5

TECHNOLOGY TRENDS TO WATCH

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INNOVATION IN ACTION

5 TECHNOLOGY TRENDS TO WATCH

Welcome to the latest edition of *Five Technology Trends to Watch*. This annual Consumer Electronics Association (CEA)® publication looks at the new technologies that will impact our lives.

The $206 billion consumer electronics (CE) industry represents a bright future of growth and progress. Change and innovation are CE hallmarks. To determine five areas to track in our fast-moving industry, CEA analysts used the latest consumer research and market forecasts.

In the 2013 issue, we look at 3D printing, the next-generation of TVs and displays, the evolution of audio, how wireless technology is changing lives in Africa and the impact of technology on education. This year we also have included an addendum that examines where our analysts got past predictions correct and where we may have missed the wave. For example, we were spot on discussing the looming broadband bottleneck in 2006, but perhaps a little ahead of the curve predicting in 2004 that consumers may have a domestic robot within 10 years.

Of course, the best place to keep an eye on new technologies is the 2013 International CES® in Las Vegas. Held January 8-11, CES is where some 20,000 new products are launched each year. For example, HDTV, DVR, HD radio, OLED TV, 3D HDTV, connected TV, smart appliances, Ultrabooks and Android 4.0 tablets all got their start at CES.

With 3,000 exhibitors and more than 150,000 attendees, including 35,000 international visitors, CES is the worldwide showcase for new products. It is also the best place to learn about new advances with our world class keynotes and more than 800 industry experts speaking in 300 conference sessions.

To see award-winning technology, check out the Innovations Design and Engineering Awards showcase, which honors achievement in product and engineering design, Eureka Park, which displays entrepreneurs' new products, services and ideas, and more than 20 TechZones which cover areas like cloud computing, the Digital Health Summit, gaming, GoElectricDrive, CEPro@CES and PMA@CES.

Come to CES and see innovation in action. For the latest show updates, visit CESweb.org.

Gary Shapiro
President and CEO

A LOOK AT PAST PREDICTIONS
By Sean Murphy

Every year we identify five specific technology trends that we expect will loom large in years to come. Of course, we are unable to predict with certainty what the future holds for consumer electronics, but armed with market research, consumer studies and an ever-expanding industry forecast, our analyst team prides itself on being able to anticipate which products and trends will have a serious impact on the market.

This year we decided to examine the last decade of technology forecasts to ascertain where we got it right. Which analysts had their powers of prognosis especially dialed in? As we looked back through our reports and revisited the moments in recent history that have made waves in the industry, several discernible patterns emerged. First, although consumer electronics are constantly evolving, certain issues related to technology like access and retail sales models continue to impact the market. Further, innovation ensures that our industry is never stagnant: today is invariably better and brighter than yesterday. But we are also building on the advancements of others, and the causes and concerns that we observe and editorialize one day may resurface many years down the road.

In 2004, we explored the exciting future of portable entertainment. Considering the proliferation of iPods, followed by tablets and smartphones, it is safe to conclude we were quite prescient here:

Music consumption patterns are shifting in a decidedly digital direction and portable digital video is gaining momentum thanks to falling prices. New business opportunities like licensed digital music services are emerging and fostering purchase intent. In turn, purchase intent for portable entertainment solutions among consumers is at levels conducive to industry growth. And as falling prices intertwine with new features and functions, expect even more consumers to embrace new digital solutions for portable entertainment. Without a doubt, portable entertainment is one category to keep an eye on.

In 2006, we ran an essay called "The Looming Broadband Bottleneck." Certainly this issue continues to be a concern, and debates over broadband access and bandwidth are as relevant now as they were six years ago:

The issue of Net Neutrality is a huge one that is pending before the U.S. Congress. The stakes are enormous in this debate and however it plays out it will have a great influence on the Internet of tomorrow. Regardless, consumers will continue to demand Internet telephone service and Internet video service and will find ways to obtain the

content. *It is clear that all players need to come to agreement so that the innovation that created and spurred the Internet's growth will continue.*

In 2007, we considered "The Future of Radio." With the explosion of portable devices and pay-as-you-go content, radio may have been overlooked or relegated to an afterthought. Today, Internet radio is booming. Recent research by TargetSpot found 42 percent of U.S. households with broadband Internet listen to Internet radio.

Among consumer electronics products, radio has remained one of the most popular forms of media among U.S. consumers. Radio was the first CE product and, over nearly nine decades of broadcasting, has become the media equivalent of comfort food for the majority of the U.S. population. In the digital age, there is no shortage of products and content competing for consumer's money, time and attention, yet nothing seems to threaten radio's dominance. This is partially because radio continually evolves to meet consumer demand for content and partially because the term "radio" is applied to any sufficiently passive audio delivery mechanism that emerges.

In 2008, in a piece entitled "The Future Has Already Arrived," we examined the "localization" of the Internet. If anything, some of the observations and predictions seem quaint, considering the quantum leap forward our mobile connected devices have taken.

The Web radicalized dissemination of free, fast information; the ability of portable devices to deliver ubiquitous Internet access has revolutionized it. We now are increasingly able to reach the Internet at all times, in almost any location. Conversely, the identification of our location, and the ability of others on the Internet to reach us, is unceasing. Naturally, this will enable individuals taking advantage of progressive technology to live a dual online existence. As we've already noticed, shrewd businesses are eager to maximize the ways they can communicate with, and market to, this growing online community. At the same time, social networking sites like Facebook are further empowering friends and strangers to exchange opinions, advice and suggestions. The immediate impact of these advances will be almost entirely positive: active and busy people will be the beneficiaries of machines communicating with each other to produce targeted and actionable data.

Also in 2008 we took a close look at the Cloud and its implications for computing. With features like Dropbox hugely popular and issues of storage as prevalent as ever:

In this next era of the Internet, devices will do much of the sorting, filtering, contextualizing and connecting of data currently done by individuals. Presently, most of our technology experiences require significant user involvement. We tell the Web browser where to go then are subsequently required to parse the abundance of information retrieved. We segment and isolate content across software applications – from calendars and photo-sharing services to social networks and music subscriptions.

Just this summer, a Citris-Wakefield Research study found that the majority of Americans still think that bad weather will interfere with cloud computing. Most of the respondents also said they never used the cloud – but after further questioning, it turns out that 95 percent of respondents actually do.

It's safe to say CEA had an eye on technology trends even before the first *Five Techs* publications was released at the turn of the century, and we will continue to do so.

Ahead of The Curve

We are, of course, not oracles. Every year there are events and technologies that, for various reasons, generate buzz and garner attention. Sometimes that hype is more short-lived than anyone would have guessed. In other cases, a particular design is overtaken by the next new device. For every successful product there are many disappointments. And perhaps certain features have staying power, but their future has yet to arrive. In the spirit of reviewing how we did, it's only right to recount the instances where our analysts confirmed that they are, in fact, human. Let's take a look at some of the trends that did not pan out as quickly or successfully as we anticipated.

In 2000, we investigated the up-and-coming fad of "wearable computers." Interestingly, several of the quotes and observations were not incorrect so much as misapplied.

How at ease a person feels donning and using a PC in public will ultimately affect the wearable industry. "Wearable computers, like clothing or a watch, need to follow the basic rules of comfort without drawing attention," remarks [MIT Media Lab Research Scientist Steven] Schwartz. He and other scientists envision computing devices, sensors, communications devices and other electronics embedded into clothing and accessories such as bracelets and watches. Each article of clothing and accessory might be responsible for a different task, but together behave as a fully integrated computer.

As it turned out, some of the technical applications of computer-powered clothing were brought to fruition by smartphones as well as tablets. As CE products have become mobile and connected, consumers increasingly have the power of the Internet with them at all times, they just do not need to "wear" it so much as carry it.

In 2004 we looked at "hybrid white goods" and "smart" kitchens. Not unlike the example above, some of the initiatives discussed came into being via notebook, tablet and smartphone technology.

The need for speed coupled with the desire for old fashioned "home cooking" has led to the invention of several new products that could make the kitchen the center of the home. Called hybrid white goods, or simply the smart kitchen, the new category features such novelties as refrigerators that come with cable-ready TV screens, refrigerators that can monitor the shelf life of your in-box items, ovens that can download and execute recipes via the Internet, and even ovens that can be temperature-controlled during the day so they can store and eventually cook food via a cell phone request while you're still at the office.

Even without our ever-smarter portable devices, it is fair to wonder if even the most connected consumer would want or need this level of performance—bordering on science fiction—embedded in a refrigerator!

Finally, in the 2006 edition, we discussed robotics, and this may be a perfect example of an inevitable progression that is still ahead of its time. Or not…

This year, when CEA asked consumers how long they thought it would be before they could buy or rent a mobile domestic robot to accomplish their most hated chore, 57 percent of consumers surveyed expected to own a domestic robot within the next ten years. Is the robot they expect in ten years already on its way? Will 2005 be the first year since the advent of the dishwasher that consumers can say, "I bought it so I didn't have to do that chore anymore?" Only the engineers inside the world's electronics companies know for sure, but the odds that robots will arrive sooner than expected look promising. ■

3D PRINTING ARRIVES, LAYER BY LAYER

By Mark Chisholm

Imagine working on some home improvements and breaking the last drill bit in the house. Or, while working on your home PC, the batteries in your wireless mouse give out and you're left trying to navigate your system with just the keyboard. Today, these occurrences require a trip to the hardware or corner store to continue your work. But in the future it may be possible to save yourself the trip and 'print' such necessities with a 3D printer.

While the technology behind 3D printing, also known as additive manufacturing, has been around (and commercialized) for decades, such systems are now becoming common enough to show up on the mainstream consumer's radar. To be sure, the days when such 3D printers are commonplace enough to show up in consumers' homes (especially those sophisticated enough to print a battery) are a ways off, but the effects of 3D printing are beginning to be felt across a wide variety of industries. As the technology behind 3D printing evolves and prices drop, there may be no limit to what could feasibly be printed via additive manufacturing.

The Foundation

Many modern 3D printing systems trace their ancestry back to the 1980s, but the basis of additive manufacturing goes as far back as the 1960s, when researchers at the Battelle Memorial Institute first solidified a liquid using lasers. Forming an object out of a liquid resin is considered an additive fabrication technique – rather than a 'subtractive' one, such as milling or grinding. Laser-based experiments continued into the 1980s until the introduction of rapid prototyping and stereolithography.

Rapid prototyping was one of the earliest uses of 3D printing technology, and produced a scale model of a part. Stereolithography is considered by many to be the first rapid prototyping technique.

The term "stereolithography" was first coined by Charles W. Hull, founder of 3D Systems. In 1984, Hull applied for a U.S. patent on "Apparatus for Production of Three-Dimensional Objects by Stereolithography." Hull's method involved focusing ultraviolet (UV) light on curable liquids known as liquid photopolymers. Using this technique, a 3D object could be created by hardening the liquid layer by layer. Hull was awarded his patent in 1986 – the same year he founded 3D Systems. The company would go on to be the first to commercialize 3D printing with its SLA-1 system in 1988.

Stereolithography took advantage of the rising popularity of computer-aided design (CAD) systems during the 1980s. CAD software assists designers in the creation of both 2D and 3D models. Such models are the basis of 3D printing, and are fed to 3D printers from a computer. CAD software has evolved along with 3D printing technology in the years since its inception. A wide spectrum of 3D design software is available at price levels ranging from professional grade software suites to freeware applications.

Similarly, in the years since the first U.S. patent related to 3D printing was awarded, a number of other processes for additive manufacturing have been developed. Three additional 3D printing processes were commercialized in 1991. In January 2012, the International standards organization ASTM International (formerly the American Society for Testing and Materials) Technical Committee F42 on Additive Manufacturing Technologies published a list of seven different processes under the 3D printing umbrella. These processes are: binder jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photopolymerization (stereolithography). There are also a number of other 3D printing processes in development.

Of the processes defined by the ASTM International Committee, material extrusion is the most common among deployed 3D printing systems, according to the *Wohlers Report 2012: Additive Manufacturing and 3D Printing State of the Industry* from Wohlers Associates Inc.

The Multiple Applications of 3D Printing

A diverse group of industries have discovered the benefits of 3D printing, including automotive, aerospace, industrial and medical. "3D printing enables applications as diverse as customized in-ear hearing aids, fuel efficient transportation, better and more affordable consumer products, to medical and dental models and individualized implants that improve patient outcomes," says Cathy Lewis, vice president of global marketing for 3D Systems. "And it is all manufactured with near to zero waste because of the additive nature of 3D printing."

As part of its 2012 report, Wohlers Associates conducted a survey of manufacturers of 3D printing systems and 3D printing service providers to determine which industries were most commonly serviced by 3D printing. The survey found that the number one industry served by 3D printing firms was 'consumer products/electronics' at 20.3 percent, followed by the 'motor vehicle' (19.5 percent) and 'medical/dental' (15.1 percent) industries.

Consumers and CE: The uses of 3D printing in the production of consumer products are as varied as the industries named by the Wohlers report. Consumer products created via 3D printing include jewelry, unique kitchenware, decorations, figurines and electronics accessories such as cell phone cases. While it's exciting to imagine all the products we dream of creating via 3D printing, the technology also finds its way into products we might never consider. For example, the 3D Systems website features a holiday costume mask designed and produced by 3D printing.

Additive manufacturing is also sure to have a significant impact on the consumer electronics (CE) industry, well beyond the production of cell phone accessories. "3D printed circuit boards are evolving, and although the output is a little rudimentary right now, it is set to develop rapidly into sophisticated, accurate manufacturing," says John Alpine, vice president of engineering at Geomagic, a provider of software that creates digital versions of real world objects, and delivers 3D touch-enabled sculpting and design tools.
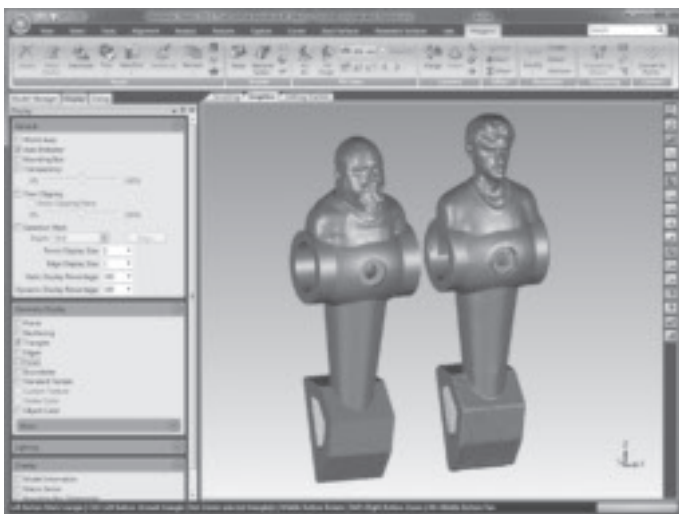

Geomagic Studios 2012 scanning software

As an example, Alpine points to a 3D-printed circuit board on Indestructables, a website owned by CAD software maker Autodesk that specializes in user-created and uploaded do-it-yourself projects. "Combine 3D printing of circuit boards with 3D printed metal or plastic casings and you could see the production time for new consumer products become limited only by the amount and velocity of the ideas behind them," says Alpine.

But the CE industry will also have its own impact on 3D printing's evolution. At the 2012 International CES, Geomagic demonstrated software that employed Microsoft's Kinect sensor to capture a 3D model of a user's face. The Kinect-to-Print app makes use of a CE product found in many consumers' homes to deliver a 3D scan of a user's bust that can later be sent to a 3D printer and transformed into a physical object. This is just one example of CE facilitating a low-cost of entry into the 3D printing space.

This relationship between 3D printing and existing CE technology enables creations such as Glove One, a wearable mobile phone created by artist Bryan Cera that uses a 3D printer. While Cera has no plans to commercialize the device, the implications for future innovations are intriguing. The glove incorporates recycled
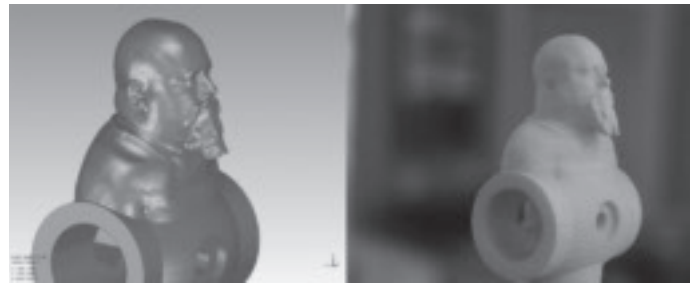
Left: a 3D scan of a Geomagic employee. Right: A customized 'foosball' player with the employee's scan.

electronics parts and a 3D-printed chassis to transform a user's hand into a cell phone with the addition of a SIM card. A speaker is incorporated into the thumb of the glove and a microphone is embedded in the pinky finger. The user dials numbers located on the fingers of the glove and when necessary, charges Glove One via a micro-USB port.

Automotive Applications: Many automotive applications are obvious, like producing automobile parts via 3D printer, which allows car manufacturers to prototype and test parts in-house. Audi, for example, uses an Objet 3D printer (utilizing the photopolymerization technique) to produce parts. A video posted on their YouTube channel – "Print My Audi" – demonstrates the process. Jay Leno is also getting in on the automotive 3D printing game. On his Web series, *Jay Leno's Garage*, the talk show host and car enthusiast demonstrated 3D scanning technology from NextEngine. During the video, parts are scanned and printed. Such applications will be great fun for classic car collectors.

Further down the line, more large-scale projects may be possible. In July 2012, a group of engineers named 'Group T' unveiled a 3D-printed racecar "Areion" as part of the Formula Student 2012 challenge. Using a "Mammoth stereolithography machine" developed by Belgium-based Materialise – capable of creating parts up to 2100x680x800mm – the team was able to print the entire body of the racecar and integrate specific parts such as cooling channels and an aerodynamic outer texture. Areion was capable of reaching 100km/h in just four seconds. In years ahead, as 3D printers grow in size and popularity and shrink in cost, we may see a full-sized car printed.

## "Products [could] become limited only by the amount and velocity of the ideas behind them."
-John Alpine, Geomagic

Medical Applications: One of the most exciting areas where 3D printing is fueling innovation is the medical sector. From custom creations which have already arrived to encouraging proofs of concept, 3D printing has the potential to revolutionize medical care. "Today we see the greatest opportunities in our healthcare solutions because we are improving the quality of life for individuals facing challenges like losing a limb," explains 3D Systems' Lewis.

Three-dimensional CT scans give additive manufacturing systems the data required to create a number of different prosthetics. In

addition to limbs, commonly printed prosthetics include hips, teeth and jaws. San Francisco-based Bespoke Innovations – one of a number of companies acquired by 3D Systems in the last two years – focuses on developing custom prosthetic limbs via 3D printing technology. Users can choose from custom designs, patterns, templates and materials. "Our Bespoke prosthetics empower [patients] to not only walk again but also to express their style and personality," says Lewis.

Annual Global 3D Printing Revenues (millions)

Source: Wohlers Associates Inc.   ■ Services   ▪ Products
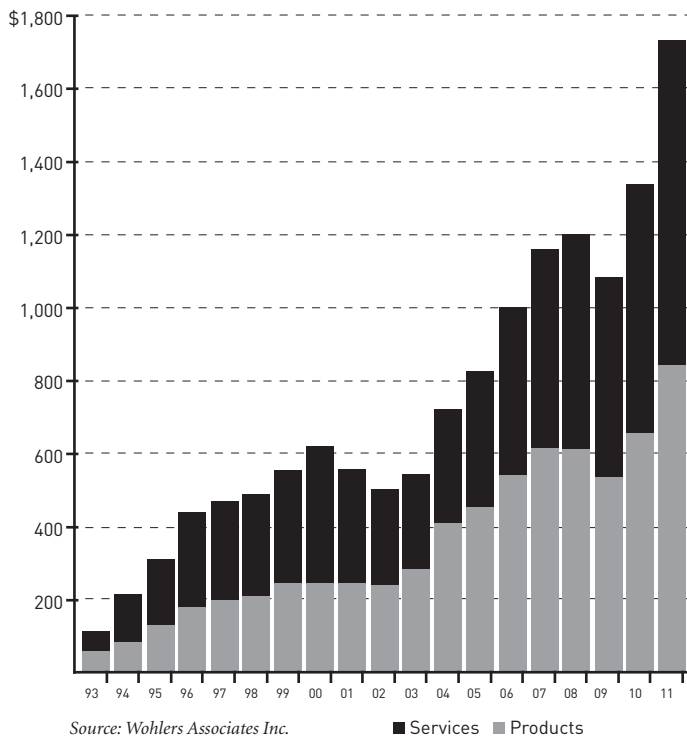
Even more advanced medical applications may be possible. Dr. Anthony Atala, director of Wake Forest Institute for Regenerative Medicine and chair of the department of urology, gave a speech at the TED Conference in March 2011 where he explored the possibility of printable, transplantable organs. Atala, who led the team that developed the first lab-grown organ, a bladder, to be implanted in a human, described how 'smart biomaterials' could be combined with living cells. In some cases, the printing could be done directly onto the patient. Finally, Atala demonstrated how using a CT scan to analyze the organ layer by layer and produce a 3D model, a printed kidney structure could be created. Disclaimers warn that kidneys produced were "early prototypes that are being studied experimentally and are years away from functional and clinical use."

Thanks to the wide array of industries benefitting from additive manufacturing, the industry has seen solid growth. According to the Wohlers report, the compound annual growth rate (CAGR) of all products and services over the last 24 years is 26.4 percent. The report estimates that the worldwide market for 3D printing, including both products and services, reached $1.7 billion in 2011.

In the Hands of Consumers

Despite already being the largest segment of the 3D printing industry, consumer products should continue to grow and boost the 3D printing industry as the cost of 3D printing drops. Already, a number of affordable systems and services have surfaced.

New York-based Shapeways (Shapeways.com) offers users not only a way to print their designs, but also a community with which to share their creations. Originally a part of the Philips' Lifestyle Incubator (PLI), Shapeways spun out in late 2010 and moved its headquarters to New York City.

The website enables users to upload their designs and have them created by Shapeways' 3D printing systems. The community aspect comes into play as other users can rate, purchase and print each other's designs. "Anyone can be a creator, the necessary toolbox is now just a computer and an idea, time to market goes from months to hours, designers can rapidly iterate on products and incorporate feedback after launch," says Peter Weijmarshausen, CEO and co-founder of Shapeways. The community currently boasts 160,000 members and more than 6,000 shops, and has printed more than a million products. Submitted designs range from unique cell phone cases to jewelry and eyeglass frames.

Such services offer consumers a way to realize their creations without the purchase of an expensive printer of their own. But new, consumer-oriented systems are making the dream of printing an object at home real. 3D Systems, for instance, recently launched Cube – a consumer-focused printer. "The biggest obstacles to the growth and mainstream adoption of the 3D printing industry are affordability and creation tools," says 3D Systems' Lewis. "We are breaking down these barriers with ease-of-use, a sleek consumer design and tools for content creation."

The trend is catching on: more than 23,000 personal 3D printers and kits were sold in 2011, according to the Wohlers report. This represents a year-over-year growth of 289.2 percent. The average selling price of personal 3D printer in 2011was $1,122. Combine the declining cost of systems with the available 3D scanning capabilities of accessories such as Microsoft's Kinect sensor and we may be closer than we think to the dream of printing objects at home.

Do It Yourself: Early adopters don't usually wait for such things, however, and a number of tinkerers have begun to take things into their own hands. On an episode of *The Ben Heck Show*, Benjamin Heckendorn, also known as Ben Heck, from Revision3, took it upon himself to create a 3D printer that can fit in a briefcase. The printer itself measures in at five-inches thick, and can print from a design saved on an SD card, completely removing the need for a computer.

Looking for an even lower-cost entrance to the 3D printing scene? There are several open-source projects for that, such as lemon-curry, a photopolymer printer available on General Public License (GPL). The CE industry once again finds itself in the 3D printing mix, as the readily available designs explain how to cure resins via a digital light processing (DLP) projector. The website also provides links to several freeware CAD programs.

Disruptive Technology

As 3D printing grows in popularity in both the manufacturing and consumer realms, there are bound to be some major shifts in the way our surroundings are built. Changes in the manufacturing process, already evident in cases such as the creation of parts for Audi automobiles, should be significant. "When you think about 'making things,' it is industrial manufacturing that first comes to mind. Manufacturers will have to assess how the availability of 3D printing might affect demand for mass production lines," says Geomagic's Alpine. "When you're creating hundreds of thousands of a single product, traditional mass production is going to stay viable for a long time, but short runs are inevitably going to move to 3D printing over traditional methods."

The technology behind 3D printing could present a lower cost of entry, eliminate segments of the supply chain and simplify R&D. Manufacturers may have more to consider, however, as the implications of 3D printing go well beyond the supply chain.

Global Forecast for 3D Printing Revenue (millions)
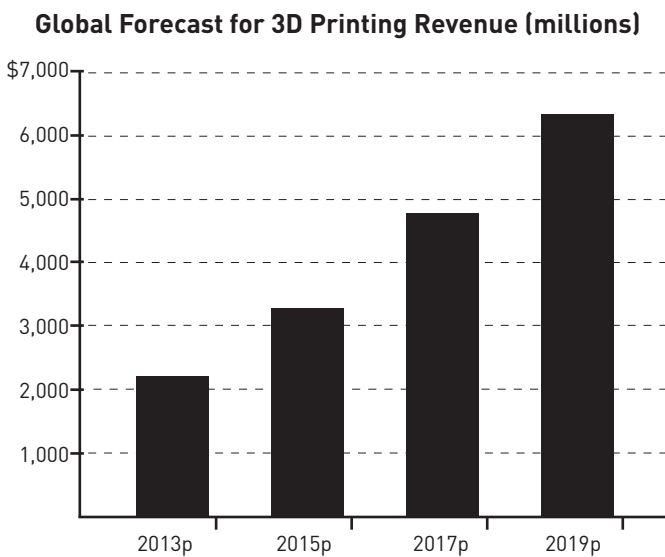
Source: Wohlers Associates Inc.

Intellectual Property: With 3D scanning and printing technology, it doesn't take a crystal ball to see that there may be future concerns about counterfeit. However, unlike creative and artistic "works" which receive copyright upon creation, a physical creation is not automatically extended intellectual property (IP) protections, instead requiring an application for a patent. Therefore, there may be a grey area for 3D printing and physical replication ahead. There still exists a very real possibility that IP violations will occur because of 3D printing, and this will be an area to watch as the popularity of 3D printing grows.

Will the existence or threat of such violations result in an expansion of IP-focused legislation? Or will 3D printing prompt more creation? "The ability to quickly modify and improve objects without fear of IP-related liability could rapidly shorten innovation cycles and spur creation," writes Michael Weinberg in the Wohlers report.

Other concerns exist beyond supply chain disruptions and counterfeit, however. The first 3D-printed handgun has already been created, for example. The 3D printing industry may hold other risks that deserve our attention.

A 3D-Printed Future

It's fitting that a complicated topic such as 3D printing can have diverse applications and both disruptive and exciting possibilities, but as anyone in the 3D printing industry will say – complexity is just another layer. The 3D printing industry offers complexity at no cost and promises to grow and change the way we live. The Wohlers report estimates that by 2015, sales of 3D printing and services will hit $3.7 billion worldwide.

One thing more exciting than the forecast for the industry is the change that will be wrought, layer by layer, by 3D printing. "We believe that if someone can dream it, it will be possible to 3D print it," says 3D Systems' Lewis. ∎

NEXT-GENERATION TVS AND DISPLAYS

By Robert E. Calem

It has been about a decade and a half since the transition to high-definition television began in earnest, so consumers could be forgiven if they now take stunning video images in their living rooms for granted. But despite a drop in sales due to market penetration, industry insiders and analysts say the pace of TV technology innovation has not slowed. Now, televisions offering double the picture quality of today's best HDTVs are only months away from hitting store shelves—and, more important, are only a hint of what is possible.

Developments including new display form factors, new types of 3D displays and content, and new industry partnerships, are promising to change the way people watch television.

TV Timeline: HDTV Soars, 3D Starts Slow, OLED Accelerates and 4K Emerges

"We've essentially had two successful migrations over the last 20 years," says Richard Doherty, research director at The Envisioneering Group, a technology assessment and market research consultancy based in Seaford, N.Y. The first transition to digital TV took place from 1998 to 2008, with the launch and consumer acceptance

of HDTVs alongside digital broadcasts. "It was a home run and CEA deserves kudos for making that possible," Doherty says. "The transition that wasn't driven by CEA was driven by the Internet generation. That was IPTV (television and video programming delivered from online sources), and it's still growing."

In 2011, the number of DTVs shipped that could connect to the Internet via a home network totaled 6.4 million, and this year the figure is projected to grow to 10 million. Shipments of DTVs equipped with embedded apps totaled 3.3 million units last year, and these are expected to grow to 7.3 million units this year. And shipments of DTVs capable of displaying the best Full HD (1080p) resolution totaled 15.3 million units last year, and are projected to grow to 17.1 million this year, CEA says.

The TVs that are expected to show significant upward growth and carry the TV industry to the next decade, are two new television technologies: OLED and 4K.

"LED-LCD technology is rapidly establishing its dominance and will account for 55 percent of LCD TV sets this year, growing to more than three quarters of LCD TV units by 2015," CEA states

Digital Displays Unit Sales to Dealers (000's)	2011	2012e	2013p	2014p	2015p
Total DTV that are full HD (1080p)	15,334	17,053	18,604	20,396	22,142
Total DTV that are 4K	0	0	20	190	1,305
Total DTV that are network enabled	6,431	10,022	13,650	16,782	19,416
Total DTV that are 3D enabled	2,728	5,565	8,682	12,415	15,030
Total DTV that have embedded Internet apps	3,349	7,334	11,368	14,097	16,775
Total OLED displays	10	34	128	503	1,305

Source: Consumer Electronics Assocation

Digital Displays Average Factory/ Wholesale Price	2011	2012e	2013p	2014p	2015p
Total DTV that are full HD (1080p)	$815	$737	$659	$597	$554
Total DTV that are 4K	0	0	7,000	2,800	2,240
Total DTV that are network enabled	1,168	898	740	640	579
Total DTV that are 3D enabled	1,485	1,277	1,074	939	830
Total DTV that have embedded Internet apps	1,233	960	827	719	618
Total OLED displays	1,739	2,782	2,316	1,871	1,665

Source: Consumer Electronics Assocation

• **3DTV** — A 3D television set is one that adds a simulated sense of depth to video playback by any of several different means. These include two types of "stereoscopic" systems that require users to wear special eyeglasses while watching the video playing on the TV: a "polarized 3D" system that uses "passive glasses" with polarization filters in the lenses; and an "active shutter 3D" system, which uses "active glasses" with lenses incorporating shutters that automatically open and close in sync with the video and thus trick the eyes into perceiving 3D. Additionally, "glasses-free 3D" or "autostereoscopic" TVs can produce 3D images without requiring the viewer to wear any special eyeglasses at all. There is now also at least one example of a "head-mounted 3D display," which creates the perception of 3D using eyeglasses with temple-mounted projectors that cast the video directly onto the lenses.

• **4K TV** — A 4K television set provides quadruple the total display resolution of today's best Full HDTV sets by doubling the number of pixels shown horizontally and vertically: to 3840x2160 or 8.3 megapixels from 1920x1080 or 2.1 megapixels. 4K TV is also known as quad full high-definition (QFHD) TV. It also is the lower-resolution of two versions of what is known as ultra-high-definition television (UHDTV).

• **8K TV** — The higher-resolution version of UHDTV, 8K TV offers a total display resolution that is 16 times greater than today's best Full HDTV sets by quadrupling the number of pixels shown horizontally and vertically, to 7680x4320 or 33.2 megapixels.

• **OLED TV** — An OLED (organic light-emitting diode) is a type of LED (light-emitting diode) that contains a layer of film composed of an organic semiconductor compound. This emissive electroluminescent layer, situated between two electrodes, lights up in response to an electric current. And since one of those electrodes is transparent, the resulting light can be used as a pixel element in a digital display, such as an OLED TV. Compared to a typical LCD (liquid crystal display) television set, an OLED TV is thinner and lighter, uses less power, and achieves a higher contrast ratio to display deep black levels.

• **Head-Mounted Displays** — As the nomenclature suggests, a head-mounted display is one worn on the head. It may be housed in a monocular form that covers one eye, or in a binocular form that covers each eye but forms one display image.

in its most recent industry forecast report from July 2012. Nonetheless, the report states, "The industry must come to grips with a steadily declining market opportunity for TVs as it crosses the cusp to the next upgrade cycle embodied by 4K OLED sets in the second-half of the decade."

CEA estimates OLED TV shipments growing to 34,000 units this year from only 10,000 units in 2011, and rising sharply and swiftly to 128,000 units in 2013, 503,000 units in 2014 and 1.3 million units in 2015.

Similarly, CEA estimates 4K TV shipments to commence at only 20,000 units in 2013, and then rise sharply and swiftly to 190,000 units in 2014 and 1.3 million units in 2015.

As usual with CE products, rapidly falling prices are expected to accompany this growth—although probably not beginning until the middle of this decade, industry analysts say.

"In early 2015 [OLED TV] will get a little bit more mainstream," says Michael Inouye, senior analyst at ABI Research in Scottsdale, Ariz. But through at least 2013, he says, these TVs will still account for less than one percent of all flat-panel TV unit sales—and they will increase their share to only nine percent of all flat-panel unit sales in 2017—primarily because of OLED prices continuing to be relatively high versus LED-LCD TVs. Meanwhile, LED-LCD TVs will grow to 75 percent of the flat-panel TV market in 2017, from 35 percent of the market in 2011, ABI Research says.

Price Matters but so Does Content

"Everybody agrees [OLED] is going to be the solution," says Jon Peddie, president of Jon Peddie Research based in Tiburon, Calif. "It's easy to see that this will get to where we want it to go. One step at a time we'll get there," as production yields improve and prices fall.

Likewise with 4K TVs, which will still be too expensive for consumers in the short run and thus at first be found only in commercial settings, Peddie says. Yet even for those early adopters, he adds, "the tricky part" with 4K is that there needs to be content. "That's going to be the barrier more than the price or the technology. In all of this looking at the future, how wonderful it's going to be, the practicality of it is not going to be realized if we don't have the mechanism for creating appropriate content to exploit these new display technologies."

This has been the problem with "stereovision" or 3DTV, for which there is "insufficient content to keep viewers happy," Peddie says. So, in developing the market for 4K TV—and later with 8K TV—the industry ought to take lessons from its experience with 3D, experts say.

Convincing Consumers to Switch

Chris Chinnock, president of Insight Media, a market research and consulting firm focused on emerging display technologies, based in Norwalk, Conn., says, "Most people are going to look at their TVs and say, 'It looks really good and crisp to me. Why do I need four times as many pixels?' And the answer is, from a visual acuity point of view, you probably don't. Most people are not going to see a difference—certainly not under a screen size of 50-inches viewed from a normal living room viewing distance."

However, with a screen size of 60-inches or larger seen from the same distance or closer, the better picture of a 4K TV will be apparent, and "the trend is to bigger screens," Chinnock says.

In fact, according to a consumer survey conducted by CEA in August that measured interest in 4K and OLED TVs, consumers will need to be convinced to upgrade to these technologies from the

HDTVs they already know. Only 26 of the survey respondents said they were interested in 4K technology, while 49 percent were not interested and 25 percent were undecided.

Regarding OLED TVs, only 17 percent of the consumers surveyed by CEA said they were interested while 55 percent were not interested, and 28 percent were undecided.

"It isn't always just about product," says Peter Weedfald, president of Gen One Ventures, a CE sales and marketing consultancy and formerly a senior marketing executive at both Samsung Electronics and Circuit City. "It has got to be about product, about people and about (retail) channels. It's got to be about all of these things combined," Weedfald adds.

All of This and More

Questions of consumer need, education and acceptance aside, though, TV makers and others in the CE industry are already moving forward with plans to bring OLED, 4K TV, 8K TV and other technology innovations—including improvements to 3DTV tech—to market in the years and decades ahead.

4K TV is "the HDTV experience on steroids," says John Taylor, vice chairman of CEA's 4K Working Group and vice president of public affairs and communications at LG Electronics USA in Englewood Cliffs, N.J. The CEA working group is endeavoring to proliferate and evangelize the 4K technology, which "gives manufacturers and retailers alike another opportunity to attract a high-end customer" with very large screen TV sets.

There already are 4K video projectors on the market, Taylor notes. By year-end, LG will bring its first 4K flat-panel TV to the U.S. market, an 84-inch LED-LCD model priced at $15,000, and a competitive model is expected to debut from Sony as well. All 4K TVs coming from various brands this year and next are expected to be priced in the $15,000 to $25,000 price range, Taylor says.

4k TV is "the HDTV experience on steroids." -John Taylor, LG Electronics USA

For demonstrations of prototype models at the 2012 International CES, LG and other TV makers took advantage of "very powerful up-conversion engines" built into the television sets that take standard HD content input and double its horizontal and vertical resolutions for playback. "Indeed, there is no 4K content available today," Taylor explains. But, "Blu-ray 4K material is not too far off," Taylor says. "And with innovation in the video compression arena you'll see 4K delivered over the Internet, through cable and even through over-the-air broadcast television" using ATSC 3.0, a new digital broadcast technology standard now in development that could debut in eight to 10 years.

OLED TVs also will be used to attract high-end customers to the TV market and "down the road, as OLED grows, and gets bigger and bigger, you're going to see the opportunity to marry that with 4K," Taylor adds. "It's just a question of the time horizon at this point, before all this merges."

What's more, both 4K and OLED technology also promise to improve the appeal of 3DTV, Taylor and other experts say. Both of LG's new 4K and OLED TVs will incorporate the company's passive 3D technology named Cinema 3D, for example.

Nearer term, head-mounted displays capable of playing 3D content, such as Epson's Android-based Moverio BT-100 ($700) see-through wearable display also could help spur consumer interest in 3D video, and could provide another possible direction for the CE industry to take with the technology, says Eric Mizufuka, product manager for new markets at Epson America in Long Beach, Calif. The Moverio simulates an 80-inch 3D display sitting 16 feet in front of the person wearing the device, and also incorporates Dolby virtual surround sound audio.

The Moverio is available now. "It's really just a peek into the future of what is to come," Mizufuka says. Among the possibilities for further development, he says, is the ability to use gesture-based or voice-based controls to interact with the content displayed on the virtual screen.

Looking even farther ahead, Taylor says, TV makers and their industry partners are already at work on 8K—an even more astounding level of picture quality that could be ready for consumers around 2025. ∎

TECHNOLOGY AND ENTERTAINMENT: AUDIO EVOLVES

By Sean Murphy

Anyone not remember the iconic image from the 1980s of a man sitting coolly in an armchair in an empty room, his hair and tie blown back by the invisible power of the stereo speaker in front of him?

The famous Maxell ad is not just from another century, it's a remnant of a world where analog ruled and audio was king. A world that was ostensibly less complicated, when we used to watch movies in theaters or courtesy of paid channels on tiny CRT screens.

Flash forward two decades, and the combination of digital content, including downloads and portable devices, along with the ascendency of all-things video, made audio more of an afterthought. Less than ten years into our new millennium, the prospects for the audio category seemed dire. Even a significant economic recession failed to halt the proliferation of flat-panel displays. Suddenly, it seemed no screen size was too big, and conversely, no audio component could be small enough. Practically overnight, consumers could conceivably store their entire sonic libraries on devices that fit in their front pockets. It was revolutionary in every way, but these advancements often came at the expense of a previously impregnable home audio sector.

MP3 players and earbuds represented a new standard in how we listened to music. The advent of the iPod in 2001 hastened the decline of physical media. In 2001, there were 882 million CD units sold. By 2011, that number was down to 241 million, according to the Recording Industry Association of America and CEA expects this downward trend will continue for the foreseeable future. Content was ubiquitous, and increasingly free, and the fact that sound quality was often spotty at best seemed a peripheral concern. The notion of whether or not the audiophile—the guy from the Maxell ad—was a relic from the past seemed settled: that dude was a dinosaur, a symbol of the old days that a new generation would never feel especially nostalgic about. Today high-quality audio can take the shape of a thin, rectangular soundbar with enough power to fill a room with top notch surround sound, or tiny in-ear headphones packed with audio substance and style. Looking ahead, we expect to see audio systems that are increasingly less bulky, including models that are both portable and wireless.

Requiem for the Audiophile

If you are of a certain age you can easily envision this person. Perhaps you were that person: the one who not only had to own the latest and most advanced high-end equipment, but also prosely-

tized about the components, compelled to convert friends and acquaintances. Perfection carried a price tag; the naysayers might be able to listen to the sounds, but they weren't really *hearing* them.

As difficult as it likely is for younger consumers to appreciate, the home audio landscape remained relatively uncomplicated for the better part of a century. Record players were challenged by cassette decks, which in turn were supplanted by CD players. For a time, audio remained a two-channel environment, all powered by a receiver and a set of speakers.

This landscape gradually changed, but the eventual paradigm shift – made inevitable by the Internet – was radical. The electrical storm of digital files and the advent of MP3 players made the consumption of audio content not unlike personal computing: a 24/7, multi-location proposition. People could take their music with them wherever they roamed, and gradually a concept that seemed exceptional became compulsory.

Take My Content, Please!

Today, digital content is driving CE audio sales. "Independent of overall industry sales – of which you could point to the disaggregation of the album into individually available songs as having a bigger direct impact than being digital – more music is consumed today than ever before," according to Jason Herskowitz, co-founder of Tomahawk, an open-source music app.

"We've now moved into an era of the disaggregation of streams, where artists offer different content across promotional platforms like Official.fm and SoundCloud, video platforms like YouTube, and subscription services like Spotify and Deezer," Herskowitz says. Tomahawk offers users a single interface through which to connect to all of their music sources, creating an overarching, translatable music platform.

While some artists and executives feared that digital audio would signal the end of music sales, downloadable content has liberated artists and helped audiences procure more music for less money. This brave new model defied initial fears and expectations and actually enabled savvy artists to accrue potentially greater profits. Online exposure benefits artists, and if this concept was once controversial, it is now conclusive. True, the mechanisms for "stealing" music remain rampant. On the other hand, artists receive invaluable – and heretofore inconceivable – exposure by presenting samples of their work on their own websites, as well as through social networking sites like YouTube and MySpace, and digital music services like Rhapsody.

"Technology has drastically altered the landscape for musicians in the production and distribution of their music. In the past it required hundreds of thousands of dollars of investment in studio time and the shipping and stocking of plastic discs all around the world," Herskowitz says. "Now it only requires a computer, an Internet connection and some spare time."

The Democratization of Content

In 2011, Jon Bon Jovi accused Steve Jobs in Britain's *Sunday Times* of being "personally responsible for killing the music business." The truth is that Jobs did as much as any single entity to change how we listen to music. The pay-as-you-go model of iTunes has done more to empower and enrich musicians as anything the most well-meaning purists could have imagined. The trajectory from the Wild West chaos of Napster to the more structured system of iTunes took a while to sort itself out, but finally certain mechanisms are in place.

The subsequent popularity of streaming services like Rhapsody and Pandora represent another positive advance for consumers, artists and the industry. This year, for the first time, consumers will spend more money on digital music than on CDs and other physical formats, according to a report by Strategy Analytics. The appeal of subscription-based services delivers a diverse quantity of music in an organized and regulated format.

Everything about music, from creation to marketing to distribution, has come almost full circle, albeit in a way that fully embraces the technological advances that digitized content has enabled.

(Re)Defining the High-End Audio Experience

For practical purposes, the authentic "high-end audio" tag historically applied to products that sold for thousands, not hundreds, of dollars. As such, it seems safe to suggest that the market for this obsession has typically catered to a wealthier, passionate minority. The good news is, as we observe time and again, ceaseless innovations in CE result in optimal quality at lower prices.

> ## "Now is the time for CE manufacturers to make great audio the selling point."
> ### -Paul Geller, Groveshark

In a roundabout way, the same device that initially stole audio's thunder may become a vital battleground for future sales. Even as digital displays get bigger and better (with price points drop-

ping correspondingly) and we eagerly anticipate the advances 4K should deliver, at a certain point, sound quality will once again become a coveted feature of the full home entertainment experience.

Total Soundbar Revenue (millions)

Source: CEA Sales and Forecast, July 2012
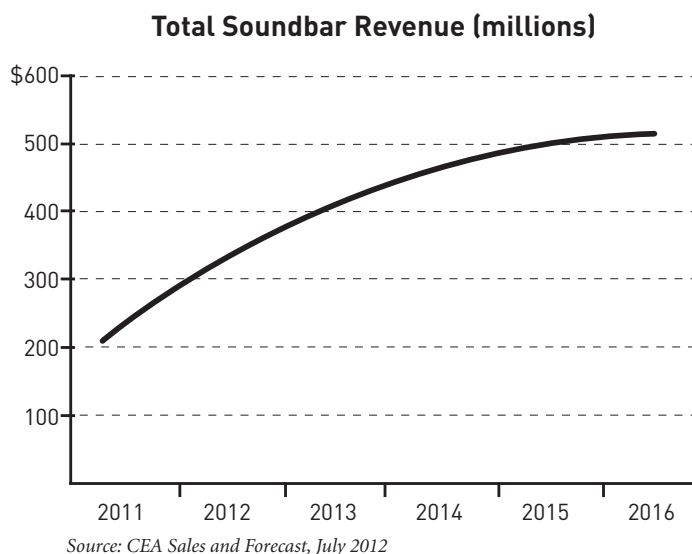
"Now is the time for CE manufacturers to make great audio the selling point," says Paul Geller, senior vice president at Grooveshark, an online music streaming service. One option for beefing up home audio without sacrificing floor space is to incorporate a soundbar. "I wish my wonderful new display with a 240Hz refresh rate had better speakers," Geller says. "I like 240Hz, but I needed to get a soundbar!"

Soundbars, initially embraced as a cost-efficient alternative to more expensive and bulky surround sound systems, are now genuine solutions in themselves. Still affordable, there are also a variety of more robust models with higher price points and improved performance. Soundbars offer a less complicated, virtually wireless solution for delivering high-quality audio. CEA expects sales to increase year-over-year through 2016. The next generation of soundbars will feature innovative designs that will enable manufacturers to pack more punch into smaller systems. And a host of upgrades, ranging from wireless capabilities to improved bass, will be incorporated in these new soundbars in the ongoing quest to design the perfect in-home sound solution.

Another excellent example of technology meeting or creating consumer demand is the advent of high-performance receivers that integrate connectivity. We may not be able to wrest the MP3 player or smartphone from a would-be customer's hand, but there is a best-of-both-worlds scenario: a receiver that allows us to "plug and play" at home. Certainly, the image of anyone listening to digital files through home speakers is anathema to the old-school audiophile, but those consumers were never part of the equation in the first place. And with the release this fall of Apple's iPhone 5 and new iPod, with their new Lightning ports, audio equipment manufacturers will need to retool their docking stations and other accessories to accomodate this new technology.

These home audio products specialize in being multi-functional, and the implementation of MP3 capability, along with Ether-

net and HDMI integration, enables a greatly enhanced in-home listening experience. Between improved amplifiers, soundbars and these more robust receiver capabilities, the previously dubious proposition of *better* audio in the home is now not only feasible, but affordable.

A Case Study: Headphones

Premium headphones may be the product category that provides a gateway to higher quality audio – and a salvation of sorts for the entire industry. Anyone who has been paying attention understands that headphone sales are not expected to slacken anytime soon. Even five years ago the suggestion that headphones, much less designer headphones, could be profitable, with price points in the hundreds of dollars, would be dismissed as outlandish. And yet, at least in hindsight, it not only makes sense, it seems inexorable.

People have increasingly plugged into their devices during their commutes, in their cubicles, while they exercise or relax on the couch. There was, quite simply, a market demand for ways to bolster these experiences, and headphones met, and exceeded, this desire. It's remarkable, even if it now feels predictable, that a device that's given away for free on airplanes could be transformed into a high(er)-end audio solution and even a fashion accessory.

Total Headphones/Earphones Revenue (millions)
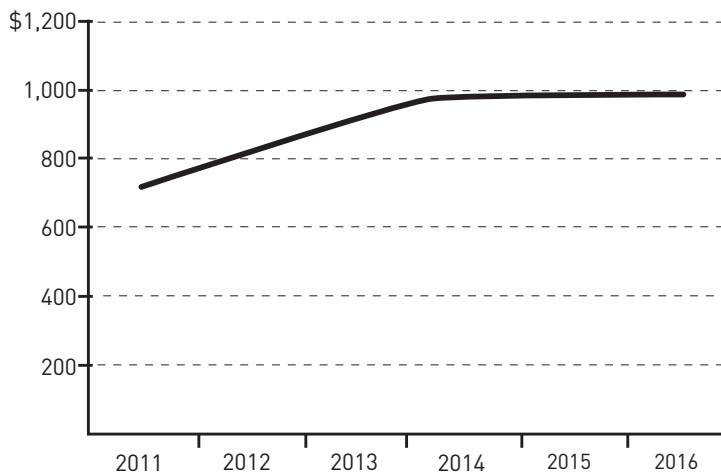
Source: CEA Sales and Forecast, July 2012

In fact, the cultural cachet of premium headphones represents a marketing gold mine. It is, for example, all but impossible to see professional athletes entering a stadium without their ever-present headsets. The authoritative case study here involves the earth-shaking success of Andre "Dr. Dre" Young's collaboration with Monster Cable. The Beats by Dr. Dre brand became arguably the most successful and high-profile celebrity-endorsed (and, in this case, created) product of the last decade.

If imitation is the sincerest form of flattery, Dr. Dre should be as flattered as he is wealthy. Other headphone brands have hastily formed, and existing manufacturers have sought luminaries to associate themselves with. Now we have Soul by Ludacris, The House of Marley and Lady Gaga Heartbeats, just to name three of the better known entities competing for share in a seller's market.

The phenomenal sales can certainly be attributed in part to a very American attraction to icon-driven product placement: seeing athletes and rock stars wearing (not to mention designing or endorsing) headphones anyone can purchase serves as an irresistible enticement. But aside from the social and cultural implications, these products have been advertised, ingeniously, as superior solutions. Not long ago, high-end headphones catered to audiophiles or frequent travelers in search of the best noise-cancellation options.

Dr. Dre's promise to deliver the type of sound quality producers hear in the studio proved to be marketing catnip. The products were hip, but they also allegedly supplied the type of sound quality never attainable in the past. We now see manufacturers like Skullcandy forging a lifestyle connection catering to the skateboarding and sporting community, which is 180 degrees apart from the old Bose target audience.

Build It and They Will Come

If it is true that history tends to be written by the winners, it is also a fact that the most successful ideas, in hindsight, seem logical. Pocket-sized devices that store entire record collections and designer headphones that cost as much as – or more than – small TVs are no longer depicted as visionary so much as inevitable creations. Predictably, with these products securely established in the marketplace the question arises: What's next?

Not so fast. Forward-thinking minds are undoubtedly designing new devices that we may well consider essential five years from now. But perhaps the more important question today is how much presently-untapped potential still exists in the market. For the foreseeable future, companies can and should take full advantage of the incredible window of opportunity surrounding the audio sector. Put simply, these days anything associated with a tablet or smartphone has the attention of a very wide audience.

"You figure out a way to connect yourself to these products," says Al Baron, who has been a product line manager for the majority of his 25-year tenure at Polk Audio. "There is a larger demographic than ever prepared to spend money on audio-related products."

A company like Polk is well-positioned for continued growth, having built up credibility over a long period of time. Nevertheless, the rules of engagement have changed a development that is not lost on Baron. "Whatever you design and develop today has to be aesthetically compelling and attractive – as well as functional," he says. Understanding the cultural elements informing the high-end headphones explosion has proven to be invaluable. As such, Polk has a revamped design center where considerable attention is being given to detail and style. There is undeniably a fashion-related aspect involved with appealing to today's consumer that was not nearly as pronounced or definable a short time ago. "More people shop with their eyes as much as their ears," Baron says. "To even be considered you must pass a certain muster that is in many ways higher than it's ever been."

Baron's impressions are consistent with those of another industry veteran, Petro Shimonishi, who manages Denon's headphones line, and has immersed herself in the audio sector from both a product

Total Home Audio Components Revenue (millions)
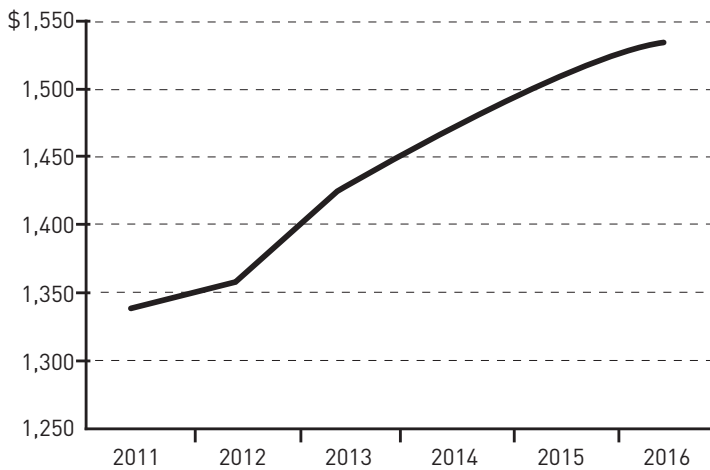
Source: CEA Sales and Forecast, July 2012

and marketing perspective. "It's all about integration," she says. "Headphones, for instance, need to cater to the types of solutions consumers are seeking." An example she gives is the Denon Sport App, which enables users to track their workouts using computing metrics—in short, doing things that used to be possible only on computers.

"Consumers expect devices to be smarter and smarter these days," she says. Echoing Baron's observation, she agrees products need to look appealing, but adds that the more accessible and functional they are the better. The key term is lifestyle: products that can seamlessly incorporate a consumer lifestyle will be more compelling. In today's market, that might mean – unlike what we've seen with displays or even last generation's home audio products – that smaller is better. "Today's receivers have better performance, but the form factors are also evolving. Design has a huge impact here." This insight reaffirms the primary trend in contemporary CE: modern consumers put a priority on products that are both connected and portable.

This trend is unlikely to change anytime soon. CEA recently found that 39 percent of the Internet population listened to online streaming content in the last 12 months and 42 percent listened to MP3 files. Internet radio has become a destination rather than an alternative. Now the onus is on manufacturers, including software companies, to continue creating, and refining, products consumers will use to enjoy this entertainment. Just as it has arguably never been a more encouraging time to be a content receiver; it is likewise an advantageous time to be in the position of designing and/or delivering content.

Innovation coupled with the freedom of choice has always been the lifeblood of the CE industry. The chief beneficiary of these advancements is the consumer. ■

A MOBILE REVOLUTION IN AFRICA

By Rachel Horn

TECHNOLOGY TRENDS TO WATCH 5

Many of the CE industry's heaviest hitters were on hand at the 2012 International CES showcasing the latest in mobile phone technology – razor-thin smartphones with lightning speed dual-core processors, front- and rear-facing cameras, and super-sized screens. Mobile phones in the U.S. have steadily been replacing landlines as the dominant form of communication – there are now more mobile phones in the U.S. than people, and mobile phones outnumber fixed-line phones by nearly two-to-one.

But for the majority of the world's population, the most powerful device in their CE arsenal might be a $75 smartphone that lacks most of those features showcased at CES but still invaluably serves as a business tool, a banking device, a Web portal, a messaging service – and, of course, a phone.

Smartphone shipments to the U.S. grew 348 percent between 2007 and 2011, and are expected to grow another 44 percent through 2013, according to CEA Market Research. A 2012 Google survey found that 93 percent of U.S. smartphone users had used their phones to access the Internet every day in the preceding seven days.

Meanwhile in Africa, about 64 percent of people have access to a mobile phone, and in some countries, like Nigeria, that figure is much higher. What's more, the number of mobile phone users has risen by nearly 20 percent there in each of the last five years, according to a 2011 report by the Groupe Speciale Mobile Association (GSMA), and that trend is expected to continue.
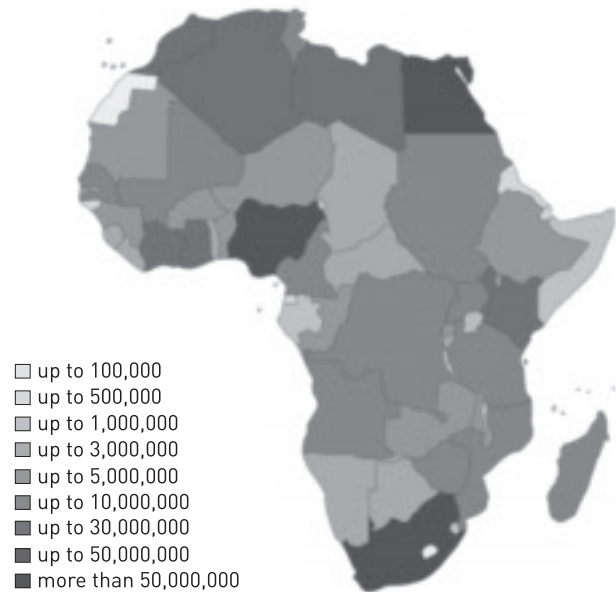
In some ways, usage of mobile phones in western countries and across Africa is very similar. However certain mobile phone applications in Africa, such as those used in mobile banking (m-banking) and social networking, are quite different from their Western equivalents, largely because smartphones are the primary Internet access point for many Africans. And, due to use and market differences, the hardware that supports these applications is different from that in the West in important ways. Accordingly, production opportunities are growing for manufacturers who are able to deliver low-cost devices that run on open-source platforms.

Exploring Africa's Unique Starting Point

Much of the developing world was never wired for Internet, at least not in any way that resembled the West. While international carriers like AT&T, British Telecom, Teleglobe Canada, France Telecom and Telefonica of Spain invested in laying submarine fiber optic cables under vast oceans from London to New York, much of

Mobile Penetration per Capita in Africa

- ☐ up to 100,000
- ☐ up to 500,000
- ☐ up to 1,000,000
- ☐ up to 3,000,000
- ☐ up to 5,000,000
- ☐ up to 10,000,000
- ☐ up to 30,000,000
- ☐ up to 50,000,000
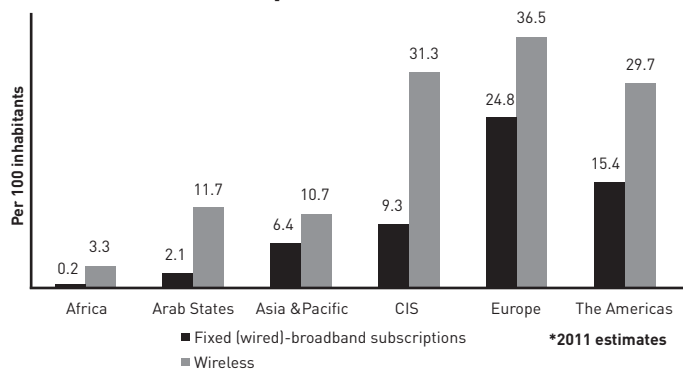- ☐ more than 50,000,000

Source: Opera Software, "The State of Mobile Web"

Africa and other developing nations were (and still are) busy building exports by extracting many of the rare earth minerals needed to create these intricate wired networks and the CE devices that rely on them.

For more than two decades, Africa lagged behind the world's economic super powers when it came to Internet connectivity. But in the last five years, as 3G networks have begun to take root across the continent and prices for smartphones have fallen, mobile Internet connectivity has grown, particularly in population-dense urban centers like Nairobi and Lagos. Smartphones outsell computers in Africa by a margin of four to one, according to a report from mobile tech firm Praekelt, and today more than half of Internet connections in Africa are exclusively mobile.

Mobile phones are supplanting computers and other connected devices in large part because 3G coverage is spreading faster than wired broadband. Mobile broadband penetration has reached four percent in Africa, compared to less than one percent for fixed broadband penetration. And 4G LTE deployments are expected to reach 11 million customers across the African continent by 2015, according to the 2012 African Mobile Factbook.

Wired vs. Mobile Broadband Subscriptions in 2011*

Per 100 inhabitants

	Africa	Arab States	Asia & Pacific	CIS	Europe	The Americas
Fixed (wired)-broadband subscriptions	0.2	2.1	6.4	9.3	24.8	15.4
Wireless	3.3	11.7	10.7	31.3	36.5	29.7

■ Fixed (wired)-broadband subscriptions
■ Wireless

*2011 estimates

Source: ITU World Telecommunications/ICT Indicators Database

Mobile Money Users in Africa

Adults using mobile phone in the past year to pay bills or send or recieve money (%)

- 0-10
- 11-30
- 31-60
- 61+
- No data

Source: Demirguc-Kunt and Klapper 2012

"Mobile phones [in Africa] are used for absolutely everything and used to the extreme by everyone," says Bruce Krogh, professor of electrical and computer engineering at Carnegie Mellon University. Krogh is also the director of the university's latest venture, a satellite campus in Rwanda's capital, Kigali. When Krogh moved to Kigali in January 2012, his Samsung Galaxy II became integral in helping him become settled. "When I applied for my resident visa, I got an SMS telling me when I could come in. I get an SMS any time there's a transaction on my bank account. I use SMS to buy electricity for my house," he says. In other words – in parts of Africa, the mobile phone as a device has displaced nearly every other form of communication and computing in ways not yet fully realized or utilized in Western countries.

The First Cashless Continent

As mobile payment programs like Square, PayPal and Intuit begin to gain traction in the U.S., cashless transfers linked to mobile devices continue to proliferate across Africa. In Africa, variations on mobile payment have been in place for more than a decade, first as a means of sending remittances to family and, more recently, as a way to replace most paper currency transactions in the marketplace.

An April 2012 report by Gallup and the World Bank entitled "Measuring Financial Inclusion" found that less than one quarter of adults in households that live on less than $2 a day have a traditional "paper" bank account. The numbers are even lower among adults living on $2 a day across the Middle East, North Africa and Sub-Saharan Africa. Compared with the developed world, where 89 percent of adults have traditional bank accounts, banking in the developing world represents a significant challenge to both financial institutions and the communities they serve.

Enter the mobile phone. By allowing users to rely on a mobile phone number as their unique bank account ID, m-banking enables those without traditional bank accounts to save and spend money cheaply, securely and reliably, according to the Gallup/World Bank report. For a small fee, m-banking customers can make deposits and withdrawals simply by visiting a local retail agent. They can also transfer money to pay bills or send remittances using simple SMS text messaging.
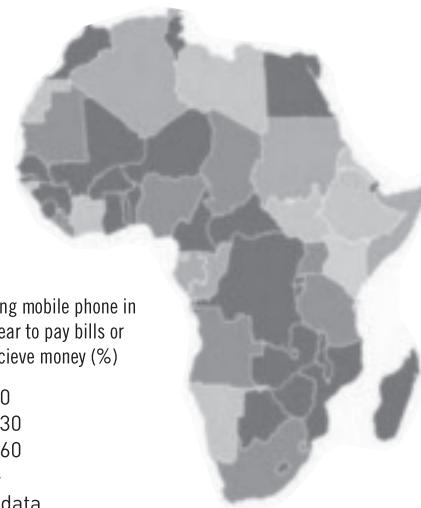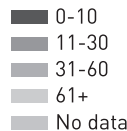
The Gallup/World Bank study found that across 15 African countries, more than 10 percent of adults said they had used m-banking in the prior year, and in some parts of the surveyed continent, usage is significantly higher. In Somalia, for example, 34 percent of adults said they used m-banking in the last year, while in Kenya, 68 percent of adults – or 86 percent of mobile phone users – said they have used m-banking. "A growing share of people especially in the developing world, rely solely on systems outside the formal banking sector," the report said. "In the 10 economies with the highest reported use of mobile payments, many mobile money users are not otherwise included in the formal financial system."

One program that has achieved considerable success in this area is M-Pesa in Kenya, which operates on the Safaricom network, and has eliminated the need to carry cash for many people. M-Pesa users register their phones with the service through Safaricom, their service provider, and can add money to their accounts by visiting a retail storefront that has signed up as a registered M-Pesa agent. Then, this virtual currency, known as E-float, can be transferred between mobile phone users through a secure text messaging service. Cashing in requires visiting an M-Pesa agent, who for a small fee will exchange E-float for physical money. Since its inception in 2007, the number of M-Pesa users has grown from fewer than 20,000 people in its first year to more than 15 million people in 2012. The total value of M-Pesa transactions over the last five years is more than $17 billion USD, and the program has expanded into Tanzania, Afghanistan, South Africa and India.

M-banking is being used more for remittances and transactional payments than as a savings vehicle, but several programs are underway in other parts of Africa to encourage savings using mobile devices. In Uganda, the Grameen Foundation has been working with mobile service providers to create a new system that lets people save and track money using a mobile phone. Me-to-Me is a forward-savings product that will allow Ugandans to deposit and set aside portions of their paychecks to save for tangible items like school fees or a wedding. David Edelstein, Grameen's senior

vice president of solutions and regions, says the foundation's goal is to understand how people at the base of the economic pyramid save and spend money and then create tools to help them save money. Me-to-Me is in the testing phase and is expected to be released to market in the next year. Edelstein says his organization is focused on connectivity. "Most of our projects have mobile phones integrated in some way," he says. "It tends to be the mobile phone that makes business networks work."

Social Networking Soars

While SMS technology has become the dominant language of transactional business in places like Rwanda, Uganda and Kenya, 3G connectivity on smartphones is now a primary driver of social communication in Africa. As in the U.S., Facebook and Google are among the most visited websites in Africa. In January 2012, Africa reported that traffic to Facebook was up 165 percent across the continent over the previous 18 months. And Internet World Stats reported 40 million Facebook users in Africa as of March 2012, representing about four percent of Africa's total population. "Facebook and social media are exploding across Africa via mobile," explains Wayan Vota, a technology expert and senior director at Inveneo.

4G LTE deployments are expected to reach 11 million customers across the African continent by 2015.

By comparison, there are 161 million registered Facebook users in the U.S., representing more than half of the country's total population. And while that number continues to grow year-over-year, the pace of growth has declined, in part because of market saturation.

Still, growth in Africa remains strong – the number of new users was up 47 percent year-over-year as of March 2012, according to Internet World Stats. The surge is due largely to social networking's relative newness in Africa. After all, traffic to Facebook in Africa didn't really pick up until 2010, six years after the site launched in the U.S.

Today social networking in Africa is used for everything from connecting people with ex-pat family and friends to helping farmers track corn harvests and trade exchange rates. Some analysts have suggested that Western-based social networks will be one of the last waves of innovation that will come from the West into Africa. Already, several new companies are finding ways to make inroads in the African social networking market, designing programs built for mobile platforms. One such company, 2go, is capitalizing on consumers' desire for free messaging, offering a free chat feature inside its mobile social network. In May 2012, 2go announced it had reached more than 20 million registered users, concentrated in Nigeria, South Africa and Kenya, and said it's adding between 40,000 and 60,000 new users each day.

Yookos, a social networking site developed in Nigeria, launched in 2012 and signed up more than six million users in its first week.

The company said it hopes to have 20 million active users by the end of 2012. Yookos' founder Tomisin Fashina, said the problem with social networking in Africa is that it has, until now, lacked local relevance. "Our early experience suggests there's a huge need for a quintessentially African social network that helps Africans interact, socialize, share information and access entertainment that is relevant to them, whether they're in London, New York or a remote village in Nigeria," Fashina told *Vanguard*, a daily newspaper in Lagos.

With 2go, Yookos and a host of other sites like Mxit, Saya.im and Bandeka popping up across the continent, social networking in Africa is more fragmented than it is in the U.S. While Facebook has the lead out of the gate, it remains to be seen which social networking site will have the greatest impact in Africa over the next five years.

Business Innovation

As access to technology spreads across Africa and a new generation of Africans grows up as native tech users, the need for education and training in computer science has increased. In July, Carnegie Mellon began offering a master's in information technology on its new campus in Rwanda. The program and partnership were envisioned in large part by the Rwandan government, as part of its Vision 2020 program. Launched by the Ministry of Finance and Economic Planning in 1999, Vision 2020 is designed to "transform Rwanda's economy into a middle income country," which, the founding charter says, "will not be achieved unless we transform from a subsistence agriculture economy to a knowledge-based society."

A major component of the CMU-R program is its innovation lab in Kigali, known as kLab, which CMU co-founded last year with the Japan International Cooperation Agency, the Rwanda Development Board and a software engineering firm called Nyaruka. KLab is a members-only meeting space for technology innovators and entrepreneurs. More than 20 innovation labs have already been established across Africa with support from local governments, foundations, and private businesses. "These are pre-incubator places where people who are interested in IT and have specific areas that they're interested in developing can work together," Krogh says. KLab is run by a board of local entrepreneurs and currently has 25 members. "It's becoming quite a vibrant space. We anticipate that it is going to be a nice resource for our students."

Scores of promising mobile tech startups are hatching all over the continent, garnering media attention and praise from non-governmental organizations (NGO) and foreign investors alike. One example of a successful tech startup capitalizing on Africa's mobile revolution is Paga. Founded in 2009, Paga's mobile money transfer application allows customers to send money to anyone with a mobile phone – either by visiting a Paga agent or by logging into a Paga account on a mobile device. The company, which has received financial backing from Silicon Valley-based venture capital firm Draper Fisher Jurvetson as well as from several non-profits and government institutions, is headquartered in Lagos and is Nigeria's largest mobile payment company. Founder and CEO

Source: mHealth Africa, June 2012

Nigeria GSM vs. CDMA Subscribers in 2007, 2009 and 2011 (millions)

2007 — 1%, 4%, 95%
2009 — 10%, 2%, 88%
2011 — 1%, 5%, 94%

Legend: CDMA ■ Fixed Wired/Wireless ■ GSM
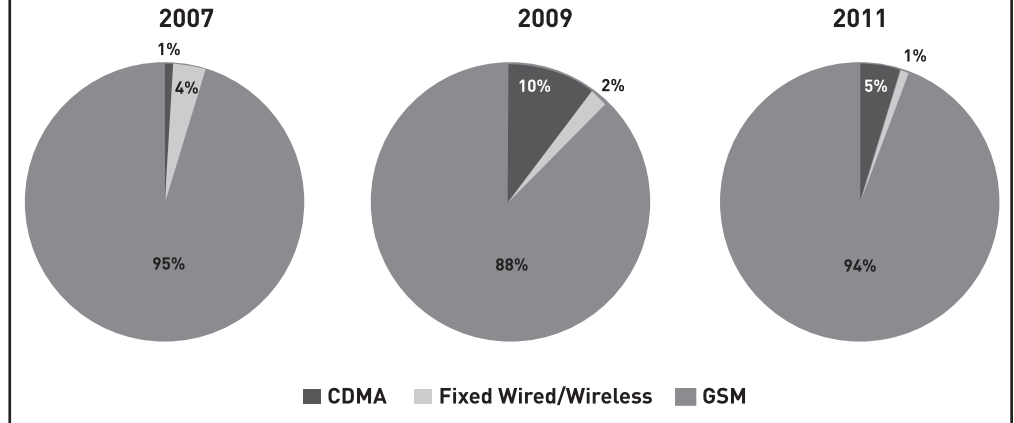
Source: NCC c. Blycroft via Africa Mobile Factbook 2012

Tayo Oviosu said in news reports this year that the company hopes to have 600,000 users by the end of 2012, and 15 million users by 2017.

The Hardware Making the Mobile Revolution Possible

With an 11-year lead over 3G CDMA, 2G GSM networks that support SMS messaging are the dominant mobile technology across Africa. But interest in smartphones and 3G networks is growing, particularly in urban centers. In Nigeria the number of CDMA subscribers increased by 92 percent between 2007 and 2011, according to the Africa Mobile Factbook.

Sending text messages over SMS can be costly – some carriers in Uganda, Zimbabwe and Namibia, for example, charge 40 cents or more per text. Services like BlackBerry's BBM messaging and other free messaging services embedded in social networking apps (like Facebook's chat feature) have driven those who can afford it to purchase smartphones, on which the per-message cost of communicating over a data plan is lower than the cost of individual texts.

Several studies of mobile phone usage have confirmed that Africans are increasingly using their mobile phones to transmit and receive more graphically rich content. A June 2012 report by Opera Software, called "The State of Mobile Web," found that data growth is outpacing page view growth across much of Africa, suggesting that, "Africans are browsing larger pages and most likely, using richer, more advanced websites."

Since mobile phones serve as the primary Internet and communication device for most Africans, there are a few key elements that make for a successful phone: it needs to be cheap and reliable, and it's best if it runs on an open source platform that can be manipulated to meet the needs of dynamic African economies.

"A growing middle class in developing countries and the falling cost of handsets are driving smartphone growth across the globe," according to "A Global Mobile Handset Forecast: 2011-2015," released by GigOm Pro last year. Julie Pohlig is the chief architect of projects and methodologies at Vital Wave Consulting, which focuses on emerging market business growth and development. Pohlig indicated that you can buy a reliable smartphone in many African countries for $50 to $100. While Nokia and to a lesser extent Samsung continue to dominate the mobile phone market in developing countries, several Chinese manufacturers, including Huawei and ZTE, have made aggressive inroads in the developing world's smartphone market, specifically developing low-cost Android smartphones and distributing them across much of Africa and India. In 2011, Huawei and ZTE sold 35 million smartphones combined, representing about seven percent of the global market. And the two firms expect 2012 smartphone sales will double their market share by rising to 90 million, according to a February 2012 report by Reuters.

The secret to low-cost smartphone success in Africa and other parts of the developing world is to pair older, low-cost technology with efficient open-source operating systems. A 2012 report by NPD In-Stat says low-cost Android handsets – those under $150 – will represent 80 percent of all smartphones in Africa, India and China by 2015. Most of these phones run on older Android 2.2 or 2.3 platforms to contain costs.

"The low-cost Android handset segment will cause some fragmentation in the Android platform," said Allen Nogee, research director at NPD In-Stat, in their report. "Most low-cost Android smartphones are likely to be released with Android 2.2 (Froyo) or 2.3 (Gingerbread), since these versions a good blend of features with modest memory and processor usage. The Ice Cream Sandwich (Android 4.0) step-up in memory and processor demands makes this release less attractive for low-cost Android devices."

ZTE has grown market share in emerging countries by employing a strategy of selling network equipment alongside their phones to telecom carriers. In 2012, ZTE is expected to sell more than

30 million smartphones – twice as many as it sold last year – due in large part to its network packages. Other manufacturers that have found success in the low-cost smartphone category include MicroMax, Motorola, Samsung and Spice.

Google's Android operating system is facing competition in Africa and other developing regions from the Windows Phone platform, as well as from newcomers to the market like Mozilla. Nokia recently announced plans to offer its new Windows Phones at prices below even the least expensive Android models. And in February 2012, Mozilla announced plans to create a mobile OS that would offer "an open, people-centric Web for consumers and developers across all devices and platforms." Mozilla's Firefox OS is based on an open HTML5 architecture.

At this time of dynamic, competitive development in telecom platforms, the manufacturers that best optimize their products for the unique needs of consumers in the developing markets will thrive. This will mean creating low-cost hardware with open-source operating systems that can meet the expanding demands of developers and users.

Learning from Africa's Mobile Success

In August, seven major U.S. retailers, including Target, Walmart and 7-11 – teamed up to create a mobile payment app dubbed the Merchant Customer Exchange. Customers who download the app on their smartphones can open it when they enter a store to see store specials and pay for their purchases. The retailers say this new app will lead to improved point-of-payment service for customers. These companies will also be able to collect detailed information about consumer spending habits, which will be valuable in the deployment of targeted advertising strategies. The platform will eventually expand to other merchants. This announcement has increased interest in m-payments here in the U.S.

But mobile payments are an area where U.S. companies – banks in particular – might look to Africa to better understand proven models. These models would need to be adapted to meet the demands of users with banking customs/bank accounts that are quite different than those of their African counterparts. For example, m-payment apps tied to banks and individual bank accounts have broader applications than store specific apps, and could be particularly useful for small businesses. Security remains a critical concern to developers of m-banking and m-payment applications in the U.S. and a chief concern in Africa, too. Already, m-banking systems like M-Pesa incorporate several security checks, at the bank-level as well as at the user level.

Improved access to technology in Africa is leading to more efficient, more responsible business practices and growing entrepreneurship. Africa's emerging middle class can access the same services as consumers in the developed world, and in some cases more, through their mobile phones. Mobile phones are eliminating the need for computers and fixed broadband connections across much of Africa. In business, the open architecture of operating systems like Google's Android allow any tech-savvy entrepreneur with a phone and an interest in programming to create – and market – new business opportunities

around the world. This open architecture is especially important in Africa, where unique social and commercial customs create new opportunities for developers. While the West experiences its own mobile revolution, it must look to Africa for ideas, opportunities and inspiration. ∎

THE EDUCATION REVOLUTION

By Jessica Boothe and Rhonda Daniel

"No more pencils, no more books." This popular chant of students from Alice Cooper's song "School's Out," alluded to the excitement of school ending for the summer. Now it has taken on a different connotation, characterizing the shift toward technological advancements in education. Education as we know it is being revolutionized. This article examines the technology-driven paradigm shift in education and identifies opportunities in the market by outlining how educators are looking to employ technology in their classrooms.

A Look Back

Technology is increasingly being used to supplement elementary, secondary and higher education, and has become more prevalent in the classroom in the last thirty years. For instance, when Smart Boards entered the market in 1990, educators were at the forefront of replacing two iconic classroom teaching tools – the overhead projector and chalkboard – with this new technology. Likewise, educators quickly moved from typewriters to computers once the latter technology became affordable for schools. But which technologies made a difference in the quality of education?

When the radio and film projector brought sound and image to students in the 1920s, inventor Thomas Edison predicted, "Books will soon be obsolete in schools. Scholars will soon be instructed through the eye." Fast forward thirty years to the 1950s where this trend continues with the release of the television. Along with this comes educational broadcast programming and the iconic videotape, changing the classroom yet again by adding entertainment to the education curriculum. Another three decades later, in the 1980s, one of the most influential technologies to impact education is released: the computer followed by the introduction of the World Wide Web.

Among those adults with kids currently enrolled in school, three quarters (75 percent) believe technology improves the learning experience.

Today, slimmer, faster and more cost-effective computers such as notebooks, e-books and tablets are transforming the classroom, giving educators opportunities to provide students with increased access to computers. 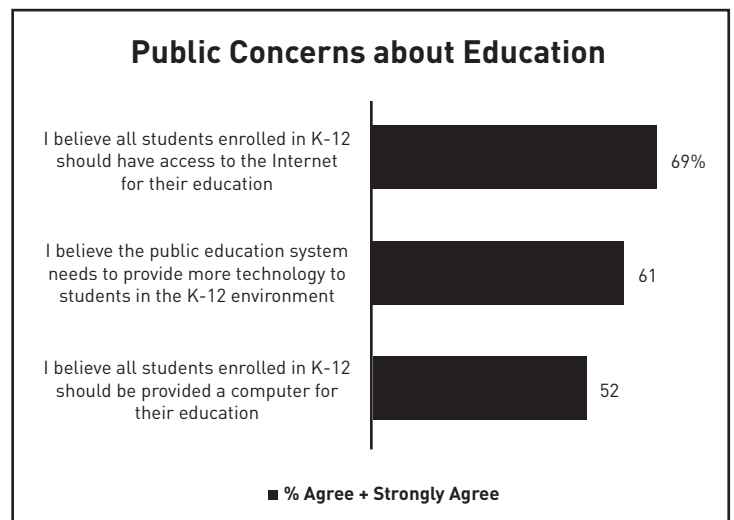The development of apps, social media and the cloud provide students with opportunities to learn in new and exciting ways using technology they've grown up with and interact with on a weekly if not daily basis.

As we inch closer to a model for education that more closely resembles Edison's vision, will students be taught "through the eye" as well as their other senses? How will modern technological advances like e-books, augmented reality programs and educational apps be incorporated into the classroom in years to come?

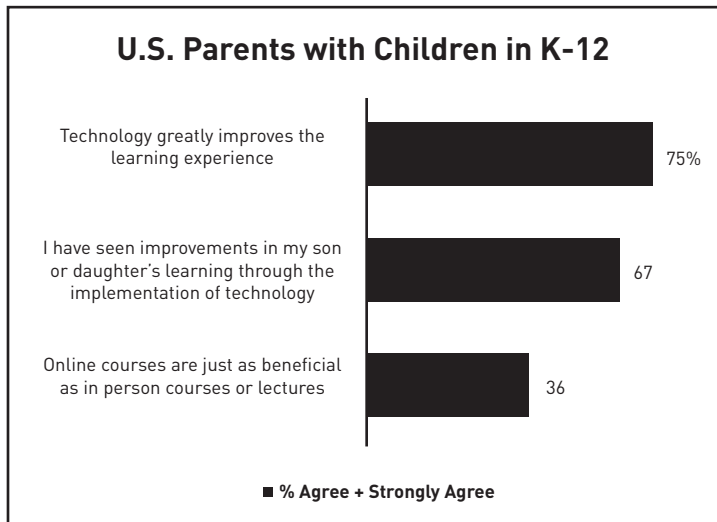### Consumer Perceptions of Technology in the Classroom

With 58 million U.S. kids ages five to 19 enrolled in K-12 public and private schools, and another eight million young adults ages 20-24 in college according to the most recent census, education is a priority on the mind of many across the nation. Among those adults with kids currently enrolled in school, three quarters (75 percent) believe technology improves the learning experience. However, with a growing number of students and budget limitations, most classrooms have limited access to technology at best.

Over half of those with children in school agree that all students enrolled in K-12 should be provided with a computer to aid in their education. And seven in 10 adults with children enrolled in school believe students should have access to the

Public Concerns about Education

	% Agree + Strongly Agree
I believe all students enrolled in K-12 should have access to the Internet for their education	69%
I believe the public education system needs to provide more technology to students in the K-12 environment	61
I believe all students enrolled in K-12 should be provided a computer for their education	52

Source: CEA Market Research

Internet for their education. This goes beyond having access at school to having access at home as well, where students can access a plethora of educational resources, content and structured lectures to benefit their education. Some school districts are finding that the Internet is so vital to education that they are even deploying wireless Internet access on school buses to give kids time to complete additional schoolwork during their commute. School officials indicate taking advantage of this "downtime," while costly, gives the children an additional 28 days of instruction.

U.S. Parents with Children in K-12

Technology greatly improves the learning experience — 75%

I have seen improvements in my son or daughter's learning through the implementation of technology — 67

Online courses are just as beneficial as in person courses or lectures — 36

■ % Agree + Strongly Agree

Source: CEA Market Research

Why would parents request such change from their K-12 establishments? Over two-thirds of adults with children in school indicate they see improvements in their children's learning because of technology. They report that teachers' websites are one of the most utilized technologies. With access to lesson notes, grades, assignments and lectures, teachers can now stay in constant communication with students as well as their parents.

In addition to classroom webpages and online lectures, social media is now heavily utilized by students as well. While social media is not a new concept, its usage within the school system is still in the preliminary stages, with fewer than half of adults reporting that their children's schools use this technology. Because this is a relatively new means of communication in education, teachers and administrators are still looking for ways to harness its reach for learning purposes.

Finally, more than one third of those with children report the usage of apps by the school for education. While most app usage comes in the form of games, apps prove to be another excellent learning tool at the disposal of educators and administrators for minimal to no cost.
Just over half of parents report their children's schools use laptops. Meanwhile, fewer than three in ten parents report their children use tablets and/or e-books for educational purposes, at home or in the classroom. While e-books and tablet computers have yet to make major inroads in the education system, about one-quarter of people with children in school prefer e-books to physical textbooks. While this preference is small, it may be

a result of the perceived costs of adopting this technology, the wear and tear children tend to put their belongings through and fear for theft or loss of the devices. Despite these concerns, tablet computers and e-books have much to offer and their presence in education will continue to grow.

What's Next in EdTech

Now that we understand which technologies are being used in classrooms across America, how will education continue to evolve to accommodate advancing technology and an up-and-coming tech savvy generation?

Education is Connected: There are many ways in which education is becoming connected, but one notable case is the textbook. Presently, most new textbooks to the market have an electronic counterpart. Electronic books offer many advantages over their physical equivalent. They weigh less, so students will no longer need to lug around heavy backpacks. They cost less, and don't suffer as much physical wear and tear over time. They also offer instant access to the content so students don't have to schedule time to visit the local bookstore and order materials which may be backordered.

Digital content is changing the traditional school day for K-12 students beyond the move to electronic books. A new trend of "flipping the classroom," means students can spend time at home mastering the essentials by accessing recorded lectures, webinars and podcasts of lessons when they would normally be focusing on homework. This allows teachers to focus on the application of the lectures and problem solving in the classroom, leading to more effective and efficient use of both students' and teachers' time.

This trend began as a result of two chemistry teachers in 2004 who were struggling with high absentee rates in their classes. To help students not fall behind, they began creating PowerPoint presentations of their lectures and posting them on the Internet for their students to watch. The program was successful – students who missed classes could keep up with their peers. The teachers no longer spent class time at the front of the room lecturing, and instead could work one-on-one with the students and have the students work with each other. Flipping the classroom is benefiting the educational environment by providing a more individualized approach to learning. It's beginning to take off across K-12 schools as well as at colleges and universities across the country.

At Penn State University, professors record short lectures or demonstrations of concepts. When students arrive at class, they are given quizzes on the concepts to help determine the areas where the professor should focus. To fully embrace this teaching method, schools would need to provide video recording, webinar or podcast technology for teachers and ensure all students have a computer and can access the Internet, either at home or through extended computer lab or library hours. Advances in this field of the reversed or "flipped classroom" will most likely occur on platforms and devices that allow for teachers and students to interact by sharing data. Whether wirelessly

or through a daily sync, a data exchange could provide information to teachers about where students have to rewind and re-watch material. This will help teachers alter future lessons to provide the best "ad-hoc" or "real time" education for classes. These models could be implemented into current technologies such as tablet computers, smartphones or other Internet-enabled devices so students can learn in any environment. They can also provide students with the ability to further their learning through interactions using touchscreens, 3D or other sensory developments.

Through this advanced model of teaching, teachers can continuously monitor their classes' progress and teach more to the needs of the individual while still advancing the class as a whole.

Learning is Tailored to Each Student: In most schools, students are taught in a one size fits all approach. They progress at the same pace and their learning is dependent on the teacher's instruction methods. Technology can facilitate an environment where each student can learn the way that is best for them, helping to further advance the goals of the federal No Child Left Behind Act. There are many ways in which learning will become tailored to the individual needs of students.

Technology will provide educators with opportunities to gauge students' individual mastery of concepts, giving students instantaneous feedback using computer-based assessments. Results of assessments can be used to group students needing extra help mastering a concept. This model not only advances technology within the education system but also revolutionizes the education system itself. By gathering data for students across the country using various assessments and software learning tools, massive amounts of data can be gathered, stored and analyzed.

Technology can facilitate an environment where each student can learn the way that is best for them.

Analysis of these data trends and patterns will lead to insights into how students solve problems differently – the individual steps and approaches different students take. Teachers can take these emerging patterns of problem solving and present a particular solution which may be best for individual students given their previous problem-solving behaviors. Analysis of this big data will also guide students on what they should learn next to master concepts effectively and efficiently. This data can easily be disseminated to parents and administrators to provide an accurate and timely picture of what is happening with their students' learning so they can step in sooner if needed and provide assistance.

One popular example of this type of program is under way at Khan Academy, a non-profit organization providing free online lessons on a variety of topics for grades K-12. Beyond offering the lessons, Khan Academy uses a technology platform to provide analytics on data gathered from the students.

Other programs are having a profound impact on tailoring learning for students with disabilities and special needs. One school in New York has found that tablets are allowing autistic children to express themselves in ways they were not able to before. And e-books offer several advantages for students with learning disabilities or visual impairments by giving them the ability to adjust font sizes or have the written text read aloud to them.

As the collection of educational stats and usage of technology builds and analytic teams work to determine the formulas to ensure the best education for students, there is little debate that technology is benefiting the education community.

Learning can Occur Anywhere: Looking ahead, education will no longer be tied to a physical place or a set time. In the K-12 environment, students will interact and learn with other students across the globe. This can help with acquisition of other languages and learning about other cultures. Home schooled students can receive the same educational opportunities as their in-school counterparts by tapping into apps, online resources and online classes. For schools short on staff and tight on budgets, students can attend online classes for specialized or advanced courses of study that they may not have been able to access before.

At the college level, massive online open courses (MOOC) are opening a world of new opportunities for students. In 2011, 160,000 students signed up for a free online course in Artificial Intelligence taught by a professor at Stanford University. Since then, more universities, including Ivy League schools, have begun offering online courses through various online providers including Coursera, edX and Udacity to name a few. At present, most of these offerings are free, so students do not receive credits toward their degrees for completing these, but the groundwork for that is being set.

When the opportunity for taking a MOOC where you pay a fee to earn credit toward a degree at a different institution comes to fruition, there are many potential implications. The costs of higher education could be lowered – a current challenge for many students. With wider access to education, more students could get degrees, especially where degree programs are not widely offered or colleges are farther away than people are able to travel. Students could design their own interdisciplinary programs by combining classes from several different universities. By breaking down barriers of distance and cost, technology allows students to get the best education possible.

Education is More Engaging: Most K-12 students are digital natives – they've never experienced a world without the Internet, computers or cell phones. By incorporating the electronic devices students use daily in their lives outside of school, like smartphones, laptops and tablets, education becomes more engaging. This is starting to happen via one of two methods: having students bring their own technology to school, known as a BYOT (Bring-Your-Own-Technology), an initiative that some school districts are trying out, or by the school providing devices like tablets, laptops, MP3 players or smartphones to

each student. Some corporations such as Apple and AT&T are working directly with some school districts to provide tablets to all students. Meanwhile, educational apps that can be used on these devices are flooding the marketplace, offering programs for different courses of study and levels of education, from preschoolers, to high school students, to college and beyond. Currently, Apple has more than 65,000 educational apps listed in their store and this is expected to grow.

Learning will become more interactive through gamification and augmented reality. Game-based learning will be taken to a new level with games that are complex, involve multiple players and focus on problem solving and collaboration. In one game, *Peacemaker*, students assume the role of a Prime Minister and resolve international conflicts. Another game, *Virtual Forensics Lab*, teaches college students how to solve crimes. These games allow students to take on roles and experiment and learn from the outcomes of their decisions, all without impacting the real world.

Through augmented reality, students can gather additional information for real life objects and places they encounter in real-time using mobile devices. Soon, students on field trips will be able to snap a picture of a sculpture or piece of artwork in a museum using a smartphone and information related to that object will be overlaid onto the screen, furthering learning in the moment.

Roadblocks and Challenges

While technology holds great promise for advancing the future of education, there are many roadblocks which must be overcome. As would be expected, funding is one of the largest hurdles. The state of education in our nation is already fragile given current budgetary constraints. Faced with the threat of further budget cuts, the picture becomes bleaker. How can we expect schools to allocate budget toward these technologies when they are barely making ends meet? Not only would funding be required for the technologies themselves and the infrastructure to support them, but there are also replacement costs as devices age or become obsolete. And training faculty to use these new tools so they can successfully incorporate them into the curriculum costs money too. The bring-your-own-technology initiative is one way schools are implementing technology to overcome some of these financial barriers, but it is met with mixed reviews, especially in instances where families cannot afford to purchase devices for their children.

Resistance to technology is another obstacle. While some staff may be comfortable with technology, others may be less at ease or knowledgeable with new devices. Training staff on how to use technology in the classroom and giving them time to master it is key. This means preparing them for the changes that are coming and making sure they are comfortable using the technology themselves.

Communication lines need to be open and unfettered, not only within the educational institution but also with others outside of it who can provide feedback, support, best practices and

interesting ways to incorporate technology into the curriculum. Politics, including the upcoming presidential election, may also play a role in the future of educational technology. Back in 2010, the Obama administration released the National Educational Technology Plan, which provides guidelines for incorporating technology into K-12 classrooms to improve the state of education and help make the nation more prosperous and competitive through a better educated workforce.

Finally, there are concerns about how these technologies will impact the behavior of students. Given that they are already used to using technology at home, providing students with tablets in school could cause more distractions in the classroom, which is one of the main reasons many schools initially issued cell phone bans. Additionally, it may also lead to cheating and plagiarism. Setting clear expectations of technology use in school and educating students on responsible behavior can help avoid these pitfalls.

Wrap-up

Incorporating technology in the classroom requires a concerted effort among all involved, from the government, educational institutions, parents and students as well as technology manufacturers and software providers, to provide the most practical and efficient devices and programs to enhance student learning. If these challenges can be overcome, the rewards will be worth it. Technology offers students improved access to education, but also gives students a more comprehensive curriculum. They can learn in a manner that works best for them. They will be more engaged and empowered to take charge of their own education. In the end, better education will make the nation more competitive in the global economy. ∎