Ship Construction: Early Diagnosis with Mesh Networks

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Abstract

Affordability in ship construction continues to be a primary concern. PEO-Ships and NAVSEA Program Managers have challenged industry to provide innovative solutions to the rising costs of ship construction. This white paper describes the benefits of deploying a temporary wireless mesh network during the construction phase of a ship to reduce the risk and associated costs of finding problems in mission critical electronics systems later in the ship construction process.

Testing mission critical electronics systems as early as possible during ship construction provides the ship builder with the opportunity to save money. Reworking any system becomes significantly more expensive the later in ship construction problems are discovered. Additionally, a problem discovered during builder's trials could result in delaying at sea trials or even ship delivery. Besides providing extremely "bad press," delays in ship delivery have been estimated to cost shipbuilders $1 million dollars per day as expensive capital equipment such as cranes, dry docks and labor (shipyard workers) are tied up or idle waiting for a solution to be delivered, installed and regression tested.

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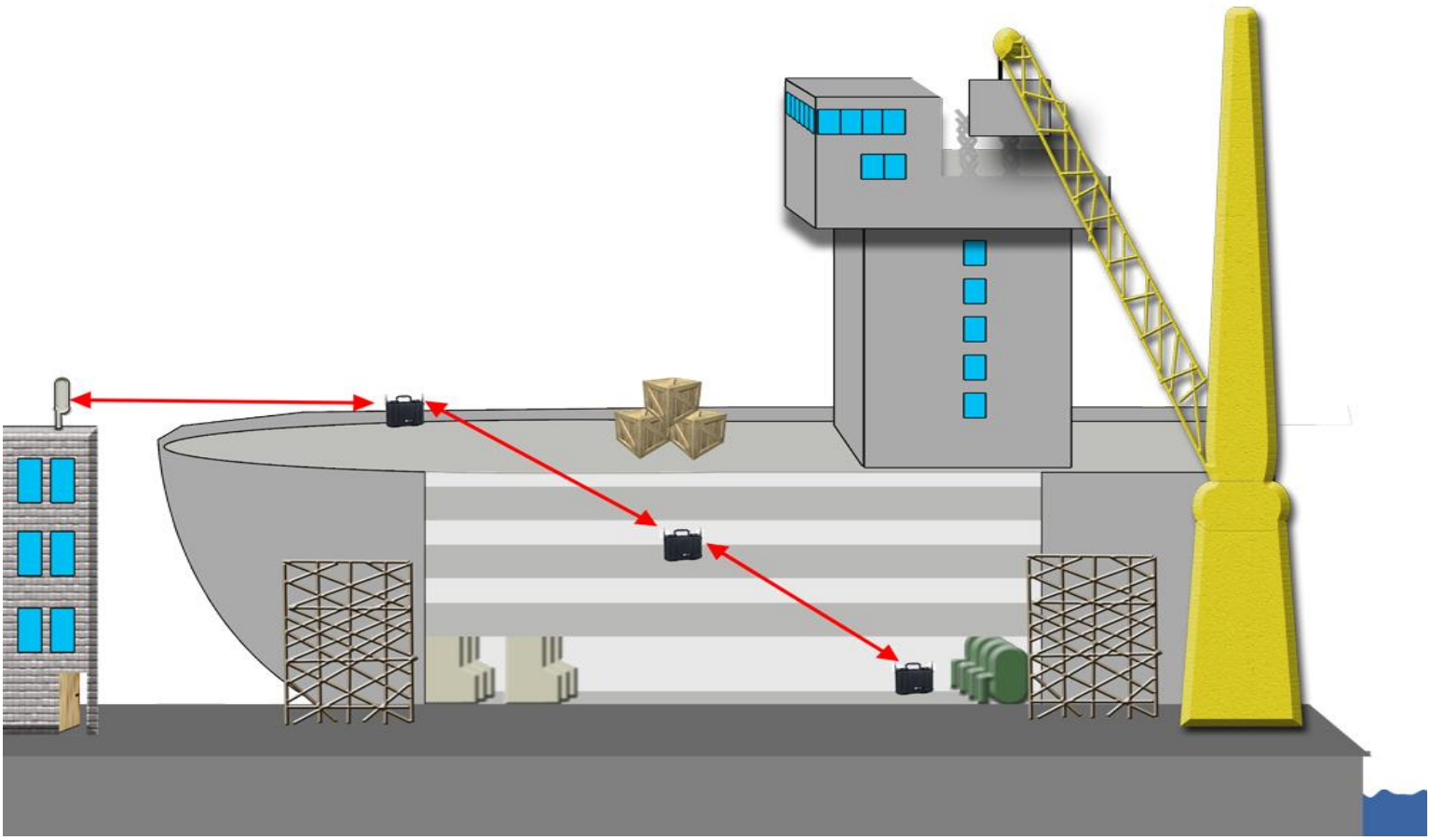
Utilizing an inexpensive, easily installed, temporary wireless mesh network allows shipbuilders to run the Machinery Control System (MCS) (or other shipyard procured electronics) in real time allowing early diagnosis of shipboard faults. In addition to early fault detection during construction, using a mesh network could be an affordable substitute for land based testing.



Mesh networks allow real-time testing of ship system's during construction

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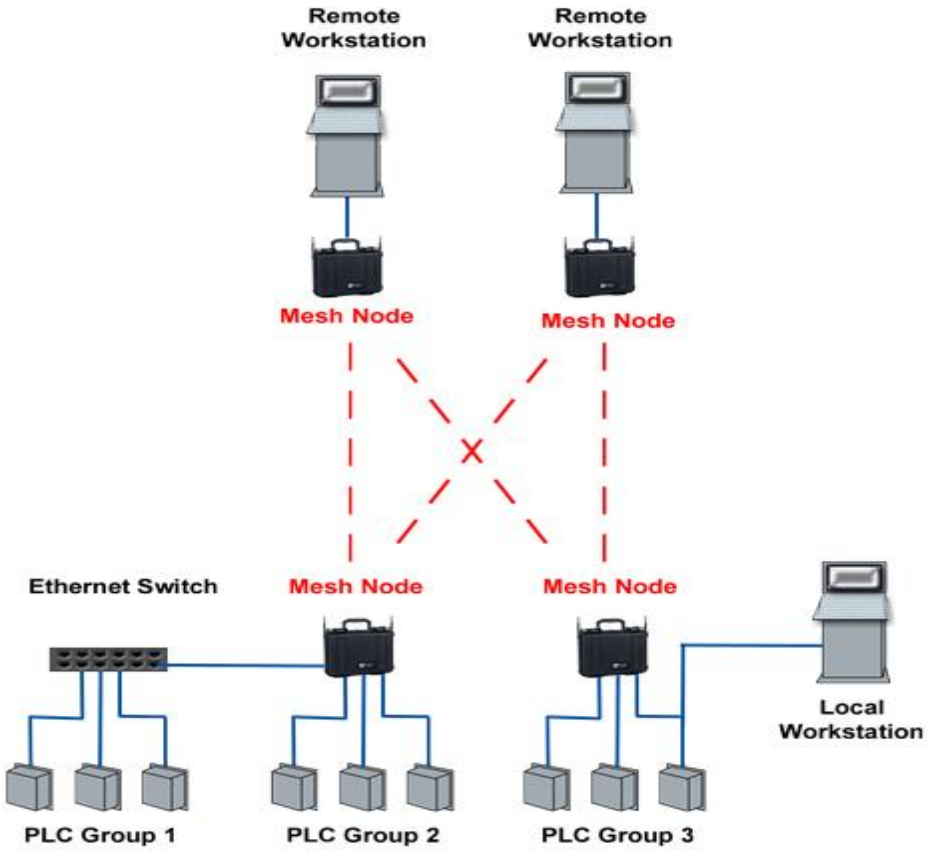
Background

New and ever evolving threats create a need to introduce game changing, disruptive technologies into modern warships. On the other hand, affordability in ship construction continues to be of primary concern. Senior leaders at NAVSEA have pointed out that ship construction costs have increased more rapidly than costs in other industries. Additionally, the tightening of Ship Construction Navy (SCN) budgets and related congressional actions (e.g., Sequestration) has caused NAVSEA to reach out to industry, soliciting ideas from "prime" shipbuilders and also from second and third tier suppliers to provide innovative methods to reduce ship construction costs.

There are several mission critical systems that shipbuilders are responsible for procuring, installing and testing. They are the MCS (otherwise known as the Engineering Control System), Ship Control System, Navigation and Integrated Bridge System and Integrated Voice/Video Communications Systems. These systems are often installed early on in the construction process, as those equipment sets are generally located deep within the bowels of the ship. Despite early installation, these systems are often only tested as an entire system after ship construction is complete since they require fiber and copper cable runs, "connectorization" and hookup. For instance the Ship Control System's steering control is installed early while the bridge workstations which control it can only be installed once the superstructure is complete.

This runs counter to the fact that it is extremely important to test mission critical systems early in the ship's construction process. At many yards, this work is often performed late in construction, allowing very little time to find and fix system-wide problems once full, system testing begins. Making changes to the ship's design, including subordinate electronics systems, becomes exponentially more expensive the further into production they are implemented.



Notional Architecture of a Ship's Control System with Mesh Network Links

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Ship Electronic System Testing

The Navy requires a series of shipboard tests prior to ship delivery. These tests are labeled stage tests and test both electronics but also various mechanical systems and functions. Following stage tests the shipyard conducts dock or builders trials and finally sea trials. Sea trials are the final test conducted by a combination of shipyard and electronics industry representatives, witnessed and evaluated by the Navy for acceptability. While designed to be robust, the at sea test does not fully replicate the operational environment when systems are manned by the ship's crew.

In addition to stage tests and trials, the Navy has embraced and at times required the use of Land Based Test Environments to test equipment sets prior to delivery to the shipyard. Besides being an added upfront cost, land based testing does not address equipment and associated cabling and connections that can only be tested after installation on the ship. Land based testing also can never fully replicate the entire suite of equipment found onboard a modern ship. There just is not enough facility space, time and money to create a full-up test of all electronics workstations, cabinets and interconnection boxes.

A land based test program can cost as much as $20 million to setup and run. Adding early testing during ship construction using a mesh network could eliminate the cost of land based testing while reducing the risk of finding problems late in ship construction. This begs the question: Is it more cost effective to create a complex, expensive land based test program or is there a more efficient and practical way to incrementally test mission critical systems onboard during ship construction?

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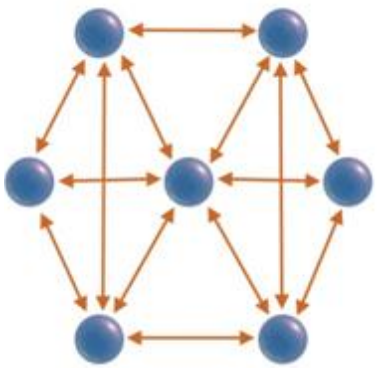
Wireless Mesh Networking



Mesh Networking

Wireless mesh networking is a topology in which all nodes act as routers, passing information from origin to destination, as opposed to traditional shipboard wireless networks which consist of Wi-Fi access points and a wired network. In mesh networks the mesh nodes act as both access points and routers thereby removing the need for a wired network and creating a purely wireless network. Purely wireless networks reduce the cost and the time of installation since there is no need to cut through bulkheads in order to install them. Wireless mesh networks provide the ability to traverse multiple decks and provide coverage throughout the ship without running any cables.

Rather than wait for construction to be completed, a shipbuilder could deploy a temporary mesh network to run the MCS and identify issues in real-time. Information can be relayed to a workstation onboard or even the shipbuilder's engineering offices. An added benefit of a temporary mesh network is that manuals and technical specifications can be sent as needed to the ship reducing downtime spent retrieving documents from the engineering offices. Finally, since the wireless mesh network is portable, once the ship is complete, the mesh nodes can be moved to the next ship to run its MCS.

Mesh Network Design

A mesh network must be designed specifically to meet shipboard requirements. Since modern ship electronic systems use non-proprietary protocols (e.g., Ethernet) the mesh network must be capable of transmitting Ethernet

Since the mesh network is emulating a fiber optic cable the latency must be optimized for system alerts.

traffic and meet the required bandwidth and security needs. Additionally, since the mesh network is emulating a fiber optic cable the latency must be optimized for system alerts. Finally, since the network will be deployed in areas where power sources cannot be guaranteed, the mesh network nodes must also include a rechargeable power source (e.g., batteries).

By selecting the right type of mesh network for the application, system designers are able to run systems with limited mesh hardware. TELEGRID has tested wireless mesh networks on several Navy ships and commercial cargo vessels. Based on the protocol and frequency selected it has been proven that mesh networks are able to penetrate multiple decks and bulkheads. For instance, on Navy vessels voice communication links were possible between four decks while on cargo vessels video was transmitted from the pilot house to the engine room with the use of only one intermediary mesh repeater.

Portable Mesh Node

Cost Savings

There are 3 potential ways to reduce acquisition costs by using a temporary mesh network during ship construction.

First, for those ship construction programs considering using a land based design integration test program, using a temporary mesh network onboard the actual ship during construction provides a viable alternative. A land based test program can cost as much as $20 million to setup and run but does not guarantee the proper function of equipment after delivery and installation is complete.

Second, using a mesh network during ship construction allows test engineers to conduct early light-off and incrementally test logical groups of equipment much like those found in Design Integration Testing (DIT) Level 2 and 1 in a land based environment. This testing will expose basic problems caused by shipping, handling and installation of equipment as well as demonstrate the physical and logical interfaces between equipment. Studies have shown that problems found later in ship construction are more expensive to fix and by some estimates, 3 to 5 times more.

Last, finding problems early in construction reduces risk and avoids the potential cost of delay and disruption including late ship delivery. For instance, creating new software builds, once problems are understood and corrections developed, can take 4 or more weeks and if found at builders trials, could impact sea trials and delivery.

Conclusion

With the increasing price and technological demands of shipbuilding NAVSEA is looking for ways to save money while maintaining a strong modern Navy. One way to save money is to adapt the lessons learned from ongoing maintenance and support efforts and promote early fault detection and mitigation. By deploying the right type of wireless mesh network during construction, shipbuilders can perform shipboard electronic system testing in real-time and identify faults earlier. This can lead to significant cost and time savings for shipbuilders and the Navy.

About the Author

Eric Sharret is the Vice President of TELEGRID Technologies, Inc. TELEGRID designs, develops and produces wireless mesh infrastructures and portable mesh networking products for austere environments. TELEGRID's mesh networking products have been used in ships, mines and underground tunnels. Eric can be reached at 973-994-4440 and sales@telegrid.com.