Application Note: Scaling ground station connectivity for satellite constellations

The rapid expansion of low earth orbit satellites (LEO) is motivating a shift in how terrestrial networks scale to support space-based connectivity. As constellation sizes grow to 10's of thousands of satellites, the need for efficient ground station interconnect will intensify. This application note demonstrates how deployment of an entirely pluggable optical line system can enable high density, power efficient and cost-effective ground station interconnect.

Network Challenge

As of January 2026, there are nearly 10,000 satellites operating in low Earth orbit (LEO), with many thousands more approved for launch. Goldman Sachs estimates that as many as 70,000 LEO satellites could be deployed by 2030 [1]. This rapid expansion of LEO satellite constellations, combined with the increasing adoption of inter-satellite links (ISLs), is expected to drive significant growth in traffic between ground stations and Points of Presence (POPs), as data from a larger number of satellites is aggregated and concentrated at fewer, higher-capacity gateway locations.

As gateway sites begin to serve larger satellite populations, ground stations will require greater rack density and power capacity, leaving less available space and power for the optical transport infrastructure needed to carry tens of terabits per second of traffic to remote POPs.

Coherent pluggable optics have emerged as an attractive solution for delivering DWDM capacity directly from routing and switching platforms between ground stations and POPs. Early deployments centered on 400G ZR interfaces, which supported a limited number of wavelengths and enabled simplified IP-over-DWDM architectures. These solutions eliminated the need for dedicated transponders but still relied on traditional line card-based optical transport equipment for functions such as amplification, protection, and performance monitoring.

As ground station traffic continues to grow alongside the expanding LEO satellite population, networks are expected to evolve toward higher capacity 800G ZR and ZR+ technologies, delivering more than 25 Tbps of fiber capacity in the C-band. In this environment, optical transport platforms that minimize footprint and power consumption become increasingly important. This is true not only at ground stations, where rack space and power are at a premium, but also at POP locations, which are often hosted in co-location facilities where recurring costs are directly tied to the space and power consumed by deployed transport equipment.

Solution Overview

The LS200 (Figure 1) is the industry's first entirely pluggable optical line system platform in a compact 1RU form factor. The LS200 supports 8 x QSFP ports that are used for pluggable line system devices as well as 2 x SFP ports for OSC connectivity. When combined with 400G or 800G ZR or ZR+ transceivers installed in co-located routers or switches, the LS200 and associated pluggable components support point-to-point connections over distances of up to 200km.

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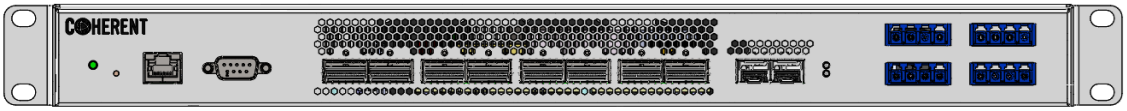

Figure 1. LS200 compact pluggable optical line system

Supported pluggable optical modules are shown in Figure 2 and described below.

Pluggable Erbium Doped Fiber Amplifier (EDFA)

The pluggable Dual EDFA module incorporates both pre and booster amplifiers in a single QSFP module with 23dBm total output power and up to 28dB gain. The amplifiers employ an innovative end-to-end gain-control architecture that dynamically partitions gain between the booster and pre-amplifier. By measuring actual span loss and exchanging information between amplifiers across the span, the system automatically adjusts the gain of each amplifier stage to match the optical span requirements with no need for manual provisioning.

Potential applications include deployment with either passive splitter-based mux and demux for low wavelength count applications or DWDM Arrayed Waveguide Grating (AWG) mux/demux for applications where achieving maximum total fiber capacity is critical.

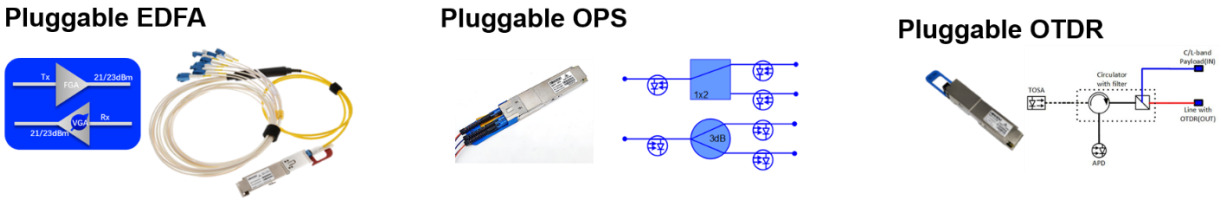

Figure 2. Supported pluggable optical line system modules in QSFP form factor

Pluggable Optical Protection Switching (OPS)

As network capacity increases, resilience becomes a critical design consideration. Route diversity and optical protection mechanisms are an essential element of the network architecture, enabling high service availability. A pluggable OPS, line protection module facilitates diverse optical paths and duplicated optical transmission providing rapid service recovery in the event of fiber cuts, equipment failures or route impairments. Pluggable OPS modules are available supporting 1+1, 1:1, 1+2 and Dual 1+1 line protection as well as with an integrated 1x2 coupler/splitter mux/demux function, maximizing architectural flexibility and simplicity.

Pluggable Optical Time Domain Reflectometer (OTDR)

Where optical transport systems are carrying 10s of terabits of traffic and strict service level agreements are in place, maintaining visibility of the underlying fiber infrastructure becomes increasingly important. A pluggable Optical Time Domain Reflectometer (OTDR) provides continuous monitoring of the fiber plant without the need for expensive stand-alone test equipment, service interruptions or truck rolls. The device enables connector degradation, excessive splice loss and fiber cuts to be rapidly detected and localized, supports a plant fiber loss up to 30dB and includes an integrated WDM to combine the OTDR wavelength with C and L-band traffic.

Another key advantage of the pluggable OTDR is its automatic optimization capability across the entire monitored fiber span. Rather than relying on a single measurement setting, the OTDR intelligently divides the fiber into four distance zones and optimizes the measurement parameters for each zone independently. The resulting traces are then combined, providing enhanced resolution and event detection accuracy, with results generated in industry standard SOR format for ease of management integration.

Solution Architecture

Figure 3 shows an example of how the LS200 can be combined with the various pluggable line system modules to provide connectivity between a ground station gateway and a remote POP. The pluggable OPS provides high system availability, while the pluggable EDFA enables high-capacity transport over spans up to 200km. The pluggable OTDR ensures continuous monitoring of both working and protection fiber routes.

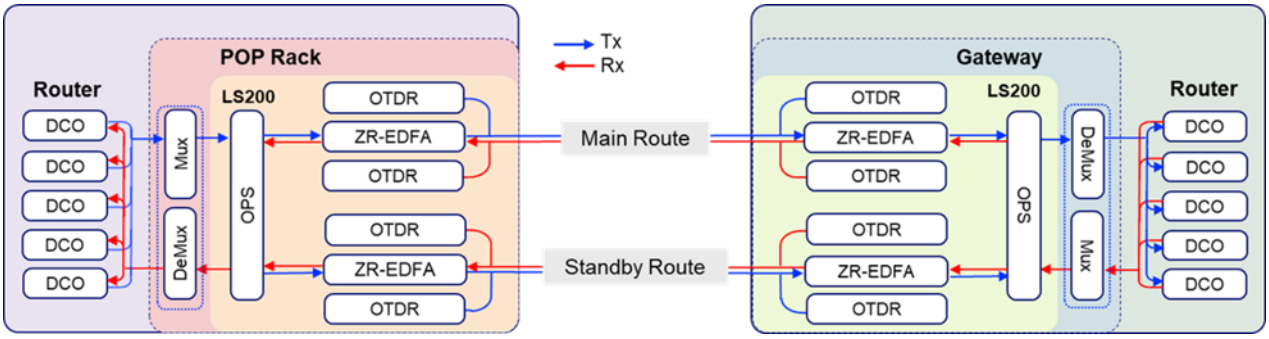

Figure 3. Example LS200 architecture with line protection and embedded OTDR

The capabilities of the LS200 line system, showing end to end DWDM performance over 200km of fiber with pluggable modules providing optical amplification, 1+1 optical line protection and OTDR will be on display in a live demonstration during the ECOC 2026 Exhibition at Coherent booth 2100.

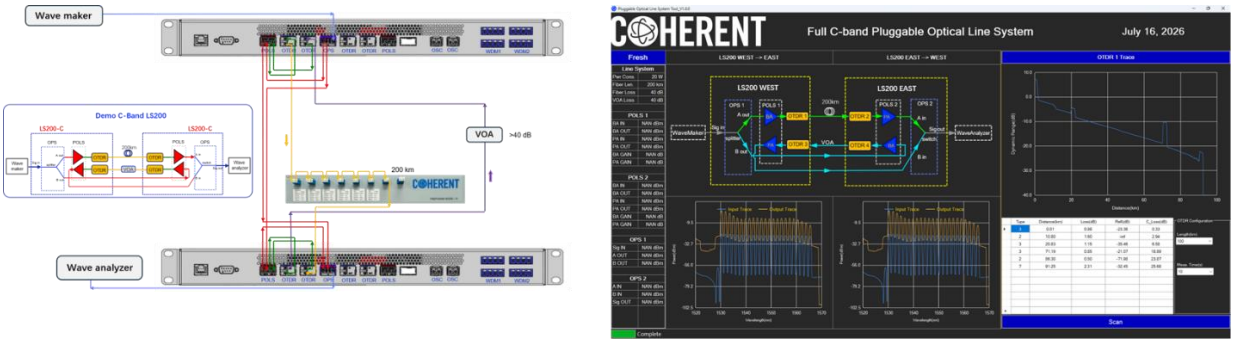

Figure 4. LS200 line system demonstration at ECOC 2026 showing pluggable optical amplification, 1+1 line protection and OTDR over a 200km point to point fiber link

Conclusion

With the number of low earth orbit (LEO) satellites increasing exponentially by the end of the decade and most of these satellites supporting inter satellite links, ground stations will need to support higher capacity connectivity to remote POP locations driving the requirement for a compact and power efficient optical line system that can support capacities of more than 25Tbps over distances up to 200km. The LS200 is the industry's first entirely pluggable optical line system in a compact 1RU form factor, enabling space, power and cost-efficient optical transport, and supporting a full portfolio of QSFP-based pluggable modules including: EDFA, Optical line protection and OTDR.

[1] https://www.goldmansachs.com/insights/articles/the-global-satellite-market-is-forecast-to-become-seven-times-bigger

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