Validating Passive Optical LANs for Large-Scale Cruise Ship Deployments

Towering multiple decks high and spanning the length of multiple football fields, cruise ships are modern engineering marvels that are technologically transforming to meet passenger demand for the same secure, fast, and reliable digital services and wireless connectivity found in land-based resorts. At the same time, cruise lines increasingly leverage smart, connected technologies to optimize highly complex day-to-day operations—all while prioritizing sustainability.

Cruise ships face significant challenges in deploying robust network infrastructure for digital technologies due to constrained space, harsh marine environments, constant motion and vibration, limited power and cooling, and stringent security and life safety requirements. Passive optical LAN technology, offering significant performance, reliability, cost, and sustainable benefits compared to traditional switched copper networks, provides a compelling solution. A recent proof-of-concept passive optical LAN deployment serving a cluster of passenger cabins on an international cruise ship has validated this potential, prompting multiple cruise lines to take a closer look at the technology.

Optimizing Shipboard Networks

Cruise ships today are tasked with meeting the modern connectivity demands of onboard retail, dining, entertainment, security, and ship management systems. Ensuring pervasive bow-to-stern Wi-Fi has become paramount for seamless connectivity and to enable innovative cruise line mobile apps for event information, wayfinding, reservations, and purchases. Today's staterooms are also increasingly equipped with advanced digital amenities, including in-cabin phones, Wi-Fi access, smart TVs, virtual concierge platforms, and interactive touch screens for controlling room temperature, lighting, and curtains.

The proliferation of technology aboard today's cruise ships necessitates designing, installing, configuring, and maintaining a complex and reliable network infrastructure. Adding to the complexity is a ship's compartmentalized design, featuring vertical fire zones that contain remote distribution points (RDPs) for managing connectivity to cabins and other spaces within the zone. Most cruise ships have historically deployed traditional switched copper networks, consisting of balanced twisted-pair copper cabling (primarily Category 6A, Category 7/7A shielded cables) from RDPs to remote edge switches that connect devices in passenger cabins.

While Category 6A and Category 7/7A shielded cables offer advantages such as 10 gigabit Ethernet support, power over Ethernet (PoE) capabilities, excellent interference immunity, and a longer lifecycle than other copper cables, they also present challenges in demanding cruise ship environments. Copper cables are susceptible to corrosion due to oxidation in the humid, salty marine air, potentially impacting signal quality and reducing cable longevity. Their larger diameter and minimum bend radius complicates routing these cables through confined ship pathways. Copper cables are also limited to a 100-meter distance, necessitating additional RDPs, network equipment, and associated power and cooling.

"When our ships are in dry dock for retrofitting work, it can be difficult to pull larger diameter cables through existing pathways. But one of the biggest disadvantages we see with copper networks on the ship is the limited distance, which often requires us to add more RDPs to reach every end device," says the IT director for a major cruise line.

In a challenging cruise ship environment, a passive optical LAN utilizing singlemode fiber optic cabling provides a compelling solution. Singlemode fiber's superior bandwidth capabilities and extended reach are essential for meeting the demands of modern cruise operations. Moreover, its inherent resistance to temperature fluctuations, moisture, and electromagnetic interference ensures exceptional reliability in harsh oceanic conditions.

Singlemode fiber's physical properties, in particular, make it a natural fit for shipboard networks. Compared to shielded copper cabling, singlemode fiber boasts about a third of the overall cable diameter and at least four times the tensile strength. These attributes translate to easier routing of cables through tight cruise ship pathways and reduced pathway space and material required to support the network, which can lower deployment costs and free up revenue-generating space.

Charting a Greener, Secure Course

Although cruise ships comprise less than 1% of maritime traffic, they must meet increasingly stringent environmental regulations around the globe. Through the use of solar panels, innovative exhaust cleaning systems, advanced waste processing, cleaner burning fuel, and even new hull designs, cruise lines are making significant strides in reducing carbon emissions and environmental impact. Passive optical LANs can help cruise ships enhance their sustainability profile.

In addition to a smaller diameter, singlemode fiber is just one-tenth the weight of shielded copper cabling. This contributes to a lighter overall ship tonnage that reduces fuel consumption since a lighter vessel requires

PASSIVE OPTICAL LAN:
A better way to build and operate cruise ship networks

- Superior performance and scalability with 200x the link distance and limitless bandwidth capacity

- Stronger security with redundant fiber technology, smaller attack surface, and centralized management with reduced human touch

- Improved reliability with immunity to interference and resistance to marine corrosion

- Greater sustainability with less material, power, cooling, and environmental impact

- Reduced ship fuel consumption and emissions with lower infrastructure weight

- Smaller cable diameter and reduced network equipment frees up revenue-generating space

- Lower capital and operating expense due to simplified deployment, less equipment, fuel efficiency, and reduced power

less engine power to maintain speed. It is worth noting that silicon dioxide, the primary component of fiber optic cables, is also one of Earth's most abundant materials, with a lower environmental impact during extraction than copper.

In a passive optical LAN, passive splitters take incoming optical signals from an optical line terminal (OLT) and split them into multiple output signals. These outputs can provide direct singlemode fiber connections to devices or powered optical network terminals (ONTs) that in turn deliver data and PoE to devices over short copper cables. Because this point-to-multipoint fiber solution can reach up to 20 kilometers, cruise ships can reduce the number of required RDPs and associated switches, power, and cooling. Not only does this allow a cruise line to reclaim valuable revenue-generating real estate, but it also reduces embodied and operational carbon impact due to less material, plastics, and PVCs. It also provides year-over-year energy savings due to reduced power and cooling.

"The cruise ship industry is keen on reducing carbon footprints and sustainability is rapidly becoming a part of the objective as we sail our ships," says the IT director. "From energy and material savings to reduced power consumption, passive optical LANs definitely have a green advantage. Plus, with fiber weighing just a fraction of copper, we have less drag and need less fuel."

The IT director also points out that the lifecycle for as passive optical LAN is significantly longer. "The lifecycle for traditional network switches is about 5 to 6 years, while OLTs and ONTs are about 8 to 10. Cruise ships are built to last 30 years, so a traditional network requires twice the number of upgrades over the lifetime of ship, each

of which is extremely costly from an asset replacement and labor perspective."

Like any facility, cruise ships need resilient, secure networks to maintain operational safety and protect against cyberattacks that can disable mission-critical systems and compromise sensitive passenger data. Fiber is inherently more secure due to the difficulty of intercepting light signals compared to electrical signals carried by copper cables. Passive optical LAN technology also delivers superior resiliency and security due to its unique, simplified redundancy capabilities using dual feed splitters (e.g., 2:32) that connect to separate OLT line cards.

In addition, intelligence in a passive optical LAN is contained within the OLT that resides on a single IP address. The splitters are passive, and the ONTs are simple, unintelligent devices that do not store network information locally and are controlled exclusively by the OLT. This reduces the number of touchpoints on the network and prevents misconfigurations that increase the potential for cybersecurity risks. An entire passive optical LAN can also be controlled and configured via a centralized management platform that defines security policies and configures VLANs, alarm settings, and other parameters that are pushed out from OLTs to all connected ONTs. These features allow a passive optical LAN to meet Zero Trust Architecture (ZTA) initiatives as recommended by leading industry network security standards.

Putting it to the Test

While OLTs and ONTs are the core active components of a passive optical LAN, the system's reliable performance hinges on premium-quality fiber optic cabling, splitters, and connectivity. Additionally, robust

copper category cables from ONTs to end-user devices are crucial for consistent data transmission and PoE delivery, ensuring network uptime and seamless operation of both mission-critical and passenger-focused digital technologies. Successfully implementing a high-performance passive optical LAN on a cruise ship also requires specialized marine-centric network integration expertise.

To validate passive optical LAN as an optimal solution for cruise lines, three industry leaders—Hubbell Premise Wiring, Tellabs, and WaveGuide Communications—collaborated to design, construct, and operate a proof-of-concept shipboard network on a new 3,260-passenger cruise ship. This initiative deployed passive optical LAN technology to serve 40 passenger cabins within a designated fire zone.

"We engaged with the cruise line's IT director to understand their cabin technology needs and presented the advantages of a passive optical LAN," explains Wil Boyd, Hubbell's Global Manager for the Cruise Line Industry. "Based on the potential savings, they agreed

to proceed with the proof of concept to test out the technology."

While passive optical LANs have been deployed on larger military vessels and throughout many land-based hotels and resorts, it is a newer technology for cruise ships. "We decided to keep the proof of concept to the guest IT network in just one fire zone in case we had any issues. This also gave us an apples-to-apples comparison to see how technology for one zone functions on a passive optical LAN versus another zone using a traditional switched network," says the cruise ship IT director.

The deployment featured a Tellabs FlexSym® Optical Line Terminal One (OLT1) in the zone's RDP connecting twenty 8-port ONTs housed in compact tech lockers, each serving two passenger cabins. Within the RDP, Hubbell's FCR-X series fiber enclosures provided superior management and protection for the singlemode fiber cabling from the ship's data center to the OLT. Singlemode fiber patch cords connected the OLT to Hubbell's 2:16 rack-mounted 1U splitter panels.

Hubbell FCR-X series fiber enclosure manages fiber to the Tellabs FlexSym OLT while Hubbell 2:16 rack-mounted 1U splitters with custom-length assemblies distribute connectivity from the OLT to tech lockers that serve passenger cabins.
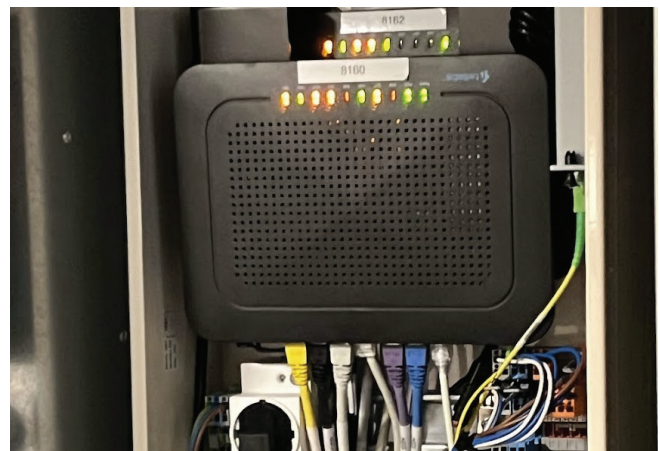
ONTs housed in tech lockers provide technology for passenger cabins via Hubbell's NEXTSPEED Ascent Category 6A shielded cabling, color-coded for straightforward application identification (Wi-Fi, phones, TVs, lighting control, etc.).

For connections from the splitters to the ONTs in the tech lockers, Hubbell custom-designed and manufactured pre-terminated, fully tested singlemode fiber trunk assemblies using premium low-loss APC/SC fiber connectors. Within each tech locker, Tellabs 8-port ONTs provide Gigabit Ethernet and PoE interfaces for in-cabin devices via Hubbell's NEXTSPEED® Ascent shielded Category 6A patch cords. These Category 6A patch cords were custom-made in various lengths and colors to easily identify the various devices and applications, including Wi-Fi, phones, smart TVs, lighting control, and access control. Hubbell also custom-designed plexiglass covers for the tech lockers that protect active ONTs and connections while enabling visibility of ONT status.

"The partnership between Hubbell, Tellabs, and Waveguide was critical. Tellabs has been deploying passive optical LAN technology for years, so they were able to lend their expertise with hands-on training for Waveguide," says the cruise ship IT director. "Meanwhile, Hubbell ensured that all the fiber cabling components could withstand the harsh ship environment. Their customization capabilities were also crucial as it allowed for fast, easy deployment of the pre-terminated fiber cables from the RDPs to the tech lockers at the same time copper cables were being deployed in other zones."

Sailing Towards Savings

Following the proof-of-concept implementation, the 146,000-ton cruise ship spanning more than 1,000 feet in length began its transatlantic journey. The vessel, notable for its generous open-air spaces and a rooftop garden featuring cantilevered pools, departed from its European port of origin. It arrived at Port Miami without a single network or connectivity issue within the fire

3000-Passenger Cruise Ship	
Operational Savings	
APPROXIMATELY	
$120,000*	
PER YEAR	
Reduction in weight (minus 35 tons of cabling)	**$35,000** of fuel savings per year
Reduction in power per TR/RDP	**$4,400** in savings per year
Reduction in power for 20 TR/RDP eliminated	**$88,800** in savings per year

Capital Savings	
APPROXIMATELY	
$800,000*	
OVER 5 YEARS	
Cost savings from eliminating switches from 20 RDPs	**$597, 495**
Cost savings from replacing switches with PON OLT/ONTs	**$200,000**

*Calculation based on actual proof of concept for one RDP serving 40 cabins

zone served by the passive optical LAN. Now fully operational for more than a year, the ship provides passengers with smart state-of-the-art technology for maximum comfort and entertainment while traveling to destinations around the world.

The passive optical LAN proof-of-concept deployment made possible via Tellabs enterprise-grade equipment, Hubbell's leading fiber infrastructure, and WaveGuide's cruise-ship expertise demonstrates the potential for significant and quantifiable savings for cruise

ships. Based on the deployment, the team has calculated that replacing heavy Category 7 shielded cables with lightweight singlemode fiber for all connections to passenger cabins would have reduced the weight of cabling by 35 tons. A weight reduction of this magnitude delivers fuel efficiency equal to an annual fuel savings of $35,000. That savings, combined with reduced power and cooling across 20 RDPs, would also equate to roughly $120,000 in annual operational savings while freeing up more valuable space. The proof of concept also demonstrated that eliminating traditional LAN switches from 20 RDPs in favor of passive optical LAN OLTs and ONTs would have provided an $800,000 capital expenditure reduction over five years.

This compelling proof of concept and potential savings is capturing the attention of major cruise lines worldwide, prompting some to consider passive optical LAN as a pivotal strategy for cost reduction, revenue maximization through space reclamation, enhanced security, and improved sustainability.

"Building a cruise ship from concept to delivery takes several years. It's difficult to switch to passive optical LAN for projects already underway, and it is challenging to change the mindset of network engineers who are used to traditional switched networks," says the cruise ship IT director. "We need shipyards to embrace the technology and effectively promote the benefits. Deploying and operating a complete ship-wide passive optical LAN would also help measure the savings over time."

As transformative technologies like high-resolution video, augmented and virtual reality (AR/VR), artificial intelligence (AI), machine learning (ML), and advanced data analytics pave the way for unparalleled personalized experiences and streamlined operations, connectivity becomes even more critical to passenger and crew well-being. Major cruise lines can proactively invest in passive optical LAN to cost-effectively expand their fleets while minimizing their environmental footprint and maximizing passenger satisfaction.

Partnering with the best

Hubbell, Tellabs and Waveguide work seamlessly together to design, build and operate premiere shipboard networks. Put their expertise to work for you.

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