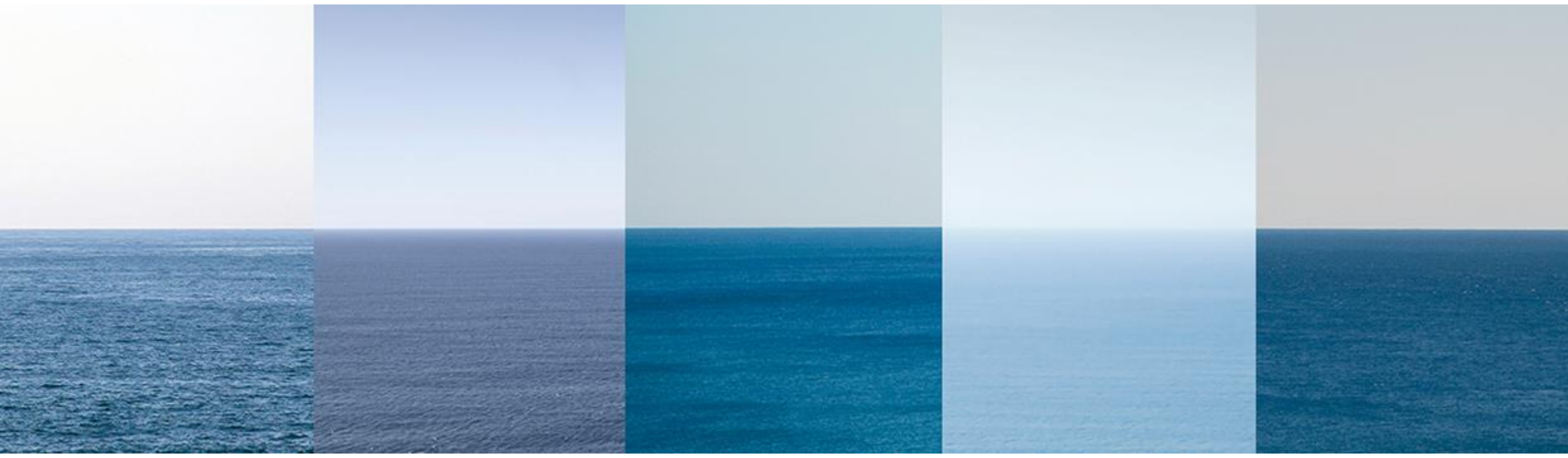

Activity Specific Operating Guidelines

Owning and Managing Operational Risk

	05/05/2017		Alessio Lombardi David R. Drew	David R. Drew	David R. Drew
	Date		Prepared by	Reviewed by	Approved by

Table of Contents

Figures

DOCUMENT ISSUE RECORD

Date	Prepared by	Reviewed by	Approved by
05/05/2017	Alessio Lombardi David R. Drew	Alessio Lombardi	David R. Drew

Global Maritime Consultancy Ltd.
2nd Floor, Office 223-227, Al Fahim Building
Street 10, Mussafah Industrial, Abu Dhabi
P.O. Box 127573

T +971 2 553 5291
F +971 2 553 5292

1. ABSTRACT

This paper describes a systematic methodology to be applied when developing Activity Specific Operating Guidelines (ASOG) for vessels engaged in Dynamically Positioned (DP) operations.

An ASOG is a tabulated method used for planning and execution of DP activities; an ASOG states both the set-up of the DP system for a defined operation and the actions to be taken by the vessel' crew following any contingency event.

IMCA 220 "Guidance on Operational Activity Planning" provides a brief overview on what is an ASOG and on how to use it, without giving details on how and on which basis this type of risk assessment shall be developed.

MTS "DP Operation Guidance" underlines the importance of a "detailed technical review of the DP FMEA, operational manual and project specific procedure" when developing the ASOG, but still does not provide additional details on how the risk assessment shall take form from the technical review of the DP related documentation.

The aim of this paper is to fill these gaps, it proposes a systematic methodology focused on obtaining a tool which allows the Vessel's owner to manage and own the risk associated with DP activities, whilst at the same time, minimizing individual operational responsibilities of DP Operators (DPOs) and other DP related personnel.

2. INTRODUCTION:

2.1 Prescriptive Vs. Risk Based Approach

2.1.1 Among all industries, the offshore business is beyond any doubt the one characterized by the largest number of entities that are able to promulgate standards, rules and guidelines, and whom require evidence of compliance.

2.1.2 National states flags, national and international safety organizations, classification societies, international industry committees and oil majors, all present specific requirements for design and operations of Dynamic Positioned (DP) vessels; these requirements often differ in content or extent, some being considered more or less stringent than others. This non-uniformity creates confusion within the industry and, what is worse, this allows non-standardized technical and operational safety regimes to operate. This generalized prescriptive approach has a number of additional short-comings. It does not encourage the analysis of the specific threats to safe operations, the consequences of failures, or the risks associated to different types of operations.

2.1.3 Moreover, it has led the offshore industry to a status of being an "incident driven industry", where incidents are too often seen as "Black Swan Events", never considered, or thought to be impossible, but proven to be possible and real by their sudden appearance.

2.1.4 A risk based approach instead promotes the evaluation of operational risks, focusing on prevention, but being at the same time prepared to react. This approach requires a change in the 'Duty Holders' attitude, from passive executor of rules and regulations, to active planner of safe and reliable operations, whilst at the same time fully aware of the accountability for, and ownership of, the risks linked to DP operations.

2.1.5 "… prescriptive approach has often turned out to encourage a passive attitude among the companies. They wait for the regulator to inspect, identify errors or deficiencies and explain how these are to be corrected. As a result, the authorities become, in some sense, a guarantor that safety in the industry is adequate and take on a responsibility which should actually rest with the companies."

Petroleum Safety Authority (Norway).

2.1.6 The Activity Specific Operating Guidelines (ASOG) is an excellent tool to promote and implement a risk based approach to planning and execution of DP operations. Before presenting the methodology outlined by this paper, the basic concepts needed for developing an ASOG will be described.

2.2 Definitions and Basic Concepts

2.2.1 <u>Dynamic Positioning system</u>

A DP system consists of components and systems acting together to achieve reliable position keeping capability. The DP system includes the power system (power generation and power management), thruster system and DP control system [2], together with all the auxiliary systems which are required to be configured correctly for redundant operations. Such systems are cooling systems, lubrication systems, hydraulic and compressed air systems, etc., where applicable.

It should be noted that the Dynamic Positioning systems considered for the purpose of this paper are redundant in the components and functions (i.e. DP2 and DP3 systems).

2.2.2 Worst Case Failure Design Intent (WCFDI)

The WCFDI is the single failure with the maximum consequences that has been the basis of the design and operational conditions of the DP system. This usually relates to a number of thrusters and generators that can simultaneously fail [2].

2.2.3 Redundancy and redundancy concept of a DP system

Redundancy is the ability of a component or system to maintain or restore its function, when a single fault has occurred. Redundancy can be achieved, for instance, by installation of multiple components, systems or alternative means of performing a function [5][].

The redundancy concept is the means by which the Worst Case Failure Design Intent is achieved.

2.2.4 Activity Specific Operating Guidelines (ASOG)

ASOG are generally presented in tabulated format and set out the operational, environmental and equipment performance limits considered necessary for safe DP operations while carrying out a specific activity. The table also sets out various levels of operator action, as these limits are approached or exceeded. The ASOG will vary depending on the activity and are unique to that activity [2].

The process of developing the ASOG table always includes the development of CAM tables; TAM tables are developed as well, if applicable.

2.2.5 Critical Activity Mode

Critical Activity Mode (CAM) is the configuration that the vessel's DP system should be set up and operated in to deliver the intent of the vessel's DP class notation. The objective is that no single failure should result in exceeding the Worst Case Failure. Each DP vessel has only one critical activity mode, which is unique to that vessel [2].

2.2.6 Task Appropriate Mode

Task Appropriate Mode (TAM) is a risk based mode. TAM is the configuration that the vessel's DP system may be set up and operated in, accepting that a single failure could result in exceeding the Worst Case Failure and could result in blackout or loss of position [2].

2.2.7 Time To Terminate

The Time To Terminate (TTT) is calculated as the amount of time required in an emergency to physically free the DP vessel from its operational activity following a DP abort status and allowing it to maneuverer clear and to proceed to safety [2].

2.2.8 DP Capability Plots and Worst Case Failure Design Intent

DP capability defines a DP vessel's station-keeping ability under given environmental and operational conditions.

DP capability plots are used to establish the maximum applied force (considered as weather + calculated current force) conditions in which a DP vessel can maintain its position and heading for a proposed thruster configuration.

The two most significant thruster configurations are:

- Vessel with DP system in intact conditions
- Vessel with DP system under WCFDI conditions

Figure 2-1 shows an example of DP capability plots in intact conditions and in Worst Case Failure Conditions.

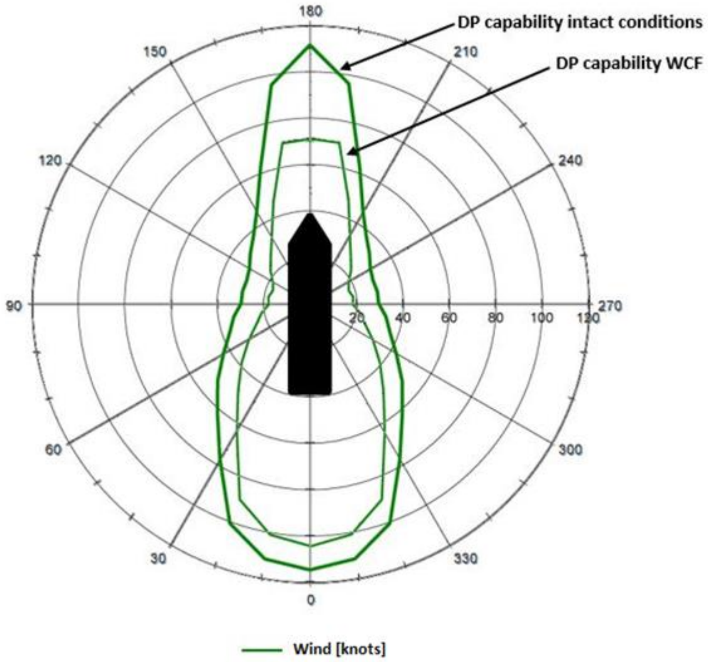

Figure 2-1 DP capability plots intact conditions and WCF conditions

2.2.9 DP Capability Plots and Critical Activity Mode

The CAM defines the DP system set-up that will assure the vessel will be able to maintain position and heading after whatever contingency event will occur: in other words, this set-up can guarantee that any failure mode or any changing in the environmental conditions will not have any effect on the vessel's station-keeping ability for that particular DP operation.

This means that when operating in CAM the vessel is considered as if it was under Worst Case Failure conditions, and its capability will be "downgraded" to the one related to the WCFDI.

2.2.10 DP Capability Plots and Task Appropriate Mode

The TAM defines the DP system set-up that will not assure the vessel will be able to maintain position and heading after a failure event or changing of the environmental conditions: drive off or drift off are acceptable risk consequences for that particular operation.

This means that, when operating in TAM, the vessel is allowed to work outside the Worst Case Failure Capability (see Figure 2-2).

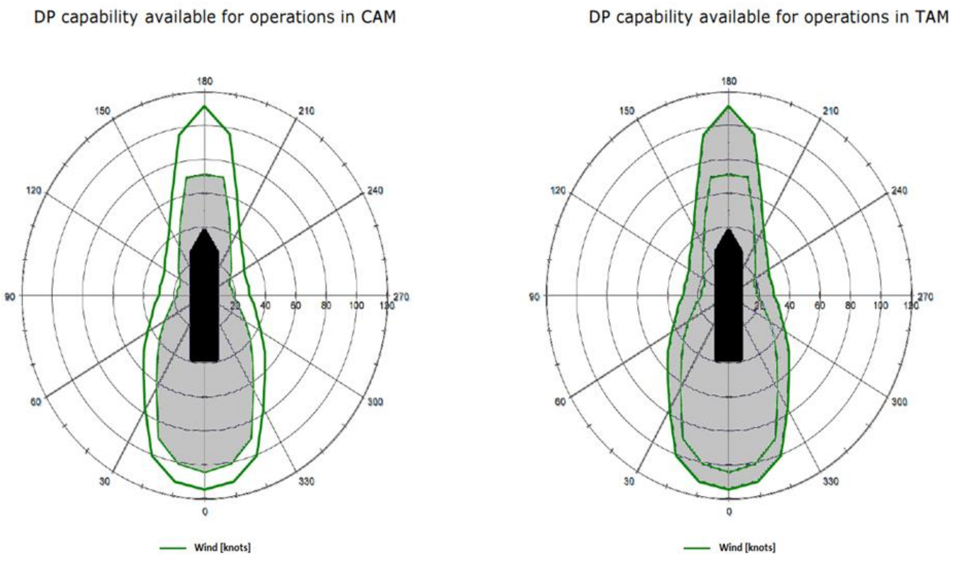

Figure 2-2 DP Capabilities for CAM operations and TAM operations

3. THE ASOG PROCESS

3.1 Input Data to the ASOG Process

3.1.1 DP FMEA and DP FMEA proving trials

The scope of an Activity Specific Operating Guidelines is to mitigate the risk of loss of position and to assess the consequences of loss of position.

In order to reach these two objectives, the risk assessment should focus on the technical design of the DP system and on the industrial mission of the vessel.

The technical design shall be characterized by the '7 Pillars of Wisdom' for a Robust DP System:

1) Independence
2) Segregation
3) Autonomy
4) Fault tolerance
5) Fault resistance
6) Fault ride through capability
7) Differentiation

All these technical aspects of the vessel DP system shall have been addressed and analyzed in the vessel DP Failure Mode and Effect Analysis (FMEA) and proven by performing the related DP FMEA proving trials.

A DP FMEA is a mandatory document to be submitted to the Classification Society before obtaining the related DP Class Notation. The DP FMEA aims to establish the effects of failures of hardware components, stating if the effects of these failures exceed the Worst Case Failure Design Intent established for the vessel, defeating the redundancy concept of the DP system.

The DP FMEA proving trials aim to prove the results achieve by the DP FMEA, by simulating on board the failure modes analysed during the desktop based design review.

It is worth emphasising that a DP FMEA is often limited such that it fulfils the requirements given by the specific Classification Society the vessel is classed with. As previously mentioned, these requirements may significantly differ from one Classification Society to another. Moreover, DP rules are being continually updated to improve their technical content, as the industry gathers more experience and knowledge. In this regard, the rules of some Classification Societies present dramatic changes from DP rules issued before and after 2013, as they introduce concepts as "fault transfer" or "fault ride through capability", which until recently have not be accurately defined in the offshore industry. It is therefore reasonable to assume that many vessels are currently being operated with obsolete and outdated DP FMEA.

3.1.2 DP operations manual

Another aspect to be highlighted concerning Classification Societies' rules is that, in general, they don't make distinctions on the particular industrial mission the vessel is going to perform.

When the industrial mission of the vessel is reviewed, the focus should mainly be in specific sets of Positioning Reference Systems and specific control modes of the DP Control System that will be used and selected.

Position reference systems should be selected with due consideration to operational requirements, both with regard to restrictions caused by the manner of deployment and expected performance in working situations [2]. Guidance on the set or reference system to be used for different operations is given in MTS guidelines "DP operations guidance".

DP control systems should be equipped with suitable DP modes and features with due consideration to operational requirements, both with regard to restrictions caused by the activity and performance criteria required to execute the activity safely and successfully [2]. A guidance on the specific DP control modes to be used for different operations is given in MTS guidelines "DP operations guidance".

All these details related to the vessel industrial mission shall be clearly specified in the DP Operations Manual that should be prepared and be specific for each DP vessel. The vessel specific DP Operations Manual is the most important operational document. The manual should contain sufficiently detailed instruction and guidance to enable the vessel to be operated safely in DP, as well as safely execute its intended activities [2].

3.1.3 DP annual trials

The last input to an ASOG process is the vessel annual DP trials.

Annual DP trials focus on proving that the DP system is fully functional and well maintained and that the redundancy concept is intact [3].

3.2 A Diagram of Risk Management Process for DP Operations

3.2.1 A Bow tie diagram provides a suitable technique for barrier based solutions to be studied, since it provides a pictorial representation of the risk assessment process, and is easily understandable by both upper management and operations groups.

3.2.2 The Bow tie diagram provides a pictorial view of the relationship between hazard, top event, threats to the hazard and related control measures to prevent the occurrence of the top event, consequence of the occurrence of the top event, and related control measures to be applied to prevent the escalation of the top event.

3.2.3 Figure 3-1 shows the typical structure of a bow tie diagram.

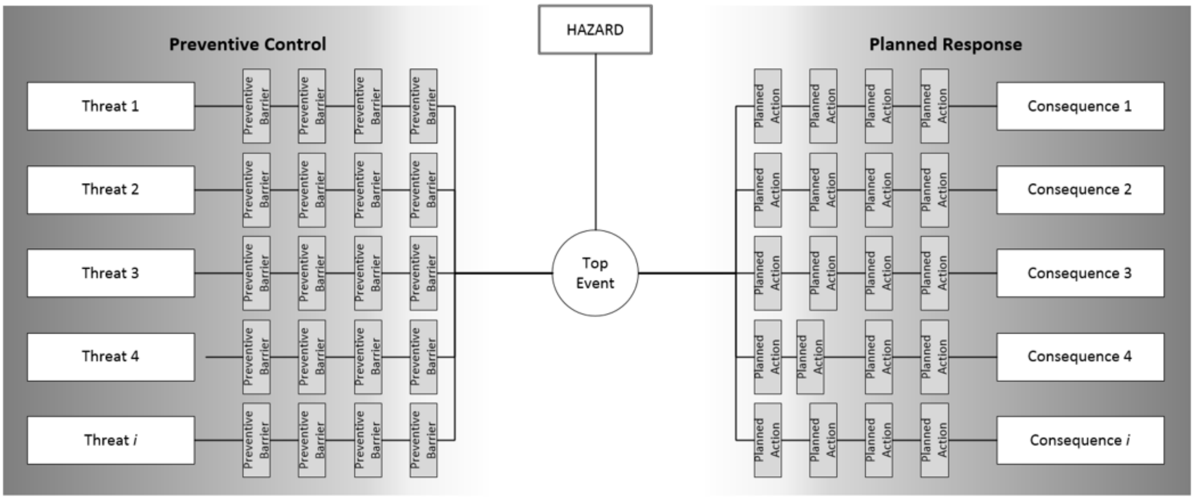

Figure 3-1 Structure of a Bow-Tie diagram

3.2.4 *Loss of position* is the top event that must be prevented when performing DP operation. This is achieved by putting in place barriers to the threats that might cause drive-off or drift-off of the vessel.

3.2.5 It is possible to categorise six different type of threats:

3.2.6 **Intrinsic failure modes**: failure modes affecting components comprised in the DP system.

3.2.7 **Extrinsic failure modes**: failure modes affecting components not forming part of the DP system, but that will have effects on the DP system itself. A typical example is the Emergency Shutdown (ESD) System. This system is not part of the DP system; however, if the design philosophy of the ESD system is not aligned to the redundancy concept of the vessel, its activation might deselect engines or thrusters in a manner to exceed the WCFDI, with consequent loss of position.

3.2.8 **Acts of maloperation**: single act of maloperation if such an act is reasonably foreseeable.

3.2.9 **Poor ergonomics**: technical faults are triggers that sometimes require operator intervention to prevent escalation; poor ergonomics might impair the operator from a prompt intervention.

3.2.10 **Specific operational deficiencies**: wrong choice of selected positioning reference system or DP control modes might lead to loss of position.

3.2.11 **Poor maintenance**: poor maintenance of the DP system might deteriorate the performance of components, decreasing the station keeping capability of the vessel or even defeating its redundancy concept.

3.2.12 Failure modes, acts of inadvertent operations and ergonomics shall be addressed in the DP FMEA, together with related barriers the design of DP system has in place to avoid exceeding of the WCFDI, which would have the consequent result of loss of position (i.e. reaching the tops event).

3.2.13 Operational requirements shall be addressed in the DP operational manual.

3.2.14 Annual DP trials reports demonstrate that the DP system has been well maintained and is in good working conditions.

3.2.15 Figure 3-2 shows the threats for DP operations, implemented in the bow tie diagram.

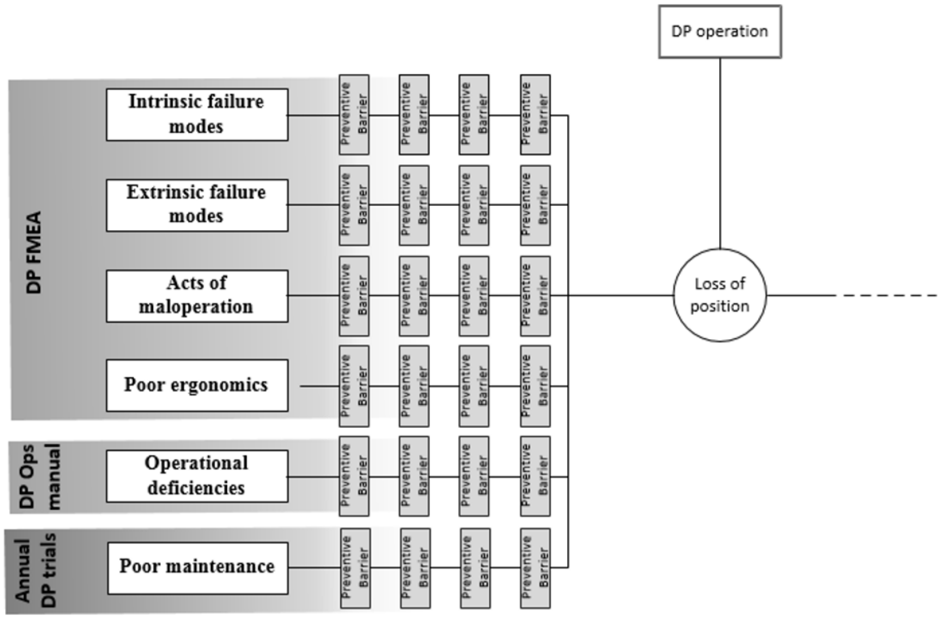

Figure 3-2 Threats to loss of position

3.2.16 Moving to the right part of the bow tie diagram, for each different DP operation, the Time To Terminate and the Consequences of loss of position shall be assessed.

3.2.17 Typically, four different kinds of consequences are assessed:

- **Consequences on people**: consequences of loss of position in terms of health effects, injuries, disabilities or fatalities
- **Consequences on environment**: consequences of loss of position in terms of spill to the sea, quantified in number of barrels (bbls)
- **Consequences on assets**: consequences of loss of position in terms of costs
- **Consequences on reputation**: consequences of loss of position in terms of corporate image and relationships

3.2.18 Each of these consequences shall be given a severity level, which shall consider impact on people, environment, assets and reputation. For each DP operation, depending on the severity level of the consequence of loss of position, it can be assessed if the vessel shall operate in CAM or in TAM.

3.2.19 Figure 3-3 shows the consequences of loss of position, implemented in the bow tie diagram.

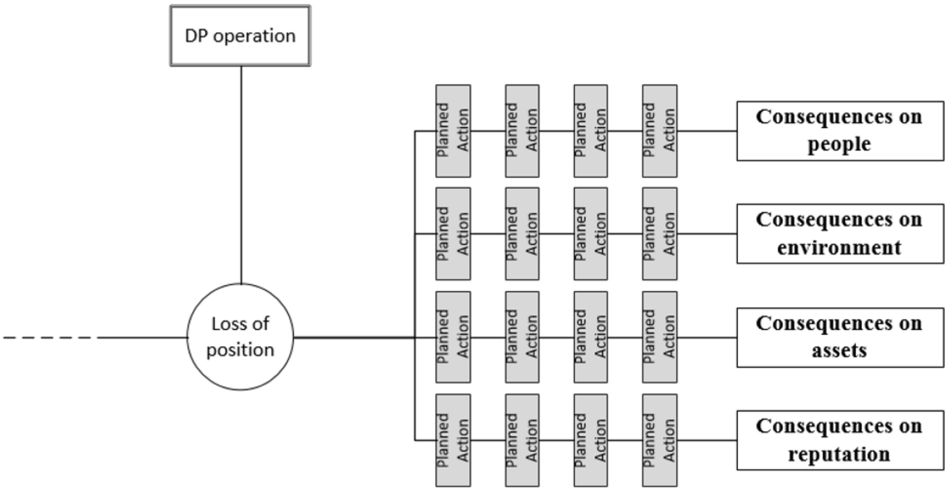

Figure 3-3 Consequences of loss of position

3.3 Gap Analysis

3.3.1 In order to outline the risk based approach at the basis of the formulation of good ASOG, it is necessary to introduce another tool, known as "Swiss cheese model".

3.3.2 In the Swiss cheese model, an organisation's 'defences' against failure are modelled as a series of barriers, represented as slices of cheese (see Figure 3-4). The holes in the slices represent weaknesses in individual parts of the system which are continuously varying in size and position across the slices.

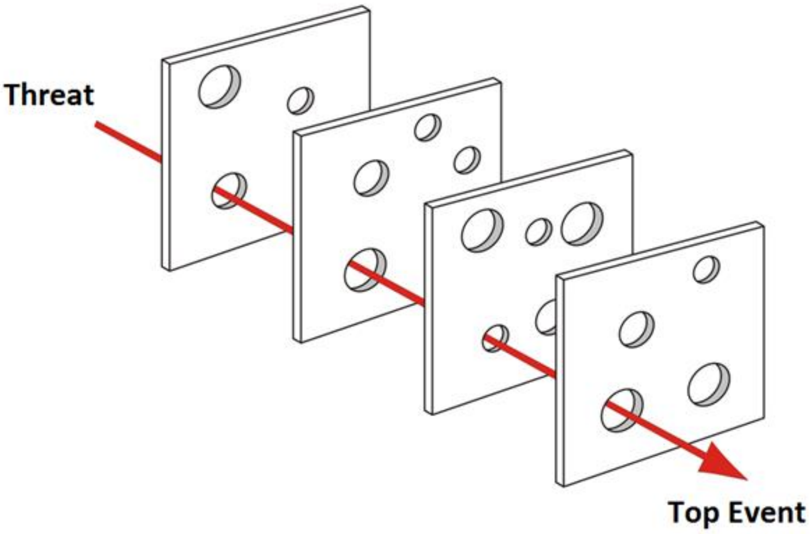

Figure 3-4 The Swiss cheese model

3.3.3 The system produces failures when a hole in each slice momentarily aligns, permitting accident opportunity, so that the effect of a threat passes through holes in all of the slices, leading to the happening of the top event.

3.3.4 Before developing an ASOG, it is necessary to identify the "holes in the slices"; this activity is known as *Gap Analysis* and is applied to the documents that asses the preventive barriers to the top event: DP FMEA, DP FMEA proving trials, DP Operation Manual and DP annual trials.

3.3.5 Standard tools available today to the industry are the following MTS guidelines:

- MTS Techop ODP 04: FMEA gap analysis
- MTS Techop ODP 01: Proving trials gap analysis
- MTS Techop ODP 08: Annual DP trials and gap analysis
- MTS Techop ODP 05: DP operations manual gap analysis

3.3.6 Once the gaps in the DP system analysis are identified, it is necessary to understand if those gaps are actually present in the DP system installation. In other words, poor DP system analysis does not necessarily mean that the design of the DP system presents the same deficiencies.

3.3.7 If deficiencies are confirmed, they have to be either eliminated or bypassed. Modification to the actual design and installation is not always feasible, due to cost and time constrain. Whenever design modifications are not implementable, specific requirements in terms of setup or operational constrains can be added to the definition of the DP set up for CAM of operation.

3.4 CAM and ASOG tables

3.4.1 Once the gap analysis is concluded, it is possible to complete the tables related to CAM and ASOG. The tables use the colours code specified in IMCA M220:

- GREEN: Continue normal operations
- BLUE: Notify Master, Chief Engineer, Offshore Facility and Clients Representative
- YELLOW: Notify Master, Chief Engineer, Offshore Facility and Clients Representative and Prepare Vessel to enable cessation of operations and movement to safe location
- RED: Notify Master, Chief Engineer, Offshore Facility and Clients Representative and Initiate emergency procedure

3.4.2 YELLOW and RED events shall be treated as a DP incident and are therefore reported; RED incidents shall trigger an investigation.

3.4.3 The DP system setup for CAM shall follow what is specified in the DP FMEA and in the DP Operations Manual. Additionally, specific setup conditions and/or operational constrains derived from the gap analysis needed to mitigate against the gaps identified in the design of the DP system shall be implemented.

3.4.4 Before commencing operations, if any discrepancy between the DP setup specified in the CAM and the actual conditions of the vessel is noted, a BLUE status is triggered. The Master, Chief Engineer, Offshore Facility and Clients Representative shall assess the risks related to performing DP operation in the actual conditions and decide if it is best to start operations or resign.

3.4.5 The ASOG shall reflect the DP FMEA and the DP Operations Manual, with the additional conditions deriving from the gap analysis.

3.4.6 Failure modes, deteriorating weather conditions or reduced visibility shall trigger a YELLOW status if their effects will be equal to Worst Case Failure conditions (i.e. the DP system is not any more fault tolerant); in any other case a BLUE status is triggered.

3.4.7 CAM and ASOG shall be discussed, validated and agreed between all the relevant stakeholders, possibly on-board the vessel during the planning stage of the specific DP operation.

3.5 CAM and ASOG Methodology Flow Chart

3.5.1 Figure 7 depicts the methodology proposed by this paper in the form of a flow chart.

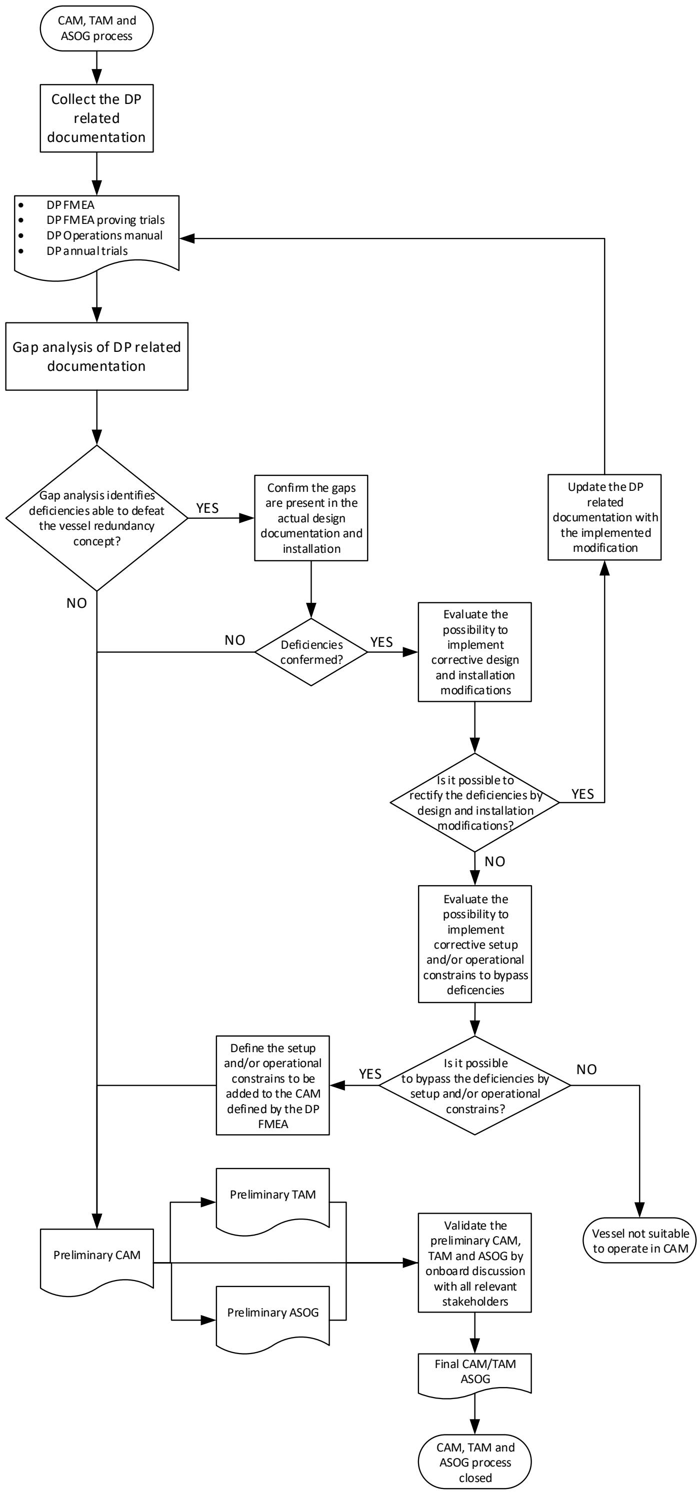

Figure 3-5 CAM, TAM and ASOG methodology

4. CONCLUDING REMARKS

4.1.1 In this paper, a methodology for the preparation of Critical Activity Mode and Activity Specific Operating Guidelines tables has been presented. This methodology can be applied to all the different types of DP systems and industrial missions.

4.1.2 What could be more important, is that this methodology requires all the relevant stakeholders to move away from a prescriptive attitude when conducting DP Operations, such that DP operations are instead planned and performed using a risk based approach. Thus, transforming the role of the parties involved from passive executors of rules and standards to active owners of the hazard they are aware of – to become conscious of the consequences that their actions might have.

5. REFERENCES

[1] Marine Technology Society - DP vessel Design Philosophy Guidelines (October 2011)

[2] Marine Technology Society - DP operations guidance (September 2012)

[3] International Maritime Contractors Association M190 - Guidelines for developing and

Conducting Annual DP trials on DP vessels (December 2012)

[4] International Maritime Contractors Association M220 - Guidance on Operational Activity Planning (November 2012)

[5] American Bureau of Shipping – Guide for Dynamic Positioning Systems (November 2013)