Goldman Sachs

Technology:
Telecom Equipment

U.S. Research

U.S. Recommended List

July 30, 1997

Ciena Corporation (CIEN)

Breaking the Bandwidth Barrier

Analysts

Mary C. Henry
mary.henry@gs.com
(212) 902-6787

Veronica W. Foo
veronica.foo@gs.com
(212) 902-3475

Valuation (X)

Absolute	1997E	1998E
P/E (Cal)	49.3	43.4
Relative		
P/E (Cal)	2.5	2.3

Performance (%)

	1 mth	6 mths
Absolute	20.2	NA
Rel to S&P 500	13.2	NA

Stock Data

52-Week Range	$57-22
Indicated Dividend	Nil
Yield	-

Capitalization

Market Capitalization (mn)	$5,667
Net Debt (cash) (mn)	-$178
Shares Outstanding (000s)	104,457

Price: $54.25 **S&P 500: 942**

- **We have added the stock to our U.S. Recommended List; we expect the stock to achieve at least an $80 price target in the next 12 months.**
- **Ciena is the leading provider of dense wave division multiplexing (DWDM) systems. The largest U.S. interexchange carriers already use Ciena's technology to strategically expand bandwidth.**
- **The market for this new technology is very large and only beginning to unfold. As DWDM is deployed more broadly by carriers, Ciena's opportunity should scale upward meaningfully. Ciena's revenue ramp is already unprecedented.**
- **Ciena's growth prospects are the best in the group. We believe there is opportunity for further significant increases in estimates.**

Table of Contents

Investment Summary

We have added the stock to our U.S. Recommended List with a minimum price target of $80 over the next 12 months. Two quarters after its initial public offering (IPO), Ciena continues to rack up the records: (1) steepest revenue ramp for any company in history, we believe, in the first 12 months of product shipments; (2) most profitable company ever in its first year of product shipments; (3) largest market capitalization of any new IPO, excluding spinoffs; and (4) largest follow-on offering for a technology company. We expect Ciena to break further records in coming years. We believe that the company could reach $1 billion in cumulative sales at some point in the next fiscal year.

We regard Ciena as one of the few companies in telecom equipment capable of creating a sea change in network design, and we expect Ciena's dense wave division multiplexing (DWDM) and other optical network products to eventually be used worldwide.

Wave division multiplexing (WDM) is the process of splitting a lightwave into colors, allowing multiple channels to be multiplexed onto a single fiber, thus creating a significant and strategic expansion in carrier bandwidth. Ciena's technology, which expands bandwidth as much as 16-fold today, is being used by long-distance carriers that urgently need more fiber capacity. The deployment of DWDM by Sprint and Worldcom alone is already creating annual revenue of hundreds of millions of dollars. Forecasts of billions of dollars for this market are now emerging.

We note the following:

- **The market for DWDM will be one of the largest new markets to emerge in telecom equipment in the next several years.** Hundreds of millions of dollars of equipment have already been shipped to domestic long-distance networks, and we believe that new international markets and new carrier markets can expand this market to billion-dollar status in the next few years.

- **Ciena should be the leader in DWDM for years to come.** Two of the four largest interexchange carriers (IXCs) already use Ciena as their primary DWDM supplier, and AT&T is expected to trial Ciena's equipment by yearend. Ciena not only has a significant technology lead, but its management has a proven ability to ramp the company at an unprecedented rate.

- **Ciena's earnings leverage is greater than that of any other company in our universe right now.** Both quarters reported after the IPO in February showed very significant positive surprises. With a few customers that need to deploy this equipment rapidly for strategic reasons, relatively high product margins, and current revenue growth in excess of expense growth, Ciena should be able to post very strong results for many quarters.

- **In the past four months, the stock has been driven primarily by revenue and earnings surprises created by existing customers.** In the next year, we expect the stock price to be driven primarily by new customers and new products, providing investors with a view of Ciena's longer-term opportunity. Regional Bell operating companies (RBOCs), international Postal Telephone and Telegraph authorities (PTTs), new IXCs, and competitive local exchange carriers (CLECs) should begin to place their first orders for Ciena's equipment. Within a year, we think that Ciena's customer base will have tripled.

- **We believe that the stock's price can reach at least $80 in the next 12 months, based on our current fiscal (October) 1999 forecast of $1.60 and a multiple of 50.** A surprising number of telecom equipment stocks are beginning to trade on 1999 estimates now, and we consider Ciena's growth prospects the best in the group.

- **The stock is also one of the most volatile in the group, a trend that will probably continue.** The technology is complex, and the customer base is still very concentrated. Competitors such as Lucent are expected to make product announcements soon. Seasonality and pricing pressures are built into our model, and they could both affect the stock's price. Significant stock distributions will occur during the first week of August and the first week of October. These factors are not material to Ciena's longer-term opportunity, in our view.

Results and Forecasts

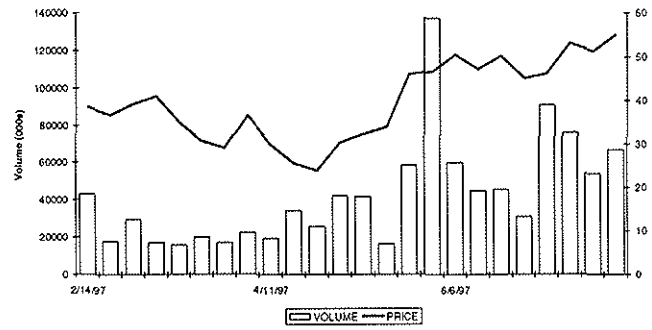
Oct Year	Earnings Per Share Amount	% Change	Consensus(a)	Operating Income Amount	% Change
1996	$0.15	NA		$ 16.4 mn	NA
1997E	0.95	533.3 %	$0.96	158.0	863.4 %
1998E	1.20	26.3	1.21	195.5	23.7
1999E	1.60	33.3		291.0	48.8

(a)First Call consensus estimates.

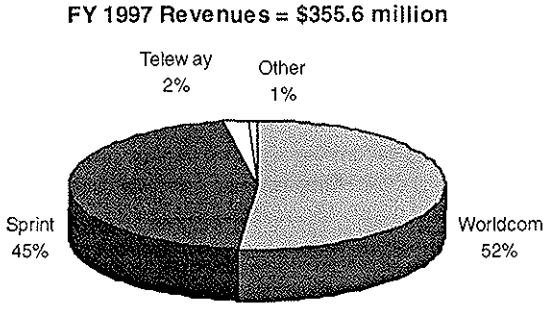
Company Profile

Ciena is the leading provider of dense wave division multiplexing (DWDM) systems. The largest U.S. interexchange carriers already use Ciena's technology to split a light wave into colors, allowing 16 channels to be multiplexed onto a single fiber, thus creating a significant and strategic expansion in carrier bandwidth. A 40-channel system should be available by early next year.

Price Chart



Sales Breakdown



Source: Goldman Sachs estimates.

Stock Ratings

GL =	Global Priority List*	TB =	Trading Buy	MP =	Market Performer
PL =	Priority List	MO =	Market Outperformer	MU =	Market Underperformer
RL =	Recommended List				

***Also on Region's Priority or Recommended Lists**

The Need for Bandwidth

The past year has wrought a fundamental change in the way that network capacity is viewed in the United States and worldwide. For many years, there was a widely held belief that a "fiber glut" existed, that too much fiber had been laid in the post-deregulation 1980s, that opto-electronics had the power to dramatically expand the capacity of the installed fiber, and that transport prices would continue to plummet based on the excess capacity in the long-distance networks. The fiber glut was seen to affect both local and long-distance networks in the United States. International markets had less excess capacity because the networks were still largely controlled by the PTTs, and new operators had not been able to overbuild to the extent seen in the United States.

By early 1996, it was becoming clear to several North American long-distance operators that the term "fiber glut" was rapidly giving way to a new term, "fiber exhaust." When many of the original network operators had constructed their networks in the 1980s, they never envisioned today's bandwidth requirements, and they tended to be capital-constrained. Therefore, they laid long-haul networks with relatively few fibers. Data was only a small part of the traffic mix, and voice traffic was growing slowly. As they combined to form such large IXCs as Worldcom, the network engineers focused primarily on developing uniform switching and services across their networks, not on expanding bandwidth.

The most recent Federal Communications Commission (FCC) figures on fiber utilization are from 1996 (see Table 1), and even with these numbers, one can see the impending capacity problem. Since these numbers were gathered, limited new fiber has been laid, traffic growth has soared, and SONET rings have begun to be implemented (requiring roughly twice the bandwidth of the old linear architectures). Most studies today suggest that most fiber networks are fully lit.

Last year, at least three factors combined to change the forecasts for bandwidth requirements. The rising importance of data traffic, new carrier architectures to improve network reliability, and telecom deregulation legislation all contributed to a dramatic shift in expected capacity needs.

Table 1: IXC Fiber Utilization

Carrier	1994 (%)	1995 (%)	1996 (%)
AT&T	50	47	60
MCI	75	78	84
Sprint	65	77	83
WorldCom	69	69	70
Stentor	75	77	79

Source: FCC, ryan hankin kent

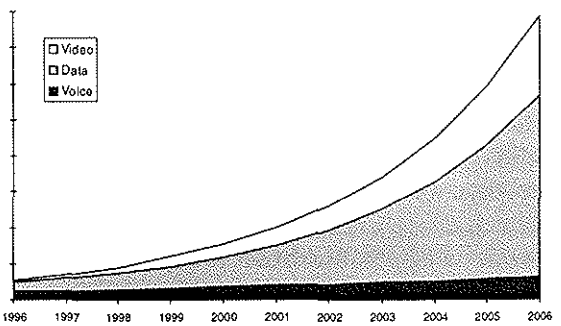
Suddenly, bandwidth was seen as a strategic weapon for service operators.

The Rising Importance of Data

By the middle of last year, most U.S. operators were reporting that data traffic now accounts for more than half of total traffic, and it continues to grow an estimated 35% per year, at least. These network operators have been accustomed to seeing most of their traffic, voice traffic, growing at single-digit annual percentage rates. Now, most of their traffic, data traffic, is growing three or four times as fast. Extrapolating these trends for even a few years produces forecasts of network capacity requirements many times that of today's networks (see Figure 1).

The drivers of data growth seem permanent. Business data services are becoming better and more affordable every year as operators try to capture traffic that once traveled on leased lines. Enterprises building private wide-area data networks are requesting dedicated synchronous optical network (SONET) pipes of OC-3 and OC-12 speeds at an

Figure 1: The Rising Importance of Data



Source: Goldman Sachs.

accelerating rate. Operators tell us that they have had to turn down corporate requests for dedicated OC-48 links because of a lack of capacity.

Deregulation

Data growth is spurring the traffic expansion, but deregulation is responsible for changing the way operators view bandwidth. As competition intensifies, we believe that bandwidth can only become more important to the strategies of the operators. Those that have sufficient bandwidth can strike resale agreements, load their networks more efficiently, control a larger share of the market, and keep new entrants from building new capacity.

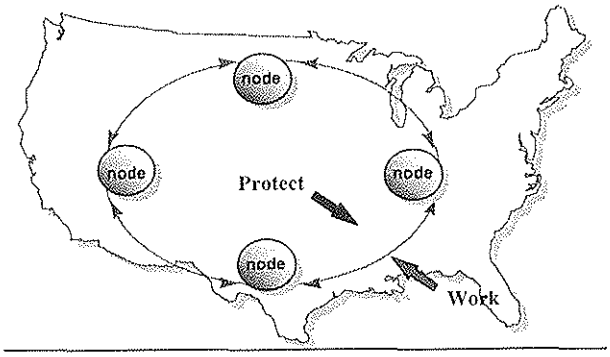
If the long distance companies had sufficient capacity a year ago, they could have been much more aggressive in striking resale agreements, and they could have prevented many of the competitive network facilities from being built. Local access companies would do well to study this lesson before AT&T, MCI, and others begin overbuilding with new technologies in the local loop.

The proliferation and consolidation of operators is also creating the trend of "fiber swaps," whereby operators actually try to exchange fiber pairs within their sheaths for those in another territory, to create larger networks. As operators negotiate with one another, they have a strong incentive to use best-of-breed WDM solutions to create more bandwidth and hence more leverage as they bargain. When a fiber swap is at stake, such issues as channel counts and span lengths become exceedingly important, because they carry definable economic value. Ciena and other WDM vendors are asked to bid now on routes that are slated for swapping as the negotiations are taking place.

The New Ring Architectures: The Ultimate Bandwidth Hogs

Just as the long-haul carriers began to see overall fiber capacity utilization rates of 70%-80% (Table 1), they decided to architect SONET ring networks to eliminate the risk of network outages caused by fiber cuts. With linear, or point to point, fiber architectures, a single fiber cut can create a serious network outage that is difficult to isolate and repair. Often, these cuts occur in a remote geographic location, and the time that it takes to get a technician to the scene means a significant loss of revenue to the network. Bidirectional two- or four-fiber SONET rings (see Figure 2) replace the linear architecture with a logical ring, which loops two-way fiber through major cities and connects the rings with smart electronics. A fiber cut on a SONET ring will trigger a rerouting of the traffic onto the protection path; therefore, there is virtually no downtime. Virtually every major long-distance operator in North America is migrating toward SONET ring deployment. Sprint issued a press release recently advertising that all of its traffic will be on SONET rings by mid-year 1998. Customers are beginning to require the service guarantees that can only be provided using SONET rings.

Figure 2: SONET Ring Architectures



The problem, of course, is that SONET ring architectures require roughly twice the fiber of the old linear architectures, and the carriers do not have much empty capacity. Sprint could not have achieved its SONET ring goals without Ciena. The other long-distance carriers cannot deploy the SONET ring architectures they have promised with their current fiber capacity.

The Bandwidth Alternatives: Adding More Fiber Will Not Be Sufficient

All network operators have ongoing fiber construction programs, but burying more fiber into the network is not sufficient to handle the expanding need for bandwidth. The construction process is lengthy and costly (at least $70,000 per mile). New construction requires right-of-way agreements, which are difficult and expensive to negotiate and sometimes impossible to achieve.

New operators, such as Qwest, have opted to build their own new fiber facilities after trying in vain to negotiate resale agreements with the existing vendors. A series of new operators are combining new builds with resale agreements (e.g., IXC, DTI). The amount of new fiber construction is back up to its record high of the 1980s, when the long-distance network was being built.

Qwest versus Ciena?

Some observers fear that the capacity additions will be difficult to absorb and that demand for WDM will fade as the capacity crunch eases. We regard the demand for bandwidth as insatiable and strategic near term; therefore, we see no reason for new operators such as Qwest to dampen the demand for Ciena's equipment. In fact, we view Qwest as another potential customer for Ciena, although Qwest is using Northern Telecom now. Digital Teleport Inc., another IXC involved in new builds, is using Ciena's equipment as part of each new build, to leverage its fiber construction investment for greater capacity. If more new builds decide to incorporate WDM from inception, the market opportunity will be greater.

Later in this report, we describe in more detail the other reasons that carriers are being drawn to WDM. Over the next few years, we expect most carriers to move rapidly toward optical networking technologies and away from electronic technologies. Optical technologies are increasingly viewed as having much greater inherent capacity and scalability, more flexibility, and greater reliability than electronic solutions. This technology, more than any other, has the opportunity to change the economics of network services.

The Limits of Today's Technologies

Today's carrier networks are characterized by two important features. The network elements are all electronic, and they utilize time division multiplexing (TDM) equipment to expand network capacity. The number of electronic elements in the network today limits the ability of most carriers to capitalize on the inherent capabilities of the fiber optic transmission trunks in their networks. Every time that the light pulses carrying digital information hit a network element, the light must be converted to electronic information, processed, and then reconverted to light pulses until it reaches the next network element. Multiplexers, signal regenerators, cross connects, and switches all have the same effect on optical transmissions – they perform necessary functions, but they limit the performance of the network, degrade the signal quality, add noise, and create multiple points of potential failure. It has been estimated that less than 1% of the capability of installed fiber is being utilized today in a standard OC-48, 2.5 Gigabits per second (Gbps) system.

TDM solutions divide a single channel into multiple time slots, so that multiple streams of information can be combined, or multiplexed, onto the original channel – creating many logical channels out of a single physical channel. Because TDM is the foundation for today's most important optical transmission standards, such as the SONET standard in the United States and the synchronous digital hierarchy (SDH) in other parts of the world, TDM should continue to hold an important place in network technology for many years to come. Current research and development efforts, however, suggest that the next generations of TDM solutions will not be as cost effective as previous upgrades and that the technology is beginning to hit the proverbial wall.

The Drawbacks of Advanced TDM Solutions

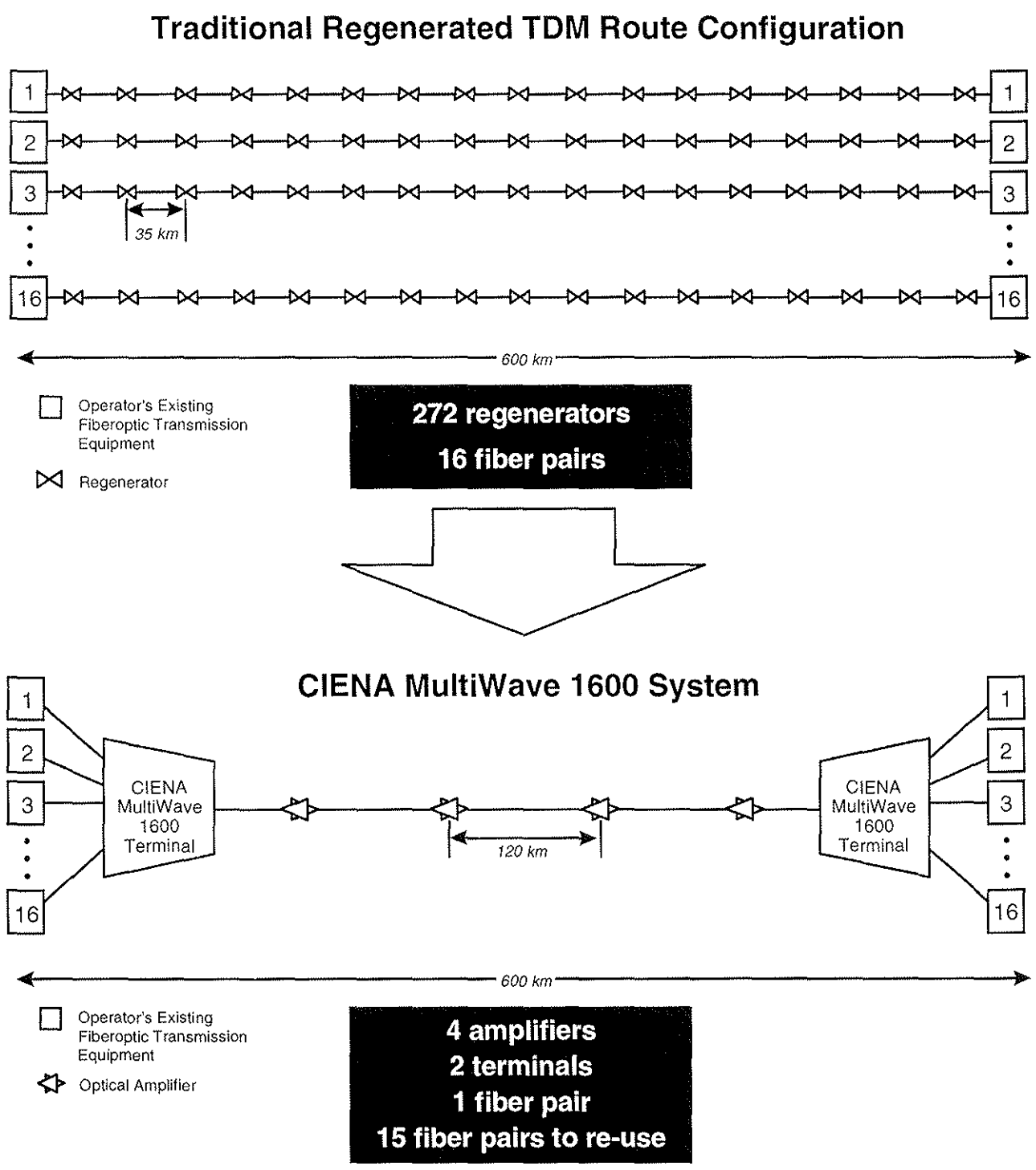
Today's domestic long-distance networks are characterized by 2.5 Gbps channels using the SONET OC-48 specification (see Figure 3). In the past, whenever more bandwidth was needed in a network, operators migrated to a higher TDM standard. The next generation of traditional TDM

Figure 3: Optical Carrier Transmission Rates

OC-3	156 Mbps	
OC-12	622 Mbps	
OC-48	2,488 Mbps	(or roughly 2.5Gbps)
OC-96	4,977 Mbps	(or roughly 5.0 Gbps)
OC-192	9,953 Mbps	(or roughly 10.0 Gbps)

Source: Goldman Sachs

Figure 4: The Ciena Solution



Source: Ciena.

upgrade would use SONET multiplexers to boost the existing fiber capacity to OC-192, which operates at 10 Gbps. Service operators have been waiting for OC-192 solutions for years, and only recently have been able to receive commercial products, initially only from Northern Telecom. While OC-192 equipment will undoubtedly be used in long-haul networks, and TDM technology will be a vital part of the public switched network for the foreseeable future, the ability of this technology to single-handedly solve the bandwidth crisis is questionable.

We note the following:

- **TDM upgrades are complex, costly, and time consuming.** An OC-192 upgrade requires the replacement of every regenerator on the route: On a typical 16-channel, a 600-kilometer (km) route mile, that means 272 regenerators (see Figure 4). All the traffic would have to be reshaped, retimed and remodulated.

- **If a carrier is experiencing fiber exhaust, it may not have the capacity to redirect traffic on the route during the upgrade process.**

- **OC-192 equipment is not widely available.** The multiyear delays that most vendors have experienced in an attempt to deliver the equipment suggests that OC-192 development is complex and that timing is difficult to predict.

- **Today's equipment does not support ring architecture.** Northern Telecom expects to deliver OC-192 ring support in the second half of 1998. Most others, of course, are still trying to get OC-192 point-to-point products delivered.

- **OC-192 equipment may not work on most of the fiber in North America.** Perhaps most dismaying to carriers, when OC-192 equipment becomes more widely available, experts predict that this solution may only work on dispersion-shifted optical fiber, which is estimated to be perhaps 10% of the current installed base. MCI, a longtime supporter of the OC-192 standard, upgraded much of its fiber in anticipation of this issue, which is why it chose the technology. New carriers, such as Qwest, can build their networks with dispersion-shifted fiber, overcoming this issue. For operators such as Sprint or Worldcom, however, with a large installed base of older fiber, OC-192 will clearly be a costly and difficult proposition.

Some operators, such as MCI, have plans to combine OC-192 equipment (10 Gbps) with 4 to 16-channel WDM products, (where one channel equals one wavelength), to create 40-Gbps+ systems that will provide as much as or more than Ciena's 40-Gbps system. Of course, by the time that these systems are installed, Ciena is scheduled to be shipping a 40-channel, 100-Gbps system. It is difficult to envision any operator winning a bandwidth war with a limited solution, but we think that the basic concept of mixing TDM and WDM solutions is viable.

The Market for WDM

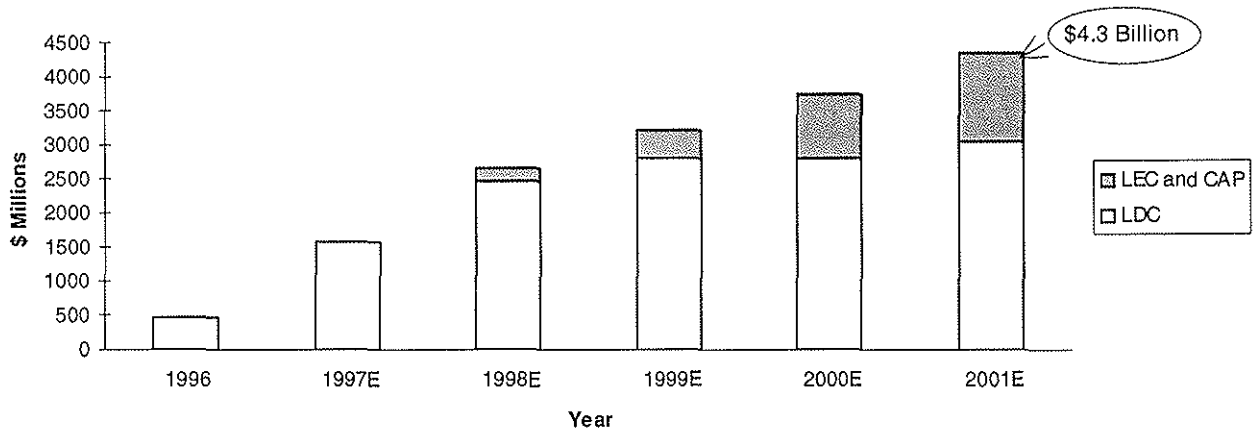
WDM market estimates remind us of data networking market forecasts in the late 1980s; they seem too low, and they will probably be revised upward steadily over the next few years. A year ago, consultants were describing the market size at $50 million. Tellabs' management showed market research in March of this year that suggested a market size of about $325 million in the year 2000. A study by IGI Consulting Inc. published in April 1997 forecasts that 1998 WDM revenues in the United States will reach about $200 million. (With Ciena having already shipped $200 million worth of equipment before the study was released, those numbers seem low.)

We believe that the best study is one published in July by Ryan Hankin Kent, which forecasts that the North American market can reach $4.3 billion by 2001 (see Figure 5). This study excludes the international markets; therefore, investors can safely assume that Ciena will have a reasonably large addressable market to support the revenue forecasts. We believe, for example, that the market in Asia (driven by near-term applications in China) can be at least as large as that in the United States.

Ciena

Ciena's founders had an inherent belief in the future of photonics and began building the company in the early 1990s. David Huber had licensed some optical technology from General Instrument, and Pat Nettles

Figure 5: North American WDM Market



Source: ryan hankin kent, South San Francisco, CA.

was brought on board by the early investors as president and chief executive officer. Dr. Nettles, with a Ph.D. in engineering, also had an important operating role at such companies as Optilink (sold to DSC), Blyth Holdings, and Protocol Engines. The early team studied the market applications and built a product and business plan. With the help of $40 million of venture capital financing, they gradually assembled a first-rate team of photonic engineers and sales professionals.

From 1994 until 1996, Ciena's product was in development. The team worked closely with Sprint's operating engineers during that time; Sprint had ambitious goals for adding network capacity, a number of network constraints, and a strong interest in WDM solutions. Sprint was one of the first customers of Pirelli's 4-channel system, for example. If WDM changes network design permanently, as we believe it will, the combination of early champions at Sprint and Ciena will receive much of the credit.

Setting Records for Revenue Ramp

By the spring of 1996, Ciena was able to ship its first trial systems to Sprint. By July, the company was shipping the product commercially. Within its first four months of product shipment, nearly $55 million of revenue was recorded. Within the first 12 months of product shipment, Ciena shipped nearly $200 million of product. As far as we can determine, this is the all-time record for a revenue ramp by any company (see Table 2).

Table 2: The Record Holders

First 12 Months' of Product Shipments Revenue Ramp	
Netscape	NM
Conner Peripherals	$113 MM
Worlds of Wonder	$117 MM
Ciena	**$196 MM**

Source: Goldman Sachs.

Ciena's First-Generation Product: Multiwave 1600

In contrast to the other options for increasing bandwidth, such as burying more fiber or running faster (10-Gbps) TDM transmissions using OC-192, the Ciena solution provides much more bandwidth; easy, rapid deployment; and an open platform to support multiple vendors' equipment. Ciena is clearly the leader in DWDM today.

The most important WDM feature today, of course, is bandwidth. Ciena is able to offer its customers 40 Gbps of bandwidth on every fiber using the 16-channel system and standard OC-48 links (16 channels at 2.5 Gbps per channel).

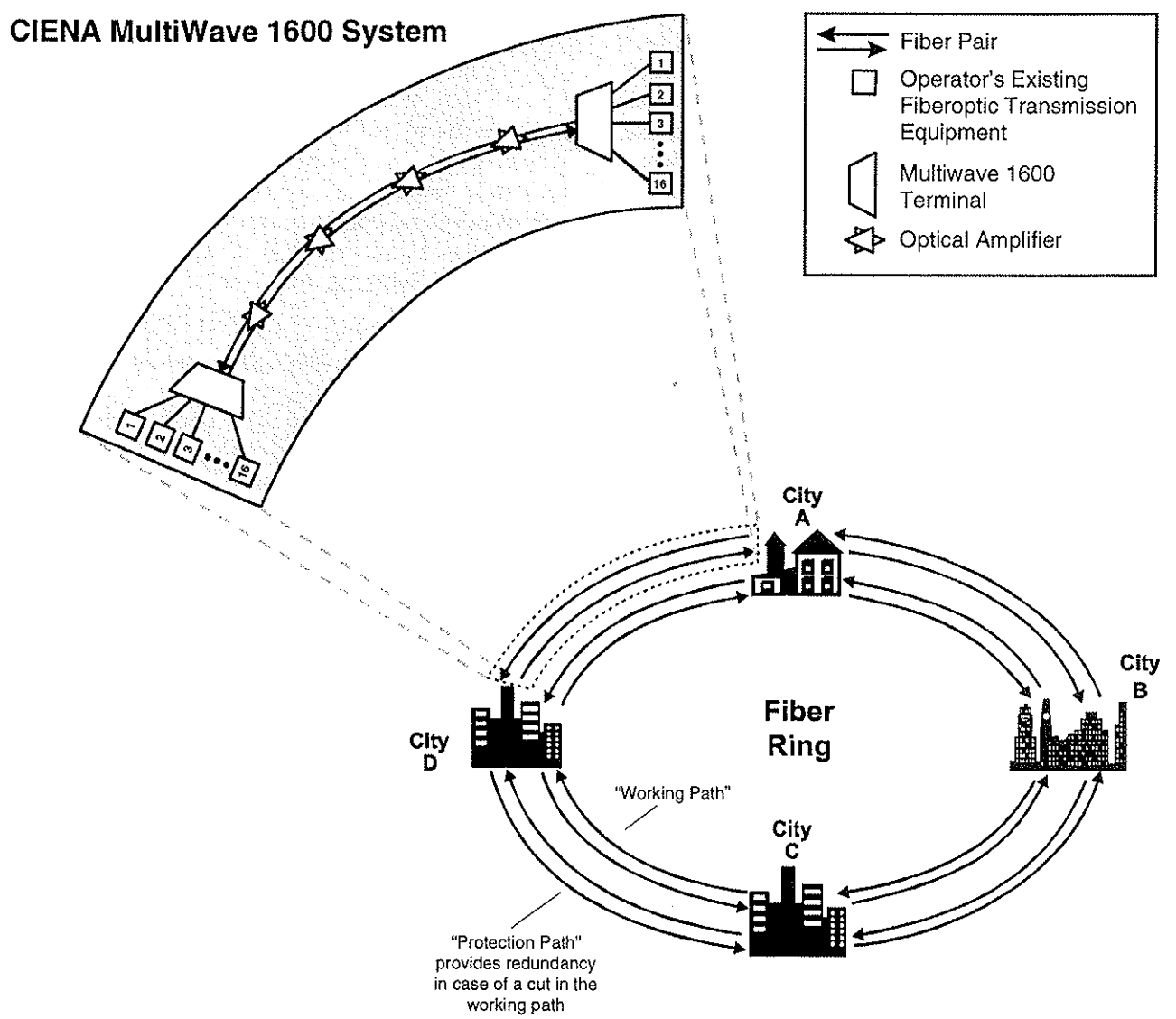
As the competitive environment intensifies, these capacity measures will be critical. Sprint, for example, sees the opportunity to use its network,

which is one-fourth the size of AT&T's, to create a network that is four times the size of AT&T's. Sprint's key technologies are Ciena's 16-channel system and ATM switching.

By the end of this year, we expect Ciena to offer a 40-channel system providing 100 Gbps. Customers of Ciena's 16-channel systems will be able to easily upgrade to the 40-channel systems. We expect most of them to move the 16-channel systems to less dense routes.

Ciena's Multiwave 1600 (see Figure 6) is easy to install; two 8-channel chassis and a controller create the terminal devices, optical amplifiers are installed every 120 km, and Wave Watcher standards-based network management software is provided. The system is modular; therefore, a carrier can buy fewer than 16 channels and upgrade channel by channel, route segment by route segment. Initially, customers were taking fewer than 16 channels and gradually expanding their channel counts within each system. In the April quarter, customers began to install all 16 channels at the outset. This rapid

Figure 6: Ciena's Multiwave 1600



Source: Ciena.

expansion in channel demand should encourage those investors who worry about demand for the 40-channel system.

Customers have given Ciena's equipment rave reviews. The architecture is open and works with any SONET vendor's equipment. The Wave Watcher software is described as "state of the art" by customers, and they are using Ciena to develop custom network management solutions. Worldcom was impressed that the equipment worked easily in the network's worst-quality fiber route, where Ciena was installed first as a test. All the customers describe Ciena as responsive and service-minded.

The system is compatible with nondispersion-shifted, reduced-dispersion-shifted, and, to a lesser extent, with dispersion-shifted fiber-optic cable. Most of the fiber installed in North America and Europe is nondispersion-shifted. (That fiber is not well suited for OC-192 solutions, as we indicated earlier.)

Ciena's Second-Generation Product: Multiwave Sentry

The new Multiwave Sentry system was a surprise when it was announced in late May, given the success of the Multiwave 1600 and given that the first-generation system was less than a year old. Sentry is a next-generation 16-channel DWDM system with several features that reduce network complexity and improve cost effectiveness for long-haul carriers. In particular, Sentry allows SONET, asynchronous transfer mode (ATM) and Internet Protocol (IP) to be mixed on a common network and allows direct connections to ATM and IP without a synchronous layer. The network management system was enhanced for Sentry as well.

In our view, Sentry probably was developed to accommodate AT&T's required feature set. Was it simply coincidence that AT&T announced its intention to trial the Sentry system about a week after Ciena introduced the product? Ciena's ability to customize its products for carriers and its responsiveness to customer concerns is one of the hallmarks of this young company.

About a week after the AT&T announcement, Cable & Wireless also announced that it would purchase the Sentry system. We expect at least $15 million to be recognized next fiscal year from Cable & Wireless. Sentry will ship later this year.

Other Products

In addition to Sentry, Ciena introduced its add/drop multiplexer and European version of the Multiwave 1600 in the quarter.

We expect at least one major product announcement every quarter for the next few quarters. These announcements are likely to include the following:

Network Management

Ciena's customers speak very highly of the company's network management capabilities. Ciena apparently embedded a number of important instrumentation hooks into its systems as they were being designed, creating the opportunity for many new software and hardware products to come. We believe that both Sprint and Worldcom are using Ciena's network management expertise to create world-class networks.

Interoffice Systems

Today, the economics of DWDM solutions are more difficult to prove in short-haul applications. By the end of the year, we expect Ciena to introduce an interoffice solution that will address shorter-haul routes, so that it can be used effectively by the RBOCs as well as by numerous carriers in Europe, where the routes tend to cover shorter geographic distances than in the United States. This product is expected to combine lower transmission speeds (e.g., OC-12) with greater channel intensity. Because it is expected to be limited to distances of 80 km and below, it will likely need no amplifiers, which will make it more economical. We expect this product, more than any other, to expand Ciena's customer count. While the size of any deal with RBOCs is likely to be fairly small at first, given that none of them can enter the long-distance market today, we expect the increase in the number of new customer relationships to have an important effect on Ciena's stock price. Similarly, relationships with a number of European carriers can have a very positive effect on the business model. While Ericsson and Alcatel will certainly have an edge with existing PTTs, Ciena should establish a strong position with all the new carriers spawned by deregulation.

The 40-Channel System

Ciena announced the 40-channel system a year ago, indicating that it would ship by late 1997 or early 1998. We expect the product to be ready for testing by yearend, and we believe that a number of the existing customers have already identified routes that are appropriate for the new higher-capacity system. While other companies may announce systems with similar performance (32-channel systems from Pirelli or NEC, for example), we do not expect any other vendor to beat Ciena's deployment time frame for this next-generation system.

Lucent is expected to announce an 80-channel system in the next few weeks, but again, we do not expect near-term shipments. (Lucent's 16-channel system will not be available until September.)

Access Products

By the middle of next year, Ciena should have some important access products available that will enable the company to further enhance its sales into its installed base of customers. At the same time, customers should begin redirecting their optical spending from the initial relief of fiber exhaust to the creation of a more reliable and functional optical network. Ciena should have the products it needs at that time, allowing for very little disruption in the portion of the capital budgets allocated to optical network technologies.

Other Key Strengths: Intellectual Property

Ciena's lead is derived from a combination of leadership in three core technologies. First, the company has licensed key enabling technologies related to its optical signal filtering technology, called in-fiber Bragg grating technology. This is the technology that actually splits the lightwave into colors and contrasts with planar waveguide technology used by Lucent or thin-film technology developed by Corning. Not only does Ciena have more engineering experience with Bragg gratings (led by Dr. Victor Mizrahi) than any other company, but Ciena is perhaps the only company in the world that can grow a significant volume of these gratings in-house. The gratings lab at Ciena's headquarters has built millions of dollars worth of inventory already and has equipment to support a much larger operation. This process, which involves the application of UV light to alter the physical properties of the fiber, is highly specialized and unlikely to be replicated soon by any other company. We believe that one of the motivations of the Pirelli lawsuit (see Risks on page 18) was to gain access to Bragg gratings licenses.

Second, Ciena was one of the first companies to leverage publicly available passive amplifier technology. Erbium doped fiber amplifiers (EDFAs) enable the direct amplification of optical signals without the use of electronic regenerators. These amplifiers, which are placed every 120 km, use the rare-earth element Erbium to excite the light as it passes through the fiber.

Finally, Ciena's network management systems leapfrogged the approach of most other telecom equipment vendors, who have been locked into cumbersome, proprietary network management techniques for years. Ciena designed its software using local area network principles, with an open systems approach that telecom service operators increasingly demand. With the enhanced version of WaveWatcher, the element management capability of the Sentry, and the ability to create custom network management products for its customers, Ciena's network management technology should be a strength for years to come.

Steve Chaddick, senior vice president of products and technologies, and Steve Alexander, the vice president of transport products overseeing the product development, have both been at the company since 1994 and were critical to the product design. Mr. Chaddick was a founder of Tridom, which was acquired by AT&T. Mr. Alexander is the associate editor for the *Journal of Lightwave Technology* and the author of a tutorial text on optical receiver design.

Manufacturing Capability

Manufacturing is a core competency of Ciena. The fact that the company has been able to ramp so rapidly is especially impressive when one considers that these optical technologies are relatively new.

In electronic technologies, vendors can design a system, manufacture some prototypes with off-the-shelf components and programmable silicon, and

then cost-reduce the design with ASICs and subcontract the entire manufacturing process to one of many board-stuffing houses with extra capacity. In optical technologies, many of the components have to be single-sourced. There is no such thing as a "board-stuffing" house for optical systems; each employee has to be carefully trained to handle these sensitive lightwave products.

While Ciena experienced capacity constraints during its first year of product shipments, we believe that the company has ample ability to meet customer demand for its products now. The company is hiring nearly 20 people per week for its headquarters near Baltimore and has roughly 600 employees now. The company recently moved to a new 96,000-square-foot facility, which doubled the manufacturing capacity, and has an additional 57,000 square feet available. Management purchased about a year's worth of inventory for most of the components that could not be dual-sourced and bought controlling rights to the component technology in at least one other case. In addition, the engineers continue to design out and around the most significant single-source components.

We expect ISO 9001 certification by the end of July, and we understand that the quality rating by this committee underscores what customers have already said – that the product quality is first-rate.

Sales and Marketing

Like Mr. Chaddick, Larry Huang was a founder of Tridom, which was acquired by AT&T, and has been the senior vice president of sales and marketing at Ciena since 1994. He has ramped the sales and marketing organization significantly in the past year, adding 30 people as well as indirect distributors internationally.

Perhaps the most important distribution relationship to watch is that with the Japanese trading company, Nissho. Nissho helped Ciena establish its relationship with Teleway, a joint effort of Toyota and the highway authority in Japan, which is now expanding its fiber backbone to compete against NTT. Nissho is now focused on China, where the thin fiber backbone never anticipated the kind of voice growth that is seen today. China is adding the equivalent of an RBOC in access lines every year, and call blockage rates are apparently greater than 50% at peak busy hour. We expect Nissho and Ciena to work with a Chinese partner to help the Ministry of Posts and Telecommunications in China create a solution to the congestion that the country's backbone network is experiencing.

Customers

Ciena is the undisputed leader in DWDM today, and its impressive customer relationships should help the company to secure significant market share for many years.

Two of the four largest IXC in North America have already chosen Ciena as the preferred or exclusive provider for this technology, and AT&T has agreed to trail the systems later this year. Ciena secured a purchase commitment from Spring of $130 million for calendar 1997, although we estimate that Sprint's actual purchases this year will exceed $160 million. Ciena is Sprint's preferred supplier until December 1998.

Worldcom gave Ciena exclusive supplier status through 1997. While the initial volume purchase discounts suggest an intent to deploy at least $80 million of product for the calendar year, Worldcom will significantly exceed that target. By the spring of this year, we think that Worldcom's management had increased its deployment program to become an even larger customer than Sprint. Based on our current estimates, Worldcom should deploy at least $185 million of Ciena's product this fiscal year.

AT&T is obviously the most important IXC in North America. AT&T has somewhat different dynamics at work than Ciena's other customers. The AT&T network was always a bit gold-plated relative to the others; therefore, its congestion problems were probably confined initially to limited routes. In addition, AT&T had used Lucent's 8-channel systems to alleviate congestion over the past year. Now, we think, that AT&T is moving toward a multivendor strategy in WDM (as in most other areas of network technology).

Table 3: Estimated Revenues by Customer

	1997-E				1998-E				1996	1997-E	1998-E	1999-E
	Jan	Apr	July-E	Oct-E	Jan-E	Apr-E	July-E	Oct-E	Year	Year	Year	Year
Sprint	40.0	46.0	40.0	35.0	40.0	40.0	40.0	40.0	54.8	161.0	160.0	120.0
Worldcom	13.9	37.0	58.0	75.0	60.0	60.0	50.0	40.0		183.9	210.0	175.0
Teleway	0.0	3.7	0.0	4.0	0.0	0.0	0.0	0.0		7.7	0.0	0.0
Cable & Wireless	0.0	0.0	0.0	0.0	10.0	10.0	0.0	0.0		0.0	20.0	30.0
AT&T				0.0	0.0	7.0	10.0	15.0		0.0	32.0	100.0
DTI			2.0	1.0	0.0	0.0	5.0	5.0		3.0	10.0	10.0
Other	0.0	0.0	0.0	0.0	0.0	3.0	25.0	45.0		0.0	73.0	365.0
Total	$53.9	$86.7	$100.0	$115.0	$110.0	$120.0	$130.0	$145.0	$54.8	$355.6	$505.0	$800.0

October fiscal years
Source: Goldman Sachs estimates.

In November, AT&T will purchase about $7 million worth of Ciena's Sentry system to begin testing it for deployment. We doubt that AT&T would make such a significant test purchase if it did not seriously intend to deploy the equipment next year. Our model (see Table 3) suggests very modest deployments relative to AT&T's network size. We expect AT&T to continue to use Lucent WDM equipment as well. Obviously, every one of these carriers has had access to all of the product plans of all of the vendors. Their decisions in favor of Ciena confirm the company's technology leadership and further its market leadership.

By deploying its systems into the world's largest carriers, Ciena is able to test its hardware and software more thoroughly than its competitors. It is also able to establish an enviable list of referenceable customers that should help the company to secure the largest contracts. Most important, Ciena's management gets a better view of its customers' network issues than outside vendors, giving Ciena an ongoing advantage in designing new products.

Financials

Ciena has reported two quarters since its IPO in February. The results of both were roughly a year ahead of expectations. While it is impossible to predict surprises of that magnitude in the future, we do believe that Ciena has more revenue and earnings upside potential than any other company in our universe. Preliminary revenues for the July quarter will be reported on August 6, and full quarterly financials will be reported during the third week of August.

The company's financial management, under the direction of Chief Financial Officer Joe Chinnici, is quite conservative. Revenues from new customer shipments and new product shipments are generally recognized six months after the shipment date, after customer acceptance is completely assured. In the January quarter, for example, several million dollars of revenue was deferred into the April quarter. Customers have often paid for the products before the revenue is recognized, which is why days sales outstanding (DSOs) are in the low 30s. (Over the next year, we expect them to rise to more normal levels, perhaps to 60 DSOs or so.)

The rest of the balance sheet is impressive as well. Cash was $180 million at the end of April, before the company received more than $40 million in proceeds from the recent offering. Cash flow will be positive for the foreseeable future. Inventory turns are already 6 times.

Operating Model: All the Ratios Will Moderate

Many investors regard the operating model as "too good" today, with no room for improvement. Sales grew so quickly in the first year that there was no way for management to match expense growth to revenues. Despite hiring 143 people and doubling its manufacturing capacity in the three months of the April quarter, Ciena's margins expanded. None of the current income statement ratios appear to be sustainable over the long term. Management expects every important ratio to moderate over time.

Gross margin is 63% today; the company's long-term model forecasts that gross margin will fall to 52%-55% over the next year or so. The operating margin is 50% today, on its way to 29%-32% in the company's target model (see Table 5.)

Table 4: Ciena Corporation, Operating Results, 1996-1999E

(millions)

	1997				1998				1996	1997-E	1998-E	1999-E
	Jan	Apr	July-E	Oct-E	Jan-E	Apr-E	July-E	Oct-E	Year	Year	Year	Year
Net sales	$53.9	$86.7	$100.0	$115.0	$110.0	$120.0	$130.0	$145.0	$54.8	$355.6	$505.0	$800.0
Cost of sales	20.8	32.0	39.0	48.0	46.0	50.5	55.5	62.5	21.8	139.8	214.5	350.0
Gross profit	33.1	54.7	61.0	67.0	64.0	69.5	74.5	82.5	33.0	215.8	290.5	450.0
R & D	3.1	4.7	6.0	8.0	8.0	9.0	10.0	11.0	8.9	21.7	38.0	64.0
Sales	2.6	4.5	6.5	8.5	8.5	10.0	11.5	13.0	3.8	22.1	43.0	70.0
G & A	6.3 (a)	2.1	2.5	3.0	3.0	3.5	3.5	4.0	3.9	13.9	14.0	25.0
Operating expense	11.9	11.3	15.0	19.5	19.5	22.5	25.0	28.0	16.6	57.7	95.0	159.0
Operating income	21.2	43.4	46.0	47.5	44.5	47.0	49.5	54.5	16.4	158.0	195.5	291.0
Non-operating income	0.3	1.9	2.1	2.5	2.5	2.5	3.0	3.5	0.6	6.8	11.5	3.5
Pretax income	21.4	45.2	48.1	50.0	47.0	49.5	52.5	58.0	17.0	164.8	207.0	294.5
Income taxes	8.4	17.6	18.8	19.5	18.3	19.3	20.5	22.6	2.3	64.3	80.7	114.9
Net income - cont. ops.	13.1	27.6	29.3	30.5	28.7	30.2	32.0	35.4	14.7	100.5	126.3	179.6
Non-recurring items	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net income	$13.1	$27.6	$29.3	$30.5	$28.7	$30.2	$32.0	$35.4	$14.7	$100.5	$126.3	$179.6
EPS - cont. ops	$0.13	$0.26	$0.28	$0.29	$0.27	$0.28	$0.30	$0.33	$0.15	$0.97	$1.18	$1.60
Shares outstanding	99.4	104.5	105.0	106.0	106.0	107.0	108.0	108.0	99.1	103.7	107.3	112.0
Gross margin	61.4%	63.1%	61.0%	58.3%	58.2%	57.9%	57.3%	56.9%	60.2%	60.7%	57.5%	56.3%
R & D	5.7%	5.4%	6.0%	7.0%	7.3%	7.5%	7.7%	7.6%	16.3%	6.1%	7.5%	8.0%
Sales	4.8%	5.2%	6.5%	7.4%	7.7%	8.3%	8.8%	9.0%	6.9%	6.2%	8.5%	8.8%
G & A	11.7%	2.4%	2.5%	2.6%	2.7%	2.9%	2.7%	2.8%	7.1%	3.9%	2.8%	3.1%
Operating margin	39.2%	50.0%	46.0%	41.3%	40.5%	39.2%	38.1%	37.6%	29.9%	44.4%	38.7%	36.4%
Pretax margin	39.8%	52.2%	48.1%	43.5%	42.7%	41.3%	40.4%	40.0%	30.9%	46.3%	41.0%	36.8%
Tax margin	15.5%	20.4%	18.8%	17.0%	16.7%	16.1%	15.8%	15.6%	4.1%	18.1%	16.0%	14.4%
Net margin	24.3%	31.8%	29.3%	26.5%	26.1%	25.2%	24.6%	24.4%	26.8%	28.3%	25.0%	22.5%
Tax Rate	39.0%	39.0%	39.0%	39.0%	39.0%	39.0%	39.0%	39.0%	13.3%	39.0%	39.0%	39.0%
Net Sales			490.9%	203.3%	104.0%	38.5%	30.0%	26.1%	NM	548.5%	42.0%	58.4%
EPS - cont. ops.	NM	NM	174.4%	166.7%	105.5%	6.8%	6.1%	13.9%	NM	552.6%	21.4%	36.3%
Net Sales	42.2%	60.7%	15.4%	15.0%	(4.3)%	9.1%	8.3%	11.5%				
EPS - cont. ops.	22.0%	100.8%	5.7%	3.0%	(6.0)%	4.3%	5.1%	10.5%				

(a) Includes one-time legal expenses of approximately $5 million (per 01/97 10Q).

Source: Company reports and our estimates.

Table 5: Operating Model

	Q3 96	Q4 96	Q1 97	Q2 97	Target Operating Model
Gross Profit	56.6%	61.8%	61.4%	63.1%	52 - 55%
Operating Expenses					
R & D	11.6	7.2	5.7	5.5	9 - 10%
Selling & Marketing	6.7	3.8	4.8	5.3	10%
G & A	6.3	4.8	11.7	2.4	4 - 5%
Operating Earnings	32.0	46.0	39.2	50.0	29-32%
Net Income	59.6%	28.2%	24.3%	31.9%	18 - 20%

Source: Company reports.

This situation reminds us of the early days of Cisco. Sales were ramping at an unprecedented rate, and there was no way to hire enough people or spend enough money to make the income statement ratios look normal. During that time, we believe that Cisco's management took the opportunity to reserve heavily, creating a financial cushion and an ability to manage its quarterly results. At the same time, the cash kept piling up, creating tremendous flexibility for the company. Also, Cisco was able to acquire numerous switching technologies, as those markets were beginning to grow rapidly.

We regard the superior operating model at Ciena as a significant positive, even though we do not expect it to be sustained in its current form. The reserving philosophy is already evident at the company; about $5 million in legal expense reserves were booked in the January quarter. We expect that Ciena will have a fair amount of flexibility and control over its results for many quarters. The shipments are not back-end loaded; Ciena ships product every week, and the low DSOs underscore the linearity in the quarters.

Most important, the company's strong operating model provides Ciena with the financial wherewithal to purchase technologies, products, or companies that can benefit Ciena's business long term, and it allows Ciena to participate in markets where vendor financing is required.

Our Assumptions Are Conservative

The income statement assumptions (see Tables 3 and 4) are conservative, in our view. Our estimates reflect a gradual slowing of today's spectacular growth rate, which reflects pent-up demand for the product today and a steady decline in gross margin. We have assumed a falloff in fiscal 1998 quarterly sales to Sprint and Worldcom versus the peak quarters of fiscal 1997. We have assumed a fairly low contribution (about one-fourth of our fiscal 1998 forecast) for new customers. We have not forecast any revenue for regions, such as China, that have clear demand but less certain timing.

Competition: Ciena Will Have Company

If the market for WDM systems is really as large as it seems, then it makes sense that Ciena will have a fair amount of company. Announced competitors include Lucent Technologies, Ericsson, Alcatel, Northern Telecom, NEC, Tellabs, Newbridge Networks, Pirelli, Hitachi, and Siemens. At SuperComm 97, WDM was practically the theme of the show. At Telecom Asia 97 in Singapore, several vendors were featuring WDM products. This announcement activity will only increase in the next several quarters, and every announcement will probably fluster a few Ciena investors.

Upcoming Trade Shows for WDM Products

NFOEC'97: September 21-25, San Diego
NCF/Infovision'97: October 20-24, Chicago
USTA Convention: Oct 26-29, Chicago
ComNet '98: January 26-29, Washington, DC.
OFC ' 98: February 22-27, San Jose
SuperComm'98: June 7-11, Atlanta

The Telecom Giants

Lucent Technologies is the most significant competitor since Bell Labs provides Lucent with the most substantial resources in optical networking. Lucent also has the advantage of having installed 4- and 8-channel systems into AT&T's network for more than a year.

However, Lucent has been behind Ciena with its DWDM solution. The 16-channel system was to have shipped earlier this year. The system will not ship for testing until September or October, according to the company. Lucent initially designed its system to work only with Lucent SONET gear and then had to design translator cards so that it could meet operator demands for open systems and multivendor support.

Lucent indicates it will announce an 80-channel system within a couple of weeks, but customers will probably be skeptical about any near-term delivery dates.

If delivery times have slipped for those in the WDM industry, it is to be expected, in our view. Similar to OC-192 systems and SONET cross connects, when vendors are trying to do ambitious things with new technology and the leapfrog products are required to interoperate with different leapfrog products from other vendors, delays are common. Usually, they are measured in years. That is why we have all been so surprised by Ciena.

At its analysts' meeting at SuperComm 97, Lucent engineers indicated that the company is also re-evaluating its optical signal filtering technology. Optical signal filtering is the technology that splits the lightwave; it is fairly basic to the design of a product. Lucent indicates it is comfortable with its current planar waveguide technology for the less dense systems; but newer products may require a different approach.

In any case, the telecom giants – such as **Lucent, Northern Telecom, and Alcatel** – should be expected to fight the coming battle in this market on two fronts. First, they will promote the idea of an all-optical networking layer, even though most of those network elements do not yet exist. Second, they will try to tie WDM solutions to OC-192 solutions. Both strategies are designed to recreate some of the proprietary, single-vendor character of the telephone network that benefited the telecom giants for many years. Both strategies also promote the systems integration capabilities of the giants.

All-Optical Technologies

In May, Lucent held a conference call on optical technology. Originally billed as a WDM call, the focus of the call became the all-optical cross connect. (Ciena stock was down in advance of that call and then rose about 4 points during the call as it became clear that Lucent was not presenting any information that threatened Ciena's near-term position. Tellabs stock closed down 3 or 4 points that day as investors began to fear competition in next-generation cross connects.)

The benefits of using all-optical cross connects to reduce dependence on SONET and electronic layer technologies were heavily promoted on that call and at a Lucent analysts' meeting at SuperComm a month later. Northern Telecom and Alcatel will both have optical cross connects as well. Like Lucent, they want their customers to begin planning for an optical layer before any standards for the optical network are in place. Network operators will be forced into single-vendor solutions for optical networks in the early days.

Alcatel has relationships with LCI and IXC, two of the smaller long-haul operators, to supply WDM systems. We expect the company to ship a 16-channel system before the end of the year, and we expect Alcatel to be more price aggressive than other competitors (similar to Alcatel's successful moves to grow its cross connect market share a few years ago). Corporate responsibility for the optical products is moving to Dallas from France, which is a good move, we expect, although some disruption is likely near term. Alcatel has apparently been negotiating a contract for some time with Worldcom's MFS division in France, although we expect MFS to use Ciena elsewhere.

The potential for integrating OC-192 products with WDM solutions was evident with Northern Telecom's Qwest announcement. Northern Telecom is supplying Qwest with OC-192 point-to-point solutions that will be integrated with 8-channel WDM products. Since the 8 channels will support OC-192 10-Gbps transmission, the system appears

to provide 80-Gbps capability. We will get better information on this system as Qwest builds its network. Northern Telecom also has a strong SONET relationship with MCI and other carriers, giving the company a good audience for its products.

Today, none of the OC-192 products support ring technology; we believe that it will be another year before any of those products ship. At that time, Northern Telecom, Lucent, and others are likely to try to convince operators to move away from "best-of-breed" products toward "end-to-end" solutions. Ciena has a fair amount of time and a good deal of financial flexibility to prepare itself for that marketing argument. Many of the OC-192 vendors are likely to want to partner with Ciena, in our view.

It is interesting to note that three giants – Lucent, Northern Telecom, and Alcatel – all have very large stand-alone optical components businesses. Ciena represents one of the largest customers of each of these divisions. While some of these organizations may try to leverage their vertical integration capabilities (bundling the amplifiers, for example), to help their market positions, the executives of the components divisions seem much more focused on pleasing Ciena right now, given the volumes that Ciena enjoys. In any case, Ciena's relationships with the telecom giants are being built quietly.

Other Competitors

Ciena has a broad range of other competitors. **Ericsson** showed an impressive-looking 8-channel system at SuperComm and Telecom Asia. The product is shipping to Telecom Finland for a pilot test this summer. Ericsson's product appears to be targeted more toward shorter-haul routes, typical of Europe, although it has indicated that it is making some progress in the United States with MCI and other operators. As with most of today's vendors, we can evaluate the plans on paper, but we cannot get any good customer references yet.

NEC is expected to begin to test its 32-channel system in the United States in August. NEC already has an ATM switching contract from Sprint; therefore, we expect Sprint to at least trial the system. NEC had a reasonably strong position in SONET regenerators; therefore, it has a good deal to lose if it cannot replace those revenues with new WDM systems. Other Japanese companies such as **Fujitsu** and **Hitachi** are looking at this market as well. Hitachi is working with MCI's OC-192/4-channel WDM project.

Pirelli apparently will have a 32-channel system to test at some point. Today, it has 4- and 8-channel systems, and the company is working with MCI as well. Ciena's ability to displace Pirelli at Sprint last year cannot be good for Pirelli's marketing efforts, however. We believe that Pirelli may need access to in-fiber Bragg grating technology for the company to achieve its 32-channel ambitions, which may have something to do with the lawsuit Pirelli initiated last year (see Risks on page 18).

Tellabs acquired some prestigious engineering talent when it hired Dr. Paul Green's team from IBM earlier this year. We expect this group to produce a WDM product that will target a market similar to Ciena's by late 1998. In the meantime, this group can help Tellabs with other optical networking interfaces and technologies.

Newbridge Networks purchased an interest in Cambrian Systems (both Canadian companies) with a different market in mind. Newbridge wants to expand the addressable market for its ATM technology by creating a WDM system that allows distributed ATM switching in a metropolitan area network. The company has indicated that it will be able to begin testing product late this year.

DSC Communications bought NKT in Denmark for its SDH multiplexing technology, but the company also inadvertently received a WDM bonus. NKT has a small unit that has been doing basic research on WDM for several years in conjunction with a local university. By the end of this year, we expect DSC to announce a product.

Other companies, such as **Siemens**, are just beginning to assemble some critical mass in WDM, and should have product announcements the next few quarters. A Bellcore spinoff, **Tellium,** will use engineers from the MONET project to create WDM solutions.

Risks

Ciena's stock price has been relatively volatile. The stock's movements are likely to be more erratic than the company fundamentals. The technology is complex and one that few investors fully understand because it is new. The customer base is seriously concentrated today. Other risks of note include the following:

Competition

As described above, all of the important telecom equipment vendors want to participate in this market. Some of them have TDM business that they cannot afford to lose, some of them simply think this is the biggest market opportunity in telecom. We are encouraged by Ciena's progress to date, and we believe that there is a relatively narrow window this year and next, when carriers will be evaluating product and standardizing on suppliers. Nevertheless, we are treating all of the competitors as serious potential threats to Ciena at this point. The market is still young, and we cannot be sure of the ultimate market shares for some time.

Pricing

Some of the new entrants will use price as a marketing tool. Alcatel has done this in the past. In any case, Ciena's customers understand just how important they are to the company, and Ciena needs to keep them happy with continued cost reductions and price reductions. Earnings models today show that this is happening gradually. However, pricing pressure could materialize a bit more suddenly, hurting the stock price.

Customer Issues

Ciena's products have to interoperate with a number of other network elements, and each customer has a different process and timetable for testing. The craftspeople who install this equipment are familiar with electronic products but not necessarily with optical technology. Simple problems, such as mishandling the cards, can create problems in deployment.

Litigation

The Pirelli lawsuit against Ciena last year, alleging the infringement of five patents, is not much of an investor issue today. Most investors seem to believe that this litigation will be settled over time, but it may take several quarters. After Ciena filed its response to the Pirelli suit, Pirelli withdrew one of its patent claims. Ciena has filed two countersuits, alleging that Pirelli infringed Ciena patents. Trials for all of these complaints will be ongoing from the fall of 1997 through at least the spring of 1998.

Seasonality

Our assumptions reflect a sequential decline in the first quarter of fiscal 1998. Ciena's customers often freeze their long-haul technology upgrade programs around Christmas, when the traffic volumes are highest. Ciena has not experienced a sufficient number of fiscal years to provide much guidance on the likely seasonality.

Distribution of Stock

Just as many numbers associated with Ciena seem unprecedented, the stock distribution issues have not been easy for investors to digest. The initial float at the time of the IPO was 5.7 million shares. Originally, at the time of the IPO, 88 million shares were scheduled for release on August 7. Subsequently, 9 million shares were released after April-quarter results were announced. Another 8 million were distributed in the recent secondary (with another million shares of new stock sold by the company). About 20 million shares of stock are held in the ESOP, but the remaining shares, approximately 55 million, are scheduled for future release. The secondary offering produced new lock-up requirements; therefore, about half of the shares will be released on August 7 and the other half on October 2.

Summary

Investors have been looking for "bandwidth plays" for years now. There is general agreement that bandwidth requirements in every network will increase and that bandwidth and capacity will be the strategic weapons in the carrier wars.

We believe that WDM will become a core telecommunications technology that will permanently alter network design and attract a significant portion of carrier capital spending. As the leader in this market and the only supplier completely focused on this market, Ciena is well positioned to benefit most from these trends, in our opinion.

GLOSSARY

Add/Drop Multiplexer (ADM)	A multiplexer capable of extracting or inserting lower-rate signals from a higher-rate multiplexed signal without completely demultiplexing the signal.
Amplifier	Device used to boost signals so that they can be sent over extended distances.
Asynchronous	Referring to two or more signals which, though they have the same nominal rates, actually operate at different rates.
Asynchronous Transfer Mode (ATM)	A fast-packet switching technology allowing free allocation of capacity to each channel. The SONET synchronous payload envelope is a variation of ATM.
Attenuation	Reduction of signal magnitude or signal loss, usually expressed in decibels.
Automatic Protection Switching (APS)	The ability of a network element to detect a failed working line and switch the service to a spare (protection) line. 1 +1 APS pairs a protection line with each working line. 1:n APS provides one protection line for every n working lines.
Bandwidth	Information carrying capacity of a communication channel. Analog bandwidth is the range of signal frequencies that can be transmitted by a communication channel or network.
Bi-directional	Operating in both directions. Bi-directional APS allows protection switching to be initiated by either end of the line.
Bit	One binary digit; a pulse of data.
Bit Error Rate (BER)	The number of coding violations detected in a unit of time, usually one second.
Bits per second (bps)	The number of bits passing a point every second. The transmission rate for digital information.
Channel	The smallest subdivision of a circuit that provides a type of communication service; usually a path with only one direction.
Circuit	A communication path or network; usually a pair of channels providing bi-directional communication.
Circuit switching	Basic switching process whereby a circuit between two users is opened on demand and maintained for their exclusive use for the duration of the transmission.
Coupler	A device that connects three or more fiber ends, dividing one input between two or more outputs or combining two or more inputs into one output.

Craft	Any personnel whose primary responsibility is the day-to-day operation and maintenance of a network.
Digital Cross-connect System (DCS)	An electronic cross-connect which has access to the lower-rate channels in higher-rate multiplexed signals and can electronically rearrange (cross-connect) those channels.
Digital signal	An electrical or optical signal that varies in discrete steps. Electrical signals are coded as voltages, optical signals are coded as pulses of light.
Digital Subscriber Line (DSL)	Modem compression technologies to send high-speed digital signal through copper wires.
Distributed feedback (DFB) lasers	These are lasers at specific wavelengths, typically in the 1530 to 1560 nm spectrum, that can provide coherent optical output to offset some of the effects of dispersion.
Erbium Doped Fiber Amplifier (EDFA)	This is the dominant method for optical signal amplification in long-haul lightwave transmission systems. EDFA eliminates the use of electrical regenerators or repeaters over a distance and thus the conversion of lightwaves into electrical signals and back to lightwaves. Optical amplification is achieved by incorporating Erbium ions into a special fiber (a process known as doping). An optical laser pump is used to energize the Erbium which directly amplifies the signals and facilitates unrepeatered transmission over 600 km.
Fiber optical terminating system	Network element which terminates the optical circuit. It serves such functions as mapping the service into the SONET carrier and making opto/electrical conversions.
Fiber Optical Bragg Grating (In-Fiber Bragg Grating)	An optical fiber grating is an optical fiber component consisting of a core length of optical fiber, where the core's reflective index has been permanently modified to precisely separate a lightwave into different wavelengths.
Fiber Taper	A legacy public carrier network design in the U.S. that attempts to mirror network traffic by installing higher fiber capacity on each coast but lower fiber capacity in between. Current fiber constraint is exacerbated by this design.
Four-fiber, bi-directional, line switched ring (4-fiber BLSR)	A network architecture deployed by public carriers that allows the rerouting of telecommunications traffic in approximately 60 milliseconds should there be a fiber cut or electronics failure and thus dramatically enhances service consistency to customers, especially for mission critical networks.
Frame	A grouping of data bits in a defined format that comprise one transmittable unit. A frame would likely contain its own control information for addressing and error checking.

Framing	Method for distinguishing digital channels that have been multiplexed together.
Frequency	The number of cycles of periodic activity that occur in a discrete amount of time.
Gigabit	One billion bits.
IEEE 802.6	Standards being developed by IEEE to govern metropolitan area networking.
Integrated Services Digital Network (ISDN)	Method for carrying many different services over the same digital transmission and switching facilities.
ISO-9000 Series	A set of international recommendations for uniform application of customer satisfaction and quality metrics. ISO-9000 accreditation signifies that a company has standard measurements in place along with staff resources capable of applying these measurements to quality processes.
Isochronous	All devices in the network derive their timing signal directly or indirectly from the same primary reference clock.
Kilobit	One thousand bits.
Laser	A device that produces highly coherent light using light amplification by stimulated emission of radiation; lasers are used in fiber optic communication systems as light sources.
Lambda (λ)	The Greek letter lambda, used to signify wavelength.
Megabit	One million bits.
Modulation	Coding of information onto the carrier frequency.
MONET	The Multiwavelength Optical Networking consortium formed by AT&T, Bellcore, Bell Atlantic, BellSouth and Pacific Telesis in 1995 that aims to establish commercial viability of the multiwavelength technology and networking capabilities, while providing the necessary leading edge WDM systems to meet specific Department of Defense needs, and to create a reconfigurable and managed optical network that allows direct optical access and the support of different transmission formats.
Multilongitudinal mode laser	A laser which transmits over a narrow range of wavelengths.
Multimode	Used to describe optical fiber that allows more than one mode of light signal transmission.
Multiplexer	A device for combining several channels to be carried by one line or fiber.

Multipoint service	Distribution of telecommunications services to two or more stations.
Network Element (NE)	Any device which is part of a SONET transmission path and serves one or more of the section, line, or path terminating functions.
Non-Dispersion Shifted Fiber	This type of fiber has been shown to display compatibility problems with high speed OC-192 TDM equipment. Non-dispersion shifted fiber constitutes the majority of fiber installed in North America and Europe.
OAM&P	Operations, Administration, Maintenance and Provisioning are surveillance and monitoring functions which are critical to ensuring smooth traffic delivery in a network and restoring traffic when disruptions or fiber cuts occur.
OC	Optical Carrier - The transport levels (optical transmission rate in the SONET standard: OC-1 at 51.48Mbps OC-3 at 155.52Mbps OC-12 at 622.08Mbps OC-48 at 2488.32Mbps (or roughly 2.5 Gbps) OC-96 at 4976.64Mbps (or roughly 5.0 Gbps) OC-192 at 9953.28Mbps (or roughly 10.0 Gbps)
Optical cross connect (OCS)	A type of cross connect that operates in the optical domain and can provide flexibility in transmitting fiber connections in the central office by routing and grooming wavelengths over assigned or alternate fibers- sending signals over alternate fibers in the same cable, or providing route diversity by sending signals over fibers in physically separate cable.
Optical Fiber	Thread-like filaments of glass or plastic employed to transmit signals (voice, data, or video) in the form of a light pulse.
Optical Filtering	A method of demultiplexing or separating wavelengths.
Optical Splitter	A device that puts the light signal from one optical fiber into two or more fibers.
Packet Switching	A transmission technique that segments and routes information into discrete units. Packet switching allows for efficient sharing of network resources as packets from different sources can all be sent over the same channel in the same bitstream.
Planar waveguides	Technologies used to produce optical devices, even optical integrated circuits, in either glass or semiconductor materials.
Plesiochronous	Each device in the network deriving its timing signal from different primary reference clocks.
Regenerator	Electronic device that restores a degraded digital signal for continued transmission; also called a repeater.

Revertive	A type of automatic protection switching which automatically switches the service back from the protection line after the working line has returned to service.
Ring Architecture	A network design which links transmission paths in a ring configuration, as opposed to linear networks with single transmission paths, so that in the event of a fiberoptic cable cut or other equipment failure between two points of the ring, the signal can be immediately redirected through the reverse "protection path" of the ring and the service break can be restored in approximately 50 milliseconds, essentially unnoticeable by customers. However, the deployment of ring architecture requires twice the fiber capacity for linear networks and will place greater demand on the existing fiberoptic networks.
SDH (Synchronous Data Hierarchy)	The European standard for high speed data, fiber optic transmission.
Signaling	Method of communication between network components to provide control management and performance monitoring.
Single Longitudinal Mode (SLM)	A laser which transmits over a single wavelength.
Single mode	Used to describe optical fiber that allows only one mode of light signal transmission.
Stentor	An alliance of Canada's 11 major telephone companies which together operate the world's longest, fully digital fiber optic network that spans 7,000 km coast-to-coast. The alliance enables its members to pool resources and share expertise in research and development, engineering, and marketing.
Synchronous Transport Signal (STS)	The signaling rate on the electrical connection side of the interface in a SONET transmission which is converted to the same signaling rate on the Optical Carrier level side of the interface. For example, the lowest level SONET signal level 1 (STS-1), has a signaling rate of 51.84 Mbps, which corresponds to the signaling rate of OC-1.
Subframe	Any one of the multiple frames that make up a superframe structure.
Subrate	Requires less than the full capacity available on a transport system's basic frame.
Survivability	A property of a system, subsystem, equipment, process or procedure that provides a defined degree of assurance that the device or system will continue to work during and after a natural or man-made disturbance.
Synchronous	Operating at the same speed, all circuits in a synchronous network are constrained to operate at their nominal rates with no significant variation.

Synchronous optical networks (SONET)	An international optical interface standard established to ensure compatibility of fiber optic transmission products from multiple vendors. In addition to standardizing the physical interface, optical line rates known as Optical Carrier (OC) signals, (See Optical Carrier) have been defined.
Transponder	Also known as translator or remodulator. Essentially, optical-to-electrical and electrical-to-optical converters, with the resulting output at a specific WDM-compliant wavelength that can be combined with other wavelengths and launched down a fiber. A transponder enables the carrier to preserve the legacy equipment while adding capacity through new transmission terminals.
Thin film filters	Stacks of different dielectric materials deposited onto an optical substrate to form optical filters such as wavelength division multiplexers (WDMs), attenuators, taps, power splitters, etc.
Tunable lasers	Lasers with the capability to change the wavelength of the output light to different desired wavelengths.
Unidirectional	Operating in only one direction. Unidirectional APS allows protection switching to be initiated only by the head-end of the line.
Virtual tributary (VT)	A payload structure that specifies where and how a sub-STS-1 signal will fit into a STS-1 frame.
Wave Division Multiplexing (WDM)	An optical transmission technique that can increase bandwidth capacity for a single fiber by dividing the fiber into two or more wavelengths, each of which carries a stream of information. The wavelengths are then separated and directed to separate receivers. Dense WDM refers to systems that support more than eight channels.
Wavelength Add/Drop Multiplexing (WADM)	A multiplexer capable of routing one or more wavelengths without optical-to-electrical conversion by allowing wavelengths to be either added to or dropped from the middle of an optically amplified span.

Source: Goldman Sachs, Applied Technologies Group.

Goldman Sachs Global Research Centers

New York
Goldman, Sachs & Co.
One New York Plaza
New York, New York 10004
United States
Tel: (1) 212-902-1000
Fax: (1) 212-902-2145

Frankfurt
Goldman, Sachs & Co. oHG
MesseTurm
60308 Frankfurt am Main
Germany
Tel: (49) 69-7532-1000
Fax: (49) 69-7532-2800

London
Goldman Sachs International
Peterborough Court
133 Fleet Street
London, EC4A 2BB, England
Tel: (44) 0171-774-1000
Fax: (44) 0171-774-1146

Paris
Goldman Sachs Paris Inc. et Cie
2, Rue de Thann
75017 Paris
France
Tel: (33) 1-4212-1000
Fax: (33) 1-4212-1499

Hong Kong
Goldman Sachs (Asia) L.L.C.
Asia Pacific Finance Twr, 36th Fl.
Citibank Plaza, 3 Garden Road
Central, Hong Kong
Tel: (852) 2978-0300
Fax: (852) 2978-0479

Singapore
Goldman Sachs (Singapore) Pte.
50 Raffles Place
29-01 Shell Tower
Singapore 048623
Tel: (65) 228-8128
Fax: (65) 228-8474

Tokyo
Goldman Sachs (Japan) Ltd.
ARK Mori Building, 10th Floor
12-32, Akasaka 1-chome
Minato-ku, Tokyo 107, Japan
Tel: (81) 3-3589-7000
Fax: (81) 3-3587-9263

Goldman, Sachs & Co. or an affiliate has managed or comanaged a public offering of Ciena securities in the past several years. Goldman, Sachs & Co. or an affiliate makes an over-the-counter market in Ciena common stock. Goldman, Sachs & Co. or an affiliate may deal as principal in any of the securities mentioned.