NOKIA | EllaLink

The world's longest optical express network runs "like clockwork"

Enhanced availability, performance and cost effectiveness

Figure 1: The EllaLink submarine cable system

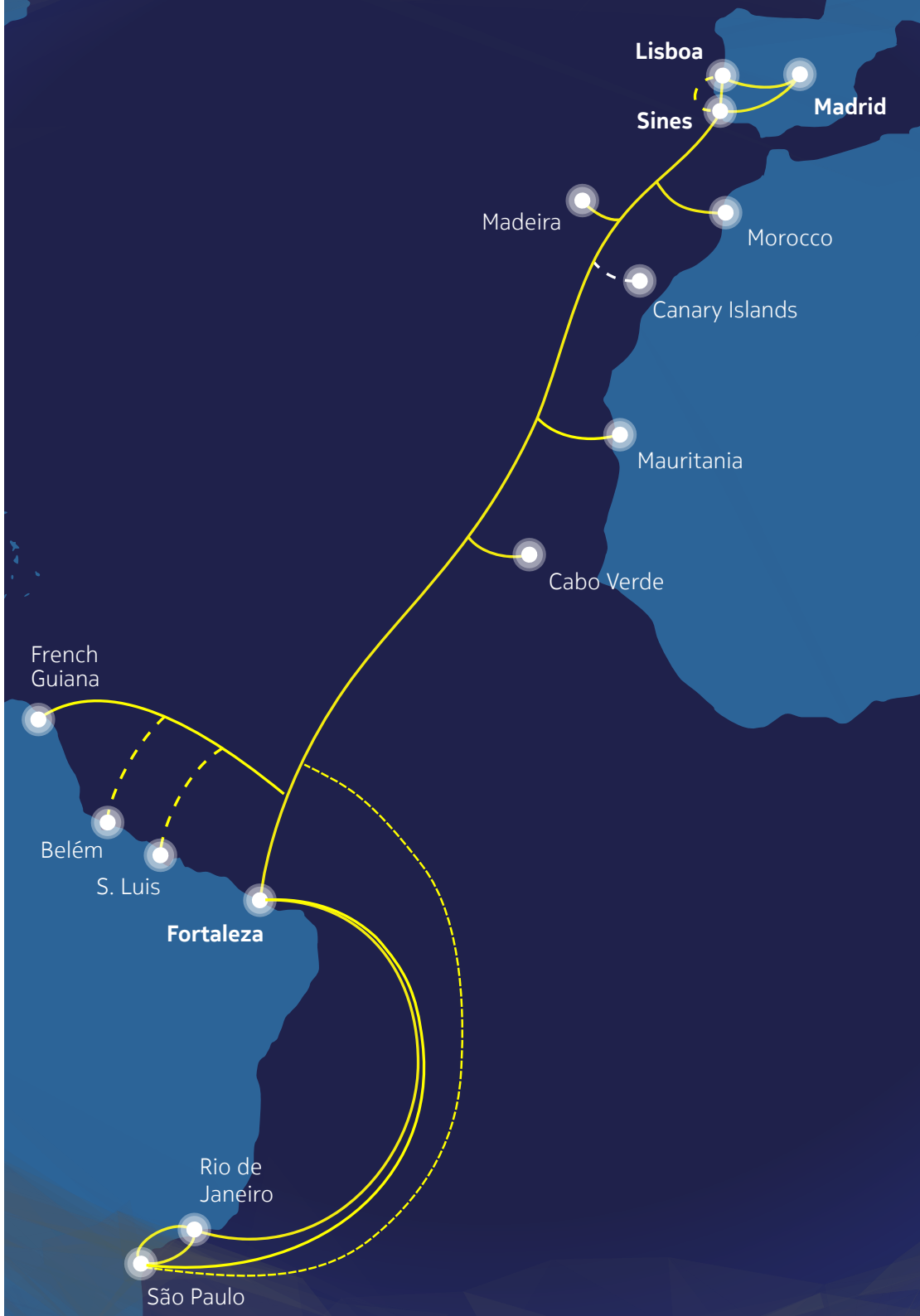
The EllaLink system

The EllaLink submarine cable system is the only submarine cable directly interconnecting Europe, Latin America and Africa across a 5,900 km subsea cable with 4 pairs of fibers.

Designed from the outset for coherent optical transmission, EllaLink places strong emphasis on data center-to-data center connectivity, where services must be delivered with the highest levels of reliability on a cost-effective optical infrastructure.

A key architectural feature of the network is the ability to optically express traffic through the cable landing station (CLS) and onward to the nearest data center. For example, while one end of the cable lands in Sines, near Lisbon, a critical data center interconnection point is Madrid, extending the optical path by 1,738 km beyond the 5,900 km trans-oceanic section. This is the longest optical-express subsea-terrestrial backhaul in operation today.

By tightly integrating Nokia ICE6 coherent transponders with the Nokia 1830 FlexILS line system, EllaLink achieves a highly reliable and cost-effective solution that provides end-to-end optical layer protection across this uniquely long, optically expressed backhaul network.



Objective

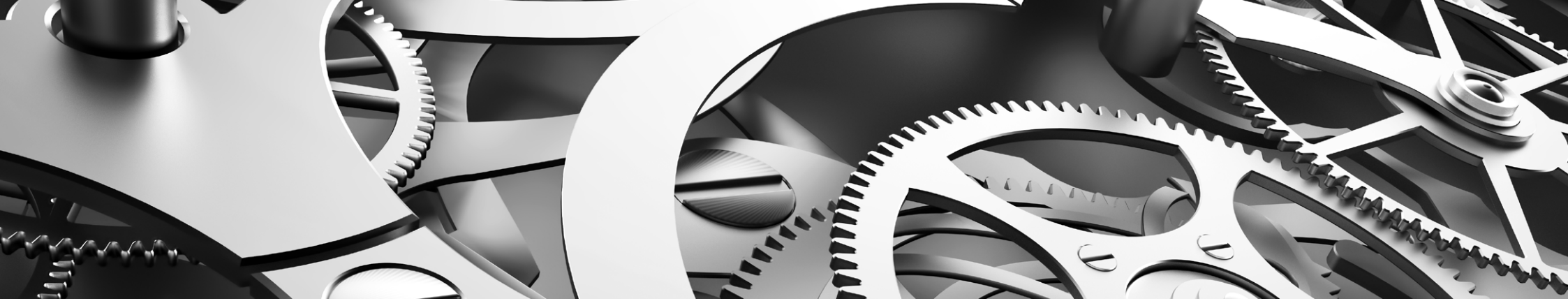
Maintain high availability over long distances while keeping costs in check

Modern submarine cable systems increasingly rely on optical express architectures to reduce cost, power consumption and latency by eliminating unnecessary optical-electrical-optical (OEO) regeneration at the CLS. However, this architectural shift places new demands on optical layer protection and optical reach, particularly when express paths extend far beyond the CLS. Nokia ICE technology delivers ample additional margin for this extended link design.

For EllaLink, this challenge was amplified by the scale of the network:

- Direct interconnection between Europe and South America
- Multiple branching units and direct data center paths
- A 1,738 km optically expressed terrestrial backhaul between Sines, Lisbon and Madrid

Ensuring rapid, deterministic protection switching across such distances without reintroducing OEO regeneration at the CLS was essential to meet service availability targets for high-priority traffic.



Solution

End-to-end all-optical protection across the world's longest optical-express submarine backhaul

EllaLink worked closely with Nokia to design and validate an all-optical protection architecture spanning both submarine and terrestrial domains.

The solution comprises:

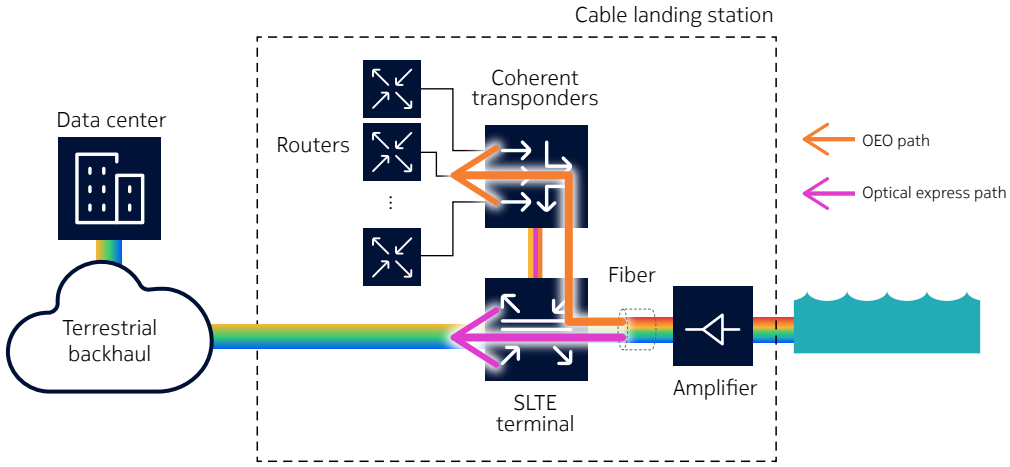
- Nokia ICE6 coherent transponders
- Nokia 1830 FlexILS submarine line system
- Nokia Optical Protection Switch Modules (OPSMs), enabling fast optical protection switching
- End-to-end optical express connectivity without regeneration at the CLS

This architecture delivers sub-50 ms protection switching while significantly reducing equipment footprint, power consumption and operational complexity at landing stations.

Optical express architecture

At the boundary between submarine and terrestrial networks, two architectures are commonly deployed: traditional OEO regeneration and optical express.

Figure 2: Illustration of OEO and optical express architectures



In an OEO architecture, wavelengths are terminated at the CLS, converted electrically and handed off to terrestrial transport equipment using back-to-back short-reach client interfaces. While this approach provides strong protection capabilities that are inherently available in terrestrial transport networks, the back-to-back OEO architecture requires substantial rack space, power and cooling, which are often limited at CLS locations.

With the increased optical budgets enabled by coherent transmission, EllaLink adopted an optical express approach, using a reconfigurable optical add/drop multiplexer (ROADM) at the CLS to optically pass-through the wavelengths from the subsea cable into the terrestrial backhaul fibers. This extends the analog optical path through the CLS and across the terrestrial backhaul network to a remote data center. As subsea cable capacities have grown, this model has become the dominant architecture for modern systems.

All-optical protection design

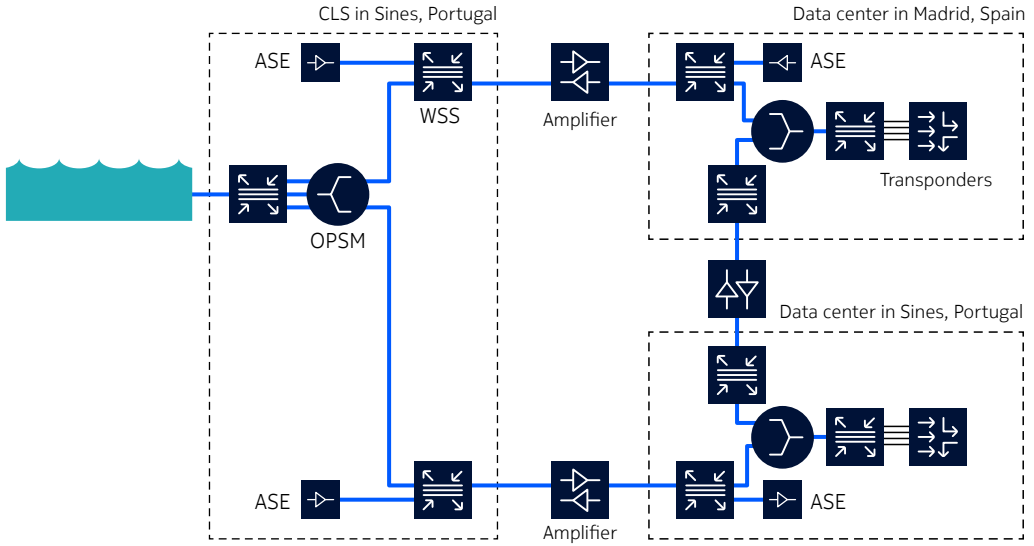
To maintain carrier-grade resilience without OEO regeneration, EllaLink implemented optical layer protection switching using OPSMs.

In this design:

- A 50:50 optical splitter sends identical signals over physically diverse paths
- An OPSM combiner selects the active path at the receive end
- Protection switching is triggered by loss of light, based on configurable attenuation thresholds
- Switching occurs in less than 50 ms, compliant with ITU T G.841

Because protection is handled entirely in the optical domain, no transmission equipment is required at the CLS, reducing space, power and operational requirements while maintaining extremely high reliability.

Figure 3: Baseline EllaLink core topology with OPSM locations



Supporting long optical express paths

Extending optical express connectivity over thousands of kilometers introduces additional challenges related to optical power stability.

EllaLink's solution incorporates:

- In-line amplifiers (ILAs) on terrestrial spans
- Constant power operation across subsea and terrestrial segments
- ASE loading to stabilize unused spectrum
- Optional optical control plane support for multi span terrestrial networks

This approach ensures stable end-to-end operation even across the longest optical express routes.

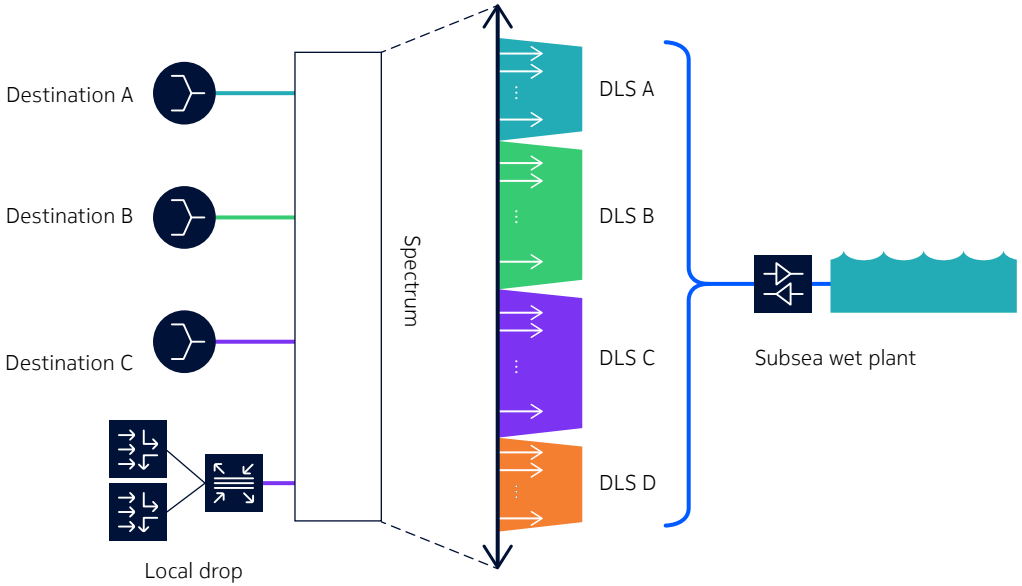
Spectrum sharing and protection

An innovative aspect of the EllaLink deployment is the ability to extend optical protection to spectrum sharing services.

Using FlexILS ROADMs and Nokia Intelligent Power Management, protection can be applied per spectrum passband, aligned with individual Digital Line Sections (DLSs). Each subsea DLS is terminated on a dedicated WSS port at the CLS, enabling per DLS optical protection without complex stacked switching architectures.

Careful configuration of switching thresholds ensures that protection events are not triggered by transponder failures, while ICE6 signal reacquisition remains within the 50 ms protection window, even for the longest differential path lengths.

Figure 4: Optical protection with spectrum sharing support



Key results

Ultra-high availability with lower cost and latency

Proven ultra-high service availability

Measured service data collected between 2022 and 2025 shows consistently high availability across a wide range of Digital Line Sections, with availability at or near 100 percent in all cases (Table 1). Where availability briefly dropped below 100 percent, root-cause analysis confirmed that the issue was related to data center power or equipment events rather than optical transmission or fiber outages. This validates the robustness of the end-to-end optical protection architecture.

Lower latency through optical express design

By enabling optical express at the CLS and eliminating unnecessary OEO regeneration, the network delivers reduced round-trip delay across both submarine and terrestrial segments. This lower latency is particularly valuable for financial, cloud and real-time applications, where even small latency improvements translate directly into improved performance and service quality.

Reduced power, space and operational complexity

Avoiding regeneration at the cable landing station significantly reduces the amount of active equipment required at these sites. This lowers power consumption and space requirements while simplifying operations and maintenance. Shifting high-capacity optical signal handling into data centers further improves efficiency, as these facilities are better suited for power, cooling, and scalability.

Table 1: Measured service availability for a range of terrestrial backhaul DLS

DLS Number	Length (km)	From	To	2022 availability %	2023 availability %	2024 availability %	2025 availability %
1	6189	Fortaleza	Lisbon	100	100	100	100
2	6821	Fortaleza	Madrid	100	99.99	100	100
3	6879	Fortaleza	Madrid	100	100	99.97	100
4	1897	Sines	Lisbon	100	99.99	100	100
5	821	Sines	Madrid	100	99.99	100	100
6	733	Lisbon	Madrid	100	99.99	100	100
7	6000	Fortaleza	Sines	100	99.99	100	100
8	8791	Sines	Madrid	100	100	99.98	100
9	781	Lisbon	Madrid	100	99.99	100	100

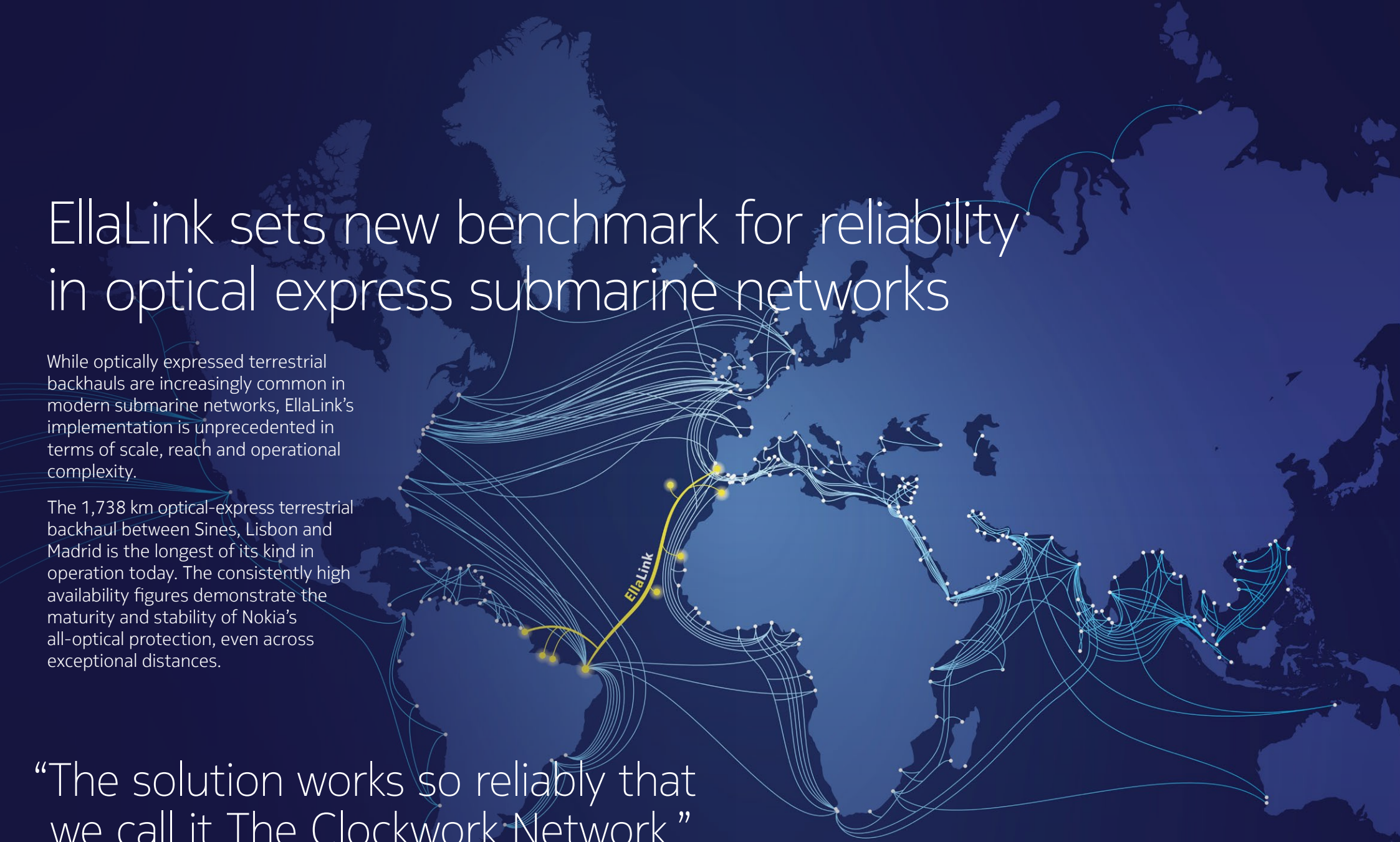
Cost efficiency without compromising reliability

The optical express architecture delivers meaningful reductions in both capital and operational expenditure by minimizing equipment, regeneration points and ongoing maintenance needs. Importantly, these cost savings are achieved without sacrificing resilience or service availability, demonstrating that a cost-effective design can still meet stringent carrier-grade reliability requirements.

EllaLink sets new benchmark for reliability in optical express submarine networks

While optically expressed terrestrial backhauls are increasingly common in modern submarine networks, EllaLink's implementation is unprecedented in terms of scale, reach and operational complexity.

The 1,738 km optical-express terrestrial backhaul between Sines, Lisbon and Madrid is the longest of its kind in operation today. The consistently high availability figures demonstrate the maturity and stability of Nokia's all-optical protection, even across exceptional distances.



"The solution works so reliably that we call it The Clockwork Network."

DIEGO MATAS, CHIEF OPERATIONS OFFICER, ELLALINK

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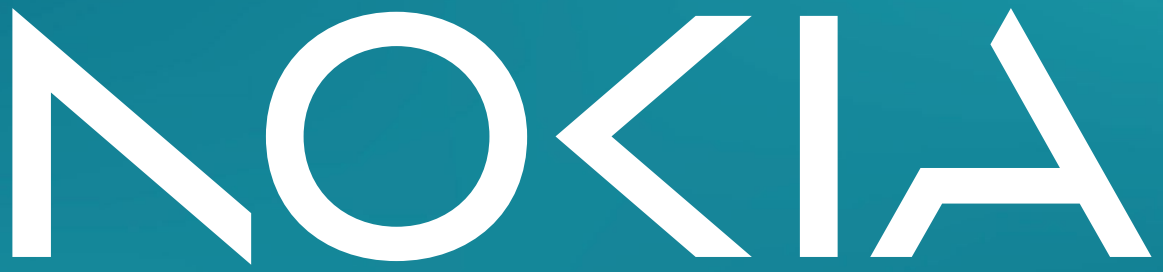

About Nokia

Nokia is a global leader in connectivity for the AI era. With expertise across fixed, mobile and transport networks, we're advancing connectivity to secure a brighter world.