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Marine Technology Society

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DESIGN SESSION

Application of Human Factors Engineering (HFE) Principles to the Design of Dynamic Positioning Systems

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ABSTRACT
Because human errors are the primary cause of the majority of incidents and accidents in the offshore industry, some of the major E&P and drilling companies have initiated special efforts to reduce these errors. One such effort has been to utilize Human Factors Engineering (HFE) in the design of offshore facilities. HFE is the specialized engineering discipline which matches known human physical, social, and psychological capabilities and limitations with the traditional engineering requirements for the design and operation of equipment and systems to maximize both the human's and hardware's contribution to safety at the job site. HFE encompasses issues ranging from designing the equipment and controlling the work environment to selecting the right person for a particular job to creating a management structure which provides for the maximum opportunity for the worker to perform his/her job safely and efficiently within an existing company organization.

This paper provides a brief introduction to the HFE profession, and an expanded discussion on the factors that influence human performance at a DP worksite on a vessel at sea. The paper presents this information as it relates to human tasks typically associated with the operation of DP and other control systems. Finally, an example is given where HFE was involved in the review and evaluation of a DP system recently designed and installed on a new deepwater drilling rig.

INTRODUCTION
Over the past twenty plus years, increased discussion and attention has been given in the shipping and offshore industries to the role of the "human element" as the cause of, or contributor to, accidents and incidents on and with maritime facilities. A 1976 report published by the National Academy of Sciences "Human Error in Merchant Marine Safety", identified fourteen human factors deemed to be the likely "root cause" of marine accidents (1). Over a decade later, a study performed by the University of California at Berkeley found that 80% of all offshore accidents in U.S. waters were due to human error (2). In 1995 the U.S. Coast Guard launched a major initiative, called Prevention-Through-People (PTP) to reduce human error as a causative factor in maritime accidents when its research found that from 75-96% of all at-sea accidents were human induced (3).

This concern with human errors in the offshore domain is not limited to the U.S. Both the UK's Health & Safety Executive (HSE) and the Norwegian Petroleum Directorate (NPD) are placing considerable attention on the prevention of human errors in their sectors of the North Sea oil fields, and human factors was a topic of interest at the Offshore Safety Conference held in 1997 in Kuala Lumpur, Malaysia (4). In 1996 the first international conference ever held to specifically discuss the current and future role of HFE in the offshore industry was held in New Orleans, LA. Finally, a full technical session containing seven papers describing projects where HFE has been included in the design and operation of offshore platforms and rigs was given at the 1999 OTC conference in Houston, TX.

There are those who state that, in reality, all maritime accidents can be attributable to human error, either in design, construction, operation, maintenance, or management of a ship or offshore facility. However, in-depth investigations of maritime disasters reveal that specific and identifiable inappropriate human action(s) were direct contributing causes in at least two-thirds to three-fourths of all maritime accidents. However loosely or tightly defined, it is an indisputable fact: human "errors" have caused much grief in the maritime world to those on the offshore structures and attendant vessels which support them, and to others who live and work on or near the seas, and to the environment and the creatures which live therein.

HUMAN AND ORGANIZATIONAL FACTORS (HOF)

Over the past seventy-five years a significant amount of research has been conducted to identify factors which shape and influence human behavior and performance in a work environment. These factors include such diverse issues as how the work place is designed, how employees are selected for particular jobs, how job aids such as operational or maintenance manuals or procedures are written and/or illustrated, how company policies and practices are presented to the workers, what elements of the working physical environment influence worker performance, how day-to-day changes in a person's life may affect how safely he/she works, how the human's physical and mental capabilities and limitations influence their work efficiency and safety, how is the best way to train a human being for a particular job or skill, and a myriad of other human behavioral issues which affect how safely and efficiently a human performs in his/her work place. This plethora of information on human behavior and performance in a work setting has become known in recent years as Human and Organizational Factors (HOF), and its application to the design and operation of maritime systems and equipment has introduced a profession called Human Factors Engineering (HFE) to the maritime world.

HUMAN FACTORS ENGINEERING (HFE)

HFE is a specialized engineering discipline dedicated to acquiring and applying information about human capabilities and limitations in the social, psychological, and physiological arenas (i.e. HOF) to enhance human performance, safety and quality of life in all aspects of a human's existence. The HFE profession is not new, tracing its roots back to the industrial revolution. However, on-shore utilization of HOF in the U.S. really began with the military's use of HFE professionals to improve military hardware design and training techniques beginning in the early 1940's. Since then, the use of HOF, and the development of the HFE profession by shore-based industries, has been significantly increasing. During this time success stories from the meat packing, nuclear power, processing, manufacturing, aerospace, transportation and military industries clearly show that HFE can contribute to reduced human error and increased employee efficiency, and it can achieve these goals in a cost effective manner (5).

As for the maritime community however, the systematic application of HOF to the design and operation of ships and offshore structures is currently very minimal at best. This is unfortunate since there is so much information available now that could be immediately applied to the design and operation of offshore structures and support vessels to reduce human errors on, to, and with these facilities.

ELEMENTS OF HOF

One of the acknowledged obstacles in utilizing HOF in the design and operation of offshore facilities is the lack of universal agreement among either the users or suppliers of HOF expertise as to what constitutes HOF. Frankly, there is disagreement among the HFE profession as to what the discipline encompasses. However, there is general consensus among the HFE professionals that the following eight factors shown in Figure 1 can and do influence how safely and efficiently a person performs on the job. Ignoring any of the eight in the design and/or operation of maritime systems and equipment will result in a less-than-optimum safe and efficient employee at work.

Further, it is the author's opinion that the effectiveness of any HOF program will be maximized in terms of the least invested dollars, and the quickest return on that investment, if the HOF effort is instituted following the "Triangle of Effectiveness" shown below. Starting with the base of any HOF effort, i.e. management participation, and then working up the triangle, a company will see its best return on its investment of time, money and personnel in terms of reducing human error on the job.

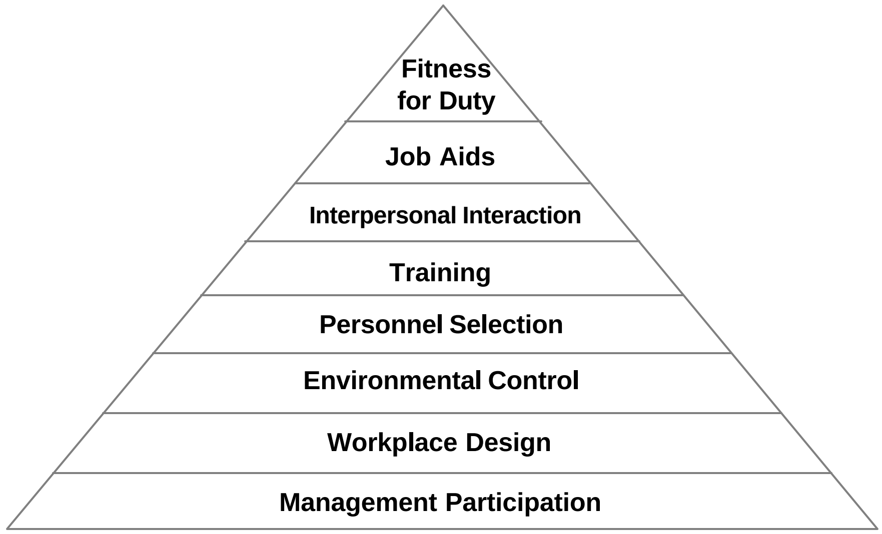

Figure 1. The "Triangle of Effectiveness" For a HOF Program to Reduce Human Error

1. Management Participation: Management participation in reducing human errors in the maritime workplace is the essential base to any HOF program. This participation can be exhibited in many ways beginning with management's full support for a HOF program starting at the top. This support should be demonstrated in every management decision made involving the human element of the company by basing those decisions on known and proven behavioral precepts for creating, encouraging, and reinforcing safe and efficient human behavior in a work setting. These decisions will cover issues such as how to organize the company and individual work units, how to set work schedules and hours, when to write company policies and practices, how to select, motivate, reward (also punish when necessary), and train their workers and how to optimize the working environment.

2. Workplace Design: Often this aspect of the HOF discipline is called ergonomics, or human factors engineering (HFE). Human beings, regardless of geographic origin or ethnic background, possess certain social, psychological, and physiological capabilities and limitations. In addition, the culture in which the individual grows up also influences his/her behavior patterns. Therefore, when placing a person in a marine working environment it is imperative that the design, arrangement, and orientation of that work site match the capabilities and limitations of the maritime employee. Work place design is concerned with such issues as: 1) whether or not sufficient (or too much) information is provided to the worker, and what form that information should take, 2) the shape, size, location, and orientation of the controls and displays used by the worker so that all things needed to be seen, turned, pushed, etc. are within acceptable reach and visual envelopes, 3) the total arrangement of all of the hardware and software the worker uses, and 4) the type, frequency and importance of communications required by the worker(s) in the work place.

Extensive research on workplace design criteria, and their impact on human behavior and performance in a work environment, has been conducted for at least the past five decades. The results of that research have been translated into several well accepted HFE design standards or references such as those published by the American Society of Testing and Materials (ASTM), United Kingdom Ministry of

Defence, McGraw-Hill Publishing, International Labor Office (ILO), and the American Bureau of Shipping (ABS). (6)(7)(8)(9)(10). The ASTM and ABS design standards and guidelines were specifically prepared for use by the marine industry. The ABS guidelines are particularly applicable to the design, orientation, and location of control system consoles and workstations such as a DP system. The ASTM standard has been used as the basis for recommended design standards for commercial and military ships and offshore structures in the U.S. and Canada since 1988. Thus, the offshore industry has the tools now in hand to apply good ergonomic design features to offshore facilities if only they would elect to do so.

3. Environmental Control: Allowing the physical environment (e.g. temperature, humidity, ventilation, noise, illumination, vibration) to exceed known and established limits can actually induce employees into making unsafe acts which can result in serious and deadly consequences. Much is known about the effects of environmental factors on human behavior and performance with upper and lower limits now well established for both comfort and job safety operational conditions. That data only awaits application to the specific world of offshore operations.

4. Personnel Selection: It is known that there are some jobs in almost every industry that require special human physical, social or psychological skills not possessed by the population at large, or even by persons now working at those jobs. This has been recognized for some years in the public safety sector (i.e. police and fire fighting) where physical and psychological screening tests are administered to job applicants to eliminate those individuals who are neither physically nor emotionally suited for the rigors of being a law enforcement officer or fire fighter.

Translating this concept to the offshore industry one could ask what special basic physical, social or psychological skills does a DP operator require? The same question could be asked about an Offshore Installation Manager (OIM), driller or supply boat master. Does the fact that a person has worked at any of these jobs for twenty years automatically mean that person possesses the unique emotional or physical makeup required to be a good DP operator, OIM, driller or master under stress? The answer is no.

Conversely, are there existing psychological, social or physiological screening devices currently available to identify that potentially good or bad DP operator, OIM, driller, crane operator, or ship’s master? At this writing the answer is also no. However, there is a company in California which has developed and uses a test to identify potential employees who are more likely to be involved in actions and unsafe acts which could lead to on-the-job accidents than their safer counterparts. This test has been validated and is now in use by some onshore industries. Further, there are individuals within the HFE profession that specialize in identifying and quantifying those special skills required for specific jobs.

It is important to note however, that up until now, the marine industry has yet to utilize this arm of the HFE discipline to improve human performance and safety in the marine work place.

5. Training: The traditional industrial approach to training is to use someone experienced in a job to train others who are not. The length of time devoted to the instructional effort, and the course content and format is often left up to the instructor based on his/her personal experiences.

The HOF approach is different. First, the specific tasks that the trainee has to learn are identified, and the level of performance desired or needed for those tasks established. Then, means of measuring when the student achieves this level of performance are created. Only when each trainee has reached the pre-determined level of performance required is that person allowed to take on the job for which he/she was trained. Wherever possible, proficiency is demonstrated through doing the actual tasks in a measurable manner. This is the way training should be conducted in the marine industry.

6. Interpersonal Interaction: Individuals who work in the marine industry seldom work in a vacuum, even on a vessel or platform with minimum sized crews. They give and take directions from others, both on a peer basis as well as a supervisor/employee basis. In the past years the maritime industry functioned on a well-defined caste system. The master is the ultimate authority on a ship. The OIM serves the same function on an offshore platform. There has always been a one-way, top down, chain-of-command. The maritime world is replete with accidents in which a subordinate crew member detected or suspected that an error had been made by a higher authority but did not believe that he/she had the authority, right, or duty to speak up.

Now however, companies of all sorts, including those in the maritime industry, are converting to more team oriented organizations. Spurred by the airline industry's innovative training efforts in what has come to be called "cockpit resource management", the maritime industry has now launched its own version of this team building training with the intent to get all who serve on an offshore facility to feel free to give and take input from the others regardless of rank or function to achieve maximum personal and structure safety. Many persons do not innately have these interpersonal interactive skills, especially those who have functioned so long in a hierarchy command structure. However, they can be taught these skills.

7. Job Aids: It is doubtful if any person beyond childhood has not at some time in their work or leisure lives been confronted with a printed or pictorial instruction on how to accomplish a task or follow directions that has not been stymied by the poor quality of those instructions. This problem exists as well in the maritime industry, and has contributed to human errors on ships and offshore structures. However, this need not be the case. Significant knowledge is now available on how to prepare job aids (e.g. operations and maintenance manuals, job procedures, hazard warnings, company policy and practice manuals, checklists, and other written materials). This knowledge is based on research that has revealed how a person reads and absorbs visually presented information. It has been transformed into behaviorally based specific preparation guidelines for the various kinds of job aids. It is time to utilize this existing knowledge in the preparation of the job aids used in the offshore industry.

8. Fitness for Duty: Every day each person working in the offshore industry brings to the job site (whether it be the corporate office, an offshore platform control room or a drill ship DP control station) psychological and/or physical burdens or blessings which can affect the way that person behaves and performs on the job.

Sometimes the burdens are externally applied, such as the constant worry over a seriously ill child, spouse or parent, a financial debt or marital problem. Other times the burden can be self-applied, such as drinking or taking drugs, or going without sleep before going on the job. If the burdens prevail, and are severe enough, they can become a safety threat to the individual, and/or others at the job site. Devising and using screening devices on a routine and regular basis to prevent that worker from performing his/her regular duties on those rare but significant days they are not suited to do so could enhance worker safety and reduce the frequency and magnitude of human errors made in a maritime setting.

Some efforts and devices now exist for screening out those under the influence of alcohol or drugs, or who have for whatever reason, reduced eye-hand coordination or concentration capability. Although some early efforts are underway with onshore companies in using these devices, the offshore industry has yet to use them. There is much here to be learned, and accurate and easy to use devices for both physical and

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psychological screening to be developed. However, to date the marine industry has not taken an active position in this area of the HFE discipline.

APPLYING HOF TO THE DESIGN AND OPERATION OF A DP SYSTEM

The human operator of a DP system performs three basic tasks. First, the operator is a sensing mechanism, i.e. the person sees or hears signal inputs defining when and how the DP system is performing. About 70% of that sensory input comes through the eyes, and 20% through the ears. Therefore, it behooves the designer of DP equipment and systems to know something about human vision and hearing and design the DP equipment or system in order to maximize the operator's/maintainer's sensory capabilities.

Second, the DP operator is an information processing unit. He/she takes the sensory inputs, processes the data and makes a decision if the DP equipment or system is performing within an acceptable range or not. This is called a cognitive function and can require the operator to use short and/or long term memory, perform calculations, make comparisons between what is versus what should be, and make decisions based on the information processed.

Third, the DP operator is a physical responder. If the decision from step 2 is to make a change in the system or equipment status the operator must perform some physical act (e.g. turn on a pump, rotate a thruster directional control, turn a speed control knob, etc.). Based on this physical action a change occurs in the equipment or system that is detected by the operator’s sensing mechanisms and the operational cycle starts over again.

Normally these tasks are completed under stress free conditions, i.e. there is no limit on response time and inaccuracy of response is not critical. However, there are the limited occasions when stress is very real, and consequence of inappropriate operator actions can be very severe. It is for these events especially that good HFE design practices can make the difference between a near miss and an observable accident.

In completing the above tasks the human operator brings certain basic needs, capabilities, and limitations to the job site that must be satisfied in the equipment's design in order for the operator to successfully complete these tasks. These human needs, capabilities and limitations are an integral part of every human being, varying in some cases due to cultural and geographical differences. Therefore, these human attributes, briefly described below, must be considered, and accommodated for, by every designer of DP equipment and systems.

1. Mental Images – If asked to draw a picture of the kitchen at home, the dash of the family car, or the work site (especially if that site consists of a specific console or work station), it is highly likely that you could do that. You can even close your eyes and still “see” those images. You can do this because it is a human trait to create, and then use, such mental images to function in the physical world in which you operate. Therefore, anything we can do in the design of the physical work site to enhance the operator’s acquisition and recall of those mental images, (especially recall in an emergency), the more efficient and safer we will make the operator in his/her everyday work cycle.

2. Spatial Relationships – One of the primary needs of a human operator is that his/her work site be spatially related to the equipment and systems the operator is monitoring or controlling. In terms of a DP system this means that the DP control console or work station must be oriented and laid out such that the location and relationship between and among the controls and displays on the console

are in the same location and relationship that exists between and among the actual hardware on the vessel or rig, as viewed by the operator facing the control console or work station. In simpler terms, controls and displays on the left side of the console or work station must control or monitor equipment or systems located to the operator's left as he/she faces the console or station. Controls and displays on the right side of the console or station must operate or monitor equipment and systems out on the ship or offshore structure located to the operator's right as he/she faces the console or work station. Controls and displays at the top of a console or work station should be associated with hardware items farthest away from the operator, those at the bottom of the console for those items closest to the operator. This seems a simple enough concept but it is surprising how often this spatial relationship concept is not provided in the design of maritime equipment.

3. Spatial Orientation – It is important that work stations or operator consoles associated with navigation and steering, and where possible, for the propulsion engine(s), be located and oriented in the ship or self-propelled offshore structure so the operator faces "forward". Specific to the DP system, this means that DP consoles or work stations must be located so the operator faces in the direction of travel of the vessel or offshore rig. This again relates to the spatial relationship issue since operators know which way is "forward" (even if they cannot see outside) and consequently which side is port and which is starboard. They constantly use this frame of reference in making those cognitive decisions mentioned above. If a console or work station is oriented or located in a direction other than "forward" the human operator will, at some time in his/her career, make a wrong turn, respond to the wrong display, activate the wrong control, or make some other human error due to the incorrect orientation or location of the console or work station.

4. Cultural Expectation – Every human grows up in a culture of some kind. As a result humans develop behavior patterns based on that culture. As an example, many cultures drive on the right side of the road, stop the car when an eight-sided octagonal sign is observed, and read from left-to-right, top-to-bottom. In most cultures red means stop and green means go, hot water taps are on the left of the faucet, and valves are turned counter-clockwise to open. Therefore, it is important to design any equipment (such as a DP system) to match the cultural expectations of the user who will operate that system.

   Within a culture there are also sub-cultures. As an example, those persons who work and live in the marine industry develop expectations and associated behavior patterns based on those expectations (e.g. port is on the left, starboard is on the right). If any piece of equipment or total system is designed with violations of those expectations the opportunity for human error is significantly increased.

5. Equipment Expectations – In addition to the cultural expectations we humans also develop equipment expectations. This means that we "expect" equipment to work in a certain manner based on its shape, size, color, or other physical characteristics, or our past experiences. Operators "expect" mushroom shaped knobs to be pushed, T-handles to be pulled, round knobs to be turned, etc. Turning a knob clockwise, or pushing a lever away from the operator, increases whatever value the knob or lever is controlling. If a piece of equipment is designed which violates these expectations human error can be induced, even after long periods of use.

6. Consistency - Humans also expect that if a piece of equipment looks and operates in one manner on a ship or offshore structure, it will be designed and operate in the same manner wherever it is found on that, or other ships or structures. In the author's opinion this is one of the biggest sources

of human error on vessels and offshore structures, i.e. the lack of consistency in the design and operation of similar or same equipments within a single vessel or between vessels. No where is this consistency more important than on equipments and systems where performance time and accuracy could be required of the operator for critical tasks (sound like a DP system in an emergency?).

7. Risk Homeostasis – Given a task to perform, human beings tend to assess that task, decide how it best can be performed with the minimal expenditure of energy, and proceed to accomplish that task. Even after initial training the operator will drift into an operational mode where “shortcuts” are taken from the originally trained operating procedures. These shortcuts will only be taken however if the operator perceives them to be safe (i.e. an acceptable risk). Each operator has a level of risk that they are willing to take (called the risk homeostasis level) and this level is mostly established by what the operator perceives the risk level to be. If a piece of equipment is designed such that the operator is required to take steps or complete tasks which the operator feels are unnecessary, and omitting or altering them can shorten the operator's task time and effort (i.e. conserve energy), it can be assured that the operator will make those changes. From a design perspective for a DP system this means that the designer must consider every scenario under which the DP system could be operated and provide enough information (and only that information) for the operator. As an example, information that would only be used for calibration or maintenance tasks should not appear in any of the operational mode displays.

APPLICATION OF HFE TO THE DESIGN OF A DP SYSTEM

In 1998 Diamond Offshore Drilling Inc. (DODI) and BP Exploration Inc. (BP) obtained the services of an HFE consultant to participate in the design effort for conversion of a North Sea Dynamically Positioned accommodations submersible called the “Polyconfidence” into a deep water (7500’) drilling semi-submersible rig re-named the “Ocean Confidence”.

Because this was a conversion project much of the existing equipment was maintained. This introduced several significant HFE problems that would not have been present with a new vessel, including the desire to keep as much of the original numbering scheme for the rig compartments and individual equipment as possible. This problem was compounded on this project since the Bridge was switched from one end of the vessel to the other which meant that the numbering scheme was often backwards from the “expected”, both from front to back, and port to starboard.

A second difficulty was that major vendor supplied hardware (e.g. the DP system) had been selected and designed early and the design initiated well before the HFE effort was first introduced. Consequently, little could be done to incorporate HFE design criteria into these major pieces of equipment. Nevertheless, some HFE input was possible on the hardware as noted below.

One of the early HFE assignments in the design area was to review and evaluate the proposed DP system from an HFE perspective. The DP system consisted of the primary control station located on the Bridge with a secondary DP control station in a dedicated room located one deck below, and inboard, from the Bridge. This was done to provide a backup DP capability in case the Bridge was lost due to a catastrophic accident. In addition, the Power Management portion of the DP control system was placed in the aft Engine Control Room from where the diesel driven generators were monitored and controlled. The eight generators were arranged in four separate rooms running along the aft end of the rig, with the Engine Control Room situated just forward of the generators with the operator consoles facing aft toward the engines. This meant that the generators, numbered from one through eight running port to starboard (the original numbering scheme), read from the operator's right to left on the generator control panels as the operator faced aft toward the control panels (this was also the original design and could not be changed).

Within these parameters the HFE evaluation was completed with the following comments and inputs:

1. The location of the primary DP control console in conjunction with other equipment/stations

   In the HFE review of the DP equipment on the Bridge, the space between the DP console and adjoining Chart Table was deemed to be adequate for normal operations. However, after completion of a simple task analysis for emergency operations it was considered to be too limited for the added number of persons who might be around the DP system during an emergency and so the Chart Table was moved aft two feet. This decision highlights one of the HFE premises for any HFE evaluation made of maritime hardware. That is that the equipment and work station design must accommodate all possible operational conditions (i.e. design for the worst case operating scenario).

   In the initial design of the Bridge the Ballast Control and other marine and support consoles (e.g. gas and fire alarm panels) were placed near the aft end of the Bridge, in a long athwartship row and stacked two high. This created a physical barrier between the DP station and the rest of the operational console personnel on the Bridge, which blocked all visual contact and made even verbal communication difficult between the two work areas. During task definition interviews by the HFE consultant with the various bridge personnel it became clear that they considered direct visual and verbal communication between the two areas to be essential. This was not only for better coordination during normal and emergency operations, but also for routine social interaction during the long periods when there were minimal task demands on both sets of operators.

2. The orientation of the consoles

   The DP consoles were located so the operator faced forward at both the primary and secondary stations to maintain the spatial relationship between the operators and the various DP equipment located throughout the rig.

3. Design of the consoles

   The DP consoles were purchased from a vendor who had a previously established console shape, size and instrumentation layout arrangement. Further, the DP purchase contract had been well underway at the time the HFE consultant was brought on board the Ocean Confidence project. Therefore, making major HFE changes in console shape, size, and layout were not possible. This is a lesson to be learned for other jobs, i.e. have HFE participation with the DP vendor from the very beginning of the project.

   Nevertheless, there was some opportunity for suggested alterations. Control/display panels for the Power Management portion of the DP system were located in the Engine Control Room. They were not a standard design by the DP vendor and as a result were made specifically for the Ocean Confidence. Consequently, the HFE specialist was allowed to review these panels and make suggested changes.

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The Power Management Consoles consisted of two parts (Figure 2 shows a DP console used on the Ocean Confidence).

Figure 2 A DP Console Used on the Ocean Confidence

a. A mimic panel (Figure 3) showing the eight generators, connected to four switchboards from which power feeds were sent to rig equipment such as two pumps, eight thrusters, SCR, DP and Drilling Transformers, and four Anchor Winches, and

b. A control/display panel (Figure 4) located beneath the mimic display containing pushbuttons, rotary switches, lights and analog gauges which were used to set up and then monitor the system depicted on the mimic board.

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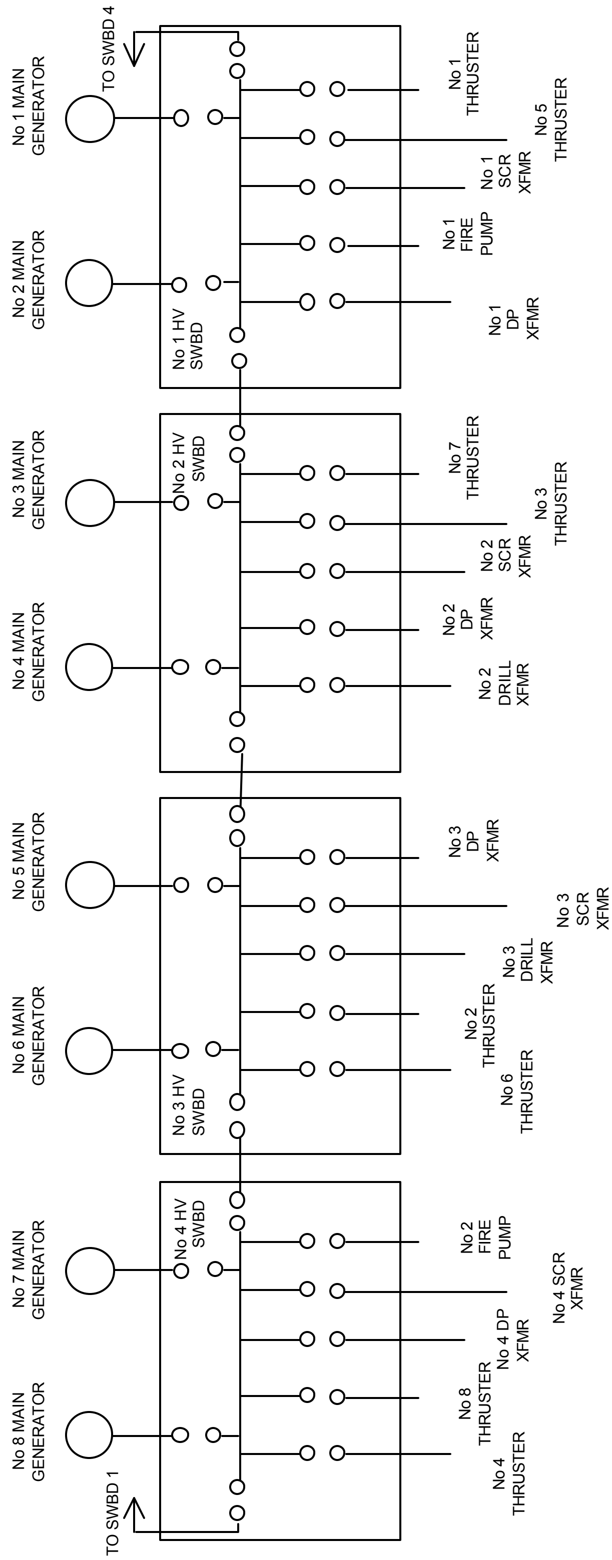

Figure 3 **Layout of Power Management System Status Board for "Ocean Confidence" DP System**

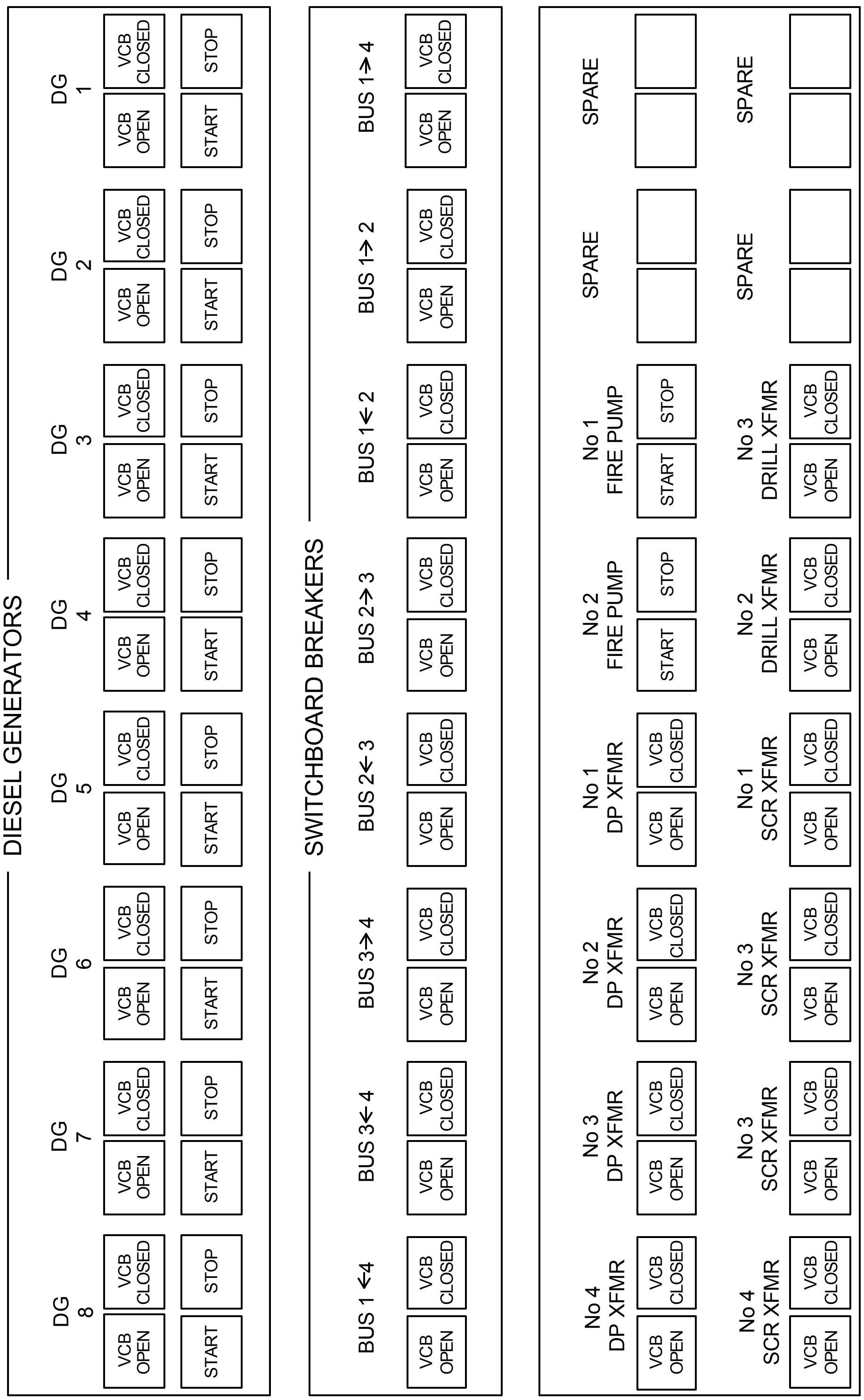

Figure 4 Layout of the Initial Power Management Control/Display Panel for "Ocean Confidence" DP System

As a consequence of this split panel design the operator would make frequent visual shifts between the upper mimic board and the lower control/display panel). As can be noted from comparing the two display areas there were several HFE issues associated with this initial design, including:

- It was not clear which generators fed which switchboards
- It was not clear which switchboard breakers were associated with which generators
- It was not clear which generators and switchboards were feeding the individual equipments,
- The Load Shifting Controls for the generators (located on the lower panel but not shown in Figure 4) were arranged in the reverse order from other generator controls and displays located both on the upper mimic and lower control panel. That is, they were numbered from one to eight reading from left to right while the other generator controls and displays matched the actual arrangement of the generators in the vessel and were numbered one through eight reading from the operator's right to left.

As apart of the HFE effort all of the available DP Operators, Mates and Captains that were to serve on the Ocean Confidence were asked to evaluate the current and proposed DP Console design. We were particularly fortunate to have one of the DP Operators with a HFE background and experience in design of equipment from an HFE perspective. Based on the combined efforts of these users and the HFE specialists, changes were made to the initial DP console design including:

- Redesign of the Power Management System Control/Display panel to match the mimic layout
- Selected and standardized colors to be used on displays and video screens
- Rewrite of questionable and overly technical labeling
- Simplification of information presented on some displays
- Enhancement of the size of text on the video screens for better viewer visibility
- Revised video screen arrangements to make them spatially correct with the DP equipment on the vessel

A good example of one of the design changes, i.e. the rearrangement of the Control/Display panel, is shown in Figure 5. The left half segment of the redesigned lower console shows how the controls and displays were rearranged so the layout of the lower panel now directly corresponds to the layout of the upper mimic panel. This makes the visual transition from one panel to the other much easier for the operator and reduces the chance for operator error. In addition, the Load Shifting Controls were rearranged so they were read in the same direction as the other generator controls and displays, i.e. from right to left.

In addition to these design changes the manufacturer was shown the two current HFE design standards (i.e. those by ASTM and ABS), on which the recommended DP design changes were based, for possible use by the manufacturer on future contracts.

These suggested changes were accepted by the manufacturer in the spirit in which they were given, i.e., a recommended improvement to the man-machine aspect of a good, technically well designed and very functional DP system.

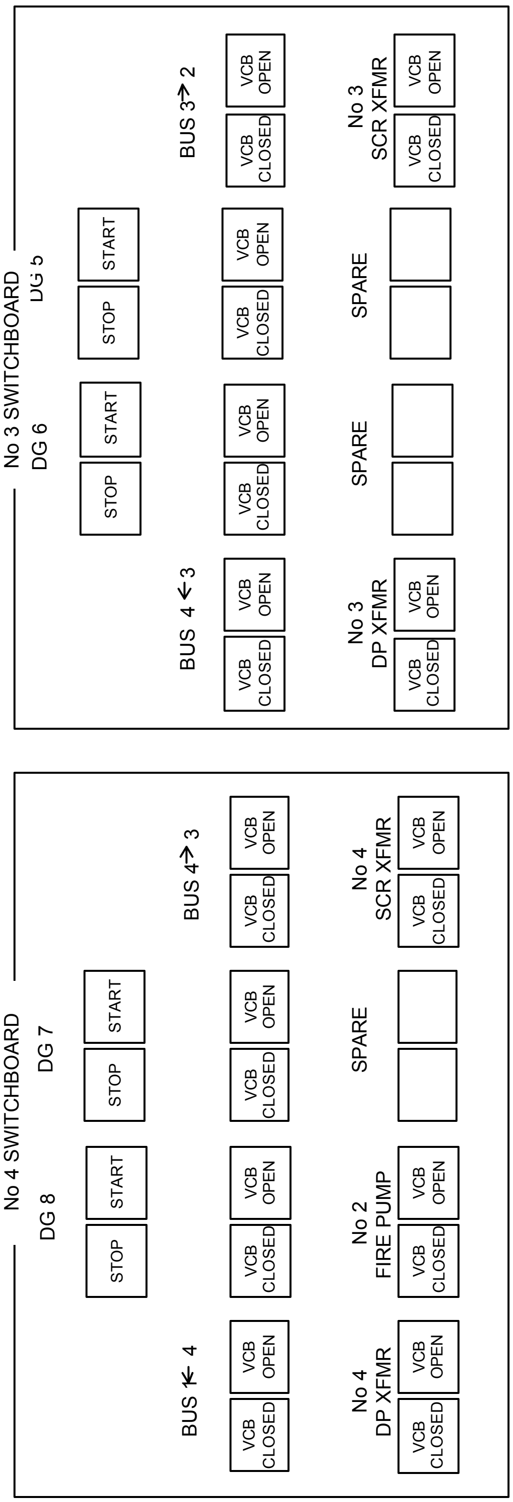

Figure 5 Layout of a Portion of the Revised Power Management Control/Display Panel for "Ocean Confidence" DP System

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SUMMARY

It is now accepted that inappropriate human action (called "human error") is the cause of, or major contributor to, the vast majority of maritime accidents and incidents at sea. In the past the attitude has been that human error was inevitable, and had to be tolerated if not accepted.

Now however, that attitude is changing. Through the HFE discipline it is now possible to anticipate when, how, and why human error may occur. Further, with the vast knowledge now possessed about human behavior, and the individual elements within the umbrella of HFE, it has been demonstrated that applying this knowledge can reduce the occurrence of human error within the workplace, and do it at an acceptable cost. This knowledge must be utilized by all who contribute to the design of offshore facilities including vendors that supply individual components destined for installation on maritime and offshore vessels.

As for DP systems specifically, DP operator error, especially during an emergency, can have serious consequences. One way to reduce these errors is through better design of the equipment to maximize the performance of the man-machine combination. To do this requires HFE participation from the very beginning of the contract placement and initial design phase, utilization of existing human performance based design standards, and a willingness for both the designer and HFE specialist to seek acceptable compromises in the design of the DP system.

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