

IT Hardware & Communications Equipment

Optical Deep Dive; Entering a Prolonged Cycle

We believe we are in the early stages of a strong optical cycle. We view GLW's optical business as a leading indicator, and see beneficiaries across US and European hardware, semiconductor and optical sectors.

The recent uptick in GLW's Optical Communications business led us to dig deeper into fiber and broadband developments. We see the industry in the early stages of an expansionary cycle, which should benefit companies across multiple sectors over the next few years. Industry drivers are as follows:

Fiber Trends: We discuss fiber industry drivers as bandwidth needs grow for telco providers and large cloud players. While some have been in play for years, new dynamics have emerged that should underpin an unusually favorable environment for the industry.

Carrier Opportunity: Investments in broadband are gaining momentum as mobile network operators accelerate 5G deployments, network densification efforts, and work to bridge the digital divide. The US lags the rest of the world in fiber penetration, and the government has been increasingly funding broadband proliferation.

Hyperscale Driving Enterprise: The accelerated pace of data center construction and megawatts deployed are key drivers of Optical in this vertical. We see a strong pipeline of data center builds and fiber densification as technology matures.

Stock Takeaways

U.S. Hardware & Comm Equipment/U.S. Comm Infra. GLW has ticked up its Optical revenue growth, but we think the scale and duration will surprise to the upside. And, with full year Display guidance set, we believe Optical leads the discussion on the stock. **CIEN** orders have been strong, but we view the better cycle as a sign that strong growth will continue for a few years. **KEYS, CSCO, CCI, DLR** and **UNIT** will also benefit, in our view.

U.S. Semiconductors. Component vendors will likely experience strong tailwinds in 2022 with cloud capex increases across all major hyperscale customers. The fastest growing area is driven by the upgrade cycle from 100G to 200/400G in the data center as the creation of more data demands faster optical transport (switching/transceivers/ROADMs). Best-positioned names include MTSI and MRVL (IPHI acquisition).

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Completed: 21-Feb-22, 10:36 GMT Released: 22-Feb-22, 05:00 GMT Restricted - External

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European Technology Hardware. **NOKIA** has already seen tremendous growth in its Network Infrastructure business (+12% y/y in FY21 vs. TAM 5%), but we expect share gains in Optical to help sustain that growth in FY22+. On the silicon IP side, we view **AWE** as the best way to play the optical cycle amid increasing data-transfer speeds and closer integration of silicon/optics.

Over the last several months, a common theme continues to emerge across our coverage – increasing bandwidth traffic (and accelerating future demand expectations) and the fiber needed to support it. Although component supply and logistics difficulties persist, we believe the underlying demand strength is a sign that we are in the early stages of a prolonged optical cycle. We view GLW as the main beneficiary, though several other companies in our coverage also benefit, as well as Optical components and European technology companies.

For the industry, we highlight a few key points:

- Overall bandwidth needs are sustaining 20%+ rates.
- Service Providers, particularly in the US, are under-penetrated with fiber and are ramping up their homes passed targets.
- Governments across the world are increasing funding for rural broadband.
- Large data center players continue to take share of IT, building more data centers and increasing the fiber content within them.

From a stock standpoint:

- **U.S. IT Hardware & Comm Equipment/U.S. Comm Infra.** **GLW** has already guided up its Optical business revenues, but we think the magnitude and duration of the strength will surprise to the upside. We view the company's Optical business as more important now since Display annual guidance was solid. **CIEN** order growth has been remarkable, and we view the company as the best way to play the equipment growth due to increased fiber deployments. We also see **KEYS**, **CSCO**, **CCI**, **DLR** and **UNIT** as plays on this trend.
- **U.S. Semiconductors.** Component vendors will likely experience strong tailwinds in '22 with cloud capex increases across all major hyperscale customers. The fastest growing area is driven by the upgrade cycle from 100G to 200/400G in the Data Center as the creation of more data demands faster optical transport (switching/transceivers/ROADMs). Best-positioned names in our view include MTSI and MRVL (IPHI acquisition).
- **European Technology Hardware.** On the European Technology Hardware side, we see two ways to play the optical cycle, namely **NOKIA** in network equipment and **AWE** in silicon IP. Nokia has already seen tremendous growth in its Network Infrastructure business (sales +12% y/y in FY21 excl. Submarine vs. TAM 5%) on Fiber deployments, but we see Optical helping sustain that growth in FY22+ on market share gains. Optical is becoming increasingly important for Alphawave (c20% of 1H21 sales), and with increasing data transfer data speeds and silicon/optics integration, we think it is well positioned.

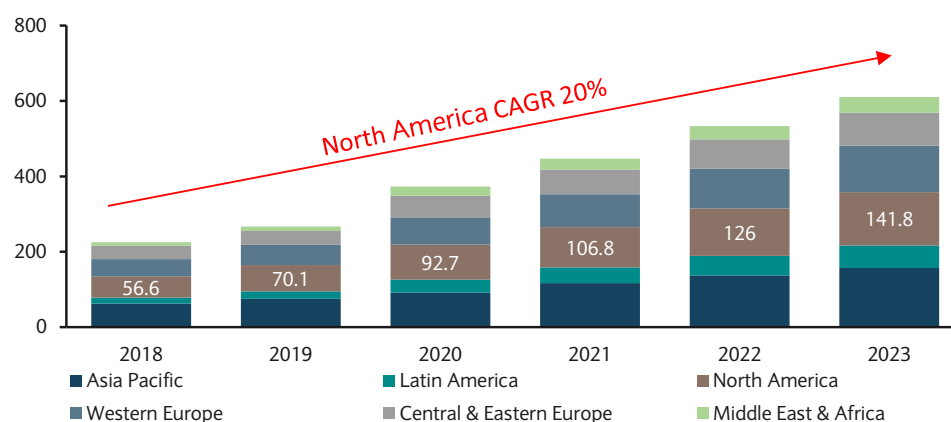
Looking at Fiber Trends

Below we discuss our views on key drivers within the fiber industry as related to Corning's optical business, which we define as both manufacturing and cabling. While some have been in play for years, we have also seen new dynamics during 2021 that we believe underpin an unusually favorable environment for Corning's Optical segment during the next three years.

Unabated Bandwidth Demand

Devices and connections are growing faster than both the population and internet users, driving the need for higher internet speed and greater transport capacity. As 5G deployments accelerate, the push to the cloud continues, and next-gen applications expand, we believe fiber is the best suited broadband technology (vs. cable, satellite or wireless) to handle ever-increasing traffic patterns, due to its capacity, reliability and latency qualities.

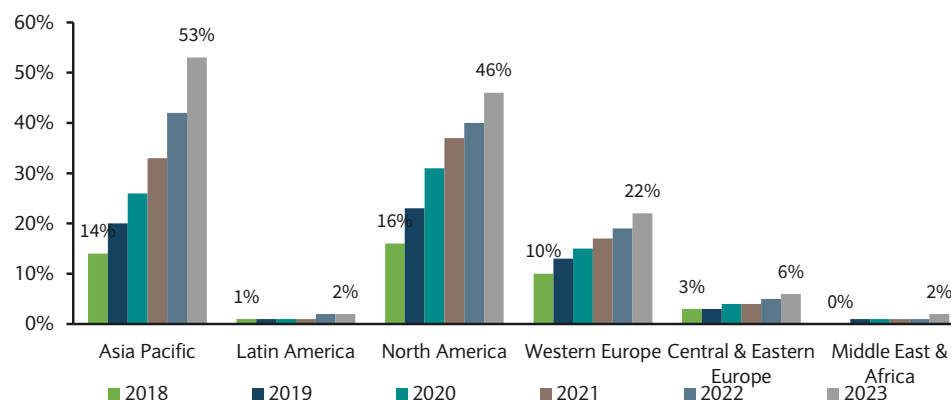
FIGURE 1. Fixed broadband speeds (in Mbps), 2018-23E



Source: Barclays Research, Cisco Annual Internet Report, 2018-2023.

We believe the North America market is especially primed to enjoy a large multi-year investment cycle as operators, with the help of government stimulus, must ready networks to accommodate this increasing network traffic and expected explosion in data demand that 5G would theoretically create.

FIGURE 2. Percentage of broadband connections that will be faster than 100 Mbps by region



Source: Barclays Research, Cisco Annual Internet Report, 2018-2023.

We believe the North America market is currently under-invested in FTTP vs. other regions due to an initial focus on fiber-to-the-cabinet/curb (vs. the premises/home), cable's historically large

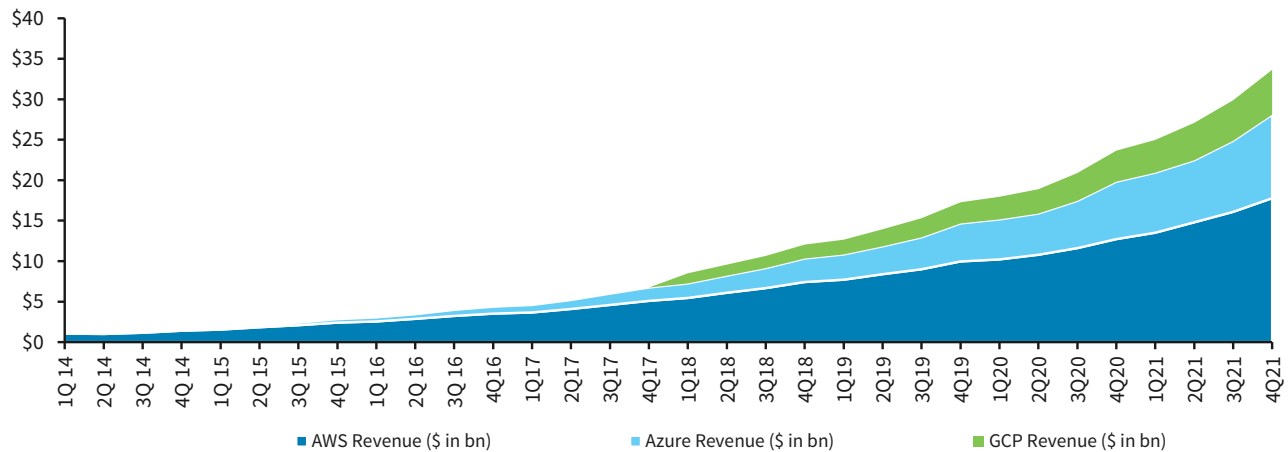
grip on the market, and slower telco fiber deployments. In fact, cable serves more than two-thirds of U.S. wireline broadband subscribers.¹

With that being said, we estimate over 2021-25, AT&T and Verizon alone will grow fiber internet subs at a CAGR of 17% and 6%, respectively. Cable operators are also actively penetrating their broadband footprints with fiber, which will rapidly increase sub growth, in our view. Our analysis suggests over 20 million of incremental passings could occur in the US between 2021-2025, not inclusive of government stimulus-funded passings, which we believe could add an additional 20 million to our estimate, albeit over a longer period of time than four years.

Push to the Cloud Continues

We believe more applications will move to the cloud as data creation continues to grow. We see rich fiber demand from the hyperscalers to continue as they expand to accommodate customer needs. In fact, the three vendors (Amazon, Google, Microsoft) are now at a collective annualized run-rate of \$135Bn, growing 42% on a y/y basis.

FIGURE 3. Azure, AWS, & GCP at \$135Bn Annualized Run-Rate



Source: Barclays Research, Company Data.

We believe this growth will continue as the average size of user requirements grows, megawatts absorbed and under construction continues to ramp, and hyperscalers continue to expand their physical presences. We do not believe that some users' move away from cloud towards a hybrid IT structure will negatively affect fiber demand, as latency requirements are growing in customer importance in both on- and off-prem infrastructures, in our view.

Corning Remains Only Large-Scale End-to-End Manufacturer

Corning remains the only large-scale end-to-end manufacturer of optical solutions, which we believe uniquely positions the company to work as more of a partner to customers, and innovate on dimensions not available to competitors. We believe Corning's global scale and supply chain access, not only drives customer relationships, but in turn, those customer relationships indirectly fuel innovation and product portfolio growth. In fact, the company recently introduced innovations to help customers speed deployments and lower costs.

- Newest additions to Evolv portfolio provide enhanced fiber deployment, flexibility, and are especially well-suited for rural deployments.
- Everon mmWave indoor small cell system delivers 5G-ready coverage in high density environments.

¹ S&P Capital IQ "Pandemic boon as fiber to pass 62% global share by 2025, lags in North America" (11/23/21)

Additionally, Corning continues to add capacity to capture expanding demand – this year the company plans to open new fiber capacity in Europe (Poland) and expand cable capacity in North America. In fact, Corning's North America capacity expansions will allow AT&T to extend its investments in fiber. Currently the company's optical fiber manufacturing facilities are in North Carolina, China, and India, and cabling operations are in North Carolina, Poland, and smaller regional locations.

Sizing the Carrier Opportunity

We believe investments in broadband are gaining momentum, on both public and private fronts, as mobile network operators accelerate 5G deployments, network densification efforts, and work to bridge the digital divide. We believe Corning's Carrier business within Optical could grow at a CAGR over 14% from 2020-2025 with North America driving the lion's share of growth.

FIGURE 4. North America Driving GLW's Optical Carrier Growth

	2020	2021	2022E	2023E	2024E	2025E	CAGR
GLW Optical Revenues (\$M)	3,560	4,349	4,775	5,262	5,883	6,615	
% change y/y	(12.4%)	22.2%	9.8%	10.2%	11.8%	12.4%	13.2%
GLW Carrier Optical Revs (\$M)	2,612	3,200	3,572	3,975	4,488	5,101	
% change y/y	(9.5%)	22.5%	11.6%	11.3%	12.9%	13.7%	14.3%
North America Revs	1,168	1,741	2,097	2,485	2,981	3,578	
% change y/y	(19.8%)	49.0%	20.4%	18.5%	20.0%	20.0%	25.1%
Europe Revs	765	780	796	811	828	844	
% change y/y	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Asia Revs	679	679	679	679	679	679	
% change y/y	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: Barclays Research estimates, Company Data.

Recent Government Stimulus Expanding Opportunities

We believe digital inclusion, including efforts to expand access to broadband, is top of mind across the global political landscape. Many countries, including the U.S., have passed large-scale legislation to fund broadband efforts to support underserved and unserved communities. We are at the beginning of a large multi-year investment cycle for optical networks, as countries aggressively deploy capital to bridge the digital divide, in our view.

United States – Infrastructure Investment and Jobs Act

Last year, infrastructure legislation was signed into place that includes a total of \$65Bn for broadband to be distributed via a variety of programs. The largest program is the Broadband Equity, Access and Deployment program at \$42.45Bn, which will allocate money to states to fuel deployments in unserved and underserved communities. Importantly, grant recipients must reliably deliver download speeds of at least 100 Mbps and 20Mbps of upload speed, making optical fiber the most likely deployment choice. As much as 10% of that ~\$42Bn could go towards passive optical infrastructure. We believe this could add as much as a ~\$1Bn a year to the market.

European Union – Recovery and Resilience Facility

The largest building block of last year's €750Bn Next Generation EU stimulus package is the €672.5Bn Recovery and Resilience Facility (RRF), which is to be used for financing, national recovery, and resilience plans around key EU policies, such as digital inclusion. In fact, each plan must dedicate at least 20% to digital actions, which assumes ~\$135M of RRF will be allocated towards gigabit connectivity, 5G, and other digital-transition initiatives.

United Kingdom – Project Gigabit

Launched last year, the £5Bn infrastructure project aims to ensure 85% of the country is covered with gigabit-capable service by 2025. The project aims to supplement industry-led efforts to expand broadband coverage, and encourage operators to accelerate network improvement

plans. The project will prioritize areas that currently have slow connections and which would have otherwise been left behind in companies' broadband rollout plans.

Canada – Universal Broadband Fund

As part of the Canadian government's goal to get 98% of Canadians access to high-speed Internet by 2026, the Universal Broadband Fund will allocate C\$2.75Bn to connect people living in rural and remote communities to high-speed Internet.

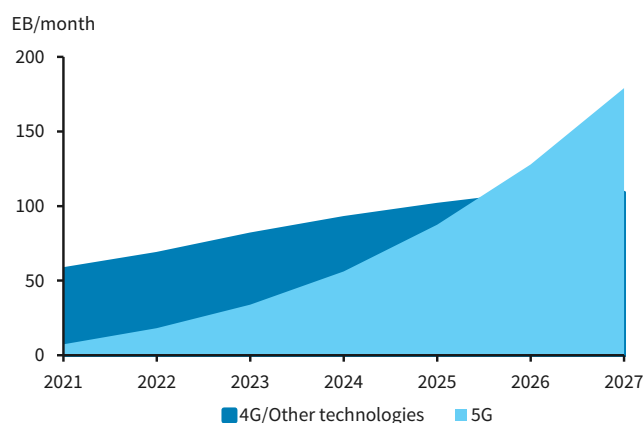
Private Companies Accelerating Build Plans

In addition to tackling the ever growing amount of mobile data traffic, we believe mobile network operators are aggressively building out fiber to accelerate 5G deployment. 5G is expected to open unprecedented opportunity for mobile network operators to provide differentiated services to consumers and enterprises.

North America

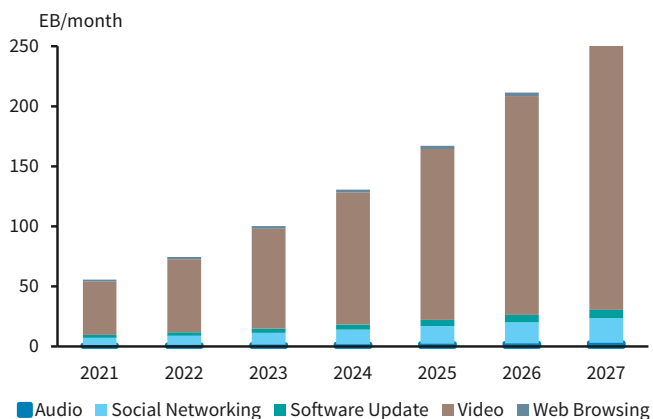
By 2027, 5G networks are expected to carry 62% of total mobile data traffic and 5G subscription penetration in North America is set to be the highest of all regions (~90%).² We believe the North America market one of the most compelling for Corning, as both public and private investments are considerable. We estimate North America currently comprises a little over 50% of total Carrier revenues, but will be ~70% by 2025.

FIGURE 5. Mobile Data Traffic by Technology - 5G growth rapidly accelerating



Source: Barclays Research, Ericsson Mobility Report (November 2021)

FIGURE 6. Mobile Data Traffic by Application Category - Video driving lion's share of traffic



Source: Barclays Research, Ericsson Mobility Report (November 2021)

In North America alone, we expect AT&T, Frontier and Altice's fiber builds (some of the largest upcoming within the US) to add ~20M incremental fiber passings from 2021 to 2025. However, we believe there could be an additional ~20M passings funded by the government in the coming years, assuming there is no overlap.

Corning has relationships with all three operators and we expect the company to continue to enjoy business from all three. In fact, we believe AT&T to be the customer with >10% revs listed in 2020. We find this data point interesting, as Corning also saw significant business (at least \$350M/year) from Verizon that year, as part of the carrier's \$1.05Bn minimum purchase commitment from 2018 through 2020.

² Ericsson Mobility Report, November 2021

FIGURE 7. Estimated Fiber Passings from Select Major Expected U.S. Builds

Fiber Passings (mm)	2021	2022E	2023E	2024E	2025E	CAGR
AT&T	17.5	20.0	22.9	26.2	30.0	14.4%
ATUS	1.5	2.5	4.0	5.0	6.5	44.3%
FYBR	4.0	5.0	6.3	8.0	10.0	25.7%
Total Incremental Passings		4.6	5.7	5.9	7.3	
Addtl Passing Govt Funded			1.5	2.3	2.3	
\$ per home passed (000s)	2,000	2,000	2,000	2,000	2,000	
Total TAM avail (M)		9,108	14,367	16,367	19,158	28.1%

Source: Barclays Research estimates, Company Documents

International

Outside of North America, UK is Corning's second largest market, followed by the developed regions of Europe and then to a lesser extent LatAm and Korea. Although we don't view these regions as material growth drivers, we are encouraged by carriers' fiber deployment plans in those countries. For example, Openreach, BT's fixed line subsidiary and a UK customer of Corning, raised its original fiber build projections from 20M homes to 25M by 2026, and increased its fiber expansion investment to \$21.2Bn from \$16.8Bn. In LatAm, America Movil announced it will spend \$8Bn this year on FTTH and 5G (\$1.1Bn is expected to be spectrum), and Millicom announced it will take fixed broadband (majority fiber) to 3M more homes over the next three years, to reach 20M.

Hyperscale Driving Enterprise Opportunity

The accelerated pace of data center construction and megawatts deployed are key drivers of Corning's Enterprise business within Optical. We assume Hyperscale currently accounts for roughly three quarters of Enterprise revenue, and estimate that rising to ~82% by 2025. We estimate Hyperscale will grow at a 12% CAGR from 2020-25 as the move to the cloud continues.

FIGURE 8. Hyperscale Driving Growth Within GLW Enterprise as Core LAN remains stable

	2020	2021	2022E	2023E	2024E	2025E	CAGR
GLW Optical Revenues (\$M)	3,560	4,349	4,775	5,262	5,883	6,615	
% change y/y	(12.4%)	22.2%	9.8%	10.2%	11.8%	12.4%	13.2%
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% change y/y	(9.5%)	22.5%	11.6%	11.3%	12.9%	13.7%	14.3%
GLW Enterprise Optical Revs (\$M)	951	1,149	1,203	1,287	1,395	1,514	
% change y/y	(19.3%)	20.8%	4.7%	7.0%	8.4%	8.5%	9.7%
Hyperscale	706	899	948	1,027	1,130	1,243	
% change y/y	(24.8%)	27.4%	5.5%	8.3%	10.0%	10.0%	12.0%
Core LAN	245	250	255	260	265	271	
% change y/y	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

Source: Barclays Research estimates, Company Documents.

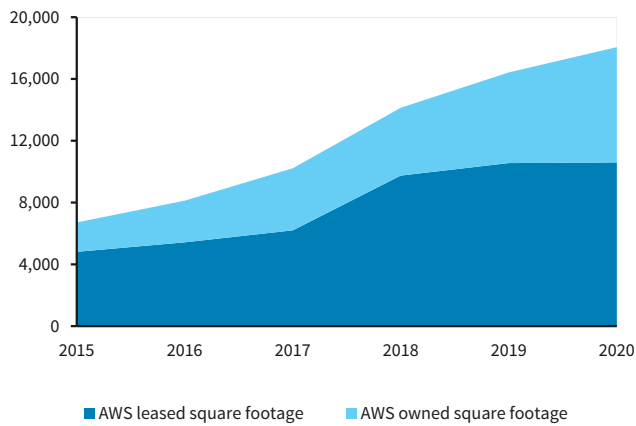
Strong Construction Portends Continued Demand

Wholesale colocation data centers across primary U.S. markets recorded 142.7 megawatts of positive net absorption in 1H21, up 3.4% from 1H20.³ However, more than 500 megawatts of construction was underway in 1H21, up over 40% y/y, with over half located in Northern Virginia and ~60% already pre-leased. We believe continued robust construction, low inventory levels, hyperscalers' continued expansions, and the move to the edge all positively contribute to the Hyperscale segment's growth expectations.

Diving deeper into hyperscaler activity, if we look at total AWS square footage, we can assume AWS added ~227 megawatts annually on average since 2015 (using the assumption that 10,000 square feet is 1 megawatt).

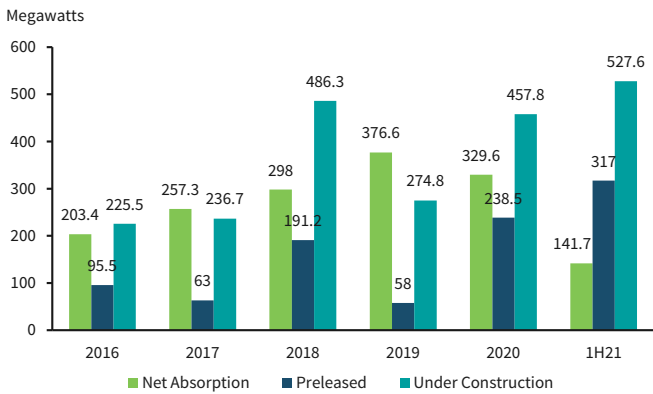
³ CBRE North American Data Center Trends Report 1H21

FIGURE 9. AWS added ~227MW annually on average since 2015



Source: Barclays Research estimates, Company Documents.

FIGURE 10. Expect large pre-leasing volume to drive 2H21 net absorption



Note: Primary Markets is defined as Northern Virginia, Dallas, Silicon Valley, Chicago, Phoenix, New York Tri-State, and Atlanta
Source: Barclays Research, CBRE Research, CBRE Data Center Solutions, H1 2021.

We believe demand remains strong as hyperscalers work to accommodate storage and processing in the cloud. Hyperscalers are evolving to a more integrated structure of compute, storage, and networking, and the optical fabric has to be fully non-blocking connectivity. It takes more fiber density to provide for this kind of equal flow connectivity, which we view as a positive to Optical demand. We also like the visibility Corning has with hyperscaler activity during a build cycle – once the hyperscale customer breaks ground, Corning equipment begins to go in the facility.

Other Company Takeaways and ESG Touchpoints

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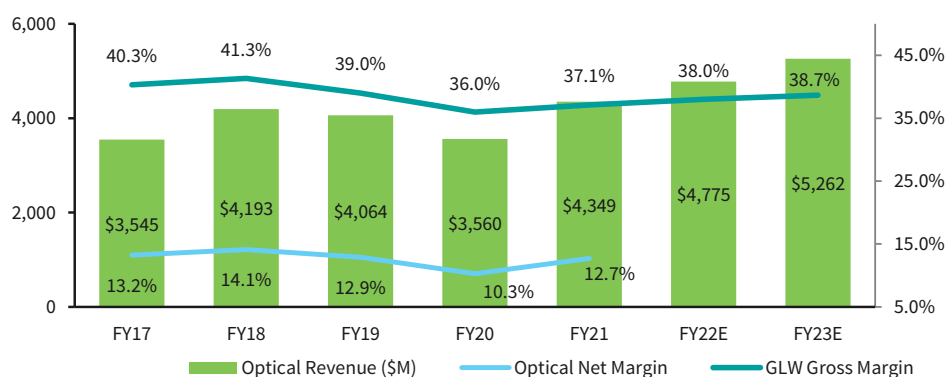
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GLW

We see potential for upside in Corning's revenue and margin expectations based on current volume and demand trends in the Optical business. However, one of the concerns we hear from investors with regard to the Optical business is the low margin relative to Corning's other businesses.

FIGURE 11. GLW Optical Communications Revenue and Margin Trends



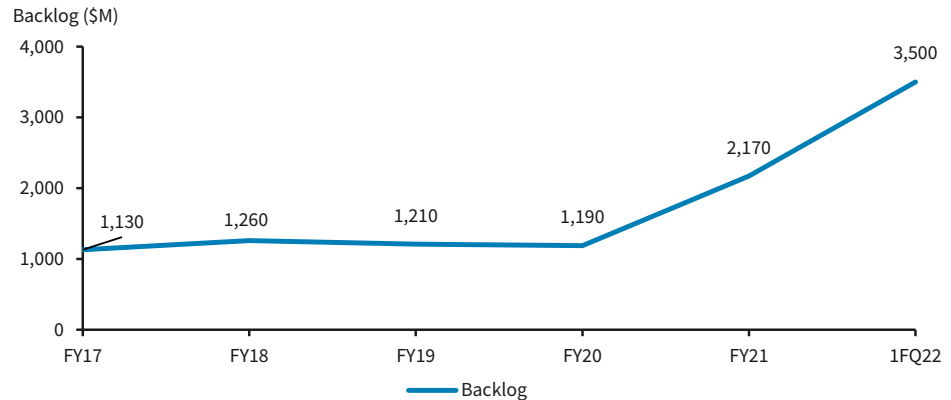
Source: Barclays Research estimates, Company Documents.

While supply chain issues and inflationary headwinds are the most recent pressures, we believe the price increases management is already in the process of instituting, along with the increase in volume, should help margin expansion moving through FY22+. Additionally, the pre-connectorized solutions for data centers and custom-made network solutions for customers in the Optical portfolio are margin accretive. These solutions reduce customer installation times, and as fiber deployments accelerate, we believe customers could increasingly rely on these connectorized solutions to meet deployment targets.

CIEN

Ciena, a leader in optical systems, counts all four major webscalers as its customers, and works with them across a broad range of applications – connecting data centers, global networks, and is their number one supplier on submarine cable, etc. Though webscale revenue is lumpy in nature, pandemic-related delays and supply chain issues also contributed to weak performance in FY20 and FY21 (after >40% y/y growth in FY19).

CIEN's strong order flow, total FY22 revenue expectations nearly double normal levels, impressive book-to-bill ratio (>2.5x) and robust backlog (>\$3Bn), give us confidence that hyperscalers are again entering a build cycle. Although we acknowledge the demand CIEN is seeing goes beyond hyperscalers and is broad-based across customer sets, in FY21 alone, the company had more than 1Bn in webscale customer orders. Management acknowledged the step up in webscale demand is largely the result of the shift to the cloud with new architectures and network builds, increasing focus on edge applications, as well as digital transformation.

FIGURE 12. CIEN backlog materially expanding as secular demand continues to grow

Source: Barclays Research estimates, Company Documents.

CSCO

Cisco had strong results for its Optical segment last quarter. CSCO continues to see exceptional performance driven by the rapid pace of adoption of its 400G solutions and routed optical networking portfolio, which grew over 50% aided by CSCO 8000 series product line, Acacia (deal closed in March 2021) and Silicon One. CSCO is also seeing strong traction with ZR Optics as part of the routed optical network strategy. Overall, its optical systems and Acacia both saw strong DD growth driven by CSCO webscale customers, both hyperscalers and T2/3 cloud.

KEYS

Keysight, an R&D-focused test and measurement company, continues to see ongoing investments in 400G and 800G R&D – in fact, increased spending in data center and network security drove double-digit order growth in network tests and visibility last Oct-Q. Hyperscalers are adopting 800G connectivity technology to address a rise in the use of 5G, AI/AR/VR, and IoT, along with data-intensive applications such as video/digital entertainment.

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CCI

Crown Castle has 80k domestic fiber route miles, primarily in the top 30 metros in the US. In addition to monetizing the fiber for traditional purposes like internet access, private networks, and cloud connect, CCI is building a small cell network to densify 5G coverage and enable faster, more data intensive applications. The company received a 15k small cell order from VZ in 1Q21, and a 35k order from TMUS in 1Q22. We anticipate additional orders, of even greater size, will likely follow in the coming years.

DLR

Global data center operator Digital Realty partnered with Zayo in 2H21 to create the largest “fabric-of-fabrics” to interconnect key locations of data exchange. Zayo provides a range of communication solutions via its 126k mile fiber network in N.America and Europe, including dark fiber, private data networks, IP backbone, ethernet and dedicated internet access. The partnership aims to remove communication barriers from legacy communication networks, improve security, and reduce latency. We anticipate the partnership can improve performance of distributed workloads, and unlock value for enterprise and hyperscale clients.

UNIT

Uniti, the only publicly traded pure-play North American fiber company, due to its national and Southeastern footprint, is seeing new interest from hyperscale carriers. In fact, last year the company announced a 20-year contract with a large international hyperscale customer to

provide high-strand count fiber along a new dark fiber route that connects data centers in Pittsburgh and Virginia. We expect to see deals like this accelerate as data centers look to increase connectivity and expand.

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IIVI

II-VI's communications business is well positioned to benefit from the upgrade cycle to higher speeds (Communications is ~2/3 of revenue). In this business, 60% is Datacom with nearly all of that revenue made up of transceivers that are the critical connections in any network architecture. Of that transceiver business, 30% is high speed >200G that will be used in new optical build outs this year at FB/GOOG/AMZN. II-VI is well positioned at those customers with what we believe is 20-40% share. The remainder of the Datacom transceiver business is related to 100G and legacy speeds. The other 40% of Communications is Telecom where the company should also see growth with transceivers, ROADMs and pump laser deployments in emerging buildouts as new networks are deployed.

LITE

Lumentum makes discrete laser chips for the Datacom market that are currently capacity constrained but should grow with new 200/400G ramps across hyperscalers. In the Telecom business, the company also has exposure to ROADMs and pump lasers and transceivers. The company recently talked about pump laser strength that is indicative of early stages of large optical network deployments. The company believes it will grow revenue double digits over the next several years fueled by Telecom and Datacom. In the near term, we are modeling both Telecom and Datacom growing for LITE in 2H CY22 as the supply situation starts to improve.

MTSI

MACOM Technology Solutions designs and manufactures semiconductor products for Telecom (31% of revenue), Industrial and Defense (47%) and Data Center (22%) industries. The company boasts a broad portfolio of optical and high-speed analog mixed-signal solutions (i.e. low-power, 2-chip analog PAM4 solution supporting 200G and 400G short-reach applications). On the Telecom side, infrastructure builds in the US/Europe should accelerate this year with MTSI well positioned to benefit with both its analog product offering and a new laser offering in fronthall buildouts. In Data Center, the company offers analog products with the goal to also eventually offer lasers as well. The DC business is expected to accelerate to strong double digit growth in the 2H22. The company expects laser revenue for Telco/DC to grow by at least 5x in the 2H vs. the 1H.

MRVL

Marvell has exposure to optical through different segments of its business (Carrier Infrastructure/DC/Enterprise). In 2021, MRVL added leading electro-optics portfolio for high speed connectivity both within and between cloud data centers through its acquisition of Inphi. Marvell maintains a dominant share of PAM-based connectivity inside data centers and will benefit as PAM based 200/400G continues to roll out. Over the next few years, ZR adds another leg of growth as pluggable transceivers replace dedicated optical devices for longer reaches. Within its Carrier Infrastructure business, MRVL expects significant additional growth over the next several years as 5G adoption continues to grow around the globe.

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NOKIA

Nokia's Network Infrastructure business was its standout division in FY21, having grown 12% y/y (excluding Submarine), far above both its TAM (5% y/y) and its group average (2%). The relative strength was largely in Fixed Networks (+34% y/y) amid CSP investment in broadband rollouts

(especially in North America) and fixed wireless access. Nokia has benefited from the continued shift to fiber, where it has higher share than copper, as well as we think market share gain from Huawei. On the optical side, growth for FY21 was limited (+1% y/y) with FY20 being a tough comp year (pent-up COVID demand) and Nokia's market share remaining fairly flat at c16%. We do however see a lot more upside for its optical business in FY22+, with Nokia likely increasing its market share (especially in Europe) as it rolls out its next gen PSE-V product (Photonic Service Engine), with clear leadership both in power consumption and optimization for 400G.

Nokia's new management team may have moved away from the prior team's "virtuous cycle" 5G rhetoric, but we still see tremendous value in its broader portfolio. Mobile and fixed demand is giving way to significant investments across the mobile backhaul, routing and in-turn the optical network. All areas where Nokia is a meaningful player. With the market also looking to eventually move towards optical IP convergence (streamlining of network layers), we see Nokia benefiting from expertise in both domains. Near-term investor concern is still likely to remain on the 5G RAN cycle potentially peaking for telecom equipment suppliers Nokia and Ericsson (and thus the need to shift towards Enterprise). But we do think Nokia's broader based exposure beyond RAN should give confidence in longer-term growth sustainability.

AWE

Alphawave (AWE) is a pure-play silicon IP company, with significant exposure to Data Networking (c30% of 1H21 sales) and with nearly all the major hyperscalers as customers. The company licenses its IP for high-speed wired connectivity, with its key competitive advantage being in DSP based SerDes which have been increasingly critical as the market has shifted to higher transfer speeds of 100G+. AWE is seeing increasing traction on the optical side (c20% of 1H21 sales), and recently bolstered its presence in optical by acquiring Precise ITC. Going forward we expect even closer integration between silicon and optics (first with on-board optics, and then co-packaged), particularly driven by power efficiency gains, and therefore see AWE's high-speed interface IP between optical/electrical as even more critical.

ESG Touchpoints

Energy Efficiency

As hyperscalers continue to grow and expand, we believe energy efficiency will continue to rise in importance. Although fiber is more energy efficient than copper, we believe the rise in data traffic will ultimately increase overall energy levels. However, we still see the rising use of fiber (vs copper) to be a net benefit for operators (both hyperscalers and carriers) not only due to higher energy efficiency in terms of cooling, but also increased ability to utilize software technologies previously untenable on copper.

Socially Positive

Broadband connectivity is increasingly being viewed as a human right, with digital inclusion viewed as a social equity issue, not just a geographic issue. Optical fiber transport is the most efficient technology to handle data rich applications, as well as future applications (5G, AI, AR/VR). Due to its technological efficiency, we believe fiber will increasingly be viewed as not only the best technology in terms of "future-proofing" a network (vs cable or copper), but also in terms of what is socially most appropriate for underserved and unserved deployments.

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Materially Mentioned Stocks (Ticker, Date, Price)

AT&T (T, 18-Feb-2022, USD 23.87), Overweight/Neutral, A/CD/CE/D/E/J/K/L/M/N

Alphawave IP (AWE.L, 18-Feb-2022, GBp 175), Overweight/Neutral, A/D/J/K/L/M/Q

Altice USA (ATUS, 18-Feb-2022, USD 11.52), Equal Weight/Neutral, A/CE/D/E/FA/J/K/L/M

Ciena Corporation (CIEN, 18-Feb-2022, USD 68.70), Overweight/Neutral, CD/CE/J/K/M

Cisco Systems, Inc. (CSCO, 18-Feb-2022, USD 57.21), Overweight/Neutral, CD/CE/J

Corning Incorporated (GLW, 18-Feb-2022, USD 41.70), Overweight/Neutral, CD/CE/J

Crown Castle International Corp. (CCI, 18-Feb-2022, USD 162.34), Overweight/Positive, A/CD/CE/D/E/J/K/L/M

Digital Realty Trust, Inc. (DLR, 18-Feb-2022, USD 135.20), Equal Weight/Positive, A/CD/CE/D/E/J/K/L/M/N

II-VI Incorporated (IIVI, 18-Feb-2022, USD 71.74), Underweight/Neutral, CD/CE/FA/J

Keysight Technologies, Inc. (KEYS, 18-Feb-2022, USD 160.59), Equal Weight/Neutral, CD/CE/D/E/J/K/L/M/N

Lumentum Holdings Inc. (LITE, 18-Feb-2022, USD 99.08), Overweight/Neutral, CD/J/K/M

MACOM Technology Solutions Holdings, Inc. (MTSI, 18-Feb-2022, USD 58.65), Overweight/Neutral, A/CD/CE/D/J/K/L/M

Marvell Technology Group, Ltd. (MRVL, 18-Feb-2022, USD 67.34), Overweight/Neutral, A/CD/CE/D/J/L

Nokia (NOKIA.HE, 18-Feb-2022, EUR 5.03), Equal Weight/Neutral, CD/CE/D/E/J/K/L/M/N

Uniti Group Inc. (UNIT, 18-Feb-2022, USD 11.31), Equal Weight/Positive, A/D/E/FA/J/L

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ASM International N.V. (ASMI.AS)	ASML Holding NV (ASML.AS)	Ericsson (ERICb.ST)
Infineon Technologies AG (IFXGn.DE)	IQE plc (IQE.L)	Nokia (NOKIA.HE)
STMicroelectronics NV (STM.PA)	TomTom NV (TOM2.AS)	

IT Hardware and Communications Equipment

Apple, Inc. (AAPL)	Arista Networks, Inc. (ANET)	Casa Systems (CASA)
Ciena Corporation (CIEN)	Cisco Systems, Inc. (CSCO)	Corning Incorporated (GLW)
Dell Technologies Inc. (DELL)	F5 Networks, Inc. (FFIV)	Harmonic, Inc. (HLIT)
Hewlett Packard Enterprise Company (HPE)	HP Inc. (HPQ)	Juniper Networks, Inc. (JNPR)
Keysight Technologies, Inc. (KEYS)	Motorola Solutions, Inc. (MSI)	NetApp, Inc. (NTAP)
Pure Storage, Inc. (PSTG)	Samsung Electronics Co., Ltd. (005930.KS)	Ubiquiti, Inc. (UI)

North America Cable, Satellite & Telecom Services

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BCE Inc. (BCE.TO)	Charter Communications, Inc. (CHTR)	Comcast Corp. (CMCSA)
DISH Network Corp. (DISH)	Liberty SiriusXM Group (LSXMA)	Rogers Communications Inc. (RCI)
Rogers Communications Inc. (RCI-B.TO)	Shaw Communications Inc. (SJR)	Shaw Communications Inc. (SJR-B.TO)
Sirius XM Radio Inc. (SIRI)	T-Mobile US Inc. (TMUS)	Telus Corp. (T.TO)
Telus Corp. (TU)	Verizon Communications Inc. (VZ)	

U.S. Communications Infrastructure

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Switch, Inc. (SWCH)	Uniti Group Inc. (UNIT)	

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