U.S. Department of Transportation
United States Coast Guard

Commander
Eighth Coast Guard District
Hale Boggs Federal Bldg.

501 Magazine Street
New Orleans, LA 70130-3396
Staff Symbol: (mvs)
Phone: (504) 589-6271
FAX: (504) 589-4999

16711/DP OSVs
D8(m) Policy Ltr 01-2003
22 January 2003

MEMORANDUM

From: D. F. RYAN II
CGD8 (m)

To: Distribution

Subj: USE OF DYNAMIC POSITIONING (DP) BY OFFSHORE SUPPLY VESSELS (OSVs) FOR OIL AND HAZMAT TRANSFERS

1. **PURPOSE:** This letter provides Eighth Coast Guard District (D8) guidance on minimum requirements for use of a DP system on an OSV for the purpose of "mooring" the vessel during oil and hazardous material (HAZMAT) transfers to and from an offshore facility or rig on the Outer Continental Shelf (OCS) within D8. A summary of the guidelines put forth by this policy letter is provided in enclosures (1) and (2). This policy letter is only intended to apply to OSVs; and its application to such things as Floating Production, Storage, and Offload (FPSO) units and their supporting shuttle tankers is specifically excluded from this policy.

2. **DIRECTIVES AFFECTED:** None.

3. **BACKGROUND:**

a. 33 CFR 156.120(a) requires that during oil and HAZMAT transfers "the vessel's moorings are strong enough to hold during all expected conditions of surge, current and weather." This regulation was written for a conventional mooring system or anchoring system and does not envision the use of DP. However, heightened oil and gas exploration and production activity in the deepwater regions of the Gulf of Mexico created a demand for OSVs with DP and a corresponding desire to use DP for "mooring" a vessel during deepwater cargo transfer operations. Questions have arisen about the use of DP as an acceptable mooring system for oil and HAZMAT transfers, so this policy letter provides guidance on what minimum requirements an OSV with DP should meet rather than complying with the mooring requirements of 33 CFR 156.120(a). It should be noted that there are deepwater installations and OSVs that are equipped for and employ means of mooring that fully comply with 33 CFR 156.120(a), and such compliance with the regulation is always acceptable.

b. The definition of an OSV can be found in 46 USC 2101(19) and 46 CFR 125.160. Under current policy and regulations, vessels meeting the definition of an OSV may be regulated under various 46 CFR subchapters, specifically Subchapters I, L and T. These vessels are also subject to the pollution prevention regulations in 33 CFR Subchapter O, and the transfer procedure requirements in 33 CFR 155.720 stipulate that vessels subject to that regulation must meet the requirements of 33 CFR 156.120.

Subj: USE OF DYNAMIC POSITIONING (DP) BY OFFSHORE SUPPLY VESSELS (OSVs) FOR OIL AND HAZMAT TRANSFERS

c. In recent years, OSVs have incorporated vessel propulsion and control systems that provide DP capability of varying degrees. These DP installations have usually been done with minimal regulatory oversight. In 1994 the International Maritime Organization (IMO) published Marine Safety Committee Circular 645 (IMO MSC/Circ 645), "Guidelines for Vessels with Dynamic Positioning Systems," which defines a DP vessel as follows: "Dynamically positioned vessel (DP-vessel) means a unit or a vessel which automatically maintains its position (fixed location or predetermined track) exclusively by means of thruster force." It also defines a DP system as "the complete installation necessary for dynamically positioning a vessel comprising the following subsystems: power system, thruster system, and DP-control system." An unknown number of OSVs currently use DP for most, if not all of their OCS facility support activities, including transfer of oils and hazardous materials.

4. **DISCUSSION:**

a. A conventional mooring system using mooring lines, as is addressed by 33 CFR 156.120(a), is essentially a passive system such that there is little risk of a "spontaneous" failure unless the mooring system is overwhelmed by operator error or extraordinary external forces, such as a severe storm or a powerful wake from a passing ship. Similarly, a DP system can fail if overwhelmed by excessive external forces that exceed the performance limits of the system. However, a DP system is an active system with working machinery and many moving parts controlled by "software," so a "spontaneous" failure is also possible unless the system has a high degree of redundancy built into it. Therefore, a DP system must have redundancy if it is to provide an equivalency to a passive mooring system, since without redundancy the failure of any piece of machinery or the control system could cause the overall DP mooring system to fail.

b. IMO MSC/Circ 645 addresses redundancy and establishes 3 classes for DP systems:

(1) **Class 1**: loss of position may occur in the event of a single fault.

(2) **Class 2**: loss of position is not to occur in the event of a single fault in any active component or system.

(3) **Class 3**: loss of position is not to occur in the event of a single failure of any active or static component or system, and does not occur if all components in one compartment are lost due to fire or flooding.

The IMO guidelines recommend that the vessel operator and their customer examine the risks associated with the operation and determine the appropriate class of DP system necessary. The USCG encourages vessel and facility operators to engage in such discussions, but recognizes that this communication may not occur in every case. Therefore, this policy will establish minimum requirements for DP transfers of oil or HAZMAT. The IMO Guideline defines redundancy as follows:

Subj: USE OF DYNAMIC POSITIONING (DP) BY OFFSHORE SUPPLY VESSELS (OSVs) FOR OIL AND HAZMAT TRANSFERS

> "Redundancy means ability of a component or system to maintain or restore its function, when a single failure has occurred. Redundancy can be achieved for instance by installation of multiple components, systems or alternative means of performing a function."

A summary of IMO's recommended criteria for each class of DP system is provided in enclosure (3).

c. *Alternative #1 (preferred) – IMO Class 2 or Class 3 DP System*: The likelihood of total failure of the DP system causing a pollution incident due to the vessel drifting off station is very remote for a vessel equipped with a Class 2 or Class 3 DP system, and even if the DP system were to fail the DP operator is likely to have ample warning so that transfer operations could be safely terminated before the vessel were to drift off station. Therefore, a vessel using a DP system that meets IMO MSC/Circ 645 as Class 2 or Class 3 will be considered acceptable for meeting the mooring requirements of 33 CFR 156.120(a) for the purpose of conducting oil and HAZMAT transfers.

d. *Alternative #2 – Classification Society "equivalency" to Class 2 or Class 3*: Any DP system that has been certified by the American Bureau of Shipping (ABS) as "DPS-2" or "DPS-3", Det Norske Veritas (DNV) as "AUTR" or "AUTRO," or Lloyds Register (LR) as "DP(AA)" or "DP(AAA)," will be considered acceptable for meeting the mooring requirements of 33 CFR 156.120(a) for the purpose of conducting oil and HAZMAT transfers. As shown in enclosure (4), some of DP criteria of these three classification societies are not as stringent as that recommended by IMO MSC/Circ 645; however, all of the DP criteria of these classification societies meets or exceeds the minimum requirements discussed below.

e. *Alternative #3 – DP System meeting Minimum Requirements specified in enclosure (2)*: Since the development of DP systems for OSVs has been done with minimal regulatory participation, there is an unknown number of OSVs in the Gulf of Mexico with DP that do not fully comply with the IMO recommendations for a Class 2 or Class 3 DP system nor do they comply with classification society rules. However, many of these OSVs may still have a highly reliable DP system. In response to this concern a review of IMO's DP criteria was conducted by D8 and alternative minimum requirements were developed which are listed in enclosure (2). These minimum requirements still emphasize the need for redundancy, but acknowledge the fact that an alternative degree of redundancy is acceptable since long-term station keeping is not necessary for oil or HAZMAT transfers. The DP system just needs sufficient redundancy so that if problems occur there will be enough time to safely terminate the transfer operation before the OSV is likely to drift off station. Therefore, an OSV using a DP system that does not meet the Class 2 or Class 3 standards but does meet the minimum requirements put forth in enclosure (2) will be considered acceptable for the purpose of conducting oil and HAZMAT transfers.

f. *Alternative #4 - Use of Breakaway Fitting with Quick-closing Valves (for OSVs with DP systems not meeting any of the above options)*: Another option for other DP equipped OSVs is to

utilize a "fail-safe" transfer system, so that even if the DP system were to fail and the OSV drifts off station the transfer system will prevent the release of any oil or HAZMAT into the environment. Therefore, for an OSV with a DP system not meeting any of the above options, the transfer system may be designed and configured using a breakaway fitting equipped with quick-closing valves. This must be engineered so that if the DP system were to fail and the vessel were to drift away from the oil platform or rig, this fitting will be the weak-link in the transfer system and will part before any other component in the system fails. When the breakaway fitting parts it must have a quick-closing valve in each half of the fitting (one half which remains connected to the OSV side of the transfer system and one half which remains connected to the oil platform or rig) that automatically closes to prevent the release of any oil or HAZMAT. Also, the transfer system must be designed so that if the breakaway fitting does part and the quick-closing valves slam shut, the transfer pump has a relief valve and re-circulation piping and/or an automatic shutdown device to prevent the system from being over-pressurized. If the transfer system is engineered and configured in this manner then the OSV may conduct oil and HAZMAT transfers in DP mode.

g. *Operational Procedures*: Regardless of which option is taken, either the DP system meets the criteria discussed in paragraphs (c), (d), or (e), or else the transfer system is configured with a breakaway fitting with quick-closing valves as discussed in paragraph (f), operational procedures similar to Section 4, "Operational Requirements," of MSC/Circ. 645, 6 June 1994, should be developed to address the full range of operational safety issues while conducting oil and HAZMAT transfers with the vessel in DP mode; and include the applicable surveys and tests of MSC/Circ. 645, Sections 5.1.1.1, 5.1.1.2, 5.1.1.3, and 5.1.1.4. It shall be the OSV owner's responsibility to ensure that all surveys and tests are properly conducted and documented, and the Coast Guard does not intend to issue a Flag State Verification and Acceptance Document. The operational procedures for conducting oil and HAZMAT transfers in DP mode may be incorporated into the transfer procedures required by 33 CFR 155.720, and should include such things as maximum environmental conditions for the DP system, emergency shut-down and breakaway procedures, etc. Also, it is strongly recommended that the OSV be positioned so that if the DP system were to fail, the OSV will drift away from the offshore facility or rig and not collide with it, and there should be procedures on how the DP operator should assess where to safely position the OSV with respect to the facility or rig.

h. Training and Qualifications for DP Operators: In addition to having acceptable oil and HAZMAT transfer procedures that include procedures for transfers while in DP mode, as discussed above, the licensed deck officer on watch during the DP operations must be suitably trained and qualified to operate the DP system.

i. Limitations of Policy Letter:

(1) Only for OCS in D8: This policy letter applies only to operations in support of the exploration or exploitation of offshore oil and mineral resources on the OCS within

Subj: USE OF DYNAMIC POSITIONING (DP) BY OFFSHORE SUPPLY VESSELS (OSVs) FOR OIL AND HAZMAT TRANSFERS

D8. Oil or HAZMAT transfer operations occurring on state waters will require the use of a conventional mooring in accordance with 33 CFR 156.120. This policy will be forwarded to the Commandant for consideration as a national policy and/or revision.

(2) Only for OSVs: This policy letter is only intended to apply to the use of DP by OSVs transferring to and from an offshore facility or rig, and application to such things as Floating Production, Storage, and Offload (FPSO) units and their supporting shuttle tankers is specifically excluded from this policy.

5. **ACTION**:

A summary of the guidelines put forth by this policy letter is provided in enclosures (1) and (2). D8 OCMIs are encouraged to distribute this policy letter to OSV owners and operators within their area of responsibility, so that the OSV owners and operators ensure they comply with this guidance for oil or HAZMAT transfers by any OSVs using DP. It is not intended that the Coast Guard will conduct any additional inspection activities to enforce this policy, but the Coast Guard will consider this guidance when investigating any casualties involving OSVs using DP. OSV owners and operators are expected to be in full compliance with the provisions of this policy letter by 22 January 2005, within two years of its effective date.

6. **FEEDBACK**: Feedback or questions on this policy should be referred to the Eighth Coast Guard District, D8(m), at 504-589-6271.

#

Encl: (1) Summary of Compliance Options – OSVs using DP for Oil & HAZMAT transfers
(2) Alternative #3 – Coast Guard's Minimum DP Requirements for OSVs using DP for Oil & HAZMAT transfers
(3) Summary of IMO MSC/Circ 645, "Guidelines for Vessels with Dynamic Positioning Systems"
(4) Summary of Classification Society DP Designations & Criteria

Dist: All Eighth District MSOs, MSU Galveston

Summary of Compliance Options -
OSVs using DP for Oil & HAZMAT transfers

Requirement: Mooring system (conventional mooring lines), per 33 CFR 156.120.

Alternative #1: DP system that meets IMO MSC/Circ 645 as Class 2 or Class 3.

Alternative #2: DP system that meets classification society equivalency to Class 2 or Class 3 DP system – certified by ABS as "DPS-2" or "DPS-3", DNV as "AUTR" or "AUTRO", or Lloyds Register as "DP(AA)" or "DP(AAA)".

Alternative #3: DP system that meets minimum requirements put forth in enclosure (2).

Alternative #4: Use of Breakaway Fitting with Quick-closing Valves (for OSVs with DP systems not meeting any of the above options): The transfer system is designed and configured using a breakaway fitting equipped with quick-closing valves. This must be engineered so that if the DP system were to fail and the vessel were to drift away from the oil platform or rig, this fitting will be the weak-link in the transfer system and will part before any other component in the transfer system fails. (*NOTE: This may preclude use of Cam-Lock fittings for connecting the transfer hose, unless the strength characteristics of the Cam-Lock fittings are considered in the design of the system so that it does not become the weak-link in the system).* When the breakaway fitting parts it must have a quick-closing valve in each half of the fitting (one half which remains connected to the OSV side of the transfer system and one half which remains connected to the oil platform or rig) that automatically closes to prevent the release of any oil or HAZMAT. Also, the transfer system must be designed so that if the breakaway fitting does part and the quick-closing valves slam shut, the transfer pump has a relief valve and re-circulation piping and/or an automatic shutdown device to prevent the system from being over-pressurized.

Additional Requirements:

i.) *Operational Procedures:* Operational procedures similar to Section 4, "Operational Requirements", of MSC/Circ. 645, 6 June 1994, should be developed to address the full range of operational safety issues while conducting oil and HAZMAT transfers with the vessel in DP mode; and include the applicable surveys and tests of MSC/Circ. 645, Sections 5.1.1.1, 5.1.1.2, 5.1.1.3, and 5.1.1.4. It shall be the OSV owner's responsibility to ensure that all surveys and tests are properly conducted and documented. The operational procedures for conducting oil and HAZMAT transfers in DP mode may be incorporated into the transfer procedures required by 33 CFR 155.720, and should include such things as maximum environmental conditions for the DP system, emergency shut-down and breakaway procedures, etc. Also, it is strongly recommended that the OSV be positioned so that if the DP system were to fail the OSV will drift away from the offshore facility or rig and not collide with it, and there should be procedures on how the DP operator should assess where to safely position the OSV with respect to the facility or rig.

ii.) *Training and Qualifications for DP Operators*: Additionally, the licensed deck officer on watch during the DP operations must be suitably trained and qualified to operate the DP system and respond to any alarm or emergency that might arise during transfer operations while in DP mode.

Alternative #3 – Coast Guard's Minimum DP Requirements for OSVs using DP for Oil & HAZMAT transfers

General comments:

1. 33 CFR 156.120(a) requires that for oil or HAZMAT transfers "the vessel's moorings are strong enough to hold during all expected conditions of surge, current, and weather …"
2. The following guidance has been developed so OCMIs and OSV owners/operators can determine what minimum requirements a DP system must meet for an OSV to conduct oil and HAZMAT transfers on the Outer Continental Shelf within the Eighth Coast Guard District.
3. The burden is on industry to ensure they comply with this guidance whenever conducting oil or HAZMAT transfers; however, OCMIs may use their discretion to spot-check OSVs and ensure this guidance is being followed.
4. For questions about redundancy, please refer to the definition provided at the bottom of page 2 of this policy letter.

Systems or Components			Comments	IMO equiv-alency	Req'd by Sub I or L?	Req'd by Sub T?
Power Systems	Generators & Prime Movers	Redundant		Class 2	Yes	No
	Main Switchboard with Bus-Tie Breaker	1	This must be an automatic bus-tie breaker, which may not have been installed on some of the older OSVs.	Class 2	Maybe (not on some older OSVs)	No
	Distribution System	Redundant		Class 2	Yes	No
	Uninterruptible Power Supply (UPS)	1 for each computer	Where multiple computers are provided, one UPS is acceptable if it can provide power to each computer.	Class 2-	No	No
Thrusters	Arrangement of Thrusters	Redundant *	* A configuration with 2 stern thrusters & one bow thruster is acceptable as long as the vessel can still hold station long enough to safely disconnect after losing any one of these thrusters. NOTE: Thrusters may include fixed shafts with controllable or fixed pitch propellers, tunnel thrusters, Z-drives, etc.	Class 2-	No	No
	Hold Station with Single Thruster Failure	Yes *	* Long enough to safely disconnect.	Class 2-	No	No
Control	IMO General guidelines for DP Control systems	Recommended	IMO MSC/Circ 645, section 3.4.1, contains general guidelines for DP Control systems, including DP info display, alarms & warnings, etc.	Class 1, 2 & 3	No	No
	Automatic Control – Number of Computers	1	2 are preferred, but 1 is acceptable since some redundancy is achieved by having Manual Control as back up.	Class 1	No	No
	Manual Control – Integrated Joystick with Auto heading	Yes	Where the Integrated Joystick is computer controlled, that computer shall be independent of the Automatic Control computer and shall have UPS provided.	Class 1, 2 & 3	No	No
	Individual Control Levers for each Thruster	Yes		Class 1, 2 & 3	No	No

Continued next page…

Alternative #3 – Coast Guard's Minimum DP Requirements for OSVs using DP for Oil & HAZMAT transfers

Continued…

Systems or Components			Comments	IMO equiv-alency	Req'd by Sub I or L?	Req'd by Sub T?
Sensors & Control	Position reference system	2	The 2 position reference systems shall be based on different principles of operation, or if both are GPS-based then the differential corrections shall be from independent sources and shall be transmitted/received separately.	Class 1+	No	No
	External Wind Sensors	2		Class 1+	No	No
	VRS/MRU (Vert. Response Sensor/Motion Response Unit)	1 *	* VRS/MRU is not required if the DP system has two years of satisfactory operational history without a VRS/MRU.	Class 1	No	No
	Gyrocompass	2 *	* Required redundancy may be satisfied by other sensors that read or compute vessel heading information (e.g. corrected magnetic compass output or satellite compass), in which case only one gyrocompass is required.	Class 1+	No	No
	Consequence Analysis	Required *	* Equivalencies may be considered, including operational controls; and Consequence Analysis is not required if the DP system has two years of satisfactory operational history without a Consequence Analysis software program.	Class 2-	No	No

Summary - IMO MSC/Circ 645,
"Guidelines for Vessels with Dynamic Positioning Systems"

Part 2, "Equipment Classes" [1.]	
Class 1	Loss of position may occur in the event of a single fault.
Class 2	Loss of position is not to occur in the event of a single fault in any active component or system. • Normally static components will not be considered to fail where adequate protection from damage is demonstrated and reliability is found satisfactory by the Administration. • Single failure criteria include (must be consider for): o Any active component or system (generators, thrusters, switchboards, remote controlled valves, etc). o Any normally static component (cables, pipes, manual valves, etc) that is not deemed properly protected or adequately reliable. Summary: Redundancy of all active components (ie, those w/moving parts).
Class 3	Loss of position is not to occur in the event of a single failure of any active or static component or system, and does not occur if all components in one compartment are lost due to fire or flooding. Summary: Redundancy of all components (active & static) and physical separation of components.

Footnotes:

1. Some classification societies have a category for DPS-0, but IMO does not recognize this class of DP system.

Enclosure (3)

Summary - IMO MSC/Circ 645, "Guidelines for Vessels with Dynamic Positioning Systems"

Part 3, "Functional Requirements"					
			Minimum Requirements for Equipment Classes [1.]		
					Class 3
Power (3.2)	Generators & Prime Movers		Non-Redundant	Redundant	Redundant, in Separate Compts
	Main Switchboard [2]		1	1 w/Bus Tie	2 normally open Bus Ties, in Separate Compts
	Bus Tie Breaker		0	1	2
	Distribution System		Non-Redundant	Redundant	Redundant, in Separate Compts
	Power Management System (3.2.6)		Optional	Optional	Optional
	UPS (3.4.2.7)		1	1 per computer	2, in Separate Compts
Thrusters (3.3)	Arrangement of		Non-Redundant	Redundant	Redundant, in Separate Compts
Control (3.4)	Auto Control – Number of Computer Systems (3.4.2)		1	2	3, with 1 in separate compartment from main control station & separated by A-60 boundary
	Manual Control – Joystick (3.4.1.7)		Yes	Yes	Yes
	Single Levers for each Thruster (3.4.1.7)		Yes	Yes	Yes
	Back-up Control Station (3.4.2.6)		No	No	Yes, in Separate Compt
	Consequence Analysis or "DP Alert System" (3.4.2.4)		No	Yes	Yes
Sensors	Position Reference System (3.4.3)		1	3	3, with 1 connected to back-up control system & separated from other units by A-60 boundary
	External Sensors (3.4.4.)	Wind	1	3	3, with 1 connected to back-up control system & separated from other units by A-60 boundary
		VRS [2.]	1	3	3, with 1 connected to back-up control system & separated from other units by A-60 boundary
		Gyro	1	3	3, with 1 connected to back-up control system & separated from other units by A-60 boundary
		Other [3.]	1	3	3, with 1 connected to back-up control system & separated from other units by A-60 boundary

Footnotes:

1. Some classification societies have a category for DPS-0, but IMO does not recognize this class of DP system.
2. These items are not specifically addressed by the standard, but can be implied.
3. Other sensors might include ones to monitor sea state, water depth, magnetic compass interface, or other passive environmental sensors.

Enclosure (3)

Summary of Classification Society DP Designations & Criteria

The following table provides a summary comparison of the various DP standards. For specific requirements refer to the referenced guideline or standard. Classification Society Standards are derived from, but do not exactly match the IMO Guideline. A Class 0 designation is not addressed in the IMO Guideline.

Subsystem or Component		Minimum Requirements in Group Designation		
Authority	IMO MSC Cir 645	Class 1	Class 2	Class 3
	ABS	DPS-1	DPS-2	DPS-3
	DNV	AUT	AUTR	AUTRO
	Lloyds	DP(AM)	DP(AA)	DP(AAA)
Power Systems	Generators & Prime Movers	Non-Redundant	Redundant	Redundant, Separate Compartments
	Main Switchboard	1	1 with Bus-Tie	2 normally open Bus Ties, Separate Compartments
	Bus-Tie Breaker	0	1	2
	Distribution System	Non-Redundant	Redundant	Redundant, Separate Compartments
	Power Management	IMO-Optional ABS-No DNV-No Lloyds-No	IMO-Optional ABS-Yes DNV-Yes Lloyds-Yes	IMO-Optional ABS-Yes DNV-Yes Lloyds-Yes
	Uninterruptible Power Supply (UPS)	1	1 per computer	2, Separate Compartments
Thruster	Arrangement of Thrusters	Non-Redundant	Redundant	Redundant, Separate Compartments
	Hold Station with Single Thruster Failure	IMO-No ABS-No DNV-No Lloyds - Yes	Yes	Yes
Control	Automatic Control – Number of Computers	1	2	3, 1 in separate compartment from main control station & separated by A-60 boundary
	Manual Control – Integrated Joystick with Auto heading	Yes	Yes	Yes
	Individual Control Levers for each Thruster	Yes	Yes	Yes
	Position reference system	IMO-1 ABS-2 DNV-2 Lloyds-2	3	3, 1 connected to back-up control system & separated from other units by A-60 boundary
	External Wind Sensors	IMO-1 ABS-2 DNV-1 Lloyds-2	IMO-3 ABS-2 DNV-2 Lloyds-2	3, 1 connected to back-up control system & separated from other units by A-60 boundary
	VRS/MRU	IMO-1 ABS-N/A DNV-1 Lloyds-2	IMO-3[1] ABS-2 DNV-2 Lloyds-2	IMO-3[1] 2, 1 connected to back-up control system & separated from other units by A-60 boundary
	Gyrocompass	IMO-1 ABS-2 DNV-1 Lloyds-2	IMO-3 ABS-2 DNV-2 Lloyds-2	3, 1 connected to back-up control system & separated from other units by A-60 boundary
Misc	Alternative Control System	No	No	Yes
	Consequence Analysis	No	Yes	Yes
	Performance Capability Rating (PCR)	Lloyds only – Factor that gauges the percentage of time a ship can remain on station when subjected to a set of standard environmental conditions with (1) all thrusters online and (2) with most effective thruster inoperative		
	Environmental Regularity Number (ERN)	DNV only – Factor used to indicate the position keeping ability of a vessel with (1) all thrusters operating; (2) minimal effect of single thruster failure; and (3) maximum effect of single thruster failure		

1. If DP-control system is fully dependent on correct signals from vessel sensors, then signals should be based on 3 systems serving the same purpose.