Return to session menu

DYNAMIC POSITIONING CONFERENCE
October 9-10, 2012

QUALITY ASSURANCE SESSION

Template for FMEA Quality Improvement

By Russell Hodge & Paul D Kerr

C-MAR & Independent Consultant

Abstract

A well prepared and comprehensive Dynamic Positioning (DP) Failure Mode and Effect Analysis (FMEA) is fundamental to proving DP redundancy and ensuring safe operation. The DP FMEA is generally the only document on board a ship that provides a general overview of the critical installed equipment and their interaction. As such, it provides a valuable resource for understanding vessel operation and safe position keeping. However, the thoroughness, accuracy and readability of most FMEAs leads them to be largely ignored by operational staff.

The first DP FMEAs began to appear in the late 1980's although it was not until the 1990's that industry requirements began to make them mandatory. Since that time these documents have become increasingly sophisticated yet quality and formats vary considerably. Class Societies and industry bodies, such as IMCA and MTS, have responded to this by further detailing basic requirements but no defined standard exists that provides a reliable guide for vessel comparison for risk analysis purposes.

This paper will discuss these concerns and proposes to bridge the gaps by creating a tool in the form of a generalized template integrated with Jan 2012 DP requirements. This tool will help FMEA creators to cover important subjects and functions and compare findings with applicable standards. It will also allow users to evaluate an FMEA's completeness. This generic FMEA template will provide an example of how existing applicable standards may be harmonized to increase FMEA analysis quality in the general DP industry. Use and features of the template will be explained and the paper will include a copy of the template for MTS use or adoption.

Introduction

What is an FMEA?
FMEA is an acronym for Failure Mode and Effect Analysis. It is a standard analysis tool which has been in use for more than sixty years. It is intended as a systematic approach to analyzing critical systems in order to detect weaknesses that will cause failure to deliver the required function. It does this by examining each component or important function, determining how it can go wrong (fail) and what will happen (effect). If every important item has been examined in detail then the possible failure modes of the combined system can be identified and the acceptability and risks of the system evaluated and, if deemed necessary, improved. A good FMEA makes risks visible so they can then be properly mitigated or managed.

What is DP?
DP stands for Dynamic Positioning. This is the process used by unmoored vessels to stay in the same spot. It does this by using its thrusters to push back against wind, wave, current and other external forces to stay in the same position and heading. Some of these forces can be measured and others cannot so the vessel uses position sensors and environmental models to make up for this lack. Dynamic positioning is flexible and efficient for short-term jobs, deep water, or where movement is required whether following a set track or avoiding a threat. It is an active control system so it has a number of interesting and complex failure modes. The risk of these failures to vessel operations needs to be managed.

DP Risk Management
Offshore DP operations vary from close-in accommodation, shallow and deep water drilling, diving, pipelaying, production, ROV, supply, survey, tanker, to well intervention. The consequences vary widely but the primary failure mode of concern is the same - movement from the set position or path. This could leave divers stranded below, cause a collision with a platform or other vessel, or damage a pipeline or

wellhead. Variations beyond an acceptable boundary are dangerous and possibly deadly and standards were created to manage these risks but still allow for variation. Because of the wide variety of DP operations and risks, the vessels were divided into classes and the exact allowable deviations and environmental capability left for definition. Redundancy was chosen as the measure of classifying the vessel safety and three classes created DP1 – no redundancy, DP2 - redundant systems, and DP3 - redundant and physically separated. These classes changed and evolved over time. For example, DP1 became redundant sensors and independent joystick while DP2 took on a probability limitation which DP3 lacked.

DP FMEAs

FMEAs have become the standard tool to prove DP redundancy, as they are ideal for the task. A well-prepared FMEA provides a simple and digestible presentation of the system under analysis and of the probable effects on a vessel's position keeping ability in the event of failure. Standards used in the preparation of DP FMEAs initially used simple criteria but have been elaborated more and more over time, as the industry has matured and comprehension of the issues, technical and political, have improved. DP FMEAs are required for Class 2 and 3 vessels but are sometimes performed on DP1 vessels for risk identification and management.

The Problem

The effectiveness of DP FMEAs in reducing vessel operational risk was less than hoped. Clear standards were available from other industries and application of this standard methodology should have greatly reduced vessel and industry risk yet this was not, and in many cases remains not, the case. The human factor cannot be discounted: it is people who prepare FMEAs and human ignorance, shortcuts and politics can, and do, interfere with the results. Following the mandatory requirement for a DP FMEA on Class 2 and 3 vessels by all major Classification Societies by the year 2000 loss of position events continued to occur. The industry responded by increasing the specified redundancy requirements and creating new standards and guidelines. Yet Single failures continue to cause vessels to lose position with consequent damage to life, property and environment. Many of these failures were due to operator errors and others due to lack of adequate test and commissioning procedures. To some extent human error, testing and FMEAs are part of a failure triangle and interdependent such that some of these issues may be affected by improved FMEA processes. However, our focus is on the FMEA process and we shall leave others to discuss these issues.

Problems with FMEAs

Is there a problem?

Class and Industry requirements specify that no single points of failure should result in the loss of a vessel's position keeping capability. Unfortunately, many in-service vessels that we are asked to look at have them. Both authors are FMEA practitioners so there is the possibility that we are being too fussy about our own practice. Yet we are not the only ones; several names well known to the MTS DP Committee such as Howard Shatto, Doug Phillips and Ian Harper have given papers or presentations on this subject in past conferences. From the Oil Majors, Shell's concerns have given rise to increased FMEA review and requirements in its DEP program to mitigate risk. BP has long practiced internal DP audit verification and has significantly increased their third party oversight in recent years. Over the last year USCG has expressed its concerns with DP operation safety and substantially increased its reporting requirements. All oil companies try to vet potential vessels, as they cannot trust the paper work. DNV has put out a new guideline and new standards of inspection in hopes of improving the quality of DP FMEAs. Nonetheless concern and criticism increase from Class, clients, consultants, operators and owners. This year alone, workshops focusing on DP FMEA improvement are a feature of the European

DP Conference in London, the Asian OSV Conference in Singapore, the Middle-East OSV Conference in Dubai as well as MTS Houston. The annual IMCA DP incident reports only show a fraction of the yearly DP incidents but they continue to show basic problems which should have been detected by FMEAs and operating modes that FMEAs should have clearly disallowed. Interestingly, this was but one conclusion in a report commissioned and published by the British Health and Safety Executive on DP Redundancy in 2004[1] (HSE RR 195). The problems are obviously bigger than the FMEAs themselves but, as we noted above; one paper, one problem. We will return to HSE RR 195 because it provides criteria to compare our solution against but in the meantime we will do our own thinking.

What are the problems?

The problems vary from single points of failure that can cause loss of control, loss of power or failure to full thrust to basic design errors that leave no safe mode of operation. Some FMEAs are so basic as to only consider if something is on or off. Others provide tremendous detail in the wrong places and do not consider the important points. This often reflects the author's bias or training, as many are created by individuals who do not understand and, therefore, cannot address all vital systems. In all these cases, the concern is with incorrect conclusions and undiscovered risks. Problems that are known can be dealt with but hidden problems cannot be mitigated or managed as easily. Some FMEAs are truly complete and accurate but huge and challenging to read. Some DP FMEAs are commissioned with the intent of meeting multiple additional criteria, beyond their primary objective: the demonstration of an adequate level of redundancy, in consequence they may become even more challenging to read and comprehend.

Simple Complexity

So why, despite the number of standards and guidelines, do single point failures continue to slip through the cracks? Some of the problems are structural, some are due to increasing complexity, some to wishful thinking and some to budget. FMEAs are a simple and effective methodology. It should be merely an affair of applying the acceptance criteria to how the vessel works. This is where simple rules become complex. It's as simple as cause and effect and as complex as the vessel and people involved. It requires knowledge of increasingly complex systems but also requires client and class management and acceptance criteria agreement.

Increasing Complexity

FMEAs are really quite simple. It is only necessary to apply the rule of "no DP single point failures" to how the vessel works. It is this last part where the system often breaks down: 'how the vessel works'. The DP System is not just the DP control computer: there are a lot of systems involved in dynamically positioning a vessel. Obviously, there are the DP control system, the thruster control system, the thrusters, the electrical power generation and distribution system and various support and protection systems but there are also some of which have no obvious connection until the analysis is performed. Most importantly, the Analyst has to know how the systems work and interact in detail to work out what can go wrong with them. Some say the complexity of requirements has increased over time and it is true that we have learned of problems subsequent to initial analyses but most problems are apparent by knowing how the vessel works and applying the basic rule. It is true that vessel complexity has increased and continues to increase over time. This puts a greater demand on the designers, operators and analysts and it is increasingly difficult for a single analyst, no matter how experienced, to properly cover all of these vital and increasingly complex systems. Knowing how systems work and how they go wrong is usually the tough part but not always; sometimes it can be political too.

[1] Review of methods for demonstrating redundancy in dynamic positioning systems for the offshore industry. Research Report 195, prepared by DNV Consulting for the Health and Safety Executive 2004. Author: John Sponge.

Moving the goal line

The claim that FMEAs simply apply acceptance criteria to how a vessel works is even more of an exaggeration when conflicts between acceptance criteria are considered. Acceptance criteria are fraught with pitfalls to the unwary. In theory, the approach should be to use simple, clear criteria and follow them where they lead. Unfortunately the answers this methodology creates are not always accepted with universal acclaim. This has lead to a muddying of acceptance criteria and temporary exceptions which evaporate over time as experience confirms simple analysis. This leads to outrage when an accepted vessel is found to have fundamental design flaws that were ignored in the past. Risks do not change simply because they are renamed and, barring technological change, good analysis tends to be supported by experience. The goal line moves both ways and FMEAs need to reflect customer and class requirements above the basic redundancy requirements.

Missing Criteria

Single point failure is not the only criteria, just an obvious one. A vessel is supposed to stay within a certain failure envelope in a certain maximum environment for a defined minimum time after the expected worst-case failure. Often this is not adequately analyzed in an FMEA nor always clearly stated. It is often assumed that the criteria is the vessel staying within 5m/5º for 30 minutes, if operating within the worst case failure capability plot environmental limit. Capability plots are often wrong as they do not consider the effect of power limits and the validity of the capability plots needs to be examined in the FMEA. The incident reports show numerous examples of vessels operating outside their redundant capability. Excursion limits vary with vessel mission but class have reduced the rule of thumb for acceptable excursions after a failure from <5m/5º to less than 3m/3º. The goal line moved. Few FMEAs consider if the footprint in the limiting environment exceeds this. Thirty minutes to make safe is the rule of thumb, and few are sufficiently experienced to know how this, apparently arbitrary figure was derived, but more time may be needed, according to the operation, and this is seldom explicit in FMEAs. The worst-case failure should be clearly defined but is often hidden.

The Enforcers

In theory, the Flag States are responsible to ensure FMEA quality and approval but this is usually delegated to the Class Societies. The Class Societies provide the official rule criteria and are responsible for ensuring the quality of FMEAs and overall safety of the DP system. HSE RR 195 noted that acceptance criteria varied and it has often been commented that that the criteria varies between different regions of the same Class Society. In short, regulatory governance by the Class Societies is seen as being fractured. Why is this? The answer may lie in simple economics: Class Societies operate in a commercial environment. Shipyards and Owners get to choose which Class Society they use. It's like giving people a choice of laws and enforcers and people will gravitate to the set that makes the least trouble while keeping them, at least on the face of it, 'safe'. As a result, Class Societies which enforce unpopular rules can lose customers. Some large shipyards and vessel owners have enormous influence on the Class Societies and almost appear to be able to make their own rules. This is not entirely the customer's fault as Class Societies have difficulty making consistently good decisions. The pay and hours are usually better outside Class and this tends to siphon off some of the best workers. The reviewer and surveyors who are left can enforce incorrect decisions and customers may need to appeal up the chain of command to more experienced staff to obtain rectification. The Class Societies often lack the expertise and depend on the quality of the outside FMEA. The end result is a lack of rule enforcement by omission and sometimes decision.

The Analysts

The companies that provide FMEAs are also subject to selection bias by their customers and hindered by a lack of skilled practitioners. In fact, the bias is stronger as they can be squeezed on not just result but time and price, and often cannot offer the same job stability as the Class Societies. These results can be fought with corporate culture and principles but over time these tend to collapse with changing management. Based on their results, DP FMEA companies appear to hire available people with little screening and set them at the work with little to no training. The results are extremely variable and the most telling factor in an FMEA's quality still seems to be who is involved, another point discussed in HSE RR 195. The commercial culture described above for the Class Societies above may also then prevail. In this kind of economic environment, wrong conclusions, based on insufficient analysis or lack of information, tend to say that the vessel is acceptable and other conclusions which say that it may not be can get appealed up the management chain until "corrected" to the Client's satisfaction. We have seen FMEAs developed by shipyards and Naval Architects and these are of variable quality. Here two factors often come into play. Firstly the commercial, a shipyard may be reluctant to expose an issue which could be to the ultimate detriment of the commercial success of the project. Secondly most Naval Architects and Shipyards understand how to put a boat together; they generally have very little experience of operating them. This leads to a misdirection of focus.

FMEA Providers and the DP FMEA Market

The DP FMEA providers do have the option to not be squeezed as they have the ability to select their customers. They can choose to only perform high-end work for customers who really want to know and manage risks but this often limits their size and effectiveness outside a small market sector. Regrettably, much of the market is dominated by shipyards and owners who consider an FMEA as little more than an inconvenient piece of paper which they have to buy in order to sell their product. These pieces of paper are available quickly and cheaply and FMEA companies that try to do the high-end work are not suited for these low-end markets and vice versa. Many DP consulting companies do not limit their clients and try to work in the high and low end of the market with the inevitable result of the lower standards predominating. Without systematized consistency, it takes considerable integrity to stand up to the pressure. There are small centers of excellence in each major company but these are usually under siege by commercial pressure.

Low-End DP OSV FMEA Market

There are some excellent shipyards with a deep commitment to doing right but others are more questionable. Shipbuilding is a conservative industry which has been engaged in its activity for over five thousand years. In an environment which is used to change taking place at glacial speed, the upstart FMEA is not looked upon kindly, it interferes with the yard's progress and, worse still, it comes from an 'outsider'. It is rarely seen as a design tool which will improve the product. Moreover, the Industry is bursting with "greenfield" yards, and yards which have lost their traditional market all trying to enter a market where the complexity of integration is often beyond their understanding. Such yards are beginning to dominate the offshore OSV/PSV market. A comprehensive FMEA of an OSV represents a much more significant portion of the total cost of a vessel than it does for a Drillship and cost is consequently seen as a greater issue. Ironically, lower costs are fought over much more fiercely than higher ones[2] and negotiations for such contracts can be surprisingly extensive. The OSV/PSV market is a large one which cannot be ignored. However if it is the yard who holds the casting vote, the price of the product must decrease. This can lead to a price war between competing organizations in gaining or maintain market share. This is simple supermarket economics. In such a situation, unless an organization has the resources and will to support a loss leader, quality will be the victim. Some say this war has already started. The ultimate victim however is likely to be the Owner, saddled with a vessel which has a class notation but where a subsequent audit has revealed major deficiencies which prevent the vessel from obtaining a profitable charter.

The End User

The end user needs the vessel to work safely and reliably. This lines up very well with where the DP FMEA is supposed to be focused. Generally speaking, the closer a DP consulting company is to the end

[2] Parkinson's Law and Other Studies in Administration. C. Northocote Parkinson, 1957, Riverside Press

user, the better the quality of work that can be done and the stricter the expected result. End users are aware of the problems and often use DP consultants to check the work of previous DP consultants. Thus FMEA providers are both the cause and current solution to the problem. Some problems are inherent in the design and have no immediate technical solution available and need to be mitigated by procedure and training. However this information is not always passed to other potential users and often not documented in an FMEA update that will be available to other clients or even buyers. Thus a vessel that has been carefully vetted by one oil company could retain a host of problems for the next one to discover.

The Bad News
Let's face it, people generally don't like bad news. Some industries struggle against this natural tendency and thrive on this information by using it to climb to greater and greater heights of efficiency and reliability. Some industries consider such news to be troublemaking and want the goal line moved. Portions of the offshore industry tend toward the latter but others, such as most DP conference attendees, want improvement.

Looking for Solutions

Attempted Improvement
In short the problems are as complex as the vessels in service and the people who use them. Our ancestors were hunter/gathers and we use useful short cuts in our modern world. We are well suited to using short cuts and dislike complexity and bad news. As individuals, few of us can change the underlying market structure and the tendencies it creates. The industry has responded by making more standards.

Standard Solutions?
All of these problems have led to a proliferation of increased and more detailed standards some of which don't agree and some of which limit possible solutions. For example, the latest DNV recommended practice recommends top down functional FMEAs, which we heartily agree with, but some rules mention component analysis. It recommends stopping analysis when systems are independent and fail-safe but class rules require further description, tables and analysis. There are now a number of excellent and detailed standards available but, if the fundamental requirements of simpler and clearer initial standards were not followed, what makes us think that increasing the complexity and thoroughness of the ignored requirements will help?

Standards & Work are Different
We have produced a number of standards to improve work practices but they have not increased the standard of work. It is equivalent to sending out official memos in an office where everyone is untrained and everyone is kept too busy working to read them. The standards are excellent and good but the problem is their application in the real working environment. It is the difference between the ISO 9001 work instructions devised to pass an audit and the way things are really done. More and better memos won't work, we need to get from theory to application. We don't need more standards to improve work practice, we need tools that address working practice directly.

Possible Tools
Theoretically, training, internal corporate standards and practices should be sufficient tools to properly perform the work, but, as we have seen, these effectively do not exist. Every company has little used standards, templates and procedures but we can judge their real practices by the results. DP working documents do not come structured to ensure correct completion. Many DP documents are created from an essentially blank template and most others are copied and pasted from possibly related vessels. The

practitioner is faced with a blank page and then has to remember all possible standards and correctly apply them to the vessel. This leaves the result subject to memory lapses, gaps in skill and being overwhelmed by complexity. In other industries, it is the practice to use the front line working documents to ensure compliance with requirements by structuring workflow and incorporating guidance.

Proposed Solution

That is the intention of the proposed DP FMEA template. The template is an attempt to reduce the complexity by breaking it into modular chunks that address some of the underlying problems. In short, if the problems are structural then try changing the structure. We cannot control other people but we can provide a tool that simplifies the process and findings and provides guidance. In devising the template, we have strived to create a document structure the foremost principle of which is to directly support and encourage best work practice.

How Dare We!

We fully acknowledge that DNV, MTS & IMCA have expended considerable resources in creating and improving DP FMEA guidelines. However, in practice, it has to be accepted that these standards are not adhered to where the work is done and they are often independent of the work process. A more formal structure becomes an aid to achieving that missing adherence. These standards say lots of very useful things but it is an awful lot to remember when you are actually doing the work and the problem is that often basic rules and functions are forgotten. A generic template should be useful in ensuring thoroughness and consistency. It should also make it easier to evaluate and compare FMEAs. The authors have worked as lead DP consultants for various companies and offer this as a suggestion for improvement and incorporation as a standard DP FMEA tool. We are aware of its limitations and possible abuse but believe this is better than current practice. We hope we have left room for the different styles of FMEA writing and realize that the different needs of each writer and vessel will require adaptation.

Why a DP FMEA template?

The template provides a simple framework for reminding its users to remember important systems, functions and criteria. A lot needs to be remembered and done when performing an FMEA of a complex system. This is meant as an aid in reducing complexity by listing typical important functions that need analyzed in a logical order, and breaking them into manageable modular chunks with applicable requirements and guidance information. It provides high level tools that aid analysis and structures & interpretations that avoid underlying industry problems. The goal is to make the application of the existing requirements to the vessel more manageable. Checklists are used in other industries to manage the solution of increasing complex problems and we hope to provide the same type of useful structure via the template.

The DP FMEA Template

Proprietary?

The template takes the form of a generic skeleton FMEA with table, text and drawings to be added. The structure is provided by the layout of the document and guidance notes for deletion. The structural format owes much, by reason of its genesis, to C-MAR and PML/GLND Americas FMEA documents. However, it also incorporates improvements based on the analysis of requirements and issues uncovered while preparing this paper. Mindful of this, we have taken pains to remove any copyright claimable material and attempted to ensure that anything previously company specific which is used had been released in another public forum. For example, the GLND Americas overall redundancy tables which were presented in Steve Cargill's 2011 IMCA seminar. This means that the existing template is in the public domain and may be freely used by anyone. Nevertheless some limits to who can use it are applied in the document itself.

Structure

The overall layout of the FMEA template is much like many industry FMEAs. It begins with a cover page, an executive summary, a table of findings and table of contents. This is followed by an introduction section, overview section and the individual system analysis sections. It takes the form of a top down functional FMEA. However due to rule and industry requirements for detailed descriptions and analysis it does not stop when system independence and safe failure are proven but continues until the level required by rule and guideline. This is unfortunate but one way to meet standards. There are actually three levels of review. A high-level review pass defines and validates or corrects the redundancy concept. A medium level review, applies these criteria to overall redundancy work tables that clearly indicate any problems with system independence. Finally, there is the final detailed review of each system with system drawings, discussion and detailed analysis of each vital system function in logical order so important functions are not missed. Each of these are structured to ensure completeness of analysis and guided by notes. All in all, it is an imposing document that should be easier to produce good work with. The structure also extends to communication where there are defined checks and triggers for internal FMEA team communication and communication with the customer.

Bad Good Things or Good Bad Things?

Imposing positive structure is good but it can be intimidating to first time users and the variance in guidance meant that we had to make some decisions. For instance we know that people think in different styles and have tried to incorporate this and be flexible in application. We have used extensive color-coding to make vital information easier to understand but have included alternate instructions for those who object. We have favored some guidance over others and used our experience to shape how findings are classified and presented. We have added prerequisites to force evaluation of FMEA validity – including quality of the team, information availability and information quality. A detailed structured FMEA template forces work to be done certain ways and the ways we have chosen may not always be the most popular and could be improved. While we will introduce some of the features of the FMEA template in the presentation, we will not introduce detailed features of the template in this paper, as the template is an accompanying document.

A Live Template

Finally, we do not believe that the template should be a set and frozen document but that there should be a live master template that is updated with the latest improvements and informed by analysis, trials & incident findings from the field. Use of the DP FMEA template could be adapted as a company, regional or industry standard practice going forward and lessons learned incorporated into it to ensure they do not need to be repeated and relearned. Problems currently found in the field are not widely reported and the template provides a bucket that can capture all known problems so they can be guarded against in future practice. This information would be invaluable in improving the visibility of hidden industry technical problems. Such findings are currently typically limited to isolated groups of individuals.

Is it a Meaningful Improvement?

HSE RR 195

Creation of the template was inspired by lessons learned from other industries about effective working practice and we have given our own thoughts on the current problems and how we think the DP FMEA template would be helpful in addressing them. We have noted that there are additional problems in trial and operation that we believe need similarly addressed. Now, it is time to compare the template to a more objective standard. HSE RR 195 was a study of DP FMEA problems produced in 2004 and it is worth seeing if the template addresses the thirteen problems that it identified in its executive summary.

Weakness 1: "When FMEA is used to demonstrate that no critical single point failures can occur, there is a danger that failures may be overlooked".
This danger is managed and reduced by forcing study of all expected failures by guideline and methodology, by ensuring verification of practitioner quality, procedure, information availability and information quality. These provide checks that direct the users toward the good practice of thorough analysis but do not protect against unknowns or people misusing the document. Collection and incorporation of known errors can reduce unknowns. Training, review and comparison with the common template will reduce misuse. The DP FMEA template should be effective at reducing but cannot eliminate these risks.

Weakness 2: "The definition of redundancy in the IMO Guidelines leaves unclear how common cause failures should be treated."
Common cause failures are specifically addressed in the medium level redundancy tables and lower level analysis. Proper use of the analysis structure and guidance notes addresses known and logical common faults. The DP FMEA template should be effective at reducing but cannot eliminate these risks.

Weakness 3: "Many FMEAs do not follow a systematic procedure for considering all relevant failure modes."
The DP FMEA template is structured to force systematic evaluation of failure modes. Proper use of the analysis structure and guidance notes addresses known and logical common faults. The DP FMEA template should be effective at reducing but cannot eliminate these risks.

Weakness 4: "Most FMEAs make little use of guidance documents on good practice."
Guidance has been extracted from industry guidelines and made available in the areas that apply. Thus a man working on MRUs can compare his work against class and industry requirements as it is being performed. This jogs the memory and makes application of the guidance more automatic. It cannot eliminate mistakes but it improves the odds of avoiding and catching them. The DP FMEA template should be effective at reducing but cannot eliminate these risks.

Weakness 5: "The quality of FMEAs and DP trials relies on the expertise of the personnel conducting them. Study team expertise is not usually documented."
The template provides clear criteria for study participant expertise and requires documentation of participants, their relevant qualifications, experience, training and the FMEA sections upon which they worked. This acts as a check on unqualified writers and allows others to consider the validity of work performed by the team. This may not directly ensure the veracity of this information but does provide actionable falsehood if claims are proven false. The template tries to reduce some of this risk and to make it visible but only partially reduces the risk. This could be further improved by external definition and enforcement of FMEA analyst qualification.

Weakness 6: "FMEAs of DP systems require a multi-disciplinary team to give adequate coverage of mechanical, electrical and electronic equipment."
This is covered by the same protections given above. Lack of a team will be clearly shown and documented unless falsified. The DP FMEA template should be effective at reducing but cannot eliminate this risk.

Weakness 7: "FMEAs mainly address technical failures. The human operator and the shore management are excluded from the definition of the DP system."

An FMEA template can only partially deal with these factors. The template attempts to force clear definition of redundant operating levels, redundant configuration & settings and identifies and discusses failure modes that DPOs must be prepared to correct. However, it does not deal with multiple configurations and operations unless specifically requested and does not typically provide operational advice beyond defining redundant limits and corrective actions for faults needing human correction to maintain position or hidden failures that need monitored. Most operation concerns should be dealt with in the DP operations manual. The DP FMEA template is an improvement on current practices but cannot address all related concerns.

Weakness 8: "There is sometimes a lack of information about the failure modes of bought-in systems such as DP control systems and power management systems."
The structure and guidance of the template require the analysis of the failure modes of all DP vital functions. The examples are actually required in the base information required for the FMEA to be valid and complete. This information is requested up front and failure to receive it documented and visible in the template. The DP FMEA template should be effective at reducing but cannot eliminate these risks.

Weakness 9: "There is little use of site-specific risk analysis to select the equipment class."
This is not addressed in the DP FMEA Template, as selection of DP operational class is often contractual and usually confined to the operations manual. The DP FMEA will define the limits of each class but selection of operating class is usually customer or company specific. Not addressed by the DP FMEA Template.

Weakness 10: "It is well known that some vessels are not operated in the way that is assumed in their FMEA."
This is avoided in the FMEA by the analyst using the customer agreed redundancy concept and worst case failure intent. The resultant redundant operating configuration and limits are clearly described in the template structure for inclusion in the operations manual. Finally, the template requires definition of redundant thruster configurations and thrust levels, redundant power configurations and levels, consideration of the validity and possible correction of the worst case failure environment operating envelope limits and clear statement of worst case redundant envelope limit in the executive summary for clarity. This is an improvement of current typical practice but does not guarantee crew compliance. It is considered that all FMEAs should have associated tests incorporated to demonstrate crew understanding of this and similar information but that is not currently contained in the template. The DP FMEA Template provides limited improvement that can be further enhanced but cannot resolve this problem.

Weakness 11: "FMEAs of new-buildings are often commissioned too late to influence the design."
Correct practice is encouraged in the procedural check sheets given under methodology but cannot be enforced. The template encourages early verification of the redundancy concept and the requirements needed to achieve it but it cannot enforce it. It also attempts to ensure analysis done in an effective and timely manner. Slight improvement by improving visibility but no enforcement so nasty surprises can still occur.

Weakness 12: "Review of FMEAs by classification societies is sometimes not thorough. They often do not receive the reports early enough, and cannot justify delaying the trials."
We note the generosity of the comment. The procedural checksheets are meant to ensure that the information and a dedicated team of analysts are available and the same time and defines a due date that should help avoid this common problem. This only encourages basic management but is a slight improvement.

Weakness 13: "The 3 actual cases of loss of position through DP failure on the UKCS in 2002 revealed deficiencies in the designed redundancy, which more thorough FMEAs and trials programmes might have detected and highlighted for corrective action."

The template is purposefully designed to enhance FMEA thoroughness and encourage the examination of the failure modes of all DP vital function but it is an unsubstantiated paperwork exercise until proper trials are performed. Proper use of the template should enhance the quality of the analysis and the template requires trials to be completed before it is considered fully valid. This template encourages proper trials by linking each defined failure mode to the related test in the trials for cross validation. However, it does not provide a thorough trials program template and does not fully address the issue. The DP FMEA Template provides improvement but cannot resolve this problem.

State of the Industry and budgetary limitations

HSE RR 195 also commented that many stakeholders did not consider the industry ready for more in-depth studies and that budget was also a constraining factor which limited the depth of the analysis. While the template, per-se, may not address these issues, some comment is provided below.

Meaningful Improvement

Although independently developed, the template appears to offer improvement in all areas and substantial improvement in most of the key areas identified in HSE RR 195. This validates the application of a best practice from other industries to the DP FMEA industry.

Application

Review and Correction

A potential effective improvement of industry practice has been presented and a concrete example document provided separately. This document was generated by two individuals and shares their limitations and biases. Further review and adaptation may greatly increase the usefulness of the document. This should be done by whatever bodies and groups decide to explore adopting this as a working practice. It should be noted that the DP FMEA template provides correction to only one of the three base DP documents and similar detailed templates should lead to reduction of the risks associated with trial and operation, if appropriately implemented.

Adoption Costs

The usefulness of the template is apparent but the costs are also clear. Adoption will initially increase workload until analysts adapt to using the template. Some potential participants may disagree with the interpretation or approaches used in the document and these will create adoption and adaptation costs. There is no question, and the authors fully acknowledge, that adoption of this or any process which leads to greater enforcement of existing guidelines will lead to more expensive FMEAs. The question is what will be the ultimate cost if the standards remain lax? Public and official attention has been drawn to the industry problems and the template provides a useful tool for those who wish to perform their due diligence. If generally enforced, it will increase requirements and costs in the low end of the market and will be resisted.

A Tool for Change

The advantages are clear; an open industry which will permit the exchange of information leading to greater comprehension of operation, and, by extension, of failure. The consequence of this is that designs which are dubious may either be refined to an acceptable level of fail-safe operation or phased out. An industry which exhibits strong self-governance and promotes corporate responsibility will become increasingly safer and less entrenched in its battle with its detractors.

Who's Standard?

While we believe the document is most useful as a central, master, agreed template that is updated with increased knowledge, it may be possible that it is only adopted by isolated groups and diverge over time. This will provide them with an effective working practice but will provide limited industry improvement. The Oil Companies' created and imposed the OCIMF OVID scheme to similarly reduce risk and have tried to manage FMEA risk with internal programs. Class and Professional Societies have been actively looking for tools to decrease DP FMEA risk. Conscientious major vessel providers have been trying to improve the identification of design risk. Groups such as major oil companies, Class Societies and Professional Societies would be logical champions of the template as an industry risk reduction measure. Adoption for industry use will require an organization to champion its improvement and adoption and provide a central point of reference for access and feedback. Those with the ability to promote FMEA template adoption should give it careful consideration. Requiring its use could be enforced by it being phased in as part of hiring requirements, class requirements and/or industry qualification.

Conclusion

This paper has examined the current problems associated with DP FMEA quality and proposed a different solution than currently in use. A practical working template should be a more effective tool in improving FMEA quality than further standards as it allows direct application of requirements and standards to where the work is being performed. An example template has been provided and can be found for evaluation in a sister document. Use of an effective common template has the potential to make considerable improvement in industry DP FMEA quality, if an organization can be found or established to support it.

About the Authors:

Paul D Kerr, BSc(EE), PEng
Independent Consultant
paulkerr@ieee.org

Until recently, Paul was the GL Noble Denton Americas DP Technical Authority. Before that, he was a consultant for PML, C-MAR and ModuSpec, ABS surveyor, DNV Principle Specialist Surveyor & Reviewer, GE Reliability Management Engineer and a commissioning engineer for the Canadian Patrol Frigate program & some MODUs. He believes in recognizing and managing the limits of human knowledge and ability.

Russell Hodge
C-MAR Vice President C & A
Russell.Hodge@c-mar.com

Russell leads C-MAR Group's Engineering Compliance and Assurance Division. In addition to DP systems Consultancy, he developed the Dynamic Positioning Centre's DP maintenance training program. He spent fifteen years offshore working in DP and Systems Maintenance before becoming a DP Failure analyst. In fact, he says, failure is the very touchstone by which his career may be judged.