



BRIDGE MATE™ BY MARINE TECHNOLOGIES

THE BRIDGE MATE CONCEPT

DYNAMIC POSITION AND JOYSTICK SYSTEM



FOR SHIP OWNERS CONCERNED WITH QUALITY AND SAFETY





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INTRODUCTION

Marine Technologies, LLC (MT) was established in 2002 to develop Dynamic Positioning (DP) systems for the offshore market based on new technologies.

The company headquarters is located in Mandeville, Louisiana, in the heart of the offshore industry for the Gulf of Mexico. MT also has a daughter company, Marine Technologies AS, located in Egersund, Norway. The Norwegian affiliate provides the engineering, commissioning and support of MT products delivered in Europe. The latest expansions of the company to support customers worldwide include a sales and service office in Singapore, as well as company representation in Brazil.

The initial objective of MT was to develop a DP system that complied with the International Maritime Organization (IMO) guidelines for a DP 2 class system. Only sixteen months after the foundation of the company, the first vessel with a DP system from MT received its DP 2 notation from the American Bureau of Shipping (ABS). The vessel, *M/V Amber*, is a 280' OSV owned by Edison Chouest Offshore on charter to BHP Billiton. Since that time, MT has delivered more than a hundred DP systems worldwide, the majority being DP class 2.

The overall goal for MT is to support market demand with cost effective systems that provide added value for the customer based on:

- Added safety through design and software functionality
- Reduced installation cost and commissioning time
- Reduced service cost and improved spare part availability
- Remote operation and service assistance towards fleet management





THE BRIDGE MATE DP CONCEPT

The Bridge Mate concept consists of a number of DP and joystick systems designed to meet the IMO-MSC/Circ. 645 guidelines for vessels with dynamic positioning systems and other relevant classification notations.

General requirements set by IMO for Classes I, II and III:

System/Component	Class I	Class II	Class III
No. of DP Control Computer Systems	1	2	2 + backup (fire backup)
Joystick with Auto Heading	Yes	Yes	Yes
Single Levers for Each Thruster	Yes	Yes	Yes
Positioning Reference System	1	3	3, with 1 connected to backup
Gyro	1	3	3, with 1 connected to backup
Gyro	1	3	3, with 1 connected to backup
MRU	1	2	2, with 1 connected to backup
Wind	1	2	2, with 1 connected to backup
UPS	1	2	2 x 1 separate compartment
Consequence Analysis	No	Yes	Yes

TABLE 1

The different products in the Bridge Mate range of products:

MT System Name	IMO Class	Remarks
JX	Independent joystick to all IMO classes	Joystick can be upgraded to IMO Class 1 DP System.
DP0	No Class Definition	DP0 is a single DP system designed as a DP1 system without the requirement for a backup JX system. DP0 has no formal approval from class.
DP1	Class I	A non-redundant system complying with IMO Class 1 rules which require an additional Backup JX system. Can be upgraded to IMO Class II System by adding more modules.
DP2	Class II	A fully redundant system complying with IMO Class 2. Can be upgraded to IMO Class 3.
DP3	Class III	Control computers and operator stations physically separated to avoid total loss in case of fire or flood.

TABLE 2

BASIC DP PRINCIPLES

The basic DP system control scheme is displayed schematically in Figure 1 below. The different modules in the flow chart are described in more detail in the MT DP Operator Manual.

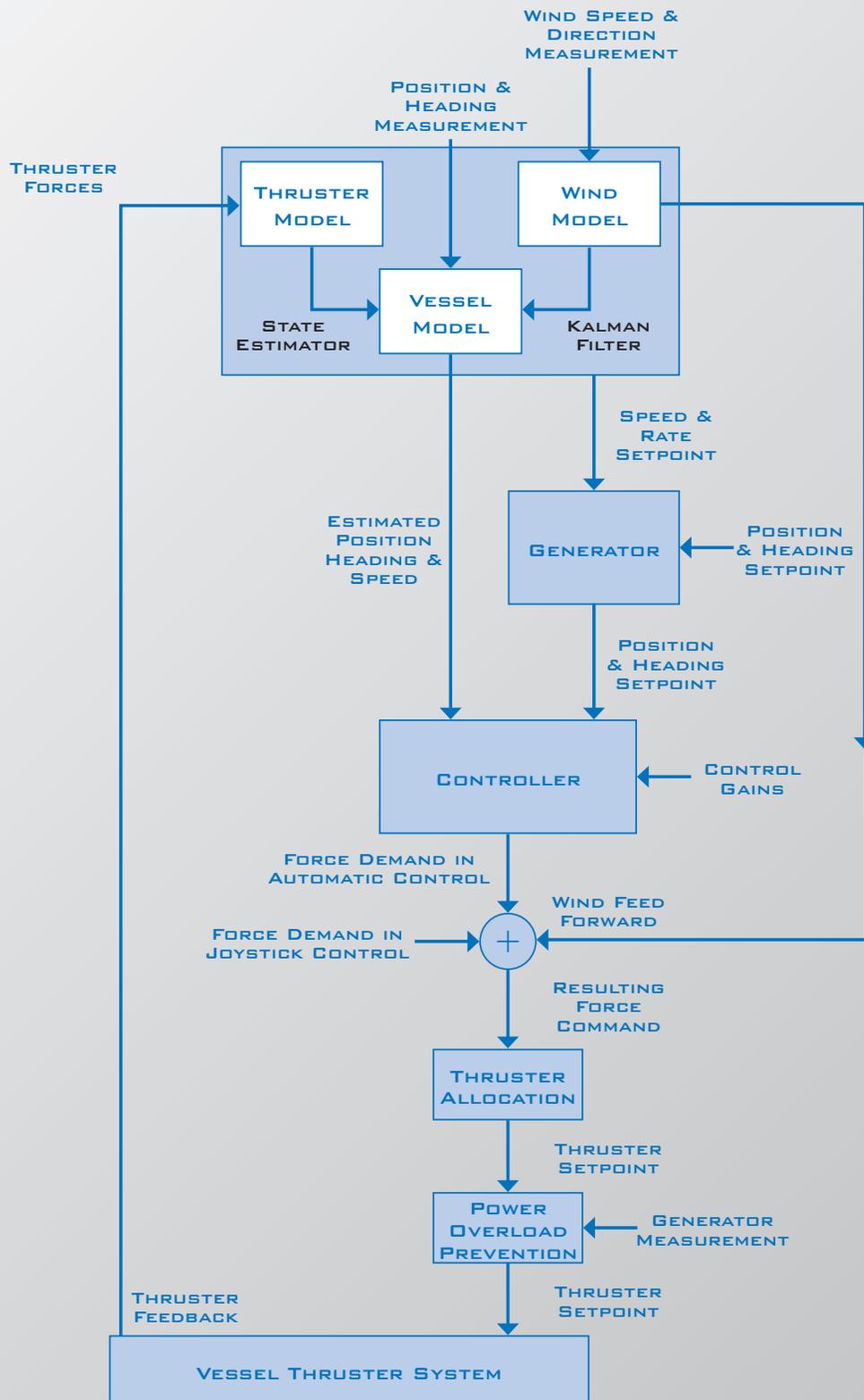


FIGURE 1 – OPERATIONAL FLOW CHART

SIX DEGREES OF FREEDOM

A vessel has a total of six degrees of freedom in which it can move: surge, sway, yaw, heave, roll and pitch. For a DP controlled vessel only the horizontal motion (surge, sway and yaw) can be controlled. This is illustrated in Figure 2 below.

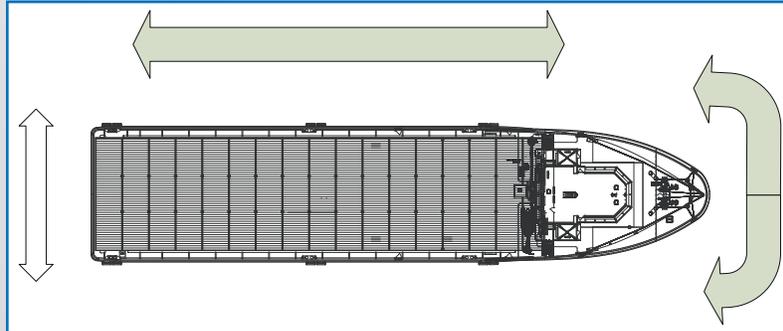


FIGURE 2 – HORIZONTAL MOTION IS CONTROLLED IN DP

The other motion components (heave, roll and pitch) cannot be controlled by the DP system, and the vessel dynamics for these degrees of freedom are neglected in the estimator and controller design. However, measurements of roll and pitch are typically used to compensate for the movement of the navigator antennas. Figure 3 illustrates the motion in heave, roll and pitch.

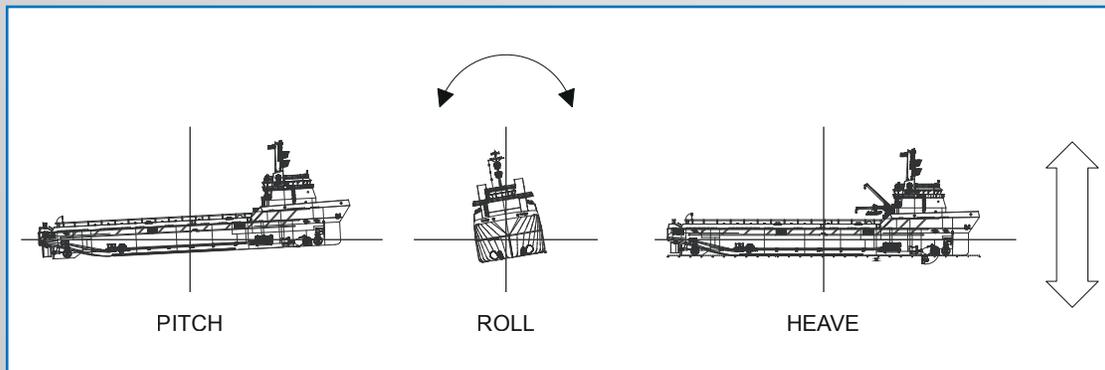


FIGURE 3 – MOTION COMPONENTS NOT CONTROLLED BY DP

BRIDGE MATE DESIGN REDUCES RISK FOR HUMAN ERROR

A large number of DP incidents are related to human error. MT has therefore emphasized user-friendly features throughout the design of the Bridge Mate products. Some of these user-friendly features are:

- Printed, backlit text on operator panels to provide visual distinction between different buttons
- Buttons are separated into different groups based on their functions
- Buttons have different shapes based on their function
- The placement of buttons on the monitor panel are linked to the graphical user interface to make the functionality of the button intuitive

The same user-friendly principle has been a criteria for design of the software that provides the graphical user interface. Some features are:

- A consistent use of colors to indicate status and error conditions
- A logical and intuitive placement of critical information in predefined locations, as well as separating features and functions into user selectable views

BRIDGE MATE ARCHITECTURE

The Bridge Mate DP Concept is based on a distributed architecture that emphasizes both redundancy and segregation philosophies. The robust design is important onboard vessels where a service and system specialist is not at hand 24 hours/day, every day.

In addition to distributed operator stations and DP control computers, the Bridge Mate system has distributed thruster and sensor interface units based on a stand-alone IO unit specially designed for use on DP vessels.

The distributed architecture reduces the cable installation considerably. Each interface unit can be placed close to the thrusters, the reference systems and the sensors to be interfaced. The design of the interface unit makes the Bridge Mate system well suited for retrofit and upgrading within all equipment classes.



BRIDGE MATE DP 1 SYSTEM

The Bridge Mate system architecture for a Class 1 system is based on a fully distributed concept as shown in Figure 4. A DP 1 system will have a single control computer, one operator station and separate IO units interfacing the sensors, positioning reference system, power source and thrusters.

An independent joystick system can be interfaced to the Bridge Mate DP system (see chapter titled "Independent Joystick").

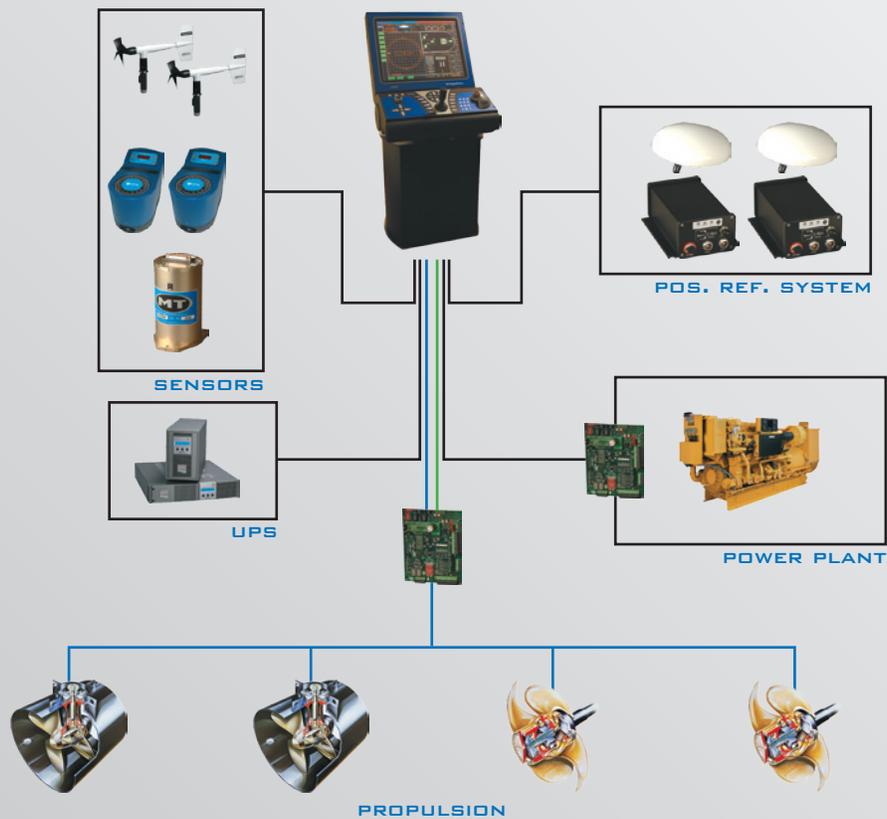


FIGURE 4 – BRIDGE MATE DP 1 SYSTEM

BRIDGE MATE DP 2 SYSTEM

A DP 2 system is composed of the same modules as a DP 1 system, but the number of modules have been increased for redundancy in order to comply with Class 2 rules. A DP 2 system will use three control computers and, typically, two operator stations. Using three control computers makes it possible to perform majority voting between the computers, and it is thus possible to reject a computer should it fail.

The number of IO units is typically much higher on a DP 2 system, as there will be a dedicated IO unit for each set of sensors, each position reference system, power source and each thruster. This configuration is used to provide redundancy at all levels to make sure that any single failure will not result in loss of position.

The compact design and distributed architecture make the system well suited for retrofit. Upgrading from a DP 1 to a DP 2 system is an easy process, since the same hardware modules are used for both types of systems, only different in the number of units used. Figure 5 shows a typical DP 2 configuration, where all the modules are connected via a redundant dual network.

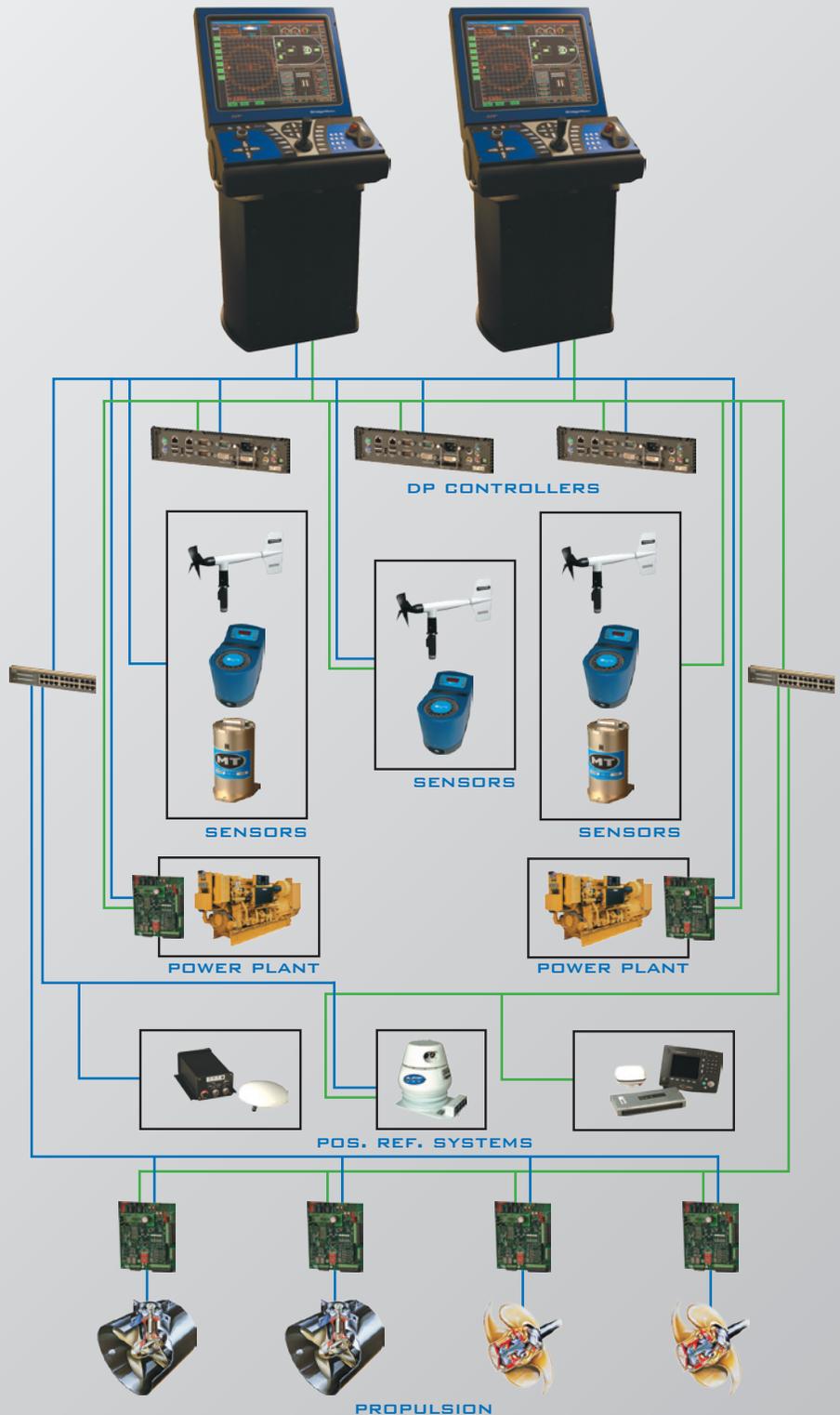


FIGURE 5 – BRIDGE MATE DP 2 SYSTEM



BRIDGE MATE DP 3 SYSTEM

A DP 3 system has an extended hardware configuration compared to a DP 2 system. The triple redundant DP controller is still used, and a minimum of three operator stations is required. There will also be three IO units to interface components, as opposed to a double set of sensors typically used in a DP 2 configuration. A DP 3 system also needs a physically separate, fire-safe compartment, where one control computer, one operator station and one sensor IO unit have to be located in order to comply with Class 3 requirements.

A typical DP 3 configuration is illustrated in Figure 6.

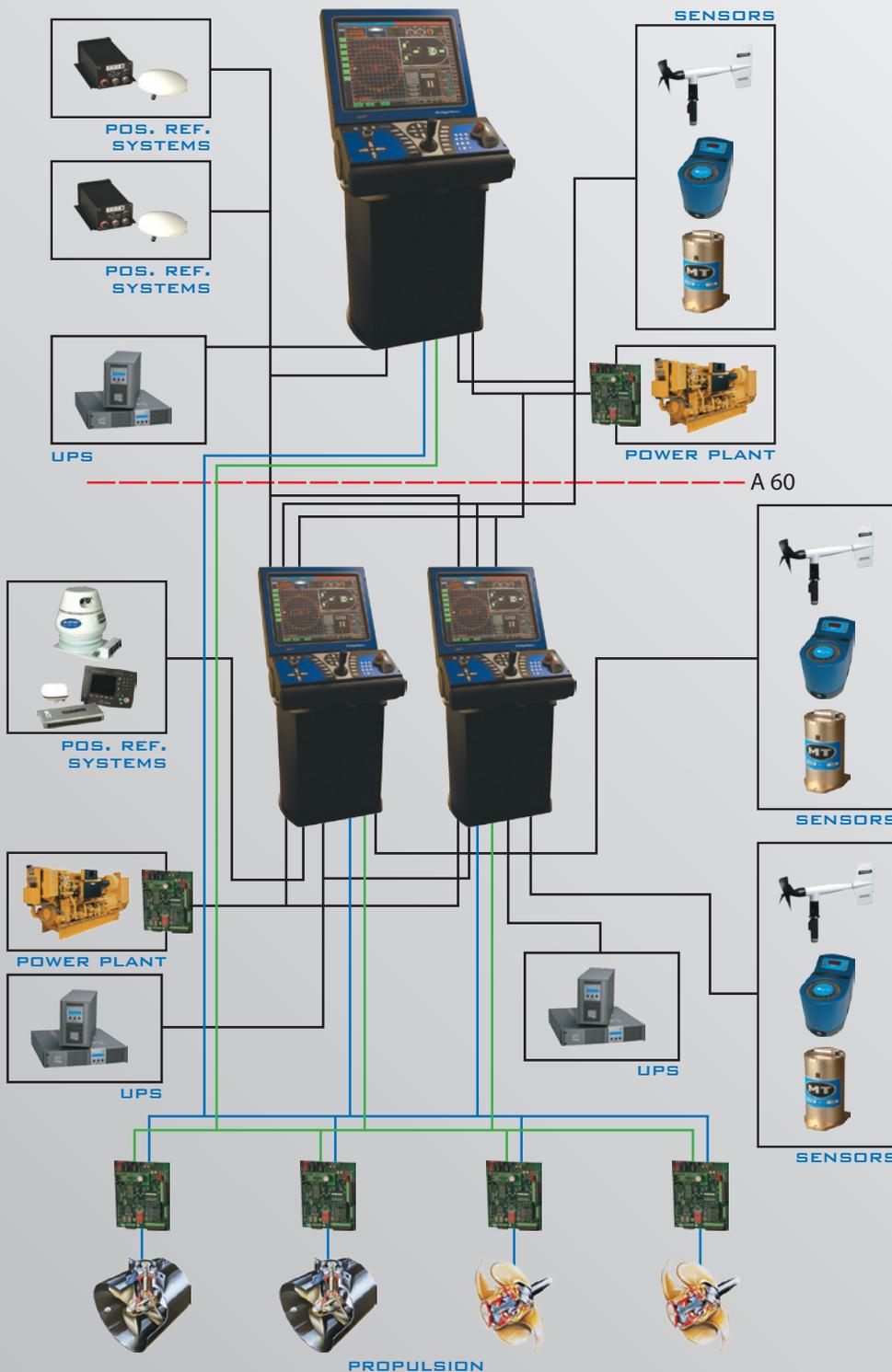


FIGURE 6 – BRIDGE MATE DP 3 SYSTEM

BRIDGE MATE JOYSTICK SYSTEM

The Bridge Mate Joystick system can be delivered as a stand-alone, independent system or as an integrated unit that is part of a DP configuration. The two alternatives are illustrated in Figure 7 below, and Figure 8 on the following page.

ALTERNATIVE 1: INTEGRATED JOYSTICK SYSTEM

Figure 7 shows an integrated joystick system connected to the redundant DP network. With this configuration the joystick system will be part of the DP network and will use the same sets of signals interfaced there, both for sensors and thrusters.

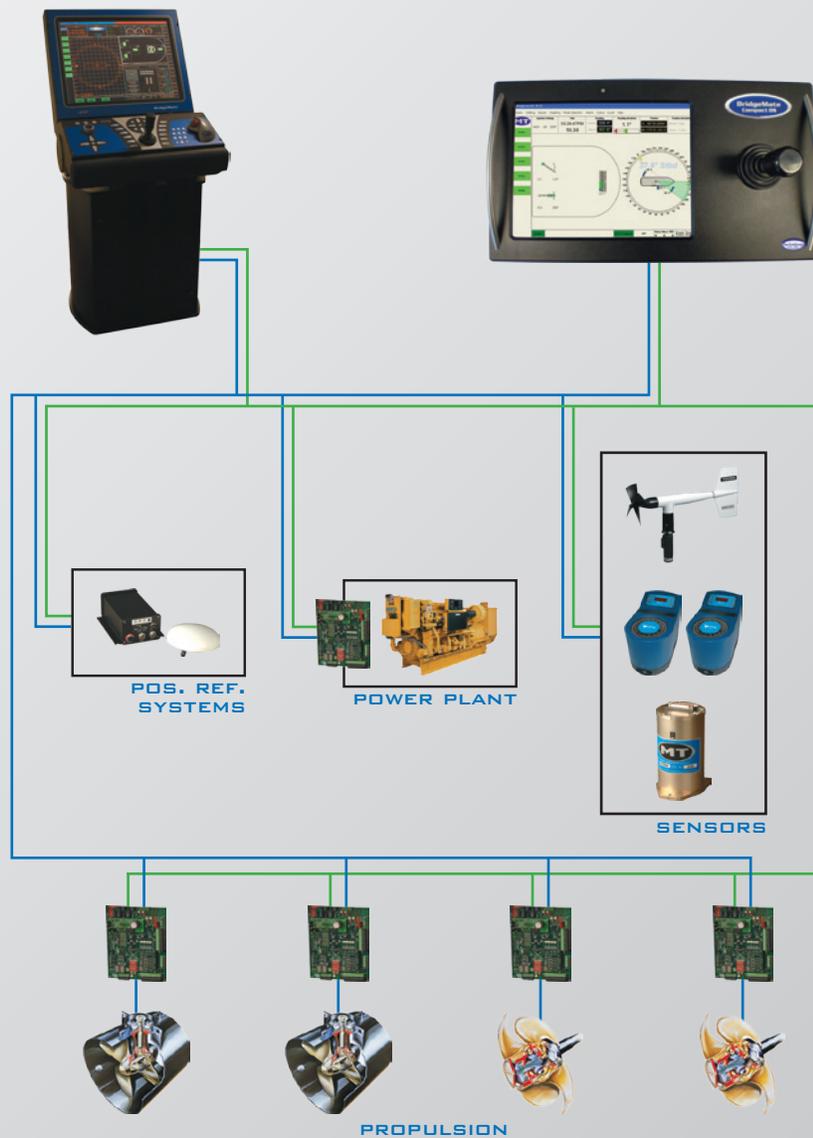


FIGURE 7 – INTEGRATED JOYSTICK SYSTEM



ALTERNATIVE 2: STAND ALONE JOYSTICK SYSTEM

As opposed to the integrated joystick system, the independent joystick system is not part of a DP network. The independent system has its own interface to both thrusters and sensors. All signals are interfaced through the standard IO unit. The stand alone system is used both as a backup system as part of a DP 1 or higher class vessel, or as a separate system for vessels that do not want full DP capability.

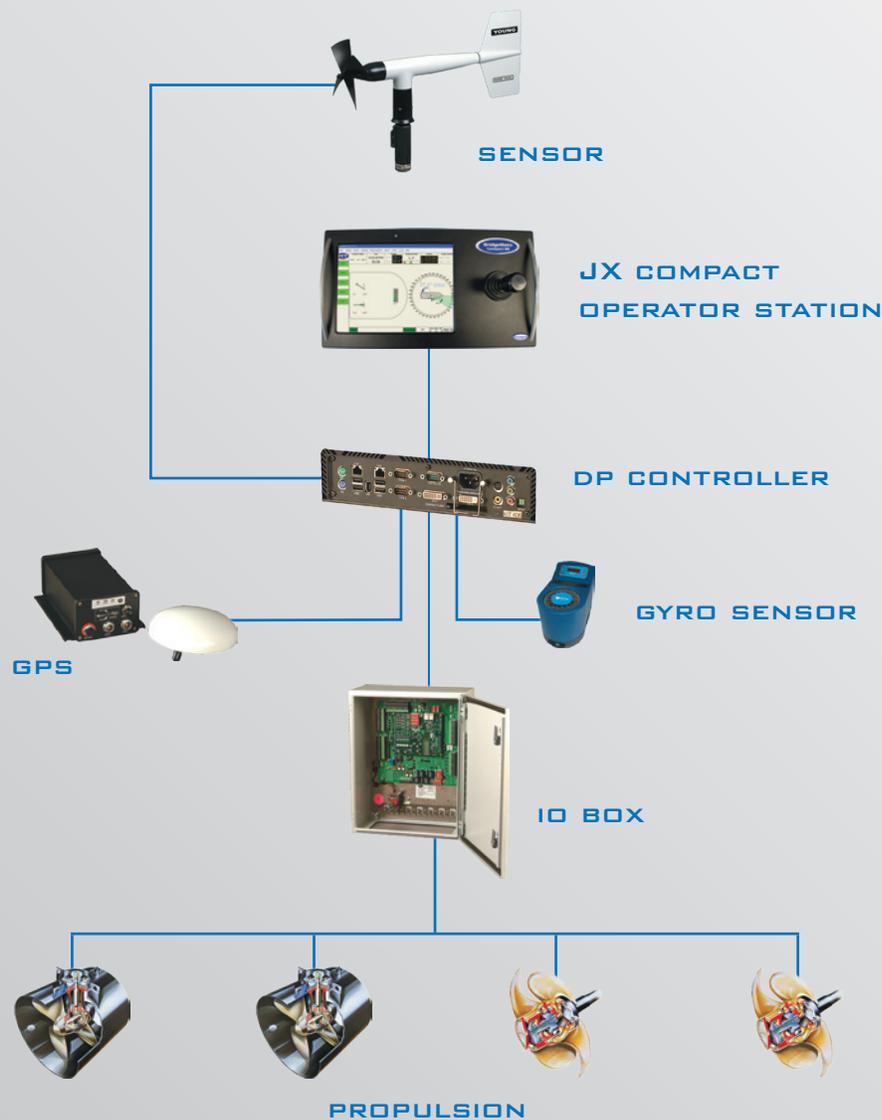


FIGURE 8 – STAND ALONE JOYSTICK SYSTEM

BRIDGE MATE TRIPLE REDUNDANT DP CONTROLLER

The three DP control computers in the Bridge Mate DP 2 and DP 3 systems are totally independent from each other, running in parallel. This means that each computer will read the same data from the sensors and run this through the same algorithms, resulting in a vector of output signals from each control computer to each individual thruster's interface unit. Each thruster's interface unit runs its own voting algorithm, comparing the signals received from the three control computers. Based on this, it is able to determine the status of a control computer. If one computer outputs a result different from the others, it will be isolated and discarded from the DP system, and an alarm will be provided to the operator. The faulty computer will then try to correct itself by performing a synchronization with the healthy control computers. This computer will only be accepted by the system if it is successful at this.

REDUNDANCY AND SEGREGATION PHILOSOPHY

The different modules that make up the DP system can easily be placed in a decentralized manner. This applies to control computers, operator stations/computers, as well as IO units. This ensures flexibility of installation and improves safety, as there is no centralized unit that will take down the entire system in case of a fire or flood. It is also a great benefit that a small set of standardized modules is used for any type of DP class system. This makes it easy to upgrade from one DP class to another and simplifies service and spare part availability.

ONLINE CAPABILITY PLOTS – NEW FEATURE

Bridge Mate now offers online simulation of vessel position holding capabilities for different environmental settings, such as current, wave or wind, or in the event of the loss of thrusters.

MOTION PREDICTION – NEW FEATURE

Bridge Mate motion prediction enables the DP system to predict how the vessel will move in the event of a system failure, such as the loss of a thruster, where the result is loss of position. The motion prediction algorithm, which is an extension of the existing consequence analysis function, will predict the speed and direction of vessel movement. The DP system is continuously performing real-time simulations to estimate how the environmental forces are affecting the vessel and how the vessel would be affected by any system failure. The drift-off projection is graphically indicated in the form of a trace line in a separate view.

NETWORKING

The DP system employs a dual Ethernet for communication between all the modules that comprise the total system. Computers and IO units are connected to the system via standard network switches using common network standards. The network solution is designed for robustness and reliability. All communication is full-duplex using User Datagram Protocol (UDP) with point-to-point communication instead of broadcast or multicast, preventing packet collision and loss of data. A typical DP 2 network configuration is illustrated in Figure 9.

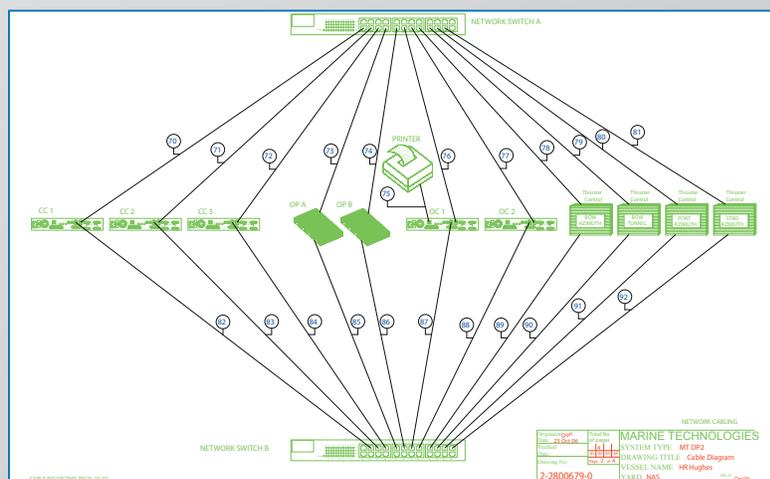


FIGURE 9 – DP 2 NETWORK CONFIGURATION



BRIDGE MATE COMPONENTS

The different hardware components used in the Bridge Mate range of products are described and illustrated in this chapter to present an overview of available configurations.

OPERATOR STATION

The operator station can take different forms, depending on DP class as well as practical considerations for fitting the system on a vessel. A typical operator station for a DP 0 – DP 3 system is illustrated in Figure 12. This console will typically include the operator panels and the monitor, as well as computers and network switches. Figure 10 displays how the different components can be fitted within the operator station console. A more distributed placement of components is also possible.

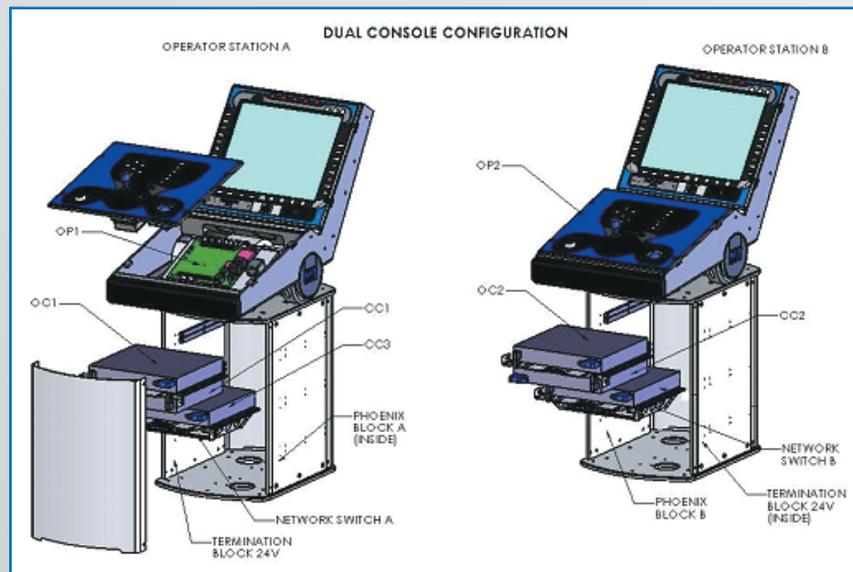


FIGURE 10 – SYSTEM COMPONENTS CAN BE FITTED IN OPERATOR CONSOLE

In addition to the operator station shown above, a compact version of the operator station is depicted in Figure 11 that can be used for both a DP system and a JX system.



FIGURE 11 – COMPACT OS



FIGURE 12 – OPERATOR STATION

OPERATOR PANELS

The typical operator station has two operator panels equipped with buttons – the upper panel and the lower panel. The lower panel is composed of four different modules. The main button module has various buttons for general control of the system. The buttons have a texture and shape that depend on the function of the button. Buttons with more important functions, like change of system mode, will require a double-push to activate the function. The lower panel additionally consists of the joystick module, the heading selector module and the trackball module. The lower panel is displayed in Figure 13.

The upper panel, or the monitor panel, is made up of the operator monitor surrounded by a panel of buttons and status lights. The buttons located on the upper panel are related to functions and symbols that are reflected on the user interface on the monitor. As an example, the buttons on the left side represent the thrusters on the vessel. Pushing one of these buttons will enable or disable a thruster from the DP system. These buttons are located next to the thruster symbols on the operator monitor which indicates the status of the different thrusters (*unavailable, running, ready or in use*).

The lower buttons represent the reference systems and are also linked to graphical status symbols on the monitor. Other buttons on this panel are linked to view settings on the monitor, as well as alarm status for the DP system.

The status lights on the very top of this panel represent the DP alarm system. The alarms are categorized into five groups. There is one status light for each computer alarm, power alarm, operation alarm, thruster alarm and sensor alarm. The alarm status lights will be blinking for new alarms and constantly illuminated for alarms that have been acknowledged but are still active.

To the immediate right of the alarm status lights are three buttons related to the alarm system. The leftmost button will open/close the alarm list, which contains all the active alarms. The middle button is used to acknowledge alarms, whereas the rightmost button is used to silence an audible alarm without having to acknowledge it.

The upper panel is illustrated in Figures 14 and 15.



FIGURE 13 – LOWER PANEL

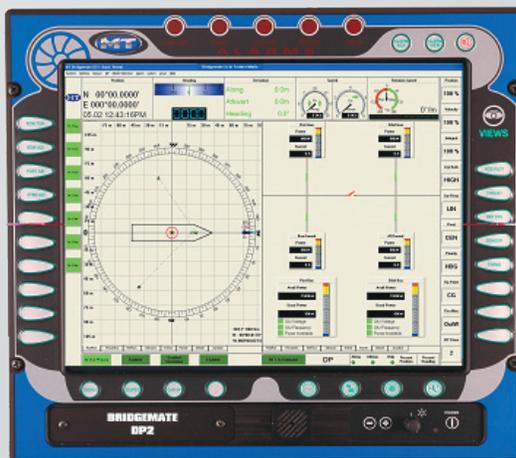


FIGURE 14 – UPPER PANEL



FIGURE 15 – UPPER PANEL
TOUCH SCREEN



INTERFACE UNIT

The IO card is a general purpose hardware unit that is used for different purposes within the DP system. It is based on Field Programmable Gate Array (FPGA) technology, which makes it possible for the IO Card to have different functions based on its configuration. The configuration is determined by the IP address switch sitting on the motherboard where the IO card is mounted.

When configured as a thruster's IO card or power IO card, the IO Card can be used to interface numerous analog and digital signals, and can read feedback signals, as well as outputting command signals from the DP system to external units. Typically, it will be used to interface thrusters, switchboards, etc. One IO card can be dedicated for one specific thruster (for redundant systems), or interface multiple or even all thrusters on a vessel.

When configured as a panel IO unit, the IO card can read serial data from sensors. Up to eight serial lines can be used for each IO card. For a higher class system where more sensors are typically interfaced, there will always be two or more panel IO cards. Thus, the number of available serial lines should always be sufficient.

When used as a panel IO card, it is also used to interface the I2C circuits that control panel lights and register button activity on the operator panels. The analog signals from the three-axis joystick are also read by the same IO card.

The IO card has additional built-in features that enhance its use in the DP system. These include:

- Built-in broken loop detection for all analog current loop input and output signals. This will ensure that wire problems will be detected by the DP system and appropriate action is taken.
- Communication over dual isolated Ethernet for redundancy.
- Onboard LCD allows for quick troubleshooting locally, including monitoring and operation of all IO in a stand alone configuration. This is a valuable service for field service personnel and allows for extensive troubleshooting without the need for hook-up with other equipment. This is important for both service and commissioning of the vessel.
- Eight optically isolated serial inputs provide interfacing to RS-232 and RS-422 signals for NMEA devices.
- Power supply to the IO Card is electrically isolated from onboard electronics, thus enhancing robustness of the IO card and reducing interference issues.
- Due to FPGA technology, any redefinitions or improvements of functionality may be made with SW update directly from a computer connected to the IO card.
- The IO amount versus board footprint ratio is very high. In its current configuration, the IOB handles more than 120 IO, and the IOB footprint is only 5.9" x 7.2". The compact size of the IO unit makes mounting easy and flexible.
- The same physical board may be used in a wide variety of applications.
- Some of the analog outputs are independently isolated, thus interface to electrically difficult devices may be performed without the need for external isolation to ensure signal integrity.

The IO card will be mounted on a motherboard that will be chosen depending on the application of the IO card. The motherboard contains the physical connection points where the actual signal wires are terminated. An IO card mounted on a thruster's interface card is depicted in Figure 16.



FIGURE 16 – IO CARD MOUNTED ON A SINGLE THRUSTER INTERFACE MOTHERBOARD

GRAPHICAL USER INTERFACE

The operator station is running on a Windows® Embedded XP operating system which provides the operator with the familiar Windows environment. This chapter briefly describes the main features and layout of the user interface.

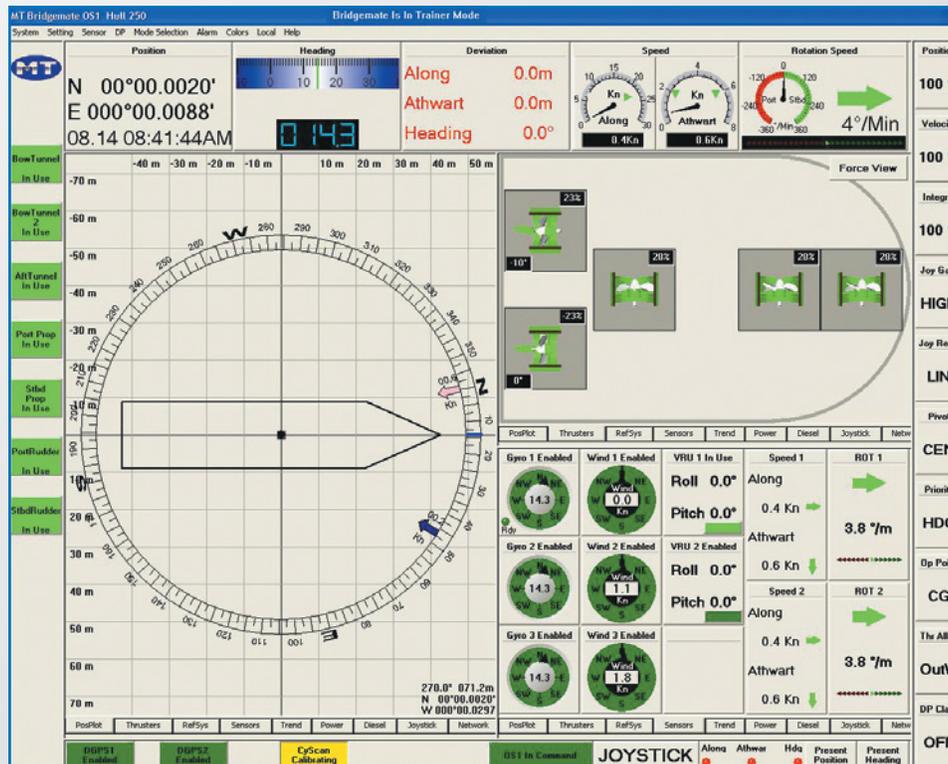


FIGURE 17 – GRAPHICAL USER INTERFACE

TITLE LINE

The title line indicates the name of the application (MT Bridge Mate) as well as the name of the vessel. If the system is running in simulator/trainer mode, this will be indicated on the title line as well.

MESSAGE LINE

The message line is on the right side of the title bar, and all alarms and warnings will be shown there.

MENU BAR

The menu bar provides the operator with functions and settings for the DP system.

PERFORMANCE AREA

The performance area is located underneath the menu bar and contains five windows that provide essential information to the operator at all times. The performance area is static in the sense that it will always display the same information to the operator. The position window is in the far left corner with *heading*, *deviation*, *vessel speed* and *rotation speed* proceeding to the right.



THRUSTER AREA

The area to the far left is the thruster area and contains symbols for the thrusters configured for the vessel. The thruster's symbols will show the status for the thrusters by using colors and text. Thrusters can be enabled/disabled by using the buttons next to these symbols or by opening windows/dialogs by clicking on the symbol with the mouse.

WORKING AREA

The working area section of the screen can be split into one, two or three views to be displayed simultaneously. For each of the view locations, the operator can open any type of view depending on what he wants to see at that time. The available views are: *position plot, thruster, sensor, reference system, joystick, trend, power, diesel* and *network view*.

SYSTEM SETTINGS AREA

The small section to the right of the work area displays some system settings that the operator can modify. The settings are modified in dialogs that are opened by clicking within the system settings area with the mouse.

REFERENCE SYSTEMS AREA

The reference system area is located on the lower left part of the screen and is similar to the thruster area to the far left. Reference system symbols indicate the status of the different reference systems, and the symbols are closely linked to the buttons that are used to enable/disable the reference systems.

STATUS AREA

This status area is located in the lower right corner of the screen and shows the status of the DP operation, such as the main mode of operation, which axes are under automatic control, and whether or not the system is in a position move or similar function.

JOYSTICK DISPLAY

Due to the small monitor used on the compact OS, the layout is quite different for this unit. Instead of using multiple, user-selectable views, there is one static view that contains all the essential information. The display is depicted in Figure 18.

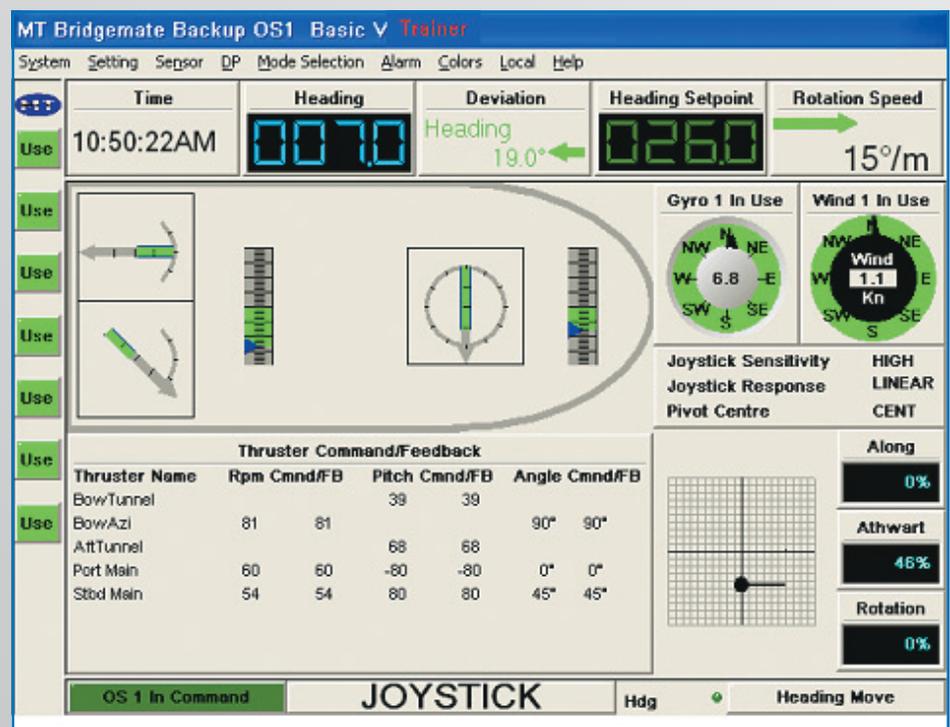


FIGURE 18 – USER INTERFACE ON A COMPACT OS

THE BRIDGE MATE DP LOG

MT, in cooperation with Shipadmin AS, is happy to announce the launch of a new and useful software program – the Bridge Mate DP Log. This software will be included in all new dynamic positioning systems that are delivered. It can also be delivered as a stand-alone system. The DP Log software was developed in close cooperation with world leading offshore companies in order to fulfill offshore industry requirements.

It is an industry requirement and a good practice to log all events taking place when performing different DP operations. However, it is often awkward and time consuming to write logs the traditional way when sitting in the operator chair. MT has solved this problem by developing a program which logs activities with the click of a button. The program also gives valuable information to the DP operator concerning all down lines and gear in use that have influence on the vessel operation. The vessel layout is displayed on the screen, assisting the operator in making decisions about the safest ways of moving the vessel without conflicting with down lines and overboard gear in use. Some examples of gear in use which can be displayed include HPR poles, drop down thrusters, tool winches, cranes, diving bells, clump weights, taut wires and A-frames. All gear in use will be displayed in red to give the operator a visual warning.

The DP Log has programmed phrases which populate the log with the ease of a click; however, the log is also flexible, allowing operators to make their own comments as needed.

The importance of creating an accurate log is always greatest at critical times when the operator has the least amount of time to record data. With the DP Log installed, all entries are made automatically, allowing the operator to stay focused on his or her main tasks.

In the event of an incident, it is important to have a correct log showing the sequence of events that took place, along with the exact timing of these events. Based on the log entries, a qualified investigation of the incident can be performed, increasing the chances that the root cause of the incident will be discovered.

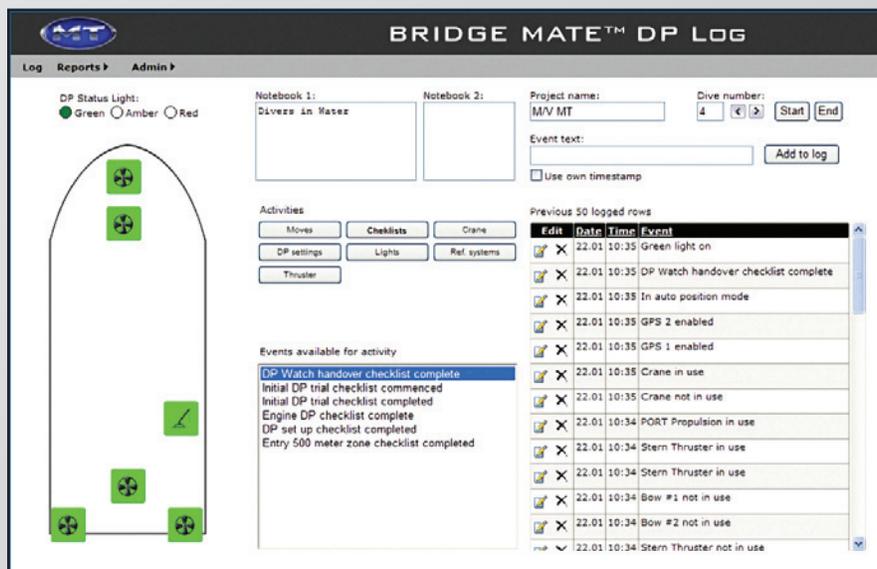


FIGURE 19



ALTERNATIVE SYSTEM INSTALLATIONS

This chapter illustrates different approaches that can be taken for installation of the DP system equipment, showing the flexibility of having a modular system where components can be mounted in a decentralized manner.



FIGURE 20

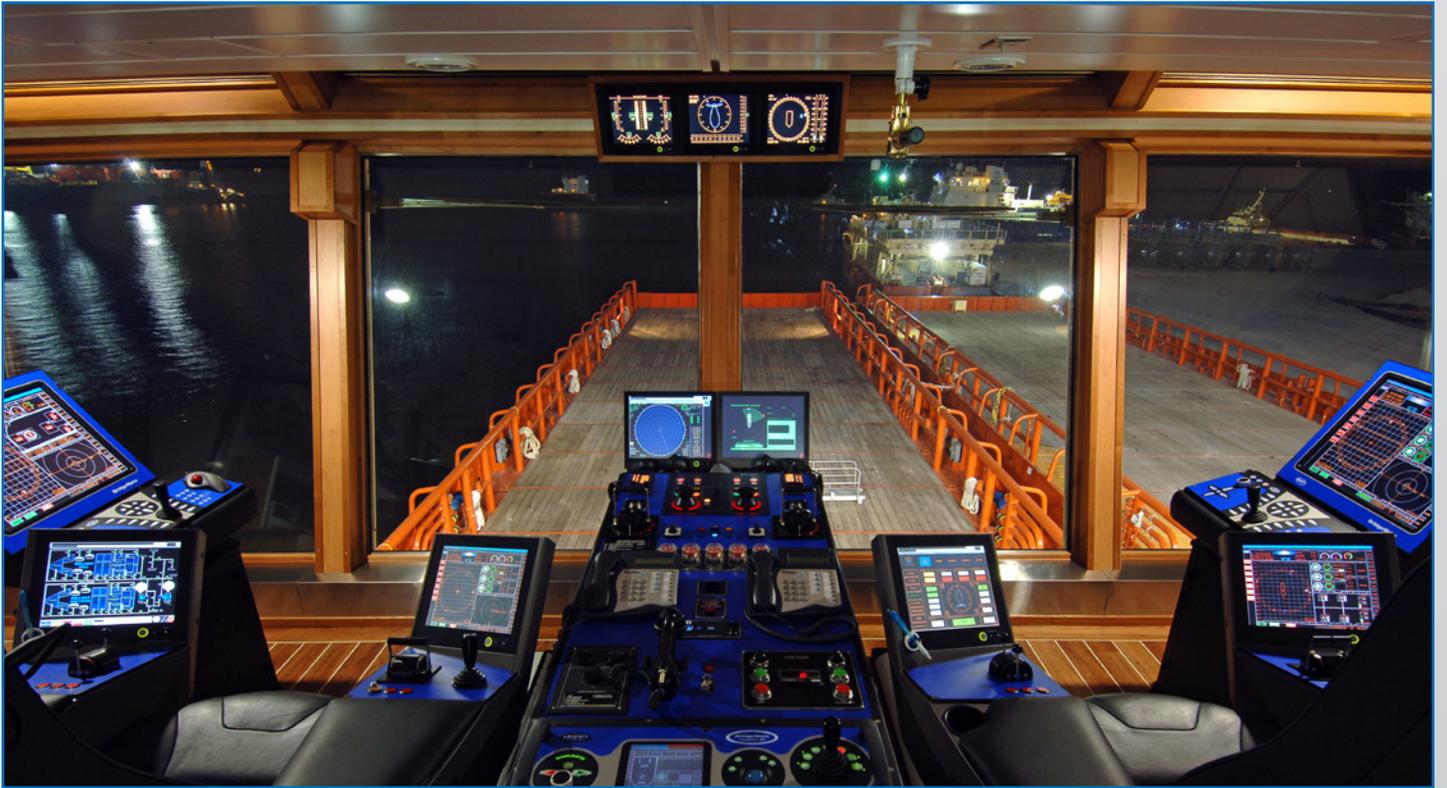


FIGURE 21



FIGURE 22



FIGURE 23



FIGURE 24

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