition monitor is quite an efficient way to diagnose fault and make plans for the maintenance. But still it is relatively costly, not all the equipment we mentioned can be equipped for one team, or for an industrial production company. First due to the cost of the equipment, as well whenever we have these equipments, we have to train one group to make sure they can operate these tools and to be effective when diagnosing equipment problems. As well the training costs may be regard as the extra money which they reluctant to pay especially when the oil price is quite low today. They would think it is possible to ask some other contractor to do special maintenance for us when there is critical faults happen, this would save a sum of temporary money, but actually it is not worthwhile to do so.

A simple example may be used to illustrate this. There is a small pump used to supply lubricant oil to the main engine and the air compressor. A few days after the periodical maintenance the chief engineer find that the lubricant oil pressure from the output of the pump is not stable and a kind of abnormal noise and vibration can be heard and felt around the pump. Because we have 3 lubricant pumps and 2 water pumps at that area to supply lubricant oil or water from different tanks, the chief engineer had to

check these pump one by one. He had to do some extra work to verify whether it is this pump making noise and cause the problem or that one. And finally he decided it was the third pump caused the problem. According to the chief engineer and the third engineer, it is the flange between the electromotor shaft and the pump are not well connected. They are not in a straight line. So they make noise and vibration which we usually named misaligning in condition monitoring course. So he decided to fix this problem and finally after about 1 hour he thought the problem was fixed.

And the test process followed; when we restart the pumps we find that the pressure is return to normal condition. But a kind of abnormal noise still can be heard. Some thinks it is ok, and others think there is still a problem. And they finally decided to run this pump under this condition for a while as a test. If no big problem happen just noise they would let it go, if new problem happen they will continue to fix the problem.

Fortunately, at that time we are in port, and there are several engineers from the suppliers are on board to carry out some specific jobs. They had equipped with some testing devices that we don't have. So he monitored the vibration as the following picture shown. And the engineer from the supplier said according to the spectrum, and what you have done before, we think that the bearing of the pump had been damaged due to the misalign before and you had kept the pump running for 2 days to test whether you had fixed the problem, this action made the bearing much worse, because that the shaft had been running under unbalanced force due to the misaligning, the bearing wear unequally. After you had fixed the misaligning, the bearing works at a balanced force again, but due to the wear before, the balls of the bear are not balanced wear, so some balls may have small gaps with the outer race. So the abnormal spectrum was monitored. And the engineer from the supplier said that, if you continue to running the pump, it will break down, and no lubricant can be used for the main engine and the compressors. It would be a big problem if you are sailing or carry out seismic jobs.

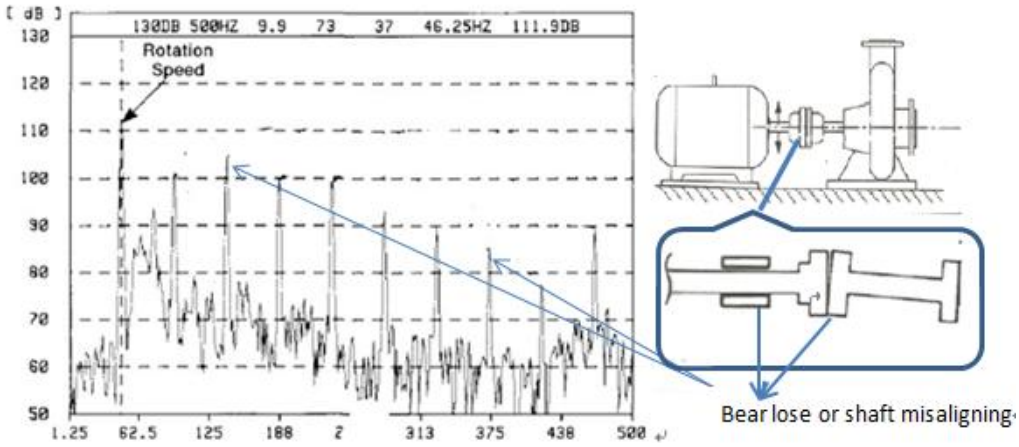

Figure 7Vibration monitoring and shaft misaligning

Source:(Markeset 2014)

As well, the engineer from the supplier said, you can also use some other methods to do monitoring, such as thermography. If thermography is applied you would find that the temperature is a little higher than other part due to the unbalanced wear. After the explanation and the instructions given by the supplier's engineer, we find that we all know the theory; we understand what he had applied and explained to us. But we didn't pay more attention on this, also we lack of some monitoring device. What we usually do is normal touch of some machine to find vibration and listen whether there is abnormal noise and normal inspection/observe the status LED lights on the panel.

It is proved to be necessary to do daily inspections, but lack of new devices to monitor the conditions of some critical equipment is really not good. We can imagine what would happen if the chief engineer doesn't talk with the supplier's engineer. In other words, it seems to be expensive to spend money on condition monitoring, but we may neglect some minor errors and may assume some situations as normal conditions, then the equipment may be running in a poor condition before we do the next periodic maintenance. And in the long run, we would always have problems here and there. That is why we always spend a lot of money and time on repairing in shipyard. If we could monitor most of the hidden problems, we could do predictive maintenance to avoid long time in shipyard or dock. This hidden cost is really worthy.

2.2.2 Maintenance cost

Do appropriate maintenance no matter the reliability centered maintenance(Moubray

and Lanthier 1991) or risk based maintenance, they would make the system last long and in good performance as well as good reliability and low risk.

The costs comprised not only from the expense for the item we purchasing to keep the equipment running in good condition but also we should consider the other costs such as how to make it lasts. We would need a special team or a subcontractor to carry out this process. As well as the documents meetings undertaking not only the meeting expense they had during these time, but also and the transportation costs etc.

1) Maintenance personnel and support cost(Chitra 2003)

First, when carry out the maintenance we need a group of professional personnel, they are professional in this field and often paid by day or hour, so it will be very expensive for them to carry out a big project. As well they need accommodation and other support. The clients should settle down all these before they could carry out the maintenance job(Zhu, Gelders et al. 2002).

On vessel HYSY720, there used to be a group of people from Rolls-Royce who are specialized at the vessel equipment like the streamer winches, gun handing boom and all the hydraulic devices. According to the contract Roll-Royce offer some free service at the beginning, and later ~~it~~fees will be charged. The contractor is that ~~is~~ HYSY720 had to pay for the accommodation and the fee on their way, as well as the salaries for the team. I remembered it is officially more than 1000US dollars per day for one person. And due to the maintenance team don't want to go offshore with us, explaining that if they go offshore with us, they may lack of support and can't solve all the problems we need to be solved and they need intermittent support from the onshore office. So we just stay at port to wait for the maintenance.

Obviously, we had paid a big sum of money for the team, but the hidden cost, the opportunity cost in financial aspects is huge. If we spend ten more days in port we lost 7 million dollars. So for the most of time, we don't want to do so. But it seems that we don't have any choice, if we don't wait until the maintenance had finished, if one of the device have problem offshore, it still costy. Fortunately, the professional engineers offer us a training last for 2 days for free. We get some hydraulic basic knowledge and obtain the basic maintenance skills and the skills on

how to fix some minor errors. This would be the best prescription for compensation.

2) Spare/ repair parts inventory cost(Thomas 2001)

Spare parts is not the same with other goods, it has its own particular characteristics, the demand for parts may be extremely sporadic and difficult to forecast; the prices of individual parts may be very high(Markeset 2014). Service requirements are higher than other services, as the effects of stock-outs may be financially remarkable; So according to the importance of effect on availability of spare part when it is required, we should classify the spare parts to some different categories. The less important categories and the lead time is short then we can have fewer in the inventory(Herbaty 1990). And the classification of the spare parts according to its importance and the lead time of the spare parts as well as the location of the suppliers etc, we can give a table(Wessels 2003) below；

Criticality / Lead time	Low	Mod-erate	High
Short	S_{SL}^{*}	S_{SM}^{*}	S_{SH}^{*}
Moderate	S_{ML}^{**}	S_{MM}^{**}	S_{MH}^{***}
Long	S_{LL}^{**}	S_{LM}^{***}	S_{LH}^{***}

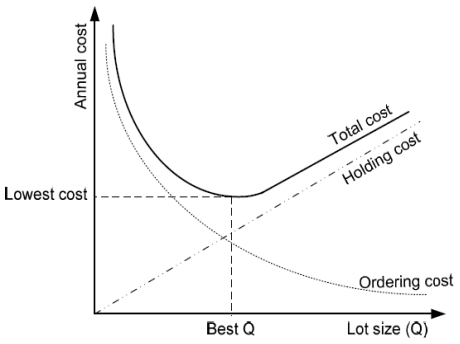

Figure 8Cost and lot size curve

Source:(Markeset 2014)

And as the importance and characteristics are different from one to another, so the numbers of the spare parts should be different. In other words, we need a spare parts logistics optimization system to minimize the inventory cost.(Kostić and Pendić 1990) In this system we need a Economic Order Quantity(EOQ) that minimizes the total inventory cost with respect to elimination of shortages(Herbaty 1990).

With this curve we can easily get the point that what we should achieve. The lowest cost and the best Q is our goal, but due to the estimation number of the spare parts is according to the based on probability, it is not so strictly a definitely number. So we can get to the zone that we think it is the most cost efficient way at the given

conditions. According to the statistic we may get the probability of the usage time of the spare time under given condition. And the supplier may give us some data for us to be referred to, which we may needed when do spare parts logistic optimization.

Considering the problem on how to get the best Q of the spare parts, we may have many solutions, for example, we could use some software to calculate the best Q. according to the calculator of WCM Consulting AB, Vaxholm, Sweden Oskar Olofsson.

We should input some numbers in to the blanks on condition that we have already get these numbers such as the down time caused in case the spare parts is available/ not available. This is a statistic number in the history or the similar field. This is an statistic number so the best Q finally calculated by the calculator can only be as a guide line. We can pay some extra money on this software to update and get more information and advice on the logistic optimization, Here i listed below is a free version of this software, despite the limited function on this free version, some key functions can still be inferred:

Spare Part	Bearing
Downtime cost per hour if the part is unavailable	5000
Downtime if the spare part is available in stock (hours)	5
Downtime if the spare part is **not** available in stock (hours)	15
Expected remaining life time of the machinery (years)	10
Estimated failure frequency (breakdowns per year)	0.2
Inventory interest (including cost for storeroom, depreciation, etc.) %	30
Cost of the spare part	10000

Extra cost per breakdown without the spare part in stock (C)	50000
Probability that the spare part will be used (P)	86 %
Expected downtime cost without the spare part (=C*P)	**43233**
Expected holding cost of the spare part (H)	17030
Expected obsolescence cost if the spare part never will be used (O)	1353
Total spare part costs (=H+O)	**18383**

Figure 9Critical Spare Parts Calculator

Source:(WCM Consulting AB)

And the other method to calculate the economic number of spare parts is the method using the spare part requirement nomograph to determine the number of the spare parts.

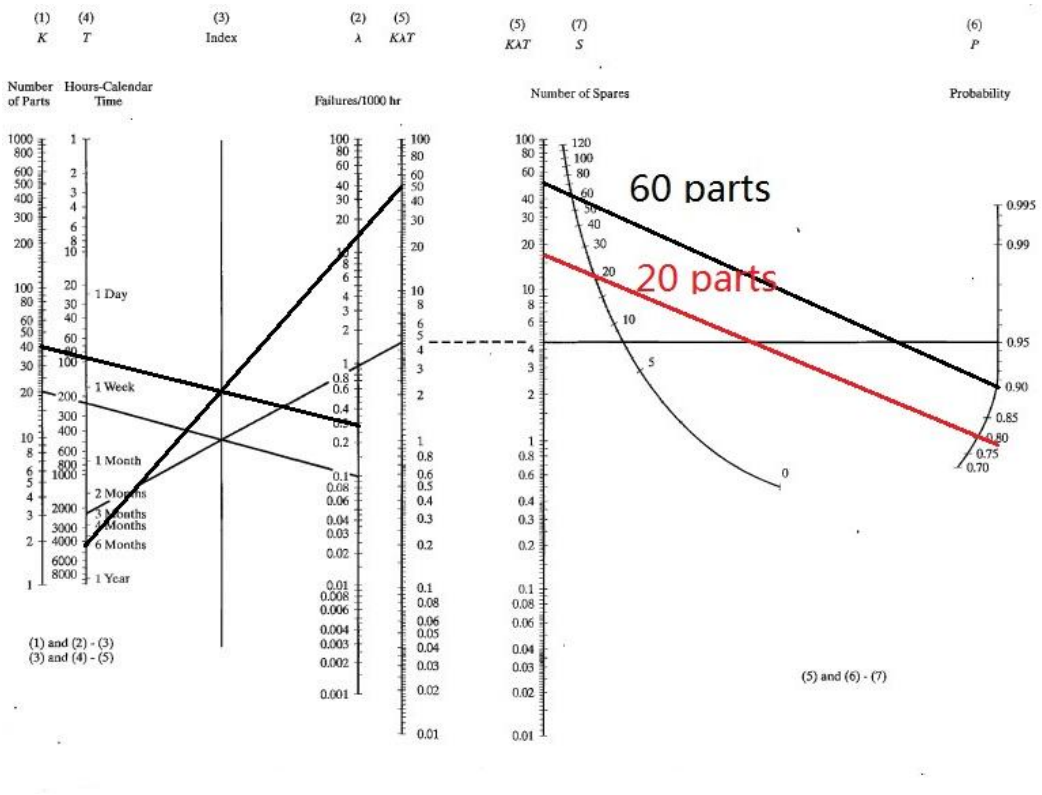

Figure 10Spare part requirement nomograph sheet 1 and sheet 2

Source:(Blanchard 10/3/2011)

According to Blanchard (Blanchard 10/3/2011), to determine the Spare-part quantity determination we could use the function which is related with the probability of having a spare part available when it is required, the reliability of the item in question, the quantity of items used in the system, and so on. Assuming that the distribution of the probability is a Poisson distribution; we can obtain the expression for spare part quantity determination is:

$$\mathbf{P} = \sum_{n=0}^{n=s} \left[\frac{(R)[-lnR]^n}{n!}\right] \tag{2.2}$$

P= probability of having a spare of a particular item available when required(Assume Poisson distribution)

S=number of spare parts carried in the stock

R=composite reliability (probability of survival); R=$e^{-K\lambda t}$

K=quantity of parts used of a particular type

ln R = natural logarithm of R

When we determine the quantity of the needed spare parts we should consider the factors that the desired protection level of this part which is the critical feature of the spare part. Here by protection level we mentioned is the *P* value in the Equation (2.2). And that would be the probability of having a spare available when it is required. We all know that if the P value is much bigger, then the greater the quantity of spares we required and vice versa. And this would lead to a consequence that we could have a higher cost for item procurement and inventory maintenance. Here the protection level, is a hedge against the risk of stock-out(Blanchard 10/3/2011).

According to what we have talked about above, when we determine the number of spare parts we needed, we should consider about the requirements for the specific operation in the system for example the effectiveness, availability of the system, etc; and find the appropriate level for that location where we could probably carry out some corrective maintenance. If the level of the corrective maintenance is different, the items we needed may be quite different. For example, parts function as the critical role on the prime equipment components when want to complete the mission, may be based on the factor that high-value or high-cost items may be handled differently from low-cost items; and so on. At any time, if we treat spare parts as an investment, there should be an optimum balance between the stock level and the cost they needed. That's the balance between the need and the costs.(Blanchard 10/3/2011)

Figures 10(a) and (b) show a chart that we can calculate the number of spare parts we need with a simple way based on the calculation of equation (2.2)

With this chart we can calculate the number of spare parts easily, just a few steps of calculation if we had known some statistic data before. We can illustrate the use of these two charts by an example(Blanchard 10/3/2011):

Suppose that we have a piece of equipment, and it contains about 40 parts of a specific type with a failure rate (λ) of 0.3 failures per 1000 hours of continuously running. The equipment works 24 hours a day, and spare parts can be purchased within 6 months' time. On this condition, How many spare parts should we keep in the inventory if we want to make sure 90% probability of having a spare part when needed?

Based on the statistics and the probability model we used to solve this problem, we have:

K = 40 parts

λ= 0.3 failure per 1000 hours

t= 6 months

We can get Kλt = (40)(0.0003)(24)(30)(6) = 51.84

p = 90%

According to the chart in Figures 10(a) and 10(b), approximately 60 spares are required. We can just calculated these numbers by connect the two sides of the chart (a) and (b). And then we can read the number from the cross point at chat (b).

Normally we may have some same parts working at different equipment, such as we have a same bearing working on the shaft of different pumps, if we have 5 pumps using this bearing. Because the working condition is different, these bearings may have different life time. Take this as a calculation example, suppose that these 5 locations named X_1, X_2, X_3, X_4, X_5 separately. This kind of bearing is very common and can be get easily within 20 days. The number of parts used for each pump, the part failure rate, and the pump operating hours per day are listed in Table 2.1

If we want to make sure an 80% chance of having a spare bearing when needed, how could we manage the inventory? Then the calculation will be a little different from the former one, we can show it as the following(Blanchard 10/3/2011):

The theory is the same as the former one; we need to find the K, λ and t, and calculate the K λt and add them up to make cross line in the chart. Then we can find the number of the spare parts.

1) The same with the former calculation,

X_1(30)(0.0001)(20)(10) = 0.6

X_2(15)(0.00005)(20)(5) = 0.075

X_3(27)(0.0003)(20)(20) = 3.24

X_4(70)(0.00015)(20)(22) = 4.62

X_5(60)(0.0003)(20)(24) =8.64

2) With these K λt, we can get the sum of these numbers that is:

$\sum K\lambda t=0.6+0.075+3.24+4.62+8.64=17.175$

It is the same with the former example in the chart 10(b), we connect the two points that from 17,175 at the K λ t side to the P value which is 80%.

The cross point with the curve is the approximate number of spares which is about 20 spare bearings needed in the inventory.

Table 1 The K λ and t value

Pump#	K	λ (failures per 1000hour)	t(daily operation hour)
X_1	30	0.1	10
X_2	15	0.05	5
X_3	27	0.3	20
X_4	70	0.15	22
X_5	60	0.3	24

Considerations for the inventory system.

Next, one needs to address not only the specific demanded factors for spares, but to evaluate these factors in terms of the overall inventory requirements. Too much inventory may ideally respond to the demand for spares; however, this may be costly, with a great deal of capital tied up in the inventory. In addition, much waste could occur, particularly if system changes are implemented and certain components become obsolete. On the other hand, providing too little support results in the probability that the system will be inoperative due to stock-out, which also can be costly. In general, it is desirable to obtain an economic balance between the quantity of items in inventory at any given point in time, the frequency of purchase order transactions, and the quantity of items per purchase order(Blanchard 10/3/2011).

•2) Maintenance cost for test and support equipment

The most important cost during maintenance is the spare parts cost which we had talked about in the previous paragraph, besides, we have other costs which may take

less percentage during the process of maintenance but it could be even more costly if we don't make full consideration and estimation for them.

When we finished the maintenance we should probably run the equipment and have a test, to verify the result of the maintenance. So the test is a necessary step. When perform the tests, some testing device would be probably used to help with us to detect whether it is running in good order.

Such as when we have fixed a lateral bird which used to keep steering of the streamer we would probably test it with the PDA. And normally a PDA is not so expensive but as we worked in a rough environment. The device would not always work in a 'green house'. It may be used in a workboat, back deck where water resistance capacity is quite necessary. The software from the ION GEO service company, is not the same as the software installed on the computer, and another license is needed. So this would cost another big sum of money. Normally we could by the PDA and its accessories at the price of 399 hundred US dollars while the maintenance cost (used for spare parts like batteries, transmit cables, and transducers etc.) also accumulates large amount of money.

According to the statistic on vessel HYSY720, test and other support devices take about 5 percent in the overall maintenance cost Percentage of this part of cost reduces since we spent less on procurement of test device.

3) Maintenance training cost

Training is one of the most important step can take up to 8-10 percentage of the maintenance process at the beginning. A team or a small group of person should be well trained to be qualified for the maintenance if we want to perform the maintenance by ourselves. Those trainings are usually held in other location or in a foreign country due to the equipment are supplied from oversea countries. The supplier could provide the best training on their maintenance. So here followed the costs, the flights' costs, the accommodation costs, the training course costs and so on; however when these professionals are trained, they can be teacher on board, and can take the responsibility to be the teacher to give instruction and guide lines for the maintenance to teach some more qualified personnel, and in our company, carry out

the training in this way. This would save a lot of money even the training costs are contained in the purchase of the equipment contract. Because not all of us are good at English or other foreign languages, so this kind of oversea training is difficult to cover all of the employees.

Take the following as an example, one of the specialized training in France was schedule to be hold every 2 or 4 years, and now this program had been cancelled due to the oil price crisis. Last few years our department spent about 50000 US dollars on a single training for about 20 days every 2 or 4 years, one group consists of 6 personnel usually. So the total costs for the 6 people would be about 0.3 million each time. And there are other departments, and other professions, there used to be a lot of training programs such as in the UK. Norway, and US etc. we could probably spent millions of money on training overseas.

Training makes our employees more qualified and well organized. Training presents a prime opportunity to expand the knowledge base of all employees, though it is expensive. An employee who receives the necessary training is better able to perform her job. She becomes more aware of safety practices and proper procedures for basic tasks. The training may also build the employee's confidence because she has a stronger understanding of the industry and the responsibilities of her job(Hearst Newspapers 2015). This confidence may push her to perform even better and think of new ideas that help her excel. Continuous training also keeps your employees on the cutting edge of industry developments. Employees who are competent and on top of changing industry standards help your company hold a position as a leader and strong competitor within the industry. So in a word, training provides both the company as a whole and the individual employees with benefits that make the cost and time a worthwhile investment(Hearst Newspapers 2015).

Besides the costs we had mentioned in the previous paragraph, there also some other maintenance costs such as Maintenance facilities costs, Transition and handling cost and Technical Data costs. In my opinion, these costs take a less weight than those 3 we had mentioned. Before we carry out the maintenance, we should organize the whole process. The logistic department, may provide help to make arrangement and

after the maintenance and test, there documents and records shall be kept to provide necessary information in case of needed later.. And if the equipment is not maintenance in the worksite but in the plant or some other workshops, the equipment after maintenance should be transported to the work sites. And this would take extra transportation costs, the truck and the high way fee which is relatively expensive in China, etc.

Conclusion

Maintenance is a quite expensive activity, but it is critical and well worth the money to strengthen efficiency and lower downtime. When we perform the protective maintenance or corrective maintenance with our spare part available, we could save a lot of time. but if we don’t have the protective maintenance we could cause more down time when production. Down time costs money, so perform proper maintenance to avoid downtime and be more efficient in the survey jobs.

When perform maintenance, we should spend a bid sum of money on the spare part logistic, when optimize the logistic of the spare part inventory, we should consider the protect level, the lead time of the spare part, the probability of the corrective maintenance performance, and other factors to minimize the spare part quantity and there costs. When the maintenance carried out, we should consider about the training of the employees and the test cost of the maintenance. These would add to our maintenance expense also.

In one word, maintenance costs, but it worth the money!

3 Investment analyses and decision making

The oil price is lower than before,we are expecting to get some contracts from the external market that outside of China, different from the usual case that we are full of project all the year round in previous years. Since the oil price becoming lower, the clients don't want to spend money on exploration, and some are waiting for the high oil price to restart the exploration projects. And most of the service companies are struggling to get contracts by lower their bid price and packed more extra service free of charge, and some are even considering serving the most advanced technology to persuade the clients to hire them. So here comes the question whether it is worthwhile to spend a bid sum of money to build new vessels or purchase new technologies? We should consider more details when we make decision on investment. We should consider how the national market will be in the following years, different scenarios may give different investment strategies; the discount rate should be considered as well. And the probability of the market will be, it will be great, moderate or awaful would probabaly affect the decision making.

Here due to the clients are pickier than before since most of the service companies are looking forward to get a contract from them. To fulfill the companies needs and get contracts, we are planning to purchase a set of new equipment and carry out wide Azimuthal seismic acquisition s which would be very expensive than the traditional 3D seismic and more equipment and vessels will be engaged in. There's market needs and we need to spend money on the equipment.

How to make decision on this scenario, we are not sure about the decision making, so we consult with some agent on this issue. The consultant suggests us that if we want to make the purchase, we'd better carry out a test to know the need of the market of this kind of wide azimuthal seismic acquisition. However, the test would cost us about 2 million dollars. And the total cost for the equipment and vessels to fulfil the wide azimuth 3D seismic is about 70 million dollars, and it would give a predict return of about 6000 square kilometers from the moment we promote the wide azimuth seismic. And if the market is not as well as we thought, it may give a predict production of

about 3000 square kilometers. And if the market turns out to be very bad, we could only perform about 900 square kilometers. And normally the unit margin of one square kilometer is about 0.02million dollars. And we also get the historical date from the consult company that the prior probability-- $P(A_i)$of the market will be great would be 45%, and the probability for the moderate market is about 25%, and the probability of the market will be awful is about 30%. And also we get the likelihood-- $P(B|A_i)$ of the accuracy of the prediction they made of the consult company in the history.

Likelihoods of test market results (alongside), given national market results (along top) from historical data as the following:

	Great	Moderate	Awful
Great	0.6	0.25	0.05
Moderate	0.3	0.6	0.58
Awful	0.10	0.15	0.37

To solve the problem we need the assistance of the decision tree(Winston and Albright 2011). With the decision tree, we could probably get the best NPV (Reilly and Brown 2011)and then finally find the solution of this problem.

Before we make the decision tree, we need to calculate some data we need. Such as the Unconditional probabilities--P(B)of test market results, and the Posterior probabilities--$P(A_i|B)$ of national mkt results on the given test mkt results. With these two values we could probably carry out the decision tree and make our choice.

According to the Bayes' law:

$$P(A_i|B) = \frac{P(A_i)P(B|A_i)}{P(B)}$$(Walpole, Myers et al. 1993)(Equation 3.1)

Where:

-$P(A_i)$ –> Prior probability of event A_i

-$P(A_i|B)$ –> Posterior probability of event Ai given information (event) B

-$P(B|A_i)$ –>Likehood, Probability of observing information/event B given A_i

-$P(B)$–> the unconditional probability of observing the new information

And according to $P(B)=\sum_1^i P(A_i)\ P(B|A_i)$(DeGroot, Schervish et al. 1986)

We get the unconditional probability of the testing market will be:

Great	0.3475
Moderate	0.459
Awful	0.1935

After we put these unconditional probabilities into the formula 1,a series of posterior probabilities can be listed as following:

	Great	Moderate	Awful
Great	0.7770	0.1799	0.0432
Moderate	0.2941	0.3268	0.3791
Awful	0.2326	0.1938	0.5736

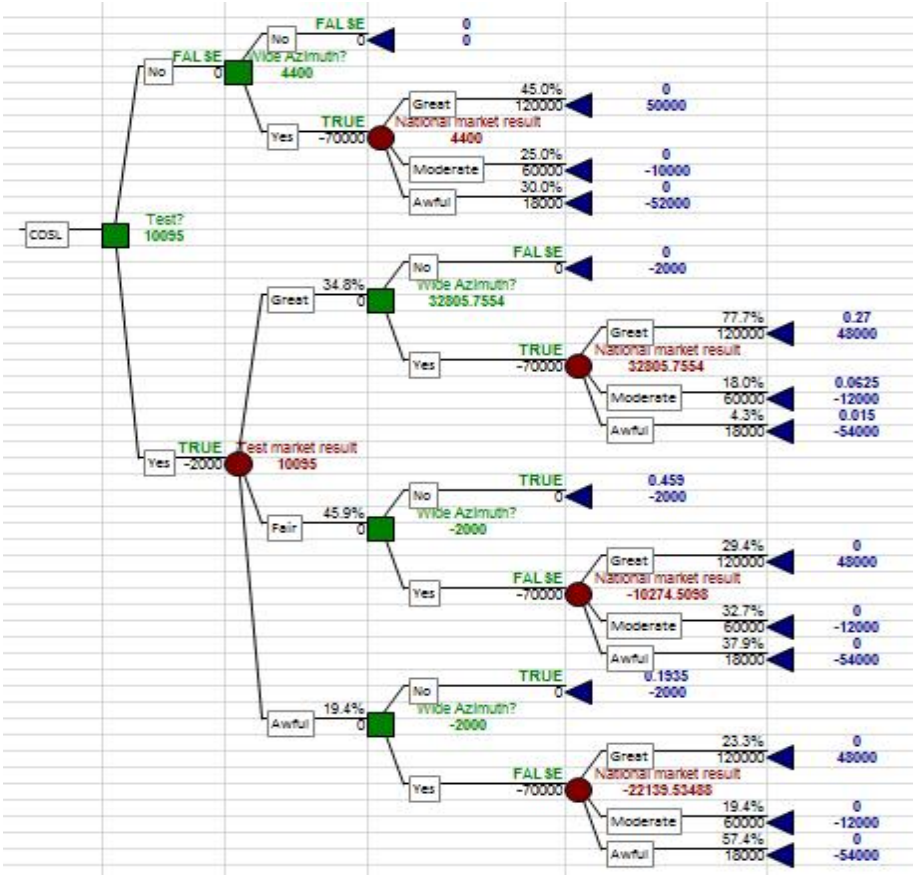

Figure 11Decision tree calculated with excel

With these data, we can get the decision tree from excel shown as the Figure 11. And we can see that the biggest NPV without the test that the consult company will carry

out, is about 50000 thousand US dollars. And the same way we can find the best choice for the other options if we carry out the test. So it means if the international market is quite good and we could probably carry out 6000 square kilometers we would probably purchase the equipment or vessels to perform the wide azimuth 3D seismic survey, and we could get the net present value at 5000 thousand US dollars. In other scenarios, if the market is not good, even we could get 3000 square kilometers we would loss some money that's the negative NPV value.

Further, we can calculate the EVSI and EVPI(Albright, Winston et al. 2010) :

Expected Value of Sample Information:

- EVSI = (EMV when sample information is free) – (EMV with no sample information)(Albright, Winston et al. 2010)

Expected Value of Perfect Information (EVPI)

- EVPI = EMV when information is free and perfect – EMV with no sample information(Albright, Winston et al. 2010)

With this formula we can get the EVSI**($1000s)**:

EMV with free Sample Information 12095

EMV with no information 4400

EVSI= 12095-4400 = 7695

And the EVPI calculation:

EMV with free Perfect Information 22500

EMV with no information 4400

EVPI=22500-4400= 18100

So the test is quite worthwhile. We should do the consult to get the useful information we need. And then make further choice according to the decision tree we had made.

This decision tree is calculated by excel automatically, and with this it is easy to find the biggest NPV which is the best choice for us. Alternatively we could do this decision tree by our own hand, and do the calculations all by hand ourselves. Also we can analysis the other factors that affect the decision making. Such as the Sensitivity Analysis that how the options would be changed if one of the value had been changed.

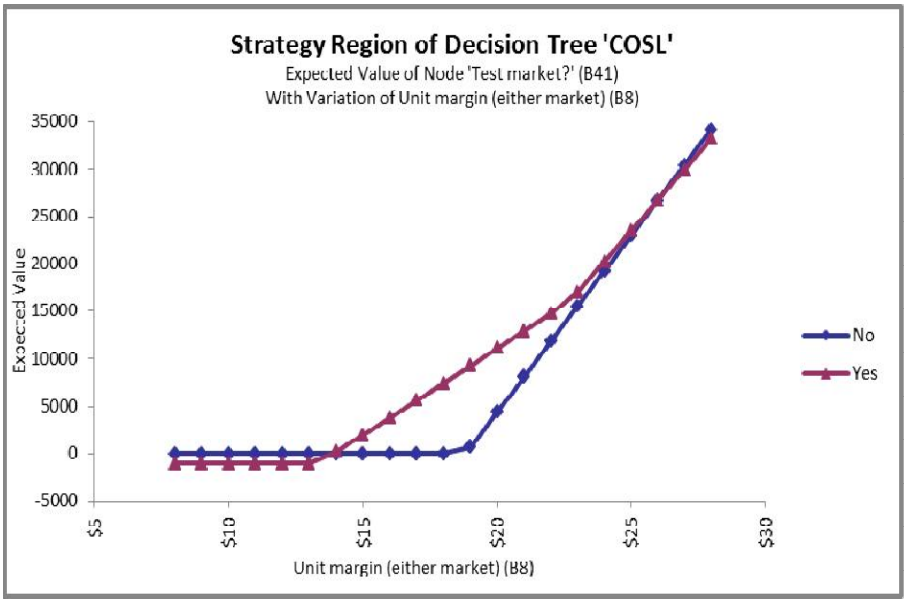

Figure 12Sensitivity analyses with the changing of unit margin

If the profit margin is less than 14000 US dollars per square kilo meters or the profit margin is larger than 27000 US dollars, we could probably choose not to make the purchase to carry out the wide azimuth seismic survey. As well we can make other analyses to see how these elements affect with the decision making.

All in all, to make decision is quite important to consider all the important factors, and proper investment analyses shall be done to make sure the investment is a good purchase. But some companies especially in China, they don't usually do this analysis, the decision usually made by some meeting discussion, and they talked about the feasibility of the investment based on some paper work and finally come to a decision. This would be bad decisions for most of the time.

In adverse situation we could loss the money we had invested, on the other hand, if we have dong proper analyses, even we didn't invest at all after the analyze due to the prospect is not so good according to the calculation. We would save a big sum of money, more than the money we had spent on the analysis. To this point, this is another efficient way in investment rather than spent few year on research and produce or build new vessels but only be proved to be a failure.

4 Environment

The environment is one of the most important factors that affect the cost and efficiency of the 3D seismic survey vessels. As we all know, seismic survey on land can be strictly affected by the topography due to the fact that we have to distribute the hydrophones according to the line which had been designed around the area we want, but if rivers, lakes even villages or some other topography that is really difficult for the workers to distribute the hydrophones when the way is blocked, we had to spend more times to bypass the block. Sometime the team has to spend one or two days to bypass the lake. Not the same with working on land, as the vessel has to sailing continuously in the sea since it had start the seismic survey, so it is easy to be affected by a series of complex factors such as the wind/typhoon, sea current, passing vessels, fishing activity, some specific sea creatures and also affected by the latitude position of the survey area etc.

4.1Wind or typhoon

Wind or typhoon can be the most important factors that affect the efficiency of the working vessel. The wave height is in proportion to the wind speed, and the vessel is more easily to be subject to the wave height. Since wave height can cause seriously roll and pitch to the vessel, in the case of wind speed is more than 14m/s, it means the wind grade is higher than 7, if we are on the deck stand towards the wind, we have the feeling that the wind is really strong and is bad to continue the job. This time, the wave height may be higher than 4 meters, in this situation the sea surface is very rough, there will be seriously rolling or pitch according to the vessel direction and the wave direction. In this condition we may think it is not so good for the seismic job, even we can not stand that uncomfortable caused by the rolling or pitch. There will be strong swell noise in the acquisition data; and this noise is not so easy to be get rid of and may cause more time and cost to get rid of this noise. So under this condition, most clients may don’t want to continue the seismic survey any more, they would better wait for the good weather. And there is a correspondence relationship between

the wind speed and the wave height which we can see from the form below (Xuekun 2011)

The swell noise is caused by the turbulence of the streamers due to the balance of the streamer is hard to maintain when the swell is high. Normally the streamer can keep at the depth we want, but if some specific position is a little heavy or light, when meet big swell, it may goes up and down due to the swell force to the depth controller which is not stable under the condition.

And we have some profiles that the big noise caused by the swell. This kind of data may be discarded later, so we have to reshoot the line if the clients don't want the noisy data. But if the clients think that they can handle the noise and the noise doesn't affect the material and they can use it to find the potential reservoir as well they may keep the data, but it is really rare to see so.

Table 2Wind speed, wave height and sea state

Wind speed, wave height and sea state table									
Wind scale	1	2	3	4	5	6	7	8	9
Wind speed (m/s)	1	2-3.3	3.4-5.4	5.5-7.9	8-10.7	10.8-13.8	13.9-17.1	17.2-20.7	20.8-24.4
Swell height (m)	0.1	0.2-0.5	0.6-1.0	1.0-1.5	2.0-2.5	3-4.0	4.0-5.0	5.5-7.5	7.0-10
Sea state	Calm-rippled	Smooth-wavelet	slight	moderate	rough	Very rough	High	Very high	Very high++

Source:(Xuekun 2011)

4.2 Typhoon

A typhoon is a kind of mature tropical cyclone that develops in the western part of the North Pacific Ocean between 180° and 100°E. This region is referred to as the Northwestern Pacific Basin,(AOML 2014) and is the most active tropical cyclone basin on Earth, accounting for almost one-third of the world's annual tropical

cyclones(Xuekun 2011). And according to NOAA There are seven tropical cyclone "basins" where storms occur on a regular basis(AOML 2014).

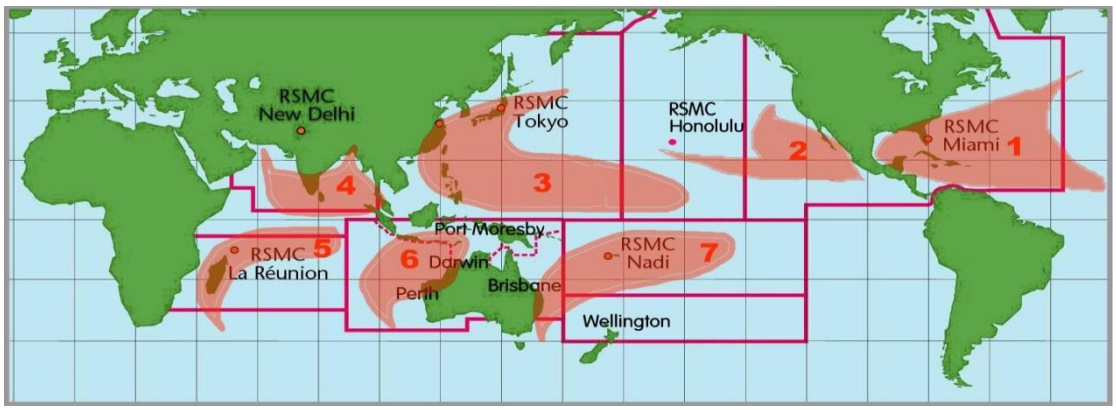

Figure 13 Tropical cyclone "basins"

Source:(AOML 2014)

Unfortunately, South China Sea is covered by the Northwest Pacific basin—area No.3 in the picture , so every year there are typhoons all around the year; however, the cold air in winter take the responsibility of the whole south china sea state, so normally in the winter and spring there are rare tropical storms or typhoons. But the cold weather can also cause serious rough bad weather. And now we main discuss the effects of the typhoons.

According to the data from China Government Typhoon forecast, I made a statistician of the previous years' typhoons that pass through the South China Sea and affect our production areas. We can see the picture below:

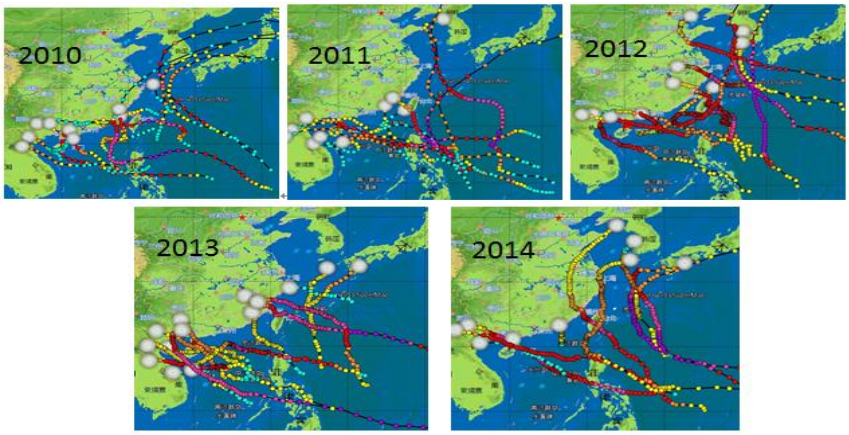

Figure 14History Typhoon pass from 2010 to 2014

Source:(HaiNan province 2013)

According to the statistic, there are 13 typhoons in 2010, 27 in 2011, 25 in 2012, 31 in

2013, 23 in 2014; however, from the picture we can see that only in 2014, there are fewer typhoons pass through the working area than the others. The number of typhoons is more or less the same, but the routines of the typhoons are unpredictable, so the numbers of typhoons that affect the working area are not exactly the same. When I look up the production statistics in 2014, the production time is much higher than the others. The time distribution of the typhoons is mainly from May to November. And typhoons in May and November are relatively fewer. We can get the number from the chart below. In 2011 and 2013 there are only 3 typhoons in May and November.

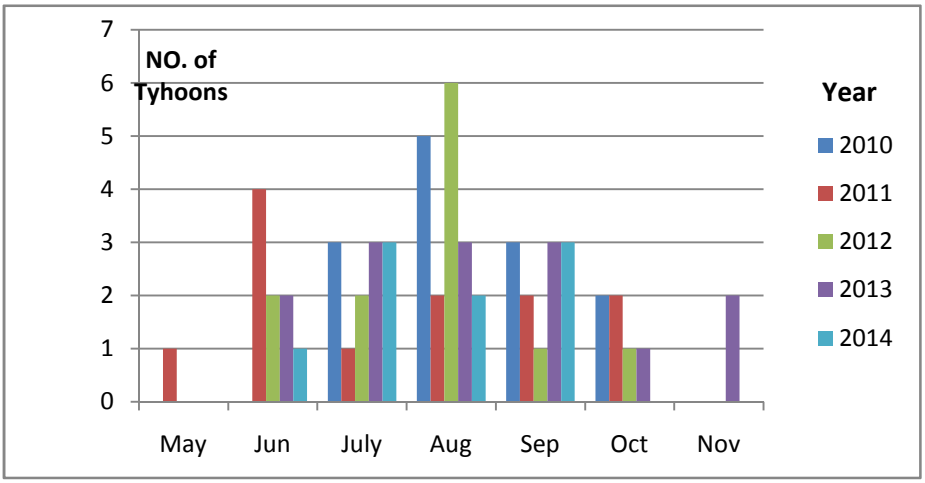

Figure 15 The statistics of Typhoons 2010-2014

In August 2012 and 2010 there are 6 and 5 typhoons, as less as to 2 typhoons. If 6 typhoons in a month, how could we get to work? Actually the date that the typhoon hit our working area in August 2012 is on 2nd Aug, 3rd Aug ,8th Aug, 8.17th Aug ,25th Aug 27th Aug.

From the production statistic in Aug 2012, we fortunately have only 2 gaps, that is from 15th—17th, and the other is from 23th—26th. We have lost about one week time.

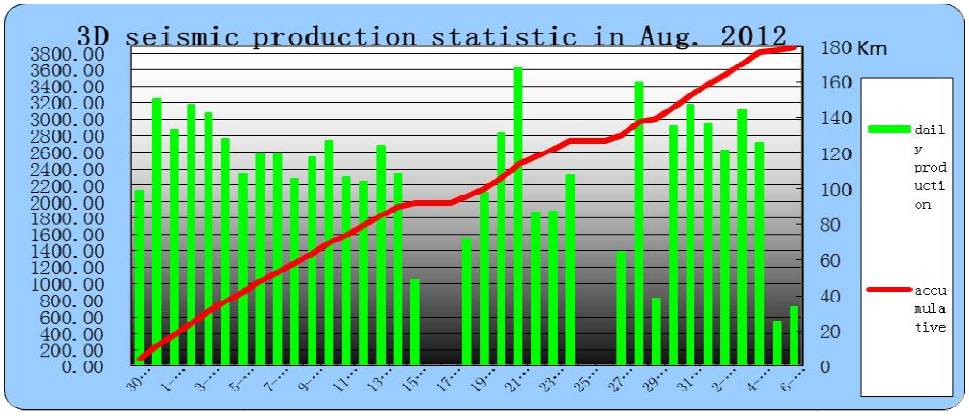

Figure 16 3D seismic production statistics

I looked up the daily report that month, it said that, the vessel was in the typhoon affect range and the vessel managed to get rid of the typhoon with towing 12 streamers by sailing away when the typhoon is quite far way, and go to the direction that beyond the effect of the typhoon. At that year, the vessel managed to avoid the typhoon affection, and with the least time consuming way. And finally with this method, the most economical way to minimize the effects of typhoon, HYSY720 managed to sailing 7028 Km and it is equals to 4217 Km^2 in August, and only lose 6 days and a half production day. And if without the typhoon, they could do more production than this, it would be 840Km more and that would be 504 Km^2. As the world wide price that moment for 3D seismic acquisition, the price is about 10 thousand dollar per square kilometers. So due to the coming of the two typhoons, we have lost about 5million dollars. If we just retrieve the streamers back and go to have a port call, we may spend 2 days on retrieve the underwater equipment and 2 days on deploying the streamers and guns, and 2 days on the way to the port or to the survey area. so we can imagine that the time consuming would be huge and we would lost more money, that's only for one typhoon, if one more, we would lost more than 14 days I think. Since we always have typhoons all the year round we have worked out some strategies to minimize the effects of the typhoons. Even we are exposed to the high risk of meet the typhoons.

And now, gradually, with the strictly forbid of get rid of the typhoon with towing streamers; considering the high risks that we could met fishing net on our way.

Sailing to unfamiliar area, with unknown weather situations, the risks would be much higher as we learned from the risk assessment course. To put ourselves to an unknown situation that we could met difficulties everywhere, so now we are not allowed to do so. That means if typhoon coming we may lost at least 5million RMB, and another coming, then another 500million RMB.

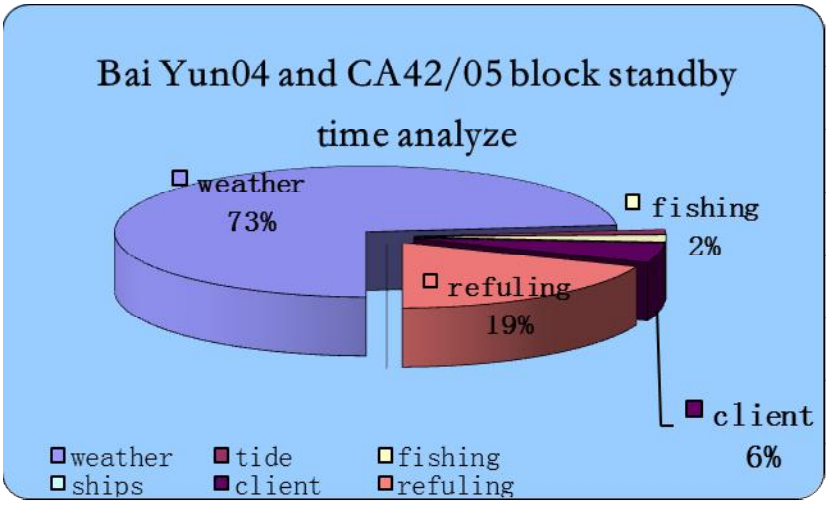

Figure 17 Standby analyze in a block in South China sea

As the time efficiency analyzes from that survey area, the production time is about 2218 hours and the standby time is about 823 hours, which take 26% of the overall standby time. The weather takes 600 hours since the whole project started on 28th April to 6th September. And during this period, most of the typhoons are coming and going. Considering that a production day would give production of at least 3million RMB and 25 days would loss 0.75 billion and this is only the typhoon.

4.3 Sea current

There are many types of sea currents, but the most common that we meet are the surface current and the tide current. Surface currents are usually found on the surface of the ocean, they are usually driven by large scale wind currents. Because they are directly affected by the wind, the Coriolis effect plays a role in their behaviors(Administration 2013). While the Tidal currents occur in conjunction with the rise and fall of the ocean tide, the vertical motion of the tides near the shore causes the water to move horizontally, creating currents, then tide currents

appears(Administration 2013)

When these currents act with our towing steamers under water, our streamers would not perform as they used to be. They used to keep at a certain depth with the help of the depth controller that we normally called compass bird. But when these currents appear, the depth controller cannot keep the streamer at the specific depth as we want. The streamer may be sinking down to 50 to 60 meters, in this situation, most of the equipment we equipped on the streamer cannot work anymore, even the streamers themselves are stopped acquiring data. And this depth is really harmful for our equipment; normally we would lose positioning data from the streamers, so we are blind to the streamers. This means the streamers are beyond the control of us during this period. This period would last from 1 to 3 hours; it depends on how fast we pass through the currents.

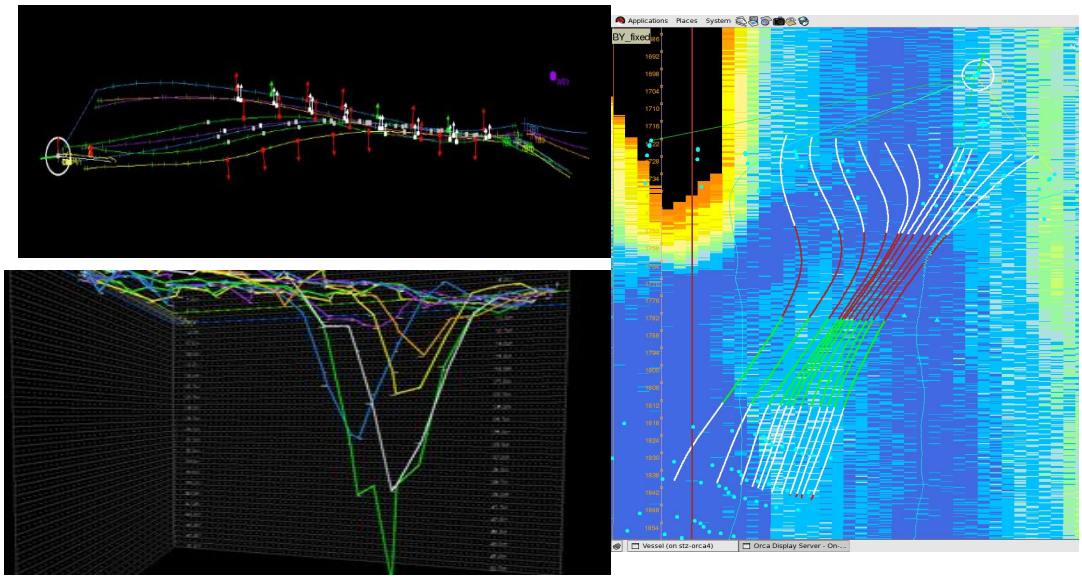

Figure 18The strong current affects the streamers

According to the record, HYSY720, one of the 12 streamer towing vessels, one of the strongest current it had experienced is the recent one in LiuHua survey area. Tthe streamers sank down to 80 meters and 28 retrievers were damaged and the vessel couldn't keep its designed routine. The vessel was blow away by the strong current. it was away from the line, so we had to stop shooting due to the vessel can't manage the position and also because the streamers are as depth as 80 meters. It takes us about 5 more hours to recover and start shooting again. As to the retrievers, the total cost is

about 0.1 million dollars. And the 5 hours cost us about 20 million dollars. Unfortunately, due to the location of the working area, the water depth range from 400 meters to 1500 meters, it has so big range of change at depth at about 20 kilometers distance, it always have currents all the day. Right now, they are at the end of the project, the down time caused by the current can make up to 41.9 hours as the party chief of HYSY 720 said.

In the previous picture(Figure 18), the streamers sink to 80 meters due to de current, it takes hours' time for them to retrieve to the normal depth, during this period of time, we can only speed up to get rid of the current area as soon as possible. But once the streamer depth are more than 50 meters, the retriever which used to surface the streamers when the streamer was broken, act as a balloon to keep the broken streamer float at the sea surface to avoid the damage of the streamers caused by the high water pressure. If the streamers sink to more than 100 meters or more, the retriever will be activated. This would cause big trouble to us, we have to handle the activated retrievers before we restart shooting. We have to launch the workboat to cut the balloons one by one. But if the weather is not allowed, we can only wait for the good weather or just pick up the streamers to handle this.

4.4 Sea creatures

Here we will only discuss the sea creatures that affect the efficiency of the seismic vessel such as the barnacle and some sea mammals like dolphin or whales. And we will talk more about the barnacle. Because in South China sea, Barnacles usually cause more problem than the whales do.

In the history there are a lot of battles happened in the sea, one of them was a major naval battle fought between Russia and Japan--the battle of Tsushima(wikipedia). Finally Japanese won the battle with little cost, and this battle is one of the most well-known cases which is the one defeat (enemy troops) with a force inferior in number, and the history teacher told us that, one reason lead the powerful navy force to the collapse is that more than 6 month longer sailing trip for the Russia navy. Most

of the navy ships' hulls are covered with thick barnacles which lose the speed and the flexibility of the vessel, and when Russia navy ships went through the Tsushima strait in very low speed, most of the Russia navy ships are destroyed by the Japanese gun fires.

Figure 19Thebarnacles on the streamer

The effect of the barnacles is so extraordinary in the history, and it is the same with today, even we had make big progress in all the field, but we don't have any technology to avoid barnacles stick to our vessel and in water equipment.

In south china in the water is quite warm all the year especially in the summer, the temperature is quite suit for the breed the of barnacles. After the streamers had been deployed for about 1 week or more, there will be thick barnacles stick on the surface of the streamers. Normally the streamer is 6-8 kilometers and a vessel usually towing 6-12 streamers. the whole under water system are covered by barnacles, this will increase the resistance force and decrease the vessel speed since the its limited towing power force. This resistance force increase the tension on the streamer, sometime it could cause the breakdown of the streamer. According to the statistic on board, normally the cable tension is about 1200-1400DaN (1.2-1.4 Tons) when new deployed, and weeks later, the tension would be 1500DaN, and later it comes to 2000, then 2500, and finally break down or just retrieve the streamers to kill the barnacles.

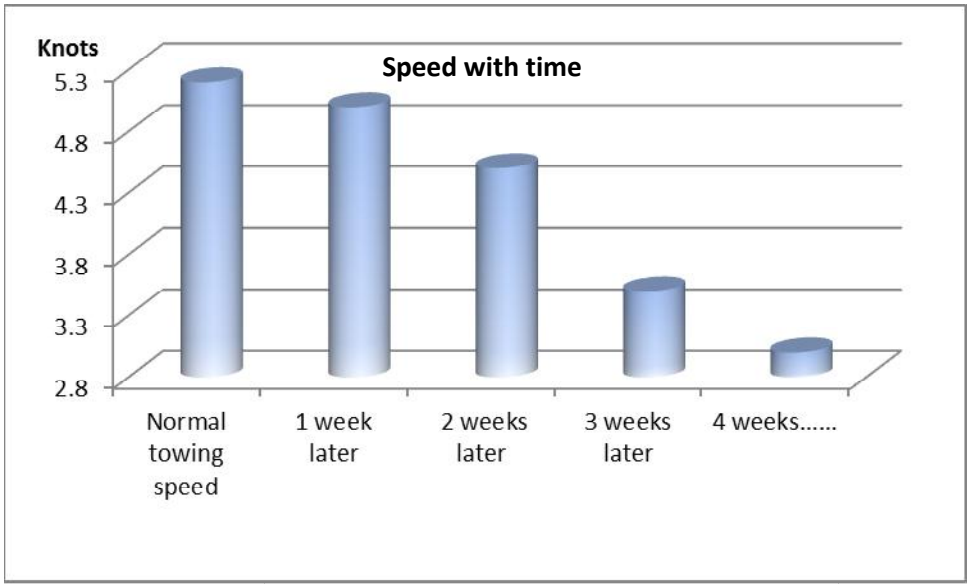

Figure 20 Vessel speed with duration

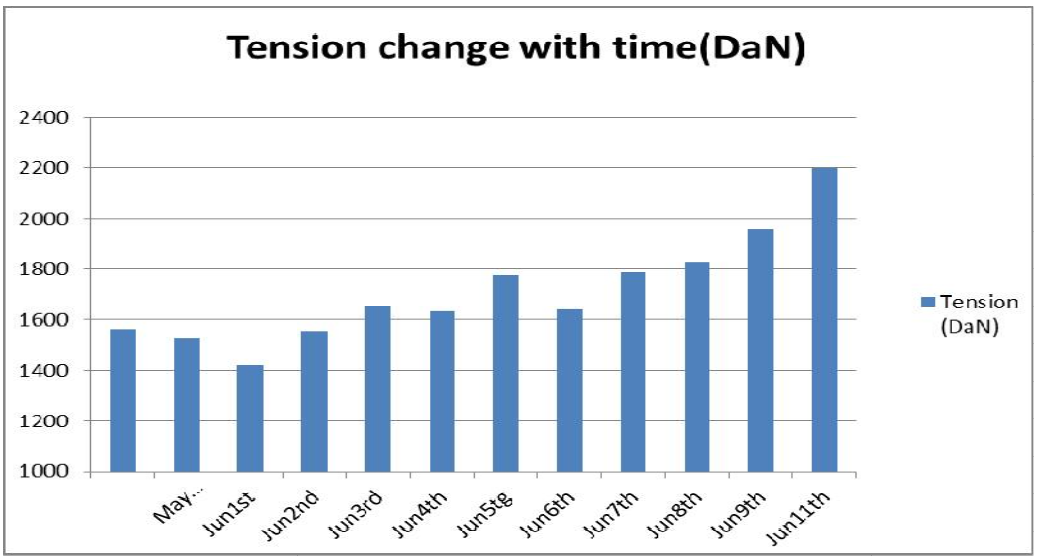

Figure 21 Streamer tension with duration

And the vessel speed lower to as high as about 3.0 knots. We have lost most of the speed and only have the basic speed to maintain the depth of the streamers, if the speed continues to lose; we couldn't keep the balance of the streamers that would cause more unexpected problems. The sample rate of the tension acquisition is about 1 second per streamer, so in a day time there supposed to be a huge number of data available. So it is invisible if we use the daily date to produce a daily tension chart and make a 12 days curve into a single chart. So here we just take the average value of each day, and we say that the average value is gradually increase. But with this method, there is a shortage that, if one day we had done some test with the acquisition

system or some trouble shooting, during that time we don't have tension data, and that would lose some data, and the average data may be a little variant from the others such as the date on Jun 5th. And more worse is that, if we retrieve cables due to the underwater equipment problems, we would never have tension data that day such as the Jun 10th.

Generally, the barnacles breed quickly in South China sea during later March to September or October. If we don't clean them for a week time, since we have 12 streamers towing in water, we would don't have time to clean each streamer. We can only launch the workboat to clean the barnacles on streamers from tail to head with manpower, and these operations can only be carried out in day time and when our vessel is in the process of line change. And according to the rules of COSL for the safety, we should not launch the workboat if the sea state is more than 2 meters unless it is permitted to. That the date we lost in the previous chart on the date Jun 10th is because that we stopped production and cleaning the barnacles all the day, and unfortunately at the end of the day, one of the streamer was broken due to the tension is so big. According to the daily record that day, the streamer 1 was broken at the front part of the streamer. And fortunately our workboat find the broken cable as soon as the protective device were activated, those recovers float the broken streamer, and we towed it to the chase boat due to the workboat can't chase the mother vessel with towing more than 6000 meters cable. And we managed to reconnect the broken streamer within 24 hours.

So from what we had talked about, we know that the barnacles problem is one of the critical problem we should solved if we want to make continuously acquisition. There are some automatic devices running on the cable to perform the task to clean the barnacles. Unfortunately it is proved to be no so efficient when it confront with the depth controller or the acoustic birds equipped on the cables. we had to launch the workboat to clean them with manpower. This would increase the exposure time to risk for our crew. And according to the normally statistics, during later March to September, we usually launch the workboat twice day, and each lasts for about 3 hours. This would increase the exposure time in high risk operation up to 180*2*3

hours. That would be about 1000 hours more than the normal circumstance.

So further more risk assessment should be carried out to minimize the risks we exposed to. And this is for the single vessel, so for the company they should carry out the risk assessment by lower the ICAF. That would be more than

ICAF = expected cost/expected lives saved = 2/0.01 millions = 2 million. That would be a huge number of money if the ICAF calculated is accurate.

4.5 Fishing

Fishing activity is quite heavy in most part of the coast lines. Very large people rely on fishing; some even don't have any property except the fishing boats. The fishing activity is so heavy that the breed speed is a problem, most of the fishes are captured when they are very small can't be trade as food but as the feedstuff. So the government banned fishing from July 1st to September the 16th. Even in this period the fishing activity is heavy as well. The fishing boat was said to capture shrimps and crabs. So there always fishing boats in the survey area all the year round and these fishing boats contribute to the most part of the down time and the equipment failure.

Fishing gears and other debris can cause big trouble for us. If our vessel confront with unknown fishing gears, it could tangled with our streamers and caused the depth controller out of service. And even break the cable in severe circumstance or break the ropes between the streamers. If we know there are fishing gears before out routine we would bypass them, in this case we could loss production, but can avoid equipment destroyed disasters. The fishing boat usually towing fishing net or fishing hook lines in the water, and some of the fishing boat owners just set a direction of the boat and goes to bed and switched the radio off. These boats would probably pass through the streamers since we can't communicate with them, these boats are the most dangerous, and they are the killer for the streamers.

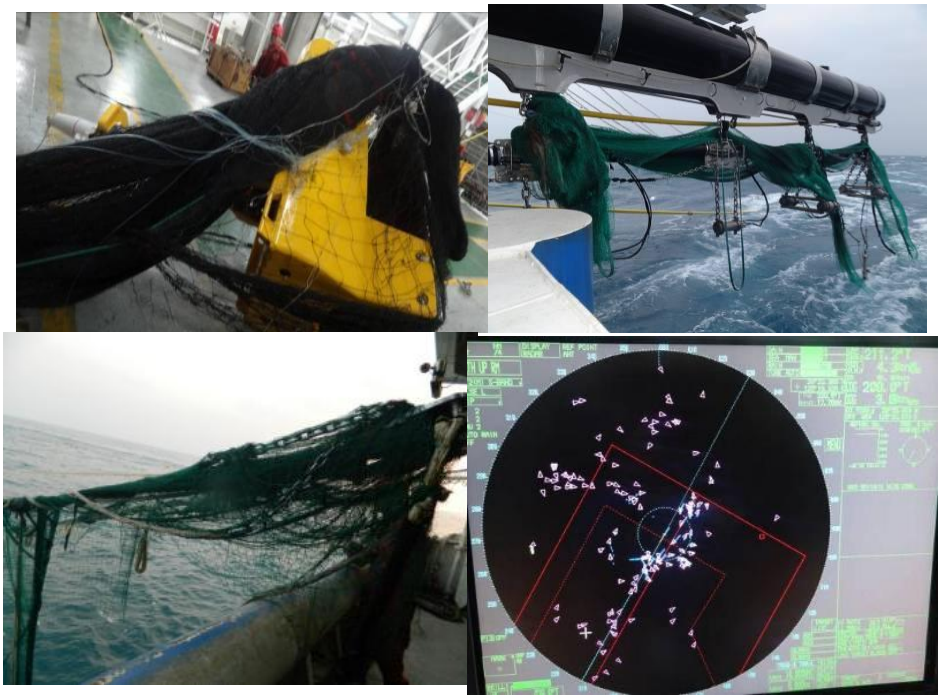

Figure 22 Fishing activities

From these pictures we have shown, the last pictures is the navigation screen for the ship's officers, the bright triangles are the fishing boats and the red rectangle is our survey area, and the blue circle is the position of our mother vessel. We are surrounded by the fishing boats, and our vessel and equipment underwater encounter unexpected danger all the time.

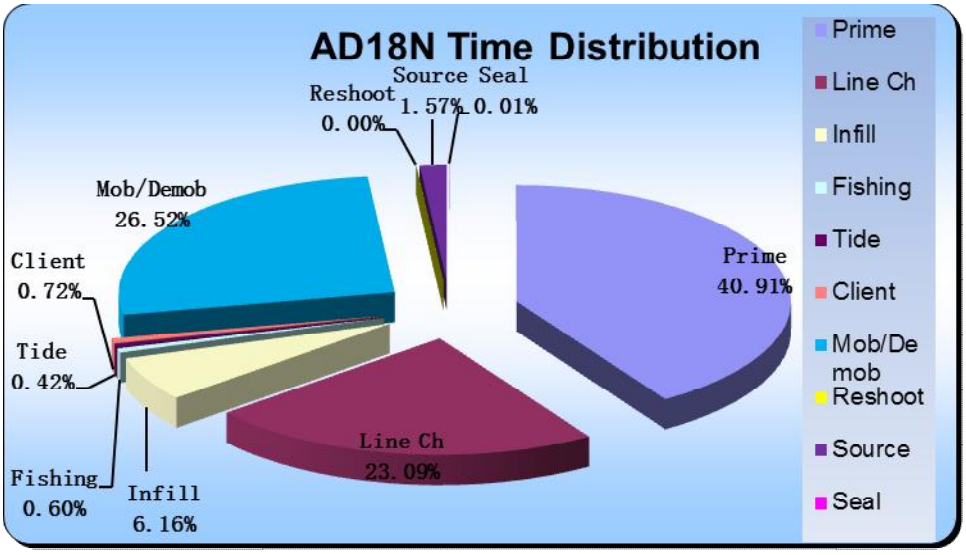

Figure 23 Time distribution in Burma block

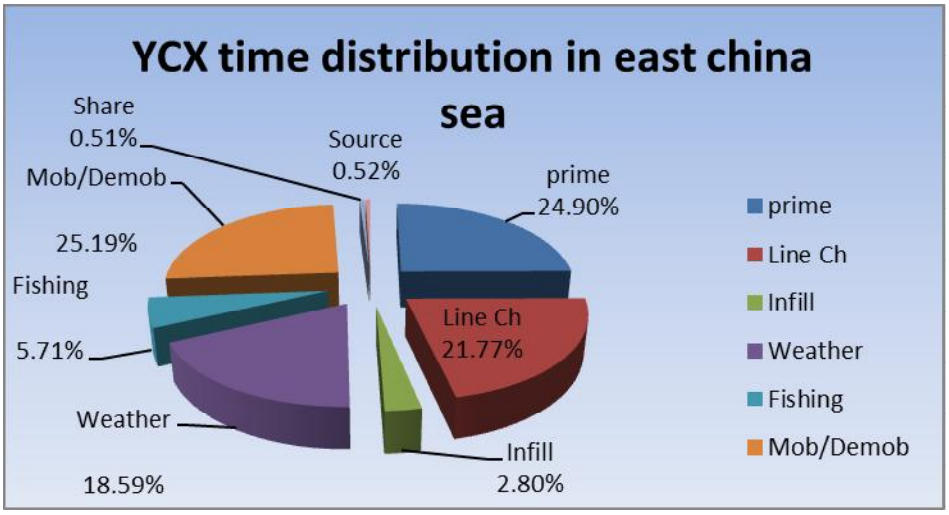

Figure 24 Time distribution in a similar block in China sea

From the time distribution of the similar two prospects we can see that, the first one which is in the Andaman Bay just outside the Myanmar, and that project last from Nov 5th to Dec 26th, about 51 days from the mobilization. And the second chart is the work area in East China Sea from Sep 8th to the Oct 27 and similarly lasts for about 51 days. These two projects are mostly the same just the working location is different. The vessel all have a long time for sailing to the work area. But the difference is quite obviously in fishing activity. As we talked about in the previous paragraph, most of the fishing boats are set out to fishing since the period of banning fishing had over. The fishing activity is very heavy that caused

about 6% of all the production time which is about 65.7 hours in total; and the prospect in the Myanmar only have 0.6% of the fishing activity, which is a fishing boat passing by the surface of our streamers. Due to there was no translator for that prospect, we had difficulty to communicate with the fishing boat, so we had to interrupt the ling and made a line change we dong really wanted. The whole time cost about 7.5 hour to the new line according to the record and the daily report. Actually we don't have many fishing activity problems that prospect area.

We had spent about10 times of the time on dealing with problems that fishing activates caused in the East China Sea prospect area. According to the normally speed and the normal production, we could do 58 hour production but unfortunately due to the fishing we can't, our loss may up to 1million dollars or more. So how to avoid

fishing activity during the acquisition is one of the most important things we should always consider about. If we don't carry out the survey carefully or we just deal with the fishing boats with little careless, we would have big loss on our property—the underwater equipment. I remembered the prospect area YCX which takes us about 51 days is the remained part by Western Geco. The reason they terminated the contract is that they had lost about 13000 meters cable in that area due to failed in dealing with the fishing boats just because they had never challenge with so many fishing boats and communication problems with them. When surrounded by so many deaf fishing boats, what you should do is try all the resource and your best to minimize the potential risk and carry out the production.

Besides those factors that affect the efficiency of the 3D seismic survey in south china sea, other factors also contribute to this, such as the passing by big vessels, they may set their routine and have a small snap in the deep night, we can't get in touch with them, so what we should do is to turn in advance in case of the cargo vessel may cut the streamers; or the passing ships are too close to the cause low efficiency.

Conclusion

In a conclusion, so many factors in the environment that will affect the production, and lead to low efficiency or potential loss of money or property. And some factors make the crew or the vessel exposed to high risks. Further risk assessment measures should be taken to handle this. Some of these factors cannot be get rid of completely, we can minimize the effects through the other factors. Such as the project plan to give full consideration of the potential difficulties and make preparation for them; and the risk identify check list to make all the crew know the potential risks they would probably exposed to and do careful JSA (Haimes 2005)before we carry out the specific jobs.

Also we could compensate the loss or the low efficiency by the other operations in the project. As we learned in the project management, the critical line will contribute to the complete of the project(Gardiner 2005) most, if one ingredient was delayed, we

can also complete the project before the dead line. We could speed up the other elements on the critical line to realize this and optimize the component of the crew. That may regard to the human factors. And we will discuss this in the following paragraphs.

5 Human resource and ergonomics

Human resource management (HRM) is being considered as the most important component in a project and can lead the project to a success or fail or contribute most to the project(Belout 1998).

Human performances during the system operation are believed to be very important in a system operation. As well we can do some measures to optimize the human performance to highlight the efficiency and promote the safety process of the project or system(Chapanis 1996).

5.1 Human performance

Optimizing human performance during operation of complex systems require that suitable strategies and steps are in place to balance-off some critical components. identifying and explaining how we would incorporate those *critical components* and *balance* them to improve the safety and efficiency of a complex work system(Wickens 1992).

The five components must be successfully managed and balanced off in system design, they are personal selection, personal training, machine design, job design, and environmental design. Here we can use the example of our seismic acquisition vessel's working process to illustrate these components in this system. Usually when we carry out date acquisition, we have several processes as we had introduced in Chapter one and according to these processes we have different groups of people working together and finally come to the goal. The jobs or the human we need in a acquisition flow can be categories as instrument, navigation, engine room, the bridge, and the source etc.

5.1.1Personal selection,

Usually with the different function/needs of each process/phase, we choose different people with different background to fulfil the data acquisition needs, such as here we

may choose some one whose back ground is checanical to work in the source process, and geophysics in instrument process, and some pilots on the bridge as well as sailor so on so forth. Here when we begin to design the system, we consider about the needs of different working flow as the principle to choose people to work in the system(Wickens 1992), only with this back ground, these people can adapt to their positions more quickly and easily, so it may be the most efficient way to do so.

Otherwise, you choose a chemical back ground person to work as the mechanic, he may know nothing about the source, it would probably cost more time and energy on training him to be qualified for his position.

5.1.2 Personal training

Since we choose people, we can training them separately. seismic crew such as the man who in charge of the data acquisition should be trained with all the basic geophysics knowledge and practical operations, source engineers should be trained on how to do maintenance on the air guns and the mechanical equipment , and how to keep most of the critical hydraulic equipment running in good order. Also including some instructions guidelines and so on so forth. With this concentrate training for specific purposes, and combined their background, they can be easily go through their trainee period and go smoothly to the qualified duty life. And some other basic knowledge on Healthy,Safety and Environment. Make sure all the employees are aware of their safety and the others and don't do harm to the environment. Such training are very important since they may not realized the problem of how to protect themselves when especially an emergency happening, not to mention to carry out the job or to save the others.

With these basic training at the beginning, when they should go on board to finish their trainee time. During these period they should know the responsibility and authorities in the daily basic operation. They should know when to do this or how to do that with the help of a tutor. When all the orientation month had finished on board, they would probability have a test to verify they are qualified for their position and a certificate will be issued. And further training followed their career with be carried

out to promote the employee' development. And then their company will get benefit soon from this training program.

5.1.3Machine or equipment design for the ergonomics purpose(Kroemer, Kroemer et al. 2001)

Machine or equipment used to carry out tasks by as least manpower as possible, as well most equipment designed are more and more consider about the ergonomics and its efficiency. People work together with the machine would think the most comfortable and efficiency the equipment they used the better. And this would promote the development of the equipment to be more suitable for the job and human and be more artificial intellegence.

As to the machine design, we used to use the specific software or hardware for these different processes, drillers operate the remote control in the control room, and mud engineers use the equipment to test the ingredients in the mud and do analysis with our software in the system, and so the others. We could use the most advanced technology when design the technical system because more advanced the machine is the higher efficiency it would probably be, and pursuit profit and safety is always our goal. So with the qualified person and the advanced new technology, we could complete the same tasks within less time and get more reliability result.

5.1.4 Job design—ergonomics

With qualified person and efficient equipment, we must specified the job, we should let the operator know his responsibilities and working process on several different usual or unusual events, such as what's your responsibility in your daily working hours, and what if an emergency or trouble shooting period. When design the work system, design a job suit for the seisimic process and don't have many paradox with the personal characteristics should be well considered, such an calculate job may need a careful person, and the drilling job may need a man who is very strong. Give specific requirement for the other components, and balance off them, then fulfil the system needs.

Ergonomics can be defined simply as the study of work. More specifically, ergonomics is the science of designing the job to fit the workers, rather than physically forcing the worker's to fit the job. Adapting tasks, work stations, tools, and equipment to fit the worker can help reduce physical stress on a worker's body and eliminate many potentially serious, disabling work related musculoskeletal disorders.(OSHA 2000)

If work tasks and equipment do not include ergonomic principles in their design, workers may have exposure to undue physical stress, strain, and overexertion, including vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting. Recognizing ergonomic risk factors in the workplace is an essential first step in correcting hazards and improving worker protection.

Oil and gas industries increasingly require higher production rates and advances in technology to be more competitive and keep the leader position in business. As a result, jobs today on board can involve the following: Frequently lifting, carrying, and pushing or pulling loads without help from others; other repeatitive operations that requires the worker to perform only one function or movement for a long period of time or day after day; and overtime is more and more often that means work more than 8 hours a day; and have tighter grips when using tools. Those work if the worker work day after day and overtime most of the time, especially if coupled with poor machine design, tool, and workshop design or the improper mananers to use

tools this would create physical stress on workers' bodies, which can lead to injury. they would probabaly get occupation health problem.

So when design the system, design the job to fit the workers and give a comfortable environment for the worker will give benefit to the company its self not only on the higher efficiency of the production but also on the realization of the long run objectives.

5.1.5Environmental design

As to the environmental design, we had to notice that we, human can make unavoidable mistakes and can lead to serious problems, so a good working

environment is quite essential. According to the ergonomics, the workers had to exposed to long hours siting or standing with specifict gestures, just imagine that the environment is noisey or vibrate very much, the workers can get injury physically or psychologically. Then the workers are not willing to work or have complains on the environment, the efficiency would be probabily low; the same, if the environment is considered not safe, the workers may exposed to high risks all the time. And sooner or later, there will be problems may cause catastrophe. the operating room for the drillers may be noisy because it is close to the cranes and whatever, noisy make operators easy to be tired and make mistakes, so a relative quiet operate room is essential; as well for the mud, if the temperature is too high we may get wrong data from the equipment, may be a relative low working place is needed for the mud equipment and so on so forth.

But if all these 5 components working alone, the system can't be efficient and safely, only when these five components interaction with each other and combined together and form the system we desired, can we be more efficiently and safely. these components are quite interdependent with the others, such as when we training people, it is affected by the person we chosen, and job design is affect by the person we chose and the technology we use as well as the training he accepted. They interact with each other and one can promote the others if it is strong or well done, on the contrary, it may becoming the lowest board in the bucket. So we should balance all of these components , and consider them with a top view to get a general structure and position of each. To strengthen the weak ones and male the strong one more reliable is a good suggestion. With all the above and other subsidiaries when carry out the working system, it will be more efficiently and safely.

5.2 Human operations

Here human operations mainly regard to the operations that will affect the seismic project and the strategies can save time or minimize the effects caused by the other factors. As we know, project is a series of unique coordinated activities with a definite

starting and finishing point, carried out by an organization or individual to meet specific objectives within defined schedule, cost and performance parameters(Gardiner 2005). According to the definition, the seismic acquisition processes have many serial activities and those activities undertaken by an organization, the objective is to get data we wanted.We have to start it in defined time and have to finish it before the deadline, the resource is limitted. we would probabily treat the seismic acquisition as a project..

So project management would be a critical factor on the executive of the project. Here we may discuss how the project management contibute to the costs and efficiency of the seismic operation.

5.2.1 Project management

Project management consists of several elements, those elements undertaken one after another and the former elements would affect the others who are following behind; if the former one is ill defined or had made modifications then the start point of the others would be delayed and then the whole time of the project will be delayed. If the project manager want to complete the project on time, then he should spent more money to promote the other elements to be completed in advance of the schedule. There's a time cost and scope triangle, since you want to change the time, then you should make appropriate change on the money and scope. No one wants to spend extra money if not necessary. So how to be more efficient and be more energy saving is always the goal for all of the companies.

5.2.1.1Planning

As it is said that every project needs a plan to explain how the project will be proceeded, and the participants need to know the goal, the steps to achieve it, the order of these steps and when these steps should be completed(Gardiner 2005). All these should be defined in the project planning stage. A good plan could give a big success while a poor plan may be the root cause of the failure of a project.

To make a good plan, the following steps are usually fully considered in seismic data

acquisition.

1) Objective

The objective of a seismic prospect is mainly focused on the contracted data acquisition work and the HSE of the workers involved, as well as the benefits for the stakeholders and the other relative parties. To realize this objective the contractor need to make all their endeavor on the seismic job and the HSE. For us, usually, we need to do some following steps.

- The scope of work

We need to know the context of the work such as the location of the prospect area and the climate, the social interactions and others.

--Timing, we need to know the duration of the prospect, such as, when should the project be completed, if we worked at arctic region, when the project should be started and when will be finished or else the sea water will be frozen that would cause big loss to us. As well the applicable laws in the area we will start the project should be identified at this stage. What should we do, and what we can't do according to the local regulations and law. Such as worked in South China Sea is quite different from working in the Norwegian sea or other countries.

--Logistics and others, the logistics is a critical part for seismic survey especially when we work at a foreign sea. To provide sufficient fuel and food as well as spare parts should be guaranteed.

2) Risk assessment

First we should take the responsibility of identify all the potential hazards that would probably do harm to the projects and the crew. The concentration of this phase is to evaluate the likelihood and the potential adverse consequence of an incident. When doing risk assessment we usually consider the crew that the human force involved the work, the environment, assets and the reputation of us and the clients.

And the level of risk may be indicate the effort and time we should spent later to make sure that the procedures are in place to reduce the risk level to as low as reasonably practicable. And if we work in a completely unknown area for us, we should identify the unknowns for us. The known to others but unknown to us may be

the bid barrier for us, in this situation lateral communication and learning would be the most efficient way.

As well, some traditional daily operations, such as deploy streamers or paravanes, the risk level are acceptable, we still need to carry out job safety analysis to make sure all involved the job are aware of the risks.

5.2.1.2 Organising

It is stated that organizing is the process of arranging the people, material and other resources to meet the project's communication, integration and decision making needs. With this properly done we could deliver the achievements on time.

- Mobilization

To mobilization the people and the equipment, and review the HSE plan and make sure that had set up a method of operation according to the HSE plan. And we should clear the responsibility in the HSE plan in case of an emergency, how the procedure will be activated, etc.

When last time we make mobilization to Andaman Bay, we confirm the parameters and the configuration of the data acquisition system, and make adjustment to the system to suit for the prospect. And we make full communication with the clients to make sure the project HSE plan are fully agreed and the responsibility of each are well understood. And it is mostly the same with the other mobilizations, but the others are not as formal as this one.

- Executive the plan

We had good plan already and well organized, as well as identified inherent risks. With the fully preparation we can execution the plan step by step. First, to carry out the scouting of the prospect, we need to know the potential obstacles in the area, such as the sink ship, platforms, and other facilities laid before, fishing activities etc.. This would be done soon, and reduce risks of the streamers been destroyed.

Second, carry out the shooting plan according to the design. Before, we had made a shooting plan according to the boundary of the prospect and had fulfilled the requirements of the clients. Take one of the designs as an example which is block for

Shell Company. According to the software, we could know the line change time and the shooting time for each line on the given shooting speed. If all the whole plan can be executed fully, it would be the most cost efficient strategy for the block. But since the design is an ideal plan, we can only get as closer as we can. However, since it doesn't make full consideration of the tide, the currents and the down time, there would probably other better solutions for the shooting.

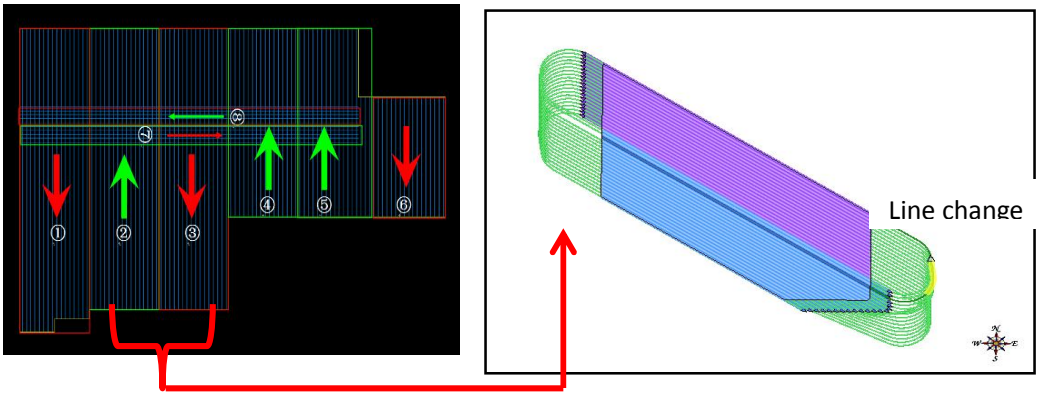

Figure 25An ideal shooting plan

5.2.1.3 Controlling

Usually in a project management we mean, the measures we take to make sure the project is managed as the former planning documents, and all the attempts at organizing become a reality. Since we may meet unexpected events, such as the typhoon in South China Sea, that would probably disturb our short term working plan, especially the tide may be quite different when the typhoon had passed. We had to figure out which line is the best to shoot to match the bin graphic. And this would delay our schedule; probably the project will be delayed. So we normally do other remedial measures to make sure the delay is controlled to a low level.

Such as refuelling at sea with towing is a traditional way to save time and energy which would save money and time. It will help us most if we are delayed due to some reason. As we had mentioned before, when should spend more than 30 hours on retrieving the streamers and more than 30 hours sailing to the port to get refuelling and supplies, 30 hours sailing back and 30 more to deploy the streamers this would

add up to more than 5 days. This kind of refuelling is the most party chiefs reluctant to see. However, if we consider the alternative option, bunking at sea with towing, this option is normally considered to be more risky than fuelling at port. Bunking at sea need well organized and proper operation for the captains and the officers on the two ships. There are a lot of constrains and limitations, one small mistake may lead to adverse consequence, so only when the sea state is quite good shall we consider this option.

Figure 26Bunking at sea

For other operations that could minimum the time cost may refer to the down time control measures. We had many kinds of measure to shrink the time that could affect the critical line of the project. With the development of the internet and more application of advanced technologies, we could diagnose problems of the equipment more efficiently and solve the problem with as little time as we could. The using of remote medical aid promotes the application of the remote assistance in all the fields. If we had met some difficulties we had never met before onboard, we could communicate with the online experts far from here, they would give us timely assistance and can shorten the downtime, minimum the downtime costs. Last time when we pay a visit to Shell Company, they even have time to time video from the drilling site on the platform. This would reduce the potential incidents and make the drilling process be more efficient. To be honest, we are not as advanced as Shell at this point, and we are working on it now, at least our remote assistant system had managed to help us out in many situations.

5.2.1.4 Leading and motivating

Leadership and team-building skills are critical to successful project managementand hinge on having a sound knowledge and unserstanding of the human.(Gardiner 2005). Anybody can do things right, but it takes leader ship to get people motivated to do the right things(Bennis and Nanus 1985). Regarding to leadership, team building is quite essential.

Initially, team building was a series of measures aimed at improving interpersonal relations and social interactions.Over time, it has developed much further, including achieve results, meet goals and accomplish tasks. First set a goal and aligning around the goal, during the process of achiving goals, the relationship beteween the workers had been improved to be more effective and more stronger. Every one had a clearly defined role in the group, less role ambiguity will minimum the possibility of passing the buck to others. All this would strenthen the ability of problem solving.

Tangible or intangible motivations would stimulate the workers, give them a sence of comfort on their job and carre, and this would make them to promote themselves more.

Conclusion

Human factor is the most tricky element we have analysed. It has its own characteristics. It is not the same with the others that we can predict and do some assessment to control the cost and eliminate the defects we don’t need. Though we had good plan, the job design is perfect and there’s adequate training for the employees, they may still perform quite different from each other. And the strategies they made to compensate the time wasted or intend to saving more money are differs from one to another. No matter how differents they are, normally good working environment, ergonomics and good team building as well as other motivation strategies are more and more popular to stimulate the workers’ proficiency to get more good solutions for practical applications.

With these good performances, the goal that minimize the cost and get more profit would be closer and closer. And to make better utilization of personal resources are always the main goal of us. we are all working hard on this to try to improve the efficiency although it seems we still had a long way to go.

Discussion

When it comes to the end, I would like to make a discussion for the factors contribute to the root cause of the topic. Those equipment if not well designed or with bad procurment(such as the compass bird though it is constrained to the location), and bad preventive maitenance plan or poor spare parts inventory, our production cost would be a great more and the time cost would be obviously increased. And the same is with the environment. It will perform a big drag force on our production if we don't have good solutions to counterbalance it.

Good investment strategy would enable us to profit more otherwise time consuming and money wasting would probably possible. To make good investigation before investment is quite neccesary. With respect to the Project management, a good plan and well orgnized system and a responsible team would be the key factors to success.what we had analyzed are the key factors that affect the cost and efficiency of the 3D seimic. If companies want to be more efficency and profit more, some of the factors can be utilized and optimized to survive in the rough background of oil and gas industry.

Though we had given many factors that had affect the seismic production, but due to the limitation on resource and time, I could not cover all the aspects such as seismic operation in the arctic region or in the well known rough sea state area—the North Sea. And the methods I used to illustrate the topic may need to be improved. So any one have good suggestions or better understanding on this would be well welcomed to communicate with me.

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