Master's degree thesis

LOG952 Logistics

Title: The use of surveillance tools in enhancing safety and security across offshore installations, A case study of oil and gas companies in Ghana.

Author(s): Doris Effah-Kesse

Number of pages including this page: 78

Molde, Date: 24.05.2019

Molde University College
Specialized University in Logistics

Mandatory statement

Each student is responsible for complying with rules and regulations that relate to examinations and to academic work in general. The purpose of the mandatory statement is to make students aware of their responsibility and the consequences of cheating. Failure to complete the statement does not excuse students from their responsibility.

*Please complete the mandatory statement by placing a mark **in each box** for statements 1-6 below.*		
1.	**I/we hereby declare that my/our paper/assignment is my/our own work, and that I/we have not used other sources or received other help than mentioned in the paper/assignment.**	☒
2.	**I/we hereby declare that this paper** 1. Has not been used in any other exam at another department/university/university college 2. Is not referring to the work of others without acknowledgement 3. Is not referring to my/our previous work without acknowledgement 4. Has acknowledged all sources of literature in the text and in the list of references 5. Is not a copy, duplicate or transcript of other work	Mark each box: 1. ☒ 2. ☒ 3. ☒ 4. ☒ 5. ☒
3.	**I am/we are aware that any breach of the above will be considered as cheating, and may result in annulment of the examination and exclusion from all universities and university colleges in Norway for up to one year, according to the Act relating to Norwegian Universities and University Colleges, section 4-7 and 4-8 and Examination regulations** section 14 and 15.	☒
4.	**I am/we are aware that all papers/assignments may be checked for plagiarism by a software assisted plagiarism check**	☒
5.	**I am/we are aware that Molde University College will handle all cases of suspected cheating according to prevailing guidelines.**	☒
6.	**I/we are aware of the University College's rules and regulation for using sources**	☒

Personal protection

Personal Data Act

Research projects that processes personal data according to Personal Data Act, should be notified to Data Protection Services (NSD) for consideration.

Have the research project been considered by NSD? ☐**yes** ☒**no**

- If yes:

Reference number:

- If no:

I/we hereby declare that the thesis does not contain personal data according to Personal Data Act.: ☒

Act on Medical and Health Research

If the research project is effected by the regulations decided in Act on Medical and Health Research (the Health Research Act), it must be approved in advance by the Regional Committee for Medical and Health Research Ethic (REK) in your region.

Has the research project been considered by REK? ☐**yes** ☒**no**

- If yes:

Reference number:

Publication agreement

ECTS credits: 30

Supervisor: Bjørnar Aas

Agreement on electronic publication of master thesis

Author(s) have copyright to the thesis, including the exclusive right to publish the document (The Copyright Act §2).

All theses fulfilling the requirements will be registered and published in Brage HiM, with the approval of the author(s).

Theses with a confidentiality agreement will not be published.

I/we hereby give Molde University College the right to, free of charge, make the thesis available for electronic publication: ☒**yes** ☐**no**

Is there an agreement of confidentiality? ☐**yes** ☒**no**

(A supplementary confidentiality agreement must be filled in)

- If yes:

Can the thesis be online published when the period of confidentiality is expired? ☐**yes** ☐**no**

Date: 24.05.2019

ACKNOWLEDGEMENT

This master thesis is my final academic work as a student in order to achieve my second master degree of the Master of Science in Petroleum Logistics at Molde University College – Specialized University in Logistics. The research work has been carried out from January 2019 to May 24, 2019.

I would like to thank my supervisor, Bjørnar Aas, you are amazing! Your prompt and enlightened feedback have been extremely helpful during this excited season. I am very grateful for all the important people you introduced me to, to get information for this thesis.

Many thanks to the CEO of Vissim Per Hernaes for taking time off your busy schedule to educate me about surveillance tools. Lots of thanks also to Knut, the Sales and New Business development manager at Vissim.

I would also like to thank Paul Bang, the Senior Advisor at Petroleum Safety Authority Norway, many thanks also to representatives at the Norwegian Coastal Administration.

To the representatives in Ghana, Tullow Oil (Mr. Kofi Oduro), representatives at GNPC, Eni Ghana, Anadarko Plc, Kosmos Energy thank you all so much!

Doris Effah-Kesse
Molde, Norway
May, 2018

SUMMARY

In 2007, Ghana National Petroleum Corporation (GNPC) and its partners discovered oil in commercial quantities in the Jubilee Field in the offshore Tano/Cape Three Points Basin of the Ghanaian continental shelf. In addition to the Jubilee field, which is the biggest exploration field in Ghana so far, there has been more discoveries in the Mahogany Deep, Odum, Tweneboa and Sankofa. Exploration activities are being intensified as both on-shore and offshore discoveries are expected to be made and more oil and gas investors would be attracted.

Piracy and armed robbery at sea in West Africa noticeably increased in 2016. Records show that 95 incidents were logged in 2016, as compared to 54 in 2015. These incidents lead to a significant cost increase in the human cost, with 1921 seafarers being affected compared to 1225 in 2015. Moreover, out of the 95 incidents, 55 occurred in international waters, however, they all fell within the Exclusive Economic Zone (EEZ), within West Africa. While the nature of incidents within and outside territorial waters may frequently be imprecise, the key element is jurisdictional. Incidents which occur outside of territorial waters fall under universal jurisdiction, regardless of whether they happen within a states' EEZ.

Moreover, fishermen around the coastal area of Ghana fish for dependency, they understand that there is a restricted area around the platforms where they are not supposed to reach. But they claim that the lights around the offshore installations attract the fish to that area and so they have to go there to fish. This and many other issues have raised concerns for the oil and gas industry to look for preventive measures to ensure safer and secured operations around their environment. New and improved software and technology such as AIS, MDN, VTS, VTSM are discussed in this work to understand how they are used and how they can benefit the offshore industry in Ghana.

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 Background of the study

The ocean, our dear ocean has been beneficial to mankind on so many levels and for so many years. Security along our marine coast is an integral accomplishment to the worldwide movement of cargo, shipping vessels, fishing and oil and gas industries. There are many issues such as piracy, illegal dumping, terrorisms, smuggling of migrates and environmental threats such as oil spills and illegal fishing (Otoo, 2012) that concerns the marine domain. Coastal security has always drawn attention to the threats that surround our marine domain. Statement concerning marine security should be defined without all the negative definitions, as Buegar (2015) suggests that discussion of maritime security should also include how law enforcement at sea can be improved (Bueger, 2015).

Ensuring a safe and secured maritime territory is of the interest to both international and local communities. A secured ocean free from terror, piracy, illegal fishing and oil spills means focused production around production areas, safe offshore operations with less risk. It therefore becomes necessary that surveillance tools, which are purposely used for monitoring, and the offshore surveillance equipment intended for a secured maritime safety for offshore platforms, vessels and total safety of marine environment is implemented.

1.2 Statement of the Problem

On November 3, 2011, fishermen working near the Jubilee oil field 60 km. off the coast of Ghana spotted a large oil slick floating towards land. The next day a dark, syrupy excretion arrived onshore, coating beaches of several fishing communities and waterfront hotels in Ghana's Ahanta West District, the coastal strip closest to the country's new, deep water oil field (Badgley, 2012).

The fishermen told authorities they suspected the spill came from the offshore operations, but the incident was greeted with seeming indifference. No official clean-up was launched, so the community was left to clean up the mess itself. Even as the Jubilee field was in development, environmentalists warned it was moving too fast. To some environmental

activists, official silence surrounding the November incident was evidence that Ghana lacked the ability to properly oversee offshore oil operations (Otoo, 2012).

Reports by non-governmental organizations show that the companies that developed the Jubilee field, and the World Bank Group officials who lent hundreds of millions of dollars to jumpstart the project, were aware of the risks from the beginning. There is clear evidence that the Ghanaian government lack the necessary regulation concerning issues like how companies should react in case of oil spill and the equipment needed to react to them. Located along Africa's Atlantic Coast, Ghana is slipping down the same unregulated slope as other countries that hug the Gulf of Guinea: Promises of economic development along with a lure of easy money have prompted governments to encourage the rapid growth of an industry in a regulatory vacuum (Badgley, 2012).

Meanwhile, new oil fields have been found and there has been an addition to the already existing problems of these coastal communities. New oil fields mean additional drilling sites, leading to a greater area of no-fishing zones, more tanker traffic and increased environmental risks. I think about Ghana in times like these.

Norway is known to have an extensive experience in the oil and gas industry since its inception in the 1960's. The country has seen some of its major discoveries which gives a lot of contributions to their Gross Domestic Product (GDP), it is no doubt that the use of surveillance tool to detect oil spills, monitor activities around the various platforms on the Norwegian Continental Shelf (NCS) is one of the contribution factors. It is also worth noting that legislation, which gives room for operators along the continental shelf to comply with. This thesis would like to consider some of the surveillance tools that is used in offshore and marine waters in Norway, and how these two elements has contributed to the success of its Continental Shelf. There would later be some comparisons between the Norwegian model of coastal surveillance and the Ghanaian model of coastal surveillance on the national level.

After all this problem description, the main research problem for this master thesis would be:

How do oil and gas companies in Ghana appreciate the use of surveillance tools in their operations, and what are the rules and regulations set by government concerning the use of surveillance in Ghana offshore?

1.3 Research Objectives

From the discussions above,

1. To investigate how surveillance can improve safety in offshore activities in Ghana.
2. To identify types and use of surveillance tools for offshore operations.
3. To examine the rules and regulations regarding offshore activities and surveillance in Norway and Ghana.

1.4 Research Questions

1. How can surveillance tools provide monitoring of offshore installations?
2. What are the available surveillance tools for offshore operations and what are their uses?
3. What are the rules and regulations governing offshore operations and surveillance in Norway and Ghana?

1.5 Significance of the study

Apart from the November 2011 incident stated above, the Jubilee field development through Kosmos Energy experienced several mishaps. The company acknowledged spilling toxic drilling mud on three occasions, including a spill of some 600 barrels (25,000 gallons) in December 2009 (Otoo, 2012). With more oil fields being developed, and many international companies showing interest in Ghana's continental shelf, it becomes necessary for government or intuitions in the oil and gas activities to be more involved with safety measures to ensure safe people and a safer environment. This thesis is significant because it will bring to light the main rules and regulations concerning the use of surveillance in offshore activities, to inform investors who are interested in setting up companies in Ghana.

Moreover, it aims to update oil and gas companies in Ghana about the current surveillance tools they can adopt to ensure safe and secured offshore operations. It will also guide as a research reference to other researchers interested in similar topics.

Validity and Reliability

First, as it is discussed in the methodology further in the thesis, there was some limitations concerning the data collection. Some government agencies in Ghana whom I was supposed to interview were difficult to get in contact with. There are emails on their website, however, you do not get any replies when you send a message to that email. Because of that, my supervisor suggested that I should use telephone calls, this led to a high response from most of the companies, but some of them still wanted to see me face-to-face in their office before they will speak to me. This limited some of the information needed to online sources.

During the crucial 'rush-hour' of this thesis, being the time, I had to give my supervisor the first draft for review, it was during this same time between the 1st of May and 20th of May 2019, that most of the Norwegian state institutions had an upgrade on their website. Now this thesis made use of both primary source of data and the secondary data were also very useful. Some of the information that I had preserved for later, were met with "Error" when I try to get such information from the websites. I however, decided to make telephone calls to get the same information instead of getting them from the websites. This gave me the opportunity to meet a lot of nice and highly experienced people really authentic and reliable information for this thesis.

2.0 LITERATURE REVIEW & THEORETICAL FRAMEWORK

The chapter aims to define surveillance, offshore surveillance, and the supporting technologies. This chapter would also take into account theoretical framework for this thesis, by giving a brief discussion about centralization and decentralization. The discussion is brief because they are further discussed in relation to the industry later in the findings.

2.1 Digital Technology

Digital technology is now commonly interpreted as such usage of Information and Communication Technology, when not trivial automation is performed, bit fundamentally new capabilities are created in business, government institutions, and in people's and societal life (Collin, et al., 2015). Tools that are used to improve performances of an enterprise in an essential way (Gimpel & Roglinger, 2015) (Kane, et al., 2015).

Kokkinakos et al, has argued that like data analytics and social software, state-of-the-art technologies revolutionize the every-day operations of modern organizations in every possible ways. Digital Transformation has been seen to be a predominant term among the famous World Wide Web; many authors have attempted to define and discuss the exact notion of Digital Transformation because of how important the term has become. The boundaries in defining digital transformation has not been defined making it a challenge to tackle the academic literature. A lot of reviewed literature have defined digitization, Fitzegarld, et al., (2013), defined the term as the "the use of digital technologies, such as social media, mobile, analytics or embedded devices, in order to enable major business improvements like enhancing customer experience, streamlining operations or creating new business models" (Fitzgerald, et al., 2013)(Solis , et al., 2014).

While digitization describes the process of the conversation of analogue and noisy information into digital data (Brennen & Kreiss, 2016), digitalization also be said to be a tool used to describe any changes that occur in the organization and the organization's business model owing to their increasing use of technologies in order to improve the scope of their business and their performance (Rachinger, et al., 2018).

Having surveillance equipment, that can determine an in-coming vessel, boat, or ship towards your domain, could be a huge step for oil and gas companies to protect themselves and their environment. Due to the numerous challenges being faced by offshore operations, in terms of monitoring, a lot of technologies are being emerged to cater for these challenges. The following overview considers some of these emerging trends of technologies.

2.2 Offshore Technologies

To acknowledge the types of offshore technologies and their uses, it is important to understand the kind of threats that are being faced by offshore operators and how these technologies can help them to be safe and secured in their operations.

Honeywell in their 2008 report about meeting threats to the offshore oil and gas industry, gave a scenario that can happen to any offshore operator: Imagine a small group of men in a fast speedboat, with knives and maybe guns is able to seize a ship no hesitation. What would happen if a well-trained group of terrorists with sophisticated weapons can do to high-valued properties such as an offshore rig? By virtue of their nature, offshore is the only energy related installations that are prone to attacks by targeted pirates. Offshore installations can be attacked from underwater, through the surface, and from the air (Honeywell, 2008). This can be a traumatized moment for personnel offshore, then becomes very important for companies to know what is going on around them so that they can prepare for the worse it case it should happen.

In a report about observations made on attacks on and unlawful interferences with offshore oil and gas installations, it was noted that the number of attacks has generally increased in recent years. The type of installations that are mostly affected include fixed offshore production platforms, mobile offshore drilling rigs, floating production storage and offloading units (FPSOs), floating storage and offloading units (FSOs) offshore oil export terminals and other types of offshore installations such as oil derricks and wellhead platforms (Kashubsky 2011). This section gives examples of ***threats*** that has occurred on offshore activities across the world.

Terrorism

Terrorism poses a high security threat to offshore oil and gas installations. An example of such attack was when a speedboat fill of explosives crashed into an Indian oil platform located 160 kilometers off the coast of Mumbai, which caused a massive explosion killing fifteen crewmembers, and hundreds of millions of dollars were wasted in effect of no resources left. As if this was not enough, the explosion caused a massive leak of oil, which posed a huge threat to the ecological life in the area (Harel 2012).

Insurgency

Insurgency comes as a result of political struggle, and the people involved usually end up causing damages and casualties to offshore installations. This type of attacks is responsible for about one-third of attacks on offshore platforms (Kashubsky 2011). Just recently, Anadarko Petroleum's convey near its liquefied natural gas project in northern part of Mozambique was attacked by a group of insurgents. This activity caused injuries to four people with one person losing his life (WorldOil 2019).

Piracy

The issue of piracy needs to be addressed when threats to offshore installations are being discussed. In fact, piracy is one of the main issues that is facing oil and gas companies in the Gulf of Guinea area, which includes Ghana. In the last seven years, six piracy attacks have been reported worldwide (M. Kashubsky 2013). There is a record that majority of offshore incidents which is more than 60 percent of all incidents occur in Nigeria. It must be noted that Ghana and Nigeria are all West-African countries and their distant along the gulf of guinea is not so far.

2.3 Surveillance

Surveillance is an integral part of maritime domestic security, which appears in many sources and in many forms. Monroe, (2002) in his creation of patent to the United States described surveillance as: "an assembly of monitoring and recording activity comprising: a motion sensor for detecting motion outside of an enclosed location and position on an exterior surface outside of the enclosed location; a camera for receiving video input, a camera located within a tube between the exterior surface and the interior surface; a microphone for receiving audio input; the camera and the microphone being operably

connected with a transmission unit for transmitting the audio input and the video input to a remote receiving unit" (Adaval & Monroe, 2002).

2.4 Offshore Surveillance

Offshore activities in general are confronted with numerous risks in terms of safety, security and navigation. The maritime industry continuously seeks to optimize supporting operations offshore in terms of services and supply. However, neither have adequate means to detect and visualize the observational updates with enough accuracy or numerical modelling to depend on for decision making. Offshore surveillance develops sensor solutions that improve safety, security and navigational efficiency for offshore activities.

History shows that, there has been major accidents on all of the world's continental shelves, causing damage to the environment, loss of lives and destruction of assets (DNV, 2017). Numerous strategies have been put in place since then to limit or eliminate the occurrence of these accidents. One of the strategies being used by most offshore operators, is surveillance. New and improved systems have been adapted to support the environment upon which these oil and gas companies operate. The use of offshore surveillance has been proven to be effective safety and security item as it helps to monitor activities.

Offshore surveillance tools can thus be categorised as a form of technology/ digitization that is used to influence the processes surrounding the data and information management across the entire oil installation and across the sea.

It is in this order, that technology that enhances safety and improves production offshore, and at the same time ensure the lives of the personnel on board are secured, need to be discussed.

A RADAR

A radar (radio detection ranging) is a tracking system, which was originally developed during world war two, to track enemies from aircraft. It has been adopted by the marine industry for decades as a system that transmits radio pulse and through antenna at a certain interval. The pulse from the radio then transmits into a radar display or represented on plotting programs. The radar system vary in sizes, prices and features. Moreover, it can be installed on any vessel size or platform (Kline 2018). New technology that can be infused in a radar is capable of detecting oil spills so that immediate action can be taken to minimize the impact (Kongsberg,2014).

AUTOMATIC IDENTIFICATION SYSTEM – AIS

AIS tracking systems is used to conduct identification and analysis for vessel operators to avoid collision at sea. Many commercial vessels are required by law to have a transmitter of an AIS signal on a very-high-frequency marine band, which includes information concerning the ship's name, its call sign, its position and speed. The information gathered from the AIS can be displayed on an electronic chart display and information system that can be used for decision-making (Kline 2018).

RADIO VIDEO SURVEILLANCE (SVR) FOR WIDE AREA SURVEILLANCE

The radar dome consists of a stainless steel or aluminum support structure and a dome made from fiberglass composite that does not affect electromagnetic equipment performance. The dome can accommodate three, six, eight, 12 and 18ft scanners. The radome is available in size 1.02m, 2.43m, 2.8m, 4.2m and 6.1m. There is a built-in function for the remote monitoring of pressure, temperature and operational status of the system. Radar dome fulfils the European Standard EN 50014 and has the patented air system.

MARITIME MONITORING SYSTEM FOR 24/7

A safety radar-based system solution developed in accordance with offshore industry standards that assures twenty-four hours monitoring of the maritime situation around offshore installations. The system gathers data from the radars, AIS. CCTV VHF and other sensors and communicate the details to control rooms both offshore and onshore. It has qualities as being user friendly and flexible as it is also suitable for larger control rooms.

VESSEL TRAFFIC MANAGEMENT SYSTEMS (VTMS)

To manage vessel traffic in ports, harbours and coastal areas effectively, the VTMS is a state-of-the-art solution that is particularly aimed at that ensuring efficient traffic flows. Its information is presented at a single operator display, all functions and additional modules like VHF and CCTV are available on one screen in order to simplify the operator's routine and allow effective traffic management (Offshore Technology 2019).

2.5 Why The Need For Offshore Surveillance?

Security

Surveillance systems enable highly accurate observations of objects surrounding offshore platform, coastal infrastructure or around a ship, it aids as an additional pair of monitoring system that greatly improves the safety and efficiency of sea transport and coastal and offshore infrastructures. It detects and localises targets that use wireless communication such as very-high frequency (VHF) or short-band radio. Combined with the Ladar system (an innovative sensor surveillance system that can observe the ocean's surface layer), security on both above water and below water can be monitored 24 hours a day (Ladar Ltd, 2019).

Sea Ice Detection

Ice bergs and floating sea ice in polar waters become increasingly problematic, particularly as the Northern Sea route and polar oil/gas production gain popularity. Current monitoring capabilities rely on satellite monitoring systems but their temporal (and spatial) coverage is insufficient for the needs of the maritime industry. In addition, mandatory on-board radar systems do not typically detect floating ice. This is because most of the volume of the sea ice is floating below the sea surface, thus being hardly exposed to radar backscatter. The characteristics of the Ladar system make it possible to detect floating sea ice, as the system is specifically designed to detect objects in the ocean surface layer. This would not be needed in offshore Ghana since it does not snow in Africa, however, it is worth talking about it (Kongsberg, 2018).

Search and rescue operations

Any major disaster initiates search and rescue operations with the goal to detect and confine humans in the ocean surface layer, in order to save their lives. A surveillance system like Ladar can help to detect humans in the ocean surface layer in a reduced amount of time. And time is crucial — surveillance tools can decide between life and death. With the aid of specific tags attached to life vests or surveillance suits, the location viof persons can be easily determined. There are systems that instantaneously detects when a person is falling overboard and automatically alarms the crew (Ladar Ltd, 2019).

Detection of floating debris

Surveillance systems can detect floating debris and other objects by continuously scanning the ocean surface layer. They can detect oil spills from the platform area, pipelines or the well. With a high-resolution surveillance overview of objects at near distance, a variety of observations are made, including vessels, markers, floating ice, wave characteristics and oil spill observations. The system complements normal navigation radar, which has much less resolution and sensitivity but a longer range (SpaceNav, 2018).

High-precision positioning and docking aid

Surveillance tools provides for precise observations of distances to adjacent objects, for example the required 10-meter distance to offshore platforms for supply and offloading operations. It supports dynamic positioning without the need to locate reflectors on adjacent objects. Coastal and offshore infrastructures can use the same system for helicopter landing areas, crane operations, supply and offloading operations, and more. In addition, vessels equipped with AIS radars benefit from a precise docking aid through high-resolution observations of the docking area (Controp, 2019).

2.6 Centralization and Decentralization

The French mining engineer who witnessed the industrial revolution, noticed a great need for a systematic approach for management theory and training. He outlined 6 activities as technical, commercial, financial, security, accounting and managerial activities in his book

General and industrial management (Fayol 1949). Within these activities come the 14 managerial principles that makes the 6 activities successful. Within these 14 principles was Centralization. Henri defined Centralization as "the command exercised by the higher authority and which, be it direct or through successive levels in the organization, and the responses which return in the reverse sense, either directly or through the levels, to the central authority" (Fayol, 1949). In order words, centralization can be referred to as the concentration of management and decision-making power at the top of the organizational hierarchy for the purpose of coordinating human, financial and other business resources.

Advantages related to centralization include:

- The generation of economies of scale
- Aiding in adoption of best practices
- Increased collaboration between departments
- Easier integration with external stakeholder
- Flexible talent deployment

Some of its disadvantages include:

- Fostering one-size fits all approach
- Further from the customer making it less responsive
- Slower decision making
- Reduced empowerment
- Fewer career opportunities for employees

Decentralization refers to the transfer of national responsibilities and functions, from central government to sub-national levels of government, or from central agencies to regional bodies, or to non-governmental organizations or private concerns. It is the redefinition of structures, procedures and practices of governance to be closer to the individual citizen (Miller, 2002). It must be noted that, decentralization is not associated only with getting value from administration, but also a civic dimension, since it increases the opportunity for citizens to take interest in public activities.

The definition given by the United Nations (DDSMS and UNDP) 1996, on their report on innovative policies fits better for this work: decentralization is a complex phenomenon involving many geographic entities, societal actors and social sectors. The geographic entities include the local, sub-national, national and international. It argues that a mixture of fiscal, political functions, administrative and relationships are what decentralization is about. In addition, it is essential to use a systems-approach containing all the social sectors and the different requirements that each makes (UNPD, 1999).

These two elements come with their own advantages and disadvantages. It must be noted that decentralization is not an alternative to centralization. It involves the roles and relationships of all the societal actors, whether governmental, civil society or private sector. Therefore, if organizations must consider a design of decentralization, all these factors must be taken into account (UNDP, 1998).

Some of the advantages of decentralization include

- The promotion of experimentation and innovation
- Closer to the customer making it more responsive
- More autonomy; giving in to speedy decision making
- Greater career options
- Increased empowerment

Disadvantages include

- Leads to the duplication of work and resources
- Slower to adopt best practices
- Performance across units are difficult to compare
- Harder to involve other functions or third parties
- Difficulty deploying talent across different units

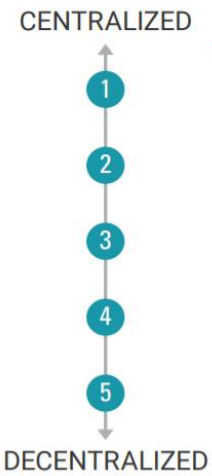
Centralization in fact, both are needed and regarded as complementary in order for government and private institutions can benefit from their coordination. A company can adopt centralization, when for example its main activities are geared towards costs, or when

specialized production capabilities are necessary. Alternatively, decentralization is more appropriate when different products and services for individual markets are needed and the customer focus is more of a priority and the company would like to open new branches to get closer to the customers.

HYBRID COORDINATION APPROACHES

It is important for an organization to understand the model they fall under and how it works. However, offshore industries are one of the most complicated organizations and a hybrid model designed by AlixPartners, LLP (2016) as illustrated in the figure below become more ideal to accept. The hybrid models as they call it, gives more room to coordination in the organization. They believe a common grounds such as formal decision rights, and informal decision approaches such as the use of information technology, frequent water cooler discussions and management forums brings about enhanced coordination and share of best practices at the work place.

Hybrid coordination approach

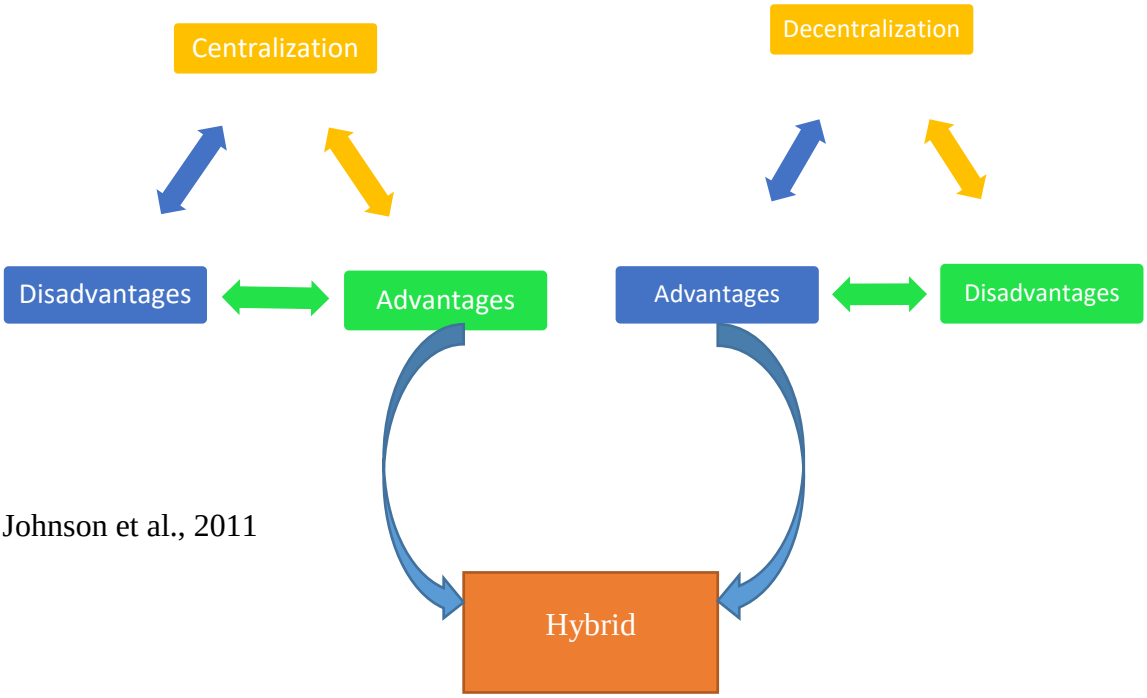


Type of coordination	Description
Central operation	Global centralized unit located in corporate or in a specific region or business unit
Integration	Global manager with direct reporting-line authority over multiple regions or business units
Coordination	Prescribed coordination mechanisms such as management processes, leader forums, or common information technology systems that link different regions or business units
Differentiation	Informal exchanges of information such as water cooler conversations between regions or business units
Independence	Multiple, autonomous units with no formal or informal coordination mechanisms

Source: (AlixPartners 2016)

Although most arguments usually go in favour of decentralization, centralised structures are capable of offering potentially significant cost savings. In determining which model is right for your company, customer satisfaction and employee engagement must be taken into consideration for a successful business approach (AlixPartners 2016).

Ii also believe that a simplest approach to hybrid just as Johnson et al., (2011) suggested, is to take the combination approach to the advantages and disadvantages of both centralization and decentralization.



Johnson et al., 2011

2.7 Legislation

Environmental problems has been a subject of worry to all seas between the many users and uses, this is particularly among the developed, industrialized and agricultural regions along the European sector (Van, 2013). Same can be said of the African coast which is also popular in agricultural activities such as fishing, and industrialised activities such as oil and gas exploration (Boyes & Elliott, 2014). It is for this reason, that rules and regulations are structured and enforced to ensure safe marine environment. Legislation as defined by the Cambridge Dictionary, is a law or set of laws suggested by a government and made official by a parliament. It is one of the most important tools that government uses to protect its citizens and the environment (Cambridge Dictionary, 2019).

Having a structured and detailed rules and regulations for offshore operations is very important. The purpose of having regulations for offshore activities include but are not limited to preventing the adverse effect of petroleum activities on the environment, to promote high standards for health and safety and the environment in carrying out petroleum activities and to provide the minimum health, safety and environment requirements for contractors, licensees, corporations and persons who are interested in engaging in petroleum activities (HSE Act, 2011).

Comparison of Norway and Ghana's offshore safety regimes based on six parameters, as covered by Theophilus and Rainer (2018): Legal framework and structure, regulatory authority workforce involvement, compliance, inspections and sanctions, cost sharing and objects covered.

Regulatory Focus Between Norway And Ghana

Table 1 Comparative analysis of the offshore safety regimes between Norway and Ghana.

Parameter	*Norway*	*Ghana*
Legal framework and structure	a. Coherent and integrated laws and regulations. Petroleum Act (1963); Regulations relating to safe practices (1975 & 1976); Work Environment Act (1977); Principles of internal control (1981); Petroleum Act (1985); Revised regulations (2011)	a. Non-integrated laws and regulations However, attempts are being made to bring all relevant health and safety legislations through the Offshore Petroleum (Health and Safety Bill), 2010
	b. Laws primarily founded on Nordic Law with close ties to European Law and some Common Law elements.	b. Other relevant legislations include: Labour Ac, 2003(Act 651); Minerals Act, 2006 (Act 703); Ghana Petroleum Exploration and Production Law 1984, Petroleum Commission Act, 2011 Act 821, Draft Petroleum (Exploration and Production) Bill 2014; and Factories, Offices and Shops Acts of 1970.
	c. Risk and performance-based with use of legal standards with	c. No specific health and safety regime, regulatory or policy framework but sections of PNDC Law 84; Petroleum

	flexible interpretation and use of industrial standards.	Commission Act, 2011; Draft Petroleum (Exploration and Production) Bill 2014 which apply offshore mandates operators to conduct operations in accordance with international best practices.
Regulatory Authority Workforce Involvement	The Petroleum Safety Authority Norway (PSA) Network of safety representatives mainly from the unions with a mandate to monitor and ensure safety compliance backed with a legal mandate.	Petroleum Commission Safety representatives are present but do not have any legislative mandate to ensure compliance. Under the Draft Offshore (Health and Safety) Bill 2010, employers will be legally mandated to manage its petroleum operation and supervise the health and safety aspects of the petroleum operation personally on every day on which an employee is at work.
Compliance – Inspections and Sanctions	Government Inspectorate	Government Inspectorate (The Petroleum Commission & Ghana Maritime Authority) Installations are also required to have a Certificate of Fitness from a Certifying Authority, or an employer may seek approval to operate a Verification Scheme.
Cost Sharing	General government budget allocation. Regulatory supervision expenses such as working hours and travel costs are refunded by the duty holders and paid to the Treasury. This typically amounts to about 40% of PSA's total operational budget.	General government budget allocation. In addition, the Petroleum Commission may recover the costs and expenses that accrue to the Commission in the performance of its duties.
Objects Covered	Legislation encompasses both offshore and onshore installations including production installations, FPSOs, MODUs, flotels, subsea arrangements, pipelines and processing plants. Pipe laying barges, lifting barges, diving and other support vessels are also regulated by the regime.	Legislation covers primarily offshore activities. Objects covered include offshore installations with floating structures (e.g. FPSOs) but not ships, MODUs, Support vessels are only covered if they are within 500 m of any part of the structure or vessel. There are no existing regulations covering offshore pipelines and transport facilities.

(Theophilus & Rainer, 2018)

3.0 RESEARCH METHODS

3.1 Research Design

This research work pursues a descriptive research with a comparative process, that is questions, descriptions and analysis. Information and characteristics of the relevant issues pertaining to surveillance use in offshore operations is considered, the work is designed in such a way that the use of surveillance tools on the Norwegian continental shelf is identified, the activities that makes surveillance successful is also identifies. After knowing how surveillance equipment is benefiting the Norwegian oil industry, suggestions and recommendations are made to the Ghanaian operators offshore to enable them to enhance their safety and collaboration in offshore operations.

3.2 Sources of Data

This master thesis makes use of primary data where information is collected from the field under my control. Primary data has been known to be the new information that is collected directly from source for the research. This type of data usually takes the form of in-depth interviews, which present the opportunity to gather detailed insights from a leading participants about their business, it can also be a survey with questionnaires, a telephone call or emails to obtain information that did not exist in the secondary data. However, secondary data on the other hand, is the information collected from already existing sources such as journal articles, government statistics, trade publications, company websites (Wolf, 2016).

Primary data is information obtained from scratch using questionnaire, face-to-face interviews, telephone and skype calls and emails. More attention with this source of data was given to the main oil and gas operators in Ghana, Petroleum Safety Authority Norway, and the companies who provide surveillance tools to some of the individual companies along the NCS. Secondary data which makes use of data collected from already published reports through desk reviews. Secondary data was collected through desk research, already published journal articles, books, thesis, and company websites. The desk research involved assembling policy and legislative documents on oil and gas as well as relevant available publications. With regards to primary data, an interview guide was prepared. The idea of the

primary data collection was to identify the existing and expected surveillance tools that are in operation offshore Ghana.

Data Analysis

Mainly, data that was primarily qualitative, the analysis is centred on comparing the actual view expressed by the oil and gas companies during the interviews, other public statements, official legislation documents, and other official documents. The objective of generating options for facilitating the implementation of modern surveillance on Ghana offshore, the types of surveillance and a comparison of the Norwegian and Ghanaian model of surveillance on a national level, and recommendations for improving the process.

Case study and Qualitative research

Baxter & Jack, (2008) indicates that qualitative case study methodology provides tools for researchers, giving them the opportunity to learn cases that involves peculiarities that are complex in their contexts. When qualitative research is applied correctly, it gives way to developmental interventions and valuable methods for health science research (Baxter & Jack, 2008). The thesis makes use of case study approach, with data analysis being qualitative. It is to determine if oil and gas companies in Ghana are using surveillance in their operations offshore in order to enhance safety and collaboration offshore.

3.3 Research Participants

I made interactions with a lot of oil and gas companies. Considering the bureaucratic life of some Ghanaian ministries and public services, it was narrowed to a few companies who are in one way or the other active in offshore operations. The five main Offshore active companies namely, Kosmos energy, Tullow oil plc, Anadarko Corp, Petro SA and the Ghana National Petroleum Corporation (GNPC). These companies are discussed further under the study area section.

Ghana Maritime Authority, (GMA)

GMA is a governmental institution operating under the Ministry of Transport. GMA was established by an act of parliament, that is the Ghana Maritime Authority Act, 2002, (Act 630). The functions of the GMA includes: Ensuring Safety of navigation, dealing with matters pertaining to maritime search, rescue and coordinating activities of the Ghana Armed Forces, the Ghana Ports and Harbours Authority and other bodies during search and rescue operations. Regulate activities on shipping in the inland waterways including the safety of navigation in inland waterways, planning, monitoring and evaluating training programmes of seafarers to ensure conformity with standards laid down by international maritime conventions, in collaboration with other public agencies, prevent marine source pollution, protection of the marine environment and response to marine environment incidents (Ghana Maritime Authority, 2017). The reason for contacting GMA was because they are in charge of safety navigation of vessels on the coastal and marine waters of Ghana, they are also responsible for marine search and rescue in case of accidents.

Ghana Aviation Authority

The Ghana Civil Aviation Authority (GCAA) is the regulatory agency of the Republic of Ghana for air transportation in the country. It also provides air navigation services within the Accra Flight Information Region (FIR), which comprises the airspace over the Republics of Ghana, Togo and Benin and a large area over the Atlantic Ocean in the Gulf of Guinea. The Civil Aviation Act, Act 678 of November 2004 provides for the establishment of a Civil Aviation Authority, which will focus on the core functions of Airspace management and Safety Regulations whilst allowing for a different organization to handle Airport development and operations. Since the use of drones to monitor offshore activities can be categorised as a surveillance tool, it became necessary to contact because it was important to understand how it could be arranged and they are responsible for issuing an authority for the use of drones (Ghana Civil Aviation Authority, Updated: 2019).

Ghana National Communications Authority (GNCA)

As it turns out, before a technology company can establish itself in Ghana, whether onshore or offshore, there are some permits and types of electronic equipment within the law (discussed in chapter 6) which are either accepted by the GNCA or not. This became necessary to get them involved in this thesis in order to be acquainted with the rules and regulations pertaining to the use of surveillance, which involves technology.

Vissim

Vissim is a Norwegian company with 20 years of experience in the development and supply of radar-based surveillance systems. The company has supplied Offshore, Coastal and Port VTS solutions to more than 27 countries. In Norway, their key customer is Statoil, now Equinor. They supply Offshore Sea Surveillance systems to Equinor for managing vessel activity around their offshore platforms. They have sensor sites at more than 70 locations (mostly offshore) and a main onshore Control Centre in Bergen. An offshore surveillance system is very similar to a coastal surveillance system in terms of the technology used. Vissim has been successful in both Offshore Oil & Gas and Offshore Wind markets and has established a leading position in both sectors. In addition, Vissim has successfully supplied Coastal Surveillance and Port VTS Solutions to many countries worldwide. In Egypt, the Gulf of Suez is being installed with a new Vissim Coastal Surveillance solution, and in Malaysia, part of Sabah uses Vissim Coastal Surveillance (Vissim, 2019). Contacts were made with the CEO and the Sales and Business development manager of Vissim to discuss about the recent trend in surveillance equipment that can be suitable for offshore activities in Ghana.

Norwegian Coastal Administration (Kystverket)

The Norwegian Coastal Administration is an agency of the Norwegian Ministry of Transport and Communications responsible for services related to maritime safety, maritime infrastructure, transport planning and efficiency, and emergency response to acute pollution. The Norwegian Coastal Administration was contacted to determine the processes involved in monitoring the marine activities in Norway. This is further discussed in chapter 4 where

an illustration is given on how the coastal surveillance of Norway is monitored. The NCA was contacted to get an overview of this.

3.4 Research model

This work pursues a descriptive research as a basis of the Ghanaian offshore, with the companies involved, the fields in operations and the discoveries made so far since Ghana started with oil and gas operations. It also contains comparisons with the Norwegian model of monitoring offshore activities and the Ghanaian model. This would be done with regards to how they relate to each other in terms of regulations, the contributions of Norwegian oil and gas to the Norwegian economy, and the contribution of the industry to the Ghanaian economy. The Norwegian model of offshore surveillance will be illustrated along with the Ghanaian model. Review of the offshore surveillance tools would be described with the information from the various representative companies. It can therefore be said that it contains both descriptive and comparative studies.

3.5 Interview Procedure

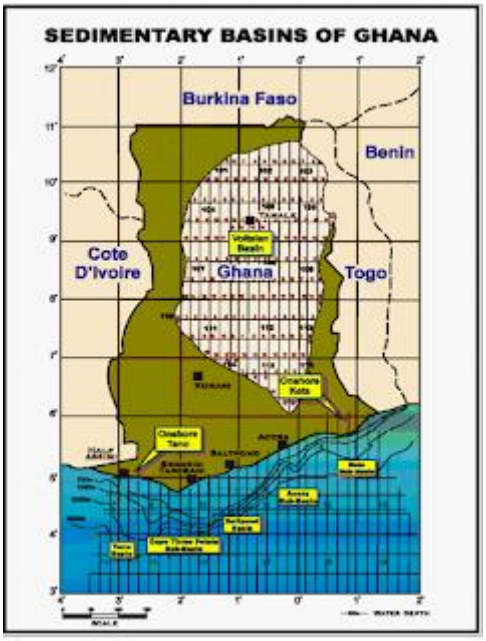
Fink in his second edition of his "The survey handbook" said, for an interview to happen, there should be at least two people; one to ask the questions (interviewer) and one to answer them (interviewee), (Group interviews are also possible). According to him, an interview can be face-to-face; can be over the phone, emails and through video-conferencing (Fink, 2003).

3.6 Data Collection Process

Emails were first sent with no reply, and later, telephones calls were made to all the oil and gas companies involved in this work to establish contact for interviews. All the oil and gas companies were eager to participate in the assignment, it was however difficult to get some of the public institutions to collaborate. Some of them wanted a face-to-face interview which was not possible given the distance between us. It all eventually ended with telephone calls.

3.7 Study Area

Figure 1: Map of the Sedimentary Basins of Ghana



[Source: (Graphic Online, 2017)]

Ghana has four sedimentary basins. These are the Cote d'Ivoire-Tano Basin (including Cape Three Points Sub-basin), the Saltpond Basin, the Accra/Keta Basin and the Inland Voltaian Basin. The offshore basins cover about 60,000 km^2 (0-3500m water depth) extending from the Cote d'Ivoire-Ghana maritime border in the west to the Ghana-Togo maritime border in the east. The onshore/coastal expressions of the Tano and Keta basins, respectively, located at the south-western and south-eastern corner of Ghana, have a total size of about 4,000 sq.km. The Inland Voltaian basin is the largest sedimentary basin in Ghana. It occupies the central-eastern-northern part of Ghana. It is about 103,600 sq.km in size. The sedimentary basins are divided into quadrants of size one degree by one degree, which is equivalent to about 12,420 sq. km. each quadrant is further divided into eighteen (18) blocks with each block size equal to about 690 sq.km (Ghana National Petroleum Corporation, 2008).

ACTIVE PARTNERS ON GHANA OFFSHORE

Ghana National Petroleum Corporation (GNPC) 17.96%

GNPC can be deemed as one of the most important government institutions whose activities are entirely related to the oil and gas in Ghana (Osei-Tutu, 2017). It was established as a corporate body under the PNDC Law 64 of 1983. The PNDC Law 64v gives an outline of the legal framework that defines "the contractual relationship between the State, GNPC and the prospective investor in the upstream petroleum operations" (GNPC, 2012). The company have mandates which includes:

- To promote the exploration and the orderly and planned development of the petroleum resources in Ghana.
- To ensure that Ghana obtains the greatest possible benefits from the development of its petroleum resources.
- To obtain the effective transfer to Ghana the appropriate technology relating to petroleum operations.

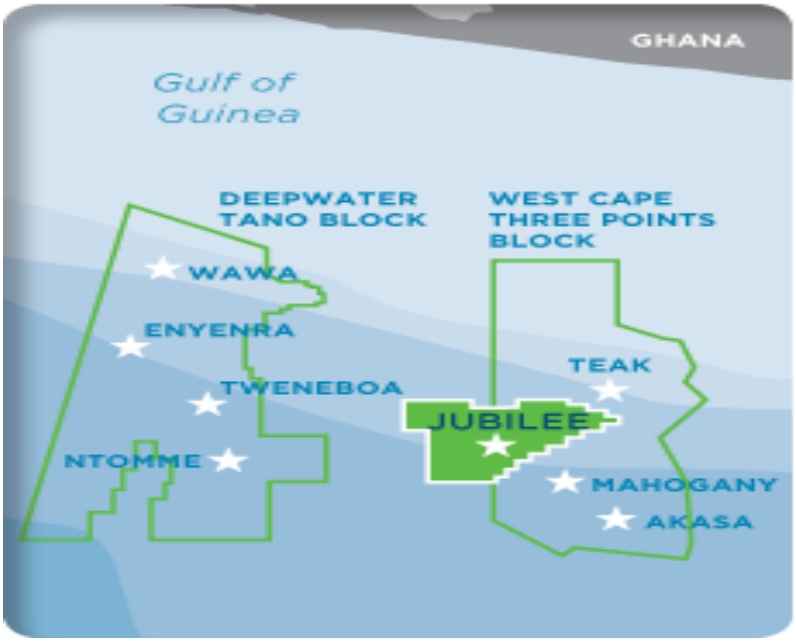
Anadarko Petroleum Corporation (22.8%)

After announcing its first oil discovery from the Jubilee field in 2010, Anadarko started oil production in 2014. Since then, Anadarko, along with its partners, has made major discoveries in the Tweneboa, Enyenra and Ntomme fields. The discoveries, referred to as TEN complex, are expected to start production by 2016. It is one of the world's largest independent oil and natural gas exploration and production companies. Anadarko is leveraging the company's deepwater experience, through their active engagement strategy with Tullow as operator to help ensure all key stakeholders realize optimum asset value (Anadarko Petroleum Coorperation, 2015).

American Kosmos Energy Ltd (22.8%)

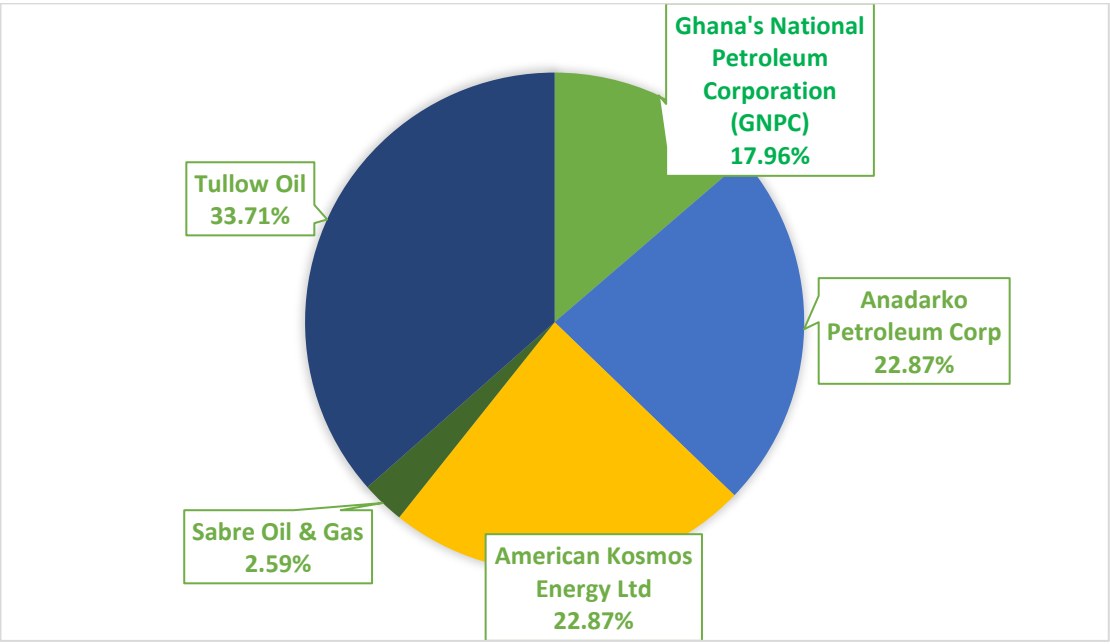
Kosmos Energy opened a significant new hydrocarbon province, the Tano Basin, with the dramatic discovery of the Jubilee Field in the deep waters offshore Ghana in 2007. The Jubilee Field straddles both the West Cape Three Points and Deepwater Tano blocks. Success at Jubilee was the result of the company's identification of the overlooked Upper Cretaceous structural-stratigraphic play concept along the Transform Margin of Africa. It was one of the largest finds of 2007 worldwide, and the largest find of the entire decade offshore West Africa. The company served as Technical Operator for Development at Jubilee. The Jubilee Field development was designed in a phased approach to bring first production on quickly and to apply early findings to follow-on phases (Kosmos Energy Ltd, 2016). The figure below illustrates the production area of Kosmos Energy.

Figure 4: Production area of Kosmos Energy



Source: (Kosmos Energy Ltd, 2016).

Figure 5: Share of Production area



Source: (Grail Research, 2015).

Tullow Oil Plc (33.71%)

Tullow Oil is a British company that primarily operates in the ***Jubilee field***, one of its flagship offshore fields in Ghana. The company witnessed an increase in revenue from USD 958.5 million to USD 1,245.3 million, a growth rate of 30%, during 2012–2013. The ***TEN Project*** is Tullow's second major offshore development in Ghana. First oil was achieved in August 2016. This milestone was reached on time and on budget, three years after the Plan of Development was approved by the Government of Ghana in May 2013. (Tullow Oil Plc, 2016). Tullow has two rigs operating in Ghana, the Maersk Venturer since March 2018 and the Stena Forth which commenced operation in October 2018. These rigs are allowing simultaneous drilling and completion activity across the TEN and Jubilee fields. The drilling programme is running to plan with four production wells and two water injector wells expected to be completed by the end of the year and gross production expected to increase to around 180,000 bopd in early 2019 (Tullow Oil Plc, 2016).

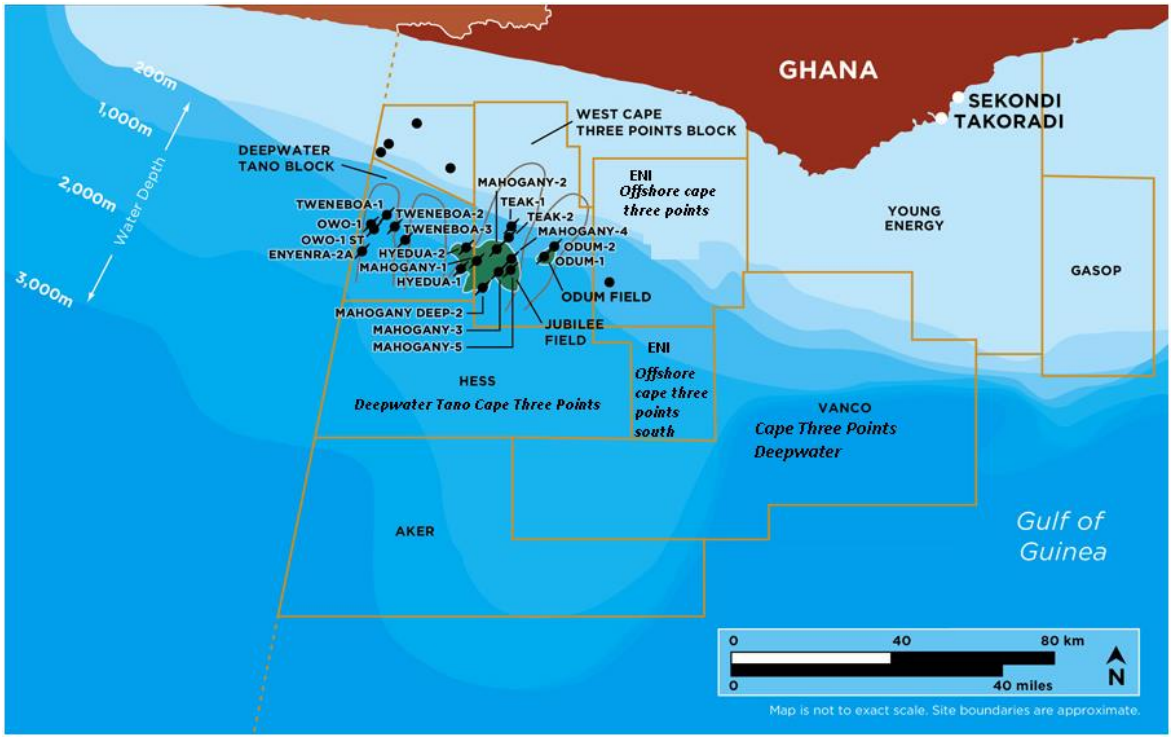
Figure 6: represents the areas where Tullow Oil is active.

Source: Tullow Oil, 2016.

The Petroleum, Oil and Gas Corporation of South Africa (Petro SA) (2.59%)

PetroSA Petro SA is the national oil company of South Africa. Extraction of natural gas from offshore oil fields and production of synthetic fuels from the gas through a gas-liquids process and the extraction of crude oil from oil fields are their main activities. Petro SA does not have a physical operating presence in Ghana, however, they partner with the operations of Tullow oil in their exploration on the TEN projects.

Figure 3: Snapshot of Oil Fields along the Coast of Ghana



Map of Ghana offshore Blocks

FLOATING, PRODUCTION, STORAGE AND OFFLOADING (FPSO'S)

FPSO Kwame Nkrumah –

The FPSO Kwame Nkrumah operates in the Jubilee oil fields off the coas of Ghana. The vessel was named after the first president of Ghana, Dr. Kwame Nkrumah. It has a width of 65 meters (213 ft) and its length is 330 meters (1080ft) long. It uses the biggest turret ever constructed in the oil industry, processing about 120,000 barrels per day of oil and 160 million cubic feet of gas production (Graphic Online, 2017).

FPSO John Evans Atta Mills –

The FPSO Professor John Evans Atta Mills, a Floating Production Storage Offloading vessel, which will produce and store oil from Ghana's Tweneboa-Ntomme-Enyenra (TEN) offshore oil fields. Six wells have already been completed, and the completion of the remaining wells were on schedule. The integrated facilities would undergo final commissioning and testing during the second quarter of this year before first oil (Government of Ghana, 2016).

FPSO John Agyekum Kofour –

The FPSO Kufuor, built in Singapore by Keppel Shipyard Limited (KSL), was named after former President Kufuor, under whose tenure oil was found in commercial quantities in 2007. The FPSO, which is 300m (985ft) long, has a storage capacity of 1.7 million barrels, a double hull to reduce environmental risks and a treatment capacity of 58,000 oil barrels per day. It also has a gas injection capacity of 150mmscfd, a maximum future gas export capacity of 210mmscfd and condensates. The project, according to the lead operator, ENI Ghana, complied with the highest environmental standards and has a complete in-field re-injection of the associated gas (Graphic Online, 2017).

Companies involved in Ghana's offshore operations

Currently, there are about 25 companies involved in the either Seismic Data Processing and interpretation phase, Appraisal phase, Development phase, Initial exploration phase or Exploration phase. Many of these companies form partnerships to initiate their activities offshore. List of companies who are involved in oil and gas activities in one way of the other are seen below:

Table 2: List of companies involved in oil and gas activities in Ghana

No.	Contract Area	Current Partners	Effective Date	Exploration Term	Current Period(Phase)/ activity	Development & Production End date
1	West Cape Three Points	Kosmos Energy Ghana HC Anadarko WCTP Company Tullow Ghana Ltd Ghana National Petroleum Corporation Sabre Oil & Gas Holdings Ltd (PetroSA)	13-Jul-2004	7yrs	Production (Jubilee) PoD Submitted (Greater Jubilee)	12-Jul-2034
2	Saltpond Oil and Gas Field	Saltpond Offshore Producing Co. Ltd Ghana National Petroleum Corporation	30-Jul-2004	N/A	Processes underway for Decommissioning	29-Jul-2024
3	Offshore Cape Three Points	ENI Ghana Exploration and Production Ltd. Vitol Upstream Ghana Ltd Ghana National Petroleum Corporation	15-Mar-2006	7yrs	Development	14-Mar-2036
4	Deepwater Tano	Tullow Ghana Ltd Anadarko WCTP Company Kosmos Energy Ghana HC Ghana National Petroleum Corporation	19-Jul-2006	7yrs	Production (Jubilee) Development (TEN)	18-Jul-2036

		Sabre Oil & Gas Holdings				
5	Deepwater Tano-Cape Three Points	HESS Exploration Ghana Ltd Ghana National Petroleum Corporation	19-Jul-2006	7yrs	Appraisal Phase	18-Jul-2036
6	East Cape Three Points	Cola Natural Resources Limited Medea Development Ltd holds Ghana National Petroleum Corporation	12-Apr-2013	7yrs	Initial Exploration Phase (Seismic Data Processing and Interpretation)	11-Apr-2043
7	South Deepwater Tano	AGM Petroleum Ghana Limited GNPC Exploration & Production Company Ltd Ghana National Petroleum Corporation	12-Apr-2013	7yrs	Exploration (Seismic data acquisition, processing and interpretation)	11-Apr-2038
8	Expanded Shallow Water Tano Block	ERIN (Formerly CAMAC) Base Energy GNPC Exploration and Production Company GNPC	27-Mar-2014	6.5yrs	Initial Exploration (G&G Studies)	26-Mar-2039
9	Central Tano Block	AMNI International Development Company GNPC	27-Mar-2014	6yrs	Initial Exploration (G&G Studies)	26-Mar-2039
10	South West Saltpond Block	BRITTANIA-U Ghana Limited Hills Oil GNPC	17-Jul-2014	7yrs	Initial Exploration	16-Jul-2039
11	South-West Tano Block	Heritage Blue Star GNPC Exploration and Production Company GNPC	17-Jul-2014	6yrs	Initial Exploration	16-Jul-2039
12	East Keta Block	Heritage Blue Star GNPC Exploration and Production Company GNPC	17-Jul-2014	7yrs	Exploration	16-Jul-2039
13	South-West Cape Three Points Block	A-Z Petroleum Products Ghana Limited ECO Atlantic Oil & Gas Limited GNPC Exploration and Production Co. Ltd PG GNPC	18-Jul-2014	6.5yrs	Initial Exploration (G&G Studies)	17-Jul-2039
14	Offshore Cape Three Points South Block	UB Resources Limited Houston Drilling Management And Royalgate Ghana Limited Ghana National Petroleum Corporation	18-Jul-2014	7yrs	Initial Exploration	17-Jul-2039
15	Shallow Water Cape Three Points Block	Sahara Energy Fields Sapholda Ghana National Petroleum Corporation	18-Jul-2014	7yrs	Initial Exploration	17-Jul-2039

List of Partners to Ghana National Petroleum Corporation (GNPC), February, (2019)

4.0 FINDINGS

In this section, I am going to discuss the history of the Norwegian oil and gas, how it has evolved. I will also do an illustration of their coastal surveillance system on the national level based on my interview with a representative from the NSA, and do the same for Ghana's coastal surveillance on a national level based on my interview with a representative from Tullow oil.

4.1 Norwegian Oil and Gas in Perspective

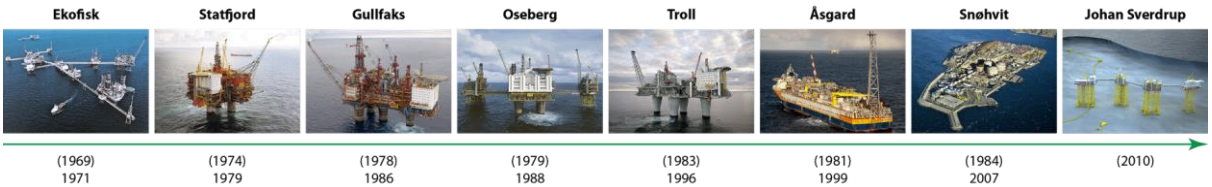
Norwegian Continental shelf (NCS)

"when the first production licenses were awarded in the mid-1960s, hardly anyone realised what a huge impact the industry would have on the Norwegian economy. Fifty years later, it is more important than ever.

History was made in the mid-1960s through 1970s. Norway, through Phillips Petroleum discovered Ekofisk, the largest oil field ever to be revealed offshore. This was when Norway's success story began with its production from the field starting from June, 1971. Leading to this discovery being the most promising and gifted, the continental shelf was gradually opened for companies to tender in their interest in operation. This led to a lot more discoveries and production on other fields such as Statfjord, Oseberg, Gullfaks, and the Troll which represent an important part of the Norwegian Petroleum industry (Norwegian Petroleum Directorate, 2019).

Historical timeline of some important fields discovered in Norway

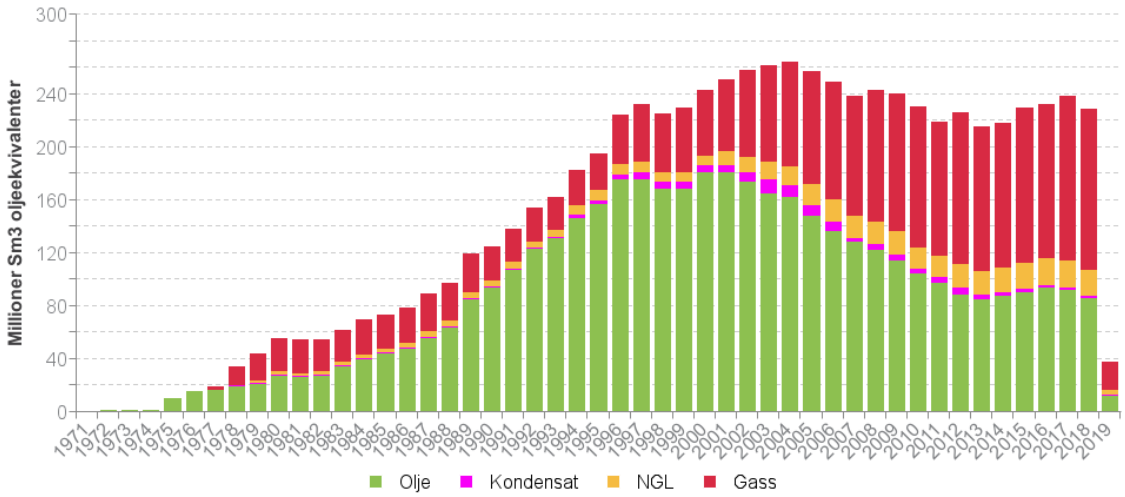
Figure 1 a historic timeline of Norway's major discoveries



Production start and year of discovery of giant oil fields (Source: The Norwegian Petroleum Directorate)

According to the NPC, Norway produced 226.7 million standard cubic meters of oil equivalents (Sm^3 o.e) of marketable petroleum in 2018. By the way of comparison, total production was 236.1 million Sm^3 o.e. in 2017 and 264.2 millionn Sm^3 o.e in 2004. Which also means that production in 2018 was about 14% lower than in the record year 2004 and 4% lower than in 2017 (Norwegian Petroleum Directorate, 2019).

Figure 2: Annual Petroleum Production Between 1971 - 2019



(Source: Norwegian Petroleum Directorate)

Figure 3: Total Production per sea Area

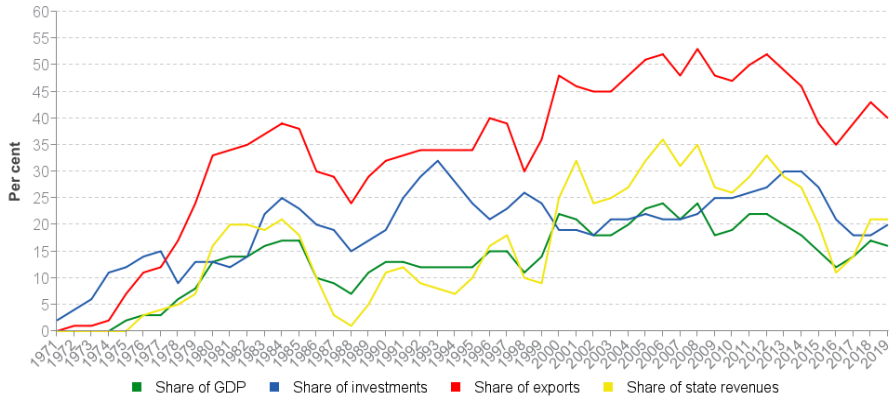
Område	Oil	Condensate	NGL	Gas	Sum o.e.
Barents sea	9.20	8.47	4.96	53.36	75.98
North sea	3727.31	74.71	283.62	1854.82	5940.46
Norwegian sea	611.01	35.89	117.23	530.27	1294.40

A snapshot of the total production per sea area as of year-end 2018 [Source: NPD]

Norway's petroleum wealth

The oil and gas sector is Norway's largest measured in terms of value added, government revenues, investments and export value.

Figure 4: Macroeconomc indicators for the petroleum sector 1971-2019



Source: (Norwegian Petroleum Directorate, 2019)

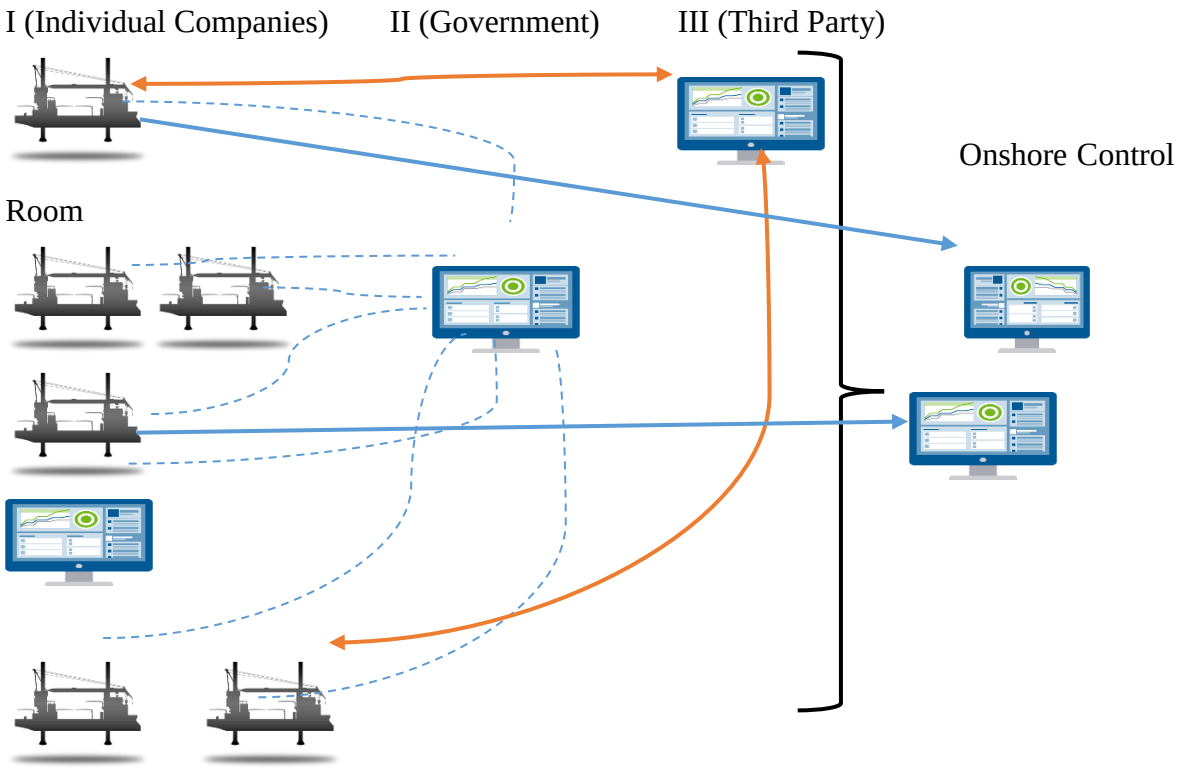
It is no doubt that technology has been one of the success factors that has brought Norwegian Continental shelf to this far. Managers of the NCS make use of an extensive range of technology, to ensure safety, security and collaboration in their operations. Norway believes that continuous improvement makes a big difference.

A statement by the Norwegian chief of Defence, Admiral Haakon Bruun-Hansen indicates that, although there is some presence of surveillance in the arctic, they argue for an extensive presence.

> *"The current security policy situation requires extensive surveillance and presence in the Arctic and high quality of such activities. An understanding of the situation must be maintained along with the ability to permanently, predictably and legitimately demonstrate sovereignty and exercise authority. Presence in the Arctic will continue with vessels, land-based forces, maritime patrol planes and fighter plane preparedness. Daily operations and situation management will remain a top priority in the time ahead" (Norwegian Chief Defence).*

4.2 The Norwegian model of coastal surveillance for national level

Figure 5: An illustration of the Norwegian Model of Coastal Surveillance for National Level



Source: Field Work (2019)

An illustration of the Norwegian coastal surveillance for national level

- Onshore control room monitoring
- Individual companies hire 3rd party companies to monitor their activities
- All installations offshore are monitored by the NCA

The Norwegian model has the individual companies taking responsibilities for their own surveillance in offshore activities. It must be noted that whiles the individual companies have their own surveillance equipment making sure that they are secured and safe, government agency like the Norwegian Coastal Administration, participates in coastal planning and exercising tasks among others like development and maintenance of fairways and fishing ports, aiding in navigational services, vessel traffic services, national preparedness against acute pollution, making sure that maritime legislation is adhered to, and port facility security (ISPS).

The individual companies then report their conclusions to the Petroleum Safety Authority Norway (NPA), The NPA, then on a regular basis, do what they call an "audit" to check all the safety standards put in place by the companies. This is also the case for inspections for offshore installations and equipment. The government in return give 'consent' for the individual companies to continue their operations or not.

In an interview with the Senior Advisor at the NPA, he explained that the 'Consent' here, does not mean approval of a facility, an equipment, components, procedures, qualifications or the like. When a consent is given, the NPA, expresses confidence in the operator (the individual companies) that they can carry out the activities within the framework of the regulations, and in accordance with the information in the consent application (Paul Bang, NPA – 2019). Data from their surveillance activities is also shared with the government institutions for decision making purposes.

Some companies like Equinor and Aker BP operating in the North Sea on the NCS have also established control rooms onshore. Although Aker BP's decision was rejected following some deviations in lack of function to bring the device to a safe state in the Facilities Regulation sub-section 33 on emergency shutdown systems as carried out by the PSA (Petroleum Safety Authority, 2018), Aker PB's decision to have a control room onshore is still persistent.

Equinor

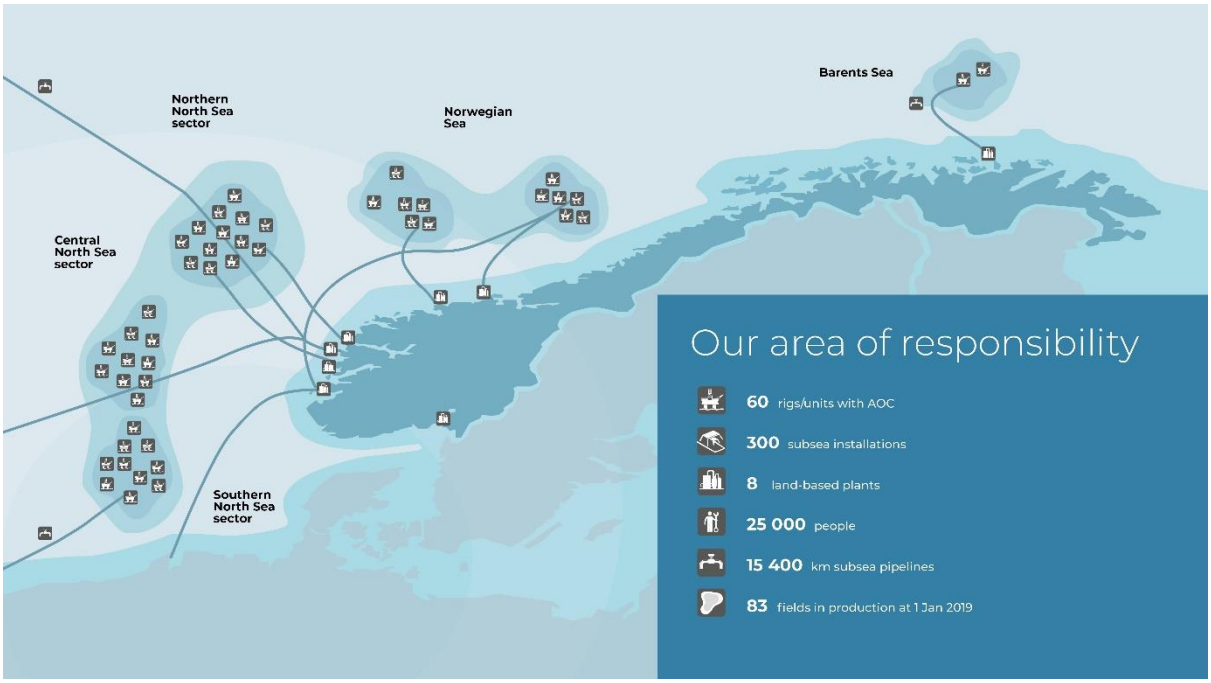
Is the leading operator on the Norwegian continental shelf and have substantial international activities. They are engaged in exploration, development and production of oil and gas, as well as wind and solar power. The company was recently awarded 29 new licences by Norway's Ministry of Petroleum and Energy as part of the Award in Predefined Areas (APA) for 2018. The offshore production platform, which is situated at Valemon, sits in about 440 feet of water on the NCS, approximately 160km west of Bergen. Valemon is one of the biggest undeveloped natural gas fields in the North Sea. Equinor anticipates reducing operating cost on the platform and improve safety across the offshore installations (Equinor, 2017).

The integrated operations centre (IOC) as they call it, is an important step in Equinor's digital roadmap, and the company believes it will enable increased production efficiency and production potential on the NCS. This IOC center is focused on production and processing of their offshore activities. The company has built a brand-new control room onshore at Sandsli in which it has installed an Experion Process Knowledge System. This distributed control system (DCS) which can also be known as a decentralised system, is a supercomputer which effectively provides a full data visualization screen for platform operators, the people in charge of the functioning and safety of the rig, which easily give evaluation on issues on the plant for managers to take the necessary action (Roberts, 2017) . Equinor believes that having a remotely controlled onshore station is one of the means of how the new ways of working and interacting can offer new possibilities and advantages.

The company has also have an agreement with Vissim to deploy solutions for surveillance of the ocean space surrounding all of their several 3rd party operated assets on the NCS and UK continental shelves. The new system which covers both incorporating machine learning and enabling surveillance of vessel traffic management systems, air traffic, subsea structures and environment and real time weather situations, is conceived to be both traditional and offshore wind assets. It is considered to be one of the largest of its kind in the world (Vissim AS, 2018)

Looking at the number of operating companies (about 75 companies) actively involved on the NCS, this could be labelled as a decentralized system of operation.

Figure 6:A snapshot of where PSA is responsible to monitor and inspect.



Source: (Petroleum Safety Authority Norway, 2018)

***Decentralization*:**

Decentralization as discussed earlier in chapter 2, refers to the transfer of state/national responsibilities or functions from a central administration to sub-national levels, in this case to oil and gas companies operating offshore, it can be a redefinition of structures, procedures and practices of direction which gives authority to the individual companies.

***Government*:** Institutions that see to the legislation, control and checks / intervene in the activities of the coastal environs including the individual companies.

Individual company: Any or all oil and gas companies established offshore on the Norwegian continental shelf, and offshore Ghana.

Advantages associated with Decentralization:

- ***Collaboration*** - There exists a collaboration solution existing in both control rooms in offshore and onshore, here, data is captured from a third-party kid, such as camera on the platform in Valemon and integrated into a support system. This shared information allows operators to access information visually and in real-time, so that

expert advice from those not on the platform can be sought and urgent decision is taken.

- ***Empowerment*** - It facilitates empowerment of the individual companies and networks, as the workers perceive the benefits of working in collaboration with local government to advance their interests, this leads to appropriate organization, systematic and orderly approach to their activities to pursue their objectives since they know that the government is somehow watching.

- ***Better Informed*** - It brings the government closer to the people, which enables the companies to be better informed in this case, with the information regarding the rules and regulations concerning their activities, and to better understand the conduct of their operations offshore. This leads to strong relationship between the individual companies and the government. 'The centre may also improve sharing of knowledge in our organization and further improve our collaboration with our suppliers and partners' says Eldar Sætre, The President and Chief Executive officer at Equinor ASA.

- ***Innovation*** – decentralization has been seen to provide opportunity for a wider diversity leading to innovation. As companies can handle their own resources and manage their own surveillance equipment, this gives room for the companies to explore all the markets available for surveillance and in turn choose what is best for their company based on what they can also afford. And this is evident looking at all the third party surveillance provision companies that exist on the Norwegian market.

- ***Prompt Decision Making*** – oil and gas activities are deemed as one of the most dangerous jobs in the world, having another 'eye' onshore in the case of Equinor and all other companies involved in the oil and gas activities on the NCS to have another eye (government) seeing to be safety and security of their operations, leads to a prompt and detailed decision making that can lead to saving lots of lives. If we take for example if there is an irregularity in the offshore operations and having a control

room onshore, the operators identify this anomaly and inform the workers offshore to make an informed decision based on the information from onshore.

- ***Integrated Control And Safety Systems*** – there is a high level of integration and control which enable personnel to easily monitor and control a wide range of production processes. Decentralized systems provide a full range of data visualization capabilities for operators so they can easily assess any issues on-board the platform. For example, for control room projectors acting as a live video feed, operators have full visual contacts with team members stationed on the platform.

- ***Better Knowledge Retention*** – the use of stations offshore and onshore, with government involvement, gives rise to share of information visually and in real time which leads to expert advice being sought from those who are not on the platform. Decentralized activities also improve collaboration between the individual companies on the NCS, the PSA and other government agencies in charge of maritime safety along the NCS, leading to a faster and best utilization of practises across a network of operating assets and therefore contributing to better knowledge retention and greater efficiency.

DISADVANTAGES OF DECENTRALIZATION

- ***Cost*** – it is no doubt that having a control room offshore on platforms and establishing another one onshore to oversee activities costs a lot of money. Information from Equinor's website indicates that the company is willing to invest up to about 1-2billion kroner in digital technology to create higher value and improve operations between 2018 and 2020, this is related to their onshore operating center only. Their partnership with Vissim, under which Vissim is to provide them with maritime surveillance, is also costing about 100 million kroner. This rises more financial burden on the company as they need to employ trained personnel, they need to mount a new onshore control rooms. With all the benefits that it brings, making a 'decentralized' decision on operations costs a lot of money.

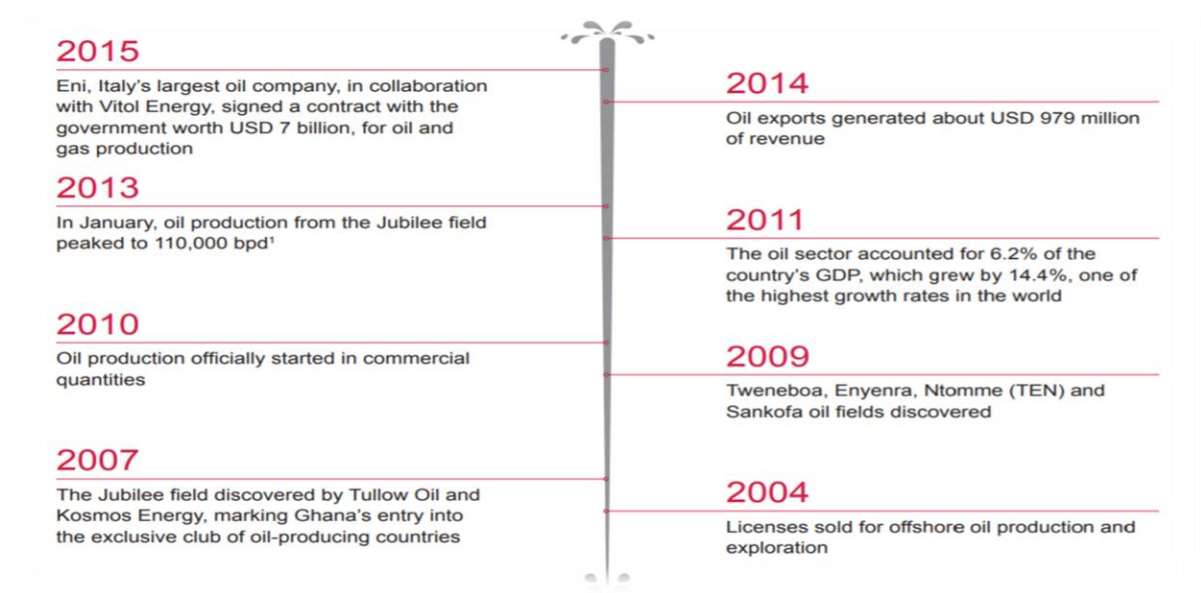
- ***The need for qualified personnel*** – decentralization may seem as a good thing, it becomes useless when there are no qualified and competent employees to monitor and control the activities onshore and give feedback when needed. It thus, requires that the company invests in trained and qualified personnel in addition to their existing staff to accomplish their mission.

- ***Varying Policies*** – decentralization could lead to different policies being followed by the individual oil and gas companies, when the regulations that they are supposed to follow are not lied down correctly or where there are misunderstanding within a regulation that they have to conform to.

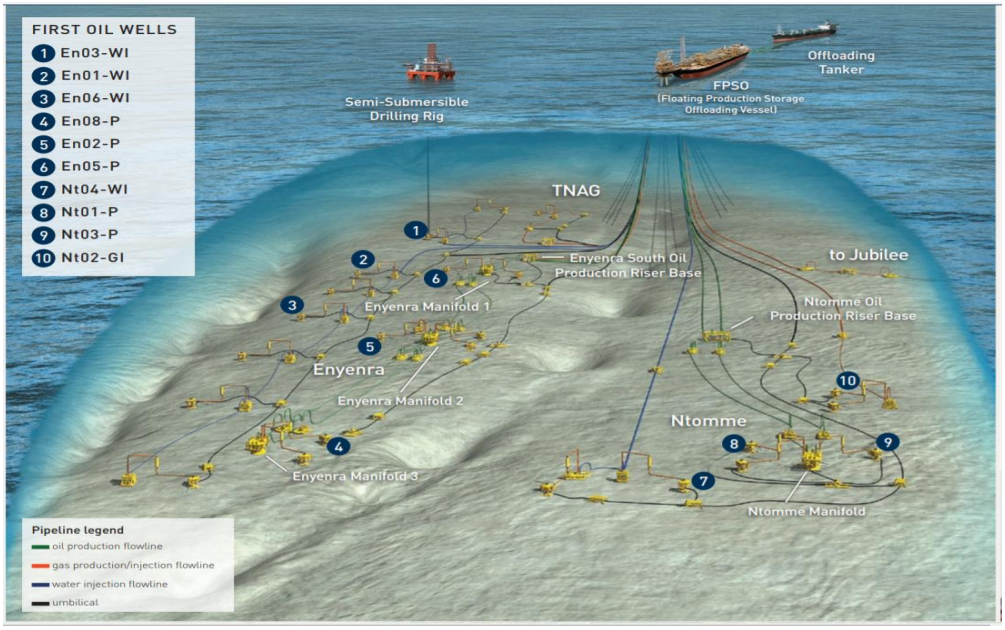
4.3 Ghana's Oil and Gas in Perspective

Petroleum has assumed a growing importance to the Ghanaian economy. It is becoming a vital source of employment for some of the teeming unemployment youth, through direct engagement and spin-off activities. The petroleum sector has contributed increasingly and consistently to Ghana's revenue and gross domestic product (GDP) over the years and helping to boost the nation's international reserves essential to economic self-sufficiency. In addition to boosting GDP, petroleum activities have become a critical source of government revenue. It was estimated that about US $444.12million was contributed to the country's GDP in 2011, there has been an increase of about 13.5 percent in 2014 (Boachie-Daanquah & Sulaiman, 2014). It should be noted that "The Ghana National Petroleum Corporation (GNPC) is expected to lead the task as the Gye-Nyame Sankofa project progresses, as well as oil production at the TEN field ramp up to its full capacity of 80,000 barrels a day by first quarter of 2017 (Seth Terkper, 2016).

How the Oil Industry has Evolved



Source: Adapted from (Grail Research, 2015).



A snapshot of the first oil wells in the TEN Project (Tullow Oil Inc, 2016)

Significance of Oil to Ghana's Gross domestic Product (GDP)

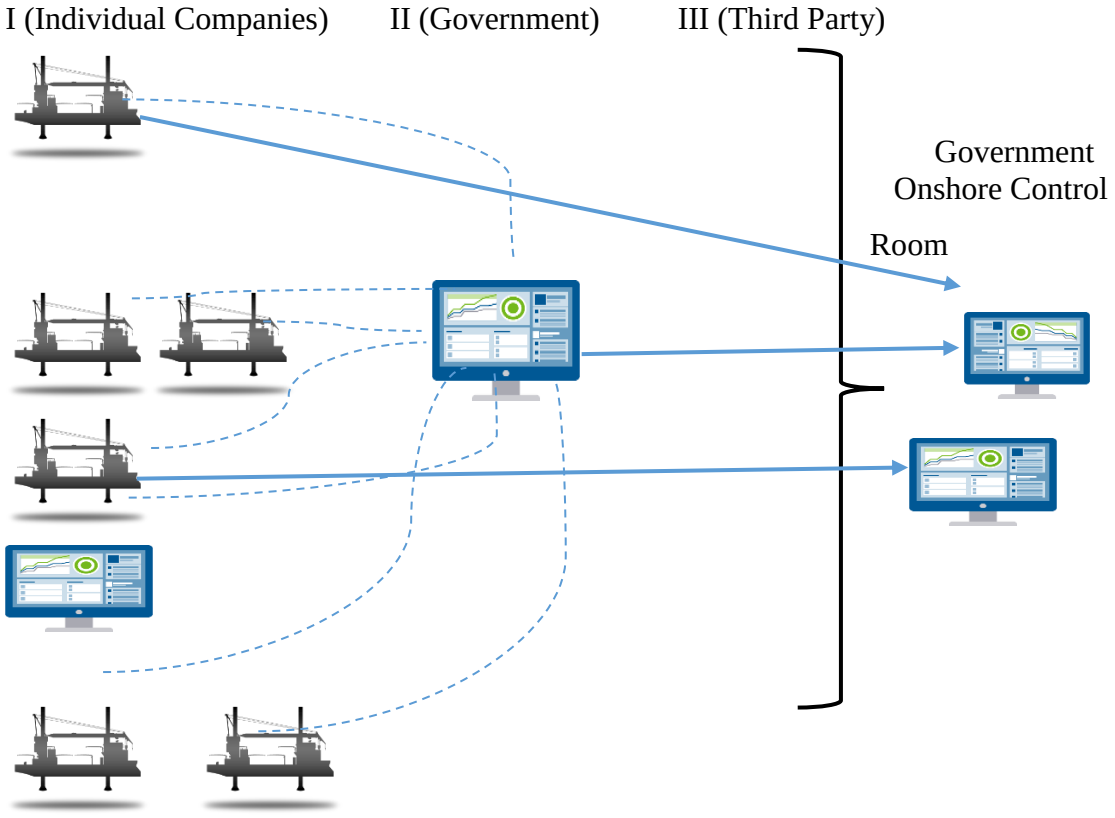
So far, $4.7billion in revenues has been realized. Total production from inception of oil production to September 30, 2018 is 242,278,382 barrels, according to data from the Ministry of Finance, while total petroleum revenue received by the government between 2011 and September 2018 is US$4.723 billion. The contribution of oil to Gross Domestic

Product (GDP) has been remarkable. Ghana experienced one of the strongest growth numbers in the world at 14.4 per cent in 2011, up from 8 per cent in 2010, according to the Ghana Statistical Service (GSS). Ghana's GDP growth hit 8.5per cent in 2017, as a result of strong performance in the oil and gas sector as well as significant growth in the country's industrial sector (Ghana Statistical Service , 2018).

With this much contribution to the Ghanaian economy, and with the high expectation of new companies to venture into the oil and gas industry, it is therefore very important that we discuss the safety measure that enhances smooth operation, accident free and seamless procedures of offshore activities with the use of surveillance tools.

4.4 The Ghanaian model of coastal surveillance for national level

Figure 7: The Ghanaian model of coastal surveillance for national level



Source: Field Work (2019)

An illustration of the Ghanaian coastal surveillance for national level

Government onshore control room monitoring

All installations offshore are also monitored by government agencies

Centralization

The system that is in Ghana on the other hand, can be referred to as a centralized system where a government institution is appointed by the government to take responsibilities of the coastal surveillance. The overall operation of seeing to the safety and security in the marine and offshore activities are in the hands of the maritime authority of Ghana and Ghana ports and harbour, both government agencies. There are no third party companies as off now, and the government agencies takes patrol on the marine environment and reports to their control room onshore.

Centralization – centralization has been defined as the concentration of authority at the top level of the administrative system. In a centralized system taking the case of Ghana into consideration, the companies are not able to act on their own when it comes to using surveillance for their activities offshore. Their problems have to be referred to a higher level of authority, an agency appointed by government to oversee the affairs of the marine and aviation security and safety. From the data collected from the oil and gas company in Ghana, they have not into any kind of surveillance as of the time of the data collection between February and March, 2019. They indicated they are considering the use of drones to monitor their activities offshore, however, due to the laws stated by the Ghana aviation authority (Laws would be discussed further in this section), they have not been able to implement it. This means that, all their monitoring and controlling is done by the Ghana maritime authority and the Ghana aviation authority (both are Government institutions).

Advantages with centralization

More effective use of limited resources – The resources that would be dispensable for individual companies and government agencies to share becomes more effective. In this case only the government is in charge of the monitoring, so the individual companies can use their resources somewhere else.

Cost savings – for the government to be in charge, it saves the individual companies from using large sum of money to invest in new projects involving new technological advancement with their processes.

It is suitable in dealing with emergencies and unanticipated matters – When cases are centralized, the people in charge of handling emergencies are averagely small, when complicated issues evolve, the government can take decisions as soon as possible without involving the individual companies at once. This ensures a quick and prompt decision making and anticipated responses in case of emergencies.

It ensures that all the work is performs in the same manner and in accordance with the rules and regulations that are outlined. – Centralized decisions means that there are no duplicate of systems, and that there is a systematic way of dealing with the individual companies in following the regulations outlined. Centralization makes it easier for the government agencies to monitor activities of the companies and keep them regulated.

Disadvantages with centralization

- ***Increased burden on Authority*** - Centralization increases the load of work for government authorities leading to little time to for them to attend important administrative functions such as planning and organizing.

- ***Bureaucracy*** – *C*entralization has been associated with bureaucratic activities. For example if Tullow oil spots an unwanted vessel or canoe around their rig, they will have to communicate this with the Ghana maritime authority, Ghana Navy patrol teams to come and check, who will then instruct them on what to do, or wait for them to act as they are the agencies in charge. Since the whole system is being monitored by government organisation, if the oil and gas companies need to make decisions it has to go through the government, which is a long process. It therefore leads to delay in securing action as the field officials have to refer the matter to the higher authority for approval. When asked one company in Ghana if they use surveillance, they replied no, however, they are considering using drones in their operations. They also need to ask the Ghana aviation centre for licenses which is taking forever to issue.

- Centralization ***does not encourage the development*** of second line of executive. Under this point, it can be said that, since oil and gas companies operating offshore know that there are government agencies in charge of monitoring the coast and its

environs, they are being reluctant and a bit relaxed in getting their own surveillance tools.

4.5 Legislation Concerning Offshore Surveillance Activities.

In the direction of hunting for the rules and regulations governing the use of surveillance in offshore operations in Ghana, numerous rules and regulations were reviewed. Some of the regulations reviewed included but not limited to the Ghana Model Petroleum Agreement, Ghana National Petroleum Corporation Law 1983, Oil and Gas Insurance Placement for Upstream Sector, the Petroleum (Exploration and Production)(Health, Safety and Environment) Regulations, 2017, and the Electronic Communication Regulations, 2011, which lies under the Ghana National Communications Authority . It is quite vague when it comes to rules and regulations regarding use of 'Surveillance' in offshore Ghana, however, I was able to get some of the regulations that can be said to be relevant in this case.

All the information acquired here were obtained from the Petroleum (Exploration and Production) (Health, Safety and Environment) Regulations, 2017.

Monitoring and Control

110. (1) A contractor, sub-contractor, licensee, the Corporation or any other person engaged in a petroleum activity shall ensure that relevant factors for prudent execution of activities as regards health and safety, are always monitored and kept under control.

(2) The contractor, sub-contractor, licensee, the Corporation or any other person engaged in a petroleum activity shall ensure that data relevant to health, safety and the environment are collected, processed and used for

(a) monitoring and checking technical, operational and organizational factors;

(b) preparing measurement parameters, indicators and statistics;

(c) carrying out and following up analysis during various phases of the activities;

(d) building generic databases; and

(e) implementing remedial and preventive measures, including improvement of systems and equipment.

Establishment of specific safety zones in hazard and accident situations

162. A contractor, sub-contractor, licensee, the Corporation or any other person engaged in petroleum activity shall apply to the Commission for an extension of the existing safety zones or creation of a new safety zone in the event of a hazard or an accident situation to prevent injury to persons or loss of human lives, serious pollution, major material damage or a substantial shutdown or production.

Monitoring of safety zone

163. A contractor, sub-contractor, licensee, the Corporation or any other person engaged in petroleum activity shall monitor activities within and outside a safety zone where the activity may result in safety risk to the petroleum activity inside the safety zone.

Warning and notification in connection with entry into safety zone

164. (1) A contractor, sub-contractor, licensee, the Corporation or any other person engaged in petroleum activity shall

(a) alert a vessel that is entering a safety zone without authorization;

(b) alert a vessel outside a safety zone if the vessel may constitute a safety risk to petroleum activities;

(c) where possible, alert the party responsible for an object where that object poses a safety risk to petroleum activities and

(d) alert the Commission and other relevant agencies of the occurrences of any of the situations specified in paragraphs (a) to (c).

Qualification and use of new technology and new method

16. (1) Where the petroleum activity entails the use of a new technology or a new method, the contractor, sub-contractor, licensee, the Corporation or any other person engaged in petroleum activity shall ensure that

(a) criteria are established for development, testing and use of that technology or methods to fulfil the requirement for health, safety and the environment;

(b) criteria are suitable for the relevant conditions of us, and the new technology or the new method is adapted to solutions already accepted; and

(c) the qualification or testing demonstrate that applicable requirements can be fulfilled using the relevant new technology or new method.

(2) For the purpose of sub-regulation (1), “new technology” means a method, process, equipment or device which may have limited information on health, safety and environmental implications but can be adopted to suit a solution which is already acceptable.

Other information gathered from the Electronic Communications Regulations, 2011, under the auspices of the Ghana National Communication Authority (NCA).

Public Coast Stations

17. (1) A public coast station shall communicate with

(a) a ship or aircraft station that operates a maritime mobile service for the transmission and reception of safety communications,

(b) a land station to facilitate the transmission or reception of safety communication to or from a ship or an aircraft station, and

(c) ships and other maritime mobile stations for the transmission and reception of public correspondence with the written authorisation of the Authority.

(2) A public coast station shall transmit meteorological and marine communications with the written authorisation of the Authority.

Limited Coast Station

18. (1) Where a national station cannot provide the required facilities, the Authority may grant a licence for a limited coast station to

(a) an agency of the Government;

(b) a person who is engaged regularly in the operation, docking, direction, servicing or management of one or more commercial transport vessels;

(c) a fishing enterprise engaged in full time operation and in control of a minimum of three vessels; or

(d) an agency responsible for the operation, control, maintenance or development of a harbour, petroleum reconnaissance, exploration and mining, port or waterway used by commercial transport vessels.

(2) A limited coast station shall not be

(a) open to public correspondence,

(b) used to transmit programme material of any kind for use in connection with radio broadcast, or

(c) used to transmit media material or new items which are not required to serve the needs of ships specified in the licence except as specifically provided in the licence.

(3) A person shall use a limited coast station exclusively in an emergency to serve the need of the Government and ships including the transmission of safety messages.

(4) Subject to sub-regulation (5), a person shall not put communications apparatus on a sea-going vessel including fishing vessel into operation while the vessel is at a port or harbour within Ghana except with the permission in writing of the Authority. (5) Sub-regulation (4) does not apply to the use of an apparatus for VHF communication between masters of ships, ship owners, agents or dock officials who are concerned with the berthing or departure of vessels or the handling of cargo or other port operational matters.

Public Telecommunications Services Fixed and mobile public telecom services 19.

The following are public communication services:

(a) carrier services;
(b) voice telephone services;
(c) cellular services;
(a) telex services;
(b) paging services;
(c) mobile multichannel service of automatic selection in a trunk radio;
(d) telegraph services;
(e) Data Transmission Exchange Services; and
(f) any other service classified as public communication services by the Authority.

Radio navigational services

40. (1) For the purpose of this regulation, a radio navigational service means a service by which it is possible to determine the position, speed, orientation, route or other characteristics of an aircraft or vessel or obtain information that regards those parameters, using radio waves.

(2) A radio navigation service is of the following two categories:

(a) aeronautical radio navigation, which is a navigational service provided to aircraft for satellite, signal collection stations located on the aircraft; and

(b) maritime radio navigation, which is a radio navigation service provided to navigable vessels and for satellite, signal collection stations located on the vessels.

Commercial vessels that operate on inland water ways

41. The Authority shall determine the frequencies for use in the operations of radio apparatus to transmit alarm signals for commercial vessels that operate on inland water ways.

Construction and installation of broadcasting facilities

54. (1) The construction and installation of facilities for the provision of a broadcast service shall commence within two years after the date of the grant of the frequency authorization and the operator shall carry out testing for its operations within the specified period.

(2) The Authority shall cause an inspection of the construction of the proposed broadcast facility and may make technical recommendations, which the operator shall comply with;

(3) The Authority may conduct a second inspection during the construction and installation period.

(4) When a second inspection is conducted, the Authority may issue a certificate that the construction and the installation comply with the standard set by the Authority or shall on written notice of not less than thirty days from the date of the second inspection to the operator, cancel the frequency authorisation if the operator is unable to meet the construction and installation standards.

Transmitters

57. A transmitter used in a broadcasting station shall conform to the frequency tolerance determined by the Authority.

5.0 ANALYSIS AND DISCUSSIONS

5.1 Research Question 1

- ***Why is it important to monitor offshore activities?***

As discussed earlier in chapter 2, issues of safety and security around offshore installations are important to every oil and gas company. As many companies are trying to improve their activities, as well as getting solutions for threats such as piracy, insurgency, and terrorism Ghana should not be an exception. Offshore operators in Ghana, need surveillance in their activities in the following manner to enable them tackle situations like:

- Traffic Organisation. To assist vessel traffic in the navigation of a difficult stretch of water. A Traffic Separation Scheme may be in place for such an area to avoid collision. Again, radars can be attached on the FPSO's to handle all unwanted trespassers who might collide with the FPSO's. All other vessels that services the platform and fishing vessels can ensure safe navigation with the use of VTS and AIS equipment.

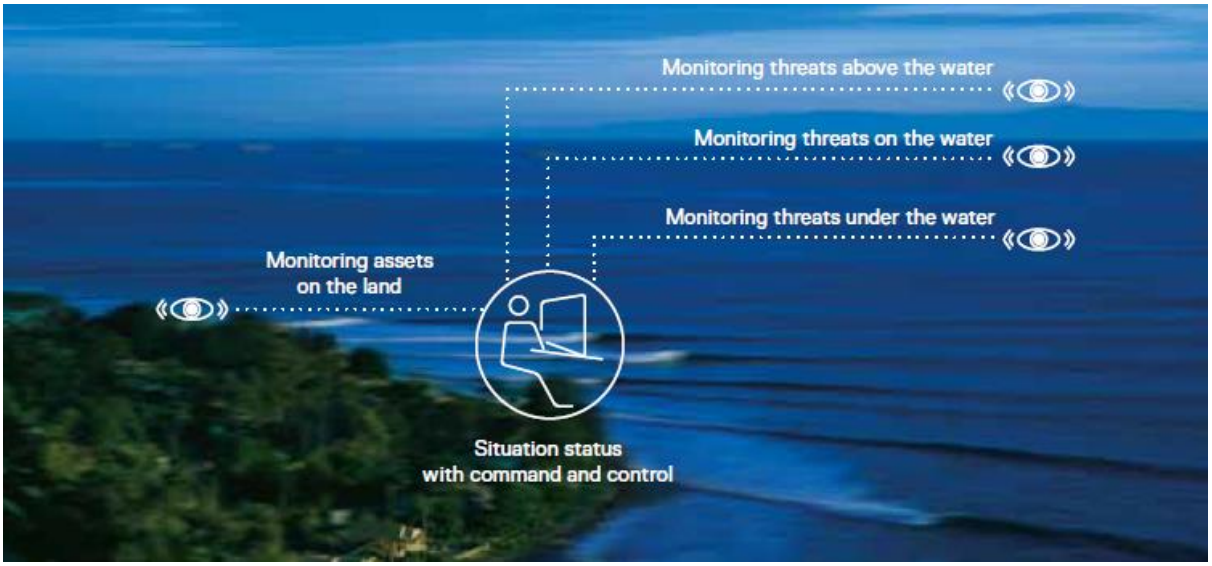
- To counter piracy against other ships or attacks on offshore platforms, offshore assets, surveillance tools such as AIS Transponder, which vessels to be automatically identified on the main Traffic Display screen. Within a Coastal Surveillance system, this normally indicates that these vessels are low risk as it the unknown vessels that become the focus of attention for the Coastal Surveillance System Operator. AIS therefore is a tool that helps to quickly establish which vessels are low risk so that the system operators can focus on the higher risk vessels.

- To protect all forms of offshore asset from collision damage by operating vessels in the area.

- To ensure early detection of any pollution, oil spills so that it can be managed and resolved before the amount of pollutant makes the clear up too difficult.

- Should a person or an object fall into the water, appropriate search area planning software can assist in the rescue / recovery operations.

Figure 8: Coastal surveillance systems and Coastal Vessel Traffic Services



Source: (Vissim, 2017)

Coastal surveillance systems are used to provide both vessel traffic services (VTS) as well as security surveillance. With increasing amounts of coastline, territorial water and Exclusive Economic Zone (EEZ) to be monitored and managed for security, environmental protection, and safety, the ideal coastal maritime surveillance system will compile a real-time Traffic Image/Common Operating Picture and highlight vessels of interest without undue operator involvement, to reduce operator workload. (Kongsberg, 2018).

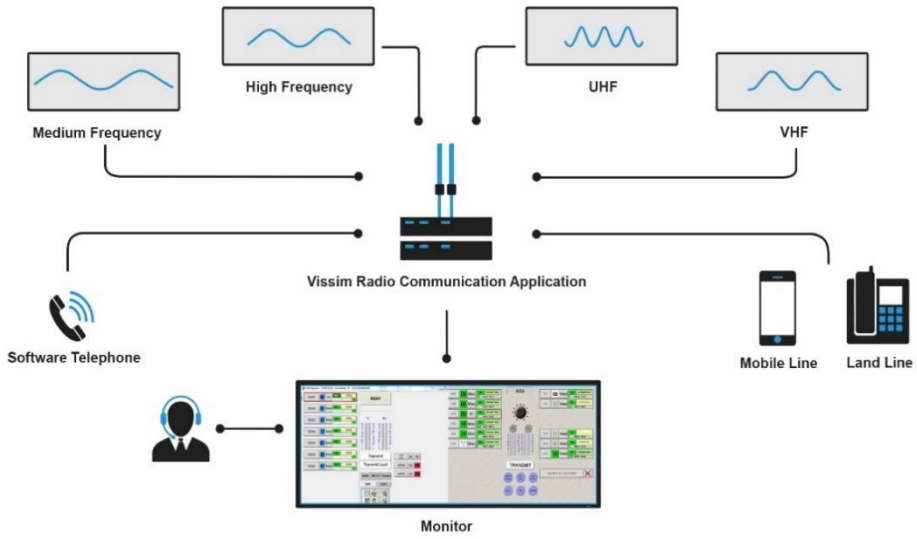
Vessel Traffic Services (VTS) and AIS Networks

A Vessel Traffic Service (VTS) system couples with an AIS Network helps ensure the safety, security and efficient use of ship traffic through high-risk areas such as Traffic Separation Schemes, wind farms and restricted areas. Many VTS systems are known to efficiently and swiftly capturing ship information, monitor speed related to CO2 emissions, are help with enhancing environmental protection through reducing groundings and oil spills and coordinating Search and Rescue (SAR) operations. (Kongsberg, 2018).

In congested maritime traffic, effective communication between vessel and VTS operator can be crucial. Reports show that difficulties in establishing effective communications frequently lead to maritime accidents. Radio Communication is a network based with full IP communication voice system which includes radio control. The Radio Communication provides received signal quality information in a digital form and automatically routes the

audio signal directly to the operator. When integrated with Vessel Traffic Management, full utilization of DSC-based communication is enabled. The Radio Communication will receive MMSI information from the VTS and create a database of vessel details. A DSC call can be established directly with such vessels by a simple click on the main traffic display. This will enable a voice communication call to be easily established by the VTS Operator through a simple single on screen action. In addition, area calls or all-ships broadcast messages can be initiated in a similar manner on any VHF (Very High Frequency) channel. Voice recording is centralized and is synchronized with the VTS in playback mode. With many marine accidents occurring due to misunderstanding during communication, the radio communication help VTS operators to be certain that they are having the correct interaction and the right decisions are being made (Vissim, 2017). How the Radio Communication works with the VTS is illustrated in the figure below:

Figure 9: Illustration of radio communication with Vessel traffic management



Source: (Vissim, 2017)

5.2 Research Question 2:

- ***What are the available surveillance tools for offshore operations and what are their uses?***

Every coastal area along the West-African coast can be prone to one threat or another. As threats approaches, it is important that visual images are identified as quickly as possible so that the appropriate reactions can be taken. Coastal surveillance systems provide authorities with the ability to improve security of the maritime domain and around the coastlines. It enables detection, identification and classification of vessels of interest. This provides images which enable officials to prevent ships from entering dangerous, sensitive and restricted zones. To identity the types of surveillance tools that offshore oil and gas companies can adopt, I was privileged to have had a conversation with Knut Kildal Hansen, the Director in charge of Sales and New Business Development at Vissim, and Per Hanaes, the CEO of Vissim, through my supervisor. Both Per and Knut are experts when it comes to surveillance tools appropriate for Ghana to depend on because they are both highly familiar with the African market and already have markets in Eastern and Southern Africa. Below are some of the surveillance tools that Ghana can implement to enhance safety in offshore operations: it must be noted that every single discussion here is credited to Vissim AS.

- **Radar**

Radar is known as the primary sensor of a VTS or Coastal Surveillance System. For many coastal surveillance requirements, it remains the primary sensor as the vessels that a coastal surveillance system needs to detect could be operating illegally. This means that they are very likely to fit an AIS transponder to automatically identify themselves and therefore, it will be the task of the radar sensor to detect them. Vissim has interface software that enables them to integrate with almost any radar sensor that is available on the market today. These can be simple low-cost Magnetron radars or the latest solid state radar systems. In general, the latest solid state radar equipment does provide better small target detection capability since it has a higher Effective Radiated Power output. Solid state radar equipment transmits almost continuously and therefore more power hits the target and then consequently, more power is reflected by the target back into the receiver circuits of the radar equipment. For coastal surveillance applications where the requirement is focused on the detection and tracking of small targets, such solid state radars are probably the best solution.

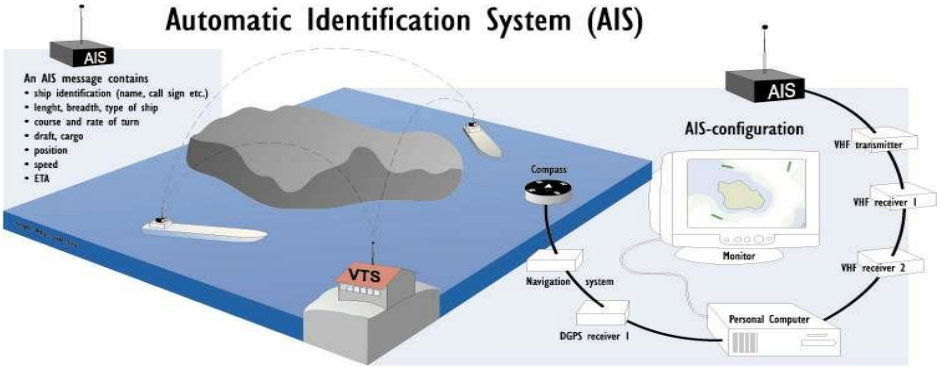
- **VIOP Voice communication system**

Voice communications is very important. A Control Centre without the ability to communicate instructions to its services offshore and onshore cannot control anything. Communication with Patrol Vessels offshore (like the navy patrol) and with ground forces onshore (such as the Police) is vital if the offshore platform is going to achieve its objectives. Vissim's VCS3000 is an advanced voice communication system. It normally comprises the maritime VHF band but can also include the VHF air band and UHF frequencies. It operates through a touch screen display that is easy to use. VCS3000 uses the Jotron TR7750C base station and is designed for coastal surveillance applications. Where vessels are between coastal radio sites, the system will measure the received signal strength at each base-station and will automatically select and route the best quality audio to the operator's headset. Within the maritime VHF band, DSC (Digital Selective Calling) is included and fully integrated. This enables an Operator to call a vessel based on its MMSI number. The system automatically receives the MMSI of every AIS equipped vessel as this data is transmitted by AIS. The VCS3000 system therefore produces its own phonebook with the Vessel name and its MMSI (as received through AIS) and uses this information to set up calls to ships through the VHF system by sending digital call set up information over DSC channel 70. This means that a Control Centre Operator can set up a call with a vessel on a working channel without needing to hail the vessel on Channel 16. The DSC messages make the radio on board the vessel ring (like a telephone) and the radio will automatically switch to the working channel when the officer of the watch picks up the radio handset.

- **AIS – Automatic Identification System**

An AIS Base-station will be included within the Coastal Surveillance system solution as it enables "AIS Transponder Equipped" vessels to be automatically identified on the main Traffic Display screen. Within a Coastal Surveillance system, this normally indicates that these vessels are low risk as it the unknown vessels that become the focus of attention for the Coastal Surveillance System Operator. AIS therefore is a tool that helps to quickly establish which vessels are low risk so that the system operators can focus on the higher risk vessels. AIS can also be used for other applications, such as the positioning of "Virtual" or "Synthetic" Aids to Navigation. These facilities can be useful should it be necessary to change the routes used by larger commercial vessels. "Virtual" and "Synthetic" Aids to Navigation will appear on the ECDIS system on the bridge of a passing vessel.

How AIS works



A screenshot of how the AIS works (Vissim, 2019)

AIS transponder

AIS antenna

- **Integrated CCTV on IP**

Electro-optic sights (EOS) (or CCTV cameras) are an important aspect of coastal surveillance. When vessels that are higher risk are unlikely to be fitted with an AIS transponder, then other means are necessary in order to identify vessels at sea. In addition, the camera can be assigned to a target vessel, through the Traffic Display software, and the camera will then follow the target as it progresses through the coastal surveillance area. By zooming the camera, it can be possible to identify the vessel target and the vessel name can then be entered into the system. The specification of an EOS system is an important aspect in the design of a coastal surveillance system and should accurately define the requirements for Target Detection, Recognition and Identification. It is important that the requirements for Identification are clearly understood and should be defined so that the range at which identification is possible is clearly captured. For example, must be able to read characters of height 20cm from 2nm.

- **Mobile Data Network**

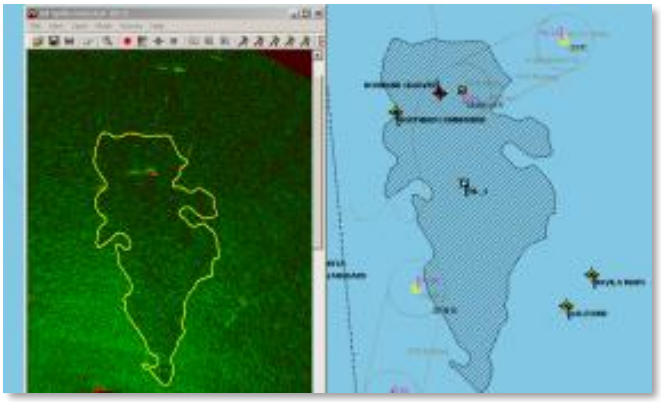
Effective and coordinated action is essential for a coastal surveillance system. Whether the action is to manage vessel traffic or to intercept illegal activity at sea or to coordinate a Search & Rescue situation, effective communication of the circumstances is vital so that all participants understand what needs to be done and instructions can be easily understood. The Modem Data Network provides a means of transmitting the Traffic Image to Patrol or Support vessels at sea so that they can be active participants in any action that the Control Centre may require. A Data Network base station will be installed at each coastal site in order to set up a VHF data network that covers the same area as the radar and other communications equipment. The same type of Data Network base station will also be installed on board the Patrol vessels along with a rigged computer display that will be used to present the Traffic Image. This approach to sharing data among all participants ensures that coordinated action can be effectively executed in order to successfully achieve the required objectives.

- VHF Radio Modems at Coastal Sites and Installed on Patrol Vessels
- On Board Traffic Display for Patrol Vessels so that Vessels target data can be shared between the Control Centre and the Patrol Vessels
- It enhances cooperation and improves operational effectiveness.

- **Oil spill detection**

This monitors the sea clutter and if it is determined that the sea clutter has been suppressed, then the system provides an alarm to indicate that an oil spill (or some other form of pollution) may have occurred. Radar sea clutter is not just noise, it represents the reflected signal from the sea surface. If an oil spill occurs, the effect is that the small waves that normally exist on the sea surface are suppressed and therefore in an area where an oil spill has occurred, the radar picture sees less sea clutter. Vissim has developed software to detect this effect and can therefore offer an Oil Spill Detection capability to complement its radar

tracking software. As you can see from the figure below, there is less sea clutter shown in the green raw radar image where the oil spill has occurred. Vissim's software detects this difference in sea clutter amplitude and draws an outline around the oil spill area. This can then be presented on the traffic display alongside the tracked targets. If the spill were caused by a vessel, this would give a very good indication, in real time, of which vessel was responsible for the spill.



- **Wave movement height**

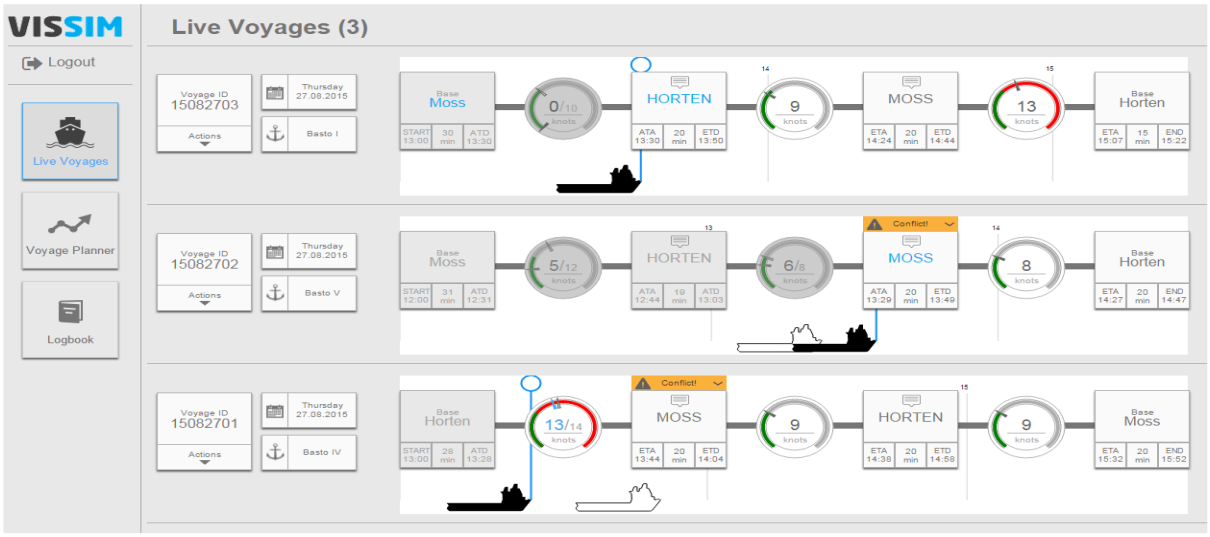
In addition to Oil Spill detection, wave height measurement from the raw radar video signal can be provided. Like Oil Spill Detection, this is a software processing feature and does not require any additional hardware. We simply use the standard Coastal Surveillance radar (so long as it is a Magnetron type). Like Oil Spills, the wave height is reflected in the sea clutter image and through advanced processing, Vissim can measure the wave height across the sea clutter area of the radar display. The key advantage of this technology is that it does measure the wave height across an area and so if the wave height is very significant in one area such that it affects the route planning of an incoming ship, the System Operator could advise a different route so that the vessel can still safely find a route to its destination. There are similar technologies used by Offshore Wind developers as it gives a good indication of the level of risk for offshore workers who must disembark from Crew Transfer Vessels onto offshore turbine sites during bad weather conditions.

- **Voyage planner**

Whole route planning is becoming an important topic within the maritime business. Currently, ships arrive at ports or congested areas without any knowledge of when they can proceed. This frequently leads to a waste of time while the vessel waits in an anchorage for clearance to proceed. By improving the route planning for a vessel and the logistics management of a port, it is possible to advise a ship on the time to arrive at the port in order that the vessel can proceed directly to its berth. This would result in the ship travelling at an optimised speed and as a result it uses less fuel. The improvements in route planning will therefore have environmental benefits. E-Navigation and VDES (VHF Data Exchange System) are topics currently under discussion at IALA and IMO. VDES will convert part of the maritime VHF spectrum from standard analogue voice to digital data communication. This technology will enable higher bandwidth data communication between ship and shore and will also be implemented via satellites in order that global data communication is possible. This will facilitate whole route planning and will enable shipping to achieve greater efficiency while its environmental impact will be reduced.

- **Voyage Planning - Logistics**

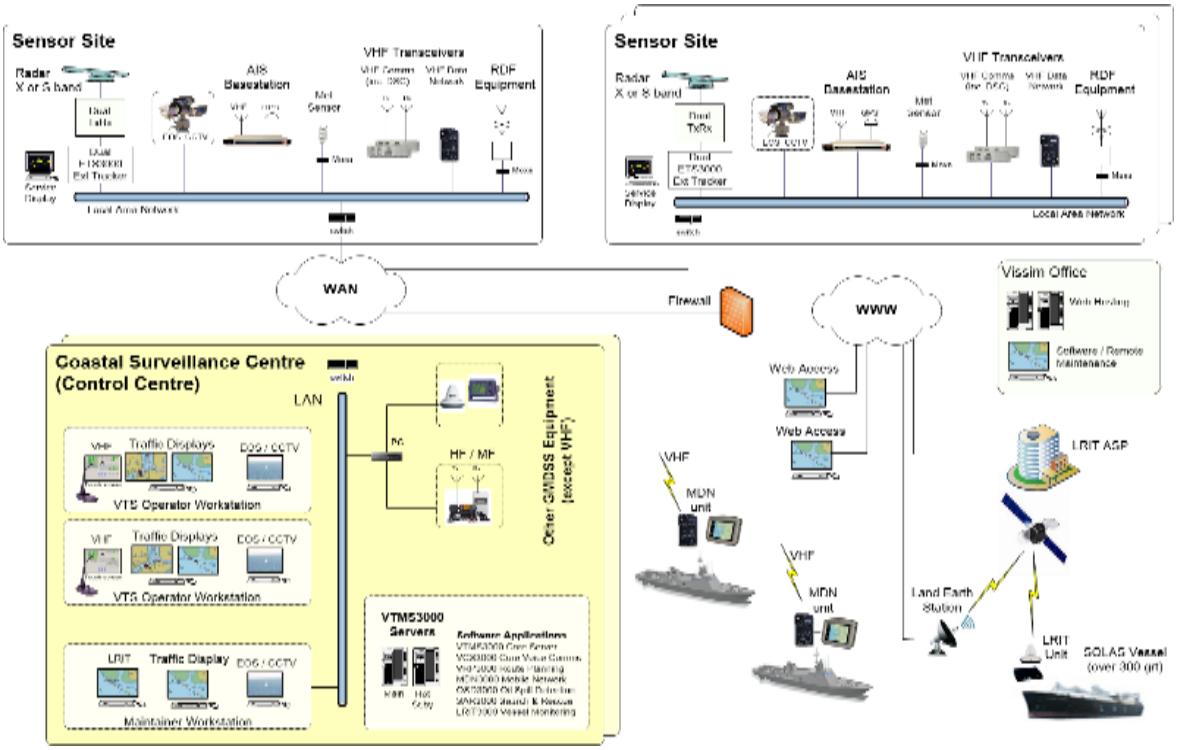
Vissim has also taken its voyage (route) planning technology further with the ability to manage optimise the voyage of a vessel through multiple ports. For the Offshore sector, this enables the management of supply vessel activity to offshore platforms. Where the schedule is tight, Voyage Planning software clearly shows where vessels are ahead or are behind their intended schedule. By fully integrating the voyage planning software with the VTS or Coastal Surveillance system, the information about progress along the route is updated in real time and so vessel managers can take decisions based on realistic information so that vessels can be brought back onto their planned schedule as quickly as possible. A voyage planner can estimate the position of the vessel and whether it is delayed or not. It has a live feature which give these indications.



- **MET Ocean Solution**

Meteorological sensors are a useful part of a Coastal Surveillance system as they provide the offshore operators with details of the environmental situation at each sensor site. A typical met sensor would typically measure: Wind Speed, Wind Direction, Temperature, Humidity, Atmospheric Pressure and Rainfall. All MET Ocean data is presented graphically on the Traffic Display against a time baseline so that the Coastal Surveillance System operator has a clear view of how conditions are changing and can then assess the impact on vessels within the coverage area.

A typical coastal surveillance solution that Ghana can adopt



Source: (Vissim, 2019)

The figure above represents a typical system architecture for a coastal surveillance system. It shows a typical sensor site that has radar, AIS, Electro Optic Sight Cameras (CCTV) VHF Communications for voice communication with vessels and a Mobile Data Network (MDN) for sharing the Traffic Display image with Patrol Vessels that are operating within coastal waters. In addition, a radio direction finder can be included which will provide a bearing indication to any vessel that is transmitting within the coastal zone. Depending on the chosen frequency band, the radio direction finder may give an indication of a radio transmission from an unknown vessel that could be engaged in an illegal activity. Met sensors complete the equipment at each sensor site and will give an indication of the environmental conditions at the remote site. The system can include as many sensor sites as are required to achieve the required surveillance coverage.

The Control Centre can be equipped with as many operator workstations as required. When planning the facilities that will be included at the Control centre, it is worth considering the emergency situations when multiple operators will be required to address multiple tasks in parallel. The Control centre may also require Traffic Display facilities within a Conference Room so that access to live, real time, data can be provided to support the planning of emergency response actions.

5.3 Research Question 3

- ***What are the rules and regulations governing the use of surveillance in offshore operations in Ghana?***

According to the NPA Senior advisor, there is something called 'implementation and enforcement' when it comes to rules and regulations. Norway puts up a performance-based approach to make sure that the companies comply with the rules set out for them to follow. And they government agencies ensue trust in these companies that they will abide by them. The performance-based approach to managing oil and gas activities, is a system orientation and dialogue between the government and the companies. This initial system had big weakness. From a supervisory perspective, for example, the companies only had to correct the faults discovered by the regulator without addressing the underlying causes of nonconformities or problems. The industry also found that the detailed requirements, restricted opportunities for innovation and technology development. But the greatest source of concern from the government's viewpoint was that detailed regulation did not help the companies to grasp their own overall responsibility. Neither was the climate of collaboration between regulator and companies good. The transition from the original reliance on detailed control to the present framework-based approach was gradual, but has however been successful (Bang, 2019).

Now Ghana, can adopt this, the intention of government in making changes with the existing policies and laws in the face of new realities imposed by the production of oil in commercial quantities. It has been evident that, Ghana lack the strategic analysis of policies concerning its oil and gas industry. As it can be seen from the findings under the legislature, that, so many rules and regulations had to be reviewed in order to ascertain some level of understanding of getting surveillance for the individual companies. The problem of making meaningful impact on this sector is seen to be hampered by 'getting the relevant documents' when needed. This is rather making the growth of this sector to be uncompromising.

6.0 CONCLUSION AND RECOMMENDATION

This research has brought to light the numerous offshore surveillance tools that are available around the world and that can be useful in the offshore operations in Ghana. These tools such as oil spill detection tools, VTMS, MDN, AIS have been elaborated on in detail and their usefulness has been outlined.

Moreover, it has been evident in the research work why it has become necessary for Ghanaian upcoming companies and already operating companies to engage in the use of surveillance equipment in their offshore operations. This is to have a collaborated system that enable all parties involved (government and individual companies) to identify what is happening around their coastal shores and around the offshore platforms and the means to act on them. Systems that would enhance collaboration across-systems, cross-discipline and where data can easily be shared with other systems onshore, offshore and on-board vessels. The new system which will act as one of Ghana oil and gas industry's main strategic move towards offshore digitalization, will incorporate the benefits of machine learning and enable surveillance of vessel traffic (VTMS), air traffic, subsea structures, environment and real time weather situations and forecasts. Moreover, having a surveillance operation offshore gives operators an almost complete overview of the ocean space. Vessel and helicopter movements get integrated with weather forecast, oil spill surveillance and integrated radio communication will enable oil and gas companies to provide surveillance services and maximize marine operational performance and logistics.

Ghana is yet to establish and enforce legislation that concern offshore activities. When Ghana is compared with Norway who are also known for producing oil and gas in large quantities, Norway has a clearly defined laws and regulations stated out in a performance-based manner, even though Ghana is said to have such laws regarding their offshore surveillance and other activities, it is vague, and has a huge gap in it, a gap such that there are no one specific document that outlines the use of offshore surveillance in terms of the regulatory authorities involved, the cost sharing of offshore activities for example if there is an oil spill.

it , and there are a whole lot of Commissions and Institutions involved which makes it difficult to identify who is actually responsible for these kind of activities and what they entails. It is can be acknowledged that all these government agencies have a role to play, getting specific information concerning surveillance use was almost impossible from Ghanaian companies due to the numerous companies involves. One company would say, we are not responsible for it, that company is, and another company would say this company must do it, and so on. It is important to learn from the best, there is always a way to improve if Ghana can adapt to and learn from Norway who are known to be one of the best when it comes to offshore operations, in terms of how surveillance tools can be positioned, the types of tools to be used, etc.

I therefore recommend that Government of Ghana need to review all the rules and regulations regarding health, safety, and security in offshore operations, a department among these numerous governmental agencies considered above, there can be created an independent agency (Commission) of their relationship in government. This commission can have the sole responsibility of creating extensive rules and regulations, and a total compliance to these rules in addition to the health, safety and the environmental standards, laws and regulations as it pertains to other offshore jurisdictions in Ghana.

What is needed is the construction of an organizational architecture that formalizes the exchange of information and coordinates succeeding activities. Whether to centralize activities or to decentralize, depends on the individual company's capabilities and their objectives. A lead company must be selected to organize the surveillance data into a recognized maritime picture that allows decision-makers to quickly access the pertinent information which is needed to support operational decisions. It must be noted that, such activities involved technical expertise from companies that are highly known and recognized for such. Many of such companies have been discussed earlier in this work. The result of such collaboration would be improvement in offshore operations which would involve a national capability to fuse surveillance data, analyse it, and coordinate action in the maritime sphere for better operations. Both advantages from centralization and decentralization can be adopted to make operations better. For example one advantage under decentralization is, it brings about innovation, and one another advantage under centralization is how it makes

companies respond to emergencies quickly, these two elements can be adopted by a company and be focused on them without being a centralized or decentralized entity.

Finally surveillance is able to improve safety and security offshore through developed softwares such as the VTS, AIS, MDN and VTMS.

Although the focus of this work has been a recommendation to oil and gas companies in Ghana, it must be noted that, looking at the numerous types of tools that have been discussed, it can be recommended that the government of Ghana, can also take the initiate to invest in modern surveillance equipment. The government needs to be proactive; it does not have to wait for our beautiful beaches filled with beautiful resorts and attractive sites to be filled with unmeasurable amount of oil from a spill before the government takes remedial measures. The time to take preventive measures is now.

6.1 Further Research

This thesis has been limited to the use of surveillance to enhance safety and securing activities offshore in Ghana. It has seen what goes on between operating companies and the government in terms of monitoring the coastal fronts of Ghana. It would be quite interesting to further develop this work to analyse the use of surveillance tools on the two ports of Ghana, namely: the Takoradi Port and the Tema Harbour. These two ports have high operations and their activities involve a lot of loading and unloading of containers, supply vessels arrival and clearing of goods from the containers. It would be interesting to know the types of surveillance tools that can be used onshore in those areas to curb theft (as a lot of customers complain of their missing goods) and secure operations.

It could also be noted that, there was a short presentation of centralization and decentralization of offshore activities. Again, by using the same methodology, there can be an extension of this research, where a researcher can further extend this work to explore what goes into having a centralized control room and a decentralized control rooms, the costs involved in both cases, and write extensively on their advantages and disadvantages.

7.0 REFERENCES

Adaval, Rashmi, og Kent B Monroe. 2002. «Automatic construction and use of contextual information for product and price evaluations.» *Journal of Consumer Research* 28 (4): 572-588.

AlixPartners. 2016. «Centralization versus decentralization: what's right for you?» *Target Magazine* (AlizPartners LLC) 1-4.

Anadarko Petroleum Coorperation. 2015. *Upstream - Africa.* Funnet May 16, 2019. https://www.anadarko.com/Operations/Upstream/Africa/Ghana/#page-tabs.

Badgley, Christiane. 2012. «Pulitzer Center.» 19 January. Funnet March 21, 2019. http://pulitzercenter.org/reporting/west-african-oil-boom-overlooks-tattered-environmental-safety-net.

Baxter, Pamela, og Susan Jack. 2008. «Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers.» *The Qualitative Report* 13 (4): 543-559.

Boachie-Daanquah, Bernard, og Isma-il Sulaiman. 2014. *ANALYSIS OF THE IMPACT OF OIL AND GAS ON GHANA'S ECONOMY.* Industry, Accra: Channel 360.

Boyes, Suzanne J, og Michael Elliott. 2014. «Marine legislation - The ultimate 'horrendogram': International law, European directives & national implementation.» *Marine Pollution Bulletin* (86): 39-47.

Brennen, J. S., og D. Kreiss. 2016. «"Digitalization", in Jensen, K.B., Rothenbuhler, E.W., Pooley, J.D. and Craig, R.T. (Eds).» *The International Encyclopedia of Communication Theory and Philosophy* 556-566.

Bueger, Christian. 2015. «What is maritime security.» *Marine Policy* 53: 159-164.

Cambridge Dictionary. 2019. *Cambridge Dictionary.* Cambridge: Cambridge University Press.

Collin, Jari, Kari Heikkana, Janne Korhonen, Marco Halen, Timo Itala, og Mika Helenius. 2015. *IT leadership in transition - The impact of digitization on Finnish organizations.* Aalto: Aalto University Publication Series.

DNV. 2017. «Enhancing offshore safety and environmental performance.» *Key Levers to Further Reduce the Risk of Major Offshore Accidents*, 5 Feruary: 1-15.

Equinor. 2017. «Norway's first platform to be remotely-operated from land.» 09 November. Funnet May 11, 2019. https://www.equinor.com/en/news/09nov2017-valemon-remote.html.

Fayol, Henri. 1949. «14 Principles of Management.» I *General and industrial management*, av Henri Fayol. London: Pitman.

Fink, Arlene. 2003. *The survey handbook.* 2nd. London: SAGE Publications.

Fitzgerald, M., N. Kruschwitz, D. Bonnet, og M. Welch. 2013. *Embracing Digital Technology: A New Strategic Imperative.* MIT Sloan Management Review, Research Report.

Ghana Civil Aviation Authority. Updated: 2019. *About us.* Funnet May 16, 2019. http://www.gcaa.com.gh/web/?page_id=342.

Ghana Maritime Authority. 2017. *Functions.* Funnet May 16, 2019. https://www.ghanamaritime.org/about_page.php?id=16.

Ghana National Petroleum Corporation. 2008. *Our Business - E & P Operations.* Funnet February 02, 2019. http://www.gnpcghana.com/operations.html.

Ghana Statistical Service . 2018. *Petroleum Report.* Funnet March 18, 2019. http://www.statsghana.gov.gh/aboutgss.php?category=Mzk1ODcxMzA1LjY0NzU=/webstats/1p7ss069os.

Gimpel, Henner, og Maximilian Roglinger. 2015. *Digital Transformation: Changes and Chances-Insights Based on an Empirical Study.* Saint Augustin: Fraunhofer IT.

GNPC. 2012. *About Us.* Funnet May 17, 2019. http://www.gnpcghana.com/home.

Government of Ghana. 2016. *FPSO Professor John Evans Atta Mills* . Funnet April 5, 2019. http://www.ghana.gov.gh/index.php/news/2527-fpso-professor-john-evans-atta-mills-arrives-in-ghana.

Grail Research. 2015. «Fueling Ghana's Growth - Oil and Gas Industry.» *Grail Research* 3-25.

Graphic Online. 2017. *FPSO John Agyekum Kufour Arrives in Country's waters.* Funnet April 5, 2019. https://www.graphic.com.gh/news/general-news/fpso-john-agyekum-kufuor-arrives-in-country-s-waters.html.

Harel, Assaf. 2012. «Preventing terrorist attacks on offshore plateforms.» *Harvard National Security Journal* 131-184.

Honeywell. 2008. «Maritime Security: Meeting Threats to the Offshore Oil and Gas Industry.» *Honeywell Process Solutions* 3-12.

IMO. 2019. *International Maritime Organization.* Funnet March 19, 2019. www.imo.org/en/ourWork/Safety/Navigation/Pages/VesselTrafficServices.aspx.

Kane, G, D. Palmer, A. Phillips, D. Kiron, og N. Buckley. 2015. «Strategy, not technology, drives digital transformation.» *MIT Sloan Management Review and Deloitte University Press* 14.

Kashubsky, Mikhail. 2013. «Protecting offshore oil and gas installations: Security threats and countervailing measures.» *Journal of Energy Security* 50-62.

Kashubsky, Mikhali. 2011. «A Chronology of attacks on and unlawful interferences with, offshore oil and gas installations, 1975 - 2010 .» *Perspectives on Terrorism* 139-167.

Kline, Aaron. 2018. «AIS vs Radar: Vessel tracking options.» *Oceaneering* 1-3.

Kongsberg. 2018. *Coastal Surveillance Systems.* Funnet March 20, 2019. https://www.kongsberg.com/en/kds/knc/systems/coastal-surveillance-systems/#.

Kosmos Energy Ltd. 2016. *Jubilee Field: World-Class Discovery and Foundation of the Company.* 16 January. Funnet November 23, 2017. http://www.kosmosenergy.com/operations-ghana-jubilee-field.php.

Miller, Keith L. 2002. *Advantages and disadvantages of local government decentralization.* Georgetown: Carribbean Conference on Local Governance.

Norwegian Petroleum Directorate. 2019. «The Government's Revenues.» 15 May. Funnet May 16, 2019. https://www.norskpetroleum.no/en/economy/governments-revenues/.

Offshore Technology. 2019. *Sea Surveillance: Complete solution for maritime safety monitoring.* 2 January. Funnet May 22, 2019. https://www.offshore-technology.com/contractors/computer/sea-surveillance/.

Osei-Tutu, John Kwadwo. 2017. *A Study of Ghana's oil and gas industry Local (Ghanaian) Content Policy Process.* Oslo: Norwegian Agency for Development Cooperation (NORAD).

Otoo, Georgina. 2012. «Modern Ghana.» 18 December. Funnet March 15, 2019. https://www.modernghana.com/news/436208/where-there-is-oil-there-is-spillage.html.

Petroleum Safety Authority. 2018. «Content Assets.» 05 November. Funnet May 11, 2019. https://www.ptil.no/contentassets/2e3df22b329449b2a9fcd7dade8868b2/2018_1186-brev-til-aker-bp-med-samtykke-til-bruk-av-kontrollrom-pa-land-for-ivar-aasen.pdf.

Petroleum Safety Authority Norway. 2018. *Psa-area-of-responsibility.* Funnet April 22, 2019. http://www.ptil.no/getfile.php/1346927/PDF/Psa-area-of-responsibility-2019NETT.jpg.

Rachinger, Michael, Romana Rauter , Christiana Muller, Wolfgang Vorraber, og Eva Schirgi. 2018. «Digitalization and its influence on business model innovation.» *Journal of Manufacturing Technology Management* .

Roberts, Freddie. 2017. «Remote monitoring in oil and gas: a new path to profitability.» 29 March. Funnet May 11, 2019. https://internetofbusiness.com/remote-monitoring-oil-gas/.

Seth Terkper, former Minister of Finance, intervjuet av Citifmonline.com. 2016. *Oil & Gas to serve as main driver of 2017 economy* (24 October).

Solis , Brian, Jaimy Szymanski, og Rebecca Lieb. 2014. «The 2014 state of digital transformation.» 21 July.

Steinhubl, Andrew, Glenn Klimchuk, Christopher Click, og Paula Morawski. 2008. «Unleashing Productivity: The Digital Oil Field Advantage.» *Booz & Co* 3-17.

Theophilus , Acheampong, og Akumperigya Rainer. 2018. «Offshore risk regulation: A comparative analysis of regulatory framework in Ghana, the United Kingdom and Norway.» *Energy Policy* (113): 701-710.

Tullow Oil Inc. 2016. «TEN PROJECT.» Accra.

Tullow Oil Plc. 2016. *About Us.* 30 August. Funnet November 22, 2017. https://www.tullowoil.com/operations/west-africa/ghana.

UNCTAD. 2011. *Review of Maritime Transport.* New York and Geneva: United Nations.

UNDP. 1998. «Factors to Consider in Designing Decentralized Governance Policies and Programmes to Achieve Sustainable Poeple-Centered Development.» *Management Development and Governance Division* (6): 1-.

UNPD. 1999. *DECENTRALIZATION: A SAMPLING OF DEFINITIONS.* Germany: Government of Germany.

Van, Tatenhove. 2013. «How to turn the tide: developing legimate marine governance arrangements at the level of the regional seas.» *Ocean Coast Management* 71: 296-304.

Vissim AS. 2018. *Equinor and Vissim agree strategic collaboration for the digitilization of marine operations.* Funnet May 21, 2019. http://www.vissimvts.com/news/equinor-and-vissim-agree-strategic-collaboration-for-the-digitalization-of-marine-operations/.

Vissim. 2017. *Vissim Radio Communication.* Funnet April 04, 2019. http://www.vissimvts.com/radio-communication/.

WorldOil. 2019. *Anadarko Mozambique attacked for first time amid insurgency.* 22 February. Funnet May 22, 2019. https://www.worldoil.com/news/2019/2/22/anadarko-mozambique-attacked-for-first-time-amid-insurgency.

Xu, Guoboa, Weiming Shen, og Xianbin Wang. 2014. «Application of wireless sensor networks in marine environment monitoring: A survey.» *Nationl Library of Medicin* 14 (9): 16932-16954.