DYNAMIC POSITIONING CONFERENCE
September 16-17, 2003

Workboats

New Waves in Workboats: Combined Control and Monitoring

Michael C. Ford

Nautronix, Inc. (San Diego)

Abstract

With budgets getting tighter and offshore support companies looking for methods to get more out of their investments, workboats are being rapidly enhanced with new technology. Integrated control and monitoring systems, long reserved for larger vessels, are now emerging as the latest opportunity for not only money savings but also for safer operations. Through improved modular approaches based on new technology, these systems are affordable and provide substantial improvements in vessel operation including reduced manning requirements and one of the newest elements for workboats, Condition Based Monitoring. This reduces maintenance downtime by monitoring the status of critical systems and reduces failures by predicting the remaining "life" of equipment. In addition, these systems further reduce the vessel manning requirements through automated monitoring. These systems can provide benefits to virtually all of the workboat community from simple supply vessels to seismic survey and well stimulation vessels. This paper presents a short review of the technology used on larger ships and then a scaled down version for use on smaller vessels. Then some of the compelling reasons to introduce integrated control and monitoring systems onto workboats will be discussed. In addition, it will detail the layout of a typical system noting the new technologies that make it easy and affordable to implement these systems on smaller vessels. The conclusion has summaries resulting from current systems in use and opportunities for further enhancements directed at the workboat market based on industry observation and field experience.

Large Ship Systems – VMS Beginnings

For many years the military has understood the need to monitor virtually every system aboard their vessels. Millions of dollars have been spent on customized machinery control systems going by the monikers of MPCMS (Machinery plant central monitoring system) or MCCS (Machinery Centralized Control System). At the same time the commercial shipping industry has been slowly incorporating standard systems that originated in land-based applications onto large ships like cruise liners and FPSOs which required more monitoring than the crew could provide. In recent years these commercial systems have been sought out by the military for Commercial off-the-shelf (COTS) programs which has further heightened interest throughout the shipping community. These larger vessel systems have included interfaces to everything from the HVAC, fire alarms, generators, pumps, watertight doors, surveillance systems and more. Virtually every system on-board is linked to the monitoring system. In some cases multiple computer networks are required to connect all of the different systems. The number of I/O points can easily reach several thousand and more. Due to this type of complexity, these systems have historically been either too expensive or too cumbersome for the workboat community. Smaller systems have been developed over the years mainly in high dollar yachts where price was not a major decision factor.

Technological Advances for a Smaller System

Workboats have significantly fewer systems aboard than large military ships and even fewer systems that could be connected to a centralized vessel monitoring system. A typical workboat can expect to have somewhere between four and five hundred points to monitor not including added job specific equipment such as ROVs etc. This is less than 20% of the size of a typical large vessel system. Previously this would have required a large amount of hardware for the input and output channels as well as expensive Programmable Logic Controllers (PLC's), costly modified central processing units (CPU's) and expensive CRT displays. One of the latest advancements in technology is serial based engine control and monitoring interfaces. Instead of having forty or fifty hard-wired I/O channels with the associated wiring, a simple twisted pair network cable can now link the engine controller directly to the vessel monitoring system (VMS). This type of link results in a substantial savings in both space required for installation as well as installation time by reducing not only the number of cables required but also the size of cable necessary. There is a trade off in the time required to calibrate the system. The more complex computer based system typically requires more time to calibrate and commission but the additional time is out-weighed by the saving in installation and material costs. A similar method can be used to connect an entire network of valves to the VMS system allowing centralized control. Blocks of I/O can even provide single input or output channels reducing extraneous I/O while still allowing for expansion of the system through added modules. Further space and time can be saved through the use of "soft-PLCs." Instead of a fixed piece of hardware, PLC's have become a virtual unit operating on the hard-disk of each CPU in conjunction with the user interface. Again, this results in significant savings in wiring and provides expanded functionality. Advancements in computer technology have made the panel PC more affordable and powerful than ever before allowing further reductions in the cost of VMS systems. While previous VMS systems would require a bulky CRT display as well as space for a rack mount CPU, now a commercial panel PC fits both an LCD display and a hardened CPU into less space than the previous CRT display alone. In addition, the reliability of these units has improved under the market pressures. Commercial software has also evolved to reduce the price for monitoring and control systems with standard libraries for typical functions and meters; software can be developed quicker with fewer errors. Computer networking has also served to improve these systems with new and faster connection methods that allow client stations to provide complete functionality at virtually any location on the vessel. Instead of a simple alarm display in the chief engineer's quarters, complete access to all of the vessel's systems can be provided.

What Can a VMS System Do For You?

Vessel management systems provide centralized locations to monitor vessel systems. This allows the crew to operate much more efficiently. They no longer have to search for the active alarm panel and then find the location of the alarm to discover the true nature of the problem. A vessel monitoring system brings all of the major alarms to a single accessible location and provides much more information than a simple blinking light typical of most of the alarms systems on the market today. The operator no longer sees a simple "high temperature alarm" for a generator, but instead sees a picture indicating which location is over temperature, what the alarm level is and what the actual temperature is. This allows the engineering staff to make a more rapid decision to remedy the situation allowing operation efficiency to go up for the entire vessel. When an incident occurs onboard a vessel, critical time can be lost waiting for the right personnel to get to the location of the alarm, and evaluate the actual situation. VMS systems help eliminate this loss of time with networked stations at additional locations around the vessel, allowing engineers to immediately review additional information and in many cases determine the proper actions much faster. Safety is always a critical consideration when adding a new system to a vessel. Integrated control and monitoring systems improve overall vessel safety by providing more critical information for timely decisions by the crew resulting in less damage to shipboard systems. In addition, machine monitoring systems allow critical elements to be monitored in real time so changes can be seen sooner, again preventing damage to critical systems. With their redundant architecture, VMS systems are explicitly designed to avoid single point failures within their own hardware and software. In many cases, regulatory agencies allow reduced manning requirements as well as reduced maintenance intervals with automated VMS systems. Notations for unmanned and periodically unmanned engine rooms require this type of system but reduce the operating expense of the vessel through reduced manning. VMS systems do require proper training though putting a higher demand on vessel operators for classroom time. VMS systems allow many additional parameters to be monitored due to their efficient presentation and ease of expansion. By closely monitoring critical parameters, maintenance can be conducted before it is necessitated by an actual failure. This in turn prevents damage and potential repairs for other systems that could be affected by the failure. For example, if a minor bearing was visually inspected, critical problems could be missed. With a VMS system monitoring the same bearing, an alarm would sound as soon as the temperature passed a dangerous level indicating a problem. With this forewarning, the damage done when the bearing failed could be avoided. Previously, the I/O modules and sensors for VMS systems were custom made with no real guarantee of support of service life. With major companies like Allen-Bradley and Siemens producing millions of modules each year, reliability of current VMS systems is dramatically improved.

The Regulatory View

There are several forms of automated systems covered by the regulatory agencies including dynamic positioning and machinery monitoring. Each has its own requirements based on the notation desired. Most regulatory bodies apply standard requirements to computer systems whether they are used for DP or for automated monitoring systems. There are specific environmental and failure criteria for operation under these notations. For even the most limited systems a ruggedized CPU, approved display and data interface system are required. Many suppliers offer Type-approved equipment to alleviate concerns over less than suitable equipment being provided. For automation systems there are two main classifications, including periodically unattended engine rooms and unattended engine rooms. Basically, the less time an engineer will spend in the engine space the more parameters that must be monitored. In each case there is typically a engine control room station with two displays for local control, with a display added to the navigating bridge for unattended engine rooms. Both versions require system redundancy to prevent a complete system shutdown. This is typically achieved with dual CPU/Server units, dual PLC's and a dual network. This prevents a single point failure from completely disabling the system. Each regulatory agency has strict guidelines regarding the type and life expectancy of these parts. In most cases suitable data must be presented if non-approved parts will be used.

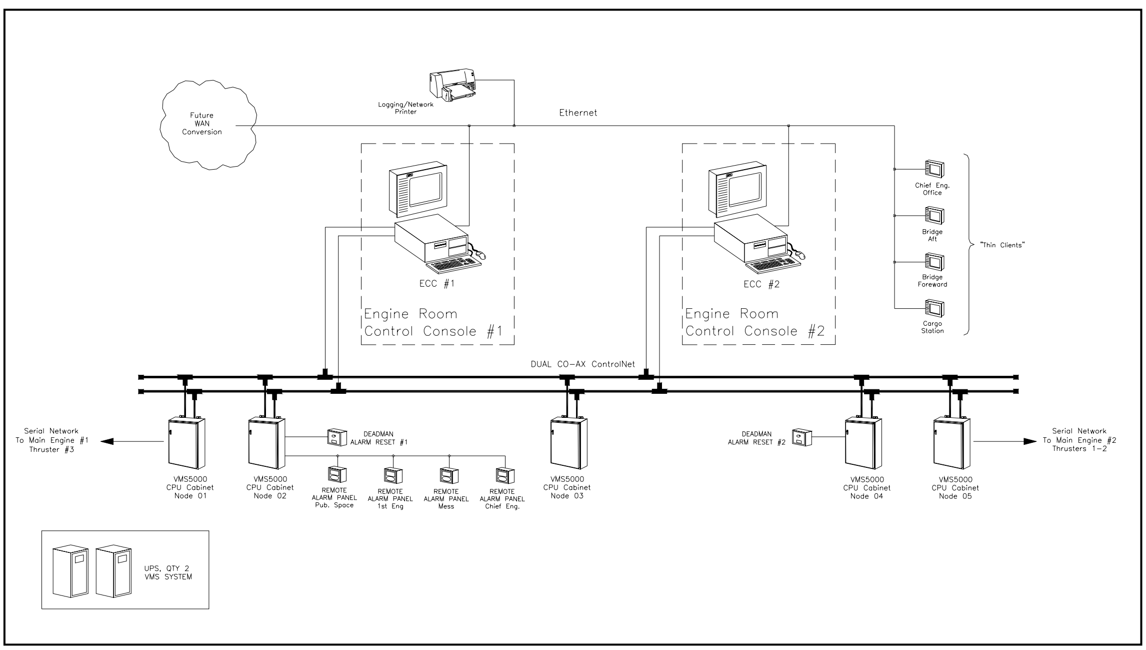

Figure 1 – Typical Workboat VMS System (Nautronix VMS5500)

A System Tailored for Workboats

As mentioned previously there are several elements that make up a vessel management system capable of monitoring and controlling various shipboard systems. Figure 1 shows a typical system designed for a workboat application. Each component will be discussed along with specific concerns and considerations for each.

The central processor unit(s) must be "ruggedized" to ensure operational service in a shipboard environment. Many customers are misled thinking that typical off the shelf components are sufficient for marine use. These units are not designed for the harsh environment and they are not guaranteed to perform under such conditions. While many specifications require certain features on the CPU including speed, the most important factor is actual performance. The CPU must be matched to the User Interface and the other system components to provide acceptable performance on-board the vessel.

The display is the next critical element in the system. Without a reliable and useful display, the additional information provided by a VMS loses its value. Typically, a display should be large enough to see all of the details from the standard operating position. It should include full brightness control for day and night operations. Many issues have arisen out of displays that provide exceptional performance in bright daylight, only to be dangerously bright during night operations. Another concern on displays is screen glare which also affects visibility during operations.

The User-Interface is possibly the most critical element for a VMS system. Without passing information smoothly to the user, the system completely loses its value. Not only does the user need to understand the meaning of each alarm, but also what actions can be taken from a particular station and what impact it will have on the system. All of this information must be relayed efficiently and understandably to the user again highlighting the need for proper training

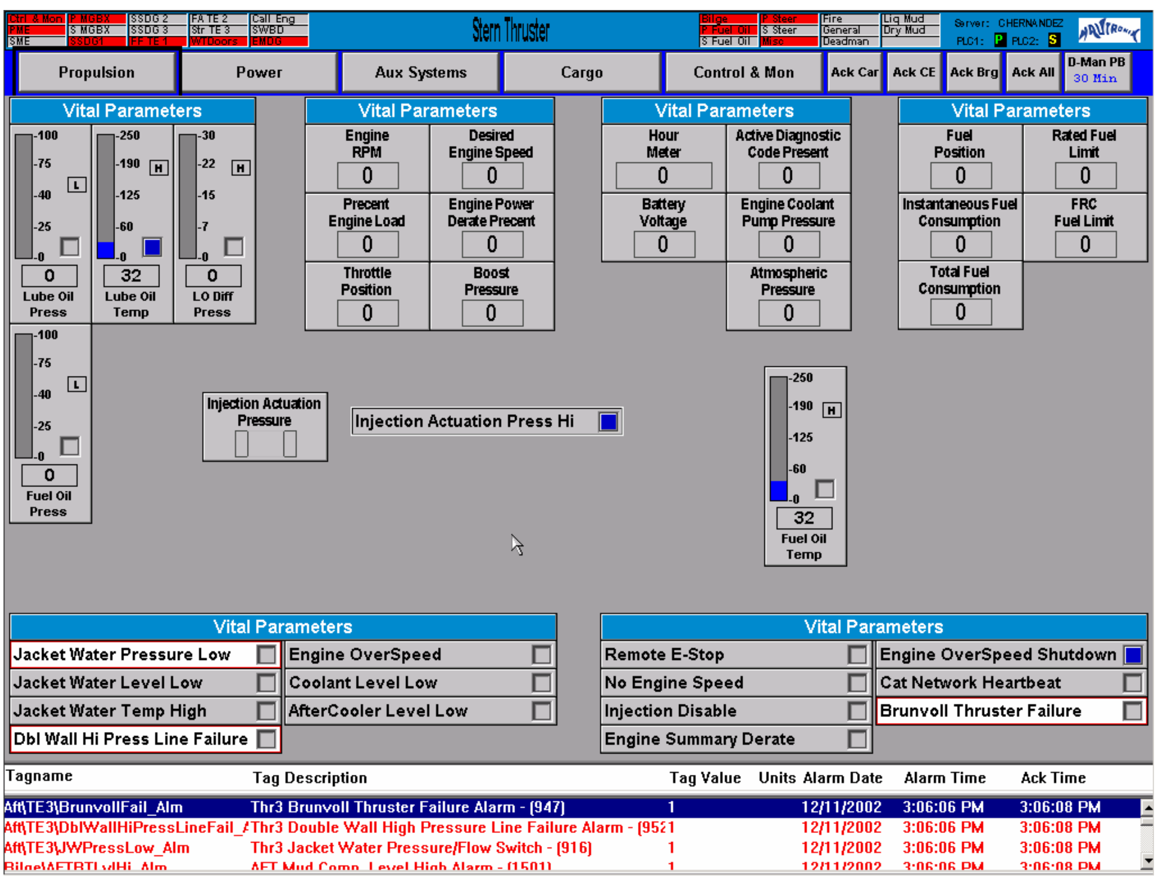

Figure 2 – Thruster Overview Page (Nautronix VMS5500)

with these systems. As more and more systems are interfaced and more and more information is available, the operator has more chances for error without proper training. Figure 2 shows a typical thruster monitoring screen. A single screen presents all of the vital information for a single propulsor as well as the connected auxiliary equipment. Most systems provide a summary alarm area (Top Left and Center-right in Figure 2 and 3) which informs the operator of any additional areas with alarms. Figure 3 shows a Bulk Mud control screen. Each valve can be opened and closed from this screen along with pump controls to completely manage the Bulk Mud cargo. A similar screen would be provided for each system on the vessel. While some systems may be combined due to the small number of I/O points, it should only be done while maintaining the integrity of the information presented. Ergonomics and human interaction should be major design factors especially when touch-screen systems are used. Each computer network of the VMS system should be redundant and reliable. Typically the control and display stations are located on an Ethernet network with the controls and PLC's on an industry standard network such as Modbus, Profibus or ControlNet. This allows multiple compatible systems to be easily integrated into the network and provides easy expansion of the system. On the "top level" Ethernet ring, additional control locations and even other shipboard computer systems, like DP can be integrated. Table 1 below notes some of the systems that can be connected to a VMS system and the functions interfaced.

Table 1 - Typical Systems Interfaced

Main Engines & Generators	Exhaust Temperatures Oil Temperature Bearing Temperature Fuel consumption Etc.	Status, temperatures, Motion, flowrates, etc.
Tank Levels	Fuel Water Ballast Bilge	Levels and specialty alarms for HH, H, L, LL.
Valves	Cargo including Fuel, Bulk Mud, potable water, etc., Ballast, Fire Systems	Controls and status indicators
Pumps	Cargo, fuel, ballast and fire systems	Controls and status indicators
Vessel Alarms	General Fire Flood	Status Indicators
Watertight Doors	Position	Status and control *(per Reg. Body requirements)*
Engine Order Telegraph	Orders	Status
Environmental Sensors	Wind Current Waves Position Attitude	Status indicators, values and trends

The Programmable Logic Controllers or PLC's are the final critical element. This element has undergone a significant change, ultimately making it much more affordable for smaller vessels. Most large ship VMS systems rely on hardware PLC's for the lowest level of control and interfacing. These units are often the most expensive component in the system. Advances in technology have led to the development of "soft-PLC's" which are software programs running simultaneously with the user interface on the same CPU. This significantly reduces the hardware expense as well as the installation effort. PLC's run simple programs to route the I/O appropriately and provide low level functionality in some cases.

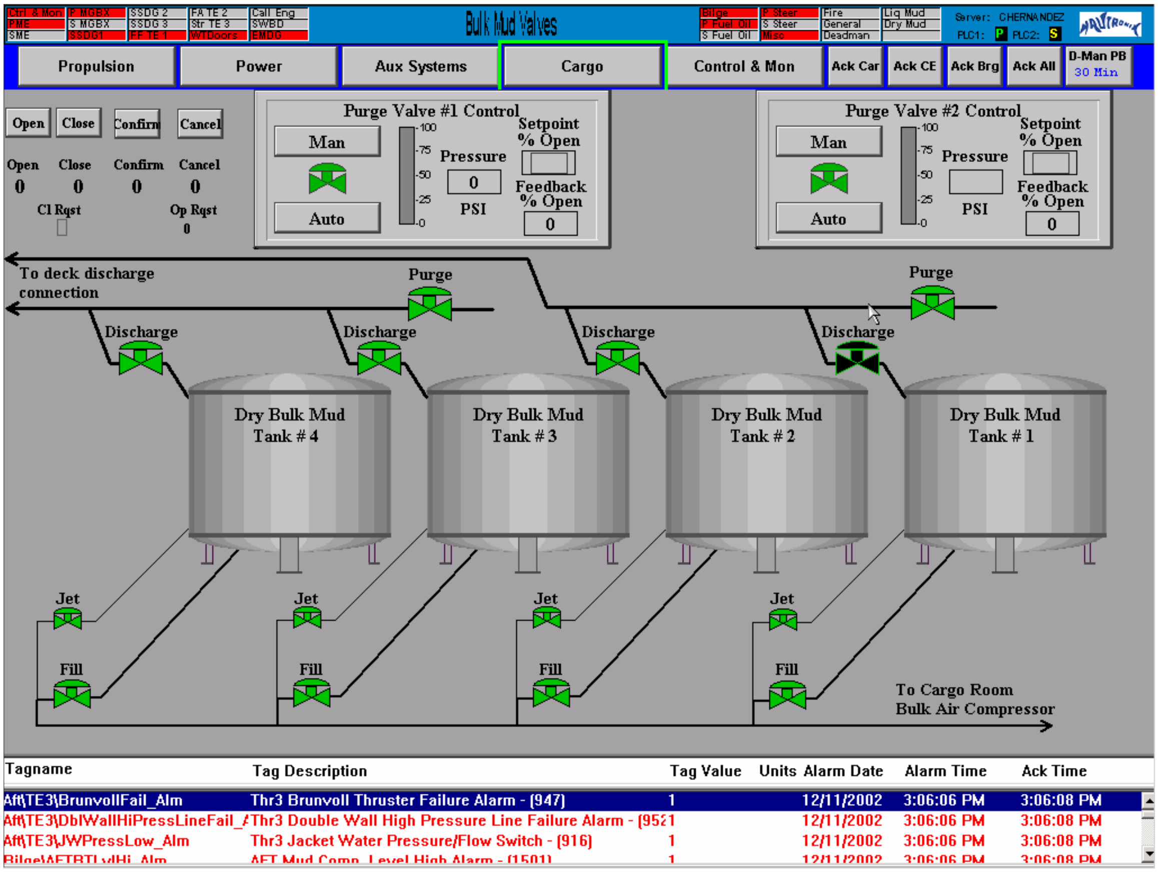

Figure 3 – Bulk Mud Page (Nautronix VMS5500)

The actual sensor devices complete the VMS system. These include numerous devices from rudimentary temperature gauges to custom vibration monitors. The sensors are a critical element to the system since they must be reliable and useful. Even though the system can provide alarms for virtually anything that can be automated, does not mean it should be incorporated into the system.

Summary

Current experiences

Currently there are several workboats with integrated control and monitoring systems installed ranging from large anchor-handlers to mid-size platform vessels. While these systems have reported a few growing pains, the majority of the feedback has been very positive. Most vessel operators have been very positive towards the reduced manning requirements VMS systems can provide. In addition, most operators have found good use for the real-time data provided by these systems. With multiple ship board systems accessible from a single location daily operations have been simplified for those with proper training. In addition, several operators have praised the ease of current systems to expand, not only adding small items such as single valves, but even adding complete systems to the VMS. The majority of the growing pains experienced have not been in the operation of the systems but in the installation. The reductions in wiring and hardware have shown reductions but the relative inexperience with these complex systems has caused longer installation and commissioning periods than predicted. Suppliers have gained a substantial amount of experience and now installations are starting to realize the savings originally predicted.

Several specific areas have been identified which have resulted in difficulties and require improvement. Few current manufacturers offer a fully integrated package for monitoring and propulsion control which is only a matter of the industry evolving and different operators seeing the potential. Engine manufacturers are already supplying governors which can interface using a serial network and valve manufacturers are providing the same. Full integration is mostly dependent on time. Coordination among the vendors is just emerging as a major component for integrated systems. While Regulatory bodies detail specific alarms required for their classifications, the responsibility for providing those alarms can often apply to several vendors. This has resulted in additional costs with sensors added to the systems after initial installation and multiple sensors and alarms for the same equipment. The VMS systems themselves have easily accepted the added I/O, further supporting their flexible nature, but it revealing a potential concern that not everything should be integrated. Finally and potentially most important, is proper training for these systems. As VMS systems integrate more and more systems, it forces the operator to be more thoroughly trained. The real-time information provided is only as useful as the training provided to the operator to use it.

Future opportunities

Most of the current vessels fall short of a fully integrated system opting for a few separate systems connected together in rudimentary fashion. Often the VMS system receives only summary alarms from some systems reducing the benefit of an integrated system. As costs decrease the trend will move toward fully integrated systems with even more features to offer. As vessel systems become more integrated, suppliers will resolve the scope of supply issues to provide concise well tailored systems which meets the customer requirements as well as the regulatory requirements. VMS systems have the potential to meet any operator's needs from simple and small to large and complex. Several vessels are already experimenting with full Condition Based Monitoring (CBM) systems that take the VMS concept further. These systems are designed to issue maintenance reminders based on the service hours and performance of the monitored item based on specific parameters derived during the initial trials of the vessel. In addition, they can generate automated reports detailing specific equipment performance indicators for each monitored system. The USCGC Healy has one of the most substantial CBM systems currently operating. The impact on the vessel has been so significant that the Coast Guard redesigned the maintenance procedures for this vessel. While workboats do not require the detailed system on-board the USCGC Healy, they can benefit from the CBM principles, especially for critical systems. With workboats almost continually in service, a CBM-type implementation could provide substantial savings both in maintenance and repairs. Finally, the fundamental principle for VMS systems is expandability. With the capacity to interface to more and more systems, vessel monitoring systems can bring even a workhorse supply boat closer to the Navy's long promoted SmartShip.

References

"Rules For Building and Classing Steel Vessels," American Bureau of Shipping, Part 4, Chapter 9 "Remote Propulsion Control and Automation," 2003.

"Rules for Classification of Steel Ships," Det Norske Veritas, Part 4 Chapter 9 "Instrumentation and Automation," 2003.

Nautronix VMS Product Description, 2003.

Pearson, Larry, "Monitoring and Control: The Computer Invades the Wheelhouse," Marine News, 22-July-2003.

HOS Bluewater, VMS5500 system, Field Reports, 2002-2003.

LCDR William J. Reicks Jr., USCG; LCDR Richard Burt, USCG; John P. Mazurana; and Russell J. Steinle, "USCGC HEALY (WAGB 20) - A CASE STUDY FOR IMPLEMENTING RELIABILITY-CENTERED MAINTENANCE," Marine Technology, Vol. 37, No. 1, January 2000.

Evans, Jefferey P., "Utilizing Advanced Monitoring and Diagnostic Technologies to Implement a Condition-Based Maintenance Program," Maintenance Strategies, Inc. white paper, 2000.

Biography

Mr. Ford has a Bachelor of Science degree in Naval Architecture and Marine Engineering from the University of New Orleans. He provided consulting services to the Houston offshore community including mooring analysis, air gap analysis and on-site naval architecture support working with David Tein Consulting. After two years of consulting, he joined Nautronix as the staff naval architect. During his initial tenure with Nautronix, Mr. Ford held several positions leading up to Product Manager for the JSDP product Line. After introducing the latest JSDP5000 product line, he took a short sabbatical from the DP community. During this two year hiatus from Nautronix, Mr. Ford provided project management services to RD Instruments and Systems Engineering services to NASSCO working on the T-AKE project. Mr. Ford returned to Nautronix as the International Product Manager for their complete vessel controls product line in 2002.