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DYNAMIC POSITIONING CONFERENCE
October 15-16, 2013

Design and Control I SESSION

Enhanced DP control systems

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Abstract

DNV and ABS has extended their DP notations. DNV has the new notation DYNPOS-E/ER, and ABS has extended the DPS-2 and DPS-3 notation with EHS-C.

Both notations are introduced in order to achieve more reliable DP control systems that utilize the technology within modern marine power plants. The new notations will have impact on both the DP control system arrangement and the functionality in the DP control system. The DP control system must be designed with more separation on the communication links, as for a main DP control system and an independent joystick system. The new notations allow the DP control system to take into account standby start of generators and changeover of thrusters and generators when calculations are performed for available thrust and power.

This paper presents adaptions made in the DP control system in order to gain enhanced reliability and so that the DP control system will fulfill the new class notations[1], [2].

Introduction

Figure 1: Focus on environmental impact and reduced maintenance has increased over the past years.

The offshore industry has been trough large changes during the past years with respect to focus on environmental impact, safety and cost reduction. The technology has been developed and is under constant improvement, but the rules and regulations for the DP vessels are mostly based on the IMO rules from 1994 which does not meet the possibilities given by modern technology.

The regulations for DP operations have had focus on safety and safety only, and have been incorporated in order to realize safety trough simple redundancy principles based on running machinery. The result is that DP operations must be carried out with many thrusters and generators connected to the switchboards regardless of the weather condition. Such a way of operating the vessel gives high cost and environmental impact. It gives high running hours on the machinery, and the load on the generators is often too low to utilize catalyst on the exhaust.

The philosophy of the new enhanced DP notations challenges the new technology. It opens up for more flexibility and utilization of modern technology in the thruster- and power systems, if it is proven to work as intended and does not compromise the safety level.

Another aspect is that the new notations provide operation of an additional DP control system in the DP center. This will strengthen the safety level for safe abortion of DP operations.

Topology

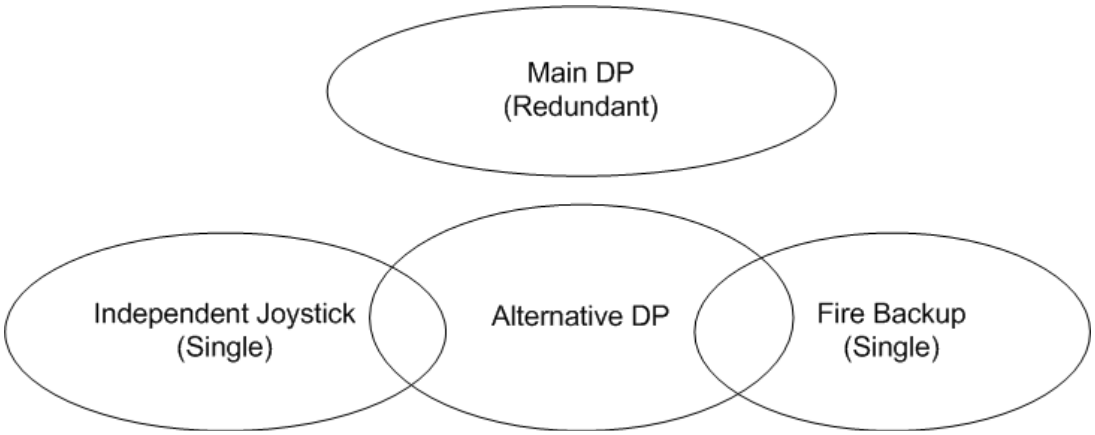

Figure 2: The alternative DP control system contains elements from both the independent joystick system and the fire backup system.

First we will have a look at the topology for a DP control system with enhanced reliability. We will see that this new concept is something in between a Class2 and a Class3 system, as indicated in Figure **2**, where the Alternative DP control system is the new DP control system in the class notations. Upgrading a Class2 vessel with the new notation can be possible due to the similarity with the setup for an Independent Joystick.

A traditional DP control system will always consist of the Main DP control system. For Class2 and Class3 systems this shall be a redundant DP control system, i.e. dual or triple. It is mandatory to have an independent joystick system and for Class3 a Fire backup system must be installed in addition.

The redundancy within the Main DP control system shall ensure continuous operation in the case of a single failure within the system. More complicated failure scenarios or accidents might lead to situations that cause the whole Main DP control system to be unusable. In such situations the command must be transferred to another control system.

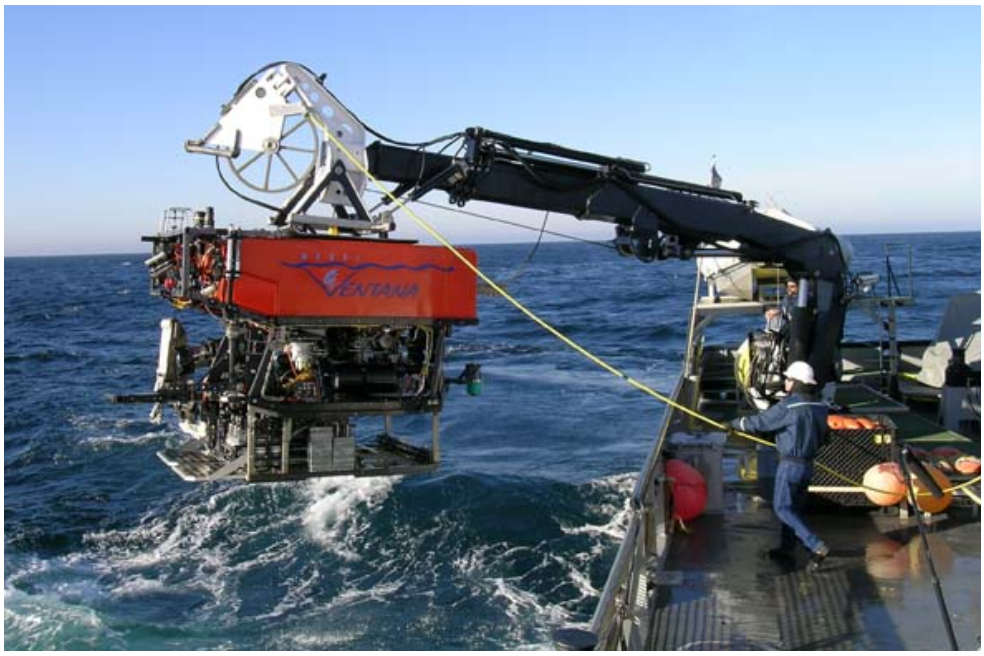

Figure 3: It can be a challenging job to keep the correct positioning of a vessel on Joystick control when the vessel should rotate around a hanging load.

The Independent Joystick system shall be a backup system on the bridge in case the Main DP control system fails or becomes unreliable. The Independent Joystick system shall not share a communication link with the Main DP control system. The Independent Joystick system has automatic heading control, and surge and sway are controlled by the joystick. Switching command to the Independent Joystick system thus leaves the DP operator with the hands on responsibility of the positioning of the vessel. This can be a difficult task, especially if the vessel is supposed to rotate around equipment in the water, e.g. a load hanging from a crane, see Figure 3. History has shown that the Independent Joystick system is seldom used as intended.

The Fire Backup system is used in cases where the Main DP Centre must be evacuated. It might share a communication link with the Main DP control system, but the Fire Backup shall not rely on any messages from the Main DP control system. The Fire Backup system shall mainly interface sensors located in its own fire zone. The operator station for the Fire backup system shall be in a different fire zone than the Main DP control center, and is often located in a space with little or no overview of the on-going DP operation. It shall be possible to set up the Fire Backup system in a "hot back-up" waiting mode, in such a way that the positioning is not affected when command is transferred to the Fire Backup system.

The advantage of the Independent Joystick system is that it is located in the DP Control Center and that the operation can be carried out from that location in case of a failure. The advantage of the Fire Backup system is that it can offer a "hot back-up" waiting mode. Both these advantages are incorporated in the new Alternative DP control system implemented in the new class notations for enhanced reliability.

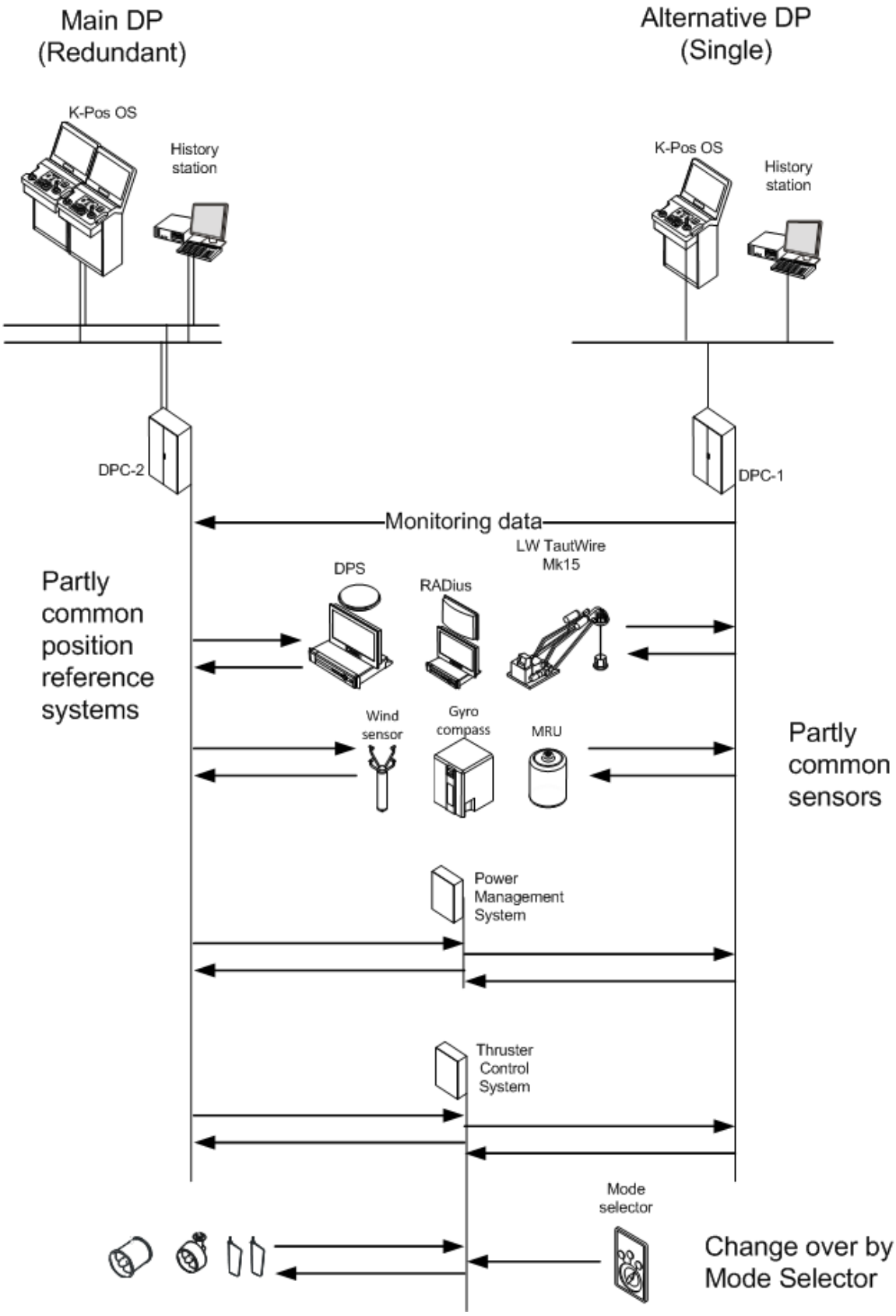

Figure 4: System topology for a DP control system with enhanced reliability.

A topology drawing for an enhanced DP control system is shown in Figure 4. Such a system will consist of a Main DP control system and an Alternative DP control system. The alternative DP system is selected as active control system from a Mode Control switch, as for an Independent Joystick system.

The main requirements to the topology of a DP control system with enhanced reliability are listed below:

- Shall consist of a redundant Main DP control system equipped as for Class2.
- The Main DP control system and the Alternative DP control system shall not share communication links.
- Minimum 4 position reference systems are required. At least one position reference system must be directly interfaced to the Alternative DP control system.
- Minimum 4 gyro-, wind- and MRU sensors are required. At least one sensor of each type must be directly interfaced to the Alternative DP control system.
- Data must be logged from both Main DP control system and Alternative DP control system. It can be a common data logger or one on each system.
- The Main DP control system shall monitor the status of the Alternative DP control system. The monitoring is done in a dialog on the K-Pos OS on the Main DP control system. The Alternative DP control system will send the monitoring data to the Main DP control system on a serial line.
- The Alternative DP control system shall provide “hot back-up” waiting mode for station keeping purposes.

Having a fully operational DP system with “hot back-up” waiting mode in the DP control center will drastically increase the safety when DP operations must be aborted due to a collapse of the Main DP control system, both technically and operationally.

Integration between DP system and Power Management system

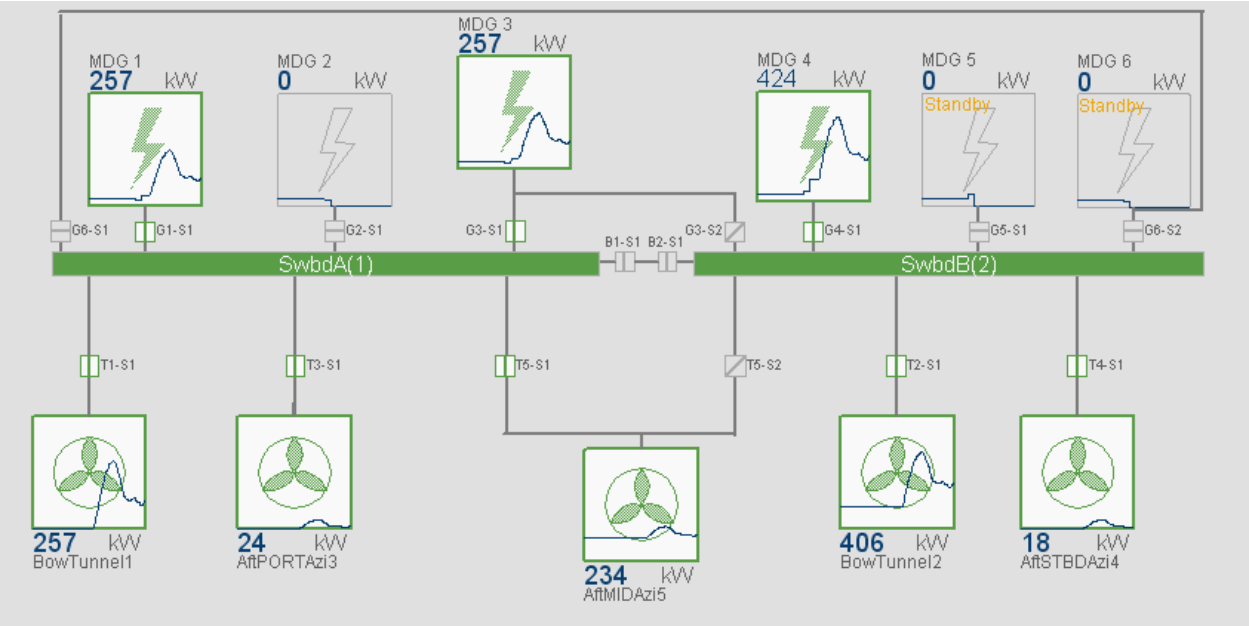

Figure 5: Standby generators and change over ready will be indicated in the power mimic.

The main change in the new DP class is on the utilization of the power plant. This will also have an impact on the DP control system, and opens up for a tighter integration between the Power Management System and the DP control system.

Standby generators can contribute to redundancy in the new DP system concept. This requires that a *standby ready* signal is interfaced to the Main DP control system for each generator. Standby generators will be taken into account in the calculation of worst single failure capability in the DP consequence analysis and in the online DP capability plot. It will not influence the calculations of available power in the power calculations in the real-time control system, i.e. in the blackout prevention functionality. The analysis must consider that at least one of the standby units fails to connect in each simulation. This means that the vessel must operate with a minimum of two standby units on one connected switchboard in order to get at least one standby unit included in the calculations.

Change-over mechanisms for thrusters and generators may also contribute to redundancy. This requires that a *change-over ready* signal is interfaced to the Main DP control system for each thruster and – generator. The switch that is ready for change over will be taken into account in the calculation of worst single failure capability in the DP consequence analysis and in the online DP capability plot. It will not influence the calculations of available power in the power calculations in the real-time control system, i.e. in the blackout prevention functionality.

Standby generators and change-over ready status will be indicated in the power mimic on the K-Pos OS as shown in Figure 5. Standby mode is indicated with the text *Standby* on top of the generator symbol as shown for MDG5 and MDG6. Change-over ready status will be shown with a slash in the breaker symbol as shown for the connection to SwbdB for thruster AftMIDAzi5 and MDG3.

A more dynamic usage of the power- and thruster systems opens up for new and more sophisticated integration between the DP control system and the Power Management system. The DP control system controls the thruster usage, and this is normally the main consumer on the power plant. It is therefore desirable that the DP control system can assist the Power Management system in certain occasions.

The K-Pos and the K-Chief have many applications that tightens the integration between the two systems, and that will improve the reliability in the operations required on dynamic power plant usage:

- *Synchronization assist:* This is a function where the Power Management system requests the DP control system to even out the load usage on a connected switchboard when a generator is ready to be connected. Heavy load variations due to the thruster usage can make it difficult to get new generators online because of large frequency variations. The assistance from the DP control system will ease the synchronization of the generators and will lead to faster connection time.

- *Zero bus-tie current mode:* This is an allocation mode that is selected manually on the DP control system or the mode can be requested from the Power Management system. In this mode the DP control system allocates thrust so that the current through a selected/requested bus-tie breaker is as low as possible. This gives a safe mode for bus tie breaker operations.

- *Adapted thrust set points:* This is a function that will adapt the thrust set points from the DP control system to a given limit from the Power Management system in cases where the Power Management system must limit the load on one or more thrusters. This function will contribute to smooth power transition when the reduction phase is over.

- *Adapted load ramp:* With this function the Power Management system provides the DP control system with a desirable ramp (kW/sec) for the generators. This is helpful during load-up and load-down phases for the generators.

- *2nd order priority power:* The Power Management system will inform the DP control system about 2nd order power consumers on a switchboard. That is consumers with lower priority than the thrusters. The Power Management system will reduce load on these consumers first so the power used by these consumers can be seen as spare power in the capability calculations for worst single failure.

Conclusion

Figure 6: Songa Equinox has completed Factory Acceptance Test for the DYNPOS ER notation.

The new DP notation covers what the ship owners and the suppliers have asked for, and several vessels are now in the project or building phase with the new notation.

The Songa Equinox is a DP-3/Mooring rig with additional DYNPOS-ER notation. It is being built at Daewoo Shipbuilding and Marine Engineering (DSME). A successful Factory Acceptance Test for the Kongsberg Maritime system was held in June 2013.

References

1. DNV rules for classification of ships. Part 6, Chapter 26, July 2013.
2. ABS Guide for dynamic positioning systems, August 2013