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Products and Services within Asset Integrity Management in the Norwegian Oil and Gas Industry: Status Quo and Innovative Trends

by

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Abstract

Owing to commercial opportunities on the Norwegian oil & gas sector, there is a growing demand for products and services for Asset integrity management (AIM). In general, the market demands greater degree of innovation in AIM. Seeking means to simplify complex work processes and at the same time to have a better understanding and awareness of inherent risks. The trends for innovative AIM products and services can always be challenged due to such factors as innovation costs, organizational capacity, technological capacity to drive innovation, as well as underlying business growth potential of the innovation. Other challenges or barriers can include financial constraints, regulatory challenges, and conservative clients to invest in revolutionary products.

The purpose of this thesis is to map the current status and to elaborate on the future trends for such products and services on the Norwegian shelf (NCS). It includes a comprehensive literature survey on Asset Integrity Management (AIM) within the Global and Norwegian O&G industry. Also, a market survey of available AIM products and services being offered by Norwegian AIM service providers was conducted to review the status quo. In addition, expert opinion from a number of Norwegian AIM service providers was included through questionnaire and informal interviews to validate results emanating from mapping the existing and new AIM products and services within the sector.

The work highlights the status and gaps through a thorough analysis of theory and what is currently available in AIM of oil and gas assets. It highlights trends emerging from service providers on the NCS that are demanded by new asset operational scenarios such as Integrated Operations. In this context, various technological capabilities take a leading role seeking significant value creation opportunities in terms of safety, cost, and production. Interestingly, there appears to be various human, technical and organizational issues such as lack of knowledge and/ or technical competence and conservative attitude of operators that regulates the development and deployment of novel Asset integrity management due to its sensitivity in terms of managing asset related uncertainties and vulnerabilities.

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You would almost never come across a project that does not require team effort. This report, though I present here as my master thesis, is the result of a unique collaboration between student, professor and industry professionals. Thus special acknowledgement goes:

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List of Abbreviations

AIM	Asset Integrity Management
ALARP	As Low As Reasonable Practicable
BS	British Standard
CBM	Condition Based Maintenance
CMMS	Computerized Maintenance Management System
EPCI	Engineering, Procurement, Construction and Installation
ERP	Enterprise Resource Planning
HRA	Human Reliability Analysis
HSE	Health Safety and Environment
ICT	Information Communication Technology
IO	Integrated Operation
ISO	International Organization for Standardization
MMO	Maintenance, Modification and Operations
NCS	Norwegian Continental Shelf
NPD	Norwegian Petroleum Directorate
O&G	Oil and Gas
O&M	Operations and Maintenance
OLF	Norwegian Oil Industry Association
PAS	Publically Available Specification
PSS	Product-Service System
RBI	Risk Based Inspection
ROV	Remotely Operated Vehicles
TIMS	Technical Integrity Management System

1. CHAPTER ONE

INTRODUCTION

Figure 1.1: Topside Offshore Assets (www.offshoreenergytoday.com)

1.1 Background

The integrity of assets has always been a major concern for operators. This concern has further increased due to the recent major incidents in the Oil and gas industry. It was said by the Petroleum Safety Authority that

"Throughout the North Sea's oil history, we have experienced great tragedies in these waters. These incidents taught many people a lot about what had gone wrong and why" (Petroleum Safety Authority, 2009).

From this, we can see that operators want to improve the safety, reliability and availability of theirs assets. This is because not only can a well-managed asset integrity program help operators identify and reduce safety risks before they escalate, asset integrity can also play a major role in both achieving operational excellence and extending the life of ageing assets (Rao et al., 2012).

Many companies have been working with these operators to develop products and services which ensure that their assets function effectively and efficiently whilst safeguarding life and the environment throughout its life cycle. This concept is known as **Asset Integrity Management.**

Asset integrity Management (AIM) in the oil and gas industry is a complex process which encompasses all the phases of an asset lifecycle from design to decommissioning and all these stages must focus on integrity. Figure 1.2 shows what AIM is needed in the lifecycle of an offshore asset.

Figure 1.2: AIM Concept in the Lifecycle of an offshore Asset (Intertek, 2011).

In the Norwegian Oil and Gas industry, many AIM contractors focus on developing solutions which includes products and services to ensure that asset integrity of the O&G production facilities on the NCS is optimally maintained. This has been done by a close collaboration between the operators and the services companies working to meet the needs of the operators so that their overall objectives can be met. Since the last two decades, there has been a steady development of closer interaction between the government, operators and various companies such as engineering contractors, equipment manufacturers, industrial service providers etc. (Kumar et al., 2009) working to carefully identify needs, wants and preferences that results in development of new asset integrity solutions. The technological innovations created are based on utilization of specific knowledge or putting existing technology to new use. Figure 1.3 shows the innovation creation process for creating new solutions.

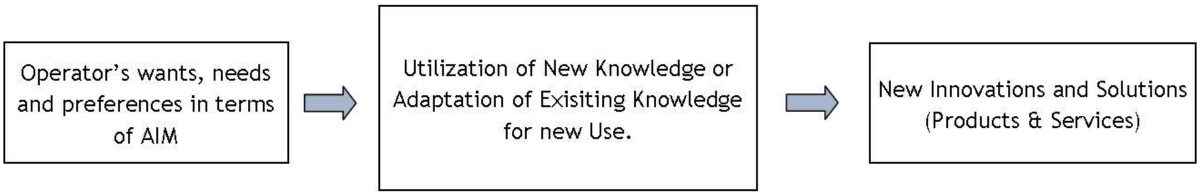


Figure 1.3: Asset Integrity Innovation Creation Process

1.2 Aim of Thesis

The purpose of this thesis is to map the current status and to elaborate on the future innovation trends of AIM products and services on the Norwegian shelf (NCS).

1.3 Scope of Work

This thesis report covers the following scope of work

A comprehensive literature survey on Asset Integrity Management (AIM) within the Global and Norwegian O&G industry.

A market survey of available innovative AIM products and services offered by Norwegian AIM service providers to review the status quo.

Expert opinion from a number of Norwegian AIM service providers was included through questionnaire and informal interviews to validate results emanating from mapping the existing and new AIM products and services within the sector.

Highlights of the status and gaps through a thorough analysis of theory and what is currently available in AIM of oil and gas assets.

Highlights of the potential challenges of human, technical and organizational issues related to innovating these AIM products and services.

1.4 Limitation of Work

The results analyzed in this thesis report are limited to four AIM contractors that provide solutions to operators on the NCS. This is as a result of time constraints and slow responses from the companies selected out of the population of AIM providers in the Norwegian O&G industry. AIM is a very wide subject which covers design, technical and operational integrity but this thesis report is limited to the area of technical integrity of O&G assets within the Norwegian industry.

1.5 Methodology

The first part of this thesis report focuses on a comprehensive literature survey of AIM and its status in the Norwegian O&G industry. A market survey was carried out to identify the current AIM products and services offered to operators on the NCS. Expert opinion was included to evaluate the needs for innovation and areas of application of AIM on the NCS.

The second part of this thesis report is based on multiple case studies conducted to identify the current success factors and barriers that AIM contractors face in creating innovative AIM product and services. The Data for carrying out this analysis was collected through questionnaires-based interviews with experts from AIM Contractors. This study help to identify based on collected data the needs of the industry in terms of AIM and the potential technological solutions that could emerge to meet these needs.

1.6 Report Structure

The Structure of this thesis report is as follows:

Part 1

Chapter 2 looks at an in depth overview of Asset Integrity Management in the oil and gas industry, with a focus on the products and services that are been offered to operators on the NCS. Chapter 3 explains more the concept of products & services and also classifies AIM product and services in general terms. Chapter 4&5 highlights the status of AIM on the NCS. It also elaborates on the AIM products & services on the NCS, their innovation trends and the MTO issues relating these innovation trends.

Part 2

Chapter 6 looks at some case studies of AIM service companies operating on the NCS. This case study highlights their deliverables, innovation processes, innovation drivers and barriers to generating innovative solutions. The focus of this investigation was to assess the AIM products & services innovation trends of AIM contractors servicing operators on the NCS.

Chapter 7 then discusses the results of the survey and highlights some of the trends and other interesting observations and

Chapter 8 gives final remarks with areas for further studies within the Asset Integrity Management in terms of products and services.

2. CHAPTER TWO

ASSET INTEGRITY MANAGEMENT: An Overview

Figure 2.1: Macondo Blowout Incident on the Gulf of Mexico 2010 (www.telegraph.co.uk)

The recent Deepwater Horizon incident in the Gulf of Mexico reinforces the fact that every operator of high-hazard physical assets is exposed to low-frequency high-impact risks. Every operator has a corporate goal of preventing major incidents by managing the governance and integrity of its assets. A robust corporate asset management framework, within which an integrity management regime can operate, is one way of achieving this aim.
(Risktec, 2010)

2.1 What is Asset Integrity Management?

From the article cited above, it can be said that an asset management structure which incorporates integrity management can be a paraphrased definition of asset integrity management. For this concept to be understood, the basic term asset integrity has to be well defined. The term "Asset Integrity" is a combination of two words which is important we look into closely to get the concept of the term in this context. The word "Asset" according to Oxford English dictionary (2007) is an object (e.g. production facility, drilling rig, wind turbine, power grid, etc.) owned by a legal entity (organization or person) that has a certain value. It could also be defined as something valuable that an entity owns, benefits from, or has use of in generating income (Business Dictionary, 2013). The term "Integrity" in this context can be seen as a state of sound, unimpaired, undiminished or perfect condition (Dictionary.com 2013). Therefore, this concept can be seen as consistency of methods, measures, principles and expectation in the outcome of an asset. Below are other definitions of Asset Integrity within the context of O&G.

Asset Integrity can be defined as the ability of an asset to perform its required function effectively whilst safeguarding life and the environment (Rao et al., 2012).

The international association of oil and gas producers (OGP, 2008) defines Asset integrity as an outcome of good design, construction and operating practices which is achieved when facilities are structurally and mechanically sound and perform the processes and produce the products for which they were designed.

Also Centre for Industrial Asset Management (CIAM) defines Asset Integrity as the inherent ability of an asset to perform its duty at specified technical, operational and business requirements in spite of any internal and/external intentional or unintentional influence or action (CIAM, 2008).

Asset Management on the other hand, is the major structural frame work which should incorporate integrity management (see figure 2.2). Increasing international consensus on good practices for managing physical assets led to the publication of PAS 55:2008 a specification based on the familiar BS ISO format used in such widely adopted standards as ISO 14001 for environmental and OHSAS 18001 for safety management. According to this standard, Asset Management is defined as Systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset system, their associated performance, risks and expenditures over their lifecycle for the purpose of achieving its organizational strategic plan.

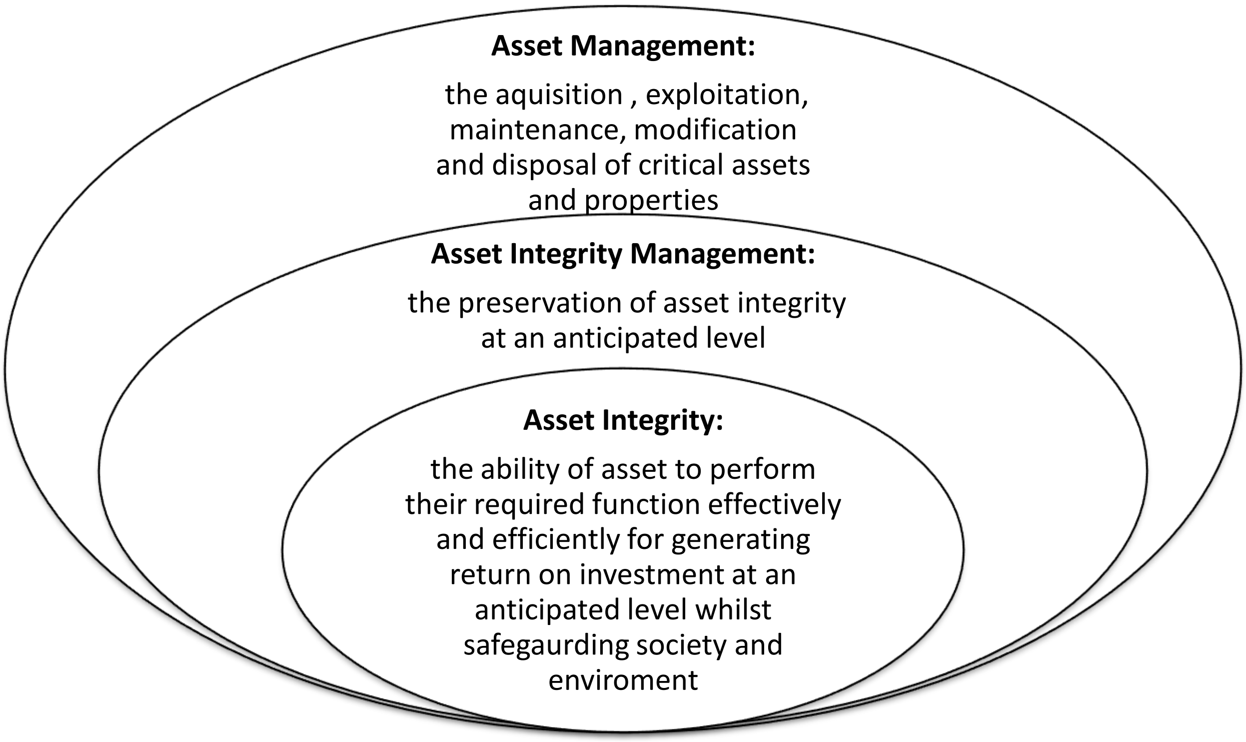


Figure 2.2: Asset Management framework (Adopted from Ratnayake, 2013).

Asset Integrity Management (AIM) can then be deduced from the concept above as the preservation of asset integrity at an anticipated level (Ratnayake, 2013). AIM seeks to ensure a consistent performance throughout the assets lifetime in order to deliver the business objectives profitably and without major accidents (Risktec, 2010). According to Maarteen Lorenz (2007), an inspection and reliability engineer at Shell Global Solutions, he defined AIM as management systems, strategies and activities aimed at maintaining plant assets in fit-for-purpose condition for the desired life of those assets. It incorporates aspects of design, operations, maintenance and inspection to maximize return from assets.

AIM can also be defined as series of activities carried out in order to optimally integrate and maintain design, operational and technical integrity of an asset throughout its intended life so as to maximize return on the investment.

In order to successfully implement an AIM system in a dynamic operating environment, it is essential that all stakeholders have a consistent and a unified understanding of what the essentials of asset integrity are and how they can be applied in their day to day operations yet this is often cited as among the most significant challenges in achieving an integrity culture within an organization. The implementation of asset management practices within an organization enables it to see tangible benefits such as lower operating costs, longer asset life, improved asset performance, greater reliability, higher safety standards, enhanced environmental support and better informed investment strategies. This is because not only can a well-managed asset integrity program help operators identify and reduce safety risks before they escalate, asset integrity can also play a major role in both achieving operational excellence and extending the life of ageing assets (Rao et al., 2012).

2.2 Elements of Asset Integrity Management

In industrial assets, AIM helps to optimally integrate its elements so as to ensure that the assets involved both tangible and intangible are functional, effective and efficient throughout their intended life. AIM seeks to ensure a consistent performance throughout the asset lifetime in order to deliver the business objectives profitably without major accidents (Risktec, 2010). The concept tries to optimize labour, tools, equipment, materials and information by integrating financial and human resources together with production, materials and enterprise resource planning (ERP) systems (Dilger, 1997). Figure 2.3 illustrates the AIM elements relationship in the AIM concept.

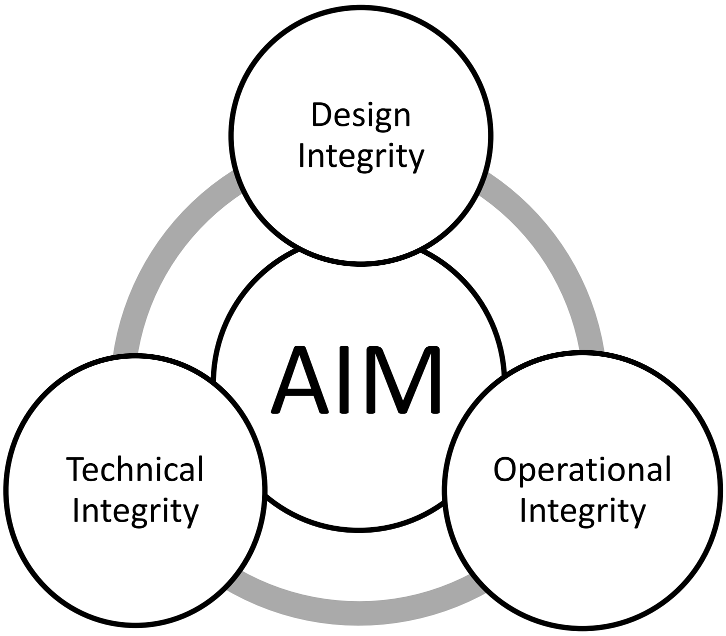


Figure 2.3: Asset Integrity Management Concept

The elements of Asset Integrity Management are:

1. Design Integrity
2. Technical Integrity
3. Operational Integrity

The elements of AIM are further explained in detail below.

Design Integrity

Design Integrity is the ability of the asset/facility designed to carry out its intended purpose effectively and efficiently without compromising its HSE impact (Rao et al., 2012). Design integrity involves calculations, simulation analysis and audits for the plant design, layout and material selection/performance of physical assets are based on the relevant requirements to achieve a certain degree of safety and functionality. During concept development, risk based inspection (RBI) principle and strategies are used to capture all related information to initiate appropriate systems that would establish asset integrity through designing barriers. The concept of creating barriers is so as to counteract the risk of an unwanted event and reducing its impact by further improving safety. Figure 2.4 shows the "see-saw" concept of improving barriers by creating more safety or less impact during an unwanted event.

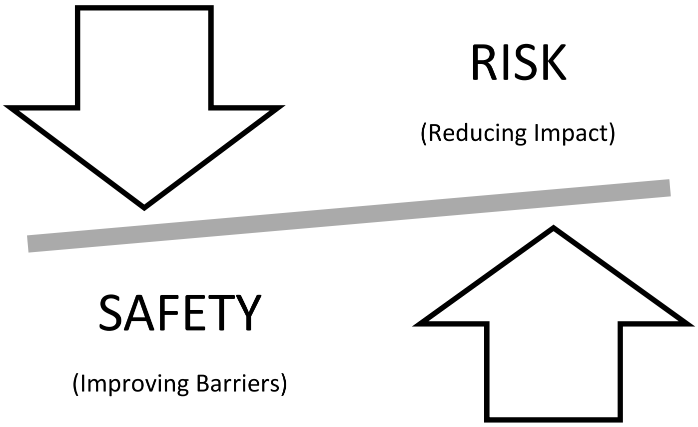


Figure 2.4: The "See-Saw" concept of Integrity Management

During construction, design integrity ensures fabrication and manufacture compliance through collection and collation of appropriate documentation and certification for safety of critical plants and equipment that would be used as a basis for inspection to ensure that integrity is maintained. In non-tangible assets, such as competencies, organizational structure and reporting structures etc., design integrity also used to determine the resilience of the structures and systems through visualizing and implementing series of control measures or barriers, which either prevent the hazard from being released, or limit the effect of the incident if the hazard is released in the system (BG group, 2013). This ensures that work processes are carried out working within the barriers so as to maintain a degree of safety during operations. No barrier is perfect to eliminate incidents therefore Asset integrity programs are focused on assuring ongoing suitability and improving the barriers so as to reduce the risks associated with major accident hazards to As Low As Reasonably Practicable (ALARP) (BG group, 2013). Establishing design integrity involves adopting methodologies such as the criticality analysis, Failure mode effect criticality analysis

(FMECA), reliability centered maintenance (RCM), Fault/Event tree analysis (FTA/ETA), HAZOP/HAZID, Human Reliability Analysis (HRA) etc., to identify potential risks in the design and implement modification so as to improve barriers to ensure that risk level is kept minimal. Figure 2.5 shows the design integrity process loop.

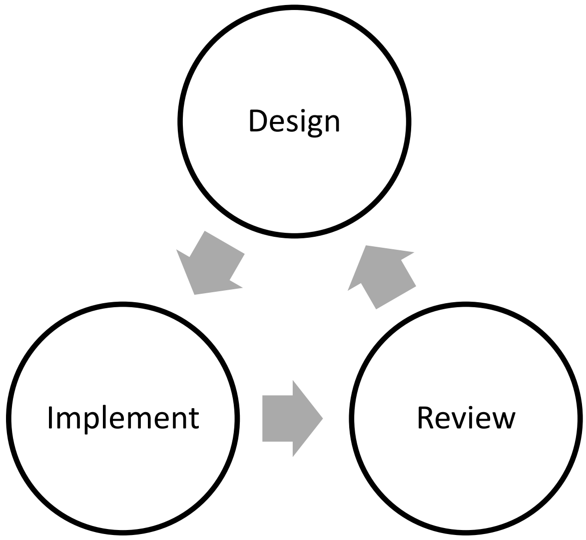


Figure 2.5: Design Integrity Process Loop

Technical Integrity

Technical Integrity can be defined as sustaining an acceptable condition of assets through maintenance, inspection, monitoring and testing activities (Erstad, 2011). Technical integrity also includes integrity improvement activities which cover mitigation, intervention and repair activities. Technical Integrity can also be defined as an item's fitness-for-service, safety and compliance with regulation for environmental protection (Kennedy, 2007). Technical integrity is usually ensured in the operations and maintenance stage of the asset lifecycle and the main objective of technical integrity management system (TIMS) in this phase of the lifecycle is to maintain the established integrity of the physical asset such as plants, equipment and other machineries. Technical integrity assurance also vitally depends on access to quality data and information, as well as models, tools and methods for analyses to assist in the decision making process. Access to quality data of equipment would help implement the following (Kumar, 2005);

Diagnostics: Control over technical condition of the equipment
Prognostics: Prediction of failure and estimation of residual life of equipment
Forensics: Analysis of failure to find out root causes

From this, the intention is to maximize the assets availability which consists of reliability, maintainability, supportability and efficiency by ensuring the condition and controlling rate of deterioration in order to execute safe and environmental friendly operations with minimized financial costs (Ratnayake and Toreset, 2010). All systems and equipment will inevitably be exposed to degrading mechanisms during their operational lifetime. In order to manage and maintain an acceptable level of technical integrity a proper management strategy have to be drawn and implemented by the organization that owns the asset. This management strategy would depend on a combination of effective methods and quality work processes (Erstad, 2011).

Figure 2.6 illustrates the maintenance management process and its components, a model well known within the oil and gas industry for managing and continuously improving the maintenance activities on oil and gas installations.

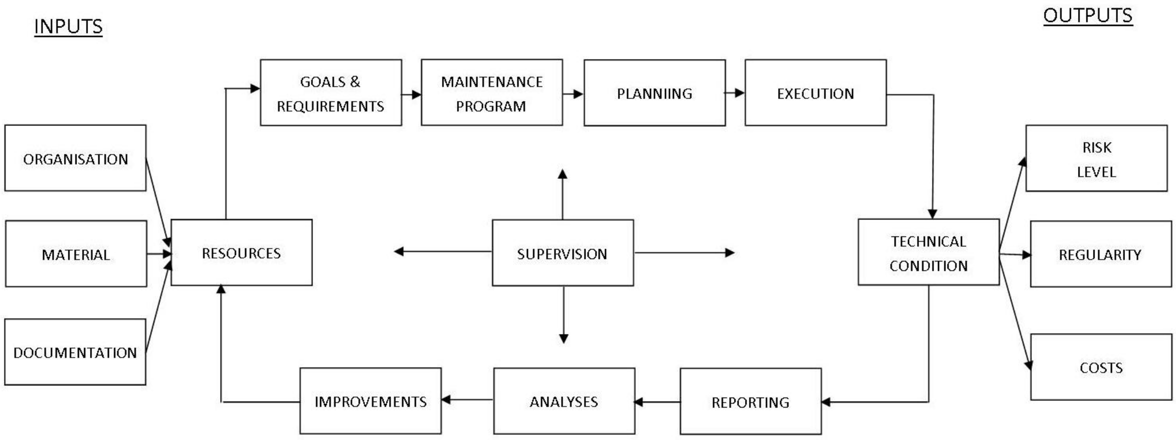


Figure 2.6: Maintenance Management Loop (NORSOK, 2011)

Operational Integrity

Operational Integrity is the ability of the asset personnel to operate the facility effectively and safely (Adair et al., 2008) . This includes human factors such as operator training, competence, management systems, reporting systems, anomaly tracking etc. This is to monitor and certify the safety and effectiveness of operation procedures and activities that are being implemented (Petrolink, 2010). However, it is important to note that equipment condition alone cannot guarantee reliable and safe operations. For a safe and reliable operation it involves people and systems then the physical asset itself. The interdependences between these actors are what really determine the level of effectiveness and efficiency in operations. When considering output targets during operations, safety and efficiency needs to be in place or everything would not be sustainable in the long run. The increasing complexity of operations and systems can make it difficult to strike the right balance between business risk and operational targets. Moreover, each operation has unique characteristics defined by its specifications and the conditions under which it is conducted. If you get it wrong, lack of operational integrity may result in an increase in accidents, non-productive time and a risk of reputation damage (Sturm, 2011).

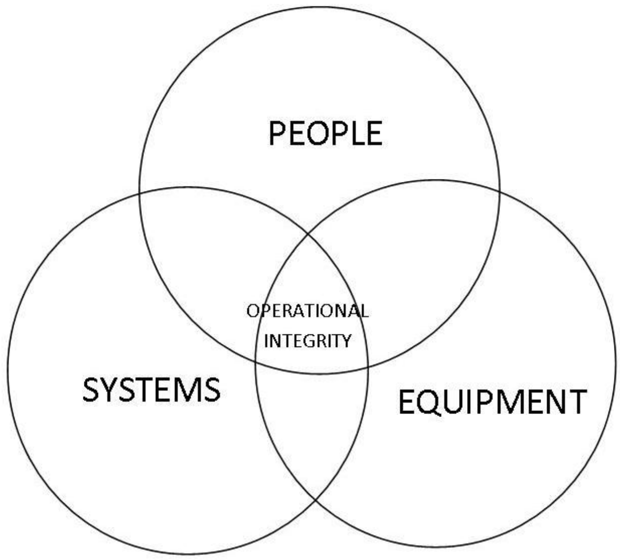


Figure 2.7: Interdependencies of Operational Integrity Elements

Operational Integrity involves the interdependence of three key elements as shown in figure 2.7 which are; people, systems and equipment. From the perspective of operational integrity, equipment, competence and system management cannot be regarded in isolation. Many cases of unplanned equipment breakdown reach beyond equipment condition into areas of crew competence and management system effectiveness (Strum, 2011). For instance, a new and adequately equipped rig will not meet its targets if the crew is not capable of utilizing the equipment to its full potential. Similarly, an adequate rig with a top-range maintenance management application and a competent crew will not work adequately if there are no effective processes binding the three together. The elements of Operational integrity is further explained in details

People: The 'People' element relates to staff suitability. This is about effectiveness of people in the broadest sense of the word. It starts with the perspective of what is critical for operational integrity, both on-site and at the support base, cascading through the entire operation. Factors of influence here are recruitment, development and monitoring, as well as the conditions under which staff operates. These conditions anchor back into equipment and systems. The people element is composed of four main aspects (Strum, 2011):

- **Structure and responsibility:** management structure, organization.
- **Human Resource (HR) Management:** job description, hiring and placement, selection criteria and communication.
- **Competence:** competence requirements, staff experience, certification; in general, the ability to demonstrate relevant experience within last five years for similar services, and circumstances, provided to any client.
- **Training:** Training requirement, training efforts; in general: the ability to demonstrate that there are an adequate systems in place to train and educate staff. This includes on site, on-the-job training, drills, exercises etc.

Improved understanding of the dynamics and the aspects that can help you optimize the people element will allow for improved harmonization with changing operational conditions involved in equipment and system innovations; a major contributor to operational integrity.

Systems: When talking about systems, we refer to the whole set of organizational arrangements that support the operation, such as processes (defining tasks, responsibilities and the interactions with others or with equipment or tools), organization structures and tools (forms, reports or software) and how they interact together into a smooth roadmap for the operation. Any operation has systems in place; HSE and maintenance management systems are usually adopted in offshore operations. A system defines what needs to happen, when, to which standard, in what sequence, by whom, using what, etc. Systems connect the elements into a joined up purpose: meeting the operational targets safely and adequately. However, in today's setting involving innovative assets, challenging operational conditions, tight labor availability and volatile markets, the need for effective systems is very much recognized. There is an increasing awareness that systems are a potential a key value driver. Systems when properly implemented can improve operation integrity but if the system is not well built can compromise operations.

Equipment: Equipment refers to a single piece of equipment or a combination of technical installations joined up in a specified way to adequately meet the intended operational and contractual requirements. In Operational Asset Integrity, equipment refers to "hardware-in-operation" and focuses on safely meeting performance standards. Equipment inspections are very effective at identifying potential problems and assessing their criticality at any point in time which can be seen as "technical Integrity" (See TI explanation above).

Real Case Study: ExxonMobil Asset Integrity Management System

ExxonMobil is committed to conducting business in a manner that is compatible with the environmental and economic needs of the communities in which it operates, and that protects the safety, security, and health of their employees, those involved with their operations, their customers, and the public. These commitments are documented in their Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (OIMS).

ExxonMobil's OIMS Framework establishes common worldwide expectations for addressing risks inherent in its business. The term Operations Integrity (OI) is used by ExxonMobil to address all aspects of its business that can impact personnel and process safety, security, health, and environmental performance.

The OIMS Framework includes 11 Elements. Each Element contains an underlying principle and a set of Expectations. The OIMS Framework also includes the characteristics of, and processes for, evaluating and implementing OI Management Systems. Application of the OIMS Framework is required across all of ExxonMobil, with particular emphasis on design, construction and operations. Management is responsible for ensuring that management systems satisfying the Framework are in place. The scope, priority and pace of management system implementation are made to be consistent with the risks associated with the business.

The Business Elements Includes the following:

1. Management Leadership, commitment and Accountability
2. Risk Assessment and Management
3. Facilities Design and Construction
4. Information/Documentation
5. Personnel and Training
6. Operations and Maintenance
7. Management of Change
8. Third-Party Services
9. Incident Investigation and Analysis
10. Community Awareness and Emergency Preparedness
11. Operations Integrity assessment and Improvement

ExxonMobil

(culled from ExxonMobil Operations Integrity Management System brochure. See Appendix 4)

3. CHAPTER THREE

AIM ON THE NCS

Figure 3.1: The Seven-day Ekofisk Bravo Oil Blowout in 1977 (PSA, 2013)

Avoiding accidents is a key goal for everyone involved in the petroleum business. Design of installations and plants, choice of technical solutions and the provision of several levels of safety systems and barriers are vital elements in this effort. The barrier concept embraces technical, operational and organizational measures intended individually or jointly to reduce the probability of undesirable incidents or their impact (Petroleum Safety Authority, 2010)

3.1 Overview of the Norwegian Oil and Gas Industry

Since the discovery of North Sea oil in Norwegian waters during the late 1960s, exports of oil and gas have become very important elements of the economy of Norway. According to the ministry of petroleum and energy (2013) the petroleum industry is Norway's largest industry. In 2012, the petroleum sector represented more than 23 per cent of the country's tota l value creation. The revenues from the petroleum sector constitute 30 percent of the state revenues. Today Norway is the 7th largest producer of oil and 3rd largest producer of gas in the world. Petroleum activities have contributed significantly to the economic growth in Norway for the financing the Norwegian welfare state (NPD, 2013).

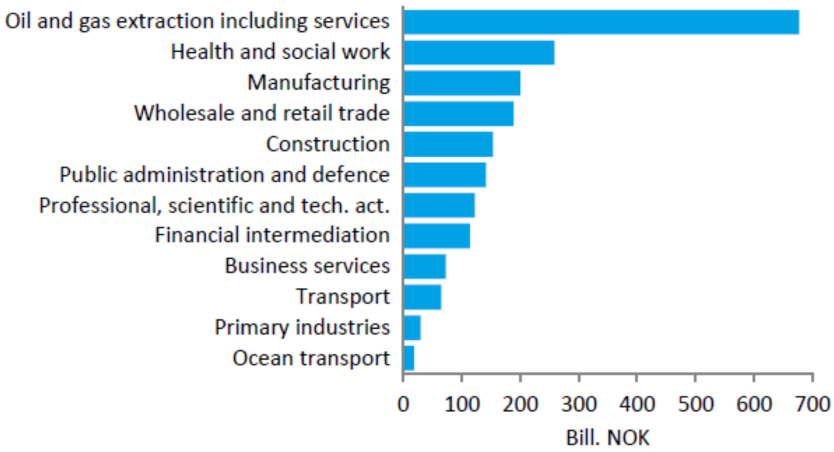


Figure 3.2: Value creation of selected industries 2012 (National Accounts, Statistics Norway)

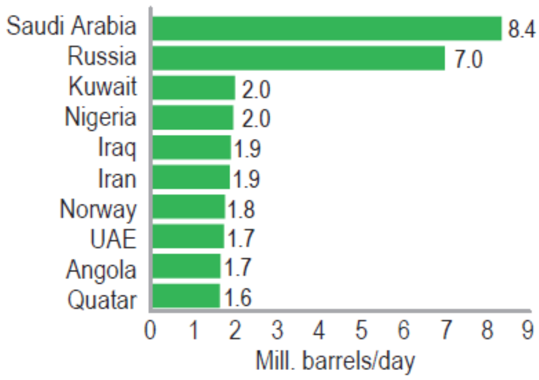


Figure 3.3: The Largest Oil exporters (Oil includes NGL and condensate) in 2011

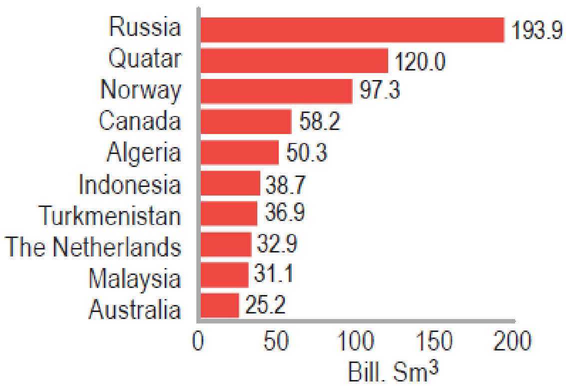


Figure 3.4: The Largest Gas exporters in 2011 (Source: KBC Market Services).

To make Norway continually prosperous, proper involvement of the government and other regulatory bodies has been made to make this industry financially viable and safe for all stakeholders involved in the oil and gas business. Figure 3.5 shows the state organization of the petroleum activities.

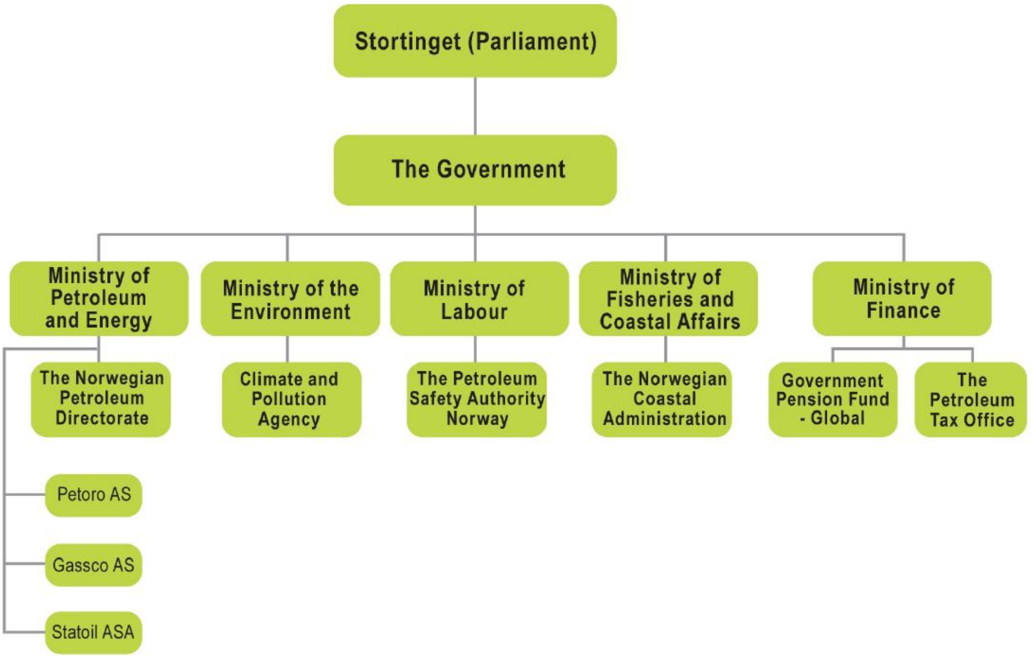


Figure 3.5: State Organization of the petroleum activities (Source: State Budget).

The NCS Structure and Operators

The NCS, which encompasses the North Sea, the Norwegian Sea and the Barents Sea, is traversed with numerous O&G fields, a large proportion (about 60%) of which are being operated by Statoil Petroleum AS, the state owned company. The remaining proportions of fields are operated by other companies (See Appendix for the NCS map and list of operators).

Organizations with Oversight Authority

The activities of all these operator companies, together with numerous other service companies, suppliers and vendors, are regulated and supervised by the following institutions so as to maintain integrity of assets and work processes:

- *Ministry of Petroleum and Energy (MPE)* – **Energy Policy Formulation** (best use, within an environmentally-acceptable framework, of all resources)

- *Ministry of Labour (MOL)* – **Labour Policy Formulation** (working environment and for safety, and emergency preparedness in connection with the petroleum activities)

- *Norwegian Petroleum Directorate (NPD)* – **Value Creation** (prudent resource management based on safety, emergency preparedness and safeguarding of the external environment)

- *Petroleum Safety Authority (PSA)* – **Regulatory Authority** (technical and operational safety, including emergency preparedness, and for the working environment)

- *Det Noske Veritas (DNV)* – **Managing Risk** (safeguarding life, property, and the environment)

Through collaborative work, the mentioned institutions above with other foreign institution not mentioned create guidelines for operation in accordance to HSE standards. This is done by providing devising the best possible way of making operators, contractors and suppliers adhere to the regulations. These guidelines and interpretations normally refer to international standards such as those from ISO, IEC and EN, and more focused ones such as NORSOK, DNV and OLF, as a means to fulfillment of the requirements of the legislation and provisions within the regulations (Lokko, 2012).

3.2 AIM Status on the Norwegian Continental Shelf (NCS)

AIM on the Norwegian Continental Shelf has been as old as the industry itself. What have changed over the four decades of petroleum activities in this area have been the methods of attaining Asset Integrity for their O&G assets. The NCS can boast of over four decades of O&G experience and technical knowhow but can it really boast of an adequate stock of personnel within operations and maintenance with the required expertise to maintain and improve upon the high local and global HSE standards in the management of their assets? A statistical analysis of unwanted events on the NCS is undoubtedly a necessary basis assessing the status of AIM on the NCS of these years of operations.

Statistics of Unwanted events on the NCS

On the NCS an unwanted event generally refers to incidents, events, near-misses and accidents. In general offshore production platforms incidents and events arise from both safety-related and technical integrity related issues (Raza and Liyanage, 2010). When analyzing unwanted events the nature of safety related incidents and technical integrity related incidents are quite different. **Safety integrity** focuses on the incidents that have some form of impact on the well-being of the humans. **Technical integrity** issues on the other hand can be considered as those mainly impacting the technical production processes.

Safety integrity incidents

Compromising AIM has its negative effects ranging from personal injuries, loss of production equipment failures to major accidents. There have been some major accidents on the NCS that have changed the way Norway and the global O&G industry manage the integrity of their assets. The major ones are Ekofisk Oil blowout in 1977 and the loss of Alexander L. Kielland flotel. According to PSA this is what they had to say about these incidents

No incident on the NCS has claimed more lives than the loss of Alexander L Kielland. This disaster left a deep impression on Norway and its petroleum industry. (Petroleum Safety Authority, 2013)

Accidents have had a profound effect on the way in which the offshore oil and gas industry performs its business (Visser, 2011). Even though there hasn't been any major accident on the NCS in recent times, injuries still occur and lessons are learnt from them so that the sources of these incidents can be identified and properly resolved. Asset Integrity compromise is usually the source of incidents and knowing the statistics rate would point us to the current status of AIM on the NCS. Tables and figures show the statistics of fatalities over the 4 decades of petroleum related activities on NCS and Injuries on the NCS from 2002 to 2011.

Period	1967-1979	1980s	1990s	2000-2009	Total
Structures and maritime systems	6	134	0	1	141
Helicopters	34	0	15	0	49
Fall accidents	25	12	6	1	44
Diving	10	6	0	0	16
Lifting	3	0	2	3	8
Work accidents on vessels	1	1	3	3	8
Fires and Explosions	5	1	0	0	6
Drilling Operations	0	1	3	0	4
Toxicity	3	1	0	0	4
Others	1	1	1	1	4
Total Fatalities	88	157	30	9	284

Table 3.1 Statistics of Fatalities from 1967 to 2009

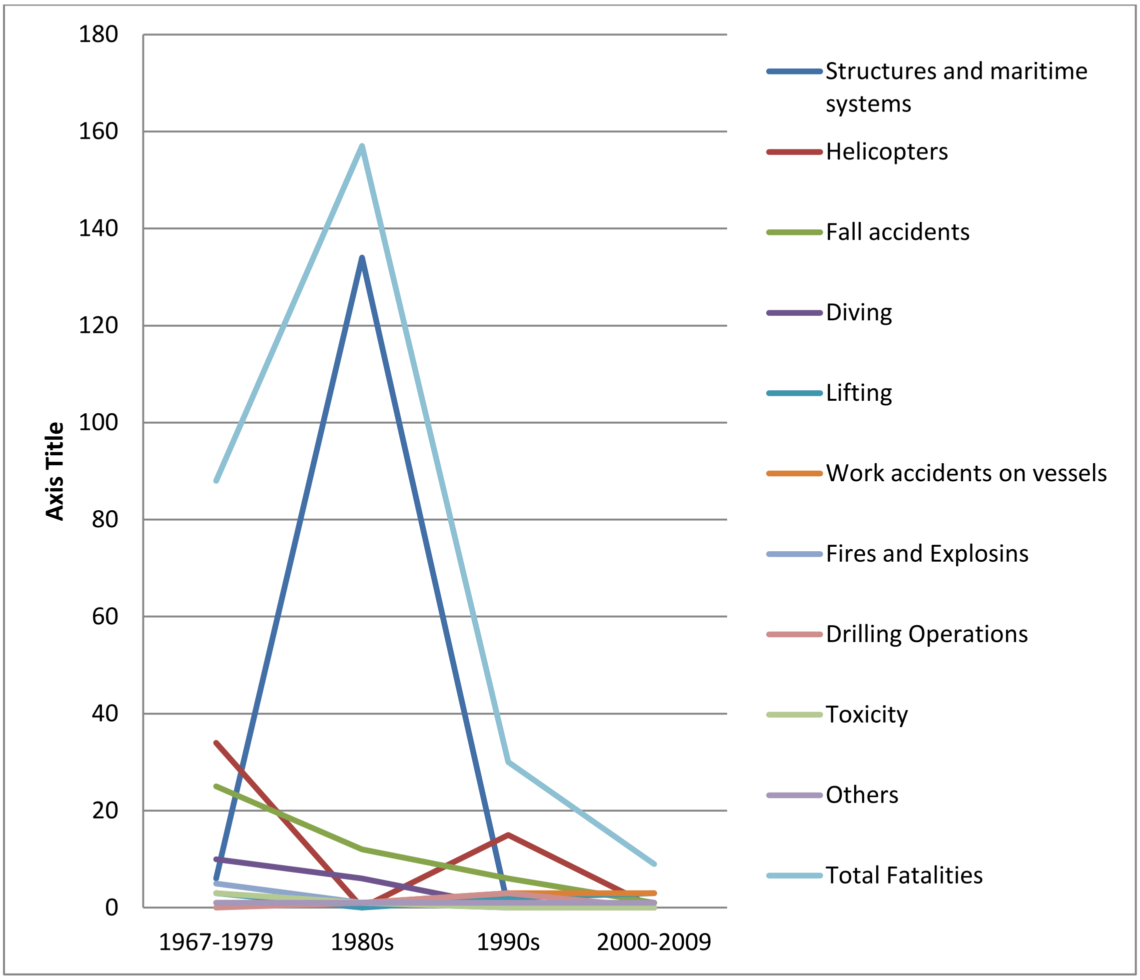
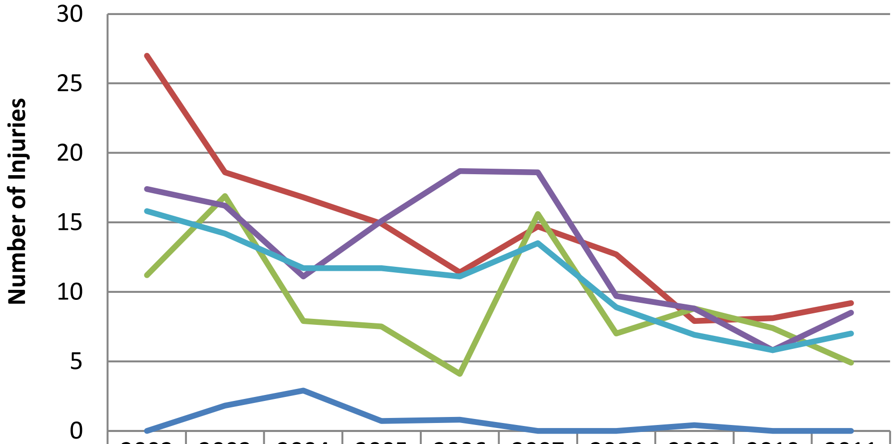


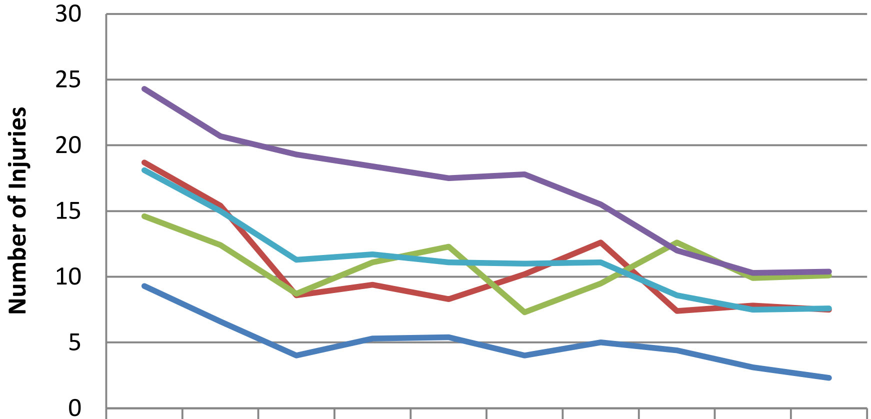
Figure 3.6: Fatalities in the Norwegian Offshore activities (Source: Norwegian Centre for Excellence)

From the data presented in table 3.1 and figure 3.6 Apart from the structural failure that occurred on Alexander Kielland in the eighties, helicopter accidents and fall related accidents accounts for most of the fatalities in the past. In recent years lifting and work accidents on vessel account for most of the fatalities that occur on the NCS. Figure 3.7 and 3.8 shows the statistics of injuries on offshore facilities in the past decade.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Admin	0	1.8	2.9	0.7	0.8	0	0	0.4	0	0
Drilling & Well Operations	27	18.6	16.8	14.9	11.4	14.7	12.7	7.9	8.1	9.2
Catering	11.2	16.9	7.9	7.5	4.1	15.6	7	8.8	7.4	4.9
Operation & maintenance	17.4	16.2	11.1	15.1	18.7	18.6	9.7	8.8	5.8	8.5
Total	15.8	14.2	11.7	11.7	11.1	13.5	8.9	6.9	5.8	7

Figure 3.7: Injuries on mobile facilities on the NCS (Source: PSA, 2012)



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Administation	9.3	6.6	4	5.3	5.4	4	5	4.4	3.1	2.3
Drilling and well Operations	18.7	15.4	8.6	9.4	8.3	10.2	12.6	7.4	7.8	7.5
Catering	14.6	12.4	8.7	11.1	12.3	7.3	9.5	12.6	9.9	10.1
Operation and maintenance	24.3	20.7	19.3	18.4	17.5	17.8	15.5	12	10.3	10.4
total	18.1	15	11.3	11.7	11.1	11	11.1	8.6	7.5	7.6

Figure 3.8: Injuries on Permanently placed facilities on the NCS (Source: PSA, 2012)

From figure 3.7 and figure 3.8 above, the chart profiles show that the number of injuries on the NCS is reducing. This can be said to be as a result of proper implementation of AIM.

Technical Integrity Incidents

Technical integrity related incidents are incidents that arise from day to day operations and those resulting in possible reduction or loss of daily production. These incidents may arise from equipment failures, system malfunctions, human errors, and deviations from technical work processes etc. (Raza and Liyanage, 2010). Technical Integrity compromise definitely would result in loss of production which could be partial or complete shutdown. Failure of equipment like generators, compressors pumps etc. initiate unit shut down and are initiated to save equipment from damaging. Production is continued on reduced level during unit shutdowns and not completely stopped. Field/plant and facility/platform shutdown are bigger scale shutdowns that lead to a complete stop of production e.g. in cases of fire, gas detection etc. Figure 3.9 and table 3.2 shows unplanned shutdowns of an offshore facility on the NCS. The data is retrieved based on data from reported corporate database over the period of 4years (from 2003-2006). Equipment and systems on offshore platform are built in a way that avoids failure propagation through installation of barriers. But due to complexity of offshore systems, it is sometimes impossible to avoid such chain of events (Raza, 2010).

Year	Unit SD	Field/plant SD	Facility/Platform SD
2003	4	11	4
2004	3	20	4
2005	13	13	11
2006	14	6	2

Table 3.2: Yearly-unplanned shutdowns based on corporate production loss database (Raza, 2010)

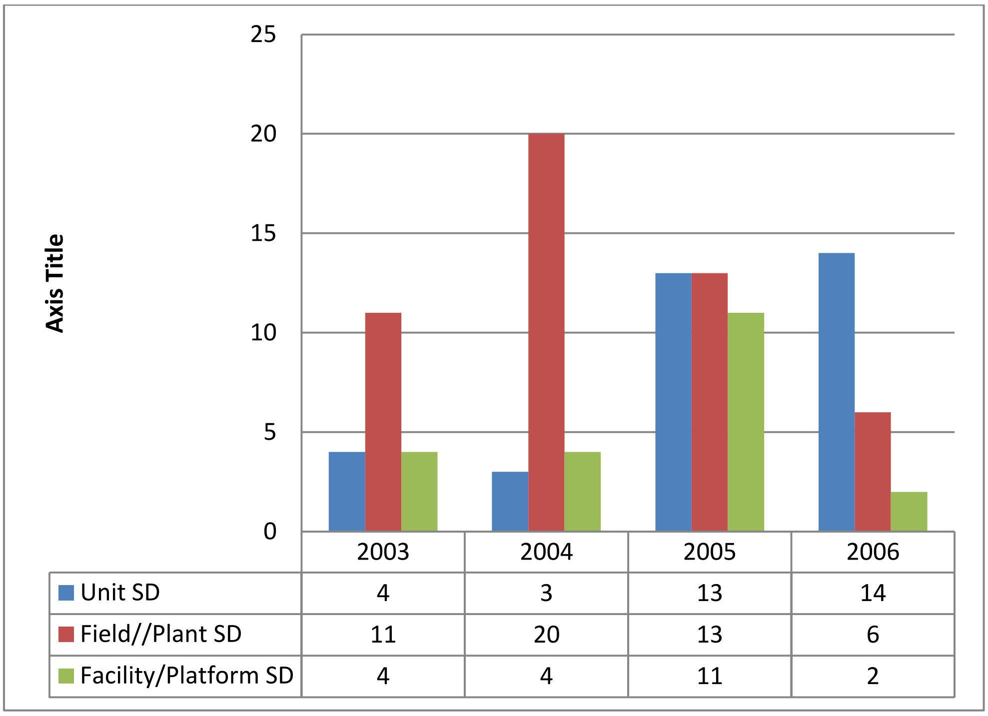


Figure 3.9:Yearly-unplanned shutdowns (SD) based on corporate production loss database (Raza, 2010).

3.3 AIM Development Trends on the NCS

The statistics above reveals the current level of asset integrity on the NCS in terms of safety and technical related issues. This level of integrity has been achieved using different management methods/techniques over the years. The development trends of how AIM is ensured on offshore facilities within the Norwegian O&G industry is further explained below.

Until the late nineteen sixties the integrity of the design and operational safety of offshore platforms was largely the responsibility of the owner-operators who used a variety of industry and in-house standards and methods mostly visual inspection. Accidents did not receive much publicity outside the industry because few were lost and at the time, there was little concern about pollution. The Ekofisk platform Bravo blowout in the North Sea that occurred in 1977 was one of the major accidents that have a profound effect on the way the offshore industry does business in Norway and worldwide (Visser, 2011). This accident created a higher level of government involvement in O&G related activities. Requirements were introduced to perform detailed platform and operational probability risk assessments in order to demonstrate the overall reliability of the facility and to see that it meets certain minimum acceptable criteria. Over the past 30 years Norway has moved away from a strict prescriptive approach to a more performance-based approach for regulating offshore O&G facilities. Performance-based regulations allow operating companies to determine the best way to achieve operational and technical safety targets. The Norwegian Petroleum Directorate (NPD) regulatory requirements are general and primarily specify the conditions that must be achieved to be compliant. Within this framework operators have the freedom to choose practical asset integrity solutions along with the responsibility to ensure compliance. To avoid misunderstandings about the requirements for compliance the Det Norske Veritas (DNV) "Offshore Standards" publications define the technical requirements and acceptance criteria (DNV, 2010).

Maintaining Technical Integrity

From literature studies and interviews from experts in this area, it has been observed that from the inception of the petroleum industry on the NCS, the method of maintaining technical integrity was through the run-to-failure management system. The main reason for adopting this method of maintaining technical integrity was because of the lack of factual data that quantifies the actual need for repair or maintenance of the plant, equipment and systems. Maintenance scheduling basically can be carried out effectively based on statistical trend data of the performance or failure of the plant/equipment. The logic of the run-to-failure management is simple and straightforward which is when the machine breaks down fix it. This is management method is a reactive management technique that waits for machine or equipment failure before any maintenance action is taken. It is in truth a "no maintenance" approach to maintaining technical integrity of production assets. This is because the major expenses associated with this type of maintenance management are: high spare parts inventory cost, high overtime labor cost, high machine downtime, and low production availability (Mobley, 1990).

The most common method of maintaining technical integrity presently on the NCS is the preventive maintenance management system. The transition to this method of maintaining technical integrity has been made by most operators on the NCS. The concept of this maintenance management method is that maintenance tasks are based on elapsed time or hours of operations i.e. time-driven (Mobley, 1990). This is generally done using the statistical life of a machine-train (See the figure 3.10). The mean-time-to-failure (MTTF) or bathtub curve indicates that a new machine has a high probability of failure, due to installation problems, during the first few weeks of operations. Following this initial period, the probability of failure is relatively low for an extended period of time before it then increases again with time.

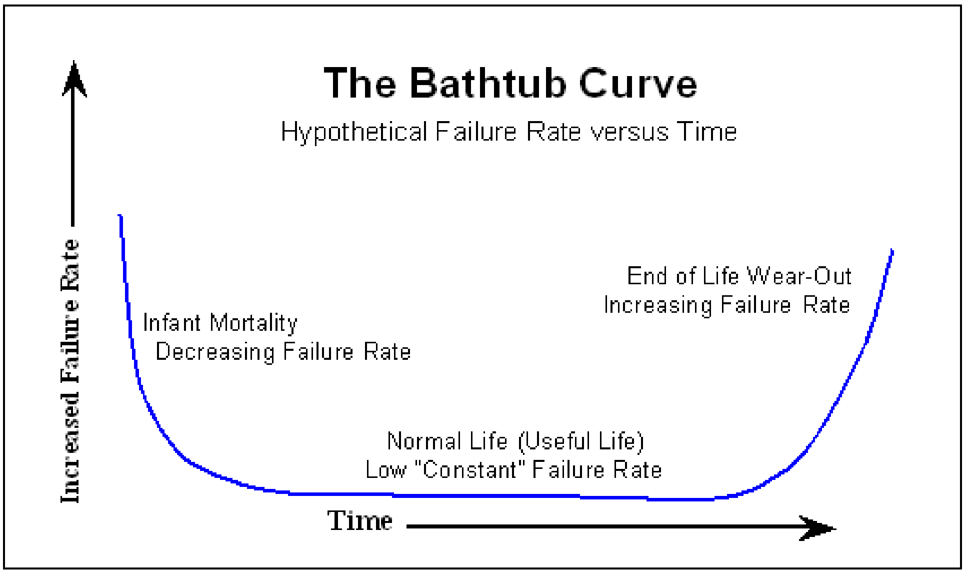


Figure 3.10: Bathtub curve for analyzing MTTF of machines and equipment

With this method of technical integrity management, machine repairs or rebuilds are scheduled based on MTTF statistic. All preventive maintenance management programs assume that machines will degrade within a time frame based on its classification. For example a single stage split case centrifugal pump will usually run 18 months before it must be rebuilt, that means using this method of maintenance management the pump must be removed at 17 months of operation to prevent total breakdown before repair. This management method is better than the previous method used because it is less expensive. The downtime of equipment using this management method is lesser and planned but it has its own disadvantages. The disadvantage of this method is that it only considers mean-time-to-failure (MTTF) but the problem is that it might end up in unnecessary repair or catastrophic failure in between these times. In the example given earlier, the pump may not need to be rebuilt after 17months. Therefore the labor and material used to make the repair are wasted. On the other hand, the pump could fail before 17 months forcing the management to use run-to-failure techniques. This has been a reason while the operators are now finding better ways of maintaining technical integrity. The method that is being developed and gradually adopted now on the NCS is using integrated operations to optimize technical integrity through real time data condition monitoring and remote diagnostics. The integrated operations concept would be further discussed later in this thesis report. In summary the development trend of maintaining technical integrity of offshore assets on the NCS has been from corrective maintenance or "no maintenance" to preventive maintenance to real time condition monitoring. Figure 3.11 shows the development trend of maintaining technical integrity on the NCS

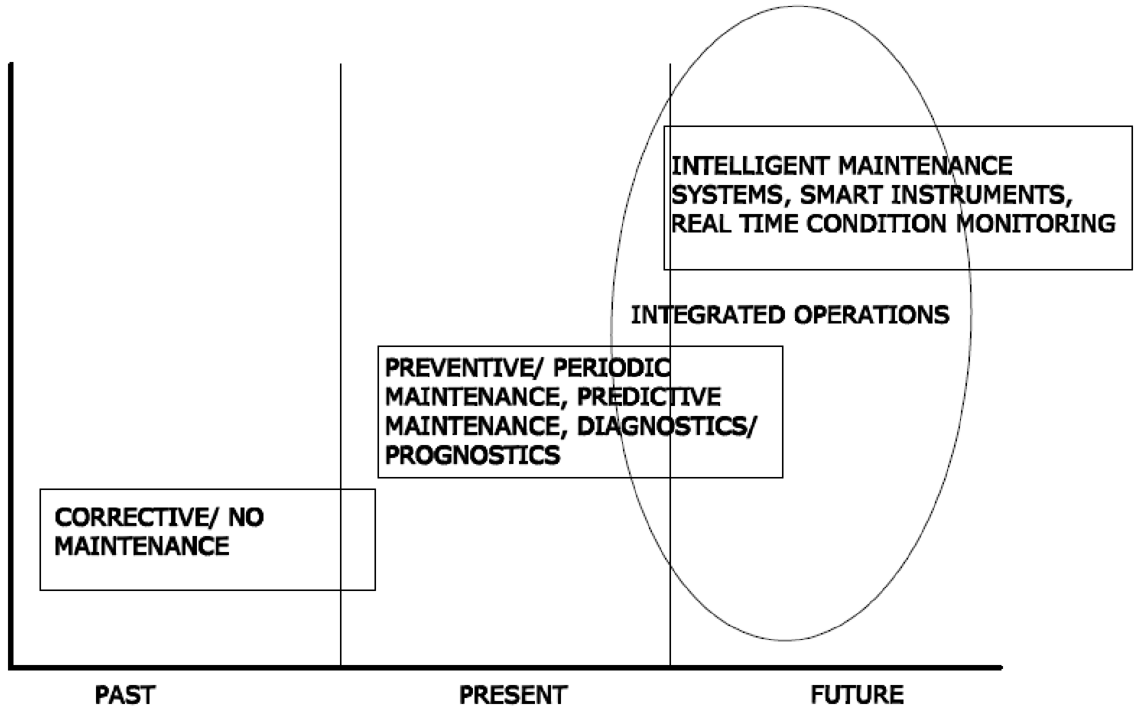


Figure 3.11: Technical Integrity Management Development Trend on the NCS

Maintaining Operational integrity

Operational integrity on the NCS is a major source of production performance and also the source of most safety related issues. The requirement for operational integrity is usually ergonomics which includes the working environment and the clarity of the information available to operate. Operational integrity on the NCS has gone through different phases of development over the years. Initially on the NCS operational integrity was achieved through on the job training. This method of ensuring operational integrity has its own consequences because the O&G industry is a high risk industry and high risk organizations do not have the luxury to learn by trial and error (Roberts and Gargano, 1990). The consequences of error in these organizations are often so great that when they occur could involve loss of lives and equipment. Also the time shift of personnel is important so as to increase personnel alertness on the job. If this is not properly looked into error would be prevalent when the alertness of the personnel is low. Currently on the NCS the way of ensuring operational integrity is through the use of simulator training. These simulators model the scenarios on an offshore platform. The trainee involved use the simulators to learn how to carry out operations procedures and respond to critical scenarios without actually having any negative effect because the environment is entirely a virtual environment. This method of ensuring operational integrity is better than the past method but also has its limitations. The major limitation of this method is the lack of knowledge. Even though different scenarios are designed in the simulators for the trainee to learn during training, in real life operations there are still scenarios that would occur which are entirely going to be new to the operator. Making a wrong decision in scenario could result in a catastrophic event. This has been a reason while the operators are now finding better ways of ensuring operational integrity. The new method that is being developed and adopted by some operators is the use of the integrated operations platform to created real-time experts online support and remote operations. The integrated operations concept would be further discussed later in this thesis report. In summary the development trend of ensuring operational integrity during operations on the NCS has been from on the job training to training with the use of simulators and to use of expert systems with collaboration with experts through remote operations/online support. Figure 3.12 shows the development trend of ensuring operational integrity on the NCS by reducing human and work related errors.

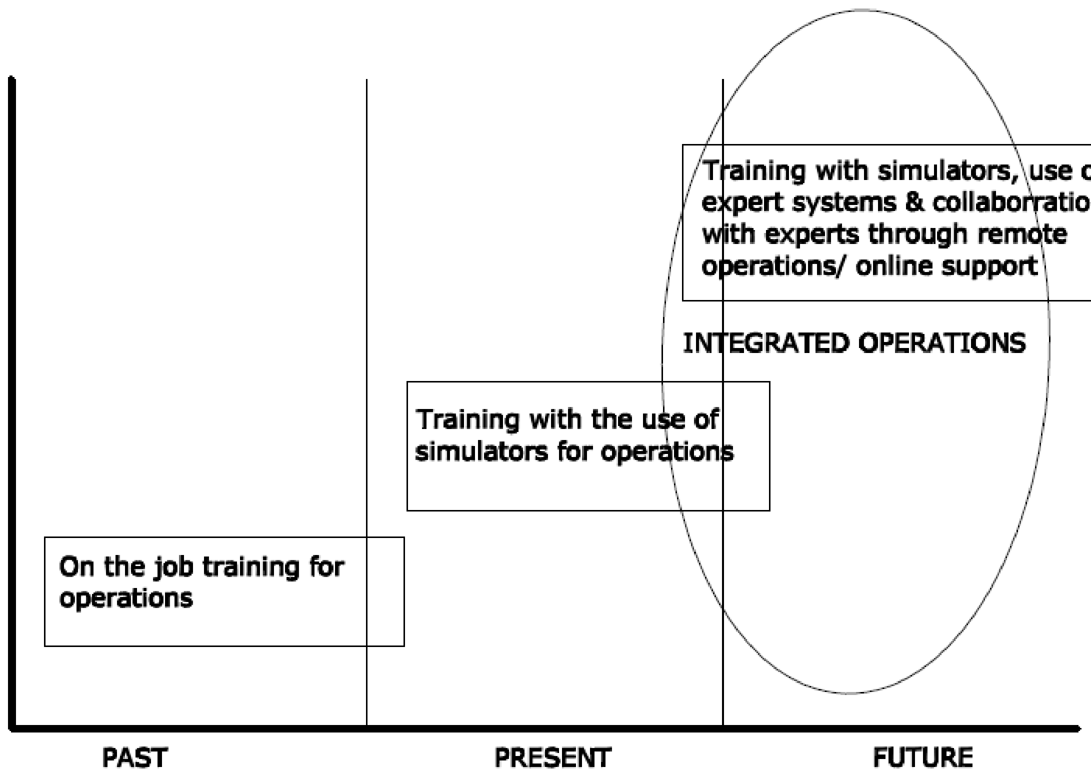


Figure 3.12: Operational Integrity Management Development Trend on the NCS

3.4 AIM Optimization on the NCS through IO implementation

Integrated operations (IO) have been the new face of optimizing AIM in the Norwegian O&G industry. IO is a term used for the implementation of ICT in the O&G industry to combine work processes, technology and organization together in a seamless way with the aim of improving production operations and support. This concept was first introduced in the O&G industry by the Norwegian petroleum industry making them the pioneer of this concept for petroleum related activities. Today the most common way of defining IO is:

"Integrated Operations (IO) is a concept about employing real time data and new technology to remove barriers between disciplines, expert groups and the company" (Statoil, 2010)

Several names have been used for this concept: e-field, smart fields, field of the future and i-field, but the Norwegian Oil Industry Association (OLF) has been an initiator to use the term Integrated Operations (Bladet "Forskning" nr 4-2006). Common for all of the different organizations names is that they include much more into the concept of IO than just technology. Figure 3.13 shows a pictorial illustration of the IO concept.

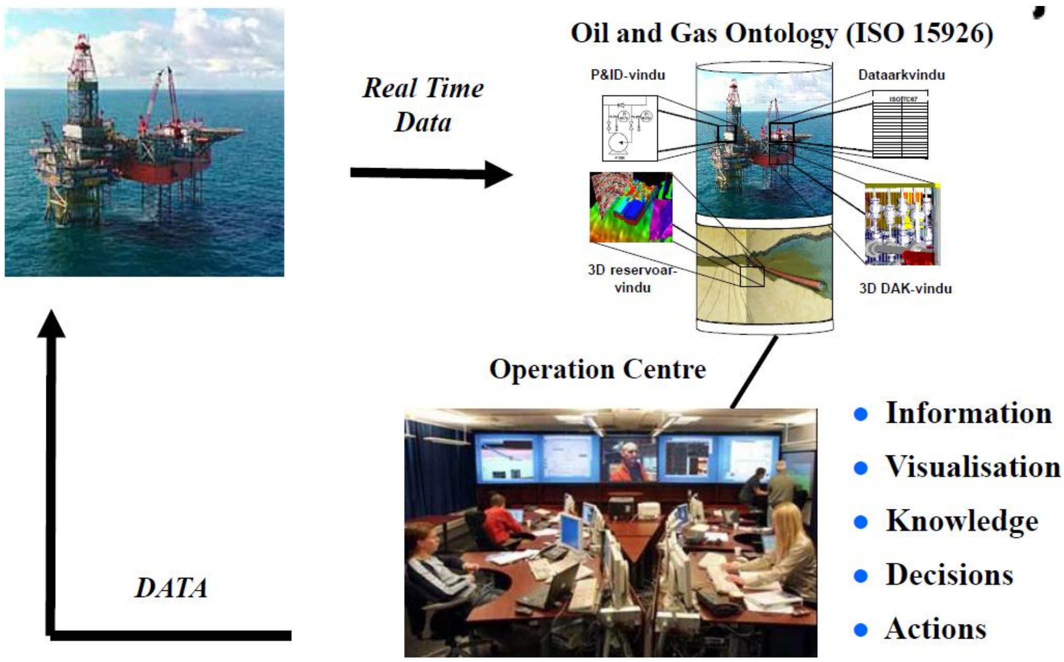


Figure 3.13: Pictorial Illustrations of the IO concept (OLF, 2007)

The most striking part of IO has been the use of always-on videoconference rooms between offshore platforms and land-based offices. This includes broadband connections for sharing of data and video-surveillance of the platform. This has made it possible to move some personnel onshore and use the existing human resources more efficiently. Instead of having e.g. an expert in equipment condition monitoring on duty at every platform, the expert may be stationed on land and be available for consultation for several offshore platforms. It's also possible for a team at an office in a different time zone to be consulting the night-shift of the platform, so that no land-based workers need work at night. Figure 3.14 illustrates AIM optimization through IO.

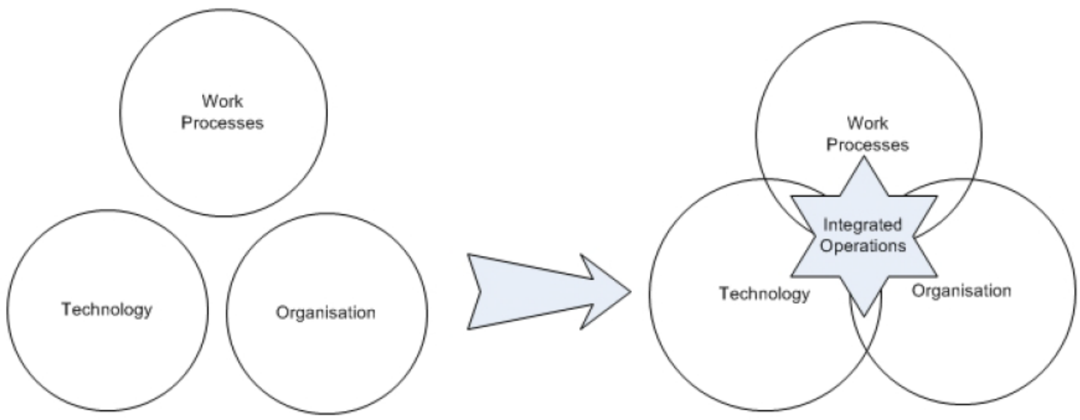


Figure 3.14: Illustration of AIM Optimization through IO

Splitting the team between land and sea demands new work processes which together with ICT is the two main focus points for IO. Tools like videoconferencing and 3D-visualization also creates an opportunity for new, more cross-discipline cooperation. For instance, a shared 3D-visualization may be tailored to each member of the group, so that the geologist gets a visualization of the geological structures while the drilling engineer focuses on visualizing the well. Here, real-time measurements from the well are important but the down-hole bandwidth has previously been very restricted. Improvements in bandwidth, better measurement devices, better aggregation and visualization of this information and improved models that simulate the rock formations and wellbore currently all feed on each other. An important task where all these improvements play together is real-time production optimization (Wikipedia, 2013).

Optimizing Asset Integrity Management with Integrated operations involves adapting to new changes in work processes and technologies. In order for this process to be successful the organization needs to be flexible and willing to change their work methods to fit the new work processes that are being implemented. Table 3.3 below shows the difference between the conventional work processes and the IO work processes.

Conventional Work Processes	Integrated Operations Work Processes
Serial	Parallel
Dependent on physical location	Independent of physical location
Decision based on historical data	Decision based on real time data
Reactive	Proactive
Single discipline	Multidiscipline

Table 3.3 Difference between the conventional work processes and the IO concept (Hauge, 2011)

Implementation of IO and growth potential for Asset Integrity

The implementation of IO on the NCS was first initiated to create cost efficient operations and increase production through the use of ICT. Also the installation of fiber optic cables has been a great contributor to this effort. This is because optical fiber helps to transfer large data in real time between offshore facilities and onshore facilities. The illustration below (figure 3.15) shows how this concept is being implemented by an operator on the NCS. On the offshore platform real time data and real time communication is being made to the appropriate onshore operations centers. For instance concerning drilling and production, data and communication is shared with their collaboration centers in Aberdeen and Stavanger which monitors the drilling and the reservoir. When specialized knowledge is needed external experts are consulted and they participate online without having to move to the platform physically. This is where the "boundaryless" organization concept is being used in creating cost efficient work processes. For vendors, they carry out their product support real time so as to monitor their products such as compressors, turbines etc. this is done to reduce offshore man-hours of their staffs and also to reduce the product downtime by real time monitoring and predictive maintenance. Technical integrity of assets is monitored by real time data generated by the equipment and thereby making it possible to assess the state of the equipment at any point in time. Operational integrity of processes is monitored not only by people on site who have little knowledge of the work processes but also by experts onshore through live communication such as video conferencing. Also critical thinking is done by experts and related back to the platform for implementation. There are also 24hours support centers onshore to monitor and ensure operational integrity.

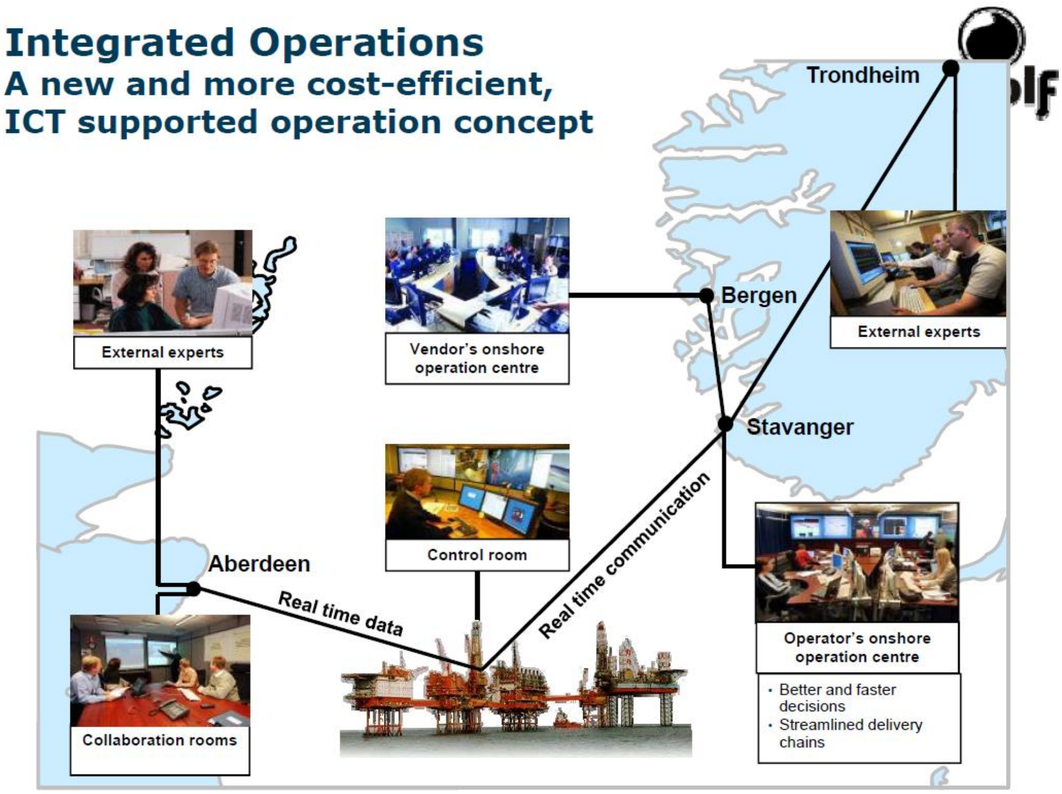


Figure 3.15: The Integrated Operations work process (OLF, 2007)

NCS Integrated work process development

The Norwegian Oil Industry Association (OLF) has agreed to further develop and implement an integrated work process through the concept of IO. This Association consists of 29 oil companies operating on the NCS and 52 service companies which cover areas such as well services, drilling, subsea entrepreneurs, catering, supply bases, logistics, safety and security services (OLF, 2007). The project is supposed to span a period of 14years which has been broken further into two generations. The project entails moving into an integrated work process from the traditional process of self-sustainable fields, specialized onshore units and periodic onshore support (Langeland, 2007). Figure 3.16 shows the integrated work processes development project.

In the 1st generation the industry should start to use video conference/interaction rooms that should be used for communication, monitoring and sharing of real time data between onshore and offshore organizations. Personnel from different departments should meet and work together in these interaction rooms instead of working in separate offices. Both production and maintenance would be planned from onshore personnel together with experts in these interaction rooms. As an addition to the video conference systems the industry would use sensors that are sending real time data onshore, in the wells and on important equipment. This real time data would help the production modeling and therefore give a much more efficient planning on how to produce the different reservoirs (OLF-report 2005).

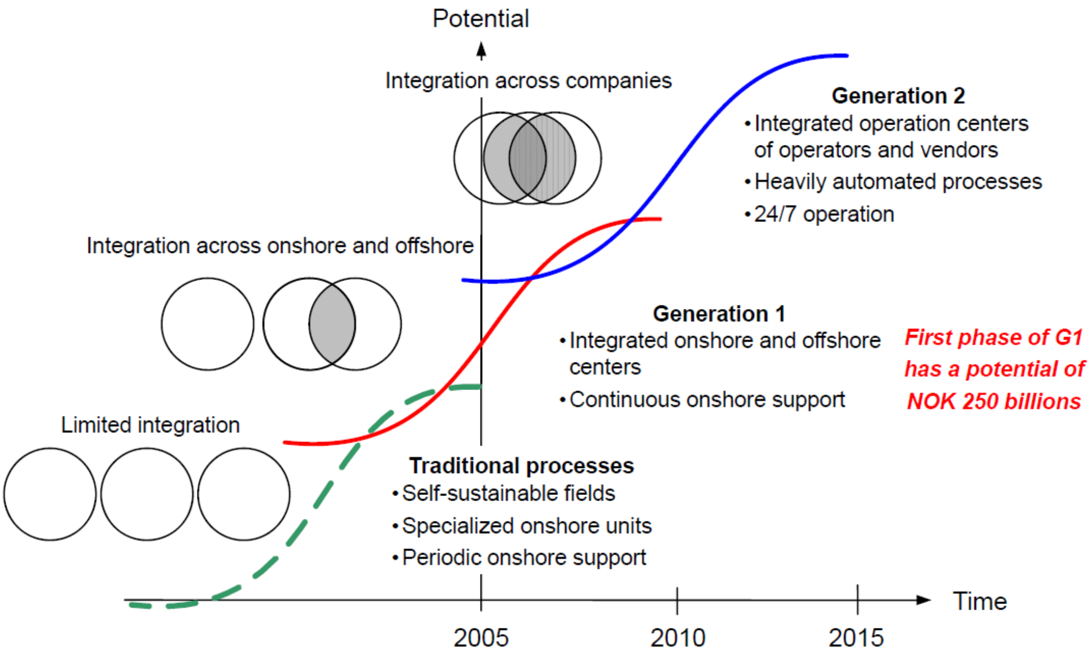


Figure 3.16: The Integrated Work Process Development Project (OLF, 2007)

In the 2nd generation from 2010 to 2015 these tools would be developed further. The interaction groups would include more people from different organizations and companies. The operating companies would also increase their cooperation and interaction with the service providers. Also the onshore support and monitoring would be on a 24 hours basis. The amount of real time data would increase and a greater part of this data would be processed by computers without human supervision. A lot of decisions would therefore be automated.

If this two generation plan was to be followed the rate of change needed to be increased. The cooperation between the parties needed to be improved, the technology standardization needed to be prioritized and the research and development of new technology was important. This figure of the two generations is often used to show where the industry had come and where they were supposed to be (Hauge, 2011).

Benefits of Optimizing AIM of NCS Assets through IO

Optimizing AIM through IO on the NCS has tremendous benefits. Some of these benefits include;

- **Reduced Operation costs:** By implementing of the IO concept operators would be able to reduce operation costs. This is because the number of man hours required offshore will reduce while still achieving the same tasks such as operations, equipment inspection and condition monitoring of their assets.
- **Decreased Downtime and Improved Availability:** Since all assets and work processes are monitored real time, break down in assets can quickly be discovered and an immediate response given to whatever is needed to improve availability.
- **Efficient maintenance:** The IO concept would allow AIM contractors to implement an efficient maintenance by predictive maintenance and real-time condition monitoring through

IT and network infrastructure for remote analysis, data access (real-time and history data, process and equipment diagnostic data, alarm and events, maintenance data, etc.), and user displays/ graphical user interfaces.

- **Mobility and portability:** The concept of IO increases portability and mobility in the field. This is because information can be stored, transferred and processed on portable electronic devices, such as PDAs and Hand held field equipment. Information can be accessed anywhere making communication fast and effective. Also the operators are not physically bound to carry out monitoring, inspection and other solutions so the "boundaryless" organization concept is fully implemented.
- **Improved Safety levels and Performance:** Safety is increased and risk reduced when there are few people that are in the field (offshore platform). Also work performance would improve if the work environment is conducive and that there is access to any needed information to carry out operations or operations support.

4. CHAPTER FOUR

AIM PRODUCTS & SERVICES

Figure 4.1: Products & Services (www.channelpro.co.uk)

4.1 What are Products & Services?

For effective and efficient integrity management of O&G assets, it requires products and services. These deliverables are used throughout the O&G asset lifecycle. To identify these products & services respectively, we need to define the concept of product & service properly.

Product

Product is a complex term in the sense that it means different things in different contexts. Product can be defined in the context of marketing according to Kotler et al. (2006) as anything that can be offered to a market that might satisfy a want or need. In retailing, products are called merchandise. In manufacturing, products are bought as raw materials and sold as finished goods. Commodities are usually raw materials such as metals and process products, but a commodity can also be anything widely available in the open market. In project management, products are the formal definition of the project deliverables that make up or contribute to delivering the objectives of the project. A product can be classified as **tangible** or **intangible**. A tangible product is a physical object that can be perceived by touch such as a building, vehicle, gadget, or clothing. An intangible product is a product that can only be perceived indirectly such as insurance policy (Wikipedia, 2013).

Service

Service is a process consisting of a series of more or less intangible activities that normally, but not necessarily always, takes place in interactions between the customer and service employees and/or physical resources, goods and systems of the service provider, which are provided as solutions to customer problems (Gronroos, 2000). These are **"intangible goods"** or products that are offered to a buyer by using an appropriate level of resources, skills, ingenuity and experience for effecting specific benefits for the service consumers. Services can be distinguished as a product with the following characteristics (Olufisayo, 2013):

Intangibility: They cannot be perceived with the physical senses such as touch, smell and sight. There is neither potential nor need for transport, storage or stocking.

Perishability: When the service has been completely rendered to the requesting service consumer, this particular service irreversibly vanishes as it has been consumed by the service consumer. Example: the passenger has been transported to the destination and cannot be transported again to this location at this point in time.

Inseparability: The service provider is indispensable for service delivery as he must promptly generate and render the service to the requesting service consumer. In many cases the service delivery is executed automatically but the service provider must have already assigned resources with systems and actively keep up appropriate service delivery readiness and capabilities. Additionally, the service consumer is inseparable from service delivery because he is involved in it from requesting it up to consuming the rendered benefits

Simultaneity: Services are some kind of horse and consumed during the same period of time. As soon as the service consumer has requested the service (delivery), the particular service must be generated from scratch without any delay and friction and the service consumer instantaneously consumes the rendered benefits for executing his upcoming activity or task.

Variability: Each service is unique. It is one-time generated, rendered and consumed and can never be exactly repeated as the point in time, location, circumstances, conditions, current configurations and/or assigned resources are different for the next delivery, even if the same service consumer requests the same service.

It can be seen that the concept of products and services are interwoven. Product encompasses services. Currently, there is an emerging concept which is a common business model today for companies that deliver AIM to operators on the NCS. This concept involves acquiring physical goods (tangible) with service delivery (intangible) to provide solutions to operators on the NCS. This concept known as the **"Product-Service System"** is illustrated in figure 4.2

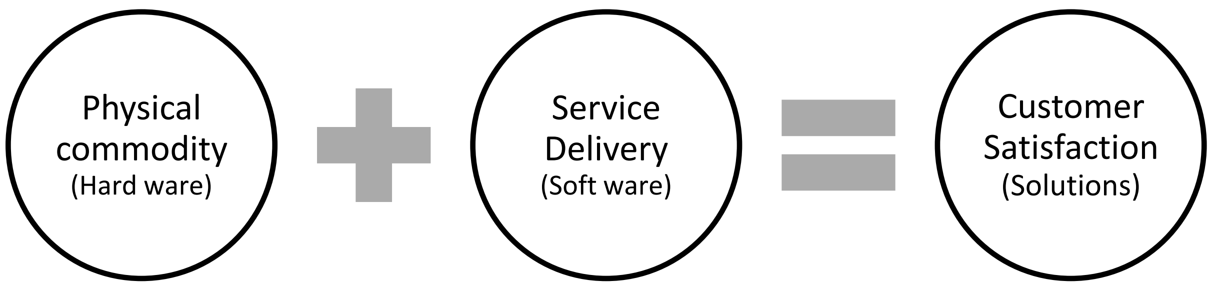


Figure 4.2: The Product-Service System concept

4.2 Product-Service Systems

Product-Service Systems (PSS) is a concept where a firm offers a mix of both products and services, in comparison to the traditional focus on products. As defined by (van Halen, te Riele, Goedkoop) as "a marketable set of products and services capable of jointly fulfilling a user's needs". The initial move to PSS was largely motivated by the need on the part of traditionally oriented manufacturing firms to cope with changing market forces and the recognition that services in combination with products could provide higher profits than products alone (Sawhney et al, 2004). Faced with shrinking markets and increased commoditization of their products, these firms saw service provision as a new path towards profits and growth (Bates et al, 2003).

It is observed that over the years, the engineering industry is changing dramatically in that product concepts are evolving into solution concepts as shown in figure 4.3 (Kalliokoski et al., 2004). In a solution concept, the customers are becoming more dependent on solution providers' services to utilize the solutions. In a solution concept, the customer is interested in the function that the product performs and the solution to a problem that the combined product and service provides (Kumar, 2005). However, the industry is not only in need of services related to products/equipment used in the production processes e.g. after sales services, product support etc. but all kinds of services such as special competence services, consulting service, organizational performance services etc. that can provide solutions to problems and assist them in enhancing performance and to become more competitive.

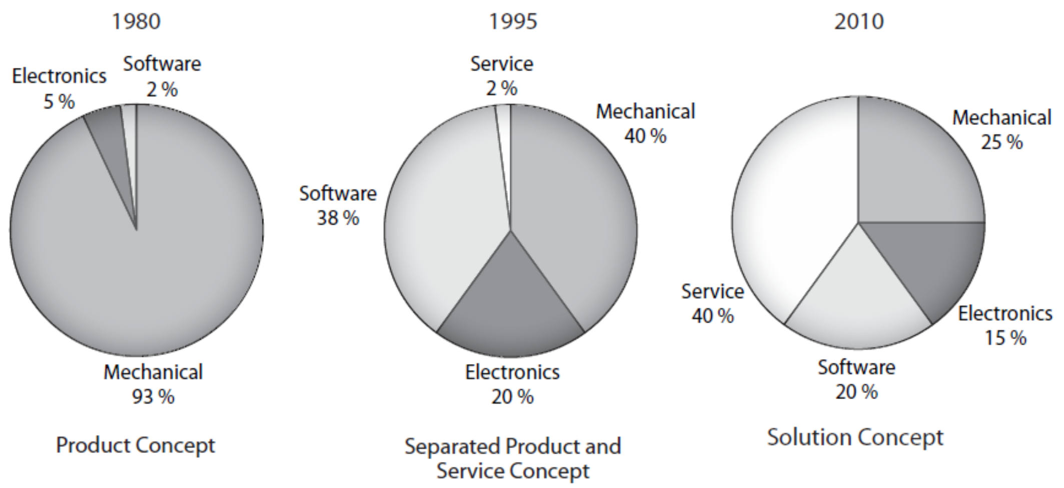


Figure 4.3: Deliverable Trends in the Mechanical Industry (Adopted from Kalliokoski et al., 2004)

The focus on service is increasing as customers are increasingly demanding comfortable and reliable services at the lowest possible cost. At the same time, the service provider's intentions are to increase the value for their customers and seek technological developments to facilitate the service creation and service delivery process (Gronroos, 2000) Service represents an important link in the commercialization process. It defines customer's needs and integrates them with appropriate technologies to solve customers' problems (Kuusisto and Meyer, 2003).

Types of Product-Service Systems

According to Cook (2004) this concept has been classified into three types namely:

1. **Product Oriented PSS:** This is a PSS where ownership of the tangible product is transferred to the consumer, but additional services, such as maintenance contracts, are provided.
2. **Use Oriented PSS:** This is a PSS where ownership of the tangible product is retained by the service provider, who sells the functions of the product, via modified distribution and payment systems, such as sharing, pooling, and leasing.
3. **Result Oriented PSS:** This is a PSS where products are replaced by services, such as, for example, voicemail replacing answering machines.

Impacts of the PSS Concept on the NCS

This concept in the Norwegian O&G industry has a lot of impact on the AIM service contractors as well as their clients (Operators). These impacts include;

- **Cost Effectiveness & Efficiency:** Instead of operators to buy tangible products (hardwares) and set up a department, recruit personnel, train these personnel then give them the task of operation. It is faster and cost efficient for them to outsource competencies to companies that are specialized in these tasks so that they can focus on their core business line which is production.
- **Long lasting Relationship:** It can also foster long relationship between AIM contractors and their clients (Operators). This is because it is not just a one time delivery process it is ongoing as long as they are meeting their client's needs.
- **Innovation through competition:** Specialization in the AIM companies can help to find better ways of implementing the tasks given to them by their operators since the operator's concern is that the AIM contractors must meet their objectives. They try to innovate to meet these objectives through finding better ways to achieve their task and get better results so as to maintain a good relationship with their clients and have a competitive advantage.

4.3 AIM Products and Services on the NCS

On the NCS, operators are increasingly demanding services and integrated solutions when buying a product. They want to buy a product that meets their quality requirements, and is delivered in the right quantity, in the right place, at the right time. These services involve a vendor who is reliable and will meet commitments in a timely manner, with proper product support and the right price. This is because according to Kussel et al. (2000) "Service has a greater influence on the decision to buy a product than the price or even the function of the product". The figure 4.4 shows the role of products and service provider in meeting operator's needs

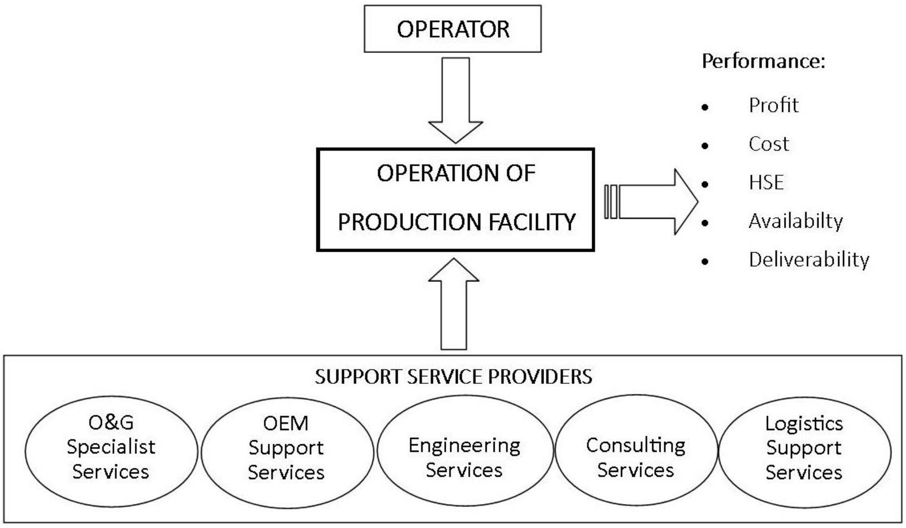


Figure 4.4: Service provider's role in enhancing the operational performance of an O&G production facility (adapted from Kumar and Markeset, 2007)

Also on the NCS, the PSS concept is currently being adopted by many operators. The impact of this system has been explained in previous texts of this report. Now the common AIM products (tangible) and services (intangible) for implementing AIM on the NCS is further discussed below.

AIM Products

In the context of this thesis report, the products we refer to are tangible. This means that they can be perceived by touch. For Integrity Management of offshore assets, the products used to ensure integrity can be grouped into the following;

Softwares/ Applications: These are computer programs/applications designed to achieve the following tasks

- Database management and administration such as real-time and history data, process and equipment diagnostic data, alarm and events, maintenance data,
- Technical tasks such as CAD/CAP, drilling, structural analysis etc.
- Simulations such as reservoir modeling, risk analysis, training etc.
- Utility and maintenance such as operational support, security systems network and communications etc.

Simulators: These are consoles that are integrated with softwares to provide virtual environments that are designed for visualization and review e.g. 3D visualization stations and aids for training, inspection and modification reviews.

Sensors and instrumentation devices: These are asset integrity devices used for measurement; control and assessment e.g. condition monitoring sensors, vibration monitoring probes etc.

Tools and equipment: These devices aids in carrying out inspections to assess technical integrity of equipment e.g. CCTV and other visualization equipments, handheld Inspection devices, Diagnostic devices, communication equipment etc.

Robots/ Remote Operated devices: These are devices for carrying out remote critical operations e.g. Remote Operated Vehicles (ROVs) for remote maintenance, robotic arms for welding and carrying out critical activities in harsh or hazardous environments etc.

AIM Services

In the context of this thesis report, the services are referred to as intangible products. With the definition and characteristics of services given above, AIM services according to this thesis can be grouped into the following:

Engineering Services: These services include design, analysis for overall maintenance and inspection philosophies. This can be used for integrity assessment and modification of assets such as concept selection, material selection, risk management strategies, availability analysis and maintainability evaluations etc. These services help to provide better decision support through developing and optimizing condition based maintenance and inspection programs using methodologies such as criticality analysis, failure mode effect criticality analysis (FMECA), risk based inspection (RBI), reliability centered maintenance (RCM) and staffing analysis(Petrolink, 2010).

Remote operations and process support: Remote support operation includes operation and consultation for offshore asset from remote centers onshore by the use of Information Technology (IT) and real time data. This can also be seen as "Integrated Operations" These services are ideal for plants with limited staffs trained in predictive maintenance techniques, operations with sites located remotely from a central facility and original equipment manufacturers that want to provide a value-added service to their customers.

Data Interpretation: Interpreting data which could include drilling logs, field seismic data, and other maintenance data information for carrying out condition based maintenance and asset integrity assessments. A combination of data collection, analysis, awareness and action is necessary for a successful program and this service is what enables improved decision.

Inspection and Monitoring: This includes monitoring of asset condition through various CBM techniques and inspection of corrosion and other visual defect on equipment and structures using inspection and monitoring technologies such as Vibration monitoring, thermographic inspection, ultrasonic inspection etc. These services are carried out to find all defects and degradations before they become critical.

Spare parts management: This includes operation support activities such as procurement, logistics and storage of OEM spare parts so as to enhance maintenance thereby reducing operation downtime. Spares optimization and management program helps to reduce inventory costs and the risk of running out of stock when spare is needed. This is done by cataloguing and linking spare part to asset criticality.

Improvement Services: These are services that provide hazard mitigation, asset intervention activities and schedule repair when necessary. This service refers to repairs and maintenance directly or indirectly related to the processes involved in the production, e.g. repairs and maintenance of technical installations, pumps, piping, compressors, and generators etc. This service involves a wide spectrum of tasks which how-ever all have one prime objective in common, guaranteeing and further optimizing the operational reliability and continuity of the production processes.

Training Services: This Service is to ensure that operations personnel always have the required understanding and skills for safe and efficient operations of facilities, systems and equipment for the following typical activities such as operations, monitoring and supervision, start-up and shut-down operations, facilitations of modification campaign and emergency response preparations. Asset integrity in this sense is to increase operation competencies through training and retraining for new modifications reducing human error tendencies.

Operations documentation: This service includes transforming technical data and operations information into user-friendly documents such as operations & procedure manuals, maintenance instructions manuals, inspection procedures and checklists, system description and specifications booklet etc. Examples of this documentation include Process Flow Diagrams (PFDs), Piping & Instrumentation Diagrams (P&IDs), General arrangement drawings, Datasheets and equipment lists etc. These documents are for storage of operation activities for assessment and investigation or monitoring operation and technical integrity.

Safety and Emergency response: This asset integrity service is for assessing safety of assets and emergency response to manage unexpected events that can cause threats to personnel and the environment. This includes facility safety assessment, inspection of exit and evacuation routes, safety equipment such as fire hose, extinguishers and carrying out basic training and drills for emergency response management.

5. CHAPTER FIVE

AIM PRODUCT & SERVICE INNOVATIONS

Figure 5.1: Innovation (www.alleywatch.com)

5.1 Introduction

Innovation is the application of new solutions to meet customer wants, needs and preferences through effective products and services. Innovation in general is considered as one of the most important ways of creating competitive advantage (Kandampully & Duddly, 1999). This is because companies that do not create new products & services or improve existing services will risk lagging behind in competitive markets. As operators on the NCS become increasingly dependent on AIM contractors, industrial service innovations can be seen as an opportunity to improve the effectiveness and efficiency of production and support processes for production facility owners as well as providing a new business opportunity for service providers to create new products or improve existing ones.

AIM product & services innovation in the context of this thesis report refers to;

Innovation in products (tangible): these are new or improved products created through technological innovation e.g. replacing the use of Bar codes with RFIDs solutions.

Innovation in service processes (intangible): these are new or improved way of designing and producing services e.g. replacing periodic maintenance and inspection with real time remote condition monitoring and 3D visualization.

5.2 Current Innovative AIM solutions in the Norwegian O&G Industry

Over the last two decades there has been a steady collaboration between operators on the NCS and AIM companies to carefully identify operators asset integrity needs so as to develop innovative solutions to meet these needs (Kumar et al., 2009). Figure 1.3 shows the innovation creation process for creating new solutions. Currently there are some emerging innovative AIM products and services that are being adopted by operators on the NCS. Some of these products & services are briefly mentioned below (See appendix 3 for more details).

RDS solutions for AIM

In general, original equipment manufacturers (OEMs)are currently focusing on improving product performance through support services such as inspections, preventive maintenance, spare part services, 24 hour support for diagnostics, prognostics services to predict operational and maintenance needs as well as forensics services to identify failure cause and effects and to learn from failures and errors (Kumar and Markeset, 2007). This is carried out through the use of Remote Diagnostic Services (RDS). Remote Diagnostics results in asset optimization by providing 24hours fast, effective remote troubleshooting and continuous condition monitoring of assets by transmitting real time data to technical support through wireless service. The availability of diagnostic information data makes it easy to assess the status of equipment at any time (ABB, 2006).

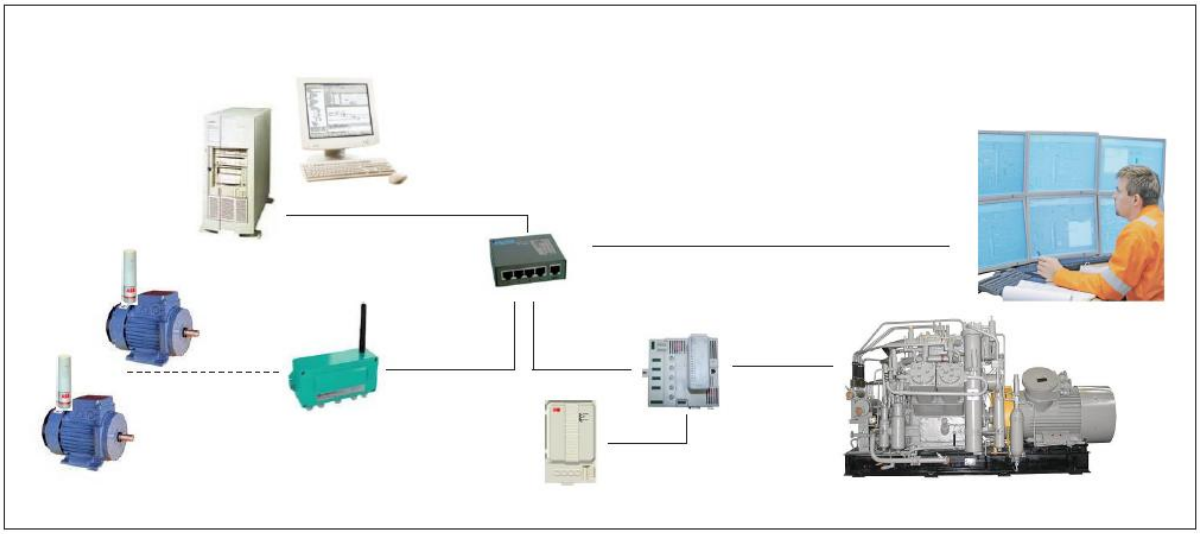


Figure 5.2: Remote Diagnostics Services (RDS) Using Wireless condition monitoring systems (ABB, 2006)

RFID Solutions within Asset Integrity Management

Even on the NCS, there has been a need for a more accurate and faster monitoring of assets. To implement this successfully, it depends on a timely and error free high value supply chain. This is because the O&G industry is capital intensive and failure of even the shortest duration anywhere along the supply chain can instantly ripple into a multi-million loss. Therefore the need for proper maintenance as well as inventory and asset management is critical for effective and efficient business management (Motorola, 2009). Operations management, tracking assets, workers, asset maintenance histories and even the production and distribution of product are a challenge in far flung operations. This has therefore called for newer or innovative ways to tackle this challenge.

According to the Association for Automatic Identification and Data Capture Technologies, an RFID was defined as "an automatic way to collect product, place, and time with transaction data quickly and easily without human intervention or error" (aimglobal.org, 2013). Radio Frequency Identification is a technique for identifying unique items using radio waves. Radio Frequency Identification (RFID) uses wireless technology operating with the 50 kHz to 2.5 GHz frequency range. A RFID system consists of a RFID tag or transponder that contains data about the tagged item/object, and antenna, a RF. transceiver to generate RF signals, and a RFID reader used for collecting RFID data, which it passes to a host system for processing (see figure 5.3)

Figure 5.3: End to end information workflow of an RFID system (OLF, 2010)

This technology is currently being adopted in the O&G industry for the following but are not limited to these only (See Appendix for more information).

- **Equipment maintenance:** The read-write capability of RFID technology enables automation of record keeping for asset maintenance. This, in turn, ensures the highly accurate and complete maintenance records required to best adhere to maintenance schedules and optimize an asset's performance. As a technician completes service, critical maintenance data can be written to the asset tag — such as service date and time, technician, service performed and next inspection date. An asset's complete history is always available to the technician with a quick read of the asset's RFID tag. And in addition, the information is not only stored directly on the asset tag, but can also be sent automatically to the EAM system, ensuring the timely scheduling of future maintenance required to maximize equipment uptime.
- **Personnel Tracking/Safety:** RFID-tagged identity badges and helmets can provide supervisors with the location information required to better protect workers in the hazardous environments of oil and gas facilities. Fixed RFID readers help ensure employee safety by automatically tracking the movements of your workers. As a result, in an emergency evacuation, you can verify that all employees have arrived in a safe muster point. In addition, if an employee remains in an area longer than expected an alarm can be automatically triggered and sent to your security/safety staff, enabling rapid identification and location of employees who may be injured or still in a hazardous area.

5.3 Innovation Processes, Drivers, Success factors and Barriers

In this reports the following terms are briefly defined to so as to serve as a bench mark for analyzing AIM innovation status on the NCS. These definitions are relevant for the case studies done in chapter 6.

- **Innovation Processes:** These are the processes implemented for the creation of new and improvement of existing products & services. These innovation processes could be planned, ad hoc (unplanned) and it could focus on incremental development or revolutionary development (entirely new solutions).
- **Innovation Drivers:** These are factors that initiate the need for innovation very. These drivers include; market demand, similar services in the market/completion, new and cost effective technological solutions (R&D), government regulations, client's specification & preferences, employee initiative and feedback.
- **Innovation Success Factors:** These are feasible factors that make an organization want to consider creating a new service or products. These factors include innovation cost, business potential, organizational capacity (people, competencies etc.), technological capacity and management policy/strategies towards new products & services.
- **Innovation Barriers:** These are the challenges that an organization face in establishing a new service or product. Innovation barriers include; financial constraints, lack of skilled personnel, complexity of available technological solution, regulatory restrictions, and customers are too conservative to buy into new products and services.

5.4 MTO Issues relating to AIM Innovative Products & Services

The Issue of integrating human, technology and organization (MTO) has been a challenge in most industries. This is because the rate of innovation and the rate at which man and organizations adapt to these innovation changes are relatively different. Figure 5.4 shows the rate of change and adaptation with time. Technology has a lot of effect on the way we do things but the bother line also is that it is just a tool in the hand of any user. With the rapid changes in technology today, the design of these solutions should be designed in a way that it adapts easily to human and organizational changes. This concept is referred to as a "socio-technical design perspective". According to Enid Mumford (2006) he said that socio-technical design is more of a philosophy than a methodology. It describes a process and humanistic set of principles that in our context is associated with technology and change. It can be used to contribute to most problem-solving in work situations, providing that both the innovators and recipients are willing to use a democratic approach. This approach would be difficult to use successfully if the parties involved are hostile to each other, disinterested in developing strategy and unwilling or unable to cooperate. In implementing and adapting man and organizations to innovative solutions, the major MTO challenges are highlighted below.

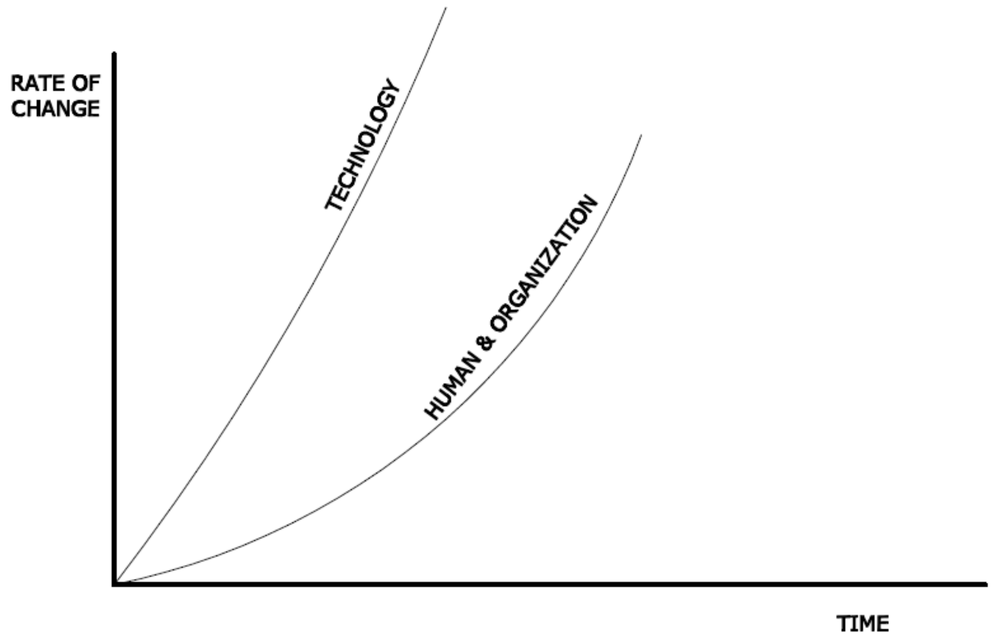


Figure 5.4: MTO rate of adapting to innovative solutions

Human Issues

The human Issue in this context has to do with human behavior in relation to these changes. For this issue to be clearly understood, the concept of human factor has to first be understood. Human factor can be defined as the behavior of human in work processes. The knowledge of these human behaviors is then used to achieve the objectives of minimizing human error and maximizing the effectiveness of human performance. The human factor challenges encountered in adaptation to innovative AIM products & services are;

- **Knowledge and education limitations:** because as new products & services are changing it also needs new information to use them optimally. This then brings about the need for training and retraining. Learning is a time consuming process. Therefore it would take the operating personnel/end user some time and a conscious effort to know the mode of operation of the new or improved products that is about to be operated or implemented. If knowledge is also not properly impacted, it would lead to human error, or underutilization of the product & services. Also because the rate of technology is continuously dynamic, it takes more effort to keep up with knowledge and this is a painstaking process especially with age. Older people's rate for assimilation of new information becomes more difficult. This makes them to stop keeping up with new information and innovative solutions and stick to prior knowledge and existing technologies unless it is mandatory to change.
- **Physical limitations:** The examples of human physical limitations are body size, sight and vision, muscle and movement, hearing and metabolism rate. Noise level, air flow, temperature, air pressure, color, humidity are the related factors that restrict to those limitations. The part of their body used for carrying out tasks to ensure asset integrity usually are sight and vision, muscle and movement and these are used in monitoring and

implementation of changes.. Therefore, the concerns of these limitations are critiques for redesign criteria.

- **Psychological limitations:** In the human sense, they have perceptions in all kind of activities in their lives. Those perceptions have influential effects to human's attitude, which directly have effects on how they adapt to innovative solutions. Human's mental and mind limitation is dissimilar in different time depending on their perceptual condition in the surrounding environment. Stress, sense of organs psychological perception, social interaction, and pressure are some examples of the mental and mind limitations.

Organizational Issues

Organizations are formal structures, policies and strategies that direct human action. In this context, we can say these are structures put in place to direct human actions towards a specific goal and objective. The major attributes of organizational cultures towards the adaptation of innovative solutions are their leadership, ethics, attitudes and beliefs (Vulchi, 2011). These attributes also would be the sources of opposition to change or innovation. The major organizational challenges encountered in adaptation to innovative AIM products & services are;

- **Unwilling to invest**: the organization has a limitation with the investment, it has to consider new technology and its advantages, and at the same time with market analysis. Investing into new businesses or development is a long process in complex organizations and that too it should has higher significance for changing the new technology replacing the old one.
- **Unwilling to work hard**: the working culture and styles of working in the organization is also a limitation. It is hard to identify the work-process and performance efficiency of the staff in high complex organization like in tightly coupled organizations. And the staff is not willing to take much risk and work hard for better profits due it is tightly coupled. There will be hierarchical differences to come and work together for success.
- **Unwilling to change**: the staff and management are used to work with old systems and old technology which have been working for 10 years at least. The management doesn't dare to change to latest and newer versions of the technology and changes in the work-procedures. The change in tightly coupled complex organizations is too difficult to organize and manage.
- **Unwilling to take the time**: the organizational management staff doesn't take time to take decisions and shaping the hierarchy in better way and efficient way for better achievements. The toughest part in the management of the organization is the time management. The organization has to face lot of the time issues for finding, implementing the changes into the organization. The organization is with lot of the top management and stakeholders and it is very hard to manage.
- **Market risks**: the organization is always connected to the market ups and downs. The newer changes and management is also depends upon the market direction. For example, in the recent recession no single company has recruited employees and no single oil company has ordered for the upgrades and even they hold the running projects from the service providers.

Technical/technological Issues

Technical or technological solutions provides user friendliness, scalability and capability of integration with existing solutions through the use of improved products & services. The Technical issues highlighted in the support of Innovative AIM products and services are;

- **Cost-effect:** the technology for monitoring and ensuring asset integrity might be very sophisticated and expensive. The organization may think twice for adopting or inviting new technology into the control room operation. It is very costly to provide new or modifying the existing technology, and also it is very dangerous for 24X7 production plants to think about changes.
- **Lack of knowledge:** Every automation company has a research team to produce the latest and new technologies for every year. But the new technology has to be trained to the service or projects departments for availability for the service at any time at customer site and it is very hard.
- **Opposition for change:** The major concern is the operators are used to one particular technology which they don't want to change for the new technology unless otherwise it is mandatory to change.
- **Technical problems:** in complex systems tracing out technical problems and resolving them is very hard because of interactions in the devices or equipment to make for a easy trouble shooting.
- **Conflicts in the standards**, the standards to follow for developing the technology for the operating company is very hard as per lot of standards. Some of them are ISO 9241-8, ISO 11581-1, ISO DIS 11064 -5, EN 954 -1, EN 61310-3, NORSOK.
- **Conflicts in the technical experts**: the technology is made for successful operation of the tasks and operations designed and programmed in it. The person designing the program may have different technique then other programmer in the same department. When the problem arrives, the developer may not be available and the other person may not understand developer's idea for the particular task and program.
- **Conflicts in the technology**: the automation company is responsible for the technology developing for the customer as per their requirements. The particular technology is for particular tasks and operation. The same technology is not suitable for other customer's requirements, but the automation company is able to produce almost same product for other customer and other requirement also. Due to lack of the knowledge as mentioned above

6. CHAPTER SIX

CASE STUDIES: Multiple Companies

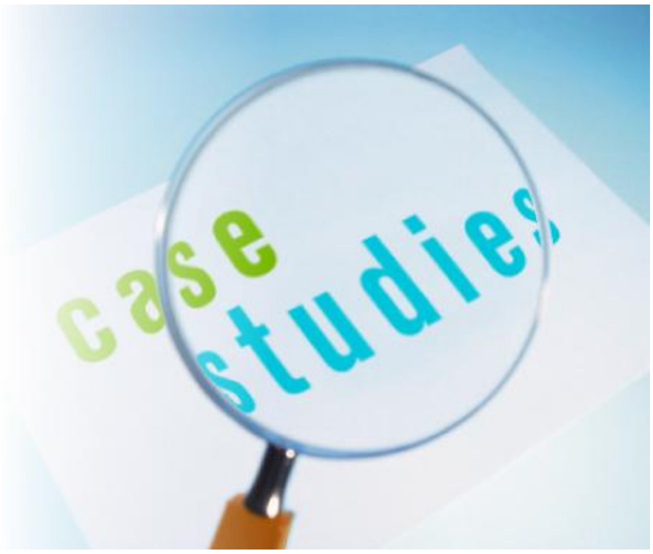


Figure 6.1: Case studies (www.steptopassiveincome.com)

This section begins the second part of this report and builds upon the literature review and analysis carried out in the first part. The second part is based on multiple case studies conducted to investigate products and services innovative trends on the NCS.

6.1 The Industrial Survey

Four persons from four AIM servicing companies operating on the NCS took part in the survey.

Due to matters relating to company and product confidentially, this report will not directly name or refer to any individual/product/company. We will simply go by the, Case 1: interviewee from company A about system A, Case 2: interviewee from company B about system B, and so on and so forth.

This survey was carried out through a questionnaire based interview. The questionnaire was adopted from Panesar's work in the study of industrial service innovation (Panesar, 2007). Interview session was scheduled with highly experienced persons from O&G servicing companies whose area of responsibility was AIM or related discipline. Each interview session was conducted over a period of 1hour 30minutes period (sometimes less or more depending on whether the interviewee had enough time to spare). The interview session covered 2 main areas;

AIM products and services the Company – the purpose of this was to know the AIM product and services the company is offering or are intending to offer in the nearest future.

Products and Services Innovation trends – the purpose of this was to understand the innovation status of the company. This is carried out through identifying the innovation process of the company, drivers of innovation, success factors and innovation barriers.

6.2 Presentation of Survey results

Each presentation begins with a brief description of the company, the interviewee and the products and services the company provides to its clients. The descriptions are kept very brief in order that one may not be able to easily identify the company, the interviewee and/or the system.

Each company's results shall be presented individually either in tabular form, graphically or in written text. Except for the written text (which will not be a reproduction of every statement made by the interviewees), everything shall be presented as provided.

6.3 Case 1: Company A

Overview of company – The first case study was conducted with a medium sized multinational AIM contractor Company with worldwide operations. The Company offers considerable AIM services and products for the O&G operators operating on the NCS.

The interviewee – The results presented in this context are based on the response of a questionnaire-based interview session with one of the Business Managers within Asset Integrity Service from the Company. The questionnaire used during the interview is attached as Appendix 1 of this thesis.

Presentation of Data

Based on the analysis of collected data, Company A has 23% products and 77% services in their current deliverables as shown in figure 6.2a. The products that make up the 23% deliverables include; Data management softwares, 3D visualization softwares, Technical Analysis softwares and tools. The AIM services that make up the 77% deliverables include; maintenance analysis and engineering, predictive maintenance (PM), Barrier assessment and management, criticality analysis, risk assessment, operations documentation, training services, spare parts management, and remote operations.

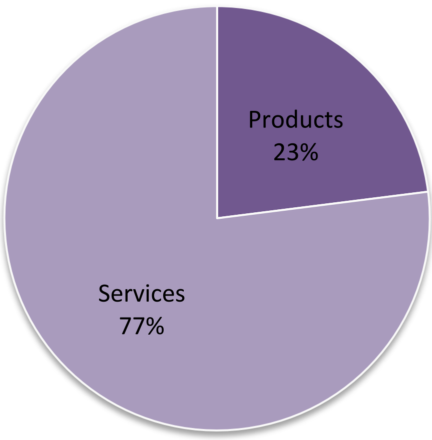


Figure 6.2a Present Deliverables of Company A

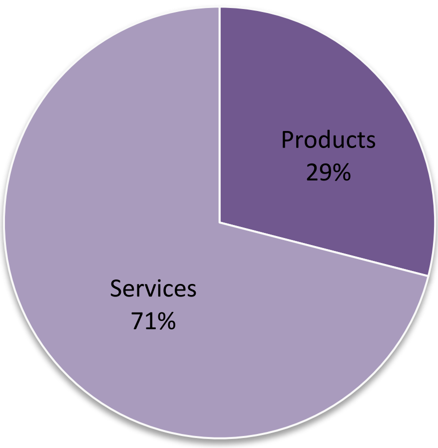


Figure 6.2b Future Deliverables of Company A

Figure 6.2: Present & Future Deliverables of Company A

The questionnaire also included queries about Company's focus towards developing future AIM products and Services. The response shows that Company A is currently embarking on projects to increase the fleet of existing AIM products and services. These ongoing innovative projects show that the pattern of AIM products and services their deliverables would change. Based on the collected data, the future AIM deliverables can be estimated to be up to 71% for the services and 29% for the products as shown in figure 6.2b.

The questionnaire identified the most common services that AIM contractors provide to their clients. These services were scaled according to how often operators demand these services from Company A. The scale was rated from 1 to 5 where 1 means the least demanded services and 5 means the most demanded services.

Based on the interview response, figure 6.3 shows the client services demand for Company A. The figure shows that consequence classification of equipment, barrier assessment, PM routines and maintenance engineering were the most demanded services from this Company.

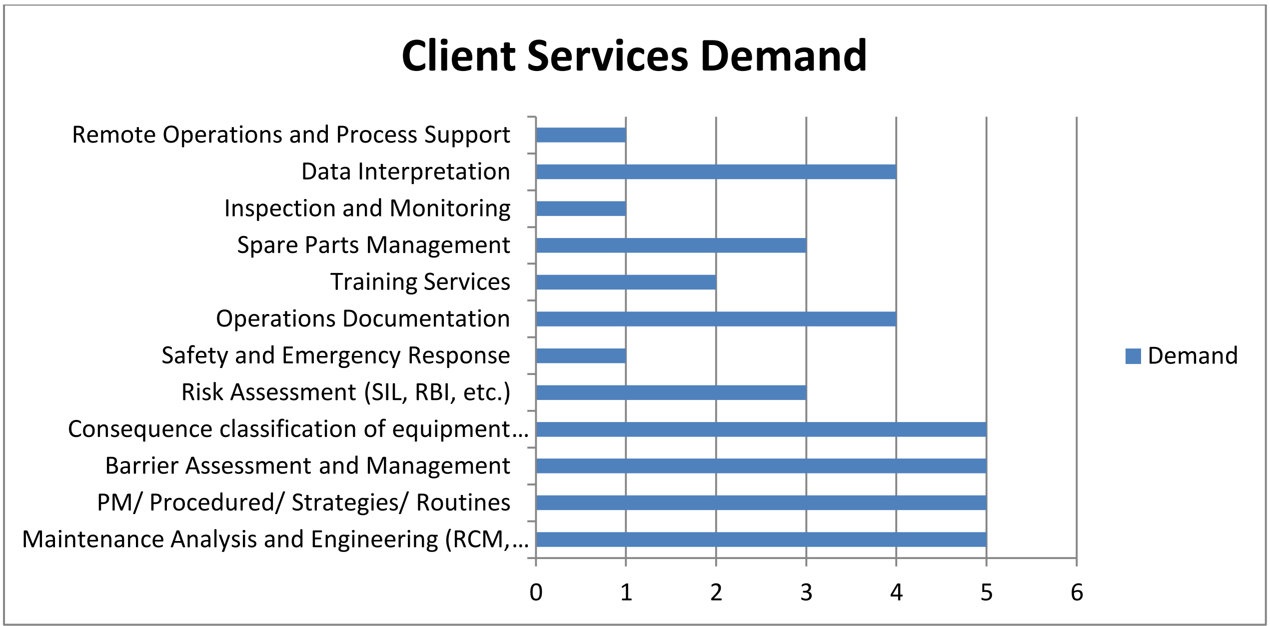


Figure 6.3: Client Services Demand for Company A

Innovation Process

The questionnaire classified the innovation process into 4 which were namely;

- Planned Process (Deliberate process of innovation with a structured plan)
- *Adhoc* Process (Unplanned innovation process)
- Incremental development (Improvement on existing deliverables)
- Revolutionary development (Entirely new way of development)

Based on the response from the interview, Company A's innovation process is seen to be as a result of planned processes with focus on incremental development.

Drivers of innovation

Drivers of Innovation in this context mean factors that initiate the need for innovation.

To map the drivers of innovative process for Company A, the questionnaire classified the drivers of innovation into the 6 categories as shown in figure 6.4 (Ref. Appendix 1). These drivers were then scaled according to their relevance i.e. how much these influence the innovative processes for developing new AIM services and products for the Company. Scale of relevance in the Figure refers to as 5 to be most relevant driver and 1the least relevant driver. Based on the interview response; major drivers for Company A for the past 5 years have been market demand and government regulation. Presently, the major drivers of innovation are market demand and availability of cost effective technological solutions.

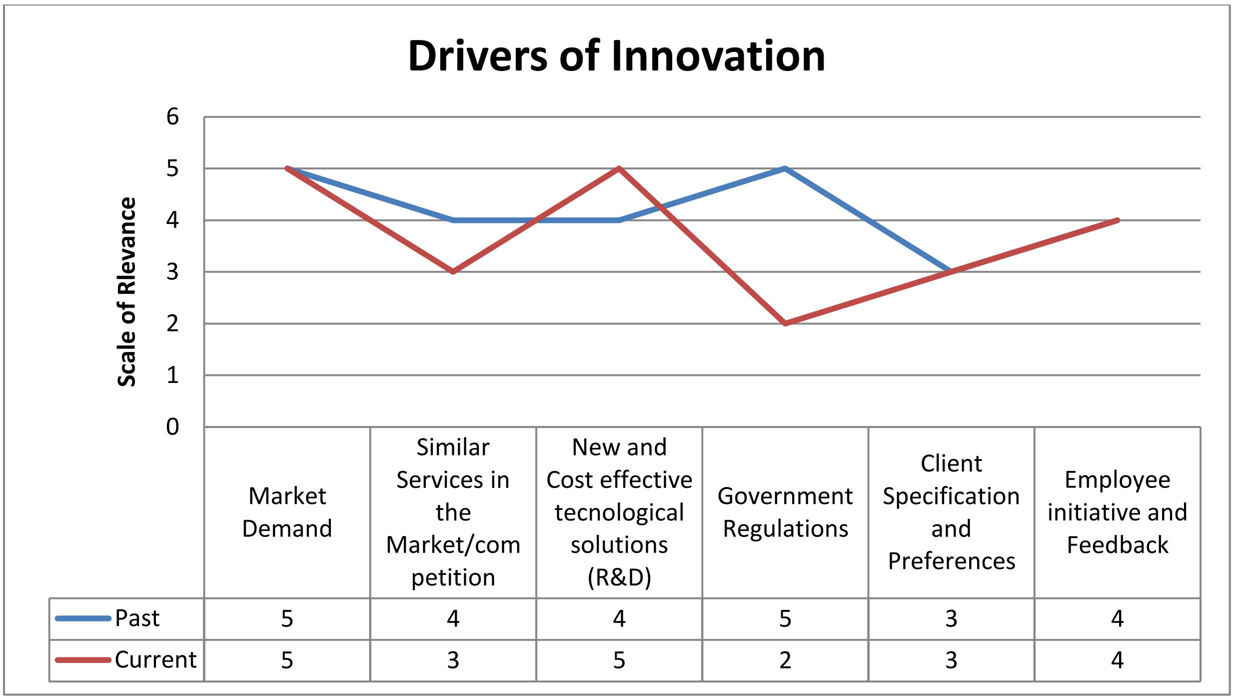


Figure 6.4: The Drivers of Innovation for Company A

Innovation Feasibility factors

Innovation feasibility factors in this context refer to factors that determine if a company would be able to embark on an innovative AIM project.

The questionnaire classified the feasibility factors for innovation into 5 factors which are shown in figure 6.5. These factors were numbered according to their scale of relevance.

(Scale of relevance where 5= to most relevant factor and 1= least relevant factor)

The response from the interview shows that the major feasibility factors for innovation in Company A are; innovation cost, business growth potential, organizational capacity and management policies towards products and services. The least factor of the five factors is technological capacity.

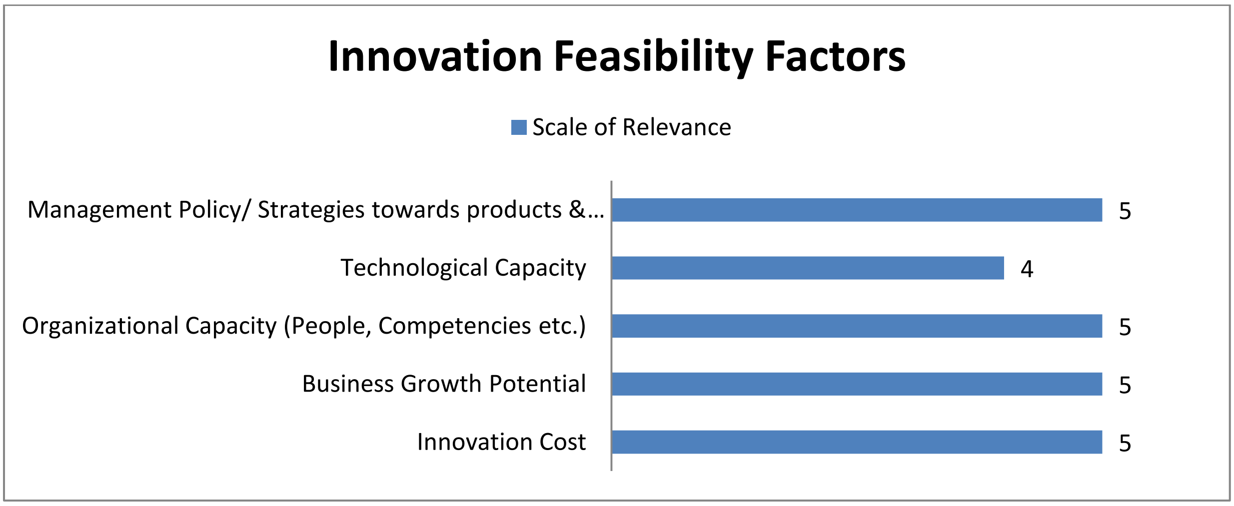


Figure 6.5: Innovation Feasibility factors for Company A

Innovation barriers

Innovation barriers in this context refers to factors that deters a company from embarking on innovative products and services within AIM

The questionnaire classified innovation barriers into 6 barriers which are shown in figure 6.5.These barriers are then numbered according to how company respond to these barriers.

(5= Major innovation barrier, 1=least/minor innovation barrier)

The response from the interview shows that the major innovation barriers for Company A are financial constraints and customer's unwillingness to participate in developing new products and services.

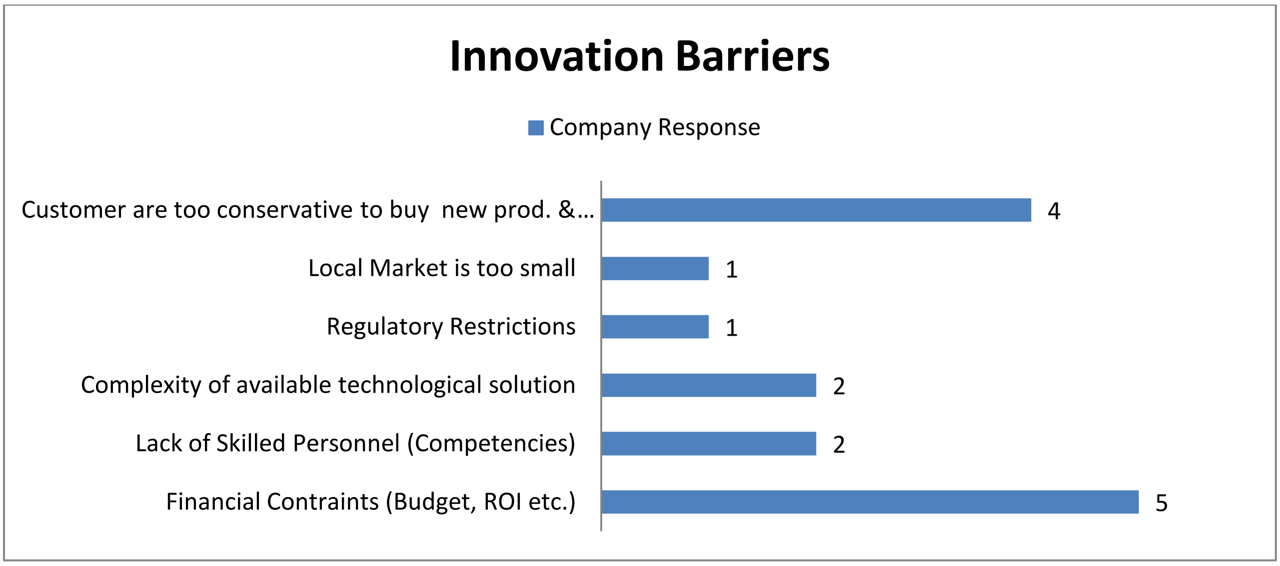


Figure 6.6: Company A response to Innovation Barriers

6.4 Case 2: Company B

Overview of company – The second case study was conducted with a large sized multinational AIM contractor Company with worldwide operations. The Company offers considerable AIM services and products for the O&G operators operating on the NCS.

The interviewee – The results presented in this context are based on the response of a questionnaire-based interview session with one of the Regional Managers within Asset Integrity Service from the Company. The questionnaire used during the interview is attached as Appendix 1 of this thesis.

Presentation of Data

Based on the analysis of collected data, Company B has 48% products and 52% services in their current deliverables as shown in figure 6.7a. The products that make up the 48% deliverables include; Data management softwares, 3D visualization softwares, Technical Analysis softwares, maintenance inspection tools, RFID devices, Remote operated devices, detectors and analyzers, safety equipment, condition monitoring equipment, simulator systems and handheld monitoring devices. The services that make up the 52% deliverables include; maintenance analysis and engineering, predictive maintenance (PM), Barrier assessment and management, criticality analysis, risk assessment, emergency response, operations documentation, training services, spare parts management, inspection & monitoring, data interpretation and remote operations.

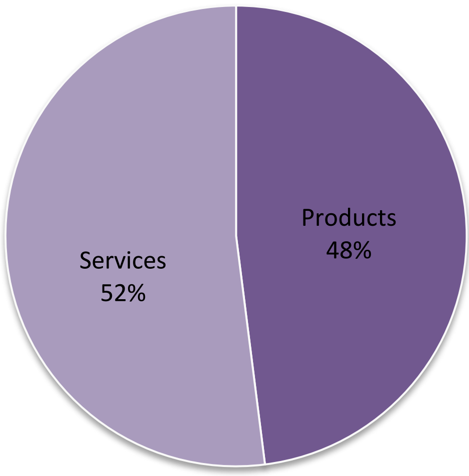


Figure 6.7a Present Deliverables of Company B

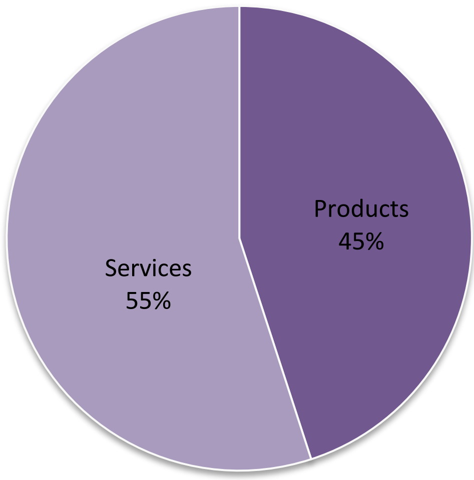


Figure 6.7b Future Deliverables of Company B

Figure 6.7: Present & Future Deliverables of Company B

Company B is currently embarking on a large number of projects within AIM which includes product and services deliverables. This information is based on the response of the questionnaire-based interview. The future deliverables after the projects are complete would be 55% for services and 45% for products as shown in figure 6.7b.

The questionnaire identified the most common services that AIM contractors provide to their clients. These services were scaled according to how often operators demand these services from AIM contractors. The scale was rated from 1 to 5 where 1 means the least demanded services and 5 means the most demanded services.

Based on the interview response, figure 6.8 shows the client services demand for Company B. The figure shows that inspection & monitoring, safety & emergency response, risk assessment, PM routines and maintenance engineering are the most demanded services from this Company.

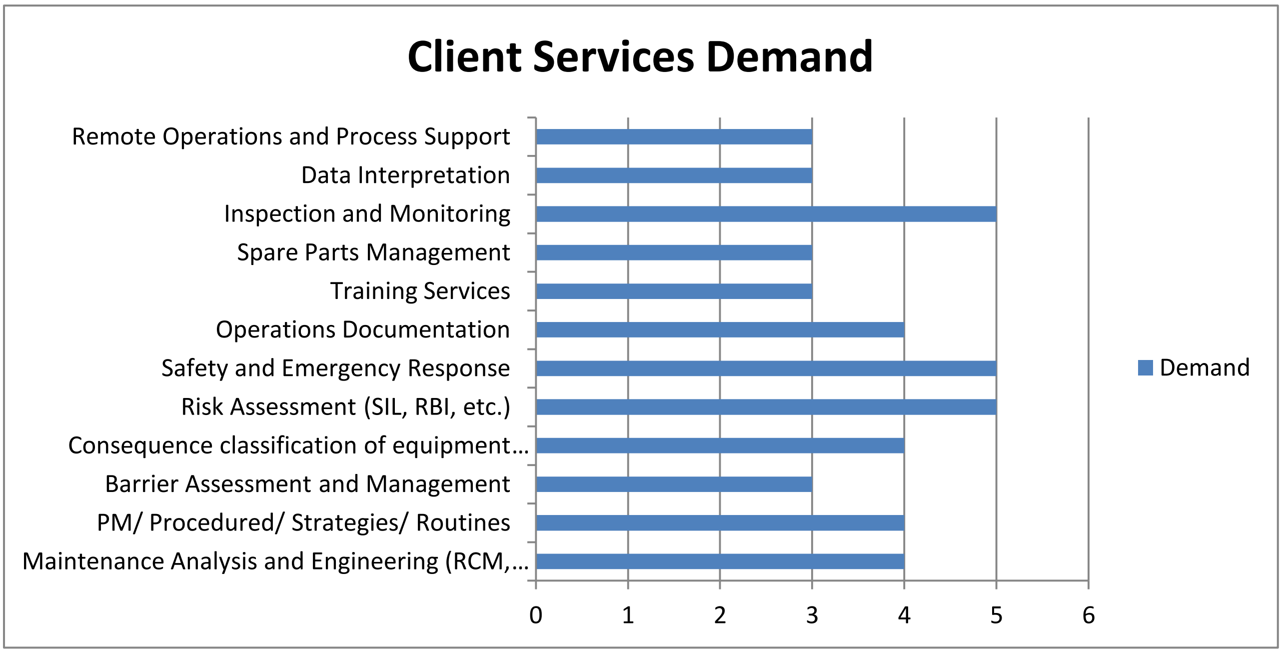


Figure 6.8: Client Service Demand for Company B

Innovation Process

The questionnaire classified the innovation process into 4 which were namely;

- Planned Process (Deliberate process with a structured plan)
- *Adhoc* Process (Unplanned process)
- Incremental development (Improvement on existing deliverables)
- Revolutionary development (Entirely new way of development)

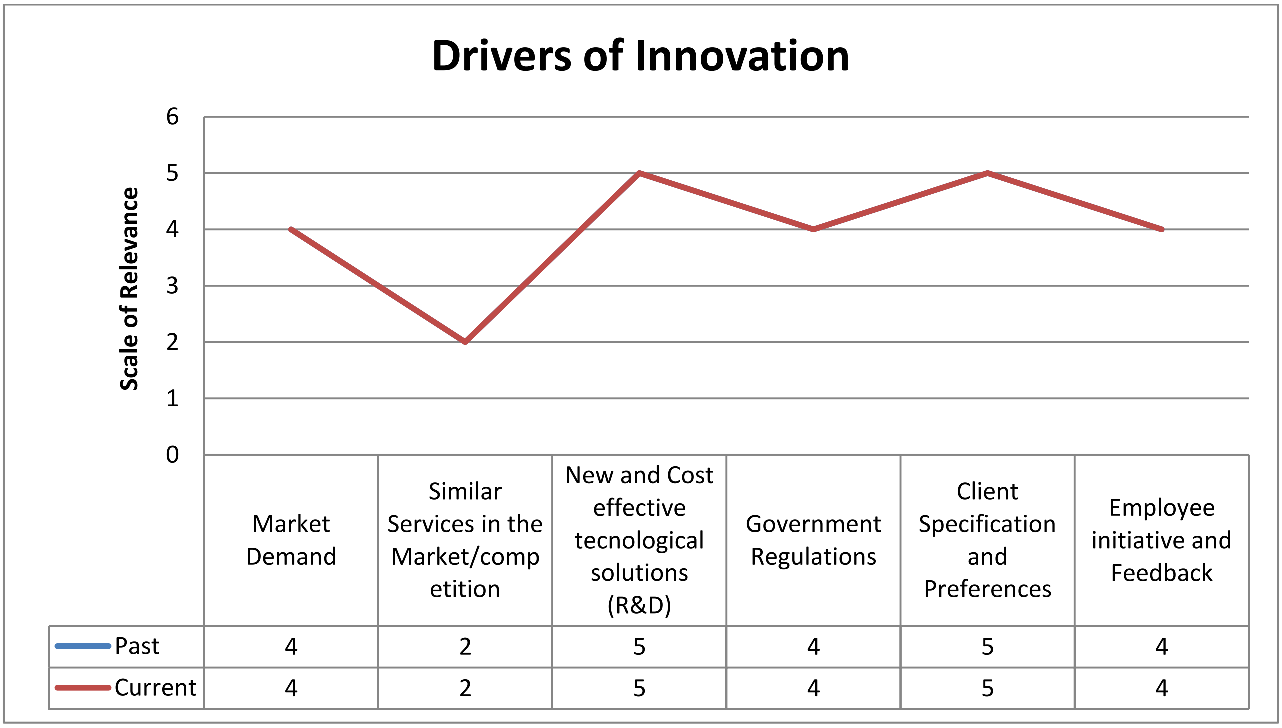
Based on the response from the interview, the company innovation process is an adhoc process (2), incremental development (3) and revolutionary development (4).

Drivers of innovation

Drivers of Innovation in this context mean factors that initiate the need for innovation.

The questionnaire classified the drivers of innovation into the 6 drivers which is shown in figure 6.9. These drivers were then scaled according to how relevant they affected innovation in Company A. Based on the interview response; the past and present major innovation drivers for Company A are consistent which are New & cost effective technological solutions and client's specification/preferences.

(Scale of relevance where 5= to most relevant driver and 1= least relevant driver)



	Market Demand	Similar Services in the Market/competition	New and Cost effective tecnological solutions (R&D)	Government Regulations	Client Specification and Preferences	Employee initiative and Feedback
Past	4	2	5	4	5	4
Current	4	2	5	4	5	4

Figure 6.9: The Drivers of Innovation for Company B

Innovation Feasibility factors

Innovation feasibility factors in this context refer to factors that determine if a company would be able to embark on an innovative AIM project.

The questionnaire classified the feasibility factors for innovation into 5 factors which are shown in figure 6.10. These factors were numbered according to their scale of relevance.

(Scale of relevance where 5= to most relevant factor and 1= least relevant factor)

The response from the interview shows that the major feasibility factors for innovation in Company B are technological capacity, innovation cost, business growth potential and management strategies towards products & services. The least factor of the five factors is organizational capacity.

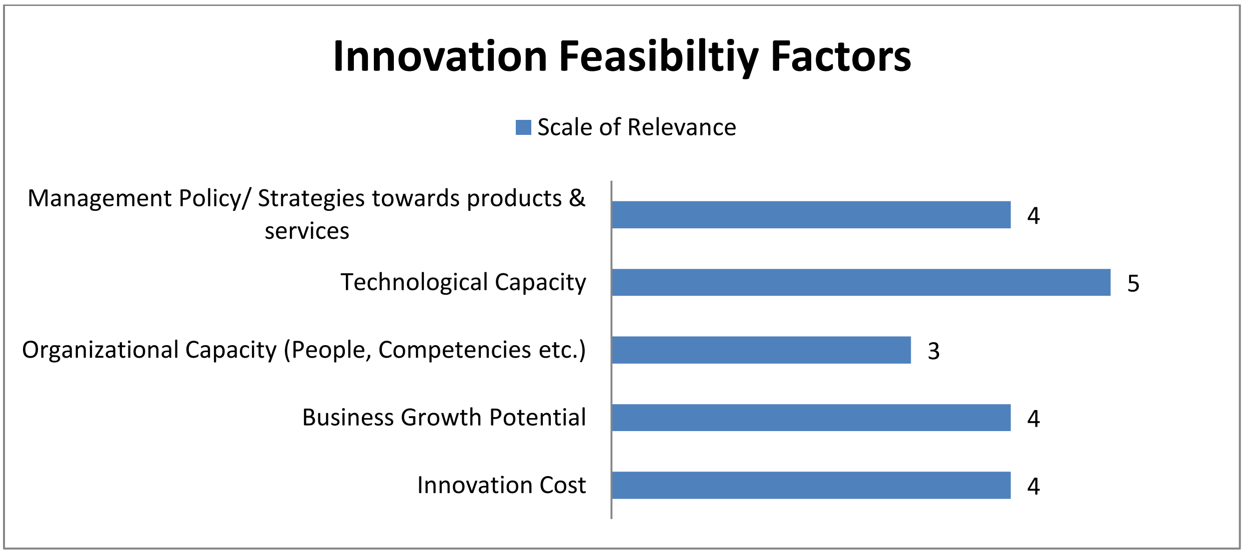


Figure 6.10: Innovation Feasibility Factors for Company B

Innovation barriers

Innovation barriers in this context refer to factors that deter a company from embarking on innovative products and services within AIM.

The questionnaire classified innovation barriers into 6 barriers which are shown in figure 6.11.These barriers are then numbered according to how Company B respond to these barriers.

(5= Major innovation barrier, 1=least/minor innovation barrier)

The response from the interview shows that the major innovation barriers for Company B are lack of skilled personnel followed by financial constraints and regulatory restrictions.

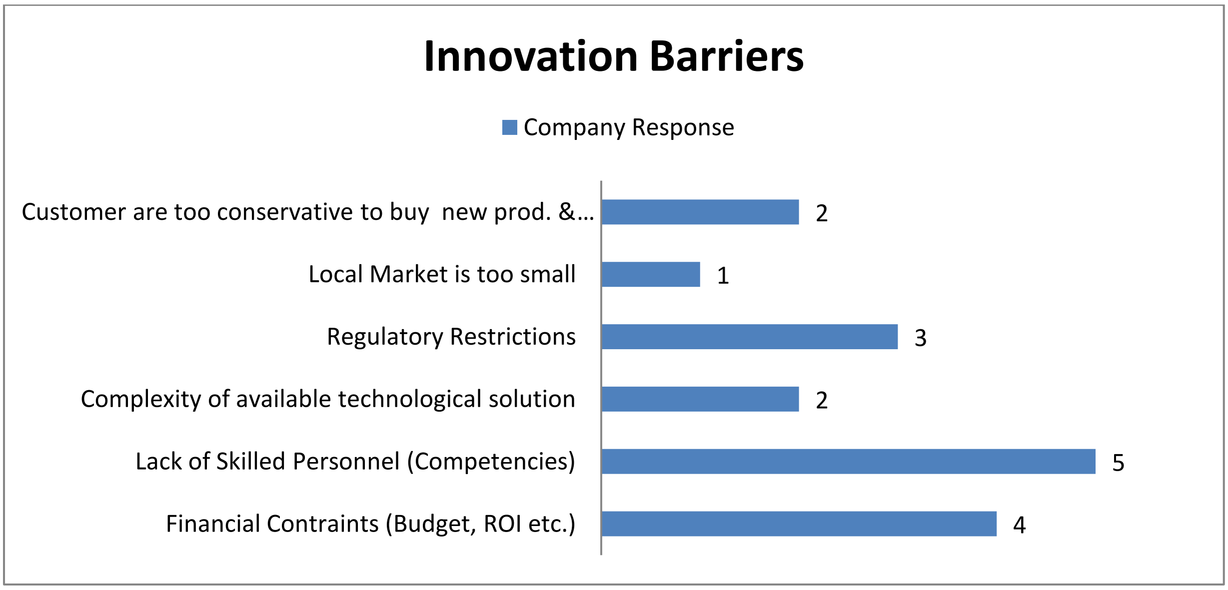


Figure 6.11: Company B response to Innovation Barriers

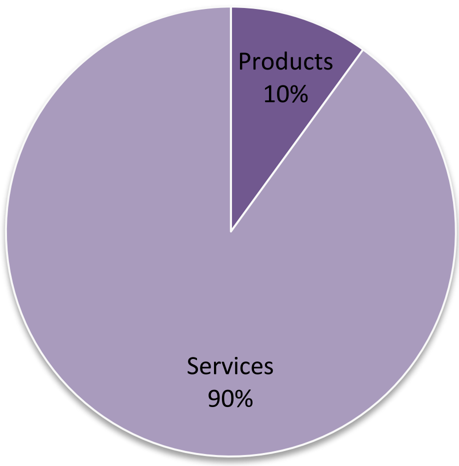
6.5 Case 3: Company C

Overview of company – The third case study was conducted with a medium sized multinational AIM contractor Company with worldwide operations. The Company offers considerable AIM services and products for the O&G operators operating on the NCS.

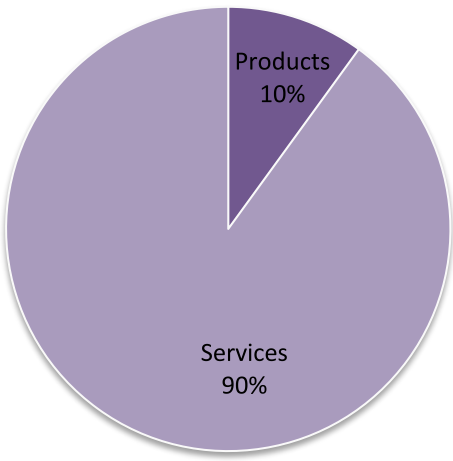
The interviewee – The results presented in this context are based on the response of a questionnaire-based interview session the Department Manager within Asset Integrity Service from the Company. The questionnaire used during the interview is attached as Appendix 1 of this thesis.

Presentation of Data

Based on the analysis of collected data, Company C has 10% products and 90% services in their current deliverables as shown in figure 6.12a. The products that make up the 10% deliverables include; visualization & 3D modeling softwares for simulation. The services that make up the 90% deliverables include maintenance analysis & engineering, PM strategies/routines, barrier assessment & management, consequence classification of equipment, risk assessment, safety & emergency response, operation documentation, training services, spare parts management, and inspection/monitoring.



6.12a Present Deliverables of Company C



6.12b Future Deliverable of Company C

Figure 6.12: Present & Future Deliverables of Company C

Company C is currently not embarking on any project of adding new product support services to their list of deliverables although they are optimally maintaining their current deliverables. Therefore their future deliverables still remains 90% for services and 10% for products as shown in figure 6.12b.

The questionnaire identified the most common services that AIM contractors provide to their clients. These services were scaled according to how often operators demand these services from

AIM contractors. The scale was rated from 1 to 5 where 1 means the least demanded services and 5 means the most demanded services.

Based on the interview response, figure 6.13 shows the client services demand for Company C. The figure shows that training services and operations documentation were the most demanded services from this Company.

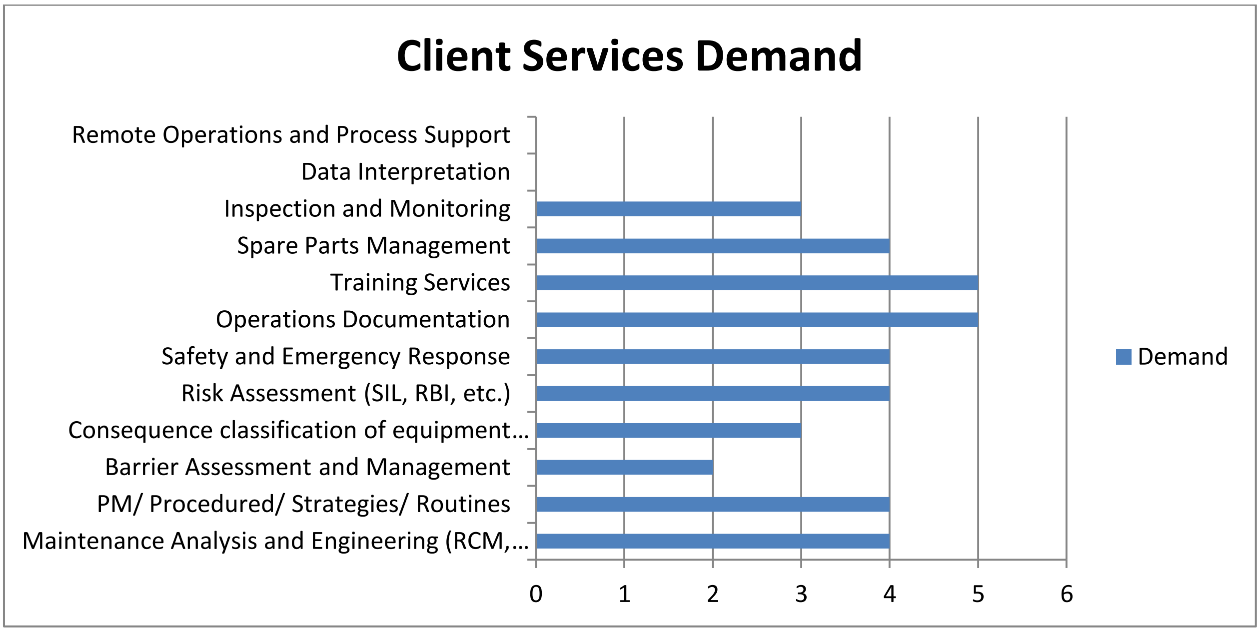


Figure 6.13: Client Services Demand for Company C

Innovation Process

The questionnaire classified the innovation process into 4 which were namely;

- Planned Process (Deliberate process with a structured plan)
- *Adhoc* Process (Unplanned process)
- Incremental development (Improvement on existing deliverables)
- Revolutionary development (Entirely new way of development)

The innovation process for Company C is usually a planned process which is deliberate i.e. they want to innovate and therefore a planned structure to innovate existing products are drawn up and worked on. Also some of the innovation process in Company C is a result of an unplanned process.

Drivers of innovation

Drivers of Innovation in this context mean factors that initiate the need for innovation.

The questionnaire classified the drivers of innovation into the 6 drivers which is shown in figure 6.14. These drivers were then scaled according to how relevant they affected innovation in Company C. Based on the interview response, it was observed that the driver of innovation for company C has been constant over the years. The major driver of innovation for Company C over the years is Market demand and government regulations as shown in figure 6.13. The reason for this trend can be that most of their product must comply with the governing bodies and these bodies are very conservative in adopting new technologies without been very sure of its impact on the industry positively or negatively.

(Scale of relevance where 5= to most relevant driver and 1= least relevant driver)

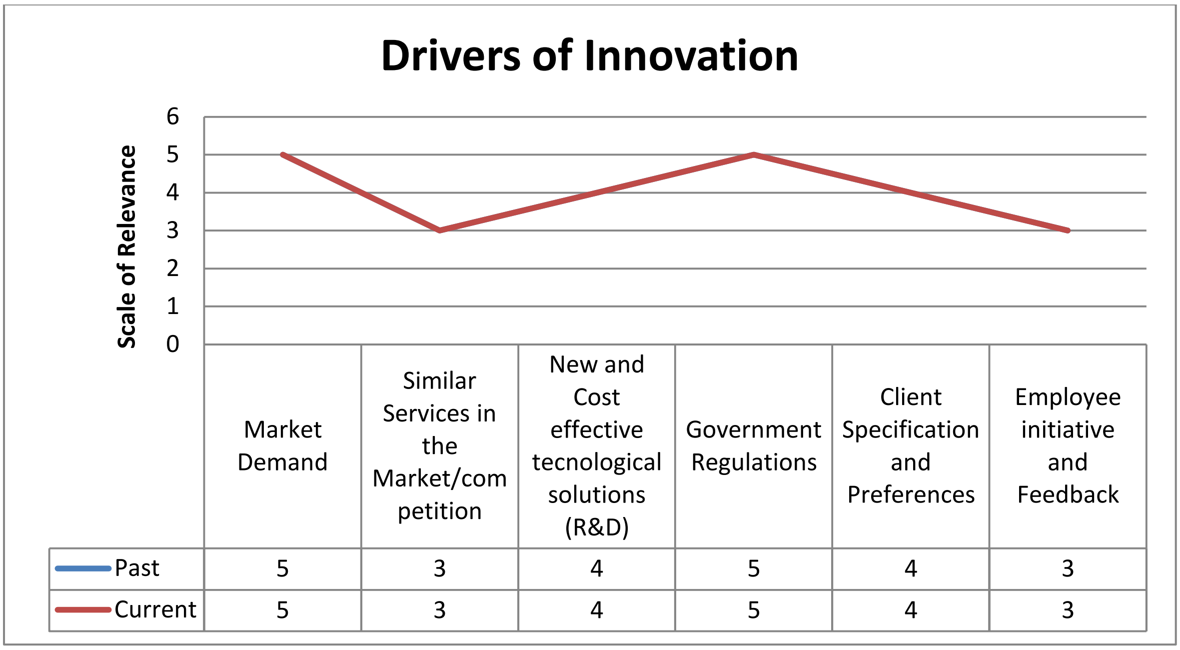


Figure 6.14: The Drivers of Innovation for Company C

Innovation Feasibility factors

Innovation feasibility factors in this context refer to factors that determine if a company would be able to embark on an innovative AIM project.

From the information provided by the company's representative, it was observed that the major innovation feasibility factor for Company C is management policy/strategies towards products and services followed by organizational capacity as shown in figure 6.15 these factors were numbered according to their scale of relevance. (Scale of relevance where 5= to most relevant factor and 1= least relevant factor)

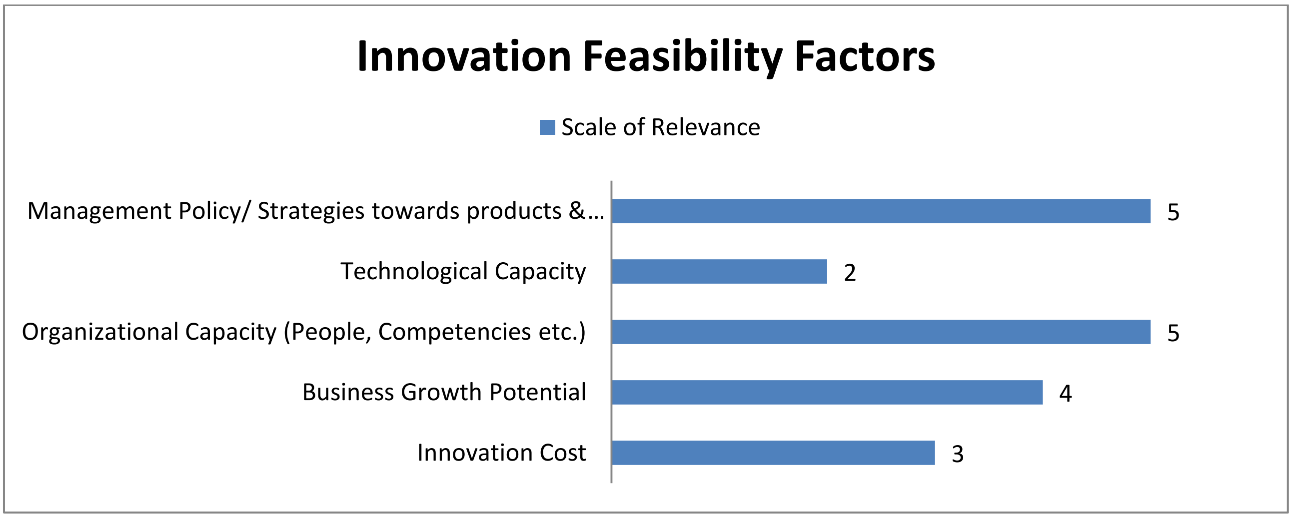


Figure 6.15: Innovation Feasibility Factors for Company C

Innovation barriers

Innovation barriers in this context refer to factors that deter a company from embarking on innovative products and services within AIM.
The questionnaire classified innovation barriers into 6 barriers which are shown in figure 6.16.These barriers are then numbered according to how Company C respond to these barriers. (5= Major innovation barrier, 1=least/minor innovation barrier)
The response from the interview shows that the major innovation barriers for Company C are lack of skilled personnel (competencies) and financial constraints followed by regulatory restrictions.

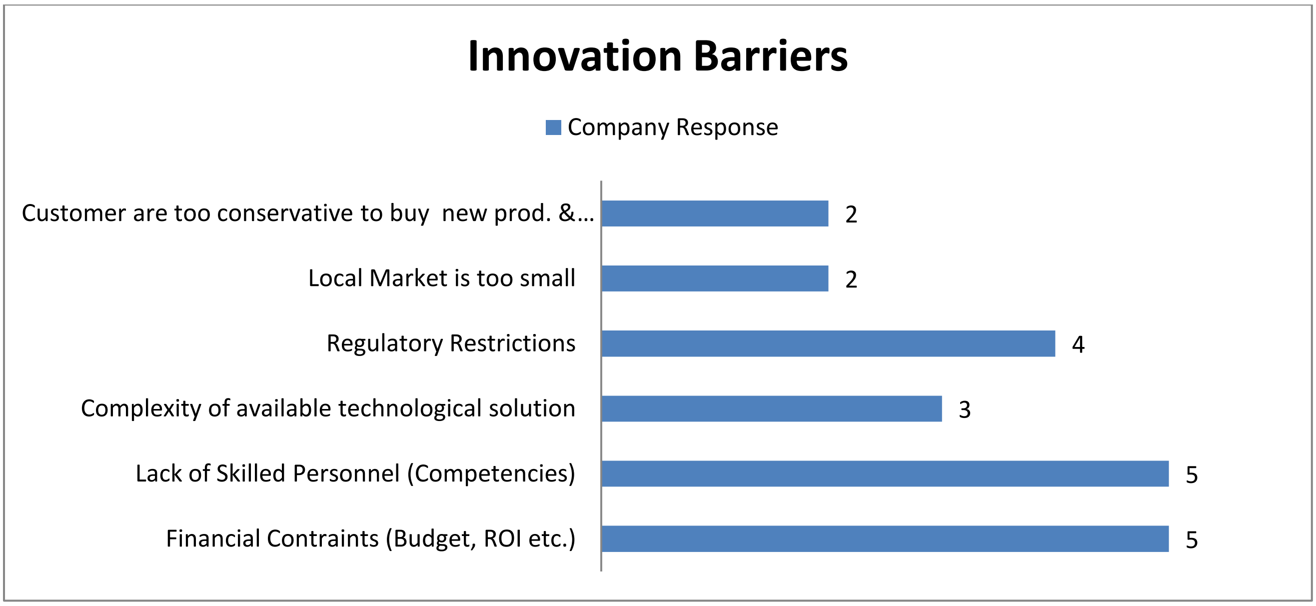


Figure 6.16: Company C response to Innovation Barriers

6.6 Case 4: Company D

Overview of company – The Company is a medium size O&G servicing firm operating with a worldwide brand and considerable operations on the NCS.

The interviewee – The results presented in this context are based on the response of a questionnaire-based interview session with one of the Engineers within Asset Management Department from the Company. The questionnaire used during the interview is attached as Appendix 1 of this thesis.

Presentation of Data

Based on the analysis of collected data, Company D has 45% products and 55% services in their current deliverables as shown in figure 6.17a. The products that make up the 45% deliverables include; Data management softwares, Technical Analysis Softwares/tools, Maintenance inspection tools and equipment, Detectors, analyzers and condition monitoring equipment. The services that make up the 55% deliverables include maintenance analysis & engineering, PM strategies/routines, consequence classification of equipment, risk assessment, training services, spare parts management, and inspection/monitoring.

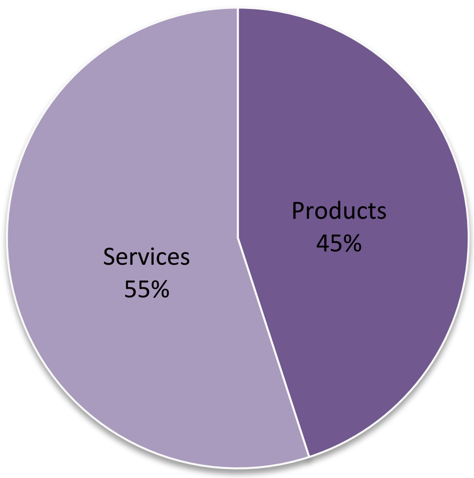


Figure 6.17a Present Deliverables of Company D

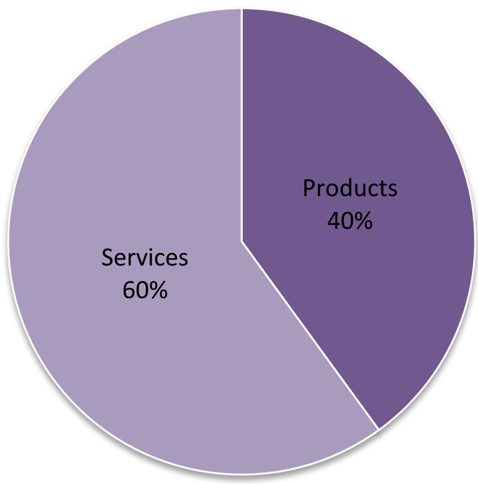


Figure 6.17b Future Deliverable of Company D

Figure 6.17: Present & Future Deliverables of Company C

The questionnaire also included queries about Company's focus towards developing future AIM products and Services. The response shows that Company D is currently embarking on projects to increase the fleet of existing AIM products and services. These ongoing innovative projects show that the pattern of AIM products and services their deliverables would change. Based on the collected data, the future AIM deliverables can be estimated to be up to 60% for the services and 40% for the products as shown in figure 6.16b.

The questionnaire identified the most common services that AIM contractors provide to their clients. These services were scaled according to how often operators demand these services from Company D. The scale was rated from 1 to 5 where 1 means the least demanded services and 5 means the most demanded services.

Based on the interview response, figure 6.18 shows the client services demand for Company D. The figure shows that remote operations & process support, inspection & monitoring followed by PM routines and maintenance engineering were the most demanded services from this Company.

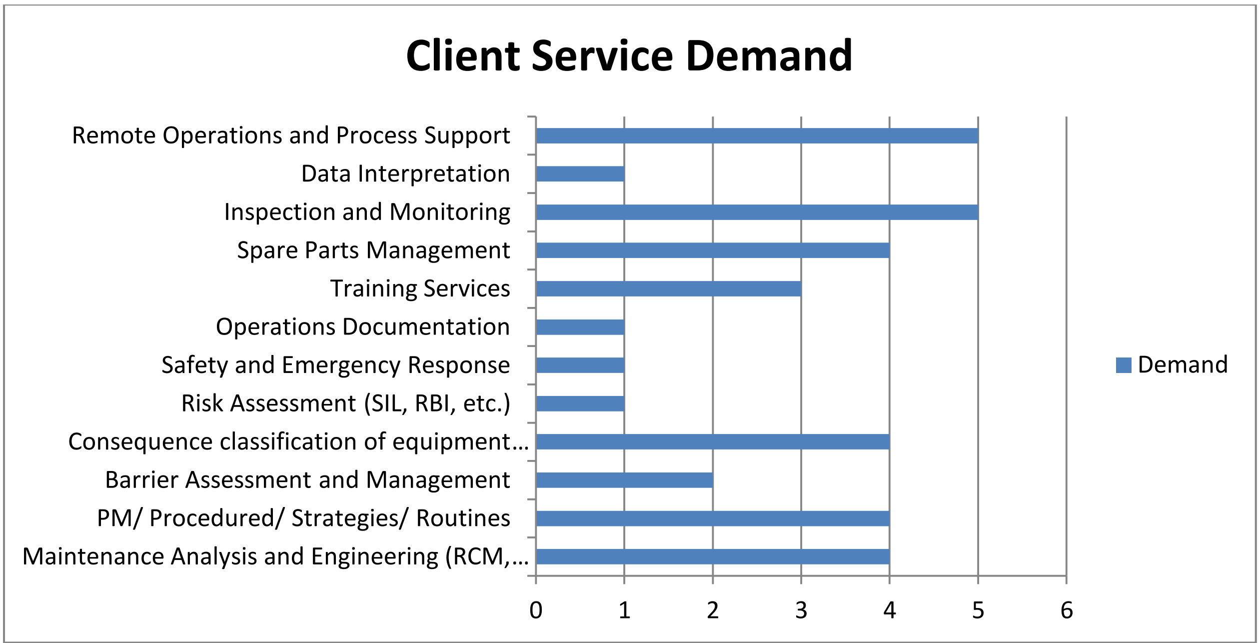


Figure 6.18: Client Services Demand for Company D

Innovation Process

The questionnaire classified the innovation process into 4 which were namely;

- Planned Process (Deliberate process of innovation with a structured plan)
- *Adhoc* Process (Unplanned innovation process)
- Incremental development (Improvement on existing deliverables)
- Revolutionary development (Entirely new way of development)

Based on the response from the interview, Company D's innovation process is seen to be as a result of planned processes with focus on incremental development.

Drivers of innovation

Drivers of Innovation in this context mean factors that initiate the need for innovation.
To map the drivers of innovative process for Company D, the questionnaire classified the drivers of innovation into the 6 categories as shown in figure 6.19 (Ref. Appendix 1). These drivers were then scaled according to their relevance i.e. how much these influence the innovative processes for developing new AIM services and products for the Company. Scale of relevance in the Figure

refers to as 5 to be most relevant driver and 1the least relevant driver. Based on the interview response; major drivers for Company D for the past 5 years have been market demand, new and cost effective solutions (R&D) and client specification and preferences. Whereas presently, the major drivers of innovation are market demand, new and cost effective solutions (R&D) and employee initiative and feedback.

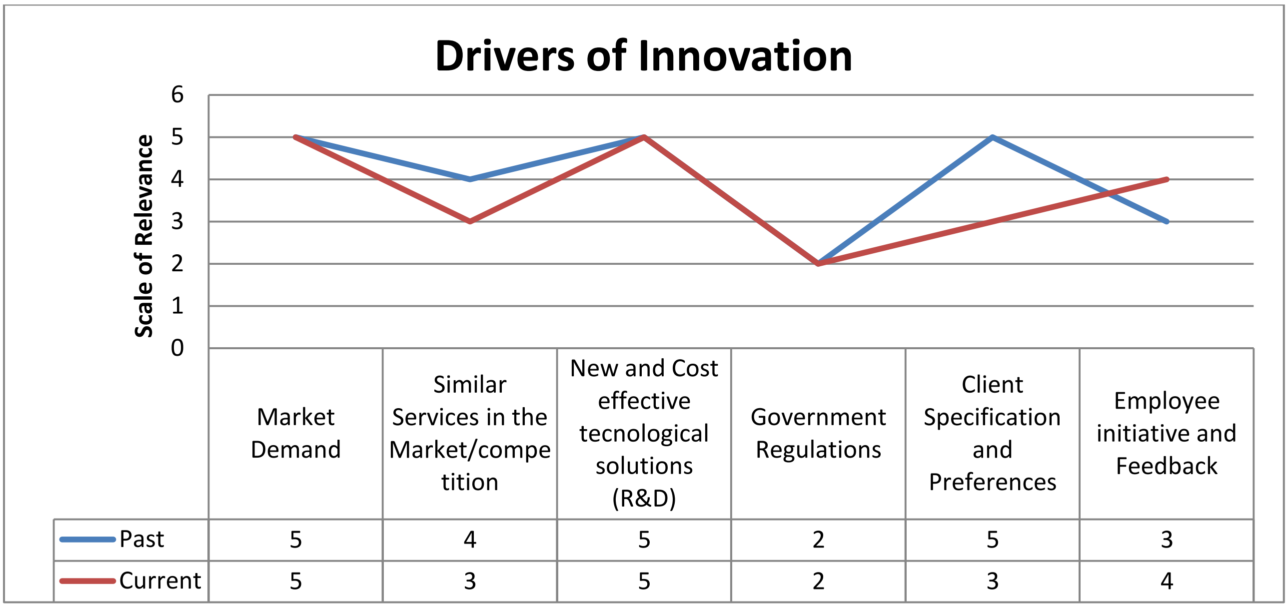


Figure 6.19: The Drivers of Innovation for Company D

Innovation Feasibility factors

Innovation feasibility factors in this context refer to factors that determine if a company would be able to embark on an innovative AIM project.
The questionnaire classified the feasibility factors for innovation into 5 factors which are shown in figure 6.20. These factors were numbered according to their scale of relevance.
(Scale of relevance where 5= to most relevant factor and 1= least relevant factor)
The response from the interview shows that the following are paramount for the feasibility of innovation for Company D which are innovation cost and business growth potential, others include technological capacity, organizational capacity and management policy/ strategies towards products and services .

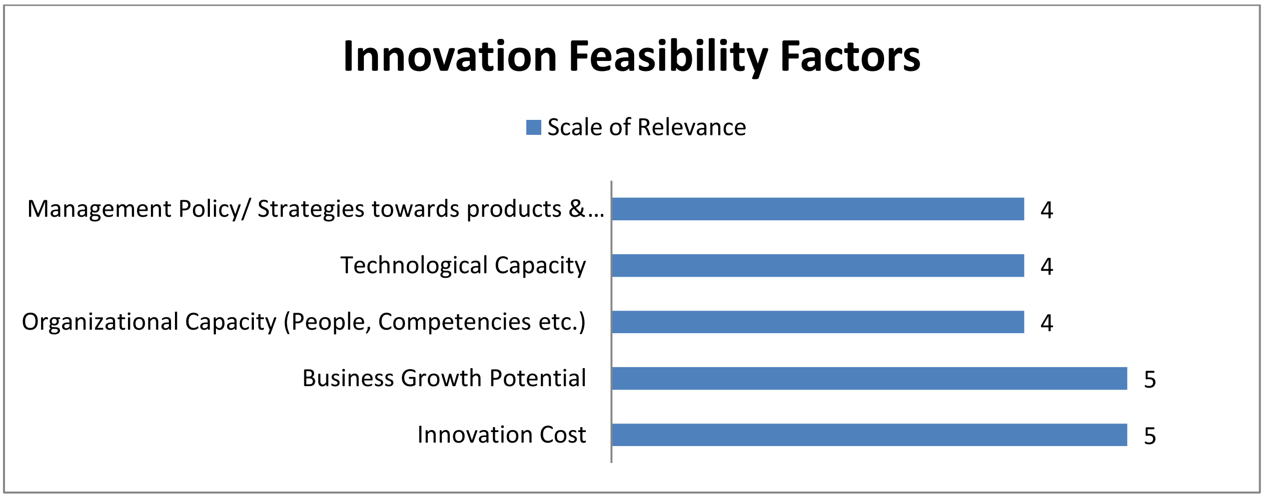


Figure 6.20: Innovation Feasibility Factors for Company D

Innovation barriers

Innovation barriers in this context refers to factors that deters a company from embarking on innovative products and services within AIM
The questionnaire classified innovation barriers into 6 barriers which are shown in figure 6.21.These barriers are then numbered according to how company respond to these barriers.
(5= Major innovation barrier, 1=least/minor innovation barrier)
The response from the interview shows that for Company D, the major innovation barrier is a financial constraint which is then followed by complexity of available technological solution and regulatory restrictions.

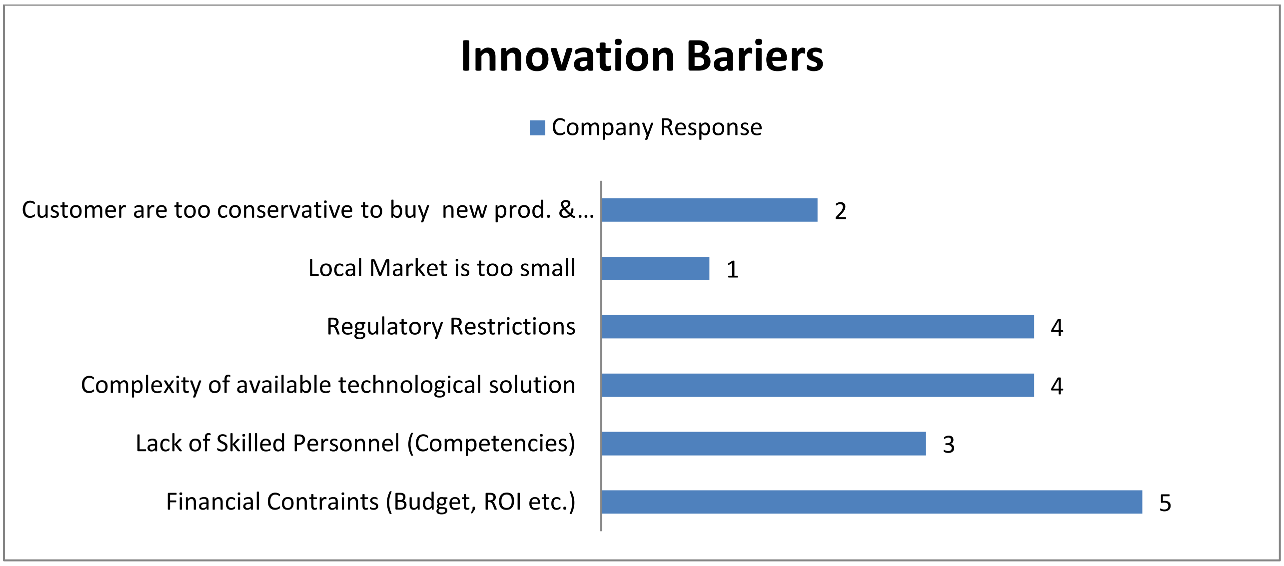


Figure 6.21: Company D response to Innovation Barriers

6.7 Analysis of Questionnaire Results

The case studies in this thesis report are being regarded as a representative of the companies delivering AIM products & services innovation trends found on the NCS. Our analysis is thus based on this premise.

Product and Services Assessment

- The questionnaire shows that all the companies studied provides generally most AIM products services. This shows that most of AIM deliverables are interrelated.
- Also their services usually correspond to them delivering some of the physical products needed to provide these services.
- Also the product and services delivered by these companies are interwoven. This means that they are moving from providing just the products or services to providing competencies which involves both products and services.
- During the questioned based interviews, it was noticed that most of these service companies buy, rent or collaborate with OEM for hardwares to carry out their AIM services.

This assessment confirms that majority of the AIM providers on the NCS are implementing a Product-Service system with their clients. This is a mix of product and services to deliver solutions to their clients. (for more information see definition of Product-Service system in section 4.2)

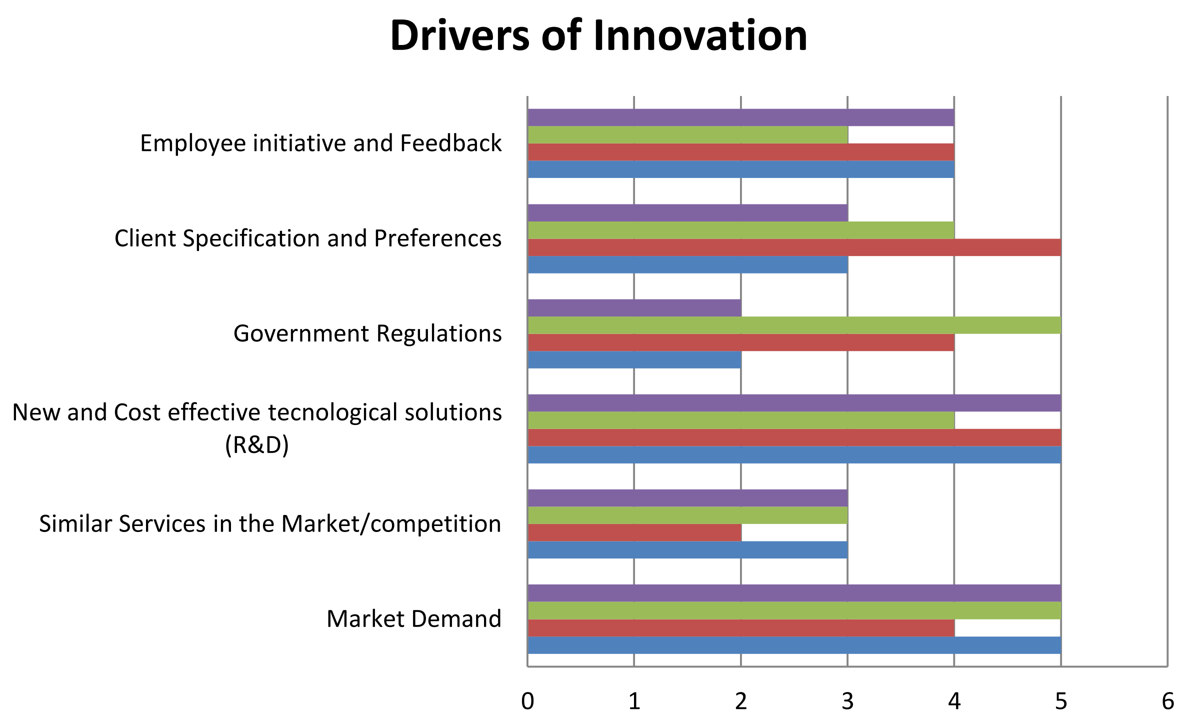
Innovation process assessment

INNOVATION PROCESS	A	B	C	D	RESULT
A planned process (Deliberate Process with a structured plan)	Yes		Yes	Yes	A,C,D
Ad hoc (Unplanned) process		Yes	Yes		B,C
Incremental development (Improvement on existing deliverables)	Yes	Yes		Yes	A,B,D
Revolutionary New technological products.		Yes			B

Table 6.1: Innovation Process Assessment for Company A - D

While the purpose of innovation is "simply" to create business value (simply is in quotes because it's obviously not so easy to do), the value itself can take many different forms. As we noted above, it can be incremental improvements to existing products, the creation of breakthroughs such as entirely new products and services, cost reductions, efficiency improvements, new business models, new ventures, and countless other forms as well. The method of creating innovation is to discover, create, and develop ideas, to refine them into useful forms, and to use them to earn profits, increase efficiency, and/or reduce costs. Here we focus on how to do that, the process of innovation. Based on the case studies provided, it is observed from table 7.1 that most company deliberately initiates their innovation process. This may be due to striving to be relevant in the industry, taking advantage of the new technological product that is transforming the industry such the IO scenario concept and finally trying of have a competitive advantage to attract more deliverable demands from them.

Drivers of Innovation

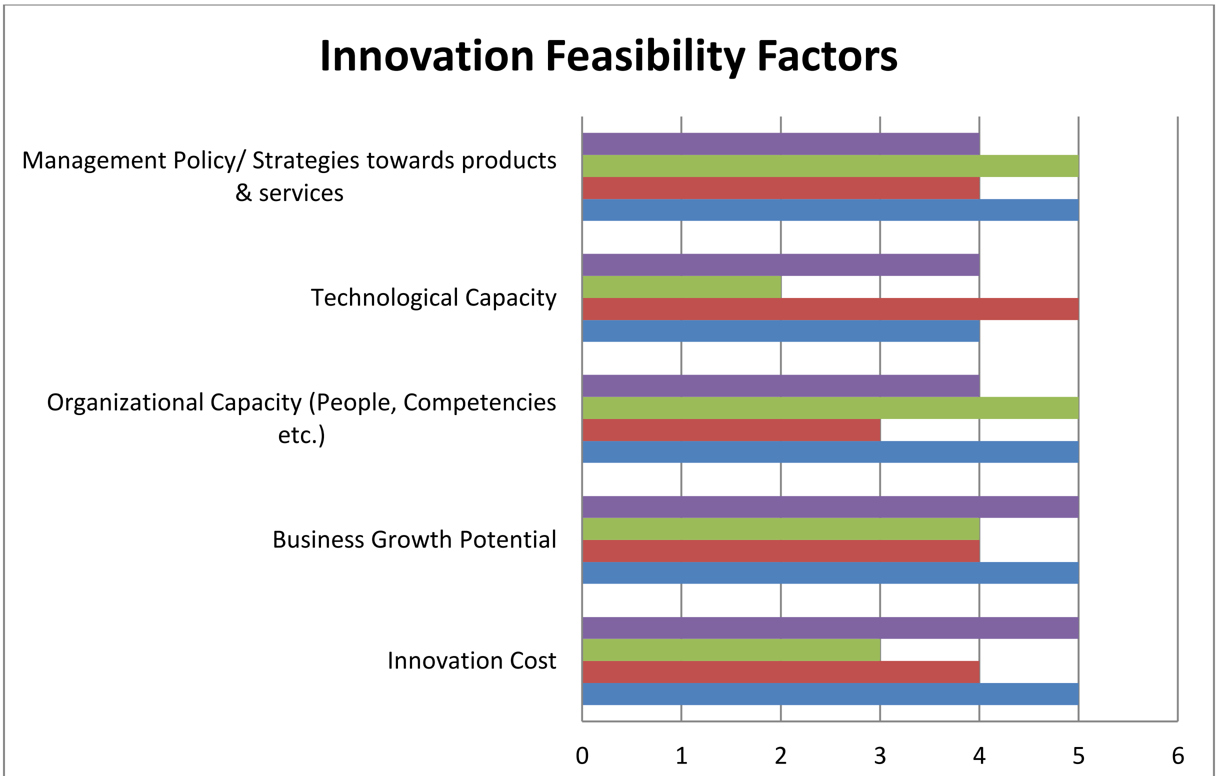


	Market Demand	Similar Services in the Market/competition	New and Cost effective tecnological solutions (R&D)	Government Regulations	Client Specification and Preferences	Employee initiative and Feedback
D	5	3	5	2	3	4
C	5	3	4	5	4	3
B	4	2	5	4	5	4
A	5	3	5	2	3	4

Figure 6.22: Innovation Drivers Assessment for case study 1-4

Drivers of innovation is very important because there lies the spark of innovation itself. Also there are many drivers and these drivers are based on different scenarios. Most of the general drivers of innovation in the O&G industry have been taken as parameters in the questionnaire that was used to analyze the innovation trends on the NCS. These drivers include market demand, similar services in the market/competition, new and cost effective technological solutions (R&D), government regulations, clients specification and preferences and finally employee initiative and feedback . Based on the data from the case studies, it was observed from figure 6.22 that the major drivers of innovation from the data are **Market demand** and **cost effective technological solutions (R&D).** These drivers seem logical because as the saying goes "necessity is the mother of all inventions". Also cost effective technological solutions is important because it helps the company to provide services and product that are more effective and efficient which would also attract customer demand for more of their deliverables.

Innovation Feasibility Factor



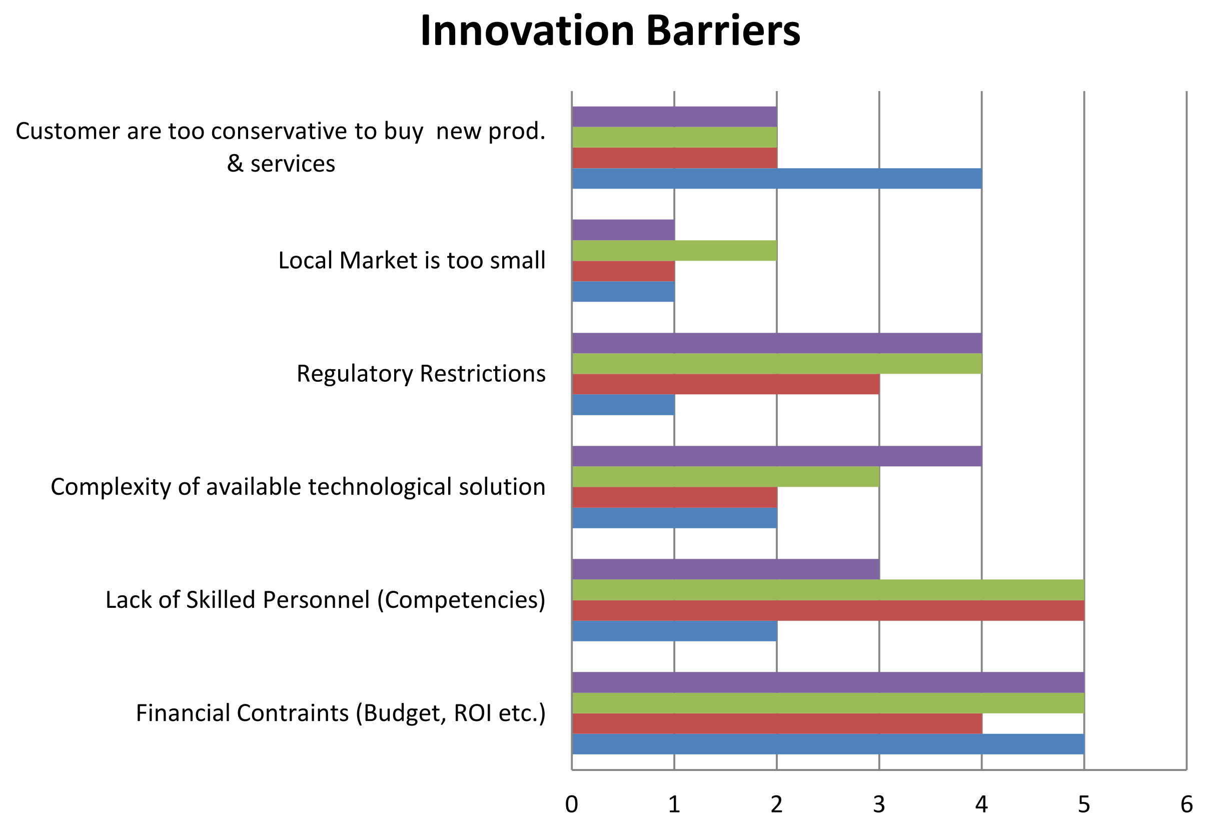
	Innovation Cost	Business Growth Potential	Organizational Capacity (People, Competencies etc.)	Technological Capacity	Management Policy/ Strategies towards products & services
D	5	5	4	4	4
C	3	4	5	2	5
B	4	4	3	5	4
A	5	5	5	4	5

Figure 6.23: Innovation feasibility factors Assessment for case study 1-4

Based on the analyzed data in figure 6.23, it shows that two out of the four companies studied has four of the innovation feasibility factors as major factors giving it a scale of 5 out of 5. Figure shows that these factors are **innovation cost, business growth potential, organizational capacities, and Management policy/strategies towards products & services.**

Technological capacity was only seen as a major feasibility factor by one of the four companies. The company which considered this as a major factor is the large AIM contractor that was studied. Their response to this factor was that since they see themselves as a "technologically focused" company, this factor is a major factor for them. The other companies studied mentioned that technology they needed could be bought either by renting equipment or completely outsourcing the needed technological capacity. An important point noted by all the experts interviewed was that Management policy/strategies towards products & services has a very important role in feasibility. One of the interviewee said that "when there is a will there would be a way to go about driving innovation".

Innovation Barriers



	Financial Contraints (Budget, ROI etc.)	Lack of Skilled Personnel (Competencies)	Complexity of available technological solution	Regulatory Restrictions	Local Market is too small	Customer are too conservative to buy new prod. & services
D	5	3	4	4	1	2
C	5	5	3	4	2	2
B	4	5	2	3	1	2
A	5	2	2	1	1	4

Figure 6.24: Innovation Barriers Assessment for case study 1-4.

Based on the data from the 4 case studies, it was observed from figure 6.24 that the predominant challenge or innovation barrier from creating new and innovative AIM deliverables is **financial constraint**. Three out of the four case studies responded to this barrier as their major barrier giving it a 5 out of a scale of 5. The other major innovation barrier also observed from the case studies is **lack of skilled personnel (competencies)**. Two out of the four cases studies mentioned this barrier also as their major barrier giving it a 5 out of a scale of 5.

Therefore using these case studies, it can be induced that financial constraint and lack of skilled personnel (competencies) are some of the major challenges AIM contractors in the Norwegian O&G industry are facing when trying to create innovative AIM products and services for their clients (operators) on the NCS.

6.8 Summary of Analysis

AIM Innovation trends can be said to have changed in the Norwegian O&G industry. This could be attributed to different factors that have been discussed in this thesis report such as market demand, government regulations and new and cost effective solutions. Innovation must be managed on the NCS because the industry is a high risk industry. Innovations that are not properly tried and tested should be carefully implemented and integrated to the industry because of the impact it could cause.

From the Interviews and questionnaires administered when studying this topic the following was observed.

AIM products and services concept in the Norwegian O&G Industry are closely related. This is because of the level that the industry is already operating in now such as IO scenario. Now the relationship of the service provider and operators are now more closely linked because of such concepts.

Also, Operators on the NCS are now looking for competencies and are not willing to get the necessary resources to carry out their AIM. For instance operators would rather outsource their AIM to competent companies rather than set up a department, hire qualified personnel and buy the necessary equipment to carry out AIM for their offshore assets. This is because it is far more cost effective, and timely efficient.

AIM providers are also working closely with their clients (operators) to maintain lasting relationships because this is what can make their companies viable. It can be observed that because of different factors mentioned in this report such as innovation cost, business growth potential, organizational capacity and technological capacity, AIM companies set their priorities before involving in innovative projects that would benefit their clients.

Some of these companies want to innovate but also factors such as lack of experienced personnel, financial constraints and regulatory restrictions and also client not willing to participate in the innovative projects makes it a daunting task for them to innovate.

7. CHAPTER SEVEN

DISCUSSIONS, OBSERVATIONS & RECOMMENDATIONS

Figure 7.1: Discussion (uwf.edu)

7.1 Objectives/Scope of Analysis

The scope of this of the analysis was to get an overview of the AIM products and services which are currently offered on the NCS. This was taken from the AIM service providers' side of view. The reasons why these companies provide these deliverables were also investigated and what makes them continuously competitive. For the companies that were examined, the challenges they face in driving innovations were also looked into.

7.2 Findings/ Observations

Based on the information gathered on during the field work, the following findings were discovered. Some of these findings seem interesting because it deviates from the normal or ideal expectations. Some of the findings are;

Irrespective of market demands, management policy and strategies towards innovative products & services was seen as a significant factor that drives innovation. Also it was observed that most operator companies usually don't drive or embrace innovation as expected or anticipated except there is a change in management, a catastrophic incident or a new government regulation which leaves them with no choice other than to drive new innovations or embrace existing innovative concepts. It was said by one of the senior staffs at an operator company that operates on the NCS that

"Most times the company is usually contented with their profit especially when production is stable and there is no threat from the regulatory authorities and the government"

This can be said that because of the nature of their profit which is also the aim of the business, they also become stagnant in their demand for more innovative products. Also at the SPE conference held at Houston in February 2013, it was said by the Chief Technology Officer of a multinational O&G company that

"The Oil and gas industry is one of the least innovative industries in the world in comparison to other industries such as the aviation industry, medical industry, communication industry etc. ".

The leap in technological advancement in the O&G industry is quite little despite the fact that the industries he mentioned too can be categorized as high risk industries. These O&G companies most of the time don't have rivals in terms of profits and that also tends to make them rest on their oars. Also having consistently abundant funds make operator companies to continue to pay exorbitant prices for product and services that they're familiar with rather than embrace new or innovative concepts that would be cost effective and efficient.

On the side of the AIM service providers, there were also some trends that were also noticed. Although it is logical for customer demand to drive innovation, some service companies drive innovation themselves without customer demand. This was noticed by one of the major service providers on the NCS. The company representative during the interview categorically said that their company is *"technologically driven"*. For this company, their belief is that these innovative solutions could be made ready and then they would make their client see the need to having these products or solutions. Also it was noticed that other less competitive companies don't see technological capacity has a challenge. This normally is supposed to be a point of concern for them but they consider collaboration and buying technology as a very viable option for them. This is because they don't see themselves as "technologically focused" but "customer demand focused". Also it was noticed that some service providers aim at using unplanned process to create revolutionary products which is not usually a norm for most service companies. Most services companies use a structured process to incrementally (evolution) develop their products. Organizational capacity also is a major challenge towards creating innovative solutions in for the service providers. The Norwegian O&G industry has lower number of human competencies than most O&G industries in the world this tend to also effect the provision of people with specialized skill too.

Innovation Gap

From the study, it can be said that the major gap that the Norwegian O&G industry is experiencing from reaching the level of innovation that is anticipated is *knowledge*. This gap could be bridged through human competencies. This factor is a major challenge in Norway because the industry does not have enough hands to run. This in turn has become a challenge for both operators and AIM providers but the AIM providers feel the impact most. Also the capability of the human competencies mentioned should not involve engineering ability only but information technology capabilities. The treasure in the future for proper innovation of work processes would include adequate or sufficient data and the human competencies of the future must have the capacity to assess and work with these data to produce insightful decisions and solutions.

Also *management strategies and organizational policies* is a gap that needs to be filled. Most leaders have never learned how to be innovative and how to lead an organization so that it becomes more innovative. They may understand that they have a key role in innovation, but they do not know how to systematically generate new and better solutions. They also do not know how to reinforce the right innovative skills for their direct reports and teams. Therefore people who have a proper grasp of innovation should be made to lead and make policies and decisions that would drive innovation in the organization.

7.3 Suggested Solutions

From the gaps identified during this study, the following suggestions solutions were prescribed:

1. Operators should be open to technological advancements like other industries such as the aviation, medical, telecommunication etc. but precautionary principles should be implemented when adopting the new technological processes. The precautionary principle states that *"if the consequences of an activity could be serious and subject to scientific uncertainties, then precautionary measures should be taken or the activity should not be carried out at all"* (Aven, 2007). The key aspect in this is that if there is a lack of scientific certainty what will become the consequences of the activity?, then actions are required.
2. Knowing well that the innovation gap in the Norwegian O&G industry is knowledge and proper access to information for effective decisions and insights, the level of partnership between IT and Engineering function on the NCS should be improved.
3. Many organizations inadvertently discourage innovation through their organizational practices (e.g. planning, budgeting, rewards). In addition, many organizations have cultures that drive short-term results and risk avoidance. Without changing some organizational practices and building a culture of innovation, leaders will not close the innovation gap. Therefore it is important that organizations implement practices and cultures that reinforce innovation.
4. The need for all employees to use their intellectual potential should be encouraged. This is because the nature of work is constantly changing and presenting complex challenges at every level of organizations. In this new economy, better solutions can only come from new ways of thinking— innovative thinking—not from conventional linear analytical thinking alone.
5. Since it is noticed that government and regulations are the major factors of what drives innovation on the side of operators, it is suggested that these points should be taken as an advantage. This is therefore suggested that government should create and implement policies that would drive innovation in the directions that they desire and also continue to review these policies to further initiate the drive for more innovation.
6. Also government should assist in improving human capital competencies in the industry through the following;
    - Providing of more competence training centers such are universities, research organizations, technical institutions etc.
    - Support research & development,
    - Protect intellectual rights.
    - Create, implement and support good labor laws
7. On the side of the AIM providers, government should support them financially so that they can initiate innovative projects in anticipation for prospective clients.

7.4 Challenges Encountered during Study/Research

Due to the limited scale of this survey, generalizations were made in order to arrive at more deductive but reasonable conclusions. Consequently, a broader and much detailed investigation may be required in order to verify these results and establish the status of AIM and innovative trends on the NCS. Also during the execution of the survey, some challenges were encountered the area of data collection for analysis. From the many companies selected to be interviewed, there were little or no response or no response from these selected companies. It was assumed that the likely reasons for the actual response level were;

- Some of the companies contacted were not willing to talk about this issue because they think it would expose their area of strength or weakness. Therefore they gave no response.
- In some companies the appropriate personnel to conduct the interview with was very busy and couldn't find out time to have an interview.
- Also it could be said that the interviewee might not have given the facts but just what he/she thinks their company innovation trends is supposed to be.

8. CHAPTER EIGHT

CONCLUSION

Figure 8.1: Conclusion (wordle.com)

8.1 Final Remarks

Proper Asset Integrity Management would always benefit all stakeholders in the O&G industry. For operators, AIM products & services would improve safety, save cost and optimize production. When AIM Contractors provide innovative products & services to their clients (operators) this would foster good relationships with their clients and external stakeholders would enjoy HSE benefits. Therefore AIM Innovations in the Norwegian O&G industry must always be looked into for effective and efficient implementation of asset integrity in the industry.

The Norwegian O&G Industry has improved in their petroleum related activities over the years but more could still be done to improve and break down innovation barriers preventing the industry from moving into the next phase of development.

8.2 Area for Further Study

This study sought to investigate the current status and future trends of AIM on the NCS especially in the area of safety & maintenance. During this study, some points were noted which could be further looked into. These areas of study were as a result of some of the challenges related to innovation in the Norwegian O&G industry which include;

- **Man-Technology-Organizational (MTO) Issues**
  Innovation is one aspect of the whole big picture but another aspect that needs to be looked into is the area of how to properly integrate human organizations and technology in a technically dynamic world. If this industry is going to have to embrace innovation how would the element of organization and humans react to it? And what can be the remedies to these solutions.

- **AIM Solutions for Operators within NCS**
  This is having to look closely into the O&G industry, their work processes then identify the gaps and fill then with innovative solutions that are practical i.e. solutions that can be implemented.

- **AIM Innovation Barriers: Causes and remedies**
  This involves the study of innovation barriers, having a comprehensive view of their causes and then suggesting solutions to tackles these barriers.

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APPENDICES

1. Survey Questionnaire
2. Map of the Norwegian Continental Shelf (NCS).
3. AIM Innovative Solutions
4. AIM Case Study Examples

APPENDIX 1

QUESTIONNAIRE

This questionnaire was developed to get relevant information in relation to my thesis which is titled**: Products and Services within Asset Integrity Management: Current Status and Innovative Trends.**

Scope: The scope of this questionnaire is to identify the products and services offered by your company and also assess the innovation trends of the products and services.

<u>CONFIDENTIALITY:</u> The information that is given would be kept anonymous and results would be used for research purposes only no affiliations.

PART 1: Company

Your name:____

Telephone number:

____

E-mail: ____

What is role of your company in the Norwegian Oil and Gas Sector?

____

____

PART 2: Products and Services

Please select the types of Asset Integrity Management SERVICES your organization offer within Maintenance, Modification and Operation (MMO)?

	Services	**Select**
1	Maintenance Analysis and Engineering (RCM, FMECA, etc.)	
2	PM/Procedures/Strategies/ Routines etc.	
3	Barrier Assessment and Management	
4	Consequence classification of equipment (Criticality Analysis)	
5	Risk Assessment (SIL, RBI, etc.)	
6	Safety and Emergency Response	
7	Operations Documentation	
8	Training Services	
9	Spare Parts Management	
10	Inspection and Monitoring	
11	Data Interpretation	
12	Remote Operations and Process Support	

Please specify any other SERVICES not mentioned

____

____

Does your company offer any Asset Integrity Management PRODUCTS to its clients?

Yes No

Please indicate the types of Asset Integrity Management PRODUCTS your organization offer to its clients?

	Products	Select
1	Data Management Softwares	
2	Visualization and 3D modeling softwares	
3	Technical Analysis Softwares/tools	
4	Maintenance inspection tools and equipment	
5	RFID devices and Tags	
6	ROV/Remote Operated Devices and Tools	
7	Detectors and Analyzers	
8	Safety and Protection Equipment	
9	Condition Monitoring Equipment and Systems	
10	Simulator/Simulator systems	
11	Handheld Inspection and Monitoring devices	

Please specify any other PRODUCTS not mentioned

____

____

Which of the services your organization provides in terms of AIM are needed most by your clients? (select relevant and grade on a scale of 5)

	Services	1	2	3	4	5
1	Maintenance Analysis and Engineering (RCM, FMECA, etc.)					
2	PM/Procedures/Strategies/ Routines etc.					
3	Barrier Assessment and Management					
4	Consequence classification of equipment					
5	Risk Assessment (SIL, RBI, etc.)					
6	Safety and Emergency Response					
7	Operations Documentation					
8	Training Services					
9	Spare Parts Management					
10	Inspection and Monitoring					
11	Data Interpretation					
12	Remote Operations and Process Support					

Please specify any other not mentioned

____

____

PART 3: Product and Service Innovation trends

Have your company developed any new SERVICE focusing on AIM within MMO in the last 5 years?

Yes No

If yes in what area?

____

____

Have your company developed any new PRODUCT focusing on AIM for MMO in the last 5 years?

Yes No

If yes in what are these products?

____

____

Are there any ongoing projects focusing on developing new Products & Services for AIM within MMO?

Yes No

If yes how many projects are ongoing in your organization at the moment related to the development of new products and services? (Mention number in terms of product and services related projects)

____

____

What process do the new product(s) and service(s) emerge from, in your organization?

(Select all relevant)

	Innovation Process	**Select**
1	A planned process (Deliberate Process with a structured plan)	
2	Ad hoc (Unplanned) process	
3	Incremental development (Improvement on existing products and services)	
4	Revolutionary New technological products(Entirely new way of due to other revolutionary products such as ICT etc.)	

What were the major DRIVERS of innovation for the products & services developed in your company in the last 5 years? (Select all relevant)

	Drivers of Innovation	**1**	**2**	**3**	**4**	**5**
1	Market Demand					
2	Similar services in the market/competition					
3	New and cost effective technological solutions (R&D)					
4	Government Regulations					
5	Client Specification and preferences					
6	Employee initiative and feedback					

Other? Please specify

____

____

What are the major DRIVERS of innovation for products & services that your company is currently developing? (Select all relevant)

	Drivers of Innovation	**1**	**2**	**3**	**4**	**5**
1	Market Demand					
2	Similar services in the market					
3	New and cost effective technological solutions (R&D)					
4	Government Regulations					
5	Client Specification and preferences					
6	Employee initiative and feedback					

Other? Please specify

____

____

Please indicate the importance of the following factors your company considers when assessing the feasibility of creating a new product or service (Select all relevant)

	Factors	**1**	**2**	**3**	**4**	**5**
1	Innovation cost (Investment cost)					
2	Business Growth Potential					
3	Organizational Capacity (People, Competencies etc.)					
4	Technological Capacity					
5	Management policy/Strategies towards new products & Services					

Other? Please specify

____

____

Please indicate the major barriers/Challenges in establishing a new service or products in your company (Select all relevant)

	Barriers	**1**	**2**	**3**	**4**	**5**
1	Financial Constraints (Budget, ROI etc.)					
2	Lack of Skilled Personnel (Competencies)					
3	Complexity of available technological solution					
4	Regulatory Restrictions					
5	Local market is too small					
6	Customer are too conservative to buy into new product and services					

Other? Please Specify

____

Thank you for your participation in the survey.

(Adopted from Panesar, 2007)

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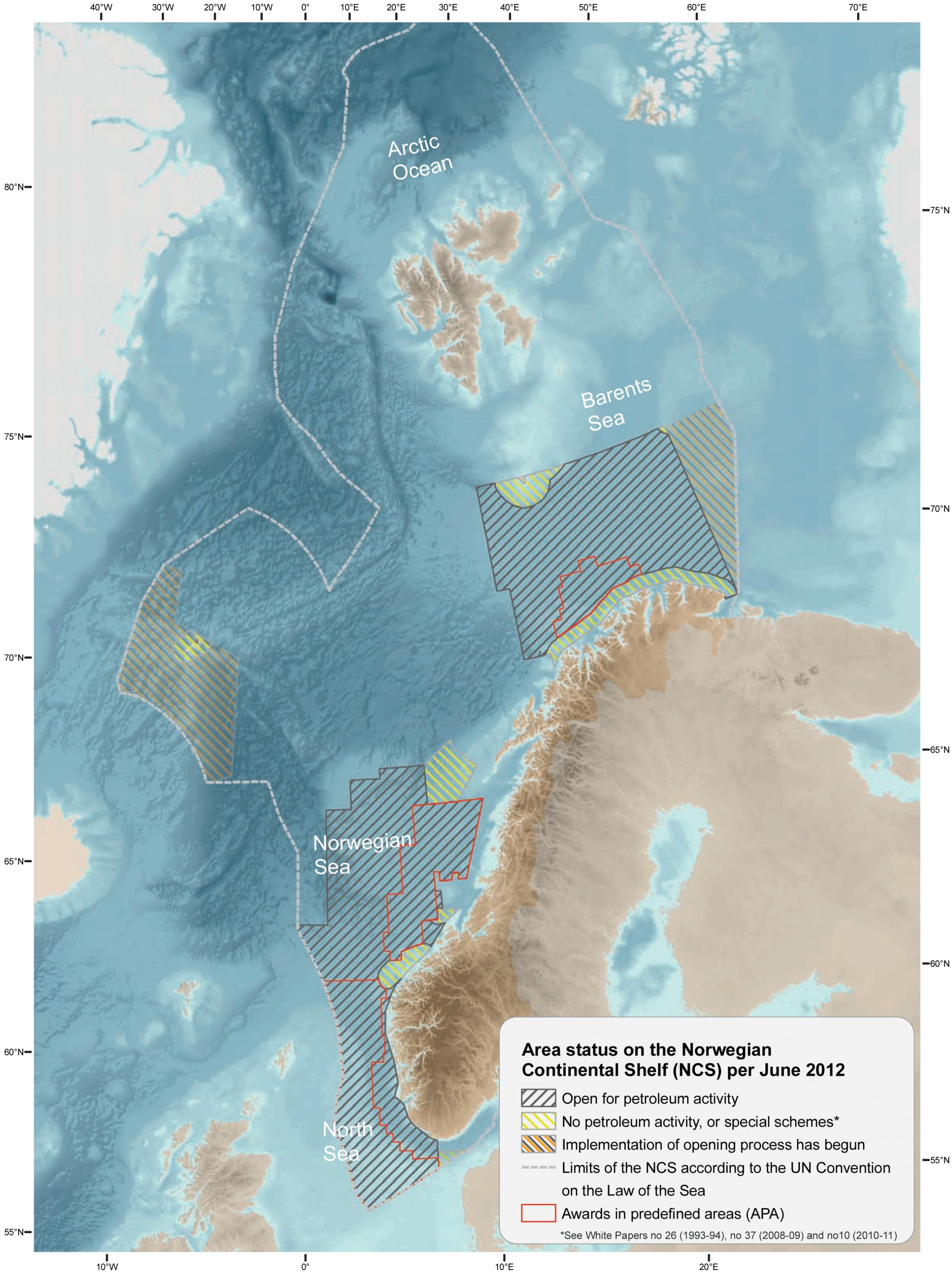
APPENDIX 2

THE NORWEGIAN CONTINENTAL SHELF



ETOPO2v2 Global Gridded 2-minute Database, National Geophysical Data Center, http://www.ngdc.noaa.gov/mgg/global/etopo2.html.