Vessel Broadband Modernization
(We don't need the Wi-Fi password anymore!)

State:
Washington

Agency:
WSDOT Washington State Department of Transportation

Category:
Cross-Boundary Collaboration & Partnerships

Project Dates:
2018-2020

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Executive Summary

Leveraging competitively awarded Federal Transit Authority (FTA) Passenger Ferry Grant program funding, and in partnership with Washington State Patrol (WSP), U.S. Coast Guard, the Equal Opportunity Office, local public safety agencies and Washington State Department of Transportation headquarters, Washington State Ferries (WSF) made an innovative and significant vessel network infrastructure investment and enhancement to modernize and revitalize Washington's public ferry system corporate data connectivity.

Washington State Ferries is the largest ferry system in the U.S. operating a fleet of 21 auto-passenger vessels, 20 terminals on 10 routes in the Puget Sound and greater Salish Sea. It is the second largest ferry system in the world for vehicles carried with an average of 10.3 million/year in 2010s (7.6 million in 2020) and is part of the state highway network serving eight counties and British Columbia, Canada.

WSF IT department is a part of the enterprise WSDOT Information Technology Department. While HQ enterprise teams provide the primary support for information technology that is used statewide, the local Ferries IT department provides the primary support for operational technologies that are specific to Ferries (e.g. ticketing) supporting frontline employee technology including cybersecurity, physical security, workstation and productivity applications, and terminal, vessel, shipyard and warehousing core IT infrastructure (network, server, telecommunication).

Data connectivity on marine vessels is best imagined as a triangle of expensive, complicated and unreliable solutions. Historically WSF vessels had limited data connectivity resulting in reliance on tedious and manual paper-based processes.

Dating back to the early 2000s and refreshed in 2013, vessels and terminals were fitted with a complicated 802.11b Wi-Fi infrastructure which allowed sporadic vessel connectivity while docked, loading and unloading passengers, and while tied up overnight. Use of the internet, email, and other network services had to be pre-planned to occur in short bursts or after business hours.

WSF network engineers architected an innovative cellular 4G LTE based model capitalizing on the unique situation and opportunity of WSF vessels transiting the Puget Sound. This geographical area is blanketed by multiple shore-based cellular data networks, allowing unprecedented low-cost broadband connectivity unheard of in the maritime industry. This level of connectivity is usually only capable via high-cost satellite uplinks or complicated microwave shots, but WSF IT was confident they could deploy a less complex, lower cost, and more resilient solution.

Partnering with Verizon, WSF engineers deployed a "Frontline" (first responder) prioritized autonomous private cellular network dedicated to WSDOT traffic, separate from the public's cellular network, and working with WSF vessel engineers and the U.S. Coast Guard, developed and installed an external antenna array. Cradlepoint hardware provided the cellular connectivity for both voice and data.

Once the pieces were in place and evaluated, this solution immediately proved to be a runaway technical and financial success, and a success in terms of "hearts and minds" with vessel deck crews, engine crews and WSF management. Crews soon preferred to be on a "Cradlepoint" boat, and the solution with only slight refinements was further deployed fleet wide as fast as vessel layup schedules allowed at a cost of around $6k per boat, or a total fleet cost of around $120k.

Looking forward, the WSF IT Infrastructure team is working with vendors Cisco and Verizon, WSF vessel engineers, and other industry professionals testing proof of concept deployments of 4G LTE Band 66 centric, and 5G capable installations. Also currently being developed is a multiple carrier solution that will allow a Cradlepoint served vessel to fail between cellular carriers, as well as bridge two carriers for more throughput and resiliency in areas where we traverse carrier network boundaries.

A Little History

Data connectivity on marine vessels is best imagined as a triangle of expensive, complicated, and unreliable solutions. Historically WSF vessels had limited data connectivity and business unit operations resulting in reliance on tedious and manual paper-based processes.

Dating back to the early 2000s and refreshed in 2013, vessels and terminals were fitted with a complicated 802.11b Wi-Fi infrastructure (like the first home wireless network technology) which allowed sporadic vessel connectivity while docked, loading and unloading passengers, and while tied up overnight. Though "better than nothing," this complicated patchwork of antennas and hardware had serious limitations operating in a marine environment.

Legacy Wi-Fi Access Point Infrastructure
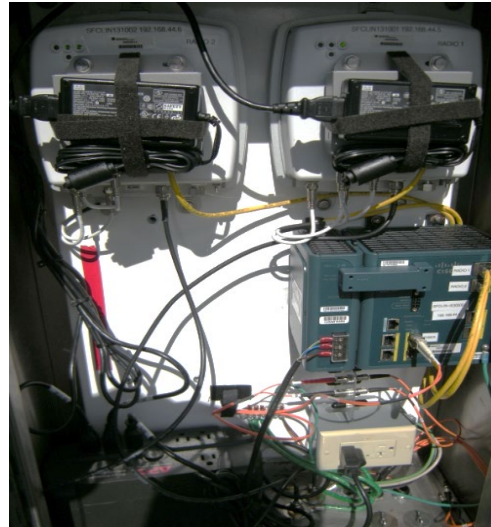
The Pain

The legacy Wi-Fi based data connectivity solution did not provide always on, real-time access to WSDOT network and cloud-based resources "on the run" and only allowed sporadic slow speed connectivity while docked. Use of the internet, email, and other network services had to be pre-planned to occur in short bursts or after business hours. Modern services reliant on this data connectivity include cloud-based SaaS solutions, email, and video conferencing (M365/Teams), state phone system and 911 access, software vulnerability mitigation and patching, crew computer-based training, real-time monitoring of physical security systems, and "Visual Paging" digital signage connectivity.
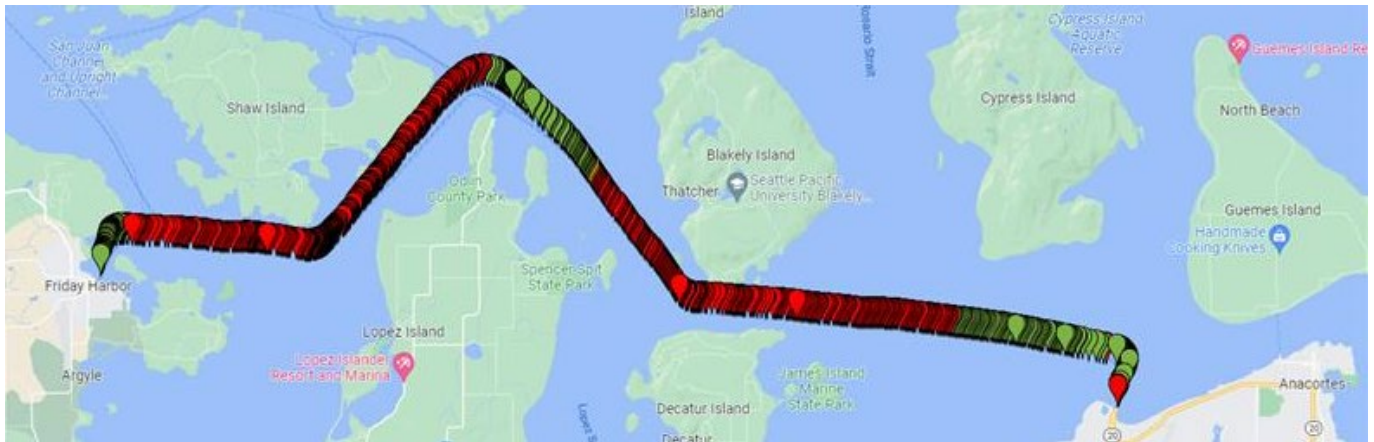
Vessel "Heat Map" of 802.11b Connectivity (San Juan Islands)

The Idea

WSF network engineers, taking direct inspiration from Safeway gas station network connectivity, architected an innovative cellular 4G LTE based model capitalizing on the unique situation and opportunity of WSF vessels transiting the Puget Sound. This geographical area is blanketed by multiple shore-based cellular data networks, allowing unprecedented low-cost broadband connectivity unheard of in the maritime industry. This level of connectivity is usually only capable via high-cost satellite uplinks or complicated microwave shots, but WSF IT was confident they could deploy a less complex, lower cost, and more resilient solution.
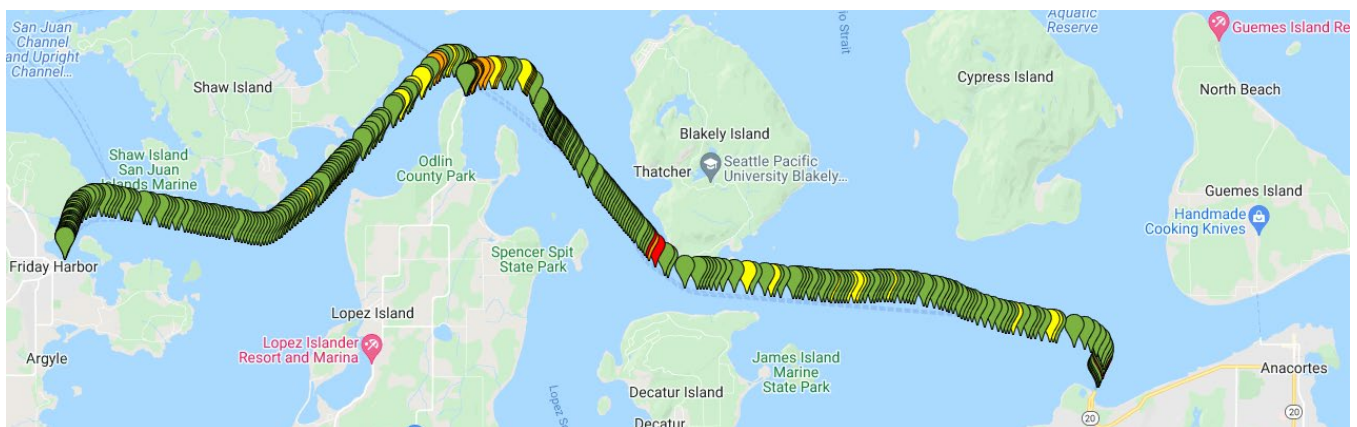
Vessel "Heat Map" of Cellular 4G LTE Connectivity (San Juan Islands)

Implementation

With competitively awarded FTA Passenger Ferry Grant program funding, and in partnership with Washington State Patrol (WSP), U.S. Coast Guard, the Equal Opportunity Office, local public safety agencies and WSDOT HQ, WSF network engineers first created a proof of concept. On the WSF vessels Chimacum and Samish, a simple and resilient hardware stack of a Cradlepoint IBR1700-1200M router, MC400LP6 modular modem, and Verizon 4G LTE sim card was installed and configured as the vessel's network gateway.

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Once the pieces were in place and evaluated, this solution immediately proved to be a runaway technical and financial success and a success in terms of "hearts and minds" with vessel deck crews, engine crews and WSF management. Crews soon preferred to be on a "Cradlepoint" boat, and the solution with only slight refinements was further deployed fleetwide as fast as vessel layup schedules allowed, at a cost of around $6k per boat, or a total fleet cost of around $120k.

Impact

Crew Productivity: Allowing vessel deck and engine crews to participate in WSDOT and U.S. Coast Guard required training "on the run," reduced issues of downtime and increased labor and travel costs for dedicated training days at WSF HQ in Seattle. This allows those crew members to remain onboard and productive in the service of WSDOT constituents, a critical issue post pandemic where recruiting efforts are extremely challenging and staff levels are at an all-time low. Crew members also now have constant high-speed access to M365 cloud-based email and productivity applications, Teams video conferencing and chat, state phone system and 911 access, and all other resources available on the statewide network. Very importantly crews also now have access to manage and submit their timesheets via the SaaS based "DOTtime" payroll tool, previously a manual paper-based process.

Cyber and Physical Security: WSP and WSF Security have been enabled to monitor onboard security systems and now have unprecedented real-time views and situational awareness for first responders dealing with emergent issues and threats. Security is also now able to monitor secure areas in real-time for issues such as ajar doors, motion detection, door force alarms and over-temperature alarms allowing proactive hardware shutdown and investigation. 24/7 network access provides the ability to scan vessel IT assets continuously for vulnerabilities and compliance and enables efficient application and operating system patch delivery.

ADA Compliance: Maintaining audio paging and digital signage uptime and connectivity is paramount in accommodating members of the public with audio and visual impairment. Broadband network connectivity provides ADA ridership access to the latest information on safety and vessel sailing status, as well as instruction in the event of a shipboard emergency. This connectivity also allows the remote health monitoring and updating of these systems, a previously very manual duty limited to afterhours visits or shipyard access during layup.
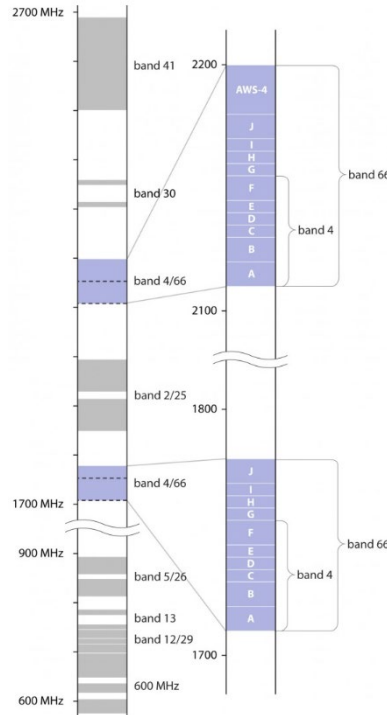
4G LTE Antenna Array, Band 66 Spectrum Utilization, Cradlepoint Routers and Cellular Modem

Data Center Modernization

Per cloud computing solutions (HB 1274, RCW 43.105.375) and Washington State OCIO Policy 184 related to locating all existing and new services in the State Data Center or Public Cloud, the Broadband Modernization project followed this mandate and the WSDOT enterprise approach. The infrastructure deployed is "serverless" and managed via a pure SaaS cloud-based solution (NetCloud). This MFA secured interface allows access and management independent of on-premises infrastructure, providing a highly resilient and redundant platform whether in the office, onsite at a remote location, or mobile.
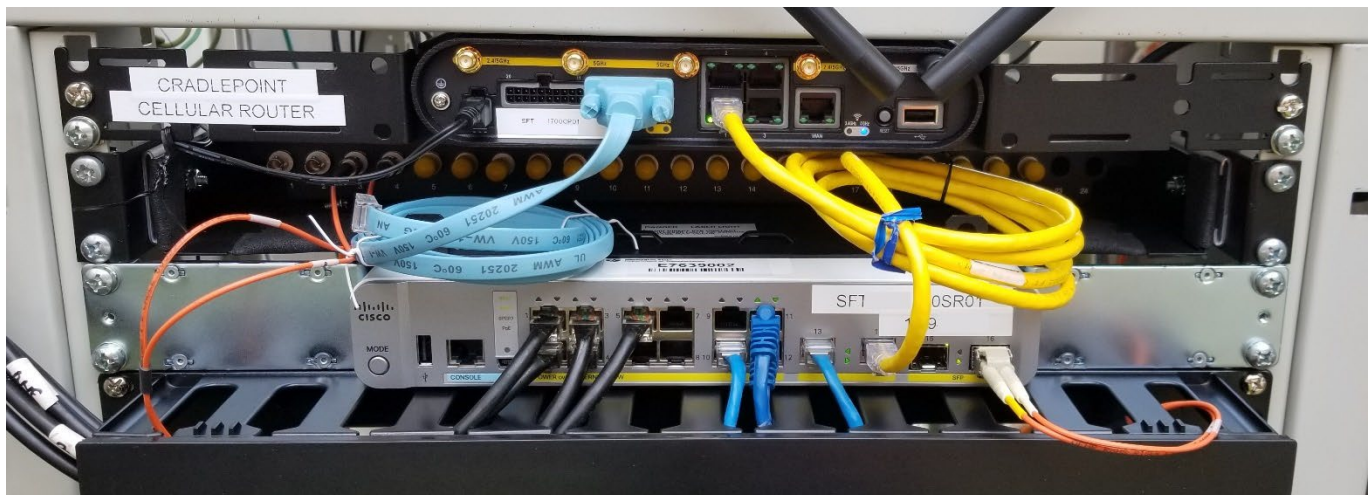
Standard Cradlepoint Router and Modem 1U Installation

Growth, and Implementation Outside WSF

The WSF proof of concept, enterpise deployment, contract, and project management experience gained in the Vessel Broadband Modernization project has paid dividends in productivity, connectivity and capability statewide. Once the technology was standardized on vessels, WSF network engineers deployed Cradlepoint CBA 850 Failover Routers at WSF terminals as an out-of-band management solution to access remote network infrastructure during ISP outages (a frequent issue in locations like San Juan Island terminals). Eningeers now have the abilty to access on-premises equipment via 4G LTE connections, to determine the root cause of a network outage and better identify the exact issue before time and money is spent dispatching personel, or escalating to ISP or vendor support.

Outside WSF, WSDOT HQ and WSP network engineers have taken notice and adopted this innovative, resilient and low cost solution to bring universal connectivity to locations that previously were served by high cost T1 lines on fragile legacy copper infrastructures, aging unreliable long distance fiber links, or worse, simply had no data connectivity. These sites include WSDOT and WSP commercial weigh stations, WSDOT and WSP fueling stations, regional WSDOT maintenance facilities (remote and mountain pass sites), jobsite trailers, and roadside cabinets that supply Google traffic data via ground loop detection circuits, sensing vehicle count and speed. This solution has become the go-to simple standard for complicated connectivity needs, with it's low cost of deployment and lifecycle replacement, durability, ease of management, and high uptime.

Future State, Upgradability

WSF network engineers are not known to rest when a job is done, and are continually looking at what is next in regards to the modernization opportunities of the current infrastructure. Working with vendors Cisco and Verizon, WSF vessel engineers and other industry professionals, the WSF IT Infrastructure team is currently testing proof of concept deployments of 4G LTE Band 66 centric and 5G capable installations. With the innovative use of new high density aerials, which encompass two separate antennas in one radome allowing multiple RF connections with fewer antennas, engineers are able to retrofit vessels and sites originally deployed with a dual antenna array, up to quad array coverage without expensive vessel engineering and shipyard costs. Also currently being developed is a multiple carrier solution that will allow a Cradlepoint served vessel to fail between cellular carriers, as well as bridge two carriers for more throughput and resiliency in areas where we traverse carrier network boundaries.

High Density MIMO Digital 4G/5G Omni-Directional 9dBi Peak Gain Antenna