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Abstract

Rig contracts represent the leading expenses in a drilling operation. The high rates and rig shortage are factors that make it urgent to come up with ways to increase the efficiency of drilling operations.

The objective of this thesis is to investigate through different literature sources how contract strategies can be used to increase the efficiency of drilling operations.

Three contract strategies have been studied, which are contract types, incentives and KPIs.

Contract types affect efficiency indirectly by improving teamworking quality, resulting in a performance improvement. Likewise, incentives affect performances indirectly, since it improves relational attitudes, leading to a better teamworking quality, which finally will result in improvement of performance.

It was concluded that KPIs are the best tool to increase the efficiency of drilling operations. The natural competition between contractors, caused by comparing their KPIs, will result in efficiency improvement. KPIs will also lead to a reduction of nonproductive time by identifying and eliminating Invisible Lost Time (ILT).

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1. Introduction

Drilling operations are project in which most of the activities realized are outsourced to drilling contractors and service companies. Drilling contractors provide rigs and personal to carry on with the main drilling tasks. Service companies will contribute with activities such as well logging and drilling fluids preparation.

Rig contracts represent the leading expenses in a drilling operation. With the stabilization of oil prices and increase in offshore activities, day rates in Norway lately became one of the highest worldwide. The prevision for the next years is that day rates may cost more than $300000 in the Norwegian market, marking a recovery in the mobile offshore drilling industry (Magazine, 2019).

Besides the high day rates, there is also a shortage of rigs available. In 2019 there are already 3808 days of unfulfilled rig demand, which means that operators are planning drilling operations but there are no available rigs to execute the projects (Magazine, 2019). The high rates and rig shortage are factors that make it urgent to come up with ways to increase the efficiency of drilling operations.

This thesis aims to investigate three contract strategies that can be used to improve the efficiency of drilling operations, which are contract types, contractual incentives and KPI analysis.

Contract types define how the contractor will be remunerated and who will carry most of the risk during the operation. The most known types of contracts used in drilling operations are turnkey contracts, day-rate contracts and footage contracts.

Contractual incentives are used to improve efficiency in many different aspects of the operations by giving rewards or incurring penalties to contractors according to their performance.

Lastly, KPI analysis are used to set targets and measure the most important performance factors in an operation.

2. Objectives

The objective of this thesis is to investigate contract strategies that can be used to increase the efficiency of drilling operations. The methodology used was literature researches in books, articles, webpages, magazines, etc.

The theory chapter will present an overview of the theoretical aspects involving project management, planning phase of drilling operations, project management tools used in drilling operations and the main trends in drilling operations realized in the Norwegian continental sea.

Chapter 4 will be present different factors involving contract management followed by chapter 5, that presents the main factors impacting the negotiation process of rig contracts.

Furthermore, the main contract strategies chosen as possible influencing factors to increase the efficiency of drilling operations will be described in chapter 6.

Finally, a discussion about how each contract strategy affects the effectivity of drilling operation will be presented

3. Theory and fundamentals

In this section, theoretical elements involving drilling operations will be discussed. First, a general overview of the main elements involving project management will be given. Second, the processes of planning drilling operations will be described. Then, the project management tools used in drilling operations will be discussed. Lastly, the trends in drilling operations in the North Sea will be mentioned.

3.1. Project management

Projects are unique processes consisted by temporary activities which are progressive elaborated, aiming to fulfill a defined goal.

The main difference between project management and functional or line management, such as business management, is that project management manages change, while functional management is focused in the continuity of operations (Lester, 2013).

The project life cycle is divided in four main phases. Each phase results in one or more deliverables, such as breakdown structures, cost estimating, end product or project evaluation. Dividing the project in phases facilitates monitoring its progress so that complex issues will not be neglected and there will not be waste of time, money and resources (Gardiner, 2005).

The following section will describe each phase of the project life cycle.

3.1.1. Initiation and definition

The first phase of a project is project initiation and definition. Its main objective is to carry out all the pre-planning and conception activities that will establish a basis for the next phases of the project (Gardiner, 2005).

According to Gardiner (2005), the main activities and deliverables resulting from the initiation and definition phase will be described below.

- Feasibility study and project assessment

Frequently, funds are limited, and an organization must therefore decide whether the project is worth investment. This is done by investigating the cost and benefits through a feasibility study and project assessment.

- Project scoping

Scoping is about identifying the project's requirement. In this process, the objectives and boundaries of the project will be defined in order to meet the needs and requests of the stakeholders. Projects are bounded by three main constraints, which are time, cost and scope/quality, forming the well-known project triangle. In certain industries a fourth constraint is introduced, which is safety. The priority order given to each constraint depends on the organization and on each individual project (Lester, 2013).

- Breakdown structures

Breakdown structures uses a chunking process to divide the project into smaller and more manageable parts, creating convenient and logical structures that facilitates management and communication. The types of breakdown structures used in project management are:

Product breakdown structure (PBS): It is used to define the product scope, which describes the components and elements that will result in the end product. This breakdown structure is mainly used when producing complex deliverables.

Work breakdown structure (WBS): It is used to define the project scoping by describing all the activities to be done throughout the project. Figure 3-1 illustrates and example of WBS.

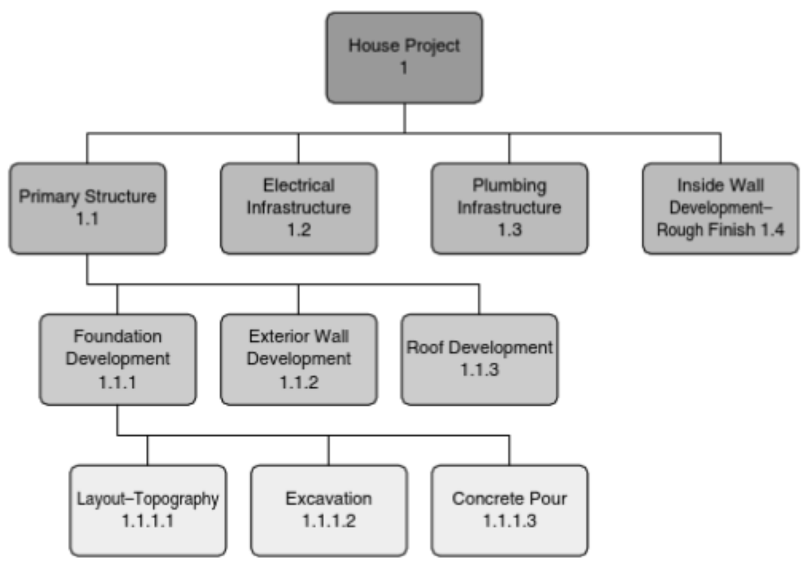


Figure 3-1 Example of a WBS (Norman et al., 2008).

Organization breakdown structure (OBS): It is used to the define all the human resources needed to carry out the activities in a project. Figure 3-2 illustrates an example of OBS.

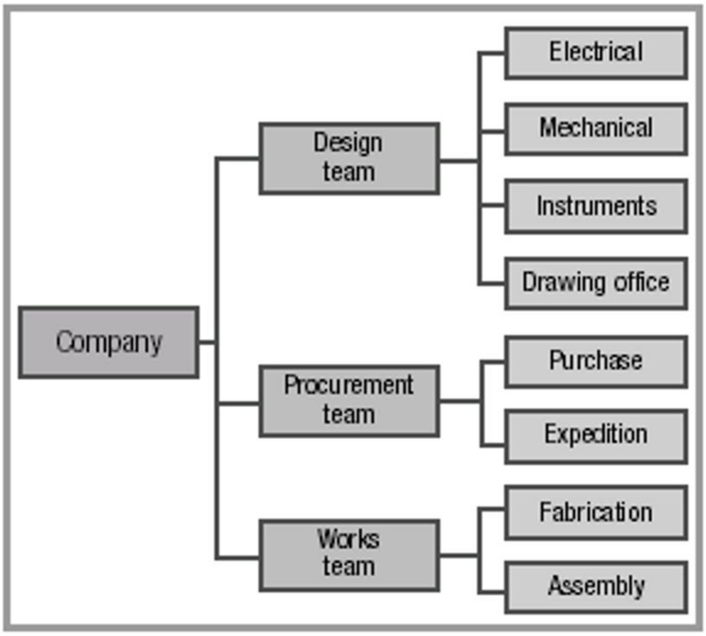


Figure 3-2 Example of an OBS (Gardiner, 2005).

It is extremely important to clarify where responsibilities lie in each part or task of the project. This will avoid confusion regarding tasks and reduce the possibility of tasks being left undone. Responsibilities can be defined by combining WBS and OBS.

- Project team building

Teamwork provides a level of progress much greater than the progress provided by individual members added together. The main objective of team building is making sure that every participant in a project team is moving towards the same goals.

Team building is essential in the initiation phase in order to lead projects in the right direction. However, team building is needed continuously throughout the project life cycle as there will be periodic inclusion of new personal according to the deliverables and activities to be accomplished at each phase. At each major milestone emphasis may change in such a drastically way that even key members of a team, such as the project manager, may be replaced for another one more qualified to lead the next stage of the project.

3.1.2. Planning and development

Planning and development is the second phase of a project life cycle, which will give basis to the execution and control phase. In this phase, all the required plans to support the development of the project will be created. In addition, all the resources required to carry out the execution of the project will be organized and mobilized. These resources may be people, equipment, knowledge, materials and so on.

The main activities carried out in this phase are:

- Project schedule

Scheduling is about forming a project network by linking activities to show the relationship between all the different activities that will be carried out in the execution phase. Through scheduling, the timing of activities and resource requirements will be established allowing milestone dates and project duration to be defined.

Common ways of estimating the duration of activities are using *historical date*, *timing activities by running trials* or using *probabilistic methods*. Eq.(**1**) shows the definition of the *weighted average technique* which is a frequently used probabilistic method to define the duration of activities.

$$\boldsymbol{Weighted\ average} = \frac{\boldsymbol{a + 4m + b}}{\boldsymbol{6}} \qquad (1)$$

In addition to duration, the relationship between activities must also be defined. Activities can be independent which is when one activity can be done at the same of other activities. However, there can also be dependencies between activities which is when the development of one activity affects another. Figure 3-3 shows that there are four types of relationships between dependent activities:

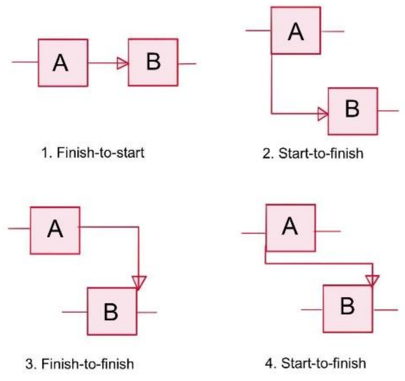


Figure 3-3 Types of relationships between dependent activities.

Tools such as network diagram and Gantt charts can be used to express the duration and relationship between activities. These tools are also used to identify the critical path of projects.

Critical path is formed by critical activities, typically characterized by the longest and most important activities, responsible for defining the expected duration of projects. If any activity forming the critical path is delayed, the whole project will be delayed. Identifying the critical path allows the project manager to plan and allocate resources for the project according to the level of criticality of each activity such that delays may be avoided.

- Project budgeting

Project budgeting is used together with project scheduling to allocate resources in advance to a project. The project budget results in a time-phased plan which is the summary of all the planned expenditures, revenues, and cash flow throughout the project life cycle. This helps the project manager to make sure the project is going on the right path and expenditures do not outstrip revenues.

The major processes included in project budgeting are resource planning, cost estimating and cost budgeting.

Resource planning is the process responsible for determining what types of physical resources (equipment, personal, materials) and quantities of each resource will be needed to perform the activities in a project. Allocating resources to activities enables the construction of histograms which can be used, for example, to identify when a specific resource is overallocated or underutilized.

Cost estimating is an assessment of the total expected cost of all resources that will be used to perform the project activities. It identifies and considers several different cost alternatives. The most used methods for cost estimating are analogous estimating, parametric estimating and definitive estimating. Analogous estimating uses actual costs of similar previous project as basis to define a cost estimative. Parametric estimating predicts costs by using the characteristics of the projects, such as volume, types of software code and weight. Lastly, definitive estimating uses the sum of cost estimative of individual work items to define a total cost estimative for a project.

Cost budgeting produces cash flow projections against time by relating cost estimates to project schedule. A cost breakdown structure (CBS) is then formed by combining the WBS and OBS. The CBS will be used as basis for the cost reporting structure of a project.

3.1.3. Execution and control

In the execution and control phase, all the gathered information and the plans developed in the previous phases will be implemented. This phase presents the highest rate of expenditure in a project, since all the allocated resources will be used. Changes may become inevitable as the project progresses and new information becomes available. The main activities happening in this phase are:

- Project monitoring and control

Project monitoring is done by collecting enough data to ensure that the project planning is been implemented correctly by the project team. Project control is a process which aims to make sure that the project deliverables are within the project's baseline, which is budget, schedule and scope/quality.

Project control can be implemented through formal or informal mechanisms. Informal mechanisms are exercised in small projects performed by small teams. Formal mechanisms are introduced in high risk projects when the expected cost of the control system does not exceed its expected benefits.

The effectiveness of the control system is measured by its traceability and average response time. Traceability is the ability of detecting the source of problems that may cause deviation. Average response time is the average time interval between the incidence of a deviation and its detection.

- Change management

A given amount of positive or negative deviations is expected when the execution phase starts in a project. The sources of change can be the client, the project team or external sources. Effective change management techniques must be applied so that project delays can be avoided or minimized, and performance can be improved.

The most important elements in a change management plan are:

1. Identification of factors that can lead to change in personnel, cost, schedule and quality.
2. Analyze how the identified changes will affect the project.
3. Develop a specific response strategy to deal with the change and its effects.
4. Communicate the response strategy to the client and obtain approval to implement it.
5. Adjust the project plan to account for the change.
6. Monitor the implications of the change.

- Milestone monitoring

Milestone monitoring is a simple method that uses milestones to control a project. It is based in the deadlines on which each milestone is supposed to be achieved and the budgeted cost of the work need to achieve it. It is not as detailed or effective as the traditional monitoring methods. However, it does not require as much sophisticated costs, time or accounting techniques as the other methods.

- EVA

Earned Value Analyses (EVA) is a cost and schedule control that detects deviations between the planned performance and the actual progress. It is done by comparing the budgeted cost of work performed (BCWP) against the budgeted cost of work scheduled (BCWS) and the actual cost of work performed (ACWP).

3.1.4. Closure

The closure phase represents the end of a project, when the project budget is closed so that there will be no more expenditures. In this phase all the documentation will be completed, the personal will be released and every contractor and supplier that took a part in the project will receive their final payments. In addition, the final product obtained throughout the project will be transferred to the custody of the owner.

Project closure should be planned already at the planning phase of projects. To complete this phase in an efficient manner, closure activities should be an ongoing process throughout the project lifetime.

The main processes going on in the closure phase are:

- Closure plan

The closure plan does not have a predefined format, it varies according to the requirements of the firm, the client and the contract. The first goal of the closure plan is to assure that there will be a budget for closing activities so that there will not be a need for using the contingency budget to support the closure phase. In addition, the team member should be made aware about their roles and responsibilities during this phase.

- Final project evaluation

Evaluation is a continuous process which examines the progress made throughout the project lifetime. Formal evaluation processes can be done at major milestones or at specified intervals. The project closure is the last major milestone to be evaluated, providing the opportunity to capture experiences obtained throughout the project, improvement in project management methodology and the opportunity to recognize and reward the efforts of the personal.

3.2. Planning drilling operations

The planning phase is the most important part of the drilling operation, ensuring safety and economic feasibility. One of the main objectives of this phase is identifying and addressing factors that may affect the process directly or indirectly. In addition, the planning aims to enhance the success of the operation by drilling with safety and efficiency in compliance with governmental rules and regulations. The team required for developing the planning phase is formed by drilling engineers, supervisors, superintendent, geologists, production and reservoir engineers (Azar and Samuel, 2007).

This phase of a drilling operation is subdivided as:

3.2.1. Licenses and contracts

The planning phase begins once target formations with defined depths are pointed out by geologists as possible sources of hydrocarbons. However, before the initiation of the drilling operations, the companies responsible for exploring the subsurface need to obtain governmental licenses in order to drill the site. The companies that obtain drilling rights are called operators. Operators will then designate companies that will be responsible for the production of oil and gas, granting them production licenses. In the Norwegian shelf, there are 39 companies responsible for the execution of drilling operations, 25 of these are operators (Norwegianpetroleum, 2019).

Most of the production companies will not use their own personnel and equipment to execute the drilling-related activities. Drilling contractors will therefore be hired, providing drilling services and staffs. In addition, service companies will also contribute to the execution of operations providing specialist services, such as mud logging and directional drilling (Haavik, 2010).

Drilling contracts specifies the start and finish date of wells and the costs involved in the operations. There are three types of drilling contracts. In *Day-rate contracts* all the risk is carried by the production companies since the costs are based on the amount of days it takes to drill and complete a well. In *turnkey contracts* all the risk is carried by the drilling contractor since a fixed price will be charged for drilling and equipping wells. Lastly, in *footage contracts* the risk is shared between the production company and the drilling contractor as the operation costs are based on the depth of wells (Fanchi and Christiansen, 2016).

3.2.2. Data acquisition and analysis

The quality of the planning depends on the completeness of the acquired data. Well proposal is the first step in data analysis, containing the objectives and predicted timescale of a well. Some of the most important data to be acquired are: precompletion and completion requirements, perforation types and intervals, simulations of the operation, temperature and pressure during production, and so on (Devereaux, 1998).

3.2.3. Well design

In this planning phase, all the features of the well design will be discussed and defined. These features may include the choice of well types, casings, wellhead, Xmas-tree, completion design, and so on. Factors such as surface topography, subsurface characteristics and planned depth of wells will exert great influence in the chosen features of the design (Devereaux, 1998).

3.2.4. Writing drilling programs

Drilling programs will define methods that will be used to implement the well design safely and efficiently. Drilling programs can be subdivided as mud program, drill bit program, drill string program, hydraulic program, casing, cementing and well control program (Devereaux, 1998).

3.2.5. Well cost and duration estimation

The cost and duration of the operation will be greatly impacted by the depth and complexity of wells. Complex wells are those drilled in a subsurface that presents a great level of variation in the formation properties. The cost of the operation will then increase proportionally with the degree of variation between each formation encountered during drilling operation. Likewise, the cost of drilling operations increases proportionally with the depth of the wells (Fanchi and Christiansen, 2016).

Azar and Samuel (2007) defines well cost and duration estimation mathematically respectively according to Eq.(**2**) and Eq.(**3**):

$$\boldsymbol{Cwdo = Cd + Co} \qquad (2)$$

Where:

Cwdo = total well cost

Cd = cost of drilling a well including only bit and rig rental.

Co = all the other costs of drilling a well, such as mud, casings, cementing, and so on.

$$\boldsymbol{Tti = 2 * \left(\frac{ts}{Ls}\right) * Di} \qquad (3)$$

Where:

Tti = trip time needed to change a bit and resume operations.

ts = average time needed to handle one stand of drill string.

Ls = average length of one stand of drill string.

Di = trip's depth.

3.2.6. Resource planning

Before any project is executed, all the resources needed to implement the activities must be defined. In drilling operations, the resource planning phase may be divided in the following parts:

- Rotary drilling rigs

Rotary drilling rigs are divided in four systems: power system, hoisting system, rotation system and circulating system. The power system is usually formed by diesel engines that provides power to the other systems, especially to hoisting and circulating systems which require more power than the rotating system. The hoisting system is responsible for raising, lowering and suspending equipment in the well. The rotating system is used in the formation to cut the hole. Lastly, the circulating system is used to pump drilling mud inside and out of the borehole (Hyne, 2012).

Rigs are often owned by drilling contractors. Offshore rigs vary in form and size. The depth of the well is one of the main factors that will affect the decision about which type of rig will be used in the operation. The deeper the well, the heavier the rig must be, and more power will be required to execute the operation. Therefore, deep wells require large rigs. Water depth is also an important factor affecting the choice of rig types. Wells drilled in shallow water or swamps require barges rigs. For relatively shallow to a few hundred feet underwater, jack-ups will be the most indicated rigs. Semisubmersible rigs are required in a couple thousand feet underwater depth. For several thousand feet underwater, drill ships will be the best option (Fanchi and Christiansen, 2016). Figure 3-4 shows some of the different types of rigs used in drilling operations.

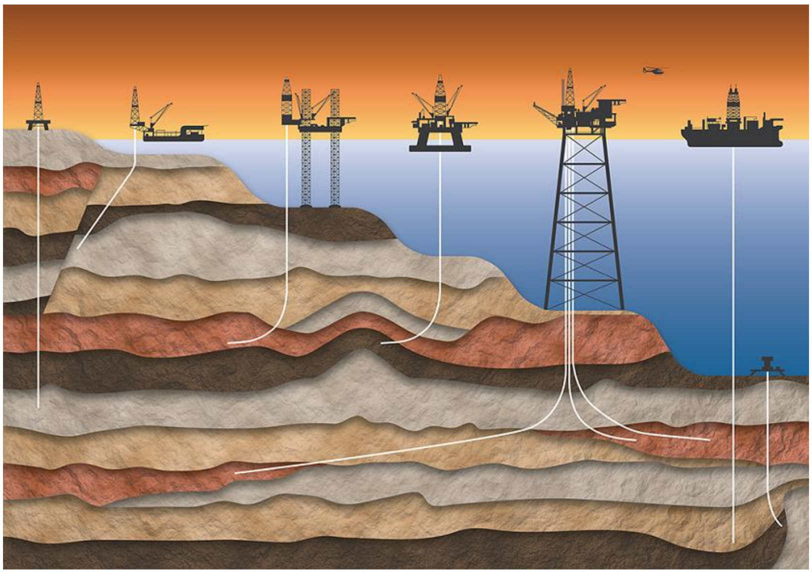


Figure 3-4 Types of oil rigs (Harry-Thomas, 2014).

The choice of drilling rigs is quite important when planning a drilling operation. The more a rig fits the purpose of an operation, less costs will be incurred in modifications and adaptations.

More details about drilling rigs will be addressed in section 5.3.

- Drilling fluids

Drilling fluids are one of the most important resources used during drilling operations. It refers to gaseous, liquid or gasified liquid substances used to perform a large amount of functions that will contribute to a successful drilling activity at the lowest overall cost. The main functions of drilling fluids are to remove drilled-cuttings, contain subsurface fluid pressure and stabilize the borehole. In addition, drilling fluids may be used to cool down and lubricate drill strings and drill bits, suspend desired solids and facilitate undesired solid removal, reduce the weight of casing and drill strings, help formation evaluation and clean the drill bit. There are two main types of drilling fluids: pneumatic and liquid drilling fluids. Pneumatic drilling fluids can be composed by dry air, mist, foam or gasified mud. Liquid drilling fluids can be composed by water, drilling mud, water-based drilling mud and oil-based drilling mud (Azar and Samuel, 2007). Service companies are responsible for providing specialists in drilling fluids.

- Drilling personnel

Drilling personnel can be divided into four main groups: The operator representative, onshore rig team, the drilling contractor staff and service personnel. The onshore rig team is responsible for writing drilling programs. The operation representative, also known as the company man, is responsible for tackling operational issues and keep the onshore rig team informed. The drilling contractor staff is formed by drillers, roughnecks, tool pushers and a derrickman who will execute the basic drilling services. The service personnel will provide specialist services in different areas such as drilling fluid services, drill bits, mud logging, cement, casings and directional drilling (Haavik, 2010).

3.3. Project management tools used in drilling operations

Section 3.3 will describe some of the most used project management tools in the Norwegian oil and gas industry.

3.3.1. Oracle Primavera P6

Primavera is one of the most used tools to manage drilling operations in Norway. It aims to provide integrated planning solutions across the entire operation cycle by presenting features that intend to reduce the duration of operations, mitigate risk, improve operational efficiency and contain costs. According to Oracle (2015), some of these features are:

- Resource optimization – Primavera provides a complete visualization of equipment and materials so that resources can be allocated in the most effective way.
- Analytics – It gives a view of all the portfolio activities, exposing risks so that they can be tackled in a proactive way.
- Supply chain management – It improves collaboration and coordination so that material shortages can be identified and quickly addressed. It also contributes so that alternate sources of supplies can be found.
- Contract management – It ensures an efficient contract documentation to facilitate record keeping and supports the preparation and negotiation of expedite payments. In addition, Primavera shortens waiting time for submittal approval and offers tools for management of subcontractors.

- Logistics and transportation – It gives a real-time resource visualization, making sure that the correct equipment is accounted for and delivered within the specified deadlines.
- Cost containment maximization – It provides functions such as *contract lifecycle management*, *bid management* and *bidder portal access* that will contribute to increase profit and reduce costs.

Figure 3-5 demonstrates how primavera can be used to develop Gant charts, which is a project management technique mentioned in section 3.1.2, used to express the duration and relationship between activities.

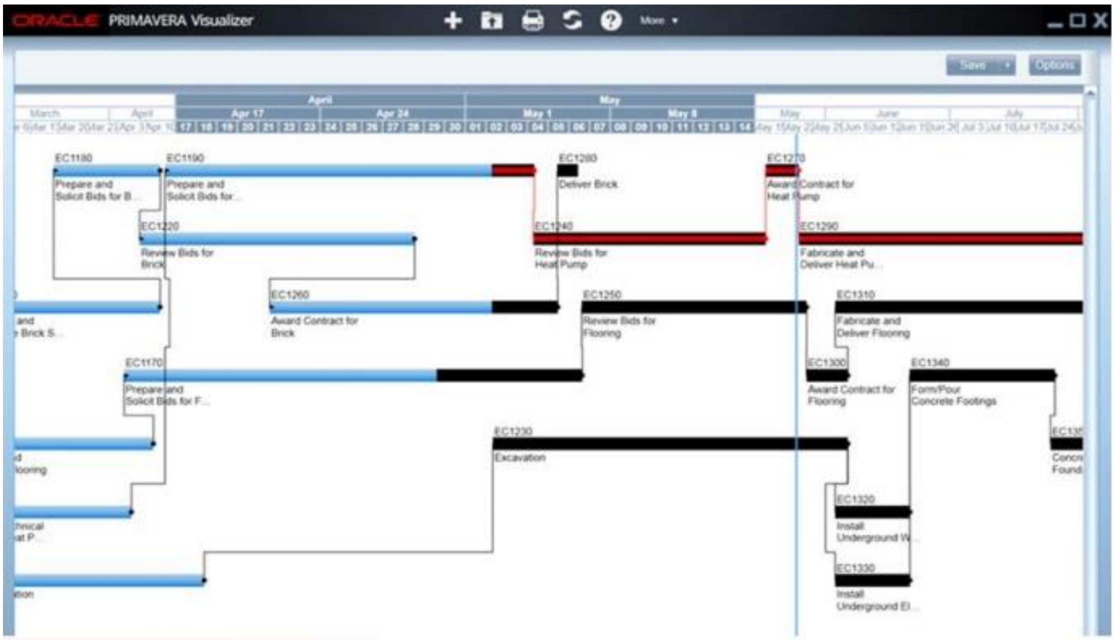


Figure 3-5 Gant chart created by Primavera (Oracle, 2015).

3.3.2. Microsoft Project

Also known as MS Project, this software is provided by Microsoft. It intends to help on keep track of projects, portfolios and resources. According to Microsoft (2019), MS project can be used in drilling operations in the following areas:

- Tracking drilling site readiness – MS project can be used to manage pre-drill tasks, from acquiring licenses to conducting assessments.
- Capturing front-end project information – MS project contributes in the development and capture of all the needed information about a new project.

- Scheduling crews and equipment – It simplifies and increase scheduling efficiency by building and managing teams based on standardized data. It can be used both with internal and contracted resources.
- Optimizing rig schedules – It maximizes value by identifying inefficiencies and scheduling drilling operations at the right time, for the right wells

3.3.3. SAP

SAP provides different types of enterprise software to manage operations and customer interactions. The main objectives of SAP in the oil and gas industry is using a digital network to connect personal, suppliers and customers; improving efficiencies; and strengthening agility, safety and cost control. According to the information found in SAP (2019), the main contributions of SAP in the management drilling operations are:

- Engineering – SAP 3D visual enterprise generator can be used to control design and engineering based on constantly actualized information.
- Project and portfolio management – SAP S/4HANA can be used to optimize management of projects and portfolios by monitoring and controlling capital assets, facilitating the management of risks, budget, costs and activities.
- Shutdown, turnaround and outages - SAP S/4HANA can also be used to improve transparency in costs and milestones by optimizing shutdown, turnaround and outages operations
- Project logistics - SAP inventory management contributes with respect to project logistics by optimizing resource scheduling and planning.

3.3.4. Standards

Recognized standards such as NORSOK and ISO presents regulations and describes in detail how things should be done, such that the Norwegian petroleum industry can operate in a safe and profitable way.

3.4. Trends in drilling operations on the Norwegian continental shelf

Every drilling site has different characteristics and there is no such a thing as a "Mondial manual for planning drilling operations", where one can foresee all the challenges that will be faced ahead. Therefore, it is fundamental to be familiarized with the environment before the start of the operation. This section will describe the aspects that must be taken into consideration when planning drilling operations in the North Sea.

3.4.1. Weather conditions

High-pressure intervening ridges, which can develop into anticyclones are one of the major influences regarding the weather conditions at the Norwegian continental shelf. In addition, the frequent travelling depressions, which are areas of low pressure, will cause a great impact on the weather conditions. Depressions will often follow the same track but suddenly change to another track. Consequently, the wind blows in different directions and at different force magnitudes, with velocities that can vary from 15 to 35 mph, reaching more than 65 mph during winter. Waves and swells created by the wind will also have different directions, resulting in cross-seas. In 1968, a platform called Ocean prince was destroyed by waves which raised to 50 ft (Harbek, 1969).

3.4.2. Marine characteristics

Tides and currents are negligible in the Norwegian continental shelf since they are not strong enough to affect the drilling operations. However, when the wind blows alongside the current, the sea may become choppy. On the other hand, the sea bottom is covered with boulders, gravels, sands and clays that are constantly shifting, creating a problem for anything that must be supported at this surface. Sand-bagging are therefore essential to support the foundation of jack-up rigs (Harbek, 1969).

3.4.3. Design requirements

Drilling rigs must be designed according to the conditions presented at the operation site. Firstly, every rig must contain storage capacity since there will be hazardous periods in which supply-boats will not be able to unload due to sea conditions. Therefore, a storage capacity for at least four weeks of food, potable and drill-water, cement, mud and bunkers supplies must be in place. There must also be space enough to fit a complete casing program and drill pipes. This will assure the continuation of operation, even under rough weather conditions. Periods of good weather can be used to load and unload supplies. In addition, anchoring systems are essential so that floating drilling vessels can endure against waves and swells during drilling operations. Anchor chains must have enough length and their links designed to prevent it to bend under tension (Harbek, 1969).

3.4.4. Regulations

The choice of drilling rig type, design, equipment and other aspects related to the operations must follow the recommendations set by working regulations in the country the operation will take place. In Norway, all the regulations regarding the oil and gas industry are described by the Petroleum Safety Authority Norway (PSA).

4. Contract management

Contract management is a process related to determining and negotiating the purchase, rental or lease of material, and products or services needed to implement projects. In this process, clients/buyers and contractors/suppliers will often have opposite viewpoints in areas such as schedule, quality and price. Therefore, effective negotiation is required in order to achieve terms and conditions that are mutually agreeable (Kerzner and Saladis, 2017).

According to Kerzner and Saladis (2017), the main activities involving contract management process are:

- Determining what will be purchased;
- Determining how materials or resources will be purchased;
- Preparation of documents that will be utilized in the process, such as, request for proposal (RFPs);
- Selection of qualified supplies that are appropriate for the project's activities;
- Contract preparation and approval;
- Contract management;
- Contract closure and termination.

The following section will describe the main elements of the contract management process.

4.1. Procurement planning

The project procurement planning is used to decide what deliverables to buy and when. According to Gardiner (2005) Procurement is divided into four main phases:

4.1.1. Requirement planning

In this phase, *the make or buy decision* is made, meaning the determination regarding which parts of the project that will be procured and which parts that will be executed in-house. In addition, the content and boundaries of the procurement are defined. The requirement planning is divided in two stages. The first stage is a requisition from the client, which is a document that contains approval signatures authorizing the purchase of services and goods and demonstrating funding commitment. In the second stage, a statement of work is developed with the objective of specifying in concise terms which tasks must be accomplished or which services must be delivered (Gardiner, 2005).

4.1.2. Solicitation

Solicitation is a process aiming to identify suppliers that will provide the services or goods needed for the projects. There are two types of solicitation: *sole source solicitation* and *bid/proposal solicitation*. *Sole source solicitation* uses a single supplier in a noncompetitive buying method. This method is implemented when there is no time to issue bids or proposal as the goods or services are needed immediately; purchases are not valuable enough to solicit competitive processes; or there are no other companies qualified to offer the product or service needed. On the other hand, *bid and proposal solicitation* is an open and competitive method used in the purchase of high value goods or services, where several suppliers are invited to give their offers. Received proposals will be evaluated according to the criteria and selection method defined in the RFP (Gardiner, 2005).

4.1.3. Awarding

In this phase the final bid is selected, and the buyer awards the contract to the chosen supplier, usually the lowest bidder. Buyers and suppliers will negotiate which type of contract and payment method will be used, so that suppliers will take reasonable risks and obtain incentives that leads to an efficient and economic performance. The award phase in concluded when the contract is signed (Gardiner, 2005).

4.1.4. Contract administration

This phase is composed by several activities to manage the contractual relationship and ensure that the contractor delivers everything agreed upon in the contract. This phase lasts until the contract closure. The main functions of contract administration includes contract change management; interpretation of specifications; adherence to quality; warranties; subcontractor management; monitoring activities; rupture of contract and dispute resolution; payment schedule and contract closure (Gardiner, 2005).

4.2. Types of contract

According to Suprapto et al. (2016), the choice of the contract type to be used in a project is based on factors such as the uncertainties involving the product or process, preferred allocation of risk, market conditions and in-house capabilities. The contract type chosen aims to encourage suppliers and buyers to work together ensuring the best outcome achieved according to with their common objectives and expectations.

The main types of contracts are:

4.2.1. Fixed price (Lump-sum)

This is the favorite type of contract from the viewpoint of a purchaser as the contractor carries most of the risk. A fixed price for the service is established in advance, providing the contractor a high incentive to complete the work on schedule. That is because any delay in the delivery would be prejudicial mostly to the contractor who will not get any additional reward for the extra time spent on executing the activities. In addition, contractors are forced to perform the contract even if the possibility of a loss is unavoidable. On the other hand, customers will not be able to control the performance of the activities executed as much as in other types of contract. Any changes in the previously agreed requirements may result in adjustment to the price (Turner, 2003, Gardiner, 2005).

4.2.2. Cost reimbursement

In a cost reimbursement contract, the costs incurred during the performance are returned to the contractor. Since only documented costs are reimbursed, contracts may lose money easily when working on the conditions purposed by this contract. There are two types of cost reimbursement contracts: *Cost plus fixed fee* and *cost plus percentage of cost*. *Cost plus fixed fee* contract is the most implemented type of cost reimbursement contract. At the end of the activities, the cost of the performance is reimbursed to the contract together with a fixed fee. In *cost plus percentage of cost* the paid fee is a percentage of the costs incurred during the performance. This contract type should be avoided as it leads to inefficiencies since the fee increases as expenditures increases (Gardiner, 2005).

4.2.3. Other types of contract

There are other types of contracts such as labor hours contract and time and materials contract. What these types of contracts have in common is that both are paid for service hours regardless if the required tasks were accomplished. However, the time and materials contract requires reimbursement for the cost of used materials beside the payments for hours of service (Gardiner, 2005).

4.3. Contractual incentives

Contractual incentives are agreements between clients and contractors developed to enhance performance in project parameters that are essential for the client and for the success of the project. Incentives can be classified according to the project's constraints, which are cost, schedule, quality and safety. In section 3.1.1, project scoping is described as wells as the constraints that form boundaries of projects. Incentives are completely self-funded as a result of the contractor's efficiency in saving or using resources wisely. Incentives make the clients expectations and objectives well known by the contractors. In addition, the best teams will be provided by the contractors to enhance performance and profitability. Through incentives, contractor will benefit from additional financial rewards. On the other hand, clients will benefit from part of the savings, any benefits generated from the early conclusion of the project or higher returns from investments (Gardiner, 2005). Incentives may also be based in penalties, such as "fee at risk" or "pain-sharing", for performances below the defined targets (Merrow and Merrow, 2011).

In the following section the different classes of contractual incentives will be described, namely the *cost incentives, schedule incentives, performance incentives* and *safety incentives*:

4.3.1. Cost incentives

Cost incentives can be seen as a combination of reward threat since clients and contractors share underruns and overruns of budget (Bower et al., 2002). The main types of cost incentives are:

- Cost plus incentive fee (CPIF): CPIF is used in cost reimbursement contracts in which the total cost of the project is reimbursed plus fee will be paid to the contractor if the determined performance objectives are satisfied. The main elements of this type of incentive are *target cost*, *target fee*, *maximum fee*, *minimum fee* and *sharing formula*. *Target cost* is an estimative of the total cost of the work done during the entire participation of the contractor in the project. *Target fee* is the payment the contractor will receive if the actual total cost is equal the target cost. *Minimum* and *maximum fees* are the final allowable profit received by contractor. Lastly, *sharing formula* determines how the difference between actual and target costs will be distributed between the client and the contractor (Gardiner, 2005, Bower et al., 2002). Figure 4-1 shows an illustration of the CPIF mechanism.

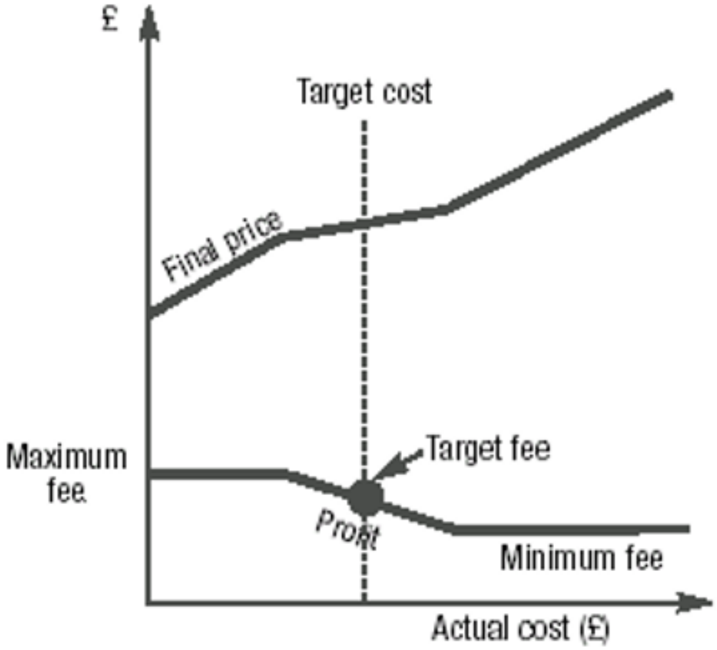


Figure 4-1 Cost plus incentive fee mechanism (Gardiner, 2005).

- *Cost plus target price*: This incentive is also implemented in cost reimbursement contracts. The contractors receive a reimbursement of the actual cost plus a fee. A target cost is determined, and the contractor shares with the clients in the savings or in the overrun. Target cost is not fixed since changes can be made as the contract progresses (Gardiner, 2005).
- *Cost plus guaranteed maximum price*: This is another type of incentive implemented in cost reimbursement contracts which works as a cost ceiling. Here a maximum fee is defined. The contractor shares the savings with the clients. However, the entire overrun will be paid by the contractor only. The guaranteed maximum price is not fixed since changes can be made as the contract progresses (Gardiner, 2005).
- *Fixed price incentive* (FPI): This incentive is used in fixed price contracts to reward contractors for accomplishing a determined performance. The reward is objectively measurable and linked to the final price paid. FPI has almost the same elements as CPIF plus price ceiling. If the actual cost is equal target cost, the contractor receives the target profit. If the incurred costs exceed target cost, the contractor receives a reward proportional to the additional costs. If the costs

overrun price ceiling, the additional costs will be paid by the contractor (Gardiner, 2005). Figure 4-2 shows an illustration of the fixed price incentive mechanism.

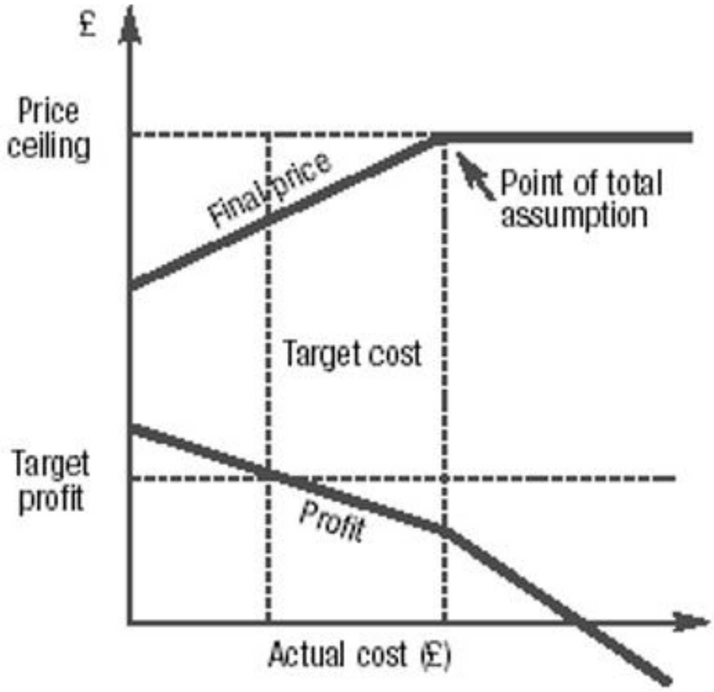


Figure 4-2 Fixed price incentive mechanism (Gardiner, 2005).

4.3.2. Schedule incentives

Schedule-based incentives are implemented in projects that have completion schedule as the most critical constraint. They are usually based on threat or penalties, giving the opportunity of saving time and costs substantially in an easy and inexpensive way. In this type of incentive, rewards are paid to contractors that deliver services before the deadline. On the other hand, rewards may decrease to negative values, becoming penalties due to passed deadlines (Abu-Hijleh and Ibbs, 1989, Bower et al., 2002).

Schedule incentives can use different types of target dates. The most common are end-of-project and intermediate milestones. End-of-project schedule incentives use a simplistic type of target date in which rewards are granted or penalties are incurred whether services are delivered before or after the date a project is supposed to be concluded. Intermediate milestones schedule incentives use sophisticated types of deadlines, basing rewards and penalties according to the date conclusion of milestones (Abu-Hijleh and Ibbs, 1989).

4.3.3. Performance incentives

Performance incentives are based on the evaluation of performance measures beyond cost and schedule. Some of the factors evaluated are quality, productivity, technical management, resource utilization, responsiveness and safety. Contractors will grant rewards if one or more performance targets are achieved. The evaluated factor will be chosen according to the area of performance a client would like to enhance. In the contract, evaluation intervals and performance targets will be defined (Bubshait, 2003, Bower et al., 2002).

4.3.4. Safety incentives

Safety incentives grants economic rewards to contractor for improvements regarding safety performance. However, the effectivity of safety incentives are doubtful. Merrow and Merrow (2011) points out that safety-based financial incentives should be discontinued because contractors who already have strong safety system and culture, will always implement them at work. However, contractors who do not have strong safety systems, will not have time to acquire them for the project.

5. Influencing factors in the negotiation of a rig contract

In this section the main factors considered when negotiating a drilling contract will be discussed.

5.1. Market value

The market value of a company reflects not just how well the company is doing financially, but also the quality of service that the company offers. In times of crisis, there is a need to see way beyond market value since any company involved with the oil industry is directly affected. However, the history of market value of companies may guide operator in the search for the best contractor.

This section will give a brief description of some of the factors that impact the market value of a company.

5.1.1. Revenue

The revenue of a drilling company is affected by fleet size, day-rates and utilization rates. The revenue generated by the companies are directly related with fleet value since more valuable fleets will generate greater earnings. Revenue depends on market conditions, which are constantly changing. Therefore, when choosing characteristics to determine the market value of a company, fleet value is better than revenue since it offers a more stable reference (Kaiser, 2014).

5.1.2. Contract backlog

Backlog is the value of existing contract commitments of a company in which rigs are working at the time of the evaluation and any future contracts. It is calculated by multiplying the remaining contract duration of a rig fleet by contract day-rate. High backlogs may increase the market value of companies since they are associated with stable revenues (Kaiser, 2014).

5.1.3. Customer concentration

Companies with many customers may be considered more valuable than companies with a small number of customers. This is due to the fact that companies which obtain most of their revenue from a limited customer base are riskier since the loss of a costumer may eliminate a major source of their revenue (Kaiser, 2014).

5.1.4. Operating costs

Net revenue is obtained by calculating contract day-rates minus daily operating costs. Low operating costs will consequently result in strong market valuations since it can be translated into high net revenue. There are several factors that affect operating costs, such as: rig class, size and age, market competition, port infrastructure and scale of economies. Companies with a good management control, newer fleets and efficient logistic network will often have a lower operating cost comparing with their competitors (Kaiser, 2014).

5.1.5. Operating margin

Operating margins is a measure of the cost structure of a company. It is represented by the ratio of operating income to revenue. A high operating ratio means that the company have large net earnings per dollar of revenue. Companies with new and active rigs usually present high operating margins (Kaiser, 2014).

5.1.6. Financial structure

The financial structure of a drilling company has to do with how the company combines debt and equity to finance the construction of fleet additions. Using debt to finance rig construction increases the risk of bankruptcy and may result in variable earnings. On the other hand, debt may lead to increase the yield to investors since it allows the company to leverage its equity (Kaiser, 2014).

5.2. Asymmetric information

Private or asymmetric information in a drilling operation context may arise when contractor withhold important information that could mislead a bidding process. It could be, for example, a contractor who bids low quality equipment and materials that do not meet the contractual specifications. However, there are two methods to deal with asymmetric information: *Signaling* and *screening*. *Signaling* consists of the request for a renowned certification or accreditation proving that the contractor holds the equipment and materials that meets the required specifications. *Screening* method consists in evaluating contractors according to qualification criteria and site visits (Enger, 2011).

5.3. Rigs

In a negotiation process it is important to find suppliers that have the type of rig that will fit the purpose of the operation. If the rig type chosen is far from what is needed to each type of operation, changes will be made to adapt the vessel. These changes are costly and time consuming. Therefore, the availability of rig types is an important element when negotiating with a drilling contractor.

5.3.1. Rig class

There are two classes of rigs: high-specification rigs and standard-specification rigs. High-specification rigs are more costly to build, maintain and operate. However, these rigs can be used to drill in deeper water than standard rigs, operate in harsh environment or drill in high temperature and high pressure wells (Kaiser, 2014).

Rig class diversification may affect market value. Contractors may operate with both standard- and high-specification rigs. High specification rigs are associated with premium day-rates in most market conditions. However, the higher operating costs may result in lower net earnings. Figure 5-1 shows the relationship between number of rigs demanded and rig class (Kaiser, 2014).

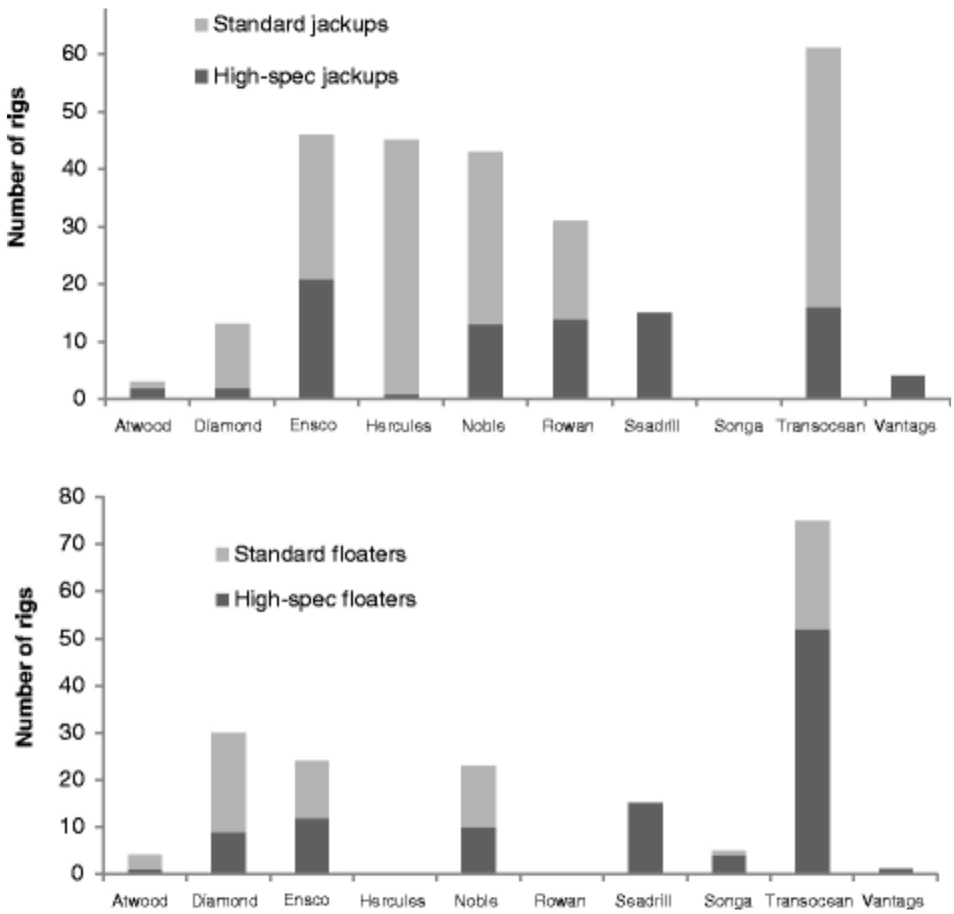


Figure 5-1 High-specification rigs vs. standard-specification rigs (Kaiser, 2014)

5.3.2. Rig fleet size

The number of rigs available and their quality are directly related with the revenue of a firm, implying the possibility of sustainable earnings and cash flows. In addition, fleet size and quality affect the ability of drilling companies to obtain financing for capital projects, cost structure and market position (Kaiser, 2014).

5.3.3. Rig fleet value

Fleet value is the sum of the net asset value (NAV) of a company's rig fleet. NAV is estimated by using cash flow models and rig-specific parameters to calculate the discounted expected future net earnings of a rig. Fleet value is considered a better indicator of the value of firms than fleet size since it considers the variation of important factors such as rig class, day-rates, specifications and contract status. Figure 5-2 shows that there is a positive correlation between fleet size and value (Kaiser, 2014).

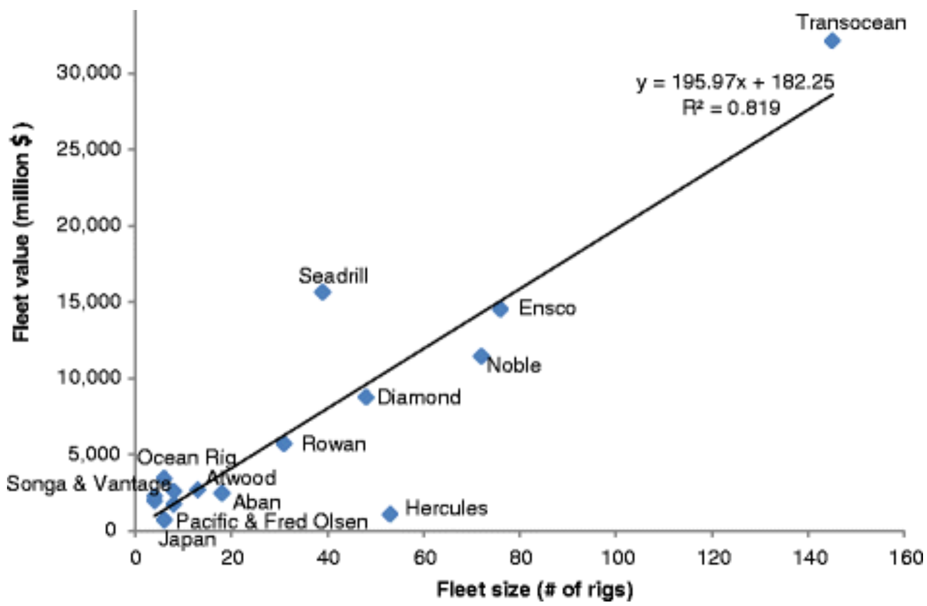


Figure 5-2 Correlation between fleet size and fleet value (Kaiser, 2014).

5.3.4. Rig fleet age

Fleet age is another factor that affect the contract negotiation. Old fleets receive lower day-rates and utilization, presenting fewer remaining time to generate revenue. They are therefore, less valuable than new fleets (Kaiser, 2014).

6. Contract strategy

In this chapter the main strategies used in contracts to increase the effectivity of drilling operations will be discussed. The first strategy described will be the contract type used in drilling operations. It will be followed by the incentives applied in those contracts. Lastly, key performance indicators will be described.

6.1. Rig contract types

In the following subchapter different types of contracts used in drilling operations will be examined. The types are *day-rate contract*, *turnkey contract* and *footage contract.*

6.1.1. Day-rate contract

Day-rate is the most used type of contract in drilling operations around the world. As the name implies, the payments are based on the amount of day a supplier uses to complete an operation. In 2018, the day rate for rigs were up to $250000 in Norway due to the harsh-environment condition (Boman, 2018). When this type of contract is implemented, the suppliers must cover all cost savings such as training and maintenance. However, suppliers will also become the residual claimant of any money saved during the operation.

6.1.2. Turnkey contract

In turnkey contracts, a fixed price is negotiated for the entire operation resulting in most of the risks being carried by the suppliers. The contractor must therefore be able to calculate the cost of the potential risks involved in the operation in order to charge a profitable price. This type of contract was first implemented in the 1980s and resulted in financial losses for drilling contractors due to the pricing charged for the services and lack of expertise in the management of the operations. However, some companies managed to build up the expertise required to operate under these conditions, allowing turnkey contract to be in use until the present days (Osmundsen et al., 2008).

Turnkey contracts are used for exploration wells and well intervention in shallow waters, utilizing jack-up rigs. The positive side of these contract is that it gives strong cost incentives to drilling contractors and it may lead to cut in drilling costs. One of the downsides of turnkey contracts are the difficult and expensive renegotiations. In addition, drilling contractor live constantly under fear that oil companies will offer the most difficult and riskier wells on this type of contracting, resulting in low profitability and delays at the end of the operation (Osmundsen et al., 2008).

6.1.3. Footage contract

Footage contracts is a type of contract mostly used in onshore operations with predicable drilling costs. Remuneration builds up on the number of meters drilled to a specific depth. Both drilling contractors and operators assume part of the risks.

Nowadays, footage contracts are rarely used due to the increasing degree of complexity in drilling operations, causing the depth of wells outside the contractor's control. First, the progress of the operations is affected by a large number of service companies. Secondly, operators often need to change the drilling programs to adapt to unforeseen formation challenges and other factors, resulting sometimes in change of drilling depth. Therefore, footage contract is not the most efficient remuneration method since any change needed in drilling depth would have to be anticipated by a renegotiation of the contract.

6.2. Incentives

Drilling operations are highly focused in compensation schemes based on incentives. The next subsection will describe the aspects involving incentives in drilling operations.

6.2.1. Challenges in incentive design

Incentive packages are difficult to design due to the fact that measurement of the contractor's performance is a quite challenging task. Performance in activities involving safety, for example, is not easy to evaluate. Therefore, incentives will be related with performance in other types of activities that are more feasible for evaluation, such as, rate of return and production. However, these incentives may lead to problems caused by a reduction of focus regarding safety aspects, which can be resolved by control measures, safety standards and regulations (Osmundsen et al., 2006).

Other challenges involving the design of incentives are:

- Unrealistic requirements: There must be feasible requirements so that contractors may obtain the reward determined by the incentive package. Requirements that are impossible to be met make the effect of incentives adverse to what is expected as it may increase remuneration for contracts without impacting the efficiency of the operations (Bakkevik and Osmundsen, 2017).

- Asymmetric information: There are many details involving drilling operations that contractors are aware about but are unknown to operators (Osmundsen et al., 2010).
- Renegotiation: The possibility of renegotiating contracts decrease the effect of incentives (Osmundsen et al., 2010).

6.2.2. Schedule incentives

As mentioned above, the most used types of contracts in drilling operations are turnkey and day-rate contract.

In *day-rate contracts*, differentiation in rates is used to introduce schedule incentives for time reduction as contractors receive penalties for down time. The contract defines *types of day-rates*, which varies according to the status of the operation. The *day-rates* types are *operating rate per day*, *standby rate per day*, *moving rate per day*, *suspension rate per day*, *lay-up rate per day*, *redrilling rate per day* and *no payment rate*. Table 6-1 shows an example of how day-rates are differentiated (Osmundsen et al., 2006).

Table 6-1 Day-rate differentiation

Types of rate	Value
Operating rate per day	OR
Standby rate per day	OR x 0,95
Moving rate per day	OR x 0,85
Suspension rate per day	OR x 0,50
Lay-up rate per day	OR x 0,50
Redrilling rate per day	OR x 0,30
No payment rate	0

Without scheduled incentives *day-rate contracts* could be compared with *cost reimbursement contracts with incentives* with low impact in the reduction of operation time (Osmundsen et al., 2006).

A downside of schedule incentives in day-rate contracts is that it presents a detrimental effect on safety since maintenance or reparation is supposed to be carried out without a delay or a pause on operations so that there will be no penalties for down time. A solution for this problem is including a clause in the contract in which defines a number of hours reserved per month to ensure maintenance and repair will be done (Osmundsen et al., 2006).

6.2.3. Incentives during standby periods

During the standby period, also known as flat-time operation activities such as running casing and BOP tests are done. This period is represented in Figure 6-1 as the horizontal part of the graph since at this moment the depth of the well remains constant. The contractors may have an option of instead getting a day-rate remuneration, and conclude these types of activities for a lump sum. This works as an extra incentive for increasing efficiency in the planning and execution during standby periods. This strategy also transfers most of the risks related with problems during operation, such as equipment failure, to the contractor (Hyne, 2012).

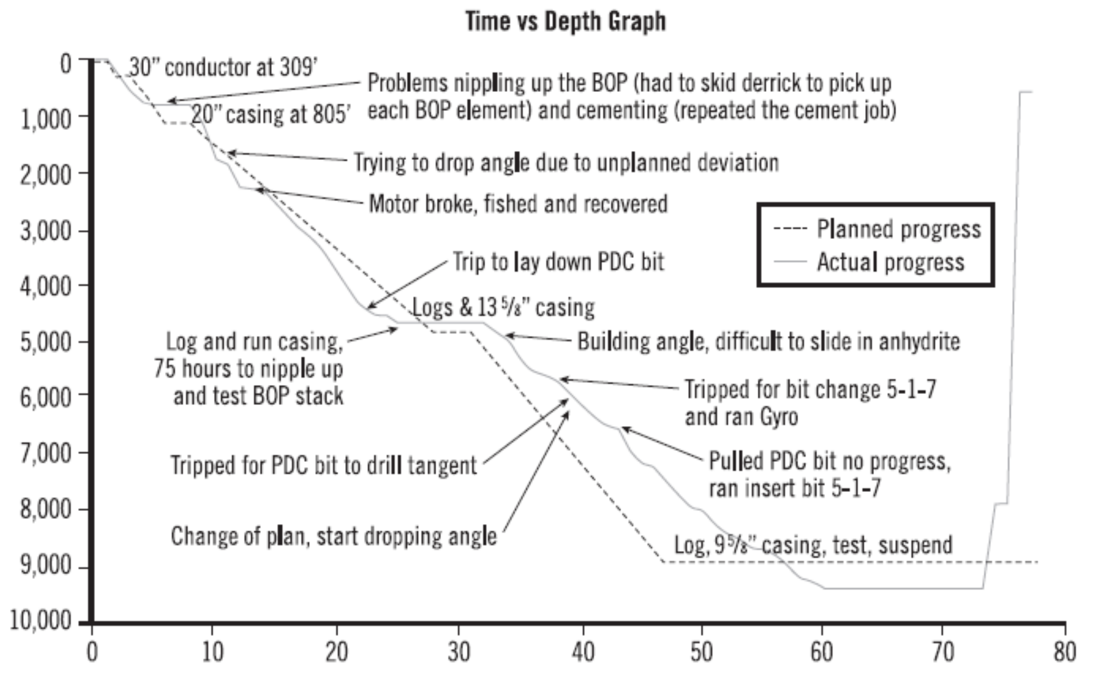


Figure 6-1 Time vs Depth graph comparing planned vs actual progress (Hyne, 2012).

6.2.4. Incentives schemes for rapid progress

In drilling operations, schedule incentives are basically penalties applied when the operating rate decreases. However, there are other types of incentives known as compensation for progress, which contain various degrees of financial rewards paid beside fixed day-rates as the operation progresses. This type of incentive is used to a narrow range and with a moderate scope. In addition, they must be compatible with the operation schemes so that they will not have a contrary effect on the progress of the activities, making sure that all the parties involved will be pulling in the same direction. Another important consideration when implementing incentives for rapid progress is that they must reach those who take important decisions and those responsible for the execution of critical efforts. In operations executed in the North Sea, performance incentives are used as compensation for rapid progress (Osmundsen et al., 2006).

6.2.5. Implicit incentives

Implicit incentives are not included in the compensation format of rig contracts but may affect the efficiency of operation in an indirect way. There are two types of implicit incentives used in drilling operations: *bid evaluation criteria* and *remuneration for next contracts*. *Bid evaluation criteria* is considered an incentive since the awards of rig assignments are based on historical figures and drilling efficiency of past operations. *Remuneration in the next contract* will also work as an implicit incentive as companies with a good performance throughout the operation will work toward a higher rate in the next contract. On the other hand, companies with an unsatisfying performance may risk a lower rate in the next contract or even unemployment at the end of the actual contract (Osmundsen et al., 2008).

6.2.6. Safety incentives

Safety incentives can be based on financial consequences in the event of accidents. The use of this type of incentives is supported by the belief that increasing the percentage of risk associated with accidents borne by the contractor will increase focus on safety (Osmundsen et al., 2006). However, there are disagreements on the efficacy of safety incentives as it is believed that they exert pressure on workers to avoid reporting accidents. It is also believed that these incentives are not fair since even those who did not have possibility to prevent or mitigate accidents will be punished (Devereux, 2012).

6.3. Measuring KPI

Key performance indicators (KPI) are quantitative information used to manage, evaluate and compare the performance of contracted companies during operation. It allows the customers to make sure that the contractors are delivering their services according to the standards of efficiency and quality that they agreed on beforehand. KPIs can be defined by the customers or by contractors which already have predefined their project management methodology, metrics and KPIs (Kerzner et al., 2011).

6.3.1. True KPIs

KPIs are essential for planning, controlling and decision-making during operations. However, there are not may companies which really monitor KPIs, but instead work with wrong performance measures. According to Badawy et al. (2016), there are four types of performance indicators:

- Result indicator (RI): tells what have been achieved.
- Key result indicator (KRI): tells what have been accomplished with focus on critical success factor.
- Performance Indicator (PI): tells what must be done.
- Key Performance Indicator (KPI): tells what must be done to have a great increase in the performance.

According to Kerzner et al. (2011), KPI can be anatomically defined as:

- Key: a critical factor that majorly contributes for the success or failure of an operation. A metric is only considered "key" if it can make or break an operation.
- Performance: a controllable metric that can be quantified, measured and adjusted. There is no reason to measure factors where the outcomes can't be changed.
- Indicator: a reasonable illustration of actual and future performance.

6.3.2. KPIs characteristics

According to Kerzner et al. (2011), the SMART Rule, which is broadly used to establish objectives for projects can also be used to identify some characteristics of KPIs, such as:

- S = Specific: KPIs must be clear and focus must be kept on the performance targets.
- M = Measurable: KPIs must be expressed quantitatively.
- A = Attainable: KPIs must provide targets that are achievable and reasonable.
- R = Relevant or realistic: KPIs must be relevant to the activities implemented in the projects.
- T = Time-based: KPIs must estipulate deadlines.

However, the applicability of the SMART Rule in KPIs is quite questionable because it does not mention one of the main characteristics of KPIs, which is the actionable targets allowing the user to control outcomes.

Badawy et al. (2016) and Kerzner et al. (2011) describes David and Wayne W. Eckerson's twelve parameters, which gives a more complete set of characteristics for KPIs, which are:

1. Aligned: KPIs must agree and cooperate with the strategies and objective adopted by the customers.
2. Owned: KPIs are usually owned by a leader or a group responsible for the outcome of the KPI.
3. Predicative: KPIs are the main indicators of the standards of performance that an organization desires to obtain.
4. Actionable: KPIs measure only what can be improved. They are formed by timely, actionable data that with intervention can change the final outcome of operations.
5. Sparse: KPIS must be few in numbers, keeping the user focused on high-value tasks instead of getting distracted with too many details.
6. Simple: KPIs must be easy to understand and straightforward, giving clear indications of what is expected to accomplish.
7. Balanced and linked: KPIs should support and balance each other instead of undermining each other.
8. Trigger changes: KPIs should initiate a chain reaction driving to the desired outcomes.
9. Standardized: KPIs must be based on standard definitions, calculations and rules to facilitate integration throughout the operation.
10. Context driven: KPIs apply targets to performances, allowing user to measure their progress over time.
11. Reinforced with incentives: compensation and incentives can be attached to KPIs to magnify their impact in the operation.
12. Relevant: KPIs must be constantly renewed and refreshed so that they are continuously relevant.

6.3.3. Developing KPIs

Developing complete, accurate and useful KPIs is a challenging task. If KPIs are not well designed, they may not work as a reliable performance management tools. In addition, incorrect KPIs may affect negatively the relationship between clients and customers, since bad targets lead to unsatisfactory performances. Cullen (2009) describes the main steps in developing KPIs, which are:

- Allocate Responsibilities: All major activities must be listed and the accountability for the accomplishment of each activity must be assigned to a party.
- Conduct stakeholder assessment: Identify the expectation of each stakeholder, and to what degree each of them are committed to the contract.
- List KPIs: Prepare a list of the KPIs the will be used.
- Set KPIs thresholds: set target goals which will represent the top line; minimum performance required which will represent what is expected of the contractor; and the absolute threshold which represents the bottom line. Figure 6-2 shows an example of KPIs thresholds.
- Generate calculation method: Identify the method for data gathering, make sure the formula is not complicated so that the stakeholders can understand them easily and make sure the source data of measurement is reliable and accessible.
- Prototype reports: Design detailed performance reports on a high-level dashboard for general distribution.
- Conduct tests: Analyze current measurements to set realistic baselines for KPIs, predict expected results from KPIs to make sure they will lead to the best outcomes and predict potential undesired results so that risk mitigation actions can be implemented.

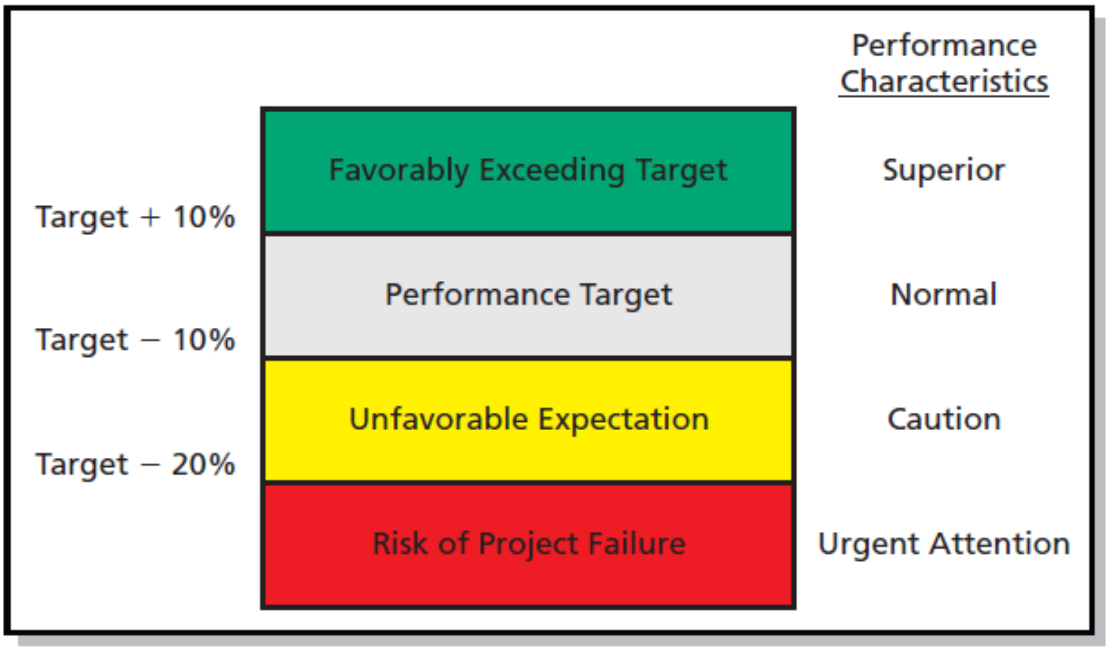
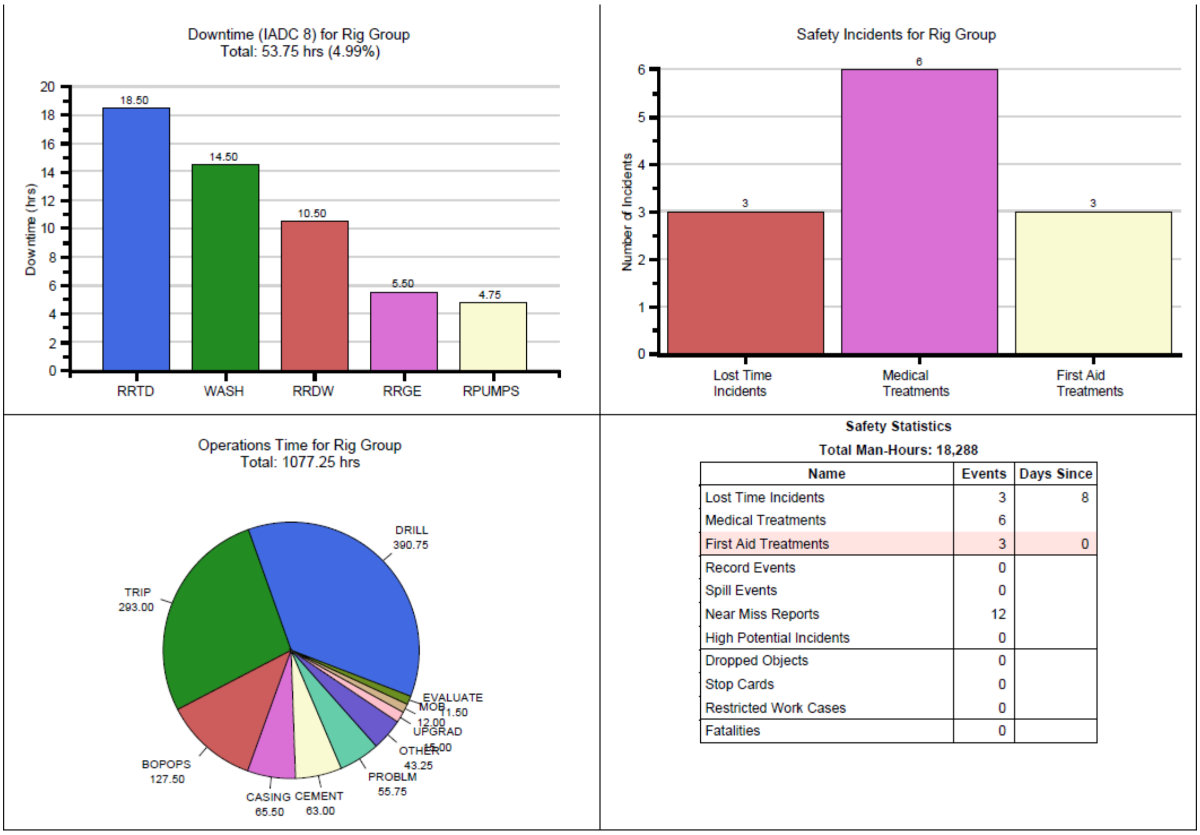


Figure 6-2 An example of KPIs thresholds (Kerzner et al., 2011).

6.3.4. Data gathering

A while ago the only KPIs analyzed in different types of operations where time and cost. Nowadays there are many other different types of data gathered to measure KPIs, such as: observations, ranges, simulations, statistics, sampling techniques and human judgment (Kerzner et al., 2011).

Data gathering is done by different types of software. Figure 6-3 shows an example of data gathering for KPI analysis of a drilling operation.



Name	Events	Days Since
Lost Time Incidents	3	8
Medical Treatments	6	
First Aid Treatments	3	0
Record Events	0	
Spill Events	0	
Near Miss Reports	12	
High Potential Incidents	0	
Dropped Objects	0	
Stop Cards	0	
Restricted Work Cases	0	
Fatalities	0	

Figure 6-3 Example of data gathering for KPIs (Infostat, 2014).

Data should be gathered and analyzed daily so that the contractors can be aware of how they are performing their activities. If performance is falling under the predefined targets, corrections can be made to improve the efficiency of the operation (Bennett, 2013).

7. Discussion

In this chapter we will discuss how rig contract types, incentives and KPI measurements affect the efficiency of drilling operations.

7.1. Rig contract types

Suprapto et al. (2016) did a research using the *partial least square structural equation modeling* (PLS-SEM) to investigate how contract types affect the owner-contractor collaborative relationship and the performance of projects. Two dimensions of the owner-contractor collaborative relationship were analyzed. First dimension is the relational attitudes which are norms and commitment that the leadership group, represented by owners and contractors, develop and share to administrate their project-specific relationship. The second dimension studied was teamworking quality in which analyze how the owner team and the contractor team interact socially and professionally when executing a project. According to Suprapto et al. (2016), relational attitudes have no direct effect in performance improvement. On the other hand, teamworking quality has a significant effect on the increase of performance efficiency. However, relational attitudes will still affect performances indirectly since they increase teamworking quality significantly.

Suprapto et al. (2016) analyzed a few contract types, such as *fixed price contracts* and *reimbursable contracts*, known in drilling operations respectively as *turnkey contracts* and *day-rate contracts*. Fixed price contracts give flexibility and less administrative burden to contractors since it demands less involvement from the clients. On the other hand, fixed price contracts may result in adversarial client-contractor relationship when changes of circumstances arise during the execution phase of projects. Further, reimbursable contracts required more intervention and support from clients, facilitating a collaborative client-contractor relationship and an integrated team. However, the contractor may perceive that the client exerts more pressure so that the target cost and schedule can be achieved. In addition, the client may perceive an increase of additional work done by the contractor which results in increase in the previously estimated cost.

At the end of the research, Suprapto et al. (2016) concludes that contract types do not have any direct effect on improving performance in projects since there is not a real difference in the performance whether the contract implemented is a fixed price or a reimbursable contract. On the other hand, contract types could have an indirect impact in performance improvement because teamworking tends to increase quality significantly, resulting in a performance improvement.

7.2. Incentives

In their research using PLS-SEM, see previous subchapter, Suprapto et al. (2016) also analyzed how incentives affects the owner-contractor collaborative relationship and the performance of projects. Suprapto et al. (2016) concludes that contractual incentives will not have a direct effect in the performance of a project. That is because the positive effects that incentives would have by giving a financial gain as a reward for efficient execution are often annulated as the incentives may not enough to motivate contractors in the work itself or in making the changes needed to obtain the stipulated reward.

In addition, basing incentives on performance parameters could lead the contractor to direct more focus on efficiency than in the quality of the operation as measurements of efficiency can be easier to obtain than measurements of quality (Førland, 2011).

On the other hand, Suprapto et al. (2016) that contractual incentives exert an indirect effect in improving performance, since it improves relational attitudes, leading to a better teamworking quality, which will finally result in performance improvement.

7.3. KPI

KPIs provide a detailed view of factors that affect the operations and separates between uncontrollable and controllable factor, which are those that can be improved. The qualitative information offers a real opportunity to improve operations because they allow critical factors to be discovered and dealt with.

KPI is used to increase effectivity and efficiency of operations because it sets targets, resulting in a natural competition between contractors and impacting their reputation. For example, if a contractor is executing the running of casings with a speed above the target, the natural reaction of other contractors is to search ways to improve their performance so that they can execute this activity as fast or faster. Contractors who remain under the target will have their reputation negatively impacted and will represent a risk for the conclusion of the operation (Kerzner et al., 2011, Lenning, 2014)

KPIs can also be used to decrease nonproductive time, which can have a significant impact in the total duration of operations. Denney (2011) explain through an experiment during an operation, how KPIs can be used in combination with automatic operation detection technology and rigorous data-quality control to determine nonproductive time and eliminate Invisible Lost Time (ILT).

The experiment was done by observing and collecting data of different crews which were performing the same operation. ILT is defined as the cumulative time above the target value set by the KPI. The performances of each group were compared, and the best performance was the one with the percentage value, indicating the smallest cumulative time above the target. Several KPIs were analyzed to indicate the best overall performance. In Figure 7-1 it is possible to visualize a discrepancy in the routine of crew J compared with Crew H in the middle and end of their performance, which were during meal time and before crew change. After demonstrating the graph to the crews, the problem was solved between themselves as Crew J became aware that they were not following the same procedures for lunch and crew change that Crew H was following. As result, Crew J changed their actions, saving 40 minutes per day of rig time, which would be approximately 1 rig day in every 1,5 months (Denney, 2011).

Comparison between rigs caused by KPIs can also result in increase of efficiency and decrease nonproductive time. In the same experiment, it was discovered differences in the procedures for execution of drilling-slip-to-slip connection between two rigs, named Rig 1 and Rig 2. Rig 1 managed to execute the activity much faster than Rig 2. At the end of the experiment, both rigs showed a great improvement, with Rig 1 improving their drilling-slip-to-slip time by 31%, and Rig 2 improving their time by 32.5% (Denney, 2011).

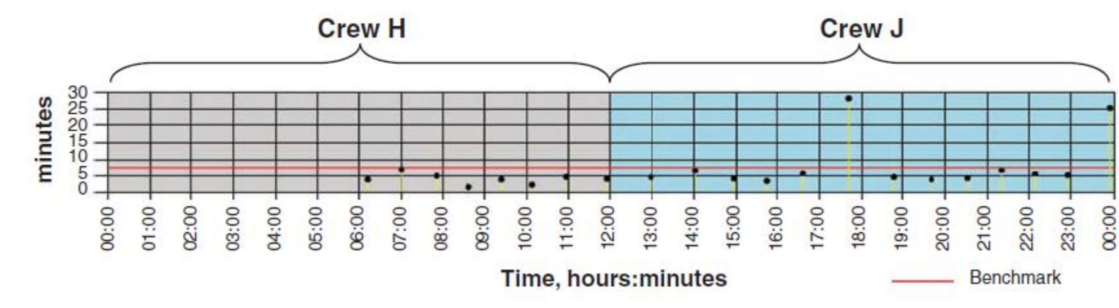


Figure 7-1 Weight-to-weight KPI report (Denney, 2011).

Based on the experiments and the considerations above we can conclude that KPIs have a direct impact in the increase of efficiency of operations.

8. Conclusion

This thesis had the objective of investigating how different contract strategies can be used to increase efficiency of drilling operations. Three contract strategies have been studied, which are contract types, contractual incentives and KPIs. Based on the discussion presented in the previous chapter, the conclusions obtained at the end of this research are:

- Contract types do not exert a direct influence in the improvement of efficiency. However, they affect efficiency indirectly by improving teamworking quality, resulting in a performance improvement.
- The same happens with incentives. The effect incentives would provide in financial gain as reward for an increase in efficiency is annulated by their negative consequences. However, incentives could affect performances indirectly, since it improves relational attitudes, leading to a better teamworking quality, which will finally result in performance improvement.
- The best method to increase efficiency is by using KPIs. The natural competition between contractors, caused by comparing their KPIs, will result in efficiency improvement. KPIs will also lead to a reduction of nonproductive time by identifying and eliminating Invisible Lost Time (ILT)

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9. Abbreviations and symbols

ACWP	Actual cost of work performed
BCWP	Budgeted cost of work performed
BCWS	Budgeted cost of work scheduled
CBS	Cost breakdown structure
OBS	Organization breakdown structure
PBS	Product breakdown structure
WBS	Work breakdown structure
RFP	Request for proposal
KPI	Key performance indicator
KRI	Key result indicator
RI	Result indicator
PI	Performance indicator
ILT	Invisible Lost Time

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