

Management Challenges in the Optical Telecommunications Industry

Research Report

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1.0 Research Objective

The objective of this project is to identify successful strategies to manage highly diverse and challenging issues in an uncertain business environment. The study focuses exclusively on the optical telecommunications industry and the locus of analysis will be the optical networking equipment segment.

As indicated in the simplistic representation below (Figure 1), optical equipment providers are in a uniquely influential position within the telecommunications value chain. However, they are positioned in-between two constantly evolving markets that are high-growth, competitive and have highly uncertain demand projections.



Figure 1: Optical Networking Industry Value Chain

The past few years have seen a major disruption in the optical networking market. The optical service provider market, once dominated by behemoths like AT&T, Sprint and MCI, has seen an influx of insurgents like Level 3 Communications. These insurgents have shifted the service provider business model away from a vertically integrated sales and marketing driven one to a horizontally integrated network engineering and design driven model. The focus now is to provide a low-cost, highly flexible and differentiated network infrastructure that can be provisioned rapidly. This recent disruption in the service provider market has caused a disruption in the network equipment provider market, creating a new breed of “intelligent” optical equipment providers. Their ability to quickly adapt to such a dynamic model is in turn highly dependent on the optical component manufacturers on the supply side as well as related technological advancements.

This supply and demand uncertainty in the value chain creates unique management challenges for all the involved players.

1.1 Scope of Analysis

This research report aims to focus primarily on the service providers, equipment vendors and component manufacturers. While end consumers are important, they are more pertinent to the service providers and less to the equipment market. Hence, limited attention is paid to end consumer issues.

In this report, we primarily aim to analyze the following areas.

1.1.a Service Providers

Service providers today are moving away from an end-to-end network solution that will lock them into an undifferentiated, commodity network architecture, with costs on par with everyone else who bought the same package. Service providers thus prefer multiple “best of breed” suppliers operating in a multi-vendor, standards based network architecture. The presence of more standardized products will reduce network design and architecture costs, thus lowering overall costs. In this environment, best of breed products will stand out against their vertically integrated counterparts as they will be able deliver more cost efficient technology and quality due to their product focus. This report analyzes these issues from a service provider as well as from a equipment vendor perspective.

1.1.b Equipment Manufacturers

As mentioned before, equipment manufacturers are delicately balanced between the component suppliers and the service providers. This report is centered on the challenges faced by them.

1.1.c Optical Component Suppliers

The disruption caused by the service providers has been reflected up the value chain all the way to the suppliers of optical components that the equipment providers use. The fluctuating demand from equipment providers for optical components and the constant need for newer components to meet the higher and stringent requirements set forth by the service providers has put component manufacturers in an unenviable position. Yet, the component manufacturers are highly concentrated, with only a few key manufacturers offering quality product in a timely manner. In such a scenario, one is not sure whether it is the component supplier or the equipment provider who is in a better bargaining position.

1.2 Approach and Acknowledgments

We have aimed to resolve the issues above by acquiring an in-depth analysis of the relevant industry fundamentals, an understanding of the technology drivers in the industry, and the ability to apply traditional strategic management tools in a result-oriented context.

After identifying the key management issues in each industry sub-segment, we have provided suggested strategies that senior managers in the optical equipment industry can adopt to compete successfully in their highly disruptive marketplace.

We believe that lessons learnt in this industry will be applicable across similar industries characterized by complex value chains, with demand-supply uncertainty at each stage of value creation.

We are extremely grateful to the leadership at Ford for giving us the opportunity to pursue research in this area. We would also like to thank Prof. Graham Mitchell for providing us guidance during various stages of this project.

2.0 Industry Overview

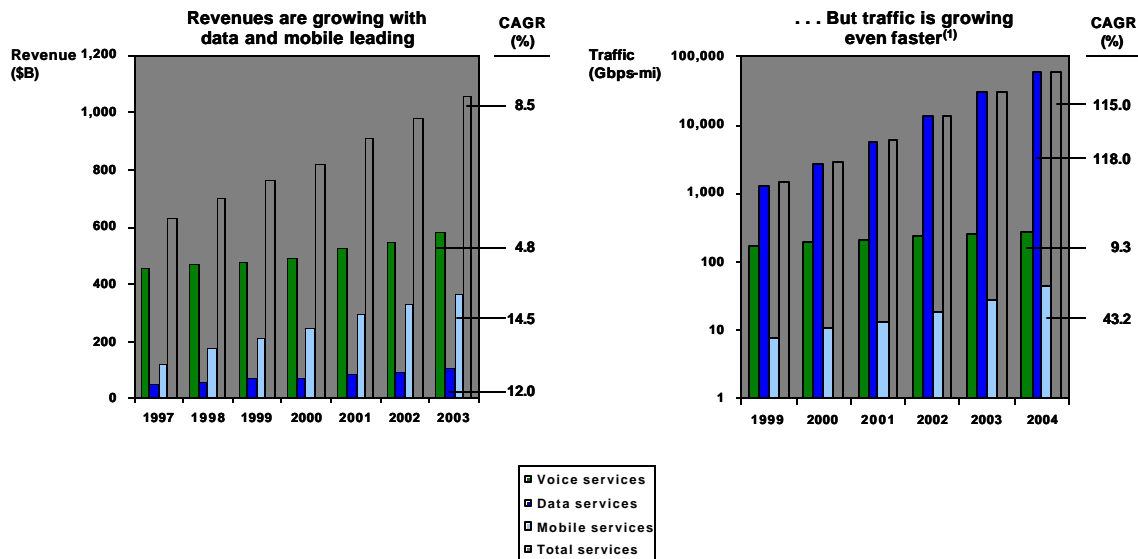
2.1 Service Providers

2.1.a Revenue Growth

Based on industry research, the overall US telecom service provider market is estimated to grow from \$820 billion in 2000 to \$1,060 billion in 2003, representing a CAGR of 8.5% for this period. A lion's share of this growth is emanating from the fastest growing mobile services segment, which is growing at 14.5% annually over this period, and accounted for 30% of the total market in 2000. The net market opportunity for data and voice services is thus \$570 billion in 2000, growing to \$690 billion in 2003.

2.1.b Traffic Growth

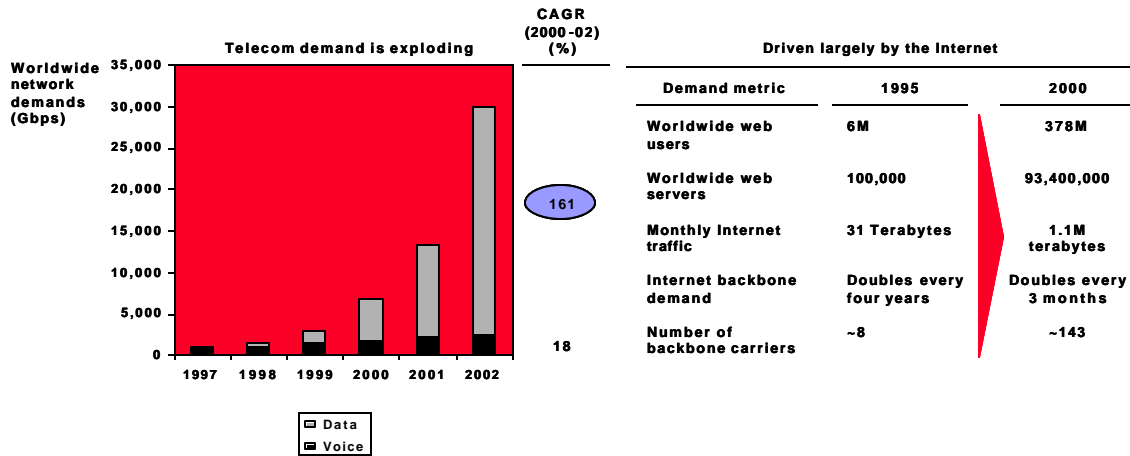
The revenue growth statistics above do not reflect the falling price per bit transported over this period. Between 1999 and 2003, the total traffic over telecom networks is expected to grow annually at 115%. Of the various sub-segments, data is projected to be the fastest growing segment, representing 118% growth during this period. Voice services on the other hand are the slowest growing segment, and are projected to represent a mere 9.3% annual growth from 1999 to 2003.



(1) Mobile traffic multiplied by 10x for visibility
 Source: Dataquest; FCC; IDC; Forester; Yankee Group

Figure 2: Revenue and Traffic Growth Trends

A major driver for growth in traffic and growth in revenues is a fundamental increase in demand for bandwidth. The analysis below demonstrates the exponential growth in bandwidth demand globally, and highlights the role of the Internet in fueling such growth.



Source: Insight research; Internet Software Consortium; Telcordia; NUA; Epoch Partners; *Business Week* (October 9)

Figure 3: Analysis of Demand

Overall, the main drivers to increase in bandwidth demand can be summarized as follows:

- /// Improving economics with technology advances and utilization
 - o Capital required to move a bit is falling dramatically
 - o Technology is enabling more efficient solutions to deliver bandwidth capacity
 - o Scale and network utilization lower costs
- /// Demand is highly elastic and new services are rapidly embraced by the customer
 - o Services
 - o Equipment
 - o Value added services

2.2 Equipment Manufacturers

Fiber optics is beginning to penetrate the overall telecommunication equipment market. The advent of DWDM technology dramatically increased the capacity of existing fiber optic networks and led to a large increase in demand for optical equipment that implemented this technology. Currently, DWDM equipment is primarily optical while SONET/SDH and ATM systems are a mix of optical as well as electrical equipment.

Equipment vendors target the following segments of the optical networking market: (a) Backbone / long-haul (b) Metro and (c) Access. As shown in Figure 4 below, the equipment vendors manufacture five categories of equipment, each with a myriad of products and services.

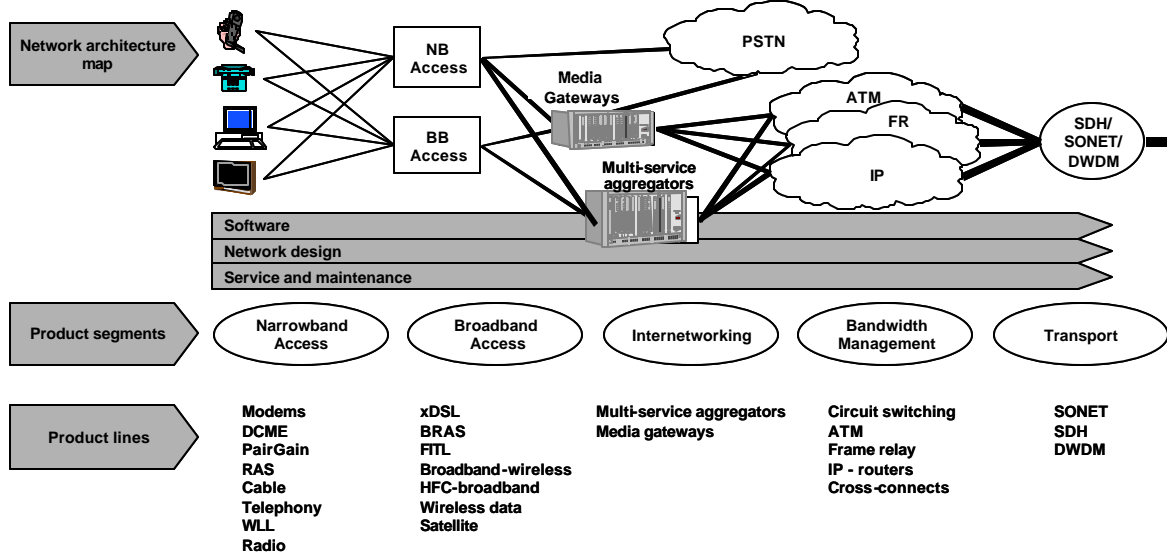
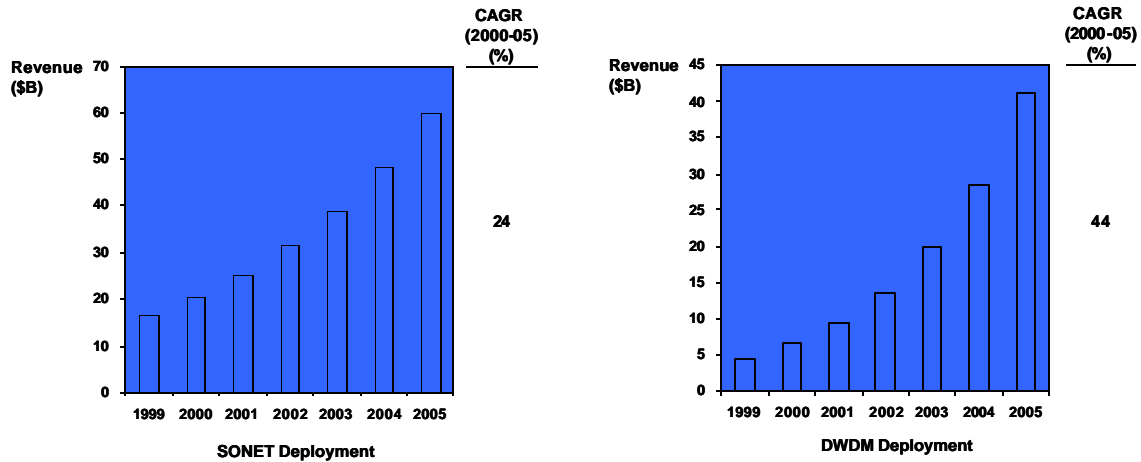


Figure 4: Categories of Optical Networking Equipment

Some characteristics of the optical equipment sector are enumerated below.

2.2.a Growth in SONET and DWDM Deployment

The SONET and DWDM markets are the primary markets for optical equipment vendors. As shown in Figure 5 below, both these markets are projected to grow rapidly over the next few years.

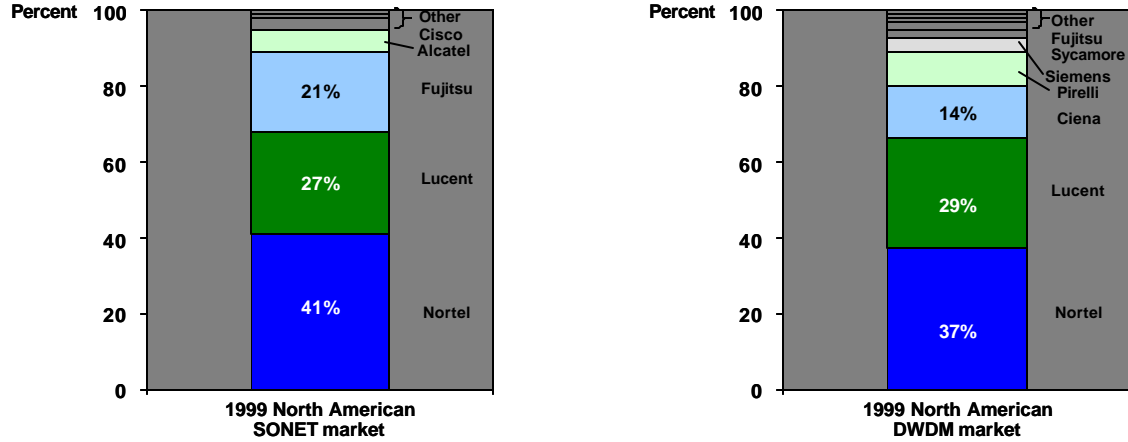


Source: RHK

Figure 5: Growth in SONET and DWDM Markets

2.2.b Competitive Landscape

The optical equipment market is extremely dynamic with strong players in each segment. As seen in Figure 6, full-service vendors such as Lucent, Nortel, Cisco, Ciena and Sycamore Networks dominate the market. However, new entrants are gaining a foothold as seen in the figure.



Source: RHK

Figure 6: SONET and DWDM Markets – Competitive Landscape

2.2.c Trend Towards Horizontal Consolidation

As startup optical companies begin to pose a threat in the market, established players are aggressively moving towards acquisitions and consolidation. In recent years, there has been a strong trend among the equipment vendors to consolidate horizontally. Figure 7 displays the increase in the number of horizontal consolidation transactions made by the vendors.

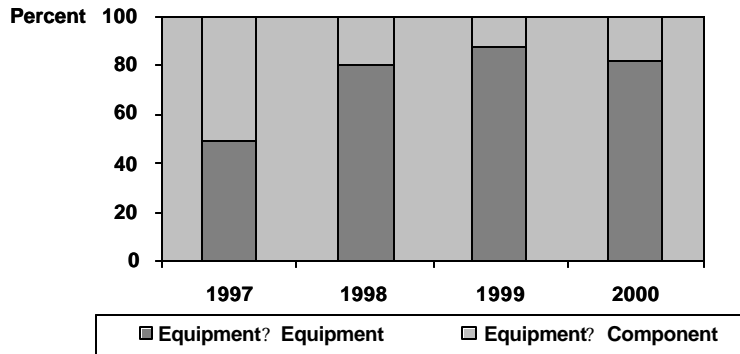


Figure 7: Consolidation Trend in the Equipment Vendor Market

2.2.d Recent Shakeout in the Equipment Market

However, in recent times the bubble has burst for the optical equipment industry. Three main reasons for the fall from the glory days of 1999 and 2000 are:

Retreat of carriers from network build-outs: After spending hundreds of millions of dollars without any wins, VCs have pulled the plug on funding carrier startups. Incumbents like AT&T are reducing

spending while CLECs like Winstar are filing for bankruptcy. As a result, equipment vendors are experiencing decline in revenues.

~~///~~ Inventory shortages turn into surpluses: A sudden boom in sales in 2000 created a component shortage that left vendors scrambling to meet demand. As vendors scaled production, carriers stopped buying. As a result, equipment vendors are writing off huge amounts in inventory. This glut will only worsen as more carriers disappear and established providers pick up cheap equipment at the auction table.

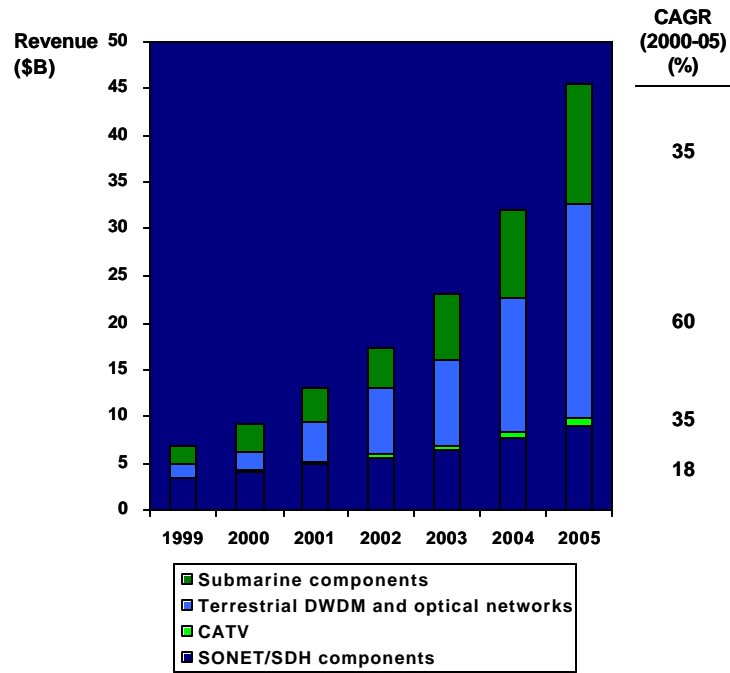
~~///~~ Plummeting valuations limit acquisitions: Acquisitions have been the main source of innovation for equipment vendors such as Cisco, Lucent and Nortel. But, as their valuations dwindle, the opportunity to buy new technology goes away. Without new technologies to stimulate demand, vendors' revenues will continue to fall.

2.3 Component Manufacturers

Optical component manufacturers supply the equipment vendors with the optical components and parts required to design a complete system. Much of the advancements in optical networking has come about due to advancements in the component technology that are the basic elements of optical network systems. There are essentially two types of components used by optical networking systems – active and passive. The market for components is highly fragmented and the industry is dominated by a handful of large suppliers such as JDS Uniphase, SDL Inc. and Corning. The component industry remains capacity constrained despite the major players' continued efforts to rapidly increase capacity. Besides manufacturing stand-alone optical components, component manufacturers have recently moved towards manufacturing and marketing integrated modules.

2.3.a Revenue Growth

Total revenues in the optical components market are projected to increase rapidly over the next few years and are expected to approach \$50B by the year 2005. Sales of optical components have been and are projected to be robust across all optical applications such as submarine networks, terrestrial DWDM and optical networks, CATV and SONET/SDH networks (Figure 8). In particular, terrestrial components are experiencing rapid growth with a CAGR of 60%.



Source: RHK

Figure 8: Optical Components Market Growth

2.3.b Move Towards Horizontal Consolidation

Similar to equipment vendors (as shown in Figure 9 below), component manufacturers are moving towards consolidating their positions horizontally rather than vertically with equipment vendors (%age calculated based on number of transactions).

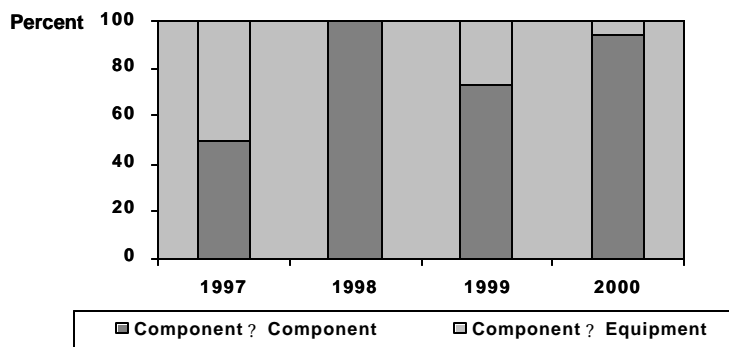


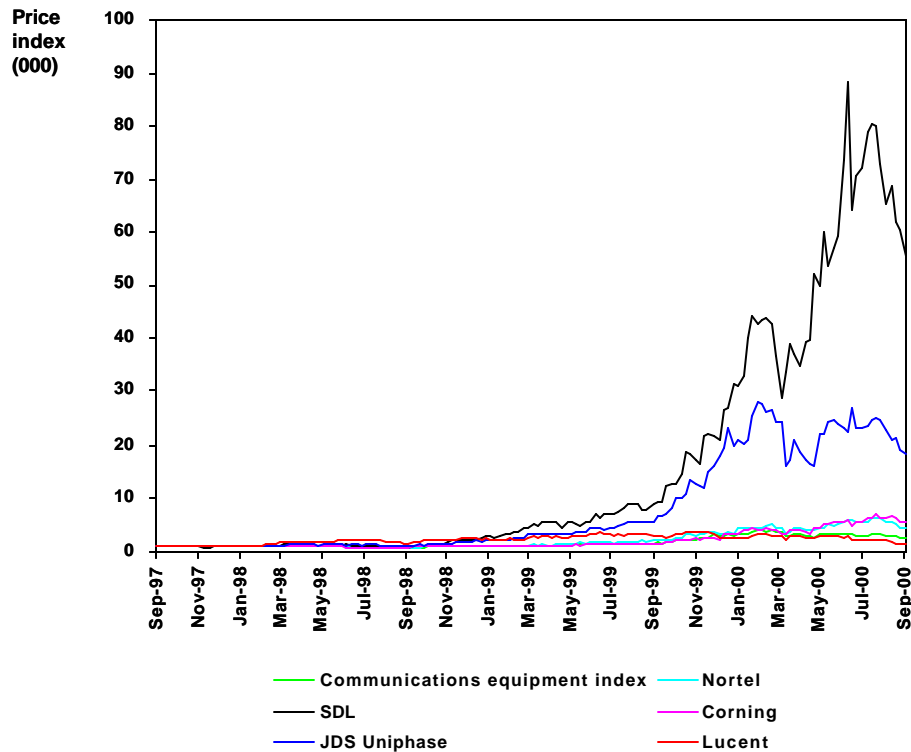
Figure 9: Consolidation Trend in the Optical Components Market

Further, most of the component manufacturers are pursuing acquisitions to primarily broaden their expertise and product portfolio. These trends towards segment consolidation and away from vertical integration are highlighted by some of the quotes below:

- ✍ “What I think may be more likely to happen is consolidation among the optical components makers where companies that specialize in components and know the components business such as JDS Uniphase may go out and seek the best in class among the components companies and use their stock price to out and buy some other players.” – Stephanie Mehta, Fortune Magazine.
- ✍ “What we did was move aggressively (to acquire companies) before other people caught on to the idea. And we did it while things were cheap.” – Kevin Kalkhoven, CEO, JDS Uniphase.

2.3.c Astronomical Valuations

Until as recently as mid-2000, component manufacturer valuations far outstripped that of equipment vendors. This was one of the main reasons that the component manufacturers were able to pursue acquisitions and consolidate.



Source: Merrill Lynch, MSN Money Central

Figure 10: Component Manufacturer Valuations

In fact, equipment vendors were trying to capitalize on these enormous valuations and IPO their components businesses, spin them off or sell them off at very good prices. The market seemed to clearly recognize the value of stand-alone components businesses.

2.4 End Consumers

As the needs of the market are evolving, customer requirements are growing more complex. These complex requirements promote the demand for optical solutions as they are, for the most part, protocol agnostic. There are three types of end consumers who have a direct or indirect impact on the demand for optical networking equipment.

2.4.a Residential Broadband

By 2003, “last mile” broadband penetration is expected to be 20%+. Applications such as home networking, video calling, Video-On-Demand (VOD) are all growing rapidly and will require significant amounts of dedicated bandwidth. Further, the evolution of content from narrowband to broadband with more interactive, dynamic and higher quality images increases the residential broadband demand.

2.4.b Business Applications

Large file transfers are becoming increasingly important for corporate customers e.g. CAD/CAM files, multimedia presentations. In spite of the lack of interest in e-commerce, bandwidth intensive B2B e-commerce is growing at greater than 100% per year. Finally, corporate video conferencing traffic is expected to explode in the next four years.

2.4.c Application Specific Providers (ASPs)

The worldwide ASP market is expected to be a \$2B market by 2003 as more ASPs adopt the “Software as a Service” business model. ASPs are beginning to replace distributed applications through computing with hosted applications enabled by the availability of tremendous bandwidth.

3.0 Key Challenges for Service Providers

3.1 Financial Issues

3.1.a Declining Profitability

While traffic continues to grow, and service providers continue to provide the bandwidth to meet additional demand, the key challenge facing service providers is rapidly increasing network costs. Based on an analysis by Ciena, an optical equipment company, network costs are growing at a faster pace than revenues, thus implying a continued spell of poor profitability in the years ahead.

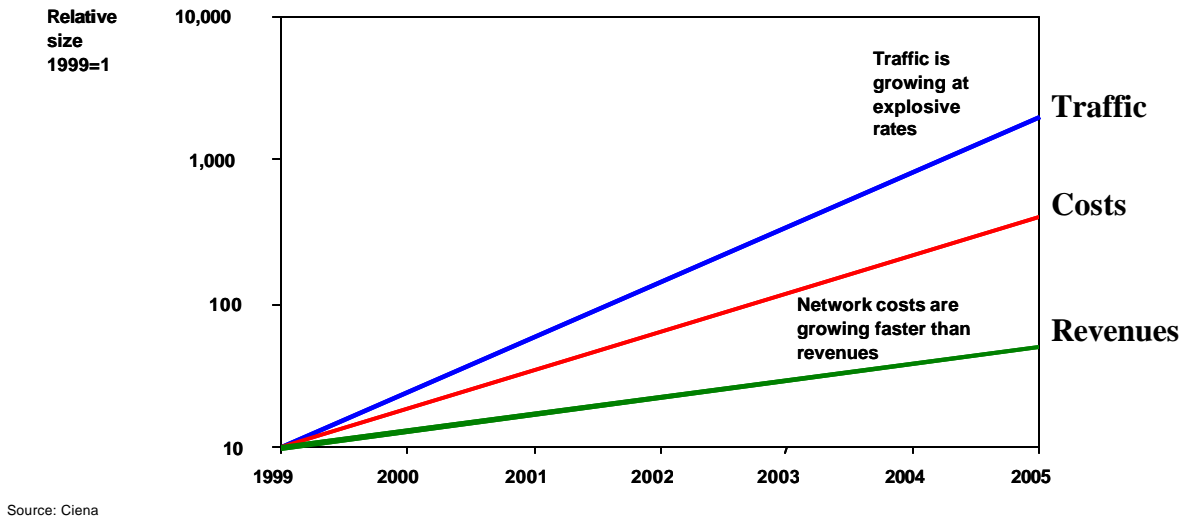


Figure 11: Declining Profitability for Service Providers

Profit growth is constrained by falling prices and increasing network costs. Customers are highly price elastic in the highly competitive, overcapacity market. Thus, there is little hope for price increases for increased profitability. Consequently, service providers such as Williams Communications have publicly stated that reduction of network costs is a top of mind concern for them. Various means by which costs can be decreased include:

- ✍ Eliminating network elements such as regenerators – this is the key value proposition for Corvis
- ✍ Simplified provisioning
- ✍ Ring architectures are inherently inefficient
- ✍ Multiple pieces of network equipment may be replaced by a single piece of equipment

Moving to an all-optical network can help alleviate this problem. Moving to optical networks is a proven way to reduce costs, as evidenced by the chart below. For instance, DWDM helped WorldCom reduce transport costs from 80% in 1994 to less than 25% in 2000.

3.2 Supply Side Issues

3.2.a Equipment Requirements

Service providers are huge purchasers of a range of equipment from optical and electronics vendors. Consequently, one would imagine their buyer power is significantly high. The equipment provider market

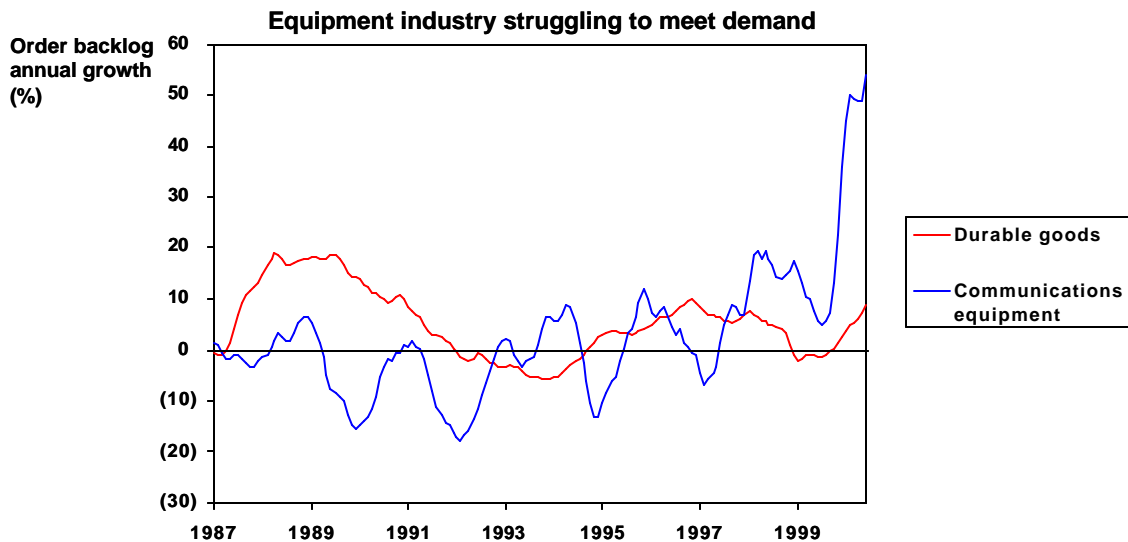
is a niche market, with very few one-stop shops. This reduces buyer power. Nevertheless, until late 2000, equipment manufacturers often offered huge discounts, or vendor financing to push sales of equipment. Table 1 below highlights the key product requirements for service providers by segment:

<u>Narrowband Access</u>	<u>Broadband Access</u>	<u>Internetworking</u>	<u>Bandwidth Management</u>	<u>Transport</u>
Modems	xDSL	Multi-service	Circuit switching	SONET
DCME	BRAS	aggregators	ATM	SDH
PairGain	FITL	Media gateways	Frame relay	DWDM
RAS	Broadband-		IP - routers	
Cable Telephony	wireless		Cross-connects	
WLL	HFC-broadband			
Radio	Wireless data			
	Satellite			

Table 1: Key Product Requirements for Service Providers

3.2.b Equipment Availability

Until the end of 2000, demand for optical equipment was extremely high. Equipment suppliers struggled to meet demand, reorganize their production schedules, and consequently suffered order backlogs. As Figure 12 below indicates, equipment was mostly unavailable during late 2000, early 2001.



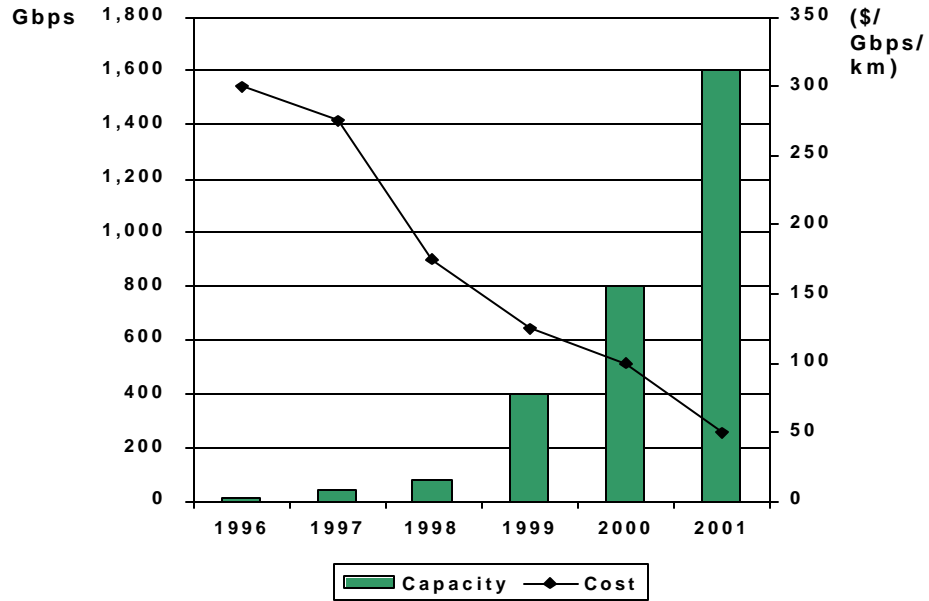
Source: Department of Commerce

Figure 12: Equipment Industry Struggling to Meet Demand

Following the meltdown of the telecom sector, demand vastly dried up for new optical equipment, as (i) capital expenditures decreased, (ii) old 2nd hand equipment became available at deep discounts. Hence, it is safe to assume that equipment is readily available currently.

3.2.c Equipment Costs

Equipment costs are declining owing to a dual effect of improved technology, and increased competition. Figure 13 below highlights the declining capacity/cost dynamic.



Source: AT&T

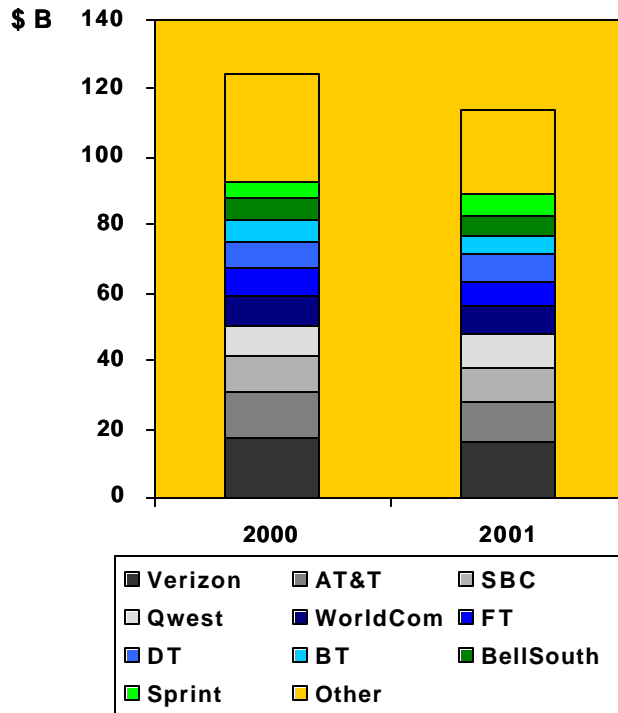
Figure 13: Declining Capacity/Cost Dynamics

Technology effects: (i) higher bandwidth, (ii) DWDM, (iii) new fiber technologies, (iv) smaller footprints, (v) increased density, and (vi) increased speed per port.

Competition effects: (i) international standards promote competition partially on price, (ii) many new entrants into the industry – high valuations, high VC funding in 1999, 2000.

3.2.d Prohibitive Capex Requirements

Total capital expenditures on telecom equipment in 2000 were approximately \$120 billion. In a capital constrained economy, and with the termination of the practice of vendor financing, capital expenditures were projected to decrease by 9% in 2001. Capital expenditures grew by 39% in 2000 over 1999. Simultaneous revenue increase was only 11% during this period. Therefore, a considerable amount of capital spend was financed with debt. Of the total spending, it is estimated that incumbents accounted for 58% of total outlay



Source: Industry Literature

Figure 14: Capital Spending by Carriers

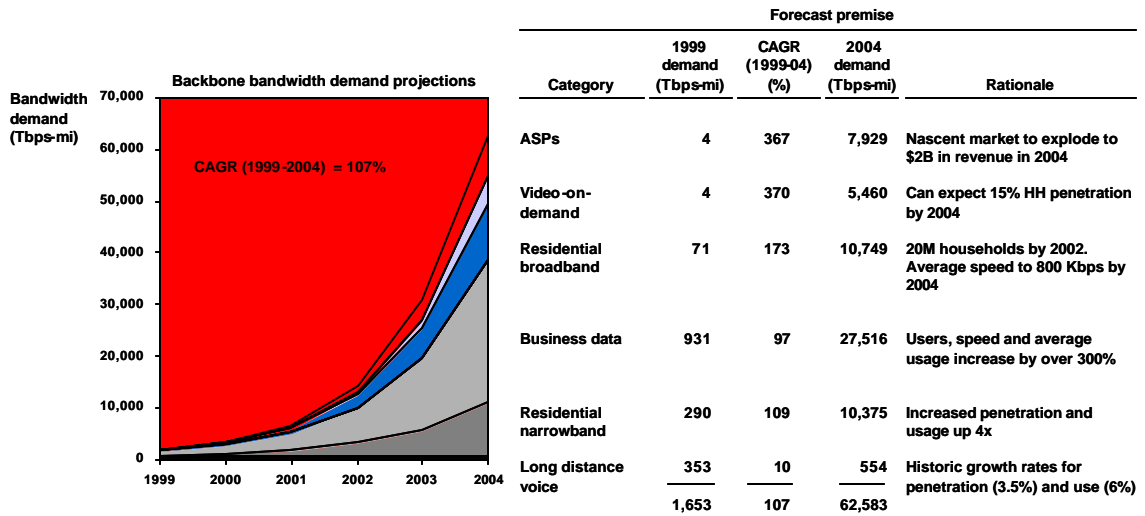
3.3 Demand Side Issues

3.3.a High Growth in Demand for Services

As elaborated in the industry section on service providers, demand has grown tremendously in recent years. Refer to earlier section for a detailed analysis of demand growth.

3.3.b Shift in Services Demanded – Focus on Value-added Services

As indicated in Figure 15 below, value added services such as ASP's and Video on Demand are the fastest growing segments, representing CAGR's of 367% and 370%, respectively, between 1999 and 2004. This shift represents a focus of service providers away from data transport services to managed network solutions.



Source: Yankee Group; IDC; Forrester; FCC; BCG analysis

Figure 15: Shift in Services Demanded

3.3.c Unique Demands by Market

Carriers demands for optics will vary considerably, with the access and backbone markets likely to show disappointing growth, while the metro market takes off. The varying demands by market are indicated in Table 2 below.

3.3.d Importance of feature by market

Feature	Description	Access	Metro	Backbone
Cost-effective	Lower operating and capital costs	High	Medium	Medium
Adaptable	Bandwidth anytime, any amount, anywhere	Medium	Medium	High
Manageable	Monitor, configure, and provision wavelengths	Medium	High	Medium
Interoperable	Standard interface between vendors	Low	Low	Low

Source: Forrester Research

Table 2: Varying Demands by Market

3.4 Suggested Strategies for Managers

3.4.a Move Away from Building Capacity – Reduce Capex

Going ahead, local and long haul carriers are going to significantly reduce the level of capital expenditures on equipment. 50% of respondents to a survey conducted by Forrester Research maintained that they would decrease capex spend in 2002. 20% of respondents said their budgets will remain flat. A particular

area of emphasis for carriers will be to force optical vendors to help lower operating and capital costs, including power and space consumption. Corroborating quotes include:

- ✍ “It’s not about the wavelengths any longer – its about the cost of service. Fiber is no longer a scarce resource, but space and power are” – Metro Carrier
- ✍ “We are looking for vendors to lower our operational expenses via eightfold reductions in space and power requirements” – Backbone Carrier

Responses to a Forrester survey of 22 carriers indicate the following statistics:

What will happen to your capex budget in 2002?	Why are you expecting a decrease in capex?
Decrease : 50%	Not enough demand: 45%
Flat: 23%	Network build complete: 45%
Increase: 14%	Still have capacity on tap: 27%
Don’t know: 14%	Expect equipment costs to decrease: 9%

Table 3: Forrester Survey of Carriers on Capex Spending

3.4.b Move Towards Managing Capacity

Manageability tops the lists of carrier complaints with today’s equipment. They list configuration, troubleshooting, provisioning, and power management as the main areas in need of improvement. Corroborating quotes include:

- ✍ “We need vendors to make our networks easier to configure. With 30,000 metro rings, we don’t have the time or resources to reconfigure a ring each time we add an optical device” – ILEC Carrier
- ✍ “We need integrated network management across multiple vendors to enable restoration and switching. We want our vendors to adopt open management standards – we don’t want to get sucked back in to the proprietary world we had with Lucent and Nortel” – Backbone Carrier

Responses to a Forrester survey of 22 carriers indicate the following statistics:

What do you dislike about optical network gear?
Hard to manage: 50%
Too expensive: 45%
High power consumption: 32%
Poor interoperability: 23%
Footprint too big: 18%

Table 4: Forrester Survey of Carriers on Managing Capacity

3.4.c Increase Buyer Power Over Suppliers

Service providers have a stated aversion to technologies that will lock them into a single source provider of equipment. A major concern for carriers is an aggregation of multiple services. While the reasoning for such strategy ranges from efficiency arguments to quality arguments, we believe that the underlying issue is buyer power. Corroborating quotes include:

- ✍ “The complexity of new all-in-one devices would make our network harder to manage and lock us in to a single vendor solution. Cisco gives us everything we need for private line and Ethernet services, while Nortel provides us with best-in-class DWDM platform for our wavelength services” – CLEC

Yet, this strategy by the carriers will lead to a consolidation wave among equipment providers, resulting in the emergence of a few, large equipment providers, thus ultimately increasing supplier power. This trend will be accelerated by the drying up of venture capital funding for equipment vendors. Proof of such trend is evident in the router and frame relay equipment markets, where a massive shakeout has led to a shrinking of players in the past few years. Forrester predicts that only five providers of such equipment shall remain by 2003.

3.4.d Reduction of Costs by Using Interoperable Equipment

Carriers will be able to shrink operating expenses by deploying interoperable gear that required fewer tweaks to work with back-end operational support systems. While waiting for standards to get baked, vendors will hard code links between proprietary management systems to provide carriers like AT&T with automatic inventory discovery, and end-to-end provisioning across multiple vendors.

3.4.e Focus on Incremental Upgrades to Harness Capacity

The capacity boom is over in the backbone, meaning upgrades to multithousand wavelength optical switches and 40Gbps DWDM equipment will be put off until 2003 at the earliest. For the next two years, backbone carriers like Sprint, Williams, and WorldCom will focus on the cost and manageability of wavelengths as:

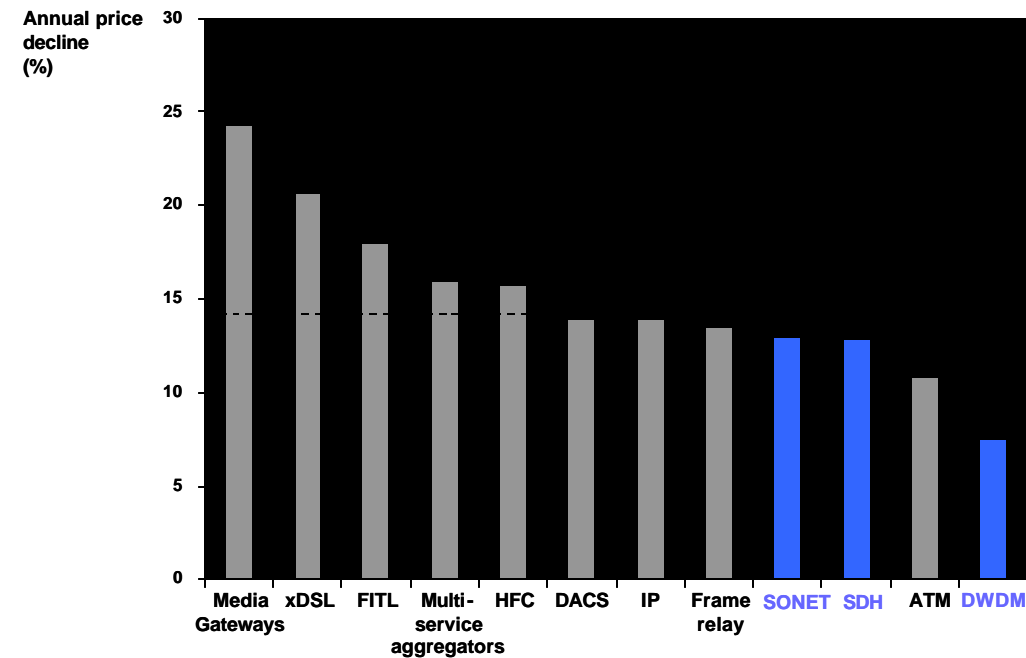
- ⚡ Backbone competition intensifies with ILEC's grabbing bankrupt assets: Incumbents will face increased competition at Allegiance, XO, and SBC expand their networks by acquiring assets of failed backbone carriers like 360 Networks.
- ⚡ All Optical switches streamline costs: Elimination of electrical regeneration devices will help carriers eliminate operating costs. However, current OO switches from Lucent, Nortel, etc. consume too much power, deliver inconsistent performance, and cannot scale far enough. Upstarts may solve such problems, but will not obtain the reputation and traction of Cisco, etc.
- ⚡ Carriers switch from prepackaged to customized service offerings: With bandwidth becoming a commodity, carriers are focusing on customer centric solutions that solve unique customer needs.

4.0 Key Challenges for Equipment Manufacturers

4.1 Financial Issues

4.1.a Declining Prices

Optical equipment vendors are in the unenviable position of being sandwiched between the component manufacturers and the service providers or carriers. As Figure 16 demonstrates, telecommunication equipment prices are steadily declining over time (even though optical equipment are holding value relative to other equipment).



Source: Dataquest: IDC

Figure 16: Decline in Telecommunication Equipment Prices

However, at the same time the cost of components that go into these systems is not declining at the same rates. In fact, most optical components are prohibitively expensive. This results in declining profitability for the equipment vendors.

4.2 Supply Side Issues

4.2.a Level of Consolidation Among Components Manufacturers

The trend towards horizontal consolidation in the optical components market is of some concern to equipment vendors. They are concerned about losing control of this critical aspect of their business. Several equipment vendors are investing a lot of money to ensure that they have some control over the channels of supply. There is a constant debate about whether equipment vendors should divest manufacturing to focus on higher-level equipment assembly. On the other hand, certain optical components can be critical and the vendors might want to control their supply by manufacturing these components themselves.

4.2.b Excess Component Manufacturing Capacity

As the following quotes by industry professionals indicate, prior to the downturn in the economy, component-manufacturing capacity was failing to meet equipment vendor demand.

✍ “As soon as we get the components, the kit is shipped. We are squeezing project schedules.” – Philippe Morin, Nortel

✍ “Even though component manufacturers are doubling capacity each year, it’s still not enough” – John Lively, RHK

Both component manufacturers and equipment vendors were cognizant of this fact and invested heavily to alleviate these manufacturing constraints. For instance, Lucent spent about \$1B in a global investment program to add capacity in Germany, China, Thailand, Russia, Brazil and the US. Similarly, Nortel invested \$1.9B in enhancing manufacturing capacity, mostly for optical components. Corning also invested around \$1B towards increasing manufacturing capacity.

While these investments were required in order to meet the strong demand, the downturn in the economy and the resulting lull in demand implies that there is excess manufacturing capacity currently in the components industry.

4.3 Demand Side Issues

4.3.a Fluctuating Demand

As mentioned previously (as a challenge for service providers), until the end of 2000, demand for optical equipment was extremely high. There was significant order backlog for optical equipment. This forced equipment vendors to ramp up their manufacturing capacity. However, with the meltdown in the telecom sector, this demand has dried up and manufacturers have excess inventory and lower sales. Managing the manufacturing process and keeping it in line with the demand forecasts is a key challenge for vendors.

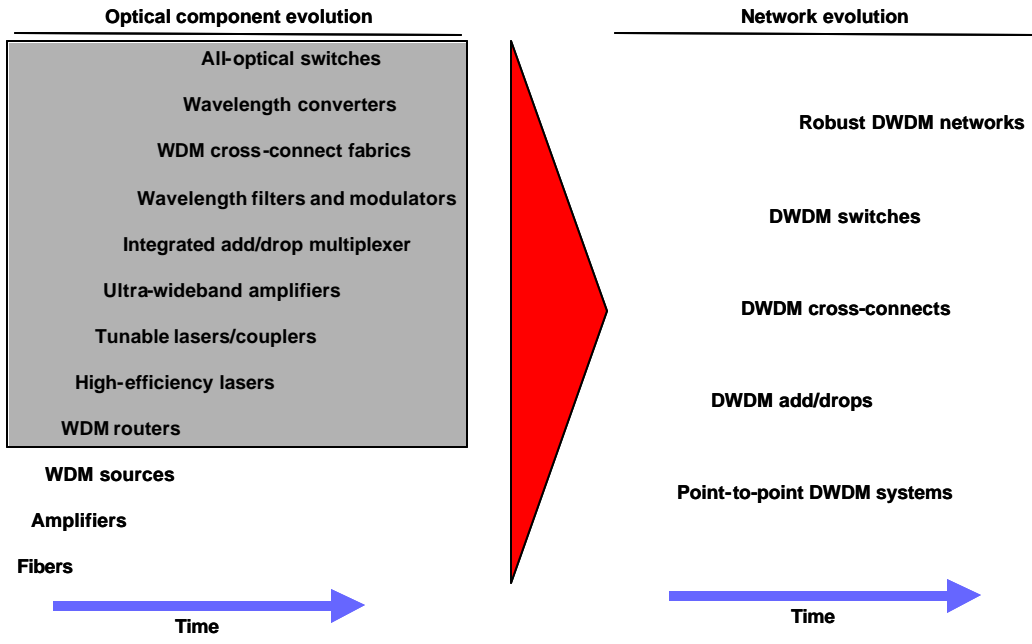
4.3.b Vendor Financing

Equipment vendors such as Nortel, Lucent etc were too focused on booking revenue at the expense of their balance sheets. These companies have been caught with hundreds of millions of dollars of bad loans to moribund carriers such as WinStar. This has led to equipment manufacturers struggling with ongoing cash flow consequences of future vendor financing promises and commitments.

4.4 Technology Issues

4.4.a Evolution of Optical Networks

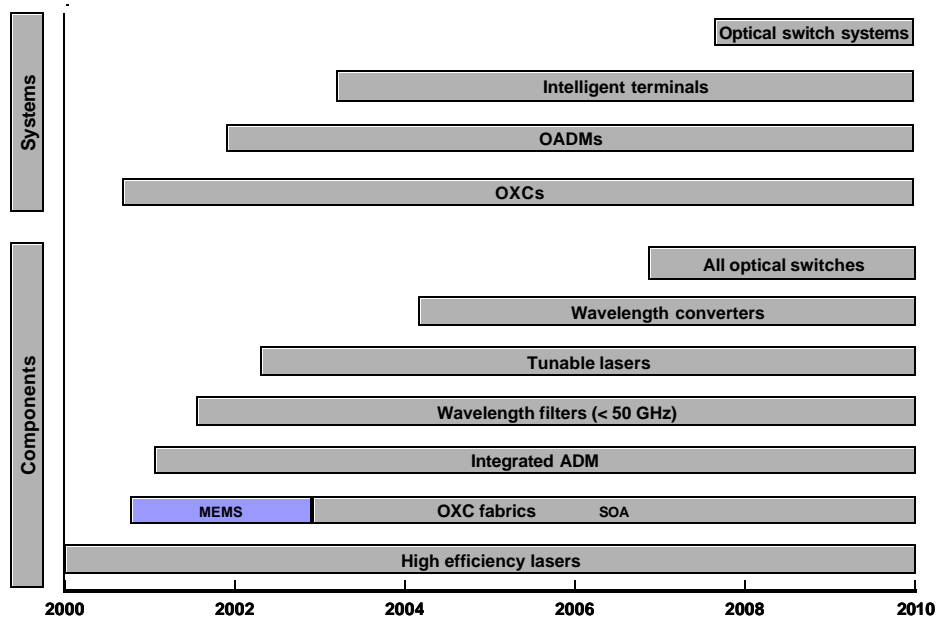
As the global telecom networks evolve into optical networks, the evolution of the network will need to be paced by the development of new optical equipment (Figure 17).



Source: BCG Analysis

Figure 17: Evolution of Optical Networks

The development of new optical equipment in turn needs to be paced by the evolution of optical components (Figure 18).



Source: BCG analysis

Figure 18: Optical Systems Evolution Paced by Optical Components Evolution

4.4.b Need for Improved Network Management and Interoperability

One of the biggest challenges for optical equipment vendors is the demand by service providers to improve network management capabilities. Equipment vendors have to carefully analyze issues such as performance management, fault management, configuration management and restoration management. In fact, as the following quotes indicate, manageability and interoperability top the list of carrier's complaints with today's equipment (Figure 19).

- ☞ “We need vendors to focus on making our networks easier to configure. With 30,000 metro rings, we don't have the time or resources to reconfigure a ring each time we add a new optical device” – ILEC
- ☞ “We need integrated network management across multiple vendors to enable restoration and switching. We want our vendors to adopt open management standards – we don't want to get sucked back into the proprietary world we had with Lucent and Nortel” – Backbone provider
- ☞ “After acquiring several smaller carriers, we have equipment from Nortel, Ciena, Lucent and Alcatel. It is a nightmare to get all of these vendors to work together” – Metro provider.

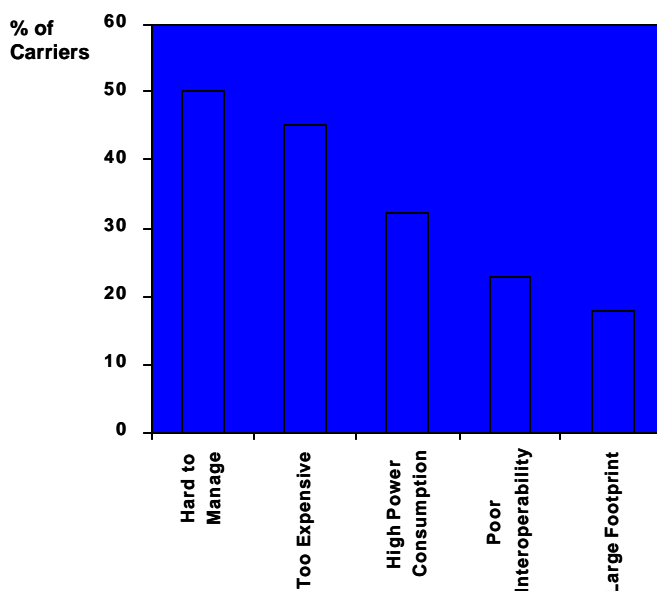


Figure 19: Carrier Complaints with Equipment Vendors

4.4.c Lack of Interest in Integrated Optical Gear

Interviews conducted with carriers servicing access networks reveal that aggregation of multiple services is their main concern. These carriers will pass on the new wave of optical devices that integrate IP, optical, Ethernet and private line services.

- ☞ “The complexity of new all-in-one devices would make our network harder to manage and lock us into a single vendor solution. Cisco gives us everything we need for private line and Ethernet services while Nortel provides us with a best-in-class DWDM platform” – CLEC
- ☞ “Many of the integrated products were designed for CLECs. The probability that they are best-in-class for all services is nil. We won't sacrifice quality for efficiency” – ILEC
- ☞ “We want the best product for the job, but we couldn't keep up with the 45 vendors that came in here. We are a network company, not a lab for vendors to troubleshoot their equipment” – Access and metro carrier

4.4.d Need for Flexible Equipment

Long-haul carriers do not seem to be interested in equipment that provides more capacity, instead they want more flexible DWDM and optical switching products that add or shift bandwidth when it is needed.

☞ “Today’s optical switches are just sophisticated patch panels. We want a system that can take raw wavelengths and switch them wherever we need them to go” – Backbone provider

☞ “We need one DWDM system where we don’t have to make a tradeoff between speed, wavelengths and reach” – Backbone provider

4.5 Suggested Strategies for Managers

4.5.a New Optical Product Development

Broadly, equipment vendors should focus on the following areas with respect to their future product development plans.

☞ Acquire leading edge technologies that cannot be developed internally.

☞ Provide migration path from legacy electronic systems to optical systems.

☞ Enable service providers to leverage existing assets and capabilities at minimal additional cost.

☞ Manage product portfolio – hedge against disintermediation of niche products.

☞ Utilize open consortia to establish new standards “friendly” to new entrants.

Further, optical equipment vendors need to accommodate service providers’ new priorities by making fundamental shifts in their product development priorities. As carriers demand “smarter” capacity, optical equipment vendors need to make their products more:

(1) Adaptable: Future optical gear needs to deliver specified amounts of bandwidth at the right time anywhere in the network. This gear should let carriers rapidly adjust to unpredictable customer demands and decrease time-to-revenue by creating new network connections in days rather than months.

(2) Manageable: New optical gear needs to make carriers’ network operations easier by improving network monitoring and configuration capabilities. This will improve network reliability, thereby saving carriers money.

(3) Interoperable: Equipment vendors should aid the carriers in reducing their operating expenses by deploying interoperable gear that requires fewer tweaks to work with back-end operational support systems.

Further, vendors should take care to not spread their product development resources too thin. They should focus on developing products within their core skill set and partner with other vendors to add other features and thereby provide a complete solution.

4.5.b Narrow Product Scope

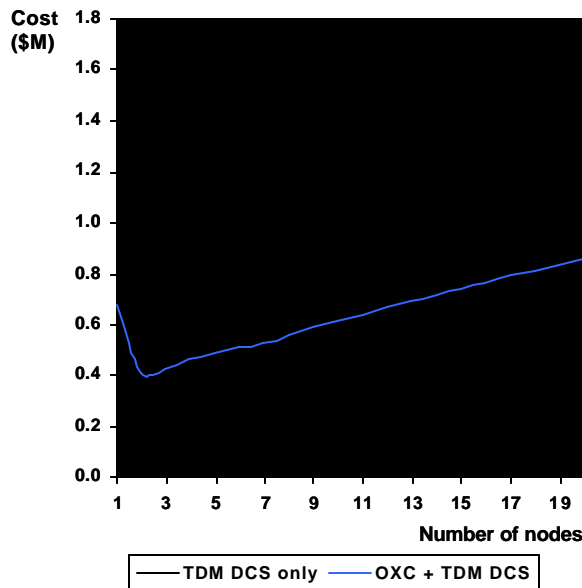
Optical equipment vendors need to narrow their product scope. Established carriers like SBC and Qwest are looking for the best-in-class for the particular service, not one product that does everything moderately well. Here, vendors should follow the leads of companies such as Riverstone Networks and ONI, which have successfully built best-in-class Ethernet and DWDM products, instead of all-in-one devices. The era of the all-in-one devices may have worked for less complex technology products, but does not apply to complex optical equipment. The key is to “provide simple solutions”.

4.5.c Target Fewer Customers

Vendors like Lucent and Nortel risk losing business if they cannot support customer demands and provide quality service to them. This has become particularly challenging due to the numerous layoffs and workforce reduction that these companies have undergone. This can only be achieved if the vendors stop focusing on low-tier carriers and concentrate on deeply penetrating key customers. This will enable these vendors to manage their inventory on pace with customer demand and also provide value-added services to their customers – both of which are key for customer retention.

4.5.d Lower Costs for Service Providers

Vendors need to focus on coming up with software, component and manufacturing enhancements that will reduce the capital and operating costs for the carriers. In this recessionary economy, this will be crucial to improve demand for optical equipment. Figure 20 below indicates how the presence of an optical cross connect in a switch provides tremendous saving to POP providers.



Source: Tellium

Figure 20: Lowering Costs of Carriers Through Product Innovation

At the same time, the vendors need to “deliver more for less”. This implies that some of the desirable network functionality mentioned previously should not be a reason for vendors to increase their prices.

4.5.e Reduce Time to Market

Vendors need to be able to predict well in advance the needs of carriers. Carriers typically spend 9 to 15 months in evaluation equipment before they deploy it. Hence, vendors typically have a short window to cut their costs for deployment. They also need to move faster than their competitors in order to reach the carriers first. This underlines the ability to forecast the technological needs of the carriers and also reduce the time to innovate and market.

5.0 Key Challenges for Component Manufacturers

5.1 Financial Issues

5.1.a Prohibitive Costs

Currently, many optical components are prohibitively expensive. Table 5 gives a good indication of how expensive these components might be.

<u>Component</u>	<u>Price</u>
Optical Modulators	\$ 3,000-5,000
Semiconductor Lasers	\$ 1,000-2,000
EDFAs	\$ 400,000
Tunable Lasers	\$ 15,000-28,000
Amplitude Modulators	\$ 4,500

Table 5: Exorbitant Prices of Optical Components

A typical optical network element can be constructed from 10s to 100s of these components – this ends up making the optical element very expensive. Several key factors currently drive the high cost of optical components. Some of them are enumerated below:

- ✂ Use of discrete components: Optical components are currently constructed of discrete pieces that must be manually assembled, packaged and tested (e.g. fiber thin film, lenses and detectors).
- ✂ Labor intensive: Current manufacturing processes are not well suited for automation with room for little economies of scale.
- ✂ Low yields: The industry average of the manufacturing yield for some components is as low as 20%.

5.2 Technology Issues

5.2.a Evolution of Optical Component Technologies

The optical components industry is very technology dominated. Market dynamics play a much lesser role when compared to technology and manufacturing issues. Currently, there are several different optical technologies on the horizon. The evolution of components will be dependent upon the technologies that are adopted. Some of the technologies likely to impact component evolutions are MEMS, tunable lasers, VCSELs, semiconductor amplifiers and modulators, electro- and non-linear optics. Each of these technologies has its own advantages and disadvantages. The winner is unclear currently. This inhibits the component manufacturers from planning ahead or even designing the components required for the winning technologies. Many technical challenges lie ahead for component manufacturers. Table 6 below lists some of the key technical challenges faced by them.

Category	Technical Challenges
Amplifiers	<ul style="list-style-type: none"> - Broadband optical amplifiers - Amplifiers with flat gain profiles - Lower cost amplifiers - Dynamic gain equalization
Lasers	<ul style="list-style-type: none"> - Wavelength selectable and tunable lasers - Closer wavelength spacings - Wavelength stabilizers and lockers
Passive devices	<ul style="list-style-type: none"> - Chirp/modulation width control - Better and dynamic dispersion compensation - Tunable and low-cost filters
Fiber	<ul style="list-style-type: none"> - Low loss fiber - Lower chromatic dispersion - Minimal polarization mode dispersion - Fiber with minimal optical nonlinearities
Active devices	<ul style="list-style-type: none"> - Switches, OADMs and cross-connects - Reconfigurable OADMs

Table 6: Key Technical Challenges for Components

5.2.b Manufacturing

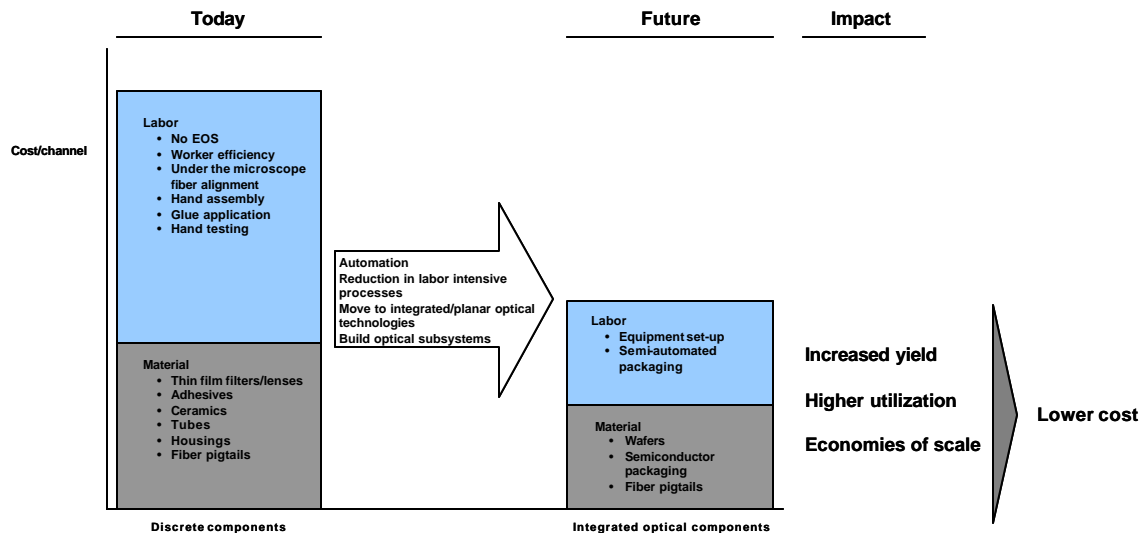
Component manufacturing continues to remain a concern for most equipment vendors. With rapidly evolving technologies and constant innovation, component manufacturers have constant manufacturing problems. In the past, they have not been able to produce components at large capacities/volumes. This leads to component shortage in the market, which in turn leads to unsatisfied end customer demand. Currently, due to the downturn in the market, there seems to be excess component manufacturing capacity.

Further, manufacturing is often very labor intensive, especially for passive components. Component testing is currently done late or at end of manufacturing process. This leads to wasted manpower, limited manufacturing capacity and the yield issues referred to previously.

5.3 Suggested Strategies for Managers

5.3.a Use of Automation in Manufacturing

Significant room for cost reduction exists through increasing manufacturing yields alone. In addition, increase in automation will further lower costs of manufacturing. Figure 21 below illustrates how automation in manufacturing will lead to not only increased yield but also higher utilization and economies of scale that finally result in cost reduction.



Source: Kymata

Figure 21: Automation in Component Manufacturing

5.3.b Acquire Significant Manufacturing Capabilities

In order to achieve automation, component vendors need to invest in upgrading or creating significant manufacturing capabilities. If this results in excess manufacturing capacity, it should be “outsourced” for non-core technologies. Further, in order to avoid excess manufacturing capacity, vendors should partner with semiconductor manufacturers and leverage their manufacturing capacity, utilization, scale and automated manufacturing expertise. Such alliances might also be a key for cost competitiveness.

5.3.c Reduce Time to Market

As the complexity level of optical modules continues to increase, time to market will be a critical success factor for component manufacturers. Companies with all the necessary elements in place – R&D, technical manufacturing expertise, directed sales efforts and skilled management stand to gain first-mover advantage in this rapidly evolving market. Component performance and design and manufacturing expertise will be as important as a sound system architecture and design.

6.0 Conclusion

The Optical Telecommunications industry is currently in tremendous turmoil, and has thus served as an excellent case for study of “Management under Uncertainty”.

As the telecommunications industry evolved rapidly in the 1990’s and increased its reliance on optical technology, the value chain appears to increasingly mirror that of the computer industry. The emphasis is now on “best of breed”, niche technology leadership.

Our analysis reveals some unique characteristics of this industry, which in certain ways defy traditional management thinking. Traditionally, a product life cycle evolves through 3 discrete stages of differentiation: (i) technology leadership, (ii) low cost, and (iii) customer intimacy. In the optical equipment industry, this discreteness has evolved to a continuum, since technology differentiation and low cost leadership strategies are being pursued simultaneously. This radical deviation from conventional product evolution strategy was fueled by very high end-customer demand expectations and capital infusion from 1996 to 2000. As growth rates have slowed, players across the value chain in the industry find themselves in a difficult situation; reduced volume of sales at decreasing prices does not generate the cash flows to subsidize new technology development. External financing for such development is not easily available either. The traditional life cycle is further challenged by the recent emergence of two new imperatives: (i) customer intimacy strategy as a key success factor, as evidenced by vendor interviews in this paper, and (ii) the necessity to deliver a suite of service solutions, with the actual products as a mere means towards this end. Thus, the nascent, immature optical telecommunications industry is experiencing all the symptoms of a mature industry/product.

The various strategies we have suggested in this paper can be summarized into one single over-arching strategy for managers – a strategy of integration, optimization and collaboration throughout the value chain.

- ✍ Within this value chain, each player will focus on maximization of end-customer value. This will increase demand for products and services, and will thus generate volumes necessary to generate sufficient cash flows for new technology development, decreasing reliance on external capital.
- ✍ In the quest towards increasing power in the value chain, and to appropriate maximum value, each player will strive to develop a core focus, offer a best of breed solution, and create end customer brand recognition (on the lines of “Intel Inside”).
- ✍ As the value chain attempts to provide a single window solution to the end-customer, integration within the value chain will improve substantially, as the suite of solutions will encompass product and service offerings of multiple vendors within the value chain.
- ✍ Improved integration will enable increased sharing of end customer data, which will result in more accurate demand forecasting throughout the value chain; the industry will eventually move to a JIT manufacturing system, reducing inventory costs, optimizing manufacturing processes, and thus lowering the overall cost structure of the value chain.
- ✍ Service solutions typically result in higher margins; this coupled with lower costs will result in significantly enhanced profitability across the value chain – which is the end goal of all managers.

The current “crisis” in the industry is an excellent opportunity to experiment with disruptive change in management strategy. We believe that managers in the optical telecommunications industry are thus currently well positioned to implement such a paradigm shift in the industry. Lessons learned from “Managing Under Uncertainty” in this industry are extremely applicable to other areas of the high-technology industry, and can be adapted to non-technology intensive industries as well. We recommend that all successful managers recognize the imperative to maximize end-customer value; a value chain approach to operating strategy appears to be the optimal way to achieve this end.

7.0 Appendix

Interview Information and Templates

Interviewees

Interviews were conducted with the following professionals/firms as part of our primary research.

1. Sathya Narayanswamy, Riverstone Networks
2. Mukul Chawla, Cisco Systems, Inc.
3. Vikram Pavate, Summer Intern, Onetta
4. Executives at Enron Broadband Services and Global Crossing

Interview Templates

(1) EQUIPMENT VENDOR INTERVIEW

Research and Development

Demand forecasting

What are the key variables that drive demand for optical equipment? - Please rank these variables in declining order of importance

What are the key information sources for these variables?

Supply forecasting

What are your key sources of market intelligence for supply forecasting?

Is there overcapacity in optical equipment manufacturing?

Product Research

What % of sales revenue is Product Research?

What is the optimal strategy to balance the continual need to innovate with the risk of technology overshoot (e.g., Gigabit Ethernet as a cost effective alternative to Metro DWDM)?

Product Development

What is the turnaround time from product conception to market in light of the “9 month” law for optical equipment?

How do optical technology improvements and the movement to network simplification affect the product value propositions? How important is the role of component suppliers in the development process? How tightly are they tied into the Product Research and Development function?

Procurement

Supplier base – single vendor sourcing or multiple vendor sourcing?

Pricing

How important a role has cost played in determining prices of optical equipment? Is there a lot of pressure to decrease costs in order to lower prices? (from carriers/customers)

Strategy

What is your key source of competitive advantage?

What do you differentiate on most - cost, technology, or customer service?

Do you foresee consolidation in the industry?

Do you form industry alliances to create complementors and thus sustain a product standard?

What are the benefits / deficiencies of pursuing a niche product strategy versus a broad product range strategy?

(2) SERVICE PROVIDER INTERVIEW

When and where should carriers deploy new optical equipment? What is the migration path to the next generation of optical networking?

How does the increased performance / price of optical equipment alter the cost positions of carriers?

Are carriers still funding the large capital requirements required to deploy optical networks?

How has bandwidth demand affected network/services deployment in 2001?

(3) COMPONENT MANUFACTURER INTERVIEW

What is the role of component suppliers in the optical equipment product development process? How tightly are they tied into the Product Research and Development function of optical equipment manufacturers?

Given the manufacturing constraints and long-term technology demands currently facing this industry, what is the optimal corporate development strategy to deal with these issues?

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