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Session: Operations 2

Operations planning and management tool for reduced downtime and enhanced reliability of DP vessels

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Abstract

The paper presents a new tool developed to facilitate reduced downtime and enhanced reliability of drilling vessels, coined the Operation Planning and Management Tool (OPMT). The tool is initially configured for use on drilling units. The philosophy and methodology adopted is to configure the tool so that it is adaptable and can be applied to a variety of applications including DP and moored drilling vessels.

The mission is to reduce downtime and enhance reliability by providing a tool that can aid the crew in making better decisions. To achieve this, the OPMT provides an environment which can be used for operation planning and training, and also as a knowledge base and information portal for the vessel's systems and their interdependencies.

The tool is well suited for operations planning as it allows easy and intuitive running of "What-if" analyses. The tool also provides a platform that the crew can use to learn and understand consequences of failures in the power system, consequences of setting up the power system in configurations that differ from the one defined as the most reliable, and consequences of having one or more components/systems unavailable (e.g. for maintenance or repair).

The operator can set up a planned configuration for a given operation (included setting equipment out of service if applicable) and immediately get feedback and guidance on whether a planned scenario is impossible or involves increased risk compared to the recommended system configuration.

A pilot version of the OPMT has been created for a turret moored drillship operating for Shell. All dependencies and redundancy in the power plant and drilling systems were analyzed in workshops and in two FMECA's. For each drilling operation, the equipment and systems required for that specific operation were mapped. Each item of equipment and system used for the drilling operations was then analyzed by FMECA to find dependencies within the power and auxiliary systems (MCC's and switchboards). The results were used to configure a simulator for the specific vessel that uses the information on dependencies and redundancy in the power plant and drilling systems to predict the effects of equipment outage.

The OPMT, as it was implemented in the pilot version, is a standalone computer program that can be run on a standard desktop or laptop PC/Mac, onboard the vessel or anywhere else, such as in an onshore support centre. Internet connection is only required for updates. The OPMT is not connected to any control system or equipment onboard.

The Need for Decision Support Tools - Background, Drivers and Challenges

Background

Hydrocarbon resource development is moving into frontier areas where there is limited experience of operations. Experience that does exist is from an era where the Regulatory Framework was significantly different.

Exploration in the Arctic poses unique challenges

- Limited Season
- Limited Experience
- High Impact Consequences caused by delays due to non availability of equipment required to deliver mission objectives

Limited Season

Exploration activities in the Arctic are seasonal. Typically, offshore exploration activities using floating assets are restricted to a period of three to four months in what is referred to as the “Open Water” Season (ice free or manageable ice).

The primary objective of the industrial mission is to gather data so that decisions could be progressed leading to hydrocarbon resource development. Failure to obtain data within the limited season would necessitate mobilizing the entire fleet and support infrastructure for the following season.
One of the causal factors identified for delays in delivery of project objectives was equipment breakdown or equipment non availability. Further focus on this factor revealed that operator error or mal operations were a significant contributor. Lack of experience was also identified as an underlying cause.

Limited Experience

The Oil and Gas Industry has experienced exponential growth. This has placed demand on resources in every facet of the Industry. Industry has coped admirably with this unprecedented demand. However, it has been acknowledged that this coping has come with the penalty of dilution of experience levels and correspondingly skills.

Exploration activity in the Arctic Regions is not insulated from these issues. In fact the lack of significant exploration activity in these regions has further diminished the potential to impart experience and skills.

Consequences due to Delays

Limited season to carry out activities poses additional challenges. Delays caused by non availability of equipment could compromise ability to gather the required data within the stipulated or available duration.

The lack of suitable existing infrastructure in these frontier regions requires the mobilization of the entire support fleet to sustain the activity. It is not uncommon to have more than 15 floating vessels supporting a seasonal campaign where one or two MODU’s are engaged. These floating assets generally have to be mobilized from regions around the world.

A couple of days delays could very well result in a failure to accomplish the objectives of the Industrial mission in the season and necessitate the need to mobilize the entire fleet for the following season.

Mission

The mission was to find a means to enhance reliability, maximize uptime and aid in achieving project objectives.

Solution

OPMT was considered to be a potential tool in the tool kit to specifically address the issue of non-availability of equipment (due to avoidable breakdowns, mal-operation etc). It was seen as a tool that could be used for Decision Support by aiding ‘what if’ analysis.

Operations Planning and Management Tool (OPMT)

An operation planning and management tool was identified as a key enabler to achieving mission objectives. The tool has the following attributes:-

1. Interactive Advisory and Decision Aiding Tool
2. Interactive FMECA
3. Allows “What-if” Analysis
4. Supplements Communications with Reports from Analysis
5. Consequence Analyzer
6. Consequence of failures in power system
7. Consequence / Penalties of deviating from Power Plant Safe Mode Configuration
8. Consequences of Equipment Non-availability
9. One Stop Access to Vessel System Information from SLDs
10. Training tool

Identifying the End User:

One of the key tasks in the development of this tool was to identify the end user. This was essential in order to configure the tool to deliver the maximum value. It was clearly established that the community likely to extract the maximum value was the on board operational and vessel management teams. Contractors Vessel Management Team (Master, Chief Engineer, Rig Superintendent), Operational team members (Chief Electrician DPO), Client’s drilling supervisor, were identified as core onboard stakeholders. The tool was configured accordingly to be used by these stakeholders.

The guiding principle of stakeholder identification was to include those personnel who had the need to clearly understand the dependencies on specific equipment to carry out specific tasks and the interdependencies that existed between station keeping equipment, industrial Equipment and the power plant. In addition to making visible the interdependencies, the tool also had to provide these stakeholders with additional information on consequences of non availability of equipment on both ongoing and upcoming operations as well as impacts on efficiency if relevant. The goal was to provide a decision support tool that these stakeholders could use.

During the course of development it became apparent that shore based support teams were to be included in the stakeholder group. No special customization was needed with the addition of this entity to the stakeholders.

OPMT Characteristics:

The OPMT, as implemented in the pilot version, is a standalone computer program that can be run on a standard desktop or laptop PC/Mac, onboard the vessel or anywhere else, such as in an onshore support center. Internet connection is only required for updates. The OPMT is not connected to any control system or equipment onboard.

Ready access is provided to dependencies between operations and systems (DP / drilling operations, drilling equipment and vessel equipment, power and DP systems.

The tool and the methodology are adaptable to any type of vessel.

Benefits:

The OPMT and the *process used to develop it* provide all the benefits of a traditional FMEA or FMECA process and much more. FMEA can:-

1. Identify single point failures or other weaknesses in the design
2. Document compliance with specification
3. Produces graded findings to rank issues in order of importance
4. Identifies risks and design flaws at a point where they can be corrected economically
5. Produces a useful guide to overall system design philosophy for communicating the design concept to stakeholders

The choice of whether an FMEA or FMECA should be executed is dependent upon the nature of the system being analyzed:

- FMEA can be applied to redundant systems to prove fault tolerance.
- FMECA (criticality analysis) is better suited to non redundant systems or systems with limited redundancy.

Systems with limited or no redundancy are full of single point failures and it is beneficial to focus on the least reliable parts of the systems to provide the greatest improvement. A project specific ‘risk matrix’ can be generated to suit project objectives.

FMEA has traditionally been used to support the design process by proving that requirements for fault tolerance and fail safe conditions have been met. One of the greatest benefits of the OPMT process is that it allows the product of the FMEA process to be used throughout the operational life of the vessel, thus extending the benefits of the initial investment.

1. The ability to plan operations in advance and validate contingency plans (drill well on paper).
2. Safer and more efficient operations
3. Easier planning of maintenance and repair (fewer surprises)

OPMT Development Methodology

The basic approach was to create an interactive simulation tool to present information and conclusions from:

1. Power plant FMECA
2. Drilling FMECA
3. General DP and power generation and distribution knowledge
4. Single line diagram
5. Protection relay coordination study
6. Selected system drawings, schematic and pictures
7. Workshops mapping of operation-equipment dependencies
8. Activity specific dependencies (from operator or drilling contractor)
9. Incidents of the past / lesson learned

10. Vessel owner operational procedures / rules / recommendations
11. Contractor operational procedures/ rules / recommendations
12. Operator operational procedures / rules / recommendations

The work process and the methodology for the development of the OPMT pilot version are illustrated in Figure 1. The work process included use of multidisciplinary FMEA teams and workshops with the drilling team to establish dependencies between operations and equipment.

The main tasks in the development of the OPMT included:

1. FMEA/FMECA studies
2. Mapping of the well construction process
3. Mapping of interdependencies between station keeping system, power plant, drilling equipment and well construction activities (based on FMECA)
4. Adapting the existing Hardware In Loop simulator technology to OPMT philosophy
5. Information gathering
6. OPMT development and configuration

It is expected that the process of developing an OPMT for a new build will be different. Incorporating OPMT development as a deliverable at the design phase can help realize optimization opportunities. Creating the tool in parallel with the design process, and keeping it up-to-dated, allows identification of risks and design flaws at an early point where the design can be corrected economically. An illustration is provided in Fig 2.

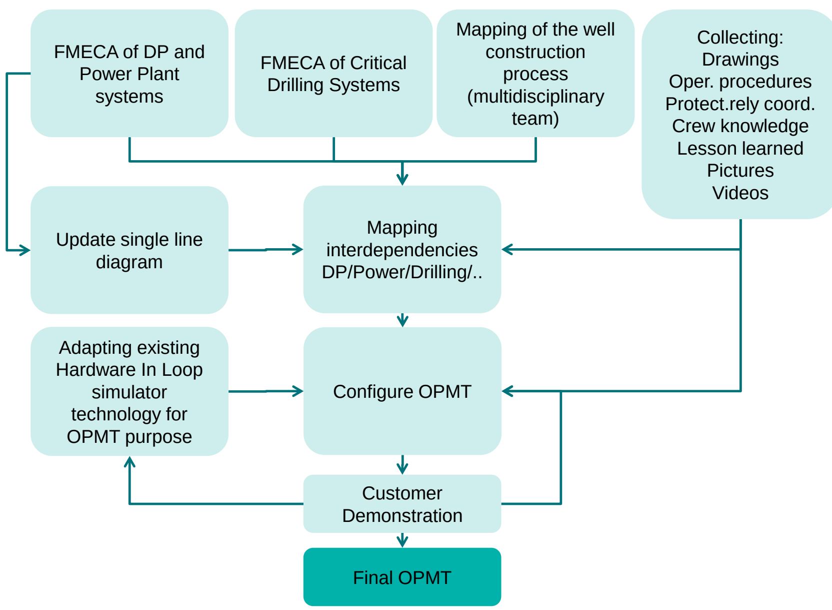


Figure 1 Illustration of work process and methodology for making an OPMT for an existing vessel (the pilot project).

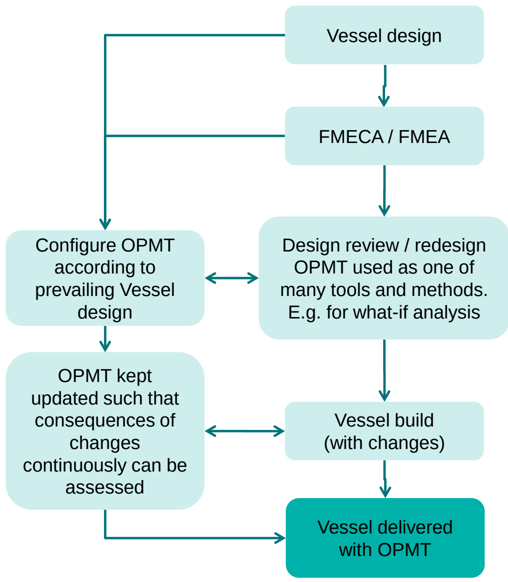


Figure 2 Illustration of how the work process and methodology for making an OPMT for a new vessel could look like.

Features of the Operations Planning and Management Tool

Output

OPMT indicates four possible conditions for a selected operation and configuration:

1. Operation possible
2. Operation possible with reduced efficiency
3. Operation possible with increased vulnerabilities and risk of failure
4. Operation not possible

Technology

OPMT is built on the Marine Cybernetics HIL simulator platform

In its current form the OPMT is implemented as a standalone computer program that can be run on a standard desktop or laptop PC/Mac, onboard the vessel or anywhere else. The OPMT, as configured for the pilot project, is not connected to any control system or equipment onboard.

Internet connection is only required for updates.

User Interface

The user interface is shown in Figure 3. The power plant single line diagram is used as main entry point. In addition there is an explorer tree to the left which allows the user to browse through operation dependencies and switchboard consumer lists.

The user can reconfigure the power plant interactively (open/close breakers, start/stop generators, modify power loads).

The power plant simulator continuously simulates the power system as it is configured and loaded. The predicted loading of components and generators is continuously displayed.

The power plant is configured with the same protection trip functions and with the same interlocks, power limitation/phase-back systems as found in the real system onboard.

Configuration errors have been identified as a significant contributor to DP incidents, A configuration page will be an integral part of the OPMT for DP systems. This will allow analysis of different DP control system and power plant configurations to reveal the effects of incorrect configurations.

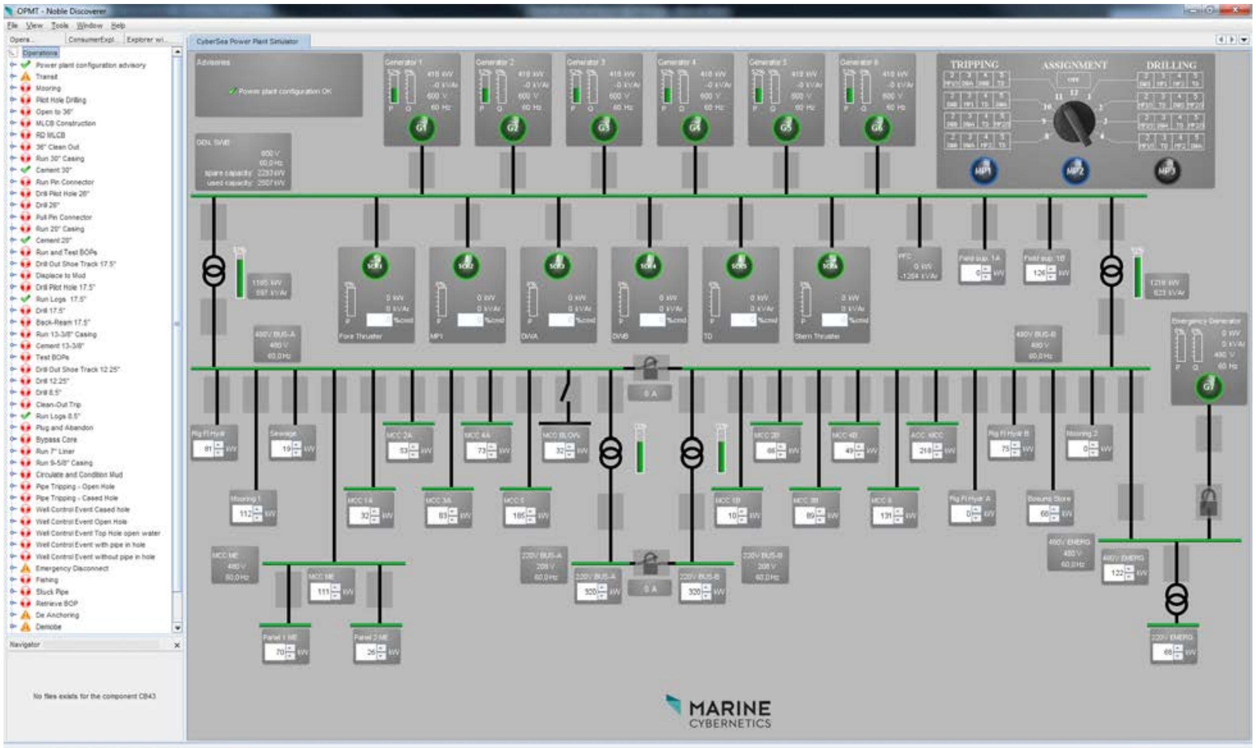


Figure 3 User interface. This page shows the power plant configuration page. The configuration of the DP system (e.g. pos.ref. and sensors) will be shown in a separate page.

Operational Dependencies

The tool is configured to keep track of the equipment and systems that must be available for a given drilling or DP operation. For each operation there is one list of equipment and systems that are necessary for the operation, one list of equipment that may add efficiency and finally one list of equipment that can facilitate concurrent activities for upcoming operations. Figure 4 lists the equipment needed for cementing a 30” casing.

The tool also keeps track of dependencies between equipment and power supply feeders. That is, the tool knows which switchboards and MCC feeders must be powered in order to operate each piece of equipment and system. This is illustrated in Figure 5 which shows further details for the Air Compressor in Figure 4 . As seen in the Figure 5, the tool also keeps track of any redundancy in equipment or power supply. In the example depicted, 1 out of 4 specified pumps must be available.

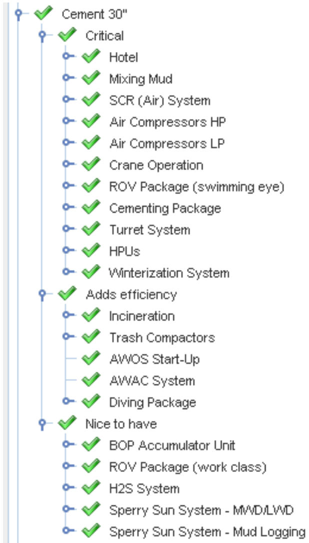


Figure 4 Illustration of operation dependencies for cementing 30" casing

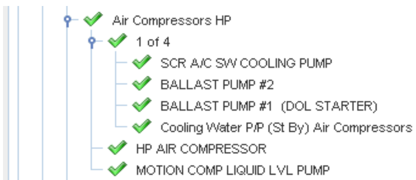


Figure 5 Illustration of which power consumers that need to be powered in order to operate the HP Air Compressors

Switchboard and MCC feeders

The tool gives easy access to lists of consumers on each switchboard and MCC. This is illustrated in Figure 6

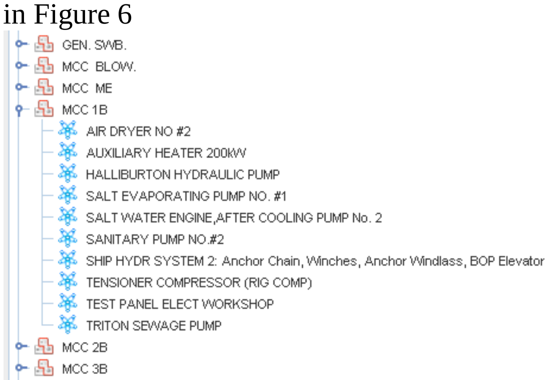


Figure 6 Example of consumer list

What-If Scenarios

The tool allows the user to immediately see the consequences of taking one or more components out of service. If, for instance, one MCC or one single feeder from an MCC is closed down, then one can immediately see in the explorer tree which operations cannot be carried out and which equipment has been lost for each operation. Figure 7 shows the consequences of losing one complete MCC on the cementing operation for the 30".

For DP vessels the tree view would also have shown how the shutdown of the MCC affected DP critical equipment.

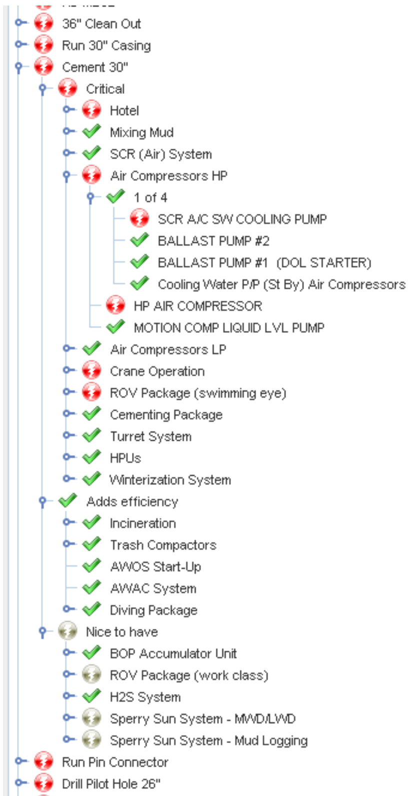


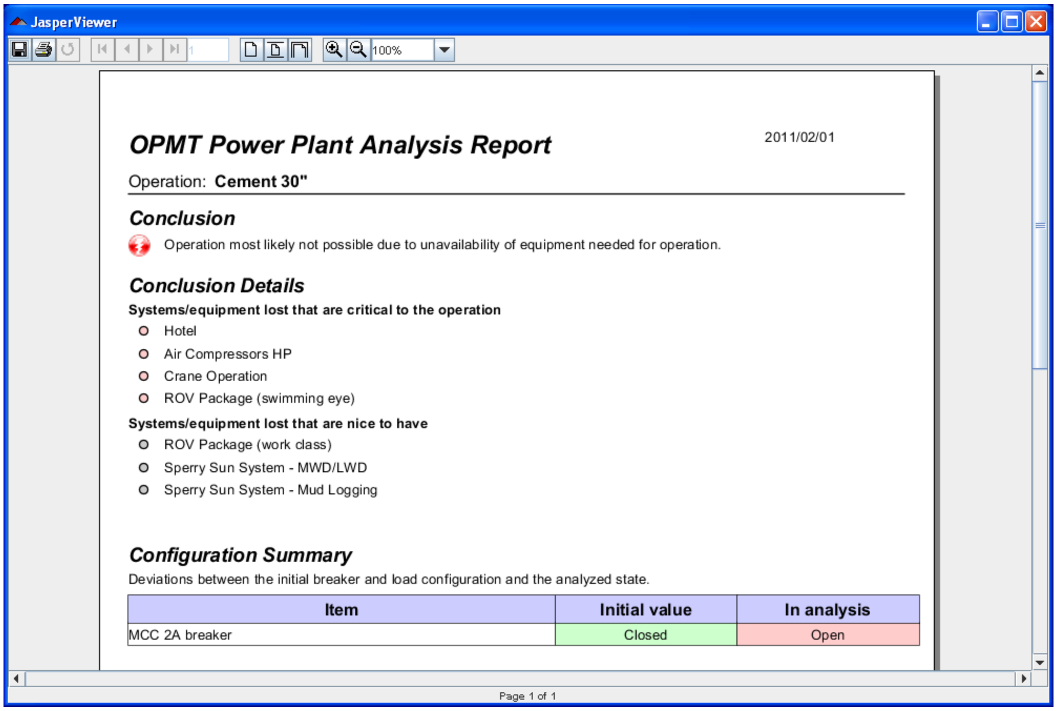
Figure 7 Consequences of losing MCC2A. The red icons indicate that critical equipment has lost, gray icons indicate loss of nice-to-have equipment.

The crew can make decisions taking into account conclusions from OPMT analysis of the planned operation. Examples:

1. Will we be able to handle a well control event if we shut down switchboard MCC3B?
2. Will maintenance of a one specific MCC cubicle affect DP critical systems?
3. Can we carry out a repair on switchboard MCC1A while running 20’’ casing?
4. A circuit breaker is not working properly. Can we continue drilling 12.25” without any increased risk?
5. Which equipment and systems are critical for “Cementing 30”?
6. What is the recommended power plant configuration?

Report Functionality

The tool can generate a report that summarizes the conclusion of a given analysis. An example of a report for “Cementing 30” with total loss of MCC2A is shown in Figure 8. These reports can supplement communication and decision making.



OPMT Power Plant Analysis Report 2011/02/01

Operation: **Cement 30"**

Conclusion

Operation most likely not possible due to unavailability of equipment needed for operation.

Conclusion Details

Systems/equipment lost that are critical to the operation

- Hotel
- Air Compressors HP
- Crane Operation
- ROV Package (swimming eye)

Systems/equipment lost that are nice to have

- ROV Package (work class)
- Sperry Sun System - MWD/LWD
- Sperry Sun System - Mud Logging

Configuration Summary

Deviations between the initial breaker and load configuration and the analyzed state.

Item	Initial value	In analysis
MCC 2A breaker	Closed	Open

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Figure 8 Report for Cementing 30" while MCC2A is lost.

Power Plant Configuration Advisory Condition

The tool will indicate an 'advisory condition' if the simulator is configured in what has been defined as a non-optimal or dangerous configuration. An example of an implemented advisory functions is shown in Figure 9. The rules for establishing advisories can be taken from vendor recommendations, procedures, 'lessons learned' etc. Similar advisory conditions can be configured for DP system configurations.

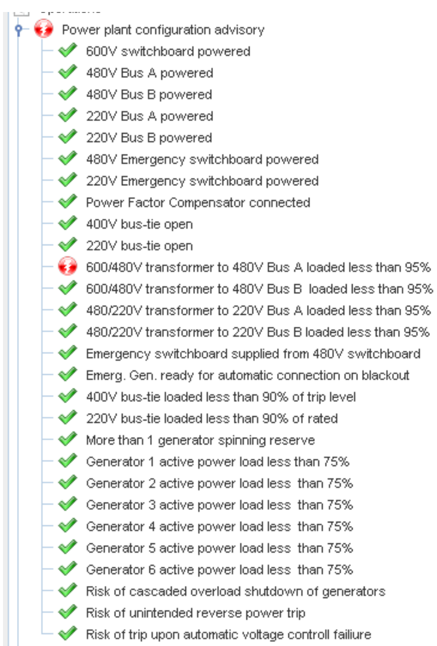

Figure 9 Example of implemented power plant advisory. The red icon indicates that an advisory condition is not fulfilled with the configuration being simulated.

Knowledge Base Functionality

The tool provides quick access to drawings, pictures, location and circuit diagrams. If the user clicks on components in the single line diagram, a list of information items appears in a navigator window (see Figure 10). The user can choose to open and inspect drawings and pictures. The list can also include instructional videos and user manuals for the equipment. This feature of the tool is beneficial for training purposes.

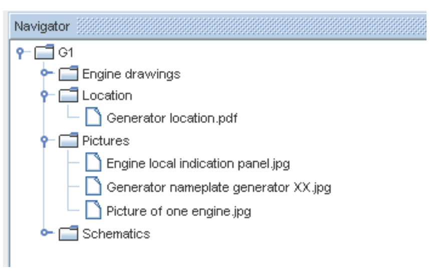

Figure 10 Example list showing information available on generator G1. The information is accessed by clicking on the generator symbol in the single line diagram.

Conclusion

The mission was to develop a tool and methodology to enhance reliability and maximize uptime. The OPMT was the result of the effort and allows the effects of the dependencies between operations, drilling equipment, power plant and DP system to be explored. The main characteristic are:

1. Interactive advisory and decision aiding tool
2. Interactive FMECA
3. Allows “What-if” analysis
4. Supplements communications with reports from analysis
5. Consequence Analyzer
6. Consequence of failures in power system
7. Consequence / Penalties of deviating from Power Plant Safe Mode Configuration
8. Consequences of equipment non-availability
9. One-Stop access to information on vessel systems in SLDs
10. Facilitates training.

Challenges:

There can be significant challenges in applying the OPMT process to older vessels in service Such challenges should not be considered as a disincentive but even greater reason to apply OPMT, as deficiencies in basic documentation will only add to the problems of lack of vessel familiarity and dilution of skills. FMEA practitioners are well suited to dealing with issues such as incomplete or out of date documentation. In the absence of reliable information:-

1. Pipe work for auxiliary systems can be traced
2. Power supplies can be traced and confirmed by testing where necessary
3. Useful knowledge and information from experienced crews can be documented

A useful byproduct of this type of work is that valid single line drawings can be generated to support the work. The effort can be complemented by other studies such as protection relay coordination, harmonics analysis and short circuit calculations.

The FMEA or FMECA document provides a useful reference guide for the crew that complements the OPMT. In some cases the FMEA is the only document on the vessel that gathers all essential system design philosophy in one place.

Bonus Outcome:

In the process of applying OPMT during an upgrade projected it became clear that the power plant simulator could also be used to confirm the advantages or disadvantages of design decisions. If the OPMT is initiated at the basic design stage it could be used to evaluate and or validate proposed design enhancements changes.

<u>Training</u>

The tool is well suited to training activities. Since it is an offline tool, there is no risk from allowing inexperienced users unsupervised access for familiarization and self-learning purposes to be complimented by more formal instruction at a later date. Experience suggests that OPMT can facilitate crew understanding of the following for the specific vessel :

1. Consequences of failures in the power system
2. Consequences of setting up the power system in different configurations (the penalties of configurations that differs from the one defined as the most reliable)
3. Consequences of having one component / machinery / equipment / out of service, e.g. for maintenance or repair
4. What is the recommended power plant configuration?
5. What is the critical equipment for each operation?

Way Forward

The OPMT pilot project was carried out using tools and technologies developed for DP vessels, on an early generation drilling vessel using turret mooring to accomplish station keeping. The challenges that were posed by lack of documentation were met by utilising the “archaeological” skills of experienced FMEA practitioners.

It is expected that implementing OPMT as a deliverable for new build DP vessels should not be fraught with insurmountable challenges. The vision is that HIL testing, a well specified and executed FMEA scope and OPMT could form the three legs of a robust process that will serve a vessel in good stead through its life cycle.(design, engineer, build and operate).

Decision support tools based on the OPMT methodology described in this paper have the potential to add values in any project where one of the objectives of the industrial mission is to enhance reliability and maximize uptime. The natural and immediate extension of the OPMT methodology is seen to be applicable for the DP systems. It is also believed that the OPMT philosophy and methodology could be used to develop decision support tools to effectively manage other high exposure activities (production facilities, loss of containment).

Implementing tools based on the OPMT methodology in the concept and design phase and configuring them for use in an iterative manner with an updated and interactive FMEA could deliver a means to assess and improve the design of new build vessels and conversion projects.