DYNAMIC POSITIONING CONFERENCE
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WORK BOATS

A 'Touch of Class' for Workboats – Dynamic Positioning Class 1 and Class 2 Explained

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Abstract

As the major push in exploration moves further offshore, new requirements are put on the support vessels. Not only are they required to carry more supplies and perform more duties, they are expected to carry on continuously through difficult weather. Redundant systems allow the vessels to operate continuously under these conditions avoiding costly downtime and providing improved margins of safety. In addition, certified redundant vessels can often command higher day rates. Previous generation workboats were typically equipped with minimal automatic control systems or at most a simple, single, non-redundant DP system with single sensors. The enormous demands of deepwater are now requiring fully compliant Class 1 systems and in some cases even moving to fully redundant Class 2 systems. This paper will discuss the required equipment to meet each of these classifications from the dynamic positioning system aspect ranging from actual sensors specified to the range of equipment possible to meet a given classification. The rules for several classification bodies including American Bureau of Shipping (ABS), Det Norske Veritas (DNV), International Maritime Organization (IMO) and others will be compared. The certification procedure will be discussed to alert vessel owners to the increased testing times and submittals required for vessel classification. This will provide a reference for all owners and shipyards involved in or considering Class 1 or Class 2 workboat projects.

Introduction

Vessel classification has long been an accepted way to assure not only a quality vessel but assist in organizing the development and construction process. After a relatively short downturn in the oil industry, exploration is again pushing further into deeper waters and with this push the 'workhorse' supply vessels are taking on additional duties and expectations. Dynamic positioning (DP) systems, relatively new to the workboat market just a few years ago, are now moving into the limelight to provide extended capabilities and safer operation. Longer operation with improved safety equates directly with higher day rates, further adding to the appeal of DP. With these new and more complex systems has come a long list of different classifications and requirements to satisfy various regulatory bodies insuring their safe operation. Classification in itself provides assurance of a properly designed control system, which will benefit the owner in a safer longer operating vessel. There are a number of regulatory bodies (Figure 1), which provide

Classification Organizations		
IMO:	International Maritime Organization	(International)
ABS:	American Bureau of Shipping	(American)
LRS:	Lloyd's Registry of Shipping	(British)
DNV:	Det Norske Veritas	(Norwegian)
BV:	Bureau Veritas	(French)

Figure 1 - Major Classification Organizations

classification for DP systems. Generally, each group requires similar equipment to meet the commonly known classifications of Class 1 and Class 2, both of which require substantially more than a simple Class 0 system which has been the standard for workboats. Figure 2 provides a listing of the various notations offered by each of the major regulatory bodies specifically for Class 1 and Class 2 systems. Moving to a Class 1 system requires approximately two times the equipment of a Class 0 system, while moving to a

Class 2 system increases the requirements approximately four times. With each step in complexity, the vessel can reasonably carryout more

	Corresponding Class Notation				
Description	**IMO**	**ABS**	**LRS**	**DNV**	**BV**
Automatic Position Control Automatic Heading Control Backup coordinated control system with Automatic Heading Control	**Class 1**	**DPS-1**	**AM**	**AUT**	**MA**
Automatic Position Control Automatic Heading Control Both during and after any single failure EXCEPT loss of a compartment	**Class 2**	**DPS-2**	**AA**	**AUTR**	**MA.R**

Figure 2 – Class 1 and Class 2 Notations

missions, which not only increases the marketability of a given vessel, but also increases the cost. Both Class 1 and Class 2 systems will be reviewed to help the potential owner decide which classification meets their needs and budget

Class 1 DP Systems

Class 1 systems are directed by a single design requirement: Loss of position can occur due to a single major fault. Class 1 systems require a single DP computer with an "independent, centralized manual position control with automatic heading control." Effectively this requires two complete control systems in addition to the standard bridge controls. However, transfer of control between each of them must be initiated manually. Each of the classification groups agrees that a separate backup system capable of automatic heading control is required. The main DP system should provide automatic heading and position control for all three axes. Some DP systems allow the operator to separate control between the fore/aft axis and the port/starboard axis, but full automatic control is required.

Class 1 Required Equipment					
	IMO	**ABS**	**LRS**	**DNV**	**BV**
Position Reference	**1**	**2**	**2**	**2**	**1**
Wind Sensor	**1**	**2**	**2**	**1**	**1**
Gyrocompass	**1**	**2**	**2**	**1**	**1**
VRU	**1**	**2***	**2***	**2**	**1**
UPS	**1**	**1**	**2**	**1**	**1**

**** - Additionals only required if DP is dependent on VRU.***

Figure 3 – Class-1 Required Equipment

The power for the DP computer must be supplied by an uninterruptible power supply (UPS), which also supplies the associated monitoring and reference systems. These monitoring and reference systems must include two position sensors, two gyrocompasses and two wind sensors with automatic changeover, i.e. if

one fails the other should continue uninterrupted. Class 1 systems (Figure 4) are relatively straightforward. Some regulatory agencies require the position

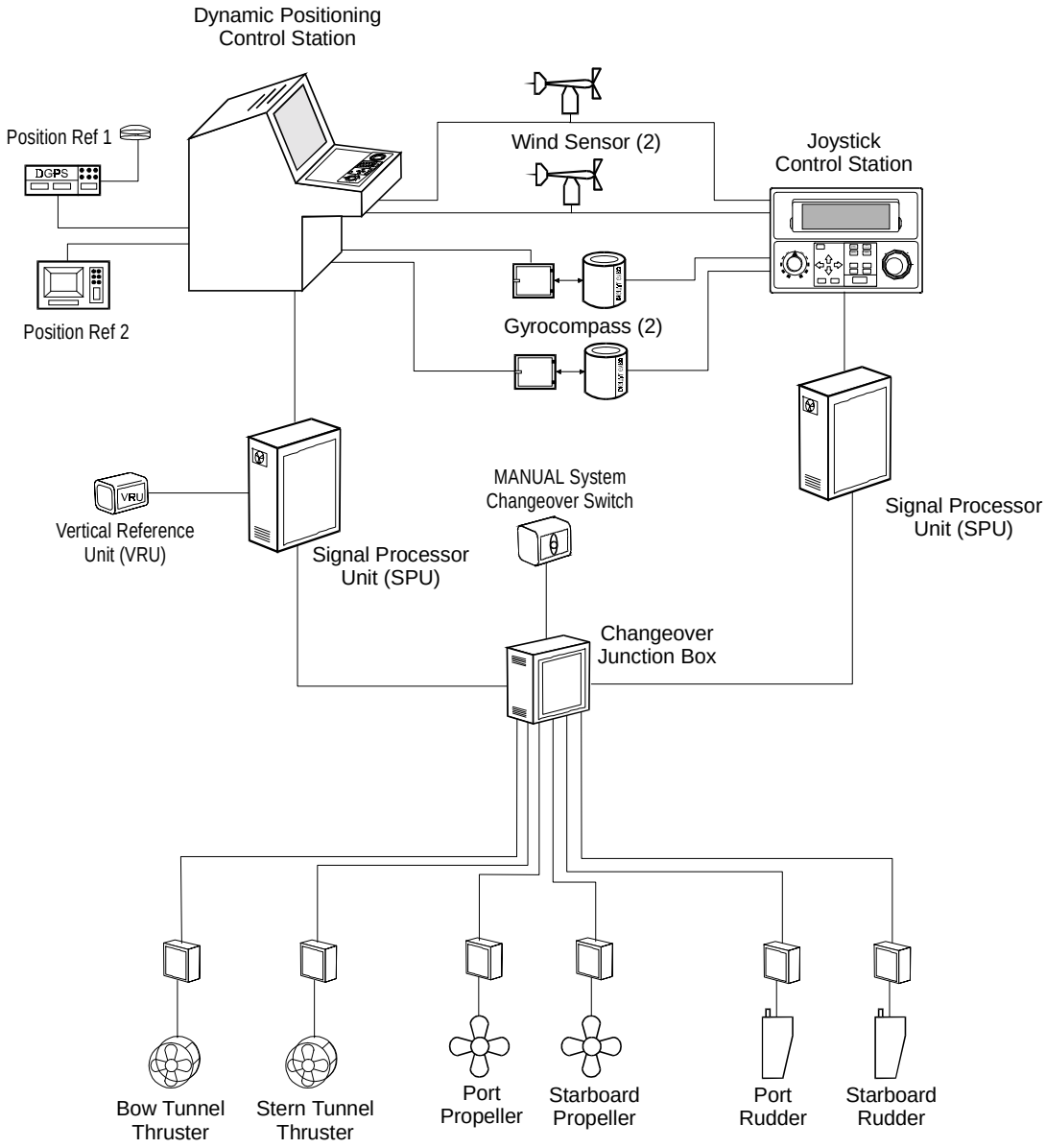

Figure 4 – Typical Class 1 System Layout

sensors to be different types such that a failure affecting one does not affect the other. Equipment requirements include the necessary thrusters to provide sufficient thrust in each axis to maintain position. This can include any variety of tunnel, azimuthing, pumpjet or other style thrusters, main propellers and rudders, to provide reasonable vessel control. A typical Class 1 system layout is shown in Figure 4. The thruster types are notable, as many retrofit vessels require the addition of new thrusters to meet the rigorous demands of DP operations. The interfacing between the DP computer and the propulsion suite can be through a single location (or signal processor). Moving from Class 0 to Class 1 involves numerous additions that roughly double the equipment required. All environmental and position sensors must be provided in duplicate and an individual separate manual back-up system capable of automatic heading

control is required. Generally the back-up system requirement is the most difficult to meet as it requires another complete interface to the vessel's propulsion and a manual control changeover.

Class 2 DP Systems

Class 2 systems dramatically increase the complexity and amount of equipment required for classification. Class 2 systems are designed to meet the following criteria: System must maintain position during and following any single fault excluding the loss of a compartment. This requires two DP computers, which do not affect each other, but provide automatic control changeover if one or the other fails. This should have no effect on the station-keeping performance of the vessel. The changeover must be fully automatic and 'bumpless.' In addition, environmental sensors including gyrocompasses wind sensors and vertical reference sensors must be provided in duplicate. Several of the regulatory agencies including BV, LRS and IMO require three of these sensors. When more than three sensors are required the DP computer must provide reasonable weighting and error checking to insure accuracy of the sensor data used. At least three position sensors based on two different methods are required as well. Unlike the Class 1 systems, the redundancy requirements cover additional vessel systems with the single fault requirement. Figure 5 summarizes the requirements for a typical Class 2 system. Sufficient thrusters must be

Class 2 Required Equipment					
	IMO	ABS	LRS	DNV	BV
Position Reference	3	3	3	3	3
Wind Sensor	3	2	2	2	3
Gyrocompass	3	2	3	2	3
VRU	3*	2	3*	2	3
UPS	2	1	2	1	2

**** - Additionals only required if DP is dependent on VRU.***

Figure 5 – Class 2 Required Equipment

provided such that any single failure, except loss of a compartment, will not result in a loss of position. A Failure Modes and Effects Analysis (FMEA) is required to verify that this criterion is properly satisfied. The FMEA covers the entire vessel including all systems that support station-keeping operations directly or indirectly. It is not limited to the DP control system. This requirement can limit the vessels that can meet this classification as many of the older workboats with clutched main engines suffer substantial position deviations if a single main engine is lost. In addition the interfacing between the propulsion suite and the DP computer must be split to meet the single point failure criteria. Class 2 also affects the power distribution for the vessel such that an entire bus bar can fail without affecting the vessel's station-keeping ability. Power management also becomes a requirement with Class 2 systems to ensure that vital systems always have sufficient power. In addition, the power management system should prevent loads from starting if insufficient power is available. The actual DP computers must be powered by UPS systems. While some classification bodies accept a single UPS for both DP computers, most require individual UPS units for each DP computer. Finally, Class 2 systems require consequence analysis software that alerts the operator to potential problems based on current factors affecting the DP system or its sensors. Figure 6 shows a typical Class 2 system.

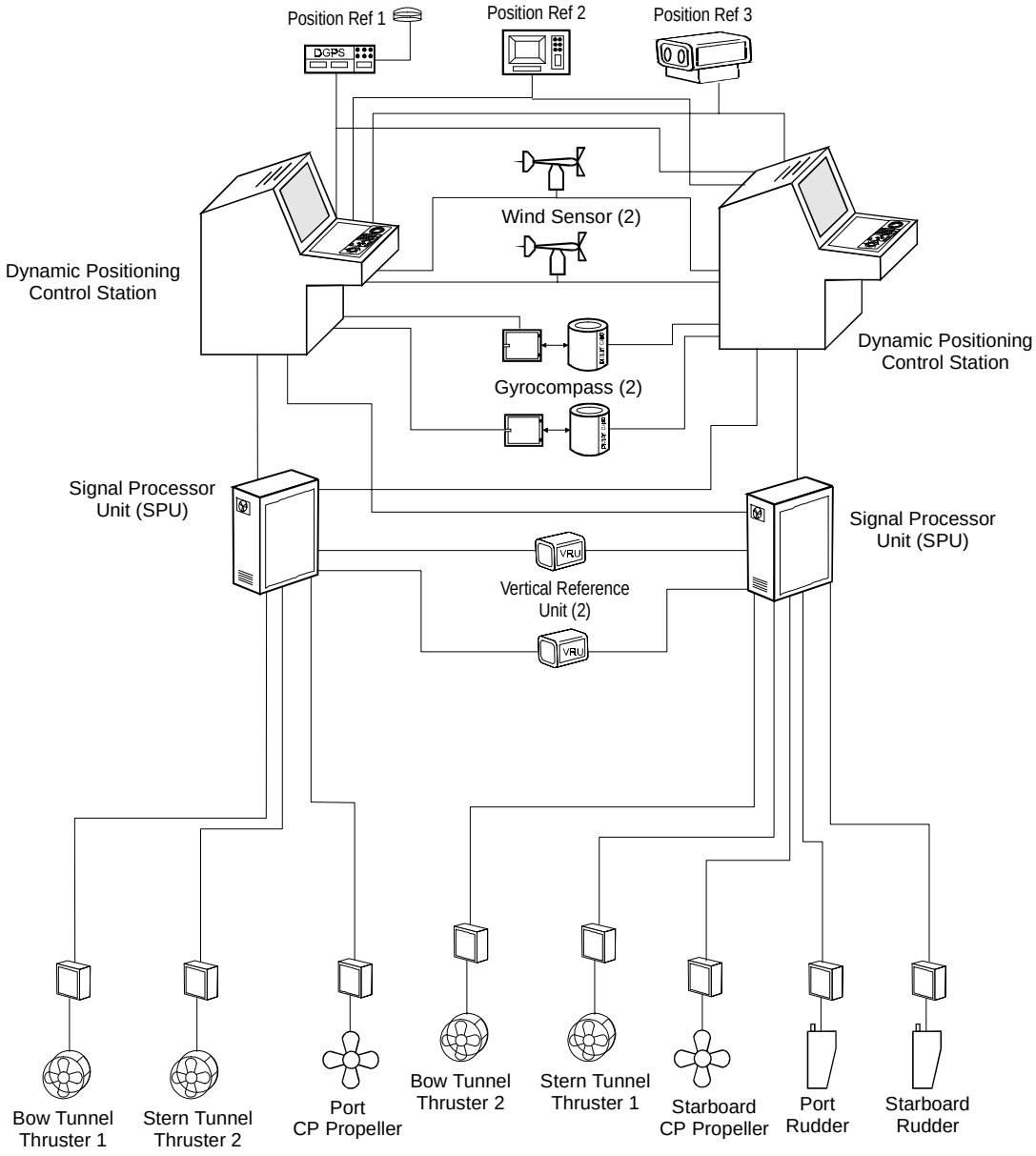

Figure 6 – Typical Class 2 System Layout

Updating from Class 1 to Class 2 is a much more involved process than the step from Class 0 to Class 1. In addition, to requiring significantly more equipment, including a full additional console and signal processor, the amount of cabling for some of the interfaced systems, roughly quadruples with each of the redundant sensors being interfaced to each DP computer.

Class 1 vs. Class 2 - Detailed Comparison

Classification offers many benefits for a vessel owner but multiple details need to be reviewed. Each classification can be met using minimal systems or fully equipped systems depending on the needs of the vessel. The biggest single difference between Class 1 and Class 2 systems is the single fault

requirement. While Class 1 systems provide simple backups for most of the components, the changeover of control requires manual intervention. Class-2 systems do not permit any single faults, and require automatic backups for all of the system components, i.e. full redundancy and 'bumpless,' automatic changeover. The amount of complexity increases over four times for Class 2 systems. All of the sensors need to be connected to each of the DP consoles. In addition, the connections to the vessel propulsion must be separated to meet the single fault criteria. Class 2 systems also demand more complicated software with the requirements for Consequence Analysis and Power Management. Consequence analysis software informs the operator of potential problems based on the current situation of the DP system. This includes not only the environmental conditions but also the power loading and the propulsion suite on-line and available. Power management software controls the loading on the generator systems to prevent critical loads from losing power. Both the propulsion suite and the power generation systems need to meet the redundancy criteria for Class 2. While single effectors for each axis are sufficient for Class 1 systems, Class 2 systems complete redundancy, which often means double the number of propulsors, generators, switchboards, transformers, etc. In the same way, each of the sensors interfaced to the DP system must have an automatic backup interfaced to both control computers. This includes gyrocompasses, wind sensors, vertical reference units and UPS systems. Position references are required to provide additional redundancy by requiring a third sensor based on a completely independent method. The increased complexity and interconnect cabling dramatically increases the cost of a Class 2 system which often dictates what type of classification is acceptable. Class 2 systems add further costs as numerous other shipboard systems must be taken into account as well. Often forgotten, even simple piping systems, cooling water systems, low and medium voltage power supplies and lubrication systems must have redundancy to meet the single failure criteria specified to meet Class 2. The redundancy for these systems must prevent them from causing any failure worse than the specified worst case DP failure. In each area, Class 2 systems significantly increase the engineering effort and cost for classification.

Classification Requirements

As the complexity of the systems increase the documentation and testing required increase as well. Substantial work is required to complete the submittal process. The formal submittals include the following:

- System description showing system layout and components
- Detailed description of DP system operation
- Details of sensor interfaces including environmental and position reference systems
- Location and control system details for all thrusters including thruster design details
- Alarm system details and any interfacing with main vessel alarm system
- Electrical power one-line diagram showing connections to DP system
- Details of consequence analyzer (if required)
- Details of power management (if required)
- Certification that all equipment is acceptable for marine use
- Environmental force calculations including design operational limits
- Failure modes and effects analysis (FMEA)
- Operations manuals
- Complete test schedule

The documentation submittals are only the first step in receiving classification for a vessel. Once the submittal is filed, the regulatory body will review each item for completeness, accuracy and applicability for the notation requested. Upon approval of the submittals, actual completion of the test schedule must

be performed. Again this includes not only verification of the physical equipment supplied to the vessel, but also the performance of the systems. During sea trials, the station-keeping performance of the system will be tested. In addition, proper interaction and alarming will be tested to ensure the system is operating safely and correctly. This often includes simulation of numerous failure modes as noted in the FMEA. Proper sea trials testing requires significant time on the vessel which is often overlooked when arranging the schedule for installing a DP system. If not properly planned for sea trials testing can become a lengthy and expensive part of the classification procedure. Successful completion of sea trials is not the final step in certification. Maintaining classification requires certain operational criteria to be observed. IMO specifically requires numerous operational procedures for operation of a DP vessel. These range from yearly inspections to daily checklists prior to each DP operation.

Summary and Conclusions

Classification for vessels provides the opportunity for safer operation and higher day rates. However, Class 1 and Class 2 vessels require substantially more equipment and testing to meet the guidelines, which increases the associated costs.

As higher certifications are required for individual contracts and the DP systems become more complex, more attention also needs to be put towards dedicated Dynamic Positioning Officers (DPO's) to maintain and monitor the DP systems.

Classification at the higher levels is not simply a certificate; it becomes integral to the operation of the vessel with required procedures and logs which generally are maintained by the DPO. IMCA (International Marine Contractors Association, formerly DPVOA) provides substantial guidelines for the operation of dynamically positioned vessels to get the most out of classification. While minimum equipment requirements are noted, IMCA concentrates on the operational details.

With the increasing costs to meet the requirements of deepwater contracts, fully classed vessels provide the operator with the opportunity to recoup some of the costs through increased operational periods and safer operation.

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About the Authors

Michael Ford

Mr. Ford started in offshore during studies at the Colorado School of Mines. He then shifted to the University of New Orleans where he graduated with a Bachelor of Science degree in Naval Architecture and Marine Engineering. He spent almost two years in Houston providing consulting services with David Tein Consulting. Projects included mooring analysis for the Zafiro Producer FPSO and other fixed moorings, airgap analysis on several semisubmersibles in addition to on-site services for the conversion of the DB-1 and DB-2 derrick barges for pipelay operations. Mr. Ford joined Nautronix in 1996 as the staff naval architect. Since then he has been a project engineer and a project manager for the JSDP line. He is now the Product Manager for the joystick positioning system line while continuing his naval architecture contributions.

Doug Phillips

Mr. Phillips has a Bachelors Honors Degree in Computer and Control Engineering and has worked with Dynamic Positioning for 26 years. The first 20 years with what is now Alstom designing, building and commissioning DP and anchor assist control systems. Initially as a project engineer, later as the manager of a team of project engineers and project managers. Then for 3 years in consultancy with Global Maritime performing FMEAs, trials etc on total DP systems on vessels with DP control systems from all suppliers including those from Simrad and ABB. During this time he also worked on DP Incidents and research for IMCA. For 3 years he was the Vessel Controls Product Manager for Nautronix mainly involved with the development of the ASK5000 range. He has recently rejoined Global Maritime heading their DP effort in Houston.