NOKIA

PSE-6s super-coherent optics

Opening new frontiers in scale and sustainability

Contents

Opening new frontiers in scale and sustainability

Technology evolves through successive waves of innovation and S-curve adoption. As one technology comes up against limits that slow further adoption — reaching its S-curve plateau — another technology emerges to overcome those limitations. In optical networking, the speed of transmission optics hit a limit in the early 2000s, unable to move past speeds of 10Gb/s per wavelength. In 2010 coherent optical transmission came to the rescue by increasing wavelengths speeds to 100Gb/s per wavelength, enabling a succession of new capacity and performance milestones. The industry is currently at another plateau. Further increases to spectral efficiency are coming up against the Shannon Limit, requiring new approaches to increasing network scale while also enabling further reductions in power consumption and total cost of operations (TCO).

Our sixth-generation super-coherent engine, the Nokia PSE-6s, breaks through those limitations, opening new frontiers in network scale and sustainable optical networking — unleashing a bold new wave in optical networking. We have harnessed the latest generation of 5-nanometer silicon integrated circuit technology to develop our next breakthrough in coherent optics. PSE-6s combines our latest digital signal processor (DSP) with advanced signal-processing algorithms and CSTAR silicon photonics to achieve greater capacity, better performance, while using much less power per bit.

As a result, the PSE-6s pushes optical networking into new frontiers of scalable and sustainable architectures. Metro network operators can achieve unprecedented network capacities. Service providers with national and continental networks can achieve game changing performance and power savings. Internet content providers (ICP), and webscale operators can migrate to the next wave of 800 Gigabit Ethernet high speed services, while reducing their carbon footprint.

PSE-6s enables the networks of tomorrow.

Solving the challenges of tomorrow's networks

As every network operator knows, a primary challenge in managing network evolution is to scale network capacity to support new, high bandwidth services, all while driving down the total cost of ownership (TCO) of the network, including costs for equipment, power and operations.

Demand for bandwidth continues to grow at exponential rates, and shows no signs of abating. Market research firm Cignal.ai forecasts the total network bandwidth provided by coherent optics will grow by over 40% per year between 2023 and 2027. This growth is fueled by ever-increasing fiberization at the edges of the network, faster service speeds for 5G, consumer and business connections, ongoing growth of video consumption, and emerging applications such as VR/AR, autonomous vehicles and Industry 4.0. All this traffic drives the need for ever-faster IP router interface speeds such as 400 and 800 Gigabit Ethernet (400GE/800GE). This in turn requires coherent wavelengths to operate at faster speeds and with better performance to enable efficient transport across metro, long-haul and sub-sea networks.

With our planet under stress due to climate change, increased performance must also reduce power consumption to meet sustainability targets. With global shocks to energy supplies and pricing uncertainty, solutions that reduce "power per bit" become ever more important by meaningfully reducing network operations costs while also mitigating risk.

Sixth-generation super-coherent Photonic Service Engines

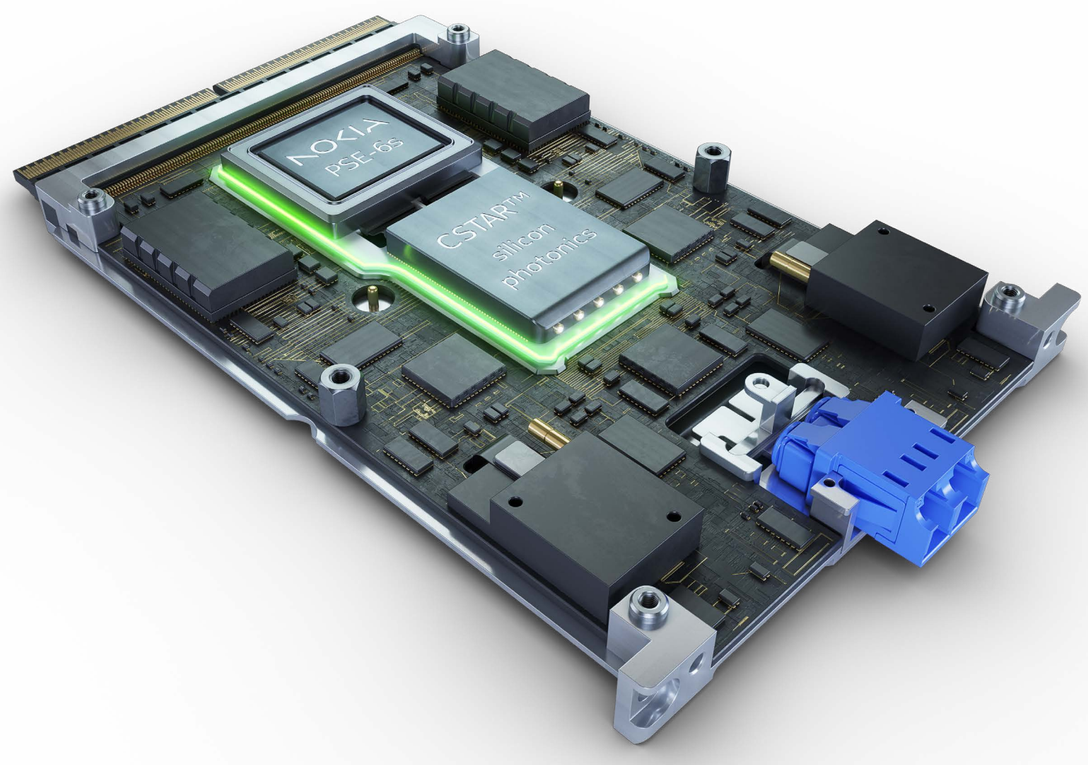
Nokia's sixth generation super-coherent Photonic Service Engine, the PSE-6s, efficiently scales network bandwidth, delivering the performance required to support a wide range of high-speed services such as 100GE/OTU4, 400GE, 800GE and future service speeds, over long-haul distances while also reducing network power consumption.

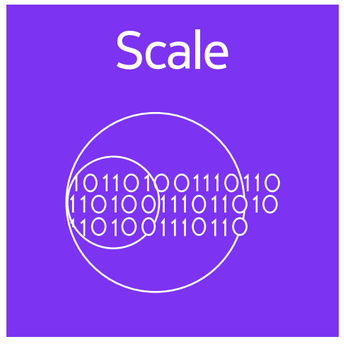
The PSE-6s closely integrates Nokia's latest coherent digital signal processor (DSP) and CSTAR silicon photonics into a digital coherent optic (DCO) module supporting the fastest wavelength speed available today at 1.2Tb/s. Leveraging the industry's only third-generation probalistic constellation shaping (PCS) with continuously adjustable baud rate and forward error correction (FEC) gain, the PSE-6s delivers the highest capacity and transmission performance available in real-world networks. Leveraging the latest silicon integrated circuit technology, PSE-6s also enables important reductions in power per bit, allowing sustainable network upgrades.

This means more scale, better performance and lower power consumption.

Faster, farther, greener. The math has never looked more sustainable.

Nokia PSE-6s





Unprecedented scale for high-speed services

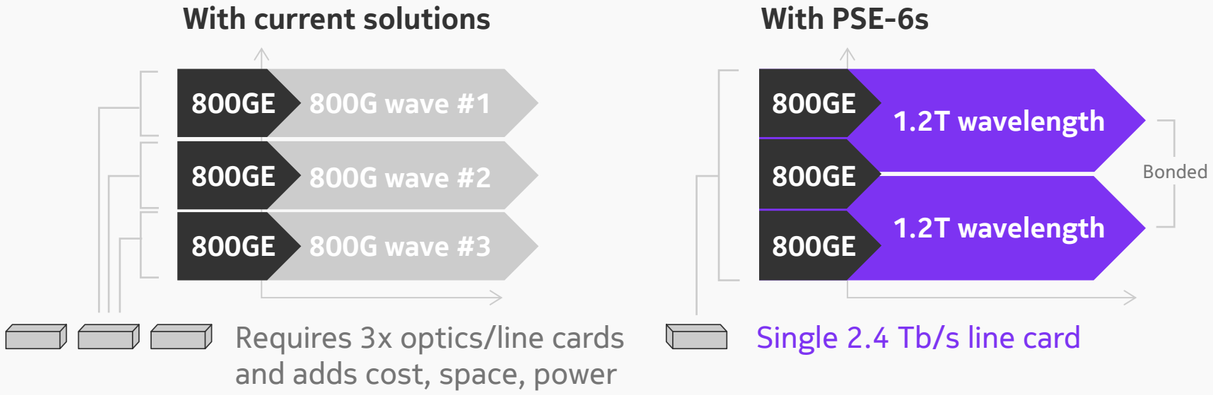
PSE-6s goes further than simply increasing wavelength capacity by 50% over current coherent solutions. Our unique ability to enable chip-to-chip communication between two PSE-6s optical modules allows us to bond two wavelengths into a 2.4Tb/s optical transport solution in a single line card.

For metro applications, the ability to transport up to 3 x 800GE services over 2.4Tb/s allows for three times as many high-speed services to be transported over a single line card compared to current coherent solutions. This benefit extends to supporting up to 6 x 400GE, 24 x 100GE/OTU4, or any combination thereof, providing network operators an extremely efficient means to scale network capacity while reducing deployment costs, equipment footprint and network power.

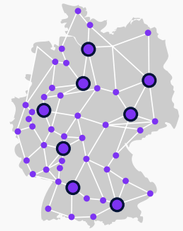
Unprecedented scale for high-speed services

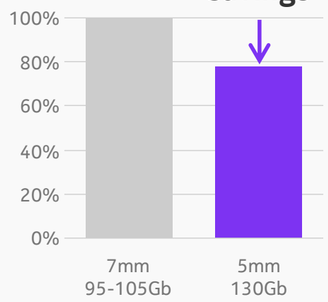
- **2.4Tb/s optical transport with 3x more capacity/line card**
- **Maximize transport capacity and efficiency for high-speed services**
- **Support up to 3 x 800GE, 6 x 400GE, 24 x 100GE/OTU4 services, in any combination**
- **Up to 25% more total fiber capacity**

Metro 800GE Transport



Metro and regional networks





Number coherent interfaces

- 800GE services
- 800G vs. 1.2Tb/s wavelengths
- Normalized to equivalent network capacity

New performance milestones to improve network economics

The PSE-6s pushes super-coherent modem technology to enable new benchmarks in optical transmission performance. Operating at 130 Gbaud or more, the PSE-6s combines the industry's only third-generation probabilistic constellation shaping (PCS) algorithms with variable-gain forward error correction (FEC) and continuous baud rate tuning to push capacity-reach performance beyond the limits of what is possible today.

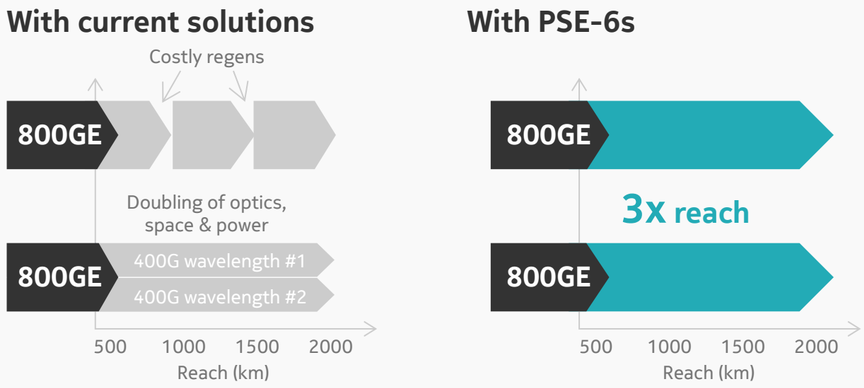
These advances deliver the performance needed for tomorrow's networks.

Performance

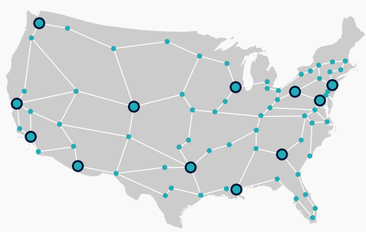
- **3x the reach at 800G**
- **Enabling 2000km+ long-haul 800GE transport**
- **Up to 50% fewer coherent interfaces in network**

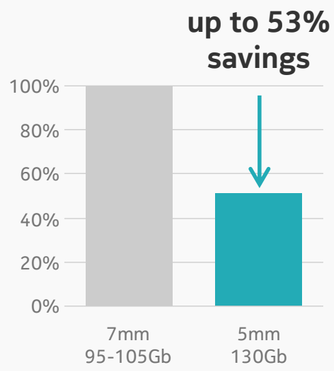
Enabling 800GE services to be transported over a single wavelength across distances up to 2,000 km, enables the transport of new high-speed services over practically any distance, including long-haul and trans-oceanic subsea cables. With new benchmarks in optical performance that allows 800GE service transport at over 3x the distance of current solutions, PSE-6s reduces the number of coherent optics needed for long-haul transport by up to 50%. This practically eliminates the need for intermediate regenerators in regional and long-haul networks, or avoids the complexity of needing to transport 800GE services across multiple wavelengths.

Long haul 800GE transport



Long haul and continental networks





Number of coherent interfaces in network

800GE services transported over 800G wavelengths

More powerful, less power-hungry

Our sixth-generation super-coherent optics leverage the latest 5-nm silicon integrated circuit technology to implement the coherent DSP used at the heart of the PSE-6s. By leveraging, Moore's Law to reduce power consumption, the PSE-6s uses 40% less power per bit than existing solutions, while concurrently increasing wavelength capacity by 50%.

The savings potential is even greater because reducing power per bit is multiplicative. With the ability of the PSE-6s to increase transmission reach threefold, network operators upgrading their networks to the PSE-6s not only deploy more capacity for a given power budget, they also need fewer optics for a given reach.

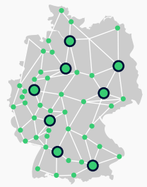
Together these can reduce total power consumption by up to 60% in regional and long-haul networks.

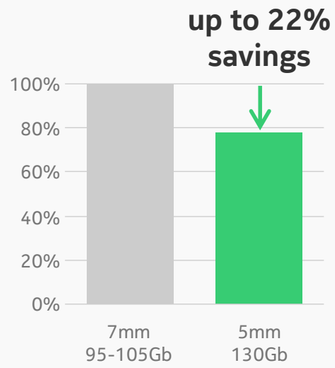
With the PSE-6s, network operators can meet the needs of greater network capacity and more sustainable networking at the same time.

Sustainability

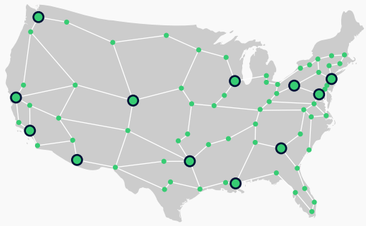
Total network power consumption
normalized Watts per Gb/s

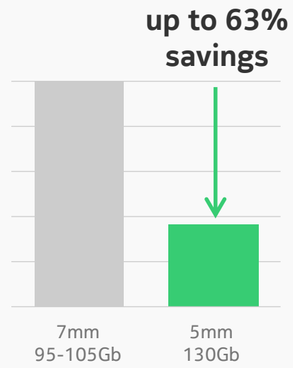
Metro and regional networks





Long haul and continental networks





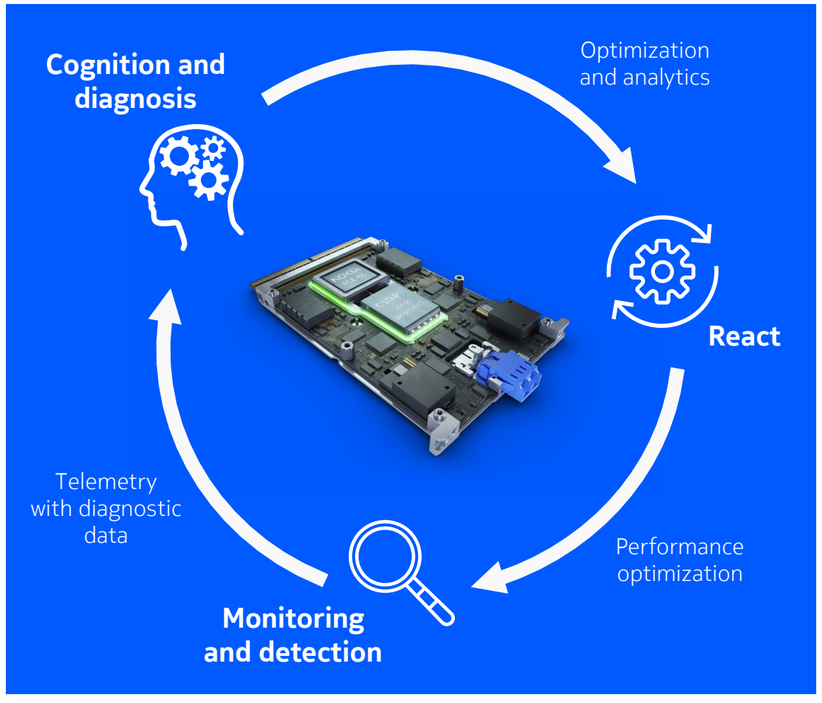
Enabling a smarter network

Beyond enabling the hat-trick of unprecedented network scale, increased reach, and lower power, the PSE-6s hides a few additional aces up its sleeve.

Leveraging the sophisticated streaming telemetry available from its coherent modem, the PSE-6s enables advanced monitoring, sensing, and analytics capabilities. By gathering information from light as it traverses fiber links, the PSE-6s provides unprecedented insight into the behavior of the fiber network and its surroundings, without the need for additional special monitoring instruments. This provides network operators important information on transmission performance, the infrastructure environment, and the ability to act upon this information.

The streaming telemetry available from PSE-6s provides valuable information to the Nokia WaveSuite Health and Analytics optical automation solution. Using advanced AI/ML algorithms for problem diagnosis, as well as troubleshooting and repair, WaveSuite optical automation software utilizes this information to uncover the sources of degradation and trigger automated fault identification notifications, assist troubleshooting, and recommend or initiate corrective actions.

PSE-6s: scale, performance, sustainability, while also enabling smarter networks.



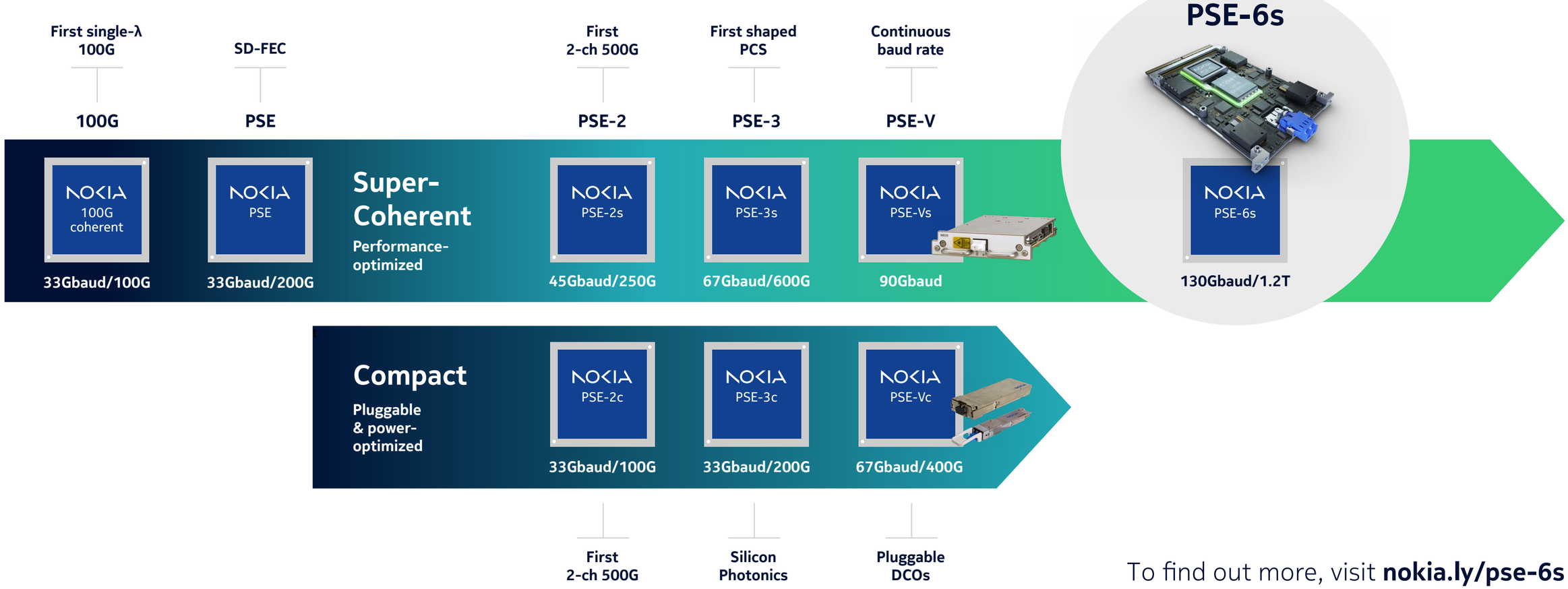
Continuous coherent monitoring of the fiber infrastructure

- Identifies potential network threats or disruptions
- Lowers the cost of monitoring while improving network performance

Delivering on our vision of continuous evolution

Enabling new optical networking advances that deliver more scale and network value is not new to Nokia. Since our introduction of the first 100Gb/s coherent optics over a decade ago, our continual focus on technical innovation and application optimization has allowed our customers to continually scale and optimize their networks while expanding their service offerings and improving their bottom line.

The PSE-6s represents the next leap in super-coherent optics. It enables new frontiers in scale, with the performance and sustainability needed for the next phase of network evolution.



To find out more, visit **nokia.ly/pse-6s**

Scale made simple

With global network capacity increasing exponentially for the foreseeable future, your network will need to evolve to meet the demand if you're to seize the tremendous opportunity presented by the next generation of bandwidth-intensive services and applications. But increasing scale cannot be done in only one dimension, or in isolation.

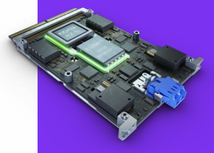
The PSE-6s is part of Nokia's mission to advance coherent optical transport and enable new frontiers of scale, performance and sustainability. Whether it is our WDM optical line systems that doubles fiber capacity with market-leading C+L band solutions or the market-leading scale of our P-OTN switching solutions, Nokia builds the industry's leading end-to-end optical solutions to enable efficient wholesale services from edge to core.

Today's business realities also demand a focus on enabling this scale with a view to sustainable growth and with close management of the total cost of operations. This means applying the power of advanced software to enable optical network automation that simplifies service delivery and enhances network resiliency and adaptability. It also includes enabling new network architectures and operational models that simplify the network, and most importantly, enabling our customers to build the networks that connect us.

At Nokia, we are driving the evolution of optical networks into new frontiers, to help you build networks that are ready for tomorrow's bandwidth demands.

Contact our sales team or visit our website to learn more about how Nokia can help you to evolve your network and open new frontiers in scale and sustainability with a market-leading and proven portfolio of optical networking solutions.

Enabling scale



Coherent Transport
Photonic Service Engines with Pluggable and Super-coherent options

Line Systems
Market leading C+L line systems and complete range of ROADM options

P-OTN Switching
Industry-leading scale supporting wholesale and network slicing services

Simplifying operations

Automation
Enable network scale while simplifying operations and lowering TCO

Network architectures
Coherent routing for IP + optical transport; open optical for new approach to network designs

Professional services
Helping build networks to simplify deployment and operation of new technologies and services

Nokia OYJ
Karakaari 7
02610 Espoo
Finland

Tel. +358 (0) 10 44 88 000

CID: 213067

nokia.com

At Nokia, we create technology that helps the world act together.

As a B2B technology innovation leader, we are pioneering the future where networks meet cloud to realize the full potential of digital in every industry.

Through networks that sense, think and act, we work with our customers and partners to create the digital services and applications of the future.