Tech breakthroughs megatrend: how to prepare for its impact

How to prepare for the technological breakthroughs megatrend, and the eight technologies to start with

pwc

The technological breakthroughs megatrend is manifesting itself in a proliferation of technologies. To remain relevant and to succeed, emerging technology strategy needs to be a part of every company's corporate strategy. The most pertinent technologies—and the corresponding strategy—will of course vary from company to company; but our analysis of more than 150 emerging technologies pinpoints the eight that most C-suites should start with. Here's a look at what sets those technologies apart—and what business leaders now need to do about them, and emerging technologies in general.

How can c-suites even begin to make sense of the swirl of technological breakthroughs affecting business today?

"Jim, how do all these AI breakthroughs impact our IoT strategy?"

That's the kind of question that CEOs are much more likely to get these days from some board members. It's rarely a comfortable question—whether it's actually about artificial intelligence or any of dozens of fast-developing technologies, and whether it is asked conversationally or out of serious strategic concern.

Given the sheer pace and acceleration of technological advances in recent years, business leaders can be forgiven for feeling dazed and perhaps a little frustrated. When we talked to CEOs as part of our annual Global CEO Survey, 61% of them told us they were concerned about the speed of technological change in their industries.[1] Sure, more and more C-suite executives are genuinely tech-savvy—increasingly effective champions for their companies' IT vision—and more and more of them know that digital disruption can be friend as well as enemy. But it's fair to say that most struggle to find the time and energy necessary to keep up with the technologies driving transformation across every industry and in every part of the world.

To help CEOs on their technology journeys, we've been evaluating more than 150 technologies globally and developing a methodology to help identify the ones most pertinent to a given company or industry. Additionally, we've been filtering for those that will have the greatest impact on the widest range of industries over the coming years. This article shines the spotlight on those eight technologies that we contend will be the most influential on businesses worldwide in the very near future—the ones we call the "Essential Eight." The article also sketches out a three-part guideline to help business leaders respond productively to emerging technologies by incorporating them into their overall strategy with the Essential Eight as a good starting point.
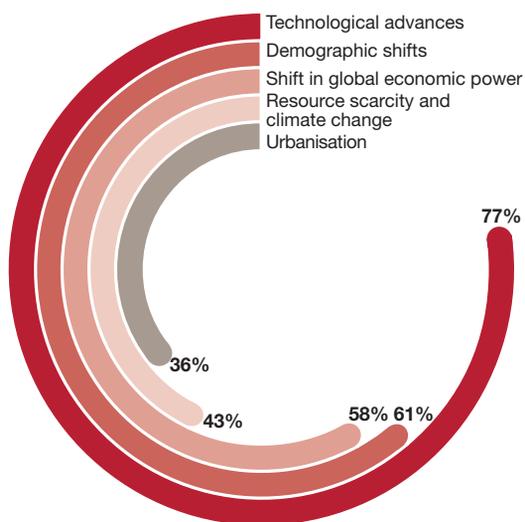
What makes technological breakthroughs a megatrend?

Technological advances
Demographic shifts
Shift in global economic power
Resource scarcity and climate change
Urbanisation

77%

36%

43%

58% 61%

Source: PwC, 19th Annual Global CEO survey, January 2016

History is littered with companies that have waited out the *Next New Thing* in the belief that it's a technology trend that won't amount to much, or that won't affect their industries for decades. Yet disruption happens. It's safe to say that the history of humankind is a history of disruption—a stream of innovations that have tipped the balance in favor of the innovators. In that sense, technological breakthroughs are the original megatrend. What's unique in the 21st century, though, is the ubiquity of technology, together with its accessibility, reach, depth, and impact.

The technological breakthroughs megatrend directly impacts every other megatrend. Every industry feels its influence now, and so does every company, of every size—everywhere. There is still a significant digital divide, but for the first time, the developed and developing worlds are using similar platforms, including the Internet, social media, and mobile technologies. Farmers in India track crop prices on their mobile phones; Kenyan and South African entrepreneurs crowdfund their new ventures.[2,3] There's new competition: Google and Uber are delving into driverless automobiles; Silicon Valley startups are competing with long-established defense contractors; and the health insurance industry is being overrun by companies that started out as SaaS (software-as-a-service) providers. [4]

Business leaders worldwide acknowledge these changes, and have a clear sense of their significance. We asked CEOs what they believe will most shape stakeholders' expectations about businesses in their industries over the next five years. Our respondents were unequivocal in pointing to technological advances as the most influential by far (see Figure 1).

2 Vikas Vasudeva, "Agriculture Ministry launches two mobile apps for farmers," *The Hindu*, December 24, 2015

3 Gabriella Mulligan, "Africa discovers the power of crowdfunding," *BBC*, June 19, 2015

4 Strategy&, 2016 Technology Industry Trends, January 2016

CEOs don't single out any particular catalyst that leads them to that conclusion. But we maintain that technological advancements are appearing, rapidly and simultaneously, in fields as disparate as healthcare and industrial manufacturing, because of the following concurrent factors:

- *Cheaper access to technology.* The three fundamental technologies of computation, storage, and connectivity are exponentially cheaper and more capable today than just a few decades ago (see Figure 2). The rapid growth of the Internet, mobility, and cloud computing, combined with the open-source movement and increased access to capital, has lowered the barriers to entry for startups and nontraditional competitors, enabling them to scale swiftly and to upend the playing field in industry after industry.

- *Globalization of technology.* For the first time, the developed and developing worlds are creating, collaborating, communicating, and consuming on similar technology platforms, spurring global innovation. Of the 146 "tech unicorns" tracked by the *Wall Street Journal*, 27% come from the Asia-Pacific region, up from 20% two years ago.[5] These highly valued, fast-growth newcomers have global ambitions and are developing innovative platforms for use in sectors as diverse as finance, online-to-offline services, and the sharing economy.

- *Increased comfort with technology.* The more we all use the Internet, laptops, mobile devices, collaboration tools, and other technologies in our personal and professional lives, the more society is comfortable with all things technology. Business users now expect the same ease of use in their workplace technologies that they experience with their personal devices, revealing consumer technology's huge influence.[6]

- *The competitive advantage of technology.* Our Digital IQ survey found that companies that are technology leaders in their industries are twice as likely to achieve rapid revenue and profit growth as the laggards.[7] Originally seen largely as a tool for improving efficiency—doing the same things better and more cheaply—technological innovations are now the fastest means of opening up new revenue streams and transforming traditional industries.

- *Multiplier effect of technology.* Individual technologies build on each other and amplify each other's effects, setting the stage for what some are calling a "fourth industrial revolution."[8] As participants noted at a recent technology panel hosted by PwC, artificial intelligence—an emerging technology—is the motive force behind robots (another evolving technology) transitioning beyond the factory floor and into hotels and office suites.
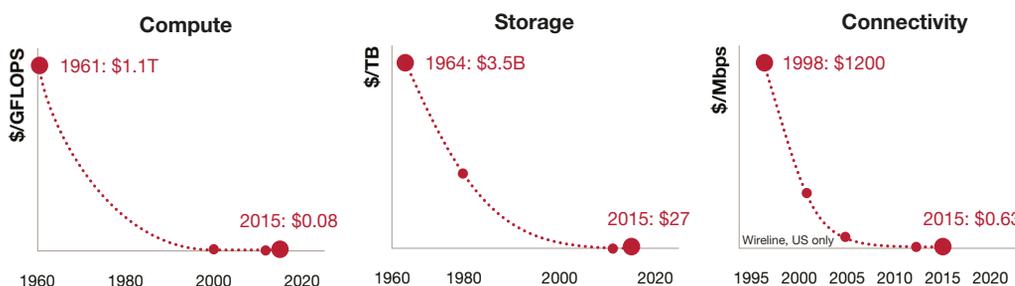
5 Scott Austin, Chris Canipe, and Sarah Slobin, "The Billion Dollar Startup Club," *WSJ*, June 2016

6 PwC *Cyber security updates* (blog), "Still worried about BYOD? Are you sure? Things have moved on. A lot." February 12, 2015

7 PwC, 2015 Global Digital IQ Survey: Lessons from digital leaders – 10 attributes driving stronger performance, September 2015

8 Klaus Schwab, "The Fourth Industrial Revolution: what it means, how to respond," *World Economic Forum*, January 14, 2016
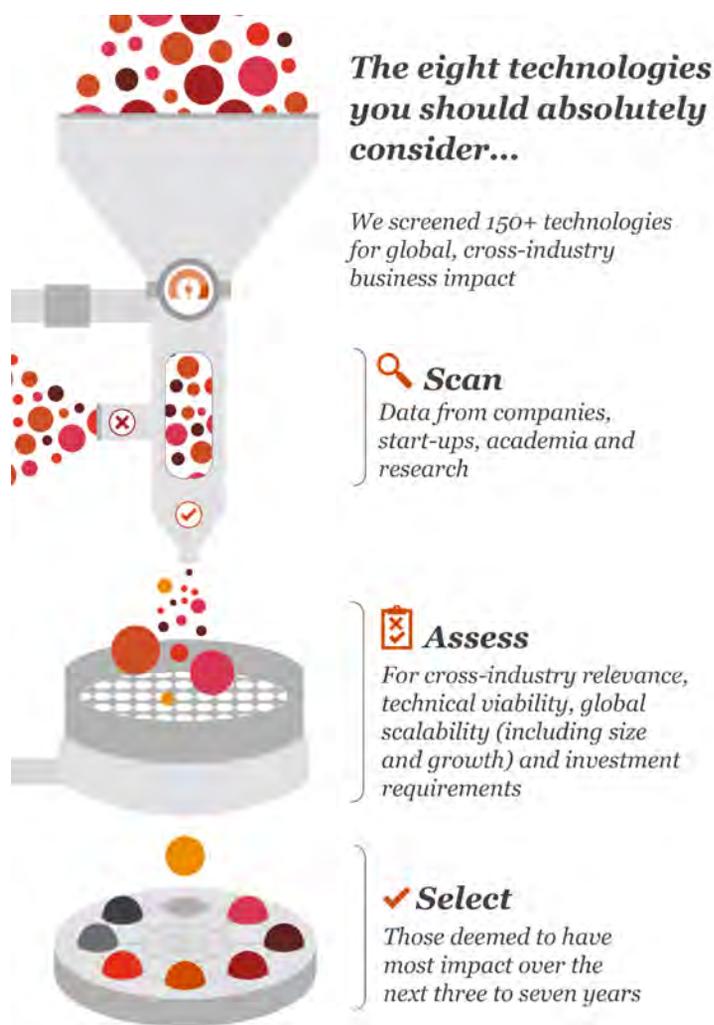
Figure 2. Technology costs are plummeting (and the reach is increasing)

Compute
$/GFLOPS
1961: $1.1T
2015: $0.08
1960 1980 2000 2020

Storage
$/TB
1964: $3.5B
2015: $27
1960 1980 2000 2020

Connectivity
$/Mbps
1998: $1200
2015: $0.63
Wireline, US only
1995 2000 2005 2010 2015 2020

Source: PwC/Strategy& analysis; Michael Driscoll/Metamarkets

The eight emerging technologies you should absolutely consider

The eight technologies you should absolutely consider...

We screened 150+ technologies for global, cross-industry business impact

Scan
Data from companies, start-ups, academia and research

Assess
For cross-industry relevance, technical viability, global scalability (including size and growth) and investment requirements

Select
Those deemed to have most impact over the next three to seven years

Collectively, those driving factors are forcing big questions to the surface—questions that C-suite executives themselves are asking. Explains Chris Curran, PwC US's Chief Technologist: "Where should we start exploring emerging technologies? What technologies should we invest in? How do we stay current? How do we reduce the associated risks of failure? These are the types of questions we're getting from CEOs."

To help provide answers, we track more than 150 discrete technologies, and have developed a methodology to identify the most pertinent of those technologies; the aperture being flexible enough to scale from a business unit to a company, an industry, or even the global enterprise landscape as a whole. The multifactor criteria screens for business impact and commercial viability of these technological breakthroughs over the next five to seven years (and as little as three to five years in developed economies). Examples of these criteria include: the technologies' relevance to the company, the industry, or across multiple industries, ranging from banking and insurance to hospitality services and industrial process manufacturing; their global reach; their technical viability, including the potential to become mainstream; their market size and growth potential; and the pace of public and private investment in them (see Figure 3).

The Essential Eight technologies that matter now

1. **Artificial intelligence (AI).** Software algorithms that are capable of performing tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and language translation. AI is an "umbrella" concept that is made up of numerous subfields such as machine learning, which focuses on the development of programs that can teach themselves to learn, understand, reason, plan, and act (i.e., become more "intelligent") when exposed to new data in the right quantities.

2. **Augmented reality (AR).** Addition of information or visuals to the physical world, via a graphics and/or audio overlay, to improve the user experience for a task or a product. This "augmentation" of the real world is achieved via supplemental devices that render and display said information. AR is distinct from Virtual Reality (VR); the latter being designed and used to re-create reality within a confined experience.

3. **Blockchain.** Distributed electronic ledger that uses software algorithms to record and confirm transactions with reliability and anonymity. The record of events is shared between many parties and information once entered cannot be altered, as the downstream chain reinforces upstream transactions.

4. **Drones.** Air- or water-based devices and vehicles, for example Unmanned Aerial Vehicles (UAV), that fly or move without an on-board human pilot. Drones can operate autonomously (via on-board computers) on a predefined flight plan or be controlled remotely. (Note: This category is distinct from autonomous land-based vehicles.)

5. **Internet of Things (IoT).** Network of objects — devices, vehicles, etc. — embedded with sensors, software, network connectivity, and compute capability, that can collect and exchange data over the Internet. IoT enables devices to be connected and remotely monitored or controlled. The term IoT has come to represent any device that is now "connected" and accessible via a network connection. The Industrial IoT (IIoT) is a subset of IoT and refers to its use in manufacturing and industrial sectors.

6. **Robots.** Electro-mechanical machines or virtual agents that automate, augment or assist human activities, autonomously or according to set instructions — often a computer program. (Note: Drones are also robots, but we list them as a separate technology.)

7. **Virtual reality (VR).** Computer-generated simulation of a three-dimensional image or a complete environment, within a defined and contained space (unlike AR), that viewers can interact with in realistic ways. VR is intended to be an immersive experience and typically requires equipment, most commonly a helmet/headset.

8. **3D printing.** Additive manufacturing techniques used to create three-dimensional objects based on digital models by layering or "printing" successive layers of materials. 3D printing relies on innovative "inks" including plastic, metal, and more recently, glass and wood.

The specific technologies most impactful to a company can—and likely will—vary, of course, but when we analyzed for technologies with the most cross-industry and global impact over the coming years, eight technologies emerged (see "The Essential Eight: Technologies That Matter Now"). They are at varying degrees of maturity; some have been around for years but are finally hitting their stride, while others are maturing rapidly. None will be surprising to CEOs; they are regular subjects of often breathless coverage in popular newspaper coverage.

So what exactly do we mean by "impact"? We believe that these technologies will shake things up across all five aspects of your business model—some in very beneficial ways, and some in quite challenging ways, as seen in the following snapshots [9]:

- *Strategy:* If strategy is about defining "what business to pursue," then these technologies are opening up a slew of new opportunities and corresponding considerations. IoT (and Industrial Internet of Things, IIoT), for example, are giving manufacturers the ability to "sensorify" their existing products, creating "intelligent" new offerings with value-added analytics and software services to go with them.[10] In some cases, these new offerings require a comprehensive rethink of innovation and portfolio strategies. In other cases, they may necessitate fresh go-to-market and even merger and acquisition strategies.

  But the technologies can accelerate and amplify bigger shifts: manufacturers' moves into service sectors, for instance, or fluid joint ventures with other corporate entities to leverage broad technology platforms for mutual advantage. For instance, John Deere recently purchased portions of Monsanto's precision planting business unit, helping redefine Deere not just as a maker of big tractors but as a prime mover in the business of "digital agriculture." [11]

9 PwC, AI In Insurance: Hype or Reality, March 2016

PwC, Technology Forecast: The road ahead for augmented reality, 2016

strategy+business, "A Strategists' Guide to Blockchain," January 11, 2016

PwC, The Industrial Internet of Things, 2016

10 PwC, The Internet of Things: What it means for US manufacturing, February 2015

11 *Crain's Chicago Business*, "Deere deal for Monsanto biz underscores push into 'digital agriculture'," November 3, 2015

Customer engagement and robots

Nao is a customer service robot being piloted by Mitsubishi UFJ Financial Group, Japan's biggest bank. Nao's visual and auditory "senses," connected to advanced artificial intelligence, allow it to "see" customers, recognizing them and the tone of their voices. Nao thus has rich interactions with customers, greeting them in their native language (it understands and speaks 19). It can support human staff during rush hours or special events that draw more foreigners to the bank. If Nao performs well, the bank is likely to employ more robotic staff in pursuit of better customer service.

- *Customer Engagement:* The Essential Eight technologies are already reshaping almost every dimension of companies' interactions with their customers, from sales and marketing to billing and after-sales support. Just one example: artificial intelligence, applied as machine learning, for instance, can help process volumes of customer-behavior data to identify patterns that enterprises can use to improve customer engagement (see sidebar on "Nao" the robot [12]).

- *Operations:* Artificial intelligence, robots, drones, and 3D printing can all improve operational efficiency and provide significant competitive advantage. Consider the following data point: we've determined that in the hospitality industry, service robots can drive down the cost of deliveries by one or two orders of magnitude. [13] Is it any wonder therefore that we see continued adoption of robots across an array of business sectors? [14]

At the same time, 3D printing is set to shrink supply chains, cut product development times, and broaden offerings for customers that expect products tailored to their preferences and needs.[15] And early adopters of virtual reality and augmented reality are already reaping benefits (see Figure 4). [16] The accompanying box showcases how Boeing and DHL are using augmented reality to be both faster and more efficient. [17]

Figure 4. Virtual reality and augmented reality get down to work

Q: How is your company using virtual and/or augmented reality technology? Please select all that apply

38.8% Product design and development

17.3% Virtual assembly/improved process design

27.6% Safety and manufacturing skills training

19.4% Maintenance, repair or operation of equipment

19.4% Data and information access

19.4% Remote collaboration

13.3% Costumer engagement and communications

7.1% Supply chain collaboration/communications

18.4% Other (please specify)

Number of resoindents: 98
Source: PwC and Zpryme survey and analysis,
"2015 Disruptive Manufacturing
Innovations Survey," conducted in November 2015

Operations and augmented reality

At Boeing, factory trainees assembling a mock airplane wing worked 30% faster and 90% more accurately using AR-animated instructions on tablets than trainees using instructions in PDF documents. Meanwhile, DHL equipped its warehouse workers with AR-enabled smart glasses that guided them through item picking for order fulfillment, resulting in fewer errors and a 25% increase in efficiency.

12 *PwC The data blog*, "Artificial Intelligence and robotics: The end of the world (as we know it)?," April 15, 2015

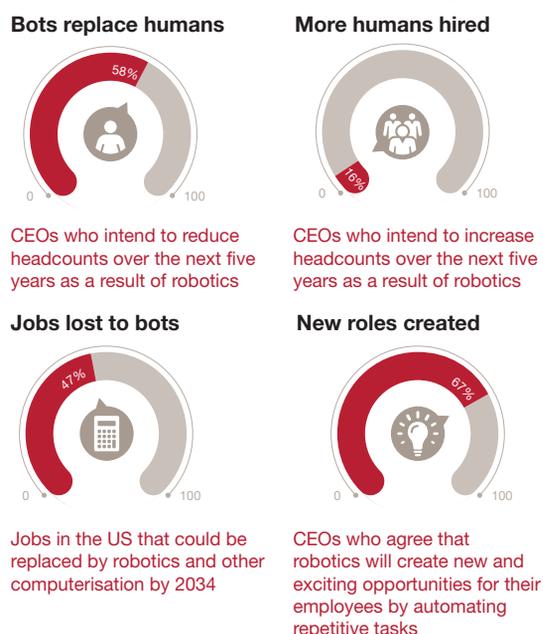13 PwC, Technology Forecast: Service Robots: The next big productivity platform, 2015

14 PwC, CEO Agenda: Pulse on Robotics, 2016

15 PwC, 3D printing: Potential to shrink the supply chain, 2014

16 PwC, For US manufacturing, virtual reality is for real, January 2016

17 PwC, Technology Forecast: The road ahead for augmented reality, 2016

Figure 5. More robots, new roles, fewer jobs?

Bots replace humans

58%

0 — 100

CEOs who intend to reduce headcounts over the next five years as a result of robotics

More humans hired

16%

0 — 100

CEOs who intend to increase headcounts over the next five years as a result of robotics

Jobs lost to bots

47%

0 — 100

Jobs in the US that could be replaced by robotics and other computerisation by 2034

New roles created

67%

0 — 100

CEOs who agree that robotics will create new and exciting opportunities for their employees by automating repetitive tasks

Source: PwC, CEO Agenda: Pulse on Robotics, 2016

- *People and talent:* The Essential Eight technologies are creating brand-new job categories, but a worrying consequence may be slower job growth. Our CEO Pulse survey showed that 56% of global CEOs expect the widening use of robots to reduce head count over the next five years (see Figure 5). [18] A recent Citibank report contended that the banking industry could lose up to 30% of its workforce over the next 10 years owing to technologies such as AI and blockchain. [19] Concurrently, new technologies beget new companies (Google, just 18 years old, has more than 61,000 employees) and new job categories (the job of a data scientist was all but unknown a decade ago). So employers will have to determine how to integrate machines into their talent pools and, at the same time, determine how to hire, retain, and develop the talent they need—talent that may need to embrace their machine-colleagues rather than fear them.

- *Compliance:* This is an often overlooked aspect of the business model. We believe the shortlisted technologies will see many companies scrambling to adapt to—and trying to influence—the resulting regulatory landscapes. The regulators themselves are likely to be in a catch-up mode for a while. How do we protect the data collected by billions of IoT devices? How is blockchain regulated (see sidebar)? How do we plan for liability and insurance considerations as drones and service robots proliferate? Questions like these are no longer hypothetical. There have already been quite a few high-profile incidents where drones have entered airspace reserved for commercial aircraft, and have injured humans.

18 PwC, CEO Agenda: Pulse on Robotics, 2016

19 Portia Crowe, "CITI: The 'Uber moment' for banks is coming – and more than a million people could lose their jobs," *Business Insider*, March 30, 2016

20 *strategy+business*, "A Strategists' Guide to Blockchain," January 11, 2016

Compliance and blockchain

We anticipate that new blockchain technology will do much to transform the compliance practices of enterprises large and small. As we noted in our recent article, blockchain enables a "central, immutable ledger of transactions" that "would allow auditors and regulators to rapidly monitor the flow of financial data, avoiding after-the-fact verification." However, there is still significant debate about how this technology gets monitored and regulated. [20]

Your job now

So what should CEOs and their leadership teams do with such brief glimpses of the business impact of these influential technologies? For starters, it is best not to treat the technologies as a kind of checklist to delegate to the CIO or the CTO. Instead, CEOs must take very seriously their own obligations to turn these technologies to strategic advantage—and to protect their organizations against others using the technologies for advantage. If that sounds something like an arms race, that's because it is: technology must be viewed as a competitive weapon, one that merits regular discussion and decision-making in the C-suite.

Technological breakthroughs megatrend is manifesting itself as a proliferation of technologies - the Essential Eight, and hundreds more. The tracking, evaluation, and action plan development for these emerging technologies, while a complex and involved undertaking, should now be an integral component of the overall corporate strategy. To do so, there are three questions that the C-suite must find effective answers to:

1) Do we have a sustainable innovation strategy and process?

2) Have we quantified the impact of new technologies? If not, how can we do that—and how soon?

3) Do we have an emerging-technologies road map? If so, are we keeping it up to date?

Answers to these fundamental questions will give you the meta-actions—moves that enable the executive team as a whole to properly and effectively harness the best new technologies.

Tracking, evaluating, and developing the action plan for emerging technologies should be an integral component of the overall corporate strategy.

1.

Do we have a sustainable innovation strategy and process?

Our research shows [21] that the most successful companies shape their future by creating the change they want to see. They do not respond to external changes as rapidly as possible—which is another way of saying that they do not chase the next exciting emerging technology as soon as it emerges. It is therefore vital to build an innovation strategy, capability, and culture that allows you and your leadership team to engage in profitable pursuit of emerging technologies aligned to your "Way to Play" (i.e., how you create value for your customers in the market).[22]

For a sustainable and repeatable innovation strategy and process, here are some things you will need to solve for:

- *Funding:* How will we fund the emerging-technology-driven innovation? Will there be a separate investment pool or will each organization be given flexibility to pursue investments within guidelines? If the former, will existing profit centers be taxed or will it be part of the corporate overhead?

- *Portfolio fit:* How will the emerging-technology pursuit fit within the overall product and services portfolio? Will it be under a separate unit or an overlay organization, or will there be incubation factories within existing organizations? Running innovation through the standard operating procedure is often a recipe for failure, so new development and go-to-market processes might be needed. What are the best ones for us? How do we mitigate risk? How do we convert successful experiments to mainstream products and services?

- *Accountability:* Emerging-technology strategy will require myriad business and technology trade-offs. Who is the senior executive on whose desk the buck finally stops? Should the CEO helm the process, or should the chief strategy officer? What about a business-line leader? Regardless of the choice, we suggest two things: the person should be experienced and seasoned in running a business, and the CEO's involvement should be hands-on.

- *Metrics and monitoring:* What does success look like? How do you make it "safe to fail" [23]? What are the milestones—public and private—you are shooting for? What is the time frame for those milestones? How will you monitor progress against those milestones? How will you ensure that the monitoring is not stifling?
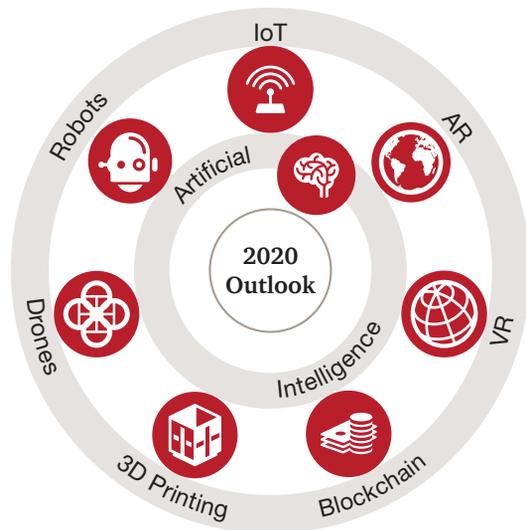
Our experience has shown that these answers have fundamental implications on both the capability systems and the culture of the company—so think hard, think well, and be bold but also pragmatic.

21 Paul Leinwand and Cesare Mainardi, *Strategy That Works: How Winning Companies Close the Strategy-to-Execution Gap*, January 2016

22 *Strategy&, Capabilities-Driven Strategy Toolkit*

23 *strategy+business*, "10 Principles of Strategic Leadership", May 18, 2016

Figure 6. The Essential Eight emerging technologies

2.

Have we quantified the impact of new technologies? If not, how can we do that—and how soon?

Championed by the CEO, the corporate strategy team should quantify the effect of these emerging technologies on all aspects of the company's business model. The team has to look both externally (in terms of new products and services, new competitors, and new substitutes made possible by the technologies) and internally (using the technologies to improve operational efficiencies and to accelerate time to market).

The overarching task is to identify the technologies that provide the greatest opportunities for growth, including expansion into adjacent markets and increasing efficiencies, with the proviso that there is a net increase in value for the enterprise. We acknowledge that this is a complex task. We have highlighted the Essential Eight emerging technologies (see Figure 6) that should definitely be on your radar, but there are hundreds more out there. The timeline and number of technologies to emphasize will vary depending on multiple factors, such as the company's size and its capabilities, its culture, its shareholders, and the industry it is part of. This is exactly the kind of problem our emerging-technologies methodology is designed to help enterprises with.

The lead technologists in the company (e.g., the CTO and the CIO) should be an integral part of this identification process from the get-go. Finally, keep in mind: it is critical, early in the technology identification process, to involve influential leaders from select lines of business because they are often closer to customers than the top team is. One thing to watch out for, though: inclusiveness must not overshadow agility.

Once the technologies with highest impact have been shortlisted (as admitted, not an overnight exercise and one deserving sustained C-suite focus), it's time to involve the relevant line(s)-of-business executives who can help prototype them. This has to be an iterative process, changing as fresh opportunities come along. Prototypes that show promise should be expanded; those that don't work, halted. All along, CEOs should keep their hands on the steering wheel, so the effort doesn't turn into a functional crusade instead of a strategic endeavor.

3.

Do we have an emerging-technologies road map?
If so, are we keeping it up to date?

With confidence about the company's strategic vision, a sustainable innovation process in place, and a clear view of the technologies that will matter most to the company over the next half-dozen years, it's time to draw up the road maps that will guide the application and implementation of those technologies across the enterprise and the customer base. The company's product and technology organizations should collaborate on creating these product and service road maps. The process of creating the maps should led by the business side of the house in order to create alignment to the enterprise goals and to cement broad buy-in across the organization.

The emerging-technology road maps cannot, of course, stand on their own; they've got to be aligned to your innovation strategy and integrated into your overall product and services portfolio. A road map that is not appropriately funded struggles to be much more than a great thought experiment. We are not saying that the road map execution necessarily needs to go through your regular development process, but we do contend that the cost and time allocation must be deliberate, clearly thought through, and continuously monitored (this is where broad business buy-in is very helpful).

A defining characteristics of the digital age is the rapid pace of change and disruption. The upshot? No technology plan is "one and done"; it must be continuously revisited, refreshed, and reworked. As pointed out, successful companies do not chase change. However, the days of static five-year road maps are over. You need a robust review mechanism of your product and services road maps and innovation strategy across your portfolio. It demands pragmatism in pruning parts of the product and services portfolio that are not delivering (and reallocating their funding)—and doubling down on the ones that show the most promise (with an eventual plan for mainstreaming should they demonstrate success). It means keeping the lines of business involved and the cross-organization lines of communication open.

This is a delicate balancing act; there's a real risk of creating more churn and uncertainty than the organization can handle. This is why choosing the right executive leader and the hands-on involvement of the CEO are critical.

No argument: it is not easy to stay ahead of emerging technologies

No argument: it is not easy to stay ahead of emerging technologies. But you really don't have a choice; your organization must adapt. By winnowing down the welter of possible technologies to a starting list of the Essential Eight, we hope we have helped provide some focus and clarity. More than that, we hope that we can begin to re-energize the C-suite's discussion of how best to leverage the right technologies in the right ways at the right time—for the right business reasons.

So, develop an innovation strategy and start making the exploration and quantification of emerging technologies (and planning for them) a core part of your corporate strategy. But before you do that, familiarize (or reacquaint) yourself with these technologies and what they can do: visit our Tech Breakthroughs Megatrend website to benefit from our experience, www.pwc.com/techmegatrend.

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