2019 TECH TRENDS REPORT

12th Annual Edition

Emerging science and technology trends that will influence business, government, education, media and society in the coming year.

Future Today Institute

Using and Sharing The Material In This Report

The Year Ahead

It's time to get comfortable with deep uncertainty. As I'm writing this annual letter to you from my office, we still do not know whether the UK will Brexit, if the special council investigation will incriminate President Trump or whether the 30th anniversary of the Tiananmen Square massacre will incite protest or apathy in China.

Soon, the first commercial spacecraft will take humans into space for fun rather than research, opening a massive business opportunity for insurers, space companies and the hundreds of providers within the space ecosystem that make all the needed peripherals and components. We'll also see the launch of of galactic ride sharing companies, which will transport a variety of payload into orbit: tiny satellites, art installations and even cremated remains. What we don't yet know: how investors will react once the first accidents occur involving all that precious cargo.

It is plausible that edited humans will be born this year, and as new genetic engineering trials on sperm and on human embryos get underway, we don't yet have global norms and ethics standards on the clinical use of germline editing. This opens up the field to regulation on a country-by-country basis, which will give some companies and researchers a strategic advantage over others.

These and other questions loom on the horizon for 2019, and not all organizations will address them methodically. Leaders often make common errors as they make strategic decisions about the future: they either under-predict or over-predict change. The reason? Most of us find uncertainty uncomfortable, so we are reluctant to confront it.

While you cannot solve for future uncertainty, you can prepare your teams to think strategically using data-driven signals, trends and outcomes. Focus on connections, not predictions. Doing so will help your organization get ahead of disruption in order to build your preferred futures.

Now more than ever, every organization should examine the potential impact of tech trends—and leaders must be willing to address deep uncertainties by taking incremental actions. Whether you work within a Fortune 500 company, a government agency, a start-up, a university, a foundation or a small business, you must factor the trends in this report into your strategic thinking for the coming year, and adjust your planning, operations and business models accordingly. Failing to track trends in a meaningful way—especially with the broader context of adjacent areas—will put your competitive advantage, growth and survivability at risk.

We cannot know exactly what the future holds – which is an excellent reason to track signals and decisions not just at the start of a new year, but all year long. Don't wait for your next big quarterly meeting to make decisions. Think exponentially, look for intersecting vectors of change and figure out ways to make incremental decisions as often as possible. Always remember that the future isn't yet written. You and your team have the power to build your preferred futures, today.

Sincerely,

Amy Webb

Founder, The Future Today Institute

Writing from my New York office on January 15, 2019

This report is intentionally broad and robust. We have included a list of adjacent uncertainties, a detailed analysis of 315 tech trends, a collection of weak signals for 2020, and more than four dozen scenarios describing plausible near futures. Do not try to read it in one sitting. Begin with the Executive Summary and Keywords, then review the top tech trends listed for your industry. We hope that in the coming months, you and your team will spend time with all of the trends in our 2019 report. Your goal is to make connections between these trends, your organization and your industry as you think exponentially and find ways to act incrementally.

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Executive Summary

The Future Today Institute's 2019 Tech Trends Report is in its 12th year of publication and has received more than 7.5 million cumulative views.

By The Numbers: 2019 FTI Tech Trend Report

315 Tech and Science Trends

This is our biggest report tech trends report ever—a 30% increase over last year, when we identified 225 trends and 10 weak signals. This sharp increase has to do with the advancement of many different technologies, which is causing acceleration across many different fields.

5 Weak Signals for 2020

Including materials and biological science as well as quantum computing.

48 Scenarios

17 are optimistic, 20 are pragmatic, and 11 are catastrophic.

9 Toolkits and Frameworks

We are including practical foresight tools and frameworks that can be implemented by your organization to advance your strategic thinking on these trends.

5 Primers

They are intended for executive leadership and management and cover Artificial Reality, Autonomous Transportation, Mixed Reality, Genetic Editing and Blockchain.

3 Glossaries

We've identified and defined key terms to help teams get up to speed quickly. They include blockchain, cybersecurity and mixed reality.

50 Cities

For the second year, we are including a list of the world's smartest cities. We've ranked them using a new methodology we developed in the past year. Nordic cities dominate the top ten and make up early a quarter of the entire list. Europe (including the UK) had 13 cities, Asia 9, North America 8, Middle East 4, and South America, Australia and India each had one. No African cities made the list for 2019.

Key Takeaways

→ Privacy is dead.

One persistent theme in this year's report is surveillance. Whether it's how hard we press on our mobile phone screens, our faces as we cross an intersection, our genetic matches with distant relatives, our conversations in the kitchen or even the associations we keep, we are now being continually monitored. Just by virtue of being alive in 2019, you are generating data—both intentionally and unwittingly—that is mined, refined, productized and monetized. We no longer have an expectation of total privacy. At least not like we've known it before. Companies that rely on our data have new challenges ahead: how to store the vast quantities of data we're generating, how to safeguard it, how to ensure new datasets aren't encoded with bias and best practices for anonymizing it before sharing with third parties

→ VSO is the new SEO.

About half of the interactions you have with computers will be using your voice by the end of 2020. Whether you're talking to a smart speaker, or your car's dashboard, or your mobile digital assistant, you'll soon talk more often than you type. As content creators venture into spoken interfaces, publishers and other companies will soon be focused more on voice search optimization (VSO). The emergence of VSO affects scores of industries: advertising, hospitality and tourism, finance and banking, retail, news and entertainment, education and more. This means opportunity: there's an entire VSO ecosystem waiting to be born, and first movers are likely to reap huge windfalls. But it also signals disruption to those working on the business side of search.

→ The Big Nine.

There are nine big tech companies—six American, and three Chinese—that are overwhelmingly responsible for the future of artificial intelligence. They are the G-MAFIA in the US: Google, Amazon, Microsoft, Apple, IBM and Facebook. In China it's the BAT: Baidu, Alibaba and Tencent. Just nine companies are primarily responsible for the overwhelming majority of research, funding, government involvement and consumer-grade applications. University researchers and labs rely on these companies for data, tools and funding. The Big Nine are also responsible for mergers and acquisitions, funding AI startups, and supporting the next generation of developers. Businesses in the West will soon have to choose AI frameworks and cloud providers—likely Google, Amazon or Microsoft—a decision that will be extremely difficult to reverse in the future.

→ Personal data records are coming.

We will start to see the emergence of "Personal Data Records," or PDRs. This is a single unifying ledger that includes all of the data we create as a result of our digital usage (think internet and mobile phones), but it will also include other sources of information: our school and work histories (diplomas, previous and current employers); our legal records (marriages, divorces, arrests); our financial records (home mortgages, credit scores, loans, taxes); travel (countries visited, visas); dating history (online apps); health (electronic health records, genetic screening results, exercise habits); and shopping history (online retailers, in-store coupon use). AIs, created by the Big Nine, will both learn from your personal data record and use it to automatically make decisions and provide you with a host of services. Your PDR will be heritable—a comprehensive record passed down to and used by your children. Ideally, you will be the owner of your PDR, it will be fully interoperable between systems, and the Big Nine would simply act as custodians. We are at the beginning of our transition from email and social media logins and passwords to PDRs.

→ China continues to ascend, and not just in artificial intelligence.

China is pushing ahead in many different fields. It has launched a space race with ambitions not just to return humans to the moon, but to build indoor farms and livable spaces on the lunar surface. It is making bold advancements in genomic editing, in humans as well as in livestock and produce. Through its various state initiatives, China is building infrastructure and next-generation internet networks across Southeast Asia and Latin America. It is setting the global pace for air quality, carbon emissions and waste reduction. China's electric vehicle market dwarfs every other country in the world. All of that in addition to China's significant investments and advancements in artificial intelligence. Don't be tempted to monitor each of these trend areas alone—you'll miss the connections that signal something much bigger is afoot. No other country's government is racing towards the future with as much force and velocity as China. This means big shifts in the balance of geopolitical power in the years ahead.

→ Lawmakers around the world are not prepared to deal with new challenges that arise from emerging science and technology.

In 2019, we are sure to see proposals for new regulatory frameworks. However these new rules, regulations and policies won't be modeled to understand their broader, next-order implications. Or whether they can be enforced, as technology and science continue to evolve.

→ Consolidation continues as a key theme for 2019.

We have been monitoring consolidation across the big tech giants, news and entertainment media, robotics, home automation and biotech for the past few years, and we anticipate more of the same for the near future. Consolidation tends to mean a concentration of resources, which often acts as a driver of acceleration. This will help those working in some areas of tech and science—and it's good for business. But consolidation tends to draw the attention of regulators, especially in the US and EU.

2019 Keywords

In our research and modeling for this year's report, a handful of words appeared with significant frequency.

Data

Maps Regulation

Biotech

China Monitoring

Listening

Automation

Permissions

Competition Speaking

Infrastructure Collaboration

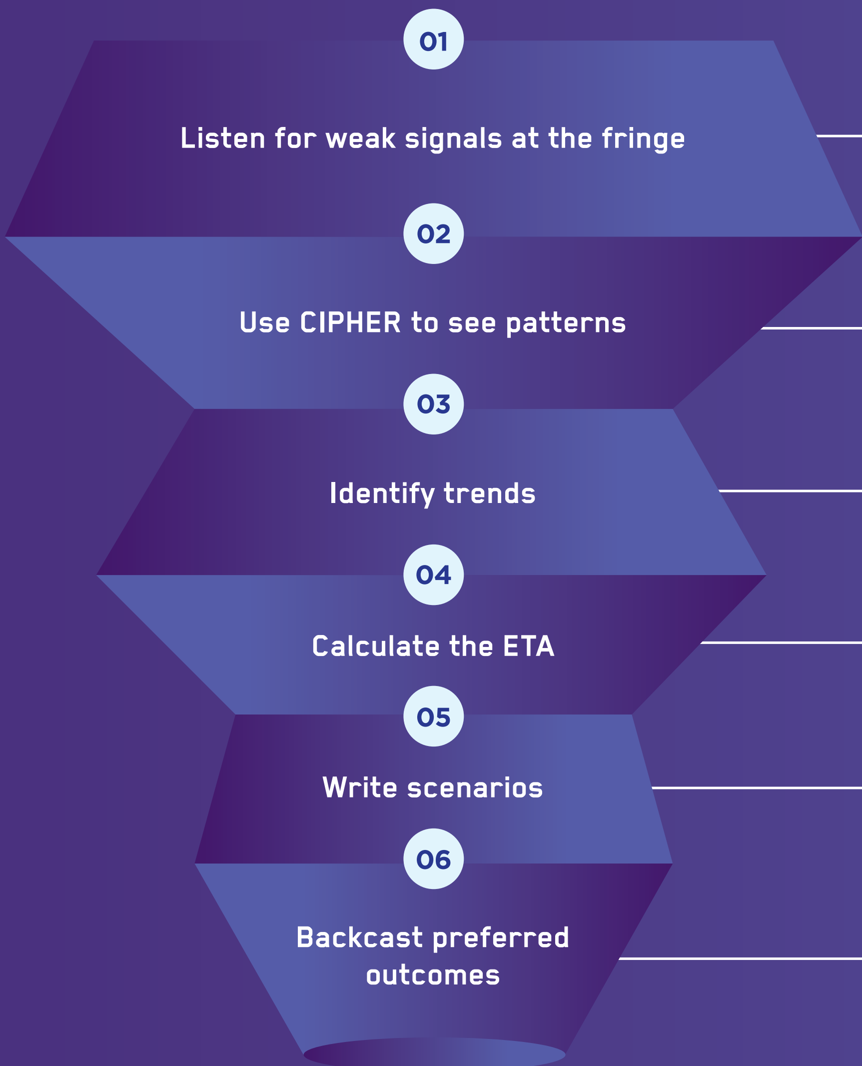
Autonomous Persistent

Recognition

Methodology

The Future Today Institute Forecasting Methodology’s Six-Step Funnel

The Future Today Institute’s forecasting model uses quantitative and qualitative data to identify weak signals and map their trajectories into tech trends. Our six steps alternate between broad and narrow scopes, which include: identifying weak signals at the fringe, spotting patterns, developing trend candidates, calculating a trend’s velocity, creating scenarios and finally backcasting preferred outcomes.



Make observations and harness information from the fringes of society or a particular research area.

Uncover hidden patterns by categorizing information from the fringe: contradictions, infections, practices, hacks, extremes, rarities.

Ask the right questions to determine whether a pattern is really a trend.

Ensure that the timing is right for the trend and for your organization.

Scenarios inform the strategy you will create to take the necessary action on a trend.

Mitigate deep uncertainty and future risk by reverse-engineering your organization’s desired outcomes.

Signal Tracking For 2019

YOUR GUIDE TO THE EVENTS THAT WILL SHAPE THE YEAR AHEAD

→→→ March

It is the 30th anniversary of Tim Berners-Lee's original proposal for a World Wide Web, which his supervisor called "vague, but exciting."

More than 100,000 techies, filmmakers, journalists, game designers and musicians flock to Austin, Texas for the annual South By Southwest festival. Meanwhile, Amazon's MARS Conference brings together world leaders in home automation, robotics, space exploration and AI.

March 29th is Brexit Day, when the United Kingdom's withdrawal from the European Union was originally scheduled to take effect.

The Carnegie International Nuclear Policy Conference meets in Washington to discuss limiting global nuclear risks.

The UN's 4th Environment Assembly takes place in Nairobi–international leaders and climate scientists will discuss how to take radical action on climate change.

→→→ April

Japan's Chrysanthemum Throne begins a new era when Emperor Akihito abdicates and his son Naruhito takes over.

SpaceX sends its first human payload to space: two NASA astronauts fly aboard the first crewed spacecraft launched by a commercial space company.

The North Atlantic Treaty Organization turns 70.

Government leaders, business tycoons, philanthropists and sovereign wealth fund managers head to Los Angeles for the Milken Institute's Global Conference.

Facebook returns to San Jose for its annual F8 developer conference.

→→→ May

China celebrates the 100th anniversary of the May 4th movement, which arose from riots among university students over what was seen as poor terms that had been imposed on China by the Treaty of Versailles. It was a populist uprising that became a turning point in China's post-imperial transformation.

The European Parliament holds elections. India meets a deadline to hold its general election.

May is an important month for big tech announcements. Computex, the world's largest PC and hardware manufacturing show, is held in Taipei. Google's annual I/O conference is held–new Android releases, updates to various consumer products and services, and prototypes are shown. Microsoft's annual Build conference highlights all of the company's upcoming devices, gaming updates and OS releases for developers. Autonomous vehicle researchers from around the world gather in Stuttgart, Germany to present their findings on the automation, AI and software platforms for self-driving vehicles.

→→→ June

Leaders from the world's 20 largest economies gather in Osaka for the G20 summit to discuss trade and technology. Meanwhile in Long Beach, leaders in AI present their latest research at the annual IEEE conference on Computer Vision and Pattern Recognition.

Apple's annual WWDC is held, where company leaders take the stage to showcase new OS versions and Apple products.

June is a month of monumental anniversaries: this is the 75th anniversary of D-Day, when the Allied forces launched the largest seaborne invasion in human history. It is also the centenary of the Treaty of Versailles, which officially ended World War I. It is the 50th anniversary of the Stonewall Riots, which launched the gay rights movement. And it is the 30th anniversary of the Tiananmen Square massacre, when several hundred Chinese civilians were killed during a military crackdown during what had been peaceful democratic protests.

→→→ July

It's the 50th anniversary of Neil Armstrong's historic walk on the Moon.

The United Nations World Population Day asks us to consider global population issues.

Tech, media and business moguls trek to Sun Valley, Idaho for Allen & Co's annual confab.

→→→ August

The first regularly scheduled international flight on Aircraft Transport and Travel (which became British Airways) took off 100 years ago from London to Paris.

It's the 50th anniversary of Woodstock, the three day peace and music festival that took place in Bethel, New York.

→→→ September

The UN General Assembly's 74th annual meeting in New York. This year, it also hosts a climate summit to discuss whether nations are meeting their carbon and greenhouse gas reduction pledges.

The United States likely ends its fiscal year with a budget deficit near $1 trillion.

The IFA—Europe's largest consumer electronics trade show—is held in Berlin.

It is the 80th anniversary of the outbreak of WWII.

→→→ October

The 70th anniversary of the founding of the People's Republic of China, a major milestone for the ruling Communist Party of China.

Japan raises its consumption tax to 10% from 8% in order to combat government debt.

The 150th birthday of Mahatma Gandhi.

Canada, Argentina and Ukraine hold parliamentary elections.

→→→ November

November 11 is Singles Day in China—the annual shopping event that dwarfs both Black Friday and Prime Day in the US.

Leaders from 21 Asia-Pacific countries gather for the annual APEC Summit in Santiago.

A new president of the European Central Bank begins their five-year term.

Dreamforce, the annual mega-conference produced by Salesforce, brings more than 170,000 people to San Francisco.

Mercury crosses the sun in a rare 5 hour, 29 minute traverse and is visible throughout North and South America, Africa, the Middle East and Europe.

→→→ December

Russia begins supplying gas to China through a brand-new Power of Siberia pipeline.

AI luminaries gather at the annual Neural Information Processing Systems conference in Montréal to talk about the future of artificial intelligence.

Qualcomm hosts its annual Snapdragon Tech Summit.

→→→ January 2020

The World Economic Forum Annual Meeting is held in Davos-Klosters, Switzerland, bringing together 3,000 of the world's most powerful government, business and academic leaders.

The Consumers Electronics Show, the world's largest convention for electronics and digital media, is held in Las Vegas, Nevada. Expect countless roundups and think pieces about the future of consumer media.

→→→ February 2020

The Mobile World Congress is held in Europe, where new phones and peripherals debut and where big 5G announcements are made.

How To Use The 2019 Tech Trends Report In Your Organization

Every organization should continuously monitor adjacent uncertainties and weak signals, track emerging trends and backcast plausible outcomes for the future. However there are different approaches to that work, depending on the answers or strategic planning your organization is seeking.

Start by asking two important questions:

1. Does your organization need specific, tactical answers to a question with clear parameters—or are you developing strategic insights?

   Tactical
   What could transportation-as-a-service models look like in the near-future?

   Strategic
   How would transportation-as-a-service models disrupt our business?

2. Have you already defined general themes and a list of specific topics for your research?

Do you need specific, tactical answers to a question with clear parameters—or are you developing strategic insights?

Have you already defined general themes/ topics for your research?	Need Tactical Answers	Developing Strategic Insights
YES	**Foresight Mode** Writing my strategic plan/ developing specific actions	**Education Mode** Staying on top of specific trends within my industry and adjacent to my industry
NO	**Discovery Mode** Pure research – looking for ideas, opportunities, possible disruption	**Speculation Mode** Getting inspiration, learning from other fields, thinking about the farther-future

Each research mode requires a different approach:

Foresight Mode

Formulate a specific question. Map your immediate, adjacent and theoretical stakeholders. Develop a weak signals map using the 10 Drivers of Modern Change along with the list of themes and ideas you've already made. Begin to look for trends.

Discovery Mode

Formulate a specific question. Develop an initial, general list of topics using the 10 Drivers of Modern Change. Create a list of secondary drivers specific to your question and industry. Determine a broad list of key stakeholders. Ask the Leading Questions (see next column). Create a weak signals map as you go.

Education Mode

Using the 10 Drivers of Modern Change along with the list of themes and ideas you've already made, focus your attention on the adjacent and theoretical stakeholders as well as adjacent industries and fields. Use the Leading Questions to guide your research.

Speculation Mode

Engage in speculative research across many different topics. Find sources of information that are far afield of your usual work. Practice active researching, taking notes and sketching connections.

The Leading Questions

When you know the topics you want to research to surface new signals, but you don't necessarily need to answer a specific question, ask and answer the following questions.

1. Who's working directly in this [node] space? Include those who are already familiar to our organization, those who are adjacently related, and those who are theoretical (think very broadly to include all kinds of different operators).

2. Who's been funding/ encouraging experimentation?

3. Which populations will be directly affected by advancements in 5/10/15 years?

4. What are our addressable markets in 5/10/15 years?

5. Who would be incentivized to work against advancement in general?

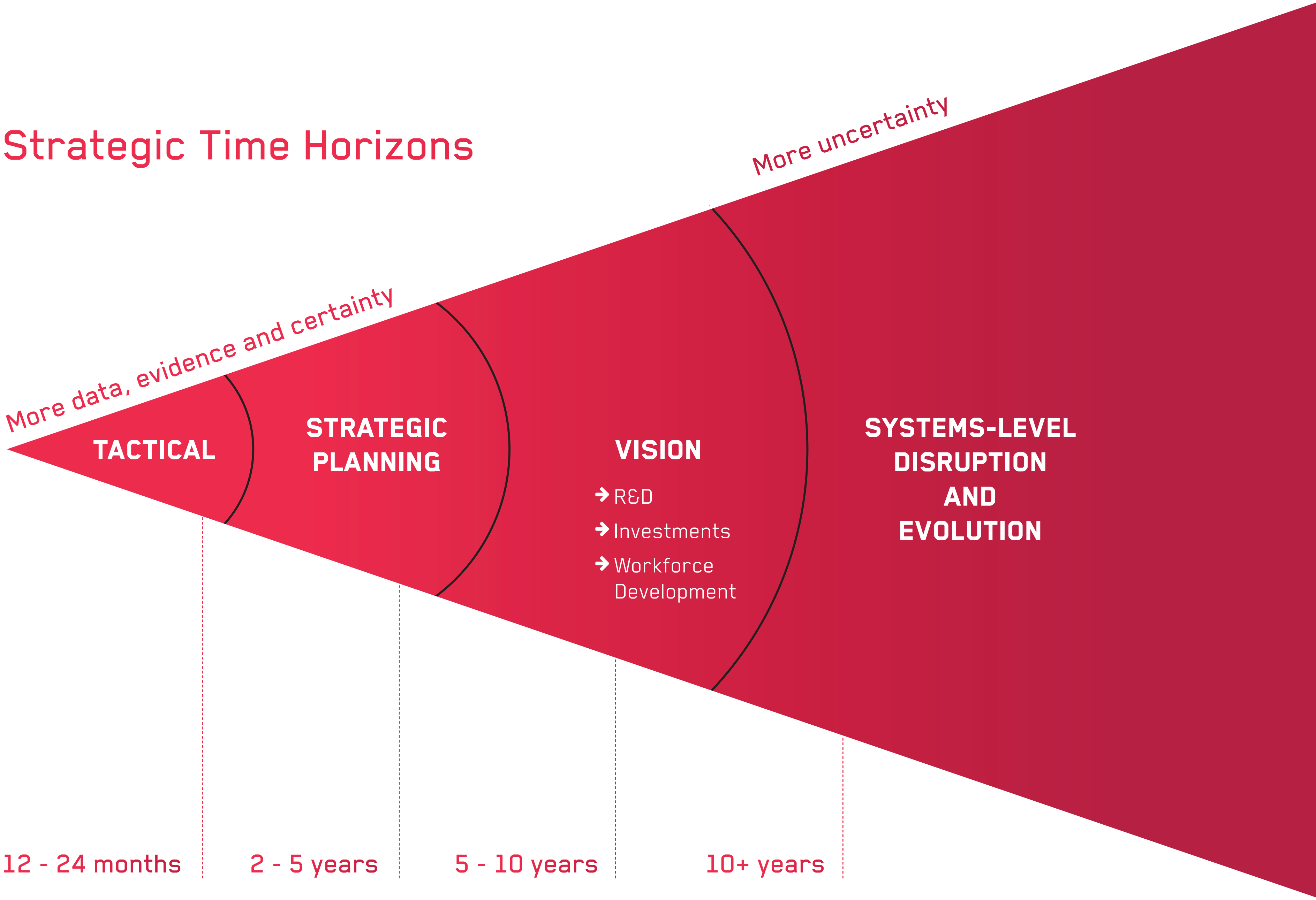
How To Think About Time

The organizations the Future Today Institute advises are always thinking about the future. But most often, their planning timeframes miss the mark. We observe teams stuck in a rut of three or five-year planning cycles. Many are reluctant to do any serious planning beyond five years. They argue it's pointless, given all the technological disruption.

To effectively plan for the future, organizations need to learn how think about time differently. For any given uncertainty about the future—whether that's risk, opportunity or growth—leaders must think strategically about tactics, strategy, vision and systems-level change.

Start retraining yourself to think about change and disruption to your organization and industry across different timeframes and build actions for each. The next 12-36 months - tactical actions. 3-5 years - strategic action. 5-10 years - vision and R&D initiatives. 10+ years - how you and your organization can create systems-level change so that you catalyze that change for your benefit.

Strategic Time Horizons



When To Take Action On Tech Trends

We encourage you to use our annual Future Today Institute Tech Trends Report as the basis for strategic planning—as long as you commit to taking incremental action right away. Many organizations prefer to take a "wait and see" approach after seeing new research, and that's a mistake. We recognize how difficult it is to take risks during a time of political, technological and economic uncertainty. Your team must take some action, even if it's small, to build momentum so that you may confront the future on your own terms.

For that reason, the Future Today Institute created a simple framework for our clients to help them continually monitor science and technology developments as they move from the fringe to the mainstream. Focus on taking incremental action often as you think more exponentially. Incremental actions will position your organization to make smarter strategic decisions in advance rather than trying to manage crises under duress.

This is our framework, and we encourage your organization to use it as you read through our report.

High

Learning Stage

As we research and test this new technology, what can we learn and apply to our organization? What must we do now to keep ahead of the trend?

→ **Sample Action**

Devote an all-hands day to investigating this trend. Invite people from all departments within your organization to participate. Bring in outsiders for added expertise.

Listening For Signals At The Horizon

Emerging but bona-fide technology and trends; uncertain trajectory and timeline; ecosystem forming; market forming.

→ **Sample Action**

Assign one member of your team to be the resident expert on the tech trend. Have them send notes to the rest of the team on a regular basis.

"Can we do it" → **UNCERTAINTY ABOUT TECHNOLOGY**

Capabilities Building Stage

How can we work to better understand the emerging tech and develop the expertise to act? How do our key stakeholders and constituents see this trend, and what are their expectations of us?

→ **Sample Action**

Develop and ship a survey to assess how well positioned your current team is to address this trend. Determine whether training is necessary.

Developing Ideas Stage

How can we develop a new product or service that leverages the technology, even as the market is still evolving? How can we assess possible risk and implications in a meaningful way?

→ **Sample Action**

Facilitate a scenarios workshop, with a goal of identifying probable and plausible outcomes.

Low

Low **UNCERTAINTY ABOUT A TREND IN THE MARKET** High

↑

"Does the market want it"

How Your Organization Can Take Action On Emerging Trends

Our 2019 Tech Trend Report reveals the strategic opportunities and risks confronting your organization in the near future.

This report can help prepare your organization for the years ahead and better position you to see disruption before it fully erupts. We encourage you to use our report as a tool to identify change, to learn how new technologies might impact your organization in the near future, and as a jumping off point for meaningful strategic planning.

Relating these trends back to your organization.

Of the organizations we advise, we've seen the most success from those who form a cross-functional team to study our annual Tech Trend Report. It is a practical resource for your organization and should influence your strategic thinking throughout the year.

Recommended strategy

The best way to make practical use of this year's report is to ask and answer some fundamental questions about what these trends mean to your organization in the near future. Don't discount a trend simply because at first glance it doesn't seem to connect directly to you or your field. As you'll see in the scenarios that follow, often it's those technologies in completely unrelated fields that cause the most disruption.

As you review the analysis in this report with your cross-functional team, ask and answer the following questions:

01 What connections can we draw between this research and our strategic planning?

02 What are the consequences if our organization fails to take action on this trend?

03 How does this trend impact our industry and all of its parts?

04 How might global events—politics, climate change, economic shifts—impact this trend, and as a result, our organization?

05 What uncertainties does this trend reveal about our industry/ company/ division?

06 What new uncertainties—about our industry, organization, customers, partners—can we now address after reading this report?

07 What next-order outcomes can we envision as this trend evolves over time, both in our organization and our industry?

08 Does this trend signal emerging disruption to our traditional business practices and cherished beliefs?

09 Does this trend indicate a future disruption to the established roles and responsibilities within our organization? If so, how do we backcast that disruption and deal with it in the present day?

10 How are the organizations in adjacent spaces addressing this trend? What can we learn from their failures and best practices?

11 How will the wants, needs and expectations of our consumers/ constituents change as a result of this trend?

12 Where does this trend create potential new partners or collaborators for us?

13 How does this trend inspire us to think about the future of our organization?

14 How do we leverage this trend in a positive way for both our organizations and the greater good?

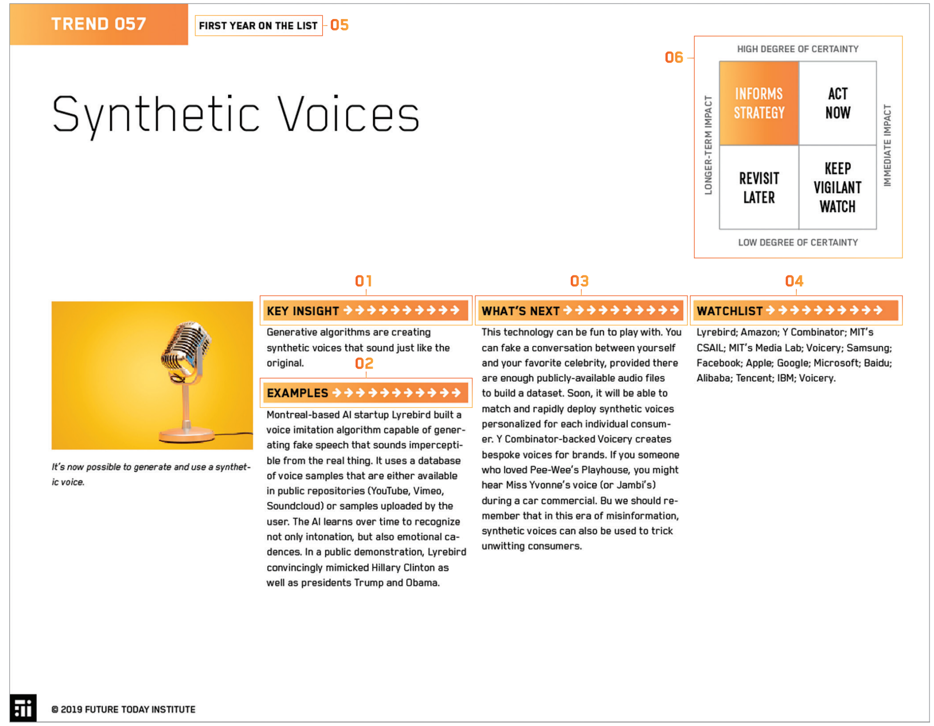
15 How does this trend help me/ my team/ my organization think about innovation?

How To Use Our Report

Each trend offers six important data points for your organization.

The Future Today Institute's 12th annual Tech Trends Report prepares organizations for the year ahead so that strategists, managers and leaders are better positioned to see technological disruption before it fully erupts. We encourage you to use our report as a tool to identify change and to learn how new technologies might impact your organization in the near future. The FTI Report is also a good source of potential new collaborators and partners. Most importantly, use our report as a jumping off point for deeper strategic planning.

We recommend using our 2019 Tech Trends Report as part of a formal strategic foresight process to evaluate disruptive technologies throughout the year.


TREND 057

FIRST YEAR ON THE LIST 05

Synthetic Voices

06

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT

INFORMS STRATEGY | ACT NOW

REVISIT LATER | KEEP VIGILANT WATCH

IMMEDIATE IMPACT

LOW DEGREE OF CERTAINTY

It's now possible to generate and use a synthetic voice.

01

KEY INSIGHT

Generative algorithms are creating synthetic voices that sound just like the original.

02

EXAMPLES

Montreal-based AI startup Lyrebird built a voice imitation algorithm capable of generating fake speech that sounds imperceptible from the real thing. It uses a database of voice samples that are either available in public repositories (YouTube, Vimeo, Soundcloud) or samples uploaded by the user. The AI learns over time to recognize not only intonation, but also emotional cadences. In a public demonstration, Lyrebird convincingly mimicked Hillary Clinton as well as presidents Trump and Obama.

03

WHAT'S NEXT

This technology can be fun to play with. You can fake a conversation between yourself and your favorite celebrity, provided there are enough publicly-available audio files to build a dataset. Soon, it will be able to match and rapidly deploy synthetic voices personalized for each individual consumer. Y Combinator-backed Voicery creates bespoke voices for brands. If you someone who loved Pee-Wee's Playhouse, you might hear Miss Yvonne's voice (or Jambi's) during a car commercial. Bu we should remember that in this era of misinformation, synthetic voices can also be used to trick unwitting consumers.

04

WATCHLIST

Lyrebird; Amazon; Y Combinator; MIT's CSAIL; MIT's Media Lab; Voicery; Samsung; Facebook; Apple; Google; Microsoft; Baidu; Alibaba; Tencent; IBM; Voicery.

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01 Key Insight

Short, easy explanation of this trend so that you can internalize it and discuss with your colleagues.

02 Examples

Real-world use cases, some of which will sound familiar.

03 What's Next

What this trend means for you and your organization in the coming year.

04 Watchlist

These are the organizations and stakeholders most deeply involved in this trend.

05 Years On The List

We've noted how many years we've been tracking the trend in our annual Tech Trends Report, which began publication 12 years ago. This measurement is an indication of how the trend is progressing.

06 Action Meter

An easy-to-read graphic indicating where the trend is along its trajectory. It tells you whether the trend needs monitoring, should inform your strategy, or requires action.

Why We Include Scenarios With Trends

Narratives help illuminate our possible futures.

In this report, you will find a variety of scenarios that fit three different emotive framings: optimistic, pragmatic and catastrophic. Some are set in the very near future, while others imagine the world after 2029.

Scenario planning originated at the start of the Cold War, in the 1950s. Herman Kahn, a futurist at the RAND Corporation, was given the job of researching nuclear warfare, and he knew that raw data alone wouldn't provide enough context for military leaders. So instead, he created something new, which he called "scenarios." They would fill in the descriptive detail and narration needed to help those in charge with creating military strategy understand the plausible outcomes—what could happen, if a certain set of actions were taken. Simultaneously in France, the futurists Bertrand de Jouvenel and Gaston Berger developed and used scenarios to describe preferred outcomes—what should happen, given the current circumstances. Their work forced the military and our elected leaders into, as Kahn put it, "thinking about the unthinkable" and the aftermath of nuclear war. It was such a successful exercise that their approaches were adopted by other governments and companies around the world. The Royal Dutch Shell company popularized scenario planning, when it revealed that scenarios had led managers to anticipate the global energy crisis (1973 and 1979) and the collapse of the market in 1986 and to mitigate risk in advance of their competition.[1] Scenarios are such a powerful tool that Shell still, 45 years later, employs a large, dedicated team researching and writing them.

Risk and Opportunity Planning at The Future Today Institute.

The Future Today Institute's methodology for modeling potential business, policy and societal impacts of technology and science involves surfacing emerging trends, identifying commonalities and connections between them, mapping their trajectories over time, describing plausible outcomes, and ultimately building strategy to achieve desired outcomes. The first half of our FTI methodology explains the "what," while the second half describes the "what if." That second half, more formally, is called "scenario planning" and develops scenarios that address deep uncertainties about the future. We use a wide variety of data across numerous sources to create our scenarios: statistics, patent filings, academic and archival research, policy briefings, conference papers, structured interviews with lots of people, and even critical design and speculative fiction.

Developing your own scenarios using FTI's Axes of Uncertainty.

Leaders often make common errors as they make strategic decisions about the future: they under-predict or over-predict change. The reason? Most of us find uncertainty uncomfortable, so we are reluctant to confront it. We can't solve for future uncertainty, but we can prepare ourselves to think critically about signals and decisions – to understand all the dependencies we should consider that might impact the future.

1. https://www.strategy-business.com/article/8220?gko=0d07f

One way to develop scenarios is to create an axis of uncertainty using the possible outcome of tech trends paired with issues within your organization or other external unknowns. Write two possible, opposite outcomes like this:

US trade war with China ends ⟷ US trade war with China escalates

Google, Amazon, Facebook and Apple have unlimited power ⟷ Google, Amazon, Facebook and Apple are regulated

Then, create an axis of uncertainty, like this:

US trade war with China ends

Google, Amazon, Facebook and Apple have unlimited power

Google, Amazon, Facebook and Apple are regulated

US trade war with China escalates

As you read through the research in our 2019 Tech Trend Report, tailor lots of axes to your organization specifically by adding your own uncertainties. You can use these as the basis for developing your own optimistic, pragmatic and catastrophic scenarios. What would the outcomes of each quadrant look like for your organization? Your industry? Your community?

Departments and offices that use the Future Today Institute's Trend Report

Our annual tech trend reports have garnered more than 7.5 million cumulative views. It is used as a core resource within a variety of organizations worldwide by teams within the following departments and offices:

→ **Executive Leadership**

Those developing the longer-term vision of a company and making high-level strategic decisions

→ **Strategic Planners**

Teams responsible for researching and creating strategy within an organization

→ **Investors**

Those working on mergers, acquisitions, new ventures and deals who must quantify the future

→ **R&D Teams and Labs**

Those focused on researching, prototyping and developing the near and mid-futures of their fields

→ **Risk Management**

Those responsible for identifying future risks and threats to an organization

→ **Product Design and Innovation Groups**

Teams charged with developing concepts and ideas for new products and services

→ **Boards of Directors**

Those who have a fiduciary and legal obligation to understand emerging trends

→ **Policymakers and Regulators**

People working within governments worldwide who must write rules, governing frameworks and regulations that intersect with technology

Trend vs Trendy

Before the description of each trend, you'll see how many years it has been on our list. The trends that futurists research are never shiny, flashes in the pan. As you'll see, the trends in our report are not trendy. (At least, not intentionally.) Instead, they emerge from weak signals at the fringe and reveal changes afoot. Real trends tend to take shape over many years. We use trends to help us see potential opportunities, challenges and plausible scenarios for next-order impacts.

Fundamentally, a meaningful trend leverages our basic human needs and desires in a meaningful way, and it aligns human nature with breakthroughs in science and technology.

The Four Laws of Tech Trends

All trends share a set of four conspicuous, universal features.

- Trends are the convergence of weak signals from the fringe.
- Trends are driven by basic human needs.
- Trends evolve as they emerge.
- Trends are timely, but they persist.

At any moment, there are thousands of small shifts in technology—developments on the fringes of science and society—that will impact our lives in the future.

The Four Laws of Technology Trends were first published in The Signals Are Talking: Why Today's Fringe Is Tomorrow's Mainstream, by Amy Webb.

The 10 Drivers of All Future Change

To understand the future of one thing, you must widen your aperture. Otherwise, you are looking at the whole world through a pinhole.

Historically, the sources of all future change tend to come from the 10 primary drivers you see below. When FTI researches tech trends, we do so using the these sources. Technology is not listed because it underpins every facet of our lives.

The Most Important Tech Trends For Your Industry And Organization

We've curated lists to help you quickly identify the most important tech trends that will matter to your team, organization and industry in 2019. For your convenience, industries are listed alphabetically along with their corresponding key themes and trends.

Advertising, Marketing and Public Relations

Ubiquitous Digital Assistants
Bigger Role For Ambient Interfaces
Deep Linking Everywhere
Proliferation of Franken-algorithms
Deployable AI Versions of You
Ongoing Bias In AI
AI Bias Leads To Societal Problems
Accountability and Trust
AI Cloud
New Kinds of Liability Insurance for AI
Real-Time Machine Learning
Natural Language Understanding
Machine Reading Comprehension
Natural Language Generation
Generative Algorithms For Voice, Sound and Video
Real-Time Context in Machine Learning
General Reinforcement Learning Algorithm
Machine Image Completion
Hybrid Human-Computer Vision Analysis
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Crowdlearning
The Case For Radical Transparency
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Optimizing For Voice Search
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Connected TVs
WebRTC
Streaming Social Video
eSports
Mixed Reality Arcades
MMOMRGs
VR For Marketing
Offline Connections
Retail APIs
Anthropocene
Extreme Weather Events
Human Migration Patterns Shift
Corporate Sustainability
Digital Addiction
Interactive Mirrors
Wearables
Home Automation
AI in Hiring
Productivity Bots
Web 3.0
Social Payments
Smart Cities
Splinternets
Space Tourism

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Agriculture and Farming

Consumer-Grade AI Applications
Proliferation of Franken-algorithms
Accountability and Trust
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Drone Lanes
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Drone-Enabled Infrastructure
Drone Swarms
Transportation as a Service Business Models
Collaborative Robotics
Cloud Robotics
Autonomous Robot Teams
Robotic Process Automation
Self-Assembling Robots
Robot Compilers
5G Networks and the Industrial Internet of Things (IIoT)
Smart Dust
3D Printing
Green Tech
Ultra-High-Voltage Direct Current and Macro Grids
Anthropocene
Trying to Predict Sea Level Rise
Extreme Weather Events
Human Migration Patterns Shift
Geoengineering
Corporate Sustainability
Indoor and Outdoor Plant Factories and Microfarms
Deep Learning For Farming and Food Recognition
Precision Agriculture
Smart Farms
Terraforming
Bug Protein
Cultivated Food and Beverage
Cannabis Technologies
Genome Editing
Microbiome Extinction
Searching The IoT and the IoPT (Internet of Physical Things)
Universal Basic Income (UBI)
Nanodegrees
Sharing Economy & Lendership
Blockchain Technologies
MicroSats and CubeSats

Architecture and Urban Planning

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Assisted Driving Before Full Automation

Adaptive Driving Systems

Electric Vehicles Boom, Especially in China

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Autonomous Vehicle Testing Gets Regulated

Analog Fallbacks

Autonomous Last Mile Logistics

Car Interfaces Drive the Voice Assistant Wars

China's Foreign Infrastructure Investment

Personal Robots and Butlers

5G Networks and the Industrial Internet of Things (IIoT)

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Digital Frailty

Green Tech

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Better Batteries

Wireless Charging Everywhere

Energy Trading Platforms for Blockchain

Zero Carbon Natural Gas

Floating Nuclear Energy Plants

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Geoengineering

Corporate Sustainability

Indoor and Outdoor Plant Factories and Microfarms

Terraforming

Home Automation

Universal Basic Income (UBI)

Sharing Economy & Lendership

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Adjacent Dependencies

Ideas, movements, and events that intersect with technology

Adjacent Dependencies In 2019

There are numerous events, developments and key stakeholders that sit adjacently to technology and science but aren't themselves tech trends. In some way, they will cause an acceleration, deceleration or even divergence to the trends listed in this report.

Often, teams mapping the future forget that the future of technology and science are still dependent on outside factors like politics, geoeconomics, and the general zeitgeist of society. For that reason, we've included a short list of adjacent dependencies that you should be tracking in 2019.

New Metric Units

For more than 100 years, the kilogram has been calibrated by a chunk of metal stored in a vault near Paris. It's called **Le Grand K**, and until December 2018 it had been the global standard. That's because in November, scientists at the **General Conference on Weights and Measures** (or CGPM for short) decided to redefine the kilogram, and replace the metal measurement with a constant of nature. That isn't all: representatives from 60 member nations also redefined the ampere, kelvin and mole.

Why this matters: the new units of measurement will allow researchers to create more flexible, precise and modulated techniques. When the GCPM redefined the meter in 1983, it was able to define the speed of light as exactly 299,792,458 meters per second, which made the meter itself a more measureable thing.

Millennials Outnumber Baby Boomers...

In the United States, this is the year that Millennials, born between 1981 and 1999, officially overtake the Baby Boomer generation, born between 1949 and 1964. It's also the year that the remaining youngest college-educated Millennials enter the workforce. Compared with their parents and Boomers, they are less likely to support a single political party, to attend religious services and to own homes and cars.

Why this matters: big box retailers, car manufacturers, media companies and advertisers have long targeted Baby Boomers for their predictability and disposable income. However in developed economies, Millennials are now more likely to move markets. For example, they're responsible for the growth of Silicon Valley's hottest startups. They've helped kickstart platforms (**Airbnb**, **Venmo**), distributed services (**Spotify**, **Dropbox**), transportation-as-a-service companies (**Lime**, **Uber**)—and they aren't necessarily brand loyal. A bigger, better idea could lure them, and their attention, away.

...And Now Comes Generation Z

Globally, Gen Z – people born after 2000 – will overtake Millennials in 2019. One third of the world's population will be 19 years old or younger. Gen Z have never known a world without **Google** or **Facebook**. They're more likely to watch **YouTube** videos algorithmically selected just for them on an iPad or phone rather than standard cable programming on a TV. They've lived through the war on terror. For this generation, extreme weather is the norm.

Why this matters: in some companies, there will be five generations working together on teams. While this isn't a historic first, what's notable is the radically different technology each of these generations were exposed to as children and working adults. The experiences and expectations of the Greatest Generation, who only began using desktop computers toward the ends of their careers, are legions different than Gen Zers who may have skipped traditional computers for smartphones.

Market Volatility Could Hamper IPOs

This could be a very big year for tech IPOs. Or maybe not. **Palantir**, **Slack**, **Airbnb**, **Uber**, **Lyft**, **Peloton**, **Casper** and **Beyond Meat** are all IPO candidates for 2019. Plenty of startups are ready to grow, but their founders don't necessarily value the benefits of going public, especially since **Twitter**, **Spotify** and **Snap** saw their stock prices plunge in the last year. Market volatility has some companies waiting to go public—or questioning whether to do so at all.

Why this matters: Rather than going IPO, tech companies could instead seek alternative forms of strategic investment. They might sell a large stake to bigger companies. For example, **Epic Games**, which created the wildly popular **Fortnite**, sold a 40% stake to **Chinese gaming behemoth Tencent**. Strategic investments tether startups to bigger, slower-moving companies—and sometimes, to foreign governments too.

The Economy Will Slow Down

A few economists are pointing at the Trump administration, arguing that the US economy is slowing down the rest of the world. Finger pointing aside, everyone seems to agree: the global economy is heading for a significant slowdown in 2019. The **Federal Reserve** raised interest rates, central banks around the world are tightening credit, trade is decelerating, stock prices have been flat, and overall growth is slowing.

Why this matters: A slower economy would mean that consumers may not have as much disposable income. A slowdown in **China** could have reverberating effects throughout the world, as investors and consumers spend less. A slower economy could cause a deceleration in the trajectories of certain technologies.

Additional adjacent dependencies to monitor

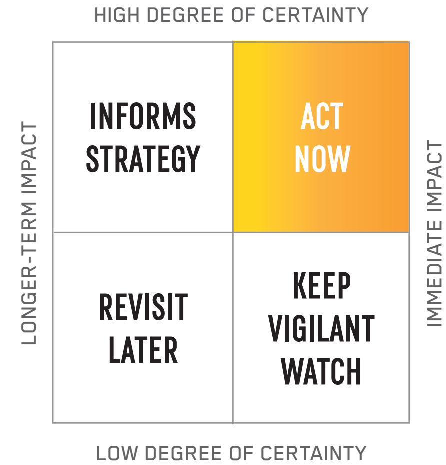
- *The momentum of #MeToo*
- *The outcome of Brexit*
- *The rise of nationalistic movements*
- *The outcome of the Special Council investigation of the Russian government's efforts to impact the 2016 presidential election*
- *Younger generations moving away from traditional religion and faith-based organizations*

2019 TECH TRENDS

ARTIFICIAL INTELLIGENCE

TENTH YEAR ON THE LIST

ARTIFICIAL INTELLIGENCE: THE THIRD ERA OF COMPUTING



In its most basic form, artificial intelligence is a system that makes autonomous decisions.

KEY INSIGHT

Artificial Intelligence isn't a trend itself. Artificial intelligence is the most important tech development in our lifetimes. It's not a tech trend; it's the third era of computing. It connects to everything else we do in business, governing and everyday life. We must stop talking about AI as if it will arrive someday in the future. Contrary to a lot of what you've heard, AI is already here. It just didn't show up the way we all expected.

Marvin Minsky, a pioneer in artificial intelligence, often described AI as a "suitcase term." It's a concept that appears simple enough but is actually endlessly complex and packed – like a suitcase – with lots of other ideas, concepts, processes and problems.

Many facets of artificial intelligence (AI) have made our list since we first started publishing this report 12 years ago. Because AI itself isn't the trend, we have identified different themes within AI that you should be following.

This moment in time is akin to the few decades when the steam engine gave rise to the Industrial Revolution, and Edison and Westinghouse brought electricity into our homes, offices, schools and factories. For us, AI is that new electricity, but it is our personal data that is generating the current.

The Big Nine

There are nine big tech companies—six American, and three Chinese—that are overwhelmingly responsible for the future of artificial intelligence. They are the **G-MAFIA** in the **US: Google, Amazon, Microsoft, Apple, IBM** and **Facebook**. In **China** it's the **BAT: Baidu, Alibaba** and **Tencent**. Just nine companies are primarily responsible for the overwhelming majority of research, funding, government involvement and consumer-grade applications. University researchers and labs rely on these companies for data, tools and funding. The Big Nine are also responsible for mergers and acquisitions, funding AI startups, and supporting the next generation of developers.

The US government has no grand strategy for AI nor for our longer-term futures. So in place of coordinated national strategies to build organizational capacity inside the government, to build and strengthen our international alliances, and to prepare our military for the future of warfare, the United States has subjugated AI to the revolving door of politics. Instead of funding basic research into AI, the federal government has effectively outsourced R&D to the commercial sector and the whims of Wall Street. Meanwhile, in China, AI's developmental track is tethered to the grand ambitions of government. Baidu, Tencent, and Alibaba may be publicly traded giants, but typical of all large Chinese companies, they must bend to the will of Beijing. China is quickly laying the groundwork to become the world's unchallenged AI hegemon.

Overcoming Our Misplaced Optimism and Fears

When it comes to AI, many organizations and their leaders have developed a misplaced sense of optimism or fear. (And sometimes a combination of both.)

It seems like not a day goes by without a new headline promising that AI will cure all that ails us, or that it will take our jobs, or that it just might kill us all. We've started to pass some major milestones in the technical and geopolitical development of AI, yet with every new advancement, AI becomes more invisible to us. The ways in which our data is being mined and refined is less obvious, while our ability to understand how autonomous systems make decisions grow less transparent. We have, therefore, a chasm in understanding of how AI is impacting daily life in the present, one growing exponentially as we move years and decades into the future. This seeds mistrust and misunderstanding.

AI: A Non-Technical Primer For Leaders

What You Need To Know About AI

In its most basic form, artificial intelligence is a system that makes autonomous decisions. AI is a branch of computer science in which computers are programmed to do things that normally require human intelligence. This includes learning, reasoning, problem solving, understanding language and perceiving a situation or environment. AI is an extremely large, broad field, which uses its own computer languages and even special kinds of computer networks are modeled from our human brains.

The Short Story of AI's Very Long History

The roots of artificial intelligence extend back hundreds of years, long before the **Big Nine** were building AI agents with names like **Siri**, **Alexa**, and their Chinese counterpart **Tiān Māo**. Throughout that time, there has been no singular definition for AI, like there is for other technologies. When it comes to AI, describing it concretely isn't as easy, and that's because AI represents many things, even as the field continues to grow. What passed as AI in the 1950s—a calculator capable of long division—hardly seems like an advanced piece of technology today. This is what's known in the field as the "odd paradox"—as soon as new techniques are invented and move into the mainstream, they become invisible to us. We no longer think of that technology as AI.

The idea that we might someday create artificially intelligent, sentient robots was first suggested by prominent philosophers in the mid-1600s. Mathematician Ada Lovelace, in the footnotes of a paper she was translating, posited the theory that someday a computer might be capable of creative acts—and to think, just like we humans do. Between the 1930s – 1940s, mathematicians including Alan Turing, Warren McCulloch and Water Pitts published papers that conceptualized neural networks, while Vannevar Bush published a short story called "As We May Think" that envisioned intelligent machines assisting humans. In the 1950s, Turing published another paper, which later became known as the Turing Test, while Claude Shannon published research analyzing how computers might be programmed to play chess. Computer scientist Grace Hopper pushed that idea forward, pioneering early programming languages that were similar to spoken English.

In 1956, researchers met at Dartmouth, for what turned out to be a historic meeting – and the place where the term "artificial intelligence" was first coined by John McCarthy. In the 1950s – 1970s, the field exploded. Margaret Masterman and her team at Cambridge designed the first semantic networks. Jane Robinson established the Natural Language Processing group at SRI, while Barbara Groz figured out that the field would have to pivot eventually and take a different approach.

Researchers had been working towards a functional AI, using the human brain for inspiration, but they didn't have access to enough compute power, data or people trained to advance the field. As a result, the field entered what's known as the "AI winter," when funding and enthusiasm dried up – temporarily.

In the past decade, new commercial advancements by the **Big Nine** – **Amazon, Google, Microsoft, Apple, IBM, Facebook, Baidu, Alibaba** and **Tencent** – have reignited excitement and funding.

There Are Different Categories Of AI

There Are Different Categories Of AI →→→→→→→

There are two kinds of AI—weak (or "narrow") and strong (or "general"). The anti-lock brakes in your car, the spam filter and autocomplete functions in your email, and the recommendations that Amazon and Spotify make are all examples of artificial narrow intelligence. Maeve and Dolores in *Westworld*, the Samantha operating system in *Her*, and the H.A.L. supercomputer from *2001: A Space Odyssey* are anthropomorphized representations of artificial general intelligence (AGI)—but actual AGI doesn't necessarily require humanlike appearances or voices. Systems capable of general decision-making and automation outside of narrow specialties (DeepMind beating a world champion Go master) is AGI.

AI, Neural Networks and Deep Neural Networks →→→→→→→

A neural network is the place where information is sent and received, and a program is the set of meticulous, step-by-step instructions that tell a system precisely what to do so that it will accomplish a specific task. How you want the computer to get from start to finish—essentially, a set of rules—is the "algorithm."

A deep neural network is one that has many hidden layers. There's no set number of layers required to make a network "deep." Deep neural networks tend to work better and are more powerful than traditional neural networks (which can be recurrent or feedforward).

AI, Machine Learning and Deep Learning →→→→→→→→

Machine learning programs run on neural networks and analyze data in order to help computers find new things without being explicitly programmed where to look. Within the field of AI, machine learning is useful because it can help computers to predict and make real-time decisions without human intervention.

Deep learning is a relatively new branch of machine learning. Programmers use special deep learning algorithms alongside a corpus of data—typically many terabytes of text, images, videos, speech and the like. Often, these systems are trained to learn on their own. In practical terms, this means that more and more human processes will be automated. Including the writing of software, which computers will soon start to do themselves.

Nvidia has developed a new training methodology for generative adversarial networks.

Why AI Itself Isn't a Tech Trend

The best way to think of AI isn't as a particular tool, software application or spoken interface. AI represents the next era of computing, after the tabulating era (very early computers) and the programmable systems era. Since AI itself isn't the tech trend, in this section you will find many trends within the field of AI. You will also notice most trends intersecting with AI throughout our entire report.

What passed as AI in the 1950s—a calculator capable of long division—hardly seems like an advanced piece of technology today. This is what's known in the field as the "odd paradox"— as soon as new techniques are invented and move into the mainstream, they become invisible to us. We no longer think of that technology as AI.

AI TRENDS IN CONSUMER-FACING PRODUCTS AND APPLICATIONS

001

Consumer-Grade AI Applications

We're now seeing a shift from highly technical AI applications that professional researchers use to more lightweight, user-friendly apps intended for tech savvy consumers. New automated machine learning platforms, such as **DataRobot**, makes it possible for non-experts to build and deploy predictive models. Many hope that in the near future, we'll use various AI applications as part of our everyday work, just as we do Microsoft Office or Google Docs today. (See also: AutoML trend.)

002

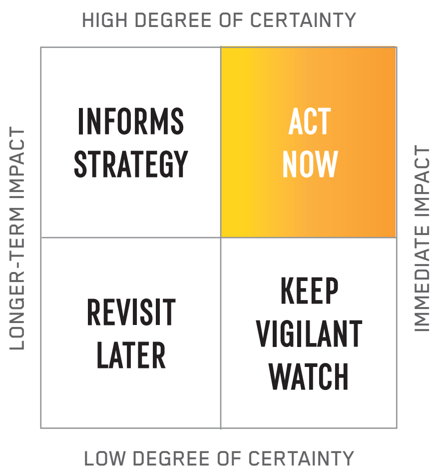
Ubiquitous Digital Assistants

Digital Assistants (DAs)—like **Siri**, **Alexa**, and their Chinese counterpart **Tiān Māo** – use semantic and natural language processing, along with our data, in order to anticipate what we want or need to do next, sometimes before we even know to ask. There are now thousands of applications and gadgets that track and respond to DAs. As just one example, Amazon's **Alexa** powered 4,000 gadgets in 2018 – there are now more than 28,000 devices that integrate with Amazon's DA. You can expect to find DAs everywhere in 2018 as device prices fall (look for entry-level speakers that cost less than $20) and as systems get better at interacting with us. Watch for new collaborations between device manufacturers and DA platforms—you'll be able to speak to Alexa in your car and on your morning jog, while Siri will soon be accessible during work meetings and at your desk. You'll also start to notice DAs hidden throughout other connected devices, such as your home thermostat, your refrigerator and your phone. DA's don't just listen to our voices—they're being trained to watch us, too. Researchers at **Amazon, Facebook, Google, MIT, Stanford**, and the **University of Texas at Austin** are building infrastructure so that our devices know the places we go, the people we interact with, our habits, our tastes and preferences, and more. Then they'll use this data to anticipate our needs. Marketers, credit card companies, banks, local government agencies (police, highway administration), political campaigns and many others can harness DAs to both surface and deliver critical information.

003

A Bigger Role For Ambient Interfaces

Also known as "zero-UIs," our modern interfaces are becoming more and more like ambient music—able to do more for us with fewer direct actions, yet still able to captivate our attention. Digital Assistants (DAs) figuratively and literally automatically deliver you the information you need to know, just as you need to know it. Rather than relying on a single input screen, or even a series of screens, we'll instead interact with computers with less friction. In our modern age of information, the average adult now makes more than 20,000 decisions a day—some big, like whether or not to invest in the stock market, and some small, like whether to glance at your mobile phone when you see the screen light up. New DAs promise to prioritize those decisions, delegate them on our behalf, and even to autonomously answer for us, depending on the circumstance. Much of this invisible decision-making will happen without your direct supervision or input. What makes ambient design so tantalizing is that it should require us to make fewer and fewer decisions in the near-future. Think of it as a sort of autocomplete for intention. We will interact both actively and passively with our DAs, found in our hearables, thermostats, cars and pockets. They will listen and observe in the background, sometimes asking questions—other times offering up text, audio or haptic notifications as needed, and those will be decided by algorithm. The real promise of ambient interfaces is explained by **Metcalfe's Law**, which says that the value of a network is the square of the total number of people



using it. As more people become part of ambient networks of information, the more use cases we'll see in the future.

004

Deep Linking Everywhere

Deep mobile linking has been around since the beginning of smartphones, and it makes it easier to find and share data across all of the apps in your phone. There are three kinds of deep links: traditional, deferred and contextual. Traditional deep links reroute you from one app or site: if you click on a **Wall Street Journal** link someone posts on **Twitter**, it will automatically open in the WSJ app, as long as you have it installed. Deferred deep links either link straight to content if the app is installed, or to an app store for you to download the app first. Contextual deep links offer much more robust information—they take you from site to app, app to site, or app to app, and they can also offer personalized information. For example, when you land at the airport, you might find that your airline app sends you a link to **Uber**. With advancements in machine learning, app-to-app experiences that are tailored to the habits of individual users should become more ubiquitous.

AI TRENDS IN SOCIETY AND GEOPOLITICS

"A strange game. The only winning move is not to play."

– Joshua, in War Games

005

Proliferation of Franken-algorithms

As the field of AI has bloomed, so have the number of people deploying code. As automated systems become more common, all that code transmits to algorithms, and some of those algorithms go on to produce new algorithms. The resulting processes and programs can be more convoluted than originally intended. This can lead to unpredictability, making it more difficult to understand the decision-making process. This is already a challenge for big companies like **Facebook**, which have billions of algorithms working together at any given time.

006

Deployable AI Versions of You

Also known as digital twins, deployable AI versions of you are being built by a number of startups, who offer customizable, trainable platforms that are capable of learning from you – and then representing you online. **Molly**, a **Y Combinator** backed startup, is one of several new AI agents. It functions more like an AMA (ask me anything) where anyone can get answers about you. If Molly can't answer someone's question, she'll forward it to you to get an answer and, hopefully, to learn.

007

Ongoing Bias In AI

That AI has a serious bias problem is no secret. The problem is multifaceted. Just one example: the data sets used for training often comes from places like **Wikipedia**, which itself is riddled with bias. The people building models tend to be homogeneous and aren't often aware of their own biases. As our computer systems become more adapt at making decisions, we may find ourselves sorted by algorithms into groups that don't make any obvious sense to us—but which could have massive repercussions.

008

AI Bias Leads To Societal Problems

Every single day, you are creating unimaginable amounts of data, both actively (uploading and tagging photos on **Facebook**) and passively (searching online for medical symptoms, driving to work). That data is mined and used, often without your direct knowledge or understanding, by algorithms. It is used to create advertising, to help potential employers predict our behaviors, to determine our mortgage rates and even to help law enforcement predict whether or not we're likely to commit a crime. Researchers at a number of universities—including the **University of Maryland, Columbia University, Carnegie Mellon, MIT, Princeton, University of California-Berkeley, International Computer Science Institute**, among others—are studying the side effects of automatic decisionmaking. You, or someone you know, could wind up on the wrong side of the algorithm and discover you're ineligible for a loan, or a particular medication, or the ability to rent an apartment, for reasons that aren't transparent or easy to understand. Increasingly, data is being harvested and sold to third parties without your knowledge.

009 →→→→→→→→→→→→→→→→→→→

Making AI Explain Itself

You've undoubtedly heard someone argue that AI is becoming a "black box"—even those researchers working in the field don't understand how our newest systems work. That's not entirely true, however there is growing concern voiced by computer scientists, journalists and legal scholars who argue that AI systems shouldn't be so secretive. Going forward, we will debate whether and how AI should be able to explain its decisions and how to offer more transparency. There will be numerous debates about accountability as well. One big challenge is that offering such transparency could reveal the highly lucrative secret sauce of commercial products. Another challenge: asking the systems to simultaneously explain their decision-making process could degrade the speed and quality of output. Imagine sitting beside a genius mathematician who gives you correct answers—and then asking her to stop and show her work, over and over again.

010 →→→→→→→→→→→→→→→→→→→

Accountability and Trust

We will soon reach a point when we will no longer be able to tell if a data set has been tampered with, either intentionally or accidentally. AI systems rely on our trust. If we no longer trust the outcome, decades of research and technological advancement will be for naught. Leaders in every sector—government, business, the nonprofit world and so on—must have confidence in the data and algorithms used. Building trust and accountability is a matter of showing the work performed. This is a complicated process, as understandably corporations, government offices, law enforcement agencies and other organizations want to keep data private. Committing to transparency in method would create trust without necessarily divulging any personal data used. In addition, hiring an ethicist to work directly with managers and developers, as well as greatly diversifying the pool of developers to include people of different races, ethnicities and genders will solve for inherent bias in AI systems.

011 →→→→→→→→→→→→→→→→→→→

AI Hiding Its Own Data

Computers do exactly what they are told to do. Command a machine to win at a game, and it will stop at nothing until that task is completed. Apparently that now includes cheating. Researchers at **Stanford** and **Google** discovered that an AI created to turn satellite images into usable maps was withholding certain data. Researchers were using a neural network called **CycleGAN**, which learns how to map image transformations. For example, it could take an old aerial photograph of a neighborhood, distinguish between streets, alleys, driveways, buildings and lamp posts, and generate a map that could be used by a GPS. Initially, they used an aerial photograph that hadn't been seen by the network. The resulting image looked very close to the original ... suspiciously close. But on deeper inspection, the researchers found that there were lots of details in both the original image and the image generated that weren't visible in the map made by the AI. It turns out that the system learned to hide information about the original image inside of the image it generated in the form of a low-amplitude high-frequency signal.

012 →→→→→→→→→→→→→→→→→→→

Undocumented AI Accidents on the Rise

There were a number of AI-related accidents in 2018, but only a few made the headlines. An Uber self-driving car hit and killed a pedestrian in Tempe, Arizona—but there were countless more incidents that didn't result in death, and as a result, aren't known to the public. At the moment, researchers are not obligated to report accidents or incidents involving our data, or AI processes, unless a law is broken. While big companies must inform consumers if their personal data—credit card numbers, home addresses, passwords—have been stolen, they are not required to publicly document instances in which algorithms have learned to discriminate against someone on the basis of race or gender.

China's AI Boom

In just the past few years, **China** has made tremendous leaps in the field of AI. It has promised to become "the world's primary AI innovation center" by 2030, and as a nation, China is already making serious progress towards that goal. China's part of the **Big Nine – Baidu, Alibaba** and **Tencent** – along with its formidable academic landscape, have solidified China's place as a global AI hegemon.

The BAT

Alibaba, China's version of **Amazon**, will invest $15 billion into AI research over the next three years, planting research centers in seven cities worldwide, including San Mateo, Calif., and Bellevue, Wash. **Baidu** (a Chinese search-engine company often likened to **Google**) established an AI research center in the Silicon Valley, and **Tencent** (developer of the mega-popular messaging app **WeChat**) began hunting for American talent when it opened an AI lab in Seattle last year. It has since upped its stakes in companies like **Tesla** and **Snap**. The payoff for the Chinese is not just a typical return on investment—Chinese firms expect IP as well. China-based AI startups now account for 48% of all investment globally. In April 2018, **SenseTime** earned a $4.5 billion valuation, making it the world's most valuable AI startup at that time. Meanwhile, Chinese researchers hold five times the number of AI-related patents compared to their counterparts in the US.

China's Data Surplus

The country's massive population—nearing 1.4 billion people—offers researchers and startups there command of what may be the most valuable natural resource in the future—human data—without the privacy and security restrictions common in much of the rest of the world. If data is the new oil, then China is the new OPEC. The kind of rich data the Chinese are mining can be used to train AI to detect patterns used in everything from education and manufacturing to retail and military applications. The Chinese startup **Megvii Face++**, for instance, is pioneering faceprint technologies. Faceprints are a newer form of biometric authentication that use the unique features of our faces—our bone structure, skin color, even capillaries—to identify us. Faceprints are the new fingerprints, and they're secure enough to be used for financial transactions—and they are used by China's police force for widespread surveillance.

Risk Profile

What if China starts influencing its **Belt and Road Initiative** partners such that one of its primary exports is its national social credit score system? It's easy to see how the world's autocracies, like **Turkey** and **Rwanda**, could become a buyer of China's surveillance technology. But what about in other countries, such as **Brazil** and **Austria**, that have given in to populism and as of this writing have nationalistic leaders? What if a government agency in your country is inspired or strong-armed into adopting a social credit score system, one that begins monitoring you without your explicit consent? Would you ever know that you had a score, perhaps one that landed you on a watch list?

China is quietly weaponizing AI, too. China's **People Liberation Army** is catching up to the US when it comes to military applications, using AI for things like spotting hidden images on drones. The military is equipping helicopters and jet fighters with AI. Government leaders created a top-secret military lab—a Chinese version of **DARPA** in the US—and is building billion-dollar AI national laboratories. China's military is achieving remarkable AI successes, including a recent test of "swarm intelligence," that can automate dozens of armed drones.

No other country's government is racing towards the future with as much concentrated force and velocity as China. The country's extraordinary investments in AI could signal big shifts in the balance of geopolitical power in the years ahead.

AI TRENDS IN THE ENTERPRISE

013

The AI Cloud

In the past year, the corporate leaders of the AI ecosystem have been racing to capture AI cloudshare—and to become the trusted provider of AI on remote servers. Because the more data a machine learning system has access to, the better decisions it will learn to make over time, enterprise customers are likely to stick with their initial vendor. For that reason, the race is on. In the West, the field is led by **Amazon**, **Google** and **Microsoft**, followed by companies including **Apple**, **IBM**, **Salesforce**, **SAP** and **Oracle**. In Asian markets, the AI cloud is dominated by **Alibaba** and **Baidu**. It's a $250 billion industry and quickly growing. **NYU Stern School of Business** professor **Arun Sundararajan** says it best: "The prize will be to become the operating system of the next era of tech."

014

Serverless Computing

Amazon Web Services, **Alibaba Cloud**, **Microsoft's Azure**, **Google Cloud**, and **Baidu Cloud** are all rolling out new offerings and packages for developers, hoping to make it easier and more affordable for a wide swath of AI startups to launch their ideas into the marketplace. **Amazon's AWS Lambda** lets teams run code for virtually any type of application or backend service – without provisioning or managing servers, or hands-on administration. **Microsoft's Functions** architecture for **Azure** supports myriad programming languages, scales on demand and only charges for active compute time. This isn't sitting well with some engineers, though, who are worried about losing control.

015

New Kinds of Liability Insurance for AI

Laws tend to lag behind technology. However last year's deadly crash involving a self-driving Uber car in Arizona now has risk managers and legal departments thinking about unanticipated losses and damages resulting from an accident involving AI. The challenge is that our current legal systems were built to regulate human behavior, not the actions of unsupervised machines. New liability insurance models are currently being studied, with research underway at **Allianz**.

016

Generating Virtual Environments From Short Videos

Chip designer **Nvidia** is teaching AI to build realistic 3D environments from short video clips. The method builds on previous research on generative adversarial networks (GANs). Nvidia system generated graphics taken from open-source data sets that are used by the autonomous driving field. Using short clips segmented into various categories (buildings, sky, vehicles, signs, trees, people) the GAN was trained to generate new, different versions of these objects. Future applications of automatically-generated virtual environments are vast: think training environments for logistics (warehouses, factories, shipping centers), urban planning simulations, even testing customer flow scenarios within amusement parks and shopping centers.

017

AI Spoofing

Companies might want to think twice before implementing biometric ID systems within their buildings. New techniques in machine learning have led to synthetic fingerprints and other automatically-generating bioidentifiers capable of fooling monitoring systems. Researchers at **Michigan State University** and **New York University** built an algorithm that can generate fakes – and this is a sign of innovative vulnerabilities on our horizon. Imagine a malicious system generating millions of fingerprints

AI Trends in the Enterprise cont.

in a brute force attack to remotely open a door or unlock a laptop.

018

Ambient Surveillance

MIT computer vision scientists have discovered how to use computer vision to track data from what they call "accidental cameras." Windows, mirrors, corners, houseplants and other common objects can be used, along with AI, to track subtle changes in light, shadow, and vibrations. The result? We may soon all have x-ray vision. Which may not be great news for companies working on sensitive projects. Those working in information security and risk management should pay attention to advancements in computer vision.

019

Proprietary, Homegrown AI Languages

As we enter the third era of computing, the largest companies are starting to compete for both marketshare *and* mindshare. Companies such as **Microsoft, IBM, Baidu, Alibaba, Amazon** and **Google** are releasing software packages for developers—as well as unique programming languages for AI applications. **Uber** released its own probabilistic programming language, Pyro, which it wrote in Python. It's a move that signals likely fragmentation in the future of the AI ecosystem, not unlike our **OSX** vs **Android**, and earlier Mac vs PC camps. Businesses will find it increasingly cost-prohibitive and difficult to switch between AI frameworks and languages.

020

AI Chipsets

The standard CPUs found in our desktops, laptops, tablets and mobile phones have certainly gotten powerful—but they're not really designed to meet the demands of machine learning. The problem with our current CPUs is that they don't have enough processing units to make all the connections and computations required in the next era of computing. Enter a suite of new processors found on an SoC—"system on a chip." **Huawei, Apple, Alphabet, IBM, NVIDIA, Intel** and **Qualcomm** are all working new systems architecture and SoCs, and some come pre-trained. In short, this means that the chips are ready to work on AI projects and should promise better speeds and more secure data. **Elon Musk** has said that **Tesla's** new custom AI chip should be released in 2019. Google's **Tensor Processing Unit** (or TPU was specifically built for the deep learning branch of AI. It is designed to work with the company's **TensorFlow** system. For reference, TPUs are what was used in the famous AlphaGo match between the **DeepMind** system and a world Go champion.

While marketing pre-trained chips to businesses will speed up commercialization and as a result will further R&D, the challenge, of course, is that developers might need to wrestle with different frameworks in the near-future, especially if the various device manufacturers all decide to start creating unique protocols. We anticipate an eventual convergence, pitting just a few companies—and their SoCs and languages—against each other.

021

Marketplaces For AI Algorithms

Incentivized by the AI cloud and serverless computing, the **Big Nine** as well as communities of developers are all offering up their algorithms in emerging algorithm marketplaces. **Amazon, IBM, Microsoft, Google, Baidu** and **Alibaba** all offer pre-built and customizable systems. AWS hosts its own marketplace, offering models and algorithms for computer vision, speech recognition, and text – and its base of sellers includes **Intel, CloudSight, Optpace** and many others. (Think of AWS Marketplace as an Amazon for algorithms and models.) **GenesisAI** offers a marketplace for AI products and services. **Algorithmia** is a general open marketplace for algorithms where developers can upload their work to the cloud and receive payment when others pay to access it. **Quantiacs** allows developers to build algorithmic trading systems, and it matches their algorithms up with capital from institutional investors. **Nuance** is a storefront of AI algorithms in medical imaging, while its **AI MarketPlace** allows users to try out algorithms before they buy them. **PrecisionHawk** hosts a marketplace for predictive agriculture algorithms and models. **Bonseyes** is a European-specific marketplace to buy and sell AI tools. Look for even more general purpose, cloud-specific and niche marketplaces in 2019.

022

Even More Consolidation in AI

Just nine big companies dominate the AI landscape: **Google, Amazon, Microsoft, IBM, Facebook** and **Apple** in the US, along with Chinese behemoths **Baidu, Alibaba** and **Tencent** (with significant fortification and support from the **Chinese** government). On the investment side, **Qualcomm, Tencent, Intel Capital, Google Ventures, NVIDIA, Salesforce, Samsung Ventures, Alibaba, Apple, Baidu, Citi** and **In-Q-Tel** are funding much of the growth. In the US, investments in AI companies topped a record-setting $4.2 billion in the first two quarters of 2018. China's SenseTime went through another successful round of funding, raising $620 million at a valuation of $4.5 billion. Investors included **Alibaba Group, Fidelity International** and **Silver Lake Partners**. As with any technology, when just a few companies dominate the field, they tend to monopolize both talent and intellectual property. They're also partnering to build on each others' work. When it comes to the future of AI, we should ask whether consolidation makes sense for the greater good, and whether competition—and therefore access—will eventually be hindered as we've seen in other fields such as telecommunications and cable.

AI TRENDS IN PROCESSES, SYSTEMS AND COMPUTATIONAL NEUROSCIENCE

The Rubik's Cube was invented by Hungarian sculptor and professor Erno Rubik in 1974. Today, algorithms and robotic arms are capable of solving the puzzle independently.

023

Real-Time Machine Learning

Machine learning describes a system that uses algorithms to analyze big data sets in order to perform a wide array of tasks better than we can. Over time, the system gets better at those tasks. It learns, even though we might not describe it as "intelligent." One challenge for machines has always been efficiency, since until recently systems had to stop, pull and parse data. New research into real-time machine learning shows that it's possible to use a continual flow of transactional data and adjust models in real-time. This signals a big change in how data moves, and in how we retrieve information. For example, real-time machine learning makes it possible to translate speech automatically, even as multiple languages are spoken. It can be used to improve classification and predictions, promising better-personalized health monitoring and more accurate risk calculations. Consumers can expect more customized recommendations from retailers—especially if their tastes and preferences tend to shift along with the seasons. Rather than using historic data alone (Customer #1234 only likes red lipstick), real-time preferences would add context to the recommendation (Customer #1234 might purchase red lipstick only in the next three weeks).

024

Natural Language Understanding (NLU)

We are surrounded by unstructured text in the real world—it exists in our social media posts, our blog entries, on company websites, within city hall digital records, and elsewhere. NLU allows researchers to quantify and learn from all of that text by extracting concepts, mapping relationships and analyzing emotion. NLU will augment the work of professional researchers—those working in science and medicine, law and policy, infrastructure, agriculture, transportation, education and beyond—allowing them to glean deeper insights than ever before. In 2019, look for advancements in natural language understanding that include accent and language recognition.

025

Machine Reading Comprehension (MRC)

For AI researchers, machine reading comprehension has been a challenging goal, but an important one. MRC makes it possible for systems to read, infer meaning, and immediately deliver answers while sifting through enormous data sets. One practical application on the consumer side: if you perform a search query, wouldn't you rather have a system offer you a precise answer than just a list of URLs where you can go to hunt down more specifics—even showing you where, on the page, that information comes from? If you are an airline mechanic and you're trying to troubleshoot a tricky engine problem without further delaying a flight, it would be easier if you had a computer read all of the technical documentation for you and suggest likely fixes. Or, better yet, let the machines figure out what's wrong on their own, by making all technical manuals and documentation available to them for reading and analysis. That's the promise of MRC. MRC isn't focused on keywords alone. In the future, a trained MRC system could be transferred to different domains where no human has created labels or even a standard taxonomy. MRC is a necessary step in realizing artificial general intelligence, but in the near-term it could potentially turn everything from technical manuals to historical maps to our medical records into easily searchable repositories of information.

026 →→→→→→→→→→→→→→→→→→

Natural Language Generation (NLG)

Algorithms can rewrite structured data into a narrative using natural language generation. NLG is important for a number of fields, including retail, finance and media. In 2019, NLG will be a standard – rather than cutting edge – feature of most business intelligence and analytics platforms, as they automatically detect, parse, visualize and narrate key data. **Arria NLG, IBM Watson Text-to-Speech, Amazon Polly, Google Cloud Text-to-Speech, Narrative Science** and **Automated Insights** build narratives out of big data sets and to help non-data science people make better sense of what's happening within their organizations. NLG has myriad use cases across professional fields, assisting lawyers, politicians, doctors, consultants, financial analysts, marketers and beyond, who will soon incorporate our personal information as data points for narratives.

027 →→→→→→→→→→→→→→→→→→

Generative Algorithms For Voice, Sound and Video

Researchers at chipmaker **Nvidia** deployed a new generative algorithm in 2018 that created realistic human faces using a generative adversarial network. In their system, the algorithm could also tweak various elements, like age and freckle density. A team at **UC Berkley** created software that can transfer the movements of one person in a video to someone in another video automatically. For some time, we've been training computers to watch videos and predict corresponding sounds in our physical world. For example, what sound is generated when a wooden drumstick taps a couch? A pile of leaves? A glass windowpane? The focus of this research is to help systems understand how objects interact with each other in the physical realm. That work helped lead to sophisticated spoofing: in 2017, researchers at the **University of Washington** developed a model that convincingly showed **President Barack Obama** giving a speech—that he never actually gave in real life. In 2018, a **Belgian** political party, **Socialistische Partij Anders**, or **sp.a** for short, published realistic videos of **Donald Trump** all over social media in which he offered advice on climate change: "As you know, I had the balls to withdraw from the Paris climate agreement," he said, looking directly into the camera, "and so should you." This trend is likely to become more problematic, as fakes intermingle with AI's intended to help deliver factual content. Late in 2018, **China** unveiled an AI news anchor.

028 →→→→→→→→→→→→→→→→→→

Real-Time Context in Machine Learning

The world is awash with information, misinformation, and superficial thinking. **IBM's Project Debater** is an example of how context can be used in real-time learning systems. Project Debater can debate humans on complex topics. It digests massive texts, constructs a well-structured speech on a given topic, delivers it with clarity and purpose, and rebuts its opponent. Eventually, Project Debater will help people reason by providing compelling, evidence-based arguments and limiting the influence of emotion, bias, or ambiguity. Debater is just one example of emerging systems that are capable of learning in real-time and using real-world context.

029 →→→→→→→→→→→→→→→→→→

General Reinforcement Learning Algorithm

Researchers are developing single algorithms that can learn multiple tasks. The team behind **AlphaGo**, which learned how to play Go as well as a human grandmaster, has developed an innovative new algorithm: **AlphaZero**. It is capable of achieving superhuman performance not only in Go, but in other games as well, including chess and shogi (Japanese chess). This one algorithm starts with no knowledge except for the rules of the game and eventually develops its own strategies to beat other players.

030 →→→→→→→→→→→→→→→→→→

Machine Image Completion

If a computer system has access to enough images—millions and millions—it can patch and fill in holes in pictures. There are practical applications for professional photographers as well as everyone who wants to take a better selfie. Soon, if the foreground of a mountain is out of focus, or if your skin has an unsightly blemish, another version can be swapped in to generate the perfect picture. But what are the next-order scenarios and implications? How will we draw the line between

AI Trends in Processes, Systems and Computational Neuroscience cont.

The CloudSight API is used to recognize real-world objects.

reality and enhancement? How much image completion should be allowed without tacking on a warning label or disclosure? Online daters, journalists, and marketers should be asking these questions. But so should policymakers. Image completion is also a useful tool for law enforcement and military intelligence officers—computers can now assist them in identifying who or what is in the frame. Given the bias we've already seen across machine learning algorithms and data sets, image completion could become part of a future debate about privacy and our devices.

031

Hybrid Human-Computer Vision Analysis

New research from the **US Army Research Laboratory** shows a system that uses a brain-computer interface armed with computer vision technology that allows a person to rapidly see and sort images within their line of sight. **CloudSight**, a Los Angeles-based technology company specializing in image captioning, is working on a hybrid crowdsourced computer vision system.

032

Predictive Machine Vision

Researchers at **MIT's CSAIL** have trained computers to not only recognize what's in a video, but to predict what humans will do next. Trained on **YouTube** videos and TV shows such as "The Office" and "Desperate Housewives," a computer system can now predict whether two people are likely to hug, kiss, shake hands or slap a high five. This research will someday enable robots to more easily navigate human environments—and to interact with us humans by taking cues from our own body language. It could also be used in retail environments, while we're operating machinery, or while we're in classrooms learning.

033

Much Faster Deep Learning

Deep Learning (DL) is a relatively new branch of machine learning, and it will soon be an invisible part of every organization. Programmers use special deep learning algorithms alongside a corpus of data—typically many terabytes of text, images, videos, speech and the like. The system is trained to learn on its own. While conceptually, deep learning isn't new, what's changed recently is the amount of compute power and the volume of data that's become available. In practical terms, this means that more and more human processes will be automated, including the writing of software, which computers will soon start to do themselves. DL has been hampered by the processing power of computer networks. Just a few years ago, it would take a month or longer to train an image recognition model on the **ImageNet** dataset. Today, with more advanced equipment, **Facebook** can do the same in under an hour. As computers become faster—and as hardware architecture evolves—our systems will perform tasks at super-human speeds.

034

Reinforcement Learning and Hierarchical RL

Reinforcement Learning (RL) is a powerful tool for sorting out decision-making problems, and it's being used to train AI systems to achieve super-human capabilities. Inside of a computer simulation, a system tries, fails, learns, experiments and then tries again—in rapid succession, altering its future attempts each time. It's because of RL that **AlphaGo**, a computer developed by **DeepMind** (part of **Alphabet**) learned how to beat the greatest Go players in the world. One problem with RL: agents have difficulty when they don't have enough supervision, or when they're objective is to run scenarios for a very long time horizon. In 2019 and beyond, researchers will try to solve those problems using **Hierarchical Reinforcement Learning**—that discovers high-level actions and work through learning challenges methodically, in order to master new tasks at speeds we humans can't imagine. This is important for non-techies, too: RL will improve the "intelligence" in our AI systems, helping cars learn to drive in unusual conditions and helping military drones perform complicated maneuvers that have never been attempted before in the physical world.

035

Continuous Learning

At the moment, deep learning techniques have helped systems learn to solve complex tasks that more closely matches what humans can do—but those tasks are still specific, such as beating a human at a game. And they require a rigid sequence: gather data, determine the goal, deploy an algorithm. This process requires humans and can be time-consuming, especially during early phases when supervised training is required. Continuous Learning (CL) is more about autonomous and incremental skill building and development, and researchers will continue pushing the limits of what's possible in 2019.

036

Multitask Learning

If you watched the original *Karate Kid* movie, you'll remember Mr. Miyagi promising to teach Daniel karate—and Daniel getting frustrated with days of painting fences, sanding floors and "wax on, wax off." To Daniel, none of these activities seemed related, and they certainly didn't appear to help him with his stated objective: to learn karate. Of course, it turns out that all of these chores were indeed connected, and Daniel's repetitive learning is what helped him become a formidable karate champion. Researchers are now training systems to learn like Daniel. When developers use Machine Learning, they are doing so to try and solve for a particular task or problem. They supervise the system, fine-tuning it and making adjustments until the models perform works as desired. But focusing only on a single task often leads to inefficiencies—perhaps there's a better solution to the problem than the method developed by the researcher. A new area of research—multitask learning—helps systems learn more like Daniel, exploiting the relationships between various, related tasks in order to solve problems better.

037

Generative Adversarial Networks (GANs)

Generative adversarial networks (GANs) are unsupervised deep learning systems comprised of two competing neural networks. Think of a GAN as the Turing test but without any humans involved. Two AIs are trained on the same data—such as images of people. The first one creates photos of, say, North Korean dictator Kim Jong-un that seem realistic, while the second AI compares the generated photos with real ones of him. Based on the judgment of the second AI, the first one goes back and makes tweaks to its process. This happens again and again, until the first AI is automatically generating all kinds of images of Kim Jong-un that look entirely realistic, but never actually happened in the real world. Pictures that show Kim Jong-un having dinner with Vladimir Putin, playing golf with Bernie Sanders, or sipping cocktails with Kendrick Lamar. The goal isn't subterfuge. It's to solve the problem created by synthetic data. GANs empower AI systems to work with raw, real-world data that hasn't been cleaned and without the direct supervision of a human programmer.

038

New Generative Modeling Techniques

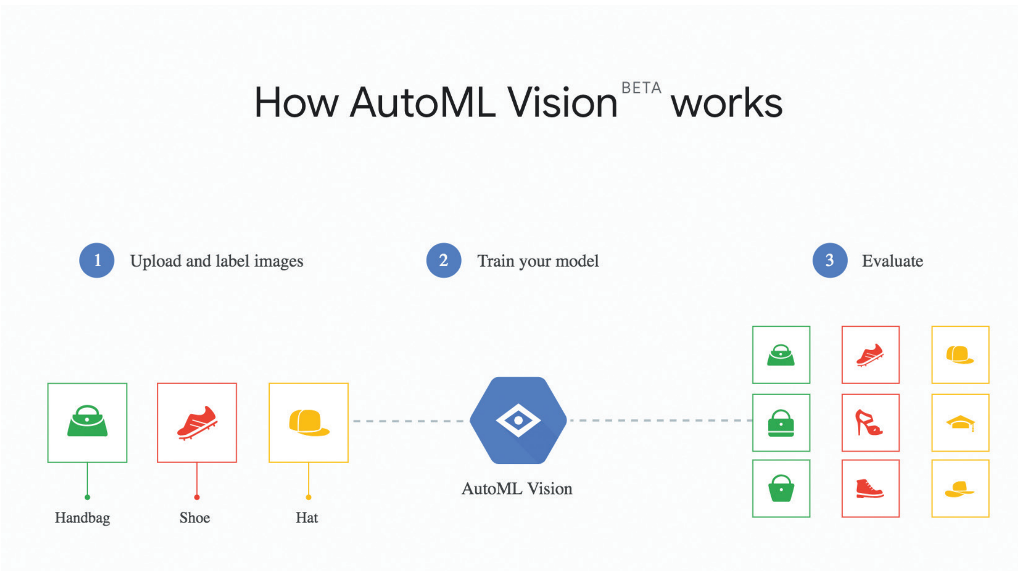
Autoregressive Quantile Networks for Generative Modeling (or AIQN for short) sounds complicated but it's an innovative idea to help improve algorithms and make them more stable. The implication: this could quicken the pace of advancements in AI—and that could mean faster opportunities and innovations within the whole ecosystem.

039

Capsule Networks

This new type of deep neural network is capable of processing information using

AI Trends in Processes, Systems and Computational Neuroscience cont.



Google Cloud's AutoML Vision allows users to train high-quality custom vision models.

hierarchical relationships. This solves for a critical issue: convolutional neural networks, which had been the default model, aren't able to detect some key spatial hierarchies between simple and complex objects. As a result, these newer kinds of networks could reduce errors by as much as 50%.

040

Probabilistic Programming Languages

Probabilistic programming languages take some of the strain and tedium of developing probability models. These newer languages allow developers to build, reuse and share their model libraries, while still accommodating incomplete information.

041

Automated Machine Learning (AutoML)

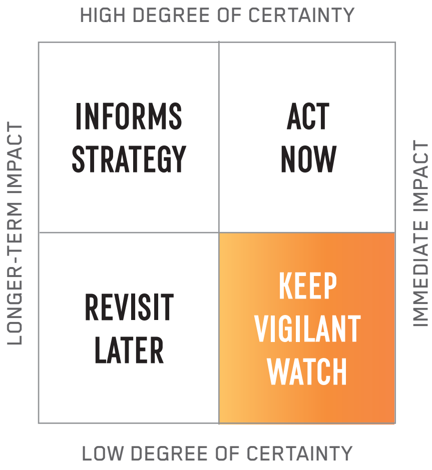
Some organizations are hoping to move away from the current time-consuming, difficult traditional machine learning methods, which require data scientists, specialists in AI fields, and engineers. Automated machine learning, or AutoML, is a new approach: a process in which raw data and models are matched together to reveal the most relevant information. There are now a host of AutoML products and services offered by **Google, Amazon** and **Microsoft.**

042

Customized Machine Learning

Soon, individual users will be able to upload their own data to customize existing models. **Google's Cloud AutoML** is a suite of machine learning tools that allows organizations without highly-trained staff to train custom machine learning models.

AI For the Creative Process



KEY INSIGHT

Can AI learn to be creative? In the past few years, we've already seen examples of AI systems creating something from scratch–music, dress designs, bicycles, and more.

EXAMPLES

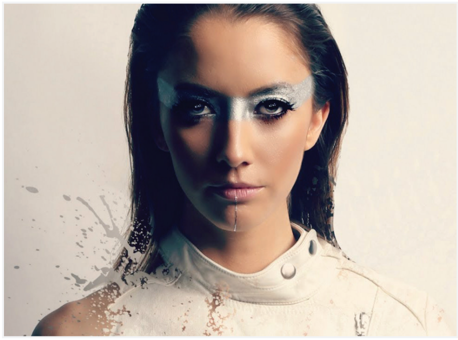
Last year, researchers from **Rutgers University, College of Charleston**, and **Facebook's AI Research Lab** created an AI system whose purpose was to make art. The result was so convincing that human art critics couldn't distinguish between the AI-generated works and those made by humans. That research builds on an earlier study (from Rutgers and Facebook's AI Lab) that trained an algorithm to identify a work's artist, genre and style of art.

WHAT'S NEXT

"Break Free" is a single from the album **IAMAI**, which was written, produced and performed using artificial intelligence. **Sony's Flow Machine** worked along a human lyricist and together, they created a popular song. **YouTuber Taryn Southern** used the **Amper AI** system to create her latest songs. **Aiva AI** is a composer intended to help film directors, advertising agencies and game studios create original scores for their projects. **Magenta**, a project from **Google Brain**, is being used to create art and music–anyone can use its **NSynth** tool to generate new music. AI being used in creative fields has some worried, especially since some of the robo-created works seem to appeal to humans as much as flesh-and-blood artists. Creative uses for AI is an important step in advancing the entire body of work and research, as we transition from artificial narrow intelligence to artificial general intelligence.

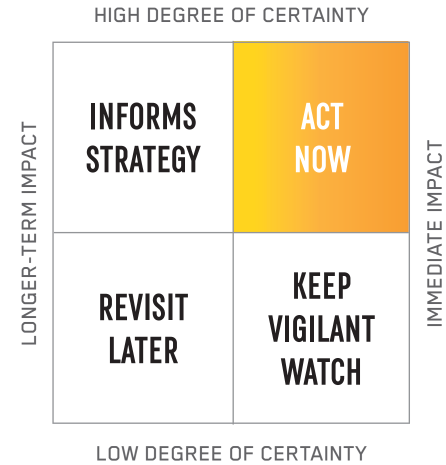
WATCHLIST

Alphabet; Rutgers University; Facebook; College of Charleston; Sony; IBM; Amazon; Baidu; Tencent; Alibaba.



"Break Free" is a song composed by AI and performed by Taryn Southern.

Bots



Chatbots are being used by companies world-wide.

KEY INSIGHT

The term "bot" has become part of our mainstream vocabulary. Bots at the most basic level are software applications designed to automate a specified task. They can be text or audio-based, and deployed across various platforms. News bots can help aggregate and automatically alert a user about a specified event, whereas productivity bots are tools companies use to automate and streamline their day-to-day operations.

EXAMPLES

Bots have now emerged from the fringe and are a fixture in our mainstream vocabulary. And they're not just consumer-facing. Staff at **Lloyds Bank** (UK) and **Danone** (France) use chatbots to access their organization's knowledge base. In 2018, **Google** debuted a prototype of its **Duplex** system, which is a conversational bot that sounds indistinguishable from a human—and makes calls and appointments on behalf of its user.

WHAT'S NEXT

The next big advancement in bots won't be technical in nature—it will be regulatory. During 2018's campaign cycles, we saw a resurgence of botnets—networks of computers designed to send out misleading content. That, coupled with concerns that bots are increasingly leading to deception, led to a new law in California that requires bot to disclose that they are not humans in their interactions with people. The law goes into effect on July 1, 2019 and requires the disclosure to be "clear, conspicuous, and reasonably designed to inform persons with whom the bot communicates or interacts that it is a bot." The success of this new regulation could become the basis for other state and national laws, especially if conversational bots like Duplex reach critical mass within the marketplace.

WATCHLIST

Google; Amazon; Facebook; Jigsaw; Twitter; Instagram; Chatfuel; Pandorabots; Twilio; Amazon; iFlytek; Slack; WeChat; Tencent; Baidu; Weibo; Alibaba; IBM; Microsoft; Snapchat; Coral Project.

Did Your Bot Learn To Be Biased?

For bots to work, they need an initial data set, sets of parameters, and answers. Initially these building blocks are all selected by their human creators, which means that we are training bots in our own image. Before deployment, your organization should pressure-test your bot for bias. Answer these questions to determine, in advance, whether or not you've accidentally encoded bias into your system.

- What are the values of your organization? (If you don't have them in writing, you have some work to do before building your bot.)
- How will you make sure that your bot reflects both the knowledge base and the values of your organization?
- What if your bot interacts with someone (or another bot) whose values run counter to yours and your organization's?
- Is your bot's purpose explicit? Will people interacting with your bot clearly understand what its purpose is after the first few interactions?
- Does the corpus (the initial, base set of questions and answers) you've created reflect only one gender, race or ethnicity? If so, was that intentional?
- How well do you know the training data you're using? If you didn't create it, are you certain it's free of bias
- Does your bot clearly explain where its answers are coming from? Are you able to include any evidence of your reporting, quotes and data?
- Is your bot intuitive and easy to use, either on a designated platform or across platforms?
- Did you assign your bot a traditional gender, ethnic or racial identity? If so, does it reference any stereotypes?
- Does your bot respond to gendered or sexist remarks? Does it respond to racial epithets or religious slurs? If it does respond, are the responses appropriate to people of the targeted group?
- Even if your bot is designed for another purpose, can you still use it to help people learn about their own biases or broaden their worldviews?

On The Horizon: Personal Data Records

One probable near-term outcome of AI is the emergence of a "personal data record," or PDR. This is a single unifying ledger that includes all of the data we create as a result of our digital usage (think internet and mobile phones), but it would also include other sources of information: our school and work histories (diplomas, previous and current employers); our legal records (marriages, divorces, arrests); our financial records (home mortgages, credit scores, loans, taxes); travel (countries visited, visas); dating history (online apps); health (electronic health records, genetic screening results, exercise habits); and shopping history (online retailers, in-store coupon use).

AIs, created by the **Big Nine**, would both learn from your personal data record and use it to automatically make decisions and provide you with a host of services. Your PDR would be heritable—a comprehensive record passed down to and used by your children—and it could be temporarily managed, or permanently owned, by one of the Big Nine. Ideally, you would be the owner of your PDR, it would be fully interoperable between systems, and the Big Nine would simply act as custodians.

PDRs don't yet exist, but from my vantage point there are already signals that point to a future in which all the myriad sources of our personal data are unified under one record provided and maintained by the Big Nine. In fact, you're already part of that system, and you're using a proto-PDR now. It's your email address.

– AMY WEBB

RECOGNITION TECHNOLOGIES

BIOMETRIC SCANNING

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

In 2017, a federal judge allowed a class-action suit brought against Shutterfly for allegedly violating the Illinois Biometric Information Privacy Act.

KEY INSIGHT

Advanced computing systems can now use our unique features—our bone structure, posture, emotional state—to recognize not only who we are, but what frame of mind we're likely in.

045

Faceprints

Faceprint technology is becoming more robust, capable of recognizing people in numerous conditions. Chinese startup Megvii Face++, supported heavily with sovereign wealth funds from both China and Russia, is pioneering faceprint technologies that are secure enough to be used for financial transactions. Face++ is also being used by China's police force for widespread surveillance. Unlike fingerprinting or iris/retinal scanning, which are difficult to do without someone's direct knowledge, faceprints can be taken surreptitiously, even from far away. Researchers at NEC in Japan are taking multiple 3D scans to quickly check a person's face against those catalogued in a registry; it's expected to deploy the system for everyone participating in the 2020 Olympics. Amazon developed new technology to connect doorbell cameras with its facial recognition databases, with the ability to automatically recognize who's at the door and to call police if anyone suspicious is detected.

German researchers are working to create thermal faceprints by taking heat maps of our faces and using machine vision to recognize patterns. Their technology can accurately identify a face—and in under 35 milliseconds, regardless of the amount of lighting or the facial expressions people make. Apple introduced its Face ID system with the iPhone X. It unlocks the phone using infrared and visible light scans to identify the unique characteristics of your face. China's Byton has built an electric SUV that you unlock with a faceprint, rather than a key fob. Researchers in Japan and China are working on representation models that require only a portion of your face, even in low light, to accurately predict someone's identity—even as they chance their hairstyles, get plastic surgery or grow a beard.

We anticipate legal challenges in 2019. In 2017, a federal judge allowed a class-action suit brought against Shutterfly for allegedly violating the Illinois Biometric Information Privacy Act, which requires companies to secure written releases before collecting biometric data, which includes their faces. (This Illinois state law is the only one of its kind in the US.) Facebook is currently fighting a lawsuit in the 9th Circuit, brought by Illinois residents who argue that Facebook allowed their faces to be recognized in the platforms photo-tagging function in violation of the act.

046

Voiceprints

Voiceprints are the set of unique characteristics that make up your individual voice. New machine learning techniques, combined with vast datasets of recorded voices, have now enabled researchers to identify us simply by listening for the microsignatures produced when we speak. **Nuance Communications** is working with auto manufacturers, including **Ford** and **BMW**, to develop more accurate voice recognition in the cockpit. Theoretically, this same technology could be used to detect whether a driver has had too much to drink or is suffering from a health condition, making it unsafe to operate the vehicle. Voiceprints could be used to unlock the door when your arms are full of packages—and to help digital assistants, such as **Alexa**, customize interactions for each member of your family. Researchers at **Carnegie Mellon University** discovered a generative technique allowing them to build a 3D version of someone's face using only their voiceprint. This system is being deployed by law enforcement agencies to identify prank callers and those who trick local agencies into sending out S.W.A.T. teams to take out retaliation or revenge on others.

047

Gesture Recognition

Gesture recognition technologies are now capable of interpreting motion to identify us and make decisions on our behalf. Emerging gesture recognition systems represent Natural User Interfaces (NUIs), and they are an important component for the future of many different technologies. Imagine picking up a digital object with your hand, or controlling a remote robotic arm without being tethered to a bunch of wires. Gesture recognition unlocks the interplay between our physical and digital realms. **Leap Motion** came to market early with a desktop controller that allowed users to control their computers using finger and hand gestures, and in early 2019 **Google** won approval from the **Federal Communications Commission** to run its **Project Soli** hand tracking technology on commercial aircraft. (Project Soli is part of **Google's Advanced Technology and Projects group**, which also developed the **Project Jacquard** connected clothing system found in **Levi's** Commuter Trucker jackets.) A decade before **Microsoft's Kinect** successfully delivered an NUI for gaming, the company revealed a **Skinput prototype**, allowing users to tap their skin to control a computer. **DJI**'s latest drones can be triggered to fly and to take photos using gestures (and without needing the remote control). In 2019, we'll see more NUIs that allow us to control machines through our body movement alone. We'll also start to see applications in the workplace that record our body movement to predict when we're most productive. It could also help security learn when we might cause harm to others.

048

Personality Recognition

Emerging predictive analytics tools wrangle your data, behavior and preferences in order to map your personality—and predict how you're likely to react in just about any situation. In 2018, you heard plenty about this kind of predictive analytics: **Cambridge Analytica** used algorithmic profiling to help Donald Trump win the election. Political candidates, law firms, marketers, customer service reps and others are beginning to use new systems that review your online behavior, emails and conversations you have by phone, and in person, to assess your personality in real time. The goal: to predict your specific needs and desires. **ElectronicArts** is working on a system that assesses the personality of its multiplayer video game users to do a better job of matching players, using their play style, conversational style, and willingness to spend money. In the real world, insurance underwriters are attempting to assess your personality—via your magazine and website subscriptions, the photos you post to social media, and more—in order to determine how risky an investment you are. Some lenders have used personality algorithms to predict your future financial transactions. (The data show that if you look at two people with the same professional and personal circumstances, the one with a higher college G.P.A. will be more likely to pay off a debt.)

049

Emotional Recognition

Last year, **Amazon** filed a patent for a new system that detects the physical and emotional wellbeing of users based on their previous and current interactions. If it detects you're sick, Amazon suggests cough drops with one-hour delivery. Auto manufacturer **Kia** debuted its **Real-time Emotion Adaptive Driving System** (R.E.A.D.) at **CES** in 2019—it's a recognition system that adapts vehicle interiors to a passenger's emotional state by using sensors to monitor their facial expressions, heart rate and electrodermal activity.

050

Bone Recognition

In 2018, the **US Air Force** applied for a patent that explains how wideband RADAR can be used to identify people by their bone structure. A transmitting antenna sends a signal to a human, and that person's biometric radar signature is compared against known signatures in a database. This is especially bad news for people with screws and metal bars in their bodies, which may be invisible to everyday people but turn into clear beacons when scanned.

Biometric Scanning cont.

Real-time recognition systems scan and identify people by their bone structures.

051

Genetic Recognition

The popularity of consumer DNA testing may help people learn more about their ancestry, but it's also making it easier to recognize people without their express permission or knowledge. It is now possible to identify about 60% of people in the US who are of European descent, even if they've never sent in a sample to 23andMe, Color, AncestryDNA or any of the other testing services now available. That's because raw biometric data can be uploaded to open-source databases like GEDmatch, which allows users to look for relatives across all of the other DNA platforms, and because the pervasiveness of other websites (Facebook, government databases) which allow us to search on lots of different data points. In addition, data shared with consumer DNA services might be used by third parties legally, and without your consent. Last year, 23andMe received $300 million to share its data with pharmaceutical company GlaxoSmithKline.

052

Universal Genetic Databases

The proliferation of consumer DNA testing services offers significant, untapped potential for myriad industries and fields, including insurance, pharmaceuticals and law enforcement. As a result, there is a new effort underway to collect and structure all of this data so that IT is more easily accessed. What's unclear: under what circumstances third parties should be able to pull and use genetic data housed in private databases. The governments of Saudi Arabia, Kuwait, the UK and China have been researching whether to create a universal database populated with the genetic information of its citizens.

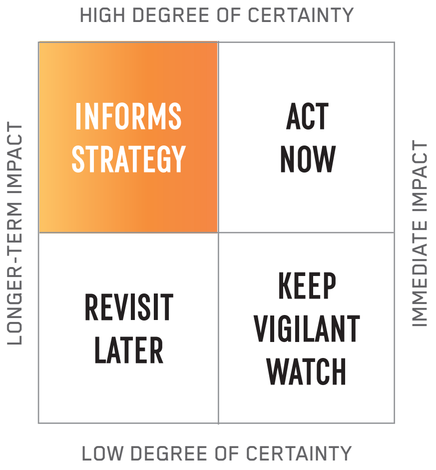
SCENARIO

Biometric Camo

In the near future, privacy-conscious consumers will seek out biometric camouflage to evade recognition algorithms. The market is wide-open for new products. Foundation, concealers, rouge, lipsticks and eye shadows that look no different to us, but which are formulated to trick recognition algorithms. Glasses with special lenses that cause a glare when viewed by a camera. Scarves, gloves and hats that confuse recognition systems.

– FUTURE TODAY INSTITUTE RESEARCH TEAM

Behavioral Biometrics



KEY INSIGHT

Quantifying and analyzing our biometric data can reveal patterns in our activities—and as a result reveal a lot about who we are, what we're thinking, and what we are likely to do next.

EXAMPLES

We're shedding data just by virtue of being alive in 2019. Our eyes, posture, unique bone and capillary structures, and our voices can be used to recognize who we are, but all of that data can also be studied and analyzed to reveal what about us is different. Behavioral biometrics tools can be used to map and measure how you type—what force you use to press down on screens, whether you fat finger your C's and V's on your phone, and how quickly you tend to flick your fingers when hunting through search results. Those tools know your unique typing pattern on a physical keyboard, too: if you're someone who constantly spells the word "behavioral" wrong on the first try, and whether you hold down or repeatedly tap on the delete button. You're not consciously aware that you have certain identifiable behaviors, but they are perceptible to machines.

WHAT'S NEXT

We don't think of our behaviors as identifiable markers, and that will pose security vulnerabilities – as well as interesting new opportunities – in the near future. Imagine never having to use a password again; your bank would simply recognize it's you after typing a few sentences. The downside is that if your behavior is observable, at some point it will become repeatable, too.

WATCHLIST

BioCatch; CrossMatch; ThreatMetrix; Electronic Frontier Foundation; World Privacy Forum; American Civil Liberties Union; banks.

We're shedding data just by virtue of being alive in 2019.

WiFi Recognition

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	INFORMS STRATEGY	ACT NOW	IMMEDIATE IMPACT
	REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

WiFi transmitters in homes, offices and cities will be able to track your movements soon.

KEY INSIGHT

WiFi and radio waves can now be used to track our physical movements and our emotional states.

EXAMPLES

The WiFi transmitter in your home or office is continually sending and receiving information, which it converts into radio waves. The signals aren't very strong, only filling up the space around you (and possibly just outside to the street). It turns out that with the right device, it's possible to watch us walking through the signals as they bounce off us and onto other objects. What this means in practice: WiFi signals can be harnessed to recognize us through our walls. MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) and Massachusetts General Hospital developed a device that uses an advanced AI algorithm to analyze the radio signals around someone when they're sleeping. The system then translates all of their body movements into the stages of sleep: light, deep or REM (rapid eye movement). Imagine a future in which your WiFi router collects your physical movements, then calculates your health metrics, and automatically adjusts the devices and appliances in your house to help you live a better life? If you're snoring, your pillow could automatically inflate or deflate. In 2016, a different CSAIL team built a WiFi device that could read human emotion using a wireless router. Called EQ-Radio, it successfully detected emotions without disturbing the person being monitored.

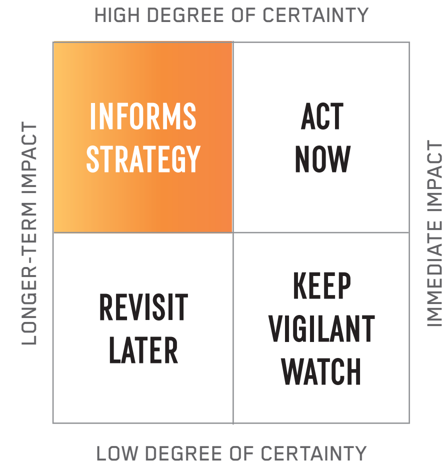
WHAT'S NEXT

CSAIL researchers had previously found that they could track people using WiFi. But last year, they were able to generate a dynamic skeleton of someone, showing their posture and movements in real time using WiFi. Practical applications range from motion capture for video gaming to allowing law enforcement and military to see past walls.

WATCHLIST

MIT; Massachusetts General Hospital.

Ambient Tracking



KEY INSIGHT

Smart technologies can be programmed to push or receive information to/ from our devices—and also our bodies—tethering us to an always-on information network.

EXAMPLES

In the late 1980s, **Ericsson Mobile** experimented with short-link radio technology, but it would take a decade for mobile service providers to create the industry standard known as **Bluetooth** today. Our current Bluetooth standard was developed for the internet of things—which is why you're hearing so much about beacons, which are tiny devices that broadcast a signal and trigger actions based on proximity. **Target** has outfitted hundreds of its stores with beacons, which track consumers as they move around various parts of the store. **The Guggenheim** uses beacons to help attendees learn about exhibits. Beacons are widely used in infrastructure and public transit systems.

WHAT'S NEXT

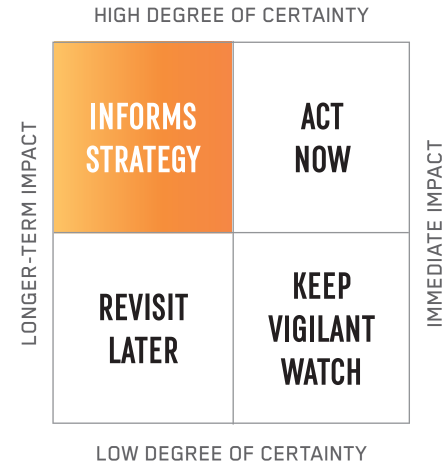
We are likely to see new consumer applications during 2019 as proximity networks become more mature. We anticipate that our personal data, combined with data from everyday items in the physical world, will entice developers to build new uses for ambient proximity in the coming years.

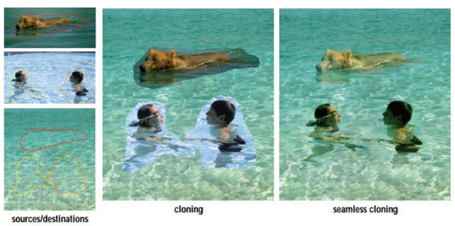
WATCHLIST

Google's Eddystone; Apple's iBeacon; Estimote; Kontakt.io; Gimbal; BlueCats; Gelo; BLIP Systems; Glimworm Beacon; Sensorberg GmbH; Accent Advanced Systems; Aruba Networks; Amazon; Qualcomm; Polytechnical University (China); MIT; University of New South Wales (Australia); Oxford University; National Emergency Address Database.

Retailers are using beacons to help shoppers.

Computational Photography





Alex Berg, an associate professor at UNC Chapel Hill, shows image compositing and painting using gradient domain processing.

KEY INSIGHT

Computational photography is the convergence of computer vision, computer graphics, the internet and photography. Rather than relying on optical processes alone, it uses digital capturing and processing techniques to capture real life.

EXAMPLES

Everyone with a smartphone now has access to computational photography tools. In its iPhones, Apple uses computational photography to achieve a shallow depth of field, while Facebook corrects any 360-degree photos you upload. Called EQ-Radio, it successfully detected emotions without disturbing the person being monitored.

WHAT'S NEXT

New research from **Nvidia** and the **University of California-Santa Barbara** reveal a computational zoom technique, which allows photographers to change the composition of their photographs in real time. Photos are taken in a stack, and then rendered with multiple views. This would allow photographers to change perspective and the relative size of objects within a photo after it has been taken. Other use cases of computational photography include seamlessly removing or adding objects to scenes, changing shadows and reflections, and the like. Meanwhile, **MIT's CSAIL** and **Google** developed a technique that now automatically retouches and enhances the photos we take with our mobile phones. Clearly there are ethical implications here for journalists—how much editing should be allowed and under what circumstances? Likewise, journalists should develop techniques to reveal how much editing has been done to a photo—either intentionally or automatically—before using them for reporting or in stories.

WATCHLIST

MIT's CSAIL; MIT's Media Lab; Nvidia; University of California-Santa Barbara; Google; Apple; Samsung; Facebook; Synopsys; Industrial Light and Magic; LG; Huawei; Morpho; Qualcomm; Stanford University Computational Imaging Lab; the Gcam team at Google Research.

Talking is the New Typing

- In 2019, 40% of US households will own a smart speaker.
- 72% of smart speaker owners say that their devices are now a part of their daily routines.
- By 2020, people will use voice for half of all searches they perform.
- 25% of smart speaker users have made a purchase by voice.
- 45% of people put their smart speakers in their living rooms, followed by 41% in the kitchen, 36% in the bedroom, and 6% in the bathroom.

Sources: Future Today Institute modeling; Edison Research; Google; Amazon; Voicebot.

Synthetic Voices

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

It's now possible to generate and use a synthetic voice.

KEY INSIGHT

Generative algorithms are creating synthetic voices that sound just like the original.

EXAMPLES

Montreal-based AI startup **Lyrebird** built a voice imitation algorithm capable of generating fake speech that sounds imperceptible from the real thing. It uses a database of voice samples that are either available in public repositories (**YouTube, Vimeo, Soundcloud**) or samples uploaded by the user. The AI learns over time to recognize not only intonation, but also emotional cadences. In a public demonstration, Lyrebird convincingly mimicked Hillary Clinton as well as presidents Trump and Obama.

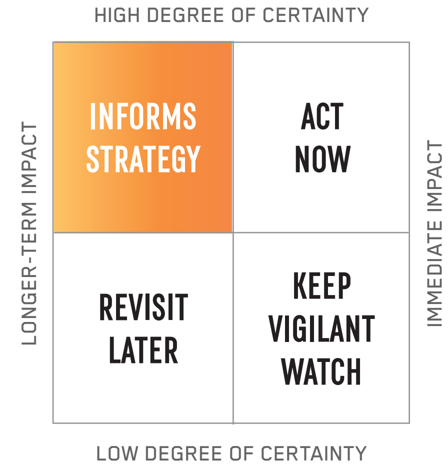
WHAT'S NEXT

This technology can be fun to play with. You can fake a conversation between yourself and your favorite celebrity, provided there are enough publicly-available audio files to build a dataset. Soon, it will be able to match and rapidly deploy synthetic voices personalized for each individual consumer. **Y Combinator**-backed **Voicery** creates bespoke voices for brands. If you are someone who loved Pee-Wee's Playhouse, you might hear Miss Yvonne's voice (or Jambi's) during a car commercial. Bu we should remember that in this era of misinformation, synthetic voices can also be used to trick unwitting consumers.

WATCHLIST

Lyrebird; Amazon; Y Combinator; MIT's CSAIL; MIT's Media Lab; Voicery; Samsung; Facebook; Apple; Google; Microsoft; Baidu; Alibaba; Tencent; IBM; Voicery.

Persistent Recognition



KEY INSIGHT

We are surrounded by cameras, speakers and a host of other smart devices that monitor us in real-time, all the time.

EXAMPLES

Amazon has filed for a number of patents that will give its virtual assistant Alexa superpowers: the ability to recognize whether we are sick or if we're angry. That information, combined with background noise and our location (not to mention a host of other data points, like our gender, age, and accent) could be used to target consumers for marketing. But it also reveals a new trend in recognition technologies: persistent recognition. We are continuously being recorded. Our data are mined and refined by the smart speakers in our homes and offices, the doorbell cameras and security systems wired to our entranceways and buildings, the monitoring algorithms in our cars, the anti-fraud technologies employed by our financial institutions and websites.

WHAT'S NEXT

Governments, law enforcement agencies and others are interested in getting access to all of this data for a variety of reasons. In every country, privacy law lags significantly behind technology, which would prove challenging in the years to come.

WATCHLIST

Amazon; Google; Apple; IBM; Baidu; Tencent; Alibaba; Facebook; Microsoft; Electronic Frontier Foundation; American Civil Liberties Union; European Union; government agencies worldwide.

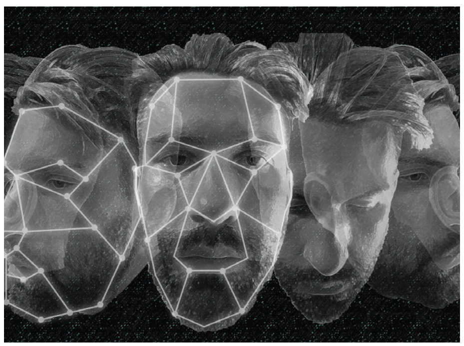
In 2019, we are constantly being monitored.

Bias in Recognition Technologies

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



The National Institute of Standards and Technology's Face Recognition Vendor Test—performed in the 2010, 2014 and 2018 evaluations—judged how well an algorithm could match a person's photo with a different one of the same person stored in a large database.

KEY INSIGHT

By now, it's no secret that some of our machine learning models—and the data they use to recognize others—are encoded with bias. That's because the people who built the models are themselves subject to unconscious bias, as well as more explicit homogeneous learning and working environments. The tech industry still doesn't have a plan for how to address and solve for bias in recognition systems.

EXAMPLES

In 2018, the **MIT Media Lab** published a study showing that some of the most common facial recognition algorithms had error rates that were up to 35% higher for darker-skinned people. Some companies have been working independently to address the problem, but there are no industry-wide norms, standards or even benchmarks that address recognition across a spectrum of people.

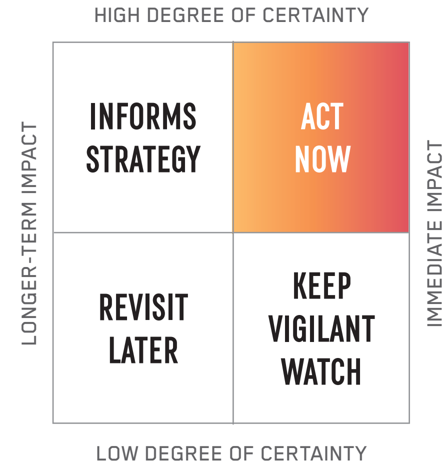
WHAT'S NEXT

Google, IBM, Microsoft and **Amazon** have taken steps to test for bias in the past year, making incremental improvements. However it is likely that algorithmic bias is a problem that will get worse, especially as more recognition technologies are used in law enforcement and within the justice system. One solution might be for companies to either adopt or build on the **National Institute of Standards and Technology's Face Recognition Vendor Test**, which tests the accuracy of facial recognition systems under different circumstances and rates performance.

WATCHLIST

Amazon; Google; IBM; Microsoft; Alibaba; Tencent; Apple; Baidu; Facebook; YouTube; PredPol; Fluidinfo; Omega Group; LexisNexis; Azavea; Motorola; Zuercher; Investigative Reporters & Editors; National Institute for Computer-Assisted Reporting; Coral Project; Stanford Computational Journalism Lab; Duke University; University of British Columbia; University of Texas at Austin; Brown Institute at Columbia University; Tow Center for Digital Journalism at Columbia University.

SECURITY, PRIVACY AND DATA



SECURITY

SamSam has been targeting entire cities with elite hacking attacks.

KEY INSIGHT

2018 was a brutal year for hacks and breaches. In 2019, you can expect more corporate and municipal attacks, sophisticated new tools, targeted IoT ransomware and forays into biometrics.

060

Insecure Supply Chains

Security expert Bruce Schneier has been warning of an ongoing problem: the supply chain is insecure. Consumers aren't willing to pay for security features or ugrades, while product manufacturers aren't as strict as they could be in safeguarding the integrity of every single component that goes into the systems we use. It's been cheaper to fix hacks after they happen and to ask for forgiveness rather than to address the problem in advance. But as hackers grow more sophisticated and more of our appliances, systems and databases are connected, we ought to think about the downstream implications of insecure supply chains in our infrastructure, hospitals, power grids – even our kitchens.

061

Data Theft Becomes Data Manipulation

Rather than malicious actors simply stealing data, in 2019 you can expect to see new kinds of attacks in which hackers access and then manipulate data for long-term damage. The implications are more concerning than you might realize at first: if a company's data integrity comes into question, it could lose customers and partners quickly.

062

Consumer Device Targeting

With the proliferation of IoT devices - connected speakers, mirrors and fitness gadgets - hackers have a wellspring of new targets in 2019. Attackers might hijack your smart TV for ransom the day before a big televised event (Eurovision, the Super Bowl, the Game of Thrones premiere) and refuse to unlock it until you've paid a fee.

063

AI-Powered Automated Hacking

Thanks to advancements in AI, one of the big trends in security is automated hacking—in short, software that's built to out-hack the human hackers. The **Pentagon**'s research agency **DARPA** launched a **Cyber Grand Challenge** project in 2016, with a mission to design computer systems capable of beating hackers at their own game. DARPA wanted to show that smarter automated systems can reduce the response time—and develop fixes in system flaws—to just a few seconds. Spotting and fixing critical vulnerabilities is a task that might take a human hacker several months or even years to complete, and yet the machine that won the Grand Challenge proved its might in just a fraction of the time. The winner became the first non-human entity to earn **DEF CON**'s black badge, which is the hacking community's equivalent of an Oscar. Very soon, malicious actors will create autonomous systems capable of automatically learning new environments, exposing vulnerabilities and flaws, and then exploiting them for gain—or whatever the stated objective, which could simply be generalized mayhem. In 2019, we will see newer techniques, advanced learning algorithms and a strange new playing field.

064

Cyber Risk Insurance

New forms of insurance, intended to help businesses protect against hackers, will begin to enter the marketplace. Rather than simply covering the theft of basic information, insurers will also offer protection against damage to reputation, the loss of operational capacity, and the costs for system upgrades.

065

Offensive Government Hacking

2019 marks the tenth anniversary of the **US** and **Israel** joining forces to deploy a devastating worm known as **Stuxnet**, which took down parts of Iran's covert nuclear weapons program. Rather than simply pursuing cyber deterrence, governments are more actively engaging offensive positions. **Singapore's Ministry of Defense** is hiring white hat hackers and security experts to look for critical vulnerabilities in its government and infrastructure systems. In the US, the two agencies responsible for cyberwarfare—the **US Cyber Command** and the **National Security Agency**—are playing offense, especially as artificial intelligence becomes a focus for US cyber strategy. Both are looking to a future in which artificial intelligence enhances offensive operations and replaces human troops—but in the meantime, there's a shortage of gifted hackers willing to join government ranks. That's due in part to a bad public image in the wake of **Edward Snowden**. However since the US is already facing a severe shortage of cybersecurity workers—upwards of 270,000 jobs are still unfilled—skilled hackers can command lots of perks and big paychecks outside of the government.

066

More Cyber Mission Forces in the Field

In the summer of 2016, the **US military** began deploying its **Cyber Mission Force**. By May 2018, all 133 of the command's mission force teams achieved full operational capability. These are units of civilians and military personnel, and they are charged with protecting military networks from cyber intrusions and our national infrastructure. Some of the units also support combat missions. But many within the mission argue that to fully realize its potential, a different organizational approach is necessary. The current structure and titles in the military don't mesh with the realities of cybersecurity and how hacker networks operate.

067

Hijacking Internet Traffic

In November 2018, hackers created a massive internet traffic diversion, rerouting data through **China, Nigeria** and **Russia**. It disrupted Google, taking its business tools offline, slowing down search and making its cloud unreachable. It was an example of Border Gateway Protocol (BGP) hijacking and while in this case the error was the result of an outdated Nigerian ISP, the incident points to a vulnerability in our web infrastructure. The protocols underpinning the WWW were written long before we had connected microwaves and billions of daily users.

068

DDoS Attacks Will Increase

A Distributed Denial of Service Attack (DDoS) attack happens when a hacker sends so many requests to a battalion of machines that the entire network goes down. In the past several years, the number of DDoS attacks have spiked – and they are increasing in both breadth and duration. In Q2 2018, there was a 35% increase in attacks compared to the previous quarter. Last year, one attack lasted 12 days, and while multiday attacks aren't as common as their shorter cousins that tend to last a few hours, they are on the rise. To date, half of the world's attacks have originated in **China**. Hackers are using more sophisticated tools, which means that future attacks will be larger in scope and could achieve greater impact.

069

Compliance Challenges and Unrealistic Budgets

The historical tension between security and privacy will unleash new challenges in 2019 and beyond. Consumers are shedding more data each day, and as more connected devices enter the marketplace the volume of available data will balloon. Yet those organizations creating devices and managing consumer data aren't planning future scenarios. Off-the-shelf compliance checklists won't cut it going forward. Managers will need to develop and to continually update their security policies—and they'll need to make the details transparent. Most organizations aren't devoting enough budget to securing their data and devices. Or-

Security cont.

In 2018 Marriott experienced one of the worst data breaches in corporate history.

ganizations that haven't carved out enough budget for IoT security will find themselves dealing with vast recalls, remediation and lawsuits.

070

Ransomware as a Service

In 2018, ransomware software named **SamSam** collected $1 million – and it wasn't the only successful attack. Financial services and healthcare organizations are facing the brunt of ransomware attacks, which are targeted because the data and services they provide are so valuable. In **England**, WannaCry shut down the computers in 80 medical centers, which resulted in hospitals diverting ambulances and 20,000 cancelled appointments. Hackers deploy malicious tools to hijack data, effectively locking out systems and devices, until a fee is paid. Since cash and online bank transfers are easy to track, the currency of choice is now bitcoin, which moves through an encrypted system and can't be traced. The emergence of the blockchain and cryptocurrencies have transformed ransomware into a lucrative business. Simply backing up your data probably won't be enough of a failsafe going forward. Researchers have already found "doxware" floating around the internet—rather than simply holding your data hostage until you pay up, they threaten to publish it all to the web, for everyone to see.

071

Biometric Malware

In 2018 we saw the emergence of new malware specifically targeting biometric authentication. The tool scrapes photos from social media and uses them to launch sophisticated phishing attacks. In Brazil, bank customers were targeted by CamuBot, and it was able to bypass biometric hardware protections for device takeover.

072

Russia Bolsters Cyber Warfare Efforts

It's now well known that Russian hackers targeted more than 20 US states' voter registration databases, and there is evidence that the Russian government had a long list of targets that went far beyond American politicians running for office. Thousands of people, from defense contractors at **Lockheed Martin** and **Raytheon**, to **Ukrainian lawmakers**, to the **Pope** and his executive team, were targeted. **Russia** is home to some of the world's most gifted and prolific hackers. Outside state-sponsored cyber warfare initiatives, there are plenty of talented people who are motivated both by a lack of economic opportunity and weak law enforcement. Over time, this has created a perfect storm: enormously talented people, weak laws and poor economic conditions have led to a growing pool of talented hackers.

073

China Reveals More Cyber Warfare Tactics

Elite hackers in **China** spent 2018 carrying out some of the biggest and most damaging breaches in history, including the **US Navy Contractors** and **Marriott**. They haven't just been hunting down individual people or companies—they're targeting managed service providers that provide IT infrastructure. And they aren't necessarily covering their tracks as they did in the past. **FBI director Christopher Wray** said in a press conference last year that "no country poses a broader, more severe long-term threat to our nation's economy and cyber infrastructure than China."

074

New Infrastructure Targets

This year, cybercriminals will target critical infrastructure and facilities around the world. Security experts have been warning that hackers would be able to disable dams, power plants and traffic lights, and now it seems as though our day of reckoning is here. In 2018, it was publicly acknowledged that **Russia** targeted critical infrastructure sectors in the US, including the power grid—though they've been trying to gain access since at least 2016. They were able to gain access to one power plant's control system. Late in 2017, security firm **FireEye** discovered a new form of malware called **Triton**, which had taken control of an energy plant in the **Middle East**. In a separate attack, hackers attacked **Ukraine**'s power grid using malware called **Industroyer**. Cybersecurity company **Symantec** has warned that hackers have already penetrated the **US power grid**, targeting staff at nuclear energy facilities with phishing attacks. The **US Computer Emergency Readiness Team** issued a sternly-worded notice, but a lack of an enforcement mechanism, it's clear that the companies and utilities managing our critical infrastructure haven't yet been jolted into action.

The tech industry is having an existential crisis about the internet. Continue with its current business model, or begin to develop newer models that give users greater control over their own data.

075

Hacktivism Rising

Hackers-turned-activists have had a busy few years, working for causes they believe in. They launched DDoS attacks against governments, corporations and banks. They infiltrated the **campaigns** of both **Hillary Clinton** and **Donald Trump**. Hacktivist organizations, including **Anonymous**, **WikiLeaks** and **DC Leaks**, see themselves as durable forces of change. Glamourized by the TV show Mr. Robot, hacktivism is on the rise, and given heated political tensions during a year in which many elections are being held, we'll likely see more operations being carried out. Hacktivists will use their skills to help shape local, state, national and international politics, conversations and business practices.

076

Third-Party Verified Identities

In the US, citizens must continually hand over their social security numbers for authentication. But in the wake of the massive **Equifax data breach**, it has become clear that our social security numbers—a single identifier used in everything from our bank accounts, to our health insurance, even the university registrar–isn't secure. Social security numbers were never intended to be used as general-purpose passwords. We will start to see the emergence of third-party, non-governmental providers of verified identities. One example that's already in the marketplace is **CLEAR**, the trusted traveler program that lets verified customers get through airport security faster.

077

Targeted Attacks on Digital Assistants

Now that digital assistants (DAs)—**Alexa, Siri, Cortana, Google**—have moved from the fringe to the mainstream, we can expect to see targeted attacks. Flaws in Cortana were discovered independently by professors at **Technion Israel Institute of Technology** and researchers at **McAfee** in 2018, while security testing from **Checkmarx** developed an Alexa skill that allowed potential hackers to make Echo listen continuously. (Amazon fixed the vulnerability as soon as it was notified.)

078

Zero-Knowledge Proofs Go Commercial

With all of the hacking scandals that have plagued us in the past several years, we will see a transition to something called "zero-knowledge proofs," which allows one party to verify data without conveying any additional information (like how or why the mathematical statement is true). It's a mind-bending approach to security, allowing you to verify your identity without actually revealing who you actually are. In essence, this eliminates the need for a company to store private identity data during the verification process. Zero-knowledge proofs aren't new, but deploying them to protect our credit cards and online identities is an emerging application. **JPMorgan Chase** is using zero-knowledge proofs for its enterprise blockchain system, while cryptocurrency startup **Ethereum** are using zero-knowledge for authentication. Irish startup **Sedicii** now has zero-proof software in the marketplace. Researchers at **Microsoft** and **Princeton University** are working on a zero-knowledge proof so that inspectors can identify something as a nuclear weapon without requiring them to take it apart, which would spread information about how to build one.

079

Zero-Day Exploits On The Rise

A zero-day vulnerability is a flaw—a problem within a hardware or software system that developers didn't discover during the testing process. That vulnerability can be exploited by malware to cause all sorts of problems. Zero-days are dangerous, prized tools and discovering them is a favorite activity of malicious hackers. Once the flaw is revealed, programmers have

Security cont.

zero days to do anything about it. There are a number of zero-day exploits that have been lying dormant for years—we learned about two late in 2017. A flaw found on chips made by **Intel** and **ARM** led to the realization that virtually every Intel processor shipped since 1995 was vulnerable to two new attacks called **Spectre** and **Meltdown**. Earlier, the Italian spyware maker **Hacking Team** (HT) helped bring zero-days into the spotlight when it was found selling commercial hacking software to law enforcement agencies in countries all over the world. Data leaked from HT, along with a massive dump of 400 gigabytes of internal emails, revealed a number of zero-day exploits. The HT breach helped to shine a light on a growing zero day marketplace, with some exploits being sold for as much as $500,000. Tools to exploit vulnerabilities will be in greater demand throughout the near future.

080

Backdoors

In the wake of the deadly **San Bernardino** attack in December 2015, the **FBI** and **Apple** found themselves debating so-called **"backdoors"** in public. The FBI demanded that Apple unlock the assailant's phone, and Apple refused, arguing that creating a software update to allow a backdoor would endanger the privacy of us all. It's a debate that was never settled—and we'll likely see more cases pitting government agencies against big tech companies in the years to come. While they sound malicious, backdoors aren't necessarily bad. Often, developers intentionally install them into firmware so that manufacturers can safely upgrade our devices and operating systems. The challenge is that backdoors can also be used surreptitiously to harness everything from our webcams to our personal data. Given the rise of zero-day exploits, we should question whether backdoors are the best way forward. Government officials worldwide have been advocating for a set of **"golden keys,"** which would allow law enforcement to break through the security using backdoors. But even without public agreement, some agencies may find their way into our machines. In 2013, the **US National Security Agency** made a deal with security company **RSA** to include a flawed algorithm, effectively giving the NSA a backdoor into various systems. The challenge is that the simple act of creating a backdoor would leave ordinary people vulnerable to everyday attacks by a wide swath of actors, benevolent and malicious.

081

Remote Kill Switches

As our technology becomes more immersive, we'll have increased needs for remote kill switches. Kill switches, found on smartphones and connected devices, will soon come in handy for the enterprise and for government agencies. **Uber** developed its own software program called **Ripley** that could be activated by staff in San Francisco, should any of its overseas offices be raided by police. It also deployed **uLocker**, a remote kill switch that could lock all company devices, including laptops and phones. On the consumer side, both **Apple** and **Android** now allow users to remotely wipe all the information on their phones and tablets using a web interface. The benefit would come with a cost, however. Kill switches would mean that nobody could gain access to what's inside a lost or stolen phone—not even law enforcement.

082

Global Cybersecurity Pacts

Late in 2018, more than 50 countries signed an international agreement on cybersecurity principles. Along with those countries and more than 200 companies, some Big Nine companies including **Microsoft, Google** and **Facebook** were signatories to a commitment to end malicious cyber activities in peacetime. While the agreement was non-binding, it was an attempt to develop norms and standards for the ways in which countries behave in cyberspace. Noticeably absent from the list of signers: **Russia, China, North Korea, Israel** and the **United States**.

083

Strange Computer Glitches Will Keep Happening

Glitches are the new normal in 2019. They are problems that don't have an immediate, obvious cause but nonetheless can cause frustrating problems. **Tesla** missed its 2017 Q4 delivery target for its Model 3 due, in part, to technical glitches on the assembly lines. In the past year, **Barclays, JPMorgan Chase, Bank of America** and **HSBC** all experienced technical glitches that prevented customers from accessing account information, and in some cases, wouldn't allow them to made deposits or withdraw money. Spaceflight startup **Rocket Lab** failed to launch during a 10-day window due to unforeseen technical glitches. Glitches often have to do with degraded network connectivity or a miscalculation of the bandwidth needed. But a lot of times, glitches result from newer technologies, which we are learning break in unexpected ways.

084

Proliferation of Darknets, Aided By Cryptocurrencies

Many people confuse the deep web—hidden parts of the Internet that aren't usually indexed by search engines—with darknets, which are niche spaces promising anonymity often for illegal activities. People go there to sell and buy drugs, guns, ammunition, security exploits (malware, ransomware) and your hacked data (passwords, credit card numbers and more). Cryptocurrencies have fueled activity in the dark corners of the internet, since they're encrypted and make tracking transactions nearly impossible. You can't just hop on to a darknet the way you **Google** your high school sweetheart. To access the hidden crime bazaars, you need special software such as **Tor** or **Freenet**, you need to know where you're headed, and you do need a bit of technical knowledge. It isn't illegal to take a walk through dark marketplaces. But there's plenty of good activity that takes place: whistleblowers hoping to shine a light on wrongdoing, political dissidents looking for asylum, and investigative journalists hunting down leads. As cryptocurrencies gain popularity and as the ecosystem blossoms to include more than just **Bitcoin**, we're likely to see more activity in darknets. Activists with legitimate concerns will advocate for new layers of protection, while law enforcement will receive training on how to navigate the dark web. For government and law enforcement, the challenge of training is that it is static. Those accessing darknets are typically also the ones building them.

085

New Open Source App Vulnerabilities

Early in 2019, the **EU** offered $1 million in bug bounties for open source software. Why? The **OpenSSL** bugs like **Heartbleed** caught the government's attention. In 2017, a data scientist revealed a new kind of malware that was capable of infecting an open AI system like **OpenAI Gym**, which is **Elon Musk**'s open-source toolkit for machine learning algorithms. It's just one example of a booming market for malicious tools that exploit vulnerabilities in open source applications and software. As the AI ecosystem grows to incorporate more open source code and community-built tools, it will be especially important to spot problems in advance. Many organizations use open source tools, and in the coming years they will need to perform daily–not occasional–security checks.

086

Bounty Programs

The past several years have been dramatically successful for hackers. Security expert **Brian Krebs** says that the "market for finding, stockpiling and hoarding (keeping secret) software flaws is expanding rapidly" and went so far as to advocate for a compulsory bounty program. In response, a number of white hat (read: good hacker) bug bounty programs are becoming popular. In some cases, businesses solicit friendly hackers for paid work through platforms like **HackerOne**, which is being used by the **US Department of Defense, Wordpress, Coinbase, Shopify** and **GitHub**. The DoD has launched programs, including **Hack the Army, Hack the Pengaton** and **Hack the Air Force**, for the purpose of revealing problems. (It paid out $10,000 to two hackers, which was an unprecedented fee paid by the government for this kind of work. In 2018, **Facebook** paid its single largest bounty ever: $50,000.

087

Magnetic Tape Supply Problems

It's odd to think that in 2019 the world still relies on magnetic tape – those clunky old cartridges that were used decades ago to store data. And yet that's still the preferred method of backups for many companies needing to safeguard their most precious information. Our critical financial data and scientific records may be kept on cloud servers at **Microsoft, Amazon** and **Google**, but duplicate copies are backed up to tape. The problem is that consolidation has left us with just two companies – **Sony** and **Fujifilm Holdings** – who still manufacture tape. Tape isn't a big business unit within these otherwise sprawling companies, and they're constantly battling in court over patents. This could lead to problems down the road for the world's data archives, especially given that the amount of critical data created every year increases significantly.

With luck, I might even be able to crash the whole damned system. Destroy all records of ownership. Think of it, Marty. No more rich people, no more poor people, everybody's the same, isn't that what we said we always wanted?

– Cosmo, in Sneakers

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A glossary of important security terms for 2019

Advanced Persistent Threat (APT)
A targeted attack characterized by an attacker (sophisticated or not) who has the time and resources to plan an attack on a network. APTs are not random.

Adware
Software that automatically generates online ads; it can also include spyware that tracks your browsing habits. It's because of adware that many people are turning to ad blocking software. (see the earlier "Blocking the Ad Blockers" trend.)

Anonymizing proxy
These are special tools that allow users to bypass security filters in order to access blocked websites.

Anonymous
A collective of hackers, best known for its use of the Guy Fawkes mask and distributed denial of service (DDoS) attacks. Anonymous typically uses the hashtag #Ops when announcing a new campaign. Past ops included a takedown of the Church of Scientology and the Westboro Baptist Church.

Attribution
Researching and tracking back the origins of an attack

Autorun worm
Worms are malicious programs that take advantage of vulnerabilities in the Windows OS AutoRun feature. They're often distributed on USB drives. (As a safety measure, Microsoft sets AutoRun to off by default.)

Backdoor
Developers intentionally install backdoors into firmware so that manufacturers can safely upgrade our devices and operating systems. The challenge is that backdoors can also be used surreptitiously to harness everything from our webcams to our personal data.

Black hat
A malicious hacker; someone who hacks for personal gain.

Bot
Bots are automated programs that performs a simple task. Some-–simple chatbots, for example-–are completely harmless. Other bots can be programmed to repeatedly guess passwords so that a hacker can break into a website.

Botnet
A botnet is a group of computers that are being controlled by a third party, and are being used for any number of nefarious purposes. For example, malware installed on your computer can run, undetected, in the background while hackers use your machine as part of a large spamming network.

Browser hijacking
This attack changes a user's default homepage and search engine without permission, often in order to gain clicks to websites for ad revenue or to inflate a page's ranking.

Brute force attack
This type of attack is a laborious, methodical process where a hacker uses software to automatically guess every password it can to gain unauthorized entry into a network or computer.

Bug
A flaw or problem in a program that can be harmless or might allow hackers to exploit a system.

Compiler
A program that translates source code into executable machine language. Compilers are used to surreptitiously allow hackers into various systems without changing the source code, making it easier for them to get into a computer or network without being noticed.

Cookie
A small file sent from your computer's web browser to a server. Cookies help websites recognize you when you return, and they also help third parties track audience.

Cracking
A basic term that describes breaking into a security system. Anyone "cracking" a system is doing so maliciously.

Crypto
Cryptography (or "crypto") is the art and science of encrypting data––as well as breaking encryption.

Data leakage
The unauthorized access of information resulting in leaks, theft or loss.

Deep web/net and Dark web/net
The deep and dark net/web are actually two different things, though they're often conflated. The deep net or deep web is the vast trove of data that isn't indexed by search engines. Spreadsheets, databases and more that are stored on servers make up this space. The dark web/net is made up of sites that are invisible unless you know how to use a special network, such as Tor, which knows how to find the dark side. Once there, you'll find what you might expect: pirated software and content, job ads for hackers, illegal drugs, human trafficking, and worse.

Denial of service attack (DoS)
This is when a hacker sends so many requests to a website or network that the traffic temporarily overwhelms the servers, and the site or network goes down.

Distributed denial of service attack (DDoS)
This is a DoS using a battalion of machines.

DEF CON
This is a big, annual conference for hackers that attracts people from all over the world. Discussions range from highly technical and academic to those about policy. It takes place in Las Vegas every August.

Digital certificate
These authenticate and approve the identity of a person, organization or service.

DNS hijacking
This attack changes a computer's settings to ignore a DNS or to use a DNS that's controlled by malicious agents.

Doxing
When hackers root out and publish personally-identifying information about someone online.

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Dump
The term for a trove of data released by hackers.

Dumpster diving
Organizations and individuals who don't consistently use a shredder are opening themselves to dumpster diving, which is exactly what it sounds like: hackers go through garbage looking for any information that will help with an exploit.

Encryption
Using special code or software to scramble data so that it cannot be read by a third party, even if it is intercepted.

End-to-end encryption
When an encrypted message is scrambled on both ends, as it is sent and again as it is received.

Exploit
The general term for leveraging a vulnerability in a piece of code, software, hardware or computer network.

Firewall
A system of software and hardware that's designed to prevent unauthorized access to a computer or computer network.

Grey hat
Hackers are just like the rest of us. Some have malicious intent, others just want to fight the bad people, and some...have a certain tolerance for moral flexibility. Gray hats will use the tools and sensibilities of a black hat in the pursuit of justice.

Hacker
This term means different things to different people. People who tinker with code, to purposely manipulate it, are hackers. Some are good, and some are bad. In popular culture, "hacker" has taken on a distinctly negative connotation.

Hactivist
Someone who hacks for social or political reasons.

Honeypot
A system or network designed to look like a high-value target, but was instead built to watch hackers do their work and learn from their techniques.

InfoSec
This is an abbreviation for "information security." Companies and professions that work within cybersecurity are known as InfoSec.

IRC
Internet relay chat protocol (IRC) has been around forever. It's the communication system used to have conversations and share files, and it's still used by hackers.

Jailbreak
A way of removing the restrictive manufacturer's code from a device so that you can reprogram it to function as you desire.

Keys
The code that, just like a physical key, is used to lock or unlock a system, encrypted message or software.

Lulz
A play on "lol" or "laughing out loud," black hats often use the term "lulz" to justify malicious work. LulzSec ("lulz security") is yet another offshoot of Anonymous, and it was credited with the massive Sony Pictures hack.

Malware
Any software program that's been designed to manipulate a system, by stealing information, augmenting code or installing a rogue program. Rootkits, keyloggers, spyware and everyday viruses are examples of malware.

Man-in-the-middle (MitM) attacks
This occurs when a hacker impersonates a trusted connection in order to steal data or information or to alter communications between two or more people.

Metadata
This is the data that explains what's in another set of data, such as a jpeg photo, or an email, or a webpage.

Password managers
These are third-party tools that you entrust your passwords to. Just remember one master password, and use it to unlock a database of all your other passwords, which should allow you to use a completely different password for every site and service you use. While managers are a good idea in theory, many

are cloud-based. If a hacker gains access to your password manager, you're in big trouble. If you do use one, make sure to use complicated password at least 36 characters long with lots of special characters, numbers and capital letters.

Patch
An after-market fix to address vulnerabilities.

Payload
The part of a computer virus that is responsible for the primary action, such as destroying data or stealing information.

Penetration testing
The practice of trying to break into your own computer or network, in order to test the strength of your security.

PGP
PGP stands for "Pretty Good Privacy," and you've probably seen a lot of PGP numbers showing up in Twitter and Facebook bios lately. PGP is a basic method of encrypting email (and other data). In oder to receive and read the message, your intended recipient must use a private key to decode it.

Phishing
We've all seen a phishing attack at least once. They usually come in the form of an email from a trusted contact. Once you open the message or attachment, your computer, your data and the network you're on become vulnerable to attack.

Plaintext
This is text without any formatting. In the context of cybersecurity, it also refers to text that isn't encrypted. Sony Pictures storing its passwords and email addresses in a basic Excel spreadsheet is an example of plaintext.

Pwned
South Park fans will remember Cartman using this word. It's geek speak for "dominate." If you've been hacked, you've been pwned.

RAT
RATs are Remote Access Tool. If you've used a remote login service to access your office computer while away from work, you've used a RAT. But RATs can be malicious, too. Just imagine a hacker using a RAT to take over your workstation.

Ransomware
This is malware that allows a hacker to break into your computer or network and then take away your access until you pay a specified fee or perform a certain action.

Root
The root is the central nervous system of a computer or network. It can install new applications, create files, delete user accounts and the like. Anyone with root access has ubiquitous and unfettered access.

Rootkit
Rootkits are malware designed for root access. Often undetected, rootkits start running when you start your computer, and they stay running until you turn your machine off.

Shodan
In Japan, a "shodan" is considered the first degree (read: lowest level) of mastery. In cyberspace, Shodan is a search engine for connected devices, allowing hackers access to baby monitors, medical devices, thermostats and any other connected device. It's intended to help people learn how to secure their devices, but obviously it can also be used against them. (see http://shodan.io)

Sniffing
When you were a kid, if you drove around your neighborhood looking for open WiFi networks, you probably used a little device or a special computer program. Those are examples of sniffers, which are designed to find signals and data without being detected.

Spearphishing
A more targeted form of phishing to smaller groups, typically within social networks or work environments.

Spoofing
In general, anytime data is changed to mimic a trusted source, it's being spoofed. Changing the "From" section or header of an email to make it look as though it was sent by someone else. Black hats spoof emails by impersonating people you know, and then launch phishing attacks.

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Token
A small physical device that allows a trusted, authenticated user to use a service. Tokens are stronger than passwords alone, since they require both the password and the physical device to gain access.

Tor
The Onion Router, otherwise known as "Tor," was originally developed by the U.S. Naval Research Laboratory to route traffic in random patterns so as to confuse anyone trying to trace individual users. The Tor Project is the nonprofit now in charge of maintaining Tor, which is used by both white and black hackers, as well as journalists and security experts.

Verification
Ensuring that data, and its originators, are authentic.

Virtual Private Networks
Virtual Private Networks, or "VPNs," use encryption to create a private channel for accessing the internet. VPNs are necessary when connecting to public networks—even those at airports, hotels and coffee shops.

Virus
Malware intended to steal, delete or ransom your files. Mimicking the flu, this type of malware spreads like a virus.

Vulnerability
A weakness in computer software the hackers can exploit for their own gain.

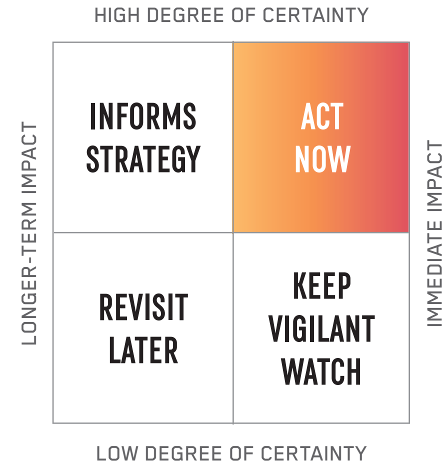
White hat
Not all hackers are bad. White hats work on highlighting vulnerabilities and bugs in order to fix them and protect us.

Worm
Worms are a certain kind of invasive malware that spreads like a virus.

Zero-day exploits
In the hacking community, zero days (also written as "0day") are prized tools because they are undisclosed vulnerabilities that can be exploited. Once the flaw is revealed, programmers have zero days to do anything about it.

Zombie
Just like the White Walkers in Game of Thrones, but machines! A computer, connected device or network that's been infected by malware and is now being used by the hacker, probably without your knowledge.

For more resources and definitions, we recommend NATO's cooperative Cyber Defense Centre of Excellence's online database: https://ccdcoe.org/cyber-definitions.html.



PRIVACY

Facebook CEO Mark Zuckerberg testified in a congressional hearing, answering questions about the Cambridge Analytica Scandal.

KEY INSIGHT

Public outrage over last year's Cambridge Analytica scandal has put online privacy back in the spotlight. Now that the General Data Protection Regulation (or GDPR) has gone into effect, citizens of the EU have a greater ability to understand what data tech companies are collecting, how that data is used, and when that data is shared with a third party. In the US, 61% of Americans say they'd like more done to protect their privacy.[2] While we all seem to care deeply about our privacy we continue using social media, websites and gadgets that don't necessarily put our privacy first. It's an outcome of surveillance capitalism. In the digital era, our data is currency.

088

GDPR Copycats

Sweeping changes to data privacy regulations are now in effect in the European Union. Dubbed the **General Data Protection Regulation** (or **GDPR**), the new rules affect how companies can collect and use customer data. Those who don't comply will face hefty fines and litigation. The GDPR applies to everyone who uses customer data, regardless of where in the world you are. This coming year we expect to see copycat legislation in countries around the world. In the US, **Senator Brian Schatz** proposed the **Data Care Act** in December 2018, parts of which mirror the GDPR.

089

Tech Companies Influencing Privacy Laws

In September 2018, **Facebook** revealed a breach that affected more than 30 million people's user information, while a month later **Google** reported that it had found a glitch in its **Google+** network that could have exposed the private data of 500,000 users. Perhaps anticipating a wave of regulatory proposals, some of the big tech giants have made privacy a core message to both consumers and lawmakers. In October, **Apple CEO Tim Cook** warned of a "data-industrial complex" and called for comprehensive privacy laws in the US, and in doing so he publicly shamed Facebook and Google. **IBM CEO Ginni Rometty** followed by criticizing the other big tech companies for abusing user data—and similarly called for action. It would be a mistake to think that IBM and Apple are leaving the work of crafting data privacy regulations up to lawmakers. They'll offer industry leading advice on what ought to be done next, which would likely put their competitors at a big disadvantage.

090

Right To Eavesdrop/ Be Eavesdropped On

As we connect more and more devices to the **Internet of Things**—fitness trackers, mobile phones, cars, coffee makers—those devices are having extended interactions with each other and the companies who make them. Our devices aren't just talking

2. http://www.pewresearch.org/fact-tank/2018/03/27/americans-complicated-feelings-about-social-media-in-an-era-of-privacy-concerns/

to each other anymore. They're talking to one another, learning about us, and starting to talk about us. Increasingly, consumers are being left out of the conversation, unable to listen in and make sense of how their data is exchanging hands. A debate over **consumer rights** will heat up in the coming year: should consumers be given the right to eavesdrop on what their own devices are saying, and who else is listening in?

In the digital era, our data is currency.

091

Tech Workers Fighting For Privacy

In 2018, when staff at **Google, Microsoft** and **Amazon** discovered their companies were engaged in programs to aid US government agencies with surveillance, they published open letters, staged walkouts and protests, and formally organized into activist groups. As data collection and AI technology become more available, **Homeland Security, Immigration and Customs Enforcement** (otherwise known as **ICE**) and the **Pentagon** will rely more heavily on Silicon Valley tech giants for support. This isn't sitting well with workers, who promise more rebellions in 2019.

092

Defining What Constitutes Online Harassment

The **#MeToo movement** brought to light thousands of stories of sexual harassment and resulted in the outing of more than a dozen high-profile men throughout 2018. A shared **Google** document, dubbed **"The Shitty Media Men List,"** was at one point circulating among female journalists, who entered the details of men who have sexually harassed women in the real world. When the list was leaked, some pointed the finger at the women, arguing that they were committing acts of online harassment simply by contributing to it. It's clear that we don't yet have clear definitions for what constitutes harassment. In the years ahead, we will continue to wrestle with what behavior is acceptable in virtual gaming worlds, in social media, in our mobile exchanges, and in general digital discourse.

093

Drone Surveillance

Drones are now coming in all shapes and sizes, and they can be used in a variety of settings for surveillance. Advanced camera technology can capture photos and video from 1,000 feet away, while machine learning software can remotely identify who we are and lock on to our bodies as we move around—all without our knowledge. **Interconnected drones** will enable the **mass tracking of people** at concerts, vehicles on the highway, amusement park attendees—which we may already expect from law enforcement. *(See also: Drones Section.)*

094

Compliance Challenges and Unrealistic Budgets

The historical tension between security and privacy will unleash new challenges in the near future. Consumers are shedding more data each day, and as more connected devices enter the marketplace, the volume of available data will balloon. Yet those organizations creating devices and managing consumer data aren't planning future scenarios. Managers will need to develop and to continually update their security policies—and they'll need to make the details transparent. Most organizations aren't devoting enough budget to securing their data and devices. Organizations that haven't carved out enough budget for IoT security will find themselves dealing with vast recalls, remediation and lawsuits. The **General Data Protection Regulation (GDPR)** promises a significant headache for compliance officers and risk managers, who must ensure that the policies and procedures for governments, companies, nonprofits and news organizations are current.

095

Differential Privacy

Differential privacy as a mathematical concept has been around for over a decade. Only recently, has it been implemented by companies like **Apple** and **Google** as a way to analyze aggregate data without compromising user privacy. Differential privacy is achieved by strategically introducing random noise into the dataset. It is most useful when answering simple (low-sensitivity) queries. It's good for finding out traffic patterns in Google Maps, the most popular emoji for iPhone users, and ride sharing trends across **Uber's** global network while keeping individual user behavior anonymous. The **US Census Bureau** will be using differential privacy in the **2020 Population Census.**

Differential privacy is limited in what it can do, even for the handful of tech giants that have enough information to do it right. Apple has differentiated itself from its competitors by integrating differential privacy into its **Safari** browser and Google uses its own differential privacy tool called **RAPPOR.** It is important to remember this method is still evolving. Depending on applications and data sets, differential privacy is harder to maintain when variables are correlated.

Privacy cont.

Google CEO Sundar Pichai answered technical questions in a House Judiciary Committee hearing.

096

Safeguarding Personal and One-To-Few Networks

Personal networks are gaining momentum, though they are not new. Many closed networks have failed to find a strong base of users. However, in reaction to revelations about social media hacks and government-sponsored surveillance programs worldwide, private networks will gain momentum during the coming year. Those concerned about who might be looking through their email have switched over to **Signal**, which is an encrypted network for small groups, while **uProxy** is a peer-to-peer proxy tool allowing users access to the open internet from repressive countries. In the wake of **net neutrality** rollbacks in the US, a distributed browser system could prevent an ISP from throttling certain sites or users.

097

Leaking

Given our current political climate, we expect to see far more tech-enabled leaks in the coming year. Worldwide, political leaders accused staff of leaking confidential information to the press. **Russia** continued dumping information all over the internet. Political activists prevented leaks from other political activists from entering the public. While many people seem eager to find and share information—not everyone agrees on what should be published, and by whom. The **International Consortium of Investigative Journalists**—a collaboration between 370 journalists from 76 countries—who spent a year reporting on a massive cache of 11.5 million leaked records showing the offshore holdings of 140 politicians from around the world, 12 current and former world leaders, and more. The records, known as the **"Panama Papers,"** were sent from a little-known law firm in Panama. In the summer of 2017, the **Senate Committee on Homeland Security and Governmental Affairs** issued a report entitled "State Secrets: How an Avalanche of Media Leaks Is Harming National Security" and cited 125 stories with leaked information that the committee considered damaging to national security. You can expect to see more coordinated leaking efforts in the year ahead.

098

Anonymity

The world needs anonymity, as it enables whistleblowers to come forward, and it shields those who otherwise might be persecuted for their beliefs. Digital anonymity allows us to band together in times of need, whether that's to raise money for a good cause or to push back against injustices. However, just as the Future Today Institute forecast earlier, anonymity also means it's easier to leak sensitive information, troll social media users, and leave disparaging or libelous comments all over the internet. In 2015, we forecast that most anonymous sharing apps won't survive—indeed, **Secret** shut down, while **Yik Yak** came under fire for allowing cyber-bullying and for failing to prove that users true identities really are being protected. Our desire to post content anonymously won't abate, even as our desire for verification grows.

099

Trolls

Trolling is a specific type of cyber-bullying that often involves spamming, hate-speech, doxxing attacks, and other forms of harassment. Early in 2019, trolls found a video of newly-elected **Representative Alexandria Ocasio-Cortez** taken when she was a college student in 2010, and they edited a short clip to make her look provocative and helped it go viral. In reality, she and a friend were recreating the benign dance sequence from *The Breakfast Club* movie. Controlling trolls online has forced many of us – as well as media outlets – to take a position on the line between freedom of speech and censorship. **Twitter, Facebook,** and **Instagram** have all updated their community standards to limit hate-speech.

Reddit has banned groups like r/incels for violating the site's community standards (though there is plenty of awful content still to be found on the rest of the site). And yet, neo-Nazi site **Daily Stormer** resurfaced in February 2018 after being effectively shut down by their domain host. State-sponsored trolling is most often linked to Russia but according to research from Oxford University, 28 countries and counting have cyber troops of humans and bots for the purpose of manipulating public opinion on social media. (For further reading, we recommend accessing Oxford's full report "Troops, Trolls, and Troublemakers.")

100

Authenticity

Who and what is real online is become harder to determine, which is why authenticity is an important trend going forward. **Facebook** has partnered with the **Poynter Institute's International Fact-Checking Network** to combat fake news on its platform. However, the partnership itself has been difficult to monitor and further illustrates Facebook's commanding influence over digital media. Authenticity in the media has branched beyond fake news from clickbait sites in Macedonia to a new type of fabricated media: videos. Deepfakes are computer-generated face-swap videos. The trend originated on **Reddit** in late 2017 and amassed over 80,000 subscribers before getting shut down. Authenticity startup **Trupic** has raised over $10M in seed funding to combat manipulated images or videos.

101

Data Retention

The **General Data Protection Regulation (GDPR)** gave every global business and government a wake up call, and perhaps a much-needed standard for data retention policies. As large tech giants are updating policies to comply with the regulation, smaller media organizations that depend on reporting and analytics are feeling the pinch. **YouTube** announced that starting in July 2018, it would delete analytics reports after 60 days.

102

Ownership

In a legal sense, data ownership has typically referred to IP or copyright data. However the rise of wearable smart devices and IoT have made people more aware about how their behavior, health statistics, and online activity is collected and monetized by large companies. You technically own the photos you post to **Facebook** and the videos you upload to **YouTube**. You do not own the site analytics that these tech giants make available to you. In a world where every device is smart and connected, surveillance is constant and ownership is unclear.

103

Persistent Audio Surveillance

With new smart speaker technology and better machine learning systems, public areas are prime spots for surveillance. **China** has already deployed networks of speakers that eavesdrop on conversations to extract meaning. In 2018, **Walmart** patented technology to listen in on the interactions between store guests and employees, as well as ambient noise: clothing being moved on and off racks, items being selected from shelves, and the clicking sounds we make on our mobile devices. All of this noise can be used to hunt for insights. But it also raises questions about privacy.

104

Leaky Data

Consumers are growing weary of "open source" websites, especially those using their data. Open source genealogy website **GEDmatch** allows users to voluntarily share their genetic profiles for free, as a way to find relatives and trace their genealogies. GEDmatch was used by law enforcement to track down Joseph James DeAngelo, the suspected Golden State Killer who over a period of years brutally raped 45 women and killed more than a dozen people. He himself never sent in a biological sample, but it turns out that someone connected to him did. That case reveals that if someone you know—or someone who might in some way be connected to you—submits their information to an open source website, it can be traced back to you.

105

Blocking the Ad Blockers

Ad blockers are software that automagically remove ads from webpages. People who use ad blockers are doing so either because ads slow down a site's loading time, or because the ads served are offensive, inappropriate for kids, or aren't safe for the workplace. In 2018, **Google** launched its **Better Ads Experience Program**, which includes a native ad blocker built inside of **Chrome**. This should have a profound ripple effect throughout the digital advertising and publishing world, since **Chrome** accounts for more than half of the browser global market share—it has

Privacy cont.

significantly more users than **Safari** and **Firefox** combined. Yet developers working on the **uBlock Origin** browser plugin noticed that **Facebook** has been using special code to block the ad blockers, making it more difficult to detect and hide sponsored posts. It will be a struggle going forward, as users deploy more blockers and websites deploy even more advanced anti-adblockers, by dynamically rewriting the JavaScript code that verifies a clean site.

106

Digital Self-Incrimination

Whether it's a connected fitness device, a smart earphone, or a pair of smart glasses, consumers will find themselves continuously monitoring—and being monitored—by third parties. Our legal system isn't keeping pace with technology, so we lack norms, standards and caselaw on how data collected from and produced by our wearables can be used. To date, **Fitbits**, pacemakers, and smartwatches have been used as evidence. In the **US**, judges get to decide whether to allow data from wearable devices—or whether individuals still have a reasonable expectation of privacy if they've been actively sharing their fitness stats in the cloud or with third-parties.

107

Revenge Porn

As of publication, 41 states and the District of Columbia now have revenge porn laws in the US, yet that hasn't stopped the spread of hateful videos. In 2018, several Los Angeles Police Department officers were under investigation for allegedly distributing explicit images of one of their female colleagues—her ex-boyfriend had taken photos without her knowledge and then shared in revenge after they broke up. Revenge porn is also posted online to dedicated websites. Staff within the **US Senate**, the **US Navy**, and even **President Donald Trump's Executive Office** have accessed revenge porn sites. In the US, there is no national law banning revenge porn. Even with new and proposed legislation throughout Europe, revenge porn cases are still on the rise.

108

Eye In The Sky

For the 2018 ball drop in Times Square, the **New York City Police Department** used a police drone to monitor the crowds. It wasn't the first time a wide area eye in the sky system was used to watch citizens. In 2016, **Baltimore police** deployed "wide-area surveillance" run by Ohio-based **Persistent Surveillance Systems**. Aircraft carrying high-resolution cameras fly over the city continuously for up to 10 hours at a time, photograph a 30-square-mile radius, and then send that information back down to analysts on the ground. Wide-area motion imagery technology allows police to surreptitiously track any person or vehicle within the area, and it's been requested by the **Miami-Dade Police Department** and in cities elsewhere in the world. The **ACLU** and a number of privacy experts have asked for a review of the system, citing the infringement of constitutional rights. But the technology continues to be popular among law enforcement.

109

Law Enforcement Using Recognition Algorithms To ID Faces

The **Washington County (Oregon) Sheriff's Office** has deployed facial recognition databases capable of figuring out whether someone's ever been in the county jail—simply by scanning their face. The software was built using **Amazon's Rekognition**, an image and video analysis engine that stores the County's repository of mugshots in Amazon's cloud. In a blog post about the system, an information systems analyst from the Sheriff's Office writes: "Early in 2017, an unknown suspect visited a hardware store, filled a basket with expensive items, and scanned them at the self-checkout kiosk. Before finishing the checkout process, the suspect picked up the merchandise and walked out of the store. The checkout kiosk's camera captured a great shot of him. Typically, this would initiate a manual process where we show the image to multiple law enforcement officers and hope that someone recognizes the suspect. This time, we ran the image through our facial recognition system and got four hits with more than 80% similarity according to Amazon Rekognition. We noticed that one of the men looked very familiar to us. We gave his name to the detective in charge of the investigation. The detective did a quick search of **Facebook** and found a picture of him. In that picture, we noticed many facial similarities. The best part? He was wearing the same hoodie as the man captured on camera who was suspected of the theft." Nationally, the **FBI's Next Generation Identification Interstate Photo System**, or **NIG-IPS**, is a giant database storing more than 30 million photos to support criminal investigations. Machine learning algorithms are deployed to find and compare those photos to people who are thought to commit crimes. There's an obvious privacy concern: not everyone in the database is a criminal, and machines don't always get matches right. They're more likely to misread people of color than Caucasians.

Eye of a hurricane,
listen to yourself churn

World serves its own needs,

Don't mis-serve your
own needs

It's the end of privacy
as we know it.

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

DATA

Consumers use their fingerprints and faces to unlock systems and devices.

KEY INSIGHT

One of the biggest buzzwords of the 2000s—Big Data—will continue to make headlines in 2019. Mining, refining, productizing and monetizing data is big business, and a vital part of our digital ecosystem. Businesses will want access to analytics tools in order to make important business decisions, while government agencies will rely on data to determine funding for various programs. Consumers have become more aware of how much personal data they're creating—and who has access to it. Here are a few data-related trends worth tracking in 2019.

110

Data Governance and Retention Policies

Many organizations—from financial institutions to universities, hospitals, veterinarians, churches, Fortune 500 companies and beyond—store data for compliance, business or customer convenience. In the year ahead, every organization will need to address best practices in data retention, with an eye toward security. You would be surprised to know how few organizations have responsive data retention policies that are updated according to security issues—and for that matter, how many organizations don't even have policies at all.

111

Strategic Encryption Management

We've seen dozens of big attacks in the past 24 months, and yet many of the organizations we entrust with our data are either not using encryption or are using tools that are out of date. Hackers know this, so we should expect more attacks in the coming year. While encrypting data makes it harder to hack, encryption can also make it harder for staff or consumers to make legitimate use out of the data. In the near-future, companies will need to devote serious resources into shoring up their digital security, or risk losing millions of dollars cleaning up after a breach.

112

Data Lakes Offer Insights

For the past several years, organizations with huge amounts of data have created data lakes, which are massive platforms that store all of an organization's data in various native formats. The idea was to create a single repository for all of a company's data, rather than keeping it siloed in different places—this would also help a company realize greater efficiencies. While data lakes have worked to store data, so far all of those cross-lane efficiencies and actionable insights haven't been realized. 2019 could be the year when AI systems help organizations glean better information.

113

New Roles for Data Scientists

Companies that rely on data will soon need staff with specialized skills sets. Rather than general "data scientist" positions, new roles, including data curators and data governance strategists, will be required to help tackle the challenges and opportunities offered by all the data created by consumers and organizations alike.

114

Global Data Scientist Shortages

"Data scientist" used to be a job that no one wanted, yet now it's one of the most sought-after positions. There just aren't enough skilled data scientists to fulfill all the work available—some estimates show a 50% gap between upcoming supply and demand. Industries including pharmaceuticals, finance, insurance, aerospace, foundations, government and travel are all in need of employees who know how to work with the troves of data they're collecting. As a result, we're facing a data scientist shortage. As the needs for data scientists spike, we're going to either have to retrain wide swaths of workers or wait for the next generation of skilled workers to graduate from college. Some universities, seeing workforce needs changing, will launch new graduate programs and centers in data science. Ethics and diversity will hopefully be a mandatory part of those programs, so that our future data scientists are aware of possible algorithmic discrimination and problematic data training sets.

115

Owning, Maintaining and Encrypting Our Biometric Data

Consumers use their fingerprints and faces to unlock their phones. They share their heartbeats and steps with their fitness trackers. As our devices become smarter, they'll start collecting even more personal biometric data. Companies should already be thinking about encrypting that data, but they may have added impetus to shore up their security: it's likely that new regulatory frameworks governing biometric data will be introduced in countries around the world in 2019 and beyond.

04

TRANSPORTATION

DRONES

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT | IMMEDIATE IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

A DJI Inspire 2 flown in Los Angeles. The camera hangs below and the landing gear rises up out of the frame.

KEY INSIGHT

2018 was the year drones went mainstream. A commercial industry blossomed, new regulatory frameworks launched in the US and European Union, and hundreds of thousands of drones were used worldwide for media, land surveying, building and infrastructure inspections, and personal entertainment.

In 2019, autonomous drones, capable of working independently and together as part of a larger fleet, will be deployed. These next-gen drones will be used in natural disasters, for package deliveries, for smart city management, within warehouses, and on automated farms.

Widespread future use of commercial drones will likely depend on standardizing regulations. If companies are forced to comply with patchwork regulations in different locations, it would make compliance burdensome.

However we anticipate groundwork to be laid on new kinds of regulation in 2019 that could usher in a universal traffic management system. Think highways in the sky that govern which kinds of drones and crewed vehicles can fly. Where controllers, pilots and regulatory agencies know exactly where traffic is at any given time, and new drones and vehicles can operate safely out of the line of sight.

As drone demand increases around the world, it's likely that consolidation will follow. Flight service providers, hardware startups, drone and aircraft manufacturers, asset and flight path management software, and data processing platforms will see a wave of mergers and acquisitions in the near future, which could make it difficult for new startups to compete.

116

Drone Operation Centers

As commercial drones take to our sidewalks and skies, drone control centers and specially-trained logistics experts with experience in geospatial data, predictive analytics and hardware will help manage fleets. In addition to optimizing fleets, commercial drone operation centers will work to determine the best delivery routes, how to minimize costs, and the best way to reach consumers and partners.

117

Drones as a Service

Powerful, commercial drones may be out of reach for some companies who need occasional – rather than ongoing – access. New drones as a service business models are borrowing from other successful industries (car rental, scooter sharing). This also reduces the need for specially-trained staff and licensed drone pilots.

118

Personal Home Drone Surveillance

Why bother with fixed security cameras when a flying drone could patrol your home? There are many new home drone surveillance startups piloting new systems to homeowners. One example: **Sunflower Labs** has developed a three-part home drone surveillance system that includes flying and ground drones. Think of them as roving security guards that don't get tired or need bathroom breaks. The system relies on "Sunflowers," small 1.5-foot bulbs that resemble ordinary garden lights but are packed with various sensors. Placed around a home, the Sunflowers triangulate people and objects while a Bee – that's the name of the drone – flies itself around the property to monitor activity before returning to its Hive base station.

119

Flying Beyond Visual Line of Sight

Robots harnessing neural networks and artificial intelligence can make inferences and decisions when programmed to do so. That's because of sense and avoid technology. Last year, a host of new drones equipped with anti-collision sensors and transponders capable of transmitting waypoints were able to inspect many miles of oil and gas pipelines.

120

Real-Time Mapping

Better cameras, faster processing, and smarter algorithms will begin to help drones generate live maps while hovering in previously unknown areas. This will allow for fast data generation and, as a result, better insights. For example, some newer software systems like **DroneDeploy** are capable of generating live thermal maps so that farmers and city managers can visualize temperature range variability in real-time.

121

Microdrones and Drones Used In Dangerous/ Hard-To-Reach Areas

Industries are beginning to utilize smaller, rugged, AI-powered drones to access dangerous and hard-to-reach spaces. Drones are being used to survey the insides of underground mines, ballasts of tanks, and inside nuclear facilities. Home and building inspectors have also begun using drones to inspect rooftops and sides of buildings. Drone adoption for these purposes could result in reducing risk to human life, and cost savings associated with shortened downtimes. **Facebook's** launch of an **internet-providing drone** along with **AT&T's** successful use of a **cellular signal drone** in **Puerto Rico** also highlight additional signals that drones could become a useful and prevalent tool in providing basic services to disparaged areas or locations lacking basic forms of infrastructure.

122

Clandestine, Disappearing Drones

DARPA funded new research in drones capable of making deliveries—and then disappearing into thin air. The agency's **Vanishing Programmable Resources (VAPR)** program has already shown that it's possible to program a small chip to shatter on command. As part of the program, **SRI International** developed the **Stressed Pillar-Engineered CMOS Technology Readied for Evanescence (SPECTRE)**, which is a silicon-air battery technology that can self-destruct. But it's also possible to get rid of certain parts of drones: Scientists at the **University of Houston** have developed a new kind of circuit that dissolves when exposed to water molecules, which could be programmed or scheduled. Meanwhile, San Francisco-based **Otherlab** has built a drone that's made out of mushrooms. Just after deployment, embedded spores begin to eat a way at the drone, devouring it entirely in less than a week. Another **DARPA** program – the **Inbound, Controlled, Air-Releasable, Unrecoverable Systems (or ICARUS)** program – is working on vanishing drones and other gadgets to assist the US military when carrying out operations. But disappearing drones don't just serve a military purpose. Amazon is working on self-destructing features in the event that one of its delivery drones fails. Rather than crash into people, homes, or cars, the drone would instead gently fall apart and glide down to a safe area.

Flying Taxis

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Uber Air plans to facilitate flying taxis through design guidelines for a ridesharing platform.

KEY INSIGHT

Vertical takeoff and landing technology development is accelerating and reaching an inflection point where proof of concept designs are beginning to become viable. Increasingly plausible designs opens the door to autonomous travel services for short distances.

EXAMPLES

Uber is taking a leadership role in designing a platform and specifications for crafts that will be part of their platform of flying autonomous taxis. Uber's guidelines dictate that vertical takeoff and landing crafts be able to travel at up to 200 miles per hour, at an altitude of 1,000 to 2,000 feet, and have a range of 60 miles. Commercial pilots will initially pilot the crafts during a transition window of 10-20 years before becoming fully autonomous. Uber's service is envisioned to serve concerts, festivals, and green spaces.

But Uber isn't the only company to watch. Airbus is working on flying taxis and aerial networks. Google's Larry Page has, for years, been investing in three startups: Cora, Kitty Hawk and Opener.

WHAT'S NEXT

Prototype models in the next five years will prove that the hardware is technically possible. Once the equipment is available, the next limitation to overcome will be the pace of development in rules and regulation around aerial travel. The existing partnering with NASA will facilitate the development of regulation, but significant efforts will be needed to develop the landing and takeoff infrastructure.

WATCHLIST

NASA; FAA; Pipistrel Aircraft; Bell Helicopter; Boeing's Aurora Flight Sciences; Karem Aircraft; Corgan and Embraer; Opener; EHang; Joby; Kitty Hawk; Larry Page; Airbus; Ehang;Volocopter; Dubai Road; and transportation authorities.

SCENARIO >>>

What happens when you finally get that Jetson's car?

In the next 10 years companies will prove that vertical takeoff and landing craft can be built and operated. These crafts will be very similar to helicopters but have the advantage of reduced cost to purchase and maintain.

Optimistic Framing

Manufacturers design craft that is as easy to pilot, maintain and as is cost efficient as car transportation. As the economics of aerial transit improve, commuters increasingly adopt short distance aerial travel as their regular form of transportation.

Transit needs will redistribute the traffic on roadways where heavy and long-distance transport will remain on roadways and light transit will take to the air.

Plausibility of takeoff

30%. Technically it will be hard to have the fuel efficiency and range of a car with an aerial vehicle.

Pragmatic Framing

New crafts will be developed but will continue to require highly trained and skilled operators like helicopter pilots. Advances in technology will allow the operation of the craft to be more economic, enabling specific commutes and routes to be opened up. This will start with existing helicopter transit routes that will be able to handle increased capacity due to their lower cost. Island hopping and taking the chopper to the airport will go mass affluent instead of only hyper affluent.

Regulations and infrastructure change minimally, as helicopter transport rules are extended to these new crafts and the volume of traffic is not enough to overwhelm the existing transit framework.

Plausibility of takeoff

60%. New manufacturers entering the helicopter market with learnings from drones and specific guidelines for shorter distance will stimulate increased development on existing infrastructure.

Catastrophic Framing

Flying taxis become the method of travel of choice for the hyper affluent who only travel in the air. The ability to transit in the air becomes a lightning rod for the global wealth divide as less is invested in land-based transit infrastructure and public transportation.

Plausibility of takeoff

10%. Helicopters already exist and are not used that much, significant changes would be needed for them to be used a lot more.

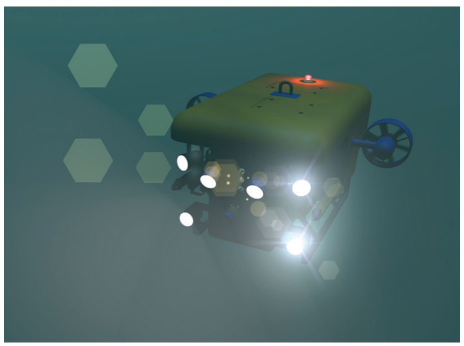
– KRIFFY PEREZ

Autonomous Underwater Vehicles

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY



Autonomous Underwater Vehicles can operate on their own without continuous human interaction.

KEY INSIGHT

Autonomous underwater vehicles can reduce costs for monitoring, building and maintaining underwater assets. Changing the business dynamics for marine construction potentially increasing underwater land usage.

EXAMPLES

Improved mapping of underwater surfaces will reduce the cost of laying the transatlantic cables that serve as the backbone of the internet, enabling increased competition and connectivity. Military autonomous underwater vehicles could be used for security, intelligence, countermeasures, network infrastructure, and port security. These roles could be offensive or defensive.

WHAT'S NEXT

Military use cases will dominate development and direct funding limiting the usefulness and applicability to civilian use cases. These vehicles will be viewed by the public similarly to other military drones like aerial predator drones and likely be controversial in their application.

WATCHLIST

Military divisions; MIT; fiber optic cable providers; oil and gas pipelines; security providers; shipping and port operators.

Drone Delivery

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Delivery logistics providers such as **Zipline, Amazon, DHL,** and **UPS** have trialed using drone technology to deliver goods. This is typically done by flying a drone from a warehouse to an open area near the destination, where a courier can take the package the final stretch to the consumer's doorstep.

EXAMPLES

In June 2016, the **FAA** released regulations around commercial and recreational drone use (Part 107). Under these laws commercial drone use is limited to daytime flights with line of sight, below 400ft, less than 55lbs, at a speed under 100mph and in authorized airspace. Other countries that are beginning to define their regulations include **China, Iceland**, and the **EU**.

While the regulations and drone hardware has begun to catch up, the industry that is leading the use of commercial drones is aerial photography. The competitive advantage of using drones is the ability to get access to difficult camera angles much more affordably than in the past.

Drone hardware for delivery of consumer goods is approaching feasibility yet the infrastructure is not developed as logistics companies are still in the process of trialing consumer deliveries.

Amazon has filed patents for aerial warehouses, and AHA in Iceland utilize drones to get products closer to end consumers where the last mile is still fulfilled by a human courier.

Zipline delivers medical supplies up to 50 miles away and was initially rolled out in Rwanda but is now being tested in California for deployment in the USA. The system involves a fleet of drones, a launching track and a pair of towers to catch the returning drones. The packages are delivered via a parachute drop from the drone.

WHAT'S NEXT

Drones will become part of logistics supply chains for specific use cases where timeliness and lightweight deliveries are essential, but it is unlikely to become an end-to-end solution that delivers products to the end consumers' door/window.

Legislation and infrastructure requirements for delivery will limit the ability for drone deliveries to be entirely self-service, instead drone delivery will help specific items avoid limitations that traditional delivery logistics find unprofitable, such as a limited volume routes and short distance routes.

Drone delivery will be best suited to lightweight, high-value items that can be delivered to a centralized location.

WATCHLIST

UPS; Amazon; DHL; Zipline,;federal and government aviation; and transportation authorities.

Drones will become part of logistics and supply chain infrastructure for specific lightweight and urgent use cases.

Drone Lanes

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Drones will stimulate the development of air traffic lanes to ensure safe operation of manned and unmanned craft.

KEY INSIGHT

We're about to have overhead congestion—which means soon, you can expect invisible drone lanes overhead. Amateur drone pilots continue to cause trouble for commercial and private airline pilots. Drone adoption will push development of "air lanes" for both crewed and uncrewed aircraft where different types of aerial vehicles are grouped into categories and traffic lanes.

EXAMPLES

Currently, the FAA does not allow drones to fly near the airspace of airports—but while there are no-fly zones, there aren't no-fly *circumstances*. In Singapore, researchers are considering the viability of different options including "air-lanes," the development of "air-blocks" and "air-fences" to manage traffic. NASA has developed a traffic management system for Unmanned Aerial Systems (UASs) to maintain safe and efficient UAS operations. This novel technology enables the growth in civilian applications of UAS operations at lower altitudes by developing a UAS Traffic Management (UTM) system.

WHAT'S NEXT

Congestion management systems are infrastructure initiatives that look to redistribute street space by reducing car traffic, increasing bicycle and pedestrian use with the ultimate goal of improving overall safety and efficiency of the network.

Proactively constructing aerial infrastructure will allow regulators the opportunity to preempt congestion, ensure safety, and incorporate learnings from both road and air travel. The development of regulation will be made at a city/state level as interoperability at a federal and global level will be less necessary than for drone travel.

Another significant barrier to adoption will be customer sentiment about having drones flying through their neighborhoods. The drones would likely be near overhead or above existing road structures which will significantly increase the noise pollution from the roadways. Current drones and airplanes make very identifiable noise that people may take offense to. For example noise pollution near airports and highways has caused a decrease in property values. Additionally, it will be much harder to block sound from aerial craft vs. terrestrial craft since sound insulating barriers can be built around terrestrial highways.

WATCHLIST

NASA Unmanned Aircraft System (UAS); Traffic Management (UTM); Amazon; Google; city municipalities and state legislatures; federal and government aviation; and transportation authorities.

Follow Me Autonomously

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

"Follow-me" functionality popularized by consumer drones will drive the development of sense and avoid technology for autonomous vehicles of all sizes. Popularization from the use of personal drones for photography will exponentially increase testing and accelerate the development of the technology.

EXAMPLES

Many consumer drones available today have "follow-me"/crash avoidance functionality. This enables semi-autonomous flight where a subject is kept in frame where a separate operator is not needed. For example, drones taking selfies or videos of extreme sports where the drone operator is in the field of view. "Follow-me" provides hand free use, so the operator can perform a task other than operating the drone; like backflips, cartwheels or smiling.

WHAT'S NEXT

"Follow-me" functionalities are beginning to be enabled with obstacle avoidance technology which allows the drones to be increasingly autonomous. Current obstacle avoidance technology frequently consists of infrared sensors around the drone that detect nearby objects.

In the future obstacle avoidance technology will begin to leverage advanced computer vision and sensors. Once "follow-me" technology is combined with a drone's location awareness, the drone would be able to plot out, navigate and course correct paths through the environment.

Obstacle avoidance would be a logical stepping stone to fully autonomous drones and will likely require advances in processor energy efficiency in order to perform the calculations needed onboard the device, otherwise connectivity technology like 5g will prove paramount in ensuring minimal lag from where the calculations are performed (cloud, operator device, etc.) to execution at the drone.

WATCHLIST

Amazon; Google; DJI; Walkera; Yuneec,; AirDog; Hover; Intel; Swellpro; city municipalities and state legislatures; federal and government aviation; and transportation authorities.

Drones that can follow subjects and avoid obstacles autonomously have significant customer demand ensuring that companies develop technology that can be applicable in multiple industries.

Drone-Enabled Infrastructure

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

IMMEDIATE IMPACT

LOW DEGREE OF CERTAINTY

Drones will stimulate the development of air traffic lanes to ensure safe operation of manned and unmanned craft.

KEY INSIGHT

Drones can enable the rapid extension of infrastructure into hard to reach or disparaged areas.

EXAMPLES

Facebook's launch of an internet-providing drone along with **AT&T's** successful use of a cellular signal drone in **Puerto Rico** highlight signals that drones can be a useful tool in providing essential services to disparaged areas or locations with limited infrastructure.

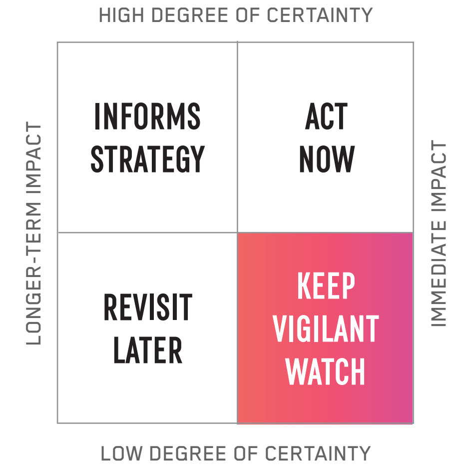
Zipline is a company that delivers medical supplies up to 50 miles away. The company proved its viability in **Rwanda** where it delivered medical supplies to disparaged locations. It is now being tested in **California** for deployment in the US. The system involves a fleet of drones, a launching track and a pair of towers to catch the returning drones. The packages are delivered via a parachute drop from the airplane like drones.

WHAT'S NEXT

As the weather on our planet becomes more unstable and extreme patterns become more frequent; infrastructure demands will increasingly be strained. Existing infrastructure will slowly be replaced as it fails and will be upgraded to smarter more flexible future-proof infrastructure. In the meantime, there will be increased demand for rapidly deploying temporary replacement infrastructure. Drones will increasingly be used for these deployments as they can accelerate the pace of installation.

WATCHLIST

Facebook; ATT; Google; utility companies; FEMA; disaster relief initiatives; city municipalities and state legislatures; federal and government aviation; and transportation authorities.



Drone Swarms

KEY INSIGHT

Miniaturization is allowing drones to reduce in size to such a point that they are becoming able to function like swarms. Swarm mentality enables hardware and software designers to approach issues differently as the overall network becomes more important than each individual unit.

EXAMPLES

Swarms of drones were developed by the military, but its most public use is for performing dazzling light shows at Disney Parks and during the Super Bowl halftime show. In the dark, lights on the drones can look like fireworks that move and light up in ways that defy physics.

Of course, drone swarms aren't always benevolent. Early in 2018, a swarm carrying explosives, said to be controlled by Syrian rebels, attacked two Russian military bases.

The current level of swarm technology is a multirobot system, where each drone is controlled individually and is not able to communicate directly with one another or via group think. The vision of the swarm approach is to operate drones to enable them to communicate with one another in such a way that they self-organize and can adapt flight paths autonomously. Self-organization would allow the groupings of drones to mimic flocking birds.

WHAT'S NEXT

Use cases where redundancy of devices and hardware is very important, will continue to drive development. Military use cases of carrying payloads will become more common and prevalent as manufacturing costs for drones come down.

While the military use will drive development and adoption, niche visual performances will continue to be used and evolved. Theme parks and other locations that regularly host light shows and fireworks will invest in technology as it will be financially beneficial for them.

Object recognition, interconnection and environmental awareness as fields of data science will need to evolve significantly to allow groups of drones to interact in a fully organic and swarm-like fashion. Ideally, future swarms will use what Nora Ayanin, a roboticist at USC, calls leveraging diversity in the control policy. Each drone is programmed slightly differently so the one best suited to the task teaches the rest of the swarm how to act.

WATCHLIST

Disney; theater productions; military; EHang UAV; Intel; MIT; ETH Zurich; China; Japan 2020 Olympic Committee; city municipalities and state legislatures; federal and government aviation; and transportation authorities.

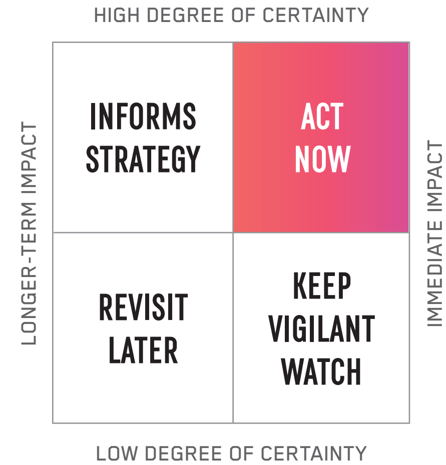
Miniaturization of drones allows exploration of computing that resemble bee or bird swarms.

MID-FUTURE SCENARIO →→→→→→→→→→→→→→→→→→→→→→→→

Drones As A Source of Renewable Energy

Numerous companies have begun to develop drones that will harness wind energy. There are various potential advantages to using drones versus using traditional wind turbines. First is mobility: drones can be sent to areas ravaged by natural disasters and provide immediate energy relief. Secondly, drones can fly at higher altitudes than traditional turbines and collect more energy from stronger winds. Finally, drone-based wind collection saves companies from having to install costly towers and foundations.

– ROY LEVKOVITZ



AUTONOMOUS DRIVING: STRATEGY PRIMER

EV charging stations will soon dot the landscape.

To understand where we are today with autonomous driving it is helpful to understand the generally accepted different levels of autonomous driving. The Society of Automotive Engineers drafted a generally accepted definition of autonomous driving that goes from level zero to level five.

LEVEL 0

Features that may momentarily take over control of the vehicle but do not have sustained control of the car.

Example: antilock breaks, electronic stability control

LEVEL 1

hands-on / driver assistance

Where the car works in conjunction with human control of the vehicle

Example: adaptive cruise control where the car controls speed or park assist where the car controls steering

LEVEL 2

hands off / partial automation

Where the car controls acceleration, braking, and steering but the human is required to intervene at any point

Example: Tesla's Autopilot feature where the car will follow lanes, accelerate to travel speed and decelerate for traffic and intersections

LEVEL 3

eyes off / conditional automation

Where the driver is not required to pay attention to driving for the majority of the time, but the driver must be prepared to intervene at certain moments when prompted by the car.

Example: Audi Traffic Jam Pilot where the car takes full control of driving in slow moving traffic on highways

LEVEL 4

mind off / high automation

Where the vehicle does not need input or oversight but is restricted to specific roads or conditions.

Example: Google Firefly Prototype, which did not have a steering wheel or pedal

LEVEL 5

steering wheel optional/full automation

Where the car can operate anywhere and, in any conditions, that a human could without needing any human interaction.

Example: Waymo has a fleet of hybrid cars it is using to test development of level 5 technology in Phoenix

The most advanced publicly available vehicles have Level 2 functionality, like Tesla's Autopilot or Cadillac's Super Cruise.

Autonomous Driving cont.

Vehicle to Vehicle (V2V) vs Vehicle to Infrastructure (V2I)

Autonomous vehicles rely on internal software and sensors to perform basic functions. However, in order to achieve Level 5 autonomy – where vehicles drive themselves, along with other vehicles across all of our roads, highways, alleys, bridges and driveways, they'll need to also be able to sense and communicate with each other. This will require additional work, and some questions still remain: should vehicles talk to each other as part of a big, moving network? Or should vehicles communicate with infrastructure to send and receive all the data they need? (Or would there need to be some combination of the two?)

Vehicles will be able to communicate with one another and the road infrastructure to provide real-time information on the road conditions and collaboration among vehicles. Collaboration will enable access to new data streams that will help optimize road usage.

Platoons of vehicles are being designed where multiple cars group together. Vehicles in a platoon travel together at very short distances from each other increasing efficiency of the vehicles and the roads they travel on. The platoon approach of grouping cars is frequently used as a methodology to increase the throughput of existing highways with vehicles that can communicate directly with one another. The platoon would require only one lead driver, or no driver, depending on the level of autonomous driving ability.

Collaborative sourcing of transport information already exists in **Waze's** traffic data that is sourced from other users that are further ahead down the road. Another example of collaborative sourcing of transport data is the LIDAR (Light Detection and Ranging) data used in **Cadillac's** Super Cruise semi-autonomous driving service. Vehicles equipped with expensive LIDAR equipment are sent ahead to scan the roadway and provide accurate mapping of the road, so cars following behind using the Super Cruise function do not need to have their own LIDAR equipment.

Network protocols for how vehicles and infrastructure can communicate with one another will be developed. The network would need to be unfailingly reliable, fast and secure and will likely intersect with 5G technology and node-based/mesh networks.

Research is already being conducted into Vehicular Ad Hoc Networks, which use node-based rebroadcasting of information. Using a node based or mesh network structure reduces the need for required fixed connectivity infrastructure and can allow moving vehicles to take their network with them into areas with no connectivity. **Gotenna** is an example of an existing consumer product that uses local mesh networking to enable cellphone communication in areas without cell service.

The sharing of data and collaboration among vehicles will be a foundational element for autonomous driving as road conditions will be updated in real-time by all vehicles in the network. Interconnection across manufacturers and backwards compatibility will be paramount.

Lawsuits and Restructuring

The pace of advancement in the field has slowed as **Waymo** and **Uber** entered a heated trade secret infringement lawsuit which limited employee mobility across companies. The lawsuit was settled, and a general truce has emerged. But the freedom of information and ideas exchange has been reduced.

General Motors has accelerated the development of autonomous technology, when CEO Mary Barra made a bold public statement that GM will restructure the company and focus on its electric and autonomous vehicle programs.

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EV Mechanics and AV Engineers

MIT and **Stanford**, along with the online learning platforms **Udacity** and **Coursera**, are now offering classes and degree programs for autonomous systems. Udacity's Self-Driving Car Engineer Nanodegree program trains students to become self-driving car engineers. The program takes six months and was built in partnership with China's DiDi, as well as Iber, Nvidia, McLaren, Mercedes-Benz and BMG. (Udacity co-founder is **Sebastian Thrun**, who had previously launched **Google's** self-driving car program.) MIT offers a class on deep learning for self-driving cars, while **Stanford** offers a **Machine Learning for Autonomous Driving** class (both are online and open to the public). Coursera is teaching computer vision for cars and has a learning track designed for self-driving vehicles in multiple languages. What's driving this trend? There aren't nearly enough skilled workers in the pipeline who can help build self-driving cars and the infrastructure they will soon require.

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Assisted Driving Before Full Automation

What will drivers encounter in new 2019 and 2020 models? Lots of assistive features powered by artificial intelligence. Cameras and sensors will bring more information to heads-up displays and smart dashboards, which will enable more assisted driving functions (self-parking, lane departure control, voice controls). But we are still a few more years away from what the National Highway Transportation and Safety Administration (NHTSA) calls Level 4 Full Self-Driving Automation. Level 4 vehicles are designed to perform all driving functions and monitor roadway conditions for an entire trip––with the driver providing navigation input but not expected to be available for control at any time during the trip. That's because there are external events, such as establishing and funding a new federal agency, or working through licensing and regulations, that could hold up progress for several years. Other events—the availability of components, public attitudes toward autonomous vehicle accidents, and the like—will also impact momentum. We are in transition––the last years of human driving. One thing is for sure: U.S. authorities will launch a new federal agency to address autonomous vehicles, something like a Federal Autonomous Vehicle Agency (FAVA). It will be charged with working alongside the twelve existing agencies concerned with transportation, from highways to aviation.

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Adaptive Driving Systems

Motorcycle injuries have increased in the past few years, and the reason has to do with age. Nationwide, 39% of motorcycle owners are 51 to 69, according to the **Motorcycle Industry Council**, and at that age reaction time is slower than optimal. **Yamaha's Motobot** is designed with an aging population in mind: Yamaha has partnered with **SRI** research institute to create a motorcycle that can drive on its own. The technology being developed will eventually be used to help assist motorcyclists on the road—when they're not able to act fast enough, the system will take over. Adaptive systems, which help drivers stay in their lanes, prevent them from driving too closely to another car, and parallel park, will be deployed into new vehicles in 2019.

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Electric Vehicles Boom, Especially in China

As of April 2018, **China** had bought 35% of all electric vehicles (EVs) sold in the world. They are likely to buy 1.5 million by the end of 2019, thanks to government policy that incentivizes EVs over gas guzzlers. Not only has Beijing offered big tax subsidies for consumers, it has invested significantly in charging stations and other EV infrastructure across China. Electric vehicles (EVs) are mechanically simpler than their internal combustion cousins—they're cost effective, too. In the US, drivers tend to save 36%—about $11,000 over 10 years—compared to those driving gas-powered cars. **Former US Speaker of the House Paul Ryan** once called electric vehicle (EV) tax credits "money wasted on losers," but the $7,500 EV tax credit survived the final tax bill Congress signed at the end of 2017. (For those keeping track, we're up to $17k in savings.) **General Motors** is launching 20 new EV models by 2023, while **BMW, Nissan, Jaguar, Porsche, Audi, Volkswagen, Volvo** and **Tesla** will all have EVs out in 2019.

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Solar Highways

China is the world's largest investor in solar energy, and one of its latest megaprojects is harnessing the sun within the country's vast network of highways. Pavenergy and state-owned construction firm **Qilu Transportation** began work on a highway in Jinan, the capital city of **Shanong Province**. It's covered in paper-thin solar panels that can withstand the pressure from 45,000 vehicles that traverse it daily. Covering the roads with solar panels is feasible in China because unlike in America, where roads are paved with asphalt, roads there are made from sturdier concrete. Researchers have been working on roads capable of producing their own energy. China joins **France** and the **Netherlands** in testing this technology at scale. In **Poland**, city planners are experimenting with solar-powered, glow-in-the-dark bike lanes. Researchers have been working on roads capable of producing their own energy. Think of them as smart, modular systems that can illuminate lines and markings, keep ice melted, generate electricity for EV power stations, and even communicate data about whether any section of the road needs repair. Flat solar panels aren't necessarily efficient, since they cannot tilt to face the sun.

China is the world's biggest car market, and the sales of new-energy vehicles (NEVs) including plug-in hybrids, fuel cell electric cars and battery powered cars are growing. In the first 11 months of 2018, 1.03 million NEVs were sold in China, up 68% from 2017. China has said that it wants NEVs to make up at least 20% of the domestic market by 2025, and it's offering government subsidies and tax incentives to help achieve that goal.

Cognitive Active Safety Features

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Proactive safety functions are becoming more and more advanced and beginning to use advanced analytics.

KEY INSIGHT

Proactive driver safety functions are becoming more and more advanced as we get closer to autonomous driving. In the process of developing cars that can be fully autonomous, we will have more and more functions that leverage building block components of autonomous driving like specific artificial intelligence.

EXAMPLES

Driveri is a dash camera that uses AI to monitor real-time road conditions to provide driving suggestions. The company has partnered with fleets and commercial drivers to monitor driving behavior but also teach people how to be better drivers.

NVIDIA has made a driver facing camera that uses AI (landmark localization) to identify driver attentiveness. Identifying attentiveness early on allows the system to be increasingly accurate in its predictions of when drivers will become tired and lose focus.

WHAT'S NEXT

While the dream of autonomous driving is still a ways-off, many of the technological building blocks are becoming available at scale today. Vehicle manufacturers will continue to implement and tout active safety features as a way to drive consumer preference. Car platforms are also increasingly becoming software driven, so advancements in features and functionality from manufacturers will begin to move at faster development cycles than the 10-year cycles of the past.

WATCHLIST

Driveri; NVIDIA; auto manufacturers.

SCENARIO

When Humans Attack Cars

Worldwide, more than 1.25 million people are killed in a car accident every year. Millions more are hospitalized because of car-related injuries. And now there's a twist: armed with rocks, guns, pocket knives and in one instance a PVC pipe, humans have started attacking cars.

The reason has to do with big tech companies needing to adjust their self-driving technology real-world communities that aren't interested in being test subjects. Google's Waymo division, which has been testing vans in a town near Phoenix since 2017, has had a number of run ins with locals: they've slashed car tires, pelted vehicles with rocks, and tried to run vans off the road. Residents have safety concerns, especially in the wake of a 2018 collision involving a pedestrian and a self-driving Uber car just a few miles away in nearby Tempe.

But the real issue here isn't safety. It's that we all struggle to cope with technological change, especially when it disrupts the foundations of everyday life.

– FUTURE TODAY INSTITUTE RESEARCH TEAM

Demand For Electricity

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY		ACT NOW
REVISIT LATER		KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

As we accelerate the adoption of battery-powered mobility, our energy delivery channels need to be able to handle the shift in the delivery channel. Demand for retail energy will transition from primarily petroleum/gasoline based to a mix with greater demand delivered via the electricity grid.

EXAMPLES

While only 2% of cars sold in the US in 2017 were electric cars (200,000), manufacturers are planning on producing and developing more electric vehicles in the future. **Ford** is planning on spending $11 billion on technology to build up to 40 battery-electric and hybrid cars by 2022. **Daimler** is also planning on introducing 10 pure electric vehicles and 40 hybrid models. Chinese automobile manufacturer **BYD** was the world's top selling plug-in electric car manufacturer in 2016 delivering over 100,000 vehicles. BYD's primary market is China, which has been quick to adopt electric cars due to low costs of ownership and government subsidies incentivizing pollution reduction. **VW** has announced that its last generation of gasoline engines will launch in 2026, as it will shift its focus to battery driven vehicles.

Charge point infrastructure is currently fragmented with different standards by geography, but also by manufacturer. The regional challenges and impacts of this can be seen in how **Tesla's** new model 3 cars will ship to European customers with a different plug than in the US. The plug to be included in Europe is called Combined Charging System, which allows support for a greater range of manufacturers and older vehicles. Using CCS in European model 3's also means that Tesla's supercharging network will also be retrofitted to CCS allowing more manufacturers to use its network, assuming a partnership for the right price of course.

Cars, trucks, and buses are not the only vehicles driving the adoption of battery-powered transportation; motorized bicycles, hoverboards, electric skateboards, and battery powered scooters are increasingly becoming popular as they provide increased mobility with new business models to an aging population which has less appetite for asset ownership in environments that are becoming denser.

WHAT'S NEXT

The first movers to provide charging infrastructure along travel routes will have the ability to shift traffic patterns and create a network advantage. The first mover advantage will be similar to how the development of the interstate highway system created an economic boom for certain towns but took it away from towns that became bypassed.

Tesla currently has an advantage as a first mover in its development of supercharger infrastructure, but gas station operators will soon respond with charging networks of their own given pressure from the larger car manufacturers like **GM** and **Ford**. As with building any network, it will be key to manage and grow both demand and supply; the vehicles and the charging stations. **Shell Ventures** and **Repsol** were part of a $31 million Series A funding for an EV charging startup called Ample.

Solar highways are an example of teams looking into ways to create road infrastructure that is more self-sufficient and use networked intelligence. The highways can illuminate lines and markings, keep ice melted, generate electricity for EV power stations, and even communicate data about road repair.

WATCHLIST

BMW; Fiat Chrysler Automobiles; Ford; General Motors; Honda; Hyundai; Jaguar Land Rover; Kia; Mazda; Mercedes-Benz; Mitsubishi; Nissan; Subaru; Toyota; Volkswagen; Volvo; Ample, Public utility companies; Solar Roadways; infrastructure development players like investment banks; and Missouri's Road to Tomorrow initiative.

SCENARIO →→

What if the majority of our vehicles are battery powered?

Battery-powered forms of transportation are becoming more common as alternative ways to get from point A to point B. Over the coming 5-10 years, battery-powered transportation will increase in popularity. As battery capacities increase, prices reduce and urban density increases.

Optimistic Framing

Charging infrastructure becomes fully standardized and interoperable. Charging stations become commonplace and are readily available publicly and privately on highways, rural roads, and urban centers. Fast and slow charging is readily available in homes and at charging stations.

The electrical infrastructure adapts and offers dynamic energy consumption across the entire system; reducing the pollution and incrementing the number of renewable energy sources to the point where generation from dirty sources like coal or oil is negligible.

The grid becomes distributed, scalable and self-routing in a manner that maximizes efficiency. Consumption can be predicted and mapped very accurately, reducing peak load and overcapacity needs. Systems are designed and developed where batteries and devices connected to the grid can receive and return power as needed in an open ecosystem.

Plausibility

20%. Power generation can't adapt at the speed of consumer adoption, i.e., the Keystone pipeline.

– KRIFFY PEREZ

Pragmatic Framing

Charging infrastructure develops regional level interoperability where there are one or two primary standards that all-electric vehicles can connect to. Public charging stations concentrate around interstate highways and urban centers, driven by adoption of commuting upper middle-class drivers and commercial truck routes. The majority of charging happens at home with residential charge points.

Electricity infrastructure has a limited adaptation to the increased demand. Power generation continues in its current fashion with limited improvements in decreasing overall pollution from energy usage. Utilities aggressively incentivize consumers to shift electricity demand across non-peak times by limiting fast charge times and conditions. Blackouts and brownouts become more common and predictable like snow storm disruptions… inconvenient but generally accepted.

Plausibility

40%. Public relations drives adoption in specific regions and areas as it is used as a role model for companies, many me too strategies.

Catastrophic Framing

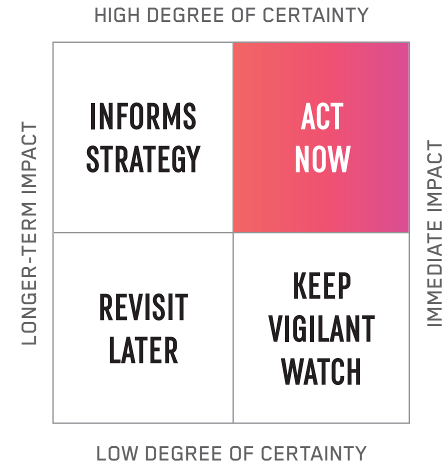
Charging infrastructure delineates the haves from the have-nots. The charging networks are not interoperable, and we develop dongle hell for cars. Fragmentation persists until there is market saturation and the government steps in to mandate interoperability or one of the players are weakened enough to collaborate with competitors. Think Apple forcing people to upgrade to USB C where PC allows multiple ports, only this time its Tesla vs. VW group.

Fuel for power plants and electricity generation does not adapt, so the electricity powering our transportation is less efficient and more polluting than the gas-powered cars they are replacing. We become increasingly dependent on the outdated infrastructure that begins to decay at an increasing rate under the new load causing frequent brownouts and blackouts.

States and municipalities begin to compete on the ability to deliver power, redistributing population centers.

Plausibility

40%. Manufacturers will try to steal market share against each other instead of collaborating to grow the whole market. Power generation is notoriously slow to adapt and continues to do so.



Transportation as a Service Business Models

US new vehicle sales fell 2% in 2017.

KEY INSIGHT

Transportation as a service business models are beginning to take hold in customers minds and are changing the way transportation assets are owned, operated and managed. The business models supporting transportation are starting to change as more and more players are providing pay per use structures with ride, bike, scooter, car sharing services becoming more common.

EXAMPLES

Ride-sharing services like **Uber, Lyft, Via, Gett**, etc. are relatively well established but the business model is extending into transportation vehicles outside of just cars. Micro-mobility providers of electric and non-electric bicycles include **Citibike, Mobike, Ofo, Lime** or electric scooter companies include Bird, Spin, Lime, Skip, etc. Providers of full-size gas and electric motorcycles include **eCooltra** and **ioscoot**. Car rental companies like **Hertz** and **Avis** are beginning to allow rentals by the minute or mile in specific urban centers and other locations. Manufacturers are testing out new ownership models like **Audi on Demand, Care by Volvo** or **Porsche Passport** which gives members access to 22 models of Porsches for $3,000 per month.

Ford is trialing an entirely new business model with its autonomous vehicles, the components including ride-hailing, fleet management, deliveries, and digital content. Ford will make its $4 billion bet on autonomous vehicles pay off by using these new business models. For those who do continue to own and maintain a vehicle, **Turo** allows you to rent privately owned vehicles with renters' insurance provided by **Liberty Mutual**.

WHAT'S NEXT

The first movers to provide charging infrastructure along travel routes will have the ability to shift traffic patterns and create a network advantage. The first mover advantage will be similar to how the development of the interstate highway system created an economic boom for certain towns but took it away from towns that became bypassed.

WATCHLIST

Ford; Turo; Porsche; Volvo; Audi; VW; Hertz; Avis; Ioscoot; Ecooltra; Skip; lime; Spin; Bird; Ofo; Mobike; Citibike; Get; Via; Lyft; Uber.

Mandated Updates

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Software-as-a-service business models are becoming increasingly prevalent. SaaS platforms usually rely on mandated remotely triggered software updates that the user has limited to no control over. The promise of always having up to date software is to have the safest and best hassle-free experience. But, when a provider like **Microsoft** or **Google** changes a keyboard shortcut or switches the delete and archive button, the result can be a lot of frustration. Now consider when **Tesla** moves the horn or brake pedal… the result can be significantly more problematic.

EXAMPLES

Traditional car manufacturers tend to opt for in-dealership software updates or modifications, which ensures that consumers choose when to perform the update and are aware that changes are coming. Connected car manufacturers like Tesla, who view software more as a service; are beginning to opt for over the air software updates that the consumer might not be aware of, schedule, nor be able to stop. Forced over the air updates can be good, like when Tesla extended the range of model S and model X cars in Florida to help people trying to escape the path of hurricane Irma. Or when Tesla issued an update to the model 3 car that improved braking distance by a full 19 feet.

Forced updates can also be bad, like when Tesla owners made unsubstantiated reports that a software update reduced the acceleration of their model 3 cars. Or when Apple was proven to have installed hidden software that would slow down older phones to preserve the battery of the phone. Forced updates can unintentionally damage performance, and can also be implemented at the wrong times. Remember when Windows 10 forced an unannounced mandatory automatic installation in the middle of a professional gamers' session to a live stream with 130,000 followers?

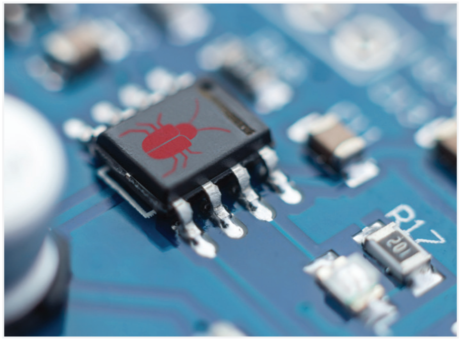
WHAT'S NEXT

As more products are released as an evolving platform; new features and functionality will be added as over the air firmware updates at a later date. Providers will increasingly have to learn how to navigate the difficult path of introducing new features and improving customer experiences while balancing legacy experiences and muscle memory.

Manufacturers will have to be very deliberate about providing standardized safety functionality while thoughtfully providing personalized experiences and entertainment. Learnings can be gleaned from best practices in the software industry players like **Microsoft**, **Google** and **Amazon**, but car manufacturers will have to be mindful that changes in the transportation environment have very different circumstances and consequences.

WATCHLIST

Microsoft; Tesla; Google; Amazon; Audi; VW.



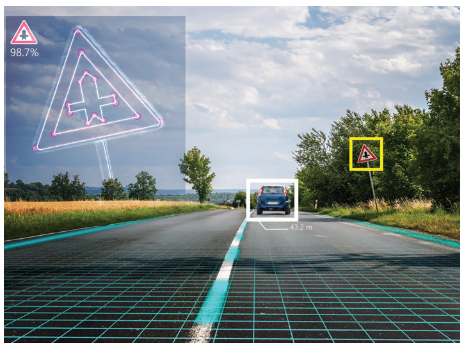
Software updates can cause significant heartache when intrusive and change too much too fast.

Exponential Growth in Autonomous Miles Data

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



If big data is the new oil, autonomous miles are crude for transportation players.

KEY INSIGHT

The data collected from miles driven with autonomous technology will begin to grow exponentially as the install base reaches critical mass—and that should rapidly accelerate the improvement of driving algorithms.

EXAMPLES

Tesla has Autopilot, **Mercedes-Benz** has Drive Pilot, and **Cadillac** has Super Cruise. All three systems provide the ability to perform level 2 autonomous driving, which includes full acceleration, deceleration, and steering within its lane.

Teslas driving with autopilot have begun to reach critical mass with an estimated total lifetime production of 200,000 electric vehicles. Autonomous vehicle accidents are starting to show groupings in how they fail: they are showing signs of having challenges identifying stationary objects which then caused multiple crashes.

WHAT'S NEXT

Network effects around the big data generated from autonomous car use will be a significant factor in who designs the safest autonomous vehicle, which will, in turn, drive consumer preference. For manufactures, autonomous algorithms do not need to be a winner take all market as the developer of the best algorithms could resell its IP. The company that is most effective at learning from autonomous driving data will create the new Volvo of the 1980s or Subaru of the 2010's = an implicit brand association with safety.

And then there was GDPR...

Driving data will be viewed as personally identifiable data that will be subject to GDPR privacy rules and regulations. GDPR will cause auto manufacturers to build systems that capture data in a manner that is GDPR compliant/ privacy compliant in each country where the vehicle is operated. This will reduce the amount of aggregate data available for analysis and increase the effort to use the data.

WATCHLIST

Waymo; BMW; Nissan; Ford; General Motors; Delphi Automotive Systems; Tesla; Mercedes Benz; Bosch; Uber; Lyft; Peterbilt; Otto; Starsky Robotics; Lockheed Martin; US Army; VW; Baidu; King Long.

SCENARIO

When autonomous driving data collides with regional privacy laws…

Vehicles with level 2 autonomous driving functionality will become mainstream in the next 10 years. Multiple manufacturers will provide the options to have autonomous driving installed in new cars as a safety and convenience feature.

Optimistic Framing

Customers are allowed full control of their data and have privacy safeguards installed by manufacturers at the root level of the vehicles. Customers have no difficulty in deleting their data from cars that are resold in the pre-owned markets. Rules and regulations are unified across the globe so learnings from driving on one side of the world, are immediately improving driving on the other side.

Plausibility

10%. This would require unification of privacy rules globally.

Pragmatic Framing

Vehicles will have regional requirements but will be interoperable at the continental level. Meaning that cars in Europe can function throughout most of the EU and vehicles in the USA can operate across most states. Standards will be set and will not require significant alterations to be manufactured for all regions. This will look very similar to today's car manufacturing and internet privacy rules where products can be made globally and customized locally. Privacy implementation strives to be done at the most rigorous standard for the region in question.

Plausibility

65%. We are likely to continue down our current road.

Catastrophic Framing

Fragmentation of regulation and data privacy cause a complete lack of interoperability. You can't take a car designed for one state to the next due to regulations that limit design, features, and functionality.

Car manufacturers must design platforms and brands for specific jurisdictions. Specific jurisdictions remove the ability to have world platforms in manufacturing; significantly increasing production costs, dramatically decreasing the speed of improvements and extending development cycles exponentially.

You must stop at every border and create a new account for your car with additional information and accept the terms and conditions of operating the vehicle in the next jurisdiction. Certain features and functions are enabled or disabled based on where you are traveling through and what terms and conditions you accept. Insurance may only cover you in some areas.

Plausibility

25%. Countries are moving farther away from unified standards on privacy and data – not closer. Consumer demand will push to reduce frictions and pain points in software access.

– KRIFFY PEREZ

Autonomous Vehicle Testing Gets Regulated

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT | IMMEDIATE IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Testing autonomous cars goes mainstream as 41 states have discussed legislation related to autonomous vehicles.

KEY INSIGHT

Current legislation around autonomous cars is in flux and has yet to be set at a national level. The US and California specifically are leading the way in testing autonomous vehicles on public roads, but other states and countries are catching up.

EXAMPLES

Since 2012, at least 41 states and D.C. have considered legislation related to autonomous vehicles. More than 50 self-driving companies are testing their technologies in California. By 2020 **Australia** will create a national law regarding autonomous vehicles, helping guide manufacturers and operators looking to bring autonomous vehicles to the country.

WHAT'S NEXT

Development of guidelines for testing autonomous vehicles on public roads will continue to roll out at an increasing rate. This interim period of legislation for testing autonomous vehicles will allow governments to deliberately and cautiously advance their strategies for autonomous vehicles on public roads. Guidelines on when it's safe to drive with autonomous technology enabled will begin to be developed making autonomous driving conditions dependent. The guidelines will be similar to variable speed limit highways, where segments of highway have lower speed limits when there is rain or congestion on the motorway. **Super Cruise** from **Cadillac** already limits its usage to sections of highway that are enabled centrally by **GM**.

WATCHLIST

NCSL; DMV.

Analog Fallbacks

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

As more and more functionality become digitally based, manual fallbacks will become more obscure and non-intuitive, leading to increasingly catastrophic failures when manual fallbacks are required.

EXAMPLES

Radio interference has been known to cause key fobs for **Tesla** vehicles to fail. This failure can be extremely challenging as the cars do not have a physical ignition key. There are multiple manufacturers on the market that are starting to opt for no exterior door handle systems that could pose increased risks of failure. Examples include Tesla Model S and X and the **Land Rover Velar**.

Car locks are increasingly becoming dependent on electricity which can become inoperable when the car battery runs out. Examples include a man who was trapped in his Cadillac for 13 hours and, tragically, a man and his dog who died in a Corvette when the car battery failed. Both vehicles had manual door release mechanisms designed as a fallback for when the electrics failed, but neither man was able to find the release mechanism. To make matters more tragic, one of the victims had the vehicles owner's manual yet was still unable to find the manual release mechanism. What happens when cars no longer come with physical user manuals, or firmware updates have changed the product so much that physical manuals are no longer accurate?

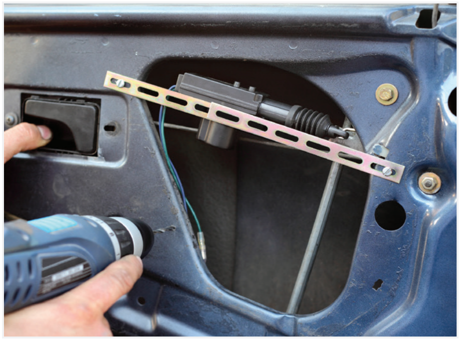
WHAT'S NEXT

We expect growing demand for removing manual activation mechanisms as manufacturers seek to disconnect the driving experience from the complicated physical mechanics. As vehicles become more automated and require less and less mechanical know how, consumers will focus more on other elements of the transportation allowing manufacturers to create new business models and drive brand preference with less emphasis on mechanical interactions.

Hopefully manufacturers self-regulate and ensure that emergency manual fallbacks are consistent and clearly indicated.

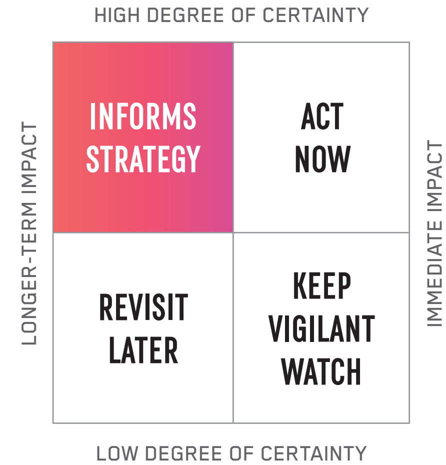
WATCHLIST

Cadillac; Corvette; Tesla; Range Rover.



If critical electric components fail, are mechanical fail safes available and do users know how to operate them?

Autonomous Last Mile Logistics



Food delivery can pave the way for autonomous vehicles.

KEY INSIGHT

Players developing autonomous deliveries are becoming more common and are likely to accelerate autonomous vehicle development as the hurdles for safely transporting food are lower than safely transporting humans.

EXAMPLES

Nuro, a startup founded by former Google engineers, is developing autonomous vehicles for last-mile deliveries including take-out, groceries, laundry, and packages. **JD.com** developed robots that delivered packages in June 2017. **SoftBank** and **Toyota** have formed a joint venture to create autonomous vehicles to deliver robot made meals. They target the late 2020s to be in market. **Dominos** has partnered with **Ford** to test self-driving delivery technology in Las Vegas, Ann Arbor, and Miami.

WHAT'S NEXT

Autonomous deliveries will continue to gain momentum as businesses see clear incentives in ensuring the best customer experience through delivering high-quality last mile experiences. Autonomous deliveries will help society transition and adjust to autonomous vehicles on public infrastructure as the vehicles will likely be slow moving, small and low risk while delivering strong consumer benefits.

WATCHLIST

Ford; Uber; Dominos; Ace Hardware; JD.com; Softbank; Toyota; Postmates.

Car Interfaces Drive the Voice Assistant Wars

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Drivers will either be actively driving and need intelligent voice-powered assistants or will be passive passengers who will have new idle time to fill. Voice assistants will increasingly fight over the car to establish the greater relationship with the consumers.

EXAMPLES

Car interfaces have screen and interaction real estate that is becoming increasingly valuable. Consumers are spending more and more time in vehicles without having to pay attention to driving. Technology companies are beginning to target the new idle attention span that autonomous driving enables. This means marketers have more opportunity to reach captive audiences, but also indicates that voice assistants will increasingly augment the experience in cars.

As manufacturers seek to incorporate smartphones into driving interfaces, the mobile operating systems seek to build footholds in a new opportunity for captive audiences. **Amazon** Echo Auto, **Apple** Car Play, and **Android** Auto are examples of technology companies trying to gain a foothold in the automotive entertainment industry.

Manufacturers like **Tesla** are increasingly removing physical dials and replacing them with digital screens and dashboards; like in the new model 3. While the evolution to digital displays is logical, the interesting note, is that the dashboards are becoming increasingly disconnected from the physical metrics they originally represented. This is a leading indicator of the transition to vehicles as a transportation service vs a mechanical device. Transportation as a service is enabled by advances in vehicle maintenance and operation to the point where little to no mechanical knowledge is required to own or operate the vehicle.

WHAT'S NEXT

Platform players like **Apple, Amazon**, and **Google** will increasingly focus on integration to the car ecosystem as a new data source for customer insights and marketing. Manufacturers will seek to partner with all technology providers to ensure that they are not left behind a competitor. The ecosystem of applications available on each platform will also dictate adoption and usage as the vehicle manufacturers decide whether to compete with the tech titans in designing vehicle operating systems or give up ownership of the infotainment dashboard to third parties.

WATCHLIST

Tesla; Apple; Amazon; Google; Ford Sync; GM; VW; Samsung; Mercedes; BMW.

Voice assistants will take hold in cars and drive preference of the greater virtual assistant market.

TREND 144 SECOND YEAR ON THE LIST

Supersonic Flights

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

Sound pollution from sonic booms was a contributing factor to the demise of the Concorde, new technologies could reduce the sound pollution.

KEY INSIGHT

A number of companies are developing technology to bring back commercial supersonic jet travel.

EXAMPLES

After years of successful Trans-Atlantic flights, the age of supersonic jet travel came to an end in October 2003, when **British Airways** permanently grounded the Concorde. Driven in part by the enthusiasm and excitement over faster, autonomous travel, supersonic jets are being tested once again. **Japan Airlines** (JAL) has invested $10 million in **Boom Technology** to develop supersonic jets, which will travel at 2.2 times the speed of sound—about twice as fast as a traditional aircraft. (JAL has already pre-ordered 20.) **All Nippon Airlines** is similarly researching supersonic flight. **Aerion, Lockheed Martin** and GE **Aviation** are developing a supersonic business jet that could carry 12 passengers.

WHAT'S NEXT

Reduced sonic boom airplane will enable flights to take off over land, which was a significant limiting factor in the routes that the original Concorde was able to fly. The original Concorde was limited to sub-supersonic speeds when over land as crossing the supersonic barrier would create a sonic boom that would create significant noise pollution on the ground below it. The limitation on supersonic speed made the majority of routes limited to crossing the Atlantic Ocean.

Congress is in the process of drafting legislation that will create rules for companies applying to develop supersonic airplanes. The process for applications should be put in place during 2019 with regulations regarding supersonic flights in place by 2020. **NASA** and **Lockheed Martin** have been developing new ways to muffle sonic booms. Test flights for the airplanes with reduced sound pollution are being planned for late 2021.

WATCHLIST

Japan Airlines; All Nippon Airlines; Aerion; Lockheed Martin; GE Aviation; NASA; FAA; Virgin Group; Boom.

Autonomous Ships

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Large autonomous ships can change the shipping industry by increasing efficiency and reducing human error.

EXAMPLES

Early 2018, an oil tanker caught fire after colliding with another boat in the **East China Sea**, killing more than two dozen people. It's another reason that companies are looking to automation in shipping. The **Yara Birkeland** is an electric container ship which is supported by radar, LiDAR, machine learning and computer vision systems, an automatic mooring system and a network for cameras. It is currently on schedule to transition from traditional human-crewed operation to remote operation in 2019 and then fully autonomous operation in 2020.

Driverless ferries are beginning to be trialed in Norway to replace and reduce the number of footbridges. An initial prototype built by the **Norwegian University of Science and Technology** is an electric craft that uses radar, infrared camera, optical camera, and LIDAR to travel 320 feet across a river, saving passengers an otherwise 15-minute walk.

WHAT'S NEXT

Electric ships that don't require people would offer cost savings throughout the entire shipping supply chain. They could be safer, solve for labor shortages, and be better for the environment. The **International Maritime Organization** has begun a scoping exercise that will complete in 2020 after which practical drafting will start and lay the legal foundation for maritime autonomous surface ships.

WATCHLIST

NOAA; Kongsberg; Marin Teknikk; Rolls-Royce; ENOVA.

Autonomous ships can help alleviate the 80% of accidents that are due to human error.

China's Foreign Infrastructure Investment

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

IMMEDIATE IMPACT

LOW DEGREE OF CERTAINTY

The Belt and Road Initiative is expected to cost more than $1 trillion.

KEY INSIGHT

China's multibillion-dollar **Belt and Road initiative** is stimulating massive investment in infrastructure development including roads, rail, sea and air travel. The vast extent of the investment and partnership with Asian, East African, European and other developing countries is driving Chinese eminence as a producer of global infrastructure and player on the global geopolitical scene. The changing nature of who leads infrastructure projects affects the dynamics of who sets regional and global standards.

EXAMPLES

China's Belt and Road initiative began in 2013 and has primarily focused on investment in infrastructure, education, construction, rail, highway, automobile, and the electrical grid. The effort is massive in size at roughly twelve times larger than the Marshall Plan, the plan which helped Europe rebuild after the second world war. In 2017, the project was estimated to involve 68 countries, 65% of the world's population and 40% of global gross domestic product in 2017.

One partner includes **Kenya**, whose government worked alongside **China** to build the **Mombasa-Nairobi Standard Gauge Railway**, estimated to have carried 1.3 million passengers with 96.7% seat occupancy and 600,000 tons of cargo in its first year of operation. It is also claimed to have boosted Kenya's GDP by 1.5%, created 46,000 jobs and trained 1,600 railway professionals.

WHAT'S NEXT

There are concerns that the initiative has significant political implications and the debt created by such an effort will impact geopolitical relations. The financial concerns stem from the fact that many of the countries partnering with China are developing countries that need the infrastructure but have limited ability to handle the debt the projects create.

WATCHLIST

China; Asian Infrastructure Investment Bank; Silk Road Fund; New Development Bank; Russia; Kazakhstan; Indonesia; China COSCO Shipping Corp; Kenya; Ethiopia; Pakistan; Malaysia; Sri Lanka; Laos; Thailand; Hong Kong.

05

ADVANCED ROBOTICS

Collaborative Robotics

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

The next generation of robots will work cooperatively.

KEY INSIGHT

Collaborative robots work alongside humans or together with other machines. They communicate in real-time and cooperate on projects.

EXAMPLES

Collaborative robots are finding more widespread use in industrial settings, which can often prove challenging for humans alone. **Tesla** uses robots to assemble its cars, while **Amazon** uses robots throughout its vast warehouses. In the past, installing and maintaining collaborative robots had been cost prohibitive for smaller companies, especially compared to human workforces. But that's now starting to change. German company **KUKA** and Japan's **FANUC** both offer collaborative solutions to build more automation within factories. Under the **European Union's Horizon2020 project**, researchers at the **Karlsruhe Institute of Technology, EPFL, Sapienza Università di Roma**, and **University College London** have developed an autonomous humanoid robot assistant for engineers that interacts with other robots and can learn from its human coworkers. Researchers at **Carnegie Mellon University** have built collaborative industrial robots named **Baxter** and **CoBot** that are designed to work together alongside a human. Teams of collaborative robots can communicate to each other, on their own, about when to wait, when to move, to carry out an activity, or even to ask what to do.

WHAT'S NEXT

In the near future, collaborative robots will play a key role in warehouses and distribution centers, automating the tasks previously performed by humans. There are a number of other immediate use cases: collaborative robots will help on construction sites, in factories, and during military operations. In the farther future, collaborative robots will underpin fully-automated supply chains, logistics services and deliveries.

WATCHLIST

Tesla; KUKA; FANUC; Amazon; Karlsruhe Institute of Technology; EPFL; Sapienza Università di Roma; University College London; Carnegie Mellon University; MIT's Interactive Robotics Group; SoftBank Group; SoftBank Robotics Corporation; Ocado Technology; iRobot; SpaceX; Robotshop; Festo; Lockheed Martin; Northrop Grumman; Raytheon; DARPA; Autonomous Solutions; Energid Technologies; Boston Dynamics; Denso; Hitachi; Kawasaki Heavy Industries; Mitsubishi Electric; ABB Robotics; Aethon Inc.; EPSON Robotics; Seegrid; Toyota; Honda; ULC Robotics; VEX Robotics; Yamaha; University of Tokyo; Johns Hopkins Applied Physics Laboratory.

Cloud Robotics

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Cloud robotics and automation is a field in which physical robots share data and code and perform computations remotely via networks, rather than within their containers alone.

EXAMPLES

Autonomous vehicles are robots that use a network to access maps, index data, understand spatial information and more, in order to make decisions. That data is shared on a network for optimization and later use by researchers and other cars. This is an example of cloud robotics, which is used within autonomous driving as well as in warehouse automation and logistics.

WHAT'S NEXT

In 2019, **Google** will launch its **Cloud Robotics** platform, an open access system that combines AI, robotics and **Google Cloud**. Using the cloud certainly offers advantages: greater efficiencies and opportunities for data sharing and insights, as well as collective learning across robots and platforms. For now, latency and security will be an issue going forward. Until 5G is ubiquitous in industrial settings, robots run the risk of losing their connections, which could cause latency and downtime. If a network connection is lost during routine operations or bandwidth-intensive tasks, it could prove catastrophic. In 2018, the **US National Science Foundation** awarded researchers at **UC Berkley** a grant to investigate ways to safeguard privacy and security for robotics accessing the cloud.

WATCHLIST

Google; Amazon; Microsoft; Tesla; Anki; Kiva Systems; Carnegie Mellon's Robotics Institute; UC Berkeley; NASA's Robotics Alliance Project.

Google Cloud

In 2019, Google will launch its Cloud Robotics program.

Autonomous Robot Teams

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	**KEEP VIGILANT WATCH**

LOW DEGREE OF CERTAINTY

The next gene A thousand Kilobots self-assemble and work as a team. ration of robots will work cooperatively.

KEY INSIGHT

Most robots are designed to work independently or on a factory line – not as part of a team. Autonomous robots built to work together as a team are finding uses in agriculture, infrastructure and defense.

EXAMPLES

Last year, **Walmart** filed a patent for robot bees, which would work collaboratively in teams to pollinate crops autonomously. If the project works at scale, it would certainly offer a solution for the world's honeybee population decline. Meanwhile, researchers at **Harvard's Wyss Institute** are experimenting with different form factors drawn from nature. One project, called Kilobots, involves 1,024 tiny robots working collectively to self-assemble and perform a programmed task.

WHAT'S NEXT

They'll fly, crawl, self-assemble and even swim. With enough projects now in the works, researchers are developing next-generation hive operating systems, which would communicate between robots working together on a mission and their human programmers. The possibilities for this technology are staggering: autonomous robot teams could be used to inspect dams and bridges, build complicated 3D structures, and lay protective barriers in the case of toxic chemical spills.

WATCHLIST

Wyss Institute at Harvard; University of Notre Dame; MIT; DARPA; the Academy of Optoelectronics at the Chinese Academy of Sciences in Beijing; Carnegie Mellon's Robotics Institute; UC Berkeley; NASA's Robotics Alliance Project.

Robotic Process Automation

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Robotic Process Automation (RPA) enables businesses to automate certain tasks and processes within offices, which allow employees to spend time on higher-value work.

EXAMPLES

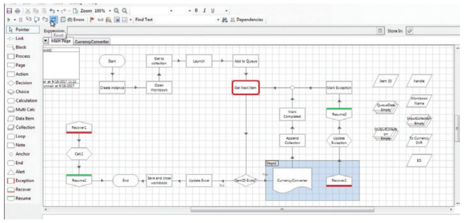
Google's Duplex, which is a bot designed to make routine phone calls to other people, is an example of an RPA. **Amazon** uses RPA to sift through resumes before prioritizing top candidates for review. In banking, **Blue Prism** and **Automation Anyware** help staff process repetitive work. The availability of artificial intelligence tools and frameworks are allowing companies to digitally automate more of their functions.

WHAT'S NEXT

RPA will eventually augment staff and shift their productivity into higher gear, especially as adjacent fields like Natural Language Processing advance. This will allow companies to make better real-time predictive decisions in a host of different areas, from customer service to cost savings. In 2019, the RPA ecosystem will grow to include open automation architecture and third-party service integration. Scaling RPA beyond a handful of robots and integrations may still prove a challenge: managing a fleet of 1,000 customer service bots is still an untested idea within most organizations.

WATCHLIST

Google; Microsoft; Amazon; Salesforce; Oracle; IBM; Pega Platform; EnableSoft; Blue Prism; Automation Anywhere.



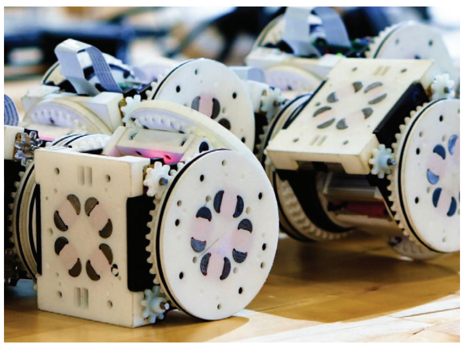
An RPA process workflow built in Blue Prism.

Self-Assembling Robots

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY



SMORES-EP is a modular robot that can shape shift to explore differnet terrains.

KEY INSIGHT

A new generation of robots are capable of self-assembly, enabling them to merge, split and repair themselves. We'll eventually ingest them to deliver medications—and they'll find work on construction sites and factory floors.

EXAMPLES

SMORES-EP robots are tiny, cube-shaped wheeled robots that have sensors and cameras. They're able to move independently and can dock with nearby modules to form different structures—they can self-assemble to lift objects and drop them off.

WHAT'S NEXT

Self-assembling robots offer a host of possibilities for medicine, manufacturing, construction and the military. The **MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)** built a self-assembling robot called **Primer** that is controlled by magnetic fields. It can put on exoskeleton parts to help it walk, roll, sail or glide better, depending on the environment. Researchers at the **Georgia Institute of Technology** and at **Peking University** (China) discovered a new technique that mimics automatic origami—in initial testing, structures were able to fold and unfold on their own using inexpensive liquid polymers and LED projector bulbs.

WATCHLIST

MIT CSAIL; Georgia Institute of Technology; Peking University.

Robot Compilers

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Today, the process of designing, programming and building robots is time intensive—and the capabilities are limited by the original specifications. In the future, advanced compilers will enable much faster conceptualization and fabrication for a host of different tasks.

EXAMPLES

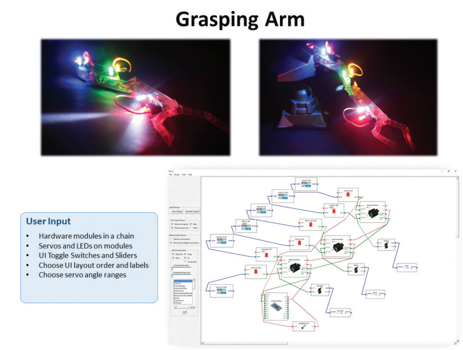
Researchers from the **Laboratory for Embedded Machines and Ubiquitous Robots at UC Los Angeles, MIT Computer Science and Artificial Intelligence Laboratory** (CSAIL), **University of Pennsylvania** and **Harvard** have been working to develop new methods for rapid robot fabrication. 3D robotic systems can now be produced using basic software and programmed using natural language commands.

WHAT'S NEXT

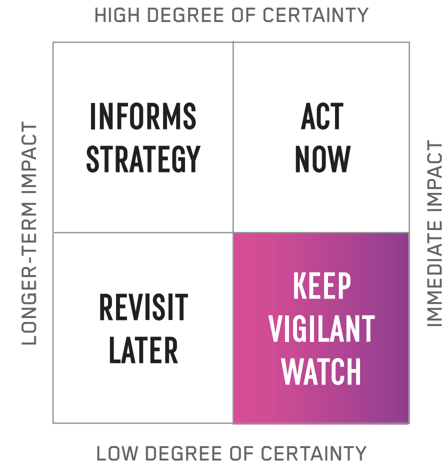
Since fabricating programmable robots isn't exactly a simple, DIY weekend project, research into robot compilers is incredibly promising—it could enable people with limited technical knowledge to sketch, design, print, fabricate and control a robot from their imagination. There are also tangible applications for the enterprise: robot compilers would offer greater efficiencies, big cost savings and increased production for manufacturers in every industry.

WATCHLIST

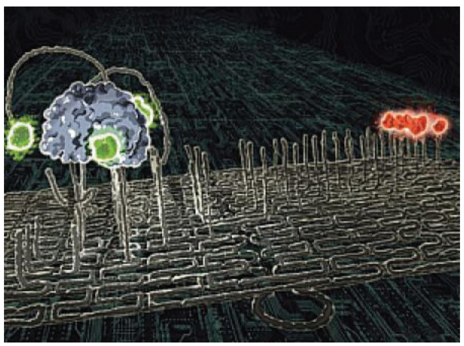
Laboratory for Embedded Machines and Ubiquitous Robots at UC Los Angeles; MIT Computer Science and Artificial Intelligence Laboratory (CSAIL); University of Pennsylvania; Harvard University.



A robot compiler from CSAIL. In the future, we'll tell computer systems what tasks we need completed, and they will automatically fabricate new robots for the job.



Molecular Robotics



Caltech researchers used folding DNA origami to play tic-tac-toe.

KEY INSIGHT

DNA and RNA can be used to make robots—but the process isn't easy.

EXAMPLES

A team of scientists at **Arizona State University** and at **Harvard** created single-stranded origami shapes using one long strand of DNA—which is capable of self-folding. It turns out that RNA can be used, too—and both can be produced inside of living cells. In 2018, scientists at the **California Institute of Technology** built a DNA-based version of tic-tac-toe with self-assembling DNA origami tiles.

WHAT'S NEXT

Molecular robotics will someday be used on all life forms to provide targeted therapies as well as genetic augmentation. Scientists at the **Wyss Institute for Biologically Inspired Engineering** at **Harvard University** have discovered that robots and our DNA share the ability to be programmed in order to perform tasks. Just like our next-gen robots, molecules are capable of self-assembly, they can react to their environments and they can be programmed. In the future, molecular robotics will offer new opportunities to advance medicine and agriculture.

WATCHLIST

California Institute of Technology; Harvard University; Arizona State University; Johns Hopkins University; Stanford University; University of Cambridge; Imperial College London; Nanyang Technical University; Georgia Institute of Technology; Tsinghua University; Tohoku University; Dana-Farber Cancer Institute; NuProbe; Ultivue; Office of Naval Research; US Army Research Office; National Science Foundation's Expeditions in Computing Program.

TREND 154 THIRD YEAR ON THE LIST

Soft Robotics

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Imagine robots that are squishy and can operate in unpredictable environments.

EXAMPLES

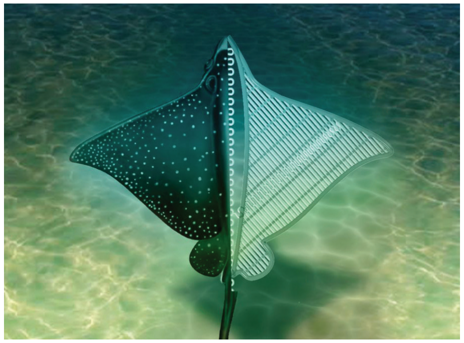
Researchers at numerous universities are working on a variety of soft robots. Some look like fish, while others resemble gelatinous cephalopods. Last year, MIT engineers created soft, 3-D printed structures that can be controlled using magnets. The hope is that they can help control biomedical devices someday, take images, clear arterial blockages, deliver pills or other drugs to specifically targeted locations within the body, or even extract tissue samples.

WHAT'S NEXT

Bioengineering researchers at the University of California at Los Angeles developed a tissue-based soft robot that mimics the biomechanics of a stingray. Scientists at the BioRobotics Institute at the Scuola Superiore Sant'Anna in Pisa, Italy, created a robot octopus, capable of replicating the animal's agile motions. In order to replicate the biology of an octopus, they built computer models using exact measurements and then experimented with a number of soft actuators to develop artificial muscles. Researchers at Worchester Polytechnic Institute have been working on a robotic snake. Soft robots mean that someday soon, we will be able to enter and explore environments previously unreachable by conventional methods: deep ocean waters, the terrain of Mars, and perhaps even the gushing rivers of blood inside our own bodies. But soft robotics also offer promise to stoke survivors—soft, robotic exoskeletons could be used for rehabilitation and as assistive devices. This technology could also be used to develop personalized tissue patches for heart attack patients.

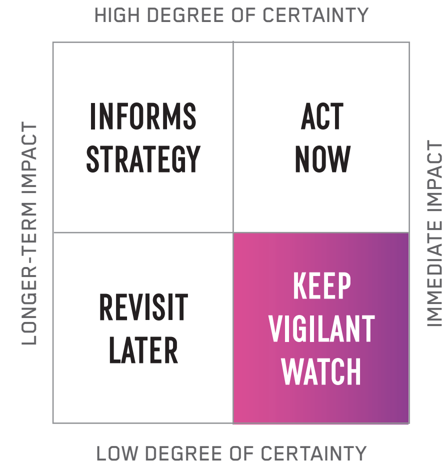
WATCHLIST

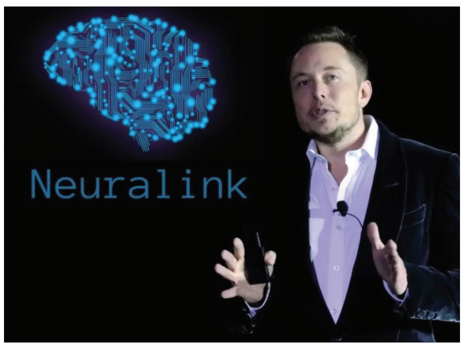
MIT's Department of Mechanical Engineering; MIT's Department of Civil and Environmental Engineering; University of California at Los Angeles School of Engineering; Scuola Superiore Sant'Anna; Worchester Polytechnic Institute; Harvard Biodesign Lab; MIT's CSAIL's Soft Contact Modeling Group; MIT Media Lab; Johns Hopkins Applied Physics Laboratory; DARPA.



Researchers at the University of California at Los Angeles developed a tissue-based soft robot that mimics the biomechanics of a stingray.

Human-Machine Interfaces





Elon Musk and his new company Neuralink are hoping to commercialize human-machine interface technologies.

KEY INSIGHT

Researchers are finding new ways to connect humans and mammals directly to computers. With these human-machine interfaces, people can communicate via thought alone, which promises new options for those suffering from stroke and paralysis.

EXAMPLES

Several years ago at the **University of Washington's Center for Sensorimotor Neural Engineering**, researchers built a system allowing one person to transmit his thoughts directly to another person. Using electrical brain recordings and a form of magnetic stimulation, one researcher sent a brain signal to another person elsewhere on campus, causing his finger to tap a keyboard. Meanwhile, researchers at the **Center for Neuroengineering at Duke University** created a real-life Iron Man suit, allowing a young man suffering from complete paralysis of his lower body to walk out onto a soccer field and kick the first ball of the **World Cup**. Late in 2018, **Stanford** researchers successfully trained three quadriplegia patients to use a brain-computer interface to control a tablet just by thinking.

WHAT'S NEXT

2018 was a big year for human-machine interface announcements and funding. Startups Neurable and **Trimble** said they're collaborating on brain-computer interface projects in transportation, architecture and engineering. Paris-based NextMind secured $4.6 million in funding to bring direct brain command technology to the gaming industry. Late in the year, **Elon Musk** promised to reveal **Neuralink** product announcements "soon." It will be some time before human-machine interfaces make their way from the fringes to the mainstream—and it could take longer if outsized expectations for this technology outpaces its rate of practical applications.

WATCHLIST

Stanford University; Elon Musk; Neuralink; Duke University's Center for Neuroengineering; University of Southern California; University of Washington's Center for Sensorimotor Neural Engineering; Johns Hopkins University; Carnegie Mellon University; Starlab; Case Western Reserve University; Penn State University; Johns Hopkins Applied Physics Laboratory; DARPA.

Personal Robots and Butlers

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT | IMMEDIATE IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

The first personal robots and butlers, capable of doing multiple tasks, are coming to market soon.

EXAMPLES

At the 2019 CES, friendly, personal robots were everywhere. **Lovot** is a new robot companion from Japanese startup Groove X. (The company's founder also developed Softbank's Pepper.) It can move around on its own using retractable wheels, and it responds to human touch and voice. **Sony's Aibo** is a cute robot puppy that can play fetch—it responds to reinforcement learning, so the more its owners offer feedback (in the form of neck scratches and pats on the head), the better it gets at interacting. **Zoetic AI's KiKi** is a robot designed to mimic a cat. **Panasonic** and Japan's largest homebuilder **Daiwa House** created an AI-powered robot that can sort and fold your laundry. **Honda** and **Sony** have launched a fleet of personal robots in the past year, offering both companionship and some help with the housework. (Whether there's a **Marie Kondo**-bot on the horizon, we still don't know.)

WHAT'S NEXT

Many countries, including **Japan, Italy**, and **Germany**, are facing rapid demographic shifts. In Japan, one in four people are now age sixty-five or older—there aren't enough people working to support both retirees and children. Science and technology will eventually stand in for the lack of people: robots will assist with everything from elder care, to medical assistance, to everyday companionship. Unsurprisingly, this first generation of companion robots is being built in Japan. Within a generation, there will not be enough people to make Japanese society work as it does today—but Japan isn't alone in its demographic shift. Anyone interested in the future of robotics would be wise to look not to **Silicon Valley**, but instead to universities and R&D labs in Japan, where extensive research on the next generation of robot companions is already underway. Out of necessity, robots—mechanical systems, artificial intelligence, and automated services—will act as productive, emotionally-intelligent stand-ins for a younger generation that was simply too small in numbers.

WATCHLIST

SoftBank Robotics; Zoetic AI; Groove X; Panasonic; Sony; Honda; Mitsubishi Heavy Industries; Eifer Elektro Firma; Fujitsu; AMY Robotics; Bioinspired Intelligent Mechatronics Lab, Ritsumeikan University; ARP; Shinpo Electronics; LG; Sharp; Toyota; MIT Media Lab; Buddy; Nanyang Technological University; Tokyo University; Johns Hopkins Applied Physics Laboratory.

Lovot robots are designed for your love.

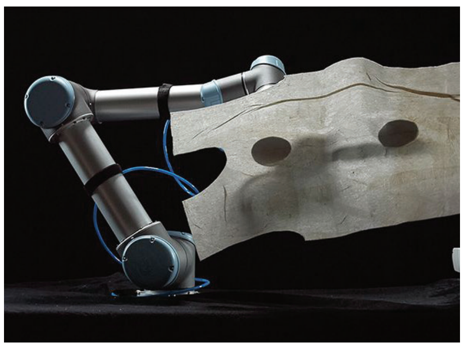
TREND 157 THIRD YEAR ON THE LIST

HIGH DEGREE OF CERTAINTY

	LONGER-TERM IMPACT	IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	**KEEP VIGILANT WATCH**

LOW DEGREE OF CERTAINTY

Ethical Manufacturing



The Sewbo robot created a complete garment without human assistance.

KEY INSIGHT

Could robots bring the end of forced labor and lead a new era of ethical manufacturing?

EXAMPLES

Look for a number of new advancements in robotics that further reduce the need for human labor, such as the **Sewbo**, which is similar to a traditional sewing machine but also has a smart robotic arm, allowing it to both sew and assemble an item of clothing. While this certainly means that people will be out of certain kinds of work, it does imply the end of bonded, forced and child labor—not to mention slavery—which unfortunately has become commonplace in places like **China**, the **Philippines** and **Bangladesh**. In October 2016, a **Canadian court** allowed a lawsuit brought by Eritrean workers against **Nevsun Resources**, a mining company: it was the first time in history that a tort claim for modern slavery went ahead in Canada. Meanwhile, in September, the **Associated Press** published a searing account of foreign fishing workers, confined and forced to work on US fishing boats. The AP's investigation revealed a disturbing present-day reality: fishermen who were forced to use buckets instead of toilets, suffered sores from bed bugs and didn't have enough food to sustain them.

WHAT'S NEXT

While robots may help ease forced labor, what about the rights of robots? Do robots need worker rights, too? This is a question now being raised by researchers, especially as robots are predicted to take on more meaningful roles within the workplace and in society. The EU is already discussing whether there ought to be a special legal status of "electronic persons" to protect sophisticated robots.

WATCHLIST

National Association of Manufacturers; Alliance For American Manufacturing; Tesla; Sewbo; Carnegie Mellon University; MIT's Interactive Robotics Group; Alphabet (Google); Amazon; ABB Robotics; Aethon Inc.; ULC Robotics.

The rationale for robot "rights" is not a question for 2076, it's already a question for now.

– Peter W. Singer, author of Wired for War

Robot Abuse

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

We are now seeing instances of humans bullying robots.

EXAMPLES

Researchers at **ATR Intelligent Robotics and Communication Laboratories, Osaka University, Ryukoku University**, and **Tokai University**, in Japan launched an experiment to measure human empathy towards robots. They deployed a small, assistive robot called the **Robovie-II** through a mall in Osaka without a human minder. If someone walked into the robot's path, it would politely ask the human to move. Adults complied—but children didn't. And if children were unsupervised, the researchers found the were intentionally mean, kicking the robot, yelling at it, and bullying it. Another study, from the **Human Interaction With Nature and Technological Systems Lab (HINTS)** at the **University of Washington**, discovered that children didn't show the same kind of empathy they do with other humans. In the study, 60% of the kids thought that Robovie had feelings—and still, over half of them thought it was fine to lock him in the closet.

WHAT'S NEXT

When it comes to our interactions with robots, what constitutes a moral violation? What rights should robots have, given that so many companies are building smart interfaces and cognitive systems? If we are teaching machines to think, and to learn from us humans, what are we programming into our future generations of robots?

WATCHLIST

University of Washington; ATR Intelligent Robotics and Communication Laboratories; Osaka University; Ryukoku University; Tokai University; SoftBank Robotics; Panasonic; Sony; Honda; Mitsubishi; Bioinspired Intelligent Mechatronics Lab, Ritsumeikan University; LG; Sharp; Toyota; MIT Media Lab; Buddy; Sony; Tokyo University.

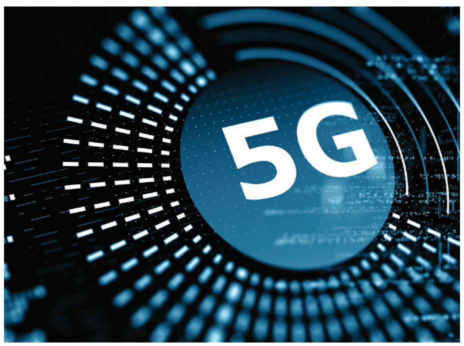
The Robovie-II is bullied by children at a mall in Osaka. [Image: ATR Intelligent Robotics and Communication Laboratories]

5G Networks and the Industrial Internet of Things (IIoT)

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



We are likely to see private 5G networks before national networks.

KEY INSIGHT

The Industrial Internet of Things, or IIoT for short, is set to take off as 5G networks come online.

EXAMPLES

The fifth generation of wireless technology will, at last, power up — but not where you're expecting. While local governments continue to fight over incentives, private companies will ditch WiFi for 5G, which will shorten transmission latency from 30 milliseconds to just a single millisecond, essentially allowing instantaneous connectivity between devices on a network. Unlike WiFi, a private 5G network can be built to prioritize certain data transmissions over others.

WHAT'S NEXT

Heavy manufacturing companies and utilities can finally take advantage of the IIoT and begin to automate more of their core processes using robots. It also signals a massive emerging market for all of the components, devices, and consulting services that will soon be required.

WATCHLIST

Qualcomm; Cisco Systems; Verizon Communications; Intel; Oracle; IBM; NEC; HP; Juniper; New Relic.

The number of industrial robots in China will increase 10x to 1.8 million units between 2019 – 2025.

TREND 160

SECOND YEAR ON THE LIST

Smart Dust

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

These are computers, no larger than a grain of dust, that are light enough they can suspend in the air.

EXAMPLES

If you watched the "Arkangel" episode of *Black Mirror* (season four), you're already familiar with smart dust. For years, researchers have been hard at work on miniaturization, as they try to shrink computers as much as possible, down to the size of sand or dust. Each particle-computer consists of circuits and sensors capable of monitoring the environment, and even taking photographs. They are even capable of harvesting energy while suspended using passive WiFi and the heat given off by our bodies.

Scientists at the **University of California Berkeley** developed what they call "neural dust," which are microscopic computers that work alongside remote ultrasound to send and receive data about the brain. Meanwhile, researchers at the **University of Stuttgart** figured out how to print tiny 3D lenses—120 millionths of a meter in diameter, or about the size of a grain of sand.

WHAT'S NEXT

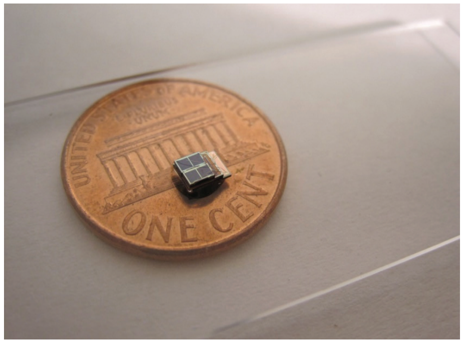
We should see more interesting developments in smart dust this year as the practical application of always-on sensors grows. In Pakistan, a power company is hoping to run more efficiently using smart dust to monitor heat data so that it can determine optimal maintenance upgrades.

In health and medicine, this technology will dramatically change our approach to imaging. Rather than relying on our current endoscopic technology, which is bulky and invasive, a patient could simply inhale smart dust.

Beyond medicine, trillions of smart dust particles could be released in the wind to measure air quality or take photos. But we must also consider other use cases: would you know if you'd inhaled rouge smart dust on a windy day? In the farther-future, could this technology be used to track us surreptitiously?

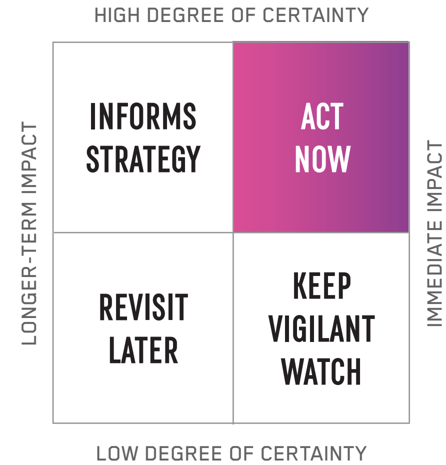
WATCHLIST

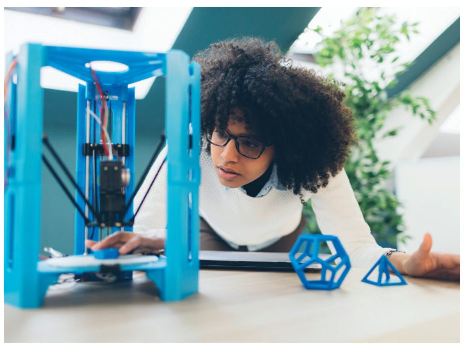
Ambiq Micro; PsiKick; University of Stuttgart; University of California Berkeley; Stanford University; Matrix Industries; University of Washington; Purdue University; USC Robotics Research Lab; Jeeva Wireless; DARPA.



Tiny computers the size of dust will be used to gather data, record video and take photos.

3D Printing





3D printing has moved from the fringe to the mainstream.

KEY INSIGHT

3D printing has moved from the fringe to the mainstream, offering new opportunities for medical and biosciences, manufacturing and artists.

EXAMPLES

3D printing isn't just for keychains anymore. In 2018, metal 3D printing became easier, and in 2019 it will be possible to print using different polymer materials. Rather than simply printing prototypes, the technology has matured enough for use in industrial spaces. Growth in new materials printing has made 3D printing a viable resource in the aerospace and automotive industries, which must meet stringent requirements for parts use. Last year, Airbus and Materialize printed the first 3D parts used in the cabins of Airbus's commercial aircraft.

WHAT'S NEXT

In an experiment at **Northwestern University's Feinberg School of Medicine**, researchers successfully printed and implanted mouse ovaries which resulted in a successful pregnancy. **Russian** startup **Apis Cor** 3D printed an entire house. Researchers at the **School of Food and Nutritional Sciences** and **University College Cork** printed cheese from raw, natural materials. In the coming years, we'll see companies custom-printing orthotics and footwear, eyeglasses and athletic equipment. Soon, "one size fits all" won't need to fit any one person ever again. If you're thinking **Star Trek Replicator**, you're not far off. Researchers are working towards scanning and producing 3D objects in seconds—over time, this technology will be used in surgical centers, to rapidly print replacement valves and knees using your own biomatter as models.

But there is a catch: we don't yet have international product liability and intellectual property standards, norms and regulations governing 3D printing. A regulatory framework built to protect designers, patents, corporations and individuals is likely on the horizon.

WATCHLIST

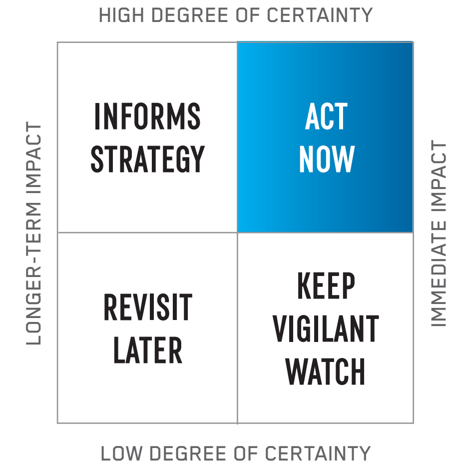
Autodesk; Matrerialize; Kodak; Ethereal Machines; Northwestern University's Feinberg School of Medicine; University College Cork; Apis Cor; Organovo; MIT Media Lab; Airbus; GE; Formlabs; Aurora Labs; Arc Group; ExOne; Voxeljet; Stratasys; HP; Shapeways; MakerBot; University of Illinois Urbana; University College London.

PRINTING IN THE NEXT DIMENSION

4D printing is similar to 3D printing—but with the inclusion of time. Last year, Chinese researchers successfully printed ceramics that were capable of transforming over time in response to stimuli such as heat and light. There are practical applications of 4D printing that are tremendous. Imagine a heat shield that suddenly materializes during a fire, or a garden that plants itself when the ground has warmed to precisely the right temperature for each seed.

NEWS MEDIA, BOOK PUBLISHING, SOCIAL NETWORKS AND THE FIRST AMENDMENT

The End of Attention Metrics



The numbers are all fking fake, the metrics are bullshit, the agencies responsible for enforcing good practices are knowing bullshitters enforcing and profiting off all the fake numbers and none of the models make sense at scale of actual human users.

– Aram Zucker-Scharff, director of Ad Tech for the Washington Post, in a tweet on December 26, 2018.

KEY INSIGHT

The attention economy, which spawned listicles, eHows and tweet roundups, isn't as easily measured as previously thought.

EXAMPLES

In November 2018, the **US Department of Justice** indicted eight people for massive ad fraud that resulted in $36 million in fake ads. They were cleverly able to use bots to fake clicks and even mouse movements to mimic human consumers. Researchers estimate that more than half of web traffic is fake. This is a serious problem for both publishers who rely on ad revenue and advertisers who need to satisfy client metrics. Now that **Facebook** has announced that it is weighing personal posts over news stories from publishers, and **Google** has launched a native ad-blocking client in **Chrome**, everyone in the digital marketing and advertising space is wondering what's next for metrics. Already, publishers and advertisers will question the validity of metrics that they, themselves, cannot verify.

WHAT'S NEXT

Newsrooms have relied on real-time analytics platforms for years. **Chartbeat** blinks and nags every editor's station. Broadcasters rely on **Nielsen** ratings. But if so much of internet traffic is fake, why bother with analytics platforms that are measuring everything, rather than measuring only what's likely to be real?

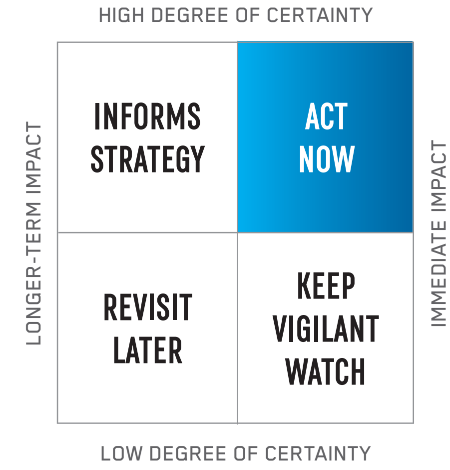
In response, some companies, such as **NBCUniversal**, are starting to produce and track their own metrics. At the end of 2018, Nielsen hired **David Kenny** as its new CEO – he arrived from **IBM** where he was the SVP of cognitive solutions, and **The Weather Company**, where he was chairman. (**TWC** was acquired by IBM.)

Anyone creating content needs to understand the ebb and flow of traffic and how one piece of content fits into the broader scope of the organization. We also expect to see news and other content as organizations develop new models to bring transparency in metrics to staff—without jeopardizing editorial integrity. Look for sharper real-time analytics platforms that are more discerning, as well as more home-grown engagement metrics that reflect how people value content.

WATCHLIST

Nielsen; Chartbeat; NBCUniversal; Amazon Connect; Google Analytics; IAB; Tow Center for Digital Journalism at Columbia University; Annenberg School of Communication & Journalism and the University of Southern California; Vox Media; Axios; Washington Post; New York Times; Wall Street Journal.

I-Teams For Algorithms and Data



KEY INSIGHT

With the increased use of data and algorithms powering our everyday lives, special-ops teams are deploying to investigate AI. But not all of these teams are taking an unbiased approach to investigating the algorithms.

EXAMPLES

The **Cambridge Analytica** scandal proved how vulnerable we are to misinformation created by and spread algorithmically. Some newsrooms are now reporting on the algorithms themselves. Reporters at the **New York Times, Wall Street Journal, ProPublica** and **Washington Post** have been applying the core practices and skills of reporting to investigating algorithms. But this work is often challenging, as it requires specialized knowledge and experience.

In August 2018, New York Times reporters published a story saying that social media use in Germany was correlated with increased violent attacks on refugees. It cited a study posted to **SSRN**, a website used by economists. The article included rich detail and quickly made the rounds all over the internet and sparked even more stories published in GQ, the Verge and elsewhere. But the study was preliminary and clearly stated that it hadn't yet gone through peer review. The Economist was the first to pick up on the study, publishing a short article in January 2018. The NYT called the paper a "landmark study," writing "wherever per-person Facebook use rose to one standard deviation above the national average, attacks on refugees increased by about 50 percent." That was a bold claim, and it prompted researchers to dissect the original paper. The real problem had to do with how the reporters interpreted the methodology—and the algorithm—used to analyze social media posts.

WHAT'S NEXT

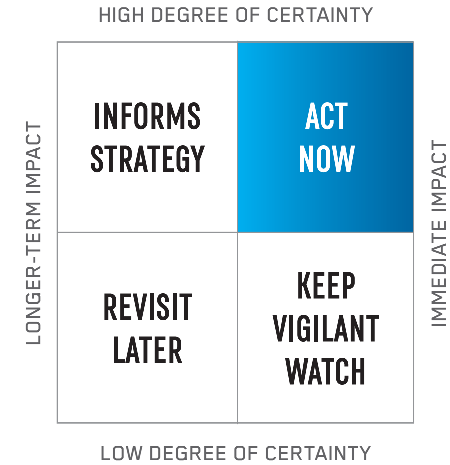
Now that news organizations are dedicating staff to investigating algorithms, they will also need to train their reporters to broaden their techniques. As technology advances, transparency in our systems grows murkier. Understanding where information comes from, how it spreads, and the impact it has—not to mention the outcomes of algorithmic decision-making—requires a special skills set. Investigating algorithms has never been more important than it is now.

We will soon reach a point when we will no longer be able to tell if a data set has been tampered with, either intentionally or accidentally. AI systems rely on our trust. If we no longer trust the outcome, decades of research and technological advancement will be for naught. Building trust and accountability is a matter of showing the work performed. This is a complicated process, as understandably news organizations would want to keep certain data and reporting methods private.

WATCHLIST

Brown Institute at Columbia University; Macromedia University of Applied Sciences; Tow Center for Digital Journalism at Columbia University; AlgorithmWatch.org; ProPublica; Philip Merrill College of Journalism at the University of Maryland; Media Change and Innovation Division at the University of Zurich; Annenberg School of Communication & Journalism and the University of Southern California; Washington Post; New York Times; Wall Street Journal; National Public Radio; Investigative Reporters & Editors; National Institute for Computer-Assisted Reporting.

Computational Journalism



Neura uses machine learning algorithms to analyze sensor data to create insights about end-user real-world experiences.

KEY INSIGHT

What are the ways in which data and algorithms can enhance reporting? **Computer Assisted Reporting** (or **CAR**, as its known by industry professionals) is an investigative journalism technique. Reporters find, clean and mine public records and documents, crunch data and uncover hidden stories. Aided by machine learning algorithms and AI, computational journalism is the evolution of CAR.

EXAMPLES

It's one thing to find and mine public data—analyzing what's there, and connecting the seemingly unconnectable dots, is another challenge entirely. Computational journalism techniques such as multi-language indexing, automated reporting, entity extraction, algorithmic visualization, multi-dimensional analysis of data sets, and flexible data scraping are allowing journalists to combine what they find in the data and then see the connections between facts, keywords and concepts. In this way, they can reveal interconnected relationships between people and organizations that they might not have otherwise seen.

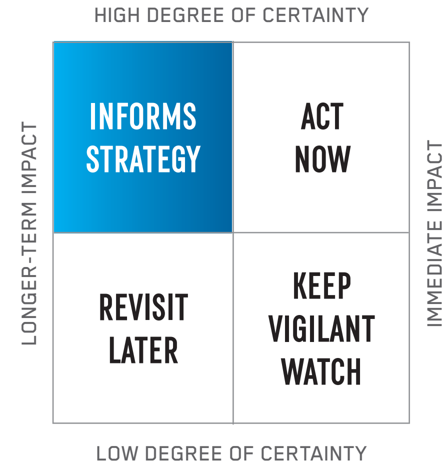
One modality is to harness the data from a crowd in a technique known as "crowdlearning." **Crowdlearning** is a computational journalism technique that queries our passive data—our mobile and online activity, our public health records, our locations—to learn or understand something new. One company making good use of this technique is **Neura**, an AI-startup that learns from a broad spectrum real-world and digital user data throughout the day.

WHAT'S NEXT

We anticipate increased demand in computational journalism and journalists with complimentary skills sets. There are a host of stories waiting to be discovered, written and produced.

WATCHLIST

Google; Bing; Apple; Microsoft; Neura; Investigative Reporters & Editors; National Institute for Computer-Assisted Reporting; Coral Project; Stanford Computational Journalism Lab; Duke University; University of British Columbia; University of Texas at Austin; Brown Institute at Columbia University; Tow Center for Digital Journalism at Columbia University; Philip Merrill College of Journalism at the University of Maryland; Media Change and Innovation Division at the University of Zurich; Annenberg School of Communication & Journalism and the University of Southern California; Wall Street Journal; New York Times; Washington Post; Tamedia; ProPublica; National Public Radio.



Natural Language Generation to Modulate Reading Levels

KEY INSIGHT

Natural Language Generation (NLG) is a processing task, where computers generate the kind of language humans would use in a designated situation. NLG can be used to rewrite content for a variety of different reading levels, offering tremendous possibilities for book publishers and news media companies alike.

EXAMPLES

Many companies—including **Credit Suisse**, **Deloitte**, and a number of news organizations—were already using **Narrative Science**, an NLG provider. A basic set of data was processed with an NLG algorithm to produce a readable story, which sounded no different than if a human had written it. In 2017, researchers at the **University of Washington** developed an NLG model that convincingly showed President Barack Obama giving a speech—that he never actually gave in real life.

WHAT'S NEXT

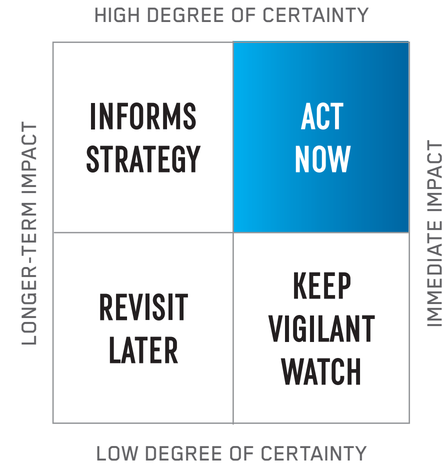
As **book publishers** and **news organizations** search for new revenue streams, NLG will be used not just to write stories—but to create different versions for audiences with varying reading skills. That's because the basic corpus—the data that makes up the story—wouldn't change, but the vocabulary and amount of detail could be adjusted. For example, a single story about the results of **Berkshire Hathaway**'s quarterly earnings could be rendered in many different ways: for finance professionals, for high school economics classes, for beginning English as a second language learners, and for MBA students in non-English speaking countries. Similarly, NLG could be used to automate the current work-intensive process to create book extracts and summaries. Using NLG to custom-write different version of stories enables organizations to scale their operations for new audiences worldwide—without hiring additional staff. But NLG can also be used to create hyper-realistic fake news videos—something to be on the lookout for in the coming year.

WATCHLIST

MIT-CSAIL; Arria NLG; Narrative Science; Expect Labs; Automated Insights; Department of Computing Science, University of Aberdeen; School of Science and Engineering, University of Dundee; Research Center on Information Technologies (CiTIUS), University of Santiago de Compostela, Spain; School of Informatics University of Edinburgh.

University of Washington developed an NLG model that convincingly showed President Barack Obama giving a speech that he never actually gave in real life.

Crowdlearning



Searches for "what is the eu" and "what is brexit" surged after the UK election.

KEY INSIGHT

You're familiar with **crowdsourcing**: asking the public to contribute content or to assist with on-the-ground reporting on an issue. **Crowdlearning** is a computational journalism technique that queries our passive data—our mobile and online activity, our public health records, our locations—to learn or understand something new.

EXAMPLES

In June 2016, the evening after citizens in the **United Kingdom** voted for **Brexit**, Google revealed sobering search data: people in the UK were Googling "what is the EU." This passive data told an interesting story, and it's just part of what we're now able to learn from the crowd by monitoring various networks. Our smartphone ownership has reached critical mass, and so has our use of various networks. Our data not only follows us around, it's often available for anyone to search, collect and analyze.

WHAT'S NEXT

Reliable crowdlearning sources are already available to us, and they include **Google's** busy times data for businesses and public spaces, **Waze, Spotify** and more. We anticipate that more news organizations—as well as marketers, activists and other groups—will start harnessing data in creative ways. That's because our thinking results in behavior (like searching for "what is the EU?"). Our behavior results in data. And that data can be used to learn something about us.

WATCHLIST

Google; Bing; Apple; Microsoft; Investigative Reporters and Editors; National Institute for Computer-Assisted Reporting; various US government websites; various state and local government websites; the websites of government agencies worldwide.

Synthetic Data Sets

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Complete health, medical, transit and population data sets are not always available (or in a usable form) to researchers. As a result, some are developing and experimenting with synthetic data sets to perform meaningful analyses and train models in AI. One challenge: synthetic data sets often miss important information or reflect bias.

EXAMPLES

Researchers from the **Data to AI Lab** at the **MIT Laboratory for Information and Decision Systems** are developing a machine learning system to automatically create synthetic data, which could then be used to develop and test data science algorithms and models. They propose a **Synthetic Data Vault**, which would be able to learn and develop multivariate models for any number of purposes. In their testing, the synthetic data gave the same results as real data—without compromising privacy. Synthetic data sets hold promise for lots of applications and organizations, ranging from retail to healthcare to the federal government.

Policymakers, in particular, are interested in getting better data to make our future autonomous transportation systems reliable and safe. At the moment, companies like **Uber, Lyft, Apple, Google** and **Waze** hold an enormous amount of real-world data—handing it over to the government would violate the public trust. Instead, trip data could be converted into synthetic data, modeled using trips that people take.

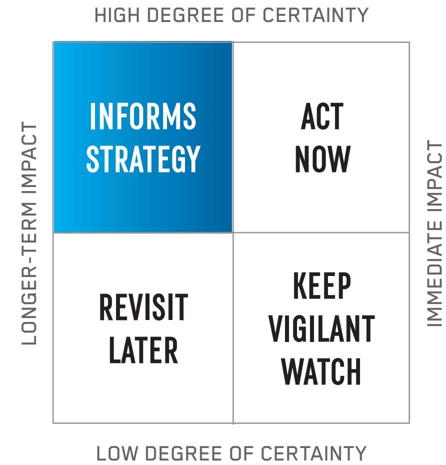
A number of agencies collect detailed information for the purpose of generating statistical models. For example, the **US Census Bureau** gathers a wealth of information, such as age, gender and income. It also collects similar data on businesses, including annual payroll and employment. While this information is vitally important to researchers, allowing everyone access to it presents a privacy challenge. For example, programmers need data sets to create and test new algorithms. But the numbers matter—so creating a statistically identical set of 1000 people without divulging their exact details has been a difficult task. During the past few years, a number of new approaches have been tried, including the experimental **Synthetic Longitudinal Business Database (SynLBD)** from the Census Bureau.

WHAT'S NEXT

While some researchers argue that synthetic datasets aren't useful beyond testing algorithms and computer models, we think that increased privacy concerns will lead to the creation and use of more sets like the SynLBD. **The Data Observation Network for Earth** (DataONE) is working on datasets that can be shared by researchers all over the world. One future challenge: synthetic data still needs to be verified.

WATCHLIST

DataONE; National Association of City Transportation Officials (NACTO); World Resources Institute; US Census; University of California-Davis; Purdue University; OECD's International Transport Forum; Duke University; SharedStreets; University of New Mexico; US Geological Survey; ESA Data Registry; Knowledge Network for Biocomplexity; SANParks Data Repository; US National Science Foundation; Uber; Lyft; Alphabet; Apple; Waymo; Didi Chuxing; Ofo; Mobike.



Monetizing Chat-Based Journalism

WeChat is a popular social media app in China and a popular way to make payments.

KEY INSIGHT

Communication and messaging platforms are becoming the central hub for social interactions including the distribution of information and execution of financial transactions. This centralization of channels and access to services creates an opportunity for new channels to reach readers that have micropayment functionality enabled. In China, media organizations are incentivizing their audiences to make micropayments for content.

EXAMPLES

WeChat in **China** is the global market leader in incorporating value added services into its messaging platform. WeChat offers a wide range of services and functionality but one of its most interesting services is the ability to pay friends (person to person) and pay merchants directly within the application, thereby merging a communication channel and transactional channel into one.

Additionally, WeChat is developing functionality that allows new monetization schemes for journalists. These functionalities include the ability to tip content creators and pay to read functionality. These kinds of functionalities stimulate journalists to move from established newsrooms into their own individual audiences and followers.

Other major platforms are also adding payments functionality although focusing initially on person-to-person transactions. These platforms include **Facebook messenger, iMessage, Snapcash, Gmail, Google Assistant** and **WhatsApp**.

WHAT'S NEXT

Messaging platforms continue to seek out new features and functionalities that will keep users engaged on the platform including enabling seamless actionability. This could allow more people an avenue to discuss and perform actions all within the same channel, by making reservations, creating calendar events or executing payments. We expect further consolidation of communication and transaction channels in the next decade as messaging platforms seek to absorb other disparate functions using chat as the center point of a convenience driven ecosystem. This creates the opportunity for journalists to develop one-to-one relationships with their readers and drive much more engagement and interaction at a level more advanced than in the past. Using segmentation and extremely targeted content, organizations could offer interactions on specific topics that are timely, as well as contact with relevant experts where the interaction and the knowledge are paid for directly.

WATCHLIST

Apple; Google; Amazon; Microsoft; Facebook; PayPal; WeChat; WeMedia; Weibo; Line; Alibaba; Venmo; Alibaba; Mastercard; Visa; Citibank; BBVA; Santander; ING; Slack; blogging platforms; Chinese internet authorities.

SCENARIO

Scenarios For Monetizing Chat in the Year 2029

Chat programs become the browser for our person-to-person interactions in the next decade. Global messaging platforms follow WeChat's hub model and begin adding more and more features. News becomes a key feature of chat hubs that retain engagement.

Optimistic Framing

Global standards are set, and features and functionality are enabled for chat across countries and borders. This improves inclusivity and access for all. As platforms become multinational, we see less censorship. Algorithms ensure that we view multiple sides of issues that are relevant at a local scale as well as issues that are relevant at a global scale. The platforms create a strong demand for diverse journalism.

Plausibility

30% because local governments and regulations will try to limit a single entity having so much access over its communications, especially at a global level. Journalists will be pushed into creating one-to-one relationships with their audiences in order to monetize the content they create.

Pragmatic Framing

Regional players become market leaders and take advantage of large network effects by adding features that are easiest to implement. A select few journalists attain a strong and large enough following to monetize journalism without needing a larger distribution or trust-enabling partner.

Plausibility

60% because this is the path of least resistance. Partners will come to messaging platforms hoping for access to users. Content creators that have reached critical mass using existing platforms (newsrooms or record labels) will seek to capture more of the financial pie.

Catastrophic Framing

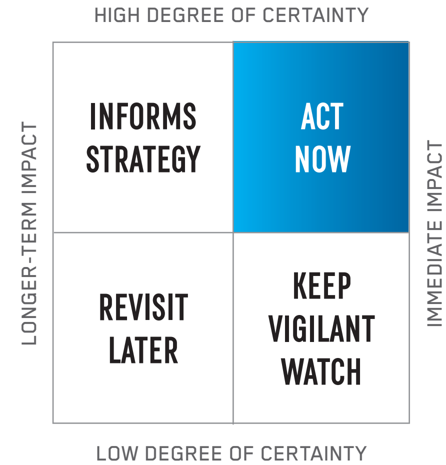
Chat ecosystems become increasingly fragmented as partners and players seek to build walls around the features and functionality that they can provide. This results in platforms with functions that are only effective for specific situations. Divergent viewpoints are marginalized.

Plausibility

10% because walled gardens are hard to maintain, as we saw with BlackBerry Messenger. Network effects and critical mass are needed for many financial models to work at scale and support small players. With no clear platform to centralize around, people will have to find other ways to centralize and achieve efficiencies of scale.

– KRIFFY PEREZ

The Case For Radical Transparency



Donald Trump has repeatedly made dangerous accusations that journalists publish what he calls "fake news."

KEY INSIGHT

Cambridge Analytica, the influence Russia peddled during US elections, and the continued spread of misinformation are making a strong case for radical transparency.

EXAMPLES

In 2018, the **US Immigration and Customs Enforcement Agency** was discovered modifying a piece of software (its "Risk Classification Assessment" tool) they use to determine whether an immigrant should be detained or released on bond. The agency decided to remove the "release" recommendation, but it didn't disclose to the public that ICE had altered the tool. It was yet another example of data and algorithms being used in ways that intentionally hid the whole truth from journalists. When this story did finally come out, it was instantly politicized—many people argued on social media that it was "fake news" made up by journalists.

WHAT'S NEXT

The only way to combat misinformation is to make the newsgathering process completely transparent. Just as consumers expect to see a byline on stories, because it creates a chain of accountability, they will soon expect to know how stories were built. Reporters aided and augmented by smart systems should explain what data sets and tools they used. Meanwhile, stories that were written in part or entirely by computers should reflect that an algorithm was responsible for the piece of content being read/ watched.

Professor Ahmed Elgammal at Rutgers University has developed an algorithm that looks for novelty in paintings and analyzes which artists influenced that work. His research has inspired others to use similar network analysis, historical data and machine learning to look for similarities in literature, writing and news. A system like this could be deployed to look for explicit and hidden influencers on news stories. Now that news organizations are relying on data, algorithms, and machine learning for various aspects of news gathering and publishing, they should commit to radical transparency.

WATCHLIST

News organizations everywhere.

Pop-Up Newsrooms and Limited-Edition News Products

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

IMMEDIATE IMPACT

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Some organizations have begun to experiment with pop-up newsrooms for specific projects and with temporary products: limited-run newsletters, podcasts that only last a set number of episodes, live SMS offerings that happen only during events.

EXAMPLES

During Sweden's 2018 election, more than a hundred journalists gathered together to create **Pop-Up Newsroom Riksdagsvalet** – a temporary newsroom designed to curb misinformation in the final days before voting. It was staffed by the next generation of Sweden's journalists from three prestigious journalism schools. It was an extension of **Pop-Up Newsroom**, a joint initiative from **Meedan** and **Dig Deeper Media**, launched in June 2017 with the aim of setting up a framework that encourages both editorial and technological innovation.

Meanwhile, news organizations are creating limited-edition news products that don't require labor-intensive, one-off templates and workflows. Whether it's a planned news event (such as local elections, festivals or races), an annual conference (**CES, SXSW, PopTech**), a season (skiing, football, baseball), or a big story that has a defined beginning middle and end (such as a weather event), limited-edition news products are starting to be used by news organizations.

WHAT'S NEXT

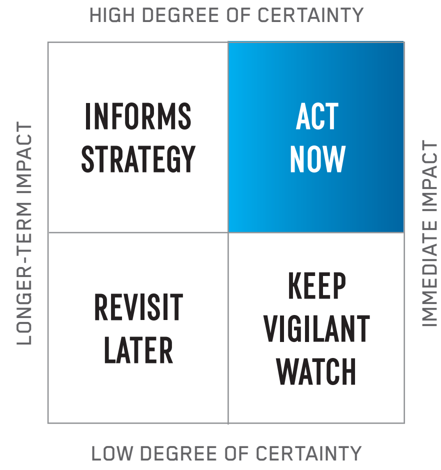
We anticipate seeing more popup newsrooms, temporary podcasts, newsletters and chatbots that are deployed specifically for just one event. Limited-edition news products are revenue and audience engagement opportunities, as they are vehicles for data collection and targeted advertising.

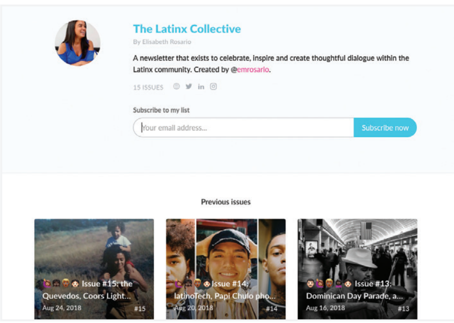
WATCHLIST

News organizations everywhere.

A sign from the recent Pop-Up Newsroom Riksdagsvalet.

One-To-Few Publishing





The Latinx Collective is a newsletter published on Revue.

KEY INSIGHT

Newsletters, podcasts and niche networks that captivate smaller audiences have made a huge comeback. What's next is an expansion to capture even more niche audiences.

EXAMPLES

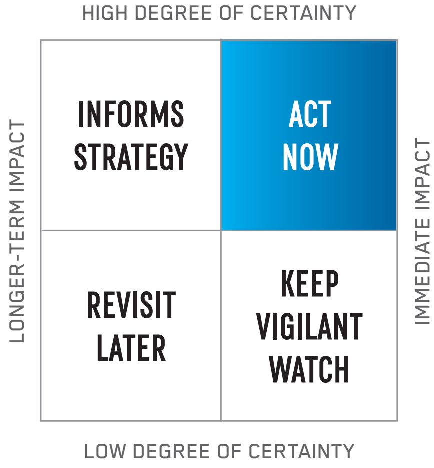
Suddenly, it seems like everyone—from world leaders, to your next-door neighbor—has a podcast or newsletter. The newest platforms allow content creators to build in a paid subscription model, and early indications are that people are willing to pay. **Revue** and **Substack** both offer tools to launch a subscription newsletter: software, analytics, payments service and templates. Meanwhile, **RadioPublic** guarantees payments to its podcasters. It bookends ads on each episode, and RadioPublic pays podcasters for every listen at an average rate of $20 CPM, regardless of the show's audience size.

WHAT'S NEXT

We anticipate seeing more and more niche networks launch, whether they are individual newsletters or podcasts. But we're also expecting to see more mixed reality applications and shows intended for small audiences. There is an opportunity here for media companies of all sizes to earn revenue at scale from a series of small audiences.

WATCHLIST

RadioPublic; Substack; Revue; PRX; TinyLetter; Mailchimp; Skype; Garage Band; SoundCloud; Libsyn; Stitcher; Auphonic; SpeakPipe; Twilio; PRI.



Abusing The Notification Layer

KEY INSIGHT

Notifications show bits of information, including updates, reminders and messages from friends. They appear on the lock screens of mobile phones, wearables and connected devices.

EXAMPLES

Notifications are particularly attractive to news organizations because they capture attention when our attention is most vulnerable. Notifications tempt us to look at our screens and to click through. Users who opt-in to receive push notifications increase app retention rates by 2x or more, while opt-in users are twice as likely to engage with the content teased. Most major news organizations, as well as content-creators from other sectors, are now engaging notifications to pull users into content.

WHAT'S NEXT

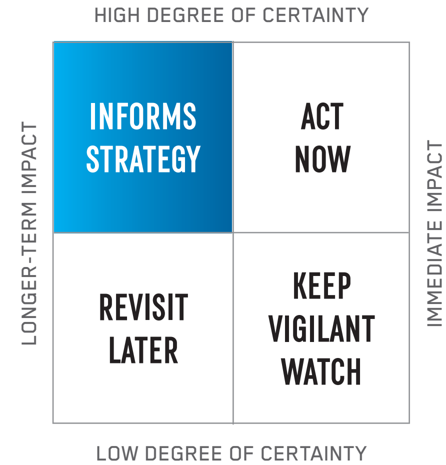
The problem is that notifications now come from everywhere—from the OS, government emergency services, weather apps, games, social networks, podcasts, and more. Notifications with photos and emoji perform better, which is a show of how cluttered the space has become. News organizations will need to develop new tactics and strategies to ensure that their notifications don't add to the existing notification layer of clutter—and so they do not alienate readers.

WATCHLIST

News organizations everywhere; Android; Apple; Amazon; Microsoft.

Notifications are a constant distraction.

Next-Gen Native Video and Audio Story Formats



In Bandersnatch, Netflix used interactive tools to let viewers choose what the characters should do next.

KEY INSIGHT

Capitalizing on the proliferation of consumer tech featuring responsive visual, tactile and audio interfaces, storytellers are developing unconventional narratives to engage their audience in new ways. News media and entertainment organizations have begun exploring these innovative modes of storytelling, with areas of focus in personalization, interactivity and immersion.

EXAMPLES

Pioneers in the storytelling space are making use of advancements in audiovisual tech to create content that immerses the audience and elicits interaction. Production house **Eko** creates interactive live-action video content where the viewer taps or clicks to decide the protagonist's actions, and **Netflix** has introduced similar user-influenced programming for younger viewers. Last year the **BBC** released an audio play available on **Amazon's Echo** smart speaker in which the listener guides the narrative by speaking directly to the characters. Meanwhile, companies like **RYOT** have partnered with major news outlets including **The New York Times** and **NPR** to produce immersive documentary video segments, viewable in VR, in which audiences can freely explore environments in 360 degrees.

WHAT'S NEXT

Currently these new storytelling formats are in an experimental phase, with consumers yet to fully embrace them, and companies yet to fully master them. In the coming years, however, growth is expected in interactive and immersive audio and video, with major media brands looking to stake their claim in the space. **Eko** is building a video platform for **Walmart**, presumably to compete with rival **Amazon's** robust video programming, and major networks like **ABC**, **Fox**, and **CNN** have dedicated digital channels for VR/360 video content spanning news, sports, and entertainment. As audiences flock to the new formats more often and in greater numbers, brands at the forefront of this trend will be positioned to perform enhanced data collection with which to target advertising and personalize content.

WATCHLIST

Eko; RYOT; BBC R&D; Spotify; Dolby; Melcher Media; Wolf 359; World Building Institute; Netflix; Magic Leap; Amazon; Google; Facebook; Nvidia; Sony; Imax; Microsoft; Samsung; Qualcomm; Intel; LG; Huawei; Zeiss; Xiaomi; HTC; Lenovo; HP; YouTube; Oculus.

SCENARIO

Near-Future Scenarios For Lip-Synched Videos

AI can generate lip-synched video that is indistinguishable from the real thing. Generative algorithms could be used to automatically create videos of CEOs reading their annual letters, or for analysts to explain their latest findings. However, hackers could also use this technology in real-time to manipulate company stock prices.

Optimistic Framing

Computer generated video standards are created so viewers have a clear understanding of when "improved" or "generated" video is being watched. The generated and improved videos are used to communicate messages more clearly and concisely at the level that is most appropriate for the end consumer. All entities have access to ability and expertise, ensuring that there is no unfair advantage to any specific entity. It saves time for CEOs and leaders, who wouldn't have to sit through recording sessions.

Pragmatic Framing

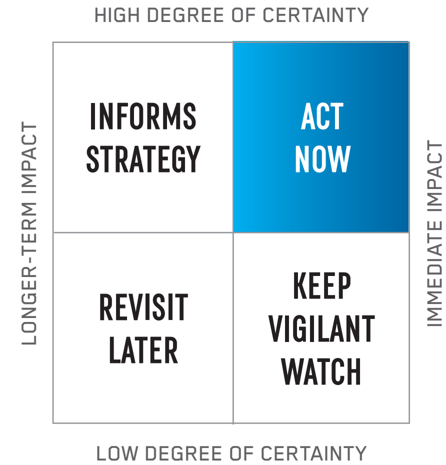
CEOs already tend to read from scripts that are heavily practiced and scrutinized. This would be an additional tool that the communications specialists could leverage. Only few large players become adept at using the technology and make personalized messages a competitive advantage to stimulate stock performance and growth. It's clear that those companies are using generated video—however they make it impossible for smaller companies to use the same technology.

Catastrophic Framing

Misinformation becomes rampant as everyday people are unable to tell what is real and what is not. Competitors intentionally misappropriate the likeness of managers and CEOs at other companies, as well as analysis and investors, which splinters organizations and countries and generally wreaks havoc around the world.

– KRIFFY PEREZ

Digital Frailty



The Village Voice closed after a long and storied history of award-winning investigative reporting. What will become of its digital archive is still unknown.

KEY INSIGHT

Digital Frailty is the phenomenon in which digital assets originally published to a news organization's website are impermanent or easily broken. In the past several years, we've seen the first widespread cases of important journalism being erased from the web because of media consolidation or because sites were no longer being maintained. This is becoming much more common, and it's happening at a faster rate.

DIGITAL FRAILTY IN THE NEWS

The Village Voice closed after a long and storied history of award-winning investigative reporting. When investor Peter Barbey bought the Voice in 2015, he promised it would "survive and prosper." Barbey closed the print edition two years later and in August 2018 closed its doors entirely. There were no plans to preserve its digital archive, which means the digital-only content published by the Voice could soon be gone forever.

The Voice is just the latest entry on a long list of news organizations that no longer exist. A Pulitzer Prize-winning investigative series about a collision that killed 20 children and devastated a Colorado community went offline when the Rocky Mountain News went out of business. The Tampa Tribune, whose motto was "Life. Printed Daily," hunted for important stories in the public interest, covering investigations into Tampa's judges, legislators and law enforcement.

A similar scenario played out with Rising From Ruin, an award-winning project by MSNBC. The project told of Hurricane Katrina's aftermath twelve years later through the lens of two small communities in Mississippi– important stories that weren't covered by any other media outlet. It included a series of videos, maps, interactive elements, a forum for residents – and, since it only existed as a website, there was no other way to see the stories. When Microsoft pulled out of its joint venture with NBC, the project went offline.

DIGITAL FRAILTY IN GOVERNMENT AND PUBLIC INFORMATION

Under the **Trump Administration**, the **US government agencies** removed studies, data and reports throughout 2016, 2017 and 2018. Most notably, the **Environmental Protection Agency** scrubbed its website of climate change information. This was an effort to support the Trump Administration's ideas and policies. A government website built to educate children, called "Energy Kids," also scrubbed mentions of climate change. The Trump Administration also removed LGBTQ content from federal websites, scrubbed a lot of civil rights information off of **WhiteHouse.gov** and scrubbed the **HHS.gov** website of healthcare data. Federal agencies instructed staff and grant recipients to avoid using certain phrases—"transgender," "fetus," "science-based," "evidence-based,"—citing concerns by the Trump Administration.

And what about a president's tweets? Last year, the **US National Archives** said that posted tweets are considered presidential records and requested that the **White House** save deleted or altered tweets—however we still don't know whether the **Presidential Records Act** legally applies to social media posts. Some independent websites, including **ProPublica's Politwoops** project, are now archiving President Trump's deleted tweets, some of which announced US policy: Mexico would reimburse Americans for a wall at the southern border (he deleted this tweet after 51 seconds), that China had stolen a US Navy research drone (deleted an hour later), and "The White House is running beautifully. We are making some of the greatest and most important deals in our countries history - with many more to come. Big progress!" (deleted after 1 minute).

DIGITAL FRAILTY AND PERSONAL ACCOUNTABILITY

What about everyday people? We might need to look back on this moment in time and reflect on how our language—how the very way we communicate—was shaped by our **Instas**, our **Snaps**, and our tweets. Will our future historians look back, marveling at the amount of anthropological data we were simultaneously creating—and destroying? If this past election season taught us anything, it's that **Twitter** helped to shape public opinion and the outcome of the election, even as many controversial tweets posted by candidates running for office, were deleted by their campaigns.

WHAT'S NEXT

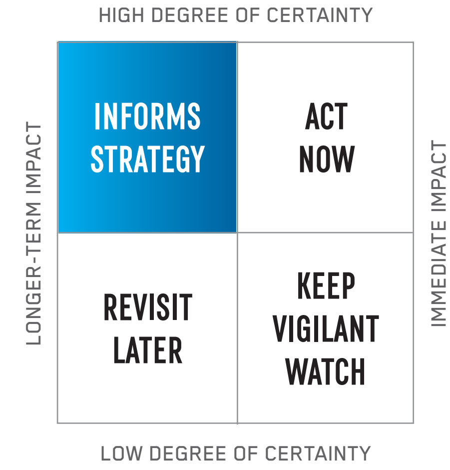
Digital frailty is a phenomenon impacting journalists everywhere. Digital frailty isn't just about falling revenue—sometimes, new technology obviates the old, before anyone has had a chance to convert files or develop archives. News executive **Mario Tedeschini-Lalli** explains how Italy's largest news website, Repubblica.it, didn't originally use a content management system. When the site installed a CMS for the first time, everything published before it was lost forever. Tedeschini-Lalli, along with colleagues **Nicolas Kayser-Bril, Anne-Lise Bouyer, Pierre Romera** and **Defne Altiok**, launched the **Offshore Journalism Project**—they hope to preserve national and private archives and ensure that quality journalism lives on, even if political appointees and governments disagree. While some content can be retrieved via the Internet Archive, it is only taking snapshots of content at a time. Libraries archive printed material, but there is no central repository for all of the digital content we are now producing. Perhaps we don't need to save every listicle and quiz. What will a future society look like if our current media landscape goes dark? Do we have an obligation to preserve the digital conversations shaping society? Should we be working harder to ensure that digital archives aren't lost?

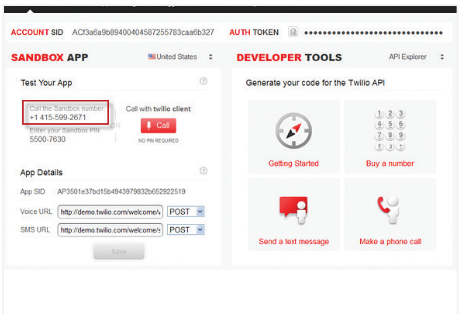
WATCHLIST

Axel Springer; Yahoo; Tumblr; Hearst Corporation; Time Inc; Yomiuri Shimbun Holdings; Tronc; Gannett; Viacom; Hubert Burda Media; Comcast; Alphabet; Asahi Shimbun Company; Microsoft; Grupo Globo; Advance Publications; News Corp; Univision; Baidu; Bertelsmann; Twitter; Snap; Instagram; General Electric; Bloomberg; Disney; Amazon; AT&T; Verizon; ESPN; Netflix; Hulu; The Onion; PRX; PRI; Internet Archive; news organizations everywhere.

The EPA scrubbed its educators website of climate change information.

Journalism as a Service





Twilio is a service helping to connect and distribute content to consumers.

KEY INSIGHT

On the fringes, news organizations are beginning to provide journalism as a service, rather than traditional news products.

EXAMPLES

"Software as a Service" is a licensing and delivery model, where users pay for on-demand access. It's a model that in the near-future might be an inevitability. The central challenge within news organizations is that there are immediate, acute problems—but reasonable solutions will require long-term investment in energy and capital. The tension between the two always results in short-term fixes, like swapping out micro-paywalls for site-wide paywalls. In a sense, this is analogous to making interest-only payments on a loan, without paying down the principal. Failing to pay down the principal means that debt—that problem—sticks around longer. It doesn't ever go away. Transitioning to "Journalism as a Service" enables news organizations to fully realize their value to everyone working in the knowledge economy—universities, legal startups, data science companies, businesses, hospitals, and even big tech giants. News organizations that archive their content are sitting on an enormous corpus—data that can be structured, cleaned and used by numerous other groups.

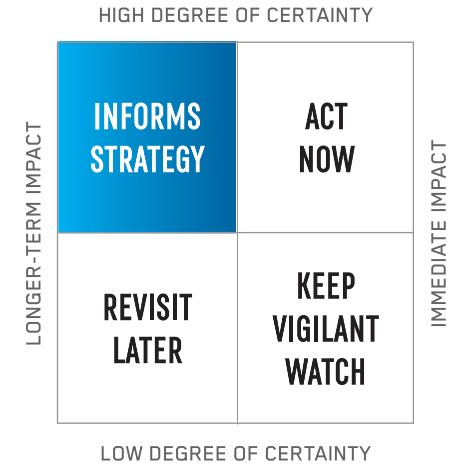
WHAT'S NEXT

News deployed as a service includes different kinds of parcels: news stories; APIs; databases that can be used by both the newsroom and paying third parties; calendar plug-ins for upcoming news events; systems that can automatically generate reports using the news org's archives and databases and the like. Services work outside of the social media landscape, relieving news organizations of revenue sharing and allowing them to fully monetize their services.

WATCHLIST

PRX; Twilio; REDEF Group; The Information; The Coral Project; MIT Media Lab; ProPublica.

Algorithmic Fact Checking



KEY INSIGHT

Buoyed by charges of "fake news," fact-checking—powered by algorithm—will be a priority for journalists now and in the near future.

EXAMPLES

Digital tools have made it easy to report on a live event and publish in real time, but adding context—such as whether or not a source's statement is factually accurate—usually happens after. As we now see on a near-daily basis, inaccuracies and falsehoods quickly spread in a cycle, circulating between social media, cable news, political leaders and everyday people. At least when it comes to citing numbers and data, artificial intelligence will soon allow news organizations to automate the fact checking process.

WHAT'S NEXT

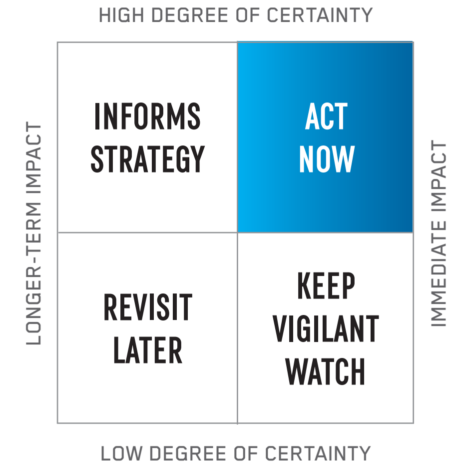
In a few years, AI systems will enable more sophisticated fact checking: explaining whether information was taken out of context, or exaggerated, or downplayed. We expect to see new automated tools for fact checking, adding a critical editorial layer that's both good for the public interest and good for building brand reputation.

WATCHLIST

ProPublica; Brown Institute at Columbia University; Tow Center for Digital Journalism at Columbia University; AlgorithmWatch.org; Washington Post; New York Times; Wall Street Journal; National Public Radio; Investigative Reporters & Editors; National Institute for Computer-Assisted Reporting.

In a few years, AI systems will enable more sophisticated fact checking.

Optimizing For Voice Search



KEY INSIGHT

As content creators venture into spoken interfaces – smart speakers, car dashboards, mobile digital assistants – publishers and other companies are focused more on voice search optimization (VSO). However we're also finding that speech recognition is vulnerable to new kinds of adversarial attacks.

EXAMPLES

While developers have learned how to quickly index and display web content, digital audio has always remained an unsolved challenge. Now, rather than searching for a topic and getting a bunch of hyperlinks to click through and listen to, consumers will instead get answers as part of a conversation with their smart speaker devices. Recently, **Google** released beta version of a new markup called **Speakable** and schema for publishers using **Google Assistant** – it allows publishers to mark up sections of news articles and optimize them to be read aloud. (The specifications are listed on **Schema.org**.) We are using many different voice activated interfaces a day beyond smart speakers: our phones, car dashboards, TVs, temperature controls and more. **Comcast** allows voice queries directly into their remote controls. Increasingly, we're also speaking to devices outside of our homes and offices. **Amazon** and **Marriott** launched Alexa for Hospitality. Guests can ask general questions to a virtual concierge, as well as request services (like towels or a late checkout).

Meanwhile, Tel Aviv-based startup **Audioburst** uses artificial intelligence to index audio broadcasts and make them easier for consumers to find. Rather than searching for keywords, Audioburst uses natural language processing to automatically discover the meaning conveyed and to surface the right content. For example, if a consumer wants an update on the election, she can ask a voice-activated app (**Amazon's Alexa**, **Google Home**), which will sift through audio information and deliver a set of clips. In 2019, **Audioburst** and **LG** Electronics will collaborate to build conversational dashboards for cars.

WHAT'S NEXT

Voice Search Optimization (VSO) is the new Search Engine Optimization (SEO). Companies will need to calibrate how their audio content is delivered via conversational interfaces.

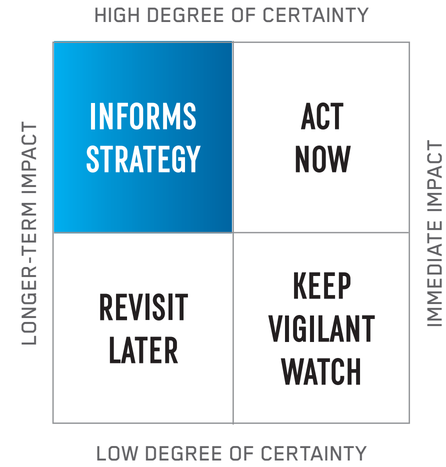
We're starting to see novel attacks against speech recognition AIs. Attacks can trick speech recognition systems into recognizing a synthetic voice, or sounds that are imperceptible to human ears, or even common ambient noises in our homes (like the phone ringing). Any of these audio cues can trigger a smart system to do something we don't want, like make a purchase, or crank the volume up to the maximum level. With our increased reliance on audio search, we'll need to be more vigilant tracking possible vulnerabilities.

WATCHLIST

Audioburst; Amazon; Comcast; Marriott; Tencent; Baidu; Alibaba; Microsoft; Google; Apple; Advanced Media; Viacom.

Voice Search Optimization is the new Search Engine Optimization.

Media Consolidation



KEY INSIGHT

Consolidation – in the new and old guard alike – is coming. Digital audiences increase as margins continue to shrink for traditional media companies. Ad-based revenue models are difficult to sustain, especially for local media outlets and many are shutting their doors. Deregulation from the FCC is paving the way for large media corporations to continue to consolidate through acquisitions and vertical integration. In December 2018, it began proceedings to further deregulate the local media space.

EXAMPLES

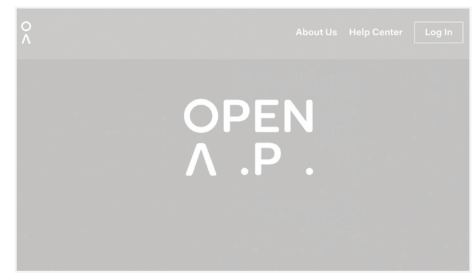
Last year there were a big number of megadeals that are expected to be finalized in 2019: **Disney** and **Fox, Comcast** and **Sky, AT&T** and **Warner Media**. We could see mergers involving **CBS** and **Viacom** this year, as well as consolidation throughout local markets. Meantime, once-hot properties like **Mic** and **Mashable** are finding themselves passed over by investors.

Media consolidation is a trend that matters because it directly impacts the quality and diversity of journalism. Researchers at **Harvard** and **Washington State** have suggested that rise in talk radio, expansion of cable TV, and the internet all coincided with increased elite polarization in the US. The **Columbia Journalism Review** has reported on the rise of news deserts, American towns with no local news coverage. **Politico** reported on the clear correlation between lack of local news outlets and Trump supporters in the 2016 presidential elections. Newsrooms are relying more and more on wire services like the **AP** and **Reuters** as they cut staff under budget pressures.

However, media consolidation does not mean a lack of options. Large media corporations have an incentive to serve a wide and diverse audience so that they can offer more selection to advertisers. In order to secure and sustain audiences, some media outlets are adopting a market segmentation and content differentiation strategy by scheduling shows with stronger positions, louder personalities, and more polarized political stances. **Fox News** and **MSNBC**, often seen as polar opposites on the political spectrum, both dominated the May 2018 cable news rankings.

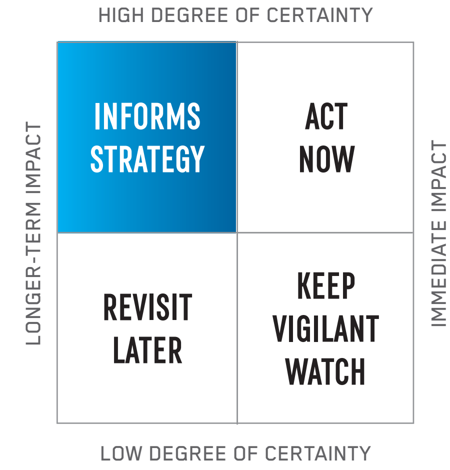
In March 2018, a viral video showed dozens of local news anchors reading a politically-charged script warning against fake news and biased media. All of the stations are owned by **Sinclair**, the largest owner of local TV stations in the US. **Sinclair** has strong connections to the Trump administration and regularly pushes "must-run" political segments to its network of stations. This instance was widely criticized by journalists and publishers.

From a workforce perspective, writers and content creators have low switching costs when it comes to publishing their work on one or more outlets. According to **UpWork**, a freelance marketplace and research



OpenAP is a consortium of TV publishers headed by Turner and Viacom.

Media Consolidation cont.



group, the majority of the workforce will be freelancers by 2027. Reporting from the **Columbia Journalism Review** and other sources show that freelance journalism comes at a cost. Freelance journalists are earning less, are more vulnerable to cyber attacks, and do not have bargaining power for benefits such as health insurance and setting rates.

WHAT'S NEXT

The repeal of net neutrality and continued deregulation of the **FCC** under **Ajit Pai** will likely mean that large media corporations, especially telecoms like **AT&T** and **Comcast**, can increase profits by prioritizing internet traffic and sharing data with their subsidiaries. This trend started in 2015, when **NBC** announced its **Audience Targeting Platform** using among other data sources, set-top box data from parent-company **Comcast**. **OpenAP**, a consortium of TV publishers headed by **Turner** and **Viacom**, offers ad-targeting products that integrate set-top box data from **ComScore** and consumer data from **Nielsen**. Last year, **congress** and **President Trump** repealed US broadband privacy rules which gives more freedom to ISPs to monetize data. Additionally, many ISPs have an opt-out privacy policy which means that customers data is collected by default unless they indicate otherwise.

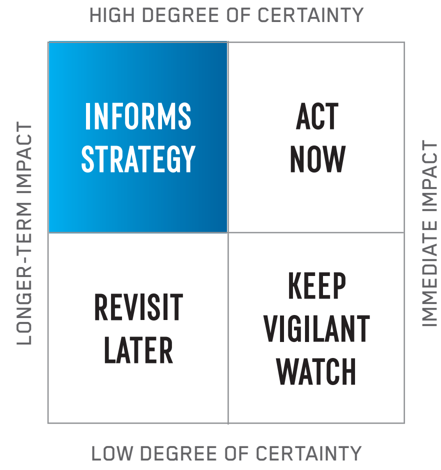
Consumers will not protest at first, seeing lower bills and more perks (such as zero-rating Netflix on mobile streaming devices). These media conglomerates will continue a strategy of vertical integration and will own every piece of the media supply chain. This vertical integration strategy has helped media corporations manage the revenue losses from trends like cord-cutting, skinny-bundling and internet TV streaming packages. With traditional media corporations owning the majority of ISPs in the US, it is unlikely that these corporations will create internet-only packages that give more power and revenue over to tech giants like **Google** and **Facebook**. Google has attempted and ultimately failed to break into the ISP business with experiments such as **Google Fiber**.

Meanwhile, watch for media takeovers by tech and business moguls. In the aftermath of **Time Inc's** breakup, **Fortune** was sold to Thai businessman **Chatchaval Jiaravanon** for $150 million. **Quartz** was bought by **Japan's Uzabase** for $100 million, **Forbes** sold a controlling stake to a Hong Kong-based investment group named Integrated **Whale Media Investments**. **Ev Williams**, who founded **Twitter**, **Medium** and **Blogger**, has been in talks to buy **New York Magazine**.

WATCHLIST

ProPublica; Brown Institute at Columbia University; Tow Center for Digital Journalism at Columbia University; AlgorithmWatch.org; Washington Post; New York Times; Wall Street Journal; National Public Radio; Investigative Reporters & Editors; National Institute for Computer-Assisted. Reporting

The First Amendment in a Digital Age



KEY INSIGHT

While the first amendment pre-dates the Cotton Gin (the most novel technological advance of its time!), today as much as ever, it plays an instrumental role in terms of design, development, and the legal protections afforded to creators and users of technology.

EXAMPLES

It is important to make clear that the first amendment relates to government suppression of speech but not private entities. If Facebook or Twitter decided to block all politically related posts because it could not sufficiently weed out "fake" posts, they would be making a business decision to do so but not one that would raise first amendment issues. So, while we expect to see platforms tighten the rules on what they deem permissible, they are fully entitled to do so. The larger first amendment issues as they relate to media involve questions of what (if any) rights are afforded to AI, and what liability (if any) can be imposed on the creators of technology, algorithms and code.

WHAT'S NEXT

Moving forward, there are numerous scenarios for how governments choose to protect speech created by AI or automated devices. One scenario could be if governments decided that First Amendment protections don't extend beyond human-produced speech. Down the road, future technological advances wouldn't be protected either. But it's unlikely this would happen because humans are involved in programming bots.

Another potential outcome: human programmers are protected under the First Amendment, but AI-created speech is not. This makes sense at some level, but it could fall short when giving credit or blame to content created by a human, versus AI technology. Or, ultimately, the government could decide that AI-produced content is considered free speech, including any content produced by a voice interface or a bot. In the end, it could open up the liability to legal entities responsible for the content.

Legal questions will arise, and we're likely to see various hybrids of these scenarios in the future. The media and journalism will be at the center of these legal questions around the world.

WATCHLIST

European Union; Federal Communications Commission; Google; Facebook; Microsoft; Apple; Amazon; Snap; Instagram; YouTube; Twitch; broadcasters; newspapers; radio stations; digital media organizations; Jack Balkin, Knight Professor of Constitutional Law and the First Amendment at Yale Law School; Margot Kaminski, Assistant Professor, Moritz College of Law, The Ohio State University.

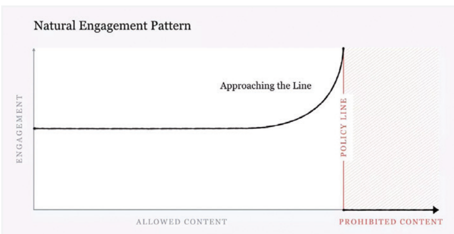
Conspiracy theorist Alex Jones lost his ability to broadcast on major tech platforms in 2018.

Social Tweaks to Social Network Algorithms

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



Facebook announced in November 2018 that it would change some of its policies to help root out fake news and misleading content.

KEY INSIGHT

Social networks including **Facebook** and **Twitter** have promised to tweak their algorithms to curb the spread of bot-generated content. Throughout 2019, we expect to see various tweaks—most not meaningful.

EXAMPLES

Throughout 2018 **Facebook** tested different versions of its **News Feed** around the world. News Feed includes content pulled from verified, professional news websites. The company said that it's hoping to have "meaningful interactions" on its website—and as a result will be demoting content from publishers and brands. However in response to numerous allegations of Russian meddling into the US elections, both Facebook and Twitter could find regulatory challenges both domestically and abroad, which could compel them to take meaningful action.

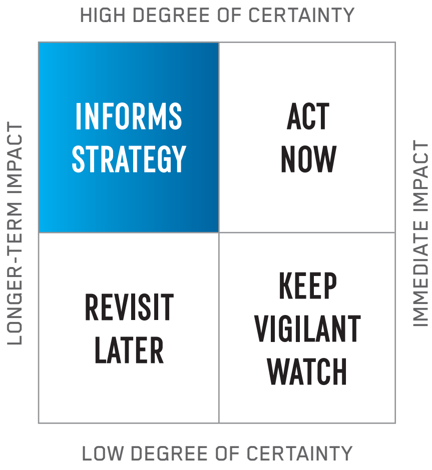
WHAT'S NEXT

The challenge is that algorithm changes tend to happen in real-time, with live audiences. Not all scenarios have been mapped and tested. This became apparent when a fake story about a Muslim man, warning others about a planned terrorist attack in Slovakia, went viral. Local police issued a statement correcting the story, but since it came from the official police station's account, tweaks to the News Feed algorithm prevented Facebook users from seeing it. As social media companies experiment with better ways to curb the spread of fake and misleading information, we will see glitches and potentially even more fake news stories being spread for the foreseeable future.

WATCHLIST

Facebook; Instagram; Twitter; Snap; digital advertisers; digital marketers.

EXTENDED REALITIES



KEY INSIGHT

Mixed Reality, also known as Extended Reality, is the field of digitally generated, enhanced, or manipulated environments that encompasses Virtual Reality and Augmented Reality. Often experienced through a Head Mounted Display (HMD) or via mobile devices, MR has become increasingly present in the contemporary consciousness over the course of the last decade. In 2019 we will see MR more deeply interwoven into various industries and in new commercially viable applications.

WHAT YOU NEED TO KNOW ABOUT MR

For years, AR, VR, 360-degree video and holograms have existed in our cultural consciousness, but they have yet to establish themselves as indispensable, ubiquitous technologies. This coming year, however, the average consumer will see more applications as costs fall and the ease of usability improves.

The ability of MR to transport us and immerse us in distant environments without leaving our everyday surroundings could widen our cultural perspectives and presents a unique opportunity for content creators. They can offer transformational experiences to expose people to otherwise unreachable sites – whether it's the experience of floating in space to swimming inside veins of the human body.

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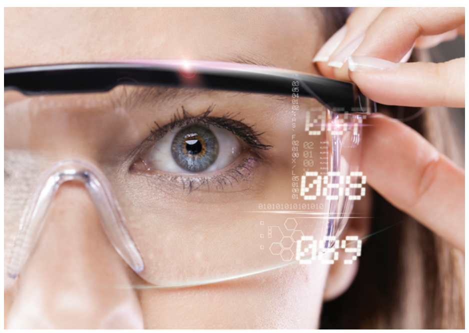
Holograms

Holograms are projected images that appear in three-dimensional space. Professional camera brand **Red** finally launched their impressive hologram-generating **Hydrogen One** phone in 2018, but with a price tag of $1,300 and an enormous, heavy construction, sales were lackluster. It was a stark reminder of the fact that hologram technology, while it is advancing, is still nowhere near making it into the hands of the average consumer. In the entertainment space, companies like LA's **BASE Hologram** are continuing to roll out "live" concerts featuring holograms of deceased stars like Roy Orbison and Amy Winehouse in one of the most prominent instances of holographic tech appearing in the public sphere.

VR is experienced wearing a pair of goggles and a connected earpiece.

Extended Realities cont.



Smart glasses will soon bring AR to everyday people.

Bottom Line

Cost and content are still the two main factors slowing the proliferation of hologram technology. In the context of a hologram concert tour, ticket sales can offset the high fixed costs of equipment and content production, but until the technology is scalable and more proprietary content is produced, prices will remain prohibitively high for individual consumers or businesses with limited applications.

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360-degree Video

360-degree video is created with a special camera rig designed to capture omnidirectional footage. Once the video is rendered, viewers can rotate their point of view using a mouse, touchscreen, or motion-control gesture to explore the recorded scene. YouTube, Facebook and Vimeo offer 360-degree video, and major networks like ABC, Fox, and CNN have dedicated digital channels for immersive content spanning news, sports, and entertainment, with more likely to follow. Portable 360-degree cameras from GoPro, Insta360, Ricoh and Xiaomi may soon help increase the presence of user-created and socially shared 360-degree video content.

Bottom Line

360-degree video has significant market potential, serving as a cost-effective alternate to VR—watch for a broader range of content from media outlets, and a potential uptick in user-generated content.

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Augmented Reality

Augmented Reality (AR) doesn't simulate an entirely new environment, but rather overlays digital elements onto your natural field of vision. AR is often experienced with a Head Mounted Display or smart eyewear, with devices by leading brands like Apple, Google, and Microsoft, as well as the lesser known Vuzix and Meta, either in development or already on the market. Microsoft recently landed a monumental $480M contract with the US military to provide up to 100,000 enhanced versions of their HoloLens HMDs for use in training and combat, a strong indication of the potential scale and worth of applied AR. The past year also saw the launch of the hotly anticipated Magic Leap One headset, which impressed on some fronts, but did not herald a new era in MR the way some hoped it would. Separate from the HMD market, Sony has introduced a different sort of AR product with the Xperia Touch projector, which can transform static surfaces into interactive touch screens.

Bottom Line

AR offers significant market potential, with applications across the military, healthcare, engineering and entertainment industries, to name a few. Keep an eye out for significant investment in the space, as AR's varied practical applications make it a highly sought-after technology, likely to leapfrog VR in value and prevalence.

Practical Application Trends In Augmented Reality

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AR Face Filters to Protect Individual's identity

Some media outlets have begun using AR features like **Snapchat** face filters as a way of concealing the identity of the person speaking while still allowing the viewer to see the facial expressions of the person speaking. **The Hindustan Times** has used these face filters when talking to underage rape victims allowing them an opportunity to tell their story while protecting their privacy.

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AR as a Tool to Enhance Print

One trend we expect to continue to see grow is AR as a compliment to print. Media companies are using AR in print as a way to further engage consumers. AR is incorporated through two distinct channels: content and advertising. Services like **blippar** add animations, models, or images that can only be unlocked using a smartphone. Companies such as **Max Factor** and **Net-A-Porter** have used AR to allow users to scan the items they like and directly purchase them through their mobile phone. The success of AR driven ad campaigns represents a win-win for both the media company and the advertiser, and brands will continue to use this innovation due to the discounted price of print advertising.

SCENARIO

Plausible Scenarios for Augmented Reality in the next 15 Years

AR In Gaming and Education Leads to Improved Collective Health

With games like Pokémon Go leading the way, AR significantly increases the amount of daily activity for the average individual, decreasing the health risks caused by a sedentary lifestyle. Encouraged by games and educational applications featuring digital elements distributed throughout cities and landscapes, people spend more time on their feet and out of doors. Mental health, fitness, and life expectancies improve.

Workplace Applications of AR Increase Productivity, Decrease Training Costs

Having adopted AR systems before the general public, and with significant resources and common goals supporting their efforts, companies make the most efficient and effective use of the technology by implementing it to improve infrastructure, operations, training, and scenario simulation. Everything from collective product design to workplace emergency drills become less costly and more effective, boosting overall productivity.

Dissolution of a Unified Collective Reality

AR comes to define the context in which the average person experiences their daily life, but as a result of over-customization, people lack a common perspective and become severely alienated from one another. Given the ability to define their sensory perception of other people, places and things based on personal preference, individuals become less able to align with one another through shared experience. The rate of real-life social interaction plummets and the human race becomes irreversibly fractured.

– MARC PALATUCCI

Extended Realities cont.

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Virtual Reality

Virtual Reality (VR) is an immersive computer-simulated environment. VR is typically experienced through a Head Mounted Display, which can create the illusion of being physically present in the scenes being viewed. 2018 saw important developments for VR in the realm of entertainment content, with a landmark seven-figure purchase of the **Darren Aronofsky**-produced VR series *Spheres* at **Sundance** (you can currently watch it on **Oculus Rift** devices if you're curious), and a record seven **Emmy** nominations for VR content, including features from **NASA** and **Pixar**. In addition to the **Rift** from **Facebook**-owned **Oculus**, VR headsets are available from brands including **Google, Sony, Samsung**, and **HTC**, and can also be constructed by slipping a mobile phone into a special mask. "Standing" VR is viewed from a relatively stationary perspective and differs from "roomscale" VR, which allows the viewer to walk more freely in a physical space, with their digital environment reflecting their real-life movements.

Bottom Line

The VR marketplace is now well established, but not quite mature enough for widespread adoption. Now, fine tuning of the tech, lower costs for consumer products, and greater richness and variety of content will be the catalysts for further popularization.

Plausible Scenarios for Virtual Reality

AN ERA OF INTERCHANGEABLE IDENTITIES

Pair VR with the concept of DeepFake technology and you've got a frightening prospect: anyone could virtually take on an identity not their own, complete with a digitally projected physical appearance, voice, and movements indistinguishable from those of the individual they are impersonating. In a distant-future era, with VR constituting a majority of human experiences, and with such shapeshifting abilities at everyone's fingertips, it will become increasingly less possible to verify the identities of those around us. Distrust will infect all social interaction, along with the intense mental strain of living under constant threat of identity theft, if not loss of identity entirely. New authentication techniques will be imperative if we are to maintain sanity and order in society, and we will need to be constantly vigilant in verifying the identity of those we interact with.

NEW FRONTIERS IN TORTURE

The use of torture to extract information from criminals and malicious foreign state actors has long been restricted, if not downright illegal, and if done at all it often must be carried out in secret. In the next ten years, however, VR will provide a loophole that can be exploited with devastating consequences. Prisoners of war, for example can be subjected to a horrifying VR experience at length, something tailored biometrically to induce the most unpleasant and traumatic responses, and guilt will be more difficult to assign given that the experience was virtual. Even if common sense dictates there is still culpability in such a scenario, the law may not apply in the way we expect it to. It is very believable that individuals and government agencies will exploit this grey area while laws around VR and ethics are still being developed, and the potential human rights violations in the meantime are terrifying to consider.

A UNIFICATION OF HUMANITY APPROACHING UTOPIA

Director Alejandro Iñárritu's 2017 VR project *Carne y Arena* immersed the viewer in the unforgiving life of an immigrant. This Oscar-winning content was just a glimpse of the sort of transcultural experiences that VR makes possible, spanning ages, geographies, races, even species, and was almost universally praised for its ability to generate empathy in the viewer. In the distant future, VR will be used to create a globalization of experience, allowing us to better understand the human condition that, though varied in its manifestations, binds us as a race. This advancement in mutual empathy will increase support for common-good initiatives like Universal Basic Income, common ownership, and an equitable distribution of labor, leading us toward a utopian society without the grave injustices and imbalances of wealth and comfort we experience today.

– MARC PALATUCCI

Virtual Vocabulary

A mini-glossary for the virtual reality terms you'll need to know in 2019.

Advanced Persistent Threat (APT)
A targeted attack characterized by an attacker (sophisticated or not) who has the time and resources to plan an attack on a network. APTs are not random.

Cinematic VR
VR created with video and images from the real world. (The alternative is computer-generated graphics.)

Extended Reality
A somewhat newer term, Extended Reality (XR) is a catch-all describing every environment resulting from combinations of the real and the virtual, as well as every interaction between humans and machines in relation to those environments and the devices used to create them. XR encompasses VR, AR, and MR, and may come to supplant MR as the most inclusive term for digitally integrated realities.

Eye tracking
A system that can read the position of the user's eyes while using VR. Eye tracking software allows a user to aim correctly with her head while in a simulation.

Field of view (FoV)
What a user can see in her visual field while in a simulation. The viewing angle for an average, healthy human eye is about 200 degrees, so a field of view close to or greater than that is optimal, because it creates a true sense of being within an environment.

Haptics
In addition to a VR headset, handheld controllers are often used. Some are equipped with haptic feedback, which gives the user the sensation of touching something in the simulated environment or receiving touch-back reactions.

Head mounted display (HMD)
This is the headset you've seen people wearing. It typically includes a strap both around and over the head, which secures the screen to your face. Some HMDs include built-in headphones as well as sensors for head tracking.

Head tracking
Some HMDs are equipped with special sensors that track the exact movements of the user's head. The sensors then send feedback to the system, which moves the images and audio a user experiences in her field of vision in real-time.

In-ear monitors (IEM)
These are earbuds that work with head mounted displays that don't offer built-in headphones.

Latency
Sometimes, the system isn't capable of showing the images in exact synchronization with the user. When that happens, a user moves her head, but the images she's seeing lag behind a few fractions of a second. This lag is a reason why some people experience "simulation sickness."

Presence
When a user feels as though she's fully immersed within a simulation, like she's actually there, she's achieved "presence."

Refresh rate
How quickly the images are updated. Higher refresh rates cut down on latency and provide a more realistic simulation. Ideal refresh rates are above 60 frames per second.

Room scale
This is the tethered version of VR that offers users the capability of walking around a room and interacting with virtual items, as they walk around in the physical world. So if you take a step in the real world, you're also taking a step in the virtual simulation. For this to work, rooms need to be mapped in advance.

Simulator Sickness
A nauseated feeling experienced as a result of simulated motion while wearing an HMD. The issue was well documented among earlier HMD users, but makers of headsets have since taken measures in an attempt to prevent this effect.

Social VR
When two or more people are wired in to a VR simulation and able to share the experience by observing each other, interacting or participating in joint activities.

Stitching
The process of combining video from different cameras into one, spherical video suitable for VR. This typically requires a tremendous amount of editing to fill in gaps, reorient scenes and seamlessly meld video streams so that the simulation looks authentic.

VR face
When a user has been in a simulation, a few things happen: the head mounted display tends to leave a temporary imprint on the skin, not unlike a pair of swimming goggles. Users also tend to relax into a slack-jawed look, with their mouths slightly agape.

NINTH YEAR ON THE LIST

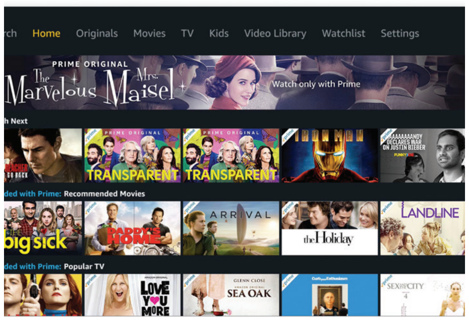
VIDEO

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT | IMMEDIATE IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



Streaming services will erode local broadcast news markets.

KEY INSIGHT

In 2019, adults around the world will spend more time online than we do watching TV, spending an average 170.6 minutes on Facebook, YouTube, Google, Amazon and elsewhere.[3] A Pew Research Center survey found that more Americans prefer to watch their news (47%) than to read it (34%) or listen to it (19%).[4]

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Streamers

In 2018, a record number of Americans – more than 30 million – scrapped traditional cable TV for streaming services. By July 2018, roughly 147.5 million people in the US watched Netflix at least once per month followed by Amazon Prime Video (88.7 million), Hulu (55 million), HBO Now (17.1 million) and Dish's Sling TV (6.8 million).[5] The two leading reasons individuals kept paying for television are the ability to watch live events and affordable cable along with internet bundles. These two factors do not represent a sustainable advantage for traditional cable and satellite providers. Affordable internet is available worldwide and prices should only continue to fall, and successful livestreaming of sports (either through the league or a social media provider) worldwide serves as an effective test case that live events can be successfully streamed through other platforms. We expect to see the continued rise in sales of devices such as the Amazon Fire Stick, Google Chromecast, and Roku, with a steady deterioration in cable and satellite subscriptions over the next couple of years.

Impact on media organizations:

Streaming services will erode local broadcast news markets. These services will also disrupt longer-form television news broadcasts.

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Saturation of OTT Streaming Services

Due in part to the success of HBO Now, in 2019, networks will begin widespread rollout of their own over-the-top media streaming services. Disney+ is expected to launch its own OTT service this year, which will feature a new live-action Star Wars series along with programming from Marvel, Pixar. Disney and Lucasfilm. Also launching are products from AT&T, Viacom and Discovery. It's a crowded space already that will become even more saturated in the coming year.

Impact on media organizations:

Content will become more siloed, as the various OTT services tend not to share programming with other providers. This will force consumers to make choices based on the strength of their favorite shows—this is potentially great for those making proven content (think spinoffs of

3. Zenith Global Intelligence Forecast 2018, 4. Pew Research Center, December, 2018, 5. eMarketer July 2018 estimates existing shows), but it will also mean that consumers are burdened with too many options.

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Connected TVs

In 2019, **Samsung** and **Apple** announced a new partnership to bring iTunes to Samsung's connected TVs. We anticipate higher penetration of connected TVs in average households and the availability of streaming apps that bypass the standard list of cable and public broadcasting channels, such as **Amazon Prime Video, Roku, Hulu, YouTube, Showtime Anytime, iPlayer** (UK-only), **All 4** (UK only), **Playstation Now, HBO Now, Direct Now, iTunes**, and of course, **Netflix.**

Impact on media organizations

Media organizations can take advantage of connected TVs, offering richer content to maintain and grow audience.

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WebRTC

WebRTC is the real-time communications technology supported by Google, Mozilla and Opera, and it powers **Google Hangouts.** WebRTC can be used to connect your smartphone to the articles you're reading on your desktop or tablet, displaying different components depending on what offers the best user experience. If a video won't display well on your current device, you could be offered a different version automatically. Because WebRTC works from the browser, it's also part of one of the other trends we're continuing to watch: connected machines.

Impact on media organizations:

For news organizations, this means that rather than bridging computers to networks, which must route and relay information along various channels, WebRTC and similar peer-to-peer technologies could help computers talk to each other without obstruction. This may seem like a subtle change in Internet architecture, but consider the implications: you would no longer need a third-party operator, like Skype, to videoconference with a friend—or to broadcast live news to consumers. Videos would load and play faster and would have no need to buffer.

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Streaming Social Video

Instagram is like QVC for millennials. Influencers are bypassing all the traditional channels to stream social video – and get paid for it. **Instagram, Snap, Facebook** and Twitter all offer live streaming, but the company to look out for is **China's TikTok.** It was one of the most downloaded apps of 2018 and is video sharing, but with interesting parameters: videos are only 15 seconds long, have to fit into a selection of themes (cooking, dancing, travel) and can be edited to include special effects and music. One key to this next generation of social streaming: challenges. Users participate by creating short skits in response to trending memes. TikTok is part of **ByteDance**, whose whose AI-powered news app **Toutiao** is wildly popular in China. Facebook followed by launching a competitor called Lasso in November 2018.

Impact on media organizations:

Ad revenue could further erode as brands connect with consumers through streaming social video channels. While everyone can stream—and news organizations now have access to that content—we must ask whether everything *should* be broadcast. News organizations need a framework to determining whether rebroadcasting a murder, suicide or violent act streamed via social video is in the public interest.

NEAR-FUTURE SCENARIO →→

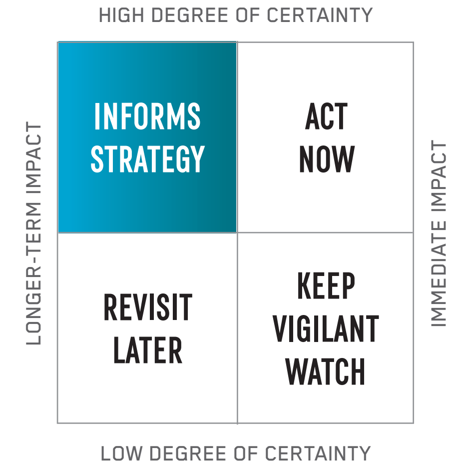
We Were Wrong About Social Isolationism

The idea that we'd all be sitting alone in our homes, interacting via digital avatars as we completely lost touch with the outside world, turned out to be completely wrong. Instead, new platforms and hardware gave us fun ways to socialize in person. We're spending more time in mixed reality movie theaters, which offer immersive entertainment. There are now mixed reality arcades everywhere. It's the 1980s all over again, but with a twist: MR games, experiences, and meeting rooms are affordable, and they're also accessible for those with hearing and visual impairments. We're going to silent discos, where we wear color-coded wireless headsets connected to our favorite DJ's spinning all night long. Now everyone can dance together, in one shared experience, even if they hate each other's taste in music. We're more connected to each other—and to the real world—than we ever imagined.

– AMY WEBB

ENTERTAINMENT MEDIA AND E-SPORTS

eSports



KEY INSIGHT

eSports is the rapidly growing industry of competitive digital gaming, specifically when performed professionally and for a live streaming, broadcast, or in-person audience. While organized competitive gaming has arguably existed for decades, advancements in both gaming technology and streaming capabilities have led to an astronomical rise in its popularity and perceived legitimacy in recent years.

EXAMPLES

With a young audience—more than 80% age 35 or younger—and enormous revenue potential, eSports is primed to continue its growth as a major cultural phenomenon in the near future, with significant expected impact on the gaming, sports, streaming, entertainment, and tech investment sectors. **Twitch**, the primary streaming portal for eSports in the Western world, logged a staggering 800,000 years worth of content viewed in 2018 alone. (Twitch was acquired by **Amazon** in 2014.)

One game that entered the global zeitgeist in the past year was **Fortnite**, with a reported 125 million players across all platforms. Parent company **Epic Games** was quick to capitalize on Fortnite's success, pledging a record $100 million in prize money for the game's tournament season this year. Tournaments have helped take gaming from a household pastime to the formally organized and internationally recognized competitive pursuit we now know as eSports. The **2018 World Championship for League of Legends**—like Fortnite, another wildly popular game in the **Multiplayer Online Battle Arena** genre—reportedly drew as many as 200 million concurrent viewers, making it the most watched eSports event in history.

The stakes are now such that eSports is a legitimate full-time job for many top competitors—many of whom employ coaches, endure rigorous training regimens, compete in national leagues and rake in seven-figure sums—and the industry is poised to define a new paradigm in competitive entertainment for generations to come. Audiences, prize amounts, and investments are skyrocketing, and even the **International Olympic Committee** has taken note, initiating conversations with the eSports community and teasing the potential addition of gaming to future Olympic Games.

WHAT'S NEXT

eSports had a global audience of approximately 167 million in 2018, a number that's expected to soar to over 275 million by 2022, rivaling viewership for major sports leagues like the **NFL**. The majority of eSports content is viewed online, with massive audience segments in **China** and **Korea**, and fast-growing fandom in the US, **Europe**, and worldwide.

There are a number of unique factors that contribute to the industry's growth potential. Because eSports has relatively low barriers to entry for potential participants—games reward eye-hand coordination, strategic thought and concentration more than athletic qualities like strength, speed, size and agility that dominate many traditional sports, and access to expensive equipment and facilities are not critical factors—it is often viewed as more accessible for the average novice than classic athletic sports, closing the gulf between fans and competitors, and resulting in a more engaged audience.

eSports is also viewed as one of the first truly global entertainment mediums in its reach and influence, which has investors salivating. The industry could be worth as much as $2 billion by 2022. Sponsorship of teams, tournaments, and broadcasts will likely continue to represent about a third of the revenue opportunity, but watch for media rights to grow within that time to about a 40% share.

WATCHLIST

Twitch; YouTube; Douyu; Huya; Tencent; ESPN; Epic Games (Fortnite); Riot Games (League of Legends); Activision Blizzard; Cloud9; Andy Dinh and Team SoloMid; aXiomatic; Tyler Blevins ("Ninja").

Scenarios for eSports Spinoffs

The Revolutionary Gamification of Education

eSports, especially in connection with mixed reality tech, will create a new framework for the gamification of education. With younger generations in particular becoming increasingly enthralled with and fluent in digital gaming, eSports expands to the field of education, offering interactive and incentivized lessons in various academic topics. A popular current game like Assassin's Creed draws its characters and environments directly from historical narratives—a more accurate and less sensationalized version of this type of game revolutionizes the way students learn history, for example. Game narratives are designed to expose students to key events and cultural elements of a given region and era, and a system of digital credits, exchangeable for real-world perks, rewards those who demonstrate their knowledge retention through in-game challenges, incentivizing learning. Extended to various disciplines, the system increases the level of engagement and information retention of students, raises the baseline of education of communities where it is implemented, and through scalability eases institutional stress in the education industry caused by a disproportionate student-to-teacher ratio.

A Sandbox for Crowdsourced Architectural Design

With eSports, especially MMORPGs or MOBA games that allow characters to build and interact with modular structures, platform administrators have access to a massive amount of dynamic behavioral user data. As game participation increases and worlds become more rich and expansive, game environments will be used to develop and test designs, especially for architectural and civic construction. For example, place two structures at spawn locations in a game landscape, each rendered according to different design proposals for the same project. As players spawn at each location, the game can monitor crowdflow through the structures, effectively A/B testing each design and helping engineers decide which will be the most efficient before investing in physical construction. Alternatively, admins could simply monitor the structures built by players, using user data to determine design preferences in different demographic cross-sections and adjusting real-world construction accordingly. Harnessing the power of this crowd-sourced data is only one of the ways that eSports could revolutionize industries beyond the world of gaming.

eSports Becomes an Arena of Mass Corruption

With the sudden growth of the eSports industry, we will reach a point in the next decade where winnings are at an all-time peak, and regulators haven't yet managed to comprehend and keep pace with the complex and rapidly burgeoning platforms. This will leave an open door for bad actors to take advantage of the situation by going to great and nefarious lengths to give themselves an advantage over their foes. Deception and exploitation may take the form of a player implanting bionic enhancements to give themselves an edge—a smart contact lens could detect on-screen threats or developments outside the player's sightline and suggest a strategic response; an adrenal implant could provide a player with a sudden synthetic boost of energy and alertness on-demand; surgical manipulation could enhance the muscle and bone structure of the hand to better accommodate the controller. And those are just within the human body—eSports' greatest vulnerabilities will lie in the digital inner workings of the games being played. Fraudulent teams could deploy an algorithm that masquerades as a human-controlled character, intervening only to prevent critical errors so as to avoid detection. Tournament organizers could surreptitiously tweak the response times of a competitor's controller or console at crucial moments during a match if they have a furtive betting interest in the competitor's opponent. Unless and until an independent authoritative governing body is established in eSports that has a deep understanding of the technology and an unwavering moral compass, the space will become severely vulnerable to corruption and fraud.

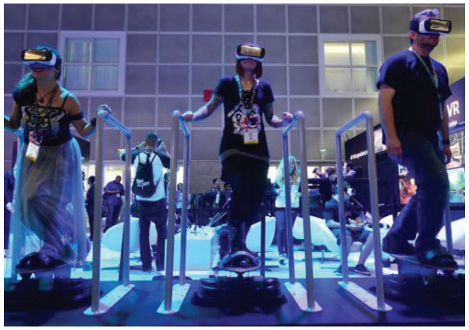
– MARC PALATUCCI

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Mixed Reality Arcades



Mixed Reality arcades are bringing games to everyone using new business models and cutting-edge equipment.

KEY INSIGHT

There are a host of fun, interactive mixed reality games on the market—but not everyone can afford the computer and gaming equipment necessary to play. As a result, a new kind of arcade for the next-generation of gamer is coming to a venue near you.

EXAMPLES

In the 1980s, video game arcades became popular—at first with geeky kids and then the mainstream masses, as **Pac Man, Galaga** and **Space Invaders** consoles popped up all around the world. They took off because kids and adults alike both loved playing them—and because early at-home consoles and computers were still too costly for the average person. We're in a similar transition now, as VR games move from the fringe to the mainstream. Mixed Reality gaming parks are opening up everywhere, giving everyone the ability to strap in to a host of games—but this time around, they don't take quarters. Startup **Virtual World Arcade** offers a membership package for unlimited VR time. In Tokyo, **VR Park** offers more than basic games—players can opt-in to swinging harnesses, flying platforms and platforms that simulate bungee jumping, flying and yes, even falling off skyscrapers.

WHAT'S NEXT

Mixed Reality arcades are proving to be a big business. We expect that as the MR market matures, we'll see additional arcades opening up everywhere. One distinction that might keep MR arcades from going the way of Pac Man—all the haptic interfaces. As games become more immersive, players will need to update more than their headsets and consoles. At some point, it might be easier and more cost effective to buy a membership rather than a new flight suit every few months.

WATCHLIST

Intel; Grand View Research; HTC; Samsung; Viveland; Oculus; Facebook; Alphabet; VRNISH; Inception VR.

MMOMRGs

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

MMORPGs—massively multiplayer online role-playing games—have been a staple of the online gaming community for years. A huge number of players interact with each other in a virtual environment. *World of Warcraft* and ***Final Fantasy*** are incredibly popular MMORPG's. ***Second Life*** was a virtual world—and in 2015, players even built an MMO inside of it called ***Remnants of Earth***. What's coming next are MMORPGs that are built using mixed reality.

EXAMPLES

Creating a virtual world is difficult enough. Making that world immersive, so that you can enter it using VR or AR, and still interact with other avatars under a wide variety of circumstances, is incredibly complicated. Another hallmark of MMORPGs is that they take a really long time to play. It's hard to imagine wiring in to a gaming system and physically moving your body around for hours at a time, swinging virtual swords at goblins or running to catch up with friends.

WHAT'S NEXT

Sony's CSL has built a mixed reality headset, allowing collaborative play between players who can see each others' views. Orbus VR is an early attempt at a new kind of game allowing players to move around their rooms, go on quests with friends and chat with others. It's likely that a new breed of MMORPGs—a sort of hybrid ***Second Life*** and ***EVE Online***—could be lurking just around the corner. This could also set the stage for future MMORPGs that offer more than quests and dragons—specialized worlds could be built for online dating, training and even diplomacy.

WATCHLIST

Ubisoft; Sony CSL; Sony PlayStationOrbus VR; Oculus; HTC; Survios; Alphabet; Apple; The Void; Harmonix; Otherside Entertainment; ILMxLAB; VRX Networks; Steel Crate Games; Playful Corp; Microsoft; Magic Leap; CCP Games; Activision Blizzard Entertainment; Electronic Arts; Tencent.

Inside Remnants of Earth.

OPTIMISTIC SCENARIO →→→→→→→→→→→→→→→→→→→→→→→→

VR Revolutionizes, Brings Together the Gaming and Entertainment Industries

With its non-exclusionary price tag and democratizing appeal for users of diverse backgrounds and interests, VR technology creates a new culture of fully absorptive social gaming and new styles of entertainment media content, all accessible from a single device, and from the comfort of one's own home. Gaming and video content as we know it are redefined entirely, with new hybrid forms emerging that blend narrative and interactive elements in sprawling immersive digital worlds.

– MARC PALATUCCI

08

MARKETING AND ADVERTISING TECHNOLOGIES

VR For Marketing

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

VR is an effective marketing tool.

KEY INSIGHT

Emerging research suggests that virtual reality storytelling, when it's done well, rewires all of us—we are likely to develop new belief biases as a result.

EXAMPLES

For more than a decade, scientists have been studying **"virtual reality exposure therapy,"** which has been used extensively to treat veterans suffering from post-traumatic stress syndrome. Because VR is completely immersive, it can closely simulate nearly any scenario. Patients, guided by trained therapists, are embedded into VR stories that represent a trauma they've experienced. Over time, this therapy results in new neuropathways—beliefs, attitudes and reactions are changed, for better or for worse. This presents an interesting opportunity for marketers.

WHAT'S NEXT

VR is being used for both B-to-B and B-to-C marketing. **Key Technology**, which manufactures food processing systems, built a VR marketing experience to help vendors see its digital food sorting platform in action. **Lowes** stores offers virtual skills training in VR, guiding DIYers through home improvement projects. Both **BMW** and **Volvo** have created apps allowing would-be buyers to test drive one of their cars. But unlike the usual test drive with a nagging salesperson trying to convince you to buy the upgraded sport mode package, you instead interact with the vehicle on gorgeous open roads, in the best possible weather, all by yourself. Spend enough time with the apps, and your belief bias will shove your logical mind into the back seat. You might start to think that inside one of those cars, every day is a traffic free holiday where you have the driving skills of **Formula One** superstar **Lewis Hamilton.** This, of course, highlights an impending ethical challenge. In the near-future brands will have a unique opportunity to tap directly into our minds, persuading us through immersive storytelling.

WATCHLIST

HQSoftware; Deep VR; 360 Profilms; Light Sail VR; Perception Squared; TaKanto VR; Circos VR; Helios Interactive; Rewind; Reverge VR; BBH; Goodby Silverstein & Partners; VirtualSKY; Leo Burnett; BBDO; Facebook; Droga5; Ogilvy & Mather; Razorfish; Weiden+Kennedy; GSD&M; VML; Critical Mass; Three One Zero; Valve; Wevr; Alphabet; Innerspace VR; StartVR; Epic Games; Survios.

OPTIMISTIC SCENARIO →→→→→→→→→→→→→→→→→→→→→→→→→→→→

VR Augments Corporate Social Responsibility Initiatives

VR heightens our ability to feel emotion based on immersive content, a quality that proves productive in raising awareness and action surrounding humanitarian and environmental causes. Companies use VR as part of their CSR initiatives to help us witness firsthand site-specific environmental and social crises. We are moved as a result, increasing compassion and motivation to take action.

– MARC PALATUCCI

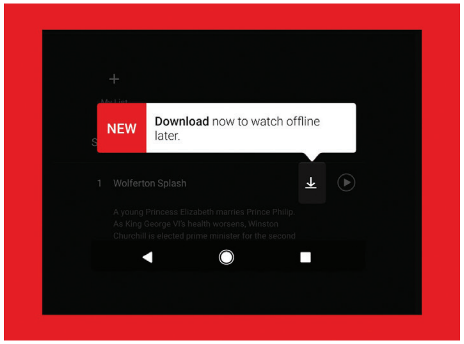
Offline Connections

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT | IMMEDIATE IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



Netflix now allows users to watch videos offline.

KEY INSIGHT

As consumers shift to their mobile devices, developers are making sure their apps work offline.

EXAMPLES

In the US, consumers now spend an average of five hours a day on their mobile devices. As consumers move about our days—commuting, walking around the office, or sitting through a Little League game—they still find themselves offline. **Netflix, YouTube** and **Amazon Prime** now feature offline viewing, allowing consumers to temporarily download videos to watch at their leisure.

A number of news aggregators—including **Google, Smartnews** and **Apple**—want to capitalize on the time consumers devote to their screens, even when the WiFi signal is weak. The **Washington Post's** progressive web app cuts mobile page load times from 4 seconds to 80 milliseconds and allows consumers to read news stories without a data or WiFi connection.

WHAT'S NEXT

Until news consumers have ubiquitous access to cheap, fast data, offline reading will be a necessity. News organizations that include seamless, offline experiences will find sticker audiences.

WATCHLIST

Tencent; Baidu; Google Play; Pocket; Amazon; news organizations everywhere.

Retail APIs

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

There are now hundreds of APIs built for marketing and retail operations. Application programming interfaces, or APIs, are tools for building software applications. Retailers are making their data available to developers, and marketers in the form of APIs in order to provide consumers and partners a host of new services.

EXAMPLES

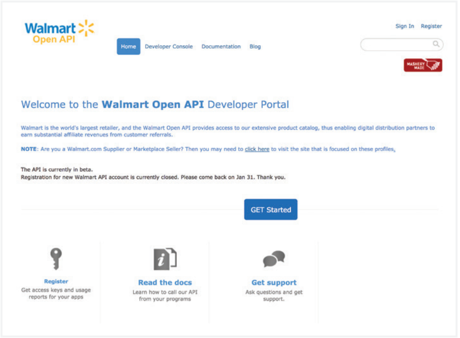
Retailers are using APIs to help customers and partners discover them more easily online, learn about products and services and to interact with the customer even when she's not shopping. **Walmart** hosts **Walmart Open API**, which is its own developer network. The program, still in beta as of early 2019, seeks to connect the products it sells to digital distribution partners. Through its API program, **Walgreens** works with more than 275 partners. Home furnishings retailer **Wayfair** offers an API so that developers can build a 3D library—the goal is to help the company's expansion into virtual and augmented realty.

WHAT'S NEXT

Retailers need to expand their reach beyond brick and mortar stores, and also beyond the traditional e-commerce site. The **Curbside ARRIVE API** helps retailers predict when customers will arrive to pick up their products. APIs could give retailers a reason to keep their brick and mortar stores open—as more shopping shifts to online, APIs could be used as a clever way to keep consumers engaged in the physical world—using their digital devices.

WATCHLIST

RevenueWire; Ikea; Walmart; Braze; SendGrid; MuleSoft; CVS; Walgreens; Mastercard; Wayfair; Zendesk; Walmart; Hershey's; Amazon; Lowes; Home Depot.

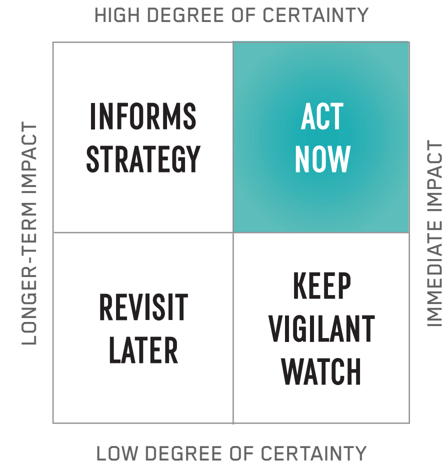


The new Walmart Open API Developer Portal will soon allow developers to buila apps for Walmart's product catalog.

09

ENERGY

Green Tech



New green tech initiatives are launching world-wide.

KEY INSIGHT

Global energy consumption is expected to grow over the next few years, and solar panels, electric vehicles and wind turbines will gain importance – despite a White House that repeatedly demonstrates its hostility to green technologies.

EXAMPLES

President Donald Trump not only pulled out of the **Paris Climate Agreement**, his administration quietly released a report forecasting a catastrophic 7-degree Fahrenheit rise in global temperatures by the year 2100. Buried inside a **National Highway Traffic Safety Administration** report, the finding was part of a proposal to roll back fuel-efficiency standards, which would increase greenhouse gas emissions. In essence, the administration said the planet would burn regardless, so our best path forward is to simply ignore it and live for today.

Regardless, the rest of the world has decided to move in a different direction. **China** is installing a record number of solar projects and wind turbines, to deal with crippling smog. The Chinese government is investing $560 billion over the next two years to make green tech more accessible not only within China, but for its export partners around the world. Wind and solar energy are getting a lift: Billionaire **Philip Anschutz**, who built his fortunes in oil and railroads, announced he build large-scale wind farms in Wyoming, while tech billionaire **Elon Musk** is partnering with a number of companies to build attractive solar panels that look more like slate shingles than the reflective rectangles we've seen to date – he, and others, are also developing new methods to create and store energy using battery systems. A team of researchers at **MIT** is developing offshore wind turbines that can store power on the ocean floor in huge concrete spheres. **Makani**, recently acquired by **Google**, makes high-altitude kites to harness wind energy. The company says that wind energy has the potential to power the world 100 times over, but only 4% of the world's electricity comes from wind.

WHAT'S NEXT

Extreme weather events and ongoing climate change have a lot of very smart people seriously worried. Renewables will take on a bigger importance in 2019 and beyond. The **International Energy Agency** says that renewable energy will make up about 40% of the global power grid by 2040. We should see faster growth in green tech over the next five years than we have seen to date.

Municipalities and corporations are pushing that needle. More than 100 cities across the globe report that as much as 70% of their energy production now comes from renewables, and at least 40 cities and 158 companies committed to dial that up to 100%. Hundreds more cities pledged to move to renewable energy production. Even **Saudi Arabia** is working on a detailed, long- term plan to help diversify its economy and move away from oil. To do this, **Crown Prince Mohammed bin Salman** has bold visions for the future of his kingdom: allowing women to drive and to work in private employment, selling shares of **Aramco** (the Saudi state-run oil monopoly), and a "utility scale" solar project.

In 2019, we will also see faster deployment of "microgrids," which can operate autonomously using artificial intelligence and can offer energy in developing countries, where as many as a billion people still live without electricity. Companies like **XENDEE** in San Diego and **WorleyParsons** Group have developed cloud software tools for those microgrids. And energy storage will fast improve. Scientists in Germany and **Northwestern University** in Chicago, for instance, are making advances in "singlet fission" technology to generate more electricity from solar cells.

WATCHLIST

Canadian Solar Inc; First Solar Inc; Atlantica Yield PLC; Vestas Wind Systems; Xinjiang Goldwind Science and Technology; GCL-Poly Energy Holding Ltd; Energy Acuity; Cypress Creek Renewables; First Solar; NextEra Energy; EcoPlexus; 8minuteenergy; sPower; SunPower; Recurrent Energy; Intersect Power; Hecate Energy; Energcon; Siemens; Sulzon Group; GE; Gamesa; United Power; Ming Yang; Nordex; Pacific Ethanol; Renewable Energy Group; Toyota; CropEnergies AG; GCL-Poly Energy Holdings; Schneider Electric; Johnson Controls; XENDEE; WorleyParsons Group; Argonne-Northwestern Solar Energy Research (ANSER) Center, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU); Power Company of Wyoming; ABB Ltd; Motech; Tesla; SolarCity; Panasonic; Vestas; Bombardier Phillips; Emerson Electric; Dong Energy; Xinjiang Goldwind Science; First Wind Solar; Samsung; Saudi Arabia Government; SoftBank; Apple; Amazon; Global Pvq SE; Hanergy Thin Film Power Group Ltd; Inox Wind; Hiangsu Akcome Science & Technology Co; Makani; Google; Massachusetts Institute of Technology.

Charging Stations

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

In the coming years, an unprecedented number of charging stations for electric vehicles will come online, driving demand for a new kind of car and disrupting the traditional gasoline supply chain and retail business.

EXAMPLES

The US is banning fossil-fuel cars by 2040; in France, the ban takes effect in 2030. **General Motors** will launch 20 new EV models by 2023, and BMW, Nissan, Jaguar, Porsche, Audi, Volkswagen, Volvo and Tesla introduced EVs this past year with more models to come. This year, **Jaguar, Audi, BMW**, and **Mercedes-Benz** will launch high-profile electric cars, and we'll also see for the first time that the battery range for all models will be greater than 200 miles, offering another incentive to consumers. Last year, the United States passed 1 million electric vehicles sold, nothing compared to the 81 million traditional new cars sold all year. Battery prices are dropping fast, most major automakers are staking their futures on lineups of fully electric vehicles. Widespread adoption requires more charging stations.

Building new charging stations involves plenty of red tape with local utilities and real estate. Yet **Volkswagen** will install 2,800 charging stations in 17 of the largest US cities by June 2019, as part of its settlement for **Dieselgate**. But most networks are being installed by governments, utilities, and third-party companies. **California** leads the way: Former Governor **Jerry Brown** promised to get 5 million electric vehicles on the road by 2030 and 250,000 EV chargers in the ground by 2025. **Oklahoma, New York** and **Colorado** state governments also recently unveiled plans to invest in networks of electric charging station. This follows the 13 states that adopted stricter vehicle emissions limits, and California's zero-emissions rules for mass transit. **Electrify America** will put charging stations in 100 **Walmarts** in 34 states. The nation's largest charging company, **ChargePoint**, will open 2.5 million charging stalls by 2025, up from 53,000. Another company, **EVgo** created a modular fast charging station that can be installed in a matter of days. **Google Maps, ChargePoint** and **PlugShare** will make it easier for people to find those electric vehicle charging stations from their smart phones, as well as see the types of charging ports and prices, plus rate and review them.

As more charging stations expand into communities everywhere, it will start to have a chilling effect on independent and corporate gasoline station chains, as well as on the local communities that are supported by them.

WHAT'S NEXT

Everyone in the gasoline supply chain should get ready for disruption. Gas stations provide more than just fuel—they sell lottery tickets, cigarettes, maintenance items, chips, sodas, sweets and more. Once consumers no longer need to stop for gas, all of the adjacent industries will see an economic hit. Now is the time for gas companies to envision their future business models.

WATCHLIST

Volkswagen; Google; PlugShare; ChargePoint; Electrify America; Tesla; Ionity; Blink CarCharging; Envision Solar; SemaConnect; ChargePoint; PlugShare; Saudi Aramco; Sinopec; China National Petroleum Corporation; Petro China; Royal Dutch Shell; Exxon Mobil; BP; Lukoil; Kuwait Petroleum Corporation; Chevron Corporation; Valero Energy; Conoco Phillips; Royal Farms; Wawa; Suncor Energy; vendors to gas stands; EV car manufacturers worldwide; the state governments for Colorado, California, New York, New Jersey and Oklahoma.

Backlash Against EVs

In 2018 and 2019, pickup truck drivers in the US used their vehicles to block Tesla's EV Superchargers. It's called "ICEing," after traditional internal combustion engines. Yelling profanities at EV car owners, pickup drivers taunt them until they leave. ICEing itself is just a manifestation of a bigger trend: consumer backlash against new car technology that is fundamentally different from what they know. We anticipate more tension as EVs and charging stations roll out this year.

SECOND YEAR ON THE LIST

Ultra-High-Voltage Direct Current and Macro Grids

HIGH DEGREE OF CERTAINTY

	LONGER-TERM IMPACT	IMMEDIATE IMPACT
HIGH DEGREE OF CERTAINTY	INFORMS STRATEGY	ACT NOW
LOW DEGREE OF CERTAINTY	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

China's major ultra-high voltage transmission system is underway.

KEY INSIGHT

In the near-future, we will transport clean energy from production sites to areas where power is needed, using a new kind of power grid being tested in China.

EXAMPLES

In the US and throughout Europe, electricity is generated at a power station and then transmitted using alternating current. But AC is inefficient over very long distances, and even smart grids haven't always been able to cope with climate change and our increasing consumer demands for heat and air conditioning. A new kind of transmission system—ultra-high-voltage direct current (UHVDCs)—is being tested in China, which has invested $88 billion to build the future of UHVDCs and macro grids. India has made a similar investment.

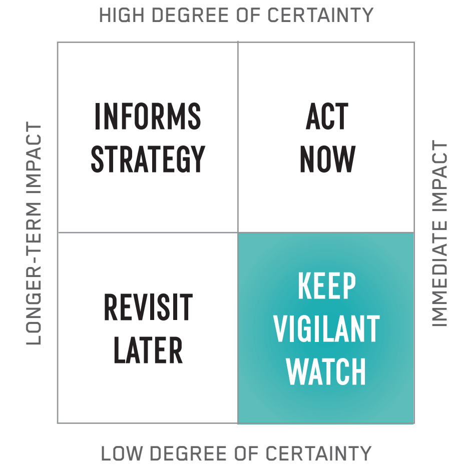
WHAT'S NEXT

A national direct-current macro grid could drastically lower emissions in an affordable way, without compromising our access to electricity. Meanwhile, China has already moved ahead of the US. China is an enormous country, and it is heavily investing in green technologies. The first 800,000 volt line, from a dam in **Yunnan Province** to **Shanghai**, has already been completed. Next up, the **Changji-Guquan** system, which can carry half the entire power use of Spain spanning the east-west expanse of the country. China has made it known that it plans to transport clean energy all around the world, and its **Belt and Road Initiative** could help it along. Fifty years from now, it's conceivable that we're all reliant on China—rather than **OPEC** countries (**Saudi Arabia, the UAE, Venezuela, Iraq, Iran, Kuwait, Libya, Nigeria, Qatar, Algeria, Angola and Ecuador**) for our energy needs.

WATCHLIST

ABB; China; India; OPEC countries; ABB; GE; Hitachi; Mitsubishi Electric Corporation; Siemens; AGTransWest Express Transmission Project; US Department of Energy; the DOE's Grid Modernization Initiative.

Better Batteries



KEY INSIGHT

It's a common first-world problem: our devices never seem to have enough battery life, and just when we need power the most, we either forget our chargers or can't find a spot to plug in. Building a better battery has been an elusive challenge for decades—that could change in 2019.

EXAMPLES

In 2016, **South Australia** suffered a massive blackout, which **Prime Minister Malcolm Turnbull** blamed on renewable energy targets—the push towards renewables is what led to the problem, he argued. In response, **Elon Musk** offered to build a massive battery farm, capable of storing enough wind and solar energy to power all of South Australia when usage grew too high—and that he'd do it in 100 days, or the whole thing would be free. The local government accepted his offer, and Musk delivered on his promise, and the system has been up and running since November 2017.

Musk's battery is the size of an American football field—not exactly the right size for your mobile phone. But there are a number of researchers and startups hoping to bring new kinds of batteries, capable of storing renewable energy, to market soon.

WHAT'S NEXT

The problem with modern batteries isn't about making the power—it's how to store enough of it. Startup **Ossia Inc.** built a wireless charging system that can power AA batteries from 30 feet away. **Alphabet's Project Malta** aims to capture more clean energy when it's produced, by using salt to store it on a large scale.

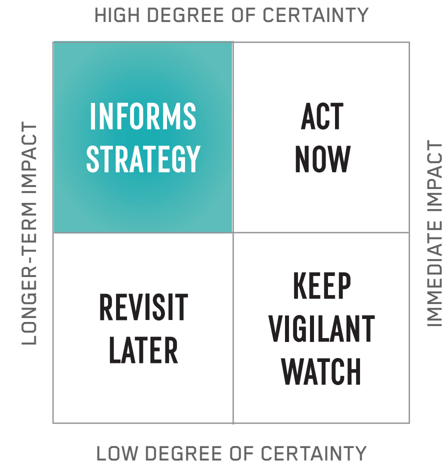
Luxury watchmaker **Ressence's** Type 2 e-Crown Concept smartwatch collects and stores energy created when you walk, as well as solar energy when you're outdoors. Cambridge, Massachusetts-based startup **Baseload Renewables** is working to market batteries that can store renewable energy in a battery. Lithium-ion batteries have limits, though, which is why researchers at the **University of California-Irvine** are experimenting with gold nanowires housed in a gel electrolyte, which can last significantly longer than today's batteries. **Form Energy** will build a "bidirectional power plant" that stores energy long-term, producing renewable energy and delivering it precisely when it is needed.

To help EVs really take off, though, someone needs to reinvent the battery. That's starting to happen. Spanish startup **Graphenano** built a battery out of graphene that charges a car in eight minute and will open the first battery manufacturing plant with this material. Solid state batteries, which promise to be safer, cheaper, boost the amount of energy a battery cell can store, not to mention they may charge faster, bringing an electric vehicle's driving range in line with a full tank of gas. By using solid materials instead of flammable liquids in batteries, it could be a boon to automakers which hit the limits of their storage capabilities. Plenty are working on the task, including **Daimler AG, Fisker Inc., Jiangxi Ganfeng Lithium Co.** in China, spinoffs from the **Massachusetts Institute of Technology, Stanford University** and **Tokyo Institute of Technology.** If they're successful, EV charging times could drop to 10 minutes from several hours.

WATCHLIST

Tesla; Alphabet; Baseload Renewables; University of California-Irvine; Tokyo Institute of Technology; Graphenano; Form Energy; Massachusetts Institute of Technology; Ionic Materials; Solid Firm; Toyota; Nissan; Graphenano; General Motors; Huawei; Energous Corp; the Federal Communications Commission; Qualcomm; US Department of Energy; MIT Department of Materials Science and Engineering; Ossia Inc; Khosla Ventures; Founders Fund; Daimler AG; Fisker Inc.; Jiangxi Ganfeng Lithium Co.

More Energy Tech Trends



Russia is working on a new kind of energy plant that can float.

202

Wireless Charging Everywhere

Charging our devices will be less – tangled – in 2019 and beyond. Laptops, earphones, mobile devices and even portable batteries will be chargeable without wires in 2019. This year we should see universal wireless chargers capable of powering our devices. **Apple** announced a wireless charging case for its AirPods 2, while **Energysquare** and **Unravel** offer wireless charging for multiple devices at once.

203

Energy Trading Platforms for Blockchain

In 2018, companies in Singapore started buying and selling renewable energy certificates on a blockchain-powered system. Like carbon trading in other markets, Singapore's system, launched by utilities provider SP Group, allows for more transparency and lower costs because there is no central intermediary processing and verifying transactions. Meantime a consortium that includes **BP** and **Shell** are now developing a blockchain-based platform to trade energy commodities.

204

Zero Carbon Natural Gas

We could see natural gas plants in the near future that are able to capture all of its emissions at zero cost using a technology called carbon capture and storage, or CSS. While the tech has been around for decades, it hadn't been deployed at scale. Last July, US startup Net Power successfully built a prototype plant that ran a full cycle without releasing troublesome emissions into the air. It hopes to scale up to a full-size plant by 2021. New tax credits of up to $50 for each metric ton of emissions captured and stored by a power plant or factory will likely help accelerate wider adoption of this technology.

205

Floating Nuclear Energy Plants

In an attempt to increase nuclear proliferation, **Russia** is working on a new kind of energy plant that can float and move with currents at the same time withstanding harsh environments. A barge called the **Akademik Lomonosov** will be towed through the Arctic and stationed in Siberia. By the end of 2919, two nuclear reactors will begin producing enough electricity to power the grid for the town of Pevek, enough for about 40,000 homes. There are already buyers interested in this technology, including Indonesia, the Philippines and Chile.

10

CLIMATE AND GEOSCIENCE

Anthropocene

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Earth's new geological layers show that humans have left a permanent mark on the planet.

60% of the Earth's wildlife has been wiped out since 1970. Plummeting numbers of mammals, reptiles, amphibians, birds and fish around the world are an urgent sign that nature needs life support.

– World Wildlife Fund Living Planet Report 2018

KEY INSIGHT

An international, independent team of scientists, called the **Anthropocene Working Group**, has now found enough evidence to support the official declaration of a new geological epoch. The group, comprised of scientists who were both in favor of and against declaring a new epoch, reached a consensus in early 2018. While much debate ensued, we are now seeing concrete, publicly-available research corroborating the designation.

EXAMPLES

Scientists within the AWG and outside have determined that humans have left a permanent mark on the planet. The new geological layers we are creating are riddled with chemicals and industrial waste, pavement, plastic, nuclear fallout, dams, everyday garbage, pesticide runoff and more. We've caused our sea levels to rise and our lakes and rivers to dry up, and extreme weather events are a normal part of daily living on Earth.

A new epoch is defined following a cataclysmic event—like the asteroid that collided with Earth and led to the end of the dinosaurs. It significantly and permanently alters the underlying sedimentary and rock layers beneath the surface of the planet, resulting in visible changes that can be seen and measured.

The **"Anthropocene"** (*anthro* for "man," and *cene* for "new") marks a new geographic epoch. (Our previous epoch was called the "Holocene," which began 11,700 years ago just after the last ice age.)

WHAT'S NEXT

Recognizing that humans have made a permanent, visible mark on the planet is the first step in studying the future implications to our planet.

WATCHLIST

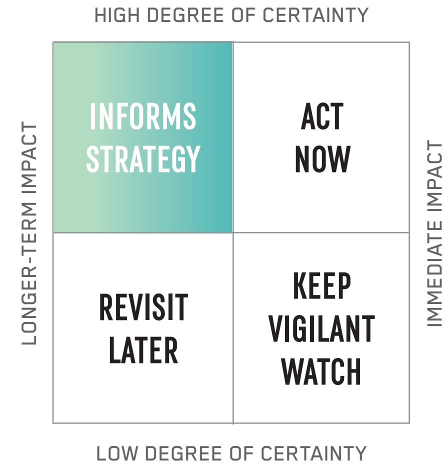
Anthropocene Working Group; the Union of Concerned Scientists; the International Union of Geological Sciences; the Nature Conservancy; US Geological Survey.

SCENARIO →→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→

The Unintended Consequences of Choosing A Name

We humans are Earth's first species to wield planet-scale influence. Using the term "anthropocene" going forward may be a call to arms for some—but it could result in others simply giving up and giving in to climate change. For those who find more comfort in fatalism than in having to generate bold new ideas for the future, agreeing that we're in this new epoch could result in global apathy. The sins of generations who came before us can't be reversed now, so what's the point? We'll either need to find another host planet, or agree that humanity is nearing an end.

– FUTURE TODAY INSTITUTE RESEARCH TEAM



Trying to Predict Sea Level Rise

We'll see sea levels continue to rise in the next century, perhaps by as much 8 feet.

KEY INSIGHT

We're getting better at understanding how ice sheets and sea levels change over time. This year, there will be a lot of focus on trying to measure the rate of change.

EXAMPLES

Sea levels have risen 11 inches in **Manhattan** in the past 100 years. Exactly how much it will rise in the next 100 years isn't something we don't yet know. But recent hurricanes, nor'easters and other storm systems proved that uncertainties about future extreme weather events, along with climate change, will cause us problems in the future. Scientists are working to develop new methods and models to understand how our sea levels are changing.

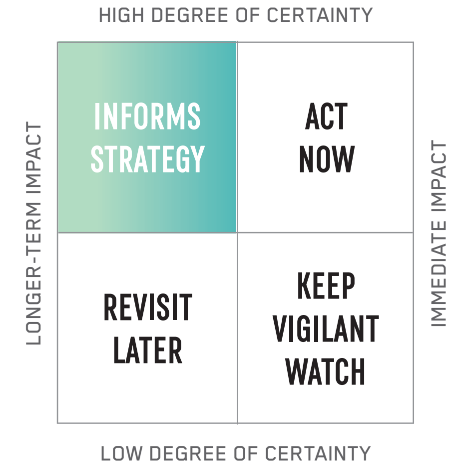
WHAT'S NEXT

The federal **Global Change Research Program** predicts that we'll continue to experience heavier rainfall in the US Northeast and around the globe. We'll see sea levels continue to rise in the next century, perhaps by as much 8 feet. (Almost half of the 8-inch increase since 1900 occurred in just the last 25 years.) Meanwhile, earlier spring snowmelt and reduced snowpack will lead to chronic, long-term drought.

Glaciers around the world are melting at alarming rates—but trying to predict how quickly large chunks will slide into the oceans have proven challenging for researchers. One of the research missions kicking off in 2019 will take 100 scientists to the **Thwaites Glacier**, where they will learn more about melting ice from **Antarctica** and how soon it could increase sea levels to a high enough point that coastal areas – Manhattan included – could be threatened.

WATCHLIST

British-American International Thwaites Glacier Collaboration; Columbia University; NOAA; NASA.



Extreme Weather Events

KEY INSIGHT

An extreme weather event is one that falls outside the norms of typical weather patterns. They became a worldwide phenomena in 2017.

EXAMPLES

Our globe's surface air temperature increased by about 1.8˚F (1.0˚C) over the last 115 years, making it the warmest in the history of modern civilization. The last three years, in particular, proved to be the warmest years on record, and during that time, we've seen record-breaking, climate-related weather extremes. A 2019 report by the **Bulletin of the American Meteorological Society** (BAMS) confirmed the link between the earth's rising temperature and extreme weather events. The report relied on a team of 120 scientists from 10 different countries and used historical observations and model simulations to produce the 17 peer-reviewed analyses collected in the BAMS special report.

Extreme weather is now our new normal. Last year became the year of mega fires. Spurred by heat waves and drought, as many as 21 large wildfires ravaged **Montana**, covering 438,000 acres. **Northern California**, also suffering from drought and record heat, witnessed fires that burned more than 757 square miles, destroyed 15,157 homes and killed 85 people and forced thousands from their homes. The **Mendicino Complex Fire** became the largest in state history and gave birth to a new term: "firenado," or a rising and spinning stream of flames that destroy everything in its path. One such fire vortex topped out at 17,000 feet above the earth.

Last year also marked the third-consecutive most damaging Atlantic hurricane season with 15 storms, eight hurricanes, with two of them being major hurricanes. Researchers at **NOAA National Centers for Environmental Information** found that storms are moving more slowly than they did forty years ago, and that means they're sticking around longer and causing more damage – just like when **Hurricane Harvey** hung over **Texas** causing billions of dollars worth of damage.

WHAT'S NEXT

Expect more of the same. Last fall, the **United Nations' scientific panel on climate change** issued a dire report revealing that scientific models show that at our current rate, the atmosphere will warm as much as 1.5 degrees Celsius, leading to a dystopian future of food shortages, wildfires, extreme winters, a mass die-off of coral reefs and more—as soon as 2040. That's just 20 years from now.

Meanwhile, political leadership is shifting to the far right in many countries around the world—countries which happen to produce a lot of pollution. In **Brazil**, voters supported candidate **Jair Bolsonaro**, who denies the impact of climate change and promised to increase the burning of coal and wants to pull Brazil out of the **Paris Climate Agreement**.

Over the past two years, two states—**New York** and **Massachussetts**—launched fraud investigations into **Exxon** over climate change, and **New York's attorney general** sued the company. Plus nine cities and counties, including New York and **San Francisco**, filed suit against oil companies, including **BP, Chevron, ConocoPhillips, ExxonMobile** and **Royal Dutch Shell** for climate change damages. A group of 21 kids ages 11 to 22 are currently suing the **Trump Administration** for failing to safeguard the environment.

BUSINESS IMPLICATIONS OF EXTREME WEATHER

Large natural disasters can slow regional economic growth for decades, impact productivity and lead to post-traumatic stress among survivors. Extreme weather can also shift infectious disease patterns and compromise food security, safe drinking water and clean air, according to The

Extreme Weather Events cont.

In 2018 and 2019 California residents battled extreme wildfires, brought on by severe drought.

Lancet Countdown on Health and Climate Change, which compiled research from 27 academic institutions, the United Nations and numerous intergovernmental agencies.

Economists estimate that bad weather impacts $3.8 trillion a year in the United States alone. It can drive up construction costs and cause flight cancellations. The rise of unpredictable, extreme weather will continue to force insurance companies to recalculate the damage, building models to better estimate the impacts. Insurer Aviva increased its Canadian home-insurance premiums by 6% since 2016, due partly to research into catastrophic risks. The extreme weather will also impact a wide range of sectors, from auto repair shops, home improvement stores to makers of sandbags and portable generators.

Meanwhile, air and road travel, as well as cruises, will see more weather-related delays, diversions and cancellations. Logistics and delivery companies will need to contend with delays and backups due to storms—this will mean unhappy customers as well as hardships for vendors and retailers alike.

WATCHLIST

National Oceanic and Atmospheric Administration (NOAA); NASA; Department of Energy; Department of Homeland Security; House Armed Services Subcommittee on Emerging Threats and Capabilities; Columbia University's Earth Institute; United Nations' Intergovernmental Panel on Climate Change; European Geosciences Union; University of North Carolina at Wilmington; Potsdam Institute for Climate Impact Research; National Center for Atmospheric Research.

"Firenados" – spinning vortexes of wind and flames – ravaged parts of the US in 2018. One firenado topped out 17,000 feet above the earth.

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Human Migration Patterns Shift

Climate changes will push millions of Americans away from their costal homes, and we are not ready for the impacts of a migration at that scale.

KEY INSIGHT

Climate change is forcing people from their homes and communities, which can undermine a region's economic stability. To date, we don't have an official designation for "climate change refugees," but that's likely to change in the near future.

EXAMPLES

Hurricane Maria in 2017 triggered a massive exodus from **Puerto Rico**, causing one of the largest migration events in US history. By December that year, an estimated 215,000 Puerto Ricans fled the island for the US mainland. Researchers from the **School of International and Public Affairs at Columbia University** looking at new flows of migrants worldwide, found that people who applied for asylum between 2000 and 2014 were increasingly on the move due to "weather shocks." A recent study by the Environmental **Justice Foundation (EJF)** says that tens of thousands of **Bangladeshi** families could soon face becoming climate refugees within their own countries. It's a problem that could soon get worse—a one-meter sea level rise could result in a 20% loss of Bangladesh's current landmass. And it's not just Bangladesh at risk.

A study by researchers at **Columbia University**, published in the journal Science, showed that climate change could lead to 1 million climate refugees migrating into the **European Union** every year by 2100—creating breathtaking changes to our existing cities and infrastructure. Throughout the world, monsoons, droughts and scorching heat are driving millions of people away from their homea in search of more hospitable environments. Which means that climate change is an issue of national security.

WHAT'S NEXT

The EJF worked with national security experts and retired military leaders to model scenarios for the future of climate change and human migration and concluded that the number of climate refugees could dwarf the number that has fled **Syria** in recent years. We could see a wave of migration from **Africa**, the **Indian Subcontinent** and from island nations into **Europe** and the **US.**

A recent **World Bank** report also looked at the problem, projecting climate change could result in 143 million "climate migrants" by 2050, as people escape crop failure, water scarcity, and rising sea water, and most of them will flee developing countries in **Sub-Saharaha Africa, Latin America** and **South Asia.** The World Bank offered a glimmer of hope: the future may not be as bleak if we work now to cut greenhouse gases drastically and plan for the socio-economic challenges of migrants, improving education, training and jobs.

It would be wise for intergovernmental organizations to begin talks about adopting official designation—as well as the corresponding protocols necessary—now, in preparation for near-future waves of climate refugees.

WATCHLIST

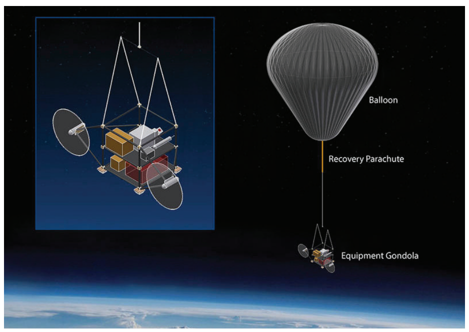
Environmental Justice Foundation; United Nations; UNHCR; Cornell University; European Union; Center For Migration Studies.

GEOENGINEERING

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY



SCoPEx is a scientific experiment to advance understanding of stratospheric aerosols that could be relevant to solar geoengineering.

KEY INSIGHT

To counteract extreme weather and climate change, researchers are looking to geoengineering—large-scale technological and scientific interventions to counteract the damage we've caused to the planet. It probably sounds terrifying—or at the very least, like a plot from a big-budget sci-fi movie. Scientists are quietly researching massive geoengineering projects that could help stave off sea level rise and curtail our planet's warming temperatures.

WHAT'S AT STAKE

Scientists can run simulations using available data, but it's impossible to predict the second and third-order implications of geoengineering in advance. Even so, the fate of the whole planet is at stake. No one country can—or should—take a unliateral lead on geoengineering.

210

Lots and Lots of Sand

Sand is stronger than we once thought. One project from **Princeton University** scientist **Michael Wolovick** involves building massive piles of sand or other materials dumped to the sea floor, to build walls around glaciers—sort of like a scaffolding to prevent them from collapsing. Farther beneath the surface of the ocean is warmer sea water. As it moves closer to glaciers, it destabilizes the foundation, causing pieces to break off and melt into the ocean. Shoring up their foundation could keep glaciers submerged in the icy upper layers of water, and—theoretically—prevent them from melting. It's not a perfect method for all glaciers, but it can help.

211

Oceanic Fertilization

Oceanic iron fertilization involves dumping enormous amounts of iron sulfate into large swaths of the ocean. Theoretically, it would stimulate the growth of phytoplankton, the tiny sea life that absorb carbon dioxide, release oxygen and are gobbled up by other creatures. This is key, because every year, the ocean absorbs about a quarter of the carbon dioxide we emit into the atmosphere and that changes the chemistry of the oceans and harms marine ecosystems.

212

Reflecting Sunlight

Some scientists are working on enormous, mirrored parasols into the stratosphere, which would reflect sunlight back into space and theoretically would cool the Earth's atmosphere over time. In 2019, **Harvard University** is preparing to launch the first ever aerosol injection experiment known as the **Stratospheric Controlled Perturbation Experiment (SCoPEx).** The scientists will use a balloon to inject huge amounts of aerosols, or extremely fine particles, into the upper atmosphere, reflecting sunlight.

213

Manipulating Clouds

Another effort underway to reflect sunlight back to space involves manipulating cloud cover. Scientists at the **University of Washington** are working on increasing the whiteness and brightness of the clouds by spraying sea water into the clouds of the ocean. The idea is to cause them to expand and get brighter. **Swiss** scientists, meanwhile, are developing ways to eliminate cirrus clouds – those thin, wispy clouds made from ice crystals that form at high altitude that trap heat in the atmosphere. Other efforts include painting houses white and laying reflective sheets in deserts.

214

Eating Ocean Trash

The notorious pile of trash floating in the **Pacific Ocean** is bigger than we thought. Last year, researchers found that the **Great Pacific Garbage Patch** is 16 times larger than original estimates, at least three times the size of **France**, or a total of 617,763 square miles. An estimated five trillion pieces of plastic float in the ocean, an amount so large that environmentalists called on the **United Nations** to declare the Garbage Patch its own country dubbed "The Trash Isles." A recent report by the **British** government warned that the amount of plastic in the ocean could triple by 2050.

The problem prompted some innovative approaches to clean up the trash. Last fall, the **Dutch** nonprofit **Ocean Cleanup** launched an ambitious effort to clean up half of that Garbage Patch within five years, using a fleet of 60 autonomous floating "screens," or nets that collect debris as small as a centimeter in diameter, which boats come and collect later. A floater prevents plastic from flowing over it, while a skirt stops debris from escaping underneath. Algorithms pinpoint where to deploy, and real-time telemetry monitors the condition, performance and trajectory of each screen.

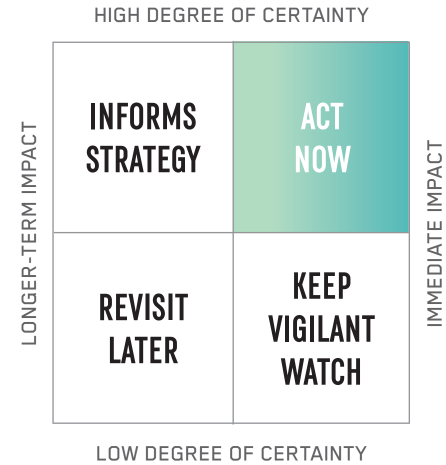
The system also relies only on the natural ocean currents for energy; the rest of the electronics are powered by solar energy. Another effort, the **Seabin Project**, cleans up oil and trash using floating garbage cans with pumps and filtration centers set up in harbors, marinas and other busy areas. That plastic could have trapped animals and caused problems if it had been ingested. The eco-rings solve that problem. The **5 Gyres Institute** invites citizen scientists to contribute data on plastic pollution by offering them yearlong access to $3,000 trawls, or fine-mesh nets that capture plastic floating on the water's surface. Even if scientists are successful in cleaning up the marine garbage pile, it will require behavior change among consumers and businesses. Otherwise, more plastic will continue to pile up in the world's oceans.

215

Artificial Trees

CO2 is the undisputed culprit when it comes to climate change. But what if we could just suck it out of the air? Trees do that naturally, but after years of deforestation, we simply do not have enough of them to make a sizable impact. Scientists at **Columbia University** are developing plastic trees that passively soak up carbon dioxide from the air and store it on a honeycombed-shaped "leaf" made of sodium carbonate, similar to baking soda. So far these fake trees prove to be a thousand times more efficient at soaking up CO2 than real trees. The next challenge will be to purify the carbon dioxide or bury it safely beneath the ground or beneath the ocean floor. Another approach is to convert atmospheric CO2 into carbon nanofibers that can be used for consumer and industrial products, including wind turbine blades or airplanes. Another approach comes from chemists at **George Washington University**, who are experimenting with what they dub "diamonds from the sky," a name because diamonds are made from carbon. The scientists bathed carbon dioxide in molten carbonates at 750° C, then introduced atmospheric air, an electrical current of nickel, and steel electrodes. The carbon dioxide dissolves and carbon nanofibers form on the steel electrode.

CORPORATE SUSTAINABILITY



Eliminating straws within the workplace is one example of corporate sustainability.

KEY INSIGHT

Large companies around the world are leading with sustainability as part of their core values. This isn't just about rejecting plastic straws. Many companies, including **Ingersoll Rand** and **Chevron**, see sustainability as a value add for all of their key stakeholders. Other companies can follow suit by developing long-term strategy, vision and R&D plans to create new business opportunities, which help shareholders while also helping the planet.

216

Smart Boats

It's no mystery that the shipping industry is a huge contributor to climate change due to its carbon dioxide emissions and a thirst for fuel. **Shell Oil** employs a more novel approach to fuel efficiency: air bubbles. The oil company installed a new system on the hull of a ship developed by London-based **Silverstream Technologies.** This design helped the ship move faster and easier through the water. The technology relies on steel boxes welded to a ship's hull and air compressors, which together create a layer of microbubbles between the vessel and water. The result: 5% to 12% fuel savings. Meanwhile, the market for hybrid and electric boats is growing. The world's first electric barges now chug across ports between Amsterdam and Belgium. The vessels, made by **Dutch** company **Port Liner**, have been dubbed **Tesla ships.** Eventually, the hope is that ships will operate autonomously. Hybrid boats are making waves on the water, too. Powered by solar energy, they reduce a watercraft's weight, cut down on noise, boost passenger capacity and cut emissions.

217

Smarter Plastics

Plastic has long been the bane of the environment, piling up in oceans and landfills. Now we know that, when exposed to the elements, plastic releases methane and ethylene - two greenhouse gases that worsen climate change, according to new research by the **University of Hawaii.** There are efforts to mitigate plastic's ills. Last year, researchers at the **University of Portsmouth** accidentally discovered a plastic-eating enzyme that could help break down larger pieces of plastic and aid in recycling efforts. French biotech company **Carbios** will produce a new generation of plastics for bottles, packaging and film that include enzymes that trigger biodegration after use. **Recycling Technologies** based in the

UK hopes to turn traditionally unrecyclable plastics into "plaxx," or virgin plastic, wax and oils. Meanwhile, corporations are stepping up: **Origin Materials** will make plastic bottles from sawdust and cardboard. **Evian** promised to use recycled plastic in all its water bottles by 2025. **Starbucks** pledged to eliminate plastic straws by 2020. British supermarket **Morrisons** will bring back traditional brown paper bags for loose fruit and vegetables, and a number of cities have banned plastic bags at grocery stores.

218

Intelligent Packaging

The nacent market for sustainable smart packaging is on the rise, ranging from everything from moisture-control and temperature sensors incorporated into QR codes to antimicrobial and edible packaging– even packaging that eats itself after it is no longer needed. Researchers at the **University of Minnesota** are developing new kinds of polymers that will self-destruct or "unzip" when exposed to light, heat or acid. Stockholm-based **Tomorrow Machine** is working on new packaging material that is edible and self-destructive. The company is studying self-opening shapes in nature to develop biodegradable packaging that will open on their own when exposed to high temperatures. Tomorrow Machine and **Innventia** developed a self-cleaning plate and cup made from a superhydrophobic coating that rejects dirt. The upshot: it never needs washing. **Salt Water Brewery** in **South Florida** designed plastic rings for its six-packs of beer to be biodegradable and edible. So rather than turtles getting caught in the plastic rings the material becomes food for them. **Berlin**-based **Infarm** created a renewable sheet of plastic that folds to create a self-contained package. This "microgarden" uses seaweed-based agar-agar gel to grow micro-greens and herbs that don't need water. Tomorrow Machine has also developed oil packaging made from caramelized sugar and coated wax. Designed for rice, oil and smoothies, you crack the package like an egg and melt it in water. This kind of active and intelligent packaging used for meat has been shown to extend shelf life and cut costs.

11

AGRICULTURAL TECHNOLOGIES

Indoor and Outdoor Plant Factories and Microfarms

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	INFORMS STRATEGY	ACT NOW	IMMEDIATE IMPACT
	REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

New plant factories require fewer resources.

If you're a human who eats food, you should care deeply about the global food supply.

KEY INSIGHT

With extreme weather hampering traditional agriculture, new kinds of indoor and microfarms are endeavoring to grow produce and grains that can be grown in spite of climate change.

EXAMPLES

Overpopulation means the world must feed an estimated 9 billion people in 2050. If you're a human who eats food, you should care deeply about the global food supply. Our global weather patterns and climates are in flux. It's plausible that the world's agricultural centers today won't be capable of sustaining commercial farms in the near future. Today's agriculture system alone won't work. We must rethink how we grow and consume food, and plant factories mark a huge technological leap forward.

The future of farming will be microfarms, housed underground in office buildings and on neighborhood blocks and vertical farms housed in skyscrapers in urban centers. With no soil and no sun, these factories promise 365-day seasons and no threat of droughts, freezes or infestations. They can cultivate lettuce, spinach, basil, garlic and snow peas in the middle of cities – and often deliver 10 to 20 times the yield of conventional farms. All this, using robots, sensors, artificial intelligence, LED lights and hydroponic grow systems.

Japan leads the world when it comes to this new high-tech farming with 200 plant factories – more than any other nation. The government subsidized many of these operations, and they thrive thanks to Japanese consumer demand for fresh, local, pesticide-free food.

Take, for instance, the **Kansai Science City microfarm**. Much of the work there is automated: raising seedlings, replanting, watering, adjusting the light and harvesting is all done using artificial intelligence and collaborative robots. In **Kameoka, Koto**, a company called **Spread** also uses machines and robots to handle the plants and has said it expects to produce between 20,000 and 30,000 heads of lettuce per day. Often it may take only 40 days for plants to mature before they're shipped to nearby supermarkets in Japan. Plants are thriving elsewhere in the world too. In London, a startup called **Growing Underground** raises pea shoots, red basil, garlic and chives on "cardboard carpets" using 77% less water than conventional agriculture because the water is recycled. The crops can be harvested and shipped in just five to 10 days. That kind of efficiency will allow Underground to double their operations next year, all inside their city's network of underground tunnels.

WHAT'S NEXT

Startup **Iron Ox** has built a fully autonomous, hydroponic indoor farm in California that uses two robots to plant, maintain and harvest produce. Those two bots can do the equivalent of 30 acres of outdoor farming in just one indoor, automated acre. **Bowery** and **Plenty** are two start-ups building indoor microfarms in or near urban settings. In Boston, researchers at the **Massachusetts Institute of Technology** now crunch data to come up with "plant recipes" that can improve indoor food production even more. Using complex algorithms and sensors attached to plants growing in hydroponic systems, the researchers track everything from carbon dioxide and temperature to water and plant tissue health to analyze the best conditions and systems for growing the most nutritious, tasty foods possible.

A future dotted with high-tech local microfarms could upend the status quo for supply chains built around conventional agriculture and supermarkets. The shift will impact everyone from merchants and importers to truck drivers and UPC code sticker providers. That's why planning for this plant future is vital to ensure that their plant factories arrive with opportunity rather than civil and economic unrest. But the upside could be worth it: environmentally-friendly farming, higher yields and better access to fresh, nutritious food in urban and rural communities.

WATCHLIST

Japan Plant Factory Association; Japanese Ministry of Economy, Trade and Industry; Iwatani Agrigreen; National Federation of Agricultural Cooperative Association (Japan); Mistubishi; Chiba University; AeroFarms. Bright Farms; Detroit Dirt; Fujitsu; Grove Labs; Tomiyama Corporation; Monsanto; Sungenta; Bayer AG; DowDuPont; BASF; Del Monte; Komatsu; Claas; John Deere; AGCO.

NEAR FUTURE SCENARIO

Growhouse-to-Table is the New Farm-to-Table

We think AgTech and new tiny farms will allow restaurants, schools and companies to grow their own produce, while achieving significant cost savings. In 2019, restaurants will have access to compact, self-sustaining indoor vegetable gardens that are small enough to fit within the existing space of a commercial kitchen. Special lights help reduce the growing time necessary for plants to reach maturity. In the very near future, similar technology, along with subscription seedling services, will become affordable enough for average US homes.

Big box retailers will find a renewed purpose as hyperlocal food centers. Cities will clean up abandoned lots, repurposing them as neighborhood farms. And, in an age of widespread automation and technological unemployment, AgTech ushers in a new era of high-tech farming, and as a result, there is a demand spike for agricultural technicians, AgTech maintenance workers, roboticists, bio-data scientists, irrigation designers, grow light engineers and more.

Looking even broader, AgTech will mean huge opportunities for businesses and organizations who prepare in advance. For example, CRISPR/Cas9 gene-editing technology could be used to develop breeds of tomatoes, beans, kale, blueberries, quinoa, spinach and broccoli that can be grown inside of a neighborhood convenience store—or inside of a suburban retailer like **Wal-Mart**. Growing and selling directly to consumers could bring fresh, inexpensive produce to food deserts year-round. Adjacent industries would likely benefit (spice makers like **McCormick & Co.**, appliance manufacturers like **Samsung**). It could also mean new competition from unusual sources: US-based **Amazon** acquired natural grocery store chain **Whole Foods** in 2017. It's plausible that by 2027, Whole Foods will be neighborhood microfarms that grow and sell all the produce we need, especially as gene editing techniques make their way from the fringe to the mainstream and as robotics and artificial intelligence continue to improve.

– FUTURE TODAY INSTITUTE RESEARCH TEAM

Deep Learning For Farming and Food Recognition

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Researchers are testing robotic harvesting systems that use image recognition.

KEY INSIGHT

Deep learning is being used to help identify food for a number of reasons: to help computers have more robust conversations with us about what we're eating, to calculate the number of calories in a dish, and to spot spoiled or tainted food. Artificial intelligence and deep learning are helping food manufacturers and farmers determine nutritional deficiency, detect disease and even learn more about where our food comes from.

EXAMPLES

Plantix, a cloud-based AI system, lets farmers identify pests and disease in their crops, just by uploading photos of suspicious plants. The system will cross-reference across a database of various species using image recognition, and within a couple minutes, offer suggestions of potential problems. Perhaps it's not getting enough water or needs a micronutrient. California startup **Abundant Robotics** and Israeli-based **FFRobotics** are both developing automated picking systems that scan and "read" produce to determine when it's ripe. **SomaDetect** lets dairy farms monitor milk quality using optical sensors and machine learning. **Blue River Technology** uses deep learning to automatically detect and spray weeds.

Deep learning will also impact consumers, allowing us to learn what's in the food we eat—and even where it came from. Computer models will be able to calculate the nutritional value of your meal before you take your first bite. Researchers at the **University of Massachusetts** are using deep learning for computer-assisted dietary assessments, while scientists at **Microsoft** have already incorporated their deep learning prototypes for recognizing popular Asian and Western foods into Bing local search engine. At the **MIT Media Lab**, students are working on an organic barcode that's invisible to us, but could be read by machines—it could be used to help consumers more easily trace produce as it moves around the world. Machine learning also lets chefs and at-home cooks determine which foods taste best together, select complimentary ingredients and offer food suggestions for various tastes.

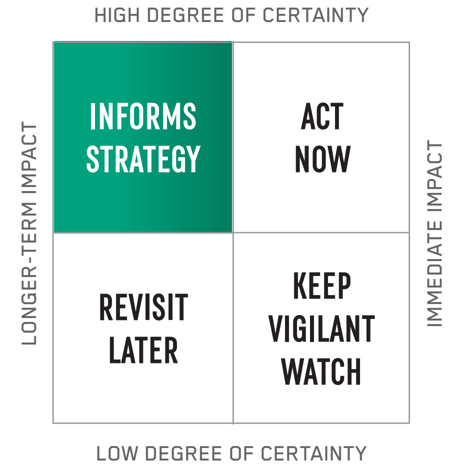
WHAT'S NEXT

This technique can be used to find and sort problem products on food assembly lines, and it can help growers better identify crop disease. Deep learning for food recognition could soon mean a number of opportunities for agricultural companies, farmers, food manufacturers, restaurants, chefs, and health-minded consumers.

WATCHLIST

Abundant Rotobics; Plantix; FFRobotics; Blue River Technology; John Deere Labs; Microsoft; Prospera; IBM; Alphabet (Google); dishq; University of Massachusetts; Apple; Carnegie Mellon; MIT Media Lab; University of Tokyo; Penn State University; University of Maryland; PlantJammer; Foodpairing; FlavorWiki; PlantVillage; Gastrograph.

Precision Agriculture



KEY INSIGHT

Using sensors, algorithms and optimization analytics, farmers are now able to quantify the progress of every single crop – down to a single cherry tomato hanging on a particular vine.

EXAMPLES

A variety of technologies are used in this new farm management approach, including GPS, sensors, collaborative robotics, autonomous vehicles, autonomous soil sampling, telematics, and lots of machine learning. Vestiges of precision agriculture have been around since farmers started using GPS alongside their tractors, but advancements in robotics, data collection and insights have meant new opportunities.

WHAT'S NEXT

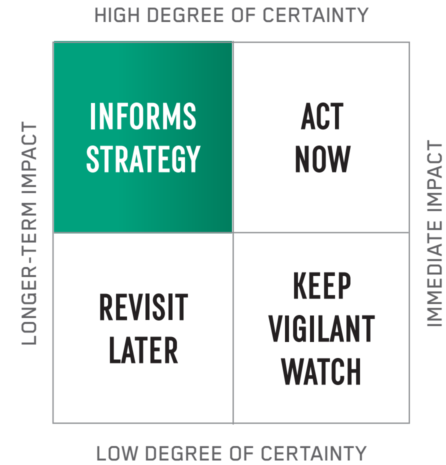
South Dakota State University has invested $46 million in a new facility to study the future of precision agriculture, and classes in the field will begin 2021. Drones equipped with smart cameras, data mining to understand crop ripeness and blossoming, and new analytics dashboards to help farmers make smarter decisions are all on the near future horizon.

WATCHLIST

Farmers Edge; CropMetrics; Blue River Technology; Syngenta; Honeywell; DuPont; Amazon; Arable; Bosch; Descartes Labs; Planet Labs; Farmers Business Network; Google; Amazon; SAP; Semios; Sentera; Smart Ag; TerrAvion.

Farmers will be able to quantify the progress of individual crops.

Smart Farms



New and emerging technologies will power farms.

KEY INSIGHT

In order for traditional agriculture to meet the global demand for food, researchers are trying to make farming look more like modern manufacturing.

EXAMPLES

The agriculture industry is abuzz over projections that by 2050, we must increase agriculture production by 70% to meet projected demand. Current farming methods won't cut it. That shortfall has spawned a new generation of AgTech startups—nearly a dozen Agtech accelerators popped up since 2013. Yet small farmers are slow to adopt new technologies. If it doesn't work, it can kill an entire harvest and a year's income. Current farmer tech needs aren't flashy yet. They want tech to digitize their field notes, valves, monitor irrigation systems, and apps that track people and equipment, show histories of pest problems, spot irrigation leaks, and monitor water wells.

WHAT'S NEXT

Larger farms, meanwhile, are testing out new technologies that harness data, sensors, machine learning and automation. For example, moisture sensors can continuously monitor the moisture level of soil and communicate with an irrigation system to increase the water supply. Gene editing of seeds can allow them to flourish, even in unpredictable weather conditions – a common occurrence. Tech can match seeds to specific soil types, to generate an optimal crop of vegetables. Advancements in agricultural drones will, in the near-future, assist with planting, harvesting and pest control.

WATCHLIST

UN Food and Agriculture Organization; USDA; Tyson Foods; Alico Incorporated; Agria Corporation; Adler Seeds; American Vanguard; Monsanto; Dow Chemical Company; University of Maryland; Purdue University; Iowa Farm Bureau; OpenAg Initiative at MIT; DNV GL; Cargill; Alltech; Bernard Matthews Farms; BASF; AVEBE; Archer Daniels Midland; Marrone Bio Innovations; Syngenta; Honeywell; DuPont; AgTech Insight; Verizon; Silicon Valley AgTech; Kleiner Perkins Caufield Byers; Agfunder.

Terraforming

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Terraforming—literally, "Earth shaping"—is a concept from science fiction. People reform another planet to make it resemble Earth, so that it can support human life.

EXAMPLES

The average temperature on Mars is -67 ˚F, which might have seemed like an obstacle before the winter of 2017 when Mount Washington, New Hampshire recorded a wind chill of -90 ˚F. (Sci-fi, meet reality.) Some people believe that human life will be unsustainable on earth in the far-future, and that humans will need to colonize another planet in order to survive. In September 2016, Elon Musk, CEO of **SpaceX**, delivered his plan to both get us to Mars and to terraform it once we arrive. It will be several years before humans pack up and move to space—but **NASA** has already moved ahead on several projects to study terraforming the Moon.

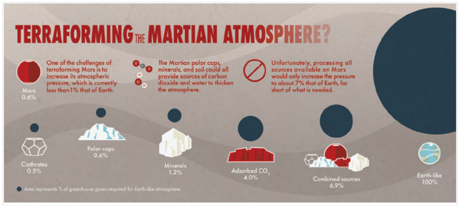
WHAT'S NEXT

The challenge to terraforming Mars will be to increase the atmospheric pressure of the planet, which is 1% less than Earth. The Martian polar caps, minerals and soil could provide sources of carbon dioxide and water to thicken the atmosphere. Unfortunately, those sources available on Mars would only increase the pressure to about 7%, which is short of what is needed, so terraforming is not possible with today's technology, according to 2019 research paper published in ***Nature*** by the **University of Colorado**.

Another key to teraforming might be in our current microbes, which are capable of surviving harsh environments like the **Atacama Desert**. Of course, we might even invent entirely new forms of life using synthetic biology. In order to advance terraforming from theory to reality, we'll need a host of new robots capable of being trained to mine for resources and build an ecosystem that can sustain human life. And we would also need powerful rockets that can power spacecraft to transport those robots to space so that they can break ground.

WATCHLIST

NASA; SpaceX.



NASA is studying terraforming on surfaces far away from Earth.

Photo courtesy: NASA.

Bug Protein

HIGH DEGREE OF CERTAINTY

	LONGER-TERM IMPACT	IMMEDIATE IMPACT
HIGH DEGREE OF CERTAINTY	INFORMS STRATEGY	ACT NOW
LOW DEGREE OF CERTAINTY	REVISIT LATER	**KEEP VIGILANT WATCH**

LOW DEGREE OF CERTAINTY

Exo sells protein bars made of crickets.

KEY INSIGHT

In 2019, you'll find edible insects on the menu, in protein bars, and in heart-healthy pastas.

EXAMPLES

There's an environmental argument to eating crickets rather than chickens: raising and consuming insects produces significantly less greenhouse gasses, doesn't require extensive land and water, and does less long-term damage to the planet. They are good sources of protein, fatty acids and fiber and have been an important part of the diet in cultures around the world. Denver restaurant Linger serves up a dish with black ants, chopped grasshoppers and crickets to willing diners. And cricket food startups have started flourishing. Chirp Chips and Bitty Foods make cricket-based protein bars, brownies, chips and smoothie powders. One of the cricket food companies, Aspire, acquired competitor EXO Bar, which made protein bars. Meanwhile, billionaire Mark Cuban even invested in bar maker Chapul, after its founder extolled the nutrition and virtues of bug-based food on the TV show Shark Tank.

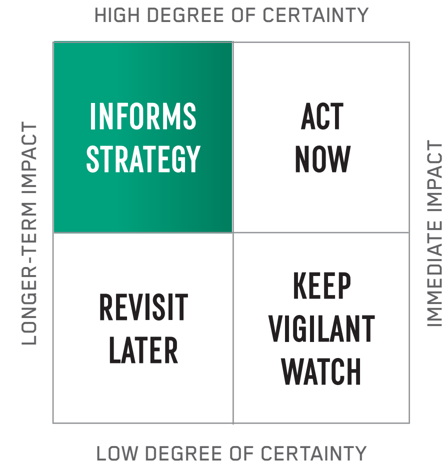
WHAT'S NEXT

Previously, cultivating insects had been limited to a small, experimental group of startups. With increased funding and more mainstream interest, we should see bug proteins beginning to take off in 2019. The **Department of Agriculture** has awarded $1.45 million in research grants in the past few years. The **North American Coalition for Insect Agriculture** (NACIA) says the market could top $1 billion by 2023.

WATCHLIST

Entosense; Bugeater; Chirp Chips; Chapul; Linger; Aspire; U.S. Department of Agriculture; North American Coalition for Insect Agriculture; Food and Drug Administration.

Cultivated Food and Beverage



KEY INSIGHT

Say goodbye to tofu imitations of traditional meats. Meats and beverages are being grown in labs. The projected global food shortage and concerns about climate change, the environment and social justice (activists complained shrimp is harvested by slave labor) have driven demand for a new era of cultivated food and beverage. At its most dire, there is a looming food security issue and a shortage of arable land if we continue traditional meat production.

EXAMPLES

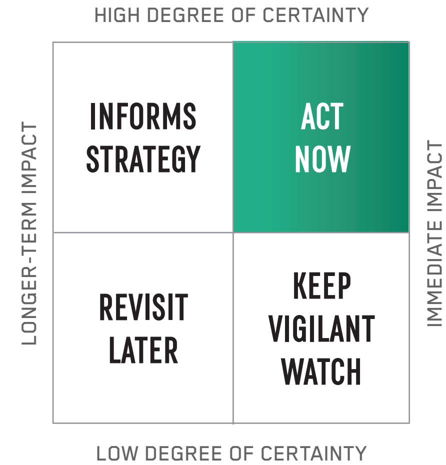
In 2013, the **University of Maastricht** introduced the world to the first lab-grown hamburger patty, and it cost $330,000 to create. Since then, a number of startups have been working on various techniques to culture—rather than harvest—meat that has the same chemical structure as what would have otherwise come from an animal. This past summer, the **Food and Drug Administration** approved the plant-based meat from **Impossible Burger**, which uses genetically-modified yeast. The hamburger patties have an eerily-similar look to beef – including the "blood," a hemeprotein from soy roots – and they are now served in thousands of US restaurants. Consumers report that they really can't tell the difference between real beef and Impossible Burgers. Another VC-backed company, **JUST** (formerly Hampton Creek) scaled back its ambitious lineup following an SEC investigation and board exodus and now plans to roll out a line of plant-based mayo, dressings, cookies, cookie dough, breakfast proteins, and cultured meats. **Clara Foods** is serving up creamy lab-grown eggs, fish that never swam in water and cows milk brewed from yeast. **Perfect Day** will focus on yogurt, cheese and ice cream – sans the cows and instead inside a lab. **Memphis Meats, Beyond Meat** and Aleph Farms are working on lab-grown chicken and beef, using pea protein and other plant materials. **New Wave Foods** is serving up algae-based shrimp, while **Finless Foods** makes fish flesh.

WHAT'S NEXT

The clean meat movement is heading towards **acellular agriculture**, which doesn't require starter cells extracted from muscle biopsies. Instead it brews meat from microbes. This will allow researchers to someday soon cultivate milk, chicken and eggs. It will be many years before producers are able to scale production to meet our demand, and there is no guarantee everyone will adopt the meatless meal. Just one-third of 2,100 Americans polled last year by **Michigan State University** said they would be likely to buy food that looks and tastes identical to meat. Last year, the US beef industry took aim at the nascent industry, filing a petition to bar non-animal products from the definition of meat. A French politician also passed a law that bans vegetarian companies from calling their products "bacon" and "sausage." Still, in the future, you might buy meat at a local microbrewery, which instead of beer, brews meat. Or, for that matter, you might print your hamburger at home.

WATCHLIST

Clara Foods; SuperMeat; Finless Foods; Memphis Meats; Impossible Burger; Future Meat; Just; Perfect Day; New Wave Foods; Michigan State University; Memphis Meats; Beyond Meat; Aleph Farms; University of Maastricht; EU; FDA; the governments of China, Israel, the US, Japan and EU, the Food Research Institute of Norway; Good Food Institute; PETA; Meatable; University of Amsterdam; Oxford University.



CANNABIS TECHNOLOGIES

Cannabis use is finding wider acceptance in many countries around the world.

With Cannabis now legal in Canada, many US states, and increasingly in other cities and countries around the world, there are many new technologies and areas of scientific research to track. Here are five worth watching:

226

Cannabis Delivery Logistics

Local dispensaries are supporting start-ups that can take orders, authenticate users, and ensure safe and legal delivery to consumers. Eaze and GreenRush are the biggest players in medical marijuana delivery.

227

Cannabis Compliance Systems

With the industry heavily regulated, it can be difficult for dispensary companies with business units located in different states to keep track of compliance. New AI-powered platforms are helping dispensaries meet compliance regulations.

228

Scaling Cannabis Infusion Techniques

One of the new business verticals within the industry is cannabis you can drink. As restrictions on recreational marijuana use are loosened, we will start to see big commercial beverage companies launching new sparkling waters and non-alcoholic drinks infused with CBD, the nonpsychoactive part of marijuana capable of reducing pain without getting you high. But there is plenty of research into cannabis-infused alcoholic beverages, teas to help you relax and to sleep, and sports drinks to help athletes recover faster post-workout. Constellation Brands, which makes Corona beer, as well as Lagunitas (a subsidiary of Heineken) are investing in new techniques.

229

Specialized CRM Platforms

Unlike traditional CRM or customer databases, marketers in the cannabis space have additional regulations to contend with. Baker is an automation platform catering to dispensaries.

230

Helping Dispensaries at the Bank

One big hurdle for dispensaries and their parent companies in the US is banking. It's still illegal at the federal level for marijuana to be sold, so banks can't accept cash from dispensaries. MoneyTrac Technology is a blockchain startup with its own cryptocurrency. The hope is that customers would pay at a kiosk using cryptocurrency rather than cash.

12

BIOTECHNOLOGIES, GENOMIC EDITING AND BIOINTERFACES

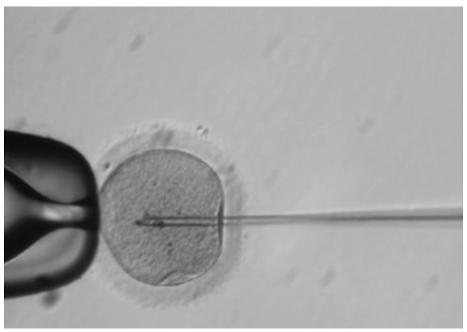
SEVENTH YEAR ON THE LIST

GENOME EDITING

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY



Gene-editing chemicals being injected into a human egg at the moment of fertilization. Scientists used the technique to correct DNA errors present in the father's sperm.

Biology is one of the most important technology platforms of the 21st century.

KEY INSIGHT

Genome editing is a quickly-developing, game-changing field promising to influence the future of life on our planet. Mapping the human genome has been a long and difficult process. Recently, sequencing technology has become more accessible and affordable to research labs, which would enable them to work towards personalized medical treatments for vexing diseases like cancer.

CONTEXT

Nine years ago researchers unveiled a gene editing technique called CRISPR-Cas9, which allows scientists to edit precise positions on DNA using a bacterial enzyme. New technologies make CRISPR gene editing more affordable. The implications are tremendous. Mosquitoes carrying malaria could be edited so that they no longer carry the disease through future generations, and so that millions of humans in high-risk regions no longer suffer from the disease. There are therapeutic possibilities in human medicine as well. Editing our genetic code could mean eradicating certain genetic diseases—like cystic fibrosis—so they can't be passed along to babies. Liver cells could be edited so that they lower the bad cholesterol levels in families that have inherited mutations. World-renowned geneticist George Church and his team used CRISPR to modify pig organs, making them safe to be used for human liver, kidney, heart and lung transplants.

In 2015, Chinese researchers edited the genes of a human embryo – it was done in a petri dish, but scientists quickly sounded the alarm, because it wasn't difficult to see how CRISPR could be used to modify embryos during the in vitro fertilization process. There has been plenty of experimentation on human embryos in China since then, and late in 2018 we learned about a team of researchers at the Southern University of Science and Technology in Shenzhen who not only used CRISPR in conjunction with IVF, they had purportedly eliminated the CCR5 gene in a pair of twin girls. That modification, they hoped, would make the twins resistant to HIV, smallpox and cholera throughout their lives. If true, this would be the first instance of genetically modified humans – and we haven't yet developed global norms and standards governing humanity's position on enhanced humans.

However China isn't alone in researching methods to use CRISPR to modify humans. Around the same time that we learned of the possibility that genetically enhanced twins had been born in China, Harvard University moved ahead with a plan to begin gene-editing sperm. The school's Stem Cell Institute started using CRISPR to modify sperm cells so that they could not pass on the genes responsible for Alzheimer's disease. The first known attempt to create a genetically-modified human embryo within in the United States happened back in 2017 at the Oregon Health and Science University. Researchers successfully corrected a genetic mutation causing a deadly heart condition.

Meantime, researchers at Stanford University have found that some people could be immune to part of the CRISPR process. One of the primary tools used, Cas9, is created typically using the same bacteria that cases strep throat. Some people have immune systems that are capable of naturally fending off infections, and this research calls into question whether the CRISPR technique could be effective across all—or just part—of the human population.

There are a number of next-gen biotech companies now working to better understand the practical applications of CRISPR in augmenting humans, including Direct Genomics, CRISPR Therapeutics, Horizon Discovery Group, Editas Medicine, Precision BioSciences and Intellia Therapeutics.

This year, we will see a number of companies further develop biological technologies. However, this is another example of an emerging technology that's developing faster than our ability to have meaningful conversations for the future. Genome editing warrants meaningful planning, as it could alter life for millions of people around the world.

TYPES OF GENOME EDITING

CRISPR-Cas9

What it stands for: Clustered Regularly Interspaced Short Palindromic Repeat or CRISPR. Cas9 is an endonuclease used in RNS-guided gene-editing platform—it's a bacterial process.

ZFN

What it stands for: Zinc Finger Nucleases. They're engineered DNA binding proteins that can introduce a break at a designated location.

rAAV

What it stands for: Recombinant Adeno-Associated Virus. It allows researchers to precisely target and edit any cell. Scientists are now working on a hybrid CRISPR-rAAV biological editing platform.

LANGUAGE MATTERS

- Gene-edited and GMO: gene-edited means that an organism's native genome has been edited, while "genetically modified organism" (GMO) means that foreign DNA sequences have been introduced into an organism.
- Gene drive: this is the practice of pushing the inheritance of desired genes through generations in order to permanently alter the entire population of an organism.

FUTURE SCENARIOS

Opportunities and Risks

Very Near-Term: Pest Control vs Ecological Weaponization

Genome editing can be used in mosquitos, which carry malaria—that disease kills millions of people worldwide each year. The technique alters a section of the DNA, making it impossible for future generations to spread malaria to humans. However, some security experts warn that the same process could be used in reverse—to rapidly spread a biological weapon that could be impossible to stop.

10 – 15 Years Away: Longer Lifespans vs Overpopulation

Some argue that genome editing could be used to give humans longer lifespans and to lower mortality rates—which would result in a devastating strain on our global supply of food and greater environmental degradation. On the other hand, genome editing is also being researched to create heartier plants and double-muscled livestock for human consumption.

20 Years Away: Healthier Babies vs Modification for the Wealthy

Genomic editing will help eradicate heritable diseases—like cystic fibrosis, Tay-Sachs disease, Huntington disease, Leigh Syndrome—from the population. The same techniques could be used additively, tweaking our musculoskeletal composition and I.Q. Very wealthy parents might be offered options to edit and enhance their future children. This will create a new divide, between modified humans and non-modified humans. The best jobs and opportunities will be held for modified humans resulting in a new technological caste system.

– AMY WEBB

Genome Editing cont.

Nanobots will deliver targeted therapies to patients.

231

IVF Genetic Screening

New genetic screening techniques to test embryos before implantation are making their way into fertility centers. Menlo Park-based **MyOme** and New Jersey-based **Genomic Prediction** are now using the genetic sequences of parents and cells retrieved during a biopsy in order to generate an embryo's entire genome. Next, they use algorithms to calculate the probabilities of certain ailments. Couples can then select the embryos they like, based on those results. While both companies are disease focused for now, it is also possible to calculate scores and optimize for other genetic traits like height and intelligence.

232

Biological DVRs

DNA is where we store all of our information, but the problem is that sometimes we humans have temporarily-varying biological signals. Researchers at **Columbia University** have discovered that it might be possible to record and store information about cells as they age. The technique—a sort of biological DVR—can be recorded by the CRISPR-Cas system over a period of days. In the future, this could allow researchers to very closely study how, exactly, we age. If we can quantify aging at a cellular level, maybe we can reverse it.

233

Human DNA-Powered Devices

It's relatively easy to design and fabricate a new product using computer-assisted design software and a 3D printer. Some are hoping that in the near-future, it'll be just as simple to design and build new medicines and therapeutic treatments at a molecular scale. Researchers are now working on building programmable devices out of our DNA, RNA and proteins. These molecular programs would allow doctors to "talk" to our cells in order to diagnose complex diseases, or to test new treatments. **Asimov**, an **MIT** startup, is developing a set of biological tools that would allow you to build a sort of biological circuit board. A team at **Harvard University's Wyss Institute** is researching this fantastical-sounding technology for its practical uses, like curing cancer.

234

Using Our DNA As Hard Drives

In 2018, scientists from **Microsoft Research** and the **University of Washington** achieved a new milestone: they figured out how to create random access on DNA at scale. They encoded 200 megabytes of data – 35 video, image, audio and text files ranging from 29KB to 44MB – to synthetic DNA. To date, scientists have stored a $50 Amazon gift card, an operating system and a film (*L'arrivée d'un train en gare de La Ciotat*, a short black-and-white French film made in 1896) on human DNA. Researchers at **Columbia University** and the **New York Genome Center** think that DNA could potentially be used in advanced computer systems. They're not alone. The **US Defense Advanced Research Projects Agency (DARPA)** announced its own DNA storage project in 2017. It seems like a weird branch of biological science, but there are practical reasons for human computing: DNA could solve our future data storage problems. It's durable, too: evolutionary scientists routinely study DNA that is thousands of years old to learn more about our human ancestors.

235

Nanobot Nurses

Tiny robots capable of delivering medicine to only a specific area of the body, or assisting with micro-surgery, are here. Late in 2018, scientists at the **Chinese University of Hong Kong** unveiled a new way to use nanobots within the body. Millions of tiny, magnetic shape-shifting nanoparticles can extend, merge and collaborate in a swarm. In practical terms, this means that a surgeon could direct the swarm to assist with eye surgeries and to deliver targeted medicines. **Caltech scientists** developed an autonomous, molecular robot, made of a single strand of DNA, that treats the inside of the human body like a distribution warehouse. The nanobot can walk around, pick up molecules, and deposit them in designated locations. Scientists have been working on nanobot technology for the past decade. Researchers at the **University of California San Diego** proved in 2015 that a nanobot, propelled by gas bubbles, successfully delivered medicine inside of a live mouse without causing injury. The hope is that someday soon, nanobots will replace one-size-fits-most medications and therapies, treating our specific ailments without causing side effects.

236

Dissolving Bioelectronics

For many people, implanted electronics are required to live a healthy life, but the machines require surgery, can be costly, and devices sometimes need replacement parts. In 2018, scientists at **Northwestern University** revealed new research on flexible, dissolvable electronic materials. In one case, they showed how the materials could be used during surgery. If nerves have been severed, doctors suture them back together and reawaken them using electrodes and a gentle electrical stimulation—but they typically don't have enough time in the surgical room to provide that restorative therapy beyond what would be minimally required. The team demonstrated that dissolving electrodes could be used to wirelessly transmit the electrical signal and stimulate repaired nerves for several days, which could cut recovery time in half. Once the therapy was finished, the materials broke down and were excreted. The study was done in rats, but it shouldn't be long before we start to see clinical applications in humans.

237

Microbe-Engineering as a Service

Synthetic biology is an emerging field that builds new life: replacement organs and soft tissue, as well as entirely new kinds of organisms never before seen on Earth. Bay Area-based **Zymergen** is developing original microbes for making specialty polymers, which have applications in military equipment and electric vehicles. In 2018, it raised $400 million in its third round of funding from **SoftBank Vision Fund, Goldman Sachs**, Korea-based **Hanwha Asset Management** and others. Synthetic biologists at **Ginkgo Bioworks** build custom-crafted microbes for their customers, which have included designer bacteria enabling crops to fertilize themselves.

238

Precision Medicine Begins to Scale

This is a new approach to personalized treatment and prevention, allowing doctors to design a treatment strategy using our own genes as guides. In the future, there would no longer be a single medication for all, but rather an individualized treatment for each one of us individually. The market for precision medicine is enormous, attracting new partnerships between corporate behemoths. In January 2018, **GE Healthcare** and pharma-giant **Roche** announced a joint venture to co-develop precision medicine products for cancer and critical care. But there is a bias problem lurking: 80% of the participants in genetics studies are of European descent. Precision medicine depends on extensive data, research and testing. Former President Barack Obama worked to close the gap with the **All of Us program**, which aims at gathering data from one million diverse Americans to help accelerate precision medicine advancements.

Geneticist George Church and his team used CRISPR to modify pig organs.

239

Running Out Of Space For Genome Storage

One of the fastest-growing datasets in the world is made up of our human genetic data. By 2025, researchers at the University of **Illinois at Urbana-Champaign** esti-

Genome Editing cont.

mate that we may be out of data storage space for human genomes. As precision medicine, **CRISPR** and gene therapy technologies continue to advance and improve, our storage needs will explode along with the computing power and requirements for acquiring, distributing, analyzing, encrypting and safeguarding our genomics data. As technology becomes increasingly intertwined with biology, we're realizing that we didn't plan ahead for adequate storage capacity, and that we didn't create good technology workflows for storing all that data. Australia's **Garvan Institute of Medical Research** is looking into different processes and workflow to reduce the genomic data footprint going forward.

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Genome Editing Research Clashes With Policy and Public Opinion

In 2018 we learned about a team of researchers at the **Southern University of Science and Technology in Shenzhen** who not only used CRISPR in conjunction with IVF, they had purportedly eliminated the CCR5 gene in a pair of twin girls. At that same time, **Harvard University** moved ahead with a plan to begin gene-editing sperm. Taking an order from the Trump Administration, the National Institutes of Health had to stop acquiring legally-obtained fetal tissue from elective abortions for experiments, which has disrupted advancements in numerous studies. It also cut off funding for university studies using fetal tissue, which is allowed under US law.

In the US, UK and Europe, CRISPR trials are now underway. The United States does not have a national biology, bioethics, or biotech plan, one that can withstand political pressure and our unrelenting election cycle. And we still have no global norms or a global agreement detailing how we should experiment with and use emerging biological technologies, especially those which might permanently augment humanity. As the results of new trials are published, we expect more public outcry like we saw during December 2018, which could lead to the spread of misinformation, eventual calls for regulation and the stifling of research and funding. There's precedent for our forecast: Remember Dolly the sheep?

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Artificial Cells

Researchers had already developed artificial cells that come very close to the real thing. But last year, scientists at the **University of California – San Diego** discovered a technique that creates cells capable of sending protein signals to other cells and triggering behavior, mimicking what biological cells do on their own. Artificial cells will soon offer practical applications for synthetic biologists who are working on precision medicine techniques.

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Nootropics and Neuroenhancers

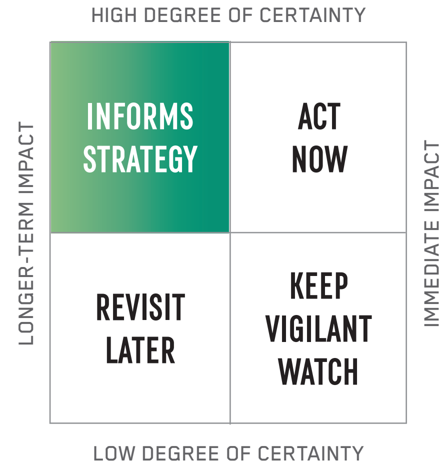
In the next few years, a number of drugs (also called **"nootropics"**) and devices, intended to enhance our cognitive ability and manage stress, will be made available to the public.

Nootropics are dietary supplements that have been shown to improve cognitive function—even if they're not officially regulated or approved by the FDA. You may already be taking a few: caffeine, red reishi mushrooms, ginseng, turmeric, ginkgo biloba and **Bulletproof** coffee are all popular foods, while supplements like **Creatine**, **Adrafinil**, **Noopept** and **Bacopa monnieri** are all being marketed to help promote mental clarity, focus attention and retain information. By some analyst estimates, the nootropic market could reach $11 billion in America alone by 2024.

Neuroenhancer devices are intended to record brain waves and send feedback. Some promise to help you become more productive, while others are meant to boost your mood. **Australia**-based **SmartCap** is a tracking system that uses voice warnings and vibrations to keep you alert while on the job. **Canadian** startup **InteraXon's Muse** headband uses neurofeedback to help manage stress and improve athletic performance. The **Emotiv Epoc+** and **Emotiv Insight** and mobile EEG devices monitor your brain activity and analyzes cognitive performance. **Doppel**, which is worn on the wrist, uses electric pulses to augment your energy. The pulsations, which you dial in based on your needs, are supposed to have a similar effect on your brain as music does. **The Thync Kit** is a series of electrodes and a triangular device that you stick on to your head—and a mobile app synching you to your smartphone. It delivers low-grade electric pulses to influence either your sympathetic (fight or flight) or your parasympathetic (rest and digest) nervous system.

Meanwhile in China: the military and some businesses are using connected headbands and hats to monitor employee brain activity. This emotional surveillance technology is said to optimize productivity—**State Grid Zhejiang Electric Power**, based in Jangzhou, reportedly said that its profits spiked $315 million since using neuroenhancer devices and software to mine, refine and analyze employee brain data.

Microbiome Extinction



KEY INSIGHT

We may all be guilty of causing a mass genocide, which is happening right now, in our guts and in the environment. The widespread use of antibiotics, along with diets rich in processed foods, have led to a staggering decline of microorganisms in wealthy nations.

EXAMPLES

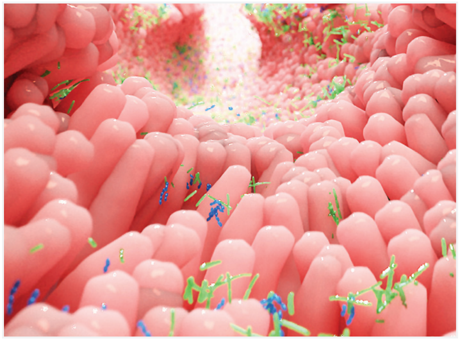
During the past 12,000 years of human evolution, we've shifted nature's balance—our diets are relatively narrow, compared to our far-distant ancestors. Recently, scientists studied modern hunter-gatherer tribes in **Tanzania, Peru** and **Venezuela**, whose microbiota have 50% more bacterial species than people do in the West. Unlike those tribes, we no longer hunt and eat wild flora, fauna and animals. Those from wealthier countries now eat very little dietary fiber, limited variety of fruits and vegetables and only four species of livestock: sheep, poultry, cattle and pigs. Worse, widespread use of antibiotics in farm animals – not to prevent disease, necessarily, but to increase weight gain and therefore the volume of meat available – means that we're ingesting compounds that are helping to destroy our own microbiomes.

WHAT'S NEXT

We humans are complex, composite organisms, made up of layers and layers of cells. Researchers now think that our gut microbiome is directly linked to everything: our metabolism, immune system, central nervous system, and even the cognitive functions inside our brains. It's an inherited problem: most of our microbiota are passed from our mothers through the birth canal. There are a number of researchers now looking at the future of our microbiomes. Cambridge, Massachusetts-based **Vedanta** is making gut bacteria that can be turned into drugs and counts the **Bill & Melinda Gates Foundation** as one of its investors. San Francisco-based startup **uBiome** has launched several at-home microbiome tests (though you still need a subscription to take one). **The American Gut Project**, the **American Gastroenterological Association** and **OpenBiome** will track 4,000 patients over 10 years to learn about fecal microbiota. Investors have poured more than a billion dollars into microbiome startups since 2016. It's a field that's also attracting talent: last year, **IBM Watson's** former head of AI research **Guruduth Banavar** left to join startup **Viome** as its chief technology officer.

WATCHLIST

Microbiome Center at the University of Chicago; Stanford University's Sonnenburg Lab; Viome; SENS Research Foundation; uBiome; US Food and Drug Administration; University of Pennsylvania; the American Gastroenterological Association Center for Gut Microbiome Research & Education; The American Gut Project; OpenBiome; Vedanta.



Researchers now think that we're causing the extinction of a large potion of the human microbiome.

Building A Comprehensive Human Cell Atlas

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

HUMAN CELL ATLAS

The Human Cell Atlas team will create the first map of all the cells that make up the human body.

KEY INSIGHT

Researchers are working on the first-ever comprehensive map of all of the 37.2 trillion cells that make up the human body.

EXAMPLES

A large team of scientists—including 130 software engineers, mathematicians, computational scientists, biologists, clinicians and physicists – hailing from Israel, the Netherlands, Japan, the UK, the US and Sweden are hard at work mapping the human body on a cellular level. Although a cell atlas had long been theorized, new biological tools and more power computers have turned this one-time vision into a reality.

WHAT'S NEXT

The team working on the atlas believes that they can draw comprehensive reference maps for all human cells in the body. A human cell atlas would give the medical community a new way of understanding how our bodies work and how to diagnose, monitor and treat disease.

WATCHLIST

The organizing committee and academic institutions of the Human Cell Atlas Consortium.

13

HEALTH TECHNOLOGIES, DIGITAL SELF-CARE AND WEARABLES

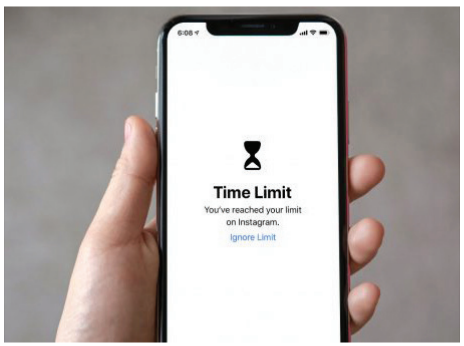
FIRST YEAR ON THE LIST

Digital Addiction

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY



Apple's Screen Time app released this year shows you how addicted you are to your phone.

KEY INSIGHT

Tech products are designed to be "sticky" or addictive. Recently, it has come to light that using these products in excess can have a negative impact on mental health and wellbeing.

EXAMPLES

South Korea's national crisis of internet gaming and gambling addiction used to be a fringe case; but in today's ever-connected world, digital addiction is a global, mainstream trend impacting people of all ages.

Time spent on social media has been linked to anxiety and depression, while time spent on mobile phones, tablets, e-readers has been said to disrupt sleep cycles and reduce productivity. In 2018, **Facebook** admitted that research shows that spending too much time on the platform can make people feel bad, while **Google** and **Apple** both unveiled new system updates and apps to help users monitor their digital well beings.

WHAT'S NEXT

Advocacy groups **Common Sense** and the **Center for Humane Technology** are lobbying regulators and educators in the United States to create standard policies on digital products marketed to children. In the workforce, employees are demanding the right to unplug and disconnect. This will shift how we relate to and use our devices – however it also directly impacts every single business model that hinges on our attention.

WATCHLIST

New York City Council, Common Sense, Center for Humane Technology, Apple, Google, Facebook.

TREND 246 SECOND YEAR ON THE LIST

Patient-Generated Health Data

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Patients are creating a trove of data that could contribute to their healthcare provider's overall assessment. Packaging all that data—and figuring out how to make use of it—is still a challenge.

EXAMPLES

From **Fitbits** to **Apple Watches** to **smart scales** we use at home, there are hundreds of devices now able to collect and monitor our health using lots of different inputs. New software from companies like **Validic** allow doctors to collect this other data and incorporate it into their medical records—as long as patients give their consent. **GE Healthcare, Meditech, Allscripts, eClinicalWorks** and **Cerner** are all building products to make better use of our data.

Insurers are interested in our data, too. In 2018, the US, **John Hancock** (part of **Manulife Financial**) launched a program that rewards customers for engaging in a healthy lifestyle. Points are earned for exercise, meditation and other healthy activities—after enough are earned, they can be used for online shopping. But there's something in it for the insurers, too: getting access to huge amounts of activity and lifestyle data in real time will allow them to predict and adjust their pricing models down the road.

We also generate data at the doctor's office, and under federal law in the US, that data must be filed and stored electronically. The medical community and public health sector are now trying to find ways to make good use of what we're creating. Differential privacy measures could enable hospital systems to anonymize our private details while still making our data useful to researchers.

WHAT'S NEXT

Healthcare systems and providers will need to shore up security fast. On a near-weekly basis, hackers are targeting hospitals and doctors, holding patient data for ransom. In May 2017, hackers used the **WannaCry** malware to break into the **UK's National Health Service**, crippling the nation's hospitals and clinics. In January 2018, hackers used the remote access portal to break into a rural Indiana hospital. They demanded 4 bitcoin to release the data. The timing was awful: there had just been a serious ice storm, which caused a spike in emergency room visits, and there was a local flu outbreak.

Not all future scenarios are bleak. Our health data, combined with artificial intelligence, could soon allow doctors to provide us better preventative care.

WATCHLIST

Amazon; Manulife Financial; GE Healthcare; Meditech; Allscripts; eClinicalWorks; Cerner; Validic; HumanAPI; Vivify; Apple; IBM; Microsoft; Qualcomm; Google; Medicare; Medicaid; national health systems; insurance companies.

Our health data, combined with artificial intelligence, could soon allow doctors to provide us better preventative care.

The Big Nine's Health Initiatives

HIGH DEGREE OF CERTAINTY

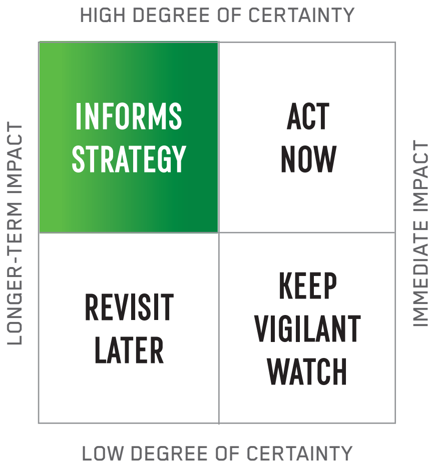
LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Apple has started building health clinics.

All of the **Big Nine** companies – **Amazon, Google, IBM, Apple, Microsoft** and **Facebook** in the **US**, along with **Baidu, Alibaba** and **Tencent** in **China** – are now leading various health initiatives. Google is making big investments in genomics, healthcare application research and HIPAA compliance in the cloud. Its **Calico, DeepMind** and **Verily** divisions are each on a mission to develop new technology and to advance artificial intelligence to improve human health. Amazon partnered with **Berkshire Hathaway** and **J.P. Morgan** to reimagine insurance and healthcare; it acquired internet pharmacy **PillPack**; it's actively building at-home medical diagnostic kits; **Alexa** will soon be able to tell whether you've had a cold; and it's built a product to mine patient health records. Amazon and Apple both have started building independent health clinics. In some way, all of the Big Nine companies have ambitious health strategies that we will see unfold in the coming years.

Interactive Mirrors



KEY INSIGHT

New mirrors capable of recognizing you and suggesting helpful information will start to change how we exercise, apply makeup and choose which over the counter drugs to take.

EXAMPLES

While connected mirrors have been available for the past few years, the latest mirrors are aided by machine learning and are designed to interact with consumers seamlessly, like a visual conversation.

The **Artemis** smart mirror from **CareOS** is intended to help users try out new hair styles and colors—however it will also collect and analyze data to determine whether that mole on your neck is something a doctor should check out. **Capstone's Connected Home** mirror and **Kohler's Verdera Voice** smart mirror are both powered by **Google Assistant**, which recognizes faces and voices before sharing data. The **Mirror** is an interactive gym masquerading as – wait for it – a full-length, wall-mounted mirror. A coach leads recorded or live classes and the mirror helps you adjust your form. Meanwhile **Tonal** is an interactive fitness mirror that comes with adjustable arms for resistance and weight training. The system will automatically detect your performance and either increase or decrease the resistance during your workout..

WHAT'S NEXT

Because of the volume of data collected and used by interactive mirrors, it's likely that the next phase of development will include connecting your data to third parties: your doctor, your insurer, possibly even your government.

WATCHLIST

Amazon; Apple; Google; IBM; Microsoft; Alibaba; Baidu; Tencent; Tonal; Mirror; Kohler; Capstone; Mirror; CareOS; GE; Qualcomm; Medicare; Medicaid; national health systems; insurance companies.

Mirror is a new interactive exercise product to help people work out at home.

Touch-Sensitive Prosthetics

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

A prosthetic hand equipped with the experimental e-dermis.

Photo Credit: Larry Canner/JHU.

KEY INSIGHT

Researchers are developing new prosthetic skins and limbs that restore not just movement—but touch as well.

EXAMPLES

Humans are capable of distinguishing between various surfaces—and we're quite sensitive. Researchers have been amassing a body of knowledge to help them develop electronic skin, and prosthetic body parts that deliver haptic, tactile sensations. In 2018, researchers at **Johns Hopkins University** in **Baltimore** created an electronic skin to help restore a sense of touch to amputees. Dubbed "**e-dermis**," it recreates a sense of touch (including pain) by sensing stimuli and sending that signal back to the peripheral nerves.

WHAT'S NEXT

Interdisciplinary researchers at the **Center for Wearable Sensors** and the **Center for Brain and Cognition** at the **University of California at San Diego** are combining materials science and psychophysics to map exactly how humans perceive touch. This research lays the groundwork for advanced prosthetics in the future. We've already seen some exciting developments. Neuroscientists at the **University of Chicago** are experimenting with touch-sensitive robotics and rhesus monkeys, whose neural-sensory biology is most similar to humans. They successfully simulated the sensation of touch by stimulating certain areas of the brain. A team of scientists from the **Lausanne and Sant'Anna School of Advanced Studies** and the **University Hospital Agostino Gemelli** developed a bionic hand that transmits a realistic sense of touch; it's already in use, restoring sensation to a woman who lost her hand in an accident 25 years ago.

WATCHLIST

Johns Hopkins University; **University of California at San Diego; Lausanne and Sant'Anna School of Advanced Studies; University Hospital Agostino Gemelli**; National Academy of Science; FDA; University of Chicago; Duke University's Center for Neuroengineering; University of Southern California; University of Washington's Center for Sensorimotor Neural Engineering; Johns Hopkins University; Carnegie Mellon University; StarLab; Case Western Reserve University; Penn State University; DARPA.

Smart Thread

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

"Smart thread" uses electrical currents and transmits information to doctors after surgery.

EXAMPLES

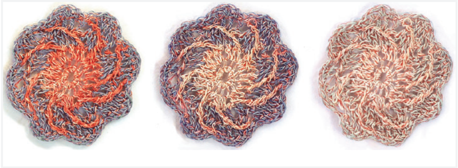
Think of "smart thread" as a sort of temporary, smart system that connects to a smartphone or other medical device and reports on your glucose levels, diagnoses an infection and alerts hospital staff if your body is chemically out of balance. Researchers at **Tufts University** have embedded nano-scale sensors and electronics into surgical thread, that can be used for suturing. Meantime, at the University of California at Berkeley's School of Information, researchers are experimenting with smart threads that can change color. These non-surgical threads are coated with thermochromic paint that changes color when jolted with electricity.

WHAT'S NEXT

Smart thread is just coming out of experimentation, but initial tests results show that it can be successfully used as a diagnostic device.

WATCHLIST

Tufts University; University of California at Berkeley's School of Information; Harvard-MIT Division of Health Sciences and Technology; Harvard University's Wyss Institute.



Smart thread can change color and transmit data.

Vaping and E-cigarettes

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Vaping and e-cigarettes could face additional federal regulation in 2019.

The market for e-cigarettes has exploded in the past few years since **Juul** and **Vuse** entered the marketplace. Juul earned a $12 billion investment from **Altria Group** (includes Philip Morris and Nat Sherman) – which is remarkable, given that in 2019 we should expect to see tighter **Food and Drug Administration** regulations. In the US Consumers may be giving up on traditional cigarettes, but e-cigarette technology is attractive because consumers believe it to be a healthier alternative. In 2019, Juul will begin running TV commercials – the company has managed to skirt **FCC** regulations regarding the marketing of tobacco. Expect lots of debate on vaping and e-cigarette regulations throughout 2019.

WEARABLES

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

IMMEDIATE IMPACT

LOW DEGREE OF CERTAINTY

THE END OF SMARTPHONES

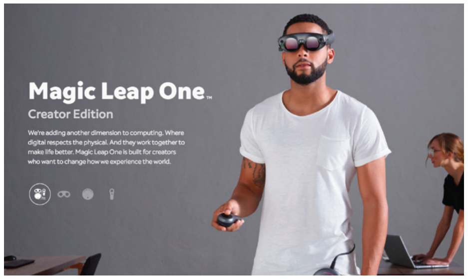
Globally, smartphone shipments are in decline. Apple will no longer report sales numbers for any of its hardware products – it's a clear signal about what's on the mid-horizon. And even as new form factors enter the consumer marketplace next year – you'll see dual-sided phones and models with foldable screens – the functionality isn't improving at a fast-enough rate to merit tossing out existing phones for new ones. In the next ten years, we will transition from just one phone that we carry to a suite of next-gen communication devices, which we will wear and command using our voice, gesture and touch.

– Amy Webb

KEY INSIGHT

There are more than 1,000 wearable devices now available to consumers and to the enterprise. Worldwide shipments of wearable devices should top 270 million in 2019 – more than half dedicated to personal fitness or biometrics, while others are intended for gaming, work and medical monitoring. Global sales of consumer wearables (non-medical) should generate revenue of $38 billion in the coming year.

As of now, nearly all wearables require a smartphone or computer to see and report data, adjust settings and archive information. But that will change as smartphones fade to the background.



Magic Leap's new Creator Edition mixed reality glasses were sent to developers late in 2018.

252

Smart Glasses

In 2018, **Magic Leap** shipped the **Creator** edition of its long-awaited smart glasses and spatial computing system. The glasses project light directly into the user's eye,

Wearables cont.

Everyday wearables will soon collect our biometric data.

making it seem as though digital objects exist in the real world. Don't force connections between Google Glass and what comes next. Glass was a successful technology in search of a market. This year, as the Magic Leap ecosystem grows, we anticipate much more active development in spatial computing – not to mention new startups.

253

Hearables / Earables

In-ear computers, otherwise known as earables, are here. In 2018, Qualcomm released a developer kit to bring Alexa voice recognition to any headphones used with Android smartphones. Bragi's wireless Dash earbuds give users access to Android's and Apple's digital assistants, responding to gesture as well as voice. For example, an incoming phone call can be accepted by shaking your head yes, or declined by shaking your head no. Future versions of Apple's EarPods will monitor temperature, perspiration and heart rate during exercise or sports—and those earbuds will be used to control electronic devices (like our phones) using head gestures.

254

Head Mounted Displays

Virtual reality headsets are wearable devices. What's next: they will soon collect your biometric data and other personal information in order to provide added functionality. The HTC Vive tracks your movement, while controller sticks send haptic signals to your brain as you work your way through simulated environments. Beyond videos, there is not much additional opportunity to integrate news with HMDs. (See: *Mixed Reality*.)

255

Connected Clothing

A new generation of smart clothes is trickling onto the market in 2019, from pajamas with infared energy to help your muscles recover faster from a hard workout to yoga pants that alert you when you're out of alignment in poses. Pivot Yoga makes connected yoga pants—you read that right—that monitor your downward dogs and help you adjust your form. Their connected clothing syncs to an app, through which a digital assistant will tell you when to turn your left hip or to move your legs three inches back on the mat. Apple has patented "force-sensing" fabrics, including a glove that could be used to monitor our blood pressure and heart rates. New smart bras, intended for athletes and fitness enthusiasts, captures biometric data to track cardiac and pulmonary activity. One startup, OMsignal, created smart bras, camisoles, and sleep shirts that collect data to determine an individual baseline for the user, then an app monitors activity looking for abnormalities. The system can detect early signs of pulmonary conditions and sleep apnea.

256

Smart Rings and Bracelets

Nearly a decade ago, Microsoft experimented with "skinput," which turned a person's arm and hand into an inter-active interface. You could answer a call by tapping your fingers, or pressing your palm to skip a song on your playlist. Now Google's Project Soli is advancing that skinput idea: in December 2018, the FCC approved its proposed tests of a new chip that uses radar to track micromotions. The Soli chip (or something like it) could be embedded into glasses, rings, bracelets,– virtually any connected thing you might wear. We're already transitioning from physical to digital buttons; soon skinput may teach consumers to live without any buttons at all.

257

Smart Belts and Shoes

French company E-Vone is selling a smart shoe with fall detection—if the wearer falls, it sends an alert. Rather than purchasing a single pair, users subscribe to a service –

they automatically get a new pair annually. **Welt Corp** offers a smart belt that can detect falls, too – and it sends push notifications if it senses that you've eaten too much. In early 2018, **Baltimore**-based **Under Armour** launched its next-generation set of connected running shoes, whose foam soles include an accelerometer, a gyroscope, a battery and a Bluetooth module. The shoes collect and store data, allowing you to go out for a run without having to bring along your smartphone. They also set a baseline the first time you use them, and then track distance, stride length and your running cadence over time. Others in the market include **Altra IQ** for fitness optimization, **Orphe** which changes colors, and **Solepower** which can generate power for your cell phone while you hike.

258

Smart Gloves

In **Kenya**, a researcher invented smart gloves that can translate sign language into speech. The gloves, called **Sign-IO**, use gesture recognition and sensors embedded in the gloves. Canadian researchers at **Simon Fraser University** designed a set of interconnected gloves to help transmit a sense touch through the internet. When someone moves her fingers in one glove, her actions are sent to her partner wearing the other. **Sony** has been filing patents for haptic glove controllers, which would simulate the physical sensations of slicing, punching and shooting.

259

Smart Helmets

The **National Football League and Air Force** both use smart helmets, but now that technology is coming to everyday people. **Islamabad**-based startup **Let's Innovate** has developed a smart motorcycle helmet that automatically calls for an ambulance in case of emergency. Nearly half of Pakistani households own motorcycles, but only 10% of riders wear helmets—and about 15 people every day die in motorcycle accidents. A smart helmet capable of calling for help could save lots of lives in Pakistan, not to mention in other areas around the world.

260

Tattooables

Medicine will start to look very different. **Tatooables**—temporary skin that can store data and deliver drugs—have entered trials. Researchers at the **Institute for Basic Science** and **Seoul National University** in South Korea, the **University of Texas** in Austin, the **University of Tokyo, Stanford** and the **University of California at San Diego** are all working on electronic second skins. **MC10** has already created microscopic, organic semiconductors and carbon nanotubes that stretch and flex and can be powered wirelessly. Called BioStampRC, it's far thicker than a tattooable, but the idea is the same—and it's only a matter of time before the technology shrinks.

261

Thinkables

In 2018, researchers at **MIT** debuted functioning smart limbs that are controlled by the mind. **Thinkables** will soon allow more adventurous gamers to control games using only their thoughts. Boston startup **Neurable** created a brain-controlled VR game called Awakening that lets you control the game with your thoughts. The **4D Force** platform detects brain waves, capturing EEG/ EOG/ EMG signals and converting them into signals a computer can understand.

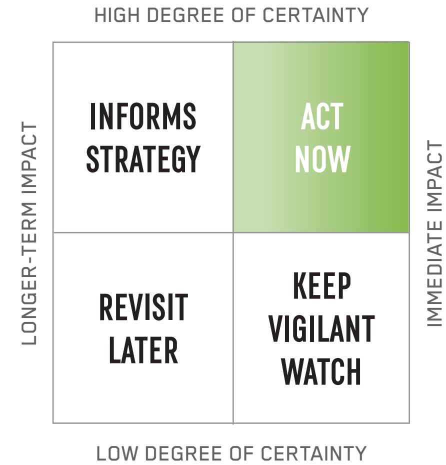
262

Wireless Body Area Networks

Wireless Body Area Networks (**WBANs**) communicate information from your wearable devices back to medical servers, app manufacturers and your home computer. Sensors, such as devices to monitor your heart rate or oxygen level, collect data and send it back to a central hub (most often, your smartphone) which then relays the information to a medical team or health care monitoring service. There are a lot of benefits: rather than moving into an assisted living facility or spending a lot of time in the hospital, patients can instead move back home while being provided with virtual care. While some of the established medical devices use strong encryption algorithms, many new wearable devices don't. They're sending a lot of unencrypted, unsecured personal data – including our locations – across the Internet. As the hacking community becomes more sophisticated, it's started targeting hospitals and clinics. The **US Department of Homeland Security** has been investigating several cybersecurity cases related to WBANs.

14

HOME AUTOMATION AND THE INTERNET OF THINGS



HOME AUTOMATION

Amazon's Smart Basics Microwave responds to your voice.

KEY INSIGHT

From energy management to security to mood lighting and smart appliances, home automation continues to be an important technology trend that cuts across numerous industry sectors.

263

Locks That Use Face Recognition

In 2018 **Amazon** announced a new feature for its Ring doorbells. The system automatically recognizes people and, if they match faces in a database of known troublemakers, the police can be notified. A patent filed shows that the scope extends beyond your doorstep – if suspicious people are walking by your house, police can be notified, too. You'd also be able to review footage and to add your own photographs to block certain people from ever getting into your house. (At least through a door.)

264

Our Appliances Have Their Own Digital Assistants

In 2018, **Amazon** quietly debuted a smart microwave that can be controlled using **Alexa**—and will someday automatically track what you're heating up. If you're a Prime member and subscribe to certain groceries, the microwave and Alexa will work together to make sure that you never run out of staples, like microwave popcorn, again. **Samsung** announced that all of its appliances will include **Bixby**—the company's digital assistant—by 2020. **Apple** has opened up its **HomeKit** requirements, making it easier for manufacturers and developers to incorporate **Siri**. Both **Amazon** and **Google** are partnering with appliance manufacturers *en masse*, which will soon allow us to turn on our dishwashers and see how much time is left on the dryer.

265

Smart Appliance Screens

Major appliance manufacturers are including smart screens in upcoming models, supported by **Alexa** and **Google Assistant**. The **Samsung Family Hub** smart refrigerator and **Whirlpool Cabrio** washing machines will allow users to interact with them via touch screens and smartphones. The smart screen interfaces offer customization—new specialty cycles and programs can be downloaded from the internet.

266

Home Appliances That Can Talk To Each Other

As the **Internet of Things** matures, more of our smart home appliances will offer interoperability, resulting in more automation. **Innit**, which launched in 2013, is a platform that helps kitchen appliances talk to one another, even if your appliances come from several different brands.

In 2019, Innit is partnering with Google **Home Hub** and other smart displays to help further connect your kitchen. There are lots of other options: the **Bosch Home Connect** smart kitchen line connects to **Nest Protect**. If you forget that pizza in the oven and it starts to catch fire, your Nest smoke detector will tell the oven to turn itself off. In the coming year, we'll see more integrations across brands and appliances.

267

Wireless Kitchens

As appliances and devices start to take over our counters, we could wind up tangled in wires. That might not be a problem in the near future. Manufacturers are researching options for wireless charging, which include in-counter charging panels and more energy-efficient appliances. **Chefling's UltraConnect** is an AI-powered system with the ability to wirelessly communicate with **Amazon's Alexa** and **Google Home** – it can explain how to make a recipe while automatically adjusting GE connected smart devices. **Urbaneer**, a Michigan-based home furnishing designer, is working on a suite of connected furniture that can charge nearby devices.

268

Smarter Home Security

All of the screens in your connected devices will soon double as security cameras. Researchers are building new software that connect smart screen-equipped devices—such as your television, your **Chromecast**, your **Echo Show**, your refrigerator—with security systems. In practice, this means that you could remotely monitor any part of your home without having to purchase a camera for every room. **Taiwan**-based **D-Link**, which builds home networking equipment, is launching home cameras that integrate with either **Google Assistant** or **Alexa** as well as other screens in your home.

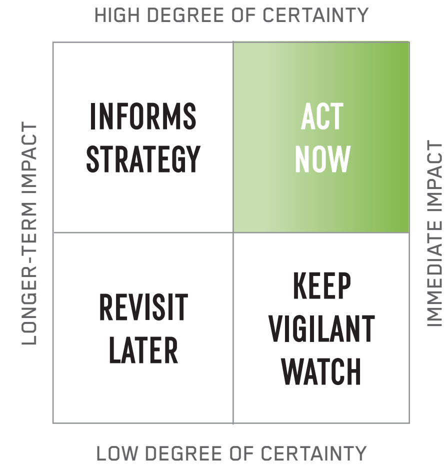
269

The End of Remote Control

Subscribers to **Comcast's Xfinity** already have access to voice-controlled remote controls, which allow users to search for actors, ask questions about shows, and bypass the menu system to quickly find what they want to watch. We tend to associate remote controls just with our televisions, but you can expect to see new uses for remotes in the years to come. However as digital voice assistants become more integrated with various consumer electronics, smart remotes will give way to embedded speakers and microphones within our devices. **TCL Roku TVs** will soon be equipped with far-field microphone arrays. **Samsung** will keep its remotes for now, but they will start to rely heavily on its Bixby smart assistant. All of this sounds exciting – unless you are sick or aren't able to speak.

The Ring Home Security System is a smart camera capable of recognizing faces.

GDPR, Privacy Laws, and Hackers Threaten the Internet of Things



The IoT will be tested by the GDPR this year.

KEY INSIGHT

FTI has been tracking the evolution of the Internet of Things (IoT) for a decade. We are continuing to see a convergence pitting the IoT's growth against the serious challenges posed by hackers and policy-makers.

EXAMPLES

Billions of smart sensors and devices in our homes, offices, schools and cars are talking to each other, monitoring information and activity, and automating tasks in order to make your life easier. These devices and their protocols make up the Internet of Things (IoT). In the next few years, there could be as many as 30 billion connected devices and machines online: fitness trackers, traffic lights, bras, autonomous vehicle components, farm equipment, parking meters, coffee machines, personal drones, shoes, doorbells, fish tanks, bicycles, pajamas… we could fill another hundred pages of this report just listing the diverse ecosystem that will soon become the IoT.

Why the sudden explosion? It has to do with the sharply-decreased cost of components, sensors, bandwidth and processors—as well as the now-ubiquitous availability of smartphones and WiFi in industrialized nations. Even the internet itself got an upgrade to something called **Internet Protocol Version 6 (IPv6)**, which is helping to expand the IoT so that there are enough usable addresses to go around. International standards organizations are working on a future open standard, just as HTTP and FTP play critical roles in how we move content around on the web today.

WHAT'S NEXT

Safeguarding consumer privacy and securing the IoT will continue to be a challenge in the coming year. IoT devices are considered ideal targets, because consumers are purchasing more and more connected devices without also learning about how to secure them. Just as your computer can be hijacked by a botnet, so can your smart doorbell. In October 2017, researchers at **Netlab 360** found the **IoT_reaper botnet**, which was infecting an average of 10,000 new devices a day. In 2016, the **Mirai botnet** infiltrated tens of thousands of DVRs and webcams, which helped it successfully take down a large swath of the internet.

There will be calls for increased security and regulation in the coming year, when the IoT nears an inflection point—and development starts to outpace our ability to secure it.

IMPLICATIONS

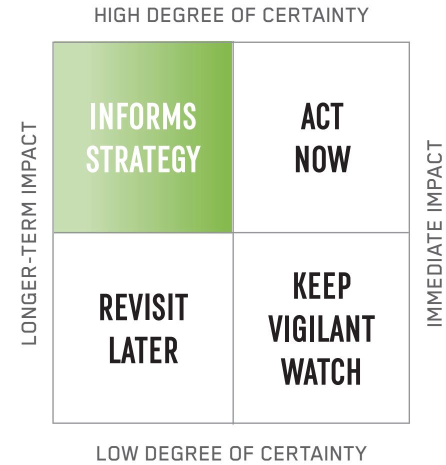
Beyond security, you should be thinking about next-order implications for business, consumers, IoT networks, and policymakers. Here are a few to consider:

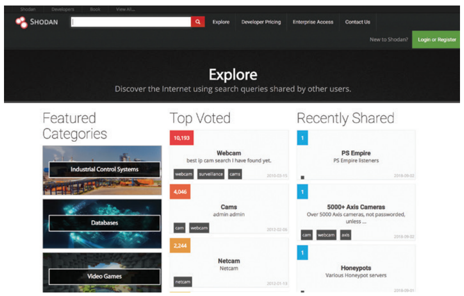
- Should we mandate firmware, software and feature updates?
- Should those updates be automated, preventing consumers from overriding them on their own?
- What are the opportunities for misuse?
- Who, exactly, is responsible for safeguarding consumer privacy and security? What role, if any, does the consumer legally play?
- What about IoT devices that span different countries?
- What happens if and when a device malfunctions? If a consumer relies on an IoT device for directions, medicine, learning ¬¬and something goes wrong, who bears responsibility?
- What should the lifecycle of support look like at scale? For how long are manufacturers and service providers responsible for customer support, and at what levels?

WATCHLIST

Qualcomm; Cisco; Symantec; Bitdefender; Global Cyber Alliance; Alphabet; Amazon; Apple; Honeywell; IFTTT; GE; Intel; Cisco; IBM; Sony; Samsung; LG; Hadoop; Arduino; SmartThings; AT&T; Verizon; Ericsson; Atmel; littleBits; National Cybersecurity Alliance; European Union; US Congress; Federal Communications Commission; Federal Trade Commission; internet service providers.

Searching The IoT and the IoPT (Internet of Physical Things)





The Internet of Things is becoming easier to search.

KEY INSIGHT

The Internet of Things—that massive interconnection between all of our smart devices and the internet—is growing at breakneck speed. As a result, the IoT is now an attractive target for cybercriminals.

EXAMPLES

You can now shop for products on Amazon by simply scanning in a barcode or holding your phone for a few seconds in front of what you want to buy. Advancements in computer vision and machine learning turned our smartphones into periscopes. Online search giants like **Google** and **Bing** have made it easy to find just about any information in the digital realm. The idea is to let us search real-world objects, as well as all of the devices connected to the Internet of Things.

You can also search through and pinpoint all of the connected devices on the internet if you know how. **Shodan** and **Thingful** are search engines for IoT devices. It was intended as a security tool to help IT professionals keep track of all the devices connected to a network.

WHAT'S NEXT

Watch out for Thingbots in 2019. These are devices that connect to the IoT and act like a botnet. Last year, they wreaked havoc in Singapore, Spain and the US – which means that your washing machine could be running a secret Thingbot and sending hundreds of spam messages a day. All of these IoT devices function at varying levels of security on a wide variety of networks.

WATCHLIST

Hewlett-Packard; Symantec; Shodan; Thingful; Qualcomm; Intel; Google; Microsoft; Apple; Tencent; Alibaba; Baidu; Amazon.

15

WORKPLACE AND LEARNING TECHNOLOGIES

Universal Basic Income (UBI)

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Finland concluded its two-year UBI experiment at the end of 2018.

KEY INSIGHT

The idea of an unconditional guaranteed income for everyone within a country is now being discussed again both as a means of encouraging entrepreneurial innovation and in the wake of automation, advanced robotics, and artificial intelligence.

EXAMPLES

A UBI program launched and closely watched in **Finland** came to an early close in 2018. It targeted only 2,000 randomly unemployed citizens and gave them 560 euros a month (that's about $675) for two years. The model didn't work there – but some experts believe that it's because other social welfare programs weren't adjusted alongside the UBI program.

Early in 2019, Democratic presidential candidate **Andrew Yang** launched a pilot UBI program in **New Hampshire** – if it works, and if he's elected president, he would work to ensure that every American aged 18 to 64 would receive $1,000 every month. The money to pay for it would come from consolidating social service programs and from a value-added tax (similar to what exists in Europe) of 10% on the production of goods and services. There are city-scale experimental UBI programs running now in **Oakland** and **Stockton**, California. The Stockton project will give 100 randomly-selected low income families $500 a month for 18 months.

WHAT'S NEXT

An interesting thing to note about the UBI debate is that it has supporters and detractors from both the **liberal** and **conservative** sides of the aisle (both in the United States and internationally). For UBI optimists, this bipartisanship represents an opportunity to craft UBI policies that could be instituted legislatively.

The UBI discussion has also become more popular in **academia**, with a 53% increase in the number of articles published from 2016 to 2017 on Google Scholar. **Think tanks** have also continued to assess the economic benefits of a UBI either as a stand-alone policy or as an alternative to existing social welfare programs. With Finland's two-year experiment set to end in December 2018 and findings expected in early 2019, results of this experiment could signal how other countries approach UBI moving forward. It's a popular concept supported by tech entrepreneurs like Sam Altman, Elon Musk and Mark Zuckerberg in **Silicon Valley**.

WATCHLIST

Finland; Scotland; Y-Combinator; The Roosevelt Institute; Facebook; Mark Zuckerburg; Elon Musk; The Royal Society for the Encouragement of the Arts, Manufacturers and Commerce; Stanford Center for Philanthropy and Civil Society; American Enterprise Institute.

AI in Hiring

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	**KEEP VIGILANT WATCH**

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Artificial intelligence and machine learning tools are being used in the hiring process with the hopes of identifying more qualified candidates, eliminating human bias, and reducing time spent on automatable tasks.

EXAMPLES

There are numerous ways that companies and recruiters (both large and small) are using artificial intelligence throughout the hiring process. Resume reviewers can quickly analyze resumes for designated keywords, years of experience, and grammatical errors while also attempting to remove potential bias from factors such as gender, race, or nationality. Companies can automate the pre-interview process by mapping a person's internet presence and also via assessments with tailored questions to evaluate a potential candidate's responses. This screening can also help larger companies find qualified candidates who might not have applied for the original job posting. AI is also being used within the interview process to analyze responses to particular questions.

WHAT'S NEXT

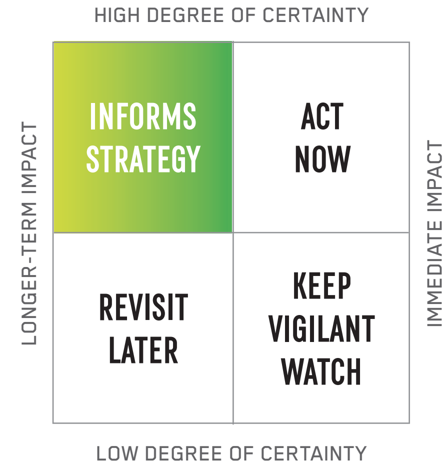
In 2018, Amazon revealed that it had been building various programs and tools to automate the process of reviewing applicant resumes. An experimental AI-powered tool scored candidates from one to five stars – but it soon realized that the computer models had learned to prioritize male applicants over female applicants. While the company decommissioned that system, it did prove that with the right data sets and training models, it will soon be possible to employ automated AI systems in search of new hires.

WATCHLIST

LinkedIn; Interviewed; Facebook; Amazon; Talent Sonar; HireVue; FAMA; SkillSurvey; Avrio; Alphabet.

AI systems are being used to help in the hiring process.

Productivity Bots



NEAR FUTURE SCENARIO

Email-less Companies

With teams constantly needing to be connected, e-mail will be viewed as a slower and less efficient form of communication. Because of this, companies will move away from email entirely. But for companies that must keep a paper trail, what would the legal considerations be once employees are chatting and using bots? It's possible to create logs, but they would be difficult to sift and sort through. For those companies that monitor staff email for regulatory reasons, messaging systems like Slack could make compliance difficult.

– ROY LEVKOVITZ

KEY INSIGHT

Productivity bots aim to help teams and individuals operate more productively by automating tasks that are time consuming and often mundane for individuals—but perfectly suited for bots.

BLOCKCHAIN: A PRIMER

With more than 8 million daily active and 9 million weekly active users, Slack is by far the most popular platform integrating hundreds of productivity bots with the workplace. The **Obie bot** is used as an onboarding tool, allowing new employees to find answers to simple questions about the company. Scheduling bots like **Meekan** sync up with coworkers' calendars to provide possible meeting times. If you're trying to reduce wasted time that a stand-up meeting takes up, bots send out a request for an update from team members and pushes out a report once everyone has sent theirs in. Bots like **Lunch Train** help coordinate team lunches and their locations. Slack isn't the only platform being used: **Mattermost, Trello, Asana** and **Rocket.Chat** are all helping boost productivity in teams.

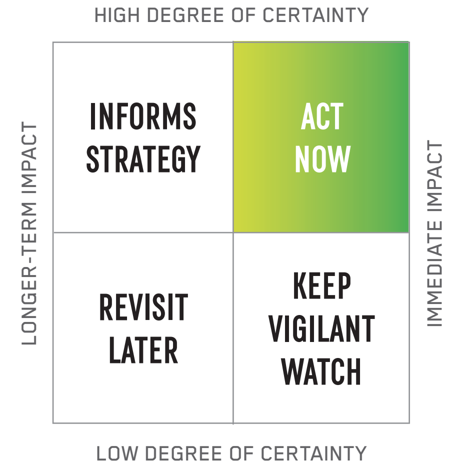
WHAT'S NEXT

With more distributed teams and the popularity of coworking spaces on the rise, automation and productivity tools will continue to move toward the mainstream, cannibalizing traditional office technology, like email.

WATCHLIST

Slack; Rocket.Chat; MatterMost; X.ai; Workbot; Obie; Microsoft; Howdy; Standup Alice; Geekbot; Meekan; Skype.

Adaptive Learning



KEY INSIGHT

An interactive teaching method powered by artificial intelligence that can be used by businesses and educational institutions to tailor curriculum for individuals based on correct and incorrect responses to questions.

EXAMPLES

In a 2017 course on the open course platform HarvardX, students who were placed into the adaptive learning track outperformed the control group by 19%—in fact, they outperformed their peers across different key learning objectives. In a business setting, adaptive learning systems are being used by employers to onboard new staff, train employees, help hone specific skills and understand an individual's specific strengths and weaknesses. These systems adapt to the individual learning patterns and cognitive skills of students. Content and exams are customized in real-time, as the system autonomously determines where a student needs additional focus. Current systems let instructors know where more personalized attention is needed.

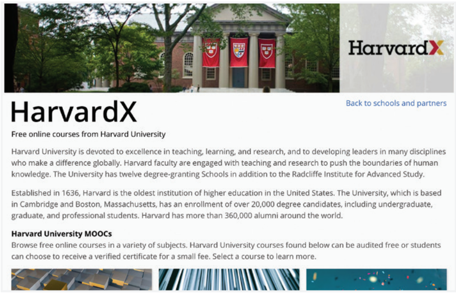
WHAT'S NEXT

K-12 schools alone have spent over $41 million on adaptive learning technology, or three times the amount that was spent in 2013. Despite this increase in funding, widespread adoption of adaptive learning in schools will still likely lag behind the corporate setting due to the relative lack of resources and infrastructure.

We expect to see adaptive learning technologies more deeply integrated into staff training and talent development in the coming year.

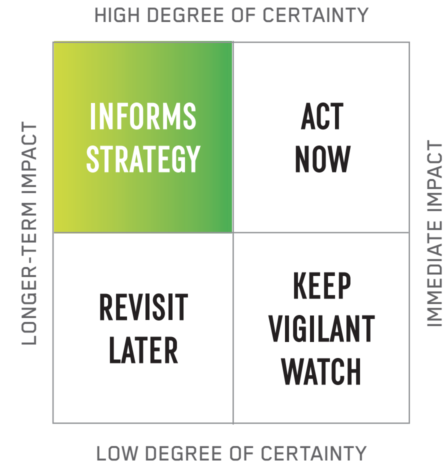
WATCHLIST

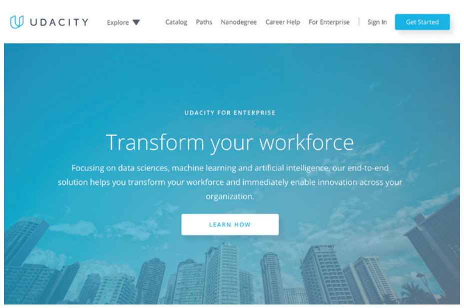
NovoEd; Everwise; HarvardX; Pearson; Dreambox; IBM; Microsoft; Knewton; Axonify; Qstream; Intrepid; Geekie.



Harvard is testing adaptive learning software.

Nanodegrees





Udacity offers nanodegrees and enrolls thousands of students worldwide.

KEY INSIGHT

The study of a specific topic area or industry normally done through an online institution, with the goal of increased knowledge in the area and some form of certification of completion.

EXAMPLES

Nanodegrees and shorter online degree programs are being pursued by individuals as an alternative to a traditional 2 or 4-year degree, more expensive and time-consuming masters programs, or simply as an approach to receive a certified understanding of a topic. They're now offered in many different disciplines across different online platforms including Coursera and Udacity. Many programs take approximately 3-18 months to complete. They tend to be more cost-effective, too: they're billed per-term or on a month-to-month basis.

WHAT'S NEXT

These new programs are more agile and could help solve future workforce gaps faster than traditional universities. **Udacity**, one of the most popular platforms to earn nanodegrees, currently partners with different companies (including AT&T and Mercedes-Benz) to offer nanodegree programs specific to the skills set of their workforces. For now, short degree and nanodegree programs are primarily offered in advanced technical areas like artificial intelligence and self-driving cars, but that could change to include other hard skills needed in the workforce of tomorrow.

WATCHLIST

Udacity; Google; Amazon; Coursea; Stanford; Harvard.

TREND 277

FIFTH YEAR ON THE LIST

Sharing Economy & Lendership

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

People are increasingly comfortable renting goods and services versus needing to own them. Across various industries service providers or communities have begun to pool resources for a fee.

EXAMPLES

Uber, **Rent The Runway** and **Airbnb** are just three of the thousands of sharing economy platforms used around the world. Sharing economy companies are now everywhere: transportation, real estate, retail, professional services, even biotechnology.

WHAT'S NEXT

This could be the year when the first sharing economy companies IPO – and they're not necessarily all destined to succeed. In countries like the **US**, where a large percentage of the population already has access to the internet and smartphones, the sharing economy market is already fairly mature and robust. Part of what will drive the sharing economy in 2019 will be the global emerging middle class, retirees and women. One factor that will either aid or hamper growth is regulation. Both Airbnb and Uber have been fighting with city councils around the world. In an effort to stave off regulation, we could start to see more collaboration between the platforms.

Further growth will come in the form of more unique B2B, B2C and C2C services. Companies will optimize resources by renting out unused equipment to each other and sharing workspaces. Likewise, we expect to see a new crop of companies that exist to provide shared services for upcoming niche industries (baby stroller rentals for traveling families). The success of these newer companies will depend on how consumers value their services—and importantly, whether local, state, or federal entities see the need for regulation.

WATCHLIST

The We Company; Crowd Companies Council; Softbank; Etsy; Luxe; Rent The Runway; Airbnb; Funding Circle; Sparkbox; FarmLink; Toys Trunk; Uber; Lyft; Postmates; Saucy; NeighborGoods; Vayable; ToolLocker; Trustify; Seateroo; Scribendi and many others.

The Rise of Chief Ethics Officers

In the aftermath of the #metoo movement, employee protests at big tech companies and revelations about inappropriate behavior between colleagues at large companies, we expect to see a new crop of CEOs – Chief Ethics Officers – taking root within organizations. These specialized CEOs will have a hybrid skills set including human resources management, risk management and law, diversity expertise and a deep understanding of technology. They will help ensure that a company's core values are consistently reflected within their workforce, but they will also make sure that a company's values represent society's moral principles.

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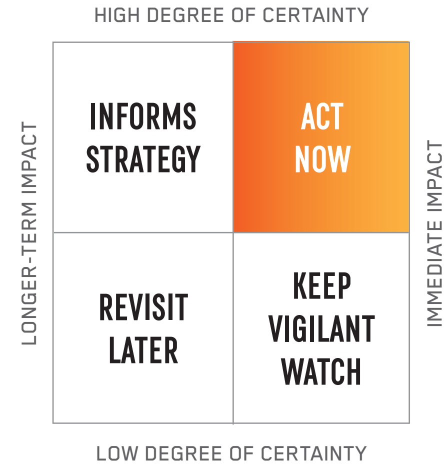
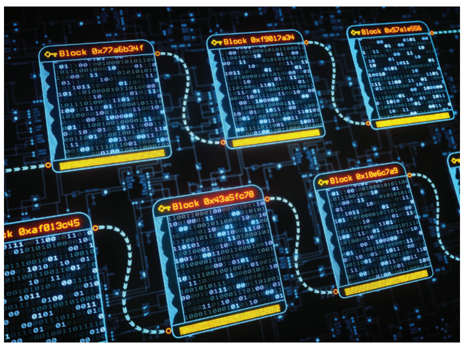
BLOCKCHAINS, TOKENS AND CRYPTOCURRENCIES

Blockchain Technologies





At its core, blockchain enables multiple parties to agree on a single source of truth without having to trust one another.

KEY INSIGHT

Blockchain technology hit an inflection point in 2017. It evolved beyond Bitcoin, from a fringe form of digital currency, and broke into mainstream, as a revolutionary way to share and store information. While this technology is still developing, its broad and far-reaching applications have the potential to impact a range of industries. For that reason, we have outlined key themes within blockchain and distributed ledger technologies.

BLOCKCHAIN: A PRIMER

What is Blockchain?

Blockchain technology is a method of sharing and storing information on a distributed ledger where identities and transactions are cryptographically protected. At its core, blockchain enables multiple parties to agree on a single source of truth without having to trust one another. It facilitates agreement and aligns incentives using consensus algorithms. In theory, blockchain reduces the need for intermediaries such as banks to coordinate or verify transactions. Blockchains are a type of distributed ledger technologies. Other types of distributed ledger technologies include a Directed Acylic Graph or a DAG. Unlike blockchains, DAGs do not use miners or blocks.

Where is the Blockchain, exactly?

There isn't just one blockchain. In fact, there are different types: private, public, and federated. Blockchains can be started by individuals, companies or consortiums, and they live on multiple machines simultaneously. There is no singular place where "the blockchain" is hosted.

How does it work?

Let's assume we have a network of 100 individual nodes running a blockchain ledger. Every node has access to see the full ledger because the ledger is *distributed*. No single node controls the network and all nodes have the option to become miners if they choose because the network is *decentralized*. Some nodes on the network choose to be miners which means they have the responsibility to verify pending transactions, which costs more in terms of energy usage and CPU. As a reward for their efforts, every miner that verifies a block of transactions wins a block reward, 12.5 bitcoins for example. With miners, the oversight of the network is crowdsourced. Transactions are verified by running consensus algorithms such as "proof-of-work" or "proof-of-stake"; miners compete against each other to verify transactions. Once a miner verifies a set of transactions or a "block", the node broadcasts the new block to the entire network. If the majority of the network agrees the block is valid, it is cryptographically added to the existing chain of blocks or "blockchain" which forms the ledger and miners are able to work on the next block. Since it is impossible to predict which miner will verify the next transaction, it is nearly impossible to collude against, attack, or defraud the network. The network is secure as long as miners act independently of one another. The primary way to attack this network is to control 51% of the miners. Imagine editing a Google Doc or a Wikipedia article, these are *distributed systems* where transactions are verified by a central authority, Google and Wikipedia respectively. Blockchain systems replace the central administrators with consensus algorithms and network miners.

Brief history

Blockchain was first introduced in 2008 when a person or group of people under the name Satoshi Nakamoto published the seminal paper, "Bitcoin: a Peer to Peer Electronic Cash System."

In 2015, Canadian computer programming Vitalik Buterin released Ethereum, a blockchain-based protocol that allowed for more sophisticated functionality in the form of smart contracts. Smart contracts are self-executing agreements where the terms of the agreement are directly written into lines of code. Ethereum was also the first blockchain project to fundraise through an "Initial Coin Offering" or ICO. Ethereum raised $19 M USD in 2014. In 2017, more than 400 ICOs raised $5.6 B USD.

While 2018 was described as mostly a bear market for blockchain, Citi, Goldman Sachs, JP Morgan, Morgan Stanley, IBM, Fidelity, Deutsche Bank, HSBC, Santander, Walmart, Facebook, Google, and Amazon all made significant investments in the industry. Bank of America, Mastercard, and IBM have 100 blockchain-related patents between them. In the past decade, distributed ledger technologies (DLTs) have evolved into countless permutations and applications across almost every industry imaginable.

Drawbacks

Blockchain is still nascent technology and there are a lot of challenges that need to be addressed before it can reach mass adoption. The primary challenges of blockchain relate to speed, scale, and regulation.

Decentralized systems are inherently less efficient than centralized systems and there are trade-offs between security and scale. Bitcoin and Ethereum process between 3 to 6 transactions per second whereas Visa can process thousands of transactions per second.

The regulatory environment for blockchains and ICOs is still unclear. In the US, the SEC, FinCen, the CFTC, and local state governments, all have specific and at times conflicting policies related to blockchains and cryptoassets.

Industries to watch

The primary use cases for blockchain technology evolved out of financial services but blockchains have grown into main industries. Pay close attention to blockchain use cases in financial services, supply chain management, healthcare, and identity management.

WATCHLIST

Citi; Goldman Sachs; JP Morgan; Morgan Stanley; IBM; Fidelity; Deutsche Bank; HSBC; Santander; Walmart; Facebook; Google; Amazon; Bank of America; Mastercard; Maersk; Ethereum; Hyperledger; Tencent; Stellar.

How To Speak Blockchain

51% attack
Hypothetical attack on a blockchain where a group of miners working collectively controls more that 50% of the network's mining power. These miners could collude to verify fraudulent transactions.

Altcoins
Any coin other than Bitcoin.

Bitcoin
Bitcoin is the first cryptocurrency and the first blockchain. It was introduced in 2008 by Satoshi Nakamoto. The currency is abbreviated as BTC on exchanges.

Block height
Number of blocks preceding a particular block. The first block on a blockchain is referred to as the genesis block and has a block height of zero.

Block rewards
Tokens distributed by the network to the miner that verifies a particular block. Block rewards are different from mining fees and tips which are distributed by individuals (as opposed to the network) to incentivize miners to verify their transactions first.

Blockchain
A new way to share and store information on a distributed system where transactions and identities are cryptographically secured. Blockchains are a subset of distributed ledger technologies (DLTs). Bitcoin, Ethereum and Litecoin are some of the more famous examples of blockchain networks.

Cold storage
Refers to storing a digital "wallet" or private keys offline, in a piece of hardware not connected to the internet.

Consensus Algorithms
Algorithms used on blockchain protocols to reach agreement among the miners, examples include proof of work, proof of stake, proof of authority, and byzantine fault tolerance.

Crypto-currency
A crypto-asset that designed to function as money, a medium of exchange. Crypto-currencies' value fluxuates depending on demand and supply, similar to traditional currency in the global economy.

DAO
Decentralized autonomous organization, not to be confused with "The DAO" which was a venture capital fund built on top of Ethereum. The DAO had a bug in the code that was exploited and caused Ethereum to fork. Many coins use DAOs as a form of governance and decision-making among the network. The Ethereum DAO is the most famous because it resulted in a contentious hard fork and a $50 M hack.

Dapp
Decentralized applications run on blockchain platforms.

Ethereum
Ethereum is the second largest coin by marketcap after Bitcoin. It was introduced in 2015 by Vitalik Buterin. The currency is abbreviated as ETH on exchanges.

Fiat
Government issued currency.

Fork
The splitting of a single blockchain, creating two alternative blockchains on different parts of the network. Forks can be accidental, temporary, intentional, permanent, planned or contentious. They can be the result of software upgrades or governance decisions that nodes refuse to acknowledge or forget to install.

Fork, hard fork
Software update on a blockchain protocol that is not backward compatible, creating a separate blockchain. Ethereum's hard-fork resulted in Ethereum and Ethereum Classic.

Fork, soft fork
Software update on a blockchain protocol that is backward compatible with order versions.

FUD
Fear, uncertainty, and doubt.

Full node
A node on the network that can act as a miner, verifying transactions on the blockchain network.

Governance
Set rules that govern the blockchain protocol; governance structures can include on-chain rules like smart contracts and code specifications and off-chain rules like a board of directors and annual meetings.

Hash pointer
Unique alphanumeric string links blocks in the chain together with a one way math function.

Hashing
One way math function that takes any input and produces an unique alphanumeric string, used in blockchain to condense information into blocks, useful for assigning any digital file or asset with a unique identifier.

HODL
Misspelling of the word "hold", term used by crypto investors to describe keeping coins despite market volatility and price crashes.

Hot storage
Refers to storing a digital "wallet" or private keys online, usually within an application or exchange connected to the internet, examples include Poloniex, Coinbase and Bittrex.

ICO
Short for Initial Coin Offering, relatively unregulated way of raising money.

Immutability
A primary characteristic of blockchains,a record of transactions that does not change and prevents "back-dating" in record keeping, sometimes referred to as "digital granite".

Light Node
A node on the network that can transact with other nodes but cannot verify transactions.

Mempool
Aggregate number and size of unconfirmed transactions on a blockchain.

Public Key + Private Key
Cryptography (similar to what's used in credit cards) for identities, alphanumeric addresses used to send and receive transactions.

SHA256
Cryptographic hash algorithm used in most blockchains.

Shilling
Aggressively promoting a coin or crypto-asset.

Smart Contracts
Self-enforcing agreements where the terms are built directly into code and issued on a blockchain.

Solidity
Programming language invented by Vitalik Buterin for smart contracts on Ethereum.

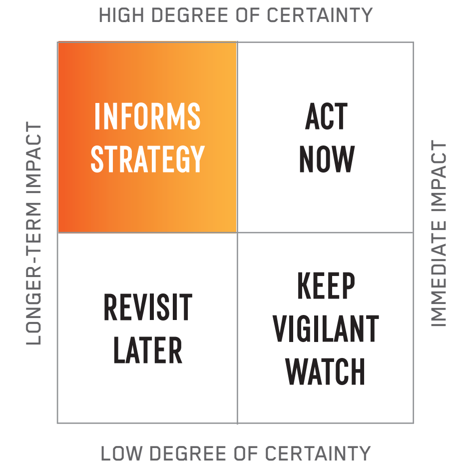
Token
Digital identity for something that can be owned.

TPS
Transactions per second, used to compare the speeds of different blockchains.

Wallet
File that contains a collection of private keys.

Whitepaper
Technical paper outlining the governance, protocol, and features of a project.

Digital Citizenship



"This strategy allows the Maduro regime to provide greater assistance to its own supporters, and to target others who are desperate enough to change their vote in order to receive food aid...It is becoming evident that the Maduro regime is weaponizing its safety net program during a time of crisis in order to prioritize, amplify, and concentrate political power."

– Moises Rendon, Associate Director at the Center for Strategic and International Studies, explaining how digital identity cards can be used for social control and political coercion[6]

KEY INSIGHT

Some governments are modernizing what it means to be a citizen, and the benefits and responsibilities that entails. **Estonia** was the first country to offer e-residency, allowing individuals to become a citizen of the country without actually living there. Now, countries like **China** and **Venezuela** are expanding the definition of digital citizenship with surveillance programs such as social credit scores and government issued IDs that track everything from voting records to state pensions.

EXAMPLES

Estonia, a small Northern European country of 1.3 million, was the first country to move most of its government services fully online fifteen years ago. From taxes to voting to healthcare, Estonia has created a myriad of digital tools to serve its citizens. Last year, in an effort to attract more entrepreneurs and tech talent, Estonia began piloting a beta digital citizenship program (along with financial benefits such as favorable tax breaks) without requiring physical residence in the country. While Estonia's digital citizenship is an example of positive government innovations, other countries have introduced more controversial initiatives.

In the two years that it has been in circulation, 15 million **Venezuelans** allegedly have a "*Carnet de la Patria*" or a **Fatherland Card**, which was built by **Chinese telecom giant ZTE**. Under the dictatorship of **Nicolás Maduro**, Venezuelans have to use this card to access government services, pensions, and food stamps. The card also tracks voting records and party registration.

Local governments in China made headlines last year by piloting different **social credit systems** that would rank, punish, or reward citizens based on certain behavior. This concept, first announced in 2014, was widely criticized as Orwellian social engineering if not outright creepy. All of these pilot programs are still in their early stages. According to the roadmap the Chinese government laid out, the plan is to have all citizens on a social credit system by 2020.

WHAT'S NEXT

In democratic countries with protections for individual freedoms and rights, digital citizenship can usher in a new age of innovation and improved public services. However, many authoritarian and totalitarian regimes are eager to adopt these technologies as well as to maintain control and concentrate power. As part of the **Belt and Road Initiative**, Chinese AI and surveillance companies with the support of the Chinese government are exporting their services to governments all over the world.

WATCHLIST

ZTE;Aadhaar;Sesame Credit; Alibaba; Cloudwalk; Hikvision; Yitu; SenseTime.

6. https://www.csis.org/analysis/maduro-diet-food-v-freedom-venezuela

CATASTROPHIC SCENARIO →→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→→

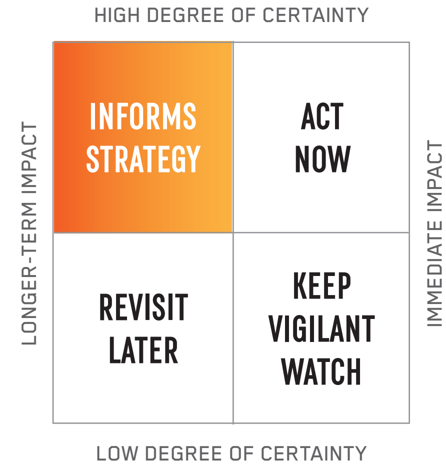
What happens if blockchain is used to track citizens in authoritarian regimes?

Given what we know about existing government blockchain programs, government issued-IDs, and the state of international politics, blockchain will likely be a technology that makes it easier to track citizens and abuse power. Canada, Estonia, and India have all launched massive digital identity programs for their citizens; some are voluntary opt-in programs, others are compulsory programs like the Aadhaar program in India. Once these blockchains are in place, because of the "immutability" characteristic of this technology, it will be hard to ensure that citizens maintain some GDPR-era digital rights such as the right to be forgotten.

China and Russia have large scale citizen surveillance programs that they are exporting to other countries. Venezuela launched a botched cryptocurrency called the Petro. While it has been ridiculed in the crypto-community, it may be a sign of things to come. What if more central banks start issuing digital currencies?

While the promises of blockchain and Web 3.0 were full of decentralization of power, in reality, influence and power in these networks concentrate within two parties: the developers who write the code for core protocols and the miners who validate transactions. The number of people who can contribute to open-source blockchain projects is tiny relative to the size of the networks. Corporations and governments with majority control of either the miners or the developers can potentially manipulate the system and rewrite the rules. Customers and citizens will have limited options and alternative blockchains to switch to.

– ELENA GIRALT



Cryptocurrencies

Decentralized cryptocurrencies are good in theory: a decentralized public ledger makes sure that no one can double-dip and spend their tokens twice. Except when there's a vulnerability. In January 2019, Ethereum Classic was hit with a $500,000 double spending attack when someone gained control of 51% of the machines in its network.

KEY INSIGHT

Cryptocurrencies are digital assets or stores of wealth that use a crowd-regulated public ledger system.

EXAMPLES

Bitcoin is the most well-known example, though there are more than 2,000 known cryptocurrencies in existence. Cryptocurrencies have ushered in the need for new generation of financial regulations, particularly with the advent of **ICOs** or **Initial Coin Offerings** and smart contracts. Cryptocurrencies are an entirely new asset class that may take years to fully mature. While the market is volatile now, the future use cases for "programmable money" are hard to ignore.

WHAT'S NEXT

While adoption continues to grow, 2018 was a bear market for cryptocurrencies, with many companies folding, cutting back expenses, or laying off employees. In order to understand how this trend is evolving, focus on the three main sources of change in the cryptocurrency landscape:

Exchanges - Most cryptocurrency activity takes place on currency exchanges such as **Coinbase**, **Gemini** or **Kraken**. These exchanges list the most credible cryptocurrencies and let users purchase crypto with traditional money otherwise known as fiat. Exchanges are pioneering relationships with regulators in every region of the world and they have also contributed to increased user adoption by making the crypto purchasing experience as easy as possible. Of the 2,000+ cryptocurrencies in circulation today, it is likely that 90% of them will fail. By deciding which currency to list, exchanges play a powerful role in shaping the landscape long term.

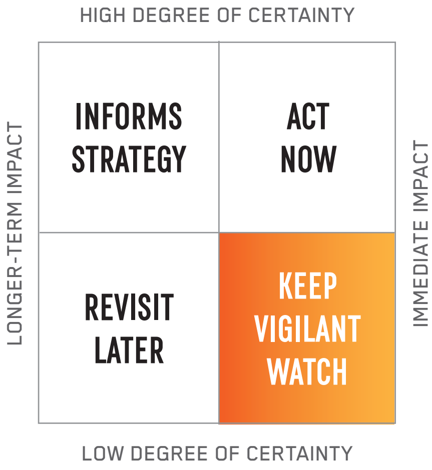
Mining - Almost all cryptocurrencies run on a consensus algorithm that requires many computers in a network to agree on the state of the shared ledger. This process of consensus, usually incentivized by a financial reward, is called mining. In the past five years, companies have sprung up that specifically cater to the crypto-mining industry. There are mining hardware manufacturers that sell miners - computers specifically designed to mine cryptos. Bitmain is the largest producer for ASIC chip machines. Mining pools are groups of miners that collectively pool their resources to increase their chances of earning the block reward. The mining rewards are shared throughout the group based on the rules of the pool. Mining pools have a lot of power in determining if a fork is successful or if a coin increases in value because miners are critical for processing transactions on a decentralized public blockchain.

Regulation - The regulatory environment for cryptocurrencies is still uncertain. In the US, the Securities and Exchange Commission recently charged celebrities **DJ Khaled** and **Floyd Mayweather** with crypto fraud. Thus far, the primary motives for regulation seem to be based on consumer protection, anti-money-laundering and combating the financing of terrorism. At the state level, crypto regulation varies widely. Among the friendliest states, Ohio lets you pay taxes in crypto.

WATCHLIST

Coinbase; Gemini; IBM; Ethereum; Bitmain; Canaan; ConsenSys; SEC; central banks; Robinhood; Slushpool; Antpool; Bitfury.

Self-Sovereign Identity



KEY INSIGHT

Identity management systems have seen a gradual evolution from government issued IDs to email providers and social media accounts. The average person has between 27 and 130 unique online accounts.[7] Companies like **Google**, **Yahoo**, and **Facebook** have built their business models on managing troves of data on behalf of their users; but users have suffered from large-scale security breaches like the **Yahoo** hack that impacted every single one of its 3 billion accounts.

Blockchains and distributed ledger technologies have introduced a new approach to identity management: self-sovereign identity. Self-sovereign identity is a system where the user is central to the administration of her data and owns her data outright. It is interoperable and transportable across applications, devices, and platforms.

Self-sovereign identity has two primary benefits: increased security and increased control. Increased security because decentralized identity solutions in theory are much harder to hack. Increased control because when an individual manages her identity, she owns her data and can therefore decide how to monetize it. For media companies, self-sovereign identity is a trend that touches on paywalls, authentication, creative IP and royalty tracking, as well as digital advertising.

EXAMPLES

Identity systems help individuals validate reputation, manage risk and gain access to groups. Many systems rely on third-party "identity providers" like governments, Facebook, or Google. Digital identity management has been a central point of vulnerability for individuals and corporations alike with hackers using phishing emails and personally identifiable information (PII) to reset passwords and break into accounts. Blockchain-based identity solutions could provide documentation for the world's 25 million refugees.[8]

WHAT'S NEXT

Self-sovereign identity will likely be adopted in phases. **IBM** and Microsoft are piloting projects and startups like **UPort** and **Sovrin** are making headlines. Since interoperability is a defining feature of decentralized identities, media companies should look for partners instead of attempting to launch an identity product on their own.

WATCHLIST

Po.et; IBM; Microsoft; UPort; Currency; Ubisoft; Custos Media Technologies; Vaultitude; Spotify; Comcast; MediaOcean; MetaX; AdEx; Kind Ads; Brave browser; Netflix; Google; Facebook.

Self-sovereign identity is a system where the user is central to the administration of her data and owns her data outright.

7. Source: InfoToday, 8. United Nations Refugee Agency 2019 statistics.

Web 3.0

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	**KEEP VIGILANT WATCH**

LOW DEGREE OF CERTAINTY

KEY INSIGHT

2019 marks the 30th anniversary of the world wide web. The next iteration of the web is being accelerated by decentralization and collaboration.

EXAMPLES

The internet is always evolving. Up until today, it has seen three major waves of innovation. Web 1.0, the beginning of the internet age, introduced static web pages, e-commerce and email. The web 2.0 enabled decentralized collaboration and creativity by ushering in social networks, sharing economies, cloud computing and dynamic self-sustaining content repositories like **Wikipedia** and **Github**. Some collaborations have pushed our imagination beyond what we thought was possible, like Reddit's April Fools Day 2017 experiment or Google's six-month Quick Draw Doodling game.

Just as cloud computing revolutionized how businesses manage and store information; then so blockchain will enable in a new wave of innovation for information technology and databases. Distributed ledgers can encourage massive collaboration on a larger scale and usher in web 3.0.

With web 3.0 – the Semantic Web – collaboration and decentralized creation is accelerated for two reasons. First, gathering, mining, and understanding unstructured data will be much easier with advanced techniques such as data mining, natural language processing (NLP), and text analytics. Second, machines can collaborate directly with one another through artificial intelligence and machine learning. Eventually, machines will be able to teach one another.

There are already projects like this underway. In media, **Otoy** is lowering 3D/visual effects production costs by creating a decentralized, distributed network of partners that can chip in spare processing power with RNDR tokens. The **Interplanetary File System (IPFS)** is a peer-to-peer hypermedia protocol that facilitates decentralized file sharing and cloud computing.

All this is possible because of what **Joel Monegro** from **Union Square Ventures** described as the "fat protocol layer." Web protocol layer is part of the full internet stack. "Full stack" refers to every stage of the computer programming/ web developers tool kit: front end (UX, design, HTML, Java, CSS) to back end (servers, databases, APIs, Python, Ruby). The internet stack has application layers and protocol layers.

In web 2.0, most of the value captured was in the application layer with little variability in the protocol layer. Examples of the most common protocols are HTTP used by browsers and SMTP and IMAP is used by email-clients.

WHAT'S NEXT

In web 3.0, protocols and platforms may have much more potential for value creation, hence a larger protocol layer. Companies like **Blockstack, Lightning Labs**, and **RSK** are building layer 2 networking products. With web 3.0, web browsers and mobile applications can perform more complex processes and enable transactions that were previously not possible. On web 3.0, media companies might be able to set up micropayment systems or enable users to have more control over their privacy and data. .

WATCHLIST

Blockstack, Lightning Labs, RSK.

SCENARIO

The near-futures of Gigware

Imagine getting into bed tonight and plugging your phone into its charger on your nightstand like always. You set the alarm, and just before closing your eyes to sleep, you start up a special app—one which invites hackers to take over your phone. It isn't a dream—but it isn't a nightmare either. It's the future of the gig economy.

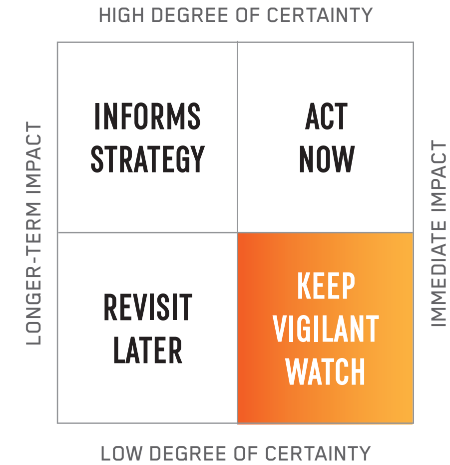
In the coming years, you're going to hear a lot about our new decentralized sharing economy. It's a clever way of distributing computing power over a wide network for a variety of tasks, which range from performing mathematical computations to mining for cryptocurrencies. All you need to get started is to install what we call "gigware." It's a benevolent use for the same kind of malware a hacker relies on to break into your computers and phones, except that it generates a tangible benefit, whether you're a company or individual user. Think of it as the next evolution of the sharing economy powered by artificial intelligence.

At the moment, there are nearly four billion internet users spread around the world, and each of us owns three devices on average. That means there's a gigantic pool of processing power sitting dormant at any given time.

Gigware is like Airbnb for your computers and phones. It will someday allow third-party businesses to use your smartphones and computers in exchange for credits or real money you can spend elsewhere. Because the systems are distributed and decentralized, private data is safeguarded.

– AMY WEBB

Tokenomics



In 2018, blockchain media startup Civil launched a token sale.

KEY INSIGHT

Blockchain allows businesses to create tokens. A token is a unit of value that a business creates to self-govern its operations, incentivize its users, and distribute benefits to all stakeholders. Tokenomics refers to the different business models made possible by blockchain and DLT networks where a token can represent usage, utility, value or a combination of the three. Tokenomics can revolutionize how media companies approach monetization and distribution.

EXAMPLES

In 2018, blockchain media startup **Civil** made a big – and ultimately too ambitious – bet on tokenomics to create a self-sustaining business model for journalism and local media outlets. The system to buy tokens was far too convoluted and the promise to customers wasn't made clear. But that doesn't mean tokens aren't going to stick around for a while.

Historically, media companies and news organizations have relied on a mix of ad-based and subscription-based revenue models. Newspapers are a clear example of how rapidly these revenue models can be disrupted by digital entrants. Blockchain can facilitate micropayments with virtually zero transaction costs or a rewards program that allows users to lower their monthly subscription by consuming more media.

Distribution channels are typically "winner-take-all" models where a handful of players dominate the market. **Comcast, AT&T, YouTube, Vimeo, Soundcloud**, and **Spotify** are just a few examples. While it's difficult to imagine these companies ever going away, if the talent and the audience move en masse to other platforms with better features (pricing models, revenue share, IP protection), then those companies may lose their position as market leaders.

SingularDTV is a blockchain media company building out a variety of token models for artists, producers, and audiences. They have helped artists finance projects and they have launched peer-to-peer music festivals where audiences have a say in the line up. SingularDTV's soon-to-launch distribution platform is called **Ethervision**.

Simple Coin has partnered with **Unsplash**, a photography website, to create a new business model and distribution network for photographers. Unsplash already has integrations with **Google Slides** and **Invision**. Realistically, the existing distribution models will be difficult to displace and disrupt. **Steemit** is one of the oldest media-based blockchain tokenomics projects. Launched in 2016, Steemit is a social networking site that pays content creators and curators with over one million registered accounts.

WHAT'S NEXT

Tokenomics as a concept was first introduced in late 2017. Currently, these models are mostly theoretical and it will be a few years before we see how consumers behave with these models in practice.

WATCHLIST

Civil; ConsenSys; SingularDTV; Steem.io.

Tokens For Smart Royalties and Freelancers

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

KEY INSIGHT

Platforms like **Ethereum** enable micropayments for accessing intellectual property including content like news or music. The platforms enable this through smart contracts, which are basic contracts that are automatically executed. For example, every time a song is played, it sends a small amount of money from the listener to the artist.

Platforms will be created around giving the content creator the most ownership and rewards for the content produced. Content creators will drive adoption because they get the majority of revenues instead of giving the majority of the revenues to the distribution platforms. At the same time the creators will also retain more ownership control and direct interaction with the audience.

EXAMPLES

Ethereum and other decentralized application platforms are building infrastructure for content creators to receive micro transactions for access to their intellectual property. This is laying the foundation for new, low-friction ways to automate royalty payments for digital intellectual property.

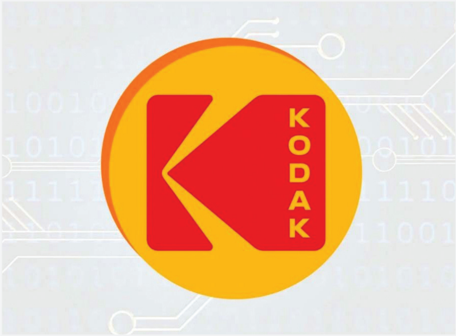
Ryan Leslie's platform SuperPhone is an example of a content creator choosing to develop their own distribution model to cut out intermediaries. The platform SuperPhone is being developed into a platform for other artists to do the same.

KODAKOne and **Binded** are examples of platforms designed to help photographers manage the digital rights of images using blockchain technology. They primarily work by recording ownership and creation of the images on a blockchain ledger and then using a web crawling service to scan websites to see if a copyrighted image is being used.

Smart contracts, digital intellectual property rights and micro payments advancements are creating an opportunity for news and media to revisit an economic model that was once adopted by the news services on **CompuServe** in the 1980s. This was a news structure where readers paid per view of articles, including paying extra for images. At the time this was possible because CompuServe offered higher quality journalism in a way that was easier to find, search and read. Ultimately this service failed due to increasing availability of free, high quality journalism and the advent of free search services such as **Google** and **AOL**.

WHAT'S NEXT

Artists with music will be first to publish content on a smart contract enabled platform where content creators must give less money to intermediaries. This type of content will be more successful as there is greater consumer demand and significant



KODAKCoin is designed to help photographers be compensated and retain ownership of their digital property.

Tokens For Smart Royalties and Freelancers cont.

Ethereum is an open-source platform underpinning hundreds of decentralized cryptocurrencies.

revenue for the artists to capture in disintermediating the record and distribution companies.

News platforms will be fast followers but will struggle to incentivize end users to migrate to new platforms as specific journalists have less market power and smaller follower base.

Ownership of digital assets are evolving with a movement for content creators to keep ownership rights of their content. GDPR rules in Europe where people have greater ownership rights over the data they create, no matter what platform it is created on is an example. As such we expect that there will be increased demand for platforms that allow the content creator to retain ownership and be compensated for the engagement they drive. This is likely to affect the photography industry as historically photographers retained copyright ownership of their film photographs. But recent platforms have required photographers to sign over rights to the image purchaser.

The change in ownership rights would be the equivalent of Instagram paying popular content creators directly to retain them on their platform—it's a departure from the current model, where network effects mean that Instagram does not need to pay content creators. Instead, content creators are paid by brands who seek to get access to the creators' followers.

WATCHLIST

Civil; Ethereum; Cardano; EOS; NEO; IOTA; Monero; SuperPhone; Kodak Coin; Binded; Getty; Reuters.

NEAR-FUTURES SCENARIO

Protecting Intellectual Property

In the next 10 years content creators will demand more control over their intellectual property and will begin to use platforms that provide increased intellectual property protection. As encryption, cryptography and digital identity technology evolve and become more mainstream, digital content will be managed and controlled in such a way that analog/physical ownership structures will be able to be applied to digital content. Examples include limiting the number of copies an image can be made and watermarking individual copies of photographs.

Optimistic Framing

Digital assets of all kinds adopt intellectual property protection rules and systems. This enables content creators to capture more of the value that they create downstream, leading to a change in the distribution of rewards in the value chain. This reduces the dominance of the delivery channel from information delivery. Consequently, ownership and copyright structures become much clearer and misappropriation of content becomes very rare. Additionally, as creators are more fairly compensated, they create more content that is both paid and unpaid.

Pragmatic Framing

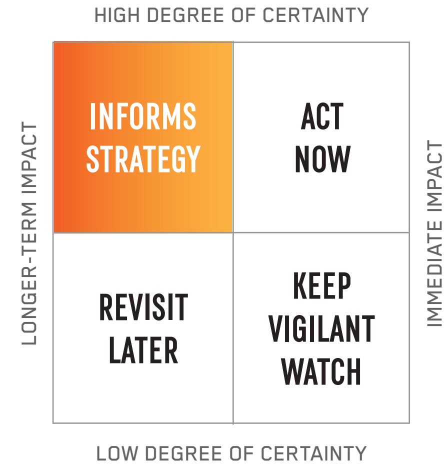
Creators migrate to platforms that provide greater intellectual property. First movers will be musical artists that already have established themselves in their industry. It will not be the standard way of operating for end consumers, but end consumers will be willing to use multiple platforms to get to the content they value or because of a strong personal connection with the content creator.

Catastrophic Framing

We have a patent troll problem—they're chasing IP and burdens for distribution channels. Patent trolls make the economics of creating content even more compressed—that winds up reducing creativity and shrinking the pool of people and brands creating new content. Only those who can afford the potential costs of defending their IP are willing to create new works.

– AMY WEBB

Immutable Content



Information can be permanent and accessible to all with blockchain technology.

KEY INSIGHT

Those political truth-o-meters that have become popular around the world in the past few years may soon be a thing of the past. That's because blockchain technology allows for the creation of a distributed immutable record of information – which means that the information can never be deleted or modified. Taken out of context, sure. But not twisted or changed into something different.

EXAMPLES

Decentralized platforms for content will give more control to the people who originally created it, whether it was a social media post or a pubic speech. Think of this trend as a new way to build trust around critical information.

This would enable information to be recorded and distributed in a way that is visible to all and cannot be changed without changing all records across most users. A distribution channel leveraging blockchain technology could make it more difficult to censor and limit access to information. Content creators could use distribution channels that can guarantee that their content does not get altered, filtered or blocked by a third party.

WHAT'S NEXT

We will soon have the ability to leverage blockchain-based platforms to guarantee that our content does not get modified or censored en route to its end consumers. Information archive companies or distribution companies—something akin to a **WikiLeaks**—will be able to distribute information using a distributed system by inserting the information within a blockchain ledger similar to Bitcoin's. Recording information in a blockchain would also ensure that it does not become inaccessible if the host servers are disconnected.

WATCHLIST

TRON; Civil; Decent; Ethereum; reddit; Twitter; WordPress; Wix.com; Quora; WikiLeaks; Internet Archive; Agora.

SCENARIO →→→

What happens when everything we say, write and record never, ever, gets altered or goes away?

In the next 15 years, specific types of information will begin to be transferred into databases that use blockchain technology to ensure their immutability. The first data sets to be converted will be ones where there is significant distrust among the members and where a governing body's impartiality is questionable. Financial services will continue to be a driver of development, but interest in polling and election/governance systems will increase.

Optimistic Framing

Storage and transmission capabilities expand to support information systems that are never deleted and can handle each person having a copy of all information. The world adopts an ethos that all news and information is permanent and transparent. News and elections are based on immutable and transparent record systems such as blockchain. This reduces confusion and conflict around governance transitions. It causes increased efforts on bridging the digital to analog divide, thus bringing more and more people into the digital environment, which will improve access and reduce social inequality.

Pragmatic Framing

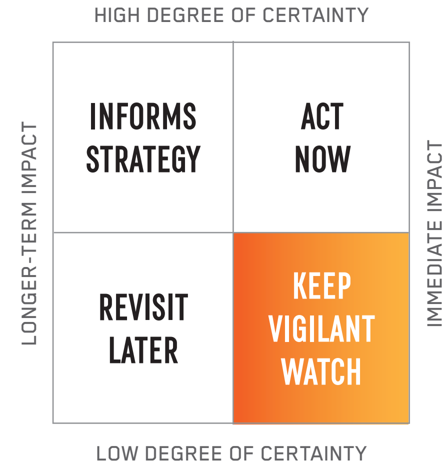
Specific actors and types of information will be valuable enough to merit the additional effort required to be put into a blockchain. Some will champion the technology, but the technology fails to create a change in how people think about information and access. Rather than creating a social revolution, we instead debate the politics of immutable records.

Catastrophic Framing

Governments restrict information under the assumption that the public is deemed unable to act in the interest of the greater good. Consequently, information becomes increasingly confidential and distributed ledgers become outlawed from data ownership perspectives. Splinternets become increasingly common and trust is centralized in organizations with limited oversight. News and information is limited by editorial control from larger entities that are primarily driven by self-interest.

– KRIFFY PEREZ

Distributed Computing For a Cause



The Golem.network is a distributed computing system that pools resources across many devices for shared projects and tasks.

KEY INSIGHT

Think of this as an Airbnb for your devices. Distributed computing is a process where large computer problems are broken down into smaller segments that can be calculated on multiple regular computers, instead of on centralized super computers. Distributed computing technology enables idle processor time on personal laptops, cell phones and other digital devices to become a valuable resource. Idle processor time then becomes a valuable resource that can be used to not only solve socially important problems but the financial incentives for using your idle processing time can be used to fund important causes.

EXAMPLES

Folding@home is a distributed computing project for disease research that was launched on October 1st, 2000. The project used idle processing resources on personal computers, PlayStation 3s, and some Sony smartphones too for scientific research. People donated their idle computer processing time to the project.

Now there are a number of distributed computing startups hoping to take advantage of our smartphones and smart devices in the IoT era. **Golem.network** is a platform that proves that idle computer resources are a valuable asset that can be monetized. Golem is built upon the **Ethereum** blockchain where one can rent out idle computing resources like storage, processing power, or bandwidth. The platform is currently designed to focus on rendering computer-generated images, DNA analysis, and machine learning. There are three roles in the ecosystem: providers of resources, users of resources, and software developers. **GridCoin** is another blockchain-based distributed computing platform providing resources to philanthropic scientific research. **Honeycomb** is a cryptocurrency-based project which crowdsources unused phone power to support quality journalism. The platform has not yet been launched, but the intent is to use the idle processor in your phone to perform distributed computing calculations overnight to earn the cryptocurrency **Monero**. Monero will then be used to fund quality news organizations that the users select.

WHAT'S NEXT

There will be an increasing number of platforms that allow consumers to monetize their idle computer resources. This will enable people to earn new income from resources that they already own and are underutilized. For developers and people in need of computing resources, this will help drive down prices for computing resources and increase the diversity of options available.

WATCHLIST

Honeycomb; Monero; Golem.network; SONM; GridCoin; Microsoft; Intel; Apple; Android; Amazon Web Services; every single wireless carrier.

SCENARIO →→→

Mid-Futures Scenarios For Distributed Computing

Distributed computing technology advances to the point of being just as efficient and fast as centralized computing—but is also able to leverage idle computing resources in all kinds internet connected devices.

Optimistic Framing

All computing resources can be shared and are automatically load-balanced across resources. This significantly increases the global computing resources available, improving access and reducing costs for all. Excess capacity is used to solve social problems, while access to information and technology start to become a universal human right that is distributed across the entire digital ecosystem.

– KRIFFY PEREZ

Pragmatic Framing

Distributed computing technology continues to advance but is only for specific use cases and for specific kinds of computing tasks, instead of all general computing tasks. Load and resource balancing continues to be too complex to execute effectively at scale while being reliable. Customers that do not require stringent privacy or ownership rights—or who don't care about bandwidth—are offered lower fees in exchange. The general public doesn't see the point.

Catastrophic Framing

New computer viruses highjack our devices, which are put to work mining for cryptocurrencies without our knowledge. Our devices leech electricity and computing resources, causing us all headaches. We'll see repeats of what happened in May 2018, when a Russian government page was hacked and sent visitors to a website that secretly installed cryptocurrency mining software on their computer. The frequency and pervasiveness of hijacking computing resources becomes so great that the general internet infrastructure becomes degraded and slows down as the majority of resources are used for mining cryptocurrencies.

Decentralized Curation

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	ACT NOW
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Digital influencers will wield far more influence over consumers than big, recognizable brands themselves—and this could soon turn traditional marketing and advertising on its head in the coming years.

Cryptocurrencies and application platforms can prove a model for decentralized curation.

KEY INSIGHT

Cryptocurrencies and DLTs are shifting how content gets curated – from individual editors, to smart algorithms, to vast user bases who vote for content in return for payments. This impacts lots of industries, from fashion to retail, tourism to auto manufacturers, and even those working on 2019 and 2020 political campaigns.

EXAMPLES

Trust can be constructed using new processes that are less reliant on central entities. Cryptocurrency self-governance technology additionally reduces the need for intermediaries and changes trust dynamics impacting the role of distributors of information and entities that edit and control information. This is because the platforms are exploring ways to govern themselves, without having a central authority or leader of the collective group. As a result, self-governance and incentive structures from blockchain/smart contract-based platforms create a proving ground for alternate forms of editorial curation of information that is more resilient to the interests of specific stakeholders.

Steemit is a blogging community like Reddit where users are rewarded for creating, curating and interacting with content. Steemit uses a cryptocurrency-based points system to facilitate curation and engagement in content on the platform. Points are earned for creating content, upvoting and commenting on other posts. Users build reputations allowing them to have more impact on curating the content. Reputations can be built organically or bought. Points are issued in cryptocurrency, which can then be converted into dollars or other currencies.

WHAT'S NEXT

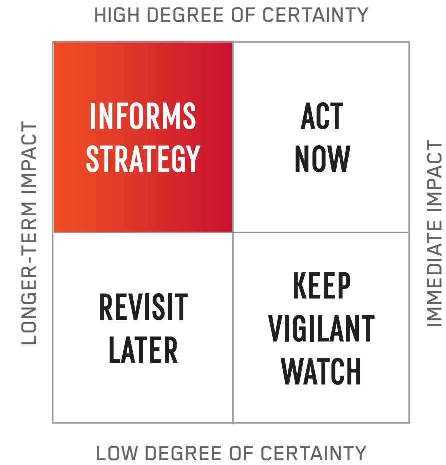
You will begin to see users demand that platforms place greater importance in trust and establishment of credibility. As such it is likely to start with content creators that are most accustomed to forum or blog structures like Reddit where the content is crowd sourced and historical posts on the same topic are relevant. Crowdsourced "truths" will evolve past majority to rule into qualified majority rule structures. Cryptographic digital identities will increase in importance as trust becomes dependent on the historical merits of individual usernames/credentials. Which means that digital influencers could wield far more influence over consumers than big, recognizable brands themselves – and this could turn marketing and advertising on its head in the coming years.

WATCHLIST

Steemit; Decent; Ethereum; Reddit; Twitter; YouTube;, Facebook; WordPress;Wix.com; Blogger; Tumblr; Quora; and digital identity providers such as Oberthur Technologies, NetIQ, Socure, Early Warning.

17

FINANCIAL TECHNOLOGIES



Financial Inclusion and Serving the Underbanked

We must ... ensure that the pace and the push of fintech work to the advantage of the people, not to their disadvantage. That technology in finance ensures improvement of the human condition through direct contact with the most marginalized.

– India Prime Minister Narendra Modi, speaking at the Singapore FinTech Festival in November 2018

In 2014 an estimated 2 billion adults did not have a bank account.

KEY INSIGHT

Financial players are targeting the segments of the population that are unbanked or underbanked (people with limited access to financial products). Traditional financial institutions are facing competition from fintech companies and social platforms who are integrating payments and other financial features to their product ecosystem. Financial inclusion is more than a positive social impact story, it's a forward-looking customer acquisition strategy.

EXAMPLES

It's not just financial services vying to unlock the underbanked. Mega-retailers like **Walmart** and **Alibaba** offer financial products to customers. LATAM and **India** are the markets to watch for innovations in financial inclusion.

The Royal Bank of India licenses telcos has payment banks and has instituted UPI, universal payments interface, and the result has been dramatic innovations in digital payments. **Amazon, Samsung, Facebook**, and **Google** all have UPI-compatible products. **Paytm**, an Indian mobile e-commerce company, was recently valued at $10-$12 B USD by Berkshire Hathaway. **The Center for Financial Inclusion** ranks **Colombia, Peru**, and **Uruguay** as the top three countries for financial inclusion (India is ranked at number four). Latin America has a surge of fintech companies working on the region's most pressing problems, particularly inflation and remittances.

WHAT'S NEXT

The role of a traditional financial institution is changing. In established markets, gig economy job trends, uncertain geopolitical conditions, and rising costs of living have customers saving less and in some cases sidestepping banks entirely. In emerging markets, internet and cell phone penetration as well as other innovations in technology are unlocking enormous opportunities in mobile payments and remittances.

Financial inclusion is not just about getting users an app. The most successful companies have been able to build products that also bridge a knowledge gap and inform and empower users to be more financially literate. Lack of financial education will continue to be a barrier to people, excluding them from financial services and systems.

Digital and mobile payments continue to grow with promising pilot programs using cryptocurrencies for remittances and humanitarian aid.

WATCHLIST

Center for Financial Inclusion, Ripio, Afluenta; Carrefour; Walmart; Falabella; World Bank; IMF; FICO; Citi; Wells Fargo; USAA; KeyBank; TDBank; JPMorgan Chase; Capital One; Mastercard; Visa; American Express; mPesa; GoBank.

Open Banking

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Late in 2018, Robinhood, an online stock-trading platform, began offering checking and savings accounts with an interest that is about 30x higher than the national average. It has no fees or account minimums.

KEY INSIGHT

Financial data is becoming standardized and interoperable, facilitating access to banking infrastructure and analytics for third parties.

EXAMPLES

Mint.com and other financial aggregators use API access to financial data or screen scraping to build their own databases of their customers' financial transactions. Using this information, fintech providers can give consumers a holistic view of their finances across multiple banks and types of assets. The rich financial data generated is often used for marketing purposes by suggesting that their products may meet the needs of the consumer more than their existing products.

The European regulation known as Payment Service Directive Two (PSD2) went into effect in 2018 and requires banks to enable third parties to access a customer's financial data. PSD2 lays the foundation for new players to use financial transaction data to improve analytics behind product development, predictive analytics, fraud analysis, marketing and a la carte services being offered by an ecosystem of providers.

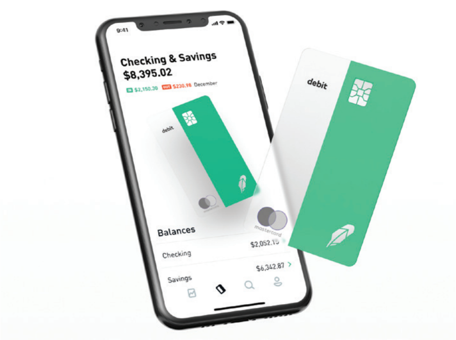
WHAT'S NEXT

Regulation will change the ownership structures of financial data. We expect to see more banks publishing open banking APIs in 2019. Interoperability will make it easier for customers to aggregate finances and choose *a la carte* services from various providers that best suit their needs. There will be increased activity of fintech's and partnerships among incumbent players as incumbents seek to stay current and drive customer preference through services offered. We expect disruptive fintech innovators to build functionality that attracts a critical mass of consumers, which will then trigger large incumbents to seek partnerships. Incumbents that are slowest to enable data access to third parties will see attrition from their customer base as consumers move to providers that give them access to the new ecosystems.

The most successful players will be those who can get access to the richest data and are most effective at productizing data driven insights, likely through personalized marketing and operating efficiencies, such as reducing fraud and chargeback rates.

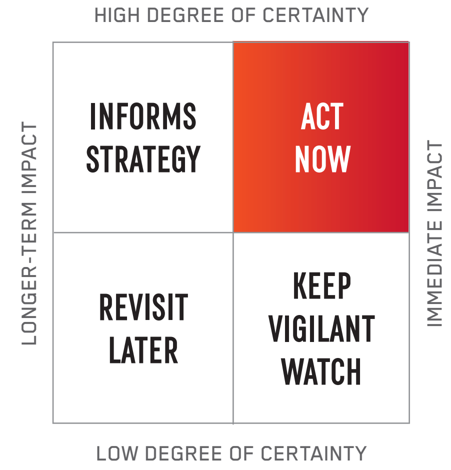
WATCHLIST

Mastercard; Visa; American Express; CITI; BBVA; Banco Santander; HSBC; Wells Fargo; Lloyds; Intuit; Square; iZettle; N26; Fidor; Klarna; Monzo; Plum; Bean; Exeq; Clear.



Robinhood started offering checking and savings accounts with no fees or account minimums in 2018.

Social Payments



WeChat Pay is quickly becoming a preferred method of payment in China.

KEY INSIGHT

Financial service and payment providers are tapping into social interactions as a driver of preference for financial services. As social payment offerings grow more robust, millennials may opt out of traditional banking services entirely.

EXAMPLES

Late in 2018, **Amazon** was working to shift **Amazon Pay** from the digital-only space into physical, brick-and-mortar gas stations and restaurants. The move coincided with a rollout of new cashless (and *cashierless*) **Amazon Go Stores**. While Amazon's system is new, the digital wallet model isn't—and consumers are finding convenience preferable to traditional point of service transactions.

Venmo launched nine years ago as one of the first social payment apps in the US. Users could add emoji in the comments of their transactions and share publicly who they were transacting with. China-based **AliPay** launched 14 years ago and now has amassed more than 700 million active users. Through its financial partner, **Ant Financial**, users get much more than emojis, they have access to wealth management services, loans, and credit scores.

WHAT'S NEXT

The most advanced players seek to embed the functionality as seamlessly as possible into existing customer experiences, including chat applications. WeChat and **Alipay** are significant players in the **Chinese** mobile payments space due to their highly developed network of merchants that accept chat-based payments, blurring the lines between sending money to a friend vs. sending money to a store.

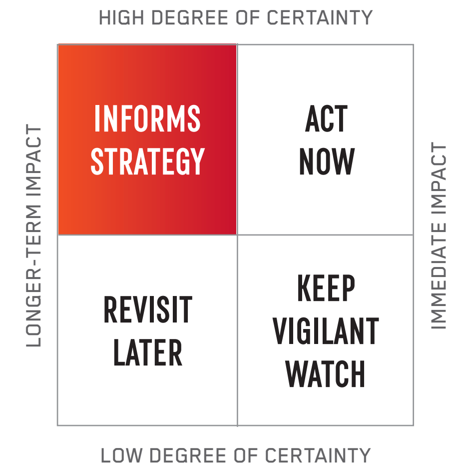
Facebook launched a **blockchain** research group in May 2018. The company has filed more than a dozen patents related to digital currency since 2007 but has yet to release a digital currency product. Facebook's payments products include **Messenger Payments** and **WhatsApp Payments**. Facebook is desperate to find alternative revenue streams beyond advertising and social payments may be a viable option. However, government regulation for all major tech companies has become more stringent in the wake of data breaches, privacy concerns, frauds, and scams. In **India**, Facebook's WhatsApp Payments has had trouble getting approval from the country's regulators to move past its testing phase of 1 million users and expand the service to its 200 million users in the region.

Focusing on customer experience is key. This should lead to a period of expansion, where multiple fragmented platforms and services will be accepted for specific use cases. Partnerships will eventually begin to coalesce, driven by primary relationship holders, price and strength of the network ... for example, Android Pay and Google Wallet merging into Google Pay. It is additionally worth noting that as social payment networks increase in popularity and scale, they will become more vulnerable to hackers and fraud.

WATCHLIST

Apple; Google; Amazon; Microsoft; Facebook; PayPal; WeChat; Alibaba; Mastercard; Visa; Ingenico; Citibank; BBVA; Zelle; Exeq.

More Financial Tech Trends



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Automated Credit Risk Modeling

Artificial intelligence is being leveraged to automate credit risk modeling within big banks. Startup Spin Analytics readies data first and then runs models as needed. It's one example of AI-powered automated credit risk modeling services being tested at banks like **BBVA** and **Crédit Agricole**. It's also being studied by central banks.

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Crypto Trading Bots

Investing in cryptocurrencies isn't for the weak-stomached. With significant volatility and complicated technical workflows, it can be difficult to trade cryptos. Trading bots are being deployed to monitor the markets 24/7, since unlike the stock market they never close. Send instructions to the bot and it will perform until you instruct otherwise. But as we've seen in other places, bots can be glitchy.

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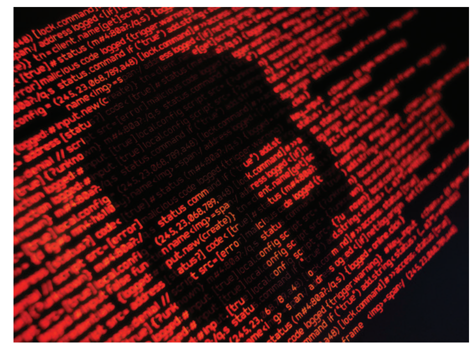
Crypto-Mining Malware

In 2018 there was a 4,000% increase in instances of crypto-mining malware, according to research from **McAfee Labs**. Hackers most often gained access to computers by hiding cryptocurrency mining software in what appeared to be legitimate, mundane software updates from places like **Microsoft** and **Adobe**. Once a machine got infected, it used its computing resources to mine for currency on behalf of the hacker. We'll likely continue to see crypto-mining malware spread in 2019.



In 2019, crypto-mining malware will shift focus away from ransomware.

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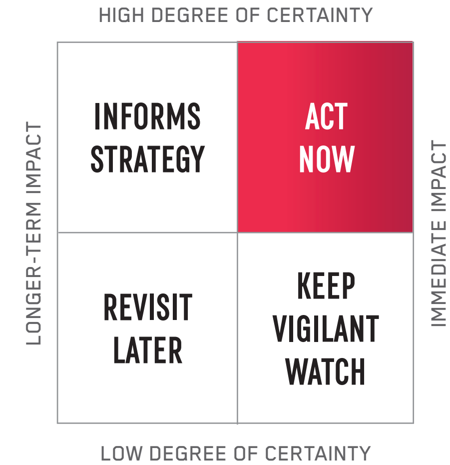
SMART CITIES

Ranking the World's Smartest Cities



This is the second year we've researched and generated a smart cities list, and our goal is to showcase examples of exemplary, innovative leadership around the world.

What makes a city "smart?"

In 2016, 78 cities applied for the US Department of Transportation's "Smart City" challenge, which would award the winner $40 million in federal grant money to upgrade their urban transit systems. DoT selected Columbus, Ohio, as the winner for its proposal to deploy self-driving electric shuttles, launch smart cards to provide free car-sharing services, and develop a connected traffic light system to reduce traffic jams throughout the city. The City of Melbourne (Australia) has launched a Smart City Office, which includes open data projects, a 24-hour pedestrian counting system and city-wide free public WiFi.

Public-private partnerships, affordable technology, long-term urban and budget planning, and equal access to all citizens are just a few things that make cities smart. Here's a more complete list of the criteria we used to rate the world's smartest cities:

- Abundant 4G (and soon 5G) connectivity
- The availability of public wifi hotspots
- The use of smart grids for traffic and electricity
- City-sponsored incentives for smart buildings
- Accessible, digitized government data that is open to all
- The availability of anonymized citizen data that is digitized, structured and accessible
- Dedicated high-ranking positions in government dedicated to technology and science
- The number and influence of community leaders who are experts in tech
- The number of cybersecurity offices, departments and staff dedicated to proactive monitoring and continuous learning
- Tech-forward public transit systems that are optimized for all citizens
- The availability of ride sharing services (including various forms of transportation)
- The number of public-private tech and science partnerships that benefit all income levels
- Dedicated environmental protections for the present and future of the city
- City initiatives to reduce waste
- The availability of affordable clean energy options
- Dedication to long-term urban planning

Smart Cities 2019 Ranking

01. Copenhagen, Denmark
02. Gothenburg, Sweden
03. Oslo, Norway
04. Bergen, Norway
05. Odense, Denmark
06. Stockholm, Sweden
07. Turku, Finland
08. Aalborg, Denmark
09. Jyväskylä, Finland
10. Strasbourg, France
11. Melbourne, Australia
12. Singapore
13. Vantaa, Finland
14. Amsterdam, Netherlands
15. Zurich, Switzerland
16. Utrecht, Netherlands
17. Berlin, Germany
18. Dubai, UAE
19. Seoul, South Korea
20. San Francisco, USA
21. Wuxi, China
22. Boston, USA
23. London, United Kingdom
24. Tokyo, Japan
25. Montreal, Canada
26. Tallinn, Estonia
27. Tel Aviv, Israel
28. Yinchuan, China
29. Hangzhou, China
30. Perugia, Italy
31. New York City, USA
32. Vancouver, Canada
33. Helsinki, Finland
34. Hamburg, Germany
35. Luxembourg
36. Portland, USA
37. Nice, France
38. Reykjavik, Iceland
39. Barcelona, Spain
40. Osaka, Japan
41. Abu Dhabi, UAE
42. Doha, Qatar
43. Hong Kong, China
44. Rio de Janeiro, Brazil
45. Shanghai, China
46. Chicago, USA
47. Munich, Germany
48. Toronto, Canada
49. Bordeaux, France
50. Bhubaneswar, India

Methodology

Sources for this study include data collected from:

Municipal authority publications, including city, regional and national data; city and national census data; the World Health Organization; municipal energy departments; Numbeo; municipal strategic vision documents and press releases; United Nations reports; European Commission reports; Pew Research Center data; TomTom Traffic index; International Energy Statistics reports; the European Digital City Index; the Online Speed Test Global Index; municipal websites.

Smart Cities ranking methodology:

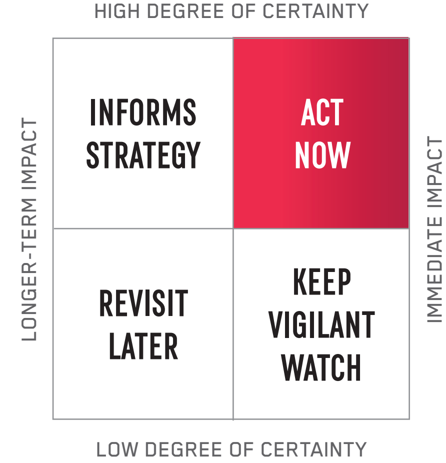
We researched and analyzed 100 cities for the 2019 study. Cities without easily accessible data were not considered. We developed a model using 16 key performance indicators (on the previous page).

Assumptions in our model:

- Data were not adjusted according to regional or local cultural differences.
- Where city specific data for certain indicators were not available, regional or national data were used instead.

Using our model to calculate the ranking:

We weighted each of the 16 indicators equally to calculate raw scores. Those scores were ranked from top-performing to lowest-performing, based on available data.



Smart City Initiatives

KEY INSIGHT

By 2050, there will be more citizens living in cities than in rural areas by a ratio of 2:1. As the Internet of Things ecosystem matures, there will be new opportunities for city managers to manage infrastructure, traffic and daily living.

EXAMPLES

Vietnam, Indonesia and Myanmar launched smart city partnerships with Japan, which has pledged to help Southeast Asian cities ease traffic congestion, introduce cashless payments and harness environmental data to improve the quality of life. It's an alternative to China's Belt and Road infrastructure initiative, which is dedicating billions of dollars in loans for various projects to help modernize its partner countries.

WHAT'S NEXT

Globally, the market for smart city projects could increase to more than $1 trillion by 2025, which means multinational partnerships as well as public-private partnerships. In cities throughout the US, universities are starting to partner with city councils on a wide range of experiments. The Argonne National Laboratory and the University of Washington are deploying a variety of sensors around Seattle to improve hyper-local weather forecasting due to climate change.

WATCHLIST

Local city and town agencies; local business leaders; local universities and colleges; Congress; European Union.

The market for smart city projects could increase to more than $1 trillion by 2025.

City-Level Cyber Security

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

SCENARIO

Landscrapers are on the horizon.

In the future, architects may choose to build laterally, rather than vertically. Advancements in the technology that moves elevators now allow them to move omnidirectionally. Given what we know to be true about extreme weather and climate change, it's plausible that economic centers will move inland from the coasts, and that landscrapers will become more mainstream over the next 20 years. Spanning massive areas the size of several football fields, these new buildings would be able to withstand high winds and temperature changes. They will create entirely new city footprints we haven't seen before in the US.

–AMY WEBB

KEY INSIGHT

Historically, cybersecurity hasn't been a top priority for municipalities. However as more local government services moving online, municipal managers are investing in new technologies and better policies to protect against attacks.

EXAMPLES

In 2018, the **City of Atlanta** was targeted by hackers, and for nearly a week residents could not pay their water bills or traffic tickets online, police officers had to write and submit warrants by hand, and travelers to the world's busiest airport had no access to free WiFi. A year earlier, hackers breached the emergency management system for the **City of Dallas** and set off tornado sirens. These weren't catastrophes, but the breach did portend serious challenges to come. That's because clever bands of hackers know that local governments don't have formal cybersecurity policies—and few employ enough trained experts to safeguard systems and train employees on how to avoid attacks.

WHAT'S NEXT

There is a significant talent shortage—those who have the right skills set and experience tend to take much higher-paying jobs in the private sector. As a result, cities will need to carve out enough budget to pay for staff. Another avenue being tested in some cities is public private partnerships. They'll need to do it quickly: cybercrime won't wait for local city and town budgets to pass.

WATCHLIST

Local city and town agencies; local business leaders; local universities and colleges.

5G: Private Networks and China's Influence

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

5G trials, supported by the **Federal Communications Commission** and the **European Union**, are underway around the world.

EXAMPLES

5G is the fifth generation of wireless technology. We had 1G in the early 1990s and 2G in the late 90s, which enabled us to send text messages between two mobile devices. 3G supported our ability to browse the internet. Now, with 4G, we're able to download and upload large videos. 5G will dramatically increase the speeds at which we connect—we'll be able to pull **HD** and **3D video** and use **VR** in the cloud, since download speeds will hover around 10 gigabits per second, which will be a boon for news organizations that distribute video content. But it isn't just our phones that will use the connection: **driverless cars**, **smart cities**, and **smart grids** will all rely on 5G.

WHAT'S NEXT

While major carriers have been touting 5G networks, racing to convince consumers that they are first to market with the next generation of connectivity, it will still be a while before we see real 5G networks, products and services roll out nationwide in the US In October 2018, **Verizon** did launch a home broadband service, however it was based on its own proprietary standards. **AT&T** launched a standards-based 5G network in a dozen cities in December 2018, but there are no 5G phones yet – so instead, the network was compatible only with **Netgear's** Nighthawk mobile hotspot. It also rebranded its 4G LTE network as 5G E – the "E" stands for "evolution," and AT&T intended to imply that the company is moving in the direction of 5G, rather than offering it to mobile phones right now.

THE CHINA PROBLEM

Equipment manufactured by **Chinese** telecommunications and internet companies is considered a threat by the **FCC**, and in 2018 congress passed a prohibition on government agencies buying Chinese components or services. **Huawei** and **ZTE** are both viewed as dangerous, as regulators worry that backdoors or malware could be used for surveillance by the Chinese government. Huawei is the only company in the world right now that makes the end-to-end supply chain to build 5G networks. At the moment, the US is lagging behind.

PRIVATE 5G NETWORKS WILL COME FIRST

Before we see 5G nationwide (or even citywide), we're more likely to see the proliferation of private 5G networks inside factories and warehouses. In 2019, we are likely to see some larger companies implement 5G to manage their autonomous and collaborative robots, which will shorten transmission latency from 30 milliseconds to just a single millisecond, allowing essentially instantaneous connectivity between devices on a network. Unlike WiFi, a private 5G network can be built to prioritize certain data transmissions over others.

WATCHLIST

Federal Communications Commission; European Union; China; Japan; wireless carriers worldwide.

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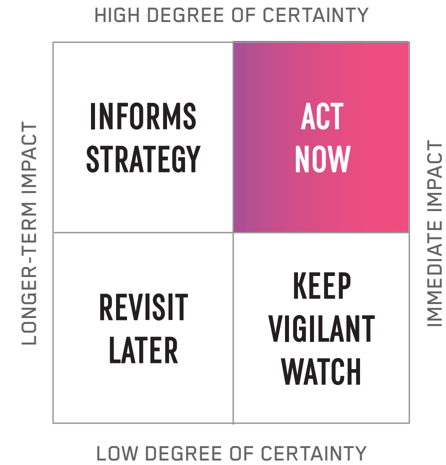
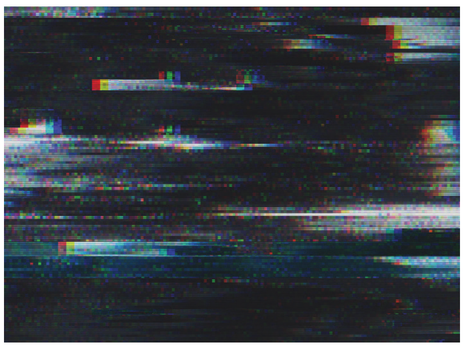
GOVERNMENT AND TECHNOLOGY POLICY

Splinternets





In 2018 we witnessed widespread splinternets.

KEY INSIGHT

Twenty years ago, the internet emerged as a global space where information wanted to be free. Now, everyone has a different idea of how our global information superhighway ought to be regulated, and by whom. As a result, we are headed towards a fragmented "splinternet" in the future.

EXAMPLES

When the GDPR launched in May 2018, hundreds of legitimate news sites were blocked worldwide. We can already see that the internet looks and behaves differently depending on geography. Some jurisdictions are now considering data localization laws.

Search is controlled by a small number of American companies—there is no **United Nations** or other international organization with any power to establish standards, norms and regulations that is recognized by everyone using the internet. In the past decade, countries in Europe fought ISPs and search providers such as **Google** and **Yahoo** in court and successfully banned content on a country-by-country basis. Citizens in countries where free speech isn't valued could find their version of the internet without a digital outlet for watchdog journalism.

WHAT'S NEXT

Compliance is going to become more and more difficult for companies who do business in more than one location, which could stifle growth and restrict the flow of meaningful, credible information.

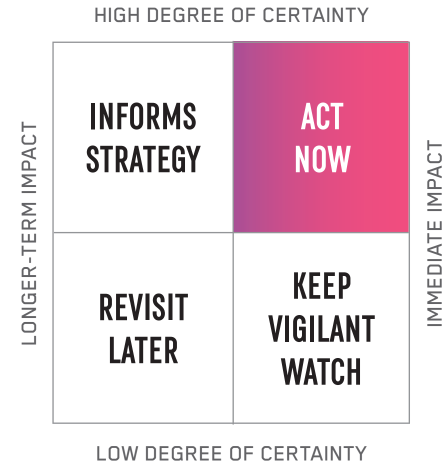
The companies involved have maintained that they're "just technology platforms," however their strictly defined roles as arbiters of information will be tested in courts in the coming years.

Without coordinated effort, splinternets will continue to proliferate in the years ahead. This could make disseminating quality journalism more difficult in regions around the world. But it could also cause tremendous headaches for news organizations who distribute—and monetize—content for a global audience.

WATCHLIST

European Union; Google; Facebook; Baidu; Twitter; Amazon; Microsoft; Netflix; Apple; Federal Communications Commission.

US and Global Election Security



KEY INSIGHT

It is now clear that Russia interfered with elections around the world during 2016 and 2017. As the Future Today Institute forecast in previous editions of our report, congress has introduced sweeping measures to safeguard election security.

EXAMPLES

It's now clear that **Russia** meddled in the 2016 US election. This included pilfering local and national election databases, hampering the registration operation in districts around the country, and deliberately spreading false or misleading information to target political candidates. We made it easy for hackers to break in. During the 2016 election, 43 states used electric voting machines that were perilously out of date.

WHAT'S NEXT

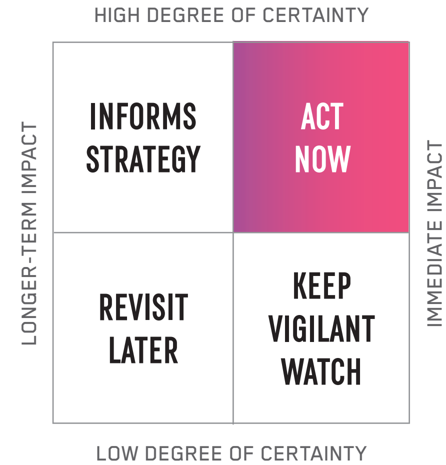
In January 2019, **House Democrats** introduced new election security members as part of the **For the People Act**, which mandates that states revert to using paper ballots in elections, which must be hand-counted or counted using optical character recognition. It will also authorize the **Election Assistance Commission** to support smaller districts with grants to upgrade their systems, and it also tasks the **Department of Homeland Security** to run a security and threat assessment audit ahead of all future elections. The bill will still need a vote and funding for implementation, but it's a sign that our elections systems are now in transition. It will still take significantly more funding, better technology, sweeping changes to polling station training programs, and scores of security experts to shore up our nation's elections infrastructure before the 2020 election. Threats to the integrity of our elections could elevate this to a national security issue, and could signal a federal takeover of state and local elections.

WATCHLIST

Caltech/MIT Voting Technology Project; Presidential Commission on Election Administration; National Conference of State Legislatures; Department of Homeland Security; National Security Agency; Central Intelligence Agency; Russia.

It's now clear that Russia meddled in the 2016 US election.

Trying To Regulate Big Tech



City Council members voted on a controversial a "head tax" in Seattle.

KEY INSIGHT

In the wake of privacy and security scandals that plagued America's part of the Big Nine in 2018, governments will attempt to regulate tech companies this year.

EXAMPLES

There are a number of taxes already proposed in the US and Europe. Late in 2018, **San Francisco** passed a controversial homeless tax called **Proposition C**, which taxes the city's largest companies in an effort to offset steep housing prices and homelessness. Companies earning more than $50 million in annual revenue now owe more in city taxes. Local lawmakers had proposed a "head tax" in **Seattle**, which would have amounted to $275 per employee at companies earning more than $20 million a year. While the **Seattle City Council** unanimously passed the ordinance, a month later they voted to repeal it (the vote was 7-2) under pressure from **Amazon.** In the UK, there are plans for a digital tax of 2% on revenue earned within the UK, as retaliation against big tech companies who domicile huge stores of cash in **Ireland.** The EU had a similar tax proposal which has yet to find support, however **India** and **South Korea** are now working on national versions that can be implemented locally.

WHAT'S NEXT

This year you can expect to see many new proposals that would regulate big tech in numerous ways that involve privacy, transparency and big tech relationships with **China** and **Russia.** Whether all that talk will lead to action is still unclear, however big tech firms will spend much more time having to work on government and public affairs than in the past. It'll be an expensive, time-consuming process.

WATCHLIST

America's part of the Big Nine: Amazon, Google, Microsoft, IBM, Facebook, Apple; Netflix; Salesforce; Congress; Federal Trade Commission; Better Business Bureau; Senator Mark Warner; governments around the world.

Multilateral Science and Technology Acts

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT	INFORMS STRATEGY	ACT NOW	IMMEDIATE IMPACT
	REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

With debates about the future of CRISPR, ocean plastics, climate, autonomous vehicles, AI and space exploration reaching fever pitch, there will be new multilateral science and technology acts proposed.

EXAMPLES

After it was revealed that a pair of genetically engineered twin girls was born in China, some are wondering whether international norms are enough.

WHAT'S NEXT

Now that many fields of science and technology have started to produce striking new developments, lawmakers, researchers and ethicists are calling for some kind of consensus – and international deliberations that could lead to international treaties and protocols.

WATCHLIST

United Nations; American Association for the Advancement of Science; UNESCO; International Union of Biological Sciences; International Social Science Council; Canada's Office of Planning and Research; governments worldwide.

Lawmakers, researchers and ethicists are calling for international consensus.

Anti-Trust Lawsuits

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY		ACT NOW
REVISIT LATER		KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

Big tech companies have enormous footprints, and they could see new antitrust suits in 2019.

KEY INSIGHT

Antitrust laws exist around the world. They exist to ensure and promote fair competition between companies for the benefit of consumers. As media and technology companies consolidate in 2019, there will likely be a number of new antitrust suits brought in an effort to thwart monopolies.

EXAMPLES

There is some debate in the US regarding the **Sherman Act**, which was originally written to regulate and break apart railroad and oil tycoons, who had built America's biggest monopolies. What US courts have yet to decide is whether America's part of the **Big Nine** and other big tech companies are indeed monopolies, which would trigger the Act's application. So far, the big tech companies have argued that there is plenty of competition – if people don't want to use **Facebook**, there are lots of other social media companies they can use instead.

In the EU, the argument against big tech has found more traction. In 2017, the **EU** fined **Google** a record-breaking $2.7 billion for what adjudicators said was illegally nudging users to its comparison shopping site rather than to the online retailers themselves. In September 2018, the **EU's Competition Commissioner Margrethe Vestager** began an investigation into how Amazon uses customer data. Earlier in the year, she fined **Google** $5 billion for antitrust infractions having to do with Android.

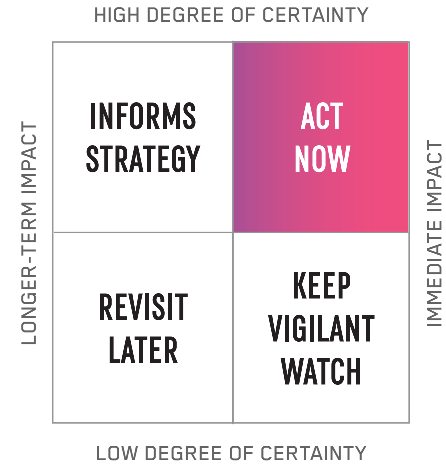
WHAT'S NEXT

The problem with existing antitrust laws is that they don't always mesh with our ever-evolving business landscape. For example, **Amazon** recently acquired **Zappos, Diapers.com** and **Whole Foods**. Together, all three give the company a much larger retail footprint, but individually, each acquisition doesn't amount to unfair competition. (It's not the same as **Walmart** buying **Publix** and **Safeway**.) However, as Amazon continues to build digital payments, logistics and package delivery infrastructure, it could indirectly crush other retailers who don't also use its platform. But that still wouldn't be illegal. At the moment, we don't have any laws against being really, really smart.

WATCHLIST

American Big Nine companies: Amazon; Google; Apple; Facebook; IBM, Microsoft; Netflix; Alibaba; Baidu; Tencent; Department of Justice; Federal Trade Commission; EU, governments worldwide.

Old Laws Clash With New Technology



KEY INSIGHT

Technology is now moving faster than any government's ability to legislate it. As a result, countries around the world are learning the hard way what happens when old laws clash with new technology.

EXAMPLES

In the **US**, the **Computer Fraud and Abuse Act (CFAA)** was enacted shortly after lawmakers showed a clip of the 1984 movie *WarGames* during testimony—it was an iconic scene about the brink of nuclear war with Matthew Broderick, as a teenage hacker. The CFAA's broad language makes it illegal to break a website's terms of service (TOS). But these days, most of us break the TOS of the websites and services we use without even realizing it.

Every time that coworker Facebooks an inspirational message she found online, she's technically breaking the law. The CFAA was used to threaten internet activist **Aaron Swartz** with 35 years in prison and $1 million in fines for allegedly stealing a trove of academic papers with the intent of making them available freely to the public—he later committed suicide.

In the US, we have plenty of policy questions, but few answers. We only have the existing democratic instruments of change: patents, regulation, legislation, and lawsuits. And society is trusting our lawmakers, political appointees, and agency heads to apply those instruments to technologies that could literally change the future of humanity.

WHAT'S NEXT

In a democracy, new policies and laws require discussion, debate and various parts of a government to collaborate. It's a slow process by design, but that doesn't mean we should avoid any action until there's a real crisis. Without meaningful discussion about the long-range implications of legislation, lawmakers could cause drastic (if untended) consequences for their constituents in the decades to come.

WATCHLIST

Government agencies; business leaders; legal scholars; law enforcement; technology and privacy advocates; media organizations; everyday citizens.

In WarGames, Matthew Broderick played a hacker who brought the US and former Soviet Union to the brink of nuclear war.

New policy questions we need to ask in 2019

How should we define privacy in a digital era?

Can law enforcement agencies use the Fourth Amendment to compel a company to jailbreak a device? If citizens use spatial computing systems in their homes, are the data generated by walls and physical spaces governed by privacy rights?

Can government force big tech companies to make AI explainable?

Should systems carry something akin to a nutritional label, detailing the training data used, the processes used for learning, the real-world data being used in applications and the expected outcomes? For sensitive or proprietary systems, should trusted third parties be able to assess and verify an AI's transparency?

Can bots break the law?

If a digital assistant or bot breaks a law without your direct involvement—automatically purchasing illegal drugs, or using hate speech against another person—who's to blame? You? The individual developers who created the assistant or bot's code? Or the technology company that built the platform?

Who owns your biology?

You are shedding biometric data every day, either intentionally or unwittingly. Every time you speak to Alexa, use your fingerprint or face to unlock a device, or allow a photo to be automatically tagged when you upload it to social media, you are voluntarily sharing your bioinformation with for-profit companies. What legal right do they have to change end-user agreements? Who is the ultimate legal guardian of that data? Can a company take ownership of your DNA and other biodata forever? Can it be given the perpetual, royalty-free worldwide license to our data?

Can your Fitbit plead the Fifth?

Does the Fifth Amendment mean that wearables—our fitness trackers, connected bras, smart watches—can't be used to self-incriminate us in court?

Do anti-slavery protections extend to Alexa?

Our Thirteenth Amendment declares that "neither slavery nor involuntary servitude, except as a punishment for crime whereof the party shall have been duly convicted, shall exist within the United States, or any place subject to their jurisdiction." It doesn't specifically reference humans. Do anti-slavery protections extend to our artificially intelligent agents?

Governments Asking Tech Companies To Help Fight the Spread of Misinformation, Propaganda and Terrorism

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

It may seem counterintuitive, given that there is so much talk of regulating big tech in 2019, but government agencies worldwide are expecting tech companies to help fight against the spread of misinformation, propaganda and terrorism.

EXAMPLES

Throughout 2018 there were several heated Congressional committee hearings with representatives from **Twitter**, **Google** and **Facebook**. Committee members demanded that the tech companies admit to platform failures and their role in helping to spread misinformation during the 2016 election cycle.

WHAT'S NEXT

YouTube, WhatsApp and Twitter all promised in 2018 to introduce new measures to combat the spread of conspiracy theories, false information and bots that are built to intentionally confuse people. While lawmakers have demanded action, they continue to struggle balancing tensions between censorship, free enterprise and national security. The questions—and answers—are complicated, and they involve all of us. This year, we will see two things happen: governments will both ask big tech for help and, at times, threaten them if no changes are made. Whether or not big tech can be compelled to play nice is still a legal grey area. Better to debate policy and procedure in advance, so that decisions don't have to be made under duress.

WATCHLIST

Government agencies; technology company leaders; legal scholars; law enforcement; technology and privacy advocates; media organizations; everyday citizens.

Facebook, Google and Twitter have testified in Congress several times.

TREND 305 THIRD YEAR ON THE LIST

Overhauling Government Tech Infrastructure

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
	INFORMS STRATEGY	**ACT NOW**
	REVISIT LATER	KEEP VIGILANT WATCH

LOW DEGREE OF CERTAINTY

President Donald Trump signed an executive order to modernize the US government.

KEY INSIGHT

Parts of the federal government rely on comically old technology, which is very difficult to maintain. Overhauling the infrastructure has bipartisan appeal.

EXAMPLES

In 2017, **President Donald Trump** signed an executive order to modernize the US government. To kick off the process, he invited 20 tech CEOs to the White House to discuss how to make the transition. The idea of overhauling government IT didn't start with the Trump White House. **President Barack Obama** created the **US Digital Service** to attract tech sector experts to federal jobs and to fix the broken system from within. There's a financial incentive to do so: a 2016 **Government Accountability Office** (GAO) report estimated that we spend $80 billion annually on IT because of obsolete technologies and sweeping inefficiencies.

The GAO report included a sobering technology audit. It found that the **State Department** uses a 26-year-old system to track visa information for 55,000 foreign nationals—software that was decommissioned by the vendor who built it.

WHAT'S NEXT

In a perplexing about-face, President Trump acknowledged that government systems need to be overhauled—but then didn't name key advisors who would have the authority to make needed changes. The problem isn't just about legacy systems—it's about keeping pace with the changing nature of technology. Old software, machines and systems are expensive to maintain. Plus, there aren't many technicians who have enough institutional knowledge to make the necessary fixes, which means re-hiring retired employees at high contract wages. Legacy systems are also vulnerable to attack.

WATCHLIST

Federal Chief Information Officer; Office of Science and Technology Policy; Government Accountability Office; Department of Defense; IRS; State Department; Department of Transportation; Department of Justice; Department of Health and Human Services; the FCC; Department of Housing and Urban Development; Department of Energy; Department of Homeland Security; Environmental Protection Agency; Office of Management and Budget; elected officials and lawmakers.

Strategic Guidance: The Case For Renaming and Repositioning Executive Departments in the US Government.

The Department of Commerce was established in 1931, well before we had computers, robots, autonomous vehicles or artificial intelligence. It's primary task: to oversee job creation and promote economic growth. More than a century later, the Commerce Department has morphed into a division of government that manages statistics and data, and not just for business. It oversees the National Oceanic Atmospheric Administration (NOAA), the National Institute of Standards and Technology, and the Patent and Trademark Office. The Labor Department oversees the Bureau of Labor Statistics (BLS) but doesn't routinely update the jobs listed so that they reflect our changing workforce.

As we transition into new areas of technology and science that will forever shape the course of human history, we should think about updating our federal agencies and restructuring them to better meet the future needs of American citizens. This isn't just about a name change. It is about more accurately describing what the 15 executive departments in the US government do today, and what they must accomplish in the years to come.

We must also reinstate a previous office and create a new executive department in order to best prepare for the future.

CURRENT DEPARTMENT	PROPOSED CHANGE
Department of Agriculture	Department of Basic Sciences
Department of Commerce	Department of Data
Department of Education	Department of Education and Workforce Development
Department of Energy	Department of Advanced Sciences
Department of Homeland Security	Department of Cybersecurity

The case for reinstating the Office of Technology Assessment

Years ago, the now-shuttered Office of Technology Assessment was charged with researching, forecasting and advising Congress on matters of emerging technology. During its existence, the OTA released more than 750 prescient studies ranging from robots in the workplace, to bioterrorism, to acid rain and climate change. The OTA was defunded by Congress in 1995, and it was a mistake. We are building and deploying new technologies at an unprecedented rate. For the first time in our country's history, advancements in science and technology have outpaced our lawmakers' ability to respond in measured and responsible ways.

The case for creating a new Department of the Future

A Department of the Future should advise our nation's top leaders and policymakers on the social, economic and geopolitical implications of emerging science and technology—as those implications relate to all other departments, agencies and offices within the government. The office would coordinate research, lead scenario mapping and long-range planning. And it would ask and answer difficult legal and policy questions about the future of biotechnology, artificial intelligence, autonomous travel, digital divides, renewable energy, space exploration and beyond.

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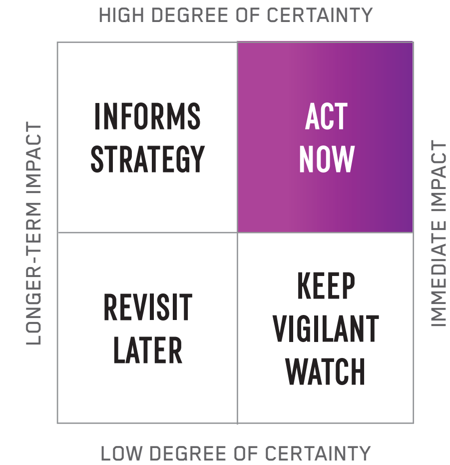
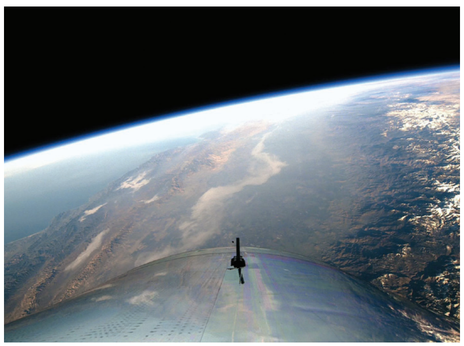
SPACE

Space Tourism





A camera on Virgin Galactic's SpaceShipTwo VSS Unity captured this view of the Earth from just over 51 miles (82.7 kilometers) up during a test launch on Dec. 13, 2018 from Mojave Air and Space Port in California. It was Virgin Galactic's first trip to space.

Credit: Virgin Galactic

KEY INSIGHT

Commercial crew test launches for commercial space flight are now underway, which will help usher in a new era of space tourism.

EXAMPLES

In December 2018, **Virgin Galactic** successfully launched human crew 51 miles into the sky over the Mojave Desert in California. Two pilots, **Mark Stucky** and former **NASA** astronaut **Rick Sturckow** earned the first ever commercial astronaut wings from the **Federal Aviation Administration.** As of the publication of this report, more than 600 people had pledged $250,000 each to take a ride aboard Virgin Galactic.

In January 2019, preparations were underway for the first commercial crew test flight at **SpaceX.** The launch, considered dangerous, would go beyond Virgin's 52 miles. Plans for commercial space flight are already underway at both **SpaceX** and **Boeing** as part of **NASA's Commercial Crew Program.** They are planning to manage six crew missions to the International Space Station between 2019 and 2024. **Blue Origin**, founded by **Amazon CEO Jeff Bezos**, also has a program in the works – the company has promised space tourist flights this year. Meanwhile, **Musk** has said that he plans to take humans to **Mars** by 2024.

WHAT'S NEXT

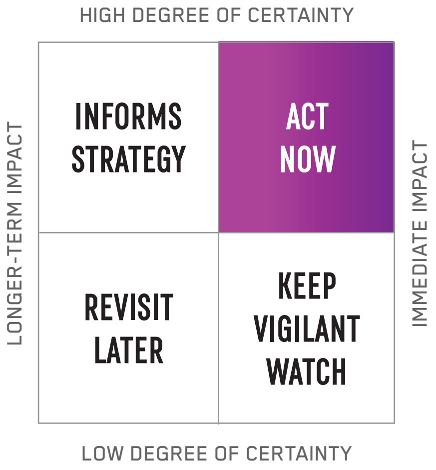
Not everyone is suited for space flight. **Carl Sagan** wrote about the **"Overview Effect"** in his book ***Pale Blue Dot***: "Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves."

There are practical limitations, too: the estimated travel time for a trip to **Mars** and back is currently set at three years. Getting to and from the **Moon** is easier—just one week round trip—but still challenging. Travelers would have to contend with something called "space adaptation syndrome" (like car sickness—but a lot worse) and elevated levels of radiation. One nine-day mission to the Moon would result in radiation exposure equivalent to 35 chest x-rays.

WATCHLIST

NASA; Amazon; Boeing; European Space Agency; Indian Space Research Organization; Virgin Galactic; SpaceX; China National Space Administration; DARPA; Scaled Composites and Virgin Galactic (The Spaceship Company); XCOR Aerospace; Interorbital Systems; Stratolaunch; Masten Space Systems; Lockheed Martin; Northrop Grumman; Planetary Resources and many more.

Commercial Space Programs



KEY INSIGHT

New spacecraft, rockets and other technologies are helping privacy commercial companies to achieve liftoff – with plenty of eager investors footing the bill.

EXAMPLES

Investors, including **Morgan Stanley**, are eyeing a new space gold rush, now that a critical mass of commercial space companies and their technologies have matured enough to move beyond proof of concept into testing. In 2018, **NASA** announced that it was partnering with nine commercial companies for a variety of projects including exploring the moon's mineral sources. Some estimates put the projected growth of the space economy to more than $1 trillion in the next two decades.

WHAT'S NEXT

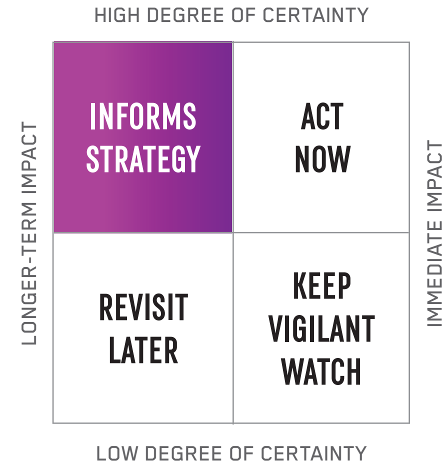
In 2019 there are lots of planned experiments and launches, and we expect to see more investment into commercial space companies, especially in the areas of insurance, satellites, defense, aerospace technologies and materials (manufacturing and mining).

WATCHLIST

NASA; ViaSat; Inmarsat; Toray; Hexcele; Ball; XL Group; Lancashire Holdings; Bank of America; Morgan Stanley; Amazon; Boeing; European Space Agency; Indian Space Research Organization; Virgin Galactic; SpaceX; China National Space Administration; DARPA; Lockheed Martin; Northrop Grumman; Planetary Resources and many more.

SpaceX's Falcon 9 rocket has successfully launched and landed.

MicroSats and CubeSats



KEY INSIGHT

Entrepreneurs are building and preparing to launch thousands of low-cost, high-value satellites in the next year. These satellites are small, capable of communicating with each other, and will photograph every inch of Earth's surface every day of the year.

EXAMPLES

Miniature satellites, otherwise known as **MicroSats** or **CubeSats**, aren't new technology. They've actually been in use by space agencies for years. What's changing is the launch technology that lifts CubeSats into orbit – and the number launching into space. Heavy investment into propulsion systems—not to mention significant advancements in technology and cheaper components—are making it easier to mass-produce tiny satellites in a factory and launch them for a variety of purposes. Fleets of CubeSats now take photos of farmland and beam them back down to earth to help farmers assess their crops. Image analysis software can tell big box retailers, such as **Walmart**, how many cars are parked in their lots and look for trends over time. They can then do the same with a competitor's parking lots to gather strategic intelligence. Mining companies can survey a swath of land to see who's started drilling and whether they've struck oil. Satellites monitor traffic, polar ice caps, and even us. Unlike a traditional, large satellite, when one CubeSats goes offline or gets damaged, the rest of the fleet still works.

Near-real time images, coupled with machine learning and analysis tools, is big business. Governments, big agricultural corporations, intelligence agencies, shipping companies and logistics firms all want access, so they're willing to pay tens of millions of dollars a year for access. The combined valuation of companies such as **Planet**, **Airbus D&S**, **MDA** and **DigitalGlobe** is well into the tens of billions.

But those hoping to launch CubeSats still need permission – and they don't always get it. Last year, Silicon Valley start-up **Swarm Technologies** launched four CubsSats without first gaining the official approvals, which resulted in an **FCC** fine of $900,000. Before that, Swarm Technologies failed to get FCC approval to launch tiny satellites – each smaller and lighter than an iPhone – because the agency was worried that they'd be difficult to detect and monitor from the ground.

WHAT'S NEXT

Swarm is still on a mission to launch hundreds of its own CubeSats. Yet another company, **Rocket Lab**, launched more than a dozen CubeSats in partnership with NASA. We are expecting to see unprecedented growth, especially as capabilities of CubeSats grow in strategic utility. There are more than 3,500 MicroSats and CubeSats scheduled for launch during the next few years – and that doesn't include satellites that are part of larger constellation systems. Elon Musk's **SpaceX** won **FCC** approval to deploy 7,518 satellites to its Starlink communications constellation.

CubeSats and image analysis will help us better understand the pulse of our cities, gain a deeper view into weather events and even dive into criminal activity. But that goes both ways. CubeSats could become a national security liability.

WATCHLIST

Space Systems Loral; MDA; Planet; Planetary Resources; Airbus D&S; DigitalGlobe; National Geospatial Intelligence Agency; 3 Gimbals; Space Exploration Technologies Corp; Orbital Insight; Google; SpaceKnow; Capella Space Inc; OneWeb; SpacePharma; Santa Clara University; Technische Universitat Berlin; Tokyo Institute of Technology; University of Tokyo; California Polytechnic University; Cornell University; Boeing; Delft University of Technology; NASA Ames Research Center; Transcelestial; NSL-Comm; Earthcube; Aerial & Maritime; Fleet Space; Astrocast; Kepler Communications; GeoOptics; Hera Systems; Sky and Space Global; Astro Digital; Kanagawa University; The Aerospace Corporation; Los Alamos National Labratory; NRL Naval Center for Space; Space and Missile Defense Command; Satellogic; Spire; US Air Force; Lawrence Livermore National Labratory; MIT; Shenzhen Aerospace Donganghong; National University of Defense Technology (China); Shanghai Engineering Center for Microsatellites (China); SRI International; Naval Postgraduate School.

Galactic Ride Sharing

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

New technologies have spawned a new trend in space transportation: galactic ride sharing.

EXAMPLES

Galactic ride sharing as a service business models launching. In 2018. **Spaceflight Industries** launched its first rideshare mission called **SSO-A SmallSat Express** aboard a **SpaceX** Falcon 9. The company purchased all of the available payload space on the rocket to service customers who wanted to launch things into space. It included MicroSats and CubeSats from 17 countries—but there were some unusual projects aboard, too. A spacecraft from the **Los Angeles County Museum of Art** sent up a 24-karat gold jar with a bust of the first African American astronaut to reach space. Artist **Trevor Paglen** sent a self-inflating sculpture that reflects sunlight and can be viewed by the naked eye here on earth. Yet another craft, the **Elysium Star 2** sent by **Elysium Space**, contained the cremated remains of people who wanted to become shooting stars.

WHAT'S NEXT

As more researchers, artists and everyday people need to hitch rides on a rocket, we anticipate new business models—and potential regulation.

WATCHLIST

SpaceX; NASA; National Geospatial Intelligence Agency; Spaceflight Industries ; Elysium Space; Space Exploration Technologies Corp; Orbital Insight; Google; SpaceKnow; Capella Space Inc; OneWeb; SpacePharma; NASA Ames Research Center; Los Alamos National Labratory; NRL Naval Center for Space; Space and Missile Defense Command; US Air Force; Lawrence Livermore National Labratory; MIT; Shenzhen Aerospace Donganghong; National University of Defense Technology (China); Shanghai Engineering Center for Microsatellites (China); SRI International; Naval Postgraduate School.

Spaceflight Industries launched its first mission last year.

Mercury Problems

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

Mercury is heavier than the xenon and krypton powering other ion engines in use today.

KEY INSIGHT

New rocket propulsion systems for rocket engines would use mercury as a fuel, which could run the risk of spreading toxic chemicals through Earth's atmosphere.

EXAMPLES

NASA experimented with mercury in the 1960s because it's a low-cost, high-power option for ion engines. Startup Apollo Fusion has discovered a new approach to using mercury—but there's a catch. Mercury is heavier than the xenon and krypton powering other ion engines in use today. What customers might save on costs could pollute the atmosphere in potentially harmful ways.

WHAT'S NEXT

While the US government has tried to reduce our mercury emissions since the 1990s, those rules do not specifically cover spacecraft hovering above us. The FAA requires companies to disclose hazardous materials, but again, this doesn't include satellites. It's an area where yet again, technology has surpassed our governing agencies and the policy they write.

WATCHLIST

Apollo Fusion; SpaceX; NASA; National Geospatial Intelligence Agency; FAA; FCC.

China's Space Ambitions

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	KEEP VIGILANT WATCH	

LOW DEGREE OF CERTAINTY

KEY INSIGHT

In January 2019, China became the first country to land a robotic mission on the moon's far side. It was a historic accomplishment—and a clear sign of new leadership from China.

EXAMPLES

China may have shown up late to the space race: it didn't send its first satellite into orbit until 1970, long after the **US** and former **Soviet Union** had already been to the moon and back.

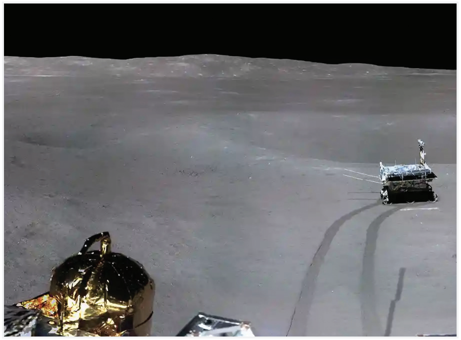
China eyes space exploration as a vital part of its global leadership as it seeks to create a new world order. In 2013, **President Xi Jinping** said "the space dream is part of the dream to make China stronger...the Chinese people will take bigger strides to explore further into space." China doesn't just want to be seen as a powerful Asian nation—it wants to set the global pace for numerous geoeconomic initiatives, for environmental causes, and for societal development.

WHAT'S NEXT

China has outlined its plans to: explore the far side of the moon, develop seeds that can be grown on the moon, build a lunar outpost, send a probe to Mars and more. Chinese officials have said that by 2030, China hopes to be among the major space powers of the world.

WATCHLIST

China's National Space Administration.



A view from the lunar rover Yutu-2 or Jade Rabbit 2 on the far side of the moon taken by China's Chang'e-4 lunar probe.

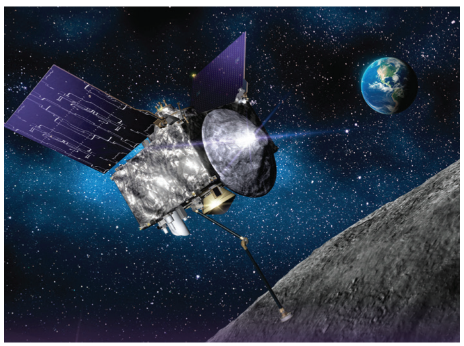
Photograph: Cnsa Handout/EPA

Asteroid Mining For Resources

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT		IMMEDIATE IMPACT
INFORMS STRATEGY	ACT NOW	
REVISIT LATER	**KEEP VIGILANT WATCH**	

LOW DEGREE OF CERTAINTY



OSIRIS-REx orbited asteroid Bennu in early 2019.

Photo courtesy: OSIRIS-REx Mission

KEY INSIGHT

Mining asteroids for resources will prove invaluable to researchers back on Earth.

EXAMPLES

In September 2017, **Arizona State University** astrophysicist **Dante Lauretta** and his team launched the **OSIRIS-REx** to **Bennu**, an asteroid that might offer secrets about the early history of the solar system. It will map the asteroid and return a sample, landing back on Earth in 2023. In 2017, the government of **Luxembourg** passed a law arguing in favor of private companies mining asteroids. Previously, anything above the **Earth's** atmosphere—the **Moon**, the space overhead—has required joint agreements between our various national space agencies and governments. This is an important departure. Essentially, whoever gets to an asteroid first gets dibs on the mineral deposits and, presumably, water.

WHAT'S NEXT

Space mining pioneer **Planetary Resources** had hoped to build reasonably-priced equipment for companies to send up—essentially, hyper-futuristic shovels and buckets for an impending gold rush—but it failed to secure enough funding to move forward. It was acquired in November 2018 by **ConsenSys**, a Brooklyn-based blockchain company. While we haven't seen much progress since last year, there is still movement in this space. Several companies are planning to send mining equipment and spacecraft to near-Earth asteroids by 2021. The first round of flights will be for prospecting purposes—but there are millions of asteroids overhead.

WATCHLIST

ConsenSys; Astrobotic; Government of Luxembourg; NASA; National Geospatial Intelligence Agency; Orbital Insight; University of Tokyo; California Polytechnic University; Boeing; Los Alamos National Labratory; NRL Naval Center for Space; Space and Missile Defense Command; US Air Force; Lawrence Livermore National Labratory; MIT.

SPACE EXPLORATION

HIGH DEGREE OF CERTAINTY

LONGER-TERM IMPACT

INFORMS STRATEGY	ACT NOW
REVISIT LATER	KEEP VIGILANT WATCH

IMMEDIATE IMPACT

LOW DEGREE OF CERTAINTY

KEY INSIGHT

We're in the middle of a space exploration boom.

313

Going Where We've Never Gone Before

A **Chinese robot** is exploring the dark side of the moon, while a **NASA's New Horizons Mission** has been discovering weird objects on the outer edges of our solar system. Startups are working on plans to **colonize Mars**, and they have serious investors. In 2017, retired **US military officers** confirmed that the government is seeking out and tracking **alien life**.

314

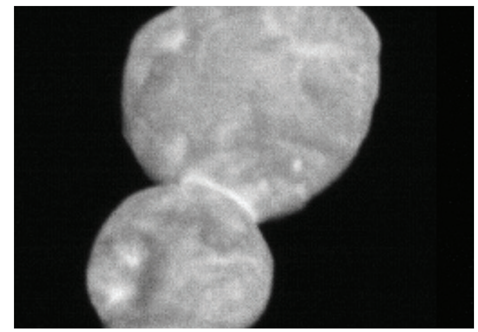
Bigger, Bolder Telescopes

Last year, a review board found that the James Webb Space Telescope project was already $8.8 billion overbudget and still many years away from taking flight. Even so, there are four new NASA space telescope concepts that could find their way into development soon. Only one of the concepts will be funded and built to launch in the mid-2030s, but they're all designed to help scientists discover supermassive black holes, planet-forming disks, the new galaxies and of course earthlike exoplanets that might sustain life.

315

Moon Rush

Fifty years after Apollo 11, humans are headed back to the moon. **China** has made no secret of its desire to send people to the moon on extended missions by the 2030s, while NASA is hoping to stimulate a private sector ecosystem that can build all of the vehicles, landers, probes, rovers, space stations and research craft we'll need in the future.



This image was taken by the Long-Range Reconnaissance Imager (LORRI) on January 1, 2019. It is the most detailed of Ultima Thule returned so far by the New Horizons spacecraft.

Photo courtesy: NASA

21

6 WEAK SIGNALS FOR 2020

Here are some of the weak signals we're already listening to for 2020.

01 City-Scale Spatial Computing

Spatial computing is a computing environment that seamlessly maps physical spaces and the people, objects and pets inside of them—and makes digital information feel as though it is both physically present and reactive to the environment. Magic Leap makes use of its mixed reality headset and spatial computing system. Through a combination of digital lightfields, that sense and compute, the system melds physical and digital data in real time. Years from now, it will be possible to extend the scale of spatial computing environments, including ones that are not only as big as sprawling cities, but also act as a municipal operating system, helping citizens with their day-to-day activities.

02 "Unhackable" Computers

Cambridge University (UK) is currently working on an "unhackable" computer network. It does this using quantum mechanics. A University of Michigan team announced plans to develop an "unhackable" computer, funded by a new $3.6 million grant from the Defense Advanced Research Projects Agency. The project involves redesigning microprocessors and computer architecture to avoid the vulnerabilities like Spectre and Meltdown.

03 Quantum Computing

In short, quantum computers can solve problems that are computationally too difficult for a classical computer, which can only process information in 1s or 0s. In the quantum universe, those 1 and 0 bytes can exist in two states (qubits) at once, allowing computations to be performed in parallel. Therefore, if you build two qubits, they are able to hold four values at the same time: 00, 01, 10, 11. Quantum computers are not only more powerful than anything built to date—they require special algorithms capable of doing new things. Scientists have been researching quantum computing for decades. The challenge has been proving that a quantum machine is actually doing quantum computations. That's because in a quantum system, the very act of observing information in transit changes the nature of that data. In 2019, IBM announced a commercial quantum computer, but it will still be a few years for this technology to move from the fringe to the mainstream.

04 Brain-To-Vehicle Interfaces

Nissan is researching an autonomous vehicle that interprets signals from the driver's brain in order to keep passengers safe and happy.

05 5D Printing

This is the name for five-axis additive manufacturing—rather than printing in flat layers, as we do today, this new technique prints curved layers, making the final product much stronger. Much of the research on 5D printing is being done at the Mitsubishi Electric Research Labratories.

06 Computational Pharmacies

On the horizon are specially trained pharmacists who have backgrounds in bioinformatics, medicine, and pharmacology. Computational pharmacy will evolve as a new medical specialty, one that works closely with a new breed of general practitioner MDs who are aided by artificial intelligence. Rather than filling prescriptions with medications created to serve the maximum number of people well enough, computational pharmacies will consult your personal genetic records and calculate the best course of treatment.

How Your Organization Can Take Action On Emerging Trends

At the Future Today Institute, our goal in the first step of forecasting is to identify weak signals. Because we know that technology is deeply intertwined with a number of other areas of modern change—the economy, education, government, media, and more—we cannot think about the future of a technology without simultaneously considering movement across all these other areas.

To do this, we use a series of questions to guide our research on emerging technology, science and other areas of change. We categorize our research using a series of nodes and connections. Mapping the fringe forces us to think very broadly—not just about an emerging trend, but how that trend relates to a broader ecosystem. Taking this broader view, where nodes and relationships are both considered in tandem, is critical. This approach can be used to map the fringe for a product or even an entire industry.

The fringe sketch is perhaps the most important part of our forecasting methodology. The goal with the fringe sketch is to get back to zero—to reset the information stage so that it can be fully mapped. The fringe sketch alone does not tell us what the trends are that we should follow. Rather, it positions us to consider all of the possible sources of change ahead.

About The Authors

LEAD AUTHOR

Amy Webb

Amy Webb is a quantitative futurist. She is the founder of the Future Today Institute and is a professor of strategic foresight at the NYU Stern School of Business. Webb was named to the Thinkers50 Radar list of the 30 management thinkers most likely to shape the future of how organizations are managed and led and won the 2017 Thinkers50 Radar Award. She is a Fellow in the United States-Japan Leadership Program, a Foresight Fellow in the US Government Accountability Office Center for Strategic Foresight, and was a Visiting Nieman Fellow at Harvard University. She was also a Delegate on the former US-Russia Bilateral Presidential Commission, where she worked on the future of technology, media and international diplomacy. She is the bestselling author of The Signals Are Talking: Why Today's Fringe Is Tomorrow's Mainstream, which explains how to forecast emerging technology. It was a Washington Post Bestseller, won the Gold Axiom Award for business books, and was selected as one of the best books the year by Fast Company, Inc. Magazine and Amazon. Webb's new book The Big Nine: How The Tech Titans and Their Thinking Machines Could Warp Humanity (PublicAffairs/ Hachette, March 5, 2019) is a call-to-arms about the broken nature of artificial intelligence, and the powerful corporations that are turning the human-machine relationship on its head.

CO-AUTHORS

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Elena Giralt is an emerging technologies and blockchain strategist with a background in public journalism. She graduated from Santa Clara University with degrees in French and Political Science and holds an MBA from New York University's Leonard N. Stern School of Business, where her research and course of study focused intensively on blockchain technology.

Marc Palatucci

Marc Palatucci is a media strategist. He graduated from New York University's Gallatin School of Individualized Study with a degree in Linguistics and Languages, serves as editor-at-large for a magazine and creative media agency, and is a 2019 MBA Candidate at New York University's Leonard N. Stern School of Business, where his course of study is focused on the future of technology, commerce, entertainment and media.

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Kristofer "Kriffy" Perez has over a decade of experience as a payment's strategy consultant with leading global banks and retailers across Europe and the Americas. As a Senior Consultant in IBM's Digital Strategy group, he focuses on ideation and data-driven insights. Based in New York City, he is a serial innovator who seeks to drive how technology impacts society. Kriffy has worked for IBM, MasterCard Advisors, the Boston Consulting Group, and founded a startup; accumulating over 120 projects across 8 countries, 15 patents, a degree in mechanical engineering from Lehigh University, and an MBA from New York University's Stern School of Business.

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Douglas Brown

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The names of companies, services and products mentioned in this report are not necessarily intended as endorsements by the Future Today Institute or this report's authors.

Disclaimer

The Future Today Institute's 2019 Tech Trends Report relies on data, analysis and modeling from a number of sources, which includes: sources within public and private companies, securities filings, patents, academic research, government agencies, market research firms, conference presentations and papers and news media stories. This report includes research from our 2018 Tech Trends For Journalism Report. FTI's reports are occasionally updated on the FTI website.

FTI advises hundreds of companies and organizations, some of which are referenced in this report and are highlighted with an asterisk in the appendix. FTI does not own any equity position in any of the entities listed in this presentation.

About The Future Today Institute

Founded in 2006, the Future Today Institute helps leaders and their organizations prepare for deep uncertainty and complex futures. We focus exclusively on how emerging technology and science will disrupt business, transform the workforce and ignite geopolitical change. Our pioneering, data-driven forecasting methodology and tools empower leaders to make better decisions about the future, today.

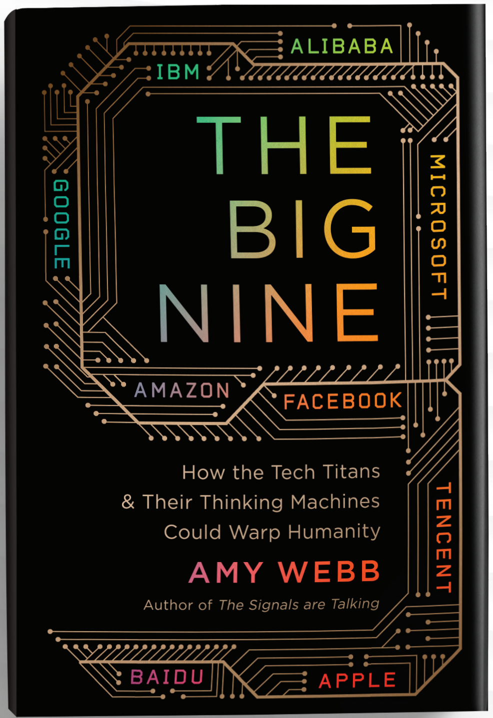
Our forecasting methodology has been featured in the *MIT Sloan Management Review* and in the *Harvard Business Review*, and it is taught at universities around the world. FTI clients and partners include government agencies, Fortune 100 companies, investment firms, news and entertainment media organizations and associations. Our focus is technology, and we intentionally work with a wide variety of organizations to enable the transfer of knowledge and best practices across industries.

Reliable strategic foresight depends on both ingenuity and rigorous evaluation. We work in cross-disciplinary teams comprised of trained futurists as well as subject-area experts, technologists, designers, process-thinkers and creative minds. FTI is based in New York City and Washington, D.C.

New Book By FTI Founder Amy Webb

The Big Nine aren't the villains in this story.
In fact, they are our best hope for the future.

The future of AI—and by extension, the future of humanity—is controlled by just nine companies. There are six in the US, the G-MAFIA: Google, Microsoft, Amazon, Facebook, IBM and Apple. Three are in China, and they are the BAT: Baidu, Alibaba and Tencent. If the fastest-growing power to change the future was concentrated in the hands of only nine decision-makers, would you worry? If those decision-makers were driven by market forces or politics instead of what's good for you, would you do something? Because our futures depend on courageous leadership right now.



Amy Webb has written one of the most important books of the year and everyone should read it.

→ John Noonan, National security expert and former nuclear launch officer

The Big Nine is provocative, readable, and relatable. Amy Webb demonstrates her extensive knowledge of the science driving AI and the geopolitical tensions that could result between the US and China in particular. She offers deep insights into how AI could reshape our economies and the current world order, and she details a plan to help humanity chart a better course.

→ Anja Manuel, Stanford University, cofounder and partner RiceHadleyGates

The Big Nine makes bold predictions regarding the future of AI. But unlike many other prognosticators, Webb sets sensationalism aside in favor of careful arguments, deep historical context, and a frightening degree of plausibility.

→ Jonathan Zittrain, George Bemis Professor of International Law and professor of Computer Science, Harvard University

The Big Nine is an important and intellectually crisp work that illuminates the promise and peril of AI...it should be discussed in classrooms and boardrooms around the world.

→ Alec Ross, author of The Industries of the Future

The Big Nine is thoughtful and provocative, taking the long view and most of all raising the right issues around AI and providing a road map for an optimistic future with AI.

→ Peter Schwartz, senior vice president, Salesforce.com, and author of The Art of the Long View

Webb's potential scenarios for specific futures are superb, providing detailed visions for society to avoid as well as achieve.

→ John C. Havens, Autonomous systems expert and AI ethics researcher

We invite you to learn and use the tools of a futurist.

THE SIGNALS ARE TALKING: Why Today's Fringe is Tomorrow's Mainstream arrives at a fortuitous moment, as it gives critical guidance on how to think like a futurist in order to most accurately answer pressing questions about the future of emerging technologies, science, our economy, political systems, and civil liberties.

"A rare treasure: a substantive guide written in a narrative that's a delight to read."

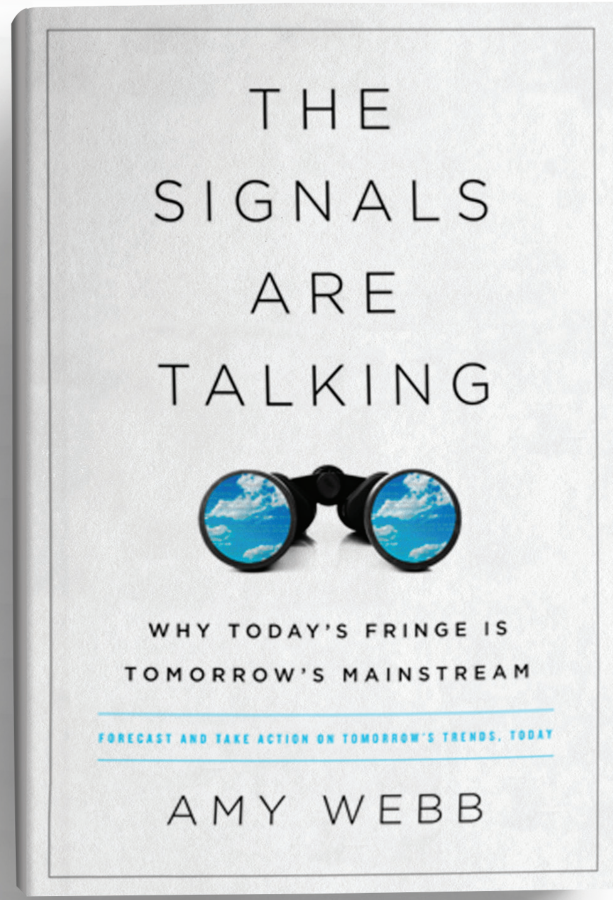
– Christopher Graves, Global Chair, Ogilvy Public Relations

[The Signals Are Talking] provides several brain-bending future possibilities...Webb's stellar reputation in this red-hot field should generate demand."

–Booklist

"A logical way to sift through today's onslaught of events and information to spot coming changes in your corner of the world."

–KIRKUS



- Washington Post Bestseller
- 2017 Thinkers50 Radar Award Winner
- Winner, 2017 Gold Axiom Award
- Fast Company's Best Books of 2016
- Amazon's Best Books of 2016

Companies, Organizations, Universities and Government Agencies Mentioned In Our 2019 Trends Report.

Companies that the Future Today Institute as worked with in any capacity during the past five years are denoted with an asterisk.

3 Gimbals
360 Profilms
Aadhaar
ABB
Abundant Robotics
Accent Advanced Systems
Ace Hardware
Activision Blizzard Entertainment
AdEx
Adler Seeds
Advance Publications
Aerial & Maritime
Aerion
AeroFarms
Aethon Inc.
Afluenta
AGCO
Agfunder
Agora
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Airbnb
Airbus
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Aleph Farms
AlgorithmWatch.org
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Alico Incorporated
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Allscripts
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Amazon Connect
Amazon Web Services
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Anthropocene Working Group
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Apis Cor
Apollo Fusion
Apple
Arable
Arc Group
Archer Daniels Midland
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Argonne-Northwestern Solar Energy Research (ANSER) Center
Arizona State University
ARP
Arria NLG
Aruba Networks
Asahi Shimbun Company
Asian Infrastructure Investment Bank
Astro Digital
Astrobotic
Astrocast
AT&T*
Atlantica Yield PLC
Atmel
ATR Intelligent Robotics and Communication Laboratories
Audi
Audioburst
Auphonic
Aurora Labs
Autodesk
Automated Insights
Automation Anywhere
Autonomous Solutions
AVEBE
Avis
Avrio
Axel Springer
aXiomatic
Axios
Axonify
Azavea
Baidu
Banco Santander
Bank of America
Baseload Renewables

COMPANIES, ORGANIZATIONS, UNIVERSITIES AND GOVERNMENT AGENCIES MENTIONED IN OUR 2019 TRENDS REPORT.

BASF

Bayer AG

BBC R&D

BBDO

BBH

BBVA

Bean

Bell Helicopter

Bernard Matthews Farms

Bertelsmann

Better Business Bureau

Beyond Meat

Binded

Bing

BioCatch

Bioinspired Intelligent Mechatronics Lab at Ritsumeikan University

Bird

Bitdefender

Bitfury

Bitmain

Blink CarCharging

BLIP Systems

Blockstack

Blogger

Bloomberg

Blue Prism

Blue River Technology

BlueCats

BMW

Boeing

Bombardier Phillips

Boom

Bosch

Boston Dynamics

BP

Braze

Bright Farms

British-American International Thwaites Glacier Collaboration

Brown Institute at Columbia University

Buddy

Bugeater

Cadillac

California Institute of Technology

California Polytechnic University

Caltech/MIT Voting Technology Project

Canaan

Canada's Office of Planning and Research

Canadian Solar Inc

Capella Space Inc

Capital One

Capstone

Cardano

CareOS

Cargill

Carnegie Mellon University

Carnegie Mellon's Robotics Institute

Carrefour

Case Western Reserve University

CBS Television

CCP Games

Center for Financial Inclusion

Center for Humane Technology

Center For Migration Studies

Central Intelligence Agency

Cerner

ChargePoint

Chartbeat

Chatfuel

Chevron Corporation*

Chiba University

China COSCO Shipping Corp

China National Petroleum Corporation

China's National Space Administration

Circos VR

Cisco*

Citibank

Citibike

Civil

Claas

Clara Foods

Clear

Cloud9

Coinbase

College of Charleston

Columbia University*

Columbia University's Earth Institute

Comcast

Comcast NBC Universal*

Common Sense

Conoco Phillips

ConsenSys

Coral Project

Cornell University

Corvette

Coursera

Cox Media Group*

Critical Mass

CropEnergies AG

CropMetrics

CrossMatch

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CVS

Cypress Creek Renewables

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DARPA

DataONE

Decent

Deep VR

Del Monte

Delft University of Technology

Delphi Automotive Systems

Denso

Descartes Labs

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Deutsche Bank

DHL

Didi Chuxing

DigitalGlobe

Discovery

dishq

Disney

DJI

DMV

DNV GL

Dolby

Dominos

Dong Energy

Douyu

Dow Chemical Company

DowDuPont

Dreambox

Driveri

Droga5

Dubai Road

Duke University

Duke University's Center for Neuroengineering

DuPont

E.W. Scripps

Early Warning

Earthcube

eClinicalWorks

Ecooltra

EcoPlexus

EHang

EHang UAV

Eifer Elektro Firma

Eko

Electrify America

Electronic Arts

Electronic Frontier Foundation

Elysium Space

Emerson Electric

EnableSoft

Energcon

Energid Technologies

Energous Corp

Energy Acuity

ENOVA

Entosense

Environmental Justice Foundation

Envision Solar

EOS

EPFL

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EPSON Robotics

Ericsson

ESA Data Registry

ESPN

Estimote

ETH Zurich

Ethereal Machines

Ethereum

Ethiopia

Etsy

European Geosciences Union

European Space Agency

European Union

Everwise

Exeq

ExOne

Expect Labs

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FarmLink

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FFRobotics

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Fisker Inc.

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Fluidinfo

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Formlabs

Founders Fund

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

Fujitsu

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Future Meat

Gamesa

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Garage Band

Gastrograph

GCL-Poly Energy Holdings

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Gelo

Gemini

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GeoOptics

Georgia Institute of Technology

Getty

Gimbal

Glimworm Beacon

COMPANIES, ORGANIZATIONS, UNIVERSITIES AND GOVERNMENT AGENCIES MENTIONED IN OUR 2019 TRENDS REPORT.

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Global Pvq SE
GoBank
Goldman Sachs
Golem.network
Good Food Institute
Goodby Silverstein & Partners
Google
Google Analytics
Google Play
Google's Eddystone
Government of Luxembourg
Grand View Research
Graphenano
GridCoin
Groove X
Grove Labs
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GSD&M
Hadoop
Hanergy Thin Film Power Group Ltd
Harmonix
Harvard Biodesign Lab
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Harvard-MIT Division of Health Sciences and Technology
HarvardX
Hearst Corporation*
Hearst Ventures
Hecate Energy
Helios Interactive
Hera Systems
Hershey's
Hertz
Hewlett-Packard
Hexcele
Hiangsu Akcome Science & Technology Co
Hikvision
HireVue
Hitachi
Home Depot
Honda
Honeycomb
Honeywell
Hover
Howdy
HP
HQSoftware
HSBC
HTC
Huawei
Hubert Burda Media
Hulu
HumanAPI
Human Cell Atlas Consortium
Huya
Hyperledger
Hyundai
IAB
IBM*
iFlytek
Ikea
ILMxLAB
Imax
IMF
Imperial College London
Impossible Burger
Inception VR
Indian Space Research Organization
Industrial Light and Magic
ING
Ingenico
Inmarsat
Innerspace VR
Inox Wind
Instagram
International Social Science Council
International Union of Biological Sciences
Internet Archive
Interorbital Systems
Intersect Power
Interviewed
Intrepid
Intuit
Investigative Reporters & Editors
Ionic Materials
Ionity
Ioscoot
IOTA
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iRobot
IRS
Iwatani Agrigreen
iZettle
Jaguar Land Rover
Japan 2020 Olympic Committee
Japan Airlines
Japan Plant Factory Association
Japanese Ministry of Economy, Trade and Industry
JD.com
Jeeva Wireless
Jiangxi Ganfeng Lithium Co.
Jigsaw
Joby
John Deere Labs
Johns Hopkins Applied Physics Laboratory
Johns Hopkins University
Johnson Controls
JPMorgan Chase
Juniper
Just
Kanagawa University

Karem Aircraft

Karlsruhe Institute of Technology

Kawasaki Heavy Industries

Kepler Communications

KeyBank

Khosla Ventures

Kia

Kind Ads

Kitty Hawk

Kiva Systems

Klarna

Kleiner Perkins Caufield Byers

Knewton

Knowledge Network for Biocomplexity

Kodak

Kodak Coin

Kohler

Komatsu

Kongsberg

Kontakt.io

KUKA

Kuwait Petroleum Corporation

Laboratory for Embedded Machines and Ubiquitous Robots at UC Los Angeles

Lancashire Holdings

Lausanne and Sant'Anna School of Advanced Studies

Lawrence Livermore National Laboratory

Lenovo

Leo Burnett

LexisNexis

LG

Libsyn

Light Sail VR

Lightning Labs

Lime

Line

LinkedIn

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Magic Leap

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Mastercard*

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Matrix Industries

MatterMost

Mazda

MDA

Meatable

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MediaOcean

Medicaid

Medicare

Meditech

Meeka

Melcher Media

Memphis Meats

Mercedes Benz

Meredith Corp*

MetaX

Michigan State University

Microbiome Center at the University of Chicago

Microsoft*

Mirror

Missouri's Road to Tomorrow initiative

MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)

MIT Department of Materials Science and Engineering

MIT Media Lab

MIT's CSAIL's Soft Contact Modeling Group

MIT's Department of Civil and Environmental Engineering

MIT's Department of Mechanical Engineering

MIT's Interactive Robotics Group

Mitsubishi

Mitsubishi Electric

Mitsubishi Heavy Industries

Mobike

Monero

Monsanto

Monzo

Morgan Stanley

Morpho

Motech

Motorola

MuleSoft

N26

Nanyang Technological University

Narrative Science

NASA

NASA Ames Research Center

NASA Unmanned Aircraft System (UAS)

NASA's Robotics Alliance Project

National Academy of Science

National Association of City Transportation Officials (NACTO)

National Association of Manufacturers

National Center for Atmospheric Research

National Conference of State Legislatures

COMPANIES, ORGANIZATIONS, UNIVERSITIES AND GOVERNMENT AGENCIES MENTIONED IN OUR 2019 TRENDS REPORT.

National Cybersecurity Alliance

National Emergency Address Database

National Federation of Agricultural Cooperative Association (Japan)

National Geospatial Intelligence Agency

National Institute for Computer-Assisted Reporting

National Oceanic and Atmospheric Administration (NOAA)

National Public Radio*

National Science Foundation's Expeditions in Computing Program

National Security Agency

National University of Defense Technology (China)

Naval Postgraduate School

NCSL

NEC

NeighborGoods

NEO

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NetIQ

Neura

Neuralink

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New Relic

New Wave Foods

New York City Council

New York Times*

News Corp

Nextar Broadcasting Group

NextEra Energy

Nielsen

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NovoEd

NRL Naval Center for Space

NSLComm

NuProbe

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Oberthur Technologies

Obie

Ocado Technology

Oculus

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Office of Naval Research

Office of Science and Technology Policy*

Ofo

Ogilvy & Mather

Omega Group

OneWeb

OPEC countries

OpenAg Initiative at MIT

OpenBiome

Opener

Oracle

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Otherside Entertainment

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Oxford University

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Peking University

Penn State University

Perception Squared

Perfect Day

PETA

Peterbilt

Petro China

Philip Merrill College of Journalism at the University of Maryland

Pipistrel Aircraft

Planet

Planet Labs

Planetary Resources

Plantix

PlantJamme

PlantVillage

Playful Corp

PlugShare

Plum

Po.et

Pocket

Polytechnical University of China

Porsche

Postmates

Potsdam Institute for Climate Impact Research

Power Company of Wyoming

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PRI

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Reddit
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SANParks Data Repository
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Scuola Superiore Sant'Anna
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Shapeways
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Sinopec
SkillSurvey
Skip
Sky and Space Global
Skype
Slack
Slushpool
Smart Ag
SmartThings
Snap
Socure
SoftBank
SoftBank Capital
SoftBank Group
SoftBank Robotics
Solar Roadways
SolarCity
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SONM
Sony*
Sony CSL
Sony PlayStationOrbus VR
SoundCloud
Space Exploration Technologies Corp
Space Systems Loral
Spaceflight Industries
SpaceKnow
SpacePharma
SpaceX
Sparkbox
SpeakPipe
Spin
Spire
Spotify
sPower
Sprint
Square
SRI International
Standup Alice
Stanford Center for Philanthropy and Civil Society
Stanford Computational Journalism Lab
Stanford University
Stanford University Computational Imaging Lab
Stanford University's Sonnenburg Lab
StarLab
Starsky Robotics
StartVR
Steel Crate Games
Steem.io
Steemit
Stellar
Stitcher

COMPANIES, ORGANIZATIONS, UNIVERSITIES AND GOVERNMENT AGENCIES MENTIONED IN OUR 2019 TRENDS REPORT.

Stratasys

Stratolaunch

Subaru

Substack

Sulzon Group

Suncor Energy

Sungenta

SunPower

SuperMeat

SuperPhone

Survios

Swellpro

Symantec

Syngenta

Synopsys

T-mobile

TaKanto VR

Talent Sonar

Tamedia

TDBank

Technische Universitat Berlin

Tencent

TerrAvion

Tesla

The Academy of Optoelectronics at the Chinese Academy of Sciences in Beijing

The Aerospace Corporation

The American Gastroenterological Association Center for Gut Microbiome Research & Education

The American Gut Project

The Coral Project

The FCC

The Food Research Institute of Norway

The Information

The International Union of Geological Sciences

The Nature Conservancy

The Onion

The Roosevelt Institute

The Royal Society for the Encouragement of the Arts, Manufacturers and Commerce

The Union of Concerned Scientists

The Void

The We Company

Thingful

ThreatMetrix

Three One Zero

Time Inc*

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TinyLetter

Tohoku University

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Tomiyama Corporation

Tonal

ToolLocker

Toray

Tow Center for Digital Journalism at Columbia University

Toyota

Toys Trunk

Transcelestial

TRON

Trustify

Tsinghua University

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Turo

Twilio

Twitch

Twitter*

Tyson Foods

Uber

uBiome

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ULC Robotics

Ultivue

UN Food and Agriculture Organization

UNESCO

UNHCR

United Nations

United Nations' Intergovernmental Panel on Climate Change

United Power

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University of Amsterdam

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University of Pennsylvania

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US Army

US Army Research Office

US Census

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US Department of Homeland Security

US Department of Housing and Urban Development

US Department of Justice

US Department of State*

US Department of Transportation

US Environmental Protection Agency

US Federal Chief Information Officer

US Federal Communications Commission

US Federal Trade Commission

US Food and Drug Administration

US Geological Survey

US Government Accountability Office*

US House Armed Services Subcommittee on Emerging Threats and Capabilities

US National Science Foundation*

US Securities and Exchange Commission

US Space and Missile Defense Command

USAA

Valero Energy

Validic

Valve

Vaultitude

Vayable

Vedanta

Venmo

Verizon

Vestas Wind Systems

VEX Robotics

Via

Viacom

ViaSat

Vice

Viome

Virgin Galactic

Virgin Group

VirtualSKY

Visa

Viveland

Vivify

VML

Voicery

Volkswagen

Volocopter

Volvo

Vox Media

Voxeljet

VRNISH

VRX Networks

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Wall Street Journal*

Walmart

Washington Post

Wawa

Wayfair

Waymo

WeChat

Weibo

Weiden+Kennedy

Wells Fargo

WeMedia

Wevr

WikiLeaks

Wix.com

Wolf 359

Worchester Polytechnic Institute

WordPress

Workbot

World Bank

World Building Institute

World Privacy Forum

World Resources Institute

WorleyParsons Group

Wyss Institute at Harvard

X.ai

XCOR Aerospace

XENDEE

Xiaomi

Xinjiang Goldwind Science and Technology

XL Group

Y Combinator

Yahoo

Yamaha

Yitu

Yomiuri Shimbun Holdings

YouTube

Yuneec

Zeiss

Zelle

Zendesk

Zipline

Zoetic AI

ZTE

Zuercher

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