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Remote Control of a DP Vessel

By Iain Huntly-Playle

Wärtsilä Dynamic Positioning

Abstract

In recent years technology advances have enabled new capabilities to the extent that both remote and autonomous operation of moving platforms has become a common everyday event. Indeed, there are many examples of this but perhaps the most appropriate is the use of unmanned surveillance aircraft which can support activities anywhere on the planet from a base half a world away. Advantages gained by this approach are:

- Removal of the pilot from a potentially dangerous situation
- Aircraft design – no equipment required to support human life
- Increased mission length – fresh “pilots” can alternate in

By many measures the maritime industry has lagged the aviation and automotive industries in terms of research and development in support of remote control and autonomous operation, however there is now much activity to correct this. This paper will focus on remote control of a DP vessel with specific focus on station keeping during loading/unloading operations.

Abbreviation / Definition

DP	Dynamic Positioning
DPO	DP Officer
IBJS	Independent Backup Joystick System
Mbps	Mega bits per second
PHY	Hardware that connects to the physical transmission medium (communications)
PMS	Power Management System
PSV	Platform Supply Vessel
VPN	Virtual Private Network

Introduction

Remote control is a simple concept – the ability to take control of an object while not situated on said object, but removed from the object by some distance. Control, of course, can pertain to one of many functions of the object, however for the purposes of this paper it is defined as control and monitoring of vessel position while station keeping next to a structure. This structure may be fixed (such as a platform resting on the ocean floor), or floating and under the control of a Dynamic Position (DP) System (such as a drill ship).

The question, of course, is why remote control? Historically offshore vessels have managed quite well with onboard DP control and supervision, supported by trained DP officers (DPOs). The issue that has been raised is that company rules for Supply Vessel operations typically require 4 DP officers to be onboard simultaneously to allow for full coverage during DP operations. Given that the timing of DP operations cannot always be planned for, and that DP operations are continuous once started, it is necessary to be able to provide uninterrupted coverage. This implies 2 separate “teams” of DPOs, with 2 DPOs included within a team to allow for continued coverage should one member have to leave the bridge.

The issue with 4 DPOs is that 3 of them fulfil general crewing requirements such as Master and other required officer positions, but the fourth often has no function onboard outside of DP operations. Considering the time required to transit to the offshore work location, and the need to standby offshore for periods of time, the cost of the fourth DPO can become significant. If it can be shown that DP operations could be operated safely from a shore station using a remote communications link, there is a potential cost savings to be realised by removing the fourth DPO position from the vessel.

For successful remote DP operations one must also consider what capabilities are required for a vessel to be operated safely from a shore station while on DP. Obviously interaction with the DP System is required but other systems must also be included in the discussion, as follows:

- DP System
- Partial data and alarms from the PMS
- Video feeds covering the aft deck and adjacent structure
- Method of remote communication with the structure and other vessels
- Method of communication with onboard crewmembers

These additional systems must be accounted for when designing the communications implementation between the vessel and the shore station to ensure that bandwidth is available to accommodate all systems, and to prevent one system from overwhelming the available bandwidth. While this paper focusses on the DP System, some mention is made of these additional systems.

Remote Communications

As suggested earlier, remote control is a simple concept, however the actual implementation is much more complex. Deployment of a remote workstation (DP or otherwise) requires the use of a communication link which can be used to transfer data between the vessel and the remote workstation. Given that the data is of a digital nature the most readily available path is the internet. Dedicated point to point links are possible if greater security is required, however these will require dedicated transceiver pairs, and are not generally practical if the vessel is travelling over large distances.

Internet access is most commonly available for vessels at sea through either satellite or 3G/4G service, with the trade-off between these 2 systems consisting of service area, bandwidth and latency. Satellite offers a lower bandwidth path (typically under 5Mbps) but provides for coverage over much of the earth's surface; whereas 3G/4G provides for higher bandwidth (5 to 12 Mbps with peaks up to 50 Mbps) but coverage is generally restricted to coastal areas (there are exceptions to this, such as the central North Sea which has extensive 4G coverage). In terms of latency satellite paths are much longer and therefore result in more latency than 3G/4G, which can become a factor when looking at real time control.

The other important aspect to recognise for a wireless communications system is that it can be intermittent, and packet losses and throughput throttling should be expected, as should longer duration interruptions. Sunspots, radio frequency noise, antenna shadowing, monsoonal rain, transmitter range; the causes are many, and any can potentially cause problems. Many digital communication systems are designed to degrade gracefully. As link errors increase the transmitter may drop the PHY rate which effectively slows the actual throughput. For a DP System connected to a remote workstation, the connection to the remote workstation must not rely on the availability of the quoted maximum allocated communications bandwidth, but must be designed to throttle the amount of data to be sent, ensuring that the remote workstation can still function (possibly with some limitations) as the throughput drops.

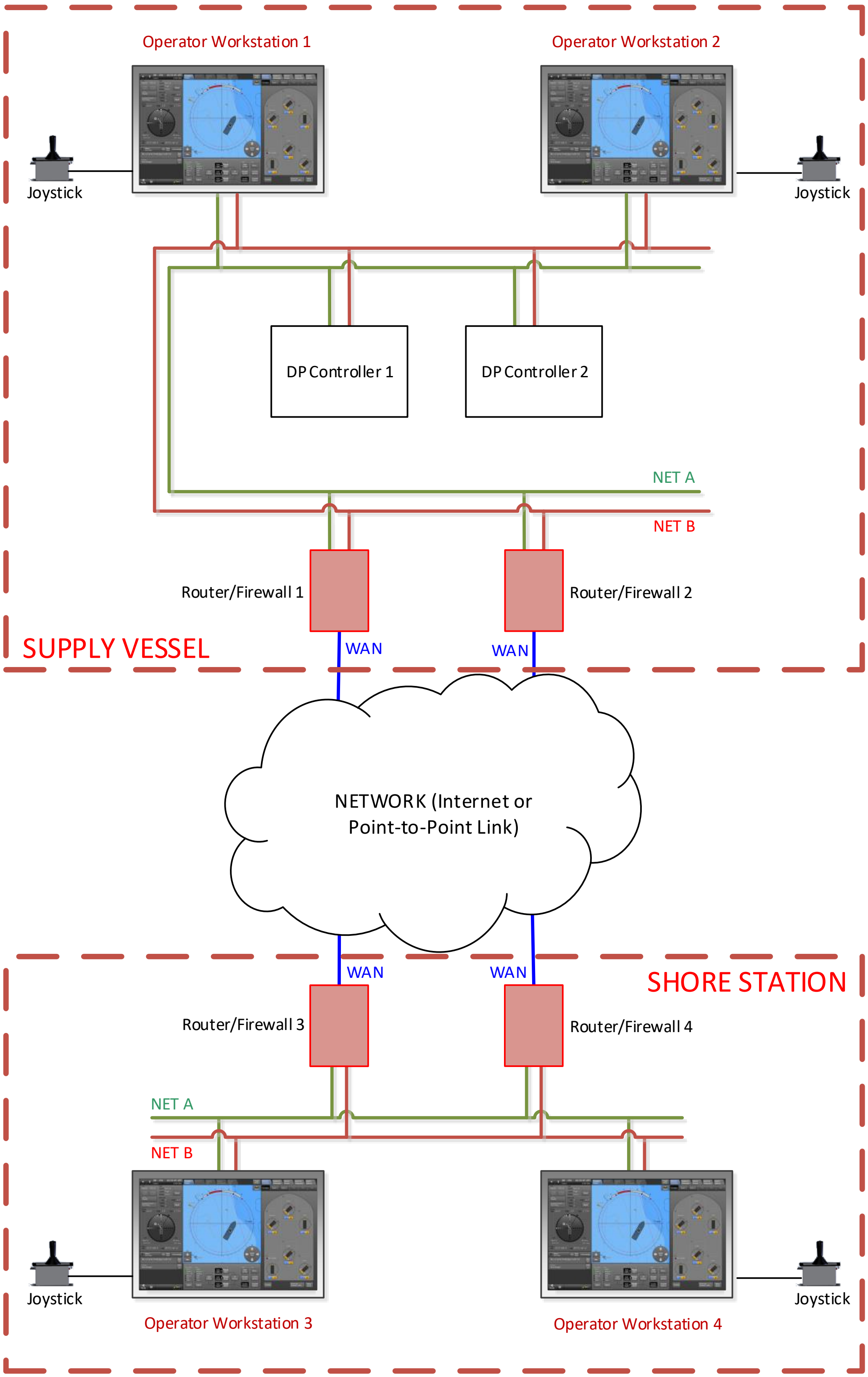

Figure 1 – DP System Topology For Remote Control

Additional methods used to improve the robustness of the communications link are the use of data compression, and the provision for a level of redundancy. In this case the use of 2 separate communications links, ideally each using a different communications standard (such as satellite and 3G/4G), with products and routers automatically switching between the two will aid in maintaining optimal performance. Adding compression standards to reduce throughput requirements will allow a remote DP Workstation to continue to function longer in worsening communication environments.

Adding remote control to a DP System requires implementation of a method of extending the system such that additional operator workstations can be added at a remote location. The simplest method of achieving this is to use routers to extend the onboard networks to the remote location using VPN. There are numerous different VPN implementations, each with different levels of security and encryption. Given that access to the networks provides the capability to take control of the vessel, selection of a router, and subsequently the VPN and encryption methodology, is the most critical aspect of the remote control implementation.

Figure *1* shows the topology for a Class 2 DP vessel modified to include dual redundant routers for communication with 2 remote operator workstations using 2 independent communication links. In this configuration it is possible to use either router to complete a VPN connection between either of the dual redundant networks, however some intelligence is required to ensure that the dual redundant networks are not interconnected, destroying the redundancy. It is equally important to ensure that there are not dual paths simultaneously connecting each network between the vessel and the remote site, as this can be problematic (unless the routers have aggregation capability).

Consider also the other equipment that must be included to support remote DP operation. Multiple video feeds will be required to provide visibility of operations on the aft deck (for a PSV) and of the structure that the vessel is station keeping adjacent to. Also desirable is some data from the PMS to indicate generator status and early alarms. To accommodate this the router must be able to invoke bandwidth limits for each product as a method of ensuring that important data receives priority, and that the video streams do not consume all of the bandwidth available.

Normally, once the VPN connections have been established that would be the end of the design process, however as addressed earlier link throttling and link interruptions must also be considered. For the DP System a link interruption implies that the remote workstation, which for remote operation is the Master workstation, is no longer connected to the DP System. For short duration interruptions the workstation should reconnect automatically once the communications link is re-established, however for long duration interruptions an alarm should sound on board the vessel. In a similar manner, video and other data feeds should automatically re-form after link interruption once the communications link is re-established.

Remote DP Control

A remote control DP implementation will have 2 modes of operation. Given that the system onboard the vessel will consist of a fully capable DP System it will include both manual and automatic operation for each of 3 axis (surge, sway, yaw). For remote control purposes this allows for direct drive of the vessel using the DP System joystick; and for semi-autonomous operation using the DP controller.

The implementation of remote control of a DP vessel must take into account the limitations of the communication system with particular attention to throughput, and potential link interruptions. Direct drive of the vessel through the use of the remote joystick (with all 3 axis set to manual) requires that the remote workstation and the on board DP controller have continuous communication. Lost data can be problematic, depending on the quantity and duration, and can result in loss of control of the vessel.

Latency in the link also becomes an issue, especially if any close manouevring is to be attempted. For this to function adequately modifications to the standard joystick function may need to be made to ensure that the DP System (in manual mode) responds to communication issues in a deterministic manner, including failover logic to gracefully handle a total loss of communication.

On the other hand, manouevring using the on board DP controller as an autonomous controller, moves all of the continuous control functions onto the vessel, and relegates the remote workstation to a command and monitor role. This simplifies the design as once the DP controller receives its instructions it will continue to carry them out until completed, or instructed otherwise. The amount of data required to command the DP controller is much lower than that required for continuous remote joystick operation, implying that this implementation is able to operate in lower bandwidth environments, and provides for a more robust solution.

A remote operator will also require visualisation or some type of situational awareness. An array of video cameras can be used to provide views of the aft deck operation along with views of any nearby structures. Standard high definition video typically consumes significant throughput, and requires significant resources for compressing the video feed in real time. It is suggested that full motion video is not required for monitoring purposes, and that frame rates can be reduced to 2 to 3 frames a second with each frame individually compressed prior to transmission. Even at these low frame rates motion sickness at the remote viewing end may be a factor, and stabilisation of the video may be required either using mechanical arrangements such as a gimbal, or through image processing.

In a similar manner the remote operator will require select information from the PMS. In particular alarms and any data that would provide an early indication of a potential failure would prove useful. While it is not expected that the remote operator should interact with the PMS, the capability to monitor the power system and to raise an on board alarm should any problems be detected should be included.

A method of communicating with adjacent structures and vessels must also be implemented. This communication traditionally takes place using VHF radio, and therefore an ideal solution would include VHF. Thus far no existing products have been identified however extending the vessel radio to a remote location would be ideal, perhaps realised by pairing a remote mic and speaker to the on board VHF radio using Ethernet. Other possibilities are the use of cellular phones (if the offshore location has coverage), network communication (as offered by applications such as Skype) or satellite phones.

Additionally, a method of communicating with the crew onboard the vessel is required such that alerts can be issued, or onboard intervention can be requested. This should include a method of alarming. For example, short duration link dropouts might be silently alarmed with a message on the Operator Workstations (on board and remote), whereas link dropouts of, say, 10 seconds or longer might automatically raise a more serious alarm on board, alerting for the need for human intervention on board the vessel.

Missing from the discussion thus far is debate on a backup system. When a DP System fails the on board DPO has the option of switching control to the IBJS or to manual levers. Should the remote DPO be afforded the same capability if there is a failure with the onboard DP System but not with the communications link? Strictly speaking the IBJS and levers are manual control systems, and therefore would require good communication with the remote location. Perhaps an argument could be made to add simple DP capability to the IBJS, thus giving the remote DPO the opportunity to quickly transfer control to the IBJS, then station keep until an onboard DPO could investigate and take local control.

Conclusion

In conclusion remote control and monitoring of a vessel under DP control is practical, and can be realised using technology that is available off-the-shelf today. Care must be taken during the development and testing phase to ensure communication link issues do not interrupt DP operation, and additional practices must be implemented to address link failures. While it is premature to expect widespread adoption at this time, further tests and demonstrations as a cooperation between equipment suppliers and vessel operators will help to build more confidence in the capability and lead to wider acceptance of this competence.

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