HARVARD | BUSINESS | SCHOOL

9-705-506

REV: MARCH 2, 2006

DAVID B. YOFFIE

E Ink in 2005

Things were looking up for Russ Wilcox, the 37-year-old CEO of E Ink. After years of laboring with products in the lab and numerous false starts, E Ink was shipping real products for Sony's first eBook. For a start-up with a leading-edge technology, this was a major accomplishment. E Ink had started in 1997 as a spin-off from MIT's Media Lab. Since its inception, management had raised over $120 million with the mission to deliver a new electronic display that would have all of the advantages of paper (reflective, high contrast, and flexible) with all the advantages of an ideal electronic device (very low power, updatable, and capable of color and video). E Ink not only demonstrated a commercial version of this product, it had also built an extensive supply chain and network of high-profile partnerships including a manufacturing agreement with a $10 billion Japanese firm, Toppan Printing. Due to a recent round of investment from Intel Capital, the company was solvent through October 2005.

Wilcox, however, was still grappling with the issues of business model and focus. As a new technology, E Ink could alternately become a licensing company, a materials supplier (supplying a layer of electronic ink sold as an imaging film ready for integration into a display), a subassembly supplier (offering display modules, including an electronic backplane and driver electronics), or even a product supplier (offering eBooks or similar products that uniquely leveraged E Ink technology). The company had flirted with all of these approaches over the course of its history and most recently had focused on selling electronic ink as a display component. Whether this was the right answer remained the ongoing topic of hot debates among the members of the management team.

The other big question was market focus. On one hand, the biggest potential market continued to be matrix displays: conservatively, Wilcox estimated that E Ink's total available revenues in the graphical display segment could reach $300 million. E Ink's technology appeared to be far ahead of that of its nearest competitors, and Wilcox felt that they might capture up to 80% market share in niches related to electronic publishing. Moreover, E Ink could probably earn better than 50% margins. However, the time frame for consumer acceptance of eBooks, e-dictionaries, and related products was unclear. No previous eBook device had yet exceeded 50,000 units sold. Moreover, finding great content for eBooks was problematic. On the other hand, E Ink could also try to apply its technology to the "segmented" display business for products such as signage in retail stores and displays for watches and clocks. Wilcox estimated that the segmented display market could be worth about $100 million in revenues. Yet unlike selling into eBooks, which were an emerging category, selling into the relatively mature signage business meant many competitors, substitute products, and, at best, a market share of 2% to 3%. Still, if E Ink could generate even modest revenues with segmented displays, it might shorten the time required to reach positive cash flow. As with many new technology companies, E Ink was facing a chicken-and-egg problem. How could they balance the resources required in the short term to generate revenues with those needed to produce a long-term home run?

Professor David B. Yoffie and Research Associate Barbara J. Mack prepared this case. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

Early E Ink

E Ink was based on a technology conceived by Joe Jacobson, a professor at the Center for Bits and Atoms at MIT's Media Lab. With two of his students, J.D. Albert and Barrett Comiskey, Jacobson moved from concept to a potentially commercializable technology. As the leader of the Molecular Machines group, Jacobson focused on reinventing microelectronics by developing processes for directly and continuously printing communication, computation, and displays onto arbitrary substrates.[1] E Ink was an effort to use a special form of ink that could be used in electronic displays and might, one day, eliminate the need for paper. The technology was protected by a number of broad patents and, in the early days, the company drew many of its first employees from MIT. Even in 2005, the company headquarters in Cambridge, Massachusetts retained much of the atmosphere of the Media Lab, with white boards displaying technical diagrams and large containers filled with the gray slurry that would become electronic ink.

The concept of electronic ink was not completely new; Xerox had experimented with "electric paper" in the late 1970s, but there were many obstacles, including power requirements, ink yields, and high costs. One of the first breakthroughs involved putting small quantities of dark and white pigments into tiny microcapsules. The tiny microcapsules could create an image by stimulating the pigments, causing the white to flow to the top and the dark to move to the bottom, or vice versa. A liquid solution of these microcapsules could then be printed directly onto a variety of materials, including glass, tin, and plastic, which would stick to the page just like normal ink. In theory, a similar process could enable a color display as well. (See **Exhibit 1** about manufacturing electronic ink.)

The original E Ink business plan from July 1997 stated the grand vision for the company: "The inventions that we are bringing to market are fundamental platform technologies that will have far-reaching impact on how our society receives its information." Ultimately, Jacobson and his cofounders believed that E Ink would create "radio paper," a flexible, electronic display that could replace books, magazines, and newspapers. The original business plan foresaw an $80 billion opportunity for radio paper.

Competing display technologies Companies around the world were exploring many new display technologies, ranging from liquid-crystal displays (LCDs), microdisplays, and organic light-emitting diodes (OLEDs) to field-emission displays and plasma displays. However, for each new technical display solution, there were trade-offs in power, cost, or technical problems, which E Ink believed it could successfully address.[2]

The most widely used form of electronic display was the LCD. However, LCDs had a number of limitations. They were costly to produce and consumed a significant amount of power, especially if they were backlit. If they were reflective, rather than backlit, the LCDs were dim in some viewing conditions. Further, most LCDs were produced on glass substrates and were subject to scratching and breakage. However, manufacturers were spending hundreds of millions of dollars on incremental improvements. Enhancements included news ways of addressing passive displays, filters to improve light transmission, the development of plastic-substrate LCDs, wider viewing angles, and a concerted effort by Asian display companies to drive down costs. As a result, LCDs would be offering better performance at reduced cost over time.

Microdisplays were a new form of display technology aimed at the handheld market. These devices consisted of a one-inch or smaller display that needed to be magnified for the viewer to discern an image. While these displays used a form of active matrix backplane, the size helped to keep the overall system cost low. However, developers struggled with the issues of yield, optical design, and system design. Since the displays required enlargement, they suffered from added

weight and image distortion. In addition, they could not properly be characterized as "direct-view" displays. Nevertheless, as development advanced, microdisplays would be well suited for virtual reality headgear, camcorders, personal digital assistants (PDAs), and projection TVs, where the image could be expanded. If costs could be driven down, microdisplays could compete with electronic ink in handheld applications.

Organic LEDs (OLEDs) offered full-color capability in a light-emitting display and were visible in the dark. As a high-potential new display technology, they were of significant interest to major display companies, but they were still in the development stage. Challenges included the fact that OLEDs were emissive and drew substantial power. There were also issues with the display's lifetime, particularly for OLEDs on plastic substrates. However, the industry was devoting substantial resources worldwide to solve these problems, and OLEDs were likely to achieve commercial status within the next few years.

Field-emission displays (FEDs) were based on the same principles as the cathode-ray tube (CRT), replicating that earlier technology on a tiny scale, with one emitter per pixel. FEDs were being commercialized by Motorola, among others, and were expected to deliver a brighter display with a wider viewing angle, higher power efficiency, and potentially a 30% cost reduction. Yet the FEDs had not achieved volume targets quickly, and LCDs had narrowed the gap in price and performance. Though the future of FEDs was not clear, the technology competed with active matrix LCDs and could become a player in the direct-view market.

Finally, plasma displays (PDPs) were a type of flat-panel display that worked by sandwiching a neon/xenon gas mixture between two sealed glass plates with parallel electrodes deposited on their surfaces. The plates were sealed so that the electrodes formed right angles, creating pixels. Much thinner and lighter weight than conventional CRT displays, plasma displays used over 16 million colors, and image quality could be stunning. PDPs offered a superior alternative to LCDs for large displays, notably those from 40 to 80 inches, and they competed primarily with projection display systems.

While there were many technical challenges to overcome, electronic ink offered some clear advantages to these alternative display technologies. Electronic ink was a high-contrast, low-power, and potentially cheaper alternative to those technologies. It looked like real ink on paper, but it could change form, allowing for a dynamic display. It could also be printed on films that approximated the thickness and flexibility of paper. The two biggest limitations to E Ink's technology in its early manifestations were 1) the displays initially worked in only two colors, blue and white, not in black and white, gray scale, or full color; and 2) the pixels could not be updated quickly enough for full-motion video. Technically, these were solvable problems, but management and investors knew that it would take time.[3]

Market opportunities for E Ink As the company took in its first rounds of financing, it moved aggressively toward protecting its intellectual property; by early 1999, it had acquired, licensed, or filed 26 patents. The company had built a world-class team, including people from Avery Dennison, Raychem, Xerox, 3M, Seagate, and Bell Labs. It had also raised $15.8 million in a round that included Atlas Ventures, Applied Technology, and Solstice Capital. Four corporate investors, Motorola, Creavis GmbH, The Interpublic Group of Companies, and The Hearst Corporation also participated. (See **Exhibit 2** for corporate and VC investments in E Ink.)

Founders Jacobson, Wilcox, and Jerry Rubin (along with recent MIT graduates Albert and Comiskey) proved to be highly capable fund-raisers. As an academic visionary, Jacobson offered investors a powerful vision of future technology and its prospects for changing the world. Wilcox, a recent Harvard MBA with previous start-up experience and a technical background, ran the business.

Rubin, the founder of Lexis-Nexis and an icon in the publishing world, brought a wealth of relationships and gravitas to the venture.

Over the next three years, E Ink expected to tackle three big market opportunities: large-area displays, flat-panel displays, and the publishing industry. The large-area display market that was suitable for E Ink products exceeded $600 million in 1995.[4] The flat-panel display market was a $13.8 billion business in 1998, with a five-year market growth rate exceeding 11%.[5] The segment of particular relevance to E Ink (not requiring movie-quality video or extreme heat tolerance) totaled $4.9 billion in 1998 and was expected to reach $6.9 billion in 2002.[6]

The publishing industry, made up of books, magazines, and newspapers, was a $135 billion business in 1998; newspapers accounted for $60 billion, and there were over 1,500 daily newspapers in the United States alone.[7] The E Ink vision for newspapers involved using radio-paper devices and wireless delivery. According to their estimates, "At a price point of $400 and an expected lifetime of two years, if newspapers purchased devices and gave them away to each subscriber, it would . . . effectively double net income."[8] Further, there were other benefits to radio paper besides improving industry economics; radio paper offered opportunities for faster turnaround, there were no space constraints, publishers could microsegment delivery zones, and the "newspaper" could have additional graphical features, including variable type sizes and fonts and functionality, including video.

E Ink corporate strategy In anticipation of rolling out products, the VCs recruited an experienced CEO, Jim Iuliano, a 1986 Harvard MBA. Iuliano had a background in semiconductor engineering and had successfully brought public a California-based company called Molecular Devices. Along with Wilcox, they recruited research and development (R&D), engineering, and process-development teams. As the management team laid out goals for E Ink, they also began to set up small business divisions. While the grand vision was to produce radio paper, the company would pursue more modest opportunities in the short term through the newly formed Immedia group. To get experience in making microcapsules and manufacturing products, E Ink found that it could build blue and white signs with its first-generation ink. These large-area signs were viewable from all angles, they blinked (as the pigments changed), and they could be electronically programmed over a paging network or the Internet. Big retailers such as JC Penney saw immediate applications, and several quickly signed up for field trials.[9] As the E Ink management team assessed the size of its various target markets, they sought to produce a launch plan that took into account adequate time for the technology development process. Early feedback was encouraging: by the end of 1999, E Ink had shipped 140 signs, generated $150,000 in revenues, and was conducting five field trials with prospective customers. They had also received over 2,000 inquiries.

Due to its connection with MIT and its impressive progress with potential customers, the young company generated significant industry buzz just one year into official operations. *Fortune* magazine named E Ink one of the "Twelve Cool Companies of 1998," and E Ink graced the cover of *Nature* in the same year. In 1999, the company was mentioned in *Forbes*, *Fortune*, *The New York Times, The Wall Street Journal*, CNN, CNBC, *National Geographic*, *Nature*, *Scientific American*, and *The Asahi Shimbun,* to name a few. Privately, the company laid out a plan to use successive rounds of funding to reach clear technical and operational goals and began conversations with investment banks for an initial public offering (IPO).

Historical View: Turning Point, 2000

The timing of the IPO effort was unfortunate. Within days of the investment banks pitching the board of directors on taking the company public in March of 2000, the IPO window closed, and soon

thereafter the traditional VC industry stopped investing as well. Although E Ink had some cash reserves, they would need to stretch far longer than previously expected.

With the Internet boom coming to an end, prerevenue companies were no longer suitable for the public markets. In addition, technical and business challenges beset the young company. First, the manufacturing process had proven to be more difficult than they had expected. Manufacturing costs were significantly above forecasts. Second, after investing in a sales force and building a distribution channel, the company discovered numerous problems in implementing the large signage business. One challenge stemmed from the fact that many potential customers did not like the blue and white color scheme. Coca-Cola, for example, would not even consider it. In addition, many large retailers could not get a paging signal inside their stores to program the signs, and the first-generation ink required a power line, which had to be installed to work at specific locations. Management discovered that, in some cases, installing the electrical wire properly cost more than the customer was willing to pay for the sign. According to the vice president of Business Development, John Ritter, "At that time, our cost forecasting was way off. When we were producing signs, for example, the costs were closer to $1,500, not $500. In a situation like that, the simple supply-and-demand curve comes into play with your customers."[10]

As a result, the signage business launch was delayed, advance bookings fell short of expectations, and losses mounted. The increased headcount and production efforts had raised the cash burn rate to over $2 million per month. Growing red ink led E Ink's management team to refocus. While there still might be opportunities in the sign business for the second-generation ink, which was faster, higher contrast, and black and white, signage would no longer be the primary target. Instead, the company would aim closer to radio paper. To make the product successful, management believed that it needed a flexible, fully addressable display (called a matrix display) that could work for PDAs, eBooks, and other applications. The market potential was higher, but the technical hurdle was also higher.

There were two immediate problems to solve: 1) without the option of an IPO, E Ink would need an infusion of new money from private sources; and 2) as the technical requirements were extended to include production of a new, fully addressable display, the company would have to find a reliable source for electronic backplanes. Electronics was not the company's core competence; it needed a supplier with electronics expertise and the ability to scale up quickly. In the fall of 2000, the company killed two birds with one stone: E Ink signed a deal with Philips to become a new partner and investor. Philips made a significant investment in E Ink and would work with the company to prototype and assess glass-based eBook and PDA displays. At a later stage, Philips would help design and build a custom display module in Japan.[11]

Organizational Survival, 2001

While Philips solved the problem of providing backplanes for fixed devices like PDAs, E Ink was still committed to delivering its ultimate dream of a flexible backplane that would have the characteristics of paper. To this end, the company invested in a specialized fabrication facility in Woburn, Massachusetts, where the engineers could develop flexible backplanes. The team conducted a fresh evaluation of the potential product lines. To drive revenues in the short term, management reconfigured Immedia into a new business unit that would be called Ink in Motion (IIM). Rather than sell large-area signs, Ink in Motion would use the second-generation, black-and-white technology to offer distinctive, attention-getting promotional display images to be used at the point of purchase (POP) in retail environments. Top customer prospects had shown interest in Ink in Motion: the specifications allowed for attractive, low-cost, blinking signs with a long battery life. The E Ink team

hoped that POP designers and in-store merchandisers would spend money on a new display technology.

For E Ink, POP display R&D seemed to lie on the path to radio paper, and they believed that production itself would require little invention and use existing competencies for the company. The sales team targeted account opportunities with leading merchandisers, POP producers, and manufacturers. Estimates indicated that revenues in each segment could approach $1 million–$3 million by 2002, ramping into the tens of millions within three years. In pursuit of short-term cash flow, the company also was looking at applications such as point-of-sale price displays, signage on public transportation, and watches. From these segments, Vossloh, a European transportation company, and a watch company were seriously interested in working with E Ink. By mid-2001, they had an agreement with the watch company for a $1.5 million guaranteed purchase order. Using E Ink technology, the watch company planned to launch the "world's thinnest watch." Finally, they explored opportunities in electrostatics, a rewritable media that used a stylus or print head for changing displays. Applications included toys and menu boards, and E Ink had discussions with a toy company and a printer. Before these products could become viable, however, E Ink would have to improve its ink-production processes.

In order to speed up the product launches, the E Ink management formed SWAT teams to resolve some of the remaining short-term technical issues. These focused team efforts resulted in significant improvements in the speed and power-consumption areas. While continuing to support its scientists and meet technical milestones that had been set with Philips, E Ink was facing pressure to reduce the burn rate and headcount dramatically. If they were to attract new investors, they would have to become a leaner, tighter organization. Staff reductions ultimately represented an annual savings of approximately $3.5 million. In addition, the fabrication plant in Woburn had fulfilled its research goals but was too small for production, so management shut that down.

To create more leverage for its internal R&D efforts, E Ink went down two paths. First, Mike McCreary, the head of R&D, obtained government research funding to help defray some costs. Second, E Ink started exploring new partnering opportunities, particularly with companies that could provide technical assistance and perhaps even joint-development projects. The team talked to many large consumer electronics and display companies. In mid-2001, E Ink discovered that one of the leading Japanese printing companies, Toppan, was excited by the technology and some of its future applications, especially color filters for future color displays. Toppan was a world-class manufacturer that could provide coating capabilities for E Ink displays. In addition, Toppan was well connected with Sony, a potential customer for selling eBooks that featured E Ink displays. And as a printer, Toppan held a strategic interest in electronic paper. E Ink and Toppan concluded a joint-development deal, with Toppan making a moderate investment in June 2001.

The eBook Race, 2002–2003

Moving into 2002, E Ink began to focus on what it called "The Matrix Mission." With strong interest (though no firm commitments) from Sony and other electronic device manufacturers, the company saw a profitable business opportunity in flat-panel displays. In order to become a major player itself, the company would have to refine its business model. The cost of building a complete display-module factory was prohibitive. Therefore, E Ink would become a supplier of ink as a sub-component to display makers. They would offer a frontplane laminate, or "FPL" (ink coated onto sheets of plastic that could be assembled by laminating the sheet onto the glass active matrix backplane), as their first product and targeted 50%-plus gross margin on the FPL. Ultimately, partners like Philips would provide the finished displays to customers such as Sony.

Although products were still not shipping, the company was making technical progress. The company could demonstrate displays with higher contrast, brighter white states, declining power consumption, as well as light, thin, flexible, and rugged form factors. Such demos made it clear to potential investors and potential customers that E Ink could be especially valuable for eBooks, PDAs, and mobile phones, where reader-centric applications were taking hold in the consumer marketplace. The company felt that it could tackle the module-addressable market, expected to top $19.2 billion by 2005. (See **Exhibit 3** for the market opportunity in addressable flat-panel displays.)[12] To penetrate the FPD market, E Ink hoped to work with customers to launch its ink-on-glass technology, achieving the look of ink on paper in a rigid form. Over time, it would move to ink-on-flex technology, ideally delivering on the vision of flexible electronic paper.

Joint venture: the Toppan deal To deliver on this vision, E Ink would need further technical development and another large infusion of cash. With such a large bet, it would be difficult to raise money from pure financial or venture investors. The best option was strategic investors that would share in the potential profits that lay in the new technology. Toppan appeared to be an ideal partner. As a $10 billion printing company, Toppan worried that electronic ink would have a huge impact on its core business. If Toppan could leverage the new technology, they could become a leader in the era of electronic printing. To help make the company successful, Toppan agreed to serve as the lead investor in a new syndicated round of $25 million. In exchange, Toppan and E Ink would create a joint venture; the goal was to ensure the delivery of a high-quality FPL and enhance E Ink's value as a credible supplier. Toppan offered improved access to E Ink's largest market, Japan. Finally, the venture with Toppan would lower the cost of goods sold and provide a combination of direct funding and burn-rate relief.[13]

Specific projects with Toppan included joint research for full-color displays and a manufacturing arrangement for the FPL. E Ink would manufacture the "liquid ink," share product-manufacturing and application capabilities, and serve as a source of ongoing R&D and technical support. E Ink would continue its marketing and demand-generation programs. For its part in the joint venture, Toppan would contribute its coating, color-filter, and manufacturing capabilities, bringing turnkey manufacturing facilities, with equipment and personnel already in place, to the deal. It would provide a supply of glass-based and plastic-based color filters, and it would offer ongoing R&D and technical support.

E Ink Production in 2002–2003

By early 2003, E Ink was getting ready to launch IIM in June and was close to an agreement with Sony to provide the display for Sony's first eBook. Flush with new money from Toppan, the company appeared ready for takeoff. But once again, technical problems began to creep into the products. The technical team found that the ink was too slow, it needed to be brighter, and it did not perform well in extremes of temperature and humidity. The ink also varied from batch to batch, and yields overall were unstable. Further, the coatings were inconsistent, the laminations had bubbles, and E Ink's adhesive supplier cancelled their product. The problems became so severe that E Ink could not even ship small quantities of IIM signs to prospective customers. Phillip Souza, vice president of Operations, stated, "The ink itself was complex, and we did not necessarily understand all of the variables in the process. Sometimes we could produce it, and sometimes we couldn't. We were making a lot of progress on the technical front for the next generation of ink, but trying to commercialize the current generation was diverting a lot of time and a lot of money for a small IIM business."[14] McCreary, vice president of Research and Advanced Development, similarly noted, "The IIM business was customized to the advertising campaign. So we were essentially in the short-run printing business with our electronic ink. But POP signage is usually ordered just a few weeks before

it is needed. We were facing tremendous demand surges, and it's very hard to manage a production line when the volume goes from 0 to 10,000 units in one month. E Ink was small, and we could not suddenly take a high-volume job when we did find one."[15] If these challenges were not enough, the more E Ink learned about the specifications for the SONY eBook and the quality requirements it would have to meet, the more E Ink realized how much work would be required. This included the requirement to solve many of its problems in Asia, where the supply chain was being established and where the customer was located. (See **Exhibit 4** for E Ink's Asian supply chain.)

Customers are waiting: the chicken-and-egg problem By mid-2003, E Ink faced issues on three fronts: it needed to launch IIM, but it could not deliver a stable product; it had promised to deliver displays to the watch company that were not yet ready; and it was trying to deliver an acceptable alpha and beta product to Sony that it could not yet achieve. It was becoming obvious to everyone that something had to give: at the current burn rate the company would run out of money at the end of the first quarter of 2004, and the inability to deliver acceptable products was pushing out opportunities to earn revenue and bring in cash. While all three business opportunities looked promising, the company could not fund three research and development efforts. Ink in Motion was the closest to commercialization, but in the long run, it was a low-margin business with limited upside. The watch company was the only major purchase order currently in hand, but it required a separate R&D effort that was off the path toward the greater opportunity in eBooks. And the effort required for the eBook would be substantial. Sony presented the biggest opportunity, but it was a demanding customer that would not be satisfied until the product was perfect. Further, Sony management was very unhappy about the pending delays in delivery.

There were many other potential graphical display customers in the sales pipeline, but E Ink had not secured any firm commitments. Wilcox and other managers had held discussions with many consumer electronics firms, but no new deals were ready to close.[16] In each case, E Ink faced a range of challenges and objections: in some cases, the pricing was a concern; other companies needed time to build a content base before proceeding with a production plan; still other companies were already conducting field trials with alternative display technologies like LCD, which was more expensive but well-known. As the vice president of Sales and Marketing, Ryosuke Kuwada, noted, "We have to manage the customers' expectations quite a bit. Some companies are looking for color, video, and high-speed transmission from E Ink, and it's just not there yet. People see movies like the *Minority Report* and want to buy screens that project images that way. They don't realize that it's still science fiction right now."[17] Like so many small companies, E Ink faced a chicken-and-egg problem; they needed revenues to fund the R&D process, but customers were not inclined to sign contracts until the technology was proven.

Restructuring the Company: 2003–2004

It was time to make some difficult decisions. In the fall of 2003, management decided to shut down development on Ink in Motion, cancel the watch contract, and bet the farm on its vision of paper-like graphical displays for electronic publishing devices. Then they would focus 100% of management and technical attention on delivering an acceptable product to Sony.

The plan quickly yielded results in reducing the cash burn of the company and increasing morale and speed of development. Furthermore, the company only needed to produce ink (no more short IIM runs), and it only needed to manage one supply chain. Yet even with a crisp focus in the R&D effort and improved execution, the company would still run out of cash in early 2004. The plan called for Sony to ship its first E Ink-based eBook in May 2004, about six weeks after the company would go broke. By the end of 2003, the function of the alpha and beta products had been generally approved by Sony, but technical and quality issues remained that would need to be solved before Sony would

purchase the product. Cash would run out before the product could be shipped, and without a shipping product, the company faced a difficult task to raise additional investment on favorable terms.

In January 2004 CEO Iuliano decided it was time for new leadership, and he left the company. Half of the board also resigned. Wilcox was appointed as the new CEO. To bridge the gap between the current state and the goal of shipping the product, he asked all existing investors to chip in 15 cents for every dollar they had previously invested and to reduce the liquidation preferences on the company. The majority of investors agreed, and with an additional $11 million in cash, E Ink would now be solvent for almost another year.

Present Day: The Launch and the Decision, 2004–2005

Just a month after the closing of the recapitalization round, all technical issues were successfully resolved, and the following month, E Ink was proud to announce the launch of the Sony eBook. The product received substantial attention in the press, and E Ink began to reap the rewards quickly—the phone was ringing off the hook. They had always known that the potential for eBooks, eNewspapers, and other forms of ePaper was great; now they were finally getting serious calls from tech customers who needed their product. As Kuwada noted, "We did not have the size and clout to say 'E Ink Inside' yet, but the business community was aware of us, and we would continue to work on branding in the year to come."[18] Due to the successful launch, E Ink met many of its goals in 2004: the burn rate was 15% below the company's projection for 2004. With product sales and government grants, revenue grew from $1 million to $4.5 million.[19] They were also better poised to attract more capital. As Ken Titlebaum, vice president of Finance, put it, "In late 2004, Intel Capital came in and took a look—they liked the possibilities of the technology, and they saw our pipeline leads as a positive, so they decided to get involved."[20] With an additional infusion from Intel Capital, E Ink extended its liquidity to October 2005.

With a single ink recipe and the practice coming from significant volumes, the ink-production team stabilized the process and established a reliable supply capability. The team then turned to yields to improve production economics and made substantial gains (and anticipated further improvements). (See **Exhibit 5** for key technical competencies of E Ink.) As the vice president of Development, Ritter, put it: "Once we focused on a common material platform, the ink, we could work in partnership on the other supply chain issues and shift our development effort to a next-generation ink that would improve performance and enable new applications."[21]

The relationship with Toppan, however, proved to be complicated. As with many joint-venture projects between U.S.- and Japanese-based companies, E Ink was facing challenges with language, time zone, and business style. Sustaining the relationship required substantial management attention from both companies. Similar challenges emerged in the relationship with Philips, which was both an investor and the current backplane supplier. In 2005, Philips decided to exit many of its display manufacturing businesses, including supplying the E Ink displays for Sony. Philips helped E Ink transition to a new manufacturer in Taiwan, a transition that caused a temporary setback to the growth of the graphical display business.

Intel Capital might play a role in replacing Philips as its high-profile electronics partner. As a new strategic investor, Intel sought to shape technical priorities and was particularly interested in color capability. A portion of the Intel investment would be dedicated to a project that would tackle the problem of offering full-color capability under low-power conditions. E Ink shared the enthusiasm for development, and many of its prospective customers valued color highly.

Furthermore, several companies were developing flexible electronics technologies that would permit E Ink to shift from glass to flexible displays. Such technologies likely would not be commercialized until 2007–2008, but by mid-2005 E Ink was working with half a dozen different display makers that were integrating electronic ink with plastic active matrix backplanes to make flexible and even rollable displays. (See **Exhibit 6** for paper-like flexibility expected in 2007.) E Ink was able to sell both ink supplies and consulting services to these companies and held significant patents in the flexible-display field.

While E Ink pushed on new tech frontiers, they also returned to their previous signage and watch customers. With a stable ink platform now available in the form of rolls and sheets of plastic coated with ink (the FPL), the management team judged it could now support all customers using the same basic product platform being manufactured at Toppan. To address the IIM opportunity, E Ink supplied rolls and sheets to two manufacturers in Asia, which handled the short-run customization and sold finished POP signs to advertisers themselves. Although E Ink had disappointed the first watch company, many other watch companies remained enamored with the technology and were interested in establishing a potential customer relationship. In March 2005, Seiko announced an $800 luxury watch using the E Ink technology. E Ink also offered to provide ink sheets to sophisticated customers who could make their own segmented display cells. In June 2005, Toppan announced its signage business in partnership with NEC, Vossloh announced its signage business in Europe, and Citizen announced a large, flexible clock product that could operate for 10 years on two AA batteries, all using E Ink's technology.

The chief impediment to growing the segmented display business was the need for a customer to set up a special assembly line to convert ink sheets into individual display cells. Only very large accounts could justify that effort. By mid-2005, E Ink had identified and qualified a manufacturer in China that could cheaply convert the ink sheets into finished display cells for many different sizes. E Ink began selling the finished display cells to its new segmented customers, thus greatly reducing the costs of adoption. E Ink also pursued further R&D contracts for development of the matrix technology and anticipated it would continue to be able to fund roughly half of its R&D from these sources. Overall the burn rate dropped from over $2 million at its peak to less than $800,000 per month.

With so many irons in the fire, Wilcox naturally had to ask the question: Was E Ink starting to take on too many diverse projects once again? The company had greatly improved its execution when it focused purely on Sony and turned away all other inquiries. With the ink sheets now available as a platform, many customers were now calling, and the single platform did not meet the needs of all of them. As McCreary explained, "In the past, E Ink chased a lot of rabbits—and it was not efficient to try and catch them all. The focus on Sony helped, but we cannot rely on just one customer or even one application. Now we again need a process to winnow down our prospects, evaluate our array of projects, and send some down and out earlier in the development effort."[22]

In 2005, the company was pushing hard to develop graphical display opportunities, but without exciting content, it might take the eBook class of products two or three years to penetrate the mass market. In the meantime, the company was devoting commercial resources and management attention to reenter the segmented display market with its existing technology, which might bring in about $10 million in annual revenue over the next few years. Management estimated that the segmented display market would turn modestly cash positive within the next six months to a year.

The segmented business was a hedge against the risk that the eBook market would take longer than expected to develop, but it was not large enough to stand alone as the single opportunity that would drive the company. In combination with the eBook business, and utilizing the same ink platform, the segmented business was likely to generate early profits. Wilcox knew that he could

return to a pure eBook or graphical display focus, possibly by raising additional cash to fund operations until the eBook sector or the flexible display field emerged. Ultimately, however, E Ink could not readily affect the timing of those markets. On the other hand, selling into the segmented business would pose a more controllable sales and marketing challenge.

In a midyear letter to investors, Wilcox spelled out the highlights of first-quarter and second-quarter 2004: the engineers and scientists had resolved many pressing technical issues, and the high-profile product launch with eBook had generated excitement in the press, the public, and, most importantly, E Ink's customer base. They had raised over $120 million since start-up in 1997, and some of their earliest investors and customers were still with them; hopefully they might now enjoy some success together. He assured investors that E Ink was diligently filling the sales pipeline and was working hard on color and flex technology that would take the company to the next level. The entire E Ink team was still highly motivated as well, as Souza, vice president of Operations, noted: "Even during 2003, with all of the uncertainty and complexity of the manufacturing process and within the company itself, the team was completely dedicated to finding solutions. Whatever came up, they were determined to fix it, whether it took days or weeks to do so."[23] Toppan saw the synergies between the graphical and segmented product lines and had started a business unit to promote the signage business in addition to the eBook business.

In spite of the apparent volume benefits of selling the same ink sheets to different types of customers, Wilcox knew that E Ink had previously failed when it tried to address multiple markets and noted, "We have to continuously look in the mirror and ask if we are doing the right thing." (See **Exhibit 7** for addressable markets for film component and **Exhibit 8** for the E Ink business model for graphical displays.)

New competition and new sources of funds Historically E Ink management was more concerned with traditional LCD technology than with direct competitors in the area of paper-like displays. Direct competitors such as Sipix and Bridgestone were targeting similar paper-like technologies, but each faced technical challenges that E Ink had solved. Sipix and Bridgestone lacked E Ink's intellectual property, and they were significantly behind in production. E Ink was realizing an order-of-magnitude improvement in the performance of its ink every second year. The ink had once required 300 volts and two seconds to change form; in 2004, it was taking 15 volts and 200 milliseconds. Yields were also up substantially in 2004. (See **Exhibit 9** for electronic ink technical performance.)

E Ink also continued to track substitute technologies. Two companies with profiles somewhat similar to E Ink's had liquidity events in late 2004. First, Iridigm, a prerevenue company, was acquired by Qualcomm for $190 million,[24] and then Cambridge Display Technologies (CDT) went public for $200 million.[25] Iridigm used a new technology, called micro-electro-mechanical systems (MEMS), combined with thin-film optics. Qualcomm believed Iridigm's MEMS technology could offer a breakthrough in displays with substantial improvements in performance, power consumption, and cost. Qualcomm was especially interested in the features for cell phones, which included color, tolerance of extreme temperatures, and viewability in any environment, including bright sunlight.

CDT was founded in 1992 by a research group in the Cavendish Laboratory at Cambridge University. In the early days, the company received funding from Cambridge and seed-stage VCs, moving into U.K.-based financiers and New York-based private equity funds through the 1990s. CDT had grown to become a leader in the development of polymer organic light-emitting diodes (P-OLEDs), focusing on their application in next-generation flat-panel displays. Leading up to the IPO, the company had over 160 published and unpublished patent findings and was exploiting its extensive intellectual property portfolio, manufacturing and engineering expertise, and partnerships with leading display companies. It had licensed the P-OLED technology to numerous companies

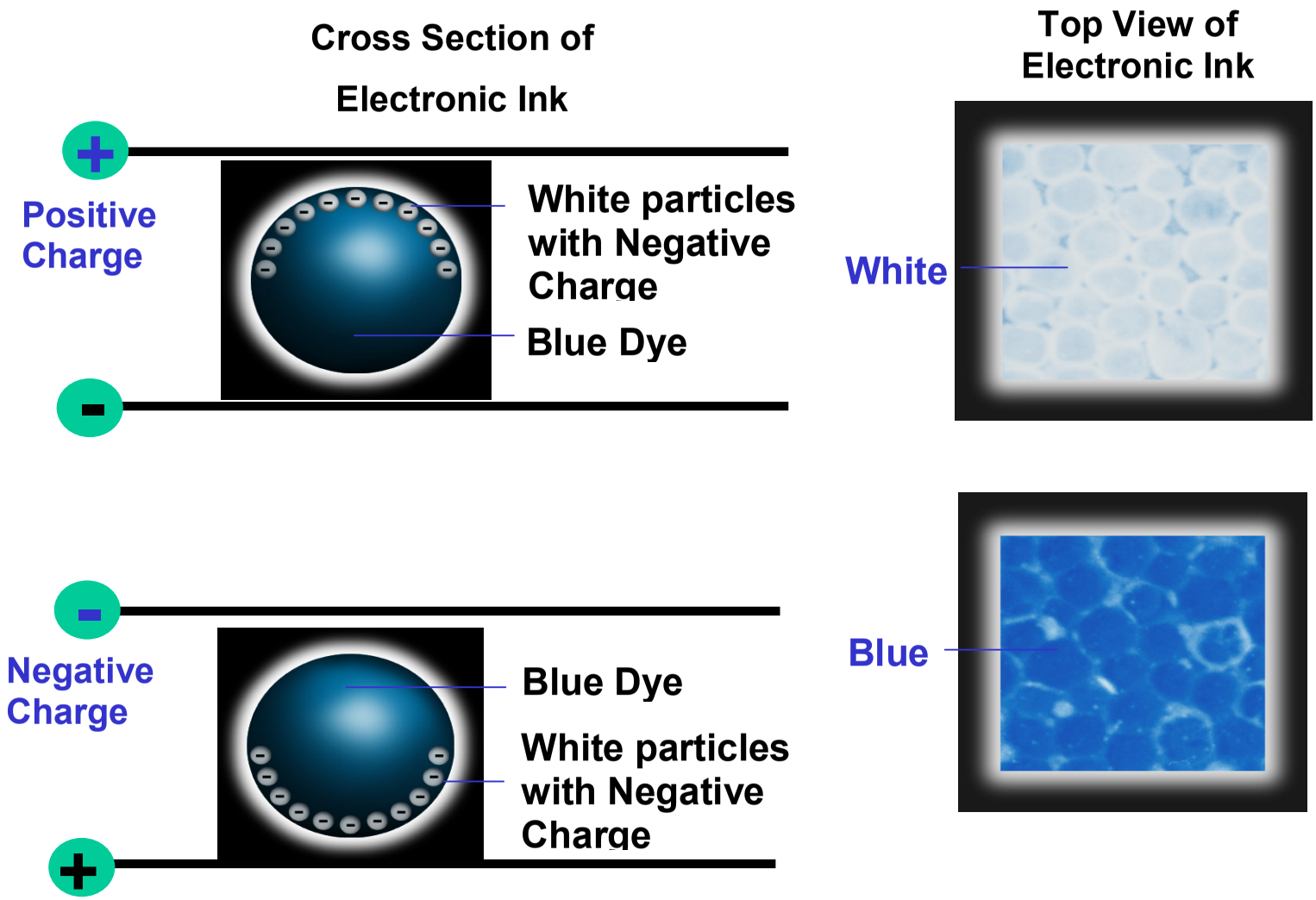
including Philips, Seiko Epson, Osram, DuPont, and Delta Electronics. Products that incorporated CDT's technology included a mobile phone, an electric shaver, an MP3 player, medical devices, and a range of point-of-purchase and other promotional items. While it was not yet cash flow positive, operating at a net loss of approximately $30 million in the third quarter of 2004, CDT successfully floated on the NASDAQ in December 2004. (See **Exhibit 10** for CDT's summary financial data and **Exhibit 11** for its consolidated balance sheet.) CDT announcements in early 2005 included a project with Ilford Imaging in Switzerland, a business collaboration with Add-Vision, and a phase two program with Toppan Printing to pave the way for more optically efficient devices in the future.[26]

As Wilcox and his team assessed the company's prospects, they knew that, at last, they were running a clear, functional organization that was shipping a high-profile product and, with their current reserves, they would be solvent until October of 2005. By squeezing performance, aggressively controlling costs, and growing revenues, the company hoped to break even by the end of 2006. Ultimately, E Ink needed $25 million in annual revenue to break even. (See **Exhibit 12** for E Ink's profit-and-loss target.)

E Ink had chosen to be an ink supplier in the value chain; this was a relatively capital-efficient strategy and brought in revenues immediately. At various points in time, some board members had suggested that E Ink pursue an even more capital-efficient strategy—that is, a pure licensing model, allowing its partners to make the entire product. Yet both licensing and ink-manufacturing business models implied a limited amount of revenue. (See **Exhibit 13** for the E Ink business model as an ink supplier.) If E Ink only sold ink or technology, its downstream customers would generate the lion's share of revenue. Meanwhile, the company had become familiar with many Asian ODMs and OEMs. This led the management team to also ask the inverse question: "Should E Ink assemble complete display modules, or even system-level products such as eBooks, that can uniquely benefit from E Ink technology?" For the short run, management would focus on ink. Wilcox stated, "We could offer downstream products in the future, especially if we can do an IPO and have enough cash to cushion the entry costs. For now we have to raise capital from private investors at expensive rates, and capital efficiency is more important." (See **Exhibit 14** for E Ink's capability road map.)

With cash still limited, there were many questions in the path forward. Should E Ink invest R&D funds in developing faster, more colorful displays that would enter more product applications but compete directly with LCD? Or should it reduce its R&D expenses and wait for the eBook market or the flexible display market to emerge, based on the existing electronic ink technology? Should E Ink drop the segmented effort to focus on graphical displays, or increase the segmented effort to create a near-term funding source? What should they do about the government contracts that provided such a significant and reliable amount of revenue for the R&D effort? How should they manage the relationship with Toppan? Should they raise a Series F round, and what should they try to accomplish over the next few months to put them in the best position? Or given the actions at Iridigm and Cambridge Display, would a merger and acquisition or IPO be a better alternative?

Exhibit 1 Manufacturing Electronic Ink, circa 1999



Source: E Ink company presentation.

Exhibit 2 Corporate and VC Investments in E Ink, 1998–2004

Industry	First Round	Media Round	Philips Round	Toppan Round	Toppan Round #2	Recapitalization	Intel Capital Round
	$16M—1998	**$40M—1999**	**$7M—2000**	**$5M—2001**	**$25M—2002**	**$11M—March 2004**	**$[N/A]—2004**
Media	***Hearst***	Hearst	Hearst	Hearst	Hearst	***Hearst***	Hearst
	L'Espresso	L'Espresso	L'Espresso	L'Espresso	L'Espresso	L'Espresso	L'Espresso
	McClatchy	McClatchy	McClatchy	McClatchy	McClatchy	McClatchy	McClatchy
	Universal-Vivendi	Universal-Vivendi	Universal-Vivendi	Universal-Vivendi	Universal-Vivendi	Universal-Vivendi	Universal-Vivendi
	Gannett	Gannett	Gannett	Gannett	Gannett	Gannett	Gannett
	The Interpublic Group (TIG)	TIG	TIG	TIG	TIG	TIG	TIG
	Creavis GMBH	Creavis GMBH	Creavis GMBH	Creavis GMBH	Creavis GMBH	Creavis GMBH	Creavis GMBH
Electronics	***Motorola***	Motorola	Motorola	Motorola	Motorola	Motorola	Motorola
	Lucent	Lucent	Lucent	Lucent	Lucent	Lucent	Lucent
Chemicals	***Degussa-Huls***	Degussa-Huls	Degussa-Huls	Degussa-Huls	Degussa-Huls	Degussa-Huls	Degussa-Huls
	Cabot	Cabot	Cabot	Cabot	Cabot	Cabot	Cabot
			Air Products	Air Products	Air Products	***Air Products***	Air Products
Displays			***Philips***	Philips	Philips	***Philips***	Philips
				Toppan	***Toppan***	***Toppan***	Toppan
Financial	***Atlas***	Atlas	Atlas	Atlas	Atlas	Atlas	Atlas
	Applied	Applied	Applied	Applied	Applied	Applied	Applied
	Solstice	Solstice	Solstice	Solstice	Solstice	***Solstice***	Solstice
							Intel Capital

Source: E Ink company documents.

Note: Bold italics indicate new investors in each round.

Exhibit 3 Market Opportunity: Addressable Flat-Panel Displays

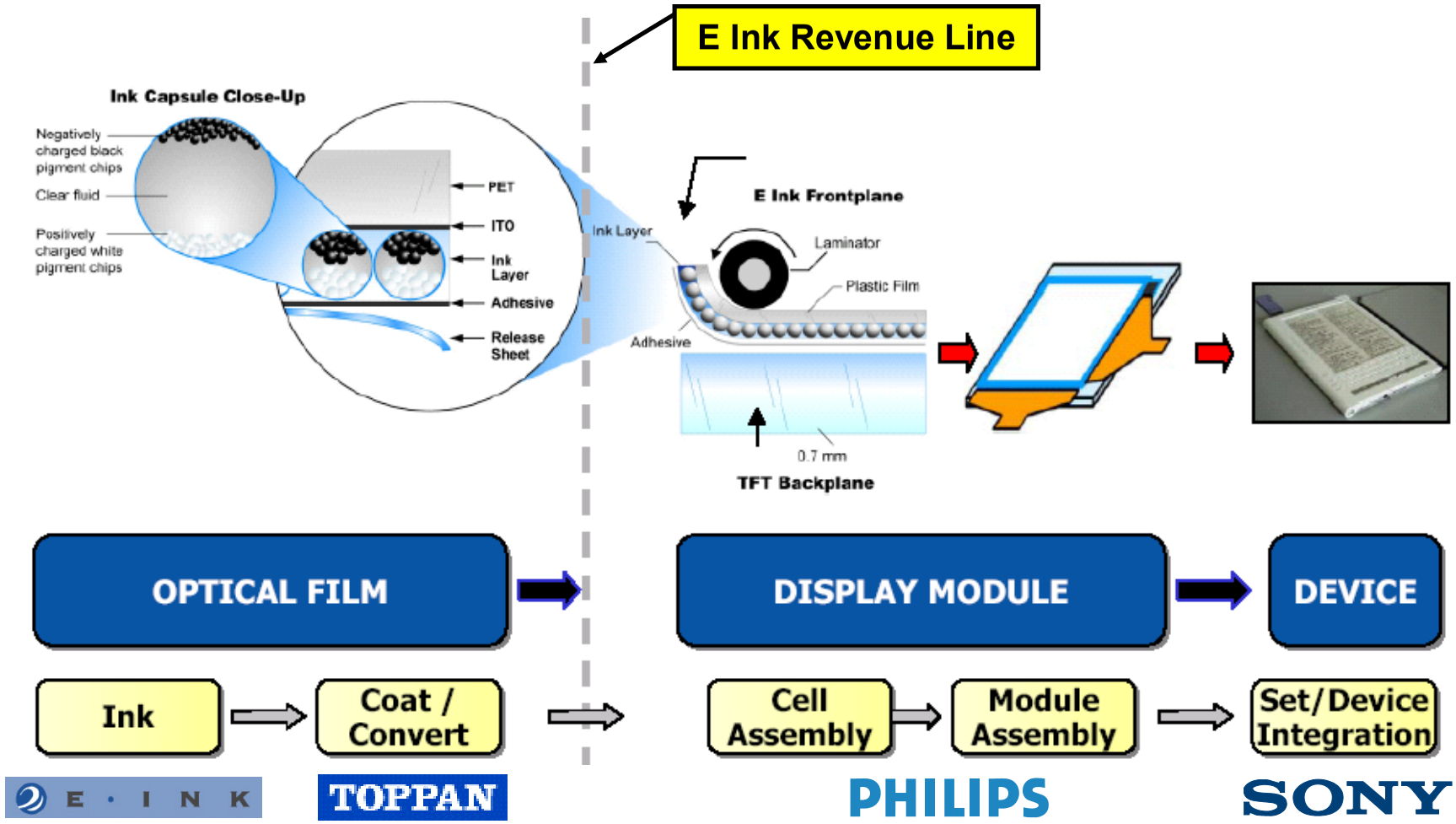
DOLLARS (billions):	2003	2004	2005	2006	2007	2008
Large-Area TFT/AM OLED	$24.0	$35.2	$32.6	$40.9	$48.2	$55.0
Small/Medium TFT/AMOLED[a]	9.4	13.3	14.7	16.6	17.9	18.7
PDP (Plasma)	2.8	4.3	5.2	6.6	7.5	7.5
Other FPDs	7.7	9.0	8.8	8.6	8.7	8.9
	$43.9	**$61.8**	**$61.3**	**$72.7**	**$82.3**	**$90.1**

UNITS (millions):	2004	2005	Growth
Notebook PCs	47.1	57.5	22%
LCD Monitors	74.6	99.3	33
LCD TVs	12.2	18.3	50
Other	4.6	6.2	35
Large-Area TFT/AM OLED	138.5	181.3	31%

Source: E Ink company presentation.

[a]10" diagonal differentiates Small/Medium vs. Large Area.

Exhibit 4 E Ink's Asian Supply Chain



Source: E Ink company presentation.

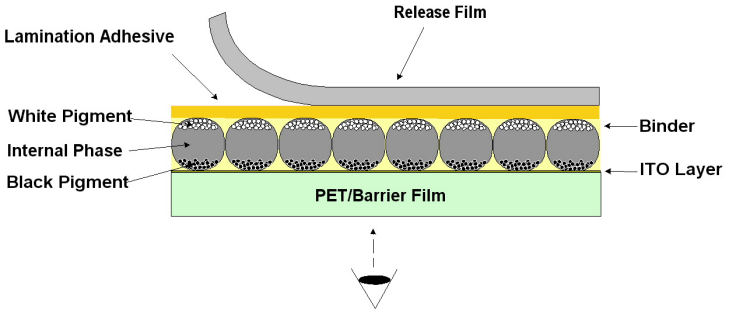
Exhibit 5 Key Technical Competencies of E Ink

Optical Film R&D

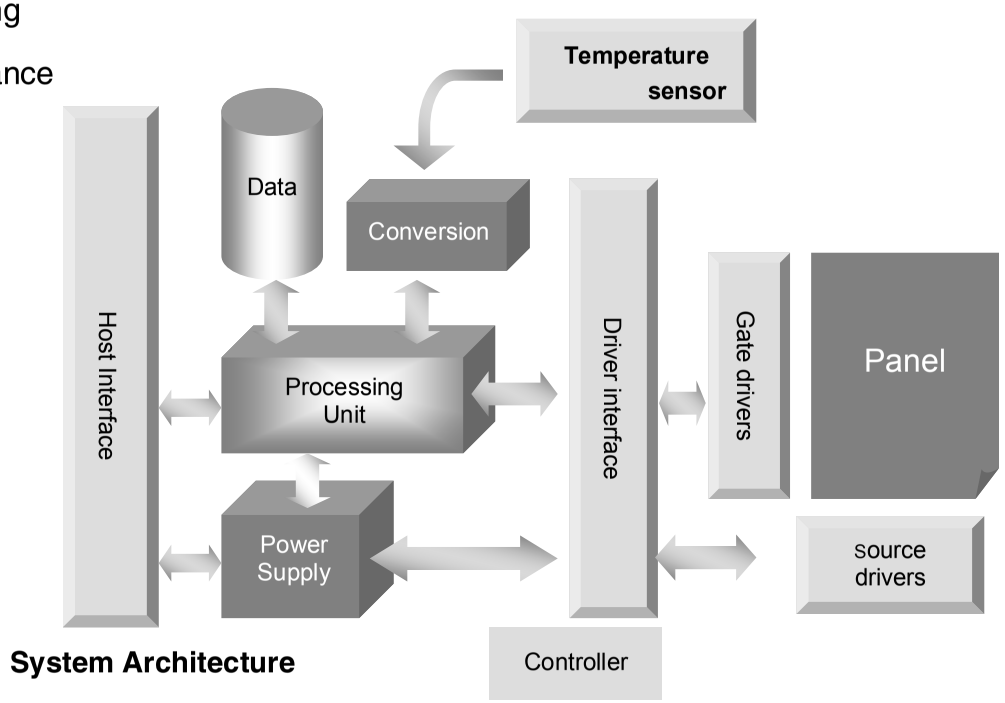
- Engineered Pigments
- Electrophoretic Suspension
- Encapsulation
- Adhesives & Substrates
- Coating Formulation
- Optical Performance
- Lifetime Test

Application Engineering

- Cell Assembly
- TFT Design
- Drive Waveforms
- Temperature Compensation
- Controller Design
- Packaging
- Performance Test



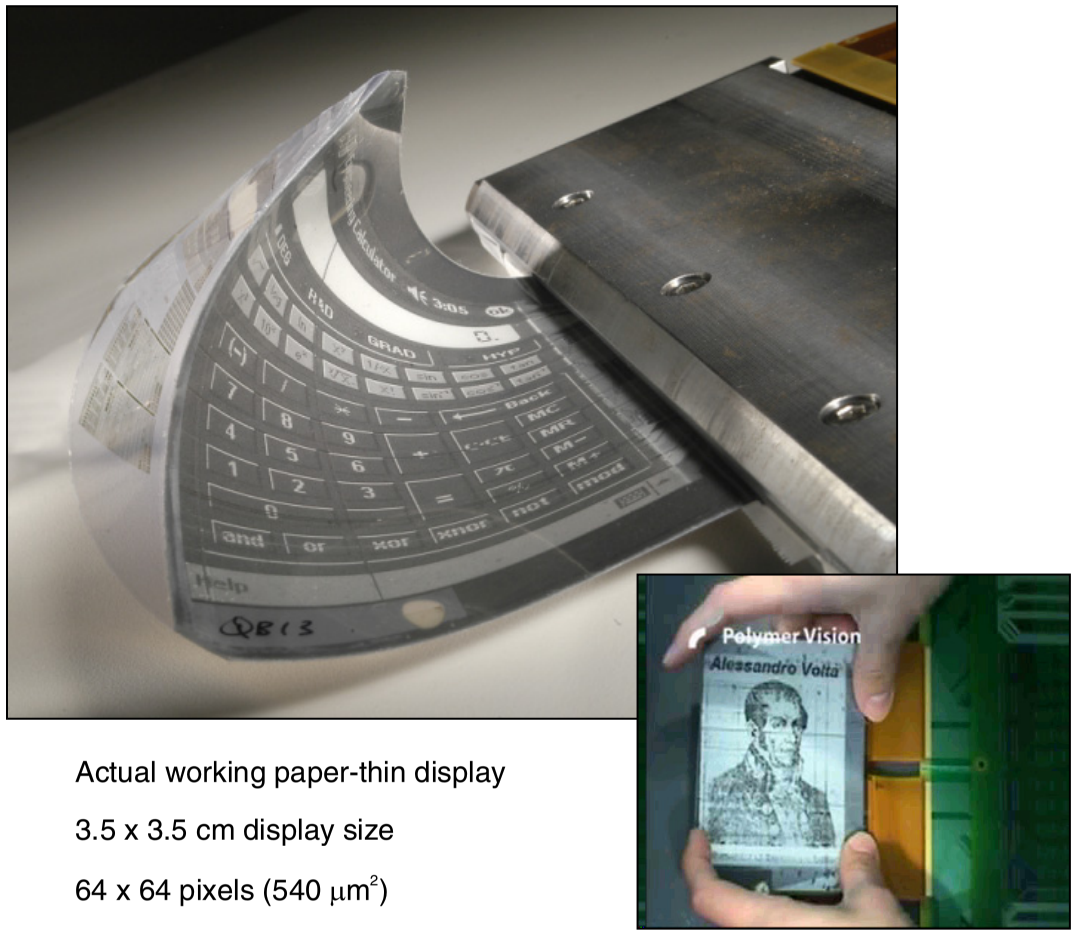
Film Design

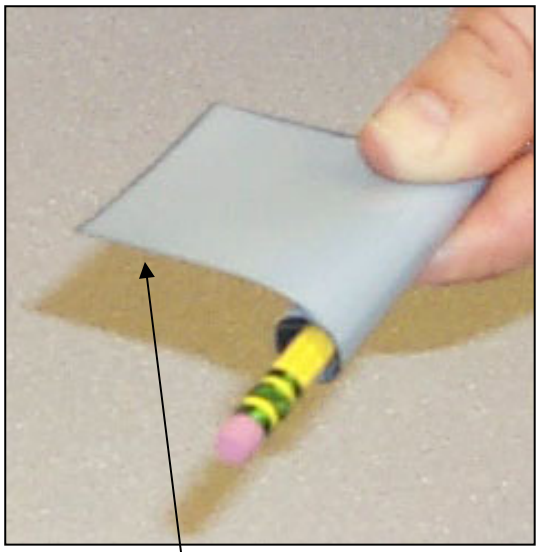


System Architecture

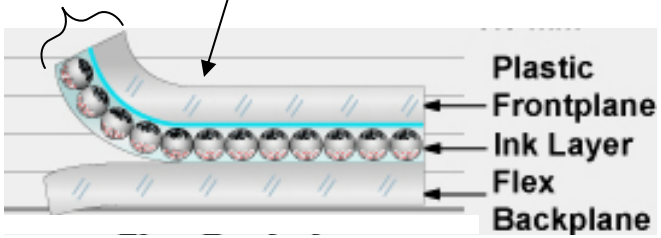
Source: E Ink company presentation.

Exhibit 6 Paper-like Flexibility Expected in 2007





E Ink Front Plane Laminate (FPL)



Actual working paper-thin display

3.5 x 3.5 cm display size

64 x 64 pixels (540 μm^2)

Rollable into a radius of ~1 cm

Pentacene transistors (spin coated)

Lithographic patterning

Ink or 1mil PET

Ref Philips Papers:

1. Nature Materials, 25 Jan. 2004
2. USDC Flex Conference Proceedings, 2004

Source: E Ink company presentation.

Exhibit 7 Addressable Markets for Film Component, Estimates in 2004

	2005BP Modules	2010BP Modules	Film Value	E Ink's TAM	Market Share	Revenue Potential
Matrix Displays for Portable Devices						
Handheld PDA/cell/pager/camera	$5,920	$7,400	20%	$1,480	5%	$ 74
eBook/eDictionary	200	1,000	20	200	75	150
Tablets, Office Viewers	880	1,100	20	220	33	73
Portable Monitor, eNewspaper		1,000	20	200	75	150
Segmented Displays						
Signage (indoor/outdoor)	$5,600	$7,000	20%	$1,400	10%	$140
Consumer Electronic Displays	2,400	3,000	20	600	20	120
Total	9,080	13,100		2,620		633

Source: E Ink company presentation.

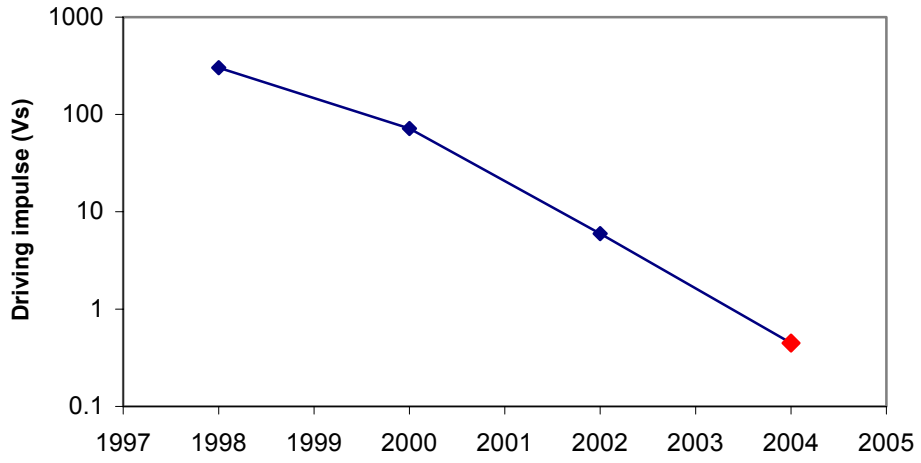
BP = Ballpark market size in thousands of dollars.
The portion open to ePaper is based on percentage of applications needing low power, high reflectance, non-emissive.
Film value is over 25% of the display module today but expected to come down a bit with volume.
Target market share is based on expected competitive intensity and cost sensitivity.

Exhibit 8 E Ink Business Model for Graphical Displays

Value Chain Position	Typical $/Unit	Gross Margins	Incremental Investment to Reach Break-even	Market Size
Licensing	$3	95%	$5 million	$45 million
Material	15	50	10 million	300 million
Display	75	15	30 million	1.5 billion
Device	125	20%	100 million	3 billion

Source: E Ink company presentation.

Exhibit 9 Electronic Ink Technical Performance



The y-axis represents the drive impulse required to shift the ink from white to black or black to white. The impulse is the product of voltage and time. The first data point is 300V times 1000ms (or 1 sec), or 300 Volt-secs. In the last six years, E Ink made an overall >600x improvement in speed per volt. The y-axis is a logarithmic scale, indicating that E Ink has achieved roughly an order-of-magnitude improvement (10x) every two years.

Source: E Ink company presentation.

Exhibit 10 Cambridge Display Technologies Summary Financial Data (in thousands, except per share data)

	Year Ended December 31		Nine Months Ended September 30	
	2002	2003	2003	2004
Operating revenues	$ 7,053	$10,680	$ 8,619	$ 5,519
Gross profit	5,261	9,153	7,348	4,302
Operating expenses	40,195	29,632	25,012	20,777
Loss from operations	(34,934)	(20,479)	(17,664)	(16,475)
Other income (expense)	(379)	(3,230)	(2,069)	(1,987)
Net loss	($31,718)	($22,777)	($18,866)	($29,072)
Net loss attributable to common shareholders	($32,019)	($29,548)	($23,886)	($34,326)
Net loss per share Basic and diluted	($1.96)	($1.78)	($1.44)	($2.07)

Source: Company information, www.cdtltd.co.uk.

Exhibit 11 Cambridge Display Technologies Consolidated Balance Sheet (as of September 30, 2004, in thousands)

	Actual	Pro Forma	Pro Forma as Adjusted
Cash and cash equivalents	$ 2,896	$ 1,700	$ 24,531
Working capital	156	(1,040)	24,290
Total assets	112,027	103,282	126,113
Short-term borrowings	2,500	2,500	--
Redeemable convertible preferred stock	43,741	--	--
Accumulated deficit	(148,179)	(148,179)	(153,864)
Unearned stock compensation	--	--	(9,360)
Total common shareholders' equity	28,472	82,196	106,881

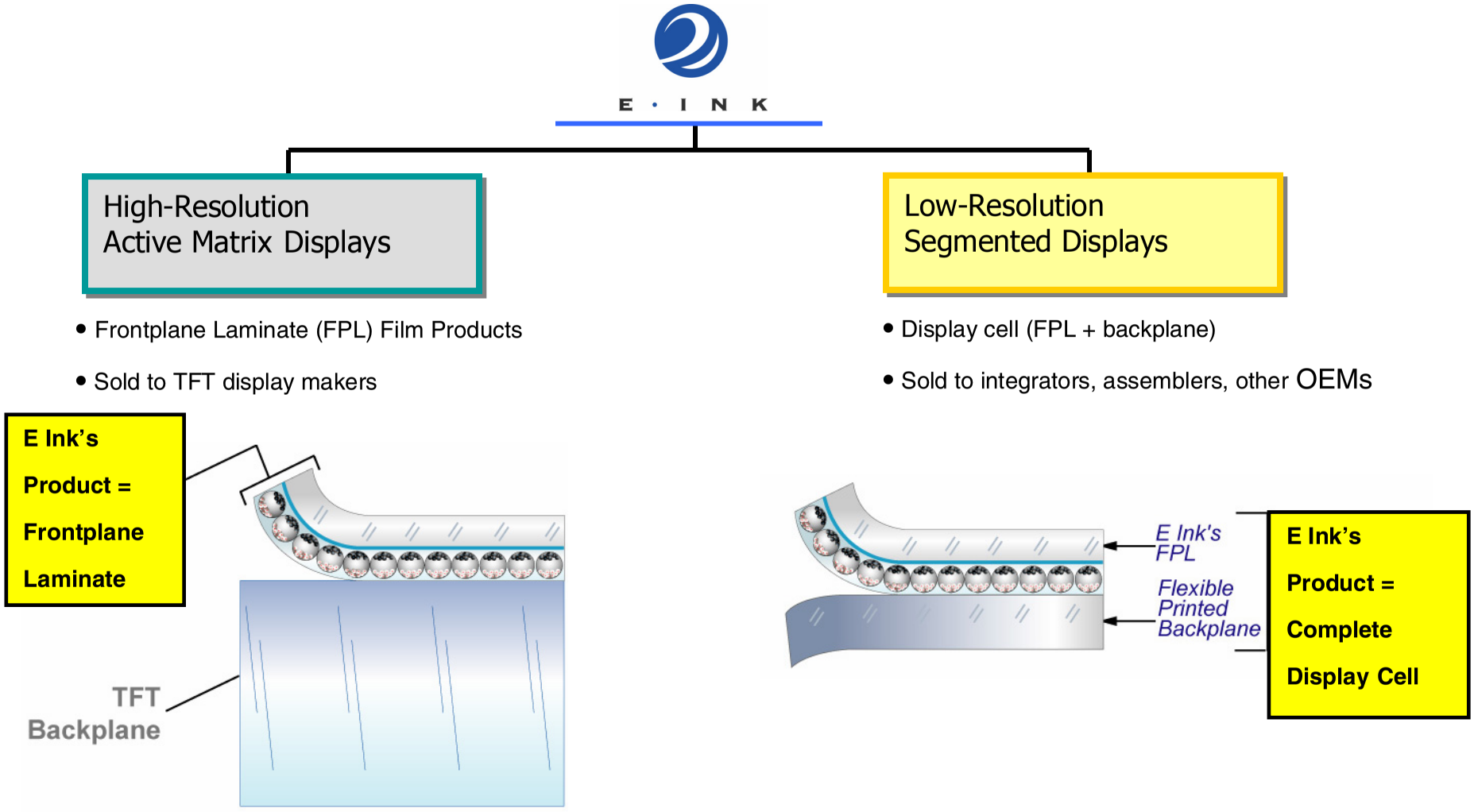
Source: Company information, www.cdtltd.co.uk.

Exhibit 12 E Ink Target P&L

Sales	100%
Cost of Goods	50
Gross Margin	50
Research	10
Development	15
SG&A	10
Operating Costs	35
Net Profit	15

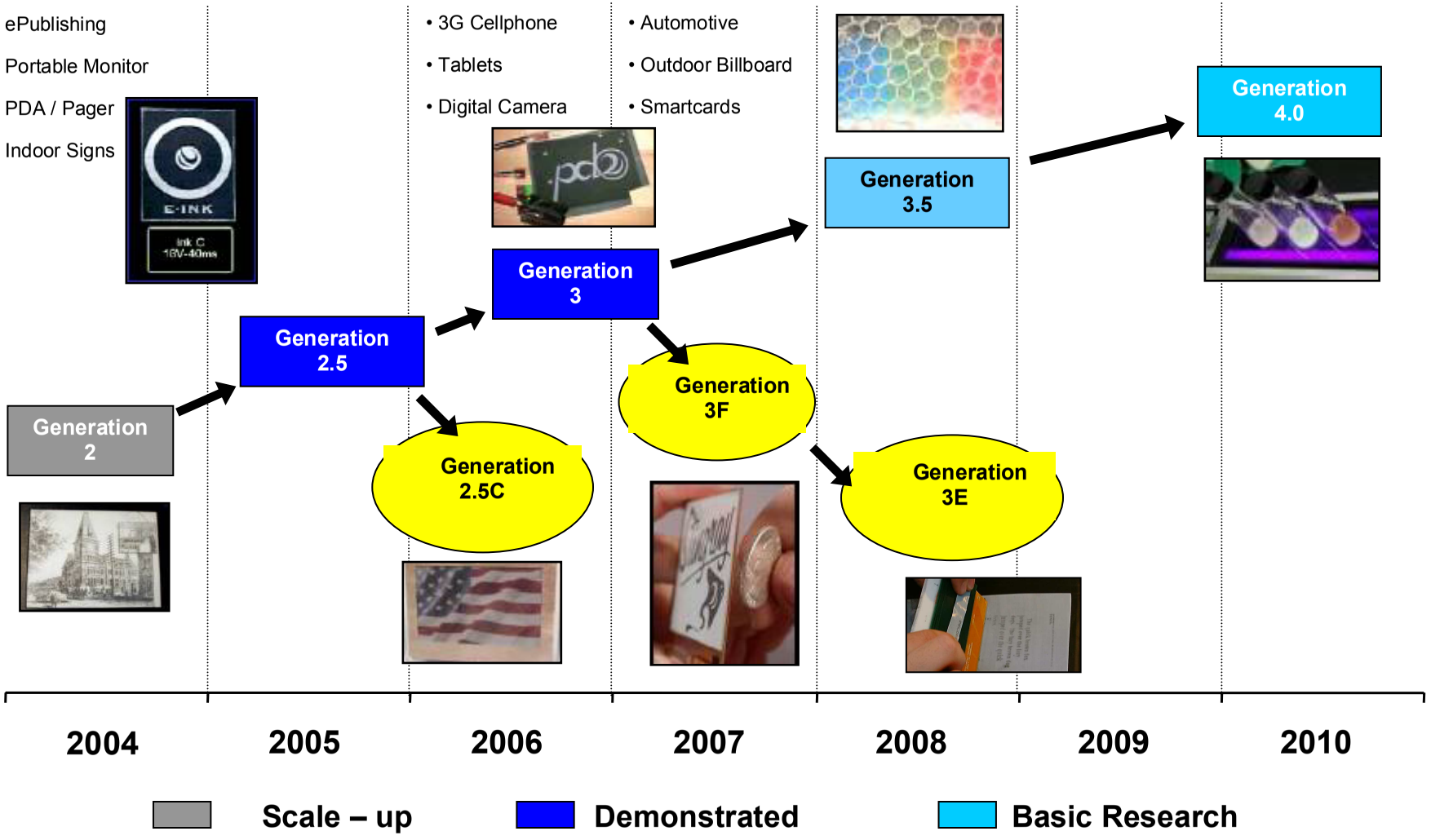
Source: E Ink company presentation.

Exhibit 13 E Ink Business Model—Ink Supplier



Source: E Ink company presentation.

Exhibit 14 E Ink Capability Road Map



Source: E Ink company presentation.

Endnotes

[1] http://www.media.mit.edu/people/bio_jacobson.html.

[2] Confidential document, "E Ink Business Plan," February 1999, pp. 15–16.

[3] Ibid., July 1997, p. 7.

[4] Ibid., February 1999, p. 20.

[5] Ibid., p. 21.

[6] Ibid., p. 22.

[7] Ibid., pp. 24 and 27.

[8] Ibid., p. 28.

[9] Ibid., p. 33.

[10] Interview with John Ritter, January 12, 2005.

[11] Confidential document, "Philips Deal Overview," October 27, 2000.

[12] Confidential document, Board of Directors Meeting, September 14, 2001, p. 3 of slides.

[13] Ibid.

[14] Interview with Phillip Souza, January 12, 2005.

[15] Interview with Dr. Michael McCreary, January 21, 2005.

[16] Confidential document, Board of Directors Meeting, May 10, 2002.

[17] Interview with Ryosuke Kuwada, January 21, 2005.

[18] Ibid.

[19] Confidential document, "Letter to Investors," February 9, 2005.

[20] Interview with Ken Titlebaum, January 12, 2005.

[21] Interview with John Ritter, January 12, 2005.

[22] Interview with Dr. Michael McCreary, January 12, 2005.

[23] Interview with Phillip Souza, January 12, 2005.

[24] http://www.iridigm.com/news_article_040909.htm.

[25] http://www.ipohome.com/common/ipoprofile.asp?ticker=OLED.

[26] http://www.cdtltd.co.uk.