GILDER TECHNOLOGY REPORT

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Strategic Storewidth

The likely winners in the explosion of digital imaging are Texas Instruments and Zoran

Inside:

The world is now flocking and flacking at the door of Google, the maker of a better mousetrap (called a search engine) and money trap (impending $20 billion IPO). But alert Telecosm and Storewidth investors already have long known how to search for Google. They go to **Equinix** (EQIX), the home of a hundred thousand Google servers, and put their money on this star of Storewidth. Equinix reports that Google's servers break all records for massive density and power consumption and yield a high percentage of Equinix's booming revenues.

Now **Microsoft** (MSFT) and **Yahoo** (YHOO) have announced plans to add some 200 thousand more servers to the search engine fray erupting around the imminent Google IPO. Soon these two estimable arachnids on the web—Microsoft and Yahoo—may well be contending for the title of Equinix's most profitable customer.

Storewidth defines the convergence of bandwidth (breaking out globally even if stifled by U.S. regulators), with storage, expanding massively everywhere. Our leading storewidth player today is Equinix.

But who would buy a stock that has appreciated by a factor of almost 15 in the last year or so? If that stock were Equinix, we would. Like so much of the telecom and Internet worlds, EQIX began 2003 priced for bankruptcy. It ended the year a top ten Nasdaq performer, apparently well-valued. But a mildly dilutive recent consolidation of debt and $75 million infusion of cash led to a price pull-back, and creates a new opportunity for investors. Its balance sheet improvements come at a time when Equinix is gaining a strategic stronghold on storewidth.

Jay Adelson founded Equinix in 1998, and by the time the company was off the ground, large telecom incumbents (**AT&T** –T, **Sprint** –FON), newer telecom upstarts (**Level 3** –LVLT), and hosting specialists (Exodust) had already built millions of square feet of space. Surely, Adelson would only exacerbate the hosting glut and be among the first to go bust.

But Adelson had already built one of the Internet's key network meeting points, the Palo Alto Internet Exchange (PAIX), for his employer, Digital Equipment Corporation. He knew the inner workings and inner politics of the Internet, all the inefficiencies and contentious peering problems. Adelson's proposition was not only to build the most secure data warehouses but also lure all the world's largest networks and content companies into these facilities. Equinix would be a *neutral* exchange, and that would make all the difference.

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In recent months, both Sprint and **Cable & Wireless** (CWP), who acquired Exodus, said they would exit the hosting business. Though AT&T survives as Equinix's top rival, the integrated strategy of running both networks and exchange points for rival networks has mostly failed. When the best-positioned carrier **Corvis** (CORV) recently bought the **Broadwing** fiber optic network, it smartly, and revealingly, did not acquire Broadwing's hosting facilities. Level 3 and AT&T still provide cheap space, but it is undifferentiated real estate. What incentive do network companies have to provide convenient peering to competitors?

If you are a major network, you cannot afford not to be in Equinix

Equinix attracts every network with public (free) peering (reciprocal interconnections). If you are a major network, you cannot afford not to be in Equinix. And if you are a minor network, or a content company, the fact that every major network is in Equinix means you cannot afford not to be there either. Adelson confirms our view, first offered more than four years ago, that as bandwidth proliferates and increasingly links to handheld devices, storage and processing will move toward the core of the net. Equinix data centers move storewidth functions away from telecom central offices and cable head ends and toward a few strategically placed storewidth centers (*a la* our old friend **Mirror Image** –XLA, which previous critic **Akamai** – AKAM is now imitating).

With the shakeout of the Internet hosting business, Equinix has established itself as the indispensable "inter" of the Internet. Exhibiting a network effect within the data center similar to Metcalfe's law—"the value of the network grows as the square of the number of connected nodes"—Equinix's scope and scale create an upward spiral of customer value and substantial barriers to entry for would-be competitors. Building on its current dominance, it offers new standardized, high-margin products beyond cabinet space, power, and neutral peering.

The Equinix GigE Exchange allows ISPs, content providers, and e-commerce companies to quickly and cheaply hook in to a Gigabit Ethernet platform connected to other major networks and ISPs. Data traffic on the GigE Exchange boomed 400 percent in 2003, peaking at 30 Gbps, or almost 10 petabytes per month. The product is so popular that Equinix will deploy a 10 Gigabit Ethernet product by year-end.

Equinix Direct is another new product, where small customers and even larger ones like **Hotwire** or **Macromedia** (MACR) can view and purchase bandwidth anonymously. Though not strictly speaking a bandwidth exchange, Equinix is standardizing products and eliminating politics in a way that enhances liquidity and efficiency in the bandwidth world. These interconnect products today produce just 18 percent of company sales. But Equinix expects that number to rise toward 30 percent in the future, as interconnect sales are growing twice as fast as hosting (space and power) sales.

Leveraged for profitability, Equinix reports that eighty percent of its costs are fixed, but 95 percent of its revenues are recurring, because its customers face high costs attempting to switch to other hosting services. This means that from now on, 70-90 percent of new sales will flow directly to the EBITDA bottom line. But the Equinix market cap of $367 million reflects mostly physical assets like real estate and equipment. Combined with positive operating cash flow, projected EBITDA of $30-35 million this year, and a share price down 30 percent from its recent high, this suggests Equinix is undervalued.

With new markets like online gaming driving needs for centralized processors and storage—"Sometimes I think Electronic Arts (ERTS) is going to rule the world," says one insider—Equinix is as well positioned to capitalize on the Internet as anyone. The largest source of coming demand for new storewidth, however, is sure to be hundreds of petabytes of new pictures and movie clips transmitted from cell phone cameras, soon likely to be equipped with **Foveon** imagers. Foveon's imagers now can deliver near-megabyte JPEG files at a full motion rate of 30 per *second*. Many less endowed digital cameras can transmit 15 per second. By the end of 2004, there will be at least 100 million digital-camera-equipped devices in the world. Assign to each of them a mere 12 gigabytes of images per year by sometime in 2006, and you have a total new payload on the storewidth facilities of the globe of 1.2 exabytes (a billion gigabytes), perhaps three times the current Internet traffic. So watch Foveon, whose saga continued to unfold tempestuously at the Photography Marketing Association convention this month in Las Vegas.

— Bret Swanson with George Gilder

Foveon RAW in Vegas

It couldn't happen to a guru more digitally Delphic than John Dvorak, beetlebrowed futurist, nerd supreme, *PC Magazine* doppelguru, cynical seer through the industry's swell and jiggle to the raw silicone below, virtuoso italicizer, brazen imbolder, crazy new talent at the Consumer Electronics Show, serial keynoter at the Photography Marketing Association, maturing as a vamp in Vegas as familiar as Cirque de Soleil or Penn and Teller and proud owner of a free **Sigma** 10 camera.

From the record breaking CES convention a month earlier in January, so goes the story at Foveon Corporation, Dvorak went on to the wedding of a friend. When the photographer failed to show, Big John saw his chance. He would take the wedding pictures. He would become: John Dvorak,

OfficialPhotographer, which is a lot easier I can tell you than expectorating two pithy columns, full of **bravado** in bold, and *ipinions* in italics, every two weeks for *PC Magazine*.

Under a canopy on a sunny day, the wedding unfolded blithely with a dark foreground and bright background for all the images. If there had been a professional photographer, he would have been gnashing his apertures and filters. But Big John didn't notice. He just clicked away relentlessly. Just like columns. Write enough of them, with enough pungent smug wild-eyed predictions, and if you are Dvorak many will prove to be amazingly on target and your column will be a gas to read. More is more. More is better. Take enough photo shots and some of them will be great, right? And with this super new digital camera bearing the Foveon X3 imager that collects all the light and all the colors at every pixel, he couldn't go wrong.

Arriving home, Dvorak booted up the Sigma Photo Pro software, linked the camera to his computer with a universal serial bus (USB), and rendered his harvest in JPEGs (the familiar compression standard of the Joint Photographic Experts Group—like MPEG for stills—that is ubiquitous on the Web). But what is this garbage on his screen? Dvorak was shocked. Every picture he took was under the dark canopy with the bright background and every picture was dungeon dark with a dazzling halo.

With JPEG images—a global compression algorithm—there was no way to fix it. Change the settings and you just get new permutations of bad pictures. You darken it enough to mitigate the blinding brightness outside and the bride's face disappears under the shadowy canopy. Brighten up the face and the outside scene "whites out" along with the wedding dress. Ready to write the experience off, perhaps with a column dissing Sigma, he made a plaintive call back to Eric Zarakov at Foveon.

No problem, says Eric. This is the digital era, John, just as you said last year giving your friendly keynote advice to all the artsy-crafty analog photographers, moldy fig film retailers, and proprietors of cramped little photography shops that they might as well all just skulk away and use their stores to rent DVDs, because it was time to sing a Hallelujah chorus of digital *uber alles*. And you were right. Once again a prophet in your own time. But for the full scale Foveon effect, you have to use the correct digital format. For redeeming botched exposures, you can't use JPEG. You have to do it Vegas style, in the RAW. The pure undressed, uncompressed output from the light sensors on the camera in digital form. All the bits and bytes from the scene arrayed in an image frame. It will look awful, but don't panic, it is totally accurate; all the information is there.

With just one simple shift of the Hubel FillLite slider bar in your Sigma Pro software, moving it to a level of perfect balance of light and shadow—even hours, days, or years after exposure—you can cook up the RAW data and serve it *au point*. The darkness will be made light and the brightness will be made mute, and the luminance lines will lie down with the chrominance lambdas and all will be well. And so it was.

By early February, when he re-keynoted the Photography Marketing Association bash, also in Las Vegas, Dvorak was a firm member of the Foveon cult. He had experienced the benefits of a real accurate window (RAW) at every pixel coupled with a simple ingenious software algorithm, FillLite, contrived by a hiree of Foveon's chief scientist Dick Lyon named Paul Hubel. FillLite is not exactly unique. Given accurate RAW files, Photoshop and other software conversion programs can do it with an array of some six different adjustments. But Hubel had made it simple and elegant and fun to use. Just slide the bar, in either the positive or negative direction, into the sun or into the shade, until the picture suits your dream. Professionals may cavil, but the later in *PC Magazine*, Dvorak was right to be bold and italicized.

Product of the year

On the crest of the digital revolution, the 2004 PMA show was the organization's eightieth and the biggest ever, with 17,000 exhibits, mostly digital cameras and accessories, sprawling over 15 acres, or a million square feet of show floor on two levels of the South End of the Vegas Convention Center off Paradise Avenue (occupying the North End near the Hilton were the spruce armies of the Gun and Rifle Dealers' show).

As Dvorak had long predicted, digital turned out not to be the death of photography but its efflorescence. In 2003, worldwide digital imager sales of nearly 50 million exceeded the experts' consensus of 38 million by nearly one third. Commandingly the product of the year, the digital camera in all its manifestations is giving vision to computers and telephones, 24 hour vigilance to ATM machines, taxicabs and convenience stores, and high resolution to cheap, adaptable cameras. And the theme of the PMA convention was RAW. Sashimi, sushi, **Canon** (CAJ), **Sony** (SNE), **Nikon**, **Konica Minolta**, and **Olympus**. But the big news, for those who knew the plot, was Foveon, which sold a nearly imperceptible share of those 50 million imagers but offered the best raw files of all.

Foveon's greater simplicity and low-power elegance will give it a decisive edge in cell phones

Still, while adding a $399 point-and-shoot camera to Sigma's S10 digital single lens reflex (DSLR), Foveon in Vegas remained chiefly in demonstration mode. The new point-and-shoot camera did not spring from some brilliant new partnership with **Kodak** (EK) or **Sanyo** (SANYY) or Nikon. It bore the somewhat tarnished name of Polaroid. But it was not made by **Polaroid** either. Polaroid was emerging from bankruptcy with an array of instant digital

TELECOSM TECHNOLOGIES

- Advanced Fibre Communications (AFCI)
- Advanced Micro Devices (AMD)
- Agilent (A)
- Altera (ALTR)
- Analog Devices (ADI)
- Avanex (AVNX)
- Broadcom (BRCM)
- Cepheid (CPHD)
- Chartered Semiconductor (CHRT)
- Ciena (CIEN)
- Corvis (CORV)
- Cypress (CY)
- Energy Conversion Devices (ENER)
- Equinix (EQIX)
- Essex (EYW)
- EZchip (LNOP)
- Flextronics (FLEX)
- Intel (INTC)
- JDS Uniphase (JDSU)
- Legend Group Limited (LGHLY.PK)
- McDATA (MCDTA)
- Microvision (MVIS)
- National Semiconductor (NSM)
- Proxim (PROX)
- Qualcomm (QCOM)
- Samsung (05930.KS)
- Sonic Innovations (SNCI)
- Sprint PCS (PCS)
- Synaptics (SYNA)
- Taiwan Semiconductor (TSM)
- Terayon (TERN)
- Transmeta (TMTA)
- United Microelectronics (UMC)
- VIA Technologies (2388.TW)
- Wind River Systems (WIND)
- Xilinx (XLNX)
- Zoran (ZRAN)

Note: The Telecosm Technologies list featured in the Gilder Technology Report is not a model portfolio. It is a list of technologies that lead in their respective application. Companies appear on this list based on technical leadership, without consideration of current share price or investment timing. The presence of a company on the list is not a recommendation to buy shares at the current price. George Gilder and Gilder Technology Report staff may hold positions in some or all of the stocks listed.

Agilent (A)

CDMA DUPLEXERS AND AMPLIFIERS, FIBER OPTIC TRANSCEIVERS

FEBRUARY 25: 33.95, 52-WEEK RANGE: 12.11 – 38.70, MARKET CAP: 16.30B

December quarter sales rose 16% to $1.64 billion, for earnings of $71 million, or $.14 per share, up from $.03 in September. CEO Ned Barnholt said the company achieved its goal of a quarterly break-even point of $1.4 billion three quarters ahead of schedule. New orders jumped 27%, and semiconductor orders surged 53%. March quarter sales and earnings, respectively, are expected to be $1.65-1.70 billion and $.20-.25 per share.

Altera (ALTR)

PROGRAMMABLE LOGIC DEVICES

FEBRUARY 25: 22.55, 52-WEEK RANGE: 11.50 – 26.82, MARKET CAP: 8.54B

December quarter net income was $45.1 million on sales of $217.4 million. Sales to Asia (ex-Japan) were up 71% year-over-year, and overall sales were up 20%. The company ended the year with over a billion dollars in cash and now commands a market cap of $8.46 billion.

Rival Xilinx's sales are 68% larger than Altera's; its market cap is 69% larger; but its profits are just 54% more. Combined with Xilinx's smaller cash position ($700 million), this suggests Altera is a slightly less expensive stock all other things being equal.

In product news, Altera announced that samples of the new high-end Stratix II field programmable logic device would be available in the second quarter. Built in a 90-nm process by Taiwan Semiconductor, Stratix II employs a brand new "adaptive logic module" architecture that replaces the "4-input look up table" architecture, standard in the industry for the last 15 years. The small geometry and more flexible, more efficient architecture yield greater processing power and a per-chip price of just $125. Altera believes Stratix II will help it invade DSP and ASIC markets in wireless base-stations, metro switches, routers, voice-over-IP gateways, and image processing for hi-resolution displays.

Analog Devices (ADI)

RF ANALOG DEVICES, MEMS, DSPs

FEBRUARY 25: 50.22, 52-WEEK RANGE: 25.75 – 52.37, MARKET CAP: 18.77B

December quarter revenue was $605.4 million, a 9% sequential increase, and net income was $116.8 million for earnings of $.30 per share. Sequential revenue growth is expected to continue at a similar pace, the company said, and earnings should rise to $.34-.35 in the March quarter.

ADI's new TigerSHARC digital signal processor was named a finalist for *EDN Magazine*'s "processor of the year" award. TigerSHARC follows the single-chip paradigm by integrating 24 megabits of embedded DRAM, three times more than the closest rival, yielding improved processing power density for high-end data-path communications products like 3G wireless base-stations. As Analog and top rival Texas Instruments continue to improve their DSP offerings, programmable logic from Altera and Xilinx is invading the market, marking a serious if nascent threat to that business segment of both Analog and TI.

Avanex (AVNX)

ADAPTIVE PHOTONIC PROCESSORS

FEBRUARY 25: 5.00, 52-WEEK RANGE: 0.71 – 7.57, MARKET CAP: 676.10M

After reporting $151 million in cash and short term investments at the end of 2003, the company raised $40 million from institutional investors in a private placement of 7.3 million shares at $5.49 per share. The December quarter was the first where results from the Corning, Alcatel, and Vitesse acquisitions were fully incorporated. Sales were $27.4 million, resulting in a net loss of $33.5 million. March quarter sales are expected to increase 5%. With a market cap of $684 million, Avanex trades at a forward-looking price-to-sales multiple of about 5.5, where larger competitor JDSU now trades at a P/S of almost 11. Bank of America Securities and other firms have recently upgraded to "buy" both companies, along with other optical and telecom suppliers. JDSU is better known, but Avanex shares have more room to move.

Blast from the past: Avanex founder Simon Cao, now the CEO of private optical firm Arasor, has united six Chinese manufacturers of optical components and subsystems in a consortium that seeks to leverage lower material and labor costs to sell optical products to larger telecom systems integrators. Cao, it is said, also will acquire privately held Lightbit, on whose board he serves with Fahri Diner (founder of Qtera) among others. Lightbit is developing optical processors for wavelength conversion.

Broadcom (BRCM)

BROADBAND INTEGRATED CIRCUITS

FEBRUARY 25: 40.62, 52-WEEK RANGE: 11.86 – 45.00, MARKET CAP: 12.30B

December quarter sales were $479.1 million, for a big 12.6% sequential increase. 2003 revenue was up 49% over 2002. The company showed quarterly GAAP profitability ($6 million) for the first time in years, and pro forma net income was $61.3 million. In its January 27 earnings call, the company predicted sales growth of around 10% for the March quarter, but three weeks later, on February 18, it boosted sales growth guidance to the 16-18% range.

Ciena (CIEN)

METRO WDM PLATFORMS

FEBRUARY 25: 5.68, 52-WEEK RANGE: 4.191 – 8.14, MARKET CAP: 2.70B

Ciena reported sales of $66.4 million, in line with reduced guidance. Seeking to counter the still-slow core optical market, the company embarked on a new last-mile broadband strategy by acquiring DSL and fiber-to-the-X vendor Catena Networks for $486.7 million and

optical Ethernet and WDM supplier Internet Photonics for $150 million. Although dilutive, the moves leave the company with some $1.5 billion in cash and investments (but $730 million in convertible notes). Catena already has some 5,500 customer deployments and seems a company poised for growth, especially if Washington and the states further deregulate the last-mile. We wonder, however, about the Internet Photonics acquisition. It also targets a growth market…but what happened to the metro and enterprise WDM products of ONI, Ciena's big acquisition of 2001? Ciena shares reached $8.14 recently but have pulled back to $6.06.

Essex (EYW)

OPTICAL PROCESSORS

FEBRUARY 25: 8.20, 52-WEEK RANGE: 2.85 – 10.45, MARKET CAP: 73.36M

Essex announced preliminary numbers for the December quarter, estimating sales of around $5 million, and $16 million for the full year, yielding revenue growth of some 250% and profitability for both periods. The company reports formal December quarter earnings March 9.

Essex also announced two executive hires: Jim Devine, a long-time National Security Agency senior manager and Booz Allen consultant, who will now head Essex's government businesses; and Fred Funk, a software executive and entrepreneur, who will lead Essex commercial operations.

Intel (INTC)

MICROPROCESSORS, SINGLE-CHIP SYSTEMS

FEBRUARY 25: 29.65, 52-WEEK RANGE: 15.59 – 34.60, MARKET CAP: 192.25B

An Intel research team announced a high frequency (1 GHz) optical modulator manufactured for the first time in a cheap, high-volume CMOS process. The company says this breakthrough in "silicon photonics" will usher in a new era of inexpensive optical components, eventually driving fiber optics deep into the microcosm of computer backplanes and chip-to-chip connections. Most optical components are made of exotic and expensive "III-V" materials like indium-phosphide or gallium-arsenide and are not easily integrated with CMOS, the ubiquitous material of mass electronics. The superior communications power of optics has thus been mostly precluded from large volume applications, slowing the roll-out of fiber to homes and into computers.

With the announcement, Intel joins the major new paradigm of the coming years. Other companies, from ST Micro and Agilent to one especially stealthy private firm, are even further along in their quests to integrate the microcosm and telecosm. Just as linking the world's computers on the macrocosmic network of the Internet dramatically increased the value of computers (Metcalfe's law), linking individual chips in microcosmic networks will exponentially boost the performance of chips.

Proxim (PROX)

BROADBAND WIRELESS NETWORKS, WI-FI

FEBRUARY 25: 2.39, 52-WEEK RANGE: 0.45 – 2.90, MARKET CAP: 293.25M

December quarter sales were $38.6 million, a 10% sequential increase. Pro-forma loss was $2.5 million, or $.02 per share. Full year revenue was $148.5 million for a pro-forma loss of $.12.

On February 5, broadband provider SkyBridge Networks said it would deploy 16 Proxim Tsunami 23 GHz links in its main Las Vegas and Henderson, Nevada, markets. On February 9, Proxim introduced the new ORiNOCO enterprise class, tri-mode Wi-Fi access point, which supports all three 802.11 variants (b/g and a) and incorporates a host of new security features.

Qualcomm (QCOM)

CDMA INTEGRATED CIRCUITS, IP, SOFTWARE

FEBRUARY 25: 62.08, 52-WEEK RANGE: 29.58 – 63.65, MARKET CAP: 49.98B

Demonstrating the value of our Telecosm Lounge online community (www.gildertech.com), reader "mullenjl" exposed the consensus Qualcomm analysis as severely conservative. In a detailed analysis, "mullenjl" showed that the consensus estimate of QCOM's long-term earnings growth is just 15-17%, when the estimates for the broad telecom and computer sectors are 18% and 20%! Using reasonable projections of chipset unit growth, average selling prices, and royalties, "mullenjl" projects compound annual earnings growth of 35% through 2007, yielding net income of some $3.89 billion and earnings per share of $4.83 that year. A P/E of 30 would result in a share price of 145, about 140% higher than today's.

The company also delivered software enhancements to the EV-DO broadband data system, including QoS (quality of service) and multicast, which will enable rich media applications like television content and video telephony.

Before we went to press with our rosy long-term scenario on Qualcomm, the company on February 23 raised its March quarter earnings guidance by some $.09 per share, causing shares to jump more than 5.5%. –Ed.

Sprint PCS (PCS)

NATIONWIDE CDMA WIRELESS NETWORK

FEBRUARY 25: 8.85, 52-WEEK RANGE: 3.40 – 10.70, MARKET CAP: 9.16B

Sprint PCS competitor Cingular, a joint venture of SBC and BellSouth, "won" the auction for AT&T Wireless. We say "won" because at $41 billion in cash, the acquisition looks to be a strategic blunder. For that money, Cingular, the third largest U.S. wireless carrier, could have paid each of AT&T's 22 million customers a thousand dollars to switch, built a brand new 3G wireless network several times over, and bought plenty of new spectrum (the asset many think Cingular needed most). Instead it gets a large but troubled network with service problems, dissatisfied customers, and no technology roadmap.

For the December quarter PCS added a net 390,000 direct subscribers and another 640,000 affiliate and wholesale customers, bringing the total customer base to 20.4 million, 15.9 million of those direct. Sales were $3.3 billion, an 8.4% increase over December 2002. The company added 600,000 new Vision data subscribers, for a total of 3.2 million customers of the $10-per-month service. Partner Virgin Mobile, who markets to younger customers and piggybacks on the Sprint network, now has 1.4 million subscribers, and affiliate and wholesale revenue now totals more than $100 million per quarter, up 100% from last year. PCS made capital expenditures of $2.15 billion for the year and added 1,800 cell sites.

In late December PCS shares began a steady march from 5 to 10. They now trade at about 9.5, with a market cap of $9.8 billion and a tiny .8 price-to-sales multiple. AT&T Wireless, by comparison, had sales one-third larger but sold to Cingular for more than three times sales and more than four times current PCS value. AT&T had a cleaner balance sheet, with around $6 billion of net debt, where PCS carries some $11 billion, but AT&T's network is also older and will require disproportionate capital outlays in the future.

Synaptics (SYNA)

TOUCH-SENSORS, FOVEON IMAGERS

FEBRUARY 25: 18.39, 52-WEEK RANGE: 5.75 – 22.424, MARKET CAP: 454.32M

The company continued its strong profitability, with earnings of $.13 per share on sales of $34.3 million in the December quarter. Although the March quarter typically exhibits a seasonal decline, strong sales of notebook PCs and "digital entertainment devices" (referring to Apple's iPod and iPod-mini, one can assume) suggest sales could be flat, and the company expects June quarter sales to be slightly higher.

Terayon (TERN)

BROADBAND CABLE MODEMS, HEAD-ENDS

FEBRUARY 25: 4.23, 52-WEEK RANGE: 1.39 – 8.25, MARKET CAP: 316.73M

December quarter sales were $43 million, and the net loss shrunk to $6 million. The company announced additional cost-cutting measures that it says could yield sustained profitability starting in the coming June quarter. In 2003 Terayon captured 13% of the worldwide CMTS (cable head end) market and rose from fifth to third in U.S. cable modem market share. With profitability close at hand, a price-to-sales multiple under 2, more than twice as much cash as convertible debt, and a strong position in the next-generation of cable infrastructure, Terayon still looks to be a good bet on broadband.

Zoran (ZRAN)

COMBINED DSPS AND IMAGING CONTROLLERS

FEBRUARY 25: 18.20, 52-WEEK RANGE: 10.82 – 27.88, MARKET CAP: 768.99M

Added to the list this month.

CONTINUED FROM PAGE 3

kiosk printers, cameras, and Polaroid legacy gear that was finding new life in the digital era. But under the stresses of its financial crisis it had licensed its name for digital cameras to an Italian from Hong Kong named Giovanni Tomaselli, head of a firm called World Wide Licenses Limited. Surely you have heard of WWLL. It is an important design and manufacturing subsidiary of an even better known company called the **Character Group PLC**. CG-PLC, as the Foveon folk were quick to stress, is listed on the London Stock Exchange in the Media and Photography Sector, just in case you are so benighted as never to have heard of the Character Group PLC.

National remains one of the more modestly valued of the analog semiconductor player

Marketing the camera in the U.S., however, would be **Uniden**. Don't ask. It is the familiar Japanese vendor of cordless telephones and exclusive U.S. distributor of Polaroid digital cameras.

Foveon's pearl

In the midst of this magpies nest of commercial and manufacturing entities lies the pearl of Foveon's intellectual property and conceptual superiority. The inelegance of the competitors' Bayer filter color routine is evident even in the twisted language it evokes. The result of using filters to focus light of only a single primary color on each pixel sensor, the Bayer pattern from conventional imagers is a mosaic of red, green, or blue pixels. A processor is needed to "guesstimate" the actual colors from the colors of adjacent pixels.

Describing the process of converting a Bayer pattern into a usable RAW file—here Foveon Chief Scientist Lyon's lips pucker with distaste—are terms such as "demosaic" and "de-Bayer," "de-jag" and "de-alias." Accurate from the outset, Foveon's colors do not need to be demosaiced and their edges do not have to be "blur-filtered" and "de-jagged," and their patterns do not need "de-aliasing" so you can see every last curlicue in the swirly design on Carver Mead's shirt.

To Foveon's partisans, it was obvious that the company had its rivals surrounded on all sides. You want perfect top of the line pictures and you get the Sigma 10 for $1200. You want high-resolution high-accuracy point-and-shoot, with 4.5 megapixels, 12x zoom, RAW files and FillLite software, and you can buy that too in the Polaroid x530. You want a camcorder, 30 frames-a-second of full motion DVD quality VGA (video graphics array) video and you can get it from that same point-and-shoot device.

Dick Lyon could explain to you the intrinsic inferiority of all the hundreds of other cameras with slightly different features glittering across the pullulating floor. If they had smaller pixels (and more "megapixels"), each pixel held less electric charge and thus could capture less dynamic range (variation between its darkest and brightest level) and was more sensitive to noise. The picture would be worse, as Sony discovered with its new 12 megapixel camera, and don't even mention the images of the new 14 megapixel Kodak.

Supporting Lyon's claims was Lawrence Matson, one of the earliest Sigma enthusiasts and a staunch defender of the faith among the professional photographers on the *DP Review* photography website. Flying in from Switzerland to attend the Vegas unveiling, Matson recounted his original excitement he felt in encountering Foveon imagers. He cited early Sigma photos (even as seen on the web!) of eyes reflecting the sky without distortion—of a frog's eye mirroring an expanse of blue sky and clouds, or the eye of a cormorant suffused with a span of heavenly blue (see www.foveon.com/gallery.html). He described a portrait of an old man with a single curl of white hair precisely distinguishable. Perfectly rendered in a Sigma portrait, Matson said, "that hair in a Bayer mosaic would become a blue and red rope or a 'barber pole'."

Because of the accurate borders between colors, Foveon etches sharp edges that give its pictures a three-dimensional property, with images seeming almost holographic. In order to avoid "jaggies," mosaic cameras use "blur filters." "That gives Canon images what their devotees like to call 'buttery smooth' textures," said Matson with a sneer.

Just as important for the future of still and motion combo cameras, the Bayer burden also afflicts full motion images. Because of the difficulty of processing huge raw files 30 times per second, all systems for full motion capture must cluster adjacent pixels and process them together. But non-Foveon imagers cannot readily cluster neighboring pixels because in a mosaic the adjacent pixels capture different colors. They would combine into chroma mud. The Bayer-based cameras thus have to perform time consuming and image distorting digital acrobatics to join together the pixels of the same color. With Foveon, the combination of neighboring pixels was natural, simple, fast and accurate.

The power of volume

In theory, all these Foveon claims are true and have been true for several years. The Foveon design, in one form or other, would ultimately dominate photography. Dramatizing the business challenge faced by Foveon, however, were the exhibits all around them on the floor of PMA. As CEO and microprocessor co-inventor Federico

Faggin put it, "In principle, Foveon is far better, but in practice it is not." Canon, Sony, **Samsung** and the others might have to push their technology harder to get a performance comparable to Foveon's but they had the clout to do it. If Sony's CCD (charge couple device) colors were distorted, they add yet another Bayer filter with emerald hue to correct them. If existing Canon CMOS (complementary metal oxide semiconductor) imagers produced jaggies, make the pixels so small that the jaggies are invisible to the naked eye.

If people judge imagers by the number of megapixels, build wafer fabs that can etch pixel transistors with geometries of 45 nanometers, about a third the size of most current technologies (130 nanometers). Sony and Samsung were already planning such factories. If Foveon cameras are intrinsically cheaper to make, produce Samsungs and Sonys in such volumes that manufacturing scale dwarfs the imager edge.

Meanwhile, make sure that all the other features of your camera are superior and multiply the features year by year. No matter how good the Foveon imager is, what is the chance that WWLL and Polaroid will eclipse Canon and the rest of the Japanese in overall camera quality? And if the large volume orders go to the Japanese camera giants, the quality of their imagers, by brute force of scope and scale, will also likely eke ahead.

That is the message from the semiconductor industry. Volume rules quality. Long experience in the semiconductor trade has confirmed the validity of [Nick] Tredennick's law: *Go for volume and you get quality. Go for quality and you forgo volume and eventually quality as well.* As the chief designer of the high quality Motorola "68000" microprocessor, eventually eclipsed even in quality by the Intel X86 line, Nick knows whereof he speaks.

Now the same process is befalling cameras. This phenomenon dooms Foveon to a "spiral of decline," declares Karl Guttag, an eminent former **Texas Instruments** (TXN) inventor/engineer with 123 patents mostly in graphics and imaging. A relentless critic of Foveon on *DP Review*, Guttag believes that Foveon can never gain the momentum to make money.

Yet the power of volume will be the ultimate source of Foveon's coming dominance. All the talk of pure camera refinements will dwindle into commercial irrelevance when high volume imager leadership is set in the market for cell phones. At PMA, reports were rife that 95 percent of new Japanese cell phones were now camera equipped. In 2003, the world's largest unit seller of cameras was already not Canon or Sony but cell phone titan Nokia. In the course of time, the highest quality imagers for the mass market would come from the cell phone imager market.

Foveon's greater simplicity and low-power elegance will give it a decisive edge in cell phones. Against CCDs, Foveon's RAW efficiency yields a fivefold power advantage. Against low power CMOS (complementary metal oxide semiconductor) imagers, the Foveon stacked pixels yield at least a twofold resolution and accuracy advantage. The ability readily to cluster pixels yields a decisive advantage in camcorder applications.

What legends are made of

Fighting alone in cameras against a massive array of established rivals—from Canon and Sony to Samsung and Kodak—so Clayton Christensen declared four years earlier—"Foveon has zero chance of success." As Faggin says, "Obviously we are going to need partners." For the necessary reinforcements, he was clearly not going to depend chiefly on Sigma and the Character Group. At the show in Vegas, he was busy seeking partners and finding more every day. Foveon's partners would take the company into the new markets for low-power, high-resolution imagers where the war would be won.

With Foveon offering the technically superior imager, the chief shadow on the Foveon show was the widespread notion that the best technology often does not win. In the *New York Times* on the Monday of convention week, John Markoff reported speculation that Foveon might become the "Betamax" of the digital image revolution. In an urban legend, Sony lost to VHS in videocassettes despite Betamax's superior quality. (In fact, Beta lost chiefly because it chose the wrong tradeoff between resolution and duration).

The difference between Foveon and Betamax, though, is that Foveon is indeed decisively superior: five times superior to CCDs in power efficiency and some 2.5 times superior to CMOS mosaics in efficiency of light capture. In the case of Foveon, there is no tradeoff in which CCDs or CMOS mosaics offer some virtue that the Foveon technology lacks. The superiority of the Canon, Sony, Nikon lineup is their momentum, brand recognition, manufacturing prowess, and financial and marketing clout. All are powerful assets but they do not eclipse the superiority of Foveon's intrinsic technology in a new world where the camera disappears into the fabric of every location that needs to be imaged or protected.

A large winner from the punitive Foveon IPO will be Synaptics, a company about one-fifteenth the size of National

Digital imaging stars

So what does all this mean about the companies that currently partake of the Foveon technology? Owner of some 30 percent of its shares, **National Semiconductor** (NSM) manufactures its chips at its waferfab in Portland, Maine, and has licensed a very limited form of the Foveon technology. National can use the Foveon stacked sensors to fit a slot in a conventional mosaic system. This contract helps National by giving it a cheaper, lower-power way to supply the existing imager market and it helps Foveon by expanding volumes. But today the largest benefit to National from its Foveon investment will derive from the company's future IPO. National also remains one of the more modestly valued and most resourcefully managed of the analog semiconductor players and it supplies more devices for digital imaging equipment than any other company. A larger winner from the putative IPO, though, will be **Synaptics** (SYNA), a company about one-fifteenth the size of National, which owns about half as big a share of Foveon (15 percent) as National does. Co-founded by Carver Mead, chairman of Foveon and by current Foveon CEO Faggin, Synaptics has been expanding its already dominant share in touchpads for controlling notebook computers, Apple iPods, DVD players, and other portable equipment.

Other likely winners in the explosion of digital imaging include Texas Instruments and **Zoran** (ZRAN). TI has just introduced a two-chip module called the OMAP 2 media access processor that supports every destination but a ground wire to the kitchen sink and lawnmower. It includes an ARM core, a high speed TI DSP, and a power graphics 3D accelerator for games, and commands interfaces to a high resolution liquid crystal screen, to a TV monitor, and to a camera and camcorder at up to 4 megapixels, capable of playback and capture of 720 by 480 pixels (Super VGA) at 30 frames per second. Built on TI's 90-nanometer wafer-fab, this entertainment bonanza is all for your cellphone. Having just returned from Korea, I can tell you that most of these features are already cobbled together on devices there, supported readily by **SK Telecom's** (SKM) EV-DO **Qualcomm** (QCOM) network.

Like TI, Zoran produces combined digital signal processors (DSPs) and imaging controllers. Unlike TI, Zoran is fabless in the midst of a semiconductor boom—an element of risk faced by all fabless firms. But as a digital camera expert for 15 years, Zoran is closer to a pure play in the field and had 14 cameras using its chips on the floor at PMA in Vegas, including Samsung's Digimax and Pentax's Optio S series. Zoran's COACH device (camera-on-a-chip) captures images from a sensor and processes them into JPEG or RAW files for dispatch to a memory card, to an Internet link, or at 30 VGA frames per second to a video device. The sensor might be Foveon's (Foveon will not disclose its processor source for the Polaroid x153). But Zoran, whose DVD and HDTV processors starred at the consumer electronics show, emerged as an increasingly powerful player at the PMA.

Although Canon is a well known and well valued player, it benefits from the digital camera revolution on all sides, providing lenses, printers, CCDs, and processor chips including its own high powered DIVIC device. Zoran joins the list this month, but TI and Canon remain somewhat safer ways to play this booming field. Their chief vulnerability may be a commitment to CCDs and ordinary CMOS imagers in the face of the Foveon breakthrough, which will propel the growth of the companies that buy into the RAW magic of X3.

— George Gilder
February 24, 2004

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