Master thesis, Industrial Economics for Kristian Holm

Offshore crane concepts for subsea operations - core competence.

The market for offshore cranes used in subsea operation is in rapid growth. The operations are performed in deeper and deeper waters, and the cranes have to handle structures that are getting heavier and bigger.

Operations offshore require that the cranes can compensate for movements in the vertical direction; this is often referred to as heave compensation. The system that is most common used is called Active Heave Compensation- AHC. The cranes are demanding in use thus the need for good simulation and training solutions are needed.

High reliability for the cranes is crucial combined with high precision and good support. A real-time measurement between ship/crane and land ensures preventive maintenance, and support from land when this is possible. These kinds of solutions are often a part of the total crane delivery.

The level of precision of the wave compensation and other advanced features often increase the complexity and thereby the price of the crane systems. Complexity can also increase the reliability.

Based on the above there are many different crane concepts that all have their pros and cons.

The thesis will be divided in three parts. The first part will contain a review of the different crane concepts that are on the market, with a focus on the crane systems that TTS have used in the past, and the current system. The two systems that TTS have been involved in is one cylinder based system, this is the old system, and now it is a secondary controlled winch based system that is a relatively new technology. This part is carried out to get the knowledge needed to make good questions for the following market analysis.

The second part will use the knowledge obtained from the technical part to make a basis for a market analysis. In this analysis the focus will be on the customer needs; what is the customer preferences when procuring an AHC crane.

The third part is based on a desired value chain, and from this define the core competence of the AHC cranes for TTS, later a shortening to value chain TTS and core competence TTS.

The goal is to use the results from the market analysis and by this way conclude on what todays' core competence is, and then an evaluation of about how the core competency should develop in the future.

The following hypotheses have been put forward:

- The secondary controlled AHC concept gives a higher degree of performance, but due to its more complex system and the fact that it is a relatively new concept, it is not as reliable as the cylinder based system.
- When it comes to selection of control system for the AHC cranes, the PC based solution gives higher possibilities than the PLC based solution.
- For the customer the most important issue is the reliability. When performing offshore operations, it is essential that the crane remains operational at all times. Performance is also important when procuring the cranes.

Summary

In this thesis, different AHC crane concepts have been studied. The purpose of the thesis is to get a better understanding of what the customer wants when procuring an AHC crane. The work has been divided into three parts, one technical part, one market analysis part and one part where I look at the value chain and core competencies of TTS.

In the first part, a technical review of different compensation systems has been the main focus. The main part has been on looking at advantages and disadvantages of the AHC crane concepts that TTS have been involved. The results can indicate that the cylinder compensated system that TTS sold earlier may have been good enough in most cases, but that the new secondary controlled winch based system has better performance, and that this most likely will be the system for the future. It was not possible to get good information on the reliability of the systems. The secondary controlled system have not been in operation long enough to get good result s on this matter as well.

In the next part, the market analysis, I have tried to get a understanding of how the market for AHC cranes works, starting with theory, and finished off with interviews with some former customers of TTS. The main focus has been to know more about what is important for the customers when procuring an AHC crane for their vessels. The results indicate that reliability is the main priority, but as it is mentioned, the reliability is not always as good as one maybe should like it to be. This seems to be the case regardless of the supplier. This makes it almost as important to have a good support organization surrounding the cranes ensuring short repair time for the cranes. Performance is said to be important, but it only has to fulfill the specification given by the customer. Extra performance is only important as long as it does not affect the reliability.

In the last part, the core competence of TTS has been assessed. The results from the market analysis indicate that the main focus should be on increasing the reliability of the cranes. If one can deliver a crane with superior reliability to your competitors you have a great advantage. So the core competency for TTS is to make a robust and safe control system, a reliable hydraulic system, to engineer and assembly the cranes properly, and to have a good support/service organization.

Preface

This thesis is the final part of my Master degree in Industrial Economy at the University of Stavanger (UiS), and has been carried out during the spring of 2011. The thesis has been executed in cooperation with TTS Energy in Bergen where I spent most part of the semester. The supervisor from UiS was Kjell Hauge, and my supervisor at TTS was Olav Bruåsdal. The purpose of this thesis has been divided in three different parts. The first one was to differentiate the crane concepts that exist. The second part is a partial market analysis, with a focus on what needs a customer have when procuring an AHC crane. In the last part I take a closer look into the value chain concept, and try to define TTS' core competence, and what should be TTS' core competency, both now and in the future.

Working on this thesis has been a very rewarding process in many areas. I have learned much about how to obtain information, and how to structure it in a good way. The process of collecting and consuming, and not least understanding new knowledge in a relatively short time has been both demanding and learning. The gathering of information from people working with the cranes and not from written material has been especially meaningful. When I started I did not know anything about any of the subjects that the thesis would include, but this was something I wanted from the start, as this gave me the opportunity to learn new things and to have a neutral view on the subjects.

I would like to thank my contact person/supervisor at TTS, Olav Bruåsdal for being available for guidance and discussion during the spring. His door has always been open and he has helped me to contact the right people when I needed it and to keep me on track the whole time, even though it has not always been too easy. He has also been very helpful in the last part of the thesis. I would also like to thanks everybody at TTS who helped during the semester. Also thanks to Stig Espeseth in ICD, Alv Nepstad and Njål Aarsland in TTS.

Kristian Holm

Abbreviations

AHC	-	Active Heave Compensation
B2B	-	Business to Business
CCS	-	Crane Control System
CCSS	-	Crane Control Safety System
CDP	-	Control Design Platform
CPU	-	Central Processing Unit
CT	-	Constant Tension
GUI	-	Graphical User Interface
ICD	-	Industrial Control Design
I/O	-	Input/output
MRU	-	Motion Reference Unit
PLC	-	Programmable Logic Controller
PHC	-	Passive Heave Compensation
SWOT	-	Strengths, Weaknesses, Opportunities and Threats
TTS	-	Total Transportation System

Contents

Figure list

1. Introduction

The need for heave compensation has been there since the first boat set out to sea. There are a number of different systems for heave compensation; you have cylinder based and winch based as the most common ones. The search and development of new oil and gas fields in deeper waters, and the installation of equipment on the seabed, is increasing the needs for heave compensation systems.

TTS' heave compensation system is a winch based system with secondary controlled hydraulics and a PLC control system, prior to this it was used a PC based control system. This system is a new concept, earlier a cylinder based system was most common, and also this was based on PLC control. Good compensation system are vital for offshore operations, they can expand the window of operations and can have great economic value. The two main concepts both have their advantages and disadvantages, when it comes to performance, price, maintenance, etc.

Further in the thesis, the knowledge obtained during the technical part is to be used as base for the market analysis part. To perform a complete market analysis would require a lot more resources and a lot more time, so the focus in this part has been to explain some theory behind marketing, and then evaluate what thee customers is looking for when procuring a crane.

The next step is to use what I have found out and try to connect this to the value chain and core competence of TTS and conclude in which areas TTS can put in more funds to improve the product.

1.1. Boundaries and assumptions

The thesis stretch over a wide specter of subjects, and would require a lot more resources and time than what is available to complete everything. Following boundaries have been set:

- Only the AHC cranes are to be included in the thesis. The crane market includes a large number of crane types and systems, and it would be too time consuming to assess them all.
- The market analysis is a large and complex task. This would require a lot more resources to complete, therefore in this thesis the focus will be on the demand side of the market theory, and we will only look on the needs of the customer.

The secondary controlled AHC cranes have not been installed and in operation very long, and I have not had access to the information required to get a clear picture of the reliability of the different types of cranes. Therefore the assumption is made that;

- Due to the complexity, that the cranes are relatively new, and the lack of good information on the reliability of the cranes, we assume that the winch compensated cranes gives a higher degree of performance than the cylinder compensated ones. But the risk of lower reliability is higher due to the complexity and the uncertainty that follows not knowing.

1.2. Methodology

The basis of this thesis is based on hypotheses put forward in the beginning. The thesis is divided into three parts, where each of the three parts requires different approaches when solving them.

Collection of information and discussion of the collected material is important in the first part, but there is not a lot of published material put out regarding the AHC cranes, so large parts of the thesis are based on meetings and interviews with people working with the cranes, either directly or indirectly. The second part required literature to explain the basics of markets and market analyses, and interviews to prepare the analysis part. This goes for the third part "from cluster to core competence as well.

In this thesis the main methodologies that are used are literature studies, interview techniques, analyses and discussions derived from interviews and the use of theoretical models. The literature studies have been used to define and map the technical solutions, and the theory is the basis of the thesis, while the interviews/meetings have given a deeper understanding of the cranes from people working with them on a daily basis. This way you learn more about how it is in the real life, and not only how it's designed in theory.

Literature

Throughout this thesis literature has been the basis to explain the theory and basics of the AHC cranes; how they work, system build up, alternative solutions, etc. All elements of this thesis have been new for me; this made it important to give a theoretical introduction to the different parts. The goal is to achieve a greater understanding of the topics so that it could help in the preparations and formulation of the market analysis and core competence. The sources of information used in this task are, books, articles, reports, user manuals, internet and presentations.

Interviews – Part 2 Market analysis

When performing the market analysis, multiple tools can be used to collect the information you need. The information can be divided into two, primary data and secondary data. Primary data is information collected on your own through telephone interviews, personal interviews, questionnaires, etc. Secondary data is information that is already collected by others, often for other purposes. In this thesis the main data collected was primary data. Further you can divide the data collected into qualitative data and quantitative data. Qualitative data is the data that can explain events, situations and behavior, and can be presented in context. One can say that qualitative data contain a history; they can describe concepts and relationships between concepts. Depth interviews are a common way to collect this kind of data.

Quantitative data is data collected through questionnaires with specific response options. This is data that is easier to collect, and easier to use in statistics, tables and graphs.

The method of collection that was chosen was telephone interviews. The reason this was chosen was because of the time available and it would be impractical to travel all across the country for only a brief interview. It was also chosen over questionnaires because of the amount of information you can get from an interview is much larger than, and you can clear up any misunderstandings if they arise during the session. The chief objective of the interviews was to get more information on the importance of different aspects when procuring the AHC cranes. Especially regarding:

- Price
- Reliability
- Performance
- Maintenance

Telephone interview – Part 2 Market analysis

A telephone interview is a useful tool when collecting information for reports and other written materials. If you need to talk to people with expertise within a field, to gather material or facts related to a subject, you often find that they are busy people who do not have the time to set up a personal meeting. They are on the other hand willing to take the time for a 10 min interview over the phone. The use of telephone interview enables a quick gathering of information without using too much of the experts time. This gives a higher degree of positive answers, and increases the amount of gathered information.

Theoretical models – Part 3 Value Chain & core competency

In the chapter 4 "from cluster to core competence" there have been used a number of different models to explain how TTS is placed in the market, then we look at the value chain of the company and in the en conclude over the core competence of TTS. To best explain these I have used theoretical models.

- **Diamond model** – this model is used to explain how clusters of companies increase the competitiveness of the companies internationally.
- **Porters five forces** – This model helps to assess and manage the long term attractiveness of an industry.
- **Value chain –** shows a chain of activities for a company operating in a specific industry.
- **Core competence** – The core competence are those capacities that are critical to a business achieving competitive advantage.

Further I am connecting these models to TTS and the activities involved in AHC crane projects.

2. Heave compensation systems

2.1. Intro/history

As the use of remote satellite wells and exploration in deeper water increases, it becomes more and more common to put the equipment on the seabed. This increases the range of the production platforms, and reduces the cost of the fields. It may also eliminate the need for a platform by linking it to shore.

When connecting equipment on the seabed, it is essential to have minimum/no risk of damages on the equipment, as this can have severe consequences timely and not least economic.

The need for heave compensation came early when test drilling and offshore crane lifts became more common. The first solutions were simple concepts that had trouble with large wave heights and velocities. The development of heave compensation equipment has gradually generated more accurate and more sensitive equipment regarding wave motions. The increasing use of floating platforms vs. fixed has increased the necessity of this development due to more difficult work tasks, more remote locations, the increased use of subsea equipment, stringent requirements for reliability, etc. Another important issue has been the possibility to expand the weather window of operations offshore. (Lindøe, 2004)

Motion compensation

A motion compensator is a device that decreases the undesirable effects of the relative motion between two connected objects. Motion compensators are usually placed between a floating object and a more stationary object, such as a vessel or a structure fixed to the seabed. (Unknown, 2009)

Heave compensation

A heave compensator is a kind of motion compensator. Heave compensation is the mechanism that reduces the motion or effects of waves working on a floating vessel or an installation. (Unknown, 2009)

For offshore drilling operation from floating installations you use telescopic pipes and flexible risers to avoid that the forces caused by the waves gets too large. When loading and offloading from supply ships, the wave motion can cause difficulties because of the relative small ships are subject to a completely different and more violent pattern of movement than a large drilling vessel or a rig. Heave compensated cranes are constructed to simplify these kinds of work situations. Here you can adjust the crane cable to pull with an almost constant force. This makes the hook able to move freely up and down while the wire is tightened until the load quickly can be lifted of deck. (leksikon, 2011)

The purpose of heave compensation is:

- Reduction in forces acting upon crane, winch, wire rope, chains, lifting lugs, hook load, sea bed foundations etc.
- Reduction and improved control of motions acting on hook load
- Expansion of operational weather window.

An offshore vessel can experience 6 degrees of freedom, or 6 ways to move in the water;

- Surge, movements in the vessel's longitudinal direction.
- Sway, movements in the vessel's transversal direction
- Yaw, rotation around vertical axis

The first three movements can be compensated for by use of Dynamic Positioning systems (DP)

- Heave, movements in vertical direction
- Roll, rotation around longitudinal axis
- Pitch, rotation around transversal axis

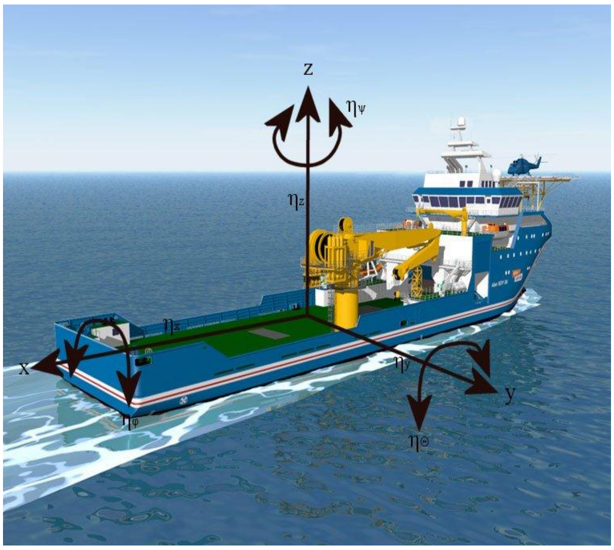

Figure 1 The 6 degress of freedom for an offhsore vessel

These movements have to be handled by a heave compensation system. (TTS1, 2010)

The critical phases during offshore lifting operations:

The landing of loads on the sea bed:

- Splash zone
- Landing zone
- Release of hook load.

Lift-off from sea bed

- Connection of hook to load
- Hoisting load off sea bed
- Splash zone

For these kinds of operations, advanced heave compensation systems are required

2.2. Crane designs

There are many different types of crane designs on the market. When deciding which to go for there are many aspects to consider;

- What kind of applications the system will be used for.
- How the weather conditions are.
- The available deck space.

To get an overview of the different systems in use, an overview of the most common crane designs is given below. All illustrations are inspired by (Adamson):

Straight boom crane

This is the simplest of the cranes. It is constructed to do relatively small and easy tasks like (Energy, 2011):

- Hose handling for tankers
- Provision/stores cranes
- Service cranes

Knuckle-boom crane

This crane is as the name suggests constructed like a human finger. It has rotating base and two or more knuckles that are controlled by hydraulic cylinders. It is also possible to have a telescopic link at the end to make the range longer. The greatest advantage of the knuckle boom crane is its flexibility for what tasks it may be used for. It may turn in all directions, and if placed properly, it can reach the whole deck. When it's not in use, it can be folded together saving deck space. Another feature is the ability to keep the load at a limitable height above the deck, hence limiting the movements of the load. However, for heavy lifting over long distances this crane may be too weak (Eikeland, 2008)

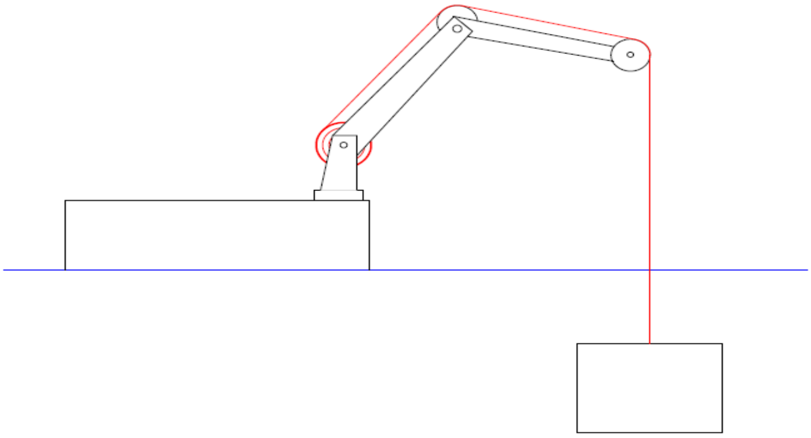

Figure 2 Knuckle-boom crane

A-Frame

The crane consists of a framework formed like an A,(Figure 3 A-frame crane)The frame may be raised and lowered using hydraulic systems. The A frame may be designed to fit for location on both the stern and on the side of the vessel, or it can be placed above a moon pool. It is usually fitted as close to the gunwale as possible. This is a very solid crane and is capable to do heavy lifts, but it requires a large deck space. (Eikeland, 2008) (TTS, 2011)

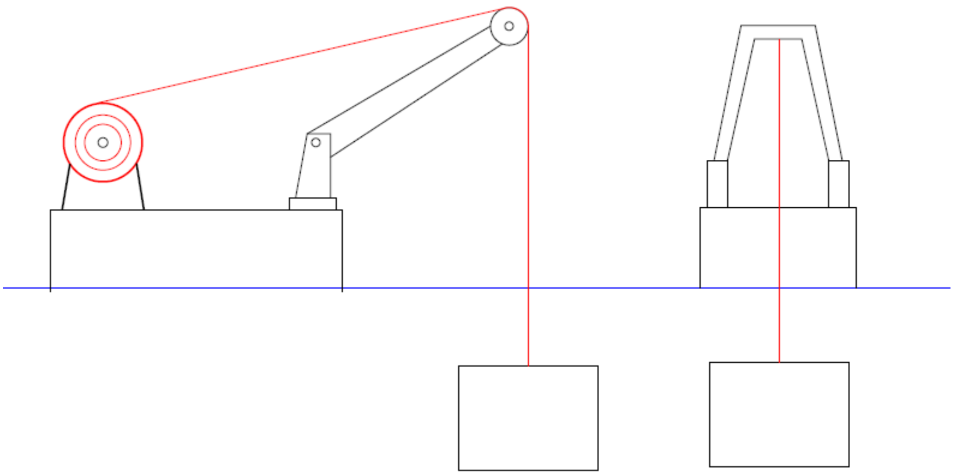

Figure 3 A-frame crane

Sub-A frame

This is a modified A-frame, where another A-frame is fitted on the inside of the main frame. This concept is a descendent of the nodding boom concept, reduced in size, complexity and power requirements. In operation the main A-frame is used to overboard or inboard the payload. And the sub A-frame is used if heave-compensation is desired. The deck space required is the same as for the regular A-frame.

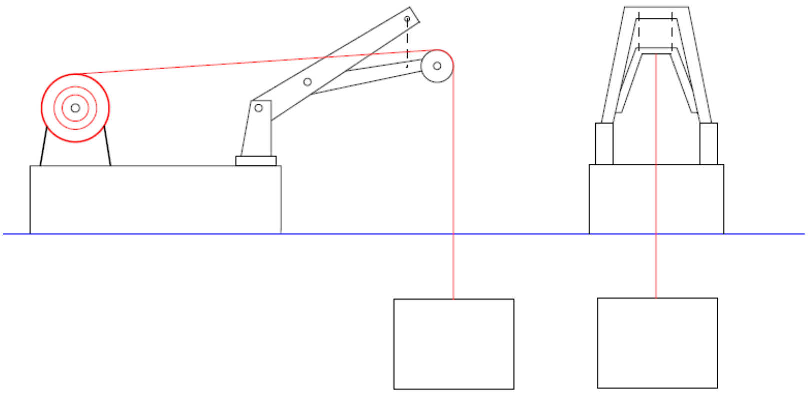

Figure 4 Sub A-frame crane

2.3. Heave compensation systems

Systems can be can be installed as one or as a combination of the following

- Passive heave compensation
- Active heave compensation
- Constant tension

2.3.1. Passive Heave Compensation (PHC)

By using a passive heave compensated system the line pull can be kept constant. The passive system relies on a spring damper, most often in the form of a cylinder with pressure on one side of the stroke. When the ship moves up, the load in the wire increases, and the cylinder contracts, but dampened by the pressure in the cylinder. This leads to a lower load in the wire and the load remains stable. This system does not require any input of a control unit and is therefore named a passive heave system.

Passive heave compensation is mostly used in situations where the load is standing or working on the seabed. It can also be used for motion compensation, the motions of the vessel cause drag forces on the load which will decrease or increase the line-pull. As a result, the hydraulic cylinder will move in or out and reduce motions of the load. (Huisman, 2011)

Advantages:

- Line pull is kept constant
- No additional energy is required
- Movement of the load is reduced
- The system does not need an input of a control unit
- Is safest to use with light loads that have a large surface

2.3.2. Constant Tension (CT)

Constant tension is used to achieve a constant line-pull set by the operator. The line-pull is measured by a load cell and monitored by the control system. If the actual value differs from the pre-set value, the winch will pay out or pay out wire rope to maintain the pre-set value. Instant adjustment of the cable tension is possible by changing the tension set point value.

Constant tension can be used to pretension a wire rope prior to lifting a load from a supply boat or after landing a load onto the seabed. CT prevents the loads to bounce on the deck or being picked up again. (Lagendijk, 2011)

Advantages

- Cable pull is constant
- Safe landing and lifting of loads
- Prevents load objects to bounce on the deck or being picked up again

2.3.3. Active Heave Compensation - AHC

To control the relative position of a load to a fixed object, active heave compensation AHC is used. The position is determined by the control system using the real-time signal of a motion reference unit (MRU) as an input signal. In response to this signal the AHC system will pay in or pay out wire rope to keep the load at constant elevation.

Active heave compensation can use two different hydraulic systems. The first is called primary system, and the latter is called a secondary system.

We are now going to take a look at the main components of an AHC system

Main Winch

The main winch consists of a steel drum with a flanged on gear-ring, one on each side of the winch drum. Drive gears is fitted on each side and are driven by a variable displacement hydraulic motor. The gear boxes are all fitted with a failsafe multidisc brake. A set of counterbalanced valves are mounted in the winch loop ensuring smooth and accurate winch operation independent of winch load.

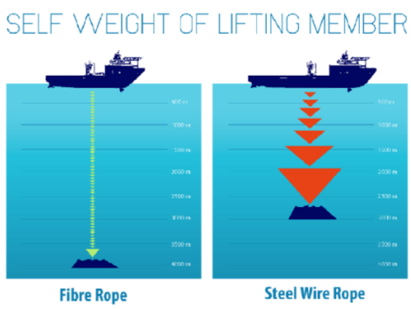

Figure 5 Fiber vs. steel rope

The winch can be equipped with either a high quality wire rope or if there are great depths you may use fiber rope. Fibre rope gives the advantage of increasing the seabed lifting capacity and reducing required winch power. (TTS, Ultra deepwater lifting system, 2011)

Hydraulic system

Primary controlled systems

A common way to control the winch movement is to use a normal transmission solution where the main pump is doing all the work. The principal can be seen to the right. To move the winch drum back and forth, the pump will have to build up pressure on one of the sides, creating torque in one direction. When the control system detects that movement in the other direction is needed, the pump will have to reduce pressure on one of the sides and increase it on the other side. This forces the pump to work against the hydraulic spring every time a change in rotational speed or direction is needed. This causes a significant delay in the efforts to control the winch drum motion.

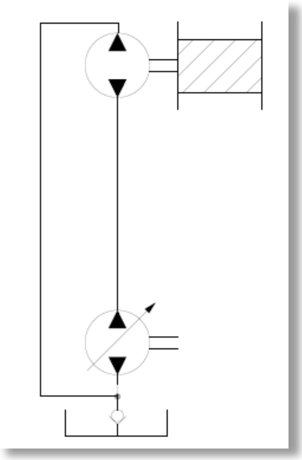

Figure 6 Primary control

Controlling on the primary side also has the big drawback that to rotate the winch drum a certain angle, a fixed amount of flow is always needed. This causes over dimensioning of the pumps if high speed at low load is wanted. (Energy, 2011)

Secondary controlled systems

Secondary control means that you have an actuator sitting on the motors that are fitted to the winch; this actuator enables us to control the swash-plate angle of the motors. The swash plate angle decides the current displacement of the hydraulic motor; it can be controlled between +1 and -1. This means that by having a high pressure on the inlet port, you can control the motors to produce torque in two different directions. This is used to drive the winch back and forth. Secondary control is a very good solution since it is energy efficient, we do not use control valves with big pressure drops to reduce the speed or pressure. Therefore we have very low losses and can also if wanted, regenerate energy back to the power system. The swash plate angle is constantly altered to meet the requests from the operator and the control system. (Andren, 2009)

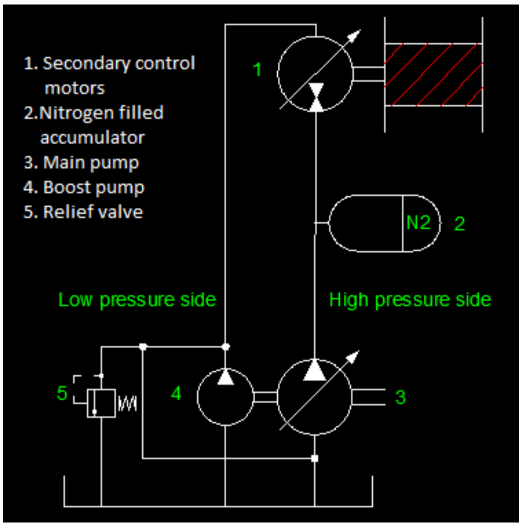

Figure 7 secondary control

Under normal operations

During normal operation, the high pressure side is pressurized to approx. 320 bars. The main pumps constantly alter the swash plate angle to maintain this pressure. The accumulator is charged to 50 % to be ready for AHC if activated. The boost pumps keeps 20 bar on the low pressure side. (Andren, 2009)

Operations of the AHC system

When AHC is turned on, the control system gathers information from the MRU and other sensors and starts to compensate for the crane tip motion by moving wire in or out. When the crane tip moves up, the wire is "pulled" out by the load, which means that the secondary controlled motors will act as pumps and pump oil back into the main pump. This will increase the pressure to 350 bars which will fill the accumulator to 100 %(If AHC is at max load and heave). The energy that was given back to the system is now stored in the accumulator, ready to be used when the crane tip moves down. When the MRU detects that the crane tip is moving down, the swash plate angle is changed so the wire can be pulled back. The secondary control motors now use the oil stored in the accumulator to pull in the wire. When the pressure drops below 320 bars, the main pump starts to flow to keep the pressure up so full performance is available. The boost pump always makes sure that we have no cavitations when the secondary control motors act as pumps and flow back to the accumulator. (Andren, 2009)

Crane Control system (CCS) of the AHC cranes

The crane control system is designed to preserve the safety of the personnel and equipment at all times.

The crane controls is usually electronic and joy sticks are integrated into an operators chair in the crane cabin. All safety functions are cutting off the control signal for the decided motion, upon signal from the crane control system. The control system inside the crane cabin can be based on both a PLC system and a PC controlled system that will be taken a closer look into below. The system guides the operator to keep an optimal crane configuration to avoid breaching any limits for safe crane operations or entering into any restricted areas. The CCS will automatically inform and alert the operator about any potential dangerous situations that might arise during crane operations

The CCS monitors the status for crane control system, safety system, hydraulic systems, load limiting system, overload protection system etc. If an error or fault is detected an alarm will sound to alert the operator. (TTS, Instruction manual , 2011)

PLC- programmable logic controller

Programmable logic controller can in the simplest terms be defined as a computer used in the industry to automate task like production and control of e.g. crane control systems.

A PLC is a specialized computer used to control processes and machines. The PLC is designed to survive in a harsh and rugged industrial atmosphere and to be flexible in how it interfaces with inputs and outputs to the real world. The PLC can be divided into three core areas.

- The power supply and rack
- The central processing unit (CPU)
- The input/output (I/O) section

Figure 8 A PLC configuration

The rack holds the components together. The brain of the PLC is the CPU module. The CPU consists of microprocessor, memory chip and other integrated circuits to control logic, monitoring and communications. A PLC is a dedicated controller and it will only run one program over and over again. One cycle through the program is called a scan time and involves reading the inputs from the other modules, executing the logic based on these inputs and then update the outputs accordingly.

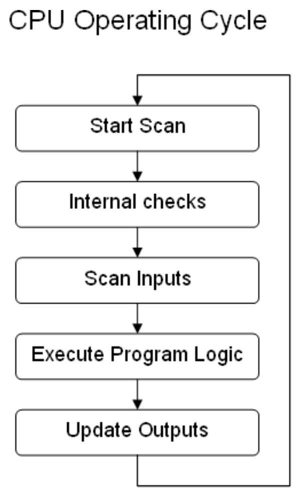

Figure 9 CPU oeprating cycle

I/O system is the physical connection between the equipment and the PLC. There are many different kinds of I/O cards the CPU can use for its logic. It's only the matter of choosing which inputs and outputs that are needed. (dev, 2011)

As mentioned, the basis of the PLC function is continual scanning of a program, by that meaning, you run through all conditions within a guaranteed period. You can divide the process into three steps (Nebojsa, 2011).

1. Testing input status. The PLC checks each of the inputs to see which one has in and which is off. It checks whether a sensor, switch, alarm etc. is connected or not. Information collected is stored in the memory to be used in the next step.
2. Program execution. The PLC executes a program, instruction by instruction. Based on the program and the status of the inputs an appropriate action is taken.

3. Checkup and correction of output status. The PLC checks up output status and adjust it as needed.

Following step 3, the PLC returns to step 1 and continually repeats these steps.

Beneath you can see a simple schematic of the PLC process. Sensors record the inputs, and send them to the input module. The central control unit responds according to the PLC program stored in the memory, and the output is sent to the actuators.

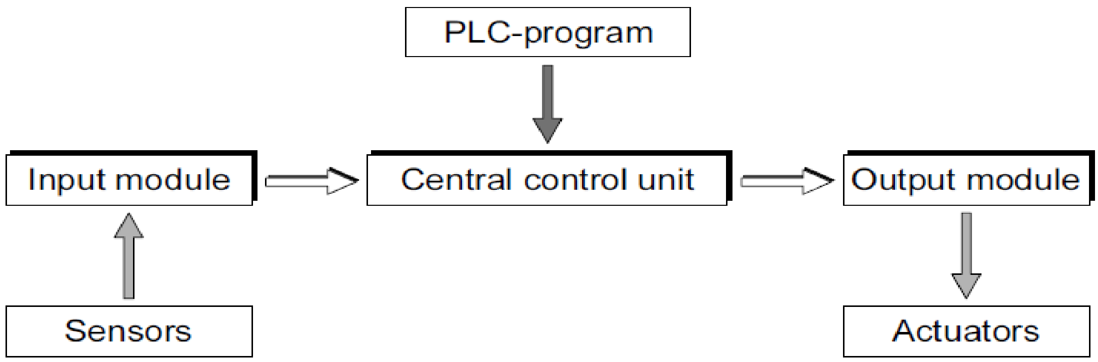

Figure 10 Schematic of the PLC process

This system has its advantages and disadvantages. (Appendix E & D)

When it comes to choosing this alternative the following arguments have been put forward;

- The functionality of the solution
- Scalability
- You have good industry standards
- Open standards, regarding development language, networks etc.
- A long life cycle/ availability, up to 10 years as spare parts after EOL
- Well known, proven and robust.
- High temperature and vibration specifications. There are no moving parts.
- Rapid development.
- Standardized development and diagnostic tools.
- Global availability of skilled resources.
- Robust vendors with a large customer base.
- There is good local and global support.

When looking at the downsides of the PLC solution

- For large complex system the run-time of the program execution time might get high.
- Limited memory size
- Limited processing speed. Higher speed can be very expensive
- You are locked to using one supplier, and their support system.

CDP Control system

The Control design platform (CDP) control system is developed by ICD (Industrial control design). The goal was to make a cost efficient control system that was to shorten the development time without negatively impact the quality. The result was the CDP –control design platform.

“CDP is a design framework for making control systems. It supports the developer during the full software lifecycle from design and implementation, through verification and testing to installation, commissioning and live operations. The CDP software is also a middleware solution which enables developers to focus on the algorithms and software functions leaving the communications and protocol translation to the CDP libraries.” (ICD)

The CDP system is made to simplify the development process of a control system. It was developed so that when making a new control system you would not have to start from scratch each time. The CDP is made up of “packages”/applications/components that are put together in collaboration with the client and customized to suit the client’s wishes and needs. By using CDP, the control application is separated into manageable objects that are individually configurable. Code and libraries are already provided to start and run your application components. You can develop what you need without having to build your own protocols, devices and tool from scratch. In Figure 11 you can see the components in hierarchical structure, this makes it easy to develop, distribute and maintain applications.

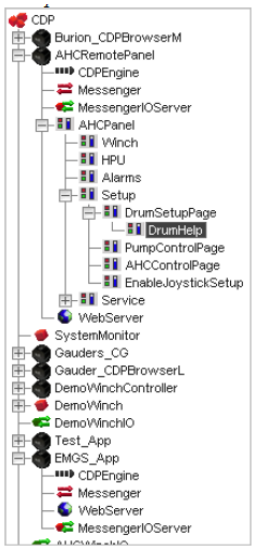

Figure 11 Hierarchical structure of the CDP system

The system supports windows XP, windows 2000, windows Vista and Linux, and supports hard real-time requirements through RTOS-32. This is the system currently in use on the AHC crane systems delivered by TTS. It also supports different field buses (industrial computer network protocols) and hardware units and can interface to other systems using other protocols and communication media:

- Modbus
- CANbus
- Ethernet UDP

The CDP can as shown in Figure 12 be interfaced to different hardware and software protocols and systems.

It is also possible to replace existing PLC systems with industrial PCs and reuse existing CoDeSys-code through Soft-PLC.

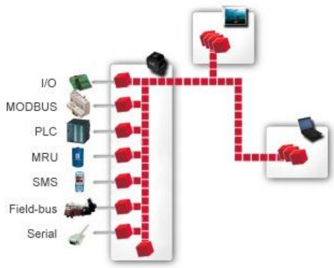

Figure 12 Different interfaces that can be connected to the CDP

CDP components can be distributed among several physical controllers. CDP will take care of seemless communication so that logical structure is independent of physical location of software components.

The distributed, component based architecture makes it easy to distribute development to separate teams or individuals. Typically, a new component will have a clear and simple specification of its interface, since all lower-level interfacing and communication issues are solved by CDP.

Another advantage to consider is the code structure. While PLC codes are written as one code for the whole system, the CDP spread codes, so instead of reading one large code for each time, it reads many short ones simultaneously.

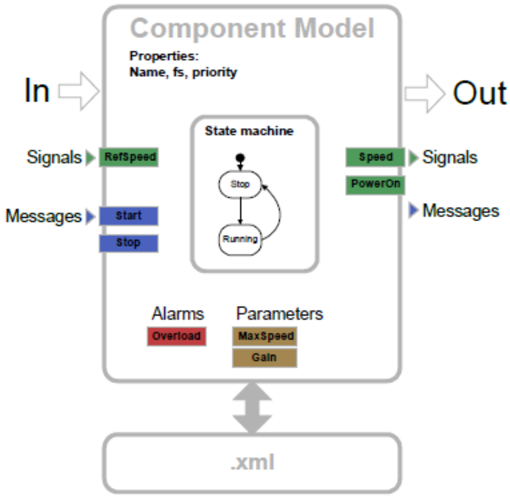

Figure 13 State machine process

Figure 13 shows a model of how a component in the CDP system works. Each component has a state machine which determines the behavior of the component by running the appropriate periodic process method. A state machine is any device that stores the status of something at a given time and can operate on input to change the status and/or cause an action or output to take place for any given change.

The periodic process runs at an interval specified in the model or component .xml (a set of rules for encoding documents in machine readable form). State transitions are triggered by events, message or signal values.

All components are based on a component model base type. The base type determines what kind of resources the component occupies and what the component can do. Components which have a state machine running the periodic processes, can receive messages, and may own subcomponents, alarms, signals and parameters.

The system can also, if desired be made redundant by adding redundancy to existing applications and reuse existing code. Especially for critical systems redundancy is important.

The CDP system also allows for simulation and control of your applications in real time. Simulation is used for testing and debugging on actual hardware without risking system failure or hazardous behavior. By running the application on a workstation it is possible to verify that the application performs as expected without having to upload to the controller hardware. This simplifies the process of testing and also allows for testing of the software before the hardware is available.

Different levels of service can be performed using the CDP tools. Parameters and signals can be verified can be verified and changed using a web interface or the CDP browser. It is also possible to download files from the controller, edit them on your workstation and then upload them again.

Components requiring restart can be stopped and started individually, not affecting the other components.

The CDP has both advantages and disadvantages. Let's start by looking at the advantages;

- The ability to choose your own hardware supplier, you are not forced to use only one provider.
- The opportunity to follow the developments on the hardware side and be independent of suppliers.
- You can avoid expensive licensing schemes.
- Runs on most operating systems
- Easy to use because of the block buildup of the CDP system, saves time during the development process.
- Support for real-time requirements
- Very suitable for advanced and complex systems. Divides the processes into smaller ones to lower the time execution time. The ability to run multiple program codes simultaneously, instead of one large.
- You can split the programs, this gives a high amount of flexibility
- Easy to simulate before you install the control system.
- Redundancy is available for all parts of the system.
- It's a flexible system that quite easily can be related to newer technology and preserve the system knowledge of the organization.

- Easy to connect to the system remotely and make adjustments and modifications.
- In progress of developing video detection systems, that might be able to make the systems safer.
- Better GUI- tools are on their way.

Disadvantages of the CDP system

- The system has lacked a good organization regarding maintenance, repairs etc.
- The configuration tools have not been good enough.
- Difficult to find supplier of hardware that can promise long availability of parts needed. A maximum of 3-5 years.
- The computer might not be as robust. Especially regarding vibrations and temperatures.
- It’s also a risk that the discs might get full and crash.

Discussion

When comparing the two alternatives, PLC and CDP, they both have their pros and cons, but the meanings are quite affected depending on who you are speaking to, and which of the two systems they know best. Beneath is an attempt of making a neutral discussion of the two systems, based on meetings and interviews with representatives from the different suppliers. The table beneath have been derived from interviews/meetings with people working with the different systems, (Appendix C,D & E)

Feature	CDP	PLC
Performance	Very good, maybe slightly better than the PLC, especially for advanced complex systems.	Very Good
Flexibility	Very high flexibility due to the block buildup of the program. The system is compatible with most of the hardware on the market.	Not as flexible as the CDP system. A PLC is programmed to do one task. When you first choose a supplier, you must use their products and services.
Stability	Stable, but not as proven as the PLC. May be vulnerable to temperature and vibrations.	Very reliable, when programed correct, it never fails. Good vibration and temperature specifications
Life cycle	3-5 years availability on computer parts.	Up to 10 years availability
Processing speed	Practically unlimited	Usually limited, higher speed can be expensive
Maintenance/support	The organization surrounding the CDP is not as good as for the PLC. There can be problems finding people with right experience if something goes wrong.	A good organization in the back with a lot of experience. It's a high availability of skilled resources.
Simulation	Easy and good real time simulation through "Real time simulator"	You need support systems when simulating, like "Simulation X"
Brand name	A small company, with their own solutions.	TTS uses Siemens. A known brand, easier to sell.

The two systems are quite similar when it comes to functionality, especially regarding crane control systems. The CDP system may have an overall advantage due to its flexibility, and opportunities for control of larger and more complex systems, but for control systems needed for crane control, the PLC performs "well enough"(Appendix D & E). On the other hand, when it comes to maintenance and support you have bigger differences. The Siemens PLC-system is a well-known product with good support organization surrounding it, and it's a high availability of skilled workers. The CDP on the other hand is a small company that doesn't have that kind support surrounding its solution. Another advantage the PLC solution has within TTS is that it's already in use in the AHC-system for the offshore drilling, this means you already have the knowledge and support you need within the organization.

2.3.4. Motion Reference Unit- MRU

A motion reference unit is basically a sensor that measure movements, angles and accelerations. It is designed for use in marine applications and is an ideal sensor for heave compensation of cranes. The unit has sensors for both linear acceleration and angular rate, and has a high reliability. The sensor is very accurate and sends back exact information about deviations on angles, and makes it easy to calculate where the crane tip is located. For heave compensation of a crane, the vertical movement is the most important one, but since roll and pitch also leads to movement of the deck compared to the horizontal plane (the seabed) and the deck, these contributions must also be taken in to consideration.

There are many types of MRU units, ranked by degrees of freedom de record data for, and various positioning data. (Gerhardsen & Krøgenes, 2006)

Earlier there was a little different system, this also used a MRU to measure the wave movement, but it did not use it in real time. The system then used the data collected to predict how the next waves would be and in most cases his worked fine. The only drawback was if there came an irregular wave that didn't fit the history recorded, then you could get a deviation from the predicted result.

2.3.5. Different heave compensators

There are multiple types of heave compensators. We are now going to take a closer look at a few of them with the main focus on the two types that TTS have been involved in.

Flying sheave

In this concept multiple sheaves expand and contract the distance between them to compensate for the heave motion. The lifting and heave compensation functions are separated – the winch only do the hoisting and lowering, and the sheave configuration pay out or pull in more lift wire as required.

An advantage using this technique is that a failure of the heave motion device does not affect the winch, but then again you need additional deck space to place the heave compensator in. (Adamson)

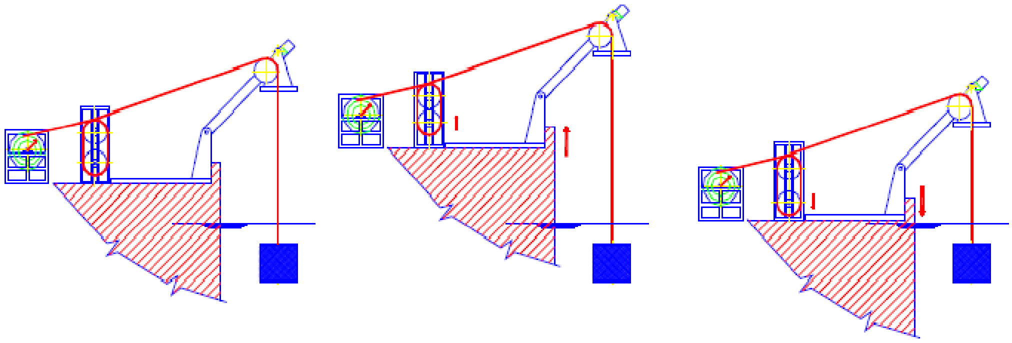

Figure 14 Flying sheave compensation system

Nodding boom compensation

The nodding boom system consists of an over boarding sheave supported at the end of a movable boom. The boom might be counterweighted to reduce steady-state operational force. The winch is only raising and lowering the load in this configuration as well. (Adamson)

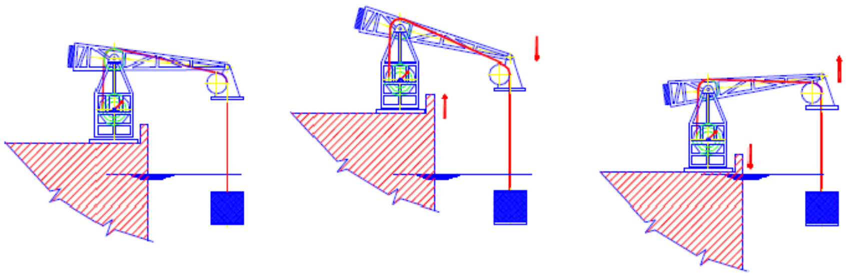

Figure 15 Nodding boom compensation system

Sub A –frame

This concept is a descendent of the nodding boom concept, reduced in size, complexity and power requirements. The moving elements are a reduced size A –frame that is attached and pivoted from a standard A-frame. (Adamson)

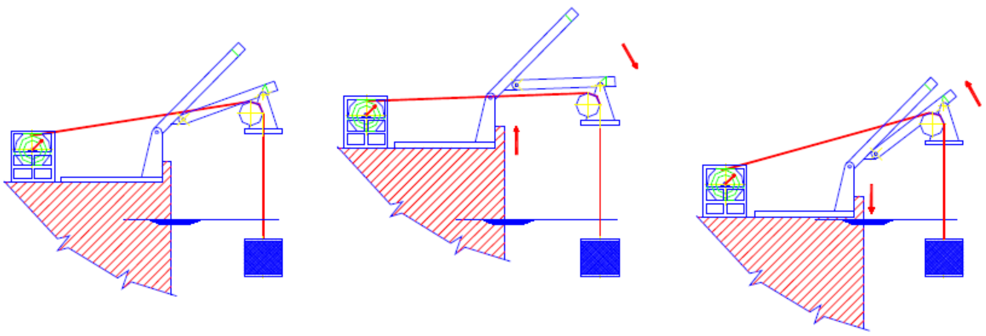

Figure 16 Sub A-Frame compensation system

Cylinder compensator system

When using a cylinder compensator the load motions are compensated using a hydraulic cylinder.

The former TTS solution consists of both a passive and an active cylinder. The passive part requires adjustment of balancing pressure, before each lift you have to calculate a new pressure that balances your lift. It requires large accumulators for pressure adjustment in HT-CT, and compressor to adjust for the preset pressure.

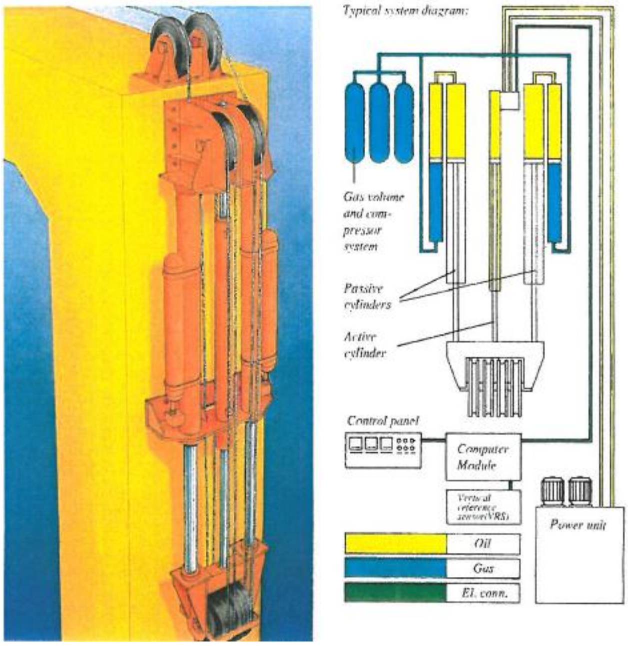

Figure 17 Cylinder compensation system

The active part consists of a separate active cylinder that is inter-connected to the passive cylinders and it got an HPU to drive the active cylinder. The mechanical system consists of an in-line compensator acting as a shock absorber. The additional wire sheaves in the system increase the wear and friction on the wire rope. The weight of the compensator also decreases the crane's load capacity. The stroke of the compensator is fixed which may result in dangerous situations if the wave height is higher than the length of the cylinders.

Winch compensator

This is the type of compensator that is currently in use in TTS' AHC cranes.

This also consists of one passive part and one active part. The passive system is a fully enclosed system that is balanced within a few seconds by displacement of hydraulic winch motors. It needs cylinder accumulators, and requires a small bank of accumulators for HC-CT, this result in quick adjustments and more flexibility during operations.

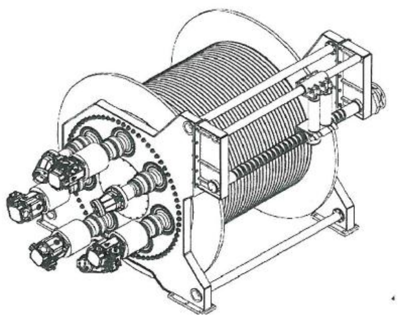

Figure 18 Winch compensator

The active part is driven by hydraulic winch motors that are divided into active and passive sides by valve selection. By use of the winch compensator you don't need additional wire rope arrangements or wire sheaves. The winch itself is used for compensation using the secondary controlled hydraulic system. The use of the winch as compensator increases the length of the compensation.

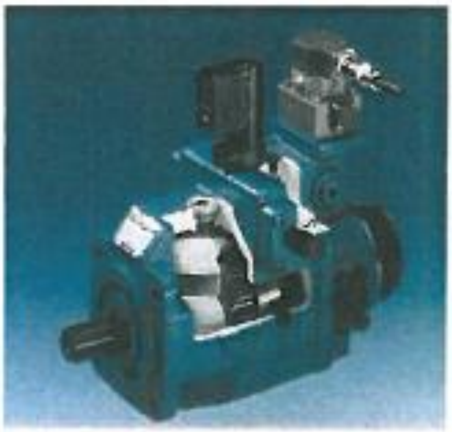

Figure 19 Winch compensator

All adjustments of speed, force and direction are controlled by the secondary controlled hydraulic winch motors, and you have constant pressure independent of load. You are always 100 % in balance, as you are continuous balancing using the control system. Constant pressure offers a high degree of utilization of the fully enclosed nitrogen accumulator. The accumulator reduces the power requirements needed. When using the winch compensator you don't need to adjust the pressure for each lift, this makes it more flexible during operations.

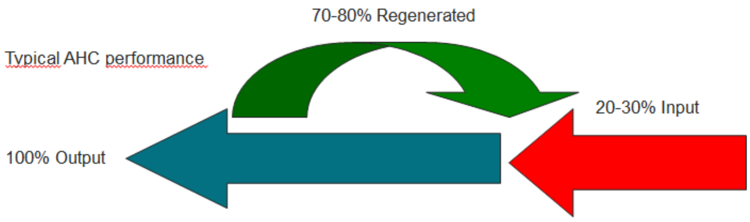

Figure 20 Secondary control power consumption

2.3.6. Assumptions made on the winch compensator

The system has not been used long enough to say something about the reliability of the system. Therefore, in cooperation with supervisor Olav Bruåsdal for further use in the market-analysis part, the assumption that; "Due to the complexity, that the cranes are relatively new, and the lack of good information on the reliability of the cranes, we assume that the winch compensated cranes gives a higher degree of performance than the cylinder compensated ones. But the risk of lower reliability is higher due to the complexity and the uncertainty that follows not knowing"

2.3.7. Comparing the two alternatives

When comparing the two alternatives that TTS have been involved in most results, answers and recommendations comes from interviews and meeting with people who works either directly or indirectly with the cranes.

Feature	Hydraulic cylinder compensated (Primary controlled)	Winch compensated (secondary control)
Performance	- The performance of this system is rated as good. - Gets increased performance if updated with a newer version of control system (Leiv Håland) - If the system is tuned right you can achieve very good heave compensation within quite narrow limits. - The stroke of the compensator is fixed. - You need to calculate a new pressure for each lift you are performing.	- This system has a better performance than the cylinder compensated system. - Quick response time, minimal delay. - Energy efficient - Increased length of compensation wire. - There are no pressure drops from control valves or other controlling devices. - Secondary control gives almost endless possibilities in making advanced operating modes such as constant tension. (TTS, AHC secondary control, 2011)
Maintenance	- A well-known system that have existed a long time with a good support organization surrounding it.	- Many valves that are subjected to a harsh environment, especially in the North Sea. May be a solution to encapsulate the valves and sensors that are out in the open. (Morten Morvik)
Price	- The cheapest of the two	- The more expensive solution

Features	Hydraulic cylinder compensated (Primary controlled)	Winch compensated (secondary control)
Reliability	- Good reliability - Proven over time.	- Not known for the long run, but have good reliability so far. - Many sensors and valves that can cause problems for the reliability (Morten Morvik, Stig Espeseth)
Complexity	- The least complex system of the two.	- Complex system with a lot of sensors

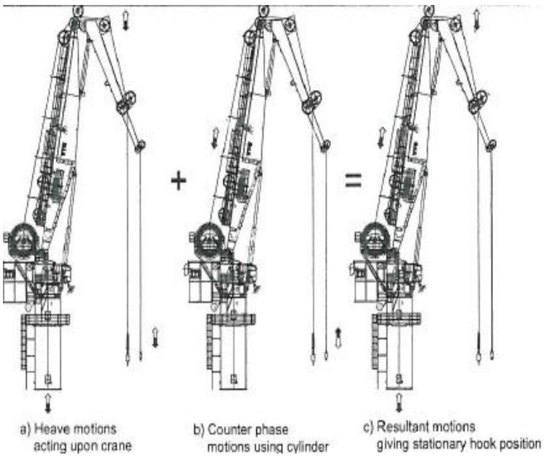

Figure 21 Cylinder compensation

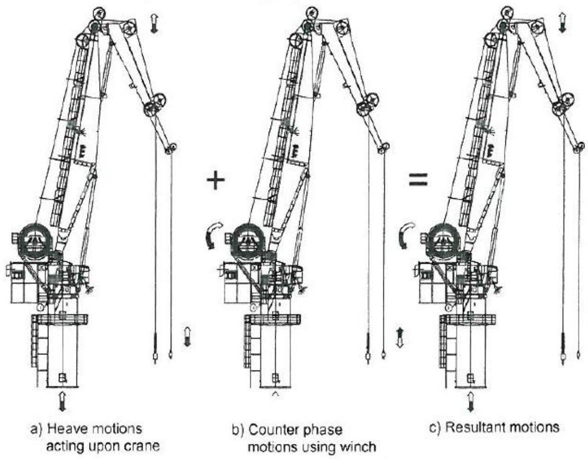

Figure 22 Winch compensation

An overall assessment of the two is based on the views of the people working with the cranes has. Most opinions of the people working with the cranes are colored by the fact that they work or have worked with one type of system. Still the conclusions are quite similar for them all over.

The cylinder compensated crane systems are all over a robust and well-known system that in most cases works well enough. (Appendix D); "In most cases it was possible to tune the system to perform within the limits specified by the customer, even for the most discerning customers". Most of the reward was lying in tuning the system to its maximum. This often gave the desired performance needed. This is repeated for whoever you speak to concerning the cylinder compensation. Even after the winch compensation system came into the market, if you replaced the old control systems of the cranes with new ones, the performance increases to a level almost comparable to the secondary controlled winch systems (Leiv Haugstad). The biggest drawback is the length of the compensator.

You will only have twice the length of the compensator cylinder, and if the wave height exceeds this limit, the system will shut down.

The winch compensated crane with secondary control is the best alternative when it comes to performance. The precision and response you get from this heave compensation is better than any of the other concepts. It responds instantly and has no maximum compensation length. It also has lower power consumption than the other concepts. Due to the lack of control valves in the system, you don't have big pressure drops in the system, and you can regenerate power back into the system, and store it in the accumulator. The downside of this concept is that you have a lot a valves and sensor that are located on the outside of the crane. These are subjected to a harsh environment, especially out on the North Sea, and this may over time become a problem. But it is still too early to say anything about this aspect, because of the relative short period the cranes have been in operation. One solution may be to encapsulate the valves and sensors to protect them for the environment. Another way to get rid of this problem is to place the winch beneath deck. As the exploration and development of new fields goes towards deeper and deeper waters, the winch required to operate at these depths becomes bigger and bigger. This result is a very heavy extra load for the ship, that if put on the crane will have dramatic effects on the center of gravity of the ships. So you will see a trend of winches placed beneath deck in the future.

An overall assessment of the two cranes can indicate that you will get the best performance, response and speed by using the secondary controlled winch compensator. On the other hand, it follows an uncertainty due to the complexity of this system compared to the cylinder compensated. This is as assumed a bit too early to tell.

2.3.8. Training and simulation

There are mainly two ways of learning how to use the crane. One is to have a simulation of the crane operator screens and controls, where the operator can learn how to maneuver the crane and how the different systems function. This is also a good way check that the system functions properly before installing it. The other one is to connect the crane to a 3D simulator. The idea is that you have a common platform for all the components that needs simulation training, and then you can take your crane and merge it with e.g. the ship. Then you get a real 3D simulation of the whole system, where you can change the environment to fit your area of operations. You may practice on unwanted situations, so that if they emerge, you can have a higher degree of preparedness. There are currently two 3D simulators in Norway, one in Haugesund and one in Ålesund, but none of them have this feature in their system yet.

3. Market

3.1. Introduction to market theory

When looking at markets, most of them are driven by the supply and demand model. The supply and demand is an economic model of price determination in the market. The basic principle of this model is that, when the price increases, demand decreases and vice versa. What type of market it is also affects the behavior of the supply and demand. In this thesis we are going to direct the attention towards the demand side of market theory. The main goal of this part of the thesis is to map the needs of the customer, and what specifications that is important for them when procuring an AHC crane.

When looking at the market theory, there are two different markets that are common. The first one is consumer markets, the second is business markets. The two market types have different kind of approaches to the customer. A comparison of the two markets is the easiest way to show the differences (Dobney, 2010)

Consumer	Business
Every customer has equal value and represents a small % of revenue	There are a small number of big customers that account for a large % of revenue
Sales are made remotely, the manufacturer doesn't meet the customer	Sales are made personally, the manufacturer gets to know the customer
Products are the same for all customers. The service element is low	Products are customized for different customers. Service is highly valued.
Purchases are made for personal use- image is important for its own sake	Purchases is mad for others to use- image is important where it adds value to customers
The purchaser is normally the user	The purchaser is normally an integrator; someone down the supply chain is the user.

Consumer	Business
Cost are restricted to purchase costs	Purchase costs may be a small part of the total costs of use.
The purchase event is not subjected to tender and negotiation.	The purchase event is conducted professionally and includes tender and negotiation.
The exchange is one off transaction. There is no longtime view (financial services differ)	The exchange is often one of strategic intent. There is the potential for long term value

The foundation of both markets is based on you knowing your customer. However, in consumer marketing, the consumer is remote, and you consequently use mass communication and distribution tools. In business to business (B2B) markets, the customer is much closer. You have far more knowledge through personal contacts, although this knowledge is typically ad hoc in nature and may be partial. (Dobney, 2010)

In B2B markets, product quality is important, still this has to be matched by quality of supply - to deliver the product when agreed, account service and support, and strategic flexibility within. These supply chain elements may have more say, in winning order than having a perfect product. This has been shown as one of the key decisions in choosing the technical solution that TTS have decided to go for, especially regarding the control system. The value chain is taken closer a look on in chapter 4 (Kotler, Wong, Saunders, & Armstrong, 1996)

There are a number of different products on the business market that can be very different, but they are usually categorized into seven classes. (Boing & Nes, 1999)

1. Heavy equipment - large machinery such as water turbines, cranes, furnaces and heavy machinery
2. Light equipment - simpler aids such as drills, calculator etc.
3. Supplies - such as office supplies, lubricating oil for machinery, products for ongoing maintenance.
4. Parts and components - electrical motors, screws, switches etc.

5. Raw materials recovered with little or no processing. Examples in Norway may be oil, fish timber.
6. Processed goods - such as glass, plastic, paper, lumber and other processed goods.
7. Services- can be divided into two types
   a) The first one is service functions exercised by the individual manufacturer to customers, such as training, expertise before a sale, technical maintenance service and other help features
   b) The other one is pure services that are not related to any product. Examples can be banking, financial services, insurance services etc.

Many businesses also prefer to buy a packaged solution to a problem from a single seller, called systems buying. This practice began with government buying of powerful weapons and communication systems. Instead of buying and putting together the components by yourself, you ask for bids from suppliers that would supply the components and assemble the package or system.

The TTS' AHC-cranes can be put in the heavy equipment class. One can say TTS is a company that sells a packaged solution. The cranes can be viewed as large projects, the planning, procuring, manufacturing and installation face, all take time and the whole process take up to 12-18 months. The cranes are assembled with parts and control systems that are procured from subcontractors on specifications given by the customer and the engineering department within TTS. But maintenance and support is also an important part of the TTS business.

Push and pull are also terms used within marketing and supply chain management. A push-pull-system in business describes the movement of a product or information between two subjects. In consumer markets, the consumer normally "pulls" the goods or information they demand for their needs, while the suppliers "pushes" them towards the consumer. (Wikipedia, 2011)

Push strategy

Push strategy describes the work a manufacturer of a product needs to perform to get the product to the customer. (Unknown, 2011) One can say that a push strategy makes use of a company's sales force and trade promotion activities to create consumer demand for a product. This strategy may

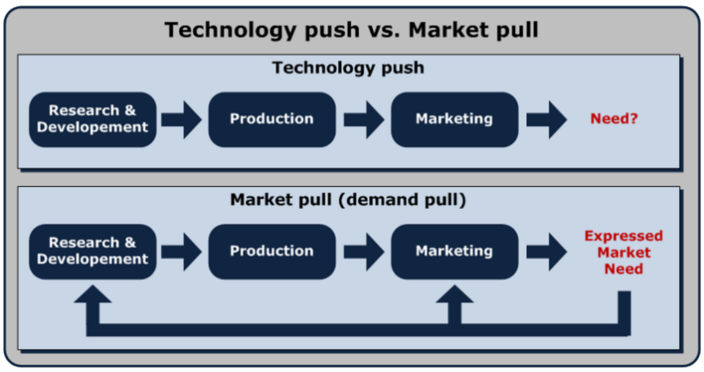

Figure 23 Push vs. Pull

be most common for consumer products. (Tutor2U, 2011) In short; you have a solution and you try to find a customers.

Pull strategy

In marketing "pull" system the customer requests the product and "pulls" it through the delivery channel. This strategy requires high brand name that makes the customer ask for the product. In a pull based supply chain, procurement, production and distribution are demand driven rather than forecasted. (Wikipedia, 2011) In short you can say use the basis of the customer's needs, and you try to come up with a smart solution to satisfy them.

But often the successful strategy is usually a mix of both "push" and "pull" strategies.

Selling to the market? Or adapt a product to the market needs?

When analyzing a market situation there are many different aspects to consider. One of them is which type of approach the company has when entering a market. Do TTS have a product that they want to sell to market? Or do they adapt the product to the market needs? Most likely it is a combination of both. The cranes are a product that TTS developed to meet a growing demand for offshore cranes, but on the same time TTS have to adapt the cranes to the needs of each new customer. This is the nature of selling a project instead of a product.

Another aspect of marketing is how the sales are executed between seller and buyer. In literature you distinguish between transactional marketing and relationship marketing.

In short, transactional marketing can be described as a short and swift deal with no strings attached after the sale is closed. Relationship marketing on the other hand is a much more demanding process. In these relations the customer is often lost for good if he first is lost. Relationship marketing can be defined as "marketing oriented towards strong and persistent ongoing relations with individual customers. When selling cranes, a good relationship between TTS and the customer is a vital to complete sales. (Biong)

The problem in a market situation is to find out, what do the customers need? What are the most important aspects and specifications for the customer when buying a crane? Is it the price, Performance, Accuracy, Maintenance, etc.?

3.1. Market research

Marketing research is to implement a process where the problem formulation, data collection and analysis will acquire information about the market. Marketing research is conducted to make futuristic decisions as good as possible. Marketing research is "the function that links the consumer, customer and public to the marketer through information – information used to identify and define marketing opportunities and problems; generate, refine and evaluate marketing actions; monitor marketing performance; and improve understanding of marketing as a process. Marketing research specifies the information required to address these issues, designs the method of collecting information, manages and implements the data collection process, analyzes the results, and communicates the findings and their implications." (research, 2011)

One can say that marketing research have three tasks. A marketing research shall:

First it must describe the market.

- What is the structure of the market?
- How many customers?
- Who are the competitors?
- Market shares?

Second, one must explain the market:

- Why does the customer do the things they do?
- Why should they buy our product?
- Why do they get the product of the competitors?

It is important to map the buying criteria and buying motives of the customer.

And third is to predict the market:

- What will be a likely pattern of development in the market going forward?
- Try to forecast:
    - What is the market potential in the future?
    - How will the growth develop in the future?
    - What share of the market can TTS have?
    - Are there any unforeseen potential customers?
    - Are there any signs of changing in the market's needs?

Market research is based on collected information. Information can be divided into two different types of information, primary data or secondary data. Primary data is information that you collect on your own through telephone interviews, personal interviews or regular interviews. Secondary data is information collected in advance by others, often for other purposes. Further you can divide the data collected into qualitative data and quantitative data. Qualitative data is the data that can explain events, situations and behavior, and can be presented in context. One can say that qualitative data contain a history; they can describe concepts and relationships between concepts. Depth interviews are a common way to collect this kind of data.

Quantitative data is data collected through questionnaires with specific response options. This is data that is easier to collect, and easier to use in statistics, tables and graphs.

This can easiest be shown using the hierarchy in Figure 24

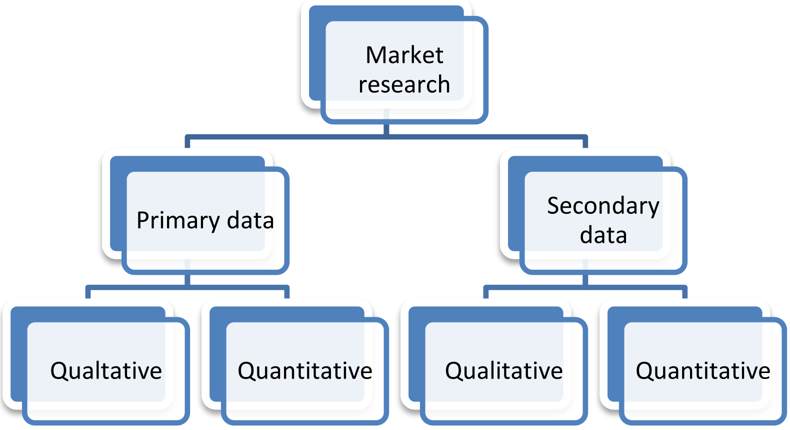

Figure 24 Market research and data collection techniques

3.2. The analysis

The execution of a complete market analysis for the market of AHC cranes would in this thesis be a too large task, and it would require a lot more resources than what is available. Therefore, in cooperation with my supervisor some refinements have been put in. The analysis is to be performed on only the demand side of marketing, and further down to the needs of the customer. The key question is; "What does the customer want?" This is only a fraction of the whole marketing research but it is a vital question to ask. If you know what your customer wants, you can better fit your product to their needs, "pull", and maybe foresee what adjustments and changes are necessary in the future.

Customer base

The customer base is relatively well known. The AHC crane market is a global market, but the majority of the customers are located on the western coast of Norway. The customers are mostly shipping companies that rent out the vessels to oil and gas business in the North Sea.

Competing companies

The main competitors in Norway are National Oilwell Varco and MacGregor a part of Cargotec.

Identification of customer needs

The customer base is as mentioned concentrated on the western coast of Norway. These companies are going to be the base of the market analysis. The purpose of the analysis is to map what aspects that are important for them when procuring the AHC crane. This information can then be used to improve existing services, come up with better solutions and try to implement this into the value chain and core competencies of TTS.

Hypothesis

The hypothesis is prepared in consultation with several of the sales personnel in TTS and advises given by other persons working with the AHC cranes. The first part has given a good overview of the solutions, and an insight into the pros and cons on the different solutions. This information has also been instrumental in preparing the interviews with the shipping companies.

Through this part of the thesis and the interviews it is possible to see the indications if the customers' needs is the same as the ones put forward in the hypothesis. Due to difficulties of getting companies to respond, and the lack of time it is only interviewed a few customers. We try to confirm or deny the following hypothesis:

The customers choose the supplier that can fulfill their needs in the best way when it comes to

- Price
- Reliability
- Performance
- Maintenance

When performing offshore operations you need the AHC crane to be functional, this is due to the high rates of renting an offshore vessel with a crane. If the crane is non-functional the whole vessel loses its function, and the costs of having these ships dead in the water can easily turn 500 000 NOK/day. (Appendix A) Therefore, the reliability is the most important aspect of a crane. Secondly the availability of maintenance and support, if the crane shuts down is essential that you can get I fixed as soon as possible.

Preparations

When preparing the interviews/meetings the most important part was to meet the right people, the ones who took part in the decision making process when procuring the cranes. It was also important not to affect the participants' meanings and that they could speak freely on the matter. It was chosen interview instead of questionnaires to increase freedom of speech for the participants. The interviews were done over phone due to the location of the companies, and the time they had available. One of the interview also replied by mail.

Interview objects

The time only allowed meeting with a few people. The first was a former customer Østensjø Rederi AS, a shipping company that owns a fleet of vessel, and has AHC- cranes from several suppliers. Kenneth Walland took the time to say something about what is important for them when procuring the AHC cranes.

The second was Knut Lussand in Solstad offshore ASA. He replied by mail on their key features.

The last one was Leif Reidar Vespestad in Eidesvik AS.

Key results

The results of the interviews are much the same for all of the interview objects. The main criteria when procuring a crane is that they satisfy the specification, regardless what crane system, that is given and this has to be in order for the cranes to be considered further. After the specifications are met, the main criteria are the reliability of the cranes. The cranes are all over, no matter which supplier who delivers them, quite unreliable equipment (Appendix A). The cranes are often the most important equipment on board; the ships are often built for the sole purpose of crane operations. This makes reliability the most important aspect. As a result of the relatively low reliability, the need of good support is essential (Appendix A, B, F). If the cranes break down it is important that the availability of support is good, and that the response is quick, as the price of having a ship dead in the water can get really high really quick. It is also important that the organization can provide support in remote areas like West Africa and Brazil (Appendix B). Good quality control systems within the organization itself are also mentioned, as this result in a better product from the crane supplier. It is also important that the supplier is willing to stock the most vital parts of the cranes, and especially the ones that have long delivery. The will to use standardized parts and solutions, so that getting a hold of them is easier, is also an aspect that is mentioned as important when procuring the cranes

(Appendix B). Price is only listed as important if all the criteria above are satisfied, and the cranes equally rated.

A summary of the criteria can be set up as follows:

1. Reliability, a high reliability is the most important feature for an AHC crane.
2. Good support organization, high availability of support personnel, and good access to spare parts are is highly valued
3. Price, if the crane solutions are on the above, then price will be decisive.

Precision is also important, but if the precision doesn't meet the specification stated at the start, the crane solution will not be considered further. One can say that high precision is only important if it does not affect the reliability.

When it comes to specific problems involving the cranes, most of the interview object did not want to say comment much about the problems. This was due to some of the cranes were from competitors of TTS and they would not want to give this information without permission. The most common areas that experiences failure that people in TTS told me about were regarding:

- Software- control system
- Hydraulic system
- That the assembly have been executed properly

Discussion

These results indicate that the quality of the cranes may be much the same for all suppliers, that for them the technical solution is not important as long as it works within the boundaries that are set, and that the cranes all over have relatively low reliability (Appendix A, C). From the interviews one may draw the conclusion that the AHC-cranes still have a potential of raising the reliability, this may be caused by the complexity of the systems, but also by the fact that the cranes are relatively new in TTS. The systems are also exposed to harsh weather conditions, especially in the North sea, and this may cause a lot of wear and tear on the valves and sensors that are located in the outside of the crane. The fact that the cranes not always satisfy the reliability that is required, makes the availability of maintenance personnel and spare parts almost as important as the reliability. So this implies that a good support organization is an important part of selling cranes. The need of good support is mentioned to be crucial, and also that support can be provided in remote areas like West Africa and Brazil. Performance is also mentioned as important, but as long as the performance keeps within the boundaries that are given in the specification, it does not matter how high it is. Price seems to have little effect on the decision of procuring AHC cranes. Only if the criteria mentioned above are equal will price be decisive.

4. From cluster to core competence

4.1. Introduction

The value chain was first described by Michael Porter in 1985. The value chain is a chain of activities for a company operating in a specific industry. The value chain analysis helps to identify the company's core competence. (Wiki V. c., 2011)

The thesis is an evaluation of the value chain for the AHC cranes to TTS and correspondent identification of core competence and further development of the competence.

The company is a part of a competitive landscape. By use of Porter's "Five Forces" (1979), the competitive landscape can be analyzed. Porter's Diamond model (1990) looks at clusters of industries where the competitiveness of one company is related to the performance of the companies and other factors tied together in the value-added chain, in customer-client relation, or in local or regional contexts. (Wiki D. m., 2011)

The thesis is not related to verify the AHC cranes to TTS in the competitive landscape or the cluster of industries. However, to get a better understanding of the dynamic processes by which competitive advantages can be created the Diamond model and Five Forces analysis will be described, the same for the much used SWOT analysis.

This gives an overview "from cluster to core competence" with focus on value chain and core competence.

4.2. Diamond model representing a cluster

Diamond model - General

Porter's "Diamond model" was presented in "The Competitive Advantage of Nations (1990)". Instead of the name "Diamond" often industry-, business- or competitive cluster are used as the name or simpler only "Cluster".

The starting point is individual industries and competitors and is building up to the economy as a whole. Nations do not compete in the marketplace, companies do. The home nation influences the ability of its companies to succeed in particular industries, with the success or failure determining the state of a nation's economy and its ability to progress.

Porter's analysis showed that companies were found to be internationally competitive because of a set of factors in the home country favourable to the development of their industry.

The phenomena that are analyzed are classified into six broad factors incorporated into the Porter diamond. A description of the factors is shown below. (Wiki D. m., 2011)

Factor conditions are human resources, physical resources, knowledge resources, capital resources and infrastructure. Specialized resources are often specific for an industry and important for its competitiveness. Specific resources can be created to compensate for factor disadvantages.

Demand conditions in the home market can help companies create a competitive advantage, when sophisticated home market buyers pressure companies to innovate faster and to create more advanced products than those of competitors.

Related and supporting industries can produce inputs which are important for innovation and internationalization. These industries provide cost-effective inputs, but they also participate in the upgrading process, thus stimulating other companies in the chain to innovate.

Company strategy, structure and rivalry constitute the fourth determinant of competitiveness. The way in which companies are created, set goals and are managed is important for success. But the presence of intense rivalry in the home base is also important; it creates pressure to innovate in order to upgrade competitiveness.

Government can influence each of the above four determinants of competitiveness. Clearly government can influence the supply conditions of key production factors, demand conditions in the home market, and competition between firms. Government interventions can occur at local, regional, national or supranational level.

Chance events are occurrences that are outside of control of a company. They are important because they create discontinuities in which some gain competitive positions and some lose.

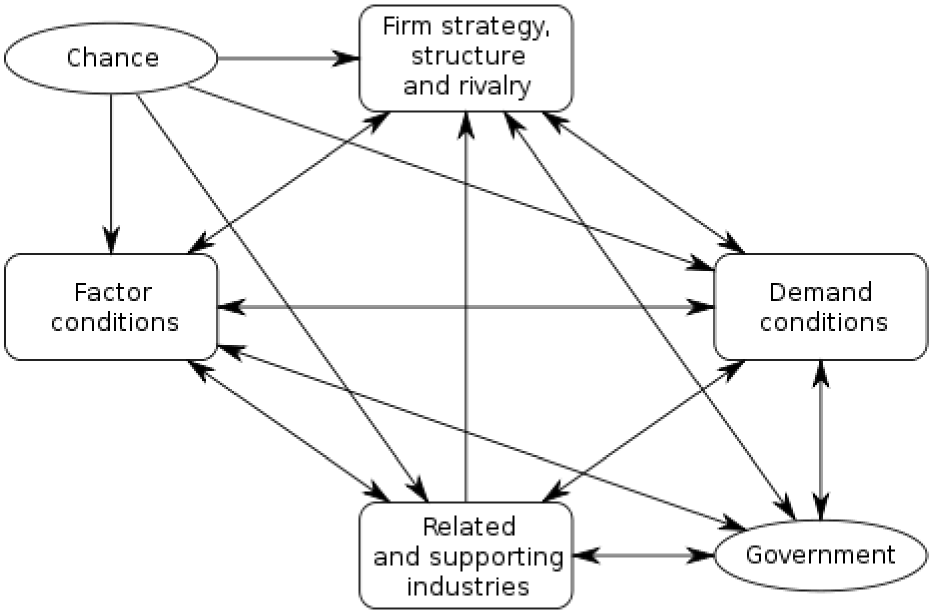

Figure 25 Diamond model

Diamond Model - Norway

Followed by Porter's "The Competitive Advantage of Nations (1990)" the correspondent Norwegian analysis "Et konkurransedyktig Norge" (A competitive Norway) was published in 1992. (Reve, 1992)

The study verifies that the oil & gas- and maritime industry in Norway were found to be internationally competitive because of their Cluster in the home country favourable to the development of their industry. "Et verdiskapende Norge" (A value added Norway) shows that that this was still the situation in year 2000. (Torgeir Reve, 2001)

"Et kunnskapsbasert Norge" (A know-how based Norway) will be published in 2011. The main focus will be competence generating and distribution. The study will take into account the two above mention studies.

Diamond Model - TTS

TTS was established in 1966 and was partly grown out of the company Munck in Bergen, a large Norwegian international company in the maritime industry. Until the end of 1996 the company's core business was in the field of shipbuilding technology, supplying production lines for steel fabrication and heavy-load handling systems for shipyards.

In 1996 TTS acquired two Norwegian companies in the marine cargo handling business. This represented a start to refocusing the core activities away from being a supplier of production technology for the shipbuilding industry to becoming a supplier of marine equipment. Since, several companies have been acquired/established in Norway and world wile.

From 1996 TTS has been a supplier of marine cranes and smaller offshore cranes. In 2000 TTS acquired a new Norwegian company and became a supplier of offshore AHC cranes.

TTS is therefore a part of the Norwegian internationally competitive marine- and oil & gas Clusters.

4.3. Five forces

Five Forces - General

The Five Forces analysis was developed by Michael Porter (1980). The analysis is also named "Competition analysis". The analysis helps to assess and manage the long term attractiveness of an industry. It is designed to explain the relationship between the five dynamic forces that affect the industry's performance as shown below.

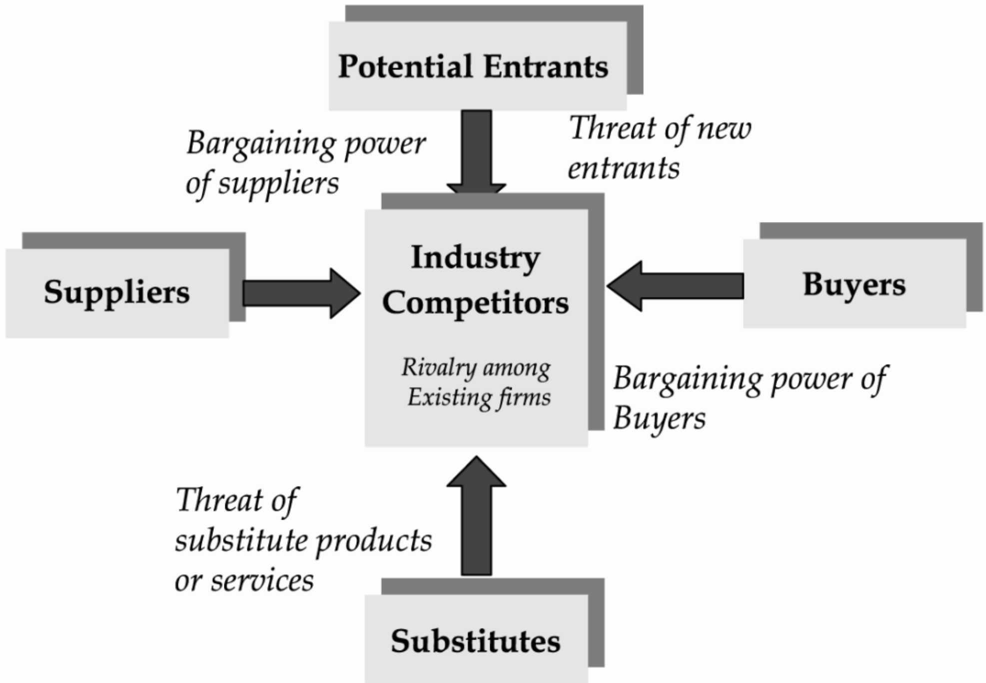

Figure 26 Porters five forces

Porter has suggested that the main five factors that influence the particular environment of an industry are the following: (Wiki P. f., 2011)

Competitive rivalry may appear when competitors are similar in size, when they offer similar, undifferentiated products or when they have similar strategies.

Suppliers' power can make an impact on each organization, as they are an important element in the value creation chain. However, their power can be even greater when they monopolize the raw materials market or if switching to other suppliers are difficult due to reasons of costs or the inexistence of substitutes for their product.

Buyers' power the power of buyers always exists, but it is higher mainly when the products are undifferentiated and consumers can switch easily or if they are highly sensitive to price.

Substitutes for the company's product represent a threat to the company's product mainly when consumers are sensitive to price and it is easy for them to switch to other products that are very similar and satisfy their needs.

New entrants on the market are high when the barriers to entering the market are low. The more and higher the barriers are, the lower the threat of new companies entering the market. Examples of such entry barriers can be governmental legislation that new entrants need to comply with, ease of the access to suppliers, the moment of achieving break-even or obtaining economies of scale etc.

Five Forces - Norway

As described under "Diamond model - TTS", TTS has a long history as a supplier of marine and offshore cranes. The same is the case for the two largest international suppliers of AHC cranes. Former Hydralift ASA acquired by National Oilwell Varco (NOV) and Hydramarine AS acquired by MacGregor (a part of Cargotec) are both located in Kristiansand.

Large demanding AHC crane customers are also from Norway, and the same with strong suppliers. The maritime and offshore industry environment creates substitutes and potential entrants.

The five forces environment for AHC cranes in Norway is therefore attractively.

Interaction - Diamond model and Five Forces

"Firm strategy, structure and rivalry" constitute the fourth determinant of the Diamond. This corresponds to the centre of the Five Forces "Industry Competitors" and the correspondent competitive rivalry. Consequently "Firm strategy, structure and rivalry" could have been re-named to "Industry Competitors".

The analysis of a Cluster by use of the Diamond model gives us a smooth transfer to analysis of the industry competitors by use of the Five Forces model.

4.4. Value chain

Michael Porter published the Value Chain analysis in 1985 in “Competitive Advantage: Creating and Sustaining Superior Performance”.

The Value Chain, bridge the gap between internal capabilities and opportunities in the competitive landscape analyzed in Five Forces.

By subdividing an organization into its key processes, functions activities, Porter was able to link classical accounting to strategic capabilities by using value as a core concept, i.e. the ways a company can best position itself against its competitors given its relative cost structure.

Porter's strength was to condense this activity based cost analysis into a generic template consisting of five primary activities and four support activities as shown below.

Primary activities

Inbound logistics cover materials handling, warehousing, inventory control, transportation.

Operations include machine operating, assembly, packaging, testing and maintenance.

Outbound logistics cover order processing, warehousing, transportation and distribution.

Marketing and sales includes advertising, promotion, selling, pricing, and channel management.

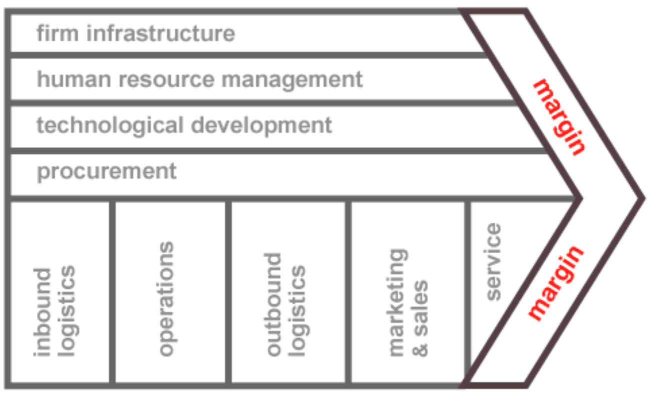

Figure 27 Value chain

Services include installation, servicing, spare part management.

Support activities

Firm infrastructure covers general management, planning, finance, legal, investor relations.

Human resource management cover recruitment, education, promotion, reward systems.

Technology development cover research & development, IT, product and process development.

Procurement covers purchasing raw materials, lease properties, supplier contract negotiations.

The Value Chan analysis can be divided into following three steps:

- Step 1 Clarify activities for AHC Crane development
- Step 2 AHC crane cost structure and earning potential
- Step 3 Interface between internal and external value chains.

4.5. Core competence

Core competencies are those capabilities that are critical to a business achieving competitive advantage. It is the result of a specific unique set of skills and/or technologies that deliver value to the customer. (Wiki c. c., 2011)

Analysis of core competence starts with the value chain analysis. The core competence can be expanded (or limited):

- Vertically:
    - Upstream, towards suppliers value chain
    - Downstream, towards customers value chain
- Horizontally:
    - Increasing market share, example closer integration with competitors
- Related:
    - Related use of the core competence

The above alternatives can be achieved by:

- Own development
- Acquisitions
- Close cooperation (example Joint Ventures)
- Market relations

Michael Porter has argued that a company's strength fall into one of the two headings:

- Cost leadership
- Differentiation

Cost leadership means that the company is a low cost producer in an industry for a given quality. Differentiation means that the company delivers unique attributes that are valued by customers and willing to pay more than similar attributes delivered by competitors.

In addition to the two headings above the "focus" is alternative three. Focus concentrate on a narrow segment (market) and within that segment attempts to achieve either a cost leadership of differentiation.

The three alternatives are named Porter's generic strategies since they are not company or industry dependent.

4.6. SWOT

SWOT analysis is a method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a company. It involves specifying the objective of the company and identifying the internal and external factors that are favorable and unfavorable to achieve that objective. The technique is credited to Albert Humphrey (1960/70). (Wiki S. a., 2011)

A SWOT analysis starts with defining a desired end state or objective and is presented according to the following structure:

- **Strengths** are internal characteristics of the business or team that give it an advantage over others in the industry.
- **Weaknesses** are internal characteristics that place the firm at a disadvantage relative to others.
- **Opportunities** are external chances to make greater sales or profits in the environment.
- **Threats** is external elements in the environment that could cause trouble for the business

The elements in the SWOT analysis can be compared with the elements in "From Cluster to core competence" analysis as shown below.

SWOT	From cluster to core competence
External:	*External:*
Opportunities and Threats	Cluster (Industry) & Competition
Internal:	*Internal:*
Strengths and Weaknesses	Value Chain- and Core Competence

4.7. Value chain – TTS

Introduction

A brief summary of TTS organization and TTS history as AHC crane supplier is described.

The business mission for TTS group gives guidelines for preferred value chain. The mission is presented in addition to correspondent mission for AHC cranes.

With reference to the theory for value chain, the activities for AHC crane development (step 1) is defined, followed by cost structure (step 2) and interface between internal and external value chains (step 3).

TTS Group

TTS Group ASA is an international group that develops and supplies handling equipment for ships, ports and offshore oil and gas installations. Operations are organized into the business areas Marine, Energy and Port and Logistics. TTS is among the world's leading suppliers within its market segments.

At the start of 2011, the TTS Group had 1 250 permanent employees (not including associated companies), with a primary emphasis on engineering skills. The group has operative units in 15 countries: Norway, Sweden, Finland, Germany, the Czech Republic, Italy, Greece, China, USA, Canada, Mexico, Brazil, South Korea, Vietnam and Singapore.

TTS Group ASA's head office is located in Bergen, Norway, and the company is listed on the Oslo Stock Exchange since 1995.

The annual turnover in 2010 was 3 240 MNOK.

TTS Energy Division is a supplier of high performance drilling and offshore & subsea equipment to the international energy industry and offshore.

The business unit "Offshore and Subsea Handling" deliver:

- Offshore Cranes
- Offshore & Subsea Winches
- A-Frames

  In addition for above:
- Services

The AHC cranes are a part of "Offshore Cranes".

The current organization of TTS with the three divisions was established in the beginning of 2010. Before 2010 marine- and offshore cranes was in the same business unit.

TTS became a supplier of offshore AHC cranes in 2000. As a result of agreements entered into in connection with an acquisition in 2002, TTS has not been an active player in the offshore cranes market for bigger offshore cranes between 2002 and 2007. In 2007 TTS acquired a software company related to AHC technology and was back in the AHC crane market.

The home page to TTS (www.tts-group.no) include "The Spirit of TTS" with the following description of business mission:

"TTS is a global corporation that develops markets and supplies complete material handling and drilling equipment systems for ship-owners, terminal operators, oil and gas companies and the international energy industry that meet markets requirements and expectations, and contribute toward increasing our client's productivity and profitability."

TTS's resources are focused on design and engineering in addition to purchasing, project management, assembly, testing and training. After sales and services are business areas of very high priority.

With reference to" TTS-Business mission" the same can be described for AHC cranes as shown below:

TTS develops markets and supplies AHC crane systems for ship-owners that meet markets requirements and expectations, and contribute toward increasing the ship owner's productivity and profitability.

TTS's resources are focused on design and engineering in addition to purchasing, project management, assembly, testing and training. After sales and services are business areas of very high priority.

Comments:

The mission gives clear guidance for the value chain with focus downstream towards the customer. Assembly is a part of the values chain, while this is not the case for production.

After sales and services is of very high priority. The same with the testing and training which is the end-delivery from new building to after sales and services.

4.7.1. Step 1 Clarify activities for AHC Crane development

The business unit "Offshore and Subsea Handling" deliver:

- Offshore Cranes
- Offshore & Subsea Winches
- A-Frames

  In addition for above:

- Services

Offshore & Subsea Winches and A-Frames (new building) are based on the same value chain. Services on another, this is not a part of the thesis and is not to be evaluated.

The value chain for new building can be divided as shown below:

- Support activities – New building
  - General Management
  - Sales & Marketing
  - Finance & Accounting
  - Technological development

- Primary activities – New building
  - Project Management
  - Design and engineering
  - Procurement
  - Assembly
  - Shipping
  - Testing& Commissioning
  - Training

4.7.2. Step 2 AHC crane cost structure

For an AHC crane new building company like TTS, the cost structure (normalized to 100 MNOK) can be as shown below:

Company - Newbuilding			
Operatrional revenue, costs and margins			
	1000	%	
Description	NOK	Costs	Margins
Revenue	**100 000**		
Material costs	-70 000	-70,0 %	
CM0	**30 000**		**30,0 %**
Direct personnel costs	-10 000	-10,0 %	
CM2	**20 000**		**20,0 %**
Direct overhead costs	-5 000	-5,0 %	
Gross Margin	**15 000**		**15,0 %**
Indirect overhead costs	-5 000	-5,0 %	
EBITDA	**10 000**		**10,0 %**
Depreciation/amotrization	-1 000	-1,0 %	
EBIT	**9 000**		**9,0 %**
Net financial costs	-500	-0,5 %	
EBT	**8 500**		**8,5 %**
Tax cost (28% of EBT)	-2 380	-2,4 %	
Net margin	**6 120**		**6,1 %**
Control:			
Total Costs	-93 880	-93,9 %	
- Net margin	-6 120	-6,1 %	
Total	-100 000	-100,0 %	
Operational costs:			
Direct personnel costs	-10 000		
Direct overhead costs	-5 000		
Indirect overhead costs	-5 000		
Total operational costs	-20 000		

Figure 28 AHC crane company - Revenue, costs and margins

With revenue of 100 MNOK, 70% correspond to material costs, which include all external costs related to the AHC crane projects.

The total internal operational costs correspond to 20%, of which 10% is direct personnel costs, 5% direct overhead- and 5% indirect overhead costs.

The direct personnel costs are typically booked towards the projects based on an hourly rate.

The classification of overhead costs is done on the basis of function. This mean that the overhead cost is categorized as either direct or indirect on the basis of its allocation to the cranes (primary activities) or support activities. Both direct- and indirect costs include their relevant part of other (than personnel) company costs, like facility-, software/IT insurance costs with more.

Contribution Margin Zero (CM0) corresponds to difference between revenue and material costs.

The difference between Contribution Margin 2 (CM2) and Gross Margin is pending on the hourly rate used and principle for booking hours towards the projects. In theory the hourly rate can include the direct overhead costs which give CM2 equal Gross Margin. The example above is in the middle.

Earnings before Interest, Tax and Depreciation (EBITDA) take into account material costs and total operational costs (except depreciation), equal 10% in the example above.

For an engineering company the fixed asset is limited. If the intangible asset also is limited the depreciation is also low, typically 1% as shown in the example, which gives EBIT equal 9 %.

The AHC crane projects have close to neutral cash flow. If the equity finances the total asset and a limited stock the net finance costs are small, 0,5 % in the example.

With a Norwegian tax of 28% the Net Margin in the example correspond to 6,1 %.

For an AHC crane newbuilding company like TTS, the cost structure for the cranes (normalized to 100 MNOK) can be as shown below:

Project			
Sales/contract price, costs and margins			
	1 000	%	
Description	NOK	Costs	Margins
Sales prices	**100 000**		
Steel (with more) 1)	-30 000	-30,0 %	
Hydraulic components	-24 000	-24,0 %	
Electric components	-4 000	-4,0 %	
Assembly	-4 000	-4,0 %	
Shipping	-3 000	-3,0 %	
Traveling	-2 000	-2,0 %	
Warranty/classification	-3 000	-3,0 %	
Total material costs	*-70 000*	*-70,0 %*	
CMO	**30 000**		**30,0 %**
Direct pers. costs	-10 000	-10,0 %	
CM2	**20 000**		**20,0 %**
1) Steel (with more):			
Steel, slewing ring/Gear, wire ropre,			
mechanical components for crane and winch			
Direct costs:			
Project Management 2)	-2000	20,0 %	
Procurement 3)	-2000	20,0 %	
Design & Engineering	-4500	45,0 %	
Testing & Commisioning	-1500	15,0 %	
Total direct costs	*-10 000*	*-100,0 %*	
2) PM and documentation			
3) Purchase, follow up the production, transportation and stock.			

Figure 29 AHC cranes – Contract price, cost and margins

As described for the company the CM2 is pending on definition. However, the same definition must be used for the projects as shown above.

The largest external cost element is related to steel (30%) with more (see definition above). Internal, design & engineering is the largest, of which the largest portion is towards steel.

The hydraulics is also a quite large part (24%). However, the portion of design & engineering is relative low.

The next cost elements, the electric components, are not the biggest in size (4%), but in this part you also got the control system, and this is also mentioned as a one of the challenges. The portion of design & engineering is relative low.

The assembly part is also important (4%). Good assembly facilities and routines can increase the reliability as the chance for error is decreasing when good systems are in place.

The AHC cranes can be several hundred tones. Assembly close to main customers can therefore be sensitive for the shipping costs.

With follow up from Norway the traveling costs are also of some extent. The same with classification costs. A complex product like AHC cranes gives some level of warranty costs.

The table above can be reorganization according to the value chain and primary activities as shown below:

Project			
Value chain - primary activities			
Sales/contract price, costs and margins			
	1 000	%	
Description	NOK	Costs	Margin
Sales prices	**100 000**		
Primary activities:			
Project Management	*-2 000*	*-2,0 %*	
Design & Engineering :			
- D&E	-4 500		
- Warranty/classification	-3 000		
Total D&E	*-7 500*	*-7,5 %*	
Procurement :			
- Procurement	-2 000		
- Travelling 2)	-500		
- Steel/hydr./Electric	-58 000		
Total Procurement	*-60 500*	*-60,5 %*	
Assembly 1)	*-4 000*	*-4,0 %*	
Shipping 1)	*-3 000*	*-3,0 %*	
Testing & Commissioning:			
- T&C	-1 500		
- Traveling 2)	-1 500		
Total T&C	*-3 000*	*-3,0 %*	
Training	*0*		
Total Primary activities	*-80 000*	*-80,0 %*	
CM2	**20 000**		**20,0 %**
1) The puchase is part of procurement responsibility			
2) Travelling simplified distributed			

Figure 30 AHC crane – value chain and cost structure

As shown the internal activities are small in values, but essential for the crane.

All experience shows that focus on project management, reduce costs and improve quality. For the AHC cranes documentation also is important (included in project management).

The design & engineering is the main internal activity and most important for the reliability for the crane. God design & engineering secure a smooth approval of the crane and a minimum of warranty costs.

Procurement is the activity with the largest correspondent costs. A professional procurement function can participate to reduce costs.

Smooth assembly secures reduced delivery time and lower total costs. The assembly site must manage changes and corrections of the cranes when needed.

Shipping of large and heavy structures like an AHC crane can be a challenge. Good planning and execution secure delivery time and reduce risk for break down, which than can become a major problem.

Testing & commissioning is a very important activity. Mistakes and possible improvements can be found and corrected. This is much cheaper than to be done later. However, most important, increase reliability and customer satisfaction.

Training is not typically a part of a newbuilding contract since the contract is towards the yard, not the user of the crane. Training can be included as an option. It is important for TTS that the user orders enough training.

4.7.3. Step 3 Interface between internal and external value chains.

Vertically, upstream the main suppliers are related to steel structure (crane and winch), slewing ring and hydraulic components. TTS have “long term agreements” with some (not may) suppliers.

Assembly is an important upstream activity defined as a key element in TTS group mission. In Fare East assembly is performed by a 100% owned TTS-company in China. In Europe the assembly is performed by some suppliers, based on long term agreements.

Vertically, downstream, training, simulation and Services are interface to customer (user) of the AHC cranes.

Horizontally it is no agreements regarding external cooperation with other AHC crane suppliers or related use of core competence.

4.8. Core competence – TTS

The result from the market analysis shows that the main focus for the customer is on getting a crane that has a high reliability. Good performance is also a requirement; it must perform within the specifications that are pre-set. What technical solution that is behind the crane is not important. Better performance is only important as long as it does not affect the reliability. The result indicates though, that the reliability may not be as high as it maybe should be, regardless of supplier, this makes the requirements for a good support organization almost as important as the reliability. When it comes to the AHC cranes it is essential that when they are in operation they work 100 %. There cannot be any failures if the crane is loaded. A good support organization have to be able to give support when needed, it must be willing to store the most common parts, and it must be able to support in remote located areas.

One can summarize the analysis

1. Reliability, a high reliability is the most important feature for an AHC crane.
2. Good support organization, high availability of support personnel, and good access to spare parts are is highly valued
3. Price, if the crane solutions are on the above, then price will be decisive.

When looking at the core competence of TTS, I am in this thesis only looking at the downstream part, the part that can be connected to the customer's value chain. One can say that TTS are selling a product after their "own development". If we are to define the strength of the company, and try to put it in one of Porter's categories, the category that fits TTS best is the "differentiation" category. TTS develops their own solution, and deliver a unique product that is valued by the customers; price is as mentioned above secondary to the reliability. In these markets one does not compete on price but on developing their own solutions (ref summary of analysis above).

For an offshore crane and especially the AHC cranes that operates with delicate equipment offshore it is essential that the crane is working at all times. The results from the analysis can indicate that this is not always the case and that. The problem areas are mentioned in the analysis and lies within the control system, hydraulics and the assembly process. These areas can also be said to be the areas where TTS have their core competence. This can indicate that there are potential for improvements in these areas.

When looking at the cost elements of the crane one can see that steel is one of the biggest elements. This area may not be the area to help enhance the reliability, but this can be an area of cost reduction and to help lower the price of the crane.

The design and engineering part of the cost structure is relatively small. In this area there can be more beneficial to put in more effort. Here one can gain both on the quality and the costs. By eliminating errors early in the process one can ensure a more dynamic and clean process without delays. This can increase product quality, but also cut the costs by eliminating unwanted changes late in the project.

By increasing the reliability of the moving parts on the cranes, e.g. the hydraulic system, you can increase stability by giving more attention to this part. It is a relatively large cost element, but the gain of getting these components to function reliable can big. The gain is not only technical, that you can get a more reliable solution; you can also cut the costs. This is next biggest cost element, hence this may be one of the areas where one can cut costs.

The control system is also essential. This is a small cost element and one can in the big picture put more funds into this element without have affecting the total costs of the crane too much.

The last one is the assembly process; this is mentioned as problem as well. By increasing this part you can increase the overall quality of the cranes, by investing in a good assembly process, with good procedures, close proximity to the supplier of materials so you can follow them up closely to ensure quality in every link, you can raise the quality of the complete product.

The cost of testing and commissioning is also a very important element. Mistakes and improvements can be found and corrected. This is much cheaper than to be done later, but most important, is to increase reliability and customer satisfaction

The last element training is also an important part.it may not have a great effect on the reliability, but by increasing the training one can build good relations to the customers that again can create value.

Today TTS' core competence or core know-how can be said to lie within the fields:

- Crane control and safety system (CCSS)
- Hydraulic system
- Engineering interfaces and assembly interfaces

Today, TTS Energy has a division working on the control system. The systems get developed to better satisfy the customers wishes, and to make the system more user friendly. They are also working on developing simulation tools for training of personnel. Currently is this only for drilling equipment, but can be adapted to crane systems as well. The user interface is also under constant development to make the cranes easier to operate.

The engineering and assembly interfaces of the cranes is also a big part of the core know how of TTS. A lot of work and effort is put in to create the crane system that TTS sell. The focus on this part should be to improve the reliability of the cranes as much as possible.

Another area that TTS have expertise is when it comes to support and service. This is a major part of the aftersales and services part that follows after selling a crane. From the results of the analysis, this stands out as an essential part of the organization. The ability to support both quick and that you have the spare parts needed is mentioned as very important for the customers.

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Appendix A

Summary telephone interview/meeting, Kenneth Walland 30.05.2011.

The base of the meeting was a mail sent earlier, regarding his thoughts about what is important when procuring an AHC-crane.

The main focus was on the areas:

- Price
- Maintenance
- Performance
- Reliability

When procuring an AHC-crane, the first that is put out is a crane specification to the yard who is building the ship. This specification is then put out to multiple suppliers of cranes, who again send back an offer if they can fulfill the order. When this is over, the yard has some alternatives to choose among. The AHC cranes are often the most important equipment on the ship, sometimes the ship is built only for this equipment. The AHC cranes are complex cranes that have relatively low reliability regardless of supplier. So it becomes a major problem for the ships, and shipping companies if the crane stops working in the middle of an operation. So the most important issue is that you have a high reliability, this is by far the most important issue. But as mentioned, the cranes can be quite unreliable and this requires a good support system that can be on the spot when needed. So the availability of service personnel is almost as important as good reliability. A result of this is also that the organization has good quality control, this helps to increase the quality of the whole organization. If these criteria’s are equal, then price is important. Performance is also important, but if the cranes do not satisfy the specification they will not be considered.

Appendix B

Mail-correspondence with Knut Lussand 31.05.2011

Kristian,

Fikk denne oversendt fra Knut Arne.

Våre vurderinger når AHC kran skal anskaffes kan kort sammenfattes som følger:

1. Driftssikkerhet, pålitelighet og
2. en godt utbygget serviceorganisasjon som er i stand til å yte service også i vanskelige områder som Vest Afrika og Brasil. og
3. at kranleverandøren er villig til å holde lager av alle kritiske deler, enten hos seg selv eller hos underleverandører. Kritiske deler som har lang leveringstid og som kranleverandør ikke har på lager må vi ha på lager selv.
4. Kranprodusenten må i størst mulig utstrekning bruke standard, lett tilgjengelige komponenter på alle sine kraner slik at lagerhold av reservedeler forenkles.

Kranens presisjon er også viktig men dette er godt ivaretatt på alle de kranene vi har.

Pris og betalingsordning er kun avgjørende når valget står mellom kranleverandører som er likeverdig med hensyn til pkt 1,2,3 og 4 ovenfor.

Mvh

Knut

Appendix C

Summary, meeting with Stig Espeseth ICD, 27.04.2011

The base of the meeting was to get an insight into the PC based control system solution, and to get their views in the PC vs. PLC debate.

ICDs PC based solution is called CDP, Control Design Platform. It is a block base system that minimizes the development time for new control systems. One can when using this system start at a "higher" starting point when developing new control systems. In the CDP the packages are already made, and it just for the developer to drag and drop the different features needed in the control system. The system supports the most common operating systems, and also supports hard real-time requirements through `RTOS-32. The system can also be interfaced to different hardware and software protocols. Even old PLC system can be connected to the CDP.

Unlike PLC that runs like one big program for the whole system, the CDP divides the system into components. This makes the CDP able to run bigger and more complex systems faster. Instead of running one program over and over, you divide it into many small ones.

Each of the components in the CDP system consists of a state machine, this is a device that stores the status at given time, and can operate on input to change status and cause and action or output to take place for any given change.

The system is also easy to simulate before installing it, this helps to debug and test it to avoid system failure when installed.

The CDP has both advantages and disadvantages. Let's start by looking at the advantages;

- The ability to choose your own hardware supplier, you are not forced to use only one provider.
- The opportunity to follow the developments on the hardware side and be independent of suppliers.
- You can avoid expensive licensing schemes.
- Runs on most operating systems
- Easy to use because of the block buildup of the CDP system, saves time during the development process.
- Support for real-time requirements

- Very suitable for advanced and complex systems. Divides the processes into smaller ones to lower the time execution time. The ability to run multiple program codes simultaneously, instead of one large.
- You can split the programs, this gives a high amount of flexibility
- Easy to simulate before you install the control system.
- Redundancy is available for all parts of the system.
- It’s a flexible system that quite easily can be related to newer technology and preserve the system knowledge of the organization.
- Easy to connect to the system remotely and make adjustments and modifications.
- In progress of developing video detection systems, that might be able to make the systems safer.
- Better GUI- tools are on their way.

Disadvantages of the CDP system

- The computer might not be as robust. Especially regarding vibrations and temperatures.

It’s also a risk that the discs might get full and crash

Appendix D

Summary meeting with Alv Nepstad 05.05.2011

The base of this meeting was to know more about the old AHC systems, and also to hear about his experiences regarding PC vs. PLC.

The system was an open loop system. When working on the cranes they never experienced that the system was inadequate when it came to performance, even for the most discerning customers. If you tuned the system good enough, you would get it to perform within the limits that were set in the specification given by the customer.

During the period when working with the cranes he also did a study on the PC vs. PLC debate. They here concluded that in most cases the PLC solution works more than good enough, and especially for crane systems the PLC is more than good enough. It was also cheaper and the organization surrounding the PLC was bigger, so the access to professionals if something went wrong was found to be better for the PLC solution.

Appendix E

Summary meeting with Njål Aarsland 06.05.2011

The base of this meeting was to get a better insight into the PLC solution and why this was considered a better alternative than the PC solution. A short summary is given in the mail beneath.

Når det gjelder fordeler og ulemper med PLC vs PC er våre argumenter for å velge en PLC løsning følgende:

Functionality
Scalability
Industry standards
Open standards (development language, networks)
Long life cycle / availability (10 years as spare parts after EOL)
Well known, proven and robust
High temperature and vibration specification (no moving parts)
Rapid development
Standardized development and diagnostics tools
Global availability of skilled resources
Robust vendors with a large customer base
Local and global support

I applikasjonene vi leverer så møter vi ingen begrensinger ved å benytte PLC løsning. Funksjonsmessig kunne vi uten tvil løst de samme oppgavene med en PC basert controller og samme type industrielle IO systemer som vi har på PLC systemet. Vi benytter PCer for HMI (Human Machine Interface) applikasjonene vi leverer for å betjene maskinene vi leverer. Ut fra våre erfaringer med bruk av PC, mener vi at de største ulempene med PC basert control er følgende:

Stability
Short life cycle for PC parts
Proprietary software applications
Availability of skilled resources to support application

Best regards Njål Aarsland

Appendix F

Summary telephone interview Leif Reidar Vespestad, 06.06.2011

The important aspects when procuring a crane is the

- Reliability
- Ability to provide good support
- Performance
- Price

That the company can provide a reliable crane is the main priority. Reputation and own experience is the main method of deciding which supplier to go for. It is also important that the supplier can provide good support if something goes wrong.