TECHNICAL AND OPERATIONAL GUIDANCE (TECHOP)

TECHOP_GEN_03 (CONDUCTING EFFECTIVE AND COMPREHENSIVE DP INCIDENT INVESTIGATIONS)

DEC 2017

DISCLAIMER AND LIMITATION OF LIABILITY

SUMMARY

This MTS TECHOP provides general guidance on conducting effective and comprehensive DP Incident Investigations. A conscious decision was made not to address DP Incident Reporting in this document. Nothing in this document is intended to negate the need to report incidents per applicable requirements (eg. Statutory, Company Policy, Charterer's Requirements).

The MTS DP Committee believes that Learnings From Incidents (LFIs) should be a clear outcome of DP incident reporting and any subsequent analysis or investigations. Incident investigations should consciously incorporate generation of the LFI amongst the primary objectives. Such LFIs should be promulgated across industry. The format of the LFI and its promulgations should be such that they can be perused in a proactive manner to address and mitigate against the potential for such incidents.

Vessel owners should be able to incorporate processes within their own management systems to leverage these LFIs to demonstrate a proactive approach to address DP station keeping risks by effective mitigations.

The guidance provided in this TECHOP follows the proven approach of addressing management of DP Operations through a focus on Design, Operations, People and Process.

CONTENTS

ABBREVIATIONS

CAM	Critical Activity Mode
ESD	Emergency Shut Down
F&G	Fire & Gas
FMEA	Failure Modes Effects Analysis
HEMP	Hazard Effects Management Processes
LFI	Learning from Incidents
OEM	Original Equipment Manufacturer
TAM	Task Appropriate Mode
USCG	United States Coast Guard

1 INTRODUCTION - TECHOP (TECHNICAL AND OPERATIONAL GUIDANCE)

1.1 PREAMBLE

1.1.1 Guidance documents on DP, Design and Operations, were published by the MTS DP Technical Committee in 2011 and 2010, subsequent engagement has occurred with:

- Classification Societies (DNV, ABS).
- United States Coast Guard (USCG).
- Marine Safety Forum (MSF).

1.1.2 Feedback was also received through the comments section provided in the MTS DP Technical Committee Web Site.

1.1.3 It became apparent that a mechanism needed to be developed and implemented to address the following in a pragmatic manner.

- Feedback provided by the various stakeholders.
- Additional information and guidance that the MTS DP Technical Committee wished to provide.
- Means to facilitate revisions to the documents and communication of the same to the various stakeholders.

1.1.4 The use of Technical and Operations Guidance Notes (TECHOP) was deemed to be a suitable vehicle to address the above. These TECHOP notes will be in two categories.

- TECHOP_ODP.
- TECHOP_GEN.

1.2 TECHOP_ODP

1.2.1 Technical Guidance Notes provided to address guidance contained within the Operations, Design or People documents will be contained within this category.

1.2.2 The TECHOP will be identified by the following:

TECHOP_ODP_ SNO_ CATEGORY (DESIGN (D), OPERATIONS (O), PEOPLE (P))

- EG 1 TECHOP_ODP_01_(O)_(HIGH LEVEL PHILOSOPHY).
- EG 2 TECHOP_ODP_02_(D)_(BLACKOUT RECOVERY).

1.3 TECHOP_GEN

1.3.1 MTS DP TECHNICAL COMMITTEE intends to publish topical white papers. These topical white papers will be identified by the following:

TECHOP_GEN_SNO_DESCRIPTION.

- EG 1 TECHOP_GEN_01-WHITE PAPER ON DP INCIDENTS.
- EG 2 TECHOP_GEN_02-WHITE PAPER ON ANNUAL DP TRIALS.

1.4 MTS DP GUIDANCE REVISION METHODOLOGY

1.4.1 TECHOPs as described above will be published as relevant and appropriate. These TECHOPs will be written in a manner that will facilitate them to be used as standalone documents.

1.4.2 Subsequent revisions of the MTS Guidance documents will review the published TECHOPs and incorporate as appropriate.

1.4.3 Communications with stakeholders will be established as appropriate to ensure that they are notified of intended revisions. Stakeholders will be provided with the opportunity to participate in the review process and invited to be part of the review team as appropriate.

2 SCOPE AND IMPACT OF THIS TECHOP

2.1 PREAMBLE

2.1.1 This TECHOP provides general high level guidance on DP incident investigations. It is intended to be utilized by personnel responsible for managing delivery of incident free DP operations (e.g. Vessel Owners, Charterers, Trade Organizations, Forums etc.) and specialist consulting organizations providing services in relation to management of DP Operations when called upon to investigate DP incidents.

2.1.2 Lessons learned from review of loss of position incidents have been summarized within the guidance documents published by the MTS DP Committee (Design, Operations and Development of People and various TECHOPS).

2.1.3 During the course of development of the MTS DP Guidance documents, loss of position incidents were reviewed to glean learnings for incorporation. It became apparent that it was not unusual to attribute operator error as the causal factor for incidents. There was a failure to recognize that there were elements of Design, Operations and Process as causal and contributory factors.

2.1.4 In several instances, this failure to recognize contributions of design, operations and process to the incident precluded effective mitigations, leading to repeat incidents which could have been avoided.

2.1.5 It was concluded that there were very few instances of DP incidents where operator error alone was the single causal factor. DP incidents typically had contributions from the four main themes of Design, Operations, People and Process.

2.1.6 It was further concluded that an effective and comprehensive DP incident investigation was one which delivered an LFI that identified those elements of Design, Operations, Process and People that contributed to the incident. Once identified, mitigations could be put in place to address these elements.

2.1.7 It was also recognized that the implementation of these mitigations could potentially be in three distinct time horizons – short, medium and long term. Short and medium term mitigations would more than likely be procedural in nature and perhaps adaption of proven approaches, while the long term mitigations could involve identification of opportunities for improvement with a view to ‘designing out’ the potential for such incidents.

2.1.8 Structured and comprehensive LFIs as described above were identified as a key deliverable from an effective DP incident investigation.

2.1.9 Promulgation of such LFIs across industry provides others with the opportunity to proactively assess and implement applicable recommendations on their own vessels. This is viewed as an effective way to minimize the potential for repeat incidents.

2.2 SCOPE

2.2.1 MTS TECHOP_GEN_XXX_(CONDUCTING EFFECTIVE AND COMPREHENSIVE DP INCIDENT INVESTIGATIONS) provides information on a suggested:

- Format of reporting a DP incident and capturing relevant information
- Method to structure DP Incident Investigations.
- Structure for an LFI.
- Method to leverage LFIs to proactively manage and deliver Incident Free DP Operations.

2.3 FOCUS OF THIS TECHOP

2.3.1 The focus of this TECHOP is to provide a structured approach to conducting comprehensive DP incident investigations and generating LFIs while facilitating standardization and consistency.

2.3.2 This TECHOP can be used to supplement existing practices of incident reporting to deliver LFIs.

2.4 IMPACT ON PUBLISHED GUIDANCE

2.4.1 This TECHOP provides supplementary information to the existing guidance published by the MTS DP Committee but does not alter or invalidate the information contained within.

2.5 ACKNOWLEDGEMENTS

2.5.1 The DP Committee of the Marine Technology Society greatly appreciates the contribution of Kongsberg Maritime, Lloyds Energy and USCG, serving members of the subcommittee on Guidance and Standards who championed and guided the development of this TECHOP.

3 CASE FOR ACTION

3.1 REPEAT INCIDENTS

3.1.1 A review of reported and known incidents indicates that a significant number were of a repeat nature. The causal and contributory factors identified had manifested themselves in earlier incidents.

3.1.2 A holistic view of the above phenomenon revealed that LFIs should be one of the key outputs of an incident investigation.

3.1.3 Comprehensive incident investigations, conducted in a structured manner, are essential for generating a quality LFI for promulgation across industry.

3.1.4 The structure provided in this TECHOP is one method of conducting such a comprehensive incident investigation.

3.2 PROACTIVE MEASURE

3.2.1 This TECHOP also provides guidance on how the LFIs generated using this process could be used proactively to reduce the potential for repeat incidents. Further details are provided in Section 6.

3.3 DEMONSTRATING MEANS OF CONTROLLING RISK

3.3.1 Implementing the guidance provided in this TECHOP as part of their own processes, provides stakeholders with a means to demonstrate diligence in identifying, managing and mitigating DP station keeping risk.

4 STRUCTURE FOR A COMPREHENSIVE DP INCIDENT INVESTIGATION

4.1 GENERAL

4.1.1 It is acknowledged that several proven processes to investigate incidents exist. It is not the intent of this TECHOP to negate the use of such processes.

4.1.2 This TECHOP provides a guided approach to conducting comprehensive DP incident investigations in a structured manner which strives to achieve the objectives of standardization and consistency and delivers an LFI as part of the output.

4.1.3 The fish bone diagram was developed by Dr Kaoru Ishikawa in 1982 as an aid to root cause analysis. It has been adapted in this TECHOP as a means to achieve a structured approach to address the elements of design, operations, people and process while investigating DP incidents.

4.1.4 The composition of the incident investigation team needs to be given careful consideration. The DP incident investigation team should have members of the DP operation team, members of the vessel's technical team, and may have members of the shore based engineering or management team, and depending on the specific incident may also need to be supplemented with equipment vendor team members.

4.2 EXPLANATION OF THE FISH BONE STRUCTURE

4.2.1 The fish bone architecture has been leveraged to provide the structure to conduct a comprehensive DP incident investigation.

4.2.2 The fish bone structure shown in Figure 4-1 lends itself to provide a guided approach to the investigation as well as a means to succinctly summarize the output of the investigation.

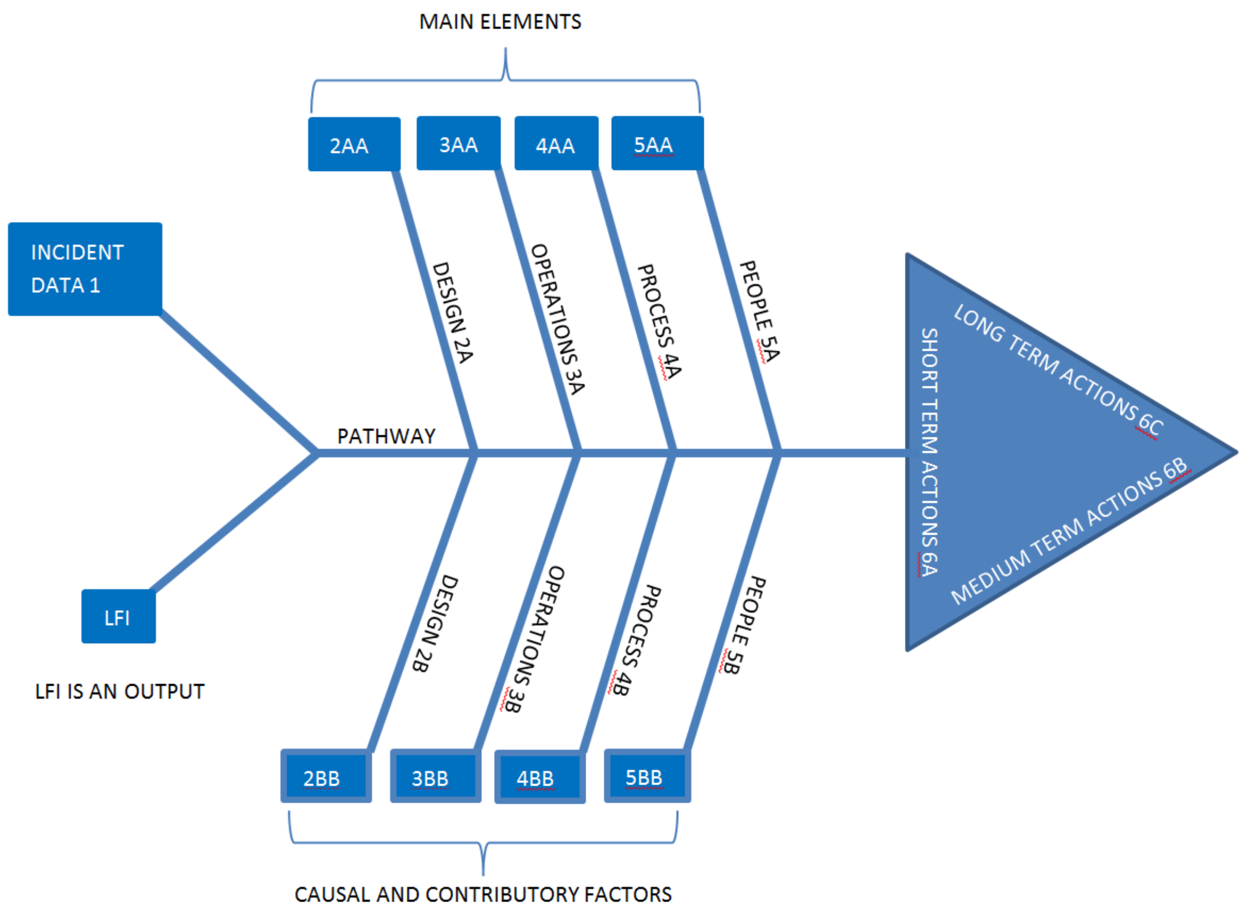

Figure 4-1 FISH BONE DIAGRAM

4.2.3 The anatomy of the fish bone includes:

- Top of Tail (Reported Incident)
- Main Bone (Pathway)
- Top Sub Bone (Four In Number) Design, Operations, Process, People
- Top Sub Sub Bone (elements within Design, Operations, Process, People. (Threads to be pulled on)
- Bottom Sub Bone (Results of investigation, Four in Number, Design, Operations Process & People)
- Bottom Sub Sub Bone (Causal and contributory factors to the incident)
- Head of Fish Bone Structure - Triangle
  - Vertical side – Short Term Actions
  - Top - Medium Term Actions
  - Bottom - Long Term Action
- Bottom of Tail (LFI)- Note LFI is an output of the process- not an input/

5 DETAIL OF THE FISH BONE STRUCTURE

5.1 THE UPPER TAIL SECTION- THE INCIDENT

5.1.1 The incident investigation team should be given the pertinent information about the incident. Appendix 1 contains an example list of pertinent information that should be gathered as part of an incident report.

Note:- The information in Appendix 1 has been provided as an example and may be used to supplement or further develop suitable incident report templates appropriate for the vessel.

5.1.2 Data gathering and preservation of the data is crucial to an effective incident investigation. Data should be captured and preserved to cover a period of the incident as well as for a period of a minimum of up to 30 minutes before the incident.

- Data includes screen shots, record of alarms, alarm printouts,
- Sources of data include DP Operator stations, history stations, data loggers, PMS/VMS systems, Position Reference Sensors, Field stations, local controls for drives, thrusters, engines
- Attention is drawn to the limited data retention capability provided in most DP related equipment. Data is logged to a buffer storage and as the buffer gets full, older data is over written. It is imperative that relevant data covering a minimum period starting from 30 minutes prior to the event is captured. It should also be recognized that such data stored in the buffer may be lost if the equipment is reset.
- A data capture and retention strategy along with the associated procedures to the level of detail required should be developed and implemented on all DP vessels
- Vendor support may be required to ensure that the procedures are appropriate for the equipment on the vessel.
- Crew training and familiarization should include a specific section on data capture and data retention for relevant personnel with a role for the conduct of DP operations on a vessel.
- Physical evidence or damage reports also provide data.

5.1.3 Effective incident investigations rely on the ability to correlate often seemingly unconnected events. To establish correlation, time stamps should be synchronized across a multitude of equipment. Divergence of time stamps should be monitored and addressed.

Note: Time stamps on distributed data acquisition systems may be time stamped at the process station or at a central location. In the case of the latter (central location) time stamps can be unreliable during an event because of congestion of the network due to volume of alarms. Time stamps need to have sufficient time resolution in order to be useful

5.1.4 It is important to record details of the activities that were being undertaken before the incident, even if they are appear to be unrelated. Examples of such activities are

- Inspection Repair Maintenance
- SIMOPS

5.1.5 There have been numerous instances where failures have manifested themselves soon after an inspection repair maintenance activity.

5.1.6 Incidents have manifested themselves when seemingly unrelated activities were being conducted (e.g. SIMOPs). The trigger points have been the manifestation of some functionality, usually caused by an inadvertent erroneous operator configurable setting. The propagation path for such incidents has usually been facilitated by a lack of information/visibility and or guidance in the operations manual.

5.1.7 The information provided following an incident should be clearly identified and labelled as factual, opinion, deduction etc and the basis of this categorization should be substantiated by supporting documentation.

5.1.8 Appendix 1 contains a table that may be used as a tool to gather pertinent information to report incidents with a view to facilitate incident investigations. The tool could also be used to compare existing formats/forms used for incident reporting to identify opportunities for improvement.

5.2 THE PATHWAY

5.2.1 The pathway is metaphorical for the steps that are undertaken to systematically review each element of the four identified elements, Design Operations, Process and People.

5.2.2 To the left of the pathway is what we look at (characterized as sub elements) in a systematic manner inside each of these elements (What was referred to as the top sub sub bone in the figure of the fish bone structure).

5.2.3 To the right of the pathway is what was found to be causal and contributory factors for each of these elements, and is captured in the boxes (referred to as the bottom sub sub bone in the structure.

5.2.4 As a visualization aid, the pathway should be seen as the sieve through which the identified causal and contributory factors of the incident pass through to fill the elements in the lower half of the fish bone structure. These are the factors that need to be addressed to prevent recurrence of such incidents.

5.3 THE UPPER HALF

5.3.1 The upper half contains the four main elements, Design, Operations, Process and People. This is referred to as the top sub bone in the fish bone structure.

5.3.2 Within each of these elements (or sub bones), there are multiple sub elements (sub sub bones) which reflects the various focus areas that need to be specifically addressed during the incident investigation. The effectiveness of the investigation is wholly dependent upon the diligence and discipline of the participants to review the pertinence of each of the focus areas. Diligence and discipline can be documented by positive verification that the identified focus areas have been reviewed even if there were no observations or findings in that particular focus area.

5.3.3 Incident investigations should systematically work through the sub elements and document the same. Positive verification should be provided that all the sub elements have been reviewed.

5.4 DESIGN

5.4.1 This element is depicted as item 2A in the fish bone structure.

5.4.2 The seven pillars (autonomy, Independence, segregation, differentiation, fault tolerance, fault resistance and fault ride through) that have been identified in the MTS DP Design Philosophy document should be leveraged during the conduct of the DP incident investigation to identify pertinent design related threads that need to be pulled on to uncover causal and contributory factors to the incident.

5.4.3 Cross connections between redundant groups are a common source of fault propagation path leading to incidents. Diligence should be exercised to uncover and analyse such cross connections.

5.4.4 Personnel engaged in investigations should be made aware of the potential for hidden or not intuitively obvious cross connections across redundant groups. The need to consciously and actively look for such insidious fault propagation paths should be emphasized. The incident investigation opportunity should be leveraged to look beyond the immediate and obvious failed equipment by evaluating adjacent equipment and or interfaces with the failed equipment to identify potential fault propagation paths and mitigations. For example, revelation of a hidden fault propagation path introduced by commonality and or cross connections between redundant equipment groups in the generators should prompt a review of the distribution system with a view to identifying similar commonalities or cross connections in that system.

5.4.5 In addition to the seven pillars, attention needs to be focused on ergonomics and configuration errors, external interfaces, commonality as potential causal and contributory factors.

5.4.6 Hidden failures: The potential for hidden failures to defeat redundancy and fault tolerance should be considered when conducting a DP incident investigation.

5.4.7 .Hidden failure is the term used to describe undetected, pre-existing faults in redundant systems which have the potential to defeat the redundancy concept when a subsequent fault occurs.

5.4.8 Hidden failures may manifest themselves in several ways including reduced performance in active redundancy, failure of standby equipment and failure of protective functions to operate on demand. The possibility that a system was already in a partially failed condition before the incident occurred should be considered.

5.4.9 Alarms and periodic testing are accepted methods of revealing hidden failures. Learnings from incidents attributed to hidden failures as a causal or contributory factor should address such periodic testing or implementation of alarm capability.

5.4.10 These sub elements have been summarized under the element “Design” and depicted as 2AA in the fish bone structure.

- Autonomy
- Independence
- Segregation
- Differentiation
- Fault tolerance
- Fault Resistance
- Fault ride through
- Ergonomics
- Configurations/Configurable Settings
- Commonality
- External Interfaces
- Potential for Hidden Failures, Alarm capability and alarm monitoring.

Note: Where Cross Connections are identified, additional emphasis should be placed on Fault Tolerance, Fault resistance, Fault ride through and Protective functions.

5.4.11 Protective functions are required to ensure redundant systems are ‘fail-safe’ and also to isolate fault propagation paths between redundant groups created by cross connections. Not all protective functions are fully selective and therefore may not contribute to the fault tolerance of the system. Potential design flaws associated with protection systems should be considered in incident investigations.

5.4.12 The effectiveness of the investigation is wholly dependent upon the diligence and discipline in reviewing pertinence of each of the focus areas in relation to the equipment that was associated with the DP incident. Incident investigation documentation should contain positive verification that the identified focus areas have been reviewed even if there were no observations or findings in that particular focus area.

5.4.13 The tool in Appendix 2 illustrates the approach identified above.

5.5 OPERATIONS

5.5.1 This element is depicted as 3A in the fish bone structure.

5.5.2 The MTS DP Committee Guidance documents (Design and Operations) draw attention to the need to supplement the requirements of DP Equipment Class with a focus on the Industrial Mission.

5.5.3 The guidance documents have introduced the concepts of configuring the vessel in either the critical activity mode (CAM) or task appropriate mode (TAM). The choice of mode that the vessel is configured in CAM or TAM, to conduct the operation is usually made taking into account the consequences of a loss position.

5.5.4 The configuration includes a determination of the position references sensors required to be able to undertake the specific activity and clearly outlining limitations if any.

5.5.5 The Industrial Mission that is being undertaken may require special modes, features or functionality within the DP control system to facilitate the execution of the activity, and maximizing predictable outcomes - ie delivery of incident free operations. Such special modes and features may require operator configurable settings. Errors in operator configurable settings can lead to unpredictable and undesirable outcomes.

5.5.6 All DP Operations should be undertaken within the identified and validated post failure capability of the vessels. The default criteria for establishing post failure capability should be the worst case failure and based on the equipment that will remain functional and capable of operating to the performance specifications after the occurrence of the worst case failure.

- A conscious decision may be made to use alternate criteria for post failure DP capability, with a view to achieving higher operability limits.
- Alternate failure criteria should only be used with the explicit acknowledgement and acceptance that the potential for the occurrence of a loss of position exists if a failure effect occurs that exceeds the severity of the failure effect that was used to establish the higher operability limit.
- Such alternate failure criteria should not be used for operations identified as requiring CAM. Risk assessments should unambiguously identify and document the potential for a loss of position and accept the associated consequences. Due diligence should be exercised in providing mitigations against such an occurrence even if operating in TAM.

5.5.7 DP station keeping equipment installed on a DP vessel is usually there to provide active redundancy and should not be treated as installed spares. Post failure capability should be established on equipment that is operational and being used, not on the basis of what is installed on the vessel.

5.5.8 Inspection, Repair and Maintenance (IRM) activities may render equipment temporarily unavailable for use. Post failure capability should be reassessed if equipment is not available and the vessel should operate within the reassessed post failure capability. The default condition should be not to carry out IRM activities when conducting operations requiring CAM.

5.5.9 Protective Functions (defending protective functions and restoration of same if disabled for IRM)

Protective functions can play a significant role in ensuring systems intended to provide redundancy are independent of each other and fail-safe. Protective functions can be applied for many different reasons including, the safety of personnel and limiting the potential for damage to equipment.

In the case of fault tolerant system based on redundancy they may be provided to isolate cross connections between otherwise separate and independent systems. In other cases their role is to ensure systems fail safe.

Disabled or faulty protective functions can compound the effects of any subsequent failure leading to effects of a much greater severity.

5.5.10 Reinstatement of equipment post intrusive maintenance or post failure comes with an increase in vulnerability to the potential for a subsequent failure. Due consideration should be given to this potential and additional mitigations should be put in place. Examples of such mitigations are

- Choosing an optimum time to reinstate equipment
- Suspending operations and moving out of the 500 m zone
- Bringing vessel activities a safe positon, configuring vessel in CAM prior to reinstating equipment
- Imposing positioning standby to bring personnel to a heightened state of awareness and in position to prevent escalation of the consequences of a failure

5.5.11 There has been a growing tendency to provide Operator Configurable Settings on DP Equipment. This has been done usually with a view to

- Provide optimization of performance
- Provide diagnostic capability (IRM focus)

5.5.12 Erroneous operator configurable settings have been the source of a considerable number of incidents. Controls should be in place to prevent the potential for such errors to be introduced.

5.5.13 These sub elements have been summarized under the element “Operations” and depicted as 3AA in the fish bone structure.

- CAM/TAM Considerations (Choice of configuration vessel is operating in)
- CAM/TAM Validation (Validation that vessel is operating in identified configuration)

- Position reference sensors (eg. Position reference sensor are suitable for the job and configured accordingly, choice of absolute and relative position reference sensor, acoustics rated for water depth, redundancy requirements in principle, Configurable settings)
- Modes and Features (Vessel was being operated in the appropriate mode (eg, Auto position, Follow target etc)
- Industrial Mission Specific Modes and Features (e.g. External Force Compensation, Heavy Lift Mode, Mode of inputting external forces,)
- Management of External Interfaces (eg ESD systems, Fire and Gas Safety Shut down systems, tensioner inputs)
- Post Failure Capability
- IRM and reassessment of post failure capability
- Protective functions and restoration of same if disabled for IRM.
- Reinstatement of Equipment post Failure
- Automatic change overs/automatic reinstatement of failed equipment

5.5.14 The tool in Appendix 2 illustrates the approach identified above.

5.6 PROCESS

5.6.1 This element is depicted as 4A in the fish bone structure.

5.6.2 Process, for the purpose of this TECHOP on incident investigation, encompasses the following three main areas:

- Verification and Validation
- Hazard Recognition
- Controls

Each of these areas are further discussed herein.

Note: Incident investigations should systematically address the sub elements listed below and identify relevant causal and contributory factors (depicted as 4AA in the fish bone structure). Positive verification of same should be documented in the output of the incident investigation.

5.6.3 Verification and Validation as discussed herein refers to the assurance activities that have been put in place to identify gaps of existing documents/processes against a defined performance standard. Measurement against the performance standard should be accomplished by objective methods to the extent achievable. Assurance in this context is broad and encompasses self, independent third party, as well as audits and inspections by regulatory/statutory or client stakeholders,

Key Documents / Processes / Actions to be Verified Validated are:

- DP FMEA’s (eg minimum performance standard DNV RP D102)
- FMEA AND PROVING TRIALS GAP ANALYSIS (eg objective evaluation - MTS published gap analysis tool)
- Annual Trials (eg Minimum performance standard IMCA M 190/M 191)
- Annual Trials Gap Analysis (eg objective evaluation - MTS DP Committee published gap analysis tools)

- DP Operations Manual (eg Minimum performance standard – MTS DP Committee guidance document)
- DP Operations Manual Gap Analysis (eg objective evaluation – MTS DP Committee published gap analysis tool)
- Documented evidence of closure and closure path of identified gaps
- Closure of findings and observations from audits
- Implementation of Applicable Technical Guidance from Vendors
- Implementation of Actions arising from Lessons learned
  - Lessons learned within Company
  - Lessons learned within Industry
- Adherence to Original Equipment Manufacturer's Recommendation
  - IRM processes
  - Performance testing
  - Post failure testing
  - Testing following Extensive intrusive maintenance

5.6.4 Hazard recognition as referenced herein is the application of Hazards and Effects Management Processes (HEMP) to manage the risks and associated consequences due to a loss of position incident on a DP vessel.

5.6.5 This requires a thorough understanding of the activities associated with the Industrial Mission and the consequences of a loss of position. The consequences can span the spectrum of loss of life, damage to the environment, damage to the asset (exposure to process safety events) at one end to non-productive time at the other.

5.6.6 HEMP processes are to be utilized to determine whether the vessel should be configured for CAM or TAM. Usually these activities should be pre-determined and listed out. It is acknowledged that the dynamic nature of the execution may result in the potential that not all activities may be predetermined. The discipline to diligently apply the HEMP processes for such unplanned activity should be adhered to. The trigger points to initiate these HEMP processes should be unambiguously identified. The tendency to normalize deviance should be consciously guarded against.

5.6.7 Any and all means should be used to clearly define the boundary conditions for the execution of the activities associated with the industrial mission. Company expectations and instructions to the vessel management team should clearly outline that the vessel is to be operated within the defined boundary conditions. Experience levels of the crews is acknowledged and respected with the view that such experience will be used to exercise stop work authority diligently before these boundary conditions are breached. Use of experience levels to justify conscious breach of such boundaries on board a vessel, should be avoided. Consideration of the potential to breach established boundary conditions should have the validation and explicit approval from the appropriate personnel who have accountability for delivery. Such personnel are usually shore based personnel. The basis of validation and approval to breach boundary conditions should be well documented.

Effective hazard recognition and mitigations, usually for non-routine or unplanned activities during the conduct of the industrial mission, may require supplementing skills of personnel on board with specialist support. The potential need for such support should be recognized and catered to.

5.6.8 Sub elements that need to be systematically reviewed during the incident investigation are

- CAM/TAM operation of the vessel (Was the vessel being operated in the configuration appropriate for the task? - Was this identified as part of the process?)
- HEMP Processes used (If a field decision was made were the HEMP processes utilized)
- Activity (Routine or non-routine, Departure from established procedures) - Was the activity being conducted of a routine nature in relation to the Industrial mission?
- Are roles and responsibilities clearly identified?
- Hazard Recognition and Management – Was there a clear recognition of the Hazards and an appreciation for the consequences of a loss of position incident.

5.6.9 Controls as referenced herein are tools, processes or barriers that are used to enhance robustness of mitigations to prevent the potential for causal and contributory factors to manifest themselves and result in a loss of position.

Examples of such controls are:

- Requirements for permit to work (PTW),
- Tool box talks,
- Job safety analysis,
- Task risk assessments,
- Imposition of positioning standby,
- Imposition of requirements to assess impacts of IRM and reassessment of post failure capability,
- Management of permitted operations (MOPOs),
- SIMOPS,
- 500 m entry checklists,
- Harsh weather precautions and checklists,
- Checklists validating configuration of vessel in accordance with the ASOG/WSOG,
- Checklists validating appropriate values for configurable settings

5.7 PEOPLE

5.7.1 This element is depicted as 5A in the fish bone structure.

5.7.2 People or personnel element for the purpose of this TECHOP addresses a broad range of factors which have manifested themselves as causal and contributory factors for DP incidents. These factors range from the relatively tangible eg training and competence to the intangible eg cultural factors, inbuilt biases (eg personal biases and biases developed from previous experiences).

Sub elements (depicted as 5AA in the fish bone structure) that need to be systematically reviewed during incident investigation are:

- Training and competence (Are minimum training and competence requirements met?)
  - Industry standards

  - Company standards
  - Client stipulated requirements
- On Job Training (OJT)
  - Structured OJT
  - Drills and Exercises including contingency planning
- Communication of expectations (Have expectations of adherence to requirements been clearly and unambiguously communicated?). As examples
  - Adherence to ASOG / WSOG
  - Defending the redundancy concept
  - Addressing IRM
  - Notification protocols and return to work authorization following a change of DP status.
  - Looking for and guarding against biases (personal and experience based)
- Mode of communication of expectations (how is this communicated?)
  - Guided or unguided (e.g. are personnel pointed to written documents and asked to figure it out themselves? – The potential for reading comprehension issues)
  - Reflective methods- (e.g. using known incidents to develop and emphasize messages and have personnel consciously reflect how such a situation can manifest itself in their area of responsibility, what steps they are going to take to recognize such potential and mitigate against the same)
- Availability of Coaching and Mentoring
- Cultural Factors
  - Ability to exercise stop work authority
  - Ability to be comfortable with chronic unease
  - Ability to feel empowered to challenge unsafe practices
- Fatigue
  - Duty cycles
  - Impacts of ongoing activities and demands placed on individuals (eg prolonged duration of positioning standby)
  - Crew change rotations
- Pressure to perform (Pressure may be real or perceived and result in temptation to breach established boundaries)
- Performance under pressure (capability to demonstrate consistency and focus on delivery of incident free DP operations all the time irrespective of pressure induced by ongoing activities)

5.8 THE LOWER HALF

5.8.1 The lower half is a mirror image of the top of the pathway discussed in section 5.2 and contains the same four main elements, Design Operations, People and Process. These elements have been discussed in the sections 5.4, 5.5, 5.6 and 5.7.

5.8.2 Section 5.2.4 describes visualizing the pathway as a sieve where the identified causal and contributory factors of the incident pass through and are captured in the elements to the right of the pathway.

5.8.3 In essence the sub elements contained within the elements in the lower half are the identified causal and contributory factors of the incident.

5.8.4 Addressing the sub elements identified in the lower half effectively and promulgating the information widely, using the LFI as a vehicle, is expected to reduce the potential for a recurrence of such incidents.

5.9 CAUSAL AND CONTRIBUTORY FACTORS – DESIGN

5.9.1 This is depicted as 2B in the figure of the fish bone structure.

5.9.2 A systematic review of 5.4 should result in the identification of the relevant causal and contributory factors pertaining to the element of 'Design'.

5.9.3 These are captured as sub elements within 2B and are depicted as 2BB in the fish bone structure.

5.9.4 2A, 2AA, 2 B and 2 BB are to be viewed as one complete theme addressing the element of 'Design'.

5.10 CAUSAL AND CONTRIBUTORY FACTORS – OPERATIONS

5.10.1 This is depicted as item 3B in the fish bone structure.

5.10.2 A systematic review of 5.6 should result in the identification of the relevant causal and contributory factors pertaining to the main element 'Operations'.

5.10.3 These are captured as sub elements within 3B and are depicted as 3BB in the fish bone structure.

5.10.4 3A, 3AA, 3B and 3BB are to be viewed as one complete theme addressing 'Operations'.

5.11 CAUSAL AND CONTRIBUTORY FACTORS – PROCESS

5.11.1 This is depicted as 4B in the fish bone structure.

5.11.2 A systematic review of 5.7 should result in the identification of the relevant causal and contributory factors pertaining to the main element 'Process'.

5.11.3 These are captured as sub elements within 4B and are depicted as 4BB in the fish bone structure.

5.11.4 4A, 4AA, 4B and 4BB are to be viewed as one complete theme addressing 'Process'.

5.12 CAUSAL AND CONTRIBUTORY FACTORS – PEOPLE

5.12.1 This is depicted as 5B in the fish bone structure.

5.12.2 A systematic review of 5.8 should result in the identification of the relevant causal and contributory factors pertaining to the main element 'People'.

5.12.3 These are captured as sub elements within 5B and are depicted as 5BB in the fish bone structure.

5.12.4 5A, 5AA, 5B and 5BB are to be viewed as one complete theme addressing 'People'.

5.13 ACTIONS THE HEAD

5.13.1 This is depicted as the triangle in the figure of the fish bone structure.

5.13.2 The head is to be viewed as the actions that result from the incident investigation and the three sides of the triangle represent the short, medium and long term actions.

5.13.3 Short, medium and long term actions are depicted as item 6A, 6B and 6C respectively in the fish bone structure**.**

5.13.4 Technical (engineering), operational support as well as vendor support may be required to develop and / or validate actions proposed to be implemented as outcome of the incident investigation.

5.13.5 MOC processes should be adhered to.

5.14 SHORT TERM REMEDIAL ACTIONS

5.14.1 Short term remedial actions are usually actions that can be implemented immediately without taking the vessel out of service for an extended period of time.

5.14.2 These actions are usually procedural in nature or may involve replacement of components like-for-like.

5.14.3 Short term remedial actions, as a means of resolution, are usually associated with:

- Incidents which should have resulted in effects not exceeding the severity of worst case failure but manifested in a loss of position or a significant event due to existing barriers being defeated (eg incorrect configurations, failure to follow procedures etc)
- Lack of training or adherence to procedures
- Failure effects of a severity that is within the worst case failure design intent but greater than predicted.

5.15 MEDIUM TERM REMEDIAL ACTIONS

5.15.1 Medium term remedial actions are also usually actions that can be implemented without taking the vessel out of service for an extended period of time but may have to wait until solutions can be developed.

5.15.2 These actions may require engineered solutions and usually are adaptation of proven remedial actions.

5.15.3 Vendor engagement should be planned for.

5.15.4 Some level of verification and validations processes may need to be undertaken, (e.g. addendum to FMEA analysis and associated proving trials)

5.16 LONG TERM REMEDIAL ACTIONS

5.16.1 Long term remedial actions are usually necessitated as a means to ‘design out’ the potential for such incidents to be repeated. It takes into account that short term and medium term remedial actions usually incorporate procedural barriers and such procedural barriers have the potential to be defeated.

5.16.2 Defeating procedural barriers is not uncommon in industry and evidence exists in the form of repeat incidents that have been experienced for the same causal and contributory factors and often times even on the same vessel. Designing out such potential causal and contributory factors should be the preferred objective.

5.16.1 Such long term remedial actions will require engineering and potentially vendor support

5.16.2 The level of verification and validation for long term remedial actions is usually higher and may need to be addressed in an addendum to FMEA and proving trials.

5.17 THE LOWER TAIL SECTION - THE LFI

5.17.1 Generating learnings from incident should be included as one of the key objectives of any incident investigation.

5.17.2 The true value of learnings from incidents is realized when they are effective in proactively preventing the potential for similar incidents across the industry. Sharing of such learning across industry is crucial.

5.17.3 The LFI should contain the following sections:

- What happened
- Why it happened
- Additional information (if applicable)
- Lessons learned
- Recommendations

5.17.4 Teams involved in DP incident investigations should be coached and mentored on being effective in capturing and communicating learnings from incidents.

5.17.5 An example LFI is contained in Appendix 4

6 LEVERAGING LFIs

6.1 ANONYMITY

6.1.1 The desire for anonymity should be respected. The value of an LFI is not reduced by lack of identification of the vessel, or the owner/manager of the vessel.

6.1.2 Authors of LFIs, should consciously strive for anonymity and provide information with the intention of promulgating learnings across industry.

6.2 PROMULGATION

6.2.1 The value generated by an LFI is exponential to the promulgation. Conscious efforts should be made to promulgate LFIs to as broad an audience as achievable.

6.2.2 MTS DP Committee welcomes the submission of LFIs and will commit to respecting anonymity of submitters. LFIs submitted to the MTS DP committee will be posted on the website and be made available for a free download in line with other guidance documents and TECHOPs

6.2.3 A template for LFIs is contained within this TECHOP in Appendix 5. The template is also available for download from the MTS website (http://dynamic-positioning.com)

6.3 EXTRACTING VALUE FROM LFI

6.3.1 LFIs as described in this TECHOP are designed to deliver value to all stakeholders who have an interest or a role to play in the delivery of incident free DP operations. Examples of stakeholders are

- Vessel Owners / Managers
- Charterers
- Regulators

6.3.2 Vessel Owners / Managers having identified that station keeping is safety critical, should address this in their management systems with the appropriate focus. This includes having processes in place to proactively seek and apply learnings from incidents to minimize potential for incidents.

6.3.3 Vessel’s within the fleet should be screened against the backdrop of such LFIs. Positive verification should be documented, that the vessels have been assessed for application of the recommendations or learnings. Such documentation should include remedial actions implemented to proactively address learnings from LFIs. If the activity results in the conclusion that the LFI is not applicable or relevant to a vessel and or fleet, this should also be documented along with a summary of how and or why such a conclusion has been reached.

6.3.4 The above approach can be used by vessel owners to demonstrate that the safety critical nature of station keeping is recognized and managed appropriately.

6.3.5 Charterer’s contractor evaluation processes usually assess contractor’s capability to effectively manage risk during execution. Such processes usually include a focus on safety critical elements identification and management.

6.3.6 Charterer’s questionnaire for evaluation of Contractor’s executing scope, which involves use of DP vessels, should include questions which elicit an understanding of how station keeping risks are being managed and one way to achieve this is to seek to understand what activities are undertaken to implement learnings or recommendations from such LFIs.

6.3.7 Regulators with a mandate to oversee compliance with Coastal State or other regulatory requirements usually have an interest in those elements which affect safety of personnel, assets or protection of the environment. It is not unusual to impose requirements on Stakeholders conducting activities within areas under their jurisdiction to demonstrate that Safety Critical elements are being managed.

6.3.8 Vessel Owners, Lease Operators/Charterers should be able to utilize active management of such LFIs as a potential means to demonstrate effectiveness of safety management processes.

APPENDICES

APPENDIX 1 - TEMPLATE TO SUPPLEMENT INCIDENT REPORTING

SUPPLEMENT TO DP INCIDENT REPORTING					
Data gathering and preservation of the data is crucial to an effective incident investigation. Data should be captured and preserved to cover a period of the incident as well as for a period of a minimum of up to 30 minutes before the incident.		DP Equipment may have limited storage capability (buffer storage) Data should be captured at first opportunity post incident. Care should be taken to capture data prior to resetting of equipment.		Vendor specific procedures to capture information should be followed. Vendor support should be obtained as necessary.	
Time stamps to be monitored for divergence. Divergence if any to be recorded and offsets in time stamps to be documented.		IRM activities (ongoing or just completed, first use after IRM) to be documented.		Ability to distinguish parameters (color) to be considered when capturing data in print or visual media (color copies suggested)	
DATA GATHERING					
Screen shots		**Trends (T-30 min)**		**Data capture from buffer storage**	
Main DP OS screens	Y/N	**Heading**	Y/N	**DP OS**	Y/N

PRS	Y/N	**Current**	Y/N	**PRS**	Y/N
PMS	Y/N	**Position**	Y/N	**FIELD STATIONS**	Y/N
VMS	Y/N	**Thrust loads**	Y/N	**Local Controllers**	Y/N
Medium - paper	Y/N	**Wind**	Y/N	**Any other source**	Insert as applicable
Medium - electronic	Y/N	**Gen Loads**	Y/N		
ACTIVITIES BEING UNDERTAKEN		**Inspection Repair and Maintenance (IRM)**			
INDUSTRIAL MISSION	Insert text	**Ongoing IRM**	Insert Text		
		Failed Equipment	When was last IRM Carried out?		Insert Text
Task within Industrial mission	Insert text		Is this first use after IRM?		Y/N- insert text as appropriate
		Peripheral or adjacent equipment	Was IRM being carried out on any adjacent or peripheral equipment?		Y/N- insert text as appropriate

SIMOPS	Insert text		Was there any anomalies experienced on adjacent or peripheral equipment?	Y/N- insert text as appropriate

Incident Related Information

Typical incident questions	Examples of explanatory questions	Relevant information from incident
What activity of the industrial mission was being undertaken?	specific task within industrial mission (e.g. transferring riser, transferring fuel, running casing etc.	Insert Text as appropriate
What happened and what were the consequences to the Industrial Mission?	Was loss of position or heading experienced. Did it result in damage	Insert Text as appropriate
What were the observations made by the vessel staff?	Thruster was seen to ramp up, position reference sensor jumped, tensions increased, etc.	Insert Text as appropriate
What were the configurations of the incident related equipment, inclusive of DP mode, thrusters online, generators online, etc. ?	number of generators online, number of position reference systems enabled to DP, main bus bar status, etc.	Insert Text as appropriate
Were there any configuration changes carried out to the incident related equipment's?	Was any 24VDC control voltage configurations changed, standby pumps changed over, etc.	Insert Text as appropriate
What were the environmental conditions at the time of the incident?	Wave current, wind wave, heading, DP current, etc.	Insert Text as appropriate
What were the activities being undertaken prior to the incident, eg. Inspection, repair, maintenance, SIMOPs, etc.?	Any additional information to supplement information that has been captured above	Insert Text as appropriate
Operator actions during and immediately after incident?	Contingency planning, ensure no reinstatement of equipment, etc.	Insert Text as appropriate

Are screen shots, alarm printouts and alarm records captured from the incident related equipment's?	Screen shots, trend and alarms recorded as captured in the Data Gathering section.	Insert Text as appropriate
Is data logged as buffer storage in DP related equipment collected?	From DP OS, PRS, Field stations, as captured in the Data gathering section.	Insert Text as appropriate
Are the time stamps across the incident related equipment's synchronized?	Divergence between DP system, Vessel Management system, etc captured	Insert Text as appropriate
Summary of Investigations carried out post incident by on board vessel management team (VMT)		
What investigation steps were carried out		
What was focused on		
Why was this focused		
What was outcome		
What supporting information can be provided on above		
Confidence level on outcomes	High Medium	Low
Basis of confidence	Substantiate why you have high medium or low confidence	

APPENDIX 2 - COMPREHENSIVE DP INCIDENT INVESTIGATION TOOL

APPENDIX 3 - WORKED EXAMPLE OF A DP INCIDENT INVESTIGATION USING THE TOOL

APPENDIX 4 - EXAMPLE LFI

APPENDIX 5 - TEMPLATE TO GENERATE LFI

TITLE DESCRIBING THE NATURE OF THE INCIDENT

Target audience

- *Vessel Management and Operations Teams on DP Vessels*
- *DP Technical Support Function of Vessel Owners / Contractors*
- *Vessel Designers, Equipment / System Vendors,*
- *FMEA Providers*
- *Classification Society DP Approval Authorities*

What happened

Describe the incident giving details of:

- *The vessel type – eg MODU, Diving, Construction etc*
- *DP equipment class*
- *How the DP system was configured for CAM or TAM*
- *The industrial mission and activity being conducted at the time of the incident*
- *The environmental conditions*
- *The effect on the DP system, position and heading*

A DP incident can be considered to be any event where the consequences of an equipment failure, operator action or the effects of external influences were more severe than expected or predicted by the DP system FMEA.

Severity can be considered in terms of loss of equipment, station keeping capability, position and heading excursion.

Why it happened

Explain why the incident occurred with reference to:

- *The response of the DP system and redundancy concept with reference to elements of performance, protection and detection that played a role in the incident.*
- *The seven pillars – autonomy, independence, segregation, differentiation, fault resistance, fault tolerance and fault ride through.*
- *The findings of the incident investigation including causal and contributory factors with reference to elements of design, operations, process and people.*

Lessons learned

- *What should be done differently to prevent recurrence of similar incidents*

Additional Notes

- *Any other pertinent information*

Recommendations

- *Describe how the findings of the incident report were addressed by short, medium and long term measures*
- *Comment on how other stakeholders could apply the learnings from this incident so as to manage similar risks to which they may be exposed.*

MTS DP COMMITTEE THANKS THE SUBMITTER OF THIS LFI ON BEHALF OF THE DP COMMUNITY. LFIs ARE PUBLISHED ON THE MTS DP COMMITTEE WEBSITE TO PROMULGATE LEARNINGS FROM INCIDENTS WITH A VIEW TO ENABLE PROACTIVE MANAGEMENT OF SUCH VULNERABILITIES AND MINIMIZE POTENTIAL FOR DP LOSS OF POSITION INCIDENTS.