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Abstract

An assessment of Continuous Classification programs of some drilling/production companies was performed using two case studies: Drilling rigs and Floating Production Units (FPUs). Similar assessment was also carried out on one of the biggest Classification Society operating in the NCS in order to gain further insights into the current classing practices of these oil and gas companies with respect to the regulatory requirements of the Society. All assessments were done through questionnaires.

The results obtained from interviews conducted indicate that among other things, standing offshore units are mostly required to go to dry-docks for renewal surveys every five years whereas, this is not the case for ship-shaped units. Robustness in stability, buoyancy and fatigue redundancy offered by the hull of the latter compared to the former is observed to be the reason for this. Also, drilling equipment appears to be one of the most challenging IMR activity for drilling rigs, while for FPUs, cargo tank surveys are the most challenging activities.

The prospects of exploring and deploying new inspection and maintenance technologies were also looked at and the use of UAVs, AUVs and Condition monitoring were the most prominent technologies being considered and implemented among the different companies.

Finally, a digital class application is proposed to assist in planning and managing continuous classing activities.

Acknowledgement

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May God bless you all, Amen.

List of Abbreviations

ABS – American Bureau of Shipping

AIMS – Asset Integrity Management Systems

CMMS – Computerised Maintenance Management System

CS – Classification Societies

DNV GL – Det Norske Veritas Germanischer Lloyd

IACS – International Association of Classification Societies

IMO – International Maritime Authority

IMR – Inspection, Maintenance and Repairs

NCS – Norwegian Continental Shelf

NDT – Non-Destructive Testing

PSA – Petroleum Safety Authority

SOLAS - Safety Of Life At Sea

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1. CHAPTER ONE

INTRODUCTION

1.1 Background

The subject of Classification of assets in the marine and offshore sector is one that has evolved over the years so much that Classification Societies (CS) have become an integral part of the industry; working closely with major players right from the concept and design phases of an offshore asset to actual construction, down to installation phase, operation and maintenance, and finally the decommissioning phase.

Fig 1.1: An Offshore Floating Production Storage Offloading (FPSO) Installation

According to (Alford & Potthurst, 1995), Classification which is concerned with the integrity and safety of marine structures, is a form of regulation based on compliance with a Society's own rules.

Certification refers to the confirmation that offshore installations satisfy the regulations imposed by the national administration on whose territorial waters they will operate. CS can provide classification rules and standards acceptable to insurers and government authorities where there are no national requirements (Alford & Potthurst, 1995).

So basically, Classification Societies establish and maintain technical standards with which ships and offshore installations are built and operated. These standards are established by the CS' Technical Committees whose members (including naval architects, marine engineers, material manufacturers, fabrication companies, ship owners, operators, underwriters, and as well government agencies) come directly from the marine industry and they represent the industry. More like a case of industry setting its own standards and administering them impartially by an organization of which many of them are a part of (Hannan & Scherwin, 1978).

Thus, a ship or platform owner builds a vessel according to the rules of a CS with an assurance that it meets a recognized standard; that the plans have been approved by the technical staff, that the steel and other materials used for construction have been tested in accordance with the rules, and that the vessel, its machinery and equipment have been surveyed during construction as contained in the rules. After completed marine vessels are put to use, CS regularly survey them throughout their useful life by subjecting them to periodic and damage surveys to ensure that the vessels are in satisfactory condition as required by the rules, following which a renewed classification certificate is issued (Hannan & Scherwin, 1978). This is what is referred to as Continuous Classification or Class Entry or Class Maintenance.

Classification certificates are required for owners of marine vessels to be able to register and insure their vessels and may be required for them to gain entry into some waterways and ports. It is also required by interested ship buyers and hirers who may want to ascertain the condition of the ships. However, a class certificate should not be construed as a warranty of safety, fitness for purpose or seaworthiness of the ship. A classification certificate stands as an attestation only that a vessel has been developed and surveyed according to the rules and standards published by the Society issuing the certificate (International Association of Classification Societies IACS, 2011).

According to (Hannan & Scherwin, 1978), CS traditionally have confined their survey roles to structural adequacy and stability of the vessel's hull, machinery installations and anchoring or mooring system; and have not concerned themselves with service equipment unless requested to do so.

It is important to state that Classification Societies are neither government agencies nor substitutes for government regulatory authorities. They are independent international organizations set up not as profitable businesses, but as industry regulators.

1.2 Aim of Thesis

The goal of the thesis is to explore and validate how a suitable classification strategy can improve class survey methods and class asset planning.

1.3 Scope of Study

This study covers Continuous Classification activities in the Norwegian Continental Shelf (NCS). It looks at the requirements, rules, standards, regulations and current practices for offshore vessels operating in this environment as well as retaining class through periodic surveys and continuous maintenance programs as stated in the CS guidelines.

Then the focus shifts to possible innovations by way of new technologies that can provide Continuous Classification improvements for concerned companies.

1.4 Methodology

An individual assessment of Classification activities of selected offshore installations operating in the Norwegian oil industry is done on two types of marine assets as case studies – Drilling rigs and Floating production/storage units.

A questionnaire was made for both units with inputs from my industrial supervisor who helped revise and refine my questions until the final version was arrived at. Also, another questionnaire was prepared for a Classification Society. This was designed to provide more insight into statutory classification requirements and activities from the perspective of the Classification Society.

Afterwards, interviews were arranged with experts in Oil & Gas Producing companies, Drilling companies and a Classification Society to discuss existing practices and possible new technologies that can be deployed to enhance continuous classing programs.

Due to the very busy schedules and distant locations of some of the experts that were consulted, the interviews were conducted through various means, depending on which was most suitable for each interviewee. Some interviews were done via telephone calls, and some through Skype and

face-to-face meetings at their company's premises, with each meeting lasting for between 30 minutes to 1 hour.

1.5 Limitation of Thesis

Several limitations were encountered while working on this thesis. One outstanding one was the difficulty in getting access to a higher number of industry experts to interview. Many of the experts that were reached out to through various means said that they were very busy while some did not respond at all. Being able to get more interviewees would have increased the depth and diversity of information gathered about classing practices of several more companies.

2. CHAPTER TWO

LITERATURE REVIEW

2.1 Origin of Classification Societies

The idea behind the need for Classification and Certification of marine assets first arose in the second half of the 18th century when marine insurers based in Lloyd's coffee house in London developed a system for an independent technical assessment of ships presented to them for insurance cover. In the year 1760, the first informal CS known as Register Society was formed in the UK to publish an annual register of the condition of ships (International Association of Classification Societies IACS, 2011).

Fig 2.1: A typical 1800s ship (Thinglink, 2016)

About six decades later, formal Class Societies were established starting with Bureau Veritas, which was founded in Antwerp in 1828 and moved to Paris in 1832. Register Society subsequently became a self-standing CS known as Lloyd's Register in 1834; RINA previously Registro Italiano Navale was founded in 1861; American Bureau of Shipping (ABS) dates back to 1862; Det Norske Veritas (DNV) was established in 1864; Germanishcer Lloyd (GL) in 1867; and Nippon Kaiji Kyokai (ClassNK) in 1899 (Benyessaad, Barras, & Rocha, 2017).

By the 20th century, a few more CS were founded including Russian Maritime Register of Shipping in 1913; Polish Register of Shipping in 1936; Croatian Register of Shipping (CRS) founded as Yugoslavia Register of Shipping in 1949; China Classification Society (CCS) in 1956; Korean Register of Shipping (KR) in 1960; and Indian Register of Shipping (IRS) in 1975 (International Association of Classification Societies IACS, 2011).

2.2 International Association of Classification Societies

The International Association of Classification Societies (ICAS) is a technical non-government organization which currently consists of twelve-member Societies. It was founded in 1968 by seven leading CS.

The creation of ICAS dates back to the International Load Line Convention in 1930 and its recommendations, among which was *the collaboration between Classification Societies to secure as much uniformity as possible in the application of standards.* Following this convention, RINA hosted the first conference of major CS in 1939 with LR, BV, ABS, DNV, GL and ClassNK in attendance, where an agreement on further cooperation was reached.

A second major conference held in 1955 which led to the creation of "working parties" on specific topics and ultimately led to the formation of ICAS; and within a short time, they realised the value of their combined level of technical knowledge and experience.

IACS whose headquarters is in the UK, is governed by a Council consisting of senior managers, one drawn from each Member of the organization. The Council "develops and implements actions giving effect to the policies, directions and long-term plans of the Council". Compliance with the IACS Quality System Certification Scheme (QSCS) is mandatory for IACS membership (International Association of Classification Societies IACS, 2011).

2.3 The Role of Asset Integrity in Classification

According to Bureau Veritas, Asset Integrity is the ability of an asset to perform its required function effectively and efficiently whilst safeguarding life and the environment.

Asset Integrity Management Systems (AIMS) ensure that the processes, systems and people who deliver integrity are in place and fit for purpose over the entire lifecycle of the asset.

The ultimate goal of AIMS is the delivery of business requirements of maximizing return on assets while maintaining stakeholder values and minimizing business risks associated with accidents and loss of production (Bureau Veritas, 2019)

In specific reference to offshore platforms, asset integrity management demands; that systems are put in place to regularly look out for defects in structural members which provide platform stability on the sea, that safety processes are strictly followed to ensure that all fluids stay in specific pipelines and pressure vessels at required thermodynamic conditions to prevent fluid leakage, that safe on-board and marine operations are strictly adhered to prevent accidents such as fires or collision from supporting vessels.

Imagine a gas leak occurs due to failure in asset containment, and an ignition source is present due to failure in assessing operational risks. This could result into a fire and consequently an explosion causing damage not just to the asset, but to personnel and the environment. Thus, AIM incorporates all aspects of asset safety management including Risk and Reliability management, Operation and Maintenance management, Technical and Process Safety management, Human Performance management, etc. with the sole purpose of reducing or possibly eliminating losses.

Fig 2.2: Deepwater Horizon/Macondo Incident in the Gulf of Mexico (Slate, 2016)

The key benefits of AIMS are:

- It delivers improvement in reliability
- It delivers improvement in safety
- Optimisation of inspection and maintenance activities to meet safety and business targets

(Bureau Veritas, 2019).

As mentioned earlier, the Classification concept consists of the development and establishment of rules and standards with regards to design, construction and survey of offshore units (DNV GL, 2017). Classification Societies ensure compliance with established rules and standards and these Societies for decades have gathered so much knowledge in the offshore oil and gas industry that they have an in-depth understanding of the technical and regulatory challenges related to offshore developments.

By publishing continuously improved design codes, rules and standards for offshore units derived from lessons learnt and experience gained over the years, CS have contributed greatly in enhancing operational safety and reliability of offshore installations, and significantly add value to the entire asset integrity management phases of marine assets till the end of their economic life (Benyessaad et al., 2017).

3. CHAPTER THREE

CLASSIFICATION ACTIVITIES IN THE NCS

3.1 The Norwegian Continental Shelf

The Norwegian Continental Shelf (NCS) is the portion of sea and seabed around the shores of Norway which it has full rights to exploit the resources in the area according to the United Nations Convention on the Law of the Sea.

The NCS is very rich in natural resources, particularly oil and gas, and the Norwegian Petroleum Directorate (NPD) is the government agency responsible for regulating and managing the petroleum resources on the NCS (Norwegain Petroleum Directorate NPD, 2019)

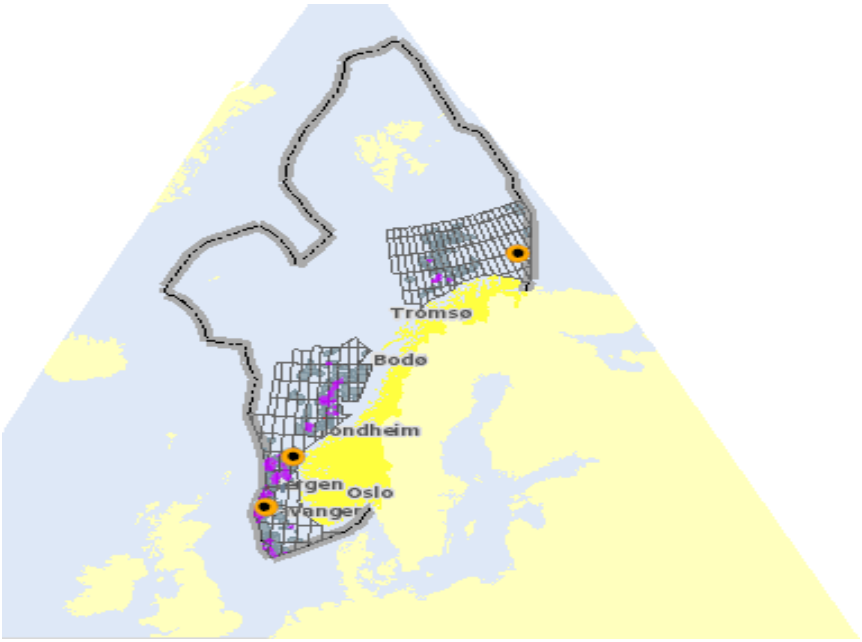

Fig 3.1: Map of the NCS (Norwegian Petroleum Directorate NPD)

The discovery of gas in Groningen in the Netherlands in 1959 caused some enthusiastic attention to be paid to the North Sea for oil and gas exploitation. In October 1962, Phillips Petroleum requested from the Norwegian authorities for an exploration licence in the Norwegian part of the North Sea. The Norwegian government proclaimed sovereignty over the NCS in May 1963 and

agreements on dividing the continental shelf primarily with Great Britain and Denmark in accordance with the median line principle were reached in March 1965.

The first licensing round was announced in April 1965 in which 22 production licences for a total of 78 oil blocks were awarded to oil companies for exclusive exploration, drilling and production rights in the licence area. The first exploratory well was drilled in 1966, but it was dry.

Fig 3.2: Ekofisk Field (Norway Exports, 2012)

It was not until December 1969 before the first discovery was made at Ekofisk field. This was termed "a great Christmas gift" for Norway. Production commenced at the field in June 1971, and a number of major discoveries were made in the following years (Norwegian Ministry Of Petroleum And Energy, 2013)

3.2 General Classification Scope and Process

The (International Association of Classification Societies IACS, 2011) scope of classification for a Newbuild consists of:

- A technical review of the design plans and related documents for a new vessel to verify compliance with applicable Rules.

- Attendance at the construction of the vessel in the shipyard by a CS' surveyor(s) to verify that the vessel is constructed in accordance with the approved design plans and classification Rules.
- Attendance by a CS surveyor(s) at the relevant production facilities that provide key components such as steel, castings, engines, generators, etc. to verify that the components conform to the applicable Rules.
- Attendance by a CS surveyor(s) at the sea trials relating to the vessel and its equipment prior to delivery to verify conformance with the applicable Rules.
- Upon satisfactory completion of the above, the builder or shipowner requests for the issuance of a class certificate by the relevant CS, which if deemed satisfactory, the assignment of class may be approved, and a Classification Certificate issued.
- Once in service, the shipowner is required by the Rules to subject the vessel to a clearly specified programme of periodical class surveys to verify that the ship continues to meet the applicable Rules and Standards for Continuous Classification.

3.3 Continuous Classification Survey

The overall responsibility of the integrity, reliability and safety of every ship lies with the shipowner. Hence, once a vessel is in service it is the duty of the owner to ensure it is regularly surveyed and continuously classed as required by the Rules.

Fig 3.3: A vessel in a Dry Dock for Classification Survey (GMC Maritime)

For Classification Societies, their main role is to ensure that offshore vessels comply with pre-defined set of rules, standards or specifications. As a custodian of offshore platforms' safety, they are a huge knowledge base in the oil and gas industry and are regularly consulted on technical & economic questions.

The effectiveness of classification significantly depends on the cooperation of the shipbuilder during construction, and the shipowner during usage. It is expected that shipowners or operators are open and transparent about disclosing information regarding the current state of their ships, particularly any damage or deterioration that may affect or influence the decision or judgement of the CS for the purpose of continuous classification.

Information may be made available by submitting documents to the Society or by requesting Surveys to be performed by the Society either at the Customer's premises, onboard the Unit or at the premises of the Customer's sub-contractors (DNV GL, 2017).

3.4 Norwegian Maritime Authority

The International Maritime Organization's (IMO) international convention on Safety of Life at Sea (SOLAS) obliges flag states to ensure that ships operating in its waters meet the appropriate safety requirements. Flag states are responsible for ensuring that ships under their flag comply with its requirements, and several certificates are prescribed in the SOLAS Convention as proof that this has been done (International Maritime Organization IMO, 2019).

The Norwegian Maritime Authority is the agency of government which among other responsibilities, oversees inspections of ships operating in the Norwegian maritime environment. Inspections and supervisions may however be delegated to the recognized Classification Societies. The following 6 Classification Societies are authorized to carry out surveys and inspections and issue statutory certificates as applicable on behalf of the Norwegian administration:

- American Bureau of Shipping – ABS
- Bureau Veritas – BV
- DNV GL
- Lloyds Register of Shipping - LR
- RINA
- Nippon Kaiji Kyokai – ClassNK

(Norwegian Maritime Authority, 2012)

3.5 Classification Society in Focus

In this section, I will be highlighting the classification practices of the biggest Society operating in the Norwegian Continental Shelf – DNV GL.

3.5.1 About DNV GL

DNV was established in Norway in 1864, while GL was founded three years after in 1867. The official merger of DNV and GL to form DNV GL took place in September, 2013.

As a Classification Society, DNV GL among other activities, develops and maintains an In-service Inspection Program (IIP) which contains items to be surveyed and constitutes the formal basis for surveys to be completed for both newbuild and existing marine assets before class certificates can be issued.

A specific program for continuous and renewal surveys must be worked out by the owner in cooperation with the Society in advance of the survey (DNV GL, 2019)

3.5.1.1 DNV GL Scope of Classification

DNV GL rules with reference standards give Main Class requirements in the following areas:

1.) Hull and Main Structures

The considerations in hull and main structure surveys are:

- Strength
- Watertight and weathertight integrity
- Stability and floatability
- Materials and welding
- Tank arrangement
- Corrosion protection
- Constructional fire protection

This survey consists usually of visual examination, measurements and testing as required for different survey categories with the aim of ensuring that the hull structure, hull equipment and piping are in satisfactory condition with respect to corrosion, deformation, fractures, damage or other structural deterioration.

A survey planning meeting will normally be held prior to the commencement of any intermediate and renewal surveys between the attending surveyor(s), the vessel owner's representative in attendance and the Non-Destructive Testing (NDT) company representative, where involved.
The surveyor may require thickness measurements in any portion of the structure where signs of wastage are evident or in areas where wastage is normally found. Where substantial corrosion, as defined by the Rules is found, additional thickness measurements shall be taken to confirm the extent of substantial corrosion.
Also, the condition of protective coating of cargo and ballast tanks shall be examined and shall be rated as GOOD, FAIR or POOR (DNV GL, 2017).

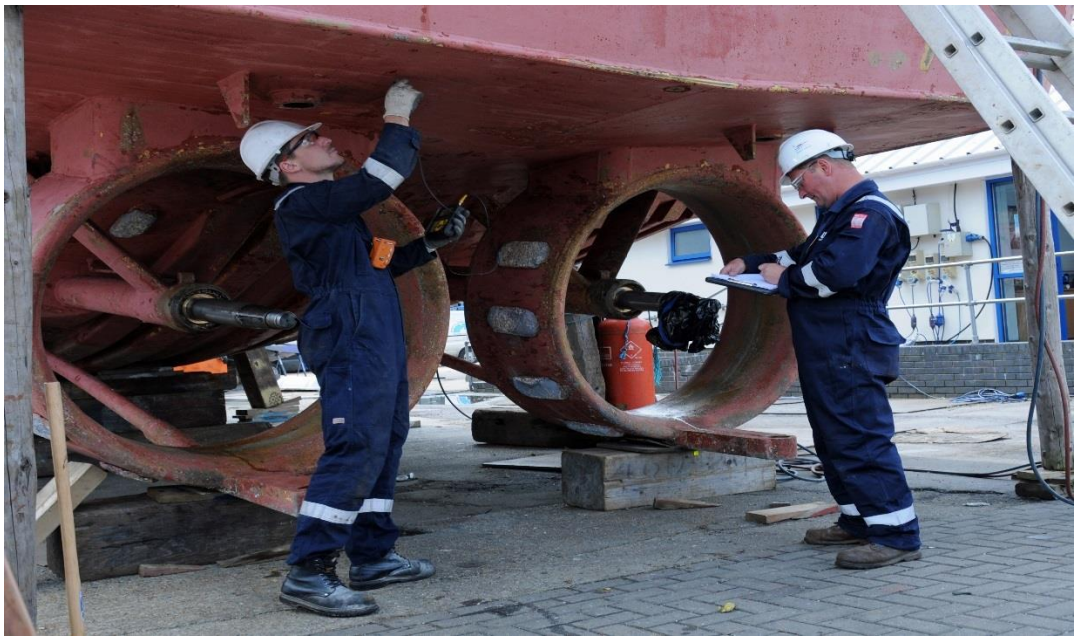

Fig 3.4: Inspectors performing NDT on a Vessel's Hull (Ultramag, 2019)

2.) Marine and Machinery Installations and Equipment

This covers systems such as:

- Position keeping or mooring system
- Propulsion and steering (if applicable)
- Ballasting
- Emergency shutdown systems
- Fire and gas detection, fire protection and extinguisher

- Drainage and bilge pumping
- Jacking system (as applicable)
- Power generation
- Other machinery installations stated in the rules.

In preparation for this survey and to allow for a thorough examination, machinery components and related spaces shall be cleaned, and this includes removal of loose accumulated corrosion scale, mud and oil residues from surfaces.

If significant repairs are carried out to main or auxiliary machinery, a dock and/or sea trial shall be carried out as required by the attending surveyor.

For propulsion systems where shaft alignment calculations are required, the alignment shall be confirmed by suitable measurements if the system has been dismantled and/or when external forces such as welding work may have influenced the alignment. The measurements shall be carried out with the ship afloat and shall be presented to the attending surveyor.

As an alternative to dismantling and opening up for inspection, measurements may be carried on certain components such as vibration dampers, elastic couplings and speed governor through hand devices (DNV GL, 2017).

3.5.1.2 DNV GL Scope of Surveys

The objective of a survey is to ascertain that the vessel, its hull structures, machinery, systems and equipment are all in compliance with established rules; and are suitable for continued safe and reliable operation. It is advised that operational survey and inspection aspects of all offshore installations are taken into consideration and planned for at the design and construction stages.

A survey may consist of a combination of audits, visual inspections, measurement, functional testing, non-destructive testing, review of inspection, maintenance and other relevant records.

Surveys may be carried out on location based on approved procedures outlined in a maintenance program and survey arrangement, without interrupting the function of the unit or installation. Parts of the periodical surveys may be carried out by companies approved by the Society (DNVGL, 2014).

Periodic surveys are catgorised as follows according to the level of survey requirements:

- ❖ Annual Survey
- ❖ Intermediate Survey
- ❖ Complete Survey
- ❖ Renewal Survey – survey required in conjunction with the issuance of a new class certificate.

The minimum extents of surveys required are prescribed for each periodical survey and are published in theRules for Classification of Offshore Drilling and Support Units, DNV-OSS-101 (DNVGL, 2014).

Periodic Survey Schedules

1.) Annual Survey

- The due date is generally 1 year of class assignment or the expiry of the previous class assignment if different.
- The Survey is normally carried out withing a time window of 3 months on either side of the due date.
- Annual Surveys are carried out each year, also those years where an intermediate, complete or renewal survey is carried out. Survey requirements applicable for annual surveys are therefore not repeated for corresponding intermediate, complete or renewal surveys.

2.) Intermediate Survey

- The due date for Intermediate surveys is generally 2.5 years or the expiry of the previous class certificate.
- The Survey is normally carried out within a time window of 9 months on either side of the due date.
- The same surveys or thickness measurements for tanks or spaces cannot be credited towards both intermediate and renewal surveys. Units that re-commissioned after being laid-up may be specially considered.

3.) Complete Survey

- The due date for this survey corresponds to 2.5 years, 5 years or 15 years interval.
- The Survey is normally carried out within a time window of 9 months before or 6 months after the due date.
- Survey required to be concurrent with the renewal survey shall be completed at no later than at the completion of the renewal survey.

4.) Renewal Survey

- The due date for renewal survey is set at 5 years interval and corresponds to the expiry date of the classification certificate.

Fig 3.5: Five year class renewal survey for Drilling rig (MESON Group)

- The Survey is normally carried out withing a time window of 3 months before the due date. Also, the survey may be commenced at the fourth annual survey or between the fourth and fifth annual surveys.
- The renewal survey shall be completed concurrently with last main class annual survey.

The same surveys or thickness measurements for tanks or spaces cannot be credited towards both intermediate and renewal surveys. Units that re-commissioned after being laid-up may be specially considered (DNV GL, 2017).

3.5.1.2.1 DNV GL Optional Class Survey

The tables below gives the surveys required for units outside the main class. The Survey requirements for each unit can be found in Rules for Classification of Offshore Units - FPSOs, DNVGL-RU-OU-0102 (DNV GL, 2017).

Table 3.1: Survey types for optional class requirements (DNV GL, 2017).

Class notation	Description	Survey type	Conjuction with main class survey
CLEAN	Arrangements for controlling and limiting operational emissions and discharges	Annual	Annual
CRANE	On board crane	Annual	N/A
		Complete (5 years)	N/A
Diving system	Diving system	Annual	Annual
		Intermediate	Intermediate
		Complete (5 years)	Renewal
DPS	Dynamic positioning system	Annual	N/A
		Complete (5 years)	N/A
DRILL	Drilling plant	Annual	Annual
		Complete (5 years)	Renewal
E0	Periodically unattended machinery space	Annual	Annual
		Complete (5 years)	Renewal
ECO	Machinery centralised operation	Annual	Annual
		Complete	Renewal
F	Additional fire protection	Complete (2.5 years)	Intermediate and renewal
FMS	Facility methodolgy for ship-shaped units	Annual	Annual
		Complete (5 years)	Renewal
HELDK	Helicopter deck	Complete (5 years)	Renewal
HMON	Hull monitoring system	Annual	Renewal
ISDS	Integrated software dependent systems	Annual	Annual
		Complete	Renewal

LCS	Loading computer system	Annual	Annual
POSMOOR	Position mooring system	Annual	Annual
		Intermediate	Intermediate
		Complete (5 years)	Renewal
Recyclable	Inventory of hazardous materia Part 1	Complete (5 years)	Renewal
TEMPSTORE	Facility for temporary storage of oil	Complete (5 years)	Renewal
TMON	Tailshaft monitoring	Annual	Annual
VIBR	Vibration level limitation	Complete (5 years)	Renewal
WELL	Well intervention systems	Annual	Annual
		Complete (5 years)	Renewal
WELLTEST	Well testing plant	Annual	Annual
		Complete (5 years)	Renewal
Winterized	Operation in cold climate	Annual	Annual
		Complete	Renewal

Table 3.2: Optional class notations without survey requirements (DNVGL, 2014).

Class notation	**Description**
COMF	Requirements for noise, vibration and indoor climate
DAT	Design ambient air temperature suitable for regular service during winter to Arctic or Antarctic waters
ICE	Navigation in ice
OPP-F	Oil pollution prevention – fuel systems
PC	Polar Class – navigation in ice-infested polar water
Polar	Arctic ice rules

3.5.1.2.2 Postponement of Surveys

The Society may accept to postpone periodical surveys upon special consideration in each separate case, except for Annual and Intermediate surveys for main class that cannot be postponed.

Postponement of main class Renewal survey may be considered only in exceptional cases, and the period of postponement shall not exceed 3 months.

Postponement of the Renewal survey may be granted only through a written request from the installation owner and the request shall be received by the Society well in advance of the expiry date of the classification certificate (DNVGL, 2014).

3.5.1.2.3 Survey of Units Out of Commission

Units which have been out of commission or laid up for a period of about 12 months shall be subjected to a condition survey and tested before re-entering service.

The extent of surveys and tests require will be considered on a case by case basis depending on:

- The time the unit has been out of commission
- The maintenance and preservative measure taken during lay-up
- The extent of surveys carried out during the time the unit was out of commission

As a minimum, function testing shall be carried out on the unit to confirm its satisfactory operation before re-entering service. Provided the vessel's hull and machinery are found in all respects free from deterioration, subsequent periodical surveys will date from the time of the condition survey (DNVGL, 2014).

3.5.1.3 Assignment of Class – Newbuild

For a new or existing offshore installation to be classified, a request for Classification is submitted in writing by the customer. The Society reserved the right to decline a request for classification. Designers or Builders unfamiliar to the Society shall provide evidence to the Society of their capability to successfully manage Classification projects. It is also the responsibility of Designers or Builders of offshore installations to instruct their subcontractors and suppliers of materials, components and systems that the Society's rules apply and that standards must be met for the Society's certificates to be issued as required by the Rules.

Welding of important structures, machinery equipment and installations shall be performed by approved welders, with approved welding materials/consumables and at welding shops approved by the Society. These requirements for welding approvals are given in a detailed aproval programme in DNV-OS-C401.

The following documentation from the Designer/Builder and Subcontractors shall be submitted when requested by the Society:

- List of relevant subcontractors to the construction yard.
- List of manufacturer of machinery installations and equipment.
- Information related to the builder's procedures for managing materials that are excluded for use on board by class or statutory requirements.
- Information related to the builder's quality control and quality management system.

The Society may require additional document and as well carry out an assessment of the builder's yard processes, systems and personnel related to classification projects in order to assess compliance with the rules. The result of the assessment usually determines the extent of involvement of the Society's surveyors in the yard.

Calculations specified in the requirements shall be carried out by computer programs supplied by or recognised by the Society. Programs applied where reliable results have been demonstrated to the satisfaction of the Society are regarded as recognised programs. Generally valid approvals for computer programs are, however, not given by the Society (DNV GL, 2017).

3.5.1.4 Assignment of Class – Existing Units

For an existing unit or installation, classing surveys will be carried out depending on the age and type of unit before class can be assigned/maintained, and the scope of the surveys will be determined by the Society on a case by case basis.

The Survey requirements are contained in the Society's checklists of main class units or equipment to be surveyed for each type of periodic survey.

After the survey is perfomed, the Society issues a Class Certificate as proof of assignment of class. In some cases, class may be assigned with Conditions of Class. And the interim certificate will be replaced with a full-term class certificate when the Society confirms that all applicable requirements have been met.

The interim renewal class certificate is valid for 15 months as opposed to 5 years for class certificates for new and existing units. A class certificate issued by a different society is valid for 5 years from the date of class assignment or, if the Society accepts the periodical surveys credited by the previous classification society, until the expiry date of the class certificate issued by the previous classification society.
When a unit has been classed, its main particulars and details of the class assigned, as well as basic information such as flag administration, ownership, etc. will be entered into the Society's Register of Vessels which is available on the Society's online portal (DNV GL, 2017).

3.5.1.5 Special Provisions for Ageing Offshore Units

Offshore units with age exceeding their initial design life (usually 20 years in many cases) shall be subject to evaluation for special provisions to maintain the required safety level. These special provisions are related to fatigue and corrosion condition of the hull and supporting structure.

Fatigue Utilization Index

According to (DNV GL, 2017), the Fatigue Utilization Index (FUI) is defined as the ratio between the effective operational time and the initially documented fatigue life.

$$FUI = \frac{Effective\ Operational\ Time}{Initially\ Documented\ Fatigue\ Life}$$

For self-elevating and column-stabilised units, FUI shall be calculated when the actual age of the unit exceeds the documented fatigue life.

Calculation of effective operational time shall be based on the recorded operation history. For the purpose of calculating the FUI, the following may be assumed:

- contribution from operation in harsh environment, e.g. North Sea, North Atlantic and Canada, equals actual operating time in such environment
- contribution from operation in other environments equals one third (1/3) of actual operating time in such environments
- periods of lay-up and yard stay may be disregarded
- for self-elevating units; contribution from transit operation.

If fatigue cracks have been found in a unit prior to its FUI reaching 1.0, and the findings are located within fatigue sensitive areas of the unit, the owner shall assess structural details in these areas at latest prior to the renewal survey for the 5-year period. The owner shall submit FUI as part of the planning process prior to renewal survey.

Operation of the unit may continue when FUI > 1.0 provided:

- the required safety level of the vessel is maintained
- no fatigue cracks have been found in critical areas of the unit
- the inspection program is extended.

When the FUI > 1.0, the following measures will in general be taken:

- The Society will issue a MO (Memo to Owner) stating the actual FUI
- The installed leak detection system for column stabilized units shall be examined for leakage two times each month and shall be confirmed at each annual survey.

For a unit with FUI > 1.0 and where cracks have been detected in fatigue sensitive areas, the required safety level is in general satisfied either by increasing the inspection frequency or extending the existing inspection program. Previous cracks located in fatigue sensitive areas shall be subject to additional NDT at intermediate surveys corresponding to the extent of the NDT inspection required for the renewal surveys.

FUI calculations are not required for ship-shaped units as they have a more robust fatigue redundancy and are considered adequately covered by standard survey arrangements (DNVGL, 2014).

3.5.1.6 Maintenance for Class Retention

It is the responsibility of the owner or operator to ensure that the vessel, its hull structure, machinery, systems and equipment are properly maintained at all times.

The vessel shall have implemented a maintenance program which ensures that:

- Inspection and maintenance are carried out at defined intervals
- Any defect is reported with its possible cause, if known
- Appropriate repair action is taken
- Records of these activities are maintained.

As required by the rules, replacements for components or systems shall be delivered with certificates and documentations for the original component or system (DNV GL, 2017).

3.5.1.7 Suspension and Withdrawal of Class

The class will automatically be suspended with immediate effect if the renewal surveys for hull, machinery, systems and equipment related to main class are not completed before the expiry date of the class certificate, and no postponement has been granted; unless the vessel is under attendance for completion of the survey.

If the annual or intermediate surveys for main class are not completed within 3 months from the anniversary date of the class certificate, the class is automatically suspended with immediate effect, unless the vessel is under attendance for completion of the survey.

In addition, the Society may at any time suspend or withdraw a vessel's class where the conditions to retain class have been violated. If the vessel is deemed to be unable to continue safe and reliable operation, e.g. as a result of a major casualty, or if any outstanding debt owed to the Society is not paid within a notified date; the Society may suspend the vessel's class with immediate effect.

A vessel's class may be suspended with immediate effect in cases where:

- Repair of deficiencies has not been carried out or otherwise dealt with in an appropriate manner
- Repair of deficiencies has not been surveyed and accepted by the surveyor
- Other requirements imposed by the Society.

If a ship has been detained as a result of port state inspections twice in a two-year period and the deficiencies are found to be serious; the Society may decide to suspend or delete class.

When class is suspended or withdrawn the Society will:

- notify the customer in writing
- notify the flag administration
- make an entry to this effect in the Society's Register of Vessels
- make the information publicly available (DNV GL, 2017).

4. CHAPTER FOUR

CASE STUDIES:
DRILLING RIGS AND FLOATING UNITS.

4.1 Industrial Surveys

This section covers the industrial surveys that were carried out on current classification practices of existing offshore installations in the NCS.

The interviews were conducted for two drilling rigs – a jack up and a column-stablised rig; two floating production/storage systems – an FPSO and an FSO; and one Classification Society representative. Having a mix of several types of Mobile Offshore Drilling Units (MODUs) and floating systems, old and new facilities, provides some insights into the peculiarities that come with the differences in operating and maintaining different offshore installations.

In all, two (2) different questionnaires were used for this survey:

- Questionnaire for Drilling Rigs/FPSOs
- Questionnaire for Classification Society.

The questionnaires can be found in the appendix section of this report.

4.2 Facilities for Case Studies

This section presents a brief summary of the different kinds of facilities that the interviews were conducted on. The names and facilities of the interviewees will be kept anonymous in this thesis report.

4.2.1 Case 1 – Rig 1

This is a semi-submersible drilling rig operating in the Barents Sea part of the NCS.

4.2.2 Case 2 – Rig 2

This facility is a jack-up drilling rig operating in the North Sea part of the NCS.

4.2.3 Case 3 – FPSO

This is a newbuild ship-shaped FPSO with a turret mooring system operating offshore Norway at a water depth of over 400m.

4.2.4 Case 4 – FSO

This vessel was an over twenty-year-old shuttle tanker converted to an FSO and operates in the North Sea part of the NCS.

4.3 Presentation of Case Studies' Results

This section presents the questions and responses that were drawn from the interviews conducted on all four case studies. The survey results are broken into three sections: General Information, Continuous Classification Sub activities and New Technology/Innovation.

General Information

1. Classification Society that performs class surveys on rig owners' offshore platforms.

Rig 1, FPSO and **FSO:** DNV GL

Rig 2: ABS

2. The survey types carried out on the four platforms.

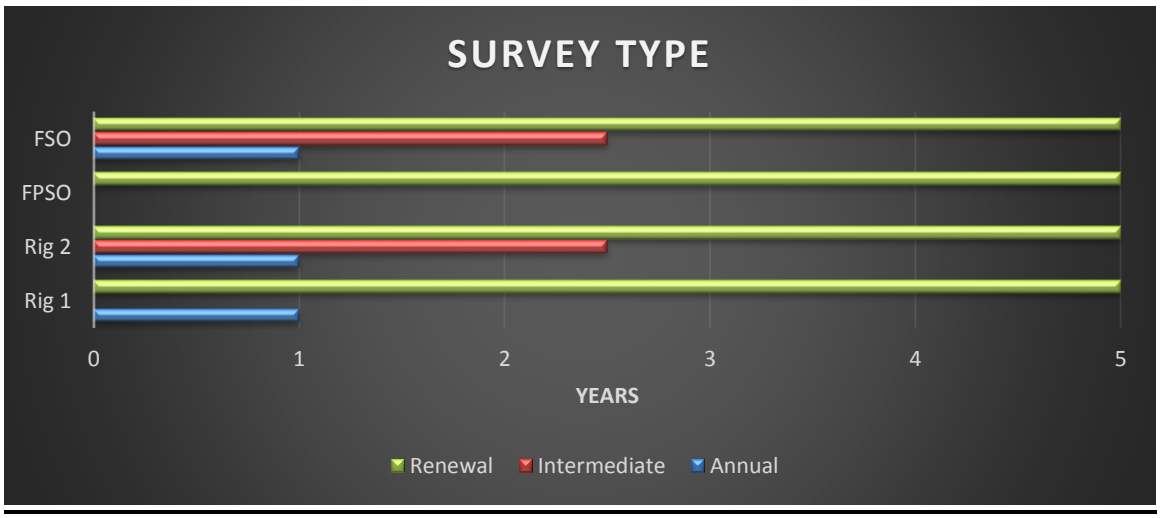

Fig 4.1: Survey Types for Drilling Rigs and FPSO/FSO.

Rig 1: Annual and Renewal surveys.

Rig 2: Annual, Intermediate and Renewal surveys surveys.

FPSO: Renewal survey.

FSO: Annual, Intermediate and Renewal surveys surveys.

3. Moving platforms to dockyard for classing.

Rig 1: Annual Surveys are performed during normal offshore operations while Renewal Surveys are done every 5 years in the dry-dock.

Rig 2: Annual and Intermediate Surveys are performed during normal offshore operations while Renewal Surveys may be done in the dockyard or afloat.

Dry-docking may be done every 5 years when major repairs have to be done on the rig. While mud pump repairs are done during normal operations. BOP, crown, top drive repairs are done as yard activities in the dock. Also, structural areas that take all the bending are surveyed in the dry-dock.

FPSO: Survey is done in water (typical for ship-shaped units).

FSO: Typically, all surveys should be done in water for ship-shaped vessels. However, this vessel goes to the dockyard every 5 years because it was converted from a tanker many years ago and does not meet recent standard requirements for ship-shaped units.

4. Inspection program or strategy for continuous classification with regards to saving cost and rig availability.

Rig 1: Maintenance program is strictly adhered to and all maintenance activities are recorded in CMMS. Fire safety systems are also regularly checked to ensure they are functional and reliable.

With regards to periodic surveys, DNV GL survey programs are strictly followed. Surveys are performed by DNV GL personnel as contained on their checklists of requirements, while the Chief Engineer on the rig shows the DNV GL personnel the records of what maintenance activities that contribute to class entry have been performed and with evidence.

Rig 2: The strategy is to do as much inspection and maintenance activities as possible during normal operations so rig does not have to move to dockyard. DNV GL verifies that those activities that contribute to class have been performed.

FPSO: Five year Condition Based Maintenance and Inspection program as part of classing.

FSO: Ship builder's operation and maintenance recommendations as well as guidelines of the Petroleum Safety Authority are followed. For inspection of structures, external structural inspectors are hired yearly to carry out detailed inspections that contribute to classing.

5. Survey of Drilling equipment as part of continuous classification.

Rig 1 and **Rig 2:** Drilling equipment are compulsorily surveyed for all categories of surveys.
FPSO and **FSO:** Not applicable due to no drilling equipment.

6. Survey, testing and certifying drilling equipment during normal operations or during yard activities.

Rig 1: Done both during normal operations and yard activities.
Annual Survey – on the sea when transiting wells, but not during drilling operations.
Renewal Survey – in the yard when drilling equipment are idle or not in use.
Rig 2: Done both during normal operations and yard activities.
As much as possible is done when offline (when the rig is offshore but not in use for drilling) and when the rig is moving from one location to another. Otherwise, major and remaining equipment are surveyed, certified and tested in the yard.
FPSO and **FSO:** Not Applicable due to no drilling equipment.

Continuous Classification Sub Activities

7. Major challenging Inspection, Maintenance and Repair (IMR) issues encountered in ensuring continuous classification.

Rig 1: Inspection of thrusters, anchor chains, anodes and hull are the most challenging.
Also, inspection of drilling equipment requires a lot of planning and interfacing with the different companies involved. It is also expensive.
Rig 2: The major challenges are with carrying out IMR activities on equipment that are in use most of the time, such as: power, hydraulic, electrical equipment and moving parts on the derrick.
FPSO: Cargo tank survey is the most challenging. Preparing the cargo tanks by emptying and thoroughly cleaning them before survey is quite demanding.

FSO: Tank and overboard valves inspections are very challenging. Bottom inspections are expensive.

8. Executing these IMR activities in-house or through third parties.

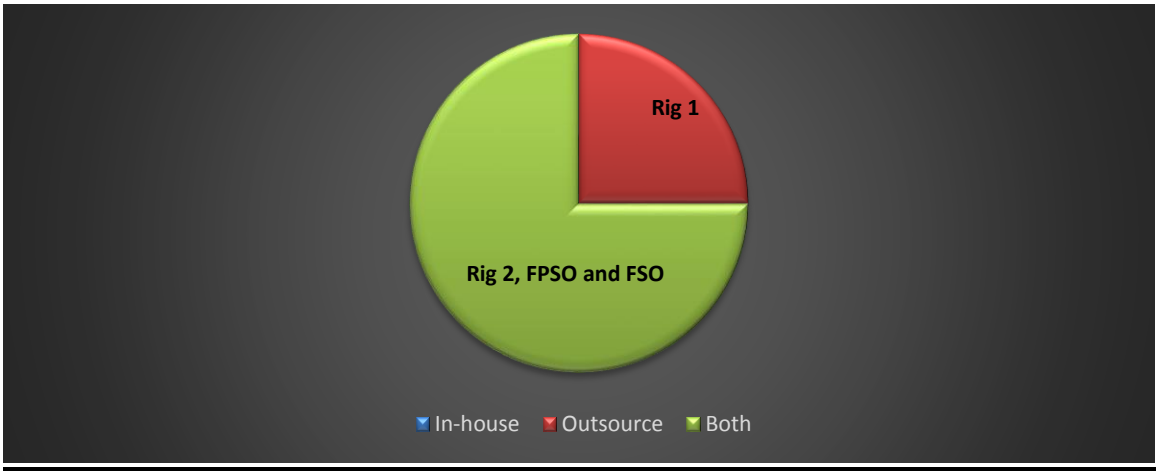

Fig 4.2: IMR Activities Outsourced or Done In-house for Drilling Rigs and FPSO/FSO.

Rig 1 outsources everything.

Rig 2, **FPSO** and **FSO** do some IMR in-house and outsource others.

9. Specify some IMR activities that are executed in-housed or outsourced.

Rig 1: Everything is outsourced while focus is totally on drilling operations on the rig.

Most systems or equipment are supplied by the Original Equipment Manufacturers (OEMs) and maintained by them or by specialised approved companies. For example, the drilling equipment OEM is responsible for the day-today functionality and maintenance of the drilling equipment.

Rig 2: Inspection is outsourced. Maintenance and Repairs are mostly done in-house.

FPSO: Most maintenance activities are done in-house. Hull and cargo tank inspections are done with in-house staff, DNV GL personnel and third-party companies. NDT is outsourced.

FSO: Bilge oil water separator inspection is done in-house. Subsea inspection is performed in-house with 1 DNV GL personnel to supervise and verify. Structural inspection is outsourced.

10. Ranked criteria/reasons for decisions in Question 9 above where the highest percentage signifies the most important criterium and the lowest signifies the least important.

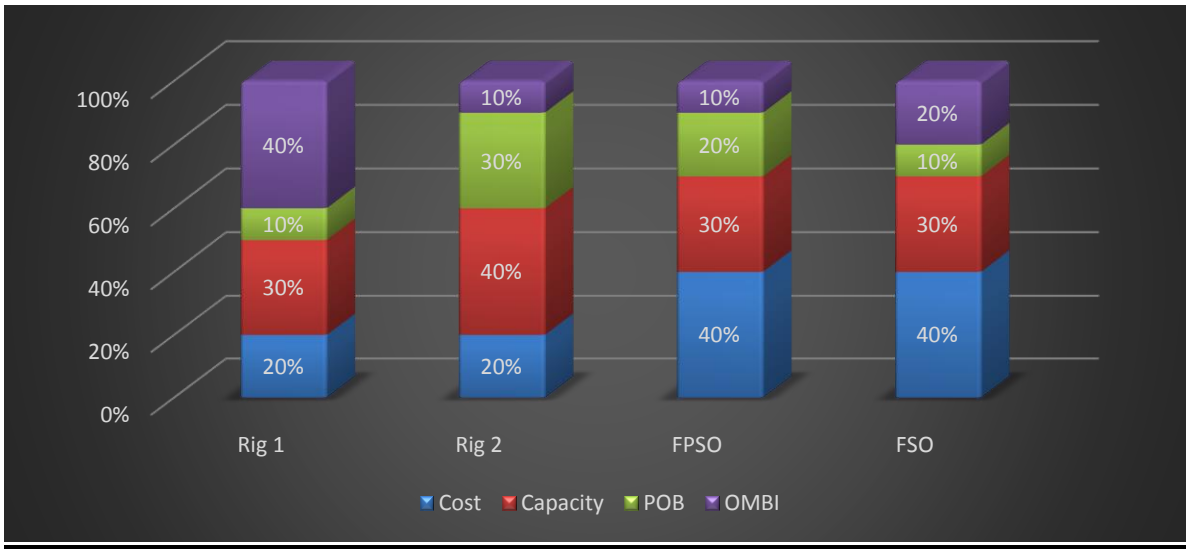

Fig 4.3: Ranked Reasons for Outsourcing IMR Activities.

Rig 1: Outside My Business Interest (OMBI) – Certainly

Capacity – no in-house capacity due to lack of business interest

Cost – not easily controlled due to outsourcing

Persons On Board (POB) – not an issue for Surveys.

FSO: Cost – applies to subsea inspection which is expensive to do in-house

OMBI – applies to subsea inspection

POB Issue – mostly occurs during cargo tank inspection.

11. Surveys done during normal rig operations.

Rig 1, Rig 2, **FPSO** and **FSO** all perform Hull and Structure surveys, Machinery equipment surveys and Anchoring system surveys during normal operations.

12. Main class surveys that require Non-Destructive Testing (NDT) to maintain class.

Rig 1: Anchoring system – certainly requires NDT.

Machinery – the cranes, lifting equipment and drilling equipment require NDT.

Hull – does not require NDT, ROV is used for visual inspection.

Rig 2: All of the above require NDT.

FPSO: Hull and structures only require NDT.

FSO: Hull and Structures require NDT.

Machinery – Crane only.

13. Means to currently access hard-to-reach areas for Hull and Structures Survey.

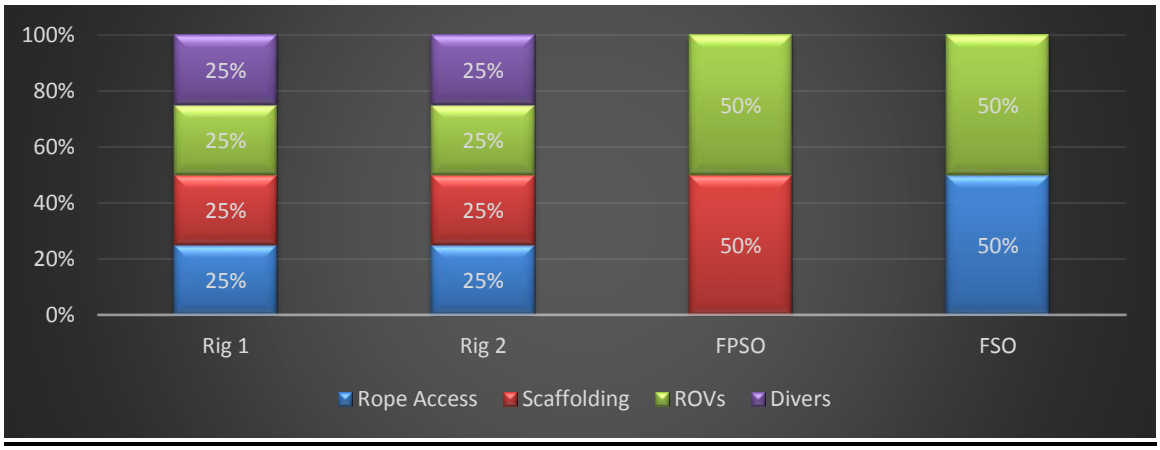

Fig 4.4: How Rig Owners Access Hard-to-reach Areas On Hull and Structures.

Rig 1 and **Rig 2:** use all of the above means to access hull and structures.

FPSO: uses scaffolding and Remote Operated Vehicles (ROVs).

FSO: uses rope access and ROVs.

14. Means to access hard-to-reach units for Machinery Survey using either Rope Access, Scaffolding or Drones.

Rig 1, **Rig 2**, **FPSO** and **FSO** use all of the above means to access machinery equipment.

15. Means to access hard-to-reach units for Anchoring System Survey using either Rope Access, Chain Barges, ROVs or Drones.

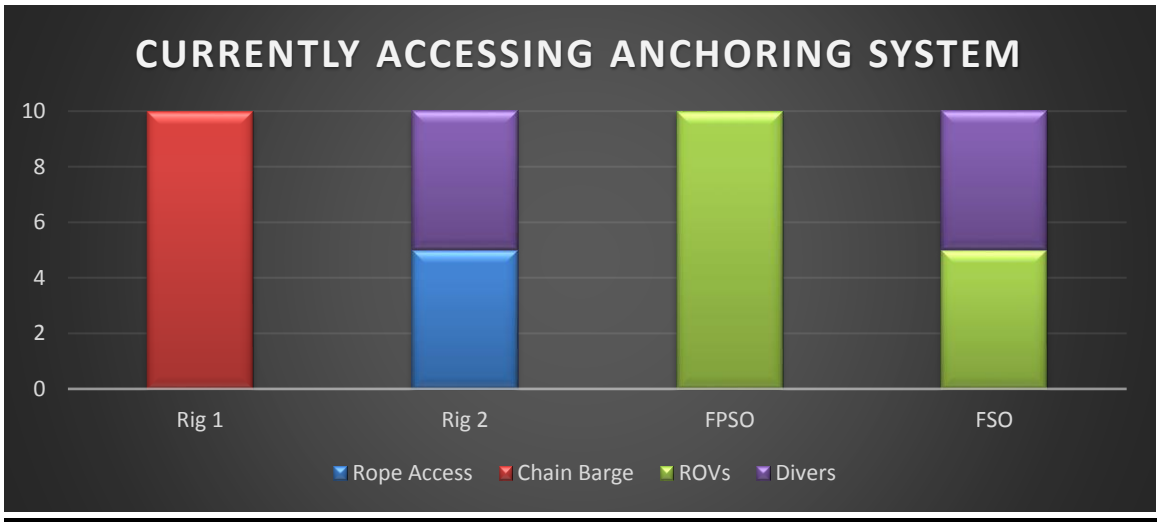

Fig 4.5: How Companies Access Hard-to-reach Areas On Anchoring System.

Rig 1: uses chain barges to access anchoring systems.

Rig 2: uses both rope access and divers.

FPSO: uses ROVs.

FSO: uses rope access and ROVs.

New Technology/Innovation

16. Exploring new automated ways of carrying out inspection/survey and maintenance activities to achieve class maintenance.

Rig 1: Currently exploring the use of Drones for surveys.

Rig 2: Considering hooking up all rig equipment on a computer for easy simulation of what is going on the rig at any time. This gives a record of all the equipment on the rig at once as well as their efficiency.

FPSO: Hoping to use ROVs for ballast and cargo tank surveys.

Also exploring autonomous underwater vehicles (AUVs) for hull and underwater inspection and maintenance which in the future will save a lot of money, risks and time.

FSO: Have used drones for cargo tanks for inspection. The drone has its own light, provided excellent HD images and surveyor was very satisfied.
For maintenance, perfomed vibation monitoring on pumps.

17. Level of interest in the use of drones and robots for inspection/survey or maintenance.

Rig 1: Higly interested in the use of drones for derrick and overboard areas. However, investing in new technology depends on the oil market, as low prices mean low income and consequently low investments in new technology.
Rig 2: Higly interested in the use of drones in areas that are hard and more costly to reach manually.
FPSO: Highly interested in drones as it's more convenient, especially in open places. Used drone for flare stack inspection last summer.
FSO: Highly Interested. Hoping to deploy drones in other areas of inspection apart from cargo tank. Also looking at being able to launch smaller ROVs on board the FSO instead of relying on external vessels for ROV services.

18. Excel-based continuous classification program or other type of digital application.

Rig 1: uses a DNV GL software called VERACITY.
Rig 2: uses Excel-based application.
FPSO: uses POSEIDON, an application owned by DNV GL.
FSO: uses a class application owned by ABS called NSE for all its fleet of vessels.

19. The need to have an independent digital application for Continuous Classification

Rig 1: does not see the need for a new application since Classification Societies already have their own classification softwares which their customers use.
Rig 2: says maybe it necessary, that it is better to have a standard application for classing.
FPSO: says maybe it is necessary.
FSO: does not see the need for that.

20. Interest in a dedicated digital application that visualizes continuous classing process.

Rig 1: Not interested. It is not necessary because all Societies have their own classification softwares, thus operators or drilling companies (customers) may not likely invest in another class software.

Rig 2: Interested in a dedicated class application.

FPSO: Not interested. Already using one.

FSO: Not interested. But might be interested in an application that puts together the rules and requirements of IMO, PSA and DNV GL. Such an application should be easy to use and search.

21. It will be great to have a digital Continuous Classification application that is integrated with CMMS.

Rig 1: Yes, integration will be great. Currently, CMMS is not integrated with the DNV GL application. However, some work orders from CMMS are manually referenced there.

Rig 2: Yes.

FPSO: Yes.

FSO: No need. Company already uses a very integrated one. NSE in addition to being a class app, is also a maintenance management application that we pay for. It takes care of all inspection and maintenance activities that contribute to class.

22. Most value or attraction about having a dedicated digital application for Continuous Classification.

Please rank using 1, 2, 3, 4, 5. according to level of interest where 5 indicates highest level of interest and 1 indicates the least.

Rig 1: Cost Saving and Acceptance by Society are not applicable. No cost saving for us, rather it incurs more cost as there is no charge for using DNV GL software. With regards to Acceptance by Society, it is not relevant.

Rig 2: All factors are equally very important reasons.

FSO: Apart from Cost Saving and Real-time Control, others are not applicable since we use ABS Class software which is well linked to CMMS

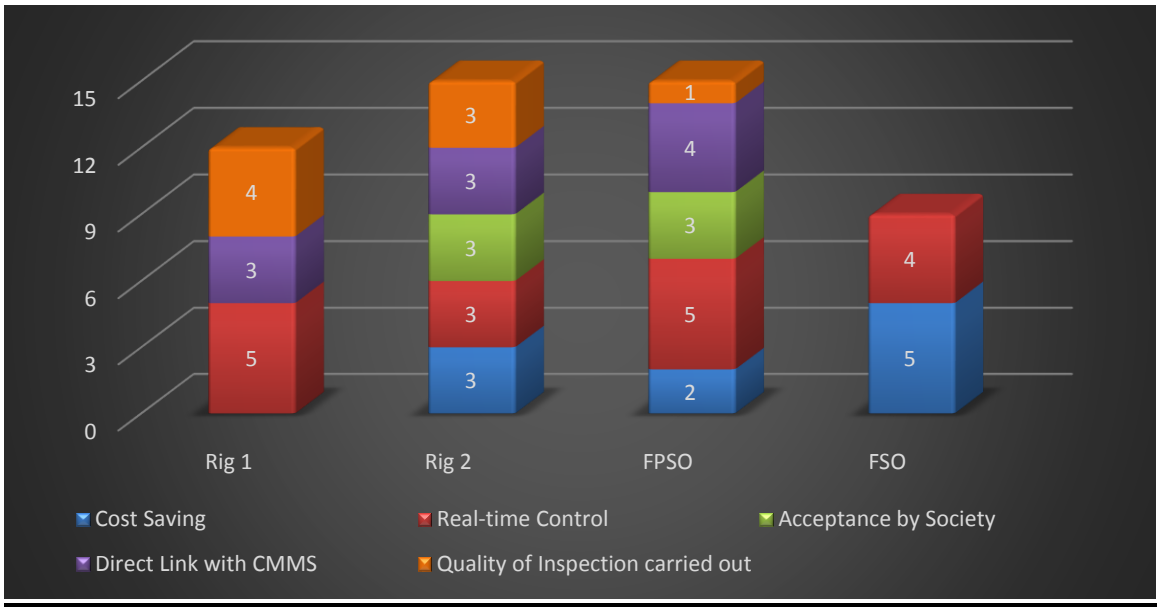

Fig 4.6: Ranked Factors of Interest for Digital Class Application.

23. Use of Condition Monitoring for rig units surveyed for class renewal.

Rig 1: Vibration monitoring is in use for thrusters. Oil analysis is done in the lab for every major component on board.

Rig 2: Condition Monitoring (CM) was implemented only for machinery equipment such as compressors, generators. CM was installed before rig commenced field operations and it's still in use for those equipment. No CM for hull, structures, anchoring equipment, etc. Working towards deploying CM for hull.

FPSO: CM is in use for most critical Machinery Equipment. Looking at deploying CM for Hull monitoring.

FSO: No CM in use. Considering applying Condition Monitoring to monitor the stress at the vessel's bottom. It's still a difficulty and not functional yet.

4.4 PRESENTATION OF SURVEY RESULT FROM CLASS SOCIETY

This section contains questions and responses obtained from the interview that was conducted with a Classification Society. The survey results are presented below in three sections.

General Information

1.) Moving drilling rigs, ships or FPSOs to the dockyard in order to maintain class.

Classing does not mandate offshore units to go to dry-dock for inspections. Classing does require a survey of the unit's underwater hull, as well as sea chests, inlet/outlet valves, thrusters, rudders etc. (where applicable). However, we accept the use of divers and/or ROVs provided that the visibility is found acceptable.

Note however that some Flag states formally require offshore units to go to dry-dock, but in most cases they will accept bottom survey afloat based on an application from the rig owner/manager. The owner has to prove that bottom survey will produce equivalent survey with dry-dock. Also, semi-submersibles rarely go to dry-dock because there are quite few dry-docks that can accommodate them.

Continuous Classification Sub Activities

2.) Survey of production and process equipment as part of continuous classification.

This is done sometimes but not mandatory. The survey scope will depend on the class notations that each separate unit has. But if a unit has the PROD class notation, then we may include the production and process equipment in the continuous Main class survey scope. Otherwise, such equipment will fall under Optional class.

3.) Survey of cargo and void tanks on FPSOs for class renewal.

The required survey scope depends on the unit's age and the condition of the tanks/spaces. But some cargo and void tanks will normally be included in the survey scope, sometimes all of them.

4.) The major challenging survey activities for you that contribute to class renewal.

- Access to tanks and spaces
- Emergency Shutdown (ESD) testing – especially the top ESD level (abandon platform level) when performed afloat
- Load testing of major lifting equipment.

5.) Accepting inspections/surveys from third party contractors as part of Continuous Classification requirement.

Yes, the Rules list typical inspection services which can be performed by approved third party companies, refer to DNVGL-RU-OU-0300 Ch.2 Sec.6.

In addition, DNV GL accepts class entry for ABS certified vessels and sometimes for vessels certified by IACS members.

6.) Surveys of Hull and Structures, Machinery Equipment or Anchoring System during normal offshore operations.

In principle, survey of all of the above during normal offshore operations can be accepted. The challenge however in many cases is to get access during normal operations. With proper planning, surveys will usually be performed between wells when drilling operation is over. In addition, the mooring lines will normally require to be pulled and inspected at regular intervals, due to the difficulty of inspecting the lines on site.

7.) Inspections that require Non-Destructive Testing (NDT) to maintain class among: Hull and Structures, Machinery Equipment and Anchoring System.

All of the above may require NDT of some kind, either thickness measurements or external/internal NDT of welds, shafts, mooring links, etc. The actual scope will as previously mentioned depend on the unit's age, type and condition.

Hull and Structures – all major legs affecting vessel's stability.

Machinery Equipment – some shafts, pressurised equipment.

Anchoring system – mooring chain main anchor structure on topside.

8.) Delegation of inspection of overboard and hard-to-reach units offshore.

Yes, these inspections can be delegated. As a small company, we used to do rope access and NDT in the olden days, but almost not anymore. Approved third party companies now handle such.

9.) Surveys that must be handled by only the Society.

Typical items:

- Function testing of safety functions
- Pressure testing of critical equipment
- Surveys of critical hull, machinery and systems items

10.) Means to access hard-to-reach units for Hull and Structures Survey using either Rope Access, ROVs, Scaffolding, Divers or Drones.

All of the above means are used either in isolation or in combination to survey Hull and Structures.

11.) Means to access hard-to-reach units for Machinery Survey using either Rope Access, Scaffolding or UAVs.

All of the above means are used for Machinery Survey.

12.) Means to access hard-to-reach units for Anchoring System Survey using either ROVs, Divers or Rope Access.

All of the above either in isolation or in combination to survey Anchoring System.

New Technology/Innovation

13.) Exploring new automated ways of carrying out inspections/surveys.

Yes. The Society is open for accepting new automatic inspection tools and methods. The hottest topics right now are drones, internal marine riser "pigs", laser scanning. They are currently in use but not very common.

14.) Level of interest in the use of drones, robots for inspection/survey.

The Society is highly interested in the use of drones. Drones have been used for tank surveys and it provides more access in the tanks than manual means. Also using drones for general inspections and following up manually for close visual inspections where necessary.

15.) Digitalization initiatives on classification and effect on cost reduction.

Yes, absolutely, there are a lot of different initiatives going on these days. In general, when talking about classification nowadays, the main intention is to reduce Class induced *downtime* of the units related to periodic dismantling and shutting down of installations through the use of Condition Monitoring, and to reduce the Class induced *costs* related to cost of preparing the units to be surveyed which are very high through the use of drones to access many more places in place of scaffolds. Actual Society survey charges are very little.

16.) Excel-based continuous classification program currently in use or other type of digital applications.

The application used by the Society is not Excel-based. An in-house developed production system called Nauticus is used which covers all Class and statutory activities, as well as some additional services. It keeps track of all surveys performed, findings, etc. A client version of this production system is also available online where clients have limited read access and can upload documents.

Nauticus production system alongside other applications is built on DNV GL's Veracity platform. Anyone can build on Veracity with different levels of access.

17.) The need to have an independent digital application for continuous classification.

No need for an application at the moment. The production system mentioned above allows for continuous classification already. There are definitely some needs for updates/developments, but it is quite certain that the current application will also be used in the coming years hence no need for an independent digital application. Clients may of course perhaps benefit from such application.

18.) It will be great to have a digital Continuous Classification application that is integrated with CMMS.

Yes, the Society's Class applications are not linked to any customer's CMMS due to issues of encroachment, who owns the data, etc. Customers usually have no permission from vendors/OEMs to share data on their equipment to external parties such as Societies. Hoping for more sharing in the future.

19.) Utmost value or attraction about having a dedicated digital application for Continuous Classification.

Rank the following attractions: Cost Saving, Real-time Control, Direct Link with CMMS, and Quality of Inspection Carried Out, using numbers 1, 2, 3, 4, 5 according to level of interest, where 5 indicates highest level of interest and 1 indicates the least.

They all go together. A direct link with CMMS will make it possible to perform real-time control of the status, which may be used for optimized overhaul and inspection. This will lead to better quality of the overhauls/inspections, and provide better reliability and hence cost savings. It is difficult to rank the items, but they are all important.

5. CHAPTER FIVE

DISCUSSIONS, CONCLUSION AND RECOMMENDATION.

5.1 Discussion of Results

From the survey results presented in the preceding chapter, one can see that different companies have different approaches in the way they go about their Continuous Classification programs. These results are discussed below in three separate sections: General Information, Continuous Classification Sub activities and New technology/innovation.

General Information

In the general section of the questionnaire, there is a trend that most standing mobile offshore units are required to go to dry-dock for renewal surveys every five years, whereas for ship-shaped mobile offshore units, this is not mandatory. The major reason adduced for this is the robustness in stability, buoyancy and fatigue redundancy that ship-shaped units offer amidst rough sea conditions compared to standing units which lack such robustness.

One can also observe that DNV GL is the most dominant Class Society in the NCS among the six Societies approved by the maritime authority in Norway. Most of the experts that were consulted said DNV GL handles classing activities for all their offshore units. Excpet one of the interviewees that said that DNV GL handles the classing for all but one of its over ten vessels on the sea; ABS handles the one.

Another observation from the interviews indicate that for drilling rigs, drilling equipment are classified as part of Main class units and have to be surveyed compulsorily. While for production units, production and process equipment can either be Main class or Optional class depending on the class notation each unit has.

Continuous Classification Sub activities

For Class surveys, vessel owners generally invite Societies during periods of little or no primary activies on the facility so as to minimize interference with the unit's primary goal of drilling/production, while still ensuring that its integrity and safety are not comprised. In cases of

drilling rigs that may have to go to dry-dock for renewal surveys, major repairs for rig equipment are usually delayed till the rig gets to shore.

With regards to continuous classing, drilling rigs generally cite inspection, maintenance and repairs of drilling equipment as one major challenging IMR issue for them that contributes to class renewal. While ship-shaped units generally cite inspection of cargo tanks as the most challenging IMR issue for them due to the huge work required to empty, clean and prepare the tanks for class surveys.

One can also see that most companies outsource one IMR activity or the other. The major reasons given for their decisions to outsource some of these activities vary across companies. While for Rig 1 it is more of lack of capacity and business interest in activities outside drilling, for Rig 2 it is more of POB and capacity issues, and for the FPSO and FSO it is more about issues related to the cost of performing these IMR activities in-house.

Another observation is that while Rig 1 which is a semi-submersible uses chain barges for its anchoring/mooring system inspection, Rig 2 which is a jack-up rig uses rope access for top side areas and divers for areas below water. And for the FPSO and FSO, ROVs are the main means of carrying out subsea inspections, with rope access to complement for top side areas.

It is evident that the various water depths in which these vessels operate in determine the means of performing subsea surveys. Typically, jack-up rigs operate in shallow waters, hence the use of divers for subsea inspections, while floating vessels operate in deepwater environments where diving is not in use, hence the use of ROVs and chain barges.

New Technology/Innovation

The use of new technologies in the business of continuous classification can be deployed in two aspects. One is in the deployment of new technology by way of a dedicated digital application than can be useful in planning IMR activities, while the other is in the deployment of remote devices in the execution of these IMR activities.

The figure below shows a breakdown of how new technologies can be incorporated into continuous classing programs as a suitable continuous classification strategy.

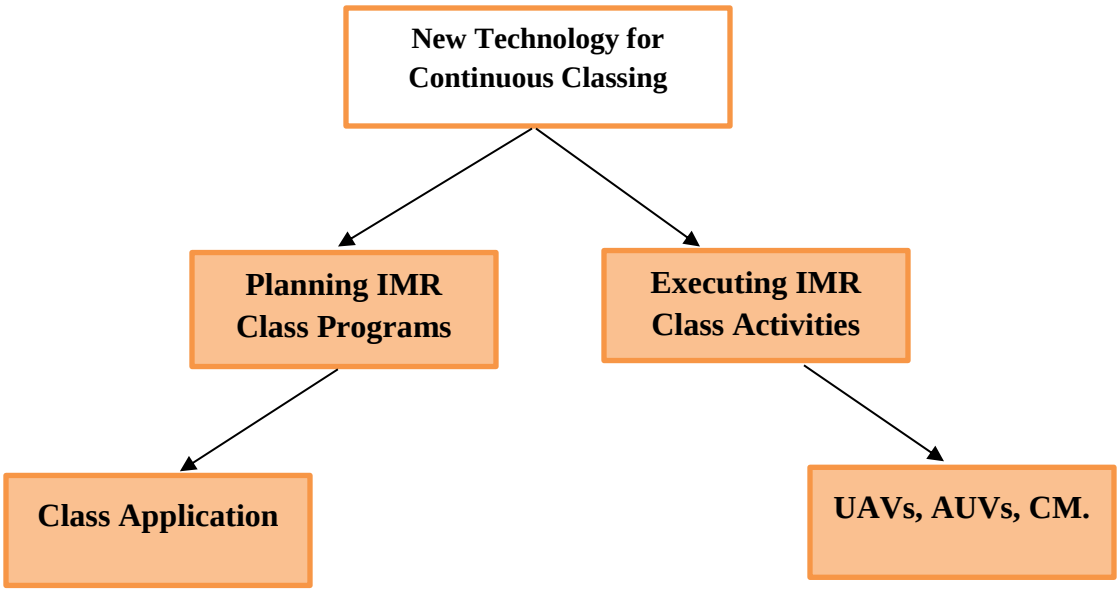

Fig 5.1: Incorporating New Technologies in Continuous Classification.

New Technologies in Executing IMR Class Activities

Looking at the latter case of deploying remove vehicles in executing surveys, drones are by far the most popular means being considered and in several cases already being implemented across companies in carrying out visual inspections especially in difficult-to-access and high risk areas. While Rigs 1 and 2 are still considering the prospect of using drones for future visual inspections, the FPSO and FSO owners as well as the Class Society are already utilizing drones for various kinds of class surveys.

In addition to drones, the FPSO owner is exploring the possible use of ROVs not just for bottom inspections alone, but for inspection of tanks that store fluid on the vessel, and also using AUVs in place of ROVs for future bottom inspections.

Lastly, almost all the respondents are keenly interested in exploring the possibility of deploying condition monitoring especially for real-time surveying of their vessels' hull.

New Technology in Planning IMR Class Programs

In the area of utilizing digital applications to manage classing, all but one of the companies are using softwares and applications of the various Societeis handling their vessel's classification. Only one utilizes an Excel-based digital application for classing. The majority of respondents who

use the Society's class softwares do not exactly see the necessity in developing or purchasing an independent digital application to manage their classing activities.

The main reasons given for this is that classing is not an integral part of their businesses but a necessary fulfilment of the statutory and safety requirements of the regulatory authorities and flag state. Thus, for them as customers, it is best for the Society to manage digital Classing applications as that is one of their core areas of responsibility. Some of the rig owners seem to be okay with a user access that allows them interact with the Society and submit documents required for classing while the Society handles the rest. The major concern for most of the interviewees is lack of direct link of the Society's software with customers' CMMS.

5.2 Conclusion and Recommendation

The need to incorporate new technologies in the oil and gas industry especially in the business of classification cannot be overemphasized. As new offshore installations are becoming unmanned through total subsea solutions, continuous classing activities should not be left.

Therefore, the use of autonomous underwater and aerial vehicles for inspection and integrity assessments of offshore units have to be fully explored and deployed .

The advantages of using UAVs and AUVs for surveys far outweigh the challenges that come with them. One major advantage of using these autonomous vehicles is the ability to use them with wireless transmitters and receive live footage of the units which can be stored and reviewed over and over again when reassessment is necessary.

In addition, autonomous vehicles almost eliminate risks to human, and as well save time and cost for the vessel owners who would have to alternatively spend huge man-hours and consequently huge amount of money making scaffolds or mobilising rope access equipment and personnels.

However, one of the challenges of using autonomous vehicles has been the short lasting battery power of drones which is rapidly being improved upon by UAV manufacturers.

Also, deploying condition monitoring where possible on more rig equipments both at the topsides or subsea will help reduce or eliminate the need for performing periodic surveys on them since CM gives real-time data about the state of the equipment being monitored.

As mentioned in the preceding chapter while presenting the survey results, the Society as well as the vessel owners acknowledge that the costs incurred while preparing rig equipment and providing access means for surveys to be performed, constitutes the major financial implication

for continuous classification of offshore units. Thus, utilizing latest technologies such as UAVs, AUVs, CM, etc. will greatly eliminate manual means of accessing difficult areas and consequently reduce the cost of class renewal for these offshore vessels.

Class Application Recommendation

A digital classing application that works with CMMS, gives real-time information and helps drilling companies and operators to keep track of their class activities as well as update the performance status of each activity is proposed and recommended.

This class application is not proposed as a substitue for the class softwares being used by the Societies. Rather, it is a digital interface designed to help the vessel owners monitor and manage their classing programs to ensure prompt and full compliance with the requirements of the CS.

It provides up-to-date information about the status of each IMR activity that contributes to the fulfilment of the different survey types/categories required by the Society. The interface can be designed on Microsoft Visual Basic or any other software.

It starts with a drop-down list of Survey Types. After selecting the survey type (intermediate survey in this case), the IMR menu pops up giving the user options to select either “Inspection”, “Maintenance” or “Repair” class actions.

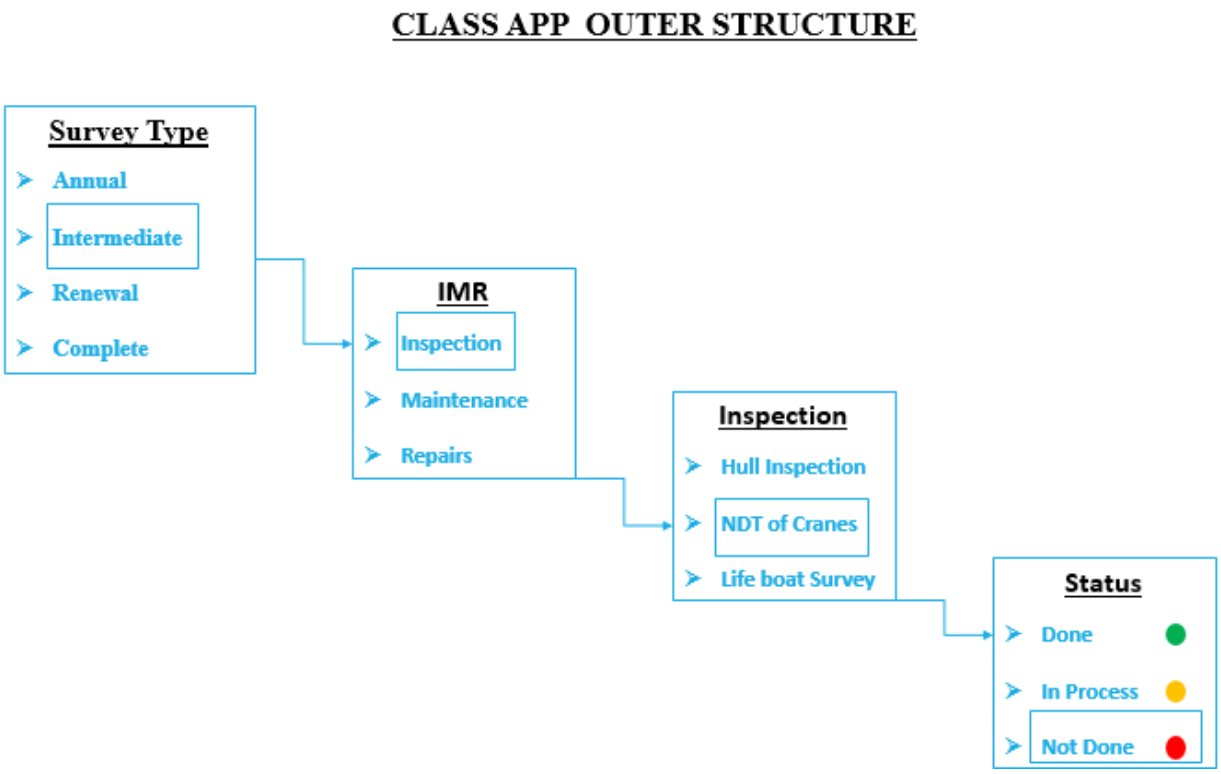

Fig 5.2: Digital Class Application Outer Structure.

If "Inspection" is selected, the list of items to be inspected as part of Intermediate Survey pops up in a listbox. These items are uploaded from the CMMS application which normally contains all planned IMR activities for an offshore installation. Already, the CMMS manages the spareparts, suppliers/vendors and other IMR aspects of the rigs. So all such information related to the Class action to be performed can easily be obtained from the CMMS.

Going forward, clicking any of the "Inspection" action items reveals its status whether the action item has been done, is in process or has not been performed. The status is accompanied with the corresponding colour indications as displayed above, where green indicates that the task has been completed, yellow indicates that work is in process and red indicates that the task has not been done.

This application for continuous classing can be likened to what CMMS is to maintenance, but in this case, the class application works directly with the CMMS to ensure that classification of offshore vessels is achieved seamlessly and promptly.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR DRILLING RIGS/FPSOs

General Information

1. Which Classification Society carries out continuous classification surveys on your rigs?

2. Are there different classification categories for your rig?

☐ Yes (Please Specify)

☐ No

3. Do you have to move your rigs to the dockyard in order to maintain class?

☐ Yes

☐ No

☐ It depends (Please explain a bit)

4. What is your inspection program or strategy for continuous classification with regards to saving cost and rig availability?

5. Are Drilling equipment surveyed as part of continuous classification?

☐ Compulsorily

☐ Yes, but not mandatory.

☐ No

6. Are drilling equipment surveyed, tested and certified during normal operations or during yard activities?

Continuous Classification Sub Activities

7. What major challenging IMR (Inspection, Maintenance and Repair) issues do you encounter to ensure continuous classification for your rig?

8. Do you execute these IMR activities in-house or do you use third parties?

☐ In-house ☐ Both

☐ Outsourced

9. Specify some IMR activities that are executed in-housed or outsourced.

10. Rank the criteria for your decision in Question 9 above using numbers 1, 2, 3, 4 where 1 indicates most important criterium and 4 indicates the least important.

☐ Capacity ☐ Persons on Board (POB) Issues

☐ Cost ☐ Outside My Business Interest

11. Which of the following do you survey during normal rig operations?

☐ Hull and Structures

☐ Machinery equipment

☐ Anchoring system

12. Which of the following Inspection(s) require Non-Destructive Testing (NDT) to maintain class?

☐ Hull and Structures ☐ Anchoring system

☐ Machinery

13. How do you currently access hard-to-reach units for Hull and Structures Survey?

☐ Rope Access ☐ ROVs

☐ Scaffolding ☐ Divers

☐ Robots ☐ Others (Please specify)

14. How do you currently access hard-to-reach units for Machinery Survey?

☐ Rope Access ☐ UAVs

☐ Scaffolding ☐ Others (Please specify)

15. How do you currently access hard-to-reach units for Anchoring System Survey?

☐ ROVs ☐ Rope Access

☐ Divers ☐ Others (Please specify)

New Technology/Innovation

16. Are you exploring new automated ways of carrying out inspection/survey and maintenance activities to achieve class maintenance?

☐ Yes

☐ No

Please specify what new technologies you have considered or are currently utilising.

17. What is your level of interest in the use of drones, robots for inspection/survey or maintenance?

☐ Highly Interested

☐ Interested

☐ Indifferent

☐ Not Interested

18. Is your continuous classification program currently Excel-based or what other type of digital application are you using?

19. Do you think it is more efficient and beneficial to have an independent digital application for Continuous Classification planning?

☐ Yes

☐ No

☐ Maybe

20. Will you be interested in a dedicated digital application that visualizes your Continuous Classification process?

☐ Yes

☐ No

☐ Maybe

21. It will be great to have a digital Continuous Classification application that is integrated with CMMS.

☐ Yes

☐ No

☐ Indifferent

22. What would be of most value or most attractive to you about a visual digital application for Continuous Classification?

Please rank using 1, 2, 3, 4, etc. according to level of interest where 1 indicates highest level of interest.

☐ Cost Saving

☐ Real-time Control

☐ Acceptance by Classification Society

☐ Direct Link with CMMS

☐ Quality of Inspection carried out.

23. Are you currently utilizing any Condition Monitoring for any rig units surveyed for class renewal?

☐ Yes (Please specify)

☐ No

APPENDIX 2: QUESTIONNAIRE FOR CLASS SOCIETY

General Information

1.) Do drilling rigs, ships or FPSOs required to be moved to the dockyard in order to maintain class?

Continuous Classification Sub Activities

2.) Are production and process equipment surveyed as part of continuous classification?

☐ Yes

☐ No

☐ Sometimes but not mandatory

3.) Are cargo and void tanks on FPSOs surveyed by the Society for class renewal?

☐ Yes

☐ No

☐ Sometimes but not mandatory

4.) What are the major challenging survey activities for you that contribute to class renewal?

5.) Does DNV GL accept inspections from third party contractors as part of Continuous Classification requirement?

☐ Yes (Please specify and state conditions if any)

☐ No

6.) Which of the following do you survey during normal operations?

☐ Hull and Structures ☐ Anchoring system

☐ Machinery equipment

7.) Which of the following Inspection(s) require Non-Destructive Testing (NDT) to maintain class?

☐ Hull and Structures ☐ Anchoring system

☐ Machinery

8.) Does the Society delegate inspection of overboard and hard-to-reach units offshore?

☐ Yes (Please specify)

☐ No

9.) Which surveys must be handled by only the Society's personnel?

10.) How do you currently access hard-to-reach units for Hull and Structures Survey?

☐ Rope Access ☐ ROVs

☐ Scaffolding ☐ Divers

☐ Robots ☐ Others (Please specify)

11.) How do you currently access hard-to-reach units for Machinery Survey?

☐ Rope Access ☐ UAVs

☐ Scaffolding ☐ Others (Please specify)

12.) How do you currently access hard-to-reach units for Anchoring System Survey?

☐ ROVs ☐ Rope Access

☐ Divers ☐ Others (Please specify)

New Technology/Innovation

13.) Are you exploring new automated ways of carrying out inspection/survey?

☐ Yes

☐ No

Please specify what new technologies you have considered or are currently utilising.

14.) What is your level of interest in the use of drones, robots for inspection/survey?

☐ Highly Interested

☐ Interested

☐ Indifferent

☐ Not Interested

15.) Any Digitalization initiatives by DNV GL on classification and any effect on cost reduction?

16.) Is your continuous classification program currently Excel-based or what other type of digital applications are you using?

17.) Do you think it is more efficient and beneficial to have an independent digital application for Continuous Classification planning?

☐ Yes

☐ No

☐ Maybe

18.) It will be great to have a digital Continuous Classification application that is integrated with CMMS.

☐ Yes

☐ No

☐ Indifferent

19.) What would be of most value or most attractive to you about a visual digital application for Continuous Classification?

Please rank using 1, 2, 3, 4, etc. according to level of interest where 5 indicates highest level of interest and 1 indicates the least.

☐ Cost Saving

☐ Real-time Control

☐ Direct Link with CMMS

☐ Quality of Inspection carried out

☐ All of the above