

Bloomberg Businessweek

The blackest black p68

SPECIAL DOUBLE ISSUE
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THE Global Tech ISSUE



The challenge

There are 2 billion people without access to basic banking.
How can Temenos help microfinance institutions
give more people access to banking?

The business

The Microsoft Cloud helped Temenos
bring banking to 10 million people
in just two years.

The solution

By putting their core banking software
in the cloud, microfinance institutions
were able to lower the cost
of borrowing by 90%.

The security

Temenos trusts the Microsoft Cloud to meet strict
security requirements to ensure clients' personal data
is protected, rather than asking each microfinance
institution to defend its own firewalls.

This cloud opens doors
of opportunity.





Resilience

Smart Innovation at High Speed

Being on the cutting edge means managing unfamiliar risks



The 3D printing market is expected to grow to \$17 billion by 2020.

Around the turn of the last century, at the most prestigious golf tournament in the world, a player with whom few were familiar showed up and completely outperformed the field. He won the title easily, but he didn't win many admirers among his fellow competitors or the media. Walter Travis triumphed at the 1904 British Amateur Championship, which at the time was the biggest competition anywhere, using a putter with an innovative and unprecedented design. The shaft attached to the center of the clubhead—unheard of in golf's early days—and its disruptive effect on the psyches of other players was invaluable.

Repercussions and risks

Technological innovation is much different today than it was in 1904, but the impact is similar. In modern business, you can gain a competitive edge by adapting new technology into your business success plan and managing the risks that always accompany opportunity.

Or you can be like those golfers who grumbled about Walter Travis while their world was disrupted.

"It's critical to understand the effects of technology on your business when the pace of innovation is as rapid as it is today," says Craig Fundum, President, Commercial Markets at Zurich North America. "For example, 3D printing will likely drive innovation in every global industry—but if you're a manufacturer, you will most likely be among the first and most profoundly affected. The Internet of Everything will be a game-changer too. How connectivity alters the way physical assets are controlled

will be felt across all business sectors. If you're a software developer, you won't be able to focus solely on moving and manipulating data. What you create could have new repercussions and cause financial loss."

The risks and potential associated with technology are especially profound as the global business world goes about its work in these early days of what is being called the Fourth Industrial Revolution. The interaction of technologies across the physical, digital and biological domains will transform many industries.

"This profusion of technology will likely affect the strategies and operations of most businesses at some point," says Fundum. "The future of businesses will be shaped by how they use these innovations—and how effectively they manage the risks associated with them."

Scope of innovation demands resilience

Improvements in artificial intelligence—especially in the areas of facial and speech recognition, video analytics and relationship analysis—are driving greater demand for data to better understand customer behavior. In turn, the demand for both structured and unstructured data will drive Internet of Everything-related revenue to

\$1.27 trillion globally by 2018, according to International Data Corporation.

At Zurich North America, the focus is on helping businesses protect themselves by understanding and managing the risks from one stage of this technological evolution to the next. Aware that its customers are embracing emerging technologies, Zurich is pursuing advances such as robotics and cognitive computing to help the company be more efficient and effective in serving customers.

"These efforts, combined with our data and analytics, are enabling us to think differently about exposures and help manage business risks like never before," says Fundum. "It's nearly impossible to fathom all of the potential innovation and growth in such a digitally connected world. Businesses must protect themselves by continually increasing their resilience to the risks created by innovation. If they can commit to a mindset of resilience and plan to mitigate new types of losses, then when challenges do arise, they can quickly get back to meeting the expectations of their customers and shareholders. By adapting to new risks and the new solutions to them, businesses can ensure that technology can be a key component of a winning strategy." ●

"Businesses must protect themselves by continually increasing their resilience to the risks created by innovation."

— Craig Fundum, Zurich North America

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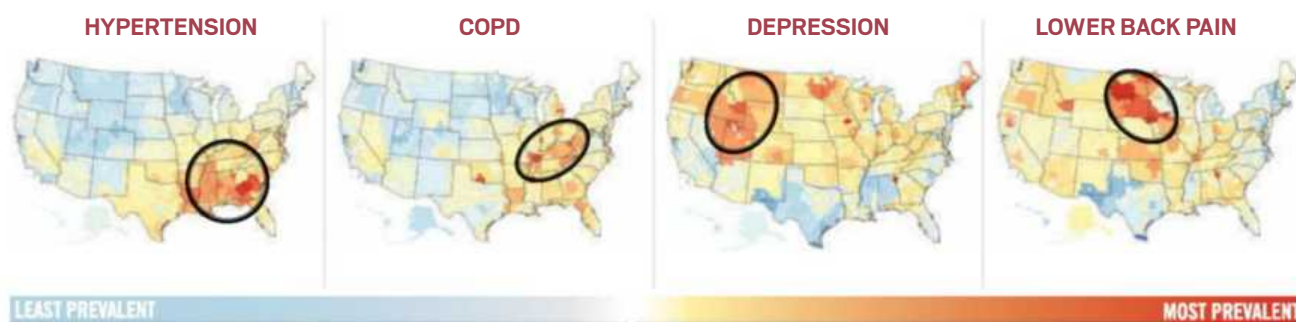
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Data-Driven Health Care

THE GEOGRAPHY OF DISEASE



◆ There are plenty of doctors, but no white coats, in the Cambridge, Mass. offices of OptumLabs™.

With a focus on science and discovery, the research and innovation collaborative examines data, not patients. Optum® partners across the entire health system in helping solve health care's biggest challenges. Its goal is to help employers, insurance companies, providers, life science organizations, governments and others understand health care in all its complexity, and find ways to improve care and reduce the costs.

The Optum™ CommunityHealth dataset tracks close to 100 different health metrics in more than 300 communities nationwide, enabling researchers to quickly visualize and understand key differences and similarities across markets. The proprietary dataset provides researchers with information from more than 100 million patients—with all the data anonymized to ensure patient privacy.

It offers comparisons of health, well-being, social factors and healthcare system quality in communities across the U.S. Using this data, employers can investigate which interventions can improve care for their employees, and where their implementation will have the greatest impact.

Some of the regional variations are easy to understand. The higher prevalence of hypertension in the South coincides with

the higher incidence of a variety of other serious conditions there, including diabetes and high cholesterol, according to OptumLabs CEO, Dr. Paul Bleicher, M.D., Ph.D. The high incidence of chronic obstructive pulmonary disease (COPD) in the Ohio River Valley, particularly in West Virginia and Kentucky, correlates with communities that report some of the highest levels of smoking per capita.

Another example: There are more reported cases of depression per capita in the Rocky Mountain states than in other regions. That may be because a higher percentage of Rocky Mountain residents are depressed—but it may also be because they are “more likely to go to the doctor, or more likely to tell the doctor about their symptoms, or the doctor may be more likely to diagnose depression than do doctors in other regions,” says Bleicher.

Sometimes even a dataset as sophisticated as the one at OptumLabs is insufficient to provide insights on some findings. For instance, none of the almost 100 factors tracked correlates closely with the high incidence of lower back pain in the Great Plains states.

In all the regions, by appreciating “the measures of community behavior that are correlated with—and in some cases are known to be responsible for—these diseases and conditions,” employers can fund preventive health care measures and interventions in a way that will deliver maximum value to them and their employees, Bleicher says. ●

WHEN WE
HAVE THE TOOLS TO
PREDICT
IT'S AMAZING WHAT WE CAN
PREVENT



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If you could see into the future and prevent something bad from happening, wouldn't you? At Optum, we use predictive analytics to provide doctors and hospitals with insights that help identify at-risk patients and get them the care they need. As a health services and innovation company, this is one of the many ways Optum connects all parts of health care to achieve better outcomes.

optum.com/healthier



WORLD CLASS AS STANDARD

Leveraging Data to Find an Edge

Whether on the golf course or in the markets, the line between stardom and mediocrity is razor-thin—and data analysis is a key differentiator

When competing at the top level in anything—especially when money is involved—the difference between being king of the road and middle of the pack is generally miniscule. Consider this stat from the PGA TOUR: At press time, the difference between the players ranked No. 1 and No. 30 in scoring average was a mere 0.946 (69.731 to 70.677), or less than a single stroke per round. Yet that disparity equated to a nearly \$4 million gap in 2016 earnings between the two players.

Finding that edge is what keeps professional golfers awake at night. In the days before Big Data came to the game, this largely meant replaying rounds in one's mind, trying to intuit patterns: *Am I coming up short on approach shots? Pushing drives? Pulling putts?* Today, there is a more efficient way to make up for that lost stroke.

Deep data dives

Using robust data technology, such as the PGA TOUR's ShotLink System that

tracks every shot by every player in every round, the opportunity now exists to be far more objective about one's performance. In golf, as in investing, however, the trick is focusing on the meaningful data, rather than on mere noise.

"You want to look underneath the scores," says Mark Broadie, a Columbia Business School professor and a pioneer in the field of golf analytics. "You need to control for other factors to understand the information content of the scores."

Data analytics has already demonstrated its clear utility as a diagnostic tool. Players whose stats are weak in a certain area—approaches from 225–250 yards, for example, or right rough avoidance—now use this information to guide their training and alter their practice routines.

Big Data isn't only impacting technique and psychology, but also course strategy. Whether on their own or with one of the number-crunching gurus beginning to appear within the players' inner circles,

top pros are now applying data analytics to decide, for example, whether to use a driver or a safer 3-wood off the tee on certain holes, which pin positions on a particular green to attack, or which par-5 holes are best attempted to reach in two shots versus three—all of this to find the sliver of edge on which outperformance rests.

Avoiding the rough in investing

This strategic approach is familiar to Standard Life Investments, the first Worldwide Partner of The Ryder Cup, the biennial match-play event between the U.S. and Europe that will take place in September at Hazeltine National Golf Club, in Chaska, Minn.

Standard Life Investments is well known in Europe and the U.K., and in the last five years it has doubled its global client base, expanding its footprint to the U.S. and beyond. Much of that success is due to an approach that emphasizes—like The Ryder Cup—melding highly talented individuals



Worldwide Partner of The Ryder Cup





“There’s more data than ever to access, but that data means nothing unless you can analyze it using sophisticated empirical approaches.”

—Jeremy Lawson, Chief Economist, Standard Life Investments

into a cohesive unit that prioritizes the prosperity of the team.

“The Ryder Cup features the best of the best players, but individual skills will not decide the winner,” says Jack Boyce, Standard Life Investments’ Managing Director of Distribution for North America. “We believe that working as a team is what gets real results, and is what drives investment success.”

Where amateur golfers quake when contemplating a fearsome shot over water to a tiny target, pros see the chance to separate themselves from the field. Investment professionals likewise recognize the opportunities presented by volatile markets. Identifying misalignments when fear reigns

offers the chance to make money when others are keen to pull back.

“You need to identify the right data to answer the question you’re interested in,” says Jeremy Lawson, Chief Economist, Standard Life Investments. “There’s more data than ever to access, but not all data is true information content. And that data means nothing unless you can analyze it using sophisticated empirical and analytical approaches to tease out the true structural relationships between variables.”

In trying to ascertain the deeper connections between various economic indicators and asset returns, and how those correlations might be changing over time, Standard Life Investments continues to develop its own

analytical tools. The company’s powerful, proprietary financial stress index, for example, takes in vast amounts of market information—volatility, credit spreads, liquidity, macro data, among numerous other variables—and summarizes how the market is behaving. Even more significantly, it contains forward-looking information about how economies are evolving and what the environment may look like over time. On the fairways and in the financial trenches alike, using data to make sense of recent history can lead to hazards avoided and a more prosperous future. ●

Find out more at
www.standardlifeinvestments.com/rydercup



Worldwide Partner of The Ryder Cup

**Standard Life
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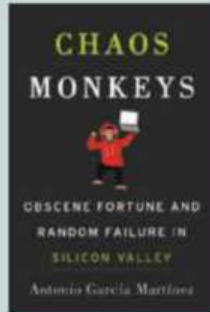
Amazon's Summer Tech Reads

Just in time for your family vacation, long weekend or daily commute (if you still insist on going into work), these technology-themed books—all coming to a Kindle near you in the coming months—pack much more intellectual punch than your typical beach-friendly page turner. But that doesn't make them any less entertaining.



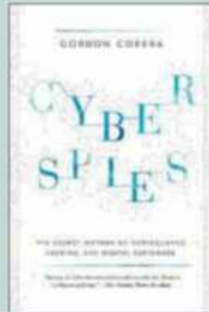
Unboxing IT: A Look Inside the Information Technology Black Box
(May 20)

Most homeowners can plunge a toilet or fix a blown fuse, yet most computer owners see their technological know-how top out at hitting control-alt-delete. Use this book to get inside the head of an IT professional, so that the next time your laptop is stuck in a rut, you'll have a better game plan than to panic and restart.



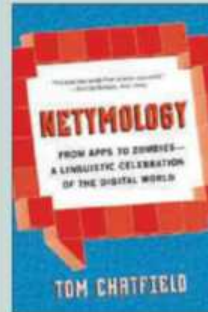
Chaos Monkeys: Obscene Fortune and Random Failure in Silicon Valley
(June 28)

Your tour guide on this behind-the-scenes look at the tech industry, Antonio García Martínez, pulls no punches—not exactly a surprise considering he's the guy who once flooded Mark Zuckerberg's desk while brewing beer at the office, and who currently lives on a 40-foot boat in San Francisco Bay.



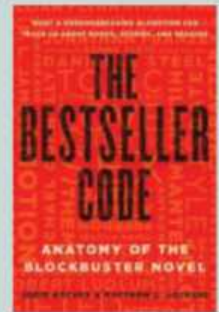
Cyberspies: The Secret History of Surveillance, Hacking, and Digital Espionage
(July 5)

The history of digital espionage is much bigger, and older, than Edward Snowden. Leaning on sources that range from hackers to heads of state, author Gordon Corera explores data collection from World War II through the Cold War, and up until today, to ponder how intelligence gathering has reshaped the world.



Netymology: From Apps to Zombies—A Linguistic Celebration of the Digital World
(Aug. 2)

Did you know that Apple's looped square command key (⌘) is known as St. John's Arms and has its origins in 1,000 B.C. Scandinavia? Probably not. But if that fact interests you, Tom Chatfield's 100-entry book exploring the origins of the Internet's most famous slang and memes will have you feeling like less of a *n00b* in no time.



The Bestseller Code: Anatomy of the Blockbuster Novel
(Sept. 20)

It sounds like something straight out of *The Da Vinci Code*: a hidden algorithm that considers plot, pacing and even punctuation to predict with 97 percent certainty if a novel will claw its way to the top of the *New York Times* bestseller list. Tip No. 1: Try to make your main character a 28-year-old woman who owns a dog. ●



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"The cover will be for our second Global Tech issue."

"What's going to be in it?"

"A diverse group of stories, ranging from a tech lab in Egypt, to a do-it-all app in China, to a DIY workshop in Australia. One of our biggest stories takes place here in the U.S., where Larry Page is investing more than \$100 million of his own money in a company developing a flying car."

"Wow! I can't wait to see what this thing looks like. Can we get a photo for the cover?"

"Yes, the writer is calling Larry's office about it now."

[One week later]

"When can we see the photo?"

"They never returned our call."

"Typical. Well, I'm sure we can get an artist to make an educated guess."

[To artist]

"Hello, we need to imagine a design for a flying car. One of the most powerful men in technology is backing it, and more than \$100 million has been invested. Think of this design as the most realistic and most futuristic vision of the next evolution of personal transportation."





WHAT HAPPENS WHEN

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Software know-how has Michigan company soaring.

Safer. Faster. That is the promise of the drone software developed by Ann Arbor-based SkySpecs. Used initially to inspect wind turbines, use for cell towers, bridges and sewer systems is not far behind. "There's a huge opportunity to augment existing inspection processes that are labor intensive, dirty or dangerous with a drone," says co-founder Tom Brady. It's the type of innovation you'd expect from a state whose aerospace industry generates nearly \$1 billion in annual sales. The kind of promise that's Pure Michigan.

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Are the days of test drives numbered?

Most buyers of new vehicles today would not consider putting down a payment without first having driven the car out of the showroom and road tested it on the surrounding streets. But the explosive growth of Virtual Reality (VR) and 360-degree video is fast providing an alternative to actual test drives.

A new form of 'try before you buy' is emerging that doesn't require the purchaser to turn the ignition key – or even visit a dealership.

In the future, some test drives will be done from the comfort of living rooms and bedrooms. The virtual test drive experience of tomorrow promises to be rich and multi-layered, allowing the buyer to learn far more about the vehicle and its performance in different environments than from a drive around the block.

Instead of starting the journey at a dealership on a suburban trading estate, the VR test driver can be instantly transported to the Big Sur, Alpine hairpins or their favourite race track.

Last September, a virtual drive featuring former racing driver, Ben Collins, in a BMW 640M went viral thanks to a 360-degree experience created by a partnership with technology company Rewind. Cutting-edge technology stitched together footage from a constellation of cameras to provide the immersive experience.

The end result is impressive on a laptop or phone, but truly comes into its own if wearing a headset that places the drive in

front of your eyes; a 3D journey with a genuinely immersive ride. Such headsets are already on sale to the public.

Louis Jebb, Founder and CEO of Immersivly, makers of editorial content in virtual reality, is among those who believes the potential use of VR and 360-degree video for test drives is enormous.

"We can expect the use of layers to deliver alternative outcomes in 360-degree video, as varied as in a traditional computer game. In a test-driving experience these could include variations in route, terrain, light and weather conditions."

These 360-degree test drives are shot from cameras placed at the driver's eye-line. For manufacturers, the limitless nature of the VR test drive offers huge advantages over traditional showrooms with their high rents and floor space for only a fixed number of vehicles. The VR test drive will mean that drivers can experience new models before they have even reached the showroom.

Julia Saini, Director of Growth Consulting for Automotive and Transportation at consultants Frost & Sullivan, predicts that such facilities in prime locations will transform the way cars are tested and sold.

"The halo effect of the digital showroom in the heart of the city is expected to drive sales to outer stores and potentially affect dealership network setups, both in terms of size and total number of traditional dealerships," she says.

Established car manufacturers are not the only ones exploring this space, with some digital and technology companies also working on creating digital showrooms where buyers can customise dream cars from a choice of millions of configurations.

Away from consumer test drives, BMW Group has become the first car manufacturer to encourage its engineers to use VR technology to 'test drive' vehicles during the designing and building process.

The engineers wear HTC Vive virtual reality headsets and use high-end computer gaming graphics to replicate multiple driving environments that help them to identify the optimum placement of components and seating without leaving the factory.

In addition to the visual sensations, BMW Group employs a reusable interior assembly to further enhance perception by producing a mixed reality experience. Precise, stereoscopic acoustic playback helps to create the characteristic BMW engine sound and intensifies the immersive experience. ●

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for the whole series



The Future is Sun(ny) in Hawaii

By leveraging solar power, the Aloha State takes its next big step to 100 percent renewable energy by 2045



Call it a sun-kissed irony: The very remoteness that makes Hawaii an ideal getaway is also the source of the energy challenges that face the island chain. Unlike the continental states, which can rely on cross-border utility systems in times of need, Hawaii is isolated. Even the islands are separated by deep-sea chasms that make running underwater cables challenging—and expensive.

Factor in the distance from the mainland (2,390 miles to California), and the current electrical system in Oahu, which gets more than 80 percent of its power from fuel oil, is becoming antiquated and costly to maintain. However, the two power sources that Hawaii has in spades—solar and wind—don't yet deliver the reliability of pricier fossil fuels.

“Solar and wind production is variable. It's not like you can say, ‘I want this amount’ and press a button,” says Dora Nakafuji, Director of the Renewable Energy Planning Division at the Hawaiian Electric Company. “Integrating significant variable resources can offer real challenges on a system that needs to maintain and manage its own reserves.” But thanks to an injection of capital from the U.S. Department of Energy (DOE) and private-sector partnerships, Hawaii's future is brightening.

As part of its SunShot SHINES Initiative, which has invested more than \$3 billion to support emerging photovoltaic technologies, the

DOE awarded \$2.5 million to Hawaiian Electric to assist in its quest to increase the integration of solar energy on Oahu. And to incorporate automation of distributed energy resources (DER) to the grid, Hawaiian Electric turned to Siemens Distributed Energy Resource Management (DERMS) software.

This intelligent grid solution from Siemens interfaces with Hawaiian Electric's solar monitoring, real-time forecasting and DER installation tracking. Together they shine a ray of light on data that had previously been difficult to see (total capacity of PV energy, near-term load forecasts, etc.) from the farthest edges of the grid, including distribution circuits with high levels of customer-sited, private solar generation that feed eastern Oahu, particularly the critical urban center of Honolulu.

With these resources, Hawaiian Electric can more effectively integrate renewable resources and manage demand, helping its grid evolve from one that simply adds capacity to one that leverages existing capacity through monitoring, control and automation. The result also increases reliability, reducing potential outages and outage times while delivering new cost efficiencies to residents.

As it strengthens its grid and information capacity, Hawaiian Electric can look ahead to smart integration of renewable power, transitioning to a multi-directional model able to maximize renewable energy use on the island. Management and coordination remain tasks, to be sure, but ones that can be met head on in collaboration with industry stakeholders and utilities.

“This is the most remote populated area in the world, so the issues here are orders of magnitude different than they are on the mainland,” says Ken Geisler, Vice President of Strategy for Siemens Smart Grid. “It's a unique situation, but it will have an amazing impact on the problems that will hit the rest of the states in the future.”

Indeed, while other states have not (yet) committed to 100 percent renewable energy by 2045, as Hawaii has done, many are watching Hawaii's efforts as the push to green energy intensifies.

“Every utility will create its own path,” says Nakafuji, but Hawaiian Electric won't go it alone. “We need like-minded partners to get there. These partners are also being pushed to adopt this information into their traditional tool sets, so together we're exploring ways to create a more optimal, efficient system.” ●



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When will an idea bring the future forward faster?

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Opening Remarks

When The State Wilts Away

By Lois Parshley



Venezuela was unraveling even before Hugo Chávez died in 2013. The situation has only gotten worse since. Despite having the world's largest oil reserves, inflation has soared to 500 percent, the murder rate is the highest in the world, and chronic shortages of food, water, and medicine make daily life a struggle. A man was recently burned alive outside a supermarket in Caracas for stealing the equivalent of \$5. "The country has been on a downward spiral for so many years," says Cynthia Arnson, director of the Wilson Center's Latin America Program, "you wonder what is going to be the final straw."

Recently, it looked like it might be the weather. Six months ago, a devastating El Niño-induced drought damaged crops, left the capital short of drinking water, and caused rolling blackouts. In April, as a lack of rain crippled the Guri hydropower project, the country's biggest electricity supply, President Nicolás Maduro announced a two-day workweek for civil services. (He also suggested women stop using blow-dryers: "I always think a woman looks better when she just runs her fingers through her hair and lets it dry naturally.") In May, Maduro changed the country's time zone by half an hour to save power. "Drought and electricity cutbacks have created a new moment that will have its own dynamic," Arnson says. "The level of inefficiency and breakdown of public services has been

so rampant that any natural disaster has been magnified."

"You've got a mess, to put it mildly," says political scientist Thomas Homer-Dixon, associate director of the Waterloo Institute for Complexity and Innovation. "Where institutions are not capable, severe environmental stress can tip society into catastrophe quickly."

That's not just true in Venezuela. In 2007 an extreme drought in Syria baked fields until they became deserts, destroying crops and driving families from their homes. The rain didn't come back for three years. Rural populations fled to cities, adding to the social tensions that eventually sparked the uprising in 2011. Years of violence followed, leading to the refugee crisis that's besetting Europe. Last spring, Colin Kelley, a meteorologist at the University of California at Santa Barbara, linked the drought—Syria's worst in 900 years—to global warming. "A drought of the severity and duration of the recent Syrian drought," Kelley wrote in a paper published at the Proceedings of the National Academy of Sciences, "has become more than twice as likely as a consequence of human interference in the climate system."

Of course, social uprisings are complicated things, and Kelley reignited a debate on just how climate affects conflict. "People for the most part don't fight over environmental resources," says Homer-Dixon. "What happens is that you get internal dislocations in

In weak nations, environmental stress can tip society into catastrophe



society. People dependent on scarce resources become poorer and may move in large numbers.”

There’s abundant potential for such dislocation in Venezuela. The weather has only exacerbated the country’s economic crisis. Last month, Maduro issued a state of emergency granting himself unilateral power over the economy. He threatened to seize idle factories. Arnson now fears violent protest may be likely.

“Powerful groups, especially in corrupt states, use their power to capture resources,” says Homer-Dixon. “You get a polarization of wealth, a weakening of state capacity, and urban stress.” Although these kinds of changes are indirect effects of a drought, they are often the tipping point for social conflict. “We are seeing these things around the world now,” Homer-Dixon says. “As environmental stresses get worse, [their effects] become more common.”

Global water shortages are predicted to decrease global gross domestic product by as much as 14 percent by 2050, according to a recent report by the World Bank, which predicts that this “severe hit” will spur conflict and migration across the Middle East, Central Asia, and Africa. Even resource-rich countries previously considered to have stable economies, such as Brazil and Russia, have become more susceptible to environmental disequilibrium. Last year production of coffee, one of

Brazil’s most important commodities, fell 15 percent as a result of drought. A lack of rain in Russia this fall damaged a quarter of its cereal crops. The last time the country’s harvest failed, rising global prices contributed to the Arab Spring in countries dependent on imported grain. Even Islamic State’s political power may soon be affected by drought. As water levels in Lake Assad in Syria plummet, Raqqa, the group’s stronghold, is facing severe shortages. Last year, Islamic State’s press officer, Abu Mosa, told Vice News that it would consider attacking Turkey to gain access to additional water resources.

Climate science has an explanation for why environmental forces can have this kind of destabilizing effect. Angel Muñoz, a postdoctoral research associate at Princeton, says, “Risk is just a multiplication of hazard by vulnerability.” Muñoz, who grew up in Venezuela and moved to the U.S. to study climate risk management, explains that a drought is a hazard, but what actually created this year’s mess was Venezuela’s lack of what he calls “adaptive capacity.” The drought was predicted months before it began—neighboring Colombia started water rationing in September 2015. Although Venezuela has far more natural resources than its neighbor, Colombia is not in such dire straits. “A society’s vulnerability is at least as important as the hazard,” Muñoz says.

As a result, when weak states

Venezuela and Syria offer a grim vision of how the world might react to a warming future

face environmental catastrophes like drought, “you might see the collapse of authoritarian regimes, as you did during the Arab Spring,” Homer-Dixon says. “But they’re probably going to be replaced with something just as bad, because a deeply divided society is still dealing with a materially stressed situation.”

If that’s the case, Venezuela and Syria offer a grim vision of how the world might react to a warming future. “In almost all conflict,” Homer-Dixon says, “a weak and corrupt state can’t evolve market mechanisms to respond to scarcity.” This means dysfunction tends to have a snowball effect: Scarcity reinforces corruption, which polarizes a political system and increases inequality. “Then everyone slides down the slope together,” Homer-Dixon says.

What that means for Venezuela now is that even the return of rain could be devastating. Meteorologists are predicting a La Niña effect will bring ample precipitation to the region—“they could go straight from drought to fast floods,” Muñoz says, because of degradation of public resources such as roads and sewage systems. The government is unlikely to be prepared. A high-ranking official in Venezuela’s military, who didn’t want to be named for fear of retaliation, says little is being done to strengthen the aging infrastructure. “We have so many resources,” he says. “It’s incredible that we’re in this situation.” He’s contemplating leaving the country, fearing a coup. “People don’t have the patience to see if things get better.”

No one knows when Venezuela will finally implode. Some factors are more visible in hindsight; just as analysts failed to see the risk of subprime debt in 2007, so far scarcity’s economic and geopolitical impacts have gone largely unacknowledged. Behavior, however, can often be predicted based on models. In a warming world, “it’s a difficult situation to build liberal institutions,” says Homer-Dixon. “I’m very worried.” With Venezuela specifically in mind, Arnson asks, “Who defines when the beginning of the end has begun?”

Parshley is a freelance journalist and photographer.

Bring on the Blockchain Future

Don't let regulation delay this global solution to the weaknesses of the financial system



In the eight years since the crash, regulators have made some progress in strengthening the global financial system, but the structure is still not as robust as one might wish. In principle, new technologies—including blockchain, the idea that underlies bitcoin—could help fix some of this fragility. It's a possibility well worth pursuing.

In what ways is the system still weak? Crucial functions—such as payments and trading—remain concentrated in large, undercapitalized banks or other central hubs; despite regulators' efforts, losses at those institutions could still have economywide repercussions. To make matters worse, the authorities don't yet have a clear real-time picture of what's happening in financial markets or where risk is concentrated. Blockchain technology is capable of addressing both issues.

Finance is about trust: Institutions evolved to enable transactions with strangers. Centralized intermediaries of various kinds solved that problem, keeping track of who owns what and who owes whom. But they also create points of systemic vulnerability. Blockchain establishes trust in a new way. It creates a so-called distributed ledger, which maintains a complete history of all participants' transactions—verified and recorded across a network of computers spread around the world. The record resides in so many places that it can't be lost or tampered with.

Now imagine all transactions—from paychecks to derivative contracts—residing on a public distributed ledger. Everyone, including regulators, would be in a much better position to see (and to head off) dangerous exposures. If a major bank ran into trouble, authorities wouldn't have to worry about the impact on vital payment or ledger systems. Governments would be better able to let large institutions fail, restoring market discipline to risk-taking and allowing regulation to be much simpler.

Getting there will take some problem-solving. The question is how to make it happen. Big banks and exchanges are participating in various projects to build private blockchain

systems. The spur is greater efficiency and lower costs. This kind of closed-architecture innovation, however, is unlikely to be transformative in itself. It's aptly known as blockchain on “training wheels.” Startups are also working on public applications, which have greater potential—but regulations put them at a disadvantage. It might be enough to suffocate, or seriously delay, a technology whose most promising uses are global.

The U.K. Financial Conduct Authority has found an elegant solution: a “regulatory sandbox,” where companies can test concepts without submitting to the full compliance burden. This approach needs to go international, with different jurisdictions agreeing to allow experiments with cross-border blockchain applications. If the U.S. took the lead in this effort, others would sign up for fear of being left behind.

The Louisiana Way To Health Insurance

The Bayou State is increasing the uptake rate for Medicaid via food stamp eligibility

Six years after Obamacare became law, about 30 million Americans still lack health insurance. Louisiana has found a trick to get a great number of them to sign up for Medicaid.

The policy is based on a simple coincidence: Medicaid and the federal food stamp program have almost the same income threshold, at least in the 31 states that have expanded their Medicaid programs under the Affordable Care Act. The Bayou State has decided to automatically check to see whether the residents who receive food stamps also qualify for Medicaid—and if so, to reach out and sign them up. This approach will at once lower the state's uninsured rate (one of the highest in the country) and cut Medicaid's administrative costs.

The strategy seems so obvious, it's a wonder no other state has made it policy. Nationwide, some 8.8 million people who are eligible for Medicaid haven't enrolled. To put that in perspective, it's more than the number in any of these categories: people who are eligible for subsidized Obamacare insurance plans but haven't signed up; people who lack insurance because their states have refused to cooperate in the Medicaid expansion; or people who can't get insurance because they're in the country illegally.

Increasing the uptake rate for Medicaid is the single most promising way to reduce the number of uninsured Americans—and it requires no action by Congress. Louisiana has already identified 105,000 potential enrollees. It's true that greater enrollment will increase Medicaid spending. But it will eliminate much of the public cost that arises when uninsured residents seek expensive care in emergency rooms.

Louisiana, whose budget shortfall is among the most severe in the country, demonstrates that enrolling more people in Medicaid doesn't undermine fiscal prudence or good government. That's a message other states should hear. **B**

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FIRST STEP: 0.37 [SEC]
TOP SPEED: 21.7 [MPH]
DISTANCE: 81.3 [FT]



The Next D

► Companies are borrowing money faster than they're making it

► Managers face pressure "to cut capital spending and inventories"

Consumers burdened by their large mortgages and maxed-out credit cards laid the groundwork for the last U.S. recession. This time, companies may play that role: Enticed by super-low interest rates, they increased total debt by \$2.81 trillion over the past five years, to a record \$6.64 trillion. In 2015 liabilities jumped \$850 billion, 50 times the increase in cash holdings by S&P Global Ratings' reckoning. Lagging profits and mounting defaults are other danger signs. Although these financial vulnerabilities aren't likely to lead to another downturn soon, economists say they point to potential risks for an expansion approaching its seventh birthday.

"Companies have been adding to their debt, and their debt has been growing more rapidly than their profits," says John Lonski, chief economist of Moody's Capital Markets Research Group. "That imbalance in the past has usually led to problems" once growth begins to flag. Some are concerned that's already happening, as evidenced by cutbacks in corporate spending and hiring. Case in point: the news that employers expanded payrolls in May at the slowest pace since 2010,

in what economists at JPMorgan Chase worry is a sign of increased company caution. Also, April marked the third straight month of falling orders for business equipment. The \$62.4 billion figure, which excludes defense and aircraft orders, was the lowest in five years, prompting Neil Dutta of Renaissance Macro Research to label business investment "pathetic."

The similarities between the pre-recession debt binge by consumers and company borrowing today are striking. Like households, corporations are using the money for short-term purposes rather than for preparing for the future. A wide gap exists between a handful of ultra-rich companies and the rest of corporate America.

The record \$1.84 trillion of cash on company books is heavily concentrated among **Apple, Microsoft, Google,** and other tech

giants, shows a study released in May by S&P analysts Andrew Chang and David Teshler. Companies that don't have big cash reserves might find it harder to meet debt payments when interest rates rise. Take away the \$945 billion the 25 richest companies rated by S&P hold, and the picture doesn't look particularly pretty for the bottom 99 percent of nonfinancial corporations. Their cash on hand as a percentage of the debts they owe is

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A rapid rebound for Iran's oil sector 24

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Debt Crisis



tripled. Mergers and acquisitions worldwide jumped about 28 percent last year, to \$3.5 trillion, according to data compiled by Bloomberg.

"If you put yourself in the seat of someone responsible for management of a company, they see weak demand," Federal Reserve Governor Jerome Powell said in a May 26 appearance at the Peterson Institute for International Economics in Washington. "They can cut costs, and they can buy back their stock, and they can make their numbers that way for a period of time." McDonald's sold \$6 billion of bonds at the end of last year to help finance higher dividends and share buybacks.

Buybacks and takeovers are starting to tail off as companies feel the effects of falling profits. S&P 500 earnings from continuing operations fell 7 percent in the first quarter of 2016 from a year earlier, data compiled by Bloomberg show. After stripping out energy

companies affected by weak oil prices, earnings were still down 1.4 percent. "There is newly intensified, broad-based pressure on business to cut capital spending and inventories," David Levy, chairman of consultant Jerome Levy Forecasting Center in Mount Kisco, N.Y., wrote in a report to clients in May.

Earnings are being squeezed by lagging worker productivity and mounting labor costs as rising demand for workers forces companies to pay more. Corporations also are confronting lower economic growth expectations. Richmond Federal Reserve Bank President Jeffrey Lacker says he now pegs the potential expansion rate of the U.S. economy at 1.5 percent. That's half the average pace in the quarter-century

that preceded the December 2007 start of the last recession.

Lonski of Moody's says it's premature to predict that the U.S. is heading ▶

at its lowest level in a decade, according to S&P. More than 50 U.S. companies have defaulted on bonds or loans so far this year, double the number in the same period in 2015. Among the companies that have missed payments, according to S&P: **Peabody Energy** and **Midstates Petroleum**.

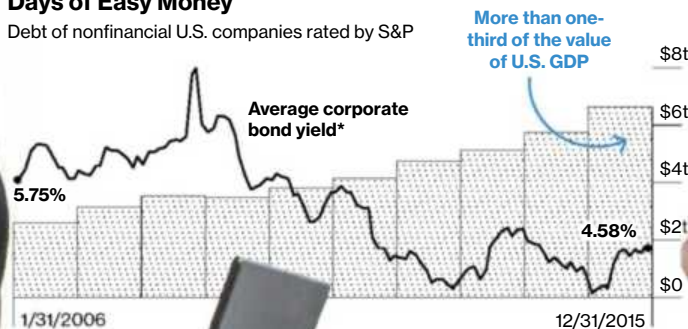
For the most part, companies aren't pouring the money they borrow into capital expenditures to increase efficiency and capacity—investments that could boost profits down the road. Instead, much of it has gone to finance share buybacks, dividend hikes, and acquisitions.

Since 2009, S&P 500 companies have spent more than \$2 trillion to repurchase shares, helping sustain a rally in which stock prices almost



Days of Easy Money

Debt of nonfinancial U.S. companies rated by S&P



*MOODY'S U.S. CORPORATE BOND YIELD INDEX OF LONG-TERM INVESTMENT GRADE NONFINANCIAL CORPORATE BONDS. DATA: S&P GLOBAL RATINGS, MOODY'S

◀ into a recession as employers are still adding workers to their payrolls, albeit at a slower rate. Yet the pressure on companies is “a risk factor that’s worth watching,” he says.

—*Rich Miller, with Tara Lachapelle*

The bottom line U.S. companies may have gone overboard borrowing at cheap rates to fuel stock buybacks, dividends, and acquisitions.

Fiscal Policy

Brazil's Temer Has A Budget Hole to Fill

▶ **Investors are expecting miracles from the acting president**

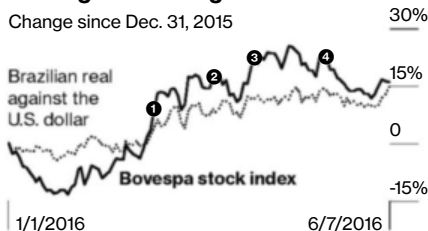
▶ **“You’re having to do this... exercise with a very weak economy”**

Investors are bullish on Brazil. The country’s Bovespa equity index is up almost 19 percent this year, while the real has gained 13 percent against the dollar. One big reason for the rally: President Dilma Rousseff has stepped aside as she awaits an impeachment trial, which has allowed Vice President Michel Temer to take over as acting president.

The financial community expects Temer, a member of the Brazilian Democratic Movement, to pursue more market-friendly policies than Rousseff, who hails from the Workers’ Party. Goldman Sachs, in a research note to clients, dubbed his economic cabinet, led by Finance Minister Henrique Meirelles and Economic Monitoring Secretary Mansueto

Betting on a Change in Brazil

Change since Dec. 31, 2015



1 Former President Luiz Inácio Lula da Silva briefly detained in corruption probe

2 Biggest party quits ruling coalition

3 Two more parties abandon Rousseff government

4 Senate votes to suspend Rousseff and hold impeachment trial

Almeida, the “dream team.” “The political transformation in Brazil is creating huge investment opportunities,” says Jan Dehn, the head of research at Ashmore Group, an emerging-markets investor.

Yet the list of problems Temer and his team must tackle is daunting. In the first three months of 2016, gross domestic product shrank 5.4 percent year-on-year, extending a recession that began in 2014. The unemployment rate is 11.2 percent, its highest since at least 2012, and the central bank is struggling to tame inflation, which is running above 9 percent this year. “Markets are getting ahead of themselves,” says Desmond Lachman, a former deputy director at the International Monetary Fund who’s now at the American Enterprise Institute. “You’re not going to find a silver bullet.”

The new government has also already been tarred by scandal. Budget Minister Romero Juca was forced to step down in May over allegations he wanted to block a probe into graft and money laundering. Fabiano Silveira, the minister of transparency and control, resigned the same month after local press published a recording of a conversation in which he criticized the graft probe known as Carwash and offered advice to a politician under investigation.

A priority for Temer and his advisers is reining in a budget deficit of 603.7 billion reais (\$179 billion), which amounts to more than 10 percent of GDP. That’s the second-highest level in the Group of 20, after Saudi Arabia. The administration has proposed putting a cap on federal spending, throttling back the costly government pension system, and withdrawing money from Brazil’s sovereign wealth fund to pay for government operations.

Making a significant dent in the deficit won’t be easy. Cut discretionary spending, and there’s the risk of a backlash from an already frustrated electorate. Raise taxes, and the recession could deepen. Privatize government companies? Beware the wrath of the unions. And any attempt to reform social security will take decades to have an impact on the nation’s balance sheet.

Lachman says that to put the economy on a healthy path, Temer needs to trim the deficit by at least 5 percentage points of GDP, plus

“Markets are getting ahead of themselves. You’re not going to find a silver bullet.”

—*Desmond Lachman, American Enterprise Institute*

address such long-term issues as social security, all without further depressing growth. “You’re having to do this whole exercise with a very weak economy,” he says. “If the politics are very difficult

now, how much more difficult are they going to be in a few months’ time if the economy keeps sliding?”

Temer must also grapple with a mounting national debt, which climbed to 4 trillion reais last year—67 percent of GDP. Interest payments hit 464 billion reais in 2015. Debt is on course to top 80 percent of GDP within two years, according to Lachman.

While Brazil has foreign currency reserves of \$376 billion, such high debt levels are worrisome for a country that missed foreign debt payments in the 1980s and received an IMF bailout in 2002. “Economies really suffer” when emerging-market governments accumulate too much debt, says Koon Chow, a London-based strategist at Union Bancaire Privée. “They tend to have more turmoil,” he says, “and asset prices are more volatile.”

—*Jonathan Levin and Ye Xie*

The bottom line The acting president has little room to maneuver as he tries to revive the Brazilian economy.

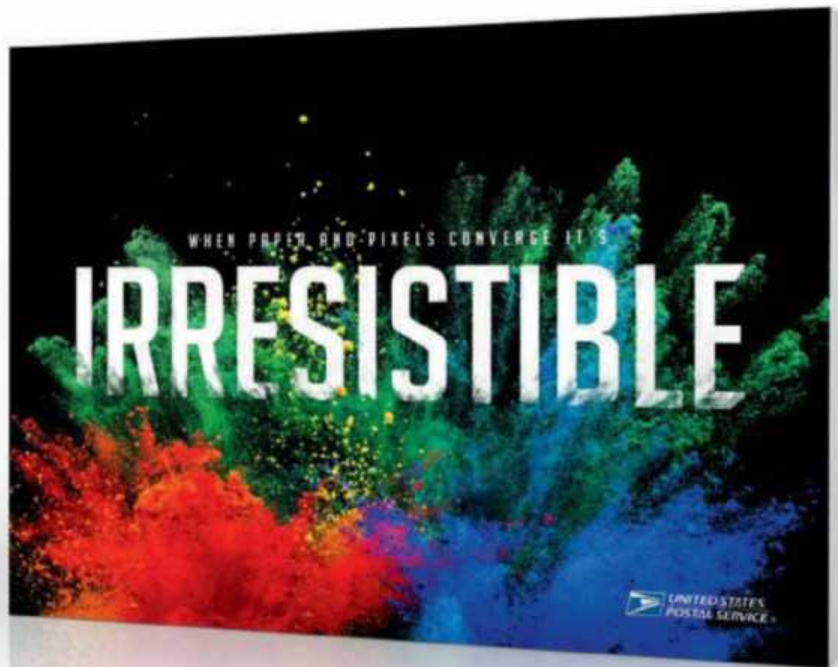
Energy

Iran Plays a Good Game Of Catch-Up

▶ **Oil production and exports are rebounding faster than foreseen**

▶ **“The increase was beyond expectations”**

At OPEC’s June 2 meeting in Vienna, delegates voted not to restrict crude production, encouraged by oil’s ascent back to \$50 a barrel—a rally sparked by disruptions in supplies from Nigeria and Canada. When questioned by reporters later, Bijan Namdar Zanganeh, Iran’s oil minister, said his fellow OPEC members were not critical of his nation’s plan to further boost output. The Persian Gulf nation, which was OPEC’s No. 2 producer before international sanctions were tightened in ▶



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◀ 2012, has restored the flow of crude more quickly than the International Energy Agency had predicted. Iran has increased output 22 percent since restrictions were lifted in January and is now pumping its pre-sanction level of 3.5 million barrels a day, according to estimates compiled by Bloomberg.

The energy industry figured that, given Iran's aging oil infrastructure, it would take the country "about a year or so to come back onto the market," says Mark Keenan, who heads commodities research in Asia at Société Générale. "The increase was beyond expectations," says Eugen Weinberg, who fills the same role at Commerzbank.

Since hitting a 12-year low on Jan. 20, the price of Brent crude, the global benchmark, has jumped more than 80 percent. For a few weeks now it's hovered around \$50 a barrel as the fires engulfing Canada's tar sands and attacks by militants on oil installations in Nigeria have offset the impact of Iran's rebound. However, the possible recovery of lost output elsewhere in the world risks putting renewed downward pressure on prices. "We are close to the balance now," says Weinberg, referring to global supply and demand. "But it's due to presumably temporary disruptions." Miswin Mahesh, an oil market analyst at Barclays, expects slower global growth, along with any increased production, to eventually drive prices lower again.

Iran is aiming to raise output to 4.8 million barrels a day within five years. Zanganeh wants OPEC, which is pumping at a record 33.2 million barrels a day, to return to a system in which

each member country is assigned a quota. Iran, he says, should account for 14.5 percent of the group's daily output—the level it held before sanctions were enacted. At present, its share is 10.5 percent.

—Ben Sharples, with Mark Shenk

The bottom line With Iran ramping up crude output faster than expected, oil's recovery to \$50 a barrel may not last.

Emerging Market

The Land Rush In Myanmar

▶ Asian money pours in, but sanctions limit U.S. investment

▶ It's "one of the few remaining largely untapped markets"

After decades of military rule, Myanmar at last has a democratically elected government. Longtime opposition leader Aung San Suu Kyi's party took charge in March, with her ally Htin Kyaw becoming president and the Nobel laureate herself serving as foreign affairs minister. In response, the U.S. last month announced a partial rollback of economic sanctions first imposed in 1990 in an attempt to get the country's generals and their cronies to relax their hold on power. The new policy will make it easier for American companies to do business in Myanmar. However, it doesn't go far enough for Khin Shwe, the founder of **Zaykabar**, a construction company that's on a U.S. blacklist of Myanmar

businesses and individuals. Now that the country has freely elected leaders, he says, "they should lift sanctions."

For Myanmar, a lot rides on whether and when the U.S. further relaxes trade and investment restrictions, which include travel bans and asset freezes targeting companies and individuals associated with the old regime. Two-thirds of its 53 million people live in the countryside, many without electricity. Annual per-capita gross domestic product is \$1,200. Myanmar "is one of the few remaining largely untapped markets in the world," wrote analysts Ong Kian Lin and Kasamapon Hamnilrat of Malaysia's RHB Research Institute in a May 31 report.

That may not last long. The Asian Development Bank projects Myanmar's economy will expand 8.4 percent this year and 8.3 percent in 2017, making it Asia's best performer. Foreign direct investment was a record \$9.48 billion in the fiscal year ended March. Most of the money is coming from other parts of Asia. Japan's **JGC** and Singapore's **Yongnam Holdings** and **Changi Airport Group** are part of a consortium that in January signed an agreement to build a \$1.5 billion airport in Yangon, Myanmar's biggest city. Vietnamese real estate developer **HAGL Group** in March started work on a \$230 million residential and office development in Yangon, having already opened a \$440 million hotel and office complex last year. Japanese Prime Minister Shinzo Abe has pledged 100 billion yen (\$935 million) in loans to fund infrastructure projects.

"The interest among investors is

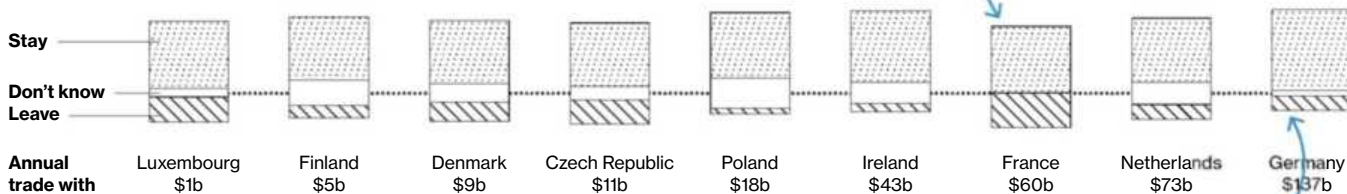


Good Neighbors

Trade Oh Britain, Please Stay

The British will vote on June 23 whether to remain in the European Union, and polls suggest the outcome will be close. A survey conducted by TNS Public Affairs in May showed a slight plurality in favor of exiting. In much of the rest of the EU, including some of the U.K.'s biggest trading partners, the majority wants the U.K. to stay put. —Mark Glassman

Share of respondents on whether the U.K. should remain in the EU



Nearly everyone in France has an opinion

The biggest economy in the EU

Global Economics

Coca-Cola



Pizza Hut



KFC



tremendous,” says Romain Caillaud, senior director covering Southeast Asia for FTI Consulting in Singapore. “There is really a lot of hope.”

The country’s oil and gas industry draws one-third of all foreign direct investment. Australia’s **Woodside Petroleum** early this year announced two offshore gas discoveries, and China’s **Guangdong Zhenrong Energy** and local partners in April won approval for a \$3 billion oil refinery with a capacity of 100,000 barrels a day.

U.S. companies have been tiptoeing in. After Aung San Suu Kyi’s party took part in the 2012 elections, President Obama lifted a ban on most Myanmar imports and allowed American companies to form partnerships with local businesses, so long as they don’t appear on the sanctions list compiled by the U.S. Department of the Treasury. **Coca-Cola** and **PepsiCo** now have bottling plants in the country, while **Ford** and **General Motors** have opened dealerships. **Krispy Kreme Doughnuts** announced plans last August for 10 shops, and private equity firm **TPG** in December bought half of **Myanmar Distillery**, which sells a popular brand of whiskey. The

country’s first fast-food restaurant, **KFC**, opened last year. There are still no McDonald’s or Starbucks.

With the latest easing of sanctions, announced in May, U.S. companies can have dealings with seven formerly blacklisted state-owned enterprises, use the main port, and work with state-owned banks. The policy change “will make life a lot easier” for companies hoping to enter oil and gas, mining, power, and real estate, says Tom Platts, a partner in Singapore with the law firm Stephenson Harwood. “We are going to see more U.S. interest in Myanmar.”

Still, American companies continue to face obstacles. Sanctions create “an unlevel playing field,” says Judy Benn, executive director of the Myanmar chapter of the American Chamber of Commerce. The restrictions against working with companies or people associated with the junta have “handcuffed” U.S. companies, she adds, estimating the policy puts “about 75 percent of the economy” off-limits. Even something as simple as wiring money is a challenge, says Aye Thiha, chief executive officer of Yangon-based Thiha Group, which has joint ventures with Thai partners to operate pizza and ice cream shops, as well as a steel pipe factory. “You have to prove you’re not on the sanctions list,” he says. U.S. banks “don’t want to go through the headaches, so they opt out of it.”

On May 22, U.S. Secretary of State John Kerry met with Aung San Suu Kyi in Naypyidaw, the capital, and said further easing of sanctions would depend on progress in democratization. The U.S. also has concerns about the treatment of the Rohingya, Muslims who are longtime residents but whom the government says aren’t citizens. Aung San Suu Kyi herself isn’t demanding the U.S. remove all restrictions. “We believe that if we are going along the right path, all sanctions should be lifted in good time,” she told reporters after meeting with Kerry. That time, she added, will come “soon.”

—Bruce Einhorn and Chris Blake

The bottom line Despite a gradual easing of sanctions, large sectors of Myanmar’s economy remain off-limits to U.S. businesses.

B Edited by Christopher Power and Cristina Lindblad
Bloomberg.com



CITIZEN
THE SIGNATURE COLLECTION



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June 13 — June 26, 2016

Farming Big Data

► Technology is boosting farmers' productivity—and triggering buyout bids like Bayer's

► Using data "to sell...the seeds and whatever other products you want to sell"

A self-driving John Deere tractor rumbles through Ian Pigott's 2,000-acre farm every week or so to spray fertilizer, guided by satellite imagery and each plot's harvesting history. The 11-ton behemoth, loaded with so many screens it looks like an airplane cockpit, relays the nutrient information to the farmer's computer system. With weather forecasts and data on pesticide use, soil readings, and plant tissue tests pulled by various pieces of software, Pigott can keep tabs on the farm down to the square meter in real time without ever leaving his carpeted office.

"This is becoming more standard," says Pigott, who grows a rotation of wheat, oilseed, oats, and barley on his farm in the rolling Hertfordshire countryside an hour north of London.

German chemical company **Bayer** cited the growth in such digitally assisted farming as a key reason for its \$62 billion bid for **Monsanto**, which has become a leading provider of analytics used by growers. Bayer Chief Executive Officer Werner Baumann says Monsanto is at the "forefront of digital farming." Acquiring the company would further Bayer's goal of identifying and providing the best-suited seeds, fertilizers, and chemicals for farms around the world.

"If you get the customers' attention by predicting what will happen on their farm, you can be closer to them

to sell them the seeds and whatever other products you want to sell them," says Bruce Erickson, a director in

A **SpecTerra** map shows the highest (blue) and lowest (red) yield forecasts for corn

the agronomy department at Purdue University who tracks farming technology. "The promise is immense."

Signs of the transformation abound: drones providing bird's-eye views of fields; mapping software locating underground water

relatively flat in recent years, even as demand is increasing because of population growth and the rising middle class in developing nations such as China.

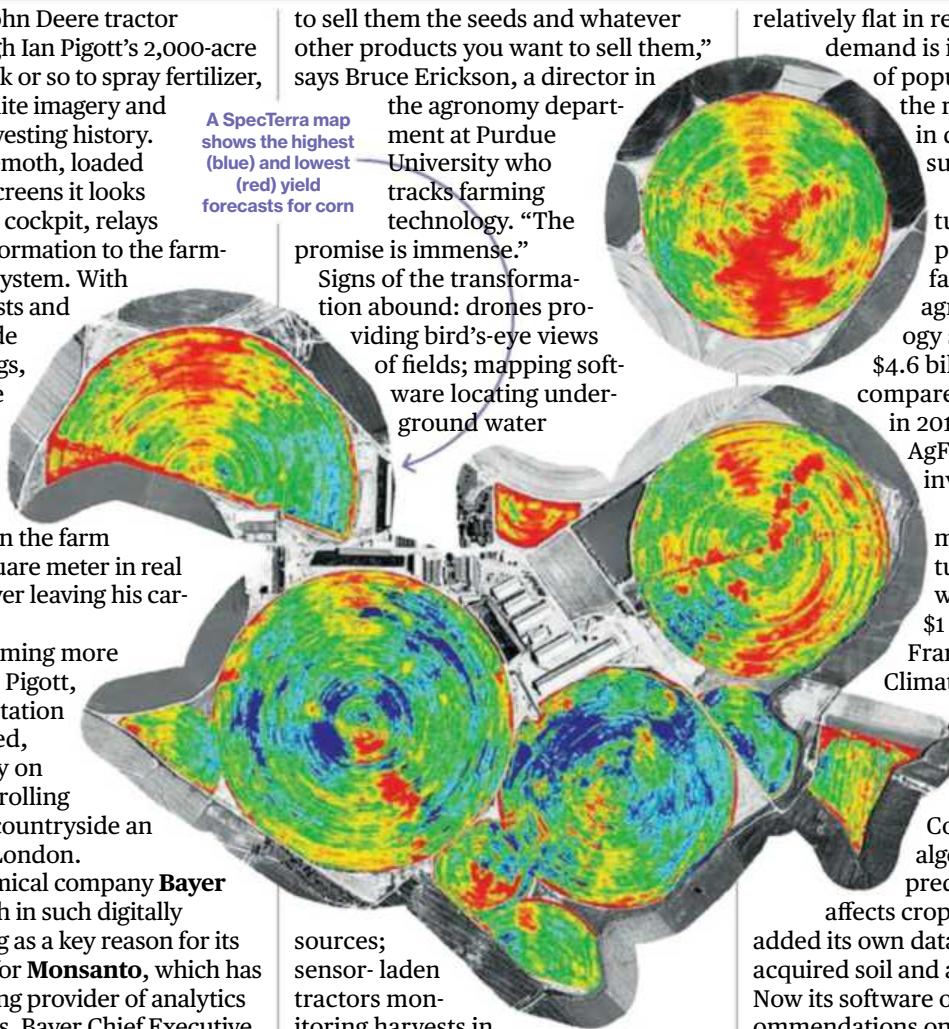
Sensing an opportunity, investment is pouring into digital farming. Food and agriculture technology startups attracted \$4.6 billion last year, compared with \$2.3 billion in 2014, according to AgFunder, an online investing platform.

Monsanto's investment in digital agriculture took off in 2013, when it spent almost \$1 billion for San Francisco-based startup Climate Corp. Founded by former Google engineers David Friedberg and Siraj Khaliq, Climate Corp. developed an algorithm that helps predict how weather

affects crop output. Monsanto added its own data from seed trials and acquired soil and analytics companies. Now its software offers farmers recommendations on what to plant and where to plant it.

"Farmers are very excited about new technology if you can show them some value, that it's not just some gimmick," says Khaliq, who's now a venture capitalist in London.

Monsanto invested in **Blue River Technology**, a California company that uses computer vision



sources; sensor-laden tractors monitoring harvests in real time. It's happening outside the fields, too. Cows' meal portions are adjusted automatically based on their milk output. Infrared cameras identify chickens with fevers, protecting flocks.

Adoption of digital tools comes amid concerns that food production isn't keeping up with the world's appetite. Crop yields have remained

technology to weed crops. It also backed **HydroBio**, which produces tools that monitor water usage, and **VitalFields**, a maker of farm management software. Meanwhile, **Planet Labs**, whose satellite monitoring technology tracks changes in crops and soils, raised \$120 million last year, and data company **Farmers Business Network** raised \$15 million from investors including Google parent **Alphabet**.

Other large agriculture companies are also investing to add technology to their product lines. Tractor maker **Deere** offers autonomous driving and tools to track real-time usage of seeds, fertilizer, and chemicals.

DuPont, which is merging with **Dow Chemical**, is expanding its Encirca farm management software unit. And **Syngenta**, which Monsanto tried to buy earlier this year and has agreed to be bought by **ChemChina**, has made several digital farming acquisitions.

Adoption of digital agriculture has been fastest in the central U.S., where industrial farms put a premium on efficiency. In central Illinois, Dale Hadden has been collecting data to improve the performance of the soybeans, corn, and wheat he grows on his almost 5,000 acres. He creates models to predict yields based on chemical use, soil types, and his land's topography.

"We can take our data, walk right into the fields with an iPad or iPhone, pinpoint exactly where we are in the

field, and see what the planting rate is, what the amount of nitrogen is, and figure out what we should be doing with each parcel of land," Hadden says. "If we have a performance issue in a certain area, we can do something about it."

Still, it's early days for such technology. "Agriculture is well behind other industries that I've been involved with in being able to collect and synthesize data and express it as solutions to problems," says Ron LeMay, the former president of telecommunications company Sprint, who founded **FarmLink**, a data company.

Many farmers, particularly outside the U.S., have taken a wait-and-see approach to find out if adopting digital tools can improve their bottom line. Such software can cost several thousand dollars per year and comes with a steep learning curve. "We're still on the cusp of being able to demonstrate at scale the financial returns," says Ros Harvey, the founder of **Yield**, an Australian startup. Her company, backed by German automotive giant **Robert Bosch**, uses sensors that allow oyster farmers to determine when contamination makes it unsafe to harvest.

The greatest potential may be in the developing world, where tapping into global communications networks may allow farmers to better manage climate change and other risks by

"We can take our data, walk right into the fields with an iPad or iPhone, pinpoint exactly where we are...and figure out what we should be doing with each parcel of land"

bringing Big Data to the world's most information-poor regions. "We're starting to see the emergence of a digital revolution," says Mick Keogh, the executive director of the Australian Farm Institute. "It's moving from decisions based on a farmer's skill to decisions based on objective information driven from technologies now available."

—Adam Satariano and Alan Bjerga

The bottom line Food and agriculture technology startups attracted \$4.6 billion in funding last year, vs. \$2.3 billion in 2014, according to AgFunder.

Compensation

Monster Beverage's Monster Payday

▶ The company's two top execs got \$598 million from stock options

▶ Stock compensation is "going to have tremendous value"

A decade ago, back when energy drink maker **Monster Beverage** was still known as Hansen Natural, its two top executives received what appeared to be a pretty standard pay package. Besides their salaries and benefits, Chief Executive Officer Rodney Sacks and Vice Chairman Hilton Schlosberg also each received 10-year options to purchase shares of the company's stock. In its 2006 proxy statement, Monster said if the shares appreciated 10 percent annually, each award could be worth \$28.7 million by 2015. That percentage estimate was used to meet a U.S. Securities and Exchange Commission requirement to show 5 percent and 10 percent appreciation estimates in proxies, the company said at the time, and "do not represent our estimates or projections."

Instead, energized by a big investment from **Coca-Cola** in 2015, Monster shares ended up soaring more than 30 percent a year, leaving Sacks and Schlosberg each with realized gains of \$299 million—the highest among U.S. executives in 2015, according to data compiled by Bloomberg.

Every year, companies grant stock to executives as incentives to spur growth and increase profitability. Those awards, included in the summary



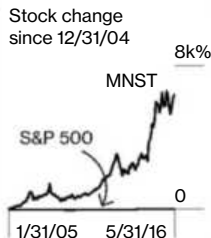
A Claas tractor tricked out with farm data gear in a field near Harpenden, U.K.



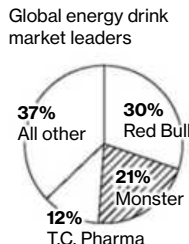
Taka Higashino, a Monster Energy endorser, competes in the X Games 2016

Jacked Up

Monster's Schlosberg and Sacks each got **\$299m** from exercising stock options in 2015, highest among U.S. executives



Coca-Cola bought 17 percent of Monster in 2015 for **\$2.1b** and will help expand its global distribution



The company spent **\$210m** on advertising and promotional expenses last year, up 22 percent from 2014

compensation table in annual proxy statements, get the most attention from investors, analysts, and the press when first disclosed. Less attention is paid to another table showing how much executives actually earn as they exercise options and receive shares granted in previous years. Those figures can vary significantly from company estimates.

“The point of stock options, and how they’re valued, is that many will end up never being in the money. Some will be a little bit in the money,” says Eric Hosken, a partner at Compensation Advisory Partners in New York. A third group of options is “going to have tremendous value.”

Sacks and Schlosberg declined to comment beyond the filings, according to Judy Lin Sfetcu, a spokeswoman for Monster at investor relations firm PondelWilkinson.

New stock awards are typically valued based on the share price on the day they’re granted, and their actual worth changes whenever the stock trades. The number of shares executives get often depends on how companies perform against targets such as earnings per share or revenue growth.

Options are even more difficult to value because their exercise price is equal to the share price on the day they’re granted, meaning that, at that moment, they have a functional value of zero. So companies use formulas such as the Black-Scholes pricing model, which accounts for variables including volatility in share price and how long executives have to exercise options, to get an estimate of what the options might be worth in the future.

But those are just estimates. Sometimes they come in low, as at Monster. It would have been hard to predict in 2005, when the options were granted, that Coca-Cola would acquire 17 percent of Monster for \$2.15 billion 10 years later, making billionaires of Sacks and Schlosberg, thanks to their

stock and option holdings. Of course, sometimes the estimates can be high: Just ask executives at companies in the S&P 500 Energy Index, which saw their stocks plunge 31 percent on average in the past two years as OPEC allowed an oil glut to send prices to their lowest levels in a decade. There’s no input in Black-Scholes for surprises like that.

Executive pay is usually skewed toward stock compensation. Sacks and Schlosberg, for instance, each received \$1.2 million in cash, bonuses, and perks in 2015—less than 1 percent of their total pay for the year.

The Monster executives weren’t alone in receiving stock-based pay last year that far exceeded initial estimates. John Martin, executive chairman of **Gilead Sciences**, had the fourth-largest take-home figure with \$232 million, about 70 percent from exercising options granted in 2006. At the time, Gilead valued the award at \$11.2 million. Then it developed the first effective cure for hepatitis C, which affects about 150 million people globally. That more than tripled Gilead’s revenue from 2012 to 2015. The company’s shares—and the value of Martin’s options—soared. During his tenure as CEO, “Gilead delivered substantial value to patients, stockholders, and health-care systems around the world,” Gilead spokeswoman Michele Rest said in an e-mail.

Likewise, **Netflix** CEO Reed Hastings had the fifth-biggest sum in 2015, \$178 million, almost entirely from exercising options, many from as long ago as 2005, when the company had less than \$1 billion in revenue. Sales were \$6.8 billion last year as the video-on-demand provider attracted 45 million U.S. subscribers.

Blackstone Group Chief Operating Officer Tony James earned the third-largest sum in 2015: \$250.2 million. Most of his payout came from stock awards including shares valued at \$174.3 million

when they vested. James has for years been among the executives taking home the most compensation, thanks to equity awards granted in connection to Blackstone’s June 2007 initial public offering. But James’s pay history shows that option value estimates can be off-base in both directions. The private equity firm granted him 32.9 million shares, valued at \$1.02 billion in 2007, that would vest over eight years. They’re now worth \$864 million.

Spokeswomen for Netflix and Blackstone say the companies declined to comment beyond the filings. Peter Grauer, chairman of Bloomberg LP, parent of *Bloomberg Businessweek*, is a nonexecutive director at Blackstone. —Caleb Melby, with Caroline Chen and Brendan Coffey

The bottom line Companies estimate the future value of stock compensation they give. But if share prices soar, so can executives’ paychecks.

Casinos

You Have an Important Call: It’s Your Croupier

- ▶ To slow money laundering, Macau tries banning phone betting
- ▶ Lax regulation “will create a loophole”

In a private room of a Macau casino’s exclusive gambling area for VIP customers, a single player sits at a baccarat table. As the cards are turned, the man, a hired hand, gives a play-by-play account via an earpiece wirelessly connected to his mobile phone. Hundreds, if not thousands, of miles away on the other end of the call is the real gambler, a player beyond the border in China.

Variations of that scenario were described by five people who work ▶

Companies/Industries



◀ at Macau's junket operators, outfits that front money to high rollers and bet on their behalf using wireless headsets—in violation of the city's new May 9 ban on using phones at betting tables. Previously, surrogates could effectively place bets initiated via phone as long as they disclosed who was on the other end, say junket operators. Now, three gambling promoters who conduct business at independently run VIP rooms inside Macau casinos operated by **SJM Holdings** and **Melco Crown Entertainment** told Bloomberg they're surreptitiously using headsets to evade the ban, with the proxy players sometimes hiding the devices in their hair. They asked not to be identified because the activities are illicit.

The preferred game is baccarat, where the player bets whether his hand or the dealer's is closest to nine. Some junkets now assign two agents; one plays at the table and announces the results loudly while a partner sits nearby with an open phone line to the gambler, say two junket operators.

A statement from Melco said its casino facilities, including VIP rooms, meet local regulations. SJM didn't respond to requests for comment. Angela Leong, SJM's executive director, said in a May 17 interview that Macau casinos, including SJM's, have increased monitoring to prevent phone betting.

Macau first banned the practice in 2001 to prevent money laundering. Mainland gamblers can get credit lines from Macau junket operators, who are repaid by the players inside mainland China. But the gambling credit stays outside China, away from scrutiny by the Chinese government and its currency controls—and where it can be cashed out in Macau as gambling proceeds.

Even after the 2001 law, regulators didn't enforce the phone-betting ban as long as operators reported the bets and gamblers' identities to Macau's gambling regulator, says local legislator José Maria Pereira Coutinho. "There's a situation of permeability for money laundering that the government must pay full attention to after the ban," he says. "A regulation without effective implementation will create a loophole."

The law took another blow from the

SARS (severe acute respiratory syndrome) epidemic in 2003, when the Gaming Inspection and Coordination Bureau let junket and casino operators use electronic devices to communicate with tables to reduce the risk of spreading the infection. That facilitated phone betting, say junket operators and Coutinho. Such bets hit \$2.6 billion in 2015, estimates Daiwa Capital Markets Hong Kong analyst Jamie Soo.

It's unclear how well the ban, which entirely forbids using mobile phones, will work, because there's no longer a

\$2.6
billion

Estimated value of phone bets placed in Macau in 2015, up 15 percent from the year before

system for reporting bettors. And the rule doesn't come with sanctions for violators, according to the gambling regulation bureau.

Casino revenue numbers suggest President Xi Jinping's corrup-

tion crackdown scared China's high rollers away from gambling tables—and prompted them to pick up the phone instead. Last year's phone-betting total was up 15 percent from the year before, even though casinos' so-called VIP revenue dropped 40 percent, Soo says. For small junket operators, phone betting may have accounted for as much as 50 percent of revenue, he says.

Phone bets have been an avenue for wealthy Chinese to skirt China's currency controls limiting outflows to the equivalent of \$50,000 a year. The gambler-cum-money-transferer never leaves the country, making it easier to conceal his or her identity. Other countries, including the U.S. and Singapore, have also banned phone betting to avoid money laundering. Not all such bets facilitate money laundering, and some countries, including the Philippines, allow the practice.

More staff and security guards will be hired to conduct checks and monitor activities in the VIP rooms through surveillance cameras, says Paulo Martins Chan, director of the gambling bureau. —Daniela Wei

The bottom line Some high rollers are placing bets at Macau casinos by phone, despite a ban. Remote betting lets players remain anonymous.

B Edited by James E. Ellis
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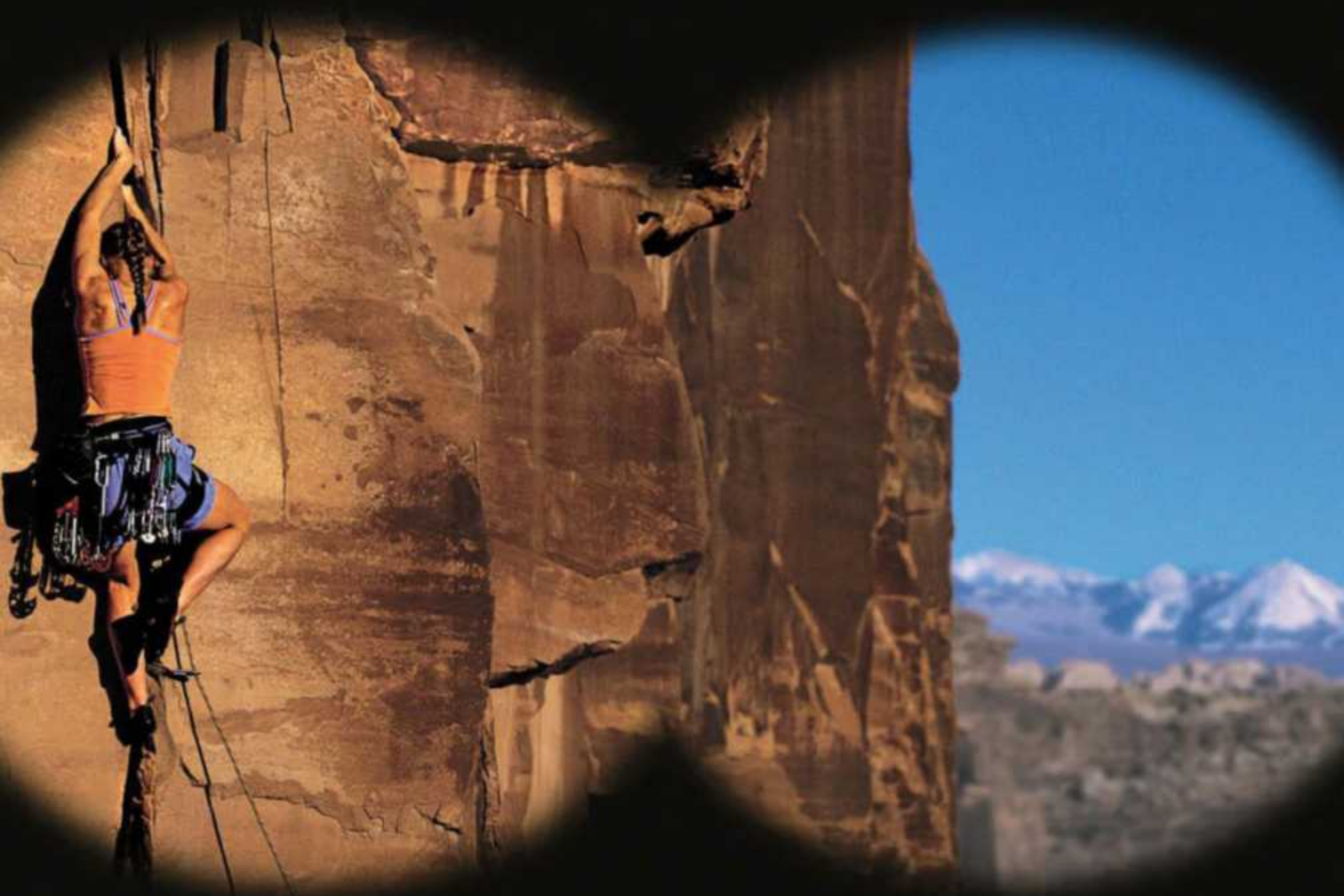
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■ SevenVentures

It's Gonna Get Ugly



On June 7, Hillary Clinton and Bernie Sanders concluded what had become, by the end, a contentious Democratic presidential primary. As the race wore on, the candidates grew more aggressive in speeches, in debates, and on Twitter. Sanders in particular criticized Clinton's hawkishness and sympathy toward Wall Street, attacks amplified by the media. But this animosity was entirely absent from one important realm. According to Kantar Media, Clinton and Sanders aired 206,528 spots between them this year—and not one was deemed “negative” by the analysts in Kantar’s Campaign Media Analysis Group (CMAG). “In an open presidential primary, this is probably unprecedented,” says Elizabeth Wilner, senior vice president for political advertising at Kantar. Indeed, Donald Trump, the presumptive Republican nominee, faced roughly \$62 million in attack ads during the primaries. Most of the spots were aired by fellow Republicans. “We’ve never seen a contrast like this before,” says Wilner.

Republican strategists hope this disparity in attacks will redound to their benefit. Clinton’s unfavorability ratings are only somewhat better than Trump’s, even though she faced no negative ads from Sanders. (GOP campaigns and super PACs did feature her in a few ads.) Republicans believe they can inflict more damage. “People think she has these really high negatives, but in reality nobody has laid a glove on her yet,” says Sean Spicer, chief strategist for the Republican National Committee. “Once you see a full-fledged ad campaign to reinforce her negatives, she’ll have a lot further to fall.”

The strange truce in the Democratic primary was due to a couple of quirks. Sanders doesn’t believe in attack ads. The closest he came was a commercial that briefly flashed an image of Clinton’s name in a newspaper headline and aired only in South Carolina. And Clinton initially felt she didn’t need to bother attacking Sanders. Later on, it became clear that she couldn’t afford to—she’ll need to win over his supporters to beat Trump. “While running negative spots tends to be more effective ▶

▶ Clinton had it easy in the primary, but that’s about to change

▶ “We’ve never seen a contrast like this before”

◀ than people like to admit, it also drives up your own candidate's negatives," says Ben LaBolt, a strategist on Barack Obama's 2008 campaign. "Given where Clinton is right now in terms of favorability rating, it's not a surprise that she didn't run negative spots against Sanders during the primary." That could help Clinton as she tries to win Sanders voters.

"It's difficult for an opponent to define someone who's already so well-known as a candidate."
—Obama 2008 strategist Ben LaBolt

The absence of negative ads is a marked shift from 2008, when Obama spent \$58 million on primary ads, while Clinton spent \$33 million. Although CMAG didn't measure sentiment that

year, both candidates aired negative spots. The most iconic was a Clinton ad boring in on Obama's lack of executive experience. "It's 3 a.m., and your children are safe and asleep," a narrator intones over images of slumbering kids. "But there's a phone in the White House, and it's ringing. Something's happening in the world. Your vote will decide who answers that call."

The forcefulness of the 3 a.m. ad temporarily upended the race. "We actually only spent \$50,000 on airtime," says Mark Penn, the ad's creator and Clinton's chief strategist in 2008. But it got picked up by cable news channels, and that "set off a whole debate" about who would better handle a foreign crisis, Penn says.

The hit on Obama came in the form of a television ad because political strategists have historically avoided letting candidates deliver such attacks for fear it would poison their image. "It's odd that the candidates themselves are now carrying the most negative messages," says Penn. "It used to be, you left that for the ads." One reason for the change is Trump, who's demonstrated that the media is now far more apt to pick up attacks made by the candidates.

While Clinton hasn't yet faced the full blast of Trump's advertising onslaught, Democratic strategists claim that her free pass in the primaries doesn't leave her vulnerable. "It's difficult for an opponent to define someone who's already so well-known as a candidate," says LaBolt.

What's more, says Mark Longabaugh, a senior adviser and media consultant to the Sanders campaign, tough ads during the primaries can cripple

a nominee in the fall: "After a lot of years in this business, let me tell you, it is always better going into a general election when you do not have a lot of damage from primary ads being run against you." Mitt Romney's experience in 2012 is a good illustration. Republican primary opponents such as Newt Gingrich and Rick Perry branded him a "vulture capitalist," an attack Obama picked up and used to defeat him. An even better example is Bob Dole. "Dole limped into the '96 election extremely damaged," says Longabaugh. "Steve Forbes just carpet-bombed him in the Arizona primary and in Iowa, and [Bill] Clinton ended up winning both in the fall. It's a tangible example of how the damage carries over."

By this measure, Trump is the more vulnerable candidate heading into the fall. And Clinton has already begun to press the attack on his fitness for office first raised by his Republican primary opponents. On June 6, after Trump attacked the Mexican ancestry of Gonzalo Curiel, the judge overseeing a civil case against him involving Trump University, Clinton's campaign produced a negative ad. It featured a succession of critics who all shared one thing in common. As Clinton herself tweeted: ".@realdonaldtrump's bigoted comments about a Latino judge are so disgusting, even other Republicans are offended." —*Joshua Green and Tim Higgins*

The bottom line Democrats hope the absence of negative ads from Sanders during the primaries will put Clinton in a stronger position to face Trump.

Energy

Warren Buffett's Dickey Power Play

► **MGM and Wynn move to leave Nevada's Berkshire-owned utility**

► **"We are working so hard to be able to compete"**

When Warren Buffett's **Berkshire Hathaway** bought Nevada's main utility, **NV Energy**, three years ago, it inherited a lucrative customer base: the neon-lit, air-conditioned casino-hotels on the Las Vegas Strip. Now

they're in the midst of a costly split. Lured by the prospect of cheaper, cleaner energy elsewhere, two of the Strip's biggest power users, **MGM Resorts International** and **Wynn Resorts**, told regulators in May they're willing to pay millions in fees to ditch NV Energy's services.

It's not uncommon for big power consumers to wrangle with utilities. But the situation is unique in Nevada, where a handful of casino-resorts exercises significant leverage. MGM and Wynn together account for more than 5 percent of NV Energy's sales in its southern territory. While losing existing casino customers is tough enough, even worse for NV Energy may be the precedent their departure sets. "It's probably going to diminish the likelihood that you could have a new casino go up and guarantee that it'll be a full-service customer of the utility," says Timothy Hay, an attorney who served on the State of Nevada Public Utilities Commission and as the state's consumer advocate.

MGM and Wynn are allowed to leave NV Energy under a 2001 Nevada law designed to attract electricity generation to the state. In December the state regulator gave the casinos the preliminary go-ahead, but the departure will be expensive: Because the regulated utility is guaranteed a rate of return on its investments, the casino operators will be charged exit fees to ensure remaining customers don't wind up shouldering increased charges.

The Public Utilities Commission determined MGM must pay \$86.9 million to NV Energy, based on its usage. The company has entered into a power purchase contract with Nebraska-based **Tenaska Power Services**, which markets natural gas and electric power. "It is our objective to reduce MGM's environmental impact by decreasing the use of energy and aggressively pursuing renewable energy sources," MGM Executive Vice President John McManus wrote in a May 19 letter to regulators.

Wynn will pay a \$15.7 million exit fee and plans to buy power from Chicago-based **Exelon**. Both MGM, which operates 11 hotels along the Strip including the MGM Grand, and Wynn, which runs the Wynn Las Vegas and the neighboring Encore resort, will keep relying on NV Energy

Share of NV
Energy's sales in
southern Nevada



wires to deliver the power they buy from Tenaska and Exelon.

NV Energy executives have publicly acknowledged the company will have to vie for customers' loyalty. "We do have concerns, but that's why we are working so hard to be able to compete," Chief Executive Officer Paul Caudill said on May 23 at a regulator conference near Lake Tahoe.

Berkshire paid \$5.6 billion for NV Energy in 2013 as part of a multiyear expansion in the western U.S. The move was in part a bet on Nevada's continued economic growth, Gregory Abel, chief executive of Berkshire's energy unit, said at the time. Berkshire Hathaway Energy referred requests to NV Energy, which declined to expand on Caudill's May 23 comments on MGM's and Wynn's exit.

Utilities face similar challenges across the U.S. as the cost of solar power and natural gas generation falls. Big corporate energy users such as **Amazon.com**, **Apple**, and **Google** have cut deals over the past two years to buy power directly from solar plants and wind farms.

Like MGM and Wynn, casino operator **Las Vegas Sands** secured regulatory approval last year to leave NV Energy, but says it intends to stay—for now. Regulators determined Sands would have to pay \$23.9 million to leave NV Energy, a sum the company indicated it thought was too high. Instead, Sands, controlled by Republican megadonor Sheldon Adelson, is backing a November ballot measure that would amend the Nevada constitution to deregulate the state's energy market, doing away with NV Energy's monopoly.

The casino gave \$500,000 to signature-gathering efforts, according

to state filings. MGM gave \$10,000. "It's important our employees and all Nevada ratepayers have a voice in this debate," says Ron Reese, a spokesman for Las Vegas Sands, regarding the casino's support of the ballot move. "We will absolutely support efforts to help those voices be heard." —*Mark Chediak and Noah Buhayar*

The bottom line Berkshire Hathaway spent \$5.6 billion on Nevada's power utility, but casino operators are switching providers.

Health Care

The FDA Quietly Walks Back a Recall

► **Devices linked to superbug outbreaks are still on the market**

► **"I've never seen a recall get changed like that"**

In November 2015 the U.S. Food and Drug Administration instructed the maker of a medical scope cleaning device tied to a deadly superbug outbreak to take the machines off the market "as soon as possible." After manufacturer **Custom Ultrasonics** offered to correct flaws, the FDA repeated itself in a February letter, writing in bold text: "FDA orders Custom Ultrasonics to immediately recall all System 83 Plus devices by removing them from use." It cited doubts about whether the 2,800 System 83 Plus machines in use at hospitals across the U.S. could properly clean duodenoscopes, which are used to look inside the small intestine and are particularly hard to disinfect.

At the end of April, Custom

Ultrasonics wrote customers saying that, in fact, they could keep using their System 83 Plus machines to clean endoscopes, as long as they weren't used on duodenoscopes. The FDA says it's pulled back its recall order and is working with the Ivyland, Pa., company to ensure its equipment is "validated in a timely manner," says agency spokeswoman Deborah Kotz. (Under FDA rules, a device is considered "validated" once a manufacturer has proved it works as advertised.) The change in recommendation was "based on information provided by the company," Kotz says. "We have nothing more to share on this at this time."

Robert Blanchard, director of product management and sales for Custom Ultrasonics, declined to comment on the FDA letters or its change in position. Edward Teitel, a Houston doctor and attorney who advises Custom Ultrasonics, says the actual duodenoscopes, not the machines used to clean them, are the root cause of difficulties in disinfecting them.

Teitel adds that the FDA has reversed itself on recalls in the past "as more information becomes available." But medical professionals say the sharp tone of the FDA's initial letters makes its silence about its decision to back down on Custom Ultrasonics puzzling. "In the 20 years that I've been in the business, I've never seen a recall get changed like that," says Mark Duro, director of sterile processing operations at New England Baptist Hospital in Boston, which doesn't use Custom Ultrasonics equipment.

Using Custom Ultrasonics machines to clean duodenoscopes was one of several factors that "likely contributed" to the spread of drug-resistant bacterial infections, according to a

◀ report issued in January by Senate Democrats. As many as 350 patients may have been affected at dozens of hospitals since 2010, according to documents released in April by the House Committee on Oversight and Government Reform. Dozens of infected patients later died.

Some outbreaks occurred at hospitals that don't use Custom Ultrasonics equipment, and other brands of cleaning machines have had trouble disinfecting duodenoscopes. An expert panel convened by the FDA in 2015 concluded that duodenoscopes aren't reliably safe. One model manufactured

by **Olympus** was recalled in January. The FDA has recommended additional pro-



Custom Ultrasonics' System 83 Plus automated endoscope reprocessor

ocols including repeat washing, testing for contamination, or using ethylene oxide gas to sterilize the scopes. Custom Ultrasonics machines clean instruments with water, disinfectant, and sound waves. A study presented

at a medical conference on May 22 suggests Custom Ultrasonics devices are more effective at cleaning endoscopes than their competitors'.

The FDA's scrutiny of Custom Ultrasonics precedes the recent outbreaks. Inspections as long ago as 1991 found "significant violations" of federal rules meant to ensure quality manufacturing and timely reporting of harm to patients, according to a civil complaint filed in 2006 by federal prosecutors in Philadelphia. In 2007, Custom Ultrasonics settled the government case; the company, which denied in court filings that its products had caused or contributed to patient injury, didn't admit any wrongdoing.

It's not clear how many hospitals still use Custom Ultrasonics devices. Nine out of 16 U.S. hospitals that had superbug cases linked to duodenoscopes were identified in the Senate staff report as using Custom Ultrasonics machines. Only one, Hartford Hospital in Connecticut, confirmed it had replaced the machines after the recall.

UCLA Medical Center in Los Angeles and Massachusetts General Hospital

in Boston both say they're switching to other vendors. Others declined to specify what equipment they're using; one, Thomas Jefferson University Hospital in Philadelphia, said the Senate report was incorrect and it had never used Custom Ultrasonics.

Lawrence Muscarella, a former director for infection control for Custom Ultrasonics who left in 2013, says the FDA's change of course "appears to be sending the wrong message." Patients should be told if their hospital is using equipment that has raised safety concerns, he adds: "It's OK for hospitals to do that, provided the patient is told of this, so the patient is aware of the care that they're getting." —*John Tozzi*

The bottom line Hospitals have gotten conflicting signals from U.S. regulators about machines used to disinfect medical scopes.

Government Services

Congress Denies Mailmen a Quorum

▶ **The USPS has eight open seats on its board, thanks to Senate politics**

▶ **"Senator Sanders thinks no board is better than a bad board"**

After a decade on the U.S. Postal Service Board of Governors, James Bilbray is ready to go. "I turned 78 on May 19," says Bilbray, the board's chairman. "I'm getting old. I'm getting tired." Yet Bilbray, whose term was extended after it expired last December, fears he'll leave a vacuum at the USPS. The U.S. Senate has

refused to confirm any of President Obama's appointees to the Board of Governors since 2010.

The board, which is supposed to have 11 members, currently has only three: Postmaster General Megan Brennan; her deputy, Ronald Stroman; and Bilbray, a former Democratic congressman from Nevada who was appointed by George W. Bush. Unless something changes, there will be only two at the year's end, when Bilbray's extension is up.

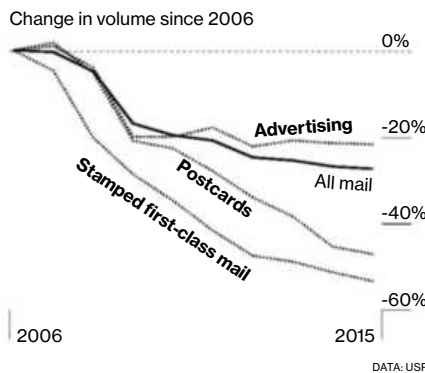
The USPS Board of Governors may seem like another nondescript oversight body in Washington made up of lawyers, ex-politicians, and businesspeople with a surplus of free time. But the board, whose members earn a \$30,000 annual salary, keeps watch over the world's largest postal service, which made \$69 billion in revenue last year, although it struggled with a \$5 billion deficit. That was because of a legally mandated obligation to set aside money for the health-care benefits of its future retirees. It's seen 28 percent of its volume vanish in the past decade but still delivered 154 billion pieces of mail last year.

Obama tried to remedy the situation by nominating five people to the USPS board in 2015. Two were Republicans: James Miller, Ronald Reagan's director of the Office of Management and Budget; and Mickey Barnett, a former Republican state senator from New Mexico. Obama also named three Democrats: Stephen Crawford, a professor at George Washington University; David Bennett, a former aerospace executive; and David Shapira, chairman of the Giant Eagle supermarket chain.

The Senate has yet to vote, because there are holds on the nominations. Typically, senators don't discuss such backroom maneuvers, but in this case one has: Vermont Senator Bernie Sanders. According to his senior policy adviser, Warren Gunnels, Sanders is blocking the two Republicans—Miller because he wants to privatize the Postal Service, and Barnett because of his ties to the payday loan industry. Sanders is also opposed to Crawford, who's proposed cutting home delivery and instead allowing people to receive scanned copies of their letters electronically, as they do in Switzerland.

By putting a hold on three appointees, Sanders prevents all five from

Mail Fail



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By Tripp Baltz and Lisa Nagele-Piazza

A Bill

Letting Moms-to-Be Sit

HB16-1438 An Act Concerning the Provision of Reasonable Accommodations by an Employer for Persons Who Have a Condition Related to Pregnancy



1. Colorado Governor John Hickenlooper, a Democrat, signed legislation on June 1 requiring employers to provide “reasonable accommodations” to pregnant women or new mothers. That includes more frequent or longer breaks for food, water, or the bathroom; limitations on lifting; transfer to less strenuous or hazardous positions; assistance with manual labor; and modified work schedules. Employers are also barred from retaliating against women who ask for special arrangements.

2. Colorado is the 17th state to pass such a bill. The legislative wave follows a 2015 U.S. Supreme Court ruling that pregnant workers can claim they’re being discriminated against if their employers place a “significant burden” on them without justification. The U.S. Equal Employment Opportunity Commission has also found that severe morning sickness, gestational diabetes, and other pregnancy-related conditions are covered by the Americans With Disabilities Act.

3. There’s wide variation on how stringent state laws are. Louisiana requires only that pregnant women be allowed to transfer their duties. In Alaska and Texas, only public-sector workers are covered. But employers have good reason to stay ahead of these laws, says Liz Morris, deputy director of the Center for WorkLife Law at UC Hastings College of the Law. Special arrangements for pregnancy, she notes, help retain workers and come with a built-in upside: “They are always temporary.”



Sponsor
Representative Faith Winter
(D-Westminster, Colo.)

Allows employers to claim exemption if accommodating pregnant workers would be prohibitively expensive

Section 1
Legislative declaration
pp. 1-2

Section 2
In Colorado Revised Statutes, 24-34-401 p. 2

Section 3
In Colorado Revised Statutes, add 24-34-402.3 pp. 2-6

Section 4
Act subject to petition—effective date pp. 6-7

1 2 3 4 5 6 7

◀ being confirmed, because the Republicans who control the Senate will hold a vote only on all five as a package. “Senator Sanders thinks no board is better than a bad board,” Gunnels says. It’s a position shared by the American Postal Workers Union, which has endorsed Sanders’s presidential run. “The APWU has been very dissatisfied with the nominees that have come out of the White House,” says Mark Dimondstein, the union’s president.

Before it lost its six-member quorum in late 2014, the board created what it calls a “temporary emergency committee” comprising the remaining members to approve the USPS’s spending and other major policy decisions. It’s unclear whether the committee will still be empowered to do so when Bilbray leaves. “According to our legal opinion, you have to have one governor appointed by the president and confirmed by the Senate,” Bilbray says. A USPS spokesman disputes this, saying the committee can continue to function even if its only members are the postmaster general and her deputy.

Bilbray says he’s skeptical of rumors that Sanders may withdraw his hold after the Democratic National Convention in July. According to Bilbray, Sanders told him he wouldn’t relent until the USPS reopens 141 mail processing plants that it’s either closed or consolidated in recent years to save money. “Bernie wants us to go back and reopen all those mail processing centers—even the ones we’ve leased,” Bilbray says. “It would cost us around \$2 billion.” Gunnels says Sanders doesn’t want all the plants reopened, but he definitely wants some of them up and running.

What happens next year when a new president is sworn in? Whether it’s Hillary Clinton or Donald Trump, there’s likely to be more gridlock. Even if Sanders withdraws his objections, Bilbray says, the unions have told him there are other senators willing to tie up the appointment process indefinitely. “That’s why we’re up a creek.” —*Devin Leonard*

The bottom line The last presidential appointee on the USPS Board of Governors retires in December, and there’s little prospect of replacing him.

B Edited by Allison Hoffman
Bloomberg.com

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Silicon Valley Tries to Build A Better Stock Exchange

▶ The Long-Term Stock Exchange could discourage quick trades and reward better decisions

▶ “You’re advertising to the markets that you’re willing to be held to a higher standard”

When Eric Ries showed friends a draft of his 2011 book, *The Lean Startup*, some advised him to get rid of a section proposing the creation of a stock exchange for tech companies that would discourage short-term thinking. It would ruin his credibility, Ries says they told him. Ignoring them, he kept the section in. The book, a guide for building successful companies, went on to be a best-seller and made Ries a cult hero among tech entrepreneurs.

While readers embraced his “fail fast” approach to get a “minimum viable product” in front of customers

as quickly as possible, no one picked up on his stock market proposal. So five years later, Ries has started building the Long-Term Stock Exchange himself.

At first, bankers, investors, venture capitalists, and regulators told him the idea was too far outside the status quo to work. “People treated me like a barbarian,” he says. Eventually, though, he persuaded a team of about 20 engineers, finance executives, and attorneys to join him and raised money—he won’t say how much—from about 30 investors, including venture capitalist Marc Andreessen and

technology evangelist Tim O’Reilly.

Launching the LTSE won’t be easy: Getting approval from the U.S. Securities and Exchange Commission could take several years. Ries is in early discussions with the agency. The next step will be to file an official application detailing his proposals, such as the listing standards, followed by a 90-day public comment period. The regulator’s decision whether to greenlight the exchange could take months.

Ries argues that existing exchanges encourage bad decision-making by companies, investors, and

Quoted

“My hope is that they will continue to invest along this path... You’ll see bigger and more ambitious programming.”

Kerry Trainor, announcing he’ll step down as chief executive officer of **Vimeo** after overseeing dramatic growth at the IAC-owned company over the past four years

Vimeo is the second-biggest video-sharing site after YouTube, with 710,000 paid subscribers. Monthly users have tripled to more than 280 million in four years.

employees. The problem, he says, begins with stock market investors who favor companies that show big increases in sales, profits, users, or other measures every quarter. When a company falls short, investors flee, and the stock plummets. Hoping to avoid such jolts, managers spend too much time focusing on short-term performance. Ries says he’s heard the same story many times: Halfway through a quarter, an executive realizes the company isn’t on track and starts slashing innovative projects to meet his numbers. Once a company goes public, he says, employees “are on Yahoo! Finance every day, and it’s palpable how much that’s affecting the decision-making of ordinary managers.”

After many discussions with companies and investors on how to combat those tendencies, Ries decided his exchange would have rules targeting three areas: how executives are paid, how companies and investors share information, and how investors vote. A company that wants to list its stock on Ries’s exchange will have to choose from LTSE-approved compensation plans designed to make sure executive pay isn’t tied to short-term stock performance. Ries complains it’s common to see CEOs or top management getting quarterly or annual bonuses tied to metrics such as earnings per share, which pushes them to goose the numbers with accounting gimmicks or other ploys. **Ries** wants to encourage companies to adopt stock packages that continue vesting even after executives have left the company.

The LTSE also wants companies to share more information, such as details on research and

development spending. And to moderate swings in a company’s stock price and increase the influence of patient investors, shareholders who hang on to their stock would see their voting rights increase over time. As Ries sees it, an LTSE-listed company will have an extra stamp of approval. “You’re advertising to the markets that you’re willing to be held to a higher standard,” he says.

Ries’s reforms may not have the intended effects. For example, granting greater voting rights to long-term shareholders would make takeovers harder, and that could end up protecting complacent managers, says Larry Harris, a professor of finance and business economics at the University of Southern California. “The threat of takeover has done far more to get good behavior out of corporations than perhaps anything else,” he says. “A sophisticated investor may shun” an exchange that creates obstacles to outsiders who want to shake things up.

Getting SEC approval is “a fairly painful process,” says Sang Lee, managing partner at Aite Group. Like Ries, Brad Katsuyama, a hero of Michael Lewis’s *Flash Boys*, is trying to address what he sees as the shortcomings of existing markets. Katsuyama has spent the better part of a year trying to get SEC approval for IEX, his alternative stock trading system designed to neutralize the impact of high-frequency traders. He faces resistance from exchanges such as the NYSE, which slammed IEX’s proposed exchange as “unfair” and “opaque” in a November letter to the SEC.

If Ries gets the go-ahead from the SEC, he will face what

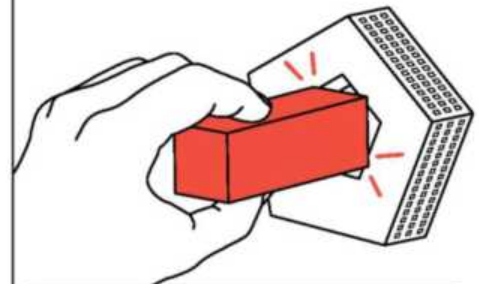
may turn out to be his biggest challenge: persuading a company to be the first to list on the LTSE.

Ries isn’t courting Uber, Airbnb, or giants that are still private. Instead he’s connecting with midsize startup founders, some of whom have invested in the LTSE. In the next few years, Ries hopes a handful of these companies will emerge as strong IPO candidates. If he’s lucky, one will decide to take the plunge. “As an industry, we all want to see these changes happen, but there’s always a little bit of an incentive for any individual actor to say this isn’t my fight,” Ries says. “I don’t begrudge those people. But if everyone does that, change doesn’t happen.” —*Ellen Huet and Brad Stone, with Annie Massa*

The bottom line Launching the Long-Term Stock Exchange, a new exchange for tech companies, could take several years.

Military

Can the Pentagon Learn to Be Flexible?



▶ **A Defense program tries to partner with tech companies**

▶ **“They had a hard time trying to shake loose funding”**

One of Washington’s biggest bureaucracies reaches out to do business with Silicon Valley’s agile and impatient entrepreneurs. What could go wrong?

Plenty, based on the initial struggles of the Defense Innovation Unit Experimental, or DIUx, the California technology outpost that’s a pet project of Department of Defense Secretary Ash Carter. DIUx’s role is to scout for new technology and help startups quickly get contracts with the Pentagon, Carter has said, without specifying the kind of projects he’s seeking.

Since DIUx was created last summer,



Technology

only 3 of 20 projects in its pipeline have gone into contract, an eternity considering a successful venture capital pitch can generate almost instant funding.

“The whole point of Silicon Valley is to be risky,” says Herbert Lin, a cyber research fellow at Stanford University. But the Pentagon’s procurement and acquisitions people generally want to remove risk from the process, he says.

DIUx has been so hobbled by the Pentagon’s red tape and cautious decision-making that last month Carter replaced its director and brought the California office—located on the grounds of the Moffett Federal Airfield in Mountain View—under his personal control, adding a second location in Boston. “We’re taking a page straight from the Silicon Valley playbook,” Carter said of the project’s relaunch.

“It took them a while to get organized, to get funding, support, to get office space,” says Andrew Hunter, a senior fellow at the Center for Strategic and International Studies in Washington. Even the office’s wireless internet connection took time to get switched on, says Ben FitzGerald, a senior fellow at the Center for a New American Security, who previously worked as an executive for technology companies with defense contracts.

The Valley has viewed the national security establishment with suspicion since Edward Snowden’s disclosure of secret surveillance by the National Security Agency. The distrust has been compounded by the FBI’s fight with **Apple** and other technology companies over encrypted data. “Not everyone in Silicon Valley is going to want to do business with DOD,” says Hunter, a former Pentagon acquisition official. The idea that getting a contract—for software, a device of some kind, or a service—could take a year or more “just didn’t translate to Silicon Valley-speak.”

While Carter’s Ph.D. in theoretical physics gives him scientific credibility in Silicon Valley, he followed a long line of military brass whose “tech tourism” was scoffed at by locals. Generals would tour “Facebook, Google, Palantir, and then call it a day,” with no follow-up on how interested companies could close a deal with the government, says Jackie Space, a former U.S. Air Force officer who’s now a partner at BMNT Partners, a technology incubator that focuses on national ▶

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◀ security. A lot of companies “felt that it was just a waste of time.”

Major Roger Cabiness, a Defense Department spokesman, in an e-mail that since opening last summer, the office, apart from the three projects already on contract, had “17 projects at various levels of negotiation with different agencies/entities.”

Some veteran Pentagon contractors say DIUx moves faster than the established Defense bureaucracy. Bob Goodson waited a year for the Pentagon to complete each of its first three contracts with the data-mining and visualization company he co-founded. In March, the company, **Quid**, pitched an idea to DIUx, and by May the Air Force was using its analysis software.

In rebooting DIUx, Carter replaced its first director with Raj Shah, a former F-16 pilot and combat veteran who headed a technology startup, and brought in Isaac Taylor, who had worked at Google on research projects including Google Glass and self-driving cars. Carter’s willingness to shake things up resonated with technology entrepreneurs, according to Lin, the Stanford

professor who is a former staff scientist for the House Armed Services Committee. “In Silicon Valley, the first time you do anything, you expect stuff to go wrong,” he says.

The unit had to scrounge for funds from the military services, according to Sonny Sinha, a former U.S. Department of Homeland Security official who’s worked with DIUx. When it was time to get moving on a contract, “they had a hard time trying to shake loose funding from the services, because they didn’t have their own pots,” he says.

The Defense Department is requesting \$30 million in new funding for fiscal 2017, Carter said in May, to “direct toward nontraditional companies with emerging commercially based technologies that meet our military’s needs.” But the House-passed version of the annual defense policy bill would eliminate that money.

The retooled innovation office may have only months to prove itself, in Washington and in Silicon Valley, before

the next president takes office and Carter is replaced. DIUx needs to show that it’s “worth keeping in that form so that they have enough institutional strength to continue on their own after the secretary leaves,” the Center for a New American Security’s FitzGerald says. —*Nafeesa Syeed*

The bottom line A year after opening an outpost in Silicon Valley to partner with tech companies, the Pentagon is having a hard time closing deals.

Human Resources

Algorithms Aren’t Just For Coders

▶ Tech companies are on a hiring spree for economists

▶ There are “these new companies with tons of digitized data”

At an April meetup organized by the National Association for Business Economics (NABE), a **Facebook** researcher named Michael Bailey presented a working paper suggesting that a buyer in Detroit might be willing to pay more for a home if he had lots of Facebook friends living in a high-priced housing market like San Francisco. For the project, Bailey and his co-authors matched public records of 525,000 home sales to anonymized data for 1.4 million Facebook users.

The daylong meeting, held at the Federal Reserve Bank of San Francisco, was the first formal gathering of tech company economists, according to NABE Executive Director Tom Beers, and included numerous stars of the consumer internet. Hal Varian, the **Google** economist who helped develop the AdWords marketplace, was there; Keith Chen, of **Uber**, presented a paper on the company’s

surge-pricing policy that refuted earlier research that said taxi drivers won’t work in the rain. Economists from **Amazon.com**, **Netflix**, and **LinkedIn**

elaborated on their work as well. “It was like a geek dream come true,” says Nela Richardson of the real estate brokerage Redfin.

The meeting gave participants a chance to trade notes about what it’s like to be at the forefront of a trend in the profession. U.S. companies went on an economist hiring spree in the late 1950s and 1960s, says Beers, as computers made econometric analysis possible and companies sought experts to forecast swings in the business cycle. Today, businesses are once again ramping up their hiring of economists, this time spurred by a boom in web-generated data and tools for storing and sorting it. Their job is to extract insights that can help businesses improve their products or user experience. Some also produce research to shape public policy. “Now you have all these new companies with tons of digitized data, and not only that, it’s data that describes human behavior,” says Andrew Chamberlain, chief economist at the jobs and recruiting website **Glassdoor**.

There were 11,500 economists working in the private sector as of May 2015, according to the Bureau of Labor Statistics, up from 5,580 in May 2010. Facebook’s data science team employs about 25 Ph.D.s in economics, says Bailey. That’s about the same number employed at a large U.S. bank, NABE’s Beers says. Amazon employs more than 60 economists, according to attendees at the NABE networking event, and its careers page lists more than 30 open positions. (The company didn’t respond to requests for comment.)

Stan Humphries joined **Zillow** in

“Some of the private data is garbage. It’s not that the people producing it are not as smart or that they don’t do hard work. The motivations are different.”
—*Bill McBride, Calculated Risk*

\$30
million

Amount the Defense Department requested for new funding for fiscal 2017, to spend on emerging technology

It’s Not All Academic

A sampling of research papers presented at a meetup of tech company economists in April

Keith Chen
Head of economic research

“Dynamic Pricing in a Labor Market: Surge Pricing and Flexible Work on the Uber Platform”

19  pages

Randall Lewis
Economic research scientist

“Ghosting Ads: Improving the Economics of Measuring Ad Effectiveness”

56 pages

Michael Bailey
Data science manager
“Social Networks and Housing Markets”

74  pages

NETFLIX

Technology

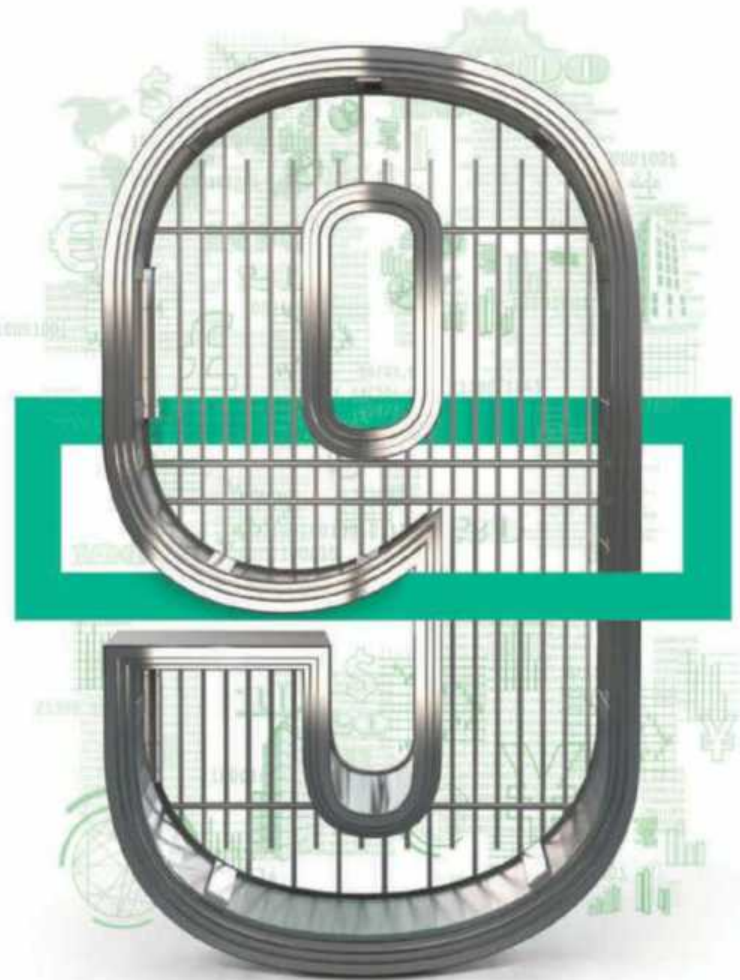
2005 to develop algorithms for estimating home prices. When the housing market started to crater, he emerged as a favorite source for journalists looking for data and commentary. “At a time when you still had industry people saying ‘Yes, we’ve had some correction in prices, but there’s nothing to see here, move on,’ I’d be the guy who came out and said, ‘No, we’re going to see another two years in housing recession; here’s why,’” says Humphries, whose current title is chief analytics officer and chief economist. “We felt being as accurate as we could would garner respect from consumers.”

Publishing data-driven research has become a popular strategy for web marketplaces and listings sites to showcase their depth of knowledge about a particular industry. That includes home renovation startups such as **Houzz** and **BuildZoom**, and jobs sites like **Indeed** and Glassdoor. More data is generally a good thing, says Bill McBride, who blogs about the housing market at Calculated Risk, but it pays to consider where it comes from and how it’s compiled. “Some of the private data is garbage,” he says. “It’s not that the people producing it are not as smart or that they don’t do hard work. The motivations are different.”

In the early days of the data boom, tech companies sought to entice big brains by allowing them to keep one foot in academia, says Susan Athey, a former chief economist at Microsoft who now teaches at Stanford. Recently, Amazon has emerged as an exception to that rule, says Athey: It keeps a tight leash on research produced by its in-house economists. Nonetheless, it’s managed to attract a team whose size and quality rivals the economics departments of top universities, Athey says, in part because the company offers access to unique data. “I can’t run an experiment on a couple of million people at Stanford. If you want to be aware of what interesting questions are out there, you almost have to go and work for one of these companies.” —*Patrick Clark*

The bottom line The giants of the web are assembling teams of economists that rival those at banks and universities.

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Smartphone banking is cool, but the tellercam is cooler 50

For now, Treasury decides that 30 years is long enough 51



Bid/Ask: T. Rowe Price has a \$194 million oops! 52

Yale the Investor vs. Yale the Do-Gooder

► Yale's endowment has a big stake in private equity, where it has less say in how its money is used

► "Limited partners are passive, and they need to be passive"

A photo of Frank Douglass's Victorian house is displayed on a website about Yale's employee homebuyer program. But Douglass, a custodian who's worked for the school for 27 years, has fallen behind on mortgage payments after carpal tunnel syndrome and a knee injury sidelined him from work. Now he's facing foreclosure by a company in which Yale's endowment is an indirect investor.

The Yale portfolio holds private equity funds managed by **Fortress Investment Group**, which owns more than 60 percent of **Nationstar Mortgage Holdings**, the servicer in charge of collecting payments on Douglass's mortgage. "Yale helped me buy my house, and now they're investing in the company that's trying to take my house from me," says Douglass, who serves on the board of alders, New Haven's city council. Douglass's case is in mediation, with a foreclosure motion pending. A court-appointed mediator said last year that Nationstar hadn't followed guidelines when it denied him a loan modification.

Another Yale investment, a hedge fund steered by **Kingstown Capital Management**, has a stake in the mortgage servicer **Ocwen Financial**. Both Nationstar and Ocwen have been investigated for unfair practices and ordered to provide relief to some

homeowners. While much of the country has moved beyond the foreclosure crisis, it's still a big issue in New Haven, the city dominated by the university. Critics are asking how the endowment's investments fit in with the school's efforts to promote homeownership. "Yale can do the right thing and exert influence over their managers and change the way they do business," says Aaron Greenberg, the head of a Yale graduate student union, and another member of the city's board of alders. Greenberg helped dig up the connection between the endowment and the servicers. The board of alders hasn't taken action, but members of its black and Hispanic caucus are looking into the role of servicers in foreclosures and the university's position as an investor.

"Yale is an ethical investor and was a pioneer" in weighing factors beyond economic return, says Tom Conroy, a university spokesman, who wouldn't comment on specific investments. During the apartheid era, it divested from 17 companies doing business with South Africa. "Yale applies its ethical investment policy to public and private positions alike," Conroy says.

Beyond the question of whether to put money into specific industries, the investments highlight ►



◀ another issue. More than half of the university's \$25.6 billion endowment is invested in private equity, hedge funds, and other illiquid assets. That can make it harder for the school to control where its dollars go.

Hedge funds can lock investors into holding them for up to three years. With private equity, investors buy into funds as limited partners and relinquish a say in investment decisions. If limited partners want to exit the fund, they have to get permission—and they may suffer a financial penalty. “Limited partners are passive, and they need to be passive,” says Michael Wolitzer, a partner at law firm Simpson Thacher & Bartlett. There are exceptions in which large investors have exerted influence, Wolitzer says, but they're rare.

Yale's endowment, the nation's second-largest after Harvard's, has appealed to outside managers to avoid investments in companies that don't reduce greenhouse gas emissions, resulting in one fund selling stakes in oil sands producers and another dropping shares in a coal company, the university said in April.

Under Chief Investment Officer David Swensen, Yale's endowment was among the first to shift its assets into private equity and hedge funds. Over 20 years, private equity earned the endowment an annualized return of 36 percent, the school said in a 2014 report.

Yale was an investor in a Fortress fund as of late April, according to a report by research firm Prequin seen by Bloomberg. A 2013 Fortress presentation showed Nationstar as a key holding in that fund. Yale had \$216 million with Kingstown, the hedge fund, as of June 2015 through a limited partnership called Ktown, which appears on a university tax

filing. Ktown, which is 97 percent owned by Yale, holds almost 2 percent of Ocwen's shares, according to filings. Kingstown declined to comment.

The U.S. Consumer Financial Protection Bureau and 49 states accused Ocwen in 2013 of engaging in “significant and systemic misconduct.” Ocwen agreed to provide \$2.1 billion in homeowner relief to settle the matter. John Lovallo, an Ocwen spokesman, says the company is committed to finding ways to keep people in their homes and has helped more than 625,000 families avoid foreclosure.

Nationstar agreed to make refunds of about \$16.2 million to borrowers related to delays in approving modifications transferred from prior servicers, the company said in a May regulatory filing. New York's Department of Financial Services requested information in 2014 about Nationstar's performance and staffing after receiving hundreds of complaints about modifications, improper fees, and lost paperwork. The agency says it's still examining the matter.

Nationstar says it's helped 600,000 borrowers with modifications, repayment plans, and other solutions since 2010. “The servicing books we have acquired from banks have seen a 50 percent improvement in delinquency rate,” said Chief Executive Officer Jay Bray in a statement. Government-backed **Fannie Mae**, which buys mortgages, gave Nationstar its highest rating for mortgage servicers last year.

Nationstar rejected Douglass's application for a mortgage modification on the grounds that it would result in a higher monthly payment. But Sarah White, an attorney with the Connecticut Fair Housing Center, who's advising

Douglass, argues that the servicer didn't follow Federal Housing Administration guidelines. Howard Kane, a court-appointed mediator, wrote in August that Nationstar's modification package was missing pages and contained forms not required by the FHA.

Douglass is one of more than 1,100 Yale employees who've received home-buyer assistance. He got about \$20,000 in taxable grants over a decade. Yale also offers free financial counseling for employees, says Conroy, the university spokesman. “I love the place,” Douglass says of his house on Elm Street. “I don't want to leave it.” —Janet Lorin

The bottom line Yale's endowment investments are made increasingly through private equity, which may be hard to untangle when ethical questions arise.

Banking

Lights! Camera! Mortgage!



▶ **As branches dwindle, Barclays bets on video tellers**

▶ **“Look into that tiny little pinhole of a webcam and be engaging”**

Over the course of her 31-year career at the U.K. bank **Barclays**, Jayne Newton went from being a cashier in a branch to making home visits to wealthy clients in the heady days before the financial crisis. She still works with customers face-to-face today—sort of. She's one of the bank's 60 video tellers, spending her days in front of a webcam in a noise-resistant pod at an office in Liverpool.

Newton says she likes working on camera, but it's demanding. “Before I do every video, I always make sure I brush my hair and put my lipstick on,” she says. “You make sure you keep your facial expressions in control.”

Jackie Brambles, a former TV show host, helped Barclays employees get comfortable on camera. “It's a real



Douglass hopes to stay

Women using this hashtag posted screen shots of the Uber app being deleted from their phones



Quoted

#سعوديات_يعلن_مقاطعة_اوبر

Translation: **#SaudiWomenAnnounceUberBoycott**. Saudi Arabia is investing \$3.5 billion in the ride-hailing company. Some Saudi women say this means the government will profit from the ban on women driving in the country. Uber maintains that its service gives women mobility.

juggling act,” she says. “They have to be able to look into that tiny little pinhole of a webcam and be engaging and informative and lovely and polite, but at the same time have that surreptitious little glance to make sure: ‘Am I being understood? Is this person getting it? Are they happy?’”

After piloting video for select customers for about a year, Barclays started expanding it in April and plans to have 110 video bankers by yearend. They’ll be reachable 24 hours a day by tapping a button in the bank’s mobile app or clicking a link on its website.

Although the bank continues to eliminate branches—from 2,000 in the U.K. a decade ago to 1,362 in 2015—managers insist video banking isn’t driven by cost cuts. “This isn’t about forcing people to change the way they talk to us,” says Steven Cooper, head of personal banking at Barclays. “It’s about giving customers choice.” Barclays is looking for ways to connect with its customers and, more important, hang on to them in the face of competition from financial-technology startups promising to let people manage their money from a smartphone.

Cooper echoes the gospel of digital-banking consultants, who argue the service should be used to make customers feel personally valued. Video tellers can act as a human support system for consumers opening an account, transferring money, or researching a loan.

Barclays has tried to simulate the branch experience. The bankers, three-quarters of whom are women, wear turquoise and navy uniforms and sit in front of a matching screen embossed with the company’s logo. For the initial training, Brambles had a makeup artist give tips to men and women alike on how to enhance one’s appearance for the camera.

A video service doesn’t necessarily make branches redundant: **HSBC**

offers video banking for mortgage queries via kiosks in 39 of its U.K. locations. It plans to expand the service later this year, says Nigel Hinshelwood, head of the bank’s U.K. business.

Some financial companies have tried video and found the investment in training and technology not worth the trouble. **Citigroup** and **American Express** have piloted services—American Express had agents available via an iPad app—which they nixed.

The technology only recently became reliable and cheap enough for mass adoption by banks, says Alyson Clarke, an analyst with Forrester Research. “It’s hard to connect with a customer unless you’ve got a high-quality image on screen,” she says. “I don’t want to have a video conversation with my bank and feel like I’m talking to my grandma on Skype.”

—*Gabrielle Coppola and Stephen Morris*

The bottom line Cheaper tech makes video banking possible, but making it personal still takes work. Barclays hired a media consultant to help.



Bonds

Why the U.S. Isn’t Locking In Cheap Rates

- ▶ **Other countries are issuing bonds that mature in 40 to 100 years**
- ▶ **“The Treasury likes to see large, liquid markets”**

The Department of the Treasury has a chance to grab a bargain. The U.S. government is the world’s biggest debtor, and its cost of borrowing is incredibly low. At the most recent auction, it had to pay only 2.6 percent on a 30-year Treasury bond. But that’s the longest-maturity debt the U.S.

sells—why not lock in low interest rates for even longer?

Since 2014, Belgium, Canada, France, Mexico, Spain, Switzerland, and the U.K. have all sold debt maturing in 40 to 100 years. In 2015, **Microsoft** and **Verizon Communications** sold bonds with 40-year maturities, and

2.6%

What the government pays on its most recent 30-year Treasury bond, the longest-maturity debt it issues

the University of California issued 100-year obligations. “If rates go up, it’s a historic missed opportunity by the U.S.,” says Campbell Harvey, a finance professor at Duke University.

The Treasury sees things differently. Since the 1970s, it’s pursued a policy of predictable, regular bond issuance. The Treasury wants to make sure the market for its \$13.4 trillion in bonds remains reliable and easy for investors around the globe to trade in. To the extent investors reward reliability with lower interest rates, the policy may save taxpayers money. A longer-maturity bond might be issued sporadically, when rates are attractive and there are enough buyers for such an unusual security.

Senator Mark Warner, the ranking member of the Banking, Housing, and Urban Affairs Subcommittee on Securities, Insurance, and Investment, nonetheless argues that longer-term issuance is worth a shot. “This is an academic discussion until we try it,” the Virginia Democrat says. Issuing longer-term bonds doesn’t reduce the debt burden, he says, “but it does remove some of the risk from interest rate spikes.”

“Treasuries are different,” said Antonio Weiss, a counselor to the secretary of the Treasury, in testimony to the Senate subcommittee in April. “We ▶

Bid/Ask

By Karen Weise



\$194m

T. Rowe Price compensates clients for a flawed proxy vote. Although the fund company was among those claiming that a \$24.9 billion buyout of Dell undervalued the computer maker, T. Rowe mistakenly supported the transaction. The payments cover the difference between the \$13.75 per share the company paid and the \$17.62 per share a Delaware court ruled should have been the deal's fair value.

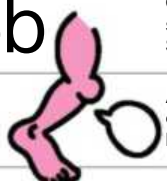
52



\$2.5b

Qatar buys a big building in Singapore. The country's sovereign wealth fund agreed to purchase the 43-story Asia Square Tower 1. It's the biggest office sale in Singapore's history.

\$1b



A device maker gets some backbone. Zimmer Biomet Holdings, one of the largest U.S. manufacturers of replacement hips and knees, agreed to buy LDR Holding, which makes spinal devices.

\$974m

Devon sheds fields. Devon Energy agreed to sell gas fields in Texas and Oklahoma and royalties in the northern Midland Basin. The company is divesting assets to reduce its debt.

\$485m

A fracker taps the market. Shale driller WPX Energy issued 49.5 million new shares to raise money for more wells, acquisitions, and pipeline construction.

\$306m

An Italian soccer club gets a new controlling shareholder. China's Suning Holdings Group will buy about 70 percent of Inter Milan. President Xi Jinping wants to make China a soccer power.

\$273m



Rothschild chases families with beaucoup bucks. The merger adviser is buying Financière Martin Maurel to expand its private banking for French families and entrepreneurs.

\$290k

Pelé scores. The soccer giant sold his winner's medal from his first FIFA World Cup. He's auctioning more than 2,000 pieces of memorabilia and donating some proceeds to a children's hospital.

◀ don't introduce new instruments and then withdraw them." He said the government was nonetheless moving to extend maturities by changing the mix of bonds it issues. The average lifespan of its debt is about 69 months, up from 49 in December 2008.

Most countries selling ultra-long debt don't do it on any regular schedule. France has issued 50-year bonds only three times since 2005, and the 50-year security Belgium sold in April was its first of that maturity. Spain's sale was its second foray into the ultra-long market. In contrast, even Treasury Inflation-Protected Securities—the least-frequently auctioned U.S. debt—are offered at least three times a year. And the government is slow to add products. After the creation of TIPS in 1997, its next addition didn't come until 2014, when it introduced floating-rate notes.

The Treasury has also gotten push-back against ultra-long bonds from the Wall Street banks that act as dealers, stepping into the market to make sure there's always a buyer or a seller. The list of investors who'd want a bond that doesn't mature for 40 or 50 years is relatively short, says Jason Sable, a trader at **Mizuho Securities USA**. The likely primary buyers—pensions and insurers—tend to prefer higher-yielding corporate debt. Other investors may deem ultra-long bonds as perilous, because their value on the secondary market could fall sharply if interest rates subsequently rose.

If eager buyers dried up, dealers could potentially get stuck with unsold bonds on their books, Sable says. The Treasury's Borrowing Advisory Committee, which includes some dealers, voiced that concern in 2011, the last time the department asked it to consider ultra-long bonds.

"The Treasury likes to see large, liquid markets," says James Moore, head of investment solutions at **Pacific Investment Management**, one of the world's biggest bond managers. "And something like a 50-year bond is not going to be particularly liquid." —*Eliza Ronalds-Hannon and Liz Capo McCormick*

The bottom line Treasury wants to keep the market for its bonds orderly and predictable, and it's willing to pass up some opportunities to do so.

B Edited by Pat Regnier
Bloomberg.com

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Run Simple

Mountain View, Calif. **Woburn, Mass.** **Gilching, Germany**
Santa Cruz, Calif. **Bratislava, Slovakia**
Karlsruhe, Germany **Tarrytown, N.Y.**

Turin, Italy
Ho Chi Minh City, Vietnam
Stuttgart, Germany
Pullman, Wash.
Palatka, Fla.

Santa Clara, Calif. **Ho Chi Minh City, Vietnam**
Penang, Malaysia
Munich

Chengdu, China
Haifa, Israel
Leixlip, Ireland

Klerksdorp, South Africa
Edmonton, Alta.
Auckland
Hillsboro, Ore.
Alexandria, Egypt
Houston

Bangalore, India
Chenoa, Ill.
Cupertino, Calif.
Stevenage, England
Cambridge, Mass.
Atlanta, Ga.
Atlanta, Ga.

Lemförde, Germany
East Sussex, England
Beijing
London
Athens, Ala.
Cambridge, Mass.
Fyffe, Ala.
Cairo

Davis, Calif.

Horace Clemmons is in his 70s, lives in the woods in Alabama, and is trying to build tractors in Cuba. Larry Page, the billionaire co-founder of Google, is in his 40s and spends his free time trying to build cars that fly. They couldn't be more different: Deep South, West Coast; overalls, hoodies. But they're both inventors with a deep curiosity about the world and a relentless ambition to improve it—something everyone in the

Global Tech Issue

shares, from an ex-convict with an idea for an undersea turbine generator to a group of young Egyptians trying to build a culture of makers post-Tahrir Square. Some of these thinkers and tinkerers work in highly funded corporate labs; some in academia. And many of them, of course, started out in that time-honored place, the garage.

Color illustrations by **Ana Benaroya** Pencil illustrations by **Armando Veve**

Larry Page is leading efforts to make flying cars. No, seriously

Three years ago, Silicon Valley developed a fleeting infatuation with a startup called Zee.Aero. The company had set up shop right next to Google's headquarters in Mountain View, Calif., which was curious, because Google tightly controls most of the land in the area. Then a reporter spotted patent filings showing Zee.Aero was working on a small, all-electric plane that could take off and land vertically—a flying car.

In the handful of news articles that ensued, all the startup would say was that it wasn't affiliated with Google or any other technology company. Then it stopped answering media inquiries altogether. Employees say they were even given wallet-size cards with instructions on how to deflect questions from reporters. After that, the only information that trickled out came from amateur pilots, who occasionally posted pictures of a strange-looking plane taking off from a nearby airport.

Turns out, Zee.Aero doesn't belong to Google or its holding company, Alphabet. It belongs to Larry Page, Google's co-founder. Page has personally funded Zee.Aero since its launch in 2010 while demanding that his involvement stay hidden from the public, according to 10 people with intimate knowledge of the company. Zee.Aero, however, is just one part of Page's plan to usher in an age of personalized air travel, free from gridlocked streets and the cramped indignities of modern flight. Like Jeff Bezos and Elon Musk, Page is using his personal fortune to build the future of his childhood dreams.

The Zee.Aero headquarters, located at 2700 Broderick Way, is a 30,000-square-foot, two-story white building with an ugly, blocky design and an industrial feel. Page initially restricted the Zee.Aero crew to the first floor, retaining the second floor for a man cave worthy of a multibillionaire: bedroom, bathroom, expensive paintings, a treadmill-like climbing wall, and one of SpaceX's first rocket engines—a gift from his pal Musk. As part of the secrecy, Zee.Aero employees didn't refer to Page by name; he was known as GUS, the guy upstairs. Soon enough, they needed the upstairs space, too, and engineers looked on in awe as GUS's paintings, exercise gear, and rocket engine were hauled away.

Zee.Aero now employs close to 150 people. Its operations have expanded to an airport hangar in Hollister, about a 70-minute drive south from Mountain View, where a pair of prototype aircraft takes regular test flights. The company also has a manufacturing facility on NASA's Ames Research Center campus at the edge of Mountain View. Page has spent more than \$100 million on Zee.Aero, say two of the people familiar with the company, and he's not done yet. Last year a second Page-backed flying-car startup, Kitty Hawk, began operations and registered its headquarters to a two-story office building on the end of a tree-lined cul-de-sac about a half-mile away

Propeller



WHAT APPEARS IN THE

from Zee's offices. Kitty Hawk's staffers, sequestered from the Zee.Aero team, are working on a competing design. Its president, according to 2015 business filings, was Sebastian Thrun, the godfather of Google's self-driving car program and the founder of research division Google X. Page and Google declined to speak about Zee.Aero or Kitty Hawk, as did Thrun.

Flying cars, of course, are ridiculous. Lone-wolf inventors have tried to build them for decades, with little to show for their efforts besides disappointed investors and depleted bank accounts. Those failures have done little to lessen the yearning: In the nerd hierarchy of needs, the flying car is up there with downloadable brains and a working holodeck.

But better materials, autonomous navigation systems, and other technical advances have convinced a growing body of smart, wealthy, and apparently serious people that within the next few years we'll have a self-flying car that takes off and lands vertically—or at least a small, electric, mostly autonomous commuter plane. About a dozen companies around the world, including startups and giant aerospace manufacturers, are working on prototypes. Furthest along, it appears, are the companies Page is quietly funding. "Over the past five years, there have been these tremendous advances in the underlying technology," says Mark Moore, an aeronautical engineer who's spent his career designing advanced aircraft at NASA. "What appears in the next 5 to 10 years will be incredible."

Northern California in particular has had a long fascination with flying cars. In 1927 a now mostly forgotten engineer named Alexander Weygers first began thinking up the design for a flying saucer that could zip between rooftops. In 1945 he received a patent for what he described as a "discopter," a vertical takeoff and landing (VTOL) machine with room inside for passengers to walk around, cook, and sleep. He depicted smaller versions landing in pods atop buildings in downtown San Francisco.

Did you know?

Los Angeles-based engineer Dezso Molnar is planning to start a flying-car racing league in 2017

No discopters were built, though it's believed that the U.S. Army, which paid visits to Weygers's compound in Carmel Valley, Calif., tinkered with a prototype.

Today, the world's premier flying-car enthusiast is Paul Moller, 79, a professor emeritus at the University of California at Davis. Fifty years ago, when he was teaching mechanical and aeronautical engineering, he developed a specific vision: an aircraft you could park in your garage, drive a few blocks to a small runway, then take skyward. He tested his first prototype, the XM-2, in 1966. The XM-2 resembled a flying saucer with a seat at its center protected by a plastic bubble. It managed an altitude of 4 feet, while graduate students held it steady with ropes. "We were worried if the machine got out of control, we might kill a few people," Moller says.

In 1989 his M200X made it to 50 feet above the ground. Then came the M150 Skycar, the M400 Skycar, the 100LS, the 200LS, the Neuera 200, and the Firefly, all variations on the same Jetsonian idea. In January 2000, Moller gave a speech on flying cars at the Palo Alto Research Center (PARC), the birthplace of the graphical user interface and, for nerds, sacred ground. Afterward, an engineer in his late 20s walked up and said he was interested in the concept but was

Heads

EDIBLE!"

THE NEXT 5 TO 10 YEARS WILL BE INCREDIBLE!"

SELF-FLYING AIRCRAFT IS SO

skeptical that streetworthy personal aircraft were technically feasible; at the time, Moller didn't recognize young Larry Page.

Moller kept trying. He says he burned through more than \$100 million developing his designs and declared personal bankruptcy in 2009.

That same year, Moore, the NASA researcher, published a paper describing a concept plane called the Puffin. Moore's big idea was to use electric motors, which are quieter and safer and have far fewer moving parts than internal combustion engines or conventional turbines. "By going to electric propulsion, you get rid of the vast majority of the complexity, cost, and unreliability," Moore says. "This is why companies looking at this area aren't insane." Moore credits Musk's Tesla and other automakers with advancing the technology. "Electric motors were mostly used in industrial settings where they were stationary, and no one cared about their weight that much," Moore says. "It wasn't until the automotive industry got interested that they started to get more lightweight."

Carmakers invested in other areas, too, that are helpful for building small electric planes, particularly batteries and the semiconductors that control them. Self-driving systems, like the kind Google uses in its Koala cars, are perhaps a decade away from mainstream use on the roads, but they may already be good enough for the skies. "Self-flying aircraft is so much easier than what the auto companies are trying to do with self-driving cars," Moore says.

Moore's paper circulated, rekindling excitement. Sometime in 2009, a small group of engineers had begun meeting in Silicon Valley to discuss funding an electric-plane project. One of them was Joe Ben Bevirt, a mechanical engineer and entrepreneur who had studied under Moller at UC Davis. Another was Ilan Kroo, an aeronautics and astronautics professor at Stanford. And another was Page. Although it initially looked as if they might all team up, Kroo and Page broke off to start Zee.Aero. Alone, Bevirt founded Joby Aviation, a company he hopes will beat Zee.Aero to market and prove that his efforts with Moller—and the older man's life's work—weren't in vain.

Bevirt owns a 500-acre compound near Santa Cruz, Calif. To get there, you turn onto idyllic California State Route 1 and drive past the boardwalk, a few blocks of strip malls, and 15 miles of undeveloped, windswept coastal dunes. Then you turn onto a dirt road, pass a lake and a grove of towering redwoods, and walk through gardens overflowing with lavender and roses. It's here that Bevirt has built a series of workshops, plus housing for about half of his 35 employees.

Bevirt grew up nearby on an electricity-free commune where his mom worked as a midwife and his father built custom homes. From a young age, he learned his way around toolboxes and construction sites, and was an avid reader. After consuming the sci-fi classic *The Forever Formula* in elementary school, he decided he wanted to build the kind of personal aircraft the book's hero flew and persuaded a friend to help. "We built lots of prototypes, but they always crashed and burned," he says. They shifted to custom bikes.

The flying-car dream stuck with Bevirt as he entered UC Davis in 1991 to study mechanical engineering, and he quickly found himself working for Moller, building one prototype after another. Bevirt eventually concluded their shared dream wouldn't be feasible until battery and motor technology improved. He figured he'd need to wait 20 years. "Paul had been working on this for 30 years, and he was 50 years ahead of his time," he says.

MUCH EASIER THAN WHAT THE AUTO

Bevirt got his bachelor's, and then a master's in mechanical engineering from Stanford. He worked in biotech after graduation, co-founding a company called Velocity11 that built robots to sequence DNA. His next company, called Joby (his childhood nickname), sold camera accessories such as flexible plastic tripods. Joby turned Bevirt into a multimillionaire. In 2008 he started Joby Energy, a maker of airborne wind turbines whose technology Google later acquired. The 20-year mark was approaching, so in 2009 he also used some of his wealth to buy the 500 acres and start Joby Aviation.

Its headquarters is an engineer's fantasyland. The focal point is a large wooden building where two dozen workers sit at a few rows of desks jammed with computers. Aside from the clusters of large black monitors, the place feels more like a barn than an office. Aircraft prototypes hang from the ceiling, as does a thick climbing rope for exercise. In the open kitchen, abutting a long redwood dining table in one corner, a cook uses ingredients from the nearby gardens to prepare three meals a day. While the smell of a Malaysian curry fills the room, a banjo twangs from speakers overhead.

The manufacturing happens at a series of buildings about 100 yards downhill, past gardens and an outdoor clay pizza oven. One of the buildings is an airy warehouse with a giant oven inside—but this one isn't for pizza. It's used to cure the carbon-fiber bodies of the planes and looks like a Quonset hut. Former members of Oracle's America's Cup sailing team, some of the world's leading materials experts, oversee the curing process, baking the carbon fiber at about 194F. In another building, engineers build cantaloupe-size electric motors; in a third, they test electronics; in a fourth, they put the finishing touches on wings and other parts. Out back, there's a large truck with an extendible arm atop its trailer like a cherry picker, which hoists propellers high into the air so engineers can perform wind tests while driving down a road at high speed. Robotic prototypes buzz around.

Bevirt funded Joby Aviation by himself until last year, when he was joined by Paul Sciarra, one of the co-founders

of Pinterest. Sciarra grew up in New Jersey, taught himself to code, hit it big with Pinterest, then went looking for something new to throw himself into. He, too, concluded that electric motors and batteries appeared to have applications well beyond the auto industry. "The goal is to build a product that impacts the lives of lots of people," Sciarra says. "Not just folks that are amateur pilots or wealthy, but everyone."

Sciarra and Bevirt hope to begin flying a human-scale prototype plane later this year. They won't give the exact specifications but suggest that it could hold, say, a family of four and travel 100 miles or so on a full charge. The vehicle looks like a plane-helicopter hybrid packed with propellers, about eight mounted on the wings and tail. For takeoff and landing, the propellers hang horizontally like a helicopter's and rotate for forward propulsion once in the air. Joby Aviation has already built smaller prototypes and has models of the plane's body, wings, and propellers scattered about the manufacturing facilities. Bevirt and Sciarra see the vehicle taking off from parking garages, roofs, or areas alongside highways. They want to offer flights as an Uber-like service—summon a plane when you need it.

COMPANIES ARE TRYING TO DO WITH SELF-DRIVING CARS"

Other Flying Cars in Development

Based in Woburn, Mass.

Full-vehicle parachute included, just in case

Launch date*

2026

The TF-X

Maker: Terrafugia
Cost: \$120,000; seats: 4

Still in the early stages of development, this flying car should have a range of 500 miles and cruise as fast as 200 mph.

Prototype named Transition has already flown



Pilots use a joystick and clever software to fly

Charges in two hours

2016

Volocopter

Maker: E-volo
Cost: \$280,000; seats: 2

Prototypes have already flown. It's all-electric for now but will be sold as a hybrid to increase flight times.

Weights 992 pounds



18 propellers—because can you ever have enough?

Looks like a helicopter but makes far less noise

Needs just a few hundred meters to land

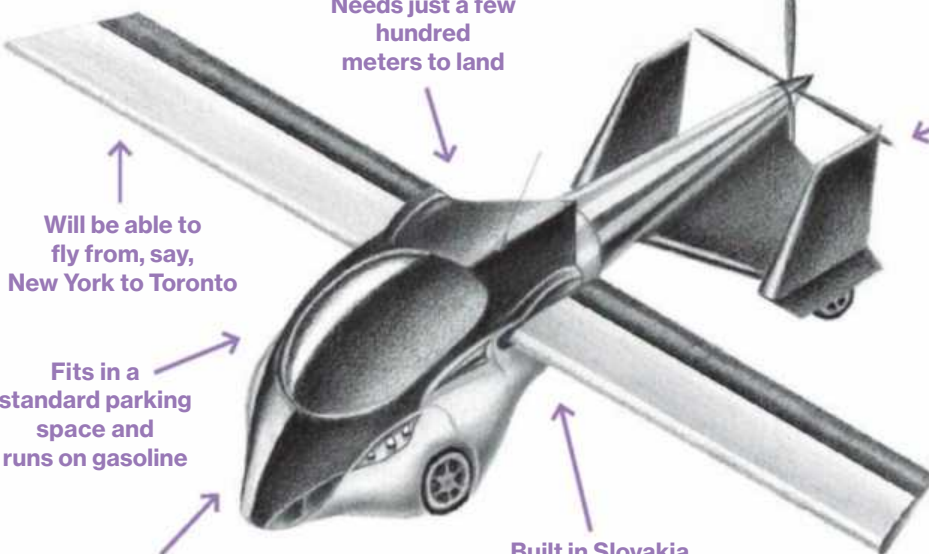
Two football fields of distance is enough for liftoff

2018-19

AeroMobil 3.0

Maker: AeroMobil
Cost: \$400,000+; seats: 4

This is a true flying car. It can cruise down the road and take off at a moment's notice as the wings spread out.



Will be able to fly from, say, New York to Toronto

Fits in a standard parking space and runs on gasoline

Will start taking orders this year

Built in Slovakia

*Launch dates obtained from companies. Handle with care.

Built at Moller's workshop in Davis, Calif.

This is the fifth-generation flying car Moller has built

Two-, four-, and six-seat versions planned

Launch date

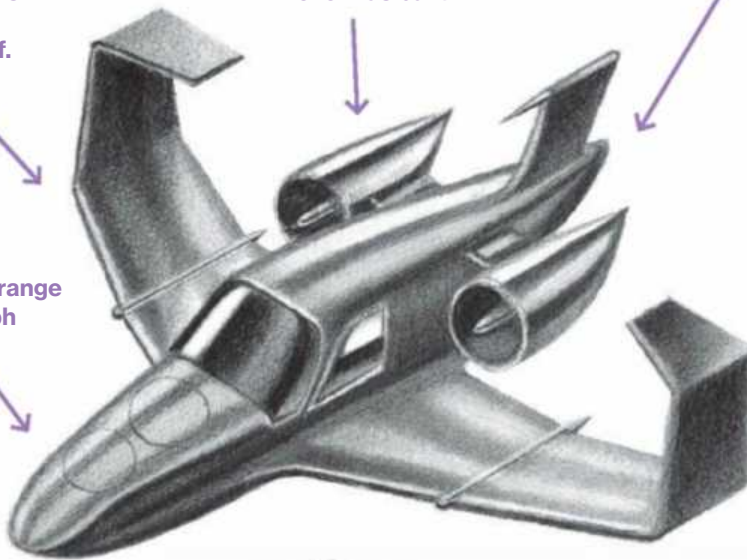
TBD

Moller Skycar

Maker: Moller International
Cost: \$500,000 to \$1 million; seats: 4

Paul Moller has been trying to make flying cars for about 50 years. Investors have pumped more than \$100 million into his largely troubled prototypes.

805 miles of range at 131 mph



Max speed of 308 mph

2018

Lilium Jet

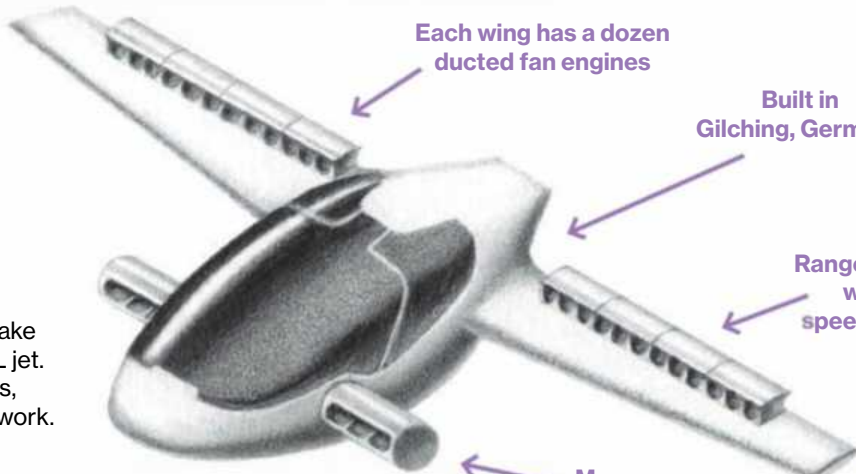
Maker: Lilium Aviation
Cost: \$TBD; seats: 2

The German startup plans to make the world's first all-electric VTOL jet. It will be easy to fly, Lilium says, with software doing much of the work.

Each wing has a dozen ducted fan engines

Built in Gilching, Germany

Range of 300 miles with a max speed of 250 mph



More fan engines

Funded by the European Union

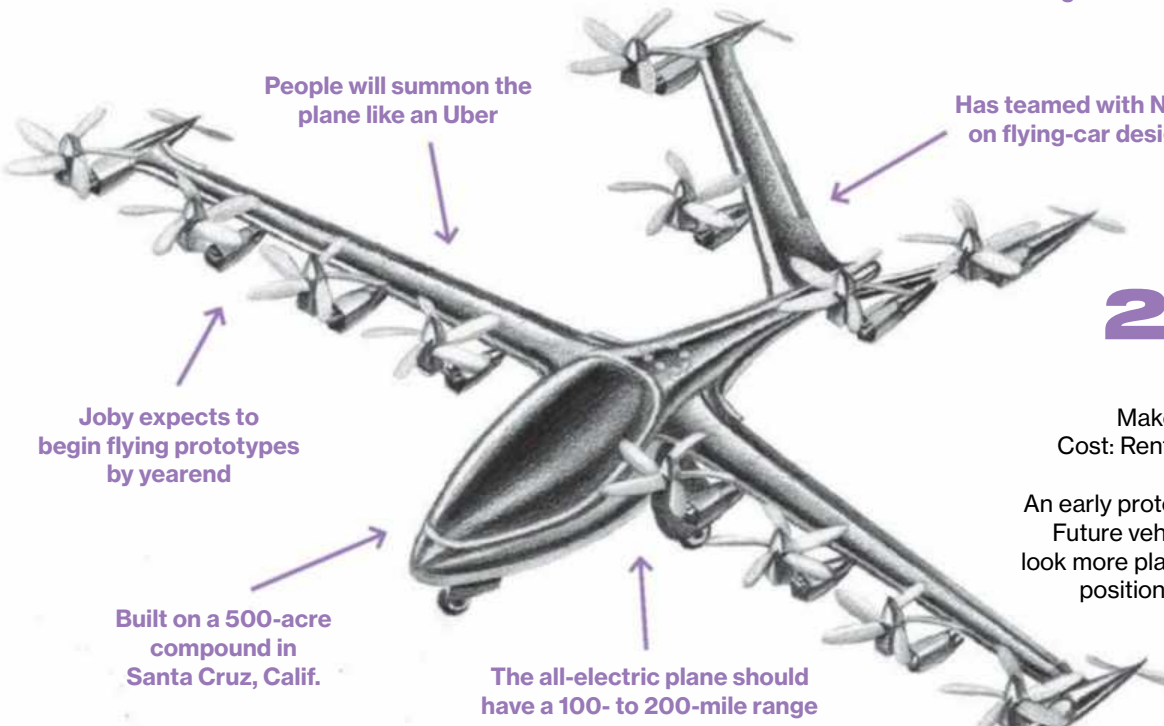
People will summon the plane like an Uber

Has teamed with NASA on flying-car designs

Joby expects to begin flying prototypes by yearend

Built on a 500-acre compound in Santa Cruz, Calif.

The all-electric plane should have a 100- to 200-mile range



2016

Joby

Maker: Joby Aviation
Cost: Rent as a service; seats: 2

An early prototype of Joby's flying car. Future vehicles will seat four and look more planelike, with six propellers positioned around the craft.

PEOPLE WORKING AT THE AIRPORT HAVE CAUGHT GLIMPSES OF

The Joby aircraft looks similar to other vehicles being built around the world. In May the German company E-volo conducted manned flights of its Volocopter, a two-seat aircraft powered by 18 propellers. Other flying-car startups include AeroMobil, Lilium Aviation, and Terrafugia. Even Airbus has built a two-seater prototype at its Silicon Valley labs, say two people familiar with the designs.

In 2013, Red Bull held one of its Flugtag competitions in Long Beach, Calif. Flugtag is a televised spectacle where hobbyists see how far they can launch their homemade flying machines off a dock. It's more about entertainment than sustained flight—the contraptions generally dive straight into the water, and everyone laughs. At this one, though, a group called the Chicken Whisperers stunned the assembled crowd. Dressed in full-body baby-chick outfits, the team pushed its glider off the dock and watched as it cruised 258 feet, breaking the previous record of 229 feet. The chickens danced. They clucked. They took a swim in the water. They were all Zee.Aero employees in disguise, having fun, trying out some designs.

In the six years since its founding, Zee.Aero has hired some of the brightest young aerospace designers, software engineers, and experts in motor and battery hardware. They've come from places such as SpaceX, NASA, and Boeing, and they're all chasing after the goal presented succinctly on Zee.Aero's spare website: "We're changing personal aviation."

At its outset, Zee.Aero was led by Kroo, the Stanford aerospace professor. He wrote the original Zee.Aero patent, No. 9,242,738, which shows a strange-looking one-seater aircraft with a long, narrow body. Behind the craft's cockpit, rows of horizontal propellers run along both sides of the body of the plane to handle the VTOL work. There's also a wing at the back with two more propellers that add forward thrust.

Zee.Aero worked on this design for a couple of years. Small, computer-controlled versions of the aircraft were photographed by reporters and hobbyists sitting in the parking lot at 2700 Broderick Way. None of the prototypes were big enough to fit a human.

Over time, the company realized this might not be the best design, according to three former Zee.Aero employees. Page also grew dissatisfied with the rate of progress. In 2015, Kroo returned to teach at Stanford full time but continued to advise Zee.Aero as "principal scientist," while the company's engineering chief, Eric Allison, took over as chief executive officer. Under Allison, the company began work on a simpler, more conventional-looking design, now coming to life at the Hollister Municipal Airport.

Hollister is a city of about 35,000 nestled among garlic and artichoke farms. Its airport is popular among amateur pilots because of favorable winds and a lack of commercial air traffic. There's a flight school, a sky-diving business, and a few run-down buildings. The least shabby structure is Building 19, which has been taken over by a dozen or so Zee.Aero workers.

The airport is open for business from 8 a.m. to 5 p.m. on weekdays, but Zee.Aero employees frequently run test flights when no one else is around. Nonetheless, people working at the airport have caught glimpses of two Zee.Aero craft in recent months. Both have a narrow body, a bulbous cockpit with room for one person upfront, and a wing at the back. In industry lingo, the planes are pushers, with two propellers in the rear. One of the prototypes looks like a small conventional plane; the other has spots for small propellers along the main body, three per side.

When the aircraft take off, they sound like air raid sirens.

The people at the airport haven't heard Page's name mentioned, but they long ago concluded Zee.Aero's owner is super rich. Zee.Aero employees receive catered lunches—sometimes \$900 worth of barbecue from Armadillo Willy's, a local chain. Recently, the company purchased a \$1 million helicopter to fly alongside the planes and gather data.

For Page, this project is deeply personal. He's been known to spend evenings with Musk, both men thinking aloud about ways to fundamentally change transportation. Musk wants to build an upscale electric VTOL jet; Page wants the down-market version. In an interview with a *Bloomberg Businessweek* reporter a couple of years ago, Page confessed that he longed to take more risks like his industrialist friend. He wanted to dabble with new forms of investment outside the confines of Google and back projects that focused on atoms, not bits. "There's a lot of money going into internet startup kinds of things, which is great," he said. "But for some of the real problems we face, I think we need other kinds of investments, too. I have young kids, so I would like them to be safe. I'd like for pedestrians to be much safer. I'd like for blind people and old people and young people to get around."

The former Zee.Aero employees describe the company as a fun place to work but don't downplay the serious expectations from Page. He wants the flying-car future, and he wants it now. If the atmosphere grew tense with Kroo's departure, it didn't lighten up when the Kitty Hawk team arrived.

Kitty Hawk has about a dozen engineers, including some Zee.Aero veterans. Others came from AeroVelo, a startup whose claim to fame was winning the \$250,000 Sikorsky Prize in 2013, for building a human-powered helicopter that could stay aloft for more than a minute. Kitty Hawk employees include Emerick Oshiro, who did self-driving car work at Google, and David Estrada, who handled legal affairs for Google X. They all listed the company as their employer on LinkedIn until they were contacted by *Bloomberg Businessweek*, at which point they erased any mention of Kitty Hawk from their profiles.

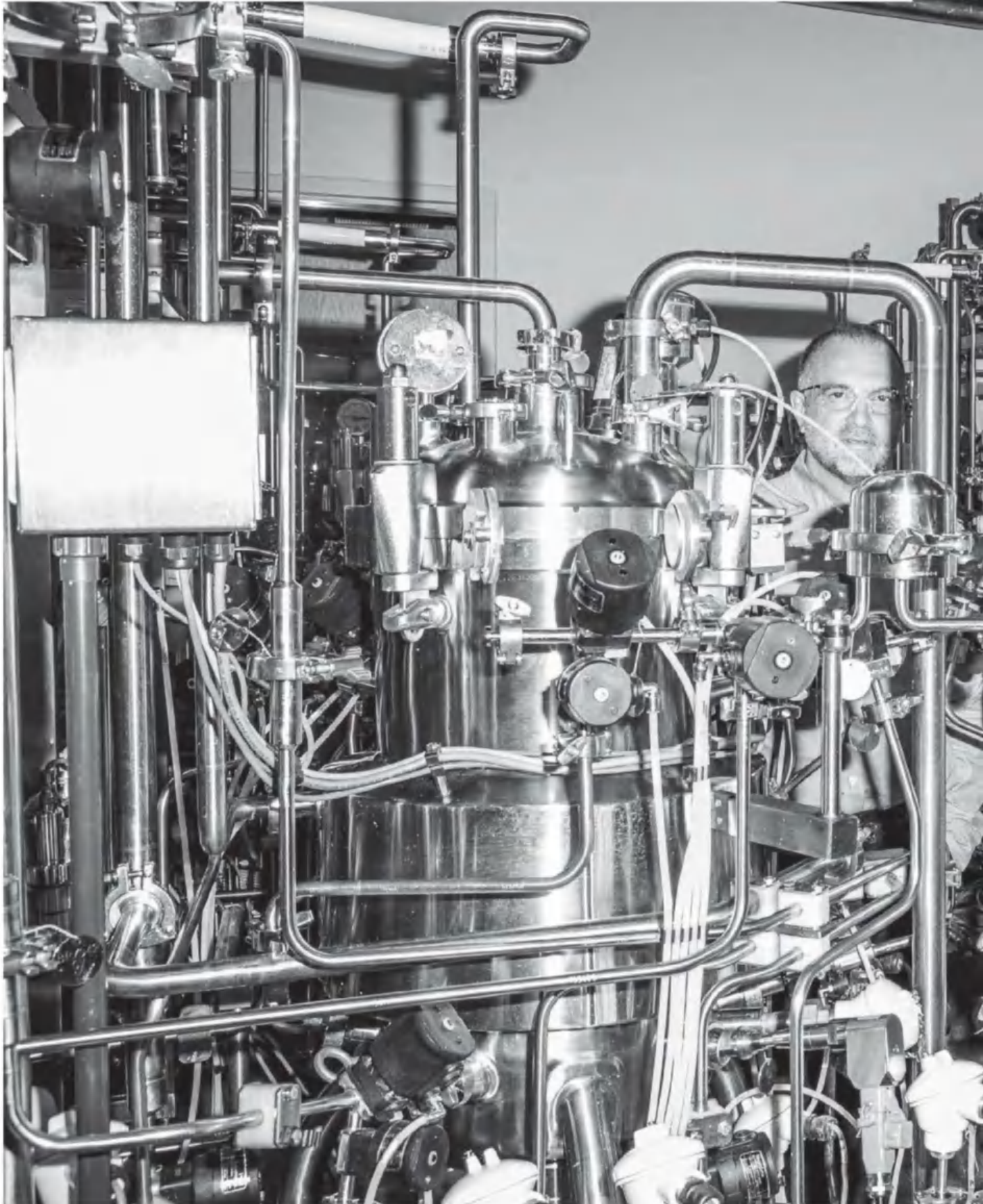
Page has drawn a line separating his two flying-car teams, employees say. It's common for the Zee.Aero engineers to speculate over lunch about what their Kitty Hawk counterparts are up to. The former Zee.Aero employees think Page wanted to see if a smaller team could move faster, and the added pressure on Zee.Aero didn't hurt. Two people say Kitty Hawk is working on something that resembles a giant version of a quadcopter drone.

There's no guarantee that Kitty Hawk's or Zee.Aero's or anyone else's flying cars will ever take to the skies. There are still technology problems to solve, regulatory hurdles to cross, and urgent safety questions to answer. Page once vowed to a colleague that if his involvement in the sector ever became public, he might pull support from the companies.

Here's hoping that's not true. If nothing else, these projects show that bold, some might say far-fetched, invention is alive and well in Silicon Valley. The place that spent the past decade focused on social network apps has trained its engineering powers on robots, cars, and now aviation. "We were promised flying cars, and instead what we got was 140 characters," a local venture capitalist once put it. Page and his cohorts are trying to get us both. **B**



② ZEE.AERO CRAFT IN RECENT MONTHS





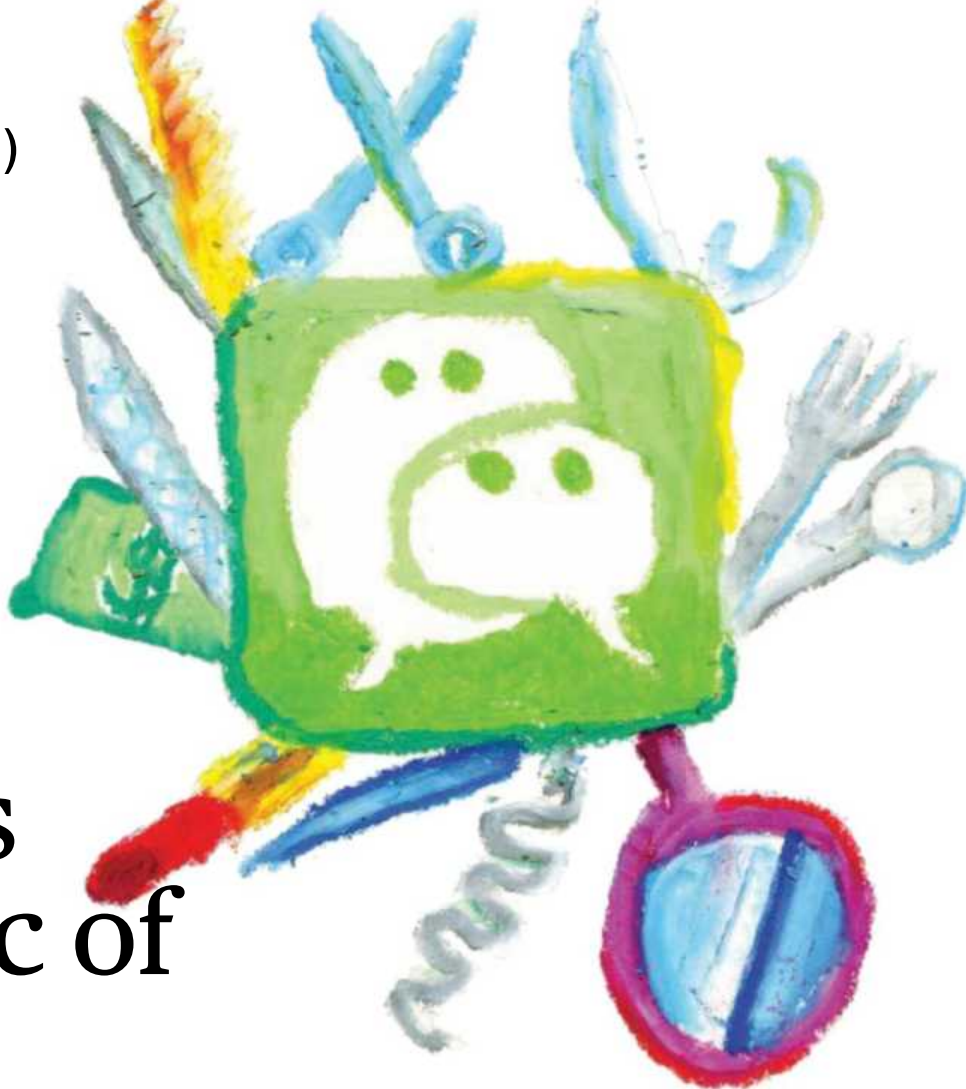
A billionaire scientist studies genetic mutations to target disease

An X-Men Approach To Medicine

George Yancopoulos is the chief scientific officer at Regeneron Pharmaceuticals, which makes drugs that treat cardiovascular disease and vision loss. (The vision-loss drug Eylea has helped make the company the best performer on the S&P 500 over the past five years—and helped make Yancopoulos rich.) Now, Regeneron is sequencing the DNA of 250,000 volunteers in an effort to identify and mimic mutations that protect against diseases ranging from high cholesterol to depression. Treatments are being developed for asthma, arthritis, and osteoporosis. “There’s nothing better than science, nothing better than what we’re doing,” says Yancopoulos, whose company took over the national Science Talent Search competition from Intel last month. “We’re just getting started.” **E**

My full (and mostly successful) immersion in China's everything app

The People's Republic of WeChat



64

I've had WeChat on my phone since a vacation to Beijing last year, when friends there essentially ordered me to download it. More than 760 million people use it regularly worldwide; it's basically how people in China communicate now. It's actually a lot of trouble *not* to use WeChat when you're there, and socially weird, like refusing to wear shoes.

In China, 90 percent of internet users connect online through a mobile device, and those people on average spend more than a third of their internet time in WeChat. It's fundamentally a messaging app, but it also serves many of the functions of PayPal, Yelp, Facebook, Uber, Amazon, Expedia, Slack, Spotify, Tinder, and more. People use WeChat to pay rent, locate parking, invest, make a doctor's appointment, find a one-night stand, donate to charity. The police in Shenzhen pay rewards through WeChat to people who rat out traffic violators—through WeChat.

It's nothing special to look at, as far as smartphone apps go. The first screen that opens is the chat stream; a menu at the bottom gets you to other areas, like a WeChat wallet and a "moments" stream for Facebook-like posts. Companies,

media outlets, celebrities, and brands also open "official accounts" that you can follow to get news and promotions. The design stands out only for its relative simplicity and calm; the online mainstream in China is overpopulated with weird click-bait and manic GIFs.

Zhang Xiaolong, WeChat's creator and something of a cult figure in China, has called WeChat a lifestyle. I rolled my eyes when I first heard that. Then I went back to Beijing in April.

My colleague Lulu Chen, who covers WeChat's parent, Tencent, has sent me the phone numbers of some potential contacts—but why call when WeChat is so much easier? I use the chat function to set up meetings during my visit. One of my contacts mentions a WeChat convention the day after I arrive, and so, on a Sunday afternoon, I show up at the Design Service Center, an industrial-chic space in the historic city center. The crowd is mostly young, a mix of Chinese and expatriate, and the mood is festive. Free wine stands three bottles deep on the bar.

I drift by company displays and find myself at the table for Yoli, a business that offers a sort of speed dating for

HE SCANS MY

English learners: 15-minute on-demand tutoring sessions with native speakers through WeChat. Two sheets of paper taped to the table each bear a pixelated QR code: Scan one to become a teacher, scan the other to become a student.

The Chinese term for this ritual, *sao yi sao*, quickly becomes familiar. Everyone and almost everything on WeChat has a QR code, and *sao yi sao*-ing with your phone is both constant and strangely satisfying. James, a tanned American with unruly blond hair who mans the Yoli table, is here to host a workshop called “How We Built a WeChat App & Recovered Our Development Costs Within 24hrs.” He scans my code, which gives him my WeChat profile and also generates the equivalent of a friend request; I accept, and we agree to meet during the week, skipping right over the old-fashioned niceties of last names and business cards.

The presentations are about to start, and jet lag is kicking in. I hurry to the coffee counter for an iced Americano. There’s a QR code in a plastic photo frame. The woman ahead of me is scanning it. I try it, and... WeChat fail. I’ve entered a credit card into WeChat, but it won’t work, and my WeChat wallet is empty. I feel distinctly self-conscious fumbling around for yuan. I’ve been in WeChat-era China one day, and already cash money feels embarrassing.

On Monday, I take the subway to meet Zhu Xiaoxiao, who’s built a WeChat-based fitness business. On the train, I notice a woman moving methodically down the car, stopping to talk to the other passengers. Is she begging? Testifying? Only when she stops before the woman next to me do I get it: She’s asking for QR scans, trying to get followers for a WeChat official account.

Zhu is an open-faced, bulked-up 25-year-old in a gray T-shirt, blue shorts, and red sneakers. He left China for school in England a skinny kid and returned in 2012 a fitness buff with the germ of a business plan—to make and sell protein powder. He and a friend developed a formula, set up manufacturing and a website, and began marketing online. In late 2013, Zhu started looking for investors, and the next February he got 2 million yuan—roughly \$300,000—from a seed fund in Beijing. At the urging of his investors, he stopped selling the protein powder and refocused on building a following of health enthusiasts, opening a WeChat official account that pushed articles on exercise and diet and lots of pictures of six-pack abs. The company, FitTime, quickly racked up 400,000 followers and an additional 9.8 million yuan in funding, and launched a standalone app.

As WeChat boomed, Zhu developed a fitness camp on WeChat, an alternative to expensive personal training in a physical gym for people already on WeChat all the time. Sign up, and you get grouped into a chat with 15 people of similar height and weight and a personal trainer who’s there to motivate you (by message and emoji) to stick to the diet and video workout plans. FitTime charges 1,000 yuan for 28 days, and more than 5,000 people have signed up for at least one month.

Stories of sudden success on WeChat abound these days, and Xi Jiutian’s is another. She’s wearing oversize nerd-cool

glasses and bright-red lipstick when we meet for lunch on Tuesday at Cafe Groove. The place looks like something out of my Brooklyn neighborhood, the mismatched chairs, the random shelves of books, even the prices—\$10-plus for an avocado salad. This is all familiar—until I go to pay with WeChat, and my credit card is rejected again. I’m definitely losing some face here.

Xi was an interaction designer at Microsoft in Beijing before getting laid off. She tried designing a smartwatch, then consulting for startups. She also began writing on Zhihu, a site similar to Quora, about makeup and skin care. In early 2015 she opened Hibetterme—as in, “Hi, better me”—a WeChat account devoted to the same topics. After a couple of months, her WeChat fans began urging her to sell beauty products. Setting up a shop on WeChat’s platform took her a couple of days. Xi, like Zhu, had an easy time finding funding when she began looking last fall. She’d been at it about a week when a friend of a friend put her in touch through WeChat with Eric Tong of Pros & Partners Capital in Shanghai. After they’d messaged on WeChat for about 15 minutes (a lot of their discussion was about tattoos), Tong told her to stop her search and committed 4 million yuan.

Xi introduces us on WeChat, and Tong responds instantly. But when I try to set up a phone call, he ignores me. People seem to talk on the phone less than they used to—though they’re happy to leave each other WeChat audio messages. I ask, by chat, how Hibetterme fits with what he looks for in an investment. In a flurry of abbreviations, he says he’s looking for professionally generated content across platforms like WeChat. It’s an investment theme that’s very, very hot, thanks to the Papi impact. Papi is Papi Jiang, known for her speed-talking comedic video monologues. In April, she auctioned off the first advertising spot to appear in one of her videos for 22 million yuan. Um, bubble? Tong’s fund stands at about 200 million yuan now. He expects to have 600 million by the end of the year.

Even those who aren’t directly selling things or running official accounts on WeChat use it constantly for work. A friend who runs restaurants in Beijing operates his entire operation, almost everything except eating and drinking, on WeChat. He trades dish ideas and discusses kitchen operations with the chefs in one group, while his accountant keeps him informed of payments on another. There’s even a group devoted to flower care at one of the restaurants. (WeChat

Did you know?

A court in the province of Henan is running a pilot program to conduct trials on WeChat

introduced a formal enterprise version in April.) Yoli, the tutoring company, takes the all-WeChat model to extremes. James, the American I met on Sunday—his last name, I finally find out, is LaLonde; he’s from Texas—moved to Beijing to found a gaming company in 2011. He decided last August to combine his interest in language learning with an experiment in creating a business run entirely on WeChat. It made sense; he rarely left the app as it was. He’s met Luke Priddy, one of his two co-founders, only twice in person. Priddy lives in New York and coordinates the growing cadre of teachers. The average wait time for a tutoring session is 20 seconds. The tag line for teachers is “teach on

QR CODE. THE TERM FOR THIS RITUAL, "SAO

YI SAO." QUICKLY BECOMES VERY FAMILIAR

the beach”; Priddy once conducted a tutoring session while floating in a pool.

On Wednesday, I need to get to Shanghai for a day of meetings and can’t decide whether to fly or take the train. Buying train tickets with an app may not sound revolutionary, but in China, I promise you, it is. The intricacies of buying tickets used to occupy whole sections of guidebooks and require feverish strategizing before holidays. Opening WeChat, I check the train schedules and get to the point of booking an overnight train—but then decide to fly. I can’t quite shake my fear of the Chinese train system.

WeChat has made Beijing a very different place from the city I lived in from 2006 to 2009. There’s so much less standing in line and waiting, particularly at the bank. Cash used to be king. I paid my rent in cash, my bills, every restaurant and shop. Now people shoot money around on their phones (not all on WeChat, of course, but a lot of it).

There’s also a lot less getting lost. Taking a taxi in China used to require getting the driver to call your destination to verify exactly where you were going. On this trip, everyone I visit drops a map into a message, with the location pinned, and I show that to the driver. The one time I get turned around, walking to an interview, I open real-time location in the WeChat conversation I’m having with my host. She finds me on the map and guides me.

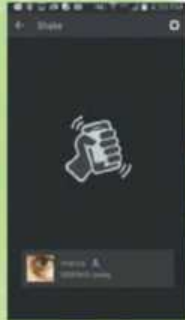
Nobody’s too cool to use WeChat, or too uncool. It’s how entire families keep in touch. A tech executive told me his mother, at 80-plus, uses it for everything; a marketing entrepreneur said his computer-illiterate parents and his daughters, ages 3 and 5, use it.

By Thursday morning, I’ve decided something important: I don’t like my QR code. The code WeChat randomly generated for me looks like a piece of candy in a blue wrapper. When I click on “Change Style” in my profile, it goes from bad to worse—a piece of toast? A cat? A pink car? Finally, some algorithm spits out a green, leaf-shaped design. I’ll take it.

I’ve also given up on using my credit card. It’s “accepted” by WeChat, and I’ve set up a PIN and all that, but I guess WeChat can’t change the fact that few local businesses take international cards. WeChat has given life in China a smoothness, a quality of efficiency I never could have imagined. But for a foreigner like me, at least, it’s still a work in progress.

I message a Chinese friend who’s in the U.S. on a fellowship and ask for a loan. Within minutes, he’s sent me two *hong bao*, or red envelopes—a play on the red envelopes traditionally used to give gifts of money. They arrive as chat messages that say, “Good fortune and good luck! You’ve received a red envelope.” Once I click on them, I have 200 yuan in my WeChat wallet.

What it looks like



Shake, which connects the user with a random person to message with



The basic message stream



The WeChat wallet

Typically, you hand out red envelopes of cash to younger relatives and friends during the Lunar New Year—to couples getting married, for children’s birthdays. Now hong bao are used...I don’t want to say willy-nilly, but sometimes just for fun.

It’s hard to tell what’s great strategy and what’s luck in WeChat’s success, but this hong bao system is genius. The company wasn’t first with electronic hong bao; that would be Alipay, the payment platform from Alibaba. But when WeChat introduced its own system just before the Chinese New Year in 2014, it added a gaming element. When you send money to a group of people, one lucky winner within the group gets a bigger windfall than the rest, while a few get nothing at all. People love the element of chance, apparently, because users of WeChat’s wallet jumped by 100 million in a month. The figure is now 300 million. For Chinese New Year 2016, 516 million people delivered 32 billion red envelopes.

Midmorning, I go to the Global Mobile Internet Conference in the China National Convention Center. Hundreds of speakers, 20 summits, and a music festival—it’s China’s South by Southwest, or trying to be. I’m exhausted from running from floor to floor to catch sessions. I stop at a cafe on the second floor to get coffee, my new WeChat riches teed up.

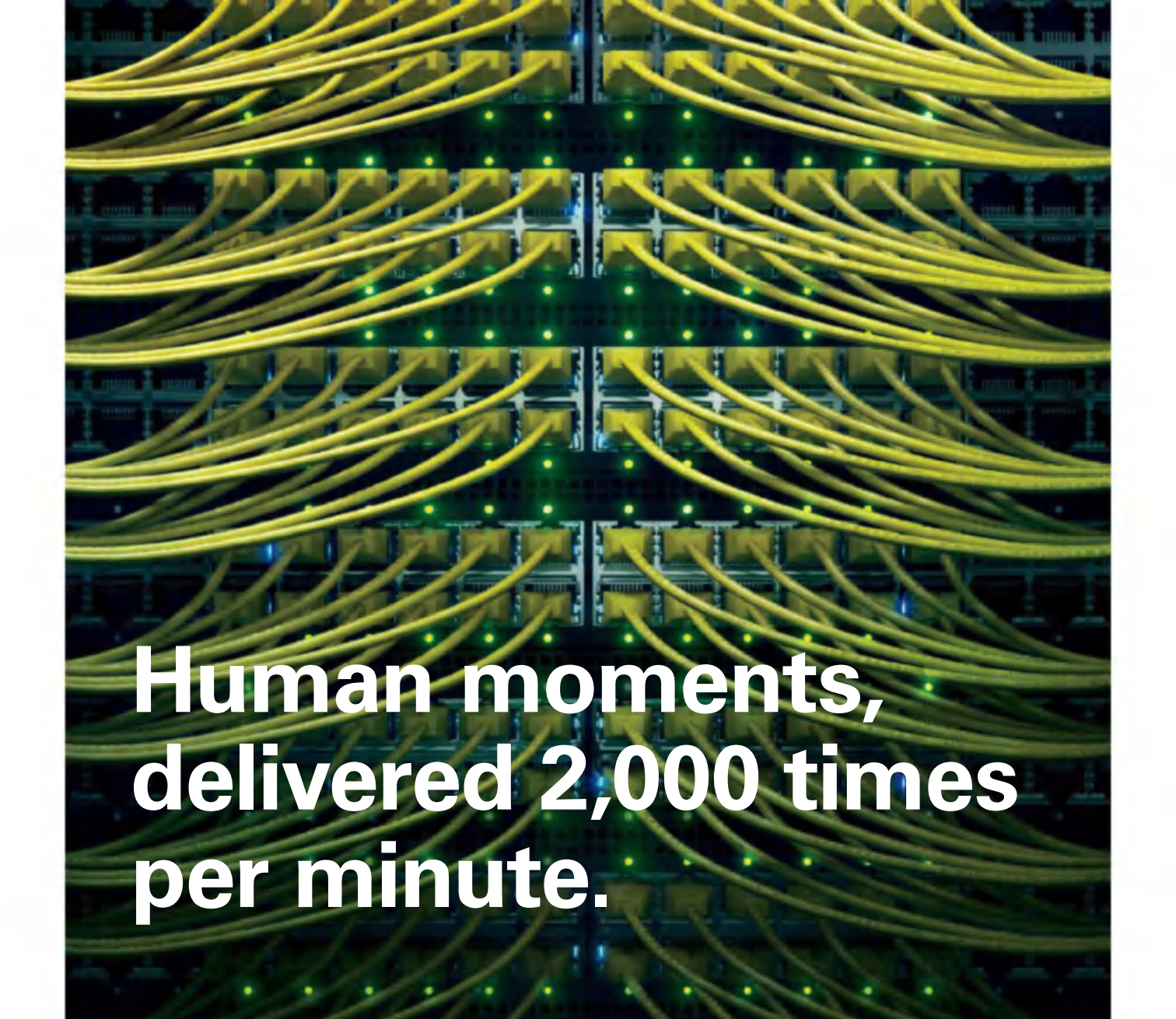
They don’t take WeChat. At a tech conference.

The next day, I return to the conference to talk to E Hao, co-CEO of the group that organizes it. I’m accosted in the elevator by a young woman who sees that I’m foreign, explains that her company organizes exchanges with foreign companies, and demands to scan my WeChat QR code. “Nice to meet you!” she sings, striding off without ever telling me her name or asking for mine.

E Hao is hoarse after a late night at the event’s opening gala at the Olympic Bird’s Nest stadium. His heavy metal band, CXO, newly formed with various fellow executives, performed for the first time. He shows me his WeChat message stream: 3,015 unread messages. He says he’s been relying on hong bao to thank and motivate his overworked employees through the long days running up to the event, sending out 1,000 yuan at a time. He sends me 100 yuan to demonstrate. I’m not sure about the etiquette. Is this for demonstration only? Should I send it back? I do, eventually.

When I get back to New York, I join a FitTime WeChat boot camp. The rest of my group seems to be Chinese students studying in the U.S., including the trainer, who’s in Iowa. First, there’s the horror of taking a selfie in spandex and sending it to a stranger, then the awkwardness of photographing every meal, with one hand held in a fist beside the plate for perspective on serving size. If I’m lucky, the trainer sends me a thumbs-up emoji in response. She frequently has to remind me of the rules, though: No kimchi, for example—too much salt, leads to bloating. The whole thing is vaguely humiliating. On the other hand, I’ve lost a few pounds, and I now know the characters for chia seeds in Chinese. And I’m on WeChat all day long. **B**

HE'S SENT ME TWO "HONG BAO," OR RED ENVELOPES. I NOW HAVE 200 YUAN IN MY WECHAT WALLET



Human moments, delivered 2,000 times per minute.

The world's largest eCard brand uses CenturyLink to handle their millions of deliveries every day – including 5 million deliveries on Valentine's Day, their busiest day of the year. Our global broadband network is secure enough for every day, and flexible enough for every moment.

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CenturyLink®
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Your link to what's next™

① Still in the labs at University College London, a self-cleaning finish that can be applied to glass, steel, cloth, and paper.

Five substances of the future

Material Progress



Effortless cleaning

Location **London**
Technology **Hydrophobic coating**

↑
② Above, the white areas show sections of glass covered with the self-cleaning finish, which repels water containing blue dye.

↑
③ Made from coated titanium dioxide nanoparticles, the finish has a texture and low surface energy that rebuffs fluids, which carry dirt away with them.

↑
④ The researchers say the substance's cleaning properties were patterned after those of lotus leaves.

Younger-looking skin

① Called XPL, or “cross-linked polymer layer,” the silicone-based material is designed to replicate the look and mechanics of youthful skin.

② It can be worn to hide wrinkles and eye bags, and protect real skin from environmental damage.

③ Two polymers, applied topically, react in combination to form an invisible elastic film. Breathable, it can be worn while swimming or exercising.



④ To remove the second skin, peel it off or use oil-based makeup remover.

⑤ XPL's creators, Olivo Labs and Living Proof, say further clinical trials will be done before the skin hits the market.

⑥ The skin may eventually be used to deliver topical medications.

❶ This lightweight, bouncy material, called Infinergy, is being used in Adidas Boost running sneakers and Dunlop rackets.



❷ BASF makes the material from tiny, oval thermoplastic polyurethane foam beads.



❸ The air-filled beads can be compressed to about half their resting volume before springing back to their original shape.



Better bounce

❹ In sneaker soles, the beads absorb shock and add bounce. Each midsole contains 2,500 beads.



❺ “Many runners have told us that the shoe feels like it is almost alive.”
 —Gerd Manz, *innovation director, Adidas*



❻ Infinergy is being tested for use in kids’ play areas and in beds for cows, which produce more milk when they spend hours lying down.



The blackest black

❶ Vantablack absorbs 99.965 percent of light, making even this piece of crinkled tinfoil look like a Looney Tunes-style portable hole.



❷ The material is being incorporated into telescopes, satellite-mounted star trackers, and luxury consumer goods, including a \$95,000 watch by MCT.



❸ Not a paint or a pigment, Vantablack is an array of carbon nanotubes with walls that are one atom thick.



❹ The carbon nanotubes are 10,000 times as tall as they are wide. Together they form a microscopic forest that traps light.



❺ Researchers at Vantablack creator Surrey NanoSystems recently developed a spray-on version of the material.



❻ "It's a physical thing that you cannot see." —*Sculptor Anish Kapoor, who's been given exclusive artistic rights to work with Vantablack*



❶ The fibers contain metals, silicon, and insulators—the basic elements of a computer chip—and can be woven into conventional textiles.



❷ Fabrics made in this fashion will be able to change color, communicate with computer networks, and detect explosives.



❸ The fibers “see and hear” by converting sound and light into electrical signals that can be understood by a computer.



❹ Future functional fabrics might be used to warm and cool wearers or monitor their health.



❺ “These fibers are to fabric what the neuron is to the brain, or the transistor is to the computer chip.”
 —MIT professor Yoel Fink, creator



❻ Fink’s institute, the Advanced Functional Fabrics of America, is working with 30 universities and 50 companies to create new textiles.



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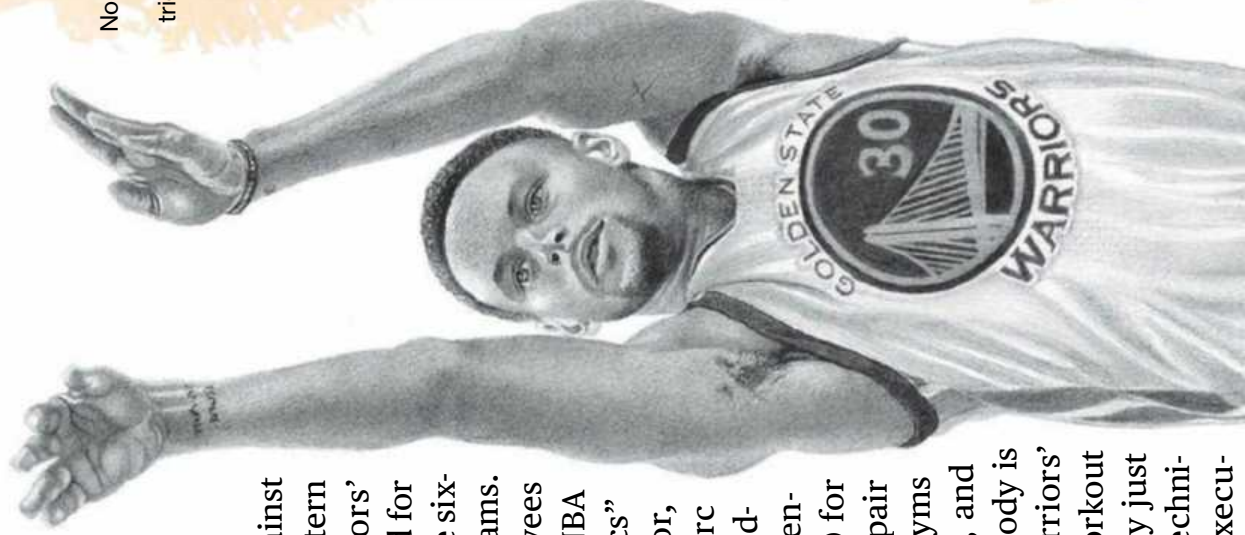
*The right people to get
the extraordinary done.*



Want to shoot threes like the NBA's two-time MVP, Steph Curry?

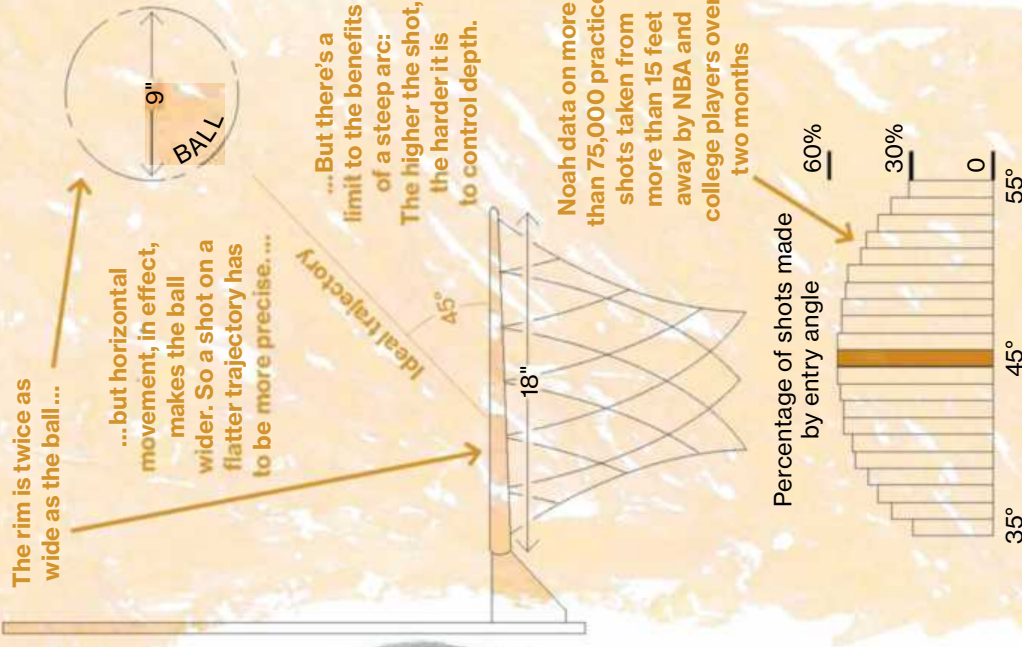
The Geometry Of Splash

In the last two games of their comeback against the Oklahoma City Thunder in the NBA's Western Conference finals, the Golden State Warriors' Stephen Curry and Klay Thompson combined for 30 three-pointers; a quarter-century ago, the six-game 1981 NBA Finals had 6 total—for both teams. For Noah Basketball, a company of six employees in Athens, Ala., the Warriors' return to the NBA Finals is perfectly timed. Its new "Noahlytics" technology uses a Microsoft Kinect sensor, mounted 13 feet above the rim, to track the arc and location of shots and provide instant feedback. Through years of testing, Noah has identified the optimal angle of entry (45 degrees) for shooting success. The Warriors installed a pair of Noah trackers at their Oakland practice gyms in April. The Dallas Mavericks, Miami Heat, and Utah Jazz are trial customers, too. "If somebody is not hitting shots," says Kirk Lacob, the Warriors' assistant general manager, "you can get a workout in using Noah and try to figure out: Are they just having a bad week? Or is there something technically wrong with the shot?" Noah's chief execu-



Deconstructing Step

To arrive at 45 degrees as the ideal angle of entry, Noah collected data on millions of shots by high schoolers, college players, and NBA players. In 2014, Curry tried it out in a practice. His average angle: 46 degrees.



ive officer, John Carter, says he plans to market the company's tech to U.S. high schools. One installation runs \$4,800, plus \$100 a month for access to the data.

The Rise of the Three

Since 1979, when the NBA introduced the three-point line—at 23 feet, 9 inches from the rim, and 22 feet at the corners—the percentage of scoring from three-pointers has grown from 2 percent to almost 25 percent.

The NBA moved the three-point line closer for three seasons, from 1994 to 1997. Instead of 23 feet, 9 inches on the arc and 22 feet at the corners, it was 22 feet all the way around. Dennis Scott took advantage by making a then-record 267 threes in 1995-96.

Larry Bird led the league with 90 threes in 1986-87. In his best season, he made 98.

Share of total NBA offense from three-pointers



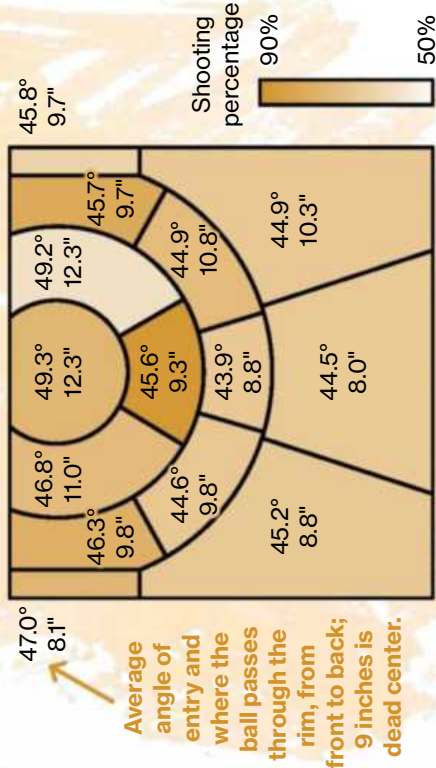
402

All-time record set this year by Curry

... That's because many shots that hit the back of the rim fall through. Noah's Carter calls these shots BRADS, for "back rim and down."

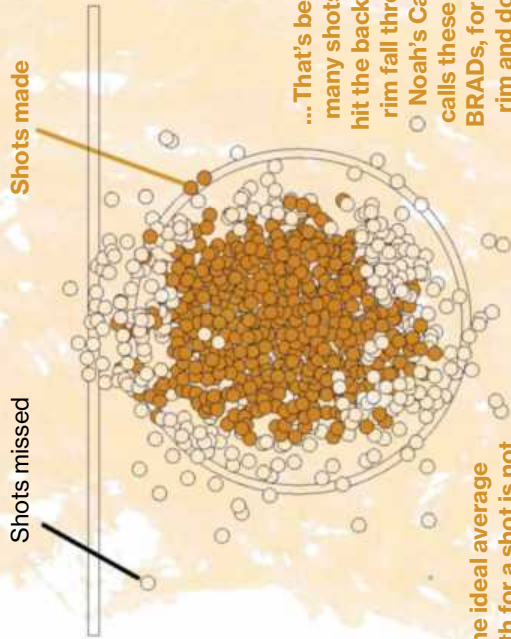
The ideal average depth for a shot is not the midpoint between the front and back of the rim. It's 2 inches deeper, at 11 inches....

This shows the same NBA player's shots by where he was standing on the floor. Teams use this data to isolate and fix problems in a player's form.



Average angle of entry and where the ball passes through the rim, from front to back; 9 inches is dead center.

This diagram from Noah's software displays more than 1,800 practice shots by an unnamed NBA player. The dots show where the center of the ball was when it crossed (or would have crossed) the plane of the rim.



GlaxoSmithKline is experimenting with grain-size implants that treat disease

When Kris Famm was 15, he became obsessed with photosynthesis. He lived with his parents and older brother, Fredrik, on a farm not far from the Baltic coast in southeastern Sweden, in an expanse of gentle hills threaded with forests of birch and spruce. It was a paradise for two energetic boys, and they spent most of their free time outside, often with their grandfather. Leading Kris and Fredrik on long hikes through the woods, he taught them about trees and wildlife and the richness of the land, which he was the last in the family to till.

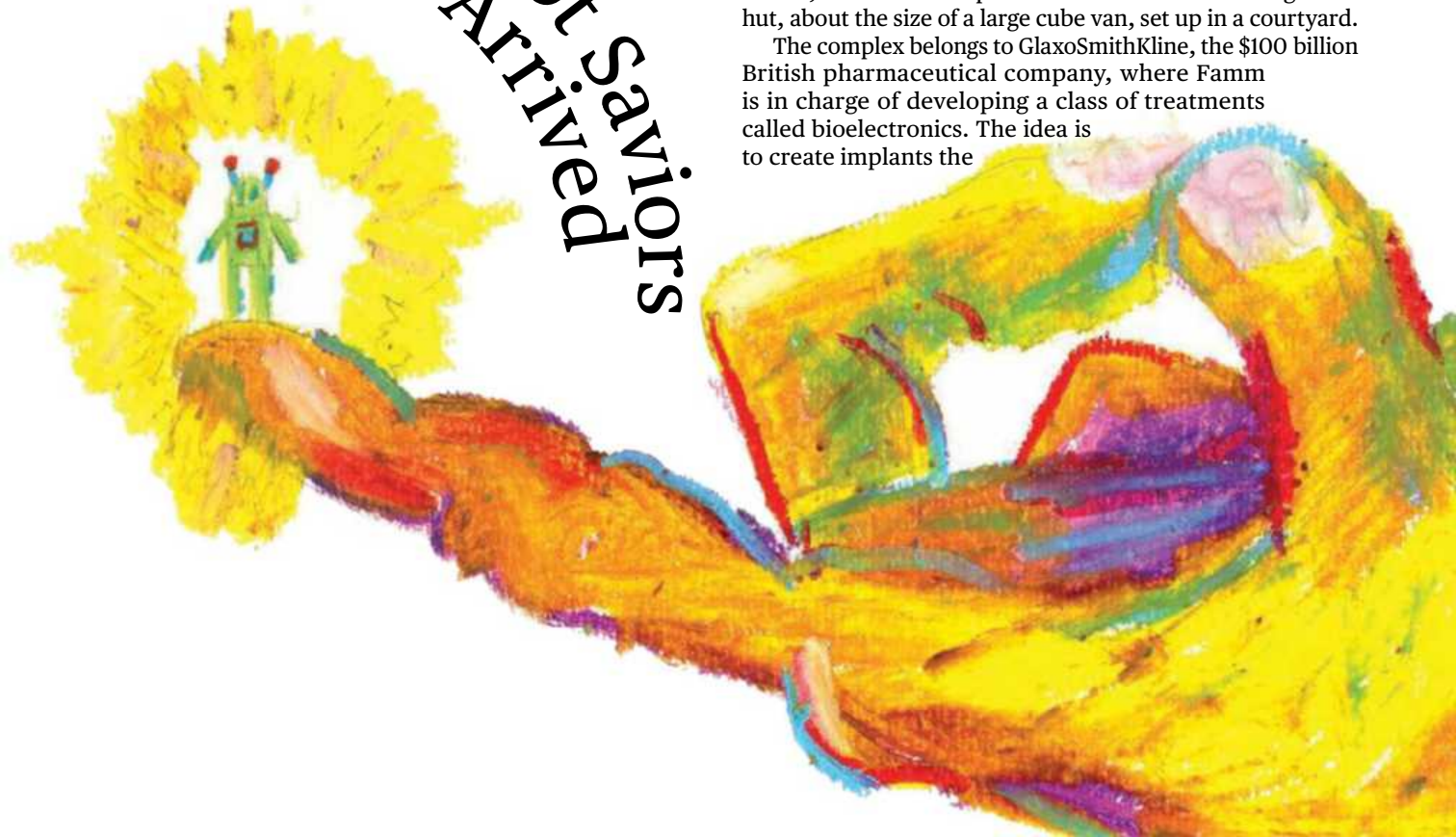
The late 1980s and early '90s were a time of rising environmental concern in Sweden. Climate change was entering the public consciousness, and the first traces of abnormal radiation from Chernobyl had been detected at a Swedish nuclear plant. To the teenage Kris, it seemed like the world would destroy itself without finding a radical new source of clean power. Photosynthesis, he thought, must hold the key: If plants could produce infinite energy from nothing but air, water, and sunlight, why couldn't humans?

"I remember thinking, 'There is this secret all around us, and we should be able to put it to use,'" Famm says. "There is clearly, in nature, a scientifically anchored way of doing this." He resolved to learn everything he could about biochemistry. For his high school thesis, Famm devised a series of experiments to measure the efficiency of photosynthesis when leaves were coated with different dyes and waxes.

Famm is now 38, with a floppy thatch of blond hair and a singsong accent that gives away his Scandinavian roots. He's traded the bucolic pleasures of rural Sweden for a maze-like research center squeezed between a highway and a rail line in Stevenage, north of London. On a blustery Tuesday in March, Famm is cramped into a sort of modernist garden hut, about the size of a large cube van, set up in a courtyard.

The complex belongs to GlaxoSmithKline, the \$100 billion British pharmaceutical company, where Famm is in charge of developing a class of treatments called bioelectronics. The idea is to create implants the

Your Nanobot Savivors
Have Arrived



"THE HARD PART OF NEUROENGINEERING IS THE NEURO PART"

size of a grain of rice, or even smaller, that can be bolted directly onto nerves to treat diseases, augmenting or replacing drugs. With internal batteries to send tiny electric pulses, the implants could alter nerve signals to loosen up airways in asthma sufferers, for example, or reduce inflammation in the gut from Crohn's disease. Even cancer is a long-term target. Side effects could be minimal, in theory, compared with those of drugs, which flood the body with foreign molecules. Doctors could stop worrying about patients forgetting to take pills.

Like photosynthetic energy, bioelectronics leverage something that already exists: the nervous-system connections linking every part of the body to the brain. "You piggyback on the circuits that are there," Famm says. "These cables go to and from all our organs. They're there to control our physiology."

The underlying concepts are well-established, and early versions of what he's describing are already on the market. Still, the project is a long-odds bet that Glaxo is virtually alone in making among its Big Pharma peers. It has started a \$50 million venture fund for bioelectronics and funded about 100 outside scientists, along with an in-house research team of 30, because the microgadgets may offer a solution to the ruthless arithmetic of drug development. The past decade has seen huge advances in conventional molecular therapies for a wide range of diseases, but the treatments are coming at ever-higher prices. The average new drug takes 10 years and \$2.6 billion to get from lab to pharmacy, according to industry group PhRMA. At the same time, hospitals and insurers in the U.S., the world's most profitable market, are resisting high prices, squeezing returns. The implants, and the advances leading to them, would all be patentable, giving their inventors a lock on the proceeds.

Although Glaxo is nowhere near abandoning traditional drug development, the company needs a hit more than most. Core earnings per share, its preferred measure of profitability, have fallen in 8 of the last 10 quarters. Glaxo's blockbuster asthma treatment, Advair, is about to face generic competition in the U.S., and major trials of a new heart drug and a cancer vaccine have failed in the final stages. The company's shares have lagged those of its peers for the last several years.

To make matters worse, Glaxo has largely missed out on the breakthroughs in immune therapy and hepatitis drugs that have supercharged rivals such as Merck and Bristol-Myers Squibb. Also, a bribery scandal in China led to a \$489 million fine in 2014. In March, Glaxo's chief executive, Andrew Witty, said he'd step down in 2017 amid investor criticism of a weak research and development pipeline.

The nervous system is a bit like a computer. Neurons are either on or off, one or zero, firing electric impulses called action potentials in patterns that carry instructions from the brain. Introducing new electrical pulses can tweak those patterns, blocking some commands and encouraging others. Scientists now believe the pulses' precise wavelength and frequency matter

immensely and may need to change moment by moment to have the desired effect.

Early prototypes of bioelectronics are being tested in rats. Those implants—about the size of a pill and packaged in resin, metal, or ceramic—are wirelessly powered. Glaxo is planning initial human trials for three major chronic diseases next year using third-party devices, with the first implant developed by the company itself to follow in 2019. It won't specify the diseases it's looking into, but arthritis and diabetes are where the big money is. Three of the world's top five best-selling

Did you know?

The average new drug takes 10 years and \$2.6 billion to get from the lab to the pharmacy

drugs are primarily used for arthritis, led by AbbVie's Humira, which pulls in more than \$14 billion a year.

Using electricity as medicine isn't a stretch. Pacemakers have been around since the 1930s. The earliest models had to be hand-cranked to generate voltage. More recently, deep-brain stimulation has become a common treatment for Parkinson's disease. Electrodes are threaded far into the brain from a battery typically implanted in the torso.

What Glaxo and a clutch of other companies and research organizations envision is far more ambitious: tiny devices that might surround a bundle of nerve fibers like a cuff, bristling with even smaller electrodes resembling spokes on a tiny wheel. They'd be capable of autonomously monitoring symptoms at the source and adjusting their electrical output accordingly, perhaps for a patient's whole lifetime.

There's a daunting list of challenges to overcome first, but one stands out: understanding the body's supremely complex wiring. Scientists still don't know which neurons control which organ functions, or how to finely adjust their behavior. As Edward Boyden, who leads a brain-mapping effort at MIT, says, "The hard part of neuroengineering is the 'neuro' part."

Famm came to Britain in 2002 to work on a doctorate in molecular biology at Cambridge. He'd dreamed of following in the footsteps of James Watson and Francis Crick, the discoverers of the DNA molecule, and he started working in the same institute where the two made their breakthrough in 1953. Famm's supervisor was Greg Winter, a scientist whose research on antibodies led to the development of Humira and the creation of a string of biotech companies. Winter was a demanding mentor, covering Famm's thesis drafts in red-penned marginalia instructing him to junk whole sections of "waffle" and zero in on a few specific concepts. Famm was focused on antibody engineering, the design of finely targeted proteins to fight disease.

Even though Cambridge was responsible for "some of the best years in my life," Famm says, he strained against the deliberate pace of academia and what seemed like a vast distance between foundational research and real-world products. He left the lab for a job at consulting firm McKinsey in 2006. Famm says his academic colleagues thought he was making a "pact with the devil"—except Winter, who told him it was the right move for making a big scientific impact later on. After three years as a consultant, Famm went to work as a strategist for Glaxo's R&D department, a job

UNDS OBVIOUS IN RETROSPECT. COULDN'T YOU DO IT ELSE?

MIT 50 II

COULDN'T YOU DO IT ELSE?



Famm holds a bioelectronic nerve implant

that required him to scan the horizons of medical research for the most promising and profitable concepts.

Glaxo's drugmaking roots date to the 1840s, when one of its predecessor companies had a hit with Beecham's Pills, a Victorian laxative made of aloe and ginger that was also marketed for "female ailments." The modern company is an assemblage of smaller ones cobbled together through decades of mergers and acquisitions. Some lab coats still bear the pale blue logo of Glaxo Wellcome, which ceased to exist in 2000 after it merged with SmithKlineBeecham.

By the time Famm arrived, the company's need for new revenue was getting acute. Patent protection had expired on four of Glaxo's 15 best-sellers in 2008, and in 2010 a major drug for diabetes, Avandia, had to be largely pulled from the market after studies suggested it might contribute to heart attacks. The same year, Moncef Slaoui, a Moroccan-born molecular biologist who headed R&D, convened a small group to explore breakthroughs in areas beyond traditional drugmaking. Famm was on the team. The instructions were "to look at the convergence between technology, IT, and biology to see if there was something there," he says. "A somewhat vague brief."

In the spring of 2011, Famm and other executives gathered at Glaxo's townhouse office in Mayfair, London's Benteleys-and-bling district, and watched a presentation on vestibular implants. The devices can help patients whose sense of balance has been damaged by disease. Placed in the inner ear, they measure the movement of the head and convert that information into precise electrical pulses they feed by electrodes into nerve branches and the brain, delivering information directly into the nervous system. They're analogous to a cochlear implant for hearing, which is to a traditional sound-amplifying hearing aid as an F-22 is to a hot-air balloon. "It sounds obvious in retrospect," Famm says. "Couldn't you do it elsewhere in the body? And why isn't it done elsewhere in the body?" He and Slaoui had found their big idea.

The two spent much of the next 18 months visiting scientists around the world, even if their research seemed only loosely relevant. One trip was to the Georgia Institute of Technology in Atlanta to meet with materials scientist Zhong Lin Wang. His work has demonstrated the feasibility of "self-powered nano-devices," which can generate their own electricity from tiny

vibrations in their environment. Zhenan Bao, a professor of chemical engineering at Stanford, was consulted for her take on interactions between nerves and electrical fields.

As they learned more, Famm and Slaoui needed to answer a big question: Would Glaxo try to design implants to insert directly into the brain to treat disease elsewhere in the body? Or would it target the peripheral nervous system, the network that connects to tissues, muscles, and organs? Trying to do both, they worried, might be too sprawling and costly. Yet another trip, to Switzerland, helped settle the issue. The pair had gone to a campus of boxy labs in Lausanne to visit Henry Markram, an Israeli neuroscientist who leads part of the European Union's flagship brain-science project. His research focuses on mapping and imaging the billions of connections in neural tissue.

Markram gave his visitors 3D glasses to view a model of a mouse's cortical column, a relatively straightforward piece of peripheral neural anatomy that nonetheless consists of millions of cells. The complexity was mind-boggling—exactly Markram's point. As Famm and Slaoui drove back to the airport, they agreed that to deliver moneymaking medicines in the next decade, they'd have to focus on the peripheral nervous system.

Famm set out to build a small team and recruit partners at university labs. MIT's Boyden was an early supporter, as was Brian Litt, the namesake of the University of Pennsylvania's Litt Lab, which develops brain implants using exotic materials such as graphene. In 2013, Glaxo made its bioelectronics efforts public. In a commentary that year in *Nature*, Famm and academic collaborators invited readers to "imagine a day when electrical impulses are a mainstay of medical treatment" and announced an initial program to fund as many as 40 external researchers. That number has since more than doubled, and the company has collected some powerful allies. Darpa, the Pentagon's skunk works, is funding experiments at MIT, Johns Hopkins, and elsewhere, while the National Institutes of Health has introduced a \$230 million program to encourage research.

Glaxo has also started an XPrize-style challenge for external researchers, with \$6 million available for teams trying to create a working implant. Famm, who leaves most of the lab work to others while he oversees strategy, won't disclose the company's total outlay. He says only that the ultimate startup costs will be "very much on par with those you often see quoted for molecular medicines"—or potentially in the billions. He thinks the economics after that could be much more attractive than those of traditional drugs, because devices could, in theory, be repurposed for many different diseases with only slight tweaks to their firing patterns.

Glaxo's ambition is to deliver a marketable product in the next decade. But to target specific bundles of nerve fibers, doctors will need to figure out which neural "circuits" control a given organ function, and such a "functional map" of the nervous system doesn't yet exist. "The technology we have today is really quite limited in terms of targeting," says Doug Weber, the manager of ElectRx, Darpa's bioelectronics program. To be useful, those maps will also need to show how patterns and frequencies of stimuli affect an organ. Or, as Slaoui says, "What does it mean to accelerate your heartbeat in terms of electrical signals? Is it beep-beep-beep? Or beeeeeeeep, beep, beeeeeeeep?"

MIT's Boyden is attempting to map nerves through "expansion microscopy": He surrounds a sample with polymers similar

to those found in diapers, then adds water, enlarging them to a scale at which their intricate connections can be studied more easily. Another avenue of study involves an exotic-sounding discipline called optogenetics. First, an artificial virus changes neurons' genetic makeup to make them sensitive to light. Researchers then use light to switch them on and off and measure the responses further downstream. That makes it possible to understand which neurons control a particular organ function and ultimately target them with implants.

Glaxo will also need to develop the following: small power sources that can last decades; computers within the implants capable of reading and analyzing biological signals and adjusting output; and materials that won't degrade over time or harm fragile nerves. At tiny scales, Slaoui says, metal and plastic don't always play well with human tissue. "Most of the materials are edgy, and biology is smooth," he says.

One substance for which Glaxo and Darpa are funding research is shape-memory polymer, which is stiff at room temperature but flexible when heated. Electronics can be layered onto the stiff surface; then the polymer is heated into a form that hugs tightly around a nerve, almost like shrink-wrap. Prototype devices are three times thinner than a human hair, placed by surgeons "with steady

hands and microscopes," researcher Walter Voit says. Other approaches could involve adhesives or magnets.

At the Mayo Clinic in Rochester, Minn., scientists are working with electrically conductive synthetic diamonds, manufactured at 3,500F, to make brain implants more effective. Diamonds are a good material for measuring the concentration of neurotransmitters, such as dopamine, in real time. Perfecting that process would help "close the loop" for some devices, allowing them to monitor the impact they have on the brain and adjust their settings autonomously. Because of the boron used in the fabrication process, the stones glow blue, like the Hope Diamond.

The scale of the unknowns and the weird-science vibe of some proposals give plenty of ammunition to skeptics. "I want well-proven products and pathways and business models. This sounds very high-risk," says Claudio Nessi, the Geneva-based managing partner at NeoMed Management,

a medical investment firm. "When certain government agencies or charities get involved in something, I don't get involved. Their mandate is to look at very futuristic technologies, and losing money isn't a problem."

But companies much smaller than Glaxo are trying to make money with the technology. Last year the U.S. Food and Drug Administration approved a device from EnteroMedics, in St. Paul, Minn., designed to reduce appetite in the very obese. Pitched as an alternative to bariatric surgery, the implant consists of a pair of quarter-inch-wide electrodes sutured around the vagus nerve, a highway that runs from the brain to the abdomen. Silicone leads are connected to a power and control unit, the size of a deck of cards, inserted just beneath the skin. The apparatus took more than a decade to develop, during which EnteroMedics lost \$285 million. Another company, NeuroPace, recently began marketing an epilepsy device called the RNS System, which monitors and stops seizures with a rapid electric impulse. It includes a curved power unit an eighth of an inch thick that's placed inside the skull. A surgeon then threads leads through brain tissue to where the patient's seizures are focused. It's been in development since the late 1990s.

Drugs remain the moneymaker at Glaxo. The vast majority of its 13,000 R&D employees are devoted to developing conventional medicines, and investors are looking to those for signs of a recovery in the company's fortunes.

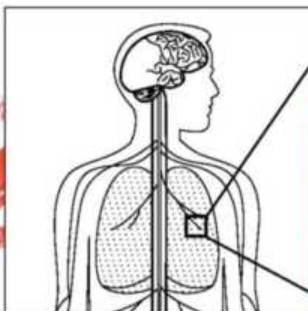
A few hundred feet from Famm's desk in Stevenage are row upon row of lab stations devoted to the grunt work of drug discovery: screening thousands of molecular compounds for their effect on a given disease. Robotic arms whir as they select tiny vials for testing; automatic dispensers measure out liquids a couple of nanoliters at a time. About 250 experiments occur every month, drawing on a library of more than 2 million compounds and generating terabytes of data.

Molecular work is what Famm, while at Cambridge, was originally trained to do. But even before that, he was primed to break away. As kids, Famm and his brother, now an executive at H&M, "had a million different clubs, just him and I," he says, devoted to tracking animals or waging mock wars with neighbors. As the eldest, Fredrik was always the leader, with just one exception. He put Kris in charge of the invention club. "There is a bit of a frontier in this space," Famm says about bioelectronics. "But that's perfect." **3**

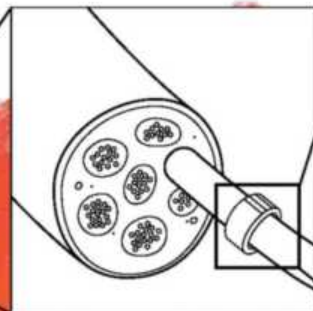
—With Ellen Huet

How it works

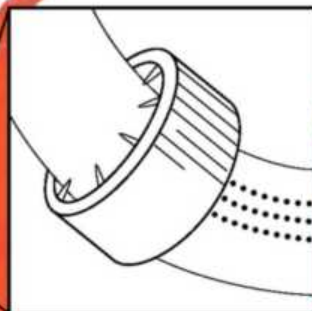
1 Peripheral nerves send signals from the brain to the rest of the body.



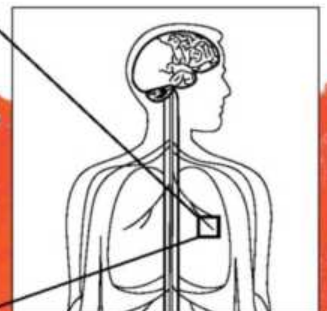
2 A device as small as or smaller than a grain of rice attaches to a nerve bundle.



3 The device blocks or alters signaling patterns passing through individual nerve fibers.



4 These modified signals travel to the target organ, treating disease.



IT DONE ELSEWHERE IN THE BODY? AND WHY ISN'T IT DONE ELSEWHERE IN THE BODY?





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Two ex-IBMers are building the first American factory in a very low-tech nation

A Tractor for Cuba

Retail price:

\$10,000

Top speed is about 10 mph

The gas tank holds 4 gallons

The hand lever controls the depth of the plow blades

Available implements include a plow, a planter, and a cultivator

The axle design also allows the driver to adjust the tractor's wheel width—ranging from 36 to 46 inches in the rear

A series of belts drives the hydrostatic transaxles, as in a lawn tractor



da

Come on, boy! Get dressed! We got to go!” yells Horace Clemmons. He’s heckling his longtime friend and business associate, Saul Berenthal, who sits cross-legged on a leather chair in the living room of Clemmons’s home in Paint Rock, Alabama. It’s a Tuesday in mid-April, and the duo is scheduled to give a presentation to a group of local investors about their new business, Cleber. In February, the U.S. Department of the Treasury approved Cleber’s request to be the first U.S.-based company to construct and operate a manufacturing facility in Cuba. They plan to build low-tech tractors for small farms.

“All right, all right!” Berenthal says, grinning, stretching his vowels. “But I need to see my choice of dress first.” He stands up and saunters into the guest bedroom. He’s come from his home in North Carolina for the event and is staying with Clemmons.

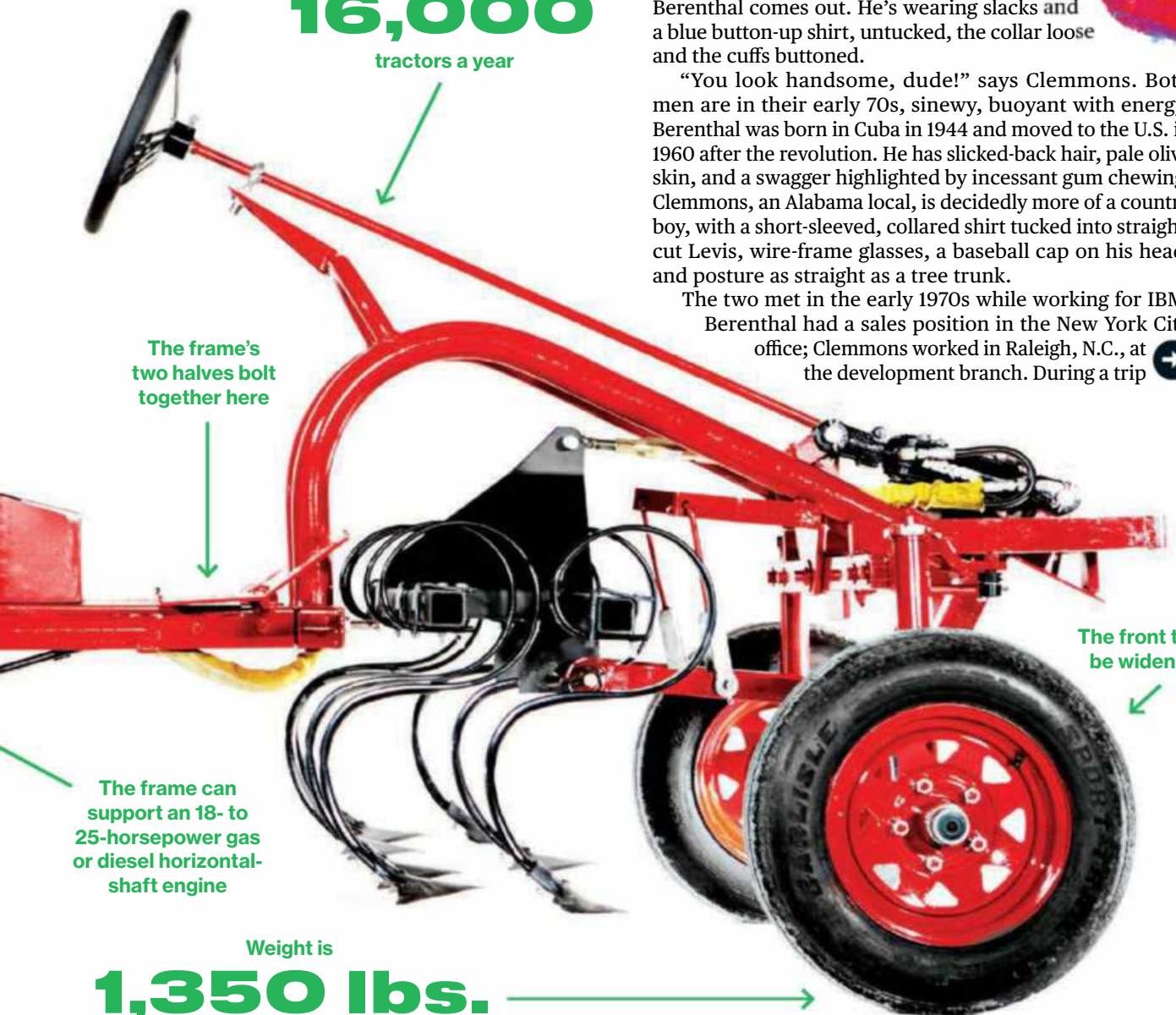
“You just have to choose if you want to wear the sport jacket or not,” Clemmons calls after him in his slouchy drawl. A minute later, Berenthal comes out. He’s wearing slacks and a blue button-up shirt, untucked, the collar loose and the cuffs buttoned.

“You look handsome, dude!” says Clemmons. Both men are in their early 70s, sinewy, buoyant with energy. Berenthal was born in Cuba in 1944 and moved to the U.S. in 1960 after the revolution. He has slicked-back hair, pale olive skin, and a swagger highlighted by incessant gum chewing. Clemmons, an Alabama local, is decidedly more of a country boy, with a short-sleeved, collared shirt tucked into straight-cut Levis, wire-frame glasses, a baseball cap on his head, and posture as straight as a tree trunk.

The two met in the early 1970s while working for IBM. Berenthal had a sales position in the New York City office; Clemmons worked in Raleigh, N.C., at the development branch. During a trip



The partners are planning to build **16,000** tractors a year



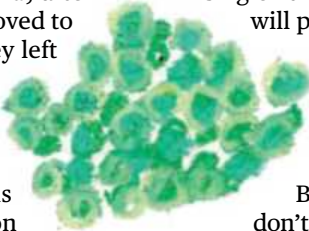
The frame’s two halves bolt together here

The frame can support an 18- to 25-horsepower gas or diesel horizontal-shaft engine

The front tires can be widened, too

Weight is **1,350 lbs.**

to Raleigh, Berenthal hit a snag with a client and needed help over a weekend. Referred to Clemmons, Berenthal drove to his home to find him in overalls, working in the yard. “I thought, ‘This is the guy that’s going to fix my problem?’” Berenthal recalls. But the guys clicked and, after Berenthal transferred departments and moved to Raleigh, became close friends. In 1983 they left IBM to start Post Software International, a point-of-sale software company. They sold the company in 1997 to Fujitsu for an undisclosed sum, though it seems to have been enough for Clemmons to build his current home, a 7,000-square-foot mansion made of cypress logs, on a 2,200-acre plot.



Now the pair are back at the entrepreneurial grind. Since getting the go-ahead from the U.S. government, they have been finalizing their first tractor’s design and sourcing materials, manufacturing prototypes to be tested in Cuba, nailing down the construction logistics of their facility, negotiating terms and conditions with the Cuban government, and hoping to raise \$15 million in funding. They’re scheduled to begin operations in 2017. They’ve just returned from a two-day road trip to Illinois to meet with a hydraulics manufacturer about some parts. Clemmons drove, while Berenthal sent e-mails and made phone calls.

As they grab their bags and head for the door, Clemmons’s wife, Elizabeth, calls out, “Good luck! Bring home lots of money!” She’s wearing a pink shirt printed with the company’s logo and “Oggún,” the name of its tractor. In the Afro-Cuban religion known as Santería, Oggún is the deity of metalworking. The spirit is a warrior and a protector. He paves the road ahead—an embodiment of potential and a symbol of hope.

Berenthal had been bugging Clemmons for years about starting a business in Cuba. He watched the changes on the island, most notably Fidel Castro’s offhand remark in 2010 that the economic model wasn’t working. In December 2014, when President Obama announced that the U.S. would begin reestablishing diplomatic relations with Cuba, Berenthal called Clemmons. As he puts it, “I said, ‘This is the time. Let’s go do it.’”

Despite being a great place to grow things, Cuba imports 80 percent of its food at a cost of \$2 billion per year. Almost 70 percent of its land, about 19 million acres, is fertile, but only 40 percent is used for farming and agriculture; 20 percent of the labor force, or about 1 million people, is employed in agriculture. The country has about 200,000 small, privately owned farms, as well as regional co-ops. The government runs the production of crops such as sugar cane. About 4 million people, 36 percent of the population, depend on agriculture in some way for their livelihood.

“Cuban farmers all agree that Cuba has the potential to produce more. All that needs to change is the mechanism of production,” says Mario González-Corzo, a professor of economics at Lehman College at the City University of New York, who was born and raised in Cuba and specializes in Cuban agriculture. “When I visit Cuba and talk to farmers, it all comes down to machinery.” Much of the island’s equipment is almost 30 years old, pieced together from allies such as China and the former Soviet Union (González-Corzo’s cousin owns a farm in Cuba; his tractor was built in the 1950s). Maintaining a working tractor has become so difficult

that many farmers have gone back to using animal labor.

“I said, ‘Saul, the Cubans will evolve differently than Americans evolved, but they will start at the same place we started,’” Clemmons says. “They are going to start at the single-row tractor.” By that, he means a small tractor that will plow one furrow at a time.

More than anything, Berenthal and Clemmons know that Cuba is still Cuba, and that the Cuban government will want a socially conscious business model. “If you are going to approach Cuba with ‘I want to sell you something,’ it ain’t going to work,” Berenthal says. “That’s not what they want. They don’t want to be dependent and buying from the rest of the world forever. If you are going to propose a project, it has to have an economic, social, and cultural justification.”

At the presentation, the two address about 15 potential investors. Clemmons opens, noting that, although they’ve received calls from interested parties about Cleber, this is their first official pitch for seed funding. He then turns the podium over to Berenthal. “Horace is inspirational, and I am operational,” Berenthal says. “I want to try and get you through how I always try to make happen what he dreams.” The crowd laughs, and Berenthal dives in.

The Oggún may be the world’s first open source tractor. The frame of the Oggún 1.0 base model is an original design but rooted in the Allis-Chalmers Model G, a mainstay of the postwar farming boom of the late 1940s and early ‘50s. (Coincidentally, the Model G was manufactured in Alabama.) It’s a bare-bones design, the tubular frame of which is reminiscent of a homemade go-cart—sturdy, simple, and open to the elements. The driver sits high up for visibility; the motor is behind, bolted to the frame between the rear wheels.

The frame of the Oggún can support an 18- to 25-horsepower gas or diesel engine. Cleber has seven manufacturers—American, Japanese, British, German, and Italian—that can supply a compatible motor, allowing more versatility when sourcing. A series of belts drives two hydrostatic transaxles—essentially, axles turned without shifting gears—one for each rear wheel, similar to many lawn tractors. You push the gas pedal and go. The axles can be widened—from 38 to 60 inches in the front and 36 to 46 inches in the rear—providing versatility when planting rows of crops, navigating narrow paths, or transporting the tractor in a trailer or the back of a truck. The rear axles can be loosened using hand tools, extended outward, and tightened again. At the front, the frame has notches every two inches. All the farmer has to do is jack it up, remove the bolts, slide the wheels over, and put the bolts back in.

Additional farming implements can be hooked up to the tractor. The more popular ones are likely to be a plow to break the ground, a cultivator to aerate the soil, and a planter to drop in seeds. Under the belly of the tractor is a hitch system for attaching implements.

Only a handful of components makes up the finished tractor: the frame, which is split into two parts that bolt together at the center; the motor and both axles; four rims and tires; the shaft for the front wheels; the steering wheel and column; the seat; hydraulic fuel tanks; and gas. “It’s excruciatingly simple,” Clemmons says.

Oggún 1.0 is expected to retail for \$10,000, which is low for a tractor of this horsepower. The parts would initially be manufactured in the U.S., sent to Cuba, and

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assembled by Cuban workers at a planned 66,000-sq.-ft. facility in Mariel, a burgeoning port and special development zone west of Havana along Cuba's northern coast. As the business expands, Berenthal explains, the company plans to eventually manufacture parts on-site and hire more employees. The Cuban government would take care of human resources, using criteria submitted by Cleber to find employees and negotiate salaries.

The company could break \$100 million in sales within 10 years if all goes well, Berenthal says. By the second year, the two hope the Mariel-based facility will be exporting tractors to other countries in Latin America.

The company's business model has its risks. It's contingent on farmers having money to buy a tractor or having family in the U.S. who can send them money to buy one; or on a European banking institution willing to give out loans; or on the Cuban government, a notoriously fickle and unpredictable entity, allocating funds in the national budget to purchase tractors for its residents. "The question really is, can they provide, or work with the government to offer, some form of financing so the farmer can afford the cost of the tractor?" says González-Corzo.

After the presentation, Clemmons and Berenthal drive back home to Paint Rock to eat a late dinner. No one at the conference made any on-the-spot offers, although a few potential investors said they were intrigued and expressed admiration. "This was a good test round, a learning experience," Clemmons tells me in his kitchen, carving slivers off a block of manchego cheese, while Berenthal eats cereal. "Like I told them at the beginning, we've never had to ask for money before."

It seems promising, though, that no one questioned the validity of their idea or the impact it would have on the Cuban people.

"How often do you get the opportunity to make history and money at the same time?" Clemmons says, munching on a slice of cheese. "All you have to do is listen to what people need."

The next day, Clemmons and Berenthal wake up at 5 a.m. After a breakfast of eggs, bacon, and rye toast with homemade blackberry jelly, they drive 40 miles east to Liberty Steel Fabrication in Fyffe, Ala., for a 9 a.m. meeting with its owner and president, Kelly Pittman, who's in charge of designing the facility in Mariel as well as manufacturing many of the parts for the Oggún 1.0. Details have to be ironed out before the team presents the plans to Cuban officials and ships a batch of five tractors to be tested on farms in different parts of the country.

Pittman, round-bellied with thick hands, leads Clemmons and Berenthal through his plant to a mock-up of their tractor. The men discuss and debate aspects of the tractor's construction and how that could play into its assembly once the parts are in Cuba. Should the frame be separate parts bolted together? How durable is the design? Are they missing anything?

"We gotta have this one tested, and six more built, and five shipped to Cuba for July, and I'm counting on you to do it," Clemmons tells Pittman.

"And that's what I'm gonna do," Pittman replies, smiling. "The biggest thing we gotta do is make sure it lasts—that it doesn't fail when it gets to work down in Cuba."

After tinkering a bit more, the men sit down and discuss construction plans for the facility in Mariel. Pittman has designed Cleber's facility to accommodate three eight-stage assembly lines that, over a four-day, single-shift workweek, could make 16,000 Oggún tractors per year. "If I'm putting a part together over and over, it's fast, it's simple," Pittman says. "It ain't a rocket we're building here." For the factory roof, he recommends a tilt-panel design with an insulated roof, a more durable option that could withstand potential hurricanes. He offers to bring down experts to oversee construction.

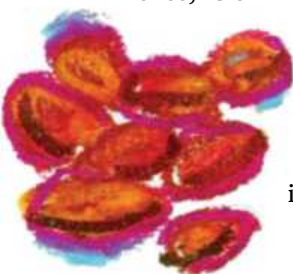
Clemmons explains that he's hiring Pittman not only to erect a building or fabricate tractor parts but also to help with every aspect. "We're not just looking at a building, we're looking at an end-to-end process of turning out 16,000 tractors a year," Clemmons tells him. Berenthal sits to his left, nodding in agreement. The facility is the linchpin of their vision, and they trust Pittman's judgment. "We'd like to say, 'Kelly, it's yours—we're dependent on you, not just for the building but the entire process.'"

Pittman gestures at the plans, which detail the assembly area as well as a section of offices. "If it's going to be as successful as you say it's going to be," he says, pointing to the offices on the blueprints, "you'll need more."

Clemmons laughs and nods to Berenthal. "He was going to retire until he met me," he says.

The men shake hands, and Clemmons and Berenthal walk out to the parking lot. "All right, I'm going to get on the road," Berenthal tells his friend. He has to drive back to North Carolina—an eight-hour trek. Clemmons walks him to his car. He gives Berenthal a hug.

"I'll see you next week," Clemmons says. "We've got a lot to do." **B**



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 **bmc** digital IT

Wary of the cops, young Egyptians are grinding and 3D-printing their way to a tech scene

The Brave Nerds Of Cairo

At a shared workspace in central Cairo, a 15-minute drive from the Nile, Mohammed Abuelhagag is working on a stem cell incubator. The bottom half, housing the motors, is made of laser-blackened wood. The top, where the stem cells will be grown, isn't done yet. Sensors to track humidity, temperature, and air quality have yet to clear customs. "Here in Egypt, if you want to make something, it's like a treasure hunt," says Abuelhagag, 29.

He's a regular at Fab Lab Egypt, a home for aspiring developers that's become an early building block of the country's tiny but growing tech scene. In the five years since the so-called Twitter revolution drove President Hosni Mubarak from power, startups, incubators, and angel investors have sprung up like shoots of grass after a drought. "The revolution showed me what people can achieve when they work together," says Hisham Khodeir, a software engineer who helped found Fab Lab in 2012.

When I visit in March, a young couple is slouched on beanbag chairs, watching videos on cell phones. A man fiddles with wiring at a workbench. Aser Nabil, 21, one of the lab's first members, shows me a wooden drone he's been working on, then he walks me through the rest of the room: 3D printer, laser cutter, a machine to print circuit boards. Nabil ends the tour at a rack of jigsaws, drill presses, and grinders. "Anything that can cut you, bruise you, or burn you is here," he says.

Since the revolution, violence and political

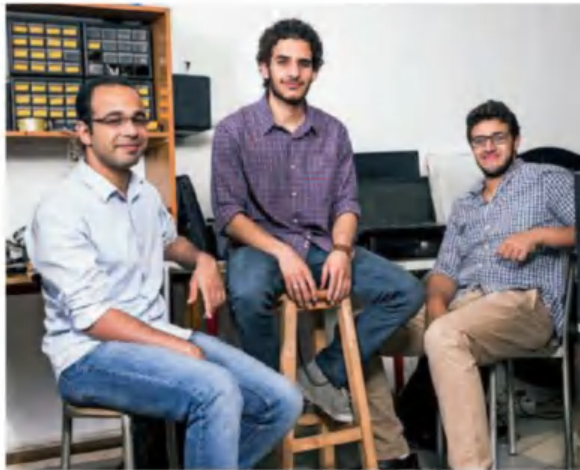
crackdowns have kept tourists and investors at bay. The country's bureaucracy can also be punishing, and not just when dealing with customs. The World Bank ranks Egypt 131st out of 189 economies in ease of doing business. "Our regulatory framework is like our archaeology," says Ahmed El Alf, a venture capitalist from California who opened a Cairo tech hub called the Greek Campus in 2013.

Education can also be a challenge. When an entrepreneur named Ahmed Shaaban set up Simplex, a company making machines for woodworking and stone carving, he had to literally educate the market. "About half of our customers didn't know how to use a computer," Shaaban says.

Then there's the police. Hobbyists and professionals alike hesitate to carry their tech projects around Cairo, where cops could mistake them for bombs. In February, two interns at a hardware company called Integreight were arrested, possibly because they were carrying chips, and detained for two months. "Somebody once got arrested for carrying a voltmeter," says Amr Saleh, Integreight's chief executive officer. Saleh recently built a game featuring a large, red countdown clock. When he brought it to the office, he was careful to keep it tightly wrapped in a bag.

Fab Lab Egypt has

Abuelhagag (left),
Elsafty (center), and Nabil take
a break in Fab Lab Egypt,
without mysterious inspectors



twice been visited by men its members presume are police. Both times, they inspected equipment, asked some questions, and left. "In Egypt, you don't know who came exactly," says Omar Elsafty, the lab's general manager.

Yet the country's challenges also suggest its potential. "When you have a lot of needs, a lot of gaps, a lot of problems to solve, you don't need to be very innovative," says Saif Edeen El Bendari, a manager at RiseUp, which organizes annual tech conferences.

Last year the lab started making enough money—through memberships, workshops, and equipment rentals—to pay a few salaries and start setting up in other cities. Some regulars are starting businesses. "A few years ago, people didn't know what a 3D printer was," Elsafty says. "Today, they're building their own."

Abuelhagag, a former medical student who treated wounded protesters in Tahrir Square in 2011, plans to use his new engineering skills to create anatomical models for med students. He also hopes to turn his stem cell incubator into a cheap, open source research kit. "Tech, it's something you can actually have an effect on," he says. "Maybe this is how you can change the world, finally." **E**

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The world is full of inventors funding their own R&D far from corporate and academic labs

The Power Of the Garage

Location **Edmonton, Alta.** Technology **Water purification membrane**



Peter Christou

I've designed a purification process that uses a membrane to filter sewage from water. There are things you don't think about. Like, if I made sewage, I'd store it in a bucket and keep it outside. In winter, I could just leave it out and freeze it, but in warmer weather it was a challenge. The sewage would get all over the place, down my driveway in the middle of suburbia. My girlfriend at the time hated me doing testing.

Technology **Health monitor**



Location **Cupertino, Calif.**

Utkarsh Tandon

In the fifth grade, I was surfing YouTube and saw a video of Muhammad Ali during the torch relay at the 1996 Olympics. His hands were shaking, so I looked online and realized he had Parkinson's. It made me want to build something to help people with the disease. It took a few years—I'm currently 16. I designed a "smart ring" that uses Bluetooth and an iOS app to collect data on things like what time of day the tremors are more severe. The data go into a report doctors can use to better treat their patients. I work at a desk in the garage. I spend a few hours there every night after wrapping up my homework, soldering the rings for my Kickstarter campaign. I'm shipping them to backers soon, 25 of them. Most are Parkinson's patients.

Ray Avery

Generally, disruptive technology doesn't come from big corporations. I've got a number of inventions that came from thinking outside of the box, and you do that if you're in the garage. You try to crack things, and you can be in there all night.

We're taking complicated medical devices and making them simple, cheap, and durable. We always work on customer-centric design, and that involves everything that you know about the customer and everything the customer may want, while trying to foretell the future. If you get that right, it has longevity.



Location **Auckland** Technology **Low-cost neonatal incubator**

"THE KICKSTARTER CAMPAIGN WAS OVERWHELMING, BUT EXCITING TO SEE THIS BECOME REAL"

Mona Zaki

I've created an app that locates missing persons globally without GPS. I travel back and forth from Houston, because I have a home in Egypt. I stay at my brother's house, and a few years ago I decided to work on the pingpong table in the garage. It offers a lot of space to do a lot of drawings. For the user's path—the first page, or login, on the app—I really need space to lay it out. The color is really calming to work with.

"ONCE YOU GET PAST THE BUILD-OUT, YOU CAN DO EVERYTHING FROM A LAPTOP"

Location **Houston; Alexandria, Egypt** Technology **Missing persons locator app**





Location **Klerksdorp,**

Christo Rossouw

Growing up, when stuff broke, my mother used to give it to me and I'd make something else out of it. I've always been interested in upgrading stuff. My latest project is the Re-Lit, a light that fits onto a bulb or tube lamp. It has a mini solar panel that converts light created by the bulb into electricity that charges an internal battery. We have a lot of power outages, so the device is a backup. When I started on my prototype, I had to travel 150 miles to find someone who could 3D-print it.

Michael Johnson

Who doesn't want a superpower? I started building things a few years ago that focus on sensory-based inventions: a ring device that allows the wearer to experience magnetic fields as a vibration; an ultrasonic walking stick for the blind with similar haptic feedback; some preliminary work on ultrasound hearing for echolocation. And I've been working to build a battery that's easily constructed, bulky, but very durable. Batteries are an intensely difficult thing to manufacture well—the worst battery you could buy in a store is a marvel of engineering.



Location **Chenoa, Ill.** Technology **Bauxite residue batteries**

The development of a microprocessor is one of the riskiest, costliest, and most technically complex feats in business

How Intel Makes a Chip

This **12"**

wafer will be chopped up into 122 Xeon E5 chips. They sell for as much as \$4,115 apiece.

Each E5 has as many as 7.2 billion transistors. The chip in the original IBM PC had 29,000.

Just building a factory capable of making these wafers costs at least \$8.5 billion.

"IF YOU NEED SHORT-TERM GRATIFICATION, DON'T BE A CHIP DESIGNER!"

Before entering the cleanroom in D1D, as Intel calls its 17 million-cubic-foot microprocessor factory in Hillsboro, Oregon, it's a good idea to carefully wash your hands and face. You should probably also empty your bladder. There are no bathrooms in the cleanroom. Makeup, perfume, and cosmetics are forbidden. Writing instruments are allowed, as long as they're special sterile pens; paper, which sheds microscopic particles, is absolutely banned. If you want to write on something, you'll have to use what is known in the industry as "high-performance documentation material," a paperlike product that doesn't release fibers.

After you put on a hairnet, your next stop is the gowning station, inside a pressurized room that sits between the outside world and the cleanroom itself. A hard breeze, sent by a cleaning system that takes up the equivalent of four and a half football fields, hits you as you walk in, removing stray matter—dust, lint, dog hairs, bacteria. You put on pre-gown gloves, then a white bodysuit with a hood and surgical-style mouth cover, followed by a second pair of gloves, a second pair of shoe covers, and safety glasses. None of these measures are for your safety; they protect the chips from you.

The air in the cleanroom is the purest you've ever breathed. It's class 10 purity, meaning that for every cubic foot of air there can be no more than 10 particles larger than half a micron, which is about the size of a small bacteria. In an exceptionally clean hospital OR, there can be as many as 10,000 bacteria-size particles without creating any special risk of infection. In the outside world, there are about 3 million.

The cleanroom is nearly silent except for the low hum of the "tools," as Intel calls them, which look like giant copy machines and cost as much as \$50 million each. They sit on steel pedestals that are attached to the building's frame, so that no vibrations—from other tools, for instance, or from your footfalls—will affect the chips. You step softly even so. Some of these tools are so precise they can be controlled to within half a nanometer, the width of two silicon atoms.

It's surprisingly dark, too. For decades, Intel's cleanrooms have been lit like darkrooms, bathed in a deep, low yellow. "That's an anachronism," says Mark Bohr, a small, serious man who has spent his entire 38-year career making chips, and who's now Intel's top manufacturing scientist. "Nobody's had the courage to change it."

Chips are made by creating tiny patterns on a polished 12-inch silicon disk, in part by using a process called photolithography and depositing superthin layers of materials on top. These wafers are kept in sealed, microwave oven-size pods called "foups" that are carried around by robots—hundreds of robots, actually—running on tracks overhead, taking the wafers to various tools. The air inside a foup is class 1, meaning it probably contains no particles at all. Periodically, the wafer is washed using a form of water so pure it isn't found in nature. It's so pure it's lethal. If you drank enough of it, it would pull essential minerals out of your cells and kill you.

Over the next three months—three times the amount of time it takes Boeing to manufacture a single Dreamliner—these wafers will be transformed into microprocessors. They'll make their way through more than 2,000 steps of lithography, etching, material application, and more etching. Each will then be chopped up into a hundred or so thumbnail-size "dies," each of which will be packaged in a ceramic enclosure. ➔

It takes about three months to manufacture a single

E5 chip

Making an E5 involves some

2,000

steps of etching and depositing materials, sometimes in layers as thin as a single atom.

If everything functions properly, none of the 100,000 or so people who work at Intel will ever touch them. The endpoint of this mechanized miracle: the Intel Xeon E5 v4, the company's latest server chip and the engine of the internet.

Intel rarely talks about how it creates a new chip. When *Bloomberg Businessweek* visited the Hillsboro fab in May, we were given the most extensive tour of the factory since President Obama visited in 2011. The reticence is understandable, considering that the development and manufacture of a new microprocessor is one of the biggest, riskiest bets in business. Simply building a fab capable of producing a chip like the E5 costs at least \$8.5 billion, according to Gartner, and that doesn't include

An unprocessed silicon wafer costs about \$300. It'll be worth more than \$300,000 when the fab is finished.

the costs of research and development (\$2 billion-plus) or of designing the circuit layout (more than \$300 million). Even modest "excursions"—Intel's euphemism for screw-ups—can add hundreds of millions of dollars in expense. The whole process can take five years or more. "If you need short-term gratification, don't be a chip designer," says Pat Gelsinger, chief executive of VMware and a longtime Intel executive who most recently served as the company's chief technology officer. "There are very few things like it."

A Google self-driving car might have three server chips on board; a single Google search might use thousands of them.

A top-of-the-line E5 is the size of a postage stamp, retails for \$4,115, and uses about 60 percent more energy per year than a large Whirlpool refrigerator. You use them whenever you search Google, hail an Uber, or let your kids stream Episode 3 of *Unbreakable Kimmy Schmidt* in your car. These feats of computer science are often attributed to the rise of the smartphone, but the hard work is being done on thousands of servers. And pretty much all of those servers run on Intel chips.

Intel, based in Santa Clara, Calif., created the first microprocessor in 1971 and, under the leadership of Andy Grove, became a household name in the 1990s, selling the chips that ran most personal computers. But PC sales have fallen over the past five years with the rise of smartphones, and Intel was slow to develop lower-power chips suited for those devices. The company recently announced layoffs of

11 percent of its workforce, as CEO Brian Krzanich puts it, to "reinvent ourselves."

Intel is still the world's largest chipmaker, and it sells 99 percent of the chips that go into servers, according to research firm IDC. Last year its data center group had revenue of about \$16 billion, nearly half of which was profit. This dominance is the result of competitors' failings and Intel's willingness to spend whatever it must to ensure large, predictable improvements to its products, every single year. "Our customers expect that they will get a 20 percent increase in performance at the same price that they paid last year," says Diane Bryant, an Intel executive vice president and general manager of the company's data center business.

"That's our mantra."

In PCs and phones, this strategy has its limits: Consumers simply don't care that much about speed and efficiency beyond a certain point. But in servers, where data centers run by such companies as Amazon.com and Microsoft compete for the right to handle data for the Netflices and Ubers of the world, performance is paramount. The electricity needed to run and cool

A human red blood cell is 7,000 nanometers across. A virus is 100nm. Intel's fabs work on a 14nm scale.

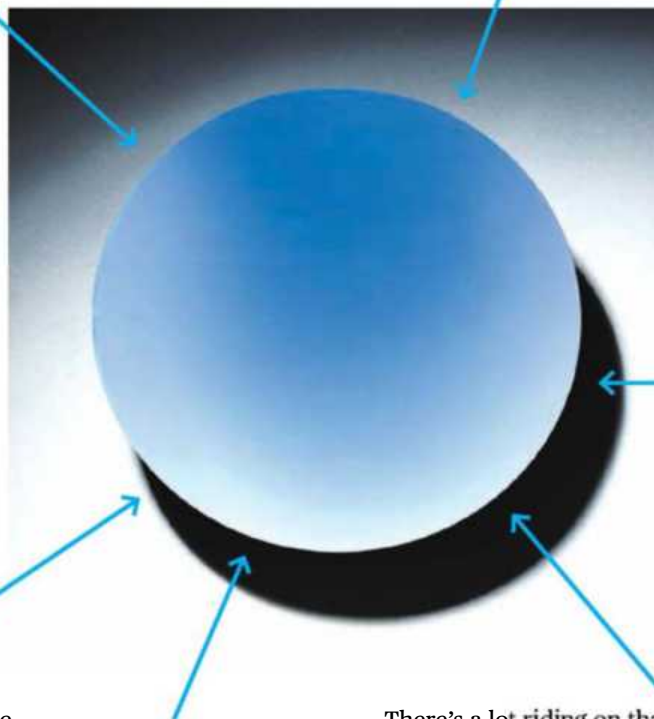
According to Gartner, a chip design needs to generate \$3 billion over its first two years to be economically viable.

servers is by far the biggest expense at the average server farm. If Intel can deliver more computing power for the same amount of electricity, data center owners will upgrade again and again.

There's a lot riding on that "if." Each year, Intel's executives essentially bet the company on the notion that they can keep pushing the limits of circuits, electronics, and silicon atoms, spending billions long before they turn a profit. Eventually chips will go the way of incandescent lightbulbs, passenger jets, and pretty much every other invention as it ages; the pace of improvement will slow dramatically. "There will be a point where silicon technology gets like that, but it's not in the next couple of decades," Krzanich says confidently. "Our job is to push that point to the very last minute."

It takes five years to make a new server chip—and just three years for that chip to become obsolete.

Microprocessors are everywhere. They're in your TV, car, Wi-Fi router, and, if they're new enough, your refrigerator and thermostat. Internet-connected lightbulbs and some running shoes have chips. Even if you don't think of them that way, these devices are in a sense computers, which means they're made of transistors.



Under late CEO Andy Grove, Intel created the "copy exactly" philosophy, which means all fabs are identical.



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IT'S LIKE YOU'VE FINISHED

A transistor is a switch. But instead of requiring a finger to turn it on or off, it uses small electrical pulses—3 billion per second in the case of a powerful computer. What can you do with a switch? Well, you can use it to store exactly one bit of information. On or off, yes or no, 0 or 1—these are examples of data that can be conveyed in a single bit, which is, believe it or not, a technical term. (There are 8 bits in a byte, 8 billion in a gigabyte.) The earliest computers stored bits in punch cards—hole or no hole?—but that was limiting, because if you want to do anything cool, you need a lot of bits. For instance, if you want your computer to store the words “God, this stuff is complicated,” it would need 8 bits for every letter, or 240 transistors. Another thing you can do with a switch is math. String seven switches together in just the right order, and you can add two small numbers; string 29,000 of them, and you have the chip that powered the original IBM PC in 1981; pack 7.2 billion on an E5, and you can predict global weather patterns, sequence a human genome, and identify oil and gas deposits under the ocean floor.

Every three years or so, Intel shrinks the dimensions of its transistors by about 30 percent. It went from 32-nanometer production in 2009 to 22nm in 2011 to 14nm in late 2014, the state of the art. Each of those jumps to smaller switches means chip designers can cram about twice as many into the same area. This phenomenon is known as Moore’s Law, and it has, for half a century, ensured that the chip you buy three years from now will be at least twice as good as the one you buy today.

The latest Xeon chips take advantage of research that began in the 1990s, when Bohr’s team in Oregon began trying to deal with quantum tunneling, or the tendency of electrons to jump through very small transistors, even when they’re switched off. It was the latest front in Intel’s ongoing war with physics. It had been conventional wisdom that once silicon transistors shrunk to below 65nm, they’d stop working properly. Bohr’s solution, unveiled in 2007, was to coat parts of the transistor with hafnium, a silvery metal not found in nature, and then, starting in 2011, to build transistors into little towers known as fin-shaped field effect transistors, or FinFETs. “Our first FinFET, instead of being narrow and straight, it was more of a trapezoid,” Bohr says with a hint of disappointment—trapezoidal fins take up more room than rectangular ones. “These are thinner and straighter,” he says proudly, gesturing at a recent photograph, taken with an electron microscope, that shows two stock-straight black shadows resting eerily on a grayish base. The images look like dental X-rays. Intel people call them “baby pictures.”

Shrinking the transistors is only part of the challenge. Another is managing an ever more complex array of interconnects, the crisscrossing filaments that link the transistors to one another. The Xeon features 13 layers of copper wires, some thinner than a single virus, made by etching tiny lines into an insulating glass and then depositing metal in the slots. Whereas transistors have tended to get more efficient as they’ve shrunk, smaller wires by their nature don’t. The smaller they are, the less current they carry.

The man in charge of the Xeon E5’s wiring is Kevin Fischer, a midlevel Intel engineer who sat down in his Oregon lab

in early 2009 with a simple goal: Fix the conductivity of two of the most densely packed layers of wires, known as Metal 4 and Metal 6. Fischer, 45, who has a Ph.D. in electrical engineering from the University of Wisconsin at Madison, started the way Intel researchers usually do, by scouring the academic literature. Intel already used copper, one of the most conductive metals, so he decided to focus on improving the insulators, or dielectrics, which tend to slow down the current moving through the wires. One option would be to use new insulators that are spongier and thus create less drag. But Fischer suggested replacing the glass with nothing at all. “Air is the ultimate dielectric,” he says, as if stunned by the elegance of his solution. The idea worked. Metal layers 4 and 6 now move 10 percent faster.

Chip design is mostly a layout problem. “It’s kind of like designing a city,” says Mooly Eden, a retired Intel engineer who ran the company’s PC division. But the urban-planning analogy may undersell the difficulty. A chip designer must somehow fit the equivalent of the world’s population into 1 square inch—and arrange everything in such a way that the computer has access to each individual transistor 3 billion times per second.

The building blocks of a chip are memory controllers, cache, input/output circuits, and, most important of all, cores. On the Pentium III chip you owned in the late 1990s, the core and the chip were more or less one and the same, and chips generally got better by increasing the clock rate—the number of times per second the computer can switch its transistors on and off. A decade ago, clock rates maxed out at about 4 gigahertz, or 4 billion pulses per second. If chips were to cycle any faster, the silicon transistors would overheat and malfunction. The chip industry’s answer was to start adding cores, essentially little chips within the chip, which can run simultaneously, like multiple outboard motors on a speedboat. The plan for the new E5 called for up to 22 of them, six more than the previous version, which would be designed at Intel’s development center in Haifa, Israel.

Another way to make a chip faster is to add special circuits that only do one thing, but do it extremely quickly. Roughly 25 percent of the E5’s circuits are specialized for, among other tasks, compressing video and encrypting data. There are other special circuits on the E5, but Intel can’t talk about those because they’re created for its largest customers, the so-called Super 7: Google, Amazon, Facebook, Microsoft, Baidu, Alibaba, and Tencent. Those companies buy—and often assemble for themselves—Xeon-powered servers by the hundreds of thousands. If you buy an off-the-shelf Xeon server from Dell or HP, the Xeon inside will contain technology that’s off-limits to you. “We’ll integrate [a cloud customer’s] unique feature into the product, as long as it doesn’t make the die so much bigger that it becomes a cost burden for everyone else,” says Bryant. “When we ship it to Customer A, he’ll see it. Customer B has no idea that feature is there.”


It takes a year for Intel’s architects—the most senior designers, who work closely with customers as well as researchers in Oregon—to produce a spec, a several-thousand-page document that explains the chip’s functions in extreme detail. It takes an additional year and a half to translate the spec into a kind of software code composed of basic logic instructions such as AND, OR, and NOT, and then translate that into a schematic showing the individual circuits. The final and most labor-intensive part

SHED A PUZZLE, AND NOW YOU COME AND TELL ME I NEED TO

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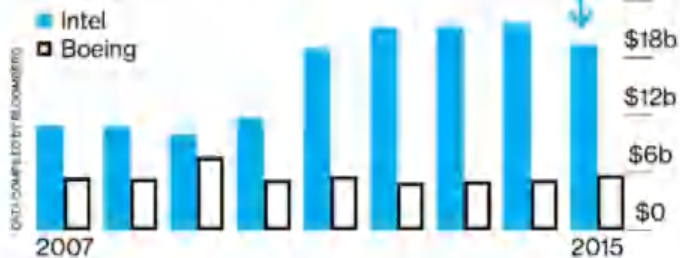
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Making a Chip Costs More Than Making a Plane

Research and development costs and capital expenditures



of this process, mask design, involves figuring out how to cram the circuits into a physical layout. The layout is eventually transferred onto masks, the stencils used to burn tiny patterns on the silicon wafer and ultimately make a chip. For the E5, mask designers based in Bangalore, India, and Fort Collins, Colo., used a computer-aided design program to draw polygons to represent each transistor, or copied in previously drawn circuit designs from a sort of digital library. "You have to have the ability to visualize what you're working on in 3D," says Corrina Mellinger, a veteran Intel mask designer.

Unlike most of the technical jobs at Intel, mask design doesn't require an advanced degree in engineering. The work is learned as a trade; Mellinger took a single class in chip layout at a community college after joining Intel in 1989 as an administrative assistant. The final few weeks of a mask design are always the most intense, as designers continually update their work to accommodate last-minute additions to the layout. "It never fits at first," says Patricia Kummrow, an Intel VP and manager of the Fort Collins design team. The best mask designers can look at the polygons and instantaneously see how to shrink the design by rerouting circuits onto different layers. "It's like you've finished a puzzle, and now you come and tell me I need to add 10 more pieces," says Mellinger. "I'm like, 'OK, let me see what kind of magic I can work.'"

Intel's chip designers are committed rationalists. Logic is literally what they do, every day. But if you get them talking about their work, they tend to fall back on language that borders on mystical. They use the word "magic" a lot.

Gelsinger, the former CTO, says he found God a few months after starting at Intel in 1979. "I've always thought they went hand in hand," he says, referring to semiconductor design and faith. Maria Lines, an Intel product manager, becomes emotional when she reflects on the past few years of her career. "The product that I was on several generations ago was about 2 billion transistors, and now the product I'm on today has 10 billion transistors," she says. "That's like, astounding. It's incredible. It's almost as magical as having a baby."

The moment of birth of a chip is known as first silicon. For the E5, first silicon happened in 2014. A team in Bangalore sent a 7.5-gigabyte file containing the full design to Intel's mask shop in Santa Clara. The masks, 6-by-6-inch quartz plates that feature slightly blown-up versions of the transistors to be printed on each chip, were shipped the

following week to an Intel fab near Phoenix that is an exact copy of the Oregon facility, and the machines began their slow, exacting work.

After all of the round-the-clock scrambling, designers spent most of 2015 waiting for new prototypes to test. Each "rev," or revision, takes three months or so to make. "It's tedious," says Stephen Smith, an Intel vice president and general manager of the data center engineering group. This, for all the intricacy of the circuits, is what makes microchip development among the highest-stakes bets in all of business. If you have more than a few excursions by the time you get to first silicon, there will be long delays and lost revenue. And with every generation of ever smaller transistor, the stakes get higher. Krzanich notes that it takes twice as long to fab a chip today as it did 10 years ago. "Making something smaller is a problem of physics, and there are always ways to solve that," he says. "The trick is, can you deliver that part at half the cost?"

The last step in the manufacturing process happens at assembly plants in Malaysia, China, and Vietnam. There, diamond saws cut the finished wafers into squares, which are then packaged and tested. In fall 2015, Intel shipped more than 100,000 chips, gratis, to the Super 7 and other big customers. Last-minute tweaks were made to the software that ships with each chip, and Intel spent six weeks or so doing final tests. Full manufacturing of the new E5 didn't begin until earlier this year, in Arizona and at another identical fab in Leixlip, Ireland. Over the next 12 months, Intel will sell millions of them.

If customers are lucky, they'll probably never see those chips, much less consider how they were made. But if you opened up a new server, you'd eventually find a healthy chip, hot to the touch and sealed in ceramic packaging that bears a blue Intel logo. If you looked inside the housing, you'd find the 13 layers of interconnects, which to the naked eye look like nothing more than a dull metal plate. Many layers below would be the silicon, shimmering in blues and oranges and purples—a tiny, teeming maze of circuits that somehow makes our whole world work. It's beautiful, you might think.

Bohr, Intel's lead manufacturing researcher, sometimes thinks the same thing. But as a scientist, he understands that what he sees aren't really colors—they're just light, reflected and refracted by the designs he and his colleagues have imprinted on the silicon. The individual transistors themselves are smaller than any wave of light. "When you get dimensions that small, color has no meaning," he says, and then excuses himself.

He's late for a meeting to discuss Intel's 5-nanometer chips, two generations from the current E5. Five nanometers is regarded by many in the chip business as the point after which it won't be possible to scale down further, when Moore's Law will finally fail. Intel hopes to use something called extreme ultraviolet light, a new technology that the industry has yet to harness effectively, to help get there. Beyond 5nm there will be new materials—some think that carbon nanotubes will replace silicon transistors—and perhaps entirely new technologies, such as neuromorphic computing (circuits designed to mimic the human brain) and quantum computing (individual atomic particles in lieu of transistors).

"We're narrowing down the options—a lot of wild and crazy ideas," Bohr says. "Some of them just won't work out." But, he adds with utter certainty, one or two will. ●

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Two carmakers have been trying to out-invent each other for more than a century

Benz vs. Bimmer

In March, BMW marked its centennial—and a century of technological rivalry with Daimler’s Mercedes-Benz. In newspaper ads, Benz, which can lay claim to having invented the car in 1886, congratulated its Bavarian archenemy: “Thanks for 100 years of competition. The 30 years before that were a little dull.” That’s like M-B doing doughnuts on BMW’s driveway. Here, a timeline of the two companies trading pole position for automotive supremacy.

Scorecard

🏆 or 🏆 is 1 point

- 1 A lederhosen-clad leg up
- 2 Opening it up on the autobahn
- 3 Pitiless *Arsch*-whipping
- 4 Hasselhoff concert

Start



1886
Karl Benz creates the Patent-Motorwagen, widely accepted to be the first automobile. 🏆🏆🏆🏆

1886
Gottlieb Daimler and Wilhelm Maybach retrofit a stagecoach with a gasoline engine. 🏆🏆

1901
Daimler receives a patent for the honeycomb radiator, still the basis for water-cooled engines. 🏆🏆

1900
Daimler-Motoren-Gesellschaft (DMG) builds the Mercedes 35 PS, a car named for a customer’s daughter.

1925
BMW’s R37 and R39 motorcycles fit production engines with cylinder heads made of lighter, cooler-running aluminum. 🏆🏆

1923
Banned from building aircraft or their engines by the Treaty of Versailles, BMW makes the R32, its first motorcycle. 🏆🏆

1921
A young DMG employee, Ferdinand Porsche, helps build the first supercharger. 🏆🏆

1916
BMW’s predecessor, aircraft maker Bayerische Flugzeugwerke (BFW), is founded.

2005
BMW unveils the Hydrogen 7, a version of the company’s 7 Series sedan featuring an engine that can run on gasoline or compressed hydrogen. 🏆🏆

2011
BMW displays a concept electric car, the i3, at the Frankfurt Auto Show. 🏆🏆🏆

1926
Mssrs. Daimler and Benz merge their companies: Mercedes-Benz is born.

1998
BMW buys Rolls-Royce.

1998
Daimler starts selling the Smart Fortwo, a two-seat microcar for city driving. 🏆

1999
If 12 cylinders is cool, then... Mercedes considers packing 24 into its Maybach limo, but ultimately settles for a 12-cylinder model.

2005
Committed to the same rotary-controller strategy that bedeviled BMW’s iDrive, Mercedes adds a similar system to its flagship S-Class. It’s also widely panned.

2015
Mercedes-Benz’s advanced research vehicle, the F 015, presents a vision of a driverless future with swiveling conference-style seats.

MERCEDES

27

That works out to Mercedes-Benz 27, BMW 24—a close race, particularly since Benz had a 30-year head start.



1929

After six years of motorcycles, BMW begins making the 3/15, its first production car, based on Britain's Austin 7.

1997

At the Tokyo Auto Show, Mercedes unveils a concept limo called the Maybach, meant to compete with Rolls-Royce.



2000

Tapping its motorcycle heritage, BMW starts selling the C1, a partially enclosed scooter for city driving.



2003

Mercedes-Benz produces the world's first seven-speed automatic transmission.



2016

BMW shows off its concept Vision Next 100, offering a glimpse of controls based on motion sensors and *Iron Man*-esque displays.

nd

**BMW
24**

BMW, however, can comfort itself with the No. 1 ranking in luxury car sales, which it took from Benz in 2005.



1931

Ditching less-responsive solid axles, the Mercedes-Benz 170 is the first car with four-wheel independent suspension.



1997

Sensing a market shift toward SUVs, Mercedes starts selling the M-Class. BMW brings one out two years later.

1996

The world's first voice-recognition system appears in the Mercedes-Benz S-Class.

2001

BMW unveils iDrive, an onboard computer system that uses a rotary controller, in its flagship 7 Series. It's widely panned.

2001

The BMW-owned Mini brand shows its new small car, the Mini Hatch/Hardtop, at the Detroit Auto Show. The car becomes a huge sales success.



1932

BMW releases its first fully original car design, the BMW AM1. (Although the body is made by Daimler-Benz.)

1936

The world's first diesel car, the Mercedes-Benz 260D, hits the road.

1995

Electronic Stability Program—an anti-skid technology that's now mandated on all vehicles by U.S. law—first appears on a Mercedes-Benz S-Class.

1988

Just to see if it can, BMW tests a 16-cylinder engine in the 767 Goldfish. The car is never approved for production.

1988

BMW stuffs a mammoth 12-cylinder engine into its 7 Series sedan. Three years later, Mercedes does the same.



1954

It's more famous for its gull-wing doors, but the Mercedes-Benz 300SL is the first production car to have fuel injection.



1956

To compete with the 300SL, BMW releases the 507. While prized today, the car is a market failure and moves BMW toward bankruptcy. Three years later, the company nearly sells itself to Mercedes-Benz.



1985

At the Frankfurt Auto Show, Mercedes unveils its all-wheel-drive system, 4Matic. BMW does one better, selling an all-wheel drive version of its 3 Series sedan, the 325iX.



1972

While a 1-year-old Elon Musk is grabbing his toes, BMW brings its all-electric concept car, the 1602e, to the Munich Olympics.

1973

BMW releases the 2002 Turbo, one of the first cars to feature a turbocharged engine.



1978

Mercedes-Benz offers an electronic antilock brake system on its S-Class sedan, beating BMW to market.

1982

Mercedes-Benz's 190E is the first production car to have a multilink rear suspension.



Herbert Williams got rich by inventing an undersea turbine. You'll never guess where he came up with the idea

The Courage of His Conviction

Even when the narcos handed over a brown paper grocery bag full of \$100 bills, Herbert Williams says, he was mostly thinking about the boat. They'd hired him to build a superfast catamaran, telling him they needed to expedite deliveries of certain goods from Colombia to, uh, Germany. Williams had experience building fast, double-hull fishing vessels, but he'd always dreamed of inventing something bigger, more outlandish. Such was his excitement in having the dream financed that he willfully ignored the warning signs. "I'm building a boat," he remembers thinking. "Chevrolet doesn't ask customers what they intend to do with its cars."

Working out of South Florida, Williams drew up plans for a 96-foot, wave-piercing craft with twin 1,000-horsepower diesel engines. He named it *Lady Jessica*, after his young daughter. He rented cranes, bought quarter-inch steel plate to form the hull, and hired a crew to help him put it all together. (This was 1987, so you can imagine how Crockett-and-Tubbs everyone looked.) In its first sea trial from Port Charlotte, the boat sliced through chop where slower craft would have bounced around, wasting energy. "It was beautiful," Williams says. "From the air, it looked like a delicate water spider or something from *Star Wars*." At 30 knots (about 34 miles per hour), it cruised faster than anything its size, even faster than the U.S. Coast Guard cutters policing the shores.

As the crew navigated back to the harbor, the maritime radio crackled with the voices of excited fishing captains marveling over the strange boat. But once the catamaran docked, dozens of uniformed law enforcement officials descended, putting everyone aboard in handcuffs. An "A-bomb for smuggling," they called Williams's creation. He was convicted of conspiracy to transport cocaine after refusing to disclose the names of his Colombian clients. He didn't talk, he says, because he feared for his life. Before 1987 was over, the judge sentenced him to 10 years in federal prison.

Federal records show Williams was transferred among penitentiary facilities 48 times in the first two years—an effort to get him to name names, he says. Each time, he found himself chained to the floor of a bus thick with diesel fumes, listening to hours of '60s rock at deafening volume. Any prisoner new to a facility must sleep for several weeks in the prison "fish tank," a solitary cell typically without bedding or heat. The next transfer always came right when Williams was about to get a permanent cell with a bed. In the fourth year, he received word his wife had divorced him.

Slowly, things got better. Without explanation, the transfers stopped. Williams started getting time off his sentence, a combination of good behavior and prosecutorial discretion. Most important, a fellow inmate taught him technical drawing. Soon, hundreds of drafting pages issued from his pencil, detailing some 32 truly weird aquatic contraptions: catamaran-shaped cruise ships, giant V-shaped crude-oil collectors, a propeller with way too many blades. "I had to make these things to keep a sense of purpose," he says. "Maybe I made them to show I exist."

Prison was horrible, of course. But it also turned Williams into a full-time inventor. "Prison set me down, allowing me to stop and think," he says. Williams's brainstorming eventually produced a design for one of the first commercial-scale turbines meant to convert tidal energy to electricity. Irish company OpenHydro later bought the patents Williams secured for his design and used them to create the first and still-biggest source of tidal power sold to consumers through the U.K. grid. In 2015, OpenHydro was sold for \$173 million to DCNS Group, a French military contractor. The parent company is deploying massive 300-ton, 52-foot-high versions of the Williams design in Canada's Bay of Fundy as well as in Brittany, France.

While Williams was locked up, it would have been hard to imagine that one of his ideas would help power tens of millions of homes. Or that as a tinkerer with no engineering education, he would secure 18 patents or build technology for a business that competes against Lockheed Martin, Siemens, and General Electric. Nothing so optimistic entered his mind during his surreal first few months riding what he calls the diesel-therapy bus.

In 1991, at the age of 48 and just shy of five years in prison, Williams was paroled. He gathered up his blueprints and the \$27 in gate money from the feds and moved to Palatka, a spot in central Florida where nobody knew him. In this rural town of 12,000 along the

"I HAD TO MAKE THESE THINGS TO"



St. Johns River, 60 miles by water to the ocean, Williams slowly rebuilt his life. He started a business driving pilings into the St. Johns to build docks. That provided a steady paycheck, which meant he could start tinkering again.

For decades, ocean turbines have posed a tough engineering challenge. Without extra armor, the machines typically don't survive saltwater or the microorganisms within it. And the turbine blades that work great on land often can't handle the stress of the water, roughly 800 times denser than air. The conventional solution has been to use carbon fiber or other exotic polymer reinforcements to make what's basically a stronger, more durable—and much more expensive—version of the three-

16-foot-diameter steel rotor. To make the whole rim into one big generator, such a wheel had to be less than a sparkplug-gap's distance from the inside of the turbine's frame. First, he built a giant turntable out of a semitruck's axle, which he used to spin the rotor against the lathe, shavings falling to the ground until it was perfectly round to within less than five-thousandths of an inch. He tested four prototypes for strength and mechanical soundness in the water, and when each failed, he threw it on a scrap heap that remains on the property today, like a pile of rusty Ferris wheels.

On the fifth try, Williams thought he had the right blend of strength and precision. With assistance from an engineer, he added magnets to the rotor and hand-wound con-

bladed machines you see on a wind farm.

Williams's first big innovation was to bolt the rotor blades to the rim of the turbine, like the spokes of a wheel, giving them more support. The new shape improved power generation: As any kid knows, a bike wheel spins slower at its center and faster at its rim. Likewise, a traditional turbine's central shaft turns relatively slowly, so engineers usually connect it to a gearbox to reach the speed needed to yield AC power compatible with the grid. Williams started thinking about ways to harvest power from the faster outer rim of his turbine.

In his dock-building machine shop—a windowless, corrugated-metal hut sheltered by two oaks—he set up a makeshift vertical lathe capable of milling a huge,

ductive coils to the turbine's steel-framed casing to make the spinning wheel itself the generator. By strategically placing additional magnets, he kept the parts from ever touching, meaning they didn't need lubrication. Working with such fine tolerances, Williams had to make sure the turbine wouldn't seize in cold ocean water. So he dragged an old aboveground swimming pool to the workshop, filled it with four truckloads of ice, and dunked the turbine to see if it would spin freely. He envisioned turbines with maintenance scheduled once a century.

Other engineers helped along the way, including some from the University of Florida, the U.S. Navy, and, later, the Department of Energy. But collaborators say Williams's biggest advantages are the instincts he honed as a boat

KEEP A SENSE OF PURPOSE. MAYBE

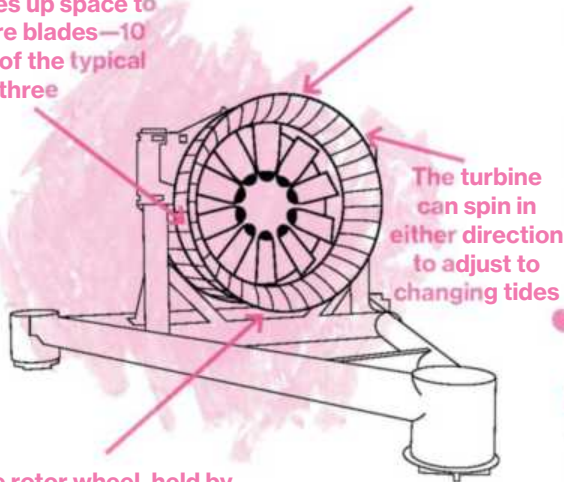
MADE THEM

TO SHOW I EXIST

How it works

In the OpenHydro turbine, attaching blades to the outside rim of the rotor frees up space to add more blades—10 instead of the typical three

Coils wound into the outer frame generate electricity, and only the main rotor moves



The turbine can spin in either direction to adjust to changing tides

The rotor wheel, held by magnets, floats in place in the outer frame

builder and fisherman. “Herbert’s often more knowledgeable about the engineering side of his machines than my Ph.D.s,” says Energy Department researcher Rob Hovsopian.

In 2004, Williams quit building docks to focus on research and development. He married Cornelia Danese, the vice president of a local phone company, and she agreed to manage his business as an equal partner. Together they hired a small staff and raised money from friends and neighbors. The big break came later that year, when they attracted interest from Brendan Gilmore, the future co-founder of OpenHydro. He brought a crew of electrical engineers to Palatka to verify Williams’s claims.

During a test run in the St. Johns, towed behind a homemade barge, the 16-foot prototype began to spark as its wires melted down in the water. But the turbine yielded enough current to power a small neighborhood, and that was good enough for Gilmore, who bought Williams’s intellectual property.

OpenHydro was assigned the patents in a 50-50 split of stock in the private company. The company also retained Williams as a consultant and made him a director. Over the years, however, Williams began to feel his advice was less welcome. He removed himself from the board in 2007, when the press took notice of his conviction, though he says he remains friendly with company executives. “We are grateful for the contribution that Herbert Williams made in the early years of the business,” Gilmore wrote in an e-mail. “We understood and respected Herbert’s decision to withdraw from the business nine years ago and wish him well with his future endeavours.”

In the last few years, as tidal-energy generators neared large-scale rollouts, turbine tech became a valuable commodity. (GE, for example, acquired Alstom’s energy divisions and Atlantis Resources purchased turbine maker MCT from Siemens.) DCNS bought OpenHydro as a way to diversify its warship-making business. “We’ve improved the design to make it more efficient, more robust, and cheaper, but from Day One, we didn’t change the principles of the turbine,” says Thierry Kalanquin, chairman of OpenHydro under

DCNS. “It’s the only one designed for the sea, not for the wind and adapted to the sea.”

Williams made millions from the sale of OpenHydro. He declines to discuss specifics, but it was enough to finance a wind-energy startup over the past eight years and the 520-acre compound in Palatka that he and his wife own. He’s now 73. He’s compact and usually wears jeans, a collared print shirt, boat shoes, and a scuffed Timex. He still works from 7 a.m. to 6 p.m. in his workshop, which is now a little bigger—the compound includes a 50,000-square-foot fabrication plant and a freshly paved airport runway.

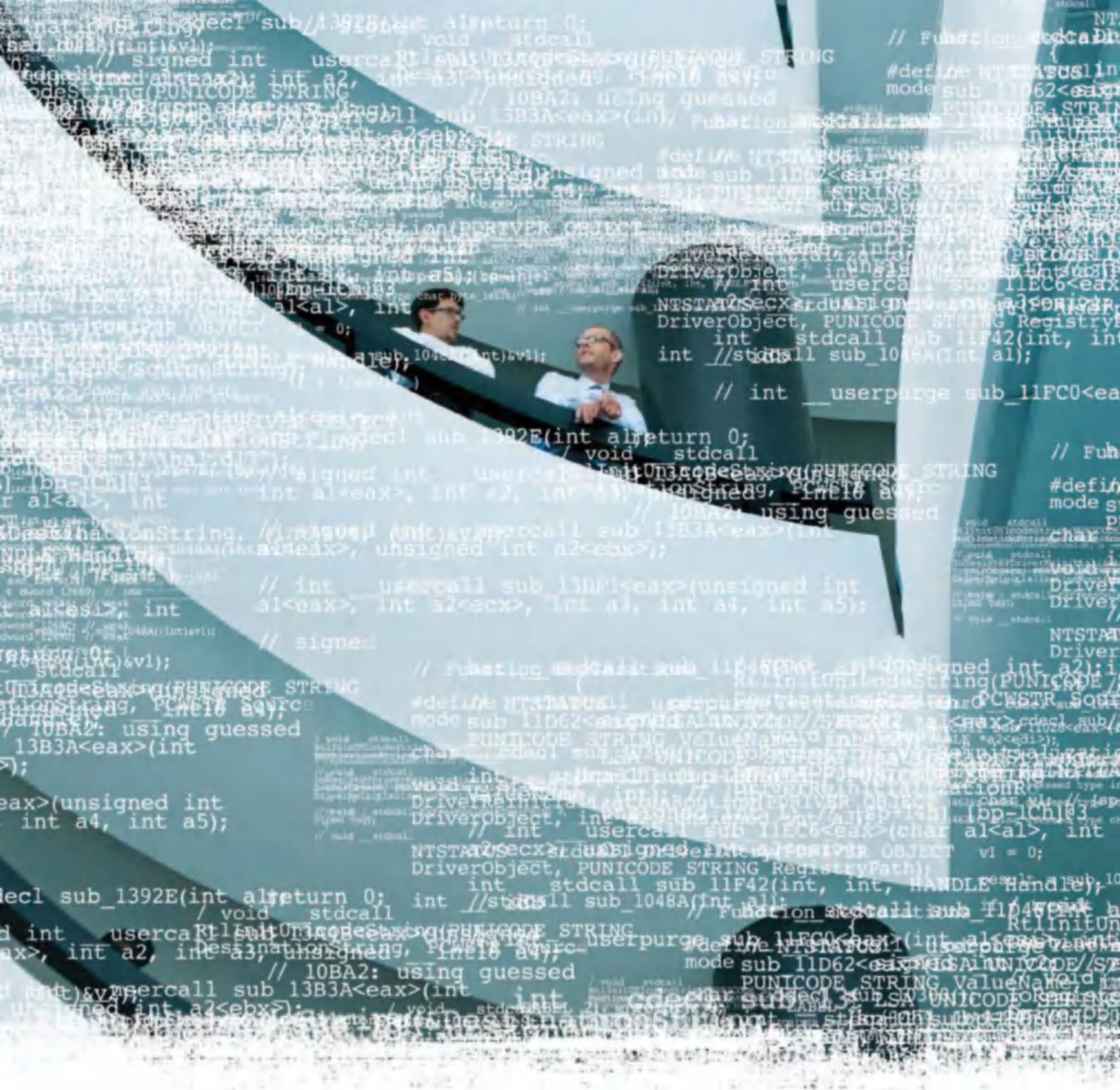
The plant is alive with the sounds of cranes and lathes and the occasional concussive thump of a fallen 70-foot steel tube. Welders are making metal pieces of staggering scale, some higher than 20 stories, some bigger around than a Boeing 737. They’re building parts for a combo generator/pump Williams has sold to the Energy Department. He says he thought of the idea in his prison cell, inspired by the multibladed windmills that helped pump water in the Old West.

His latest venture, Keuka Energy, is focused on this kind of wind machine. The prototype carries the same doughnut shape of his earlier turbines but uses an enormous drive belt to turn a pneumatic pump, yielding compressed air that can be converted into energy. In early tests at Texas Tech University, the machine captured low-altitude gusts of wind better than traditional turbines, and officials at the U.S. Department of Agriculture say it may be able to replace diesel generators; they’re trying it out as part of an environmental project in Texas, using it to force water from deep underground. “It’s got a pretty high output in terms of wind to energy,” says Jerry Hatfield, director of the USDA’s research lab. “We’re considering whether it can be used as a very efficient pump.” Hovsopian at the Energy Department says the combo generator/pump looks a lot easier to maintain than an industrial turbine. “Once he resolves a few issues,” he says, “a bicycle mechanic can work on it.”

A patent approved in November reveals Williams’s longer-term plans. It details a V-shaped barge perhaps a mile long sitting in the middle of the Atlantic, a vast repository for liquid air that can be used to drive gas turbines and generate electricity. Large rim-driven windmills store the air in supercold tanks in the barge’s hold. Periodically, natural gas tankers take the air to gas-fired power plants around the world, where it can be warmed into gas to spin the turbines. It all amounts to an efficient way to store wind energy using relatively cheap, existing infrastructure. Williams says that while he may not see this one through, it’s worth starting. “You have to get your hands on something in order to build it right,” he says. “If all the entrepreneurs and tinkerers in the country left it to GE and Westinghouse, we’d be in big trouble.”

Williams says he’s still drawing inspiration from his darker days, too. The Palatka compound has housing for his employees, including the occasional ex-con. “When you go to prison, the public turns their backs on you,” he says, but as long as convicts have ideas, they aren’t out of options. “There are possibilities.”

ENTREPRENEURS AND TINKERERS IN THE COUNTRY LEFT IT TO GE AND WESTINGHOUSE, WE'D BE IN BIG TROUBLE"



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Italians, boldly going to the final frontier, help NASA solve a mission-critical problem

Zero Gravity Espresso

Just over a year ago, aboard the International Space Station 200 miles above earth, Italian astronaut Samantha Cristoforetti slid a plastic capsule into a machine about the size and shape of a home safe. She opened a small plexiglass door, attached a pouch of water to an intake valve, and snapped on a smaller, empty plastic bag. Then she closed the door, turned the machine on, and waited for her espresso.

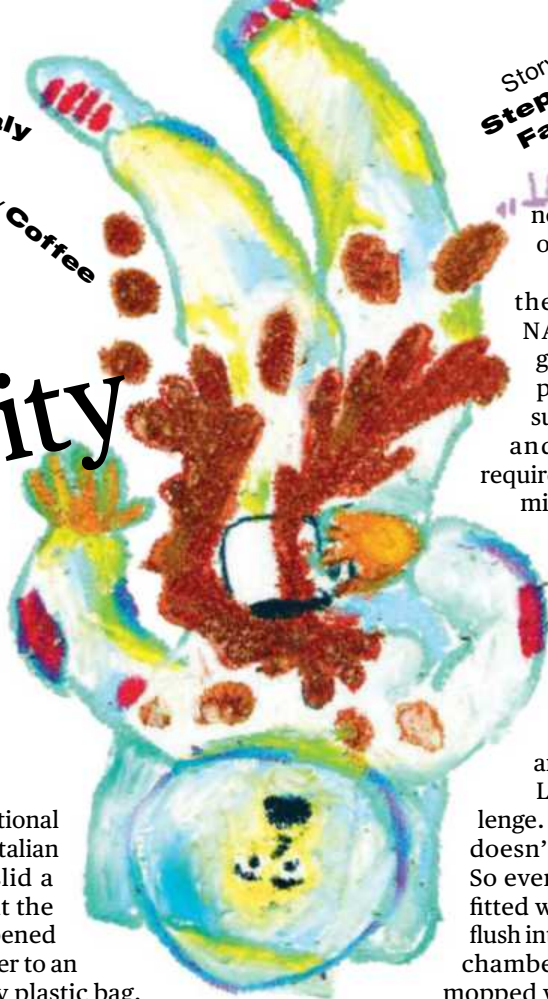
We long ago solved the problem of making coffee on earth. But building an espresso machine for the space station turned out to be a much bigger challenge than the Italian engineering firm Argotec expected when it took on the project. A team of 11 engineers—7 of them working full time—spent a year and a half coming up with a brewing process that could work in microgravity and meet NASA's rigorous safety standards. "I don't think any of us realized that every component would have to be modified," says Joshua Hall, an engineer who worked on the project, named ISSpresso.

To make espresso, you have to force almost-boiling water through finely ground coffee beans. In a typical pot placed on your home stove, the water at the bottom becomes less dense, creating convection currents that mix the heat into the rest of the container. When the water boils, steam pushes into the air above.

The ISSpresso, made by Argotec, an Italian engineering firm



But hot water behaves differently in near-zero gravity; it doesn't rise. Even as it turns to steam, it stays put, close to the heating element. The result is a superheated, and dangerous, bubble of vapor suspended in a ball of water. Argotec's solution was to run the water through thin steel pipes to ensure that it



never builds up bubbles of heat. But that didn't solve the pressure problem. NASA views anything greater than 60 pounds per square inch of pressure as a safety concern, and brewing espresso requires at least twice that. To minimize the danger of a blowout, the engineers replaced the traditional rotary pump with a plunger-like in a syringe-driven by an electric motor with just enough power to do the job, and no more.

Leaks were another challenge. In microgravity, water doesn't pool; it floats away. So every piece of piping was fitted with release valves that flush into the machine's central chamber, which can then be mopped with a towel. The engineers also designed a mechanism to blow air through the capsule into the coffee "cup"—a zip-lock bag—clearing out liquid that could otherwise drift around the cabin.

The beans needed no reengineering. Lavazza, the Italian coffee company that led funding for the project, chose a blend of Arabica delicate enough for the American palate but roasted to produce the strong espresso that Italians prefer. The capsule, however, had to be rethought and made from a material that wouldn't give off toxic fumes if it caught fire.

Like other space technology, the project could have earthly applications. Argotec and Lavazza have filed two patents: for an air jet that could save water at home and for the metal plunger that ejects the capsule in zero gravity, which could be repurposed in a wall-mounted espresso machine.

Space coffee may sound like a frivolity. But like music, phone calls to family, and other comforts of home, it can contribute to the psychological well-being of crew members in cramped, stressful conditions—and a crew's well-being will only become more important as NASA explores the possibility of a manned mission to Mars. "If something as minor as a good, tasty cup of coffee can prevent astronauts from feeling alienated, isolated, or burned out, there's just no excuse for not allowing that to be present," says Gary Beven, chief of aerospace psychiatry at NASA's Johnson Space Center in Houston.

Judging by Cristoforetti's reaction, the project has been a success. After her first sip from the zip-lock bag, she flashed the camera a smile and a quick thumbs-up. Then she squeezed out a marble-size bubble of espresso and gently floated forward to catch it in her mouth. **B**

IF SOMETHING AS MINOR AS A GOOD, TASTY CUP OF COFFEE CAN PREVENT ASTRONAUTS FROM FEELING ALIENATED, ISOLATED... THERE'S JUST NO EXCUSE FOR NOT ALLOWING THAT TO BE PRESENT.

Building a breathalyzer for weed requires the best study ever

Are You High?

In states such as Washington and Colorado, the legalization of recreational marijuana use has brought a shadow market into the open. If you're into this sort of thing, it's probably made you a lot less paranoid. But as more people legally smoke up, state and local law enforcement face a buzzkill: There's no quick way to know if a driver is stoned.

That's partly because the science of highs is sketchy. A May study from the AAA Foundation for Traffic Safety concluded that there isn't a reliable link between impairment and the level of THC, pot's psychotropic agent, in a driver's blood. Nonetheless, in Washington, as in many states, the legal limit is based on blood concentration. So officials are looking to a septuagenarian chemist to build a breathalyzer for weed. The chemist's name, of course, is Herb.

Herb Hill, a professor at Washington State University, has spent more than four decades pioneering ways to detect chemicals—or, more accurately, to detect chemical signatures based on the movement of a substance's component ions. His work helps various government and military inspectors swab laptops for explosives, sniff out mold-contaminated food, and find sarin gas on a battlefield. As he prepares to retire next year, Hill and his last graduate student, Jessica Tufariello, are applying his techniques to test for pot.

Today, if cops in Seattle suspect a driver has exceeded the legal limit (5 nanograms of THC per milliliter of blood), they must call for specially trained colleagues to run a 12-point test examining the suspect's light sensitivity, eyelid tremors, balance, and other factors. Then they'll need a search warrant to draw a sample of the suspect's blood at a nearby hospital. The whole process can take hours, during which the drug could dissipate in the bloodstream. A breathalyzer could measure drug levels in the bloodstream or at least quickly determine whether a blood draw is warranted.

"It's an interesting project to end on, and an important one," Hill says, though he acknowledges the 5ng level he's testing for is an unscientific legal guideline. "I haven't seen anybody who has determined how that relates to being impaired." He began thinking about building a breathalyzer for drugs in 2009 at the suggestion of his friend Nick Lovridge, a retired WSU political science professor who'd been doing research for the state on ways to reduce highway fatalities.

The chemistry professor was already planning for retirement, so he asked Tufariello for help. The pair originally planned to test for 10 common illicit substances but narrowed their focus to THC in 2012, after Washington voters approved a ballot measure legalizing pot. Hill says he's secured about \$300,000 in funding commitments from Chemring Group, a British defense contractor with U.S. divisions that produce detection devices for chemical and biological agents. In exchange, Chemring has exclusive rights to use his and Tufariello's work to develop a commercial breathalyzer.

The scientists are relying on a technique called differential mobility spectrometry (DMS), which generates two electric fields designed to keep THC ions flowing to a sensor at the end of a tube. The first field's charge alternates between strong positives and negatives, attracting and repelling molecules. The second field's charge is calibrated to counteract those fluctuations, meaning, as Hill



AND THAT'S GINGER AND DRIVING
TACO BELL
"I WOULD GO EAT AT TACO BELL"

says, “the THC makes it through, but the other ions don’t.”

First, the researchers tested a pure THC sample that’s commercially available in concentrations far too low to get high, and it produced the strong signal they’d hoped to see, indicating that marijuana can be detected using DMS. Then came the hard part—or the fun part if, again, you’re into this sort of thing: the field tests. “When you breathe into a tube, everybody is going to have a different set of chemicals that come out,” says Jeff Okamitsu, Chemring’s chief technology officer, who’s overseeing the commercialization efforts. To

make sure the machines wouldn’t yield false positives, Tufariello tried to replicate a marijuana smoker’s munchies. “I would go eat at Taco Bell and Thai Ginger and drink lots of coffee to contaminate my breath,” she says. So far, so good.

None of the other stuff produced a signal similar to THC.

A university board approved the lab’s human testing protocol in 2014. Tufariello says she had no problem finding

14 students willing to get high for the sake of science and pocket money.

Federal restrictions made things a little more complicated, though. The researchers couldn’t supply the pot, do the testing on campus, or explicitly pay volunteers to smoke. “We had to be very clear that we are paying people for their time,” she says.

So Tufariello got creative.

Technically, volunteers made \$10 each for having their breath measured before and after smoking weed.

They’d call her beforehand, she’d hustle over to get a pre-toke breath sample, and then she’d test again after the pot but, when possible, before the Doritos. Many of the test subjects didn’t smoke alone, so whoever made the run to the dispensary got an additional \$15 because that person was “a more dedicated volunteer,” Tufariello says. She asked everyone to use a

strain called Blue Dream,

which is easy to grow and varies little between seasons. (For the record, Blue Dream is the most popular strain for sale in Washington and Colorado, producing a “cerebral high, not too strong but quite uplifting,” according to *High Times*.)

The DMS analysis identified THC in 81 percent of the samples. In one case the researchers found THC before the volunteer had even started smoking, but it

turned out he’d forgotten to mention he’d smoked at breakfast. Last year, Chemring sent the lab new tools, including a breath-capturing device that looks like a glue

gun. They repeated the procedure, and the results improved: THC was detected 89 percent of the time.

The WSU team is starting another set of tests to correlate the THC levels found in the lab with blood samples drawn at a hospital. “That will be incredibly valuable,” says Okamitsu, Chemring’s CTO. “That lets me look at what is the smallest amount of THC we can detect.” His team and Hill’s talk weekly, and Chemring hopes to have a breathalyzer prototype for police officers to field-test this fall. Their latest model looks a little like an old-school Game Boy, with the suspect asked to blow into a tube on the side where the volume knob would have been.

One area that still needs additional research: figuring out exactly how pot use affects people’s ability to drive. A 2015 study from the National Highway Traffic Safety Administration concluded that marijuana users don’t have an increased risk of crashing after adjusting for factors such as age and alcohol use. Yet a 2013 study from the National Institutes of Health found that pot can slow reaction times, especially among casual users, and the May

AAA study found that in the first

year after Washington legalized

pot, drivers involved in fatal

crashes were twice as likely to have THC in their blood

than in the three prior years. (Many also

had alcohol in their system.)

For law

enforcement, at least, the breathalyzer can’t come

soon enough. Whenever Lovridge, the political

science professor, meets with state officials and officers, “they

say, ‘How is that thing coming? Is it ready yet?’” He laughs. “I say, ‘Science

takes time.” **B**

Did you know?

The paragraph to the right contains 420 characters including spaces, which, I mean, dude

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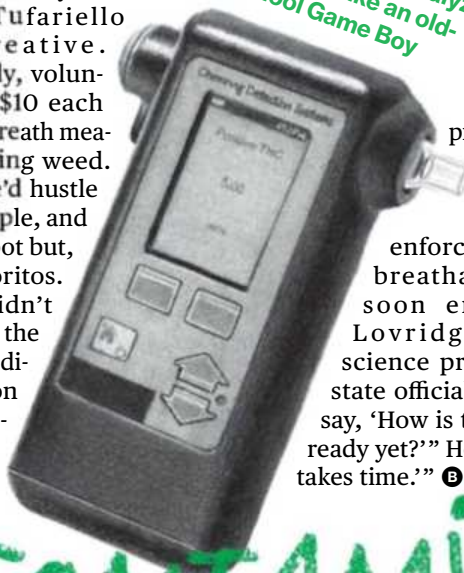
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The prototype of Chemring’s pot breathalyzer looks a little like an old-school Game Boy



LOTS OF COFFEE TO CONTAMINATE

Revisiting our tech predictions from 1996, it's clear we got a lot wrong. But what's remarkable is why

Fast-Forward

What we missed: In 2009, the mysterious "Satoshi Nakamoto" proposed that bitcoins be "mined" from data rather than issued by a central bank. At press time, a bitcoin was trading at \$569.

This spring, an antibody in some HIV patients restored hope for a vaccine. In 2015, in a move we didn't foresee, "anti-vaxxer" parents influenced by Jenny McCarthy and Donald Trump helped make measles scary again.



It's not as endearing as *The Jetsons'* Rosie, but the iRobot Roomba, an autonomous vacuum cleaner, has sold more than 10 million units.



In 1996, Alcor, a Scottsdale, Ariz., company, had 67 heads and bodies in deep freeze, cryosuspension awaiting revival. Now it has 146. Walt Disney isn't among them, but Ted Williams is. "He doesn't give us a hard time," says Alcor's Diane Cremeens. "He keeps to himself."



"An interactive TV in every home"? We said...never. (Oops.)

Key

- The year we made our predictions
- The year we said they'd be fulfilled

E-Cash Gets Real

●○ **1998** On time! PayPal opens its wallet

Global Wireless Phone Number

●○ **1998** On time!

AIDS Vaccine Available

●○ **2002** Sadly, too optimistic

Universal Picture Phones

●○ **2003** On time! Skype for PC boots up in August

Operational Space Station

●○ **2004** Late. ISS crews orbit by 1998

Computer Defeats Human Chess Master

●○ **2005** Late. Deep Blue deep-sixes Garry Kasparov in 1997

Housecleaning Robot

●○ **2006** Late. Roomba rolled out in 2002

Online Mass Retailer as Big as Sears

●○ **2007** On time, thanks to Amazon's market cap

20 Percent of Consumers Telegrocery Shop

●○ **2008** Late. Telewhat?

The Audio CD Becomes a Format of Second Choice

●○ **2010** Er ... way late. See iPod, 2001

Automated Highway Systems in U.S. Cities

●○ **2017** Wrong

Decriminalization of Drugs in the United States

●○ **2019** Thank you, Colorado and Washington

First Cryonic Reanimation

●○ **2043** We'll see

Turns out self-driving cars don't need high-tech infrastructure.



Then-VP AI Gore made the first call on an Iridium sat phone on Nov. 1. But the company was in bankruptcy the following year.



Webvan came and went, but Peapod survived, FreshDirect arose, and Walmart and Amazon.com fill plenty of fridges.



And whoa, did we overlook the return of vinyl!

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