A Consumer Products Perspective

Tech Trends 2014

Inspiring Disruption

Deloitte University Press

Contents

Introduction

WELCOME to Deloitte's fifth annual *Technology Trends* report. Each year, we study the ever evolving technology landscape, focusing on disruptive trends that are transforming business, government, and society. Once again, we've selected 10 topics that have the opportunity to impact organizations across industries, geographies, and sizes over the next 18 to 24 months. The theme of this year's report is *Inspiring Disruption.*

In it, we discuss 10 trends that exemplify the unprecedented potential for emerging technologies to reshape how work gets done, how businesses grow, and how markets and industries evolve. These disruptive technologies challenge CIOs to anticipate their potential organizational impacts. And while today's demands are by no means trivial, the trends we describe offer CIOs the opportunity to shape tomorrow—to inspire others, to create value, and to transform "business as usual."

The list of trends is developed using an ongoing process of primary and secondary research that involves:

- Feedback from client executives on current and future priorities
- Perspectives from industry and academic luminaries
- Research by alliance partners, industry analysts, and competitor positioning
- Crowdsourced ideas and examples from our global network of practitioners

As in prior years, we've organized the trends into two categories. Disruptors are areas that can create sustainable positive disruption in IT capabilities, business operations, and sometimes even business models. Enablers are technologies in which many CIOs have already invested time and effort, but that warrant another look because of new developments, new capabilities, or new potential use cases. Each trend is presented with multiple examples of adoption to show the trend at work. This year, we've added a longer-form *Lesson from the front lines* to each chapter to offer a more detailed look at an early use case. Also, each chapter includes a personal point of view in the *My take* section.

Information technology continues to be dominated by five forces: analytics, mobile, social, cloud, and cyber. Their continuing impact is highlighted in chapters dedicated to wearables, cloud orchestration, social activation, and cognitive analytics. Cyber is a recurring thread throughout the report: more important than ever, but embedded into thinking about how to be secure, vigilant, and resilient in approaching disruptive technologies.

For the first time, we've added a section dedicated to exponential technologies, working with Singularity University to highlight five innovative technologies that may take longer than our standard 24-month time horizon for businesses to harness them—but whose eventual impact may be profound. Examples include artificial intelligence, robotics, and additive manufacturing (3-D printing). The research, experimentation, and invention behind these "exponentials" are the building blocks for many of our technology trends. Our goal is to provide a high-level introduction to each exponential—a snapshot of what it is, where it comes from, and where it's going.

From a Consumer Products lens, we provided industry sector specific perspective on majority of the topics including CIO as a venture capitalist (how to leverage brand categories perspective for portfolio planning), crowdsourcing (specific strategies including crowdfunding, flexible workforce and data analysis contests), wearables (discussing the Empowered Employee and the Persistently Connected Consumer) and digital engagement (Omnichannel Brand Engagement, Ubiquitous Sensors and other topics).

Each of the 2014 trends is relevant today. Each has significant momentum and potential to make a business impact. And each warrants timely consideration—even if the strategy is to wait and see. But whatever you do, don't be caught unaware—or unprepared. Use these forces to inspire, to transform. And to disrupt.

We welcome your comments, questions, and feedback. And a sincere "thank you" to the many executives and organizations that have helped provide input for Tech Trends 2014; your time and insights were invaluable. We look forward to your continued innovation, impact, and inspiration.

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Disruptors


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Wearables

On-body computing devices are ready for business

Wearable computing has many forms, such as glasses, watches, smart badges, and bracelets. The potential is tremendous: hands-free, heads-up technology to reshape how work gets done, how decisions are made, and how you engage with employees, customers, and partners. Wearables introduce technology to previously prohibitive scenarios where safety, logistics, or even etiquette constrained the usage of laptops and smartphones. While consumer wearables are in the spotlight today, we expect business to drive acceptance and transformative use cases.

WEARABLE computing technology, dating to the 1960s' helicopter pilot head-mounted displays, is not new.[1] Even the familiar office identification badge is a type of wearable. But with recent materials science advances driving technology miniaturization and battery improvements, we're standing on the brink of widespread adoption.

Wearables are devices worn on the body in items such as watches, glasses, jewelry, and accessories. Or in the body—ingested or surgically implanted. They consist of three modular components: sensors, displays, and computing architecture. A wearable device may include one, two, or all three functions. A smart watch may contain narrowly purposed sensors that gather data about the user and his or her environment, but it may have limited display functionality and no computing power. Computing may occur in the cloud or on a multipurpose device such as a smartphone. The display may be on a nearby screen or in a pair of smart glasses, or it may even use an earbud or pendant for verbal response.[2] Think of wearables as an ecosystem—expanding capabilities that are individually interesting but more compelling when combinations are harnessed. This modularity is allowing new manufacturers to enter the market, driving demand from both consumers and enterprise users.

The mobile revolution placed powerful, general-purpose computing in our hands, enabling users to take actions in the digital world while moving about in the physical world. By contrast, wearable technology surrounds us with devices that primarily enable other devices with digital information, which in turn support us in taking real-world actions.

So why move forward now?

Few enterprises have tapped the full potential of smartphones and tablets, and many IT organizations are still learning how to design and build elegant, intuitive mobile apps. Also, the enabling infrastructure required to secure, deploy, manage, and maintain mobile assets is still being developed.[3] And many industries are just learning how to think beyond today's business scenarios: how to, instead of veneering existing processes and systems, come up with new ideas and even business models that were not previously possible. With so many opportunities left to explore using conventional mobile devices—smartphones, tablets, and laptops—why

should business leaders consider another wave of investment?

Wearables' value comes from introducing technology into previously prohibitive environments—where safety, logistics, or even etiquette have constrained traditional technology solutions. Wearables can be the first seamless way to enable workers with digital information—especially where hands-free utility offers a clear advantage. For example, using wearables, workers in harsh environmental conditions can access data without removing gloves or create records without having to commit data to memory and then moving to a sheltered workstation.

The primary goal of wearables is to enable users to take real-world actions by providing relevant, contextual information precisely at the point of decision making. Wearables shine in scenarios where using a laptop, phone, tablet, or other conventional device may not be appropriate[4] as well as in making use of the data gathered by sensors. Meeting this goal requires generating data in real time and intelligently pushing it to a device or devices according to the user's current context—just-in-time digital logistics. These use cases suggest that wearables may be most valuable deep in an organization's operations, rather than in customer-facing applications.

Making sense of sensing

Wearables can also form a bridge to related disciplines. Augmented reality (AR), for instance, overlays digital information onto the real world. Many smart glasses scenarios feature AR concepts, and overlaying reference images and graphics can be a powerful enhancement to wearables. Likewise, the Internet of Things (IoT) refers to the explosion of devices with connectivity and—potentially—intelligence. Be they motors, clothes on a retailer's shelves, thermostats, or HVAC ducts, IoT is rapidly adding to the context map that will amplify wearables' impact.

Sensors permeate the Internet of Things and are a leading focus of consumer wearables. This is especially true in the "quantified self" movement in which bracelets can gather personal data or sports gear and clothing can help monitor health. Consumer-facing enterprise applications, such as beacons that affect the behavior of wearable displays or smartphone apps, rely on consumers being surrounded by a network of always-on sensors.

Corporate uses of sensors may include temperature readings of an employee's environment or sleepiness indicators for fleet drivers. These sensors are not necessarily smart by themselves; rather, they harvest data that is processed and displayed elsewhere.

Going to work

The potential uses for wearables are staggering. In Australia, firefighters are being outfitted with a data-transmitting pill that can detect early signs of heat stress.[5] Health care insurance companies may offer policy discounts for members who quantify their healthy lifestyles by wearing fitness-tracking devices, similar to auto insurance companies' in-car efforts to track safe driving habits.[6] On the manufacturing floor, workers may be able to view metrics for nearby equipment on a smart watch. AR overlays in a warehouse can guide a worker who needs to find, move, pick, pack, and ship a particular product. Field installation, service, and maintenance professionals are being outfitted with smart glasses to access documentation, procedural tips, and skilled advice—from the top of a cell tower or beneath a boiler.[7]

Similar potential exists on the consumer side; Gartner predicts that "the worldwide revenue from wearable electronic devices, apps, and services for fitness and personal health is anticipated to be $1.6 billion in 2013 increasing to $5 billion by 2016."[8] But the market is—and will likely continue to be—highly fragmented. This fragmentation is inherent in a modular ecosystem, reflecting the lack of widely adopted technology standards.

Design principles of wearables

CONTENT

Ascribe to (much) "less is more" for content and its delivery—the design facilitates exceptionally low duration, high frequency use.

COMMUNICATION

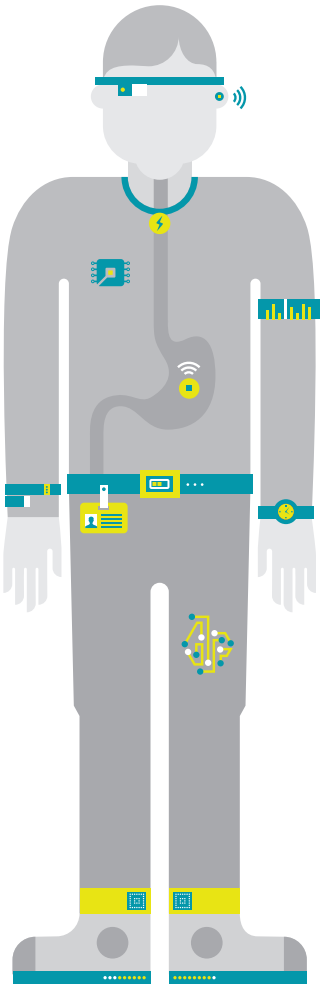
Focus on communicating rather than simply displaying data—not necessarily visually, and not necessarily via the device generating the notification.

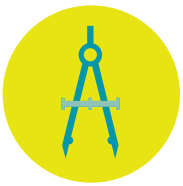
INFLUENCE

Do not force new behavior, but allow users to adjust their future behavior by providing new information or capabilities.

INTERACTION

Are careful about requiring response from the user—interaction with the device should be minimal and expedite the user's manual actions.





INTENTION

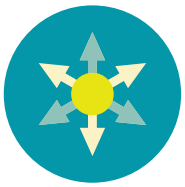
Use persistent design elements, alerts, just-in-time information, and notifications with discretion.

INTELLIGENCE

Are fueled largely by intelligence from analytics, big data, and sensors, which are often embedded in other devices.

ENHANCEMENT

Leverage the digital world to enhance the user's behaviors, actions, and experiences in the real world.



NETWORK

Communicate with an expanding community of wearables, data, devices, systems, platforms, services, and software.

More than two dozen manufacturers are aggressively pursuing head-mounted smart glasses. A dozen smart watches are already in the market. And new devices are launching virtually every day—from sensor-rich socks[9] to Bluetooth-powered rings to digital tattoos.[10]

Luckily, although the lack of industry standards in wearables can lead to policy headaches, a number of uses for wearables can be enabled using tools and governance processes similar to those needed for smartphones and tablets: device management, identity and entitlement management, security policies, content management, and app provisioning. Privacy concerns need to be managed—even though wearables are likely to be more readily accepted in the workplace than in public situations. It's important that employees perceive that the tool will help them perform more effectively on the job. Over time, social and workplace tolerance may increase, but during these early days, acceptance is a factor that must be considered.

But enterprises should not wait for consumer markets to settle and conventions to be established. Because the wearables ecosystem can benefit from the proliferation of niche players, companies don't need to hold off until marketplace standards or leaders emerge. The door is open to early experimentation—and to usher in the next wave of mobile innovation.

Consumer Products Perspective

Why should we be designing only for a smartphone or tablet when the wearable devices are reshaping how we can connect with employees, customers, and partners? That is what many Consumer Products (CP) companies are considering as they think about the future of their businesses. And there are two outcomes to be considered:

1. How will wearable technologies drive more effective execution at retail (we'll refer to this as the "Empowered Employee")

2. How will wearable technologies change the way CP companies interact with the consumer (we'll refer to this as the "Persistently Connected Consumer")

Empowered Employee

- CP companies are also eagerly anticipating the impact wearable computing will have on the traditional CP/Retail value chain. One possible future has wearable devices solving many age-old challenges such as accurate shelf restocking, reordering, promotional execution, and plan-o-gram compliance. Wearable devices have not just the opportunity to integrate into manufacturer, distributor, and retail back office systems, but can also provide a persistent set of image / video capture confirming proper performance of these business-critical functions. Companies like APX Labs and SAP are developing concepts that demonstrate how heads-up wearable devices will enable employees to operate at higher levels of efficiency and consistency. Employees who find themselves as candidates for the technology will likely weigh the utility of the technology with the invasiveness into monitoring their every action.

Persistently Connected Consumer

- While society may not be fully ready for always-on wearable computing, the technology in the market today is becoming more compact, usable, and connected thus enabling an explosion of possibilities for CP marketers. One form of wearable device, smart glasses, can recognize an object in a user's field of view in real-time and provide digital information overlaid atop the physical environment. This has obvious implications for many marketers eager to influence shopper decision making and some CP companies are already experimenting with this. Companies like Blippar have recently announced an offering that seamlessly turns the Google Glass platform into an augmented reality experience akin to many 90's sci-fi movies. The technology can use the forward looking camera on Glass to recognize labels, QR codes, and objects in natural space and overlay contextual and interactive experiences. Much of these capabilities can be demonstrated today without smart glasses on mobile phone and tablet apps.

Lessons from the front lines

The doctor is in (your stomach)

For millions of patients with chronic illness, remembering to take a daily dose of medicine can be a difficult task. According to the World Health Organization, approximately 50 percent of patients fail to take medicine correctly and more than 50 percent of medicines are prescribed, dispensed, or sold inappropriately.[11] This may cause doctors to over-prescribe medicine if they do not see the expected results.

Proteus Digital Health has developed a system that includes both a body-worn patch and a small ingestible sensor that supports patients in tracking their medicine usage and health.[12] The ingestible sensor can be embedded into a pill or tablet and consumed with a patient's prescription. It works like a potato battery—dissolving in the stomach to activate. The ingestible sensor communicates with the patch, which in turn transmits the ingestion data, along with activity and rest patterns picked up by the patch, to a secure application that can be accessed from a smartphone, tablet, or PC.[13] With the patient's consent, the data can be automatically shared with health care providers, family members, or other caregivers.

Wearable wardrobe

2013 saw an explosion of wearable devices in consumer products, with the "quantified self" movement leading the charge. Fitness and activity tracking devices are predicted to top $1 billion in sales in 2014.[14] Athletic consumer apparel brands such as Nike, Adidas, and Under Armour have either launched wearable technology products or publicly shared plans to enter the market.[15]

The trend is being embraced in the broader fashion and consumer goods industries, with a wide range of emerging categories. Heapsylon manufactures Sensoria smart socks, which track how much a user is exercising. The company has plans to expand the platform to help prevent and manage falls and foot injuries and to collect information that health care professionals can use to provide better-quality care.[16] Reebok's CheckLight beanie measures the intensity of blows to the heads of athletes participating in contact sports, sending an alert when a blow is moderate or severe.[17] Huggies announced prototype sensor-laden diapers that can tweet parents when their infants need to be changed.[18] And more products are coming, as demonstrated by the high number of wearables on display at the 2014 Consumer Electronics Show.

Hands-free patient care

Philips Healthcare brought wearable technology to the operating table through its proof of concept for using a hands-free device to improve the efficiency of surgical procedures. A surgeon typically reviews numerous screens to monitor a patient, requiring the surgeon to turn away from the procedure at hand. Now, by wearing a headset with a display in the field of vision, a surgeon can monitor required information while keeping both eyes on the patient. The prototype allows doctors to interact with an application derived from Philips' IntelliVue Solutions.[19] Using simple voice commands, a surgeon can request to view a patient's vital signs or medical history, which then would be displayed in the surgeon's line of sight.

Additionally, by giving doctors the ability to observe a patient's vital signs remotely, Philips'

prototype allows doctors to virtually be in two places at once. For example, if a doctor performing a routine procedure were called upon to assist with another patient, he or she could review the vital signs of both patients to determine the more critical need.[20]

Other companies are also exploring the possibilities of wearables in health care. Shimmer, a provider of wearable wireless health sensor products, is teaming with research enterprises. Sample use cases include remote monitoring of epileptic seizures and the delivery of biofeedback during resistance training activities.[21] Additionally, an Ohio State University Medical Center doctor recently used a head-mounted device to perform surgery. The device gave medical students the opportunity to watch the surgery in real time from a classroom and allowed the surgeon to communicate with an off-site specialist while operating.[22]

A new vision for training[23]

CraneMorley, a boutique design firm, creates tools for learning and performance support. Working extensively with clients in the automotive industry, the company has been leveraging technology more and more to drive business performance by creating solutions that target gaps in workers' knowledge and skills.

At a car dealership, salespeople should be well versed in the technology and telematics their cars are equipped with to effectively sell them to their customers. If a salesperson can't demonstrate a car's features, there is a good chance the customer won't buy the car; on the flip side, if the salesperson can demonstrate the technology seamlessly, the customer could love and buy the car and become a long-term advocate of the brand.

Rather than overloading salespeople with information about the cars, CraneMorley designed training workshops to interactively teach them what they need to know about cars' telematics and technology features. Twenty-five salespeople were equipped with tablets and placed around six cars. They established their competency in demonstrating the car's technology features, and if they struggled with one, they could watch a quick lesson on their tablet for help. The instructors were able to see a master view of the salespeople's tablet programs, and could also insert themselves to help them as required.

The program worked wonderfully—except that the salespeople had to hold the tablets while working through the demonstrations. Identifying an opportunity to pilot wearable technology, CraneMorley has developed a discovery learning training program using smart glasses. Through the use of the glasses, the salespeople are now able to interact with the cars while information is overlaid on the hands-free glasses by the augmented reality software. The ability to actively demonstrate the car's features allows the salespeople to better remember how to do it again in front of a customer at the dealership.

CraneMorley is exploring other scenarios to expand the smart glasses-powered discovery learning concept beyond training salespeople. One application for the technology could be servicing: As someone is trying to fix a car, he or she could access helpful information or contact an engineer for real-time support—allowing the specialist to see exactly what the technician is seeing in the repair bay and offer immediate guidance. Another application is on the sales floor: Many technologies have been deployed to the sales floor to help customers learn more about cars' features, such as kiosks, PCs, and tablets, but none have really been effective. Smart glasses could be a tool to teach customers about the cars that interest them in a more personal way, even allowing them to test drive a car without leaving the dealer's floor.

My take

Brian Ballard, CEO, APX Labs

At APX Labs, we are dedicated to changing the way people use wearable displays, specifically through the use of smart glasses. This new class of devices can provide people with relevant information to achieve tasks hands-free. In the United States, there are 17 million "desk-less" workers—people whose jobs take them away from offices and cubicles into the heart of where business gets done. Think manufacturing, logistics, service technicians, or medical professions. This alone is a $20 billion market for wearable technology—and only a part of the bigger opportunity.

Wearables are a crowded, and growing, ecosystem. We've focused on building a platform to lower the barrier of entry for users across multiple markets and form factors of smart glasses. We see the market in two broad categories: heads-up displays (HUDs) and true augmented reality glasses—both of which act as new tools to solve old problems.

With heads-up displays, contextually relevant information is presented via an accessible, but secondary, out-of-eye display. Think Kopin Golden-i and Google Glass. Status, workflow, and supplemental data look-ups are dominating early uses, but more are coming as the development kits have become generally available.

With augmented reality displays, smart glasses are used to present real-time information and services in the user's view of the world—ideal for the heads-up, hands-free worker. One of our first applications was for the defense industry. "Terminator Vision" was an effective initial use case—using facial recognition and background check services to visually highlight potentially hostile parties as a soldier scans a crowd. Medical use cases are also leading the charge—with the goal of giving practitioners a view of vital signs, electronic health records, procedural guidance, and simple administrative support. Applications for manufacturing, logistics, and in-stadium entertainment are targets for future adoption where large numbers of people are engaged in similar tasks that require access to the same information. More important, companies control and operate the ecosystem surrounding the business processes—simplifying funding and integration challenges.

As the wearables market begins to take off, there's a bit of a chicken-and-egg phenomenon playing out. In the consumer space, developers won't get behind a new platform unless there is a substantial market for it, and users have been hesitant to enter the wearables market before there is a defined use case for the product, which is dependent on compelling apps. This is the driving reason that we think enterprises are going to lead the charge—tackling well-defined problems to drive the required volumes to propel developers to opt in en masse.

But we're still in the early days. Some enterprise customers flock to the technology simply because it's "cool"—and then try to determine what they can use it for. A better path is for companies to holistically look at the business issues they face, evaluate their options, and determine if smart glasses are the required tool for solving specific problems. We try to help our customers identify what some of those burning issues are—and figure out how the technology will revolutionize the world around us.

Where do you start?

WE expect to see an escalating number of wearable computing devices, platforms, and applications that can enable and transform business operations. Now is the time to begin exploring the possibilities that wearables hold for improving supply chains, workflows, and processes to drive down costs and increase competitiveness.

- **Imagine "what if."** Think about how your business's effectiveness could improve if workers had the information they needed at the moment they needed it. What current processes could be discarded or refined? What could people accomplish if a photo or video could replace a paper report? What critical processes—for example, emergency procedures—are difficult for workers to master because they are rarely needed? What if employees could have specific instructions for those procedures delivered at the point of impact? What if a worker had ready access to equipment manuals while repairing an oil rig or bridge cable? What if a worker in the field could show a remote colleague real-time video from his or her point of view—while leaving his or her hands free?

- **Kick the tires.** As new wearable devices and software applications appear, experiment with various platforms and evaluate the organizations behind them. Do they fit your business operations? Is the vendor viable for the long term? Do you have a pool of early adopters who will likely embrace the technology? Remember that wearables are a modular ecosystem, so if one component doesn't measure up, the system can adapt to accommodate other players. Experimentation is the name of the game.

- **Become an early adopter.** Connect with wearable manufacturers and software developers to share your business's operational needs and explore the possibilities of working together to develop solutions. As companies are looking for beachheads in this new world, there are opportunities for teaming.

- **Simplify. Simplify. Simplify.** In design, wearables need to be treated as their own beast. Just as the design patterns from desktop, laptop, and the web were not well-suited for smartphone and tablet use, a completely different experience should be designed for wearables. Simplicity is the ultimate form of sophistication, and transparency is the ultimate form of simplicity. User interaction should be kept to a minimum. If a use case requires an explicit user response, it should be limited to spoken commands, gestures, or a gloved knuckle tap. Minuscule displays require discipline in not only what information should be displayed but how to present it; a two-tone simplified graphic can be more effective than a detailed photo. Time sensitivity becomes important, so create "glanceable" awareness of information in the applicable context. The information displayed should be curated to precisely fit the immediate situation or task, with no extraneous data. This extends to the purpose for which a device is used: Don't design a wearable experience for a function that's more effectively done on a smartphone, a tablet, or a piece of paper.

- **Anticipate data and device management.** Data generated by wearable devices could exponentially increase the quantity of

information that your IT organization should store, manage, and analyze. The volume of unstructured data, including pictures and videos, could also escalate. Also, consider how these new devices will be repaired and managed. Assume that bring-your-own-device (BYOD) will happen whether policy supports it or not and that new classes of devices will likely become smart before IT can redefine policies to manage them individually. Strive for simple rules that can govern ever-more-complex behaviors.

- **Engage the workforce.** Ask frontline employees to participate in the imagination process. What persistent problems would they like to solve? What opportunities could be created? Likewise, ask them what concerns they have about the devices, and develop plans to address those concerns. Talk with trade unions and other worker groups to understand and address concerns they may have about using wearable devices. Over time, social and workplace tolerance may increase, but during these early days, focus on employee education and constrain your use cases to those that provide demonstrable benefits to the user.

Bottom line

Wearables targeted at the consumer market are today's media darlings. Google Glass Explorer parties and Samsung's Dick Tracy-style watches make for interesting copy. But unlike tablets, which were introduced to the enterprise by consumers, we expect businesses to take the lead in building acceptance and demand for wearable computing devices. As consumer devices, wearables represent a very personal buying decision in which aesthetics and fashion are almost as important as function. But in the workplace, experience and engagement matter. Function can trump form—as long as a wearable is perceived as unobtrusive, safe, and not "creepy." The challenge is easy to articulate: Rethink how work could get done with the aid of an ever-present computing device that delivers the desired information when it's needed. Organizations that get a head start could gain an advantage over their wait-and-see competitors.

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As the mobile lead for the Deloitte Digital service line, Shehryar Khan focuses on helping clients use mobile to drive organizational transformation—identifying opportunities where mobile can truly impact both user and business goals.

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Exponentials

One more thing . . .

EACH year, this report analyzes trends in technology put to business use. To be included, a topic should clearly demonstrate its potential to impact businesses in the next 18 to 24 months. We also require a handful of concrete examples that demonstrate how organizations have put the trend to work—either as early adoption of the concept or "bread crumbs" that point toward the fully realized opportunity. Our criteria for choosing trends keeps us on the practical side of provocative, as each trend is relevant today and exhibits clear, growing momentum. We encourage executives to explore these concepts and feed them into this year's planning cycle. Not every topic warrants immediate investment. However, enough have demonstrated potential impact to justify a deeper look.

Because we focus on the nearer-term horizon, our *Technology Trends* report typically only hints at broader disruptive technology forces. This year, in collaboration with leading researchers at Singularity University, we have added this section on "exponential" technologies, the core area of research and focus at Singularity University. The fields we chose to cover have far-reaching, transformative impact and represent the elemental advances that have formed technology trends both this year and in the past. In this section, we explore five exponentials with wide-ranging impact across geographies and industries: artificial intelligence, robotics, cyber security, additive manufacturing, and advanced computing.

In these pages we provide a high-level introduction to each exponential—a snapshot of what it is, where it comes from, and where it's going. Each exponential stems from many fields of study and torrents of research. Our goal is to drive awareness and inspire our readers to learn more. Many of these exponentials will likely create industry disruption in 24 months or more, but there can be competitive opportunities for early adoption. At a minimum, we feel executives can begin contemplating how their organizations can embrace exponentials to drive innovation. Exponentials represent unprecedented opportunities as well as existential threats. Don't get caught unaware—or unprepared.

My take

Peter H. Diamandis, MD
Co-founder and executive chairman, Singularity University
Chairman & CEO, XPRIZE Foundation
Author, *Abundance: The future is better than you think*

In 2012 the world experienced what I call "the new Kodak moment." A moment in time when an exponential technology put a linear thinking company out of business. Kodak, the company that invented the digital camera in 1976, and had grown to a 145,000-person,[1] 28-billion-dollar global company at its peak, ultimately filed for bankruptcy in 2012 as it was put out of business by the exponential technology of digital imagery. In stark contrast, another company—also in the digital imagery business—called Instagram, was acquired in that same year by Facebook for $1 billion. Instagram's headcount: 13 employees.

These moments are going to be the norm as exponentially thinking startups replace linear businesses with unprecedented products and services. Although a daunting challenge, exponential technologies offer extraordinary opportunities to the businesses that can keep pace with them.

The lessons learned from Kodak are the consequences of failing to keep up with what I call the "six Ds." The first D is digitization. Technology that becomes digitized hops on Moore's Law and begins its march up the exponential growth curve. Like many companies, Kodak was blindsided by the next D—deceptive growth. When a product, such as imagery, becomes digitized, it jumps from a linear path to an exponential trajectory. The challenge is that early exponential doublings are deceptive. The first Kodak digital camera was only 0.01 megapixels. Even though it was doubling every year, when you double 0.01, to 0.02, 0.04, 0.08, 0.16, this doubling of small numbers near zero looks to the mind like linear growth, and is dismissed. It's only when you continue forward past what is called the "knee of the curve" that it begins to change. Double seven times from "1" and you get to 128. Twenty-three more doublings (a total of 30) gets you to 1 billion. Business leaders often perceive the early stages as slow, linear progress. Until, of course, the trend hits the third D—disruption.

By the time a company's product or service is disrupted, it is difficult to catch up. Disruptive growth ultimately leads to the last three Ds—dematerialization, demonetization, and democratization, which can fundamentally change the market. The smartphone in your pocket has *dematerialized* many physical products by providing their virtual equivalents—a GPS receiver in your car, books, music, and even flashlights. Once these equivalents gain market traction, the established product's commercial value can plummet. It becomes *demonetized*. iTunes®,[2] for example, is impacting the value of record stores. eBay is doing the same to specialty retailers. Craigslist has stripped newspapers of classified advertising revenue. Once products become dematerialized and demonetized, they become *democratized*—spreading around the world through the billions of connected devices we carry around.

Many business leaders confront exponentials with a stress mindset. They realize that the odds of survival aren't great. Babson College noted that 40 percent of the Fortune 500 companies in 2000 didn't exist 10 years later.[3] However, the other side of the coin is an abundance mindset—awareness of the limitless opportunity. Between now and 2020, the world's population of digitally connected people will jump from two to five billion.[4] That growth will also add tens of trillions of dollars in economic value.

To land on the opportunity side of the coin and avoid shocks down the road, companies can take two immediate steps:

- **Conduct an impact assessment:** Identify the top five strengths that differentiate your company. Then look at which exponentials could potentially erode those strengths. Also look at the flip side. What are the top five pain points that exponentials could eliminate? How?
- **Evaluate the threat:** Determine how your company's products or services could be dematerialized or demonetized. Exploiting market adjacencies is a key part of the equation. Google, for example, is focusing on autonomous cars and Microsoft continues to make forays into gaming. The goal is to not only figure out who might disrupt your business's pond but whose pond your company can disrupt.

Your competition is no longer multinational powerhouses in China or India. Your competition now is the hyper-connected startup anywhere in the world that is using exponential technologies to dematerialize and demonetize your products and services. Someone in New York can upload a new idea into the cloud, where a kid in Mumbai builds on it and hands it off to a Bangladeshi company to handle production and marketing. Companies need to make sure their plans are in sync with this world and its dynamics.

Lastly, companies should consider their strategy in the context of leveraging two types of exponentials: First, pure exponential technologies such as artificial intelligence, synthetic biology, robotics, and 3D printing; and second, what I call "exponential crowd tools": crowdsourcing, crowdfunding, and prized-based competition incentive models. If companies then marry this portfolio of exponential assets with the understanding that today's grandest societal and planet challenges are also today's most promising commercial market opportunities, it can truly be a formula for abundance.

Exponential snapshots

Artificial intelligence

Computer science researchers have been studying Artificial Intelligence (AI) since John McCarthy introduced the term in 1955.[5] Defined loosely as the science of making intelligent machines, AI can cover a wide range of techniques, including machine learning, deep learning, probabilistic inference, neural network simulation, pattern analysis, decision trees and random forests, and others. For our purposes, we focus on how AI can simulate reasoning, develop knowledge, and allow computers to set and achieve goals.

The ubiquity and low-cost access to distributed and cloud computing have fueled the maturity of AI techniques. AI tools are becoming more powerful and simpler to use. This maturity is the first part of the story: how AI is becoming democratized and can be applied across industries, not just in areas such as credit card processing and trading desks, where AI has been gainfully employed for 45 years. The next part of the story focuses on our desire to augment and enhance human intelligence.

We are increasingly overwhelmed by the flood of data in our lives—1.8 zettabytes of information are being created annually.[6] But we are saddled with an ancient computing architecture that hasn't seen a major upgrade in more than 50,000 years: the brain. We suffer from cognitive biases and limitations that restrict the amount of information we can process and the complexity of calculations we can entertain. People are also susceptible to affectations and social perceptions that can muddy logic—anchoring on first impressions to confirm suspicions instead of testing divergent thinking.

AI can help solve specific challenges such as improving the accuracy of predictions, accelerating problem solving, and automating administrative tasks. The reality is that with the right techniques and training, many jobs can be automated. That automation is underway through many applications in several fields, including advanced manufacturing, self-driving vehicles, and self-regulating machines. In addition, the legal profession is availing itself of AI in everything from discovery to litigation support. DARPA is turning to AI to improve military air traffic control as automated, self-piloted aircraft threaten to overrun air-spaces. In health care, AI is being used in both triage and administrative policies. The world's first synthetic bacterium was created using AI techniques with sequencing.[7] Energy firms are using AI for micro-fossil exploration in deep oil preserves at the bottom of the ocean. AI can also be leveraged for situational assistance and logistics planning for military campaigns or mass relief programs. In sum, AI represents a shift, a move from computers as tools for executing tasks to a team member that helps guide thinking and can do work.

Despite these successes, many of today's efforts focus on specific, niche tasks where machine learning is combined with task and domain knowledge. When we add biologically inspired computing architectures, the ability to reason, infer, understand context, develop evolving conceptual models of cognitive systems, and perform many different flavors of tasks becomes attainable.

In the meantime, AI faces barriers to its widespread adoption. Recognize that in developed nations, its use may encounter obstacles, especially as labor organizations

fight its increased use and its potential to decrease employment. The ethics of AI are also rightly a focus of attention, including the need for safeguards, transparency, liability determination, and other guidelines and mechanisms that steer toward responsible adoption of AI. But these realities should not curb the willingness to explore. Companies should experiment and challenge assumptions by seeking out areas where seemingly unachievable productivity could positively disrupt their businesses.

Inspired by lectures given by **Neil Jacobstein**, *artificial intelligence and robotics co-chair, Singularity University*

Neil Jacobstein co-chairs the artificial intelligence and robotics track at Singularity University. He served as president of Singularity University from October 2010 to October 2011 and worked as a technical consultant on AI research for a variety of businesses and government agencies.

Robotics

Mechanical devices that can perform both simple and complex tasks have been a pursuit of mankind for thousands of years. Artificial intelligence and exponential improvements in technology have fueled advances in modern robotics through tremendous power, a shrinking footprint, and plummeting costs. Sensors are a prime example. Those that guided the space shuttle in the 1970s were the size of foot lockers and cost approximately $200,000. Today, they are the size of a fingernail, cost about 10 cents, and are far more reliable.

Robotics is fundamentally changing the nature of work. Every job could potentially be affected—it's only a matter of when. Menial tasks were the early frontiers. Assembly lines, warehouses, and cargo bays have been enterprise beachheads of robotics. But that was only the beginning. Autonomous drones have become standard currency in militaries, first for surveillance and now with weapon payloads. Amazon fulfillment centers are largely automated, with robots picking, packing, and shipping in more than 18 million square feet of warehouses.[8] The next frontier is tasks that involve gathering and interpreting data in real time. Eventually these tasks can be replaced by a machine, threatening entire job categories with obsolescence. Oxford Martin research predicts that 45 percent of US jobs will be automated in the next 20 years.[9]

On the not-so-distant horizon, for example, gastroenterologists won't need to perform colonoscopies. Patients will be able to ingest a pill-sized device with a camera that knows what to look for, photograph and, potentially, attack diseases or inject new DNA. Boston Dynamics is rolling out Big Dog, Bigger Dog, and Cheetah—robots that can carry cargo over uneven terrain in dangerous surroundings. Exoskeletons can create superhuman strength or restore motor functions in the disabled. Remote health care is coming. It will likely arrive first with robotics-assisted virtual consultation, followed by surgical robots that can interpret and translate a surgeon's hand movements into precise robotic movements thousands of miles away. Companies are also pursuing autonomous cars. Personal drone-based deliveries could disrupt retail. The limits are our imaginations—but not for long.

Robotics should be on many companies' radars, but businesses should expect workplace tension. To ease concerns, companies should target initial forays into repetitive, unpleasant work. Too often robotics is focused on tasks that people enjoy. Equally important, companies should prepare for the inevitable job losses. Enterprises should identify positions that aren't likely to exist in 10 years, and leverage attrition and training to prepare employees for new roles. The challenge for business—and society as a whole—is to drive job creation at the same time that technology is making many jobs redundant. Ideally, displaced resources can be deployed in roles requiring creativity and human interaction—a dimension technology can't replicate. Think of pharmacists. After as much as eight years of education, they spend the majority of their

time putting pills into bottles and manually assessing complex drug interactions. When those functions are performed by robots, pharmacists can become more powerful partners to physicians by understanding a patient's individual situation and modifying drug regimens accordingly.

At the end of the day, there are two things robots can't help us with. The first is preservation of the human species, a concern more civic and philosophical than organizational. But the second is more practical—indefinable problems. For example, robots can't find life on Mars because we don't know what it might look like. Everything else is fair game. Be ready to open the pod bay doors of opportunity—before your competition does.

Inspired by lectures given by **Dan Barry**, *artificial intelligence and robotics co-chair, Singularity University*

Dan Barry is a former NASA astronaut and a veteran of three space flights, four spacewalks, and two trips to the International Space Station. He is a licensed physician and his research interests include robotics, signal processing with an emphasis on joint time-frequency methods, and human adaptation to extreme environments.

Cyber security

A few hundred years ago, a robbery consisted primarily of a criminal and an individual victim—a highly personal endeavor with limited options for growth. The advent of railroads and banks provided opportunities to scale, allowing marauders to rob several hundred people in a single heist. Today, cyber criminals have achieved astonishing scale. They can attack millions of individuals at one time with limited risk and exposure.

The same technological advances and entrepreneurial acumen that are creating opportunities for business are also arming the world's criminals. Criminal organizations are employing an increasing number of highly educated hackers who find motivation in the challenges of cracking sophisticated cyber security systems.[10] These entrepreneurial outlaws are a new crime paradigm that is reaching frightening levels of scale and efficiency.

A few examples illustrate the daunting landscape: Hackers are available for hire online and also sell software capable of committing their crimes. A few years ago, for example, INTERPOL caught a Brazilian crime syndicate selling DVD software that could steal customer identities and banking information. The purveyors guaranteed that 80 percent of the credit card numbers pilfered through the software would be valid. Its customers could also contact a call center for support.

Cyber criminals are also leveraging the crowd. Flash Robs, for example, are becoming a new craze where social media is used to bring individuals to a specific store to steal goods before police can arrive. Another crowdsourced crime looted $45 million from a pre-paid debit card network. Hackers removed the card limits. Thieves then bought debit cards for $10 and withdrew what they wanted. In just 10 hours, the crowd made more than 36,000 withdrawals in 27 countries.

What looms on the horizon is even more daunting. With the Internet of Things, every car, consumer appliance, and piece of office equipment could be linked and ready for hacking. As fingerprints become the standard means of authentication, biometrics will become a powerful source of ingenious theft.

The experience of the US Chamber of Commerce portends the future. The organization's photocopiers, like many, are equipped with hard drives that store printed documents. In the past, industrial criminals disguised as repairmen removed the devices. However, when the chamber installed thermostats connected to the Internet, hackers could breach the copiers. Officials only discovered the attack through a defect that inadvertently sent the hackers' documents to the copiers.

There are steps that companies can take to combat cybercrime. The first is to establish risk-prioritized controls that protect against

known and emerging threats while complying with standards and regulations. Companies should also identify which of their assets would likely attract criminals and assess the impact of a theft or breach. Organizations should then become vigilant and establish situation risk and threat awareness programs across the environment. Security and information event management capabilities can be enhanced and new functionality can be mined from tools including endpoint protection, vulnerability assessment/patch management, content monitoring, data loss prevention, intrusion prevention, and core network services. The final step is building resilience: the ability to handle critical incidents, quickly return to normal operations, and repair damage done to the business.

Companies can also turn to the crowd. Security professionals have knowledge that can help investigations and warn of potential threats. The legal environment is also important. Business leaders should advocate for laws and policies that seek to contain cybercrime and also avail themselves of resources provided by federal agencies.

Cybercrime is accelerating at an exponential pace. In the not-so-distant future, everything from our watches to the EKG monitors in hospitals will be connected to the Internet and ready to be hacked. Companies should be prepared to survive in an environment where these threats are commonplace.

Inspired by lectures given by **Marc Goodman**, *chair for policy, law, and ethics and global security advisor, Singularity University*

Marc Goodman is a global strategist, author, and consultant focused on the disruptive impact of advancing technologies on security, business, and international affairs. At Singularity University, he serves as the faculty chair for policy, law, and ethics and the global security advisor, examining the use of advanced science and technology to address humanity's grand challenges.

Additive manufacturing

The technology that supports additive manufacturing, or 3D printing, is more than 30 years old. Its recent popularity has been fueled in part by patent expirations which are driving a wave of consumer-oriented printers. Prices have fallen, putting the technology within the reach of early adopters. 3D printing is democratizing the manufacturing process and bringing about a fundamental change in what we can design and what we can create.

But the story goes much deeper than hobbyists and desktop models. The cost of a 3D printer ranges from a few hundred to a few million dollars. The machines can print with hundreds of materials, including nylons, plastics, composites, fully dense metals, rubber-like materials, circuit boards, and even genetic tissue. Breakthroughs in speed, resolution, and reliability demonstrate potential not only for scale but also for unlocking new possibilities.

The real exponential impact, however, is in the simplicity of the supporting tools. They provide a means to digitize existing objects, customize and tweak open source designs, or create brand new designs based on structural and industrial engineering know-how. Intuitive, easy-to-use tools allow "things" to be created, manipulated, and shared.

In essence, 3D printing makes manufacturing complexity free of charge, allowing otherwise impossible designs to be realized. Objects are built one layer at a time, depositing material as small as 100 nanometers exactly where and when needed. Mechanical items with moving parts can be printed in one step—no assembly required. Interlocking structures mimicking nature's design laws are possible with nearly unlimited geometrical freedom—no tooling, set-ups, or change-overs. Moreover, objects can be built just in time when and where they are needed. The capability unlocks business performance in a highly sustainable manner by reducing inventory, freight, and waste. 3D printing's value is not limited to complex objects.

On-site creation of investment castings or construction molds can supplement traditional manufacturing techniques.

3D printing is not just for prototypes and mock-ups. Many sectors already use the technology for finished parts and products. The aerospace industry, for example, has led the charge on additive manufacturing. Jet engine parts such as manifolds require more than 20 pieces that are individually manufactured, installed, welded, grinded, and tested into a finished product. The 3D printed alternative is easier to build and service and also reduces overall system weight. Medical devices use 3D printing to customize and personalize everything from dental crowns to hearing aids to prosthetics.

The potential doesn't end there. More fantastical use cases are starting to become a reality, such as mass customization of consumer goods, including personalized products ranging from commodities to toys to fashion, with "print at home" purchase options. Even food printers are entering the market, starting with chocolates and other sugar and starch staples, but moving toward meats and other proteins. Organs, nerves, and bones could be fully printed from human tissue, transforming health care from clinical practice to part replacement—and even life extension. Leading thinkers are exploring self-organizing matter and materials with seemingly magical properties. One example is already here: a plane built of composites with the ability to morph and change shape, ending the need for traditional flaps and their associated hydraulic systems and controls.

The enterprise implications are many—and potentially profound. First, organizations should take an honest look at their supply chain and market offerings—and identify where the technology could enhance or replace these offerings. As we discussed in the *Digital engagement* chapter, intellectual property and rights issues will emerge, along with new paths to monetize and disrupt. Finally, business leaders should embrace the democratized creativity the technology is unleashing. Companies can use 3D printing to drive faster product innovation cycles, especially where it can push the boundaries of possibilities based on materials science and manufacturing techniques.

Inspired by lectures given by **Avi Reichental**, *co-chair for nanotechnology and digital fabrication, Singularity University*

Avi Reichental currently serves as faculty co-chair of the additive manufacturing program at Singularity University. He has been the president and chief executive officer of 3D Systems since September 2003.

Advanced computing

Advances in raw computing power and connectivity are frequently the building blocks of our annual tech trends report. Core lessons that have guided us through the Internet revolution remain true today, and are steering us toward exponential advances in the future of computing.

The first lesson is the importance of early adopters and how they personally and commercially kick-start industries and adoption. Early adopters have an insatiable demand for improvement and for the doubling of performance. Moore's Law forecasts how many transistors per dollar could be put onto a chip wafer. Engineering curiosity and scientific prowess have fueled many advances in the field. Nonetheless, to build growth and feed customer demand, companies continue to invest in seismic performance improvements because they know there is a demand for products that are twice as good.

The second lesson is an open, hackable ecosystem with a cost contract that encourages experimentation through its lack of incremental accounting for network usage. From the system kits of the PC revolution to the open source movement to today's Arduino and Raspberry Pi hobbyists, a culture of innovation and personal discovery is driving

advances in open groups instead of proprietary labs. Lessons and learnings are being shared that accelerate new discoveries.

The third lesson is that the magical ingredient of the Internet is not the technology of packet switching or transport protocols. The magic is that the network is necessarily "stupid," allowing for experimentation and new ideas to be explored on the edges without justifying financial viability on day one.

On the computing side, we are at a fascinating point in history. Rumblings about the end of Moore's Law are arguing the wrong point. True, chip manufacturers are reaching the theoretical limits of materials science and the laws of physics that allow an indefinite doubling of performance based on traditional architectures and manufacturing techniques. Even if we could pack in the transistors, the power requirements and heat profile pose unrealistic requirements. However, we have already seen a shift from measuring the performance of a single computer to multiple cores/processors on a single chip. We still see performance doubling at a given price point—not because the processor is twice as powerful, but because twice the number of processors are on a chip for the same price. We're now seeing advances in multidimensional chip architecture where three-dimensional designs are taking this trend to new extremes. Shifts to bio and quantum computing raise the stakes even further through the potential for exponential expansion of what is computationally possible. Research in the adjacent field of microelectromechnical systems (MEMS) and nanotech is redefining "hardware" in ways that can transform our world. However, like our modest forays into multi-core traditional architectures, operating systems and software need to be rewritten to take advantage of advances in infrastructure. We're in the early days of this renaissance.

The network side is experiencing similar exponential advances. Technologies are being developed that offer potentially limitless bandwidth at nearly ubiquitous reach. Scientific and engineering breakthroughs include ultra-capacity fiber capable of more than 1 petabit per second[11] to heterogeneous networks of small cells (micro-, pico-, and femtocells[12]) to terahertz radiation[13] to balloon-powered broadband in rural and remote areas.[14]

Civic implications are profound, including the ability to provide education, employment, and life-changing utilities to the nearly five billion people without Internet access today. Commercially, the combination of computing and network advances enable investments in the Internet of Things and synthetic biology, fields that also have the ability to transform our world. Organizations should stay aware of these rapidly changing worlds and find ways to participate, harness, and advance early adoption and innovation at the edge. These lessons will likely hold true through this exponential revolution—and beyond.

Inspired by lectures given by **Brad Templeton**, *networks and computing chair, Singularity University*

Brad Templeton is a developer of and commentator on self-driving cars, software architect, board member of the Electronic Frontier Foundation, Internet entrepreneur, futurist lecturer, and writer and observer of cyberspace issues. He is noted as a speaker and writer covering copyright law, political and social issues related to computing and networks, and the emerging technology of automated transportation.

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Special thanks

Mariahna Moore—for being the heart, soul, and "buck" of this year's report—where every detail started and stopped, big or small. Your tireless leadership, spirit, and drive are truly inspirational and a singular reason we hit every ambition without compromising seemingly impossible deadlines.

Cyndi Switzer, Stuart Fano, Jill Gramolini, Kelly Ganis, and **Heidi Boyer**—the veteran dream team that makes Technology Trends a reality. Your passion, creativity, and vision continue to take the report to new heights. And your dedication, energy, and commitment never cease to amaze.

Dana Kublin, Mark Stern, and **Elizabeth Rocheleau**—for the tremendous impact made in your first year Tech Trending—from the phenomenal infographics to coordinating our volunteer army to jumping into the content fray.

Finally, a special thanks to **Mark White**, the founder of our Technology Trends report series and an invaluable contributor, mentor, and friend. Thanks for all of your continued support as we build on your legacy.

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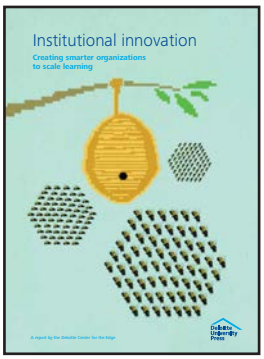

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