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Frost Radar™: Wavelength Services in North America, 2024

A Benchmarking System to Spark Companies to Action - Innovation That Fuels New Deal Flow and Growth Pipelines

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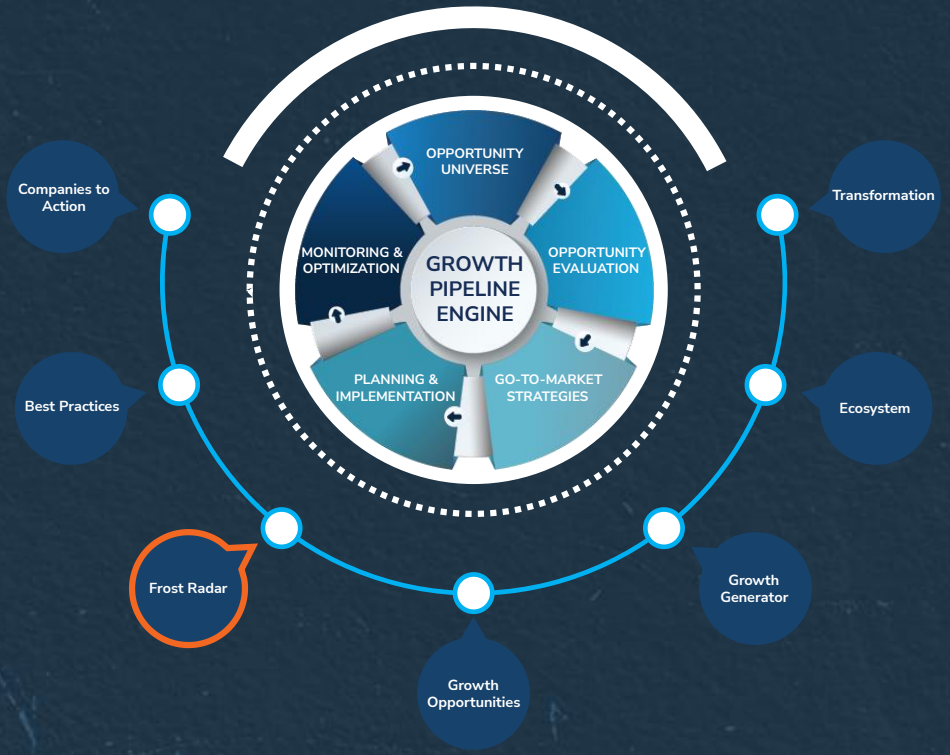

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Strategic Imperative and Growth Environment

Source: Frost & Sullivan

Strategic Imperative

- Wavelength services are high-speed, dedicated fiber-optic transport that is highly scalable and provides point-to-point connectivity. Services are typically used in networks requiring high-speed connectivity for business operations and where a massive volume of data is transmitted between data centers.
- The North American wavelength services market includes all wave services, with typical speed configurations of 1Gbps (G), 10G, 100G, and 400G, covering metro and long-haul services. Most network service providers in North America offer transparent wave services (where the service is protocol-independent) that free customers to run any protocol over the waves.
- Ethernet over waves is the most used protocol because of benefits such as low latency, while demand for other traditional/native wave protocols, including synchronous optical networking (SONET) and fiber connection (FICON), has faded in the last 5 years and is moving toward sunset.
- Ethernet private line (EPL) circuits with Ethernet delivered over dense wavelength division multiplexing (DWDM) infrastructure remain popular among businesses needing predictable routing and low-latency network services.
- The demand for high-speed connectivity has grown in the last 2 to 3 years. Service providers interviewed for this analysis stated that 100G is the typical configuration demanded, and the demand for 400G has gained traction in 2024.
- As part of innovation initiatives, network service providers have added dynamic capabilities on their self-service portals so that customers can view the providers' fiber route map, which helps them plan their network strategy. Additional capabilities may include a tool for customers to visually design, quote, and manage new routes based on their business requirements. Only top wavelength service providers offer this capability, but it is an attractive proposition from the customer's perspective.

Source: Frost & Sullivan

Strategic Imperative (continued)

- To differentiate their wavelength offerings, some providers provide waves-on-demand services, which gives customers 24 hours or less delivery time on the existing fiber routes using a self-service portal.
- As enterprises adopt AI-enabled applications, investing in 100G wavelength infrastructure becomes essential to stay competitive and future-proof operations in a data-intensive digital economy. Modern AI use cases, such as autonomous systems, large-scale language models, predictive analytics, and real-time image or video processing, require robust infrastructure supporting high-speed data transfers between distributed data centers, edge devices, and cloud platforms.
- Mobile carriers primarily drive demand for the wholesale segment. Customers' network deployment needs and their increasing deployment of 5G are driving growth in this space.
- Data center operators and content providers are other customers for wavelength services. In particular, hyperscalers, financial services, healthcare, education, and government are the key verticals driving the demand. Financial services and healthcare customers require vast amounts of bandwidth as they process and manage consistently high volumes of content and data. Customers from the government vertical run numerous offices (local, state, public, and citizen services) that jointly share data day to day. Education customers need waves to support bandwidth-intensive online classes.
- Disruption in the supply chain remains the top-of-mind challenge for many network service providers because it disturbs their planned fiber expansion. Delays in network equipment supply, including switches, routers, and fiber, interrupt route building and directly impact a service provider's entire network upgrade and expansion plan. Some network service providers have stocked equipment to address the supply chain disruption, but others that have not remain affected.

Source: Frost & Sullivan

Growth Environment

- The North American wavelength services market is in the mature stage. The primary drivers are enterprises accelerating their digital transformation initiatives, growing adoption of AI/machine learning (ML) to simplify networks and enhance business operations, increasing use of bandwidth-intensive applications, and data center interconnections. Frost & Sullivan estimated North American wavelength services revenue at $5.03 billion as of 2023 and expects it to increase at a compound annual growth rate of 6.5% from 2023 to 2028.
- Wavelength services are imperative for data center connectivity because enterprises require a secure, reliable network architecture to support the growth and distribution of their workloads. High bandwidth becomes important as businesses deploy data-heavy and latency-sensitive cloud-based applications.
- With fiber-lit buildings, network service providers can now turn up (start) services in minutes instead of what used to take months, which enhances the customer service experience.
- Network service providers have determined that demand for high bandwidth will continue to increase, so to address this demand, they are aggressively upgrading their network infrastructure to provide up to 400G connectivity. They are also building new fiber routes with 400G capabilities. A few providers have deployed an 800G wavelength system; demand was very low in 2024, but 400G will surely take off in 2025.
- As a next step, top service providers are running field trials transporting 1.6 terabits-per-second (Tbps) of data across a single wavelength in collaboration with Ciena’s WaveLogic 6 Extreme (WL6e). These trials ensure the fiber network's capability to handle high bandwidths and its readiness to offer higher configurations in the next few years. Ciena's WL6e is a programmable coherent optical solution capable of delivering impressive 1.6Tbps single-carrier wavelength services on metro networks.

Source: Frost & Sullivan

Growth Environment (continued)

- Meanwhile, 400G pluggables (optic transceivers capable of managing up to 400G speeds) continue to be common for data center interconnects, enabling the optical-to-IP conversion without additional equipment.
- Many network service providers offer encrypted wavelength services, whereas other providers leave it to the customer to add encryption. Encrypted and protected waves are highly valued in today's business environment, where organizations are generating and transmitting huge amounts of data amid increasing network security threats.
- A Frost & Sullivan study related to this independent analysis:
  - Frost Radar: Managed SD-WAN Services in North America, 2024

Source: Frost & Sullivan

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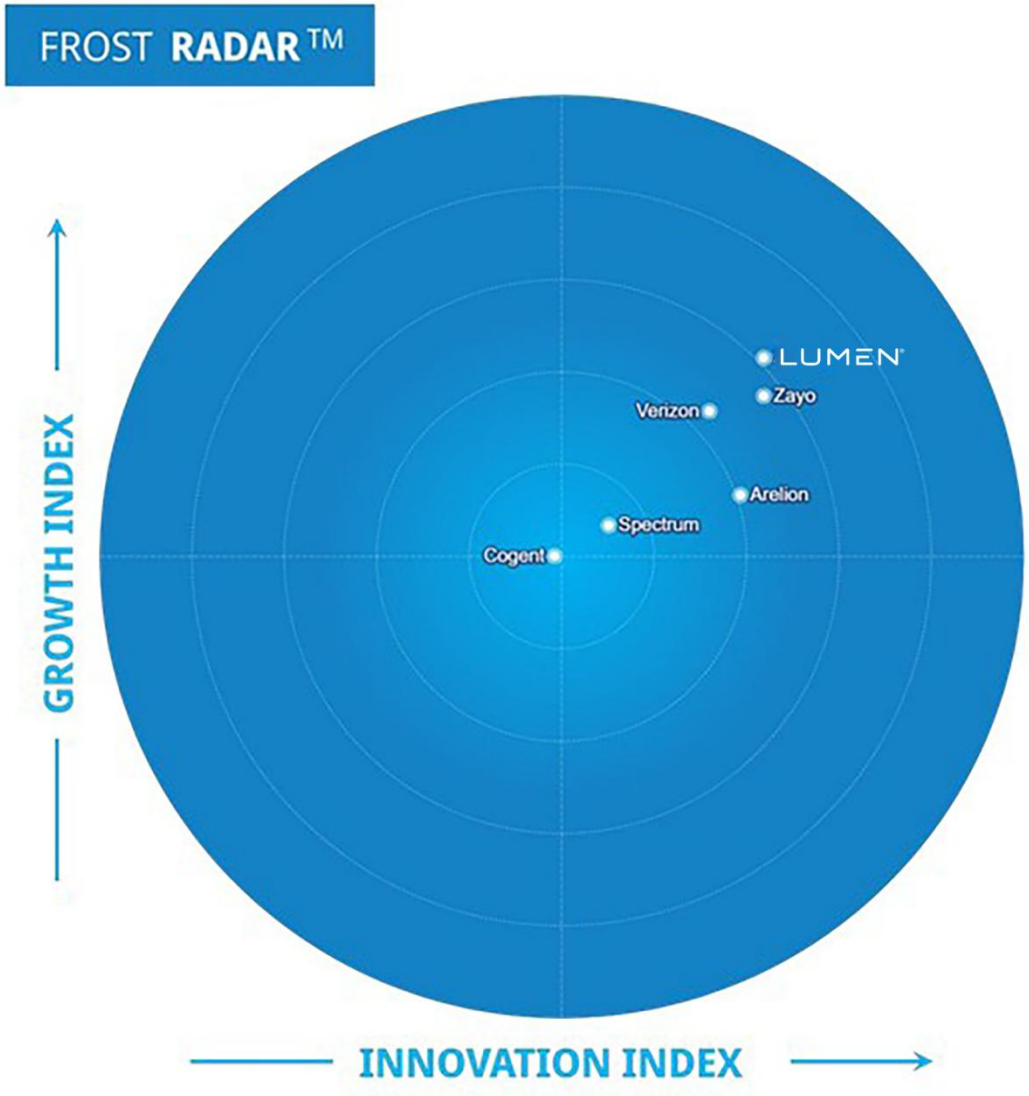
Frost Radar™: Wavelength Services in North America, 2024

Source: Frost & Sullivan

Frost Radar™: Wavelength Services in North America, 2024



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Source: Frost & Sullivan

Frost Radar™ Competitive Environment

- The North American wavelength services market consists of numerous competitors, including small local, large national, and international providers. The large national and international players are long-time network service providers with an extensive network presence and cable companies leveraging their coaxial and fiber footprint to offer wavelength services. Out of 12 major service providers in this space, Frost & Sullivan independently plotted the top 6 in this Frost Radar™ analysis, selected primarily based on their comprehensive wavelength offerings and presence in the retail and wholesale segments.
- To distinguish their wavelength services, network service providers have supplemented waves with additional services, including a tool to view fiber route maps; quote, order, and management of new wavelength services; encrypted wavelength services; and high bandwidth of 400G and 800G speeds.
- Lumen is the Frost Radar Growth and Innovation Index leader based on revenue, extensive network footprint, continued fiber expansion, and comprehensive wavelength services. Apart from being a revenue leader, Lumen's market-leading position includes its ability to provide up to 400G connectivity speeds, route diversity, encrypted wavelength services, proactive notification service, and a topology viewer to deliver a superior customer service experience.

Source: Frost & Sullivan

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Frost Radar™: Companies to Action

Source: Frost & Sullivan

Lumen

INNOVATION

- Lumen utilizes its extensive 400G-enabled, next-generation optical network across North America to deliver wavelength services with speeds ranging from 10G to 400G. The network spans 78,300 route miles, comprising ultra-low-latency routes, and is supported by industry-leading SLAs through its diverse network intercity gateways.
- Lumen's Control Center portal provides various tools to customers for visibility and control of network services. The Topology Viewer is an excellent tool that powers its wavelength suite, enabling customers to visually design, quote, and manage new routes per business requirements, such as locations, latency, and budgeting. Topology Viewer also enables wavelength customers to add more capacity and new locations to a route to support additional requirements.
- The Service Diagnostics tool in the Control Center enables customers to access detailed operational data on the performance of their wavelength services. Lumen also provides a proactive notification service that automatically alerts customers about any disruptions affecting their wavelength services.
- Lumen offers protected and unprotected wavelength solutions. Lumen's encrypted wavelength services comes with AES-256 encryption with dynamic Diffie-Hellman key exchange and separate security domain management with two-form factor authentication. Hypersensitive customers in industries such as financial services, government, and healthcare can purchase encrypted wavelength service with layer 1 encryption and manage their encryption key through Lumen's portal.

Source: Frost & Sullivan

Lumen (continued)

GROWTH

- Lumen offers wavelength services through its extensive network comprising more than 170,000 on-net buildings and approximately 350,000 route miles of fiber. Though the company operates almost exclusively in North America, its fiber footprint connects into more than 250 Lumen data centers and over 2,200 third-party data centers.
- Lumen ranks among the leading global providers, offering 400G IP transit ports across its Tier I internet backbone network in the United States and EMEA. With an aggressive focus on expanding its 400G-ready infrastructure, Lumen has already equipped more than 400 data centers with 400G wavelength services to meet the demand for high bandwidth data center interconnect (DCI) and cloud connectivity.
- Lumen has North America's largest ultra-low-loss fiber network, with 6.2 million fiber miles installed year to date as part of US intercity network expansion, connecting 50 major cities. An additional 10 million fiber miles is expected to be deployed through 2026. Lumen's 400G next-gen network it built using this latest fiber technology, which provides significant advantages from operational and network efficiency standpoints.
- To strengthen its expansion efforts, Lumen partnered with Corning Incorporated, securing 10% of Corning's global fiber capacity over the next two years to interconnect AI-enabled data centers, doubling Lumen's intercity fiber miles across the United States. Lumen also leverages Corning's new generative AI fiber, capable of fitting two to four times more fiber in existing conduits, maximizing its infrastructure efficiency.

Source: Frost & Sullivan

Lumen (continued)

GROWTH

- Lumen's recent partnerships with Meta, Google Cloud, Amazon Web Services, and Microsoft underscore its network's capability to drive AI-powered innovation. Its network supports data-heavy, AI-driven demands, solidifying Lumen's position as a preferred partner for AI-ready infrastructure in sectors such as cloud computing, finance, and healthcare.
- Lumen serves Fortune 500 companies, including customers from data center services, streaming services, and financial services. The company won recent multimillion-dollar network services contracts from the US Government Accountability Office, New Mexico Office of Broadband Access and Expansion, and the US Department of Defense.

Source: Frost & Sullivan

Lumen (continued)

FROST PERSPECTIVE

- Lumen continues to be the leader in the Frost Radar™ for North American wavelength services because of its market share, comprehensive wavelength service, route diversity, and extensive client base.
- Lumen's rapid 400G fiber infrastructure expansion reinforces its leadership in the wavelength market. Its diverse fiber routes appeal to customers with distributed operations across the United States and EMEA.
- Lumen’s recent partnerships with Meta, Google Cloud, Amazon Web Services, Microsoft, and Corning strengthen it as an AI-ready infrastructure provider. Frost & Sullivan recommends that Lumen promote itself as a preferred partner for AI-ready infrastructure as most sectors are either prepared or preparing to integrate AI capabilities in their business operations.
- Lumen also is strong in providing private connectivity fabric to hyperscalers and data centers and may need to focus on offering it through its NaaS platform as Ethernet and IP VPN services.
- Lumen’s Topology Viewer tool and proactive notification service are key differentiators. The Topology Viewer feature aligns with Lumen’s objective of enhancing customer ownership and purchase experiences, supporting customer retention.
- In the last year, Lumen made new appointments of seasoned leaders, restrategizing its focus toward opportunities generated by AI-focused transformational growth. This transition has started paying off, with Lumen recently securing a $5 billion new business and in talks with another $7 billion business.

Source: Frost & Sullivan

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Best Practices & Growth Opportunities

Source: Frost & Sullivan

Best Practices

1. Service providers must offer higher-speed configurations of up to 400G wavelength services to accommodate current and future high bandwidth demand.

2. A comprehensive customer portal allows customers to view fiber route maps and quote, order, and manage wavelength services.

3. Only a few service providers offer encrypted wavelength services, while others allow customers to add encryption independently. Service providers must give customers the choice to encrypt wavelength services as an additional layer of security.

Source: Frost & Sullivan

Growth Opportunities

1. The demand for wavelength services will continue to increase as enterprises adopt evolving technologies, such as AI/ML, stressing the need for high-speed connectivity to transmit data between branch locations and data centers. Large cloud service providers, healthcare organizations, and financial services providers will remain the key consumers of wavelength services.

2. Service capability is a differentiator. Service providers offering standard services through their customer portal need to invest in innovation, enhancing their ability to put more services in the hands of customers to deliver excellent customer service experience.

3. The demand for high bandwidth will exponentially rise in the next 2 to 3 years, primarily driven by AI-enabled technologies. Service providers must strengthen their existing fiber routes with 400G capabilities and add new fiber routes to deliver higher speeds.

Source: Frost & Sullivan

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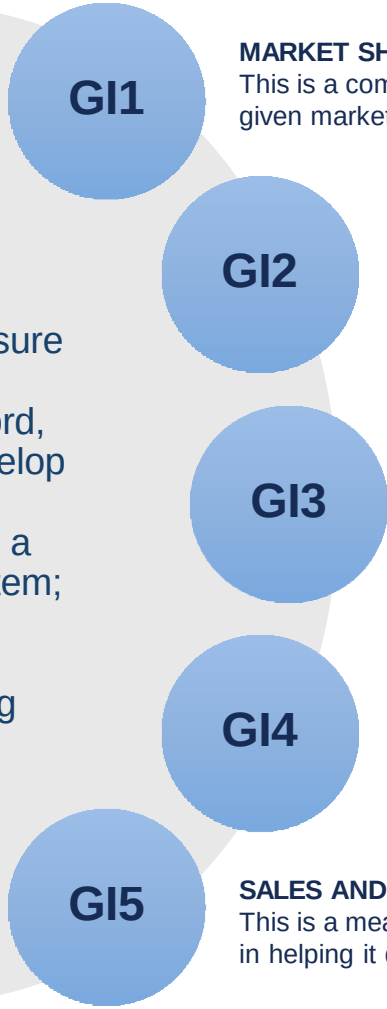
Frost Radar™ Analytics

Frost Radar™: Benchmarking Future Growth Potential 2 Major Indices, 10 Analytical Ingredients, 1 Platform

Growth Index

Growth Index (GI) is a measure of a company's growth performance and track record, along with its ability to develop and execute a fully aligned growth strategy and vision; a robust growth pipeline system; and effective market, competitor, and end-user focused sales and marketing strategies.



MARKET SHARE (PREVIOUS 3 YEARS)
This is a comparison of a company's market share relative to its competitors in a given market space for the previous 3 years.

REVENUE GROWTH (PREVIOUS 3 YEARS)
This is a look at a company's revenue growth rate for the previous 3 years in the market/industry/category that forms the context for the given Frost Radar™.

GROWTH PIPELINE
This is an evaluation of the strength and leverage of a company's growth pipeline system to continuously capture, analyze, and prioritize its universe of growth opportunities.

VISION AND STRATEGY
This is an assessment of how well a company's growth strategy is aligned with its vision. Are the investments that a company is making in new products and markets consistent with the stated vision?

SALES AND MARKETING
This is a measure of the effectiveness of a company's sales and marketing efforts in helping it drive demand and achieve its growth objectives.

Source: Frost & Sullivan