

COGNITIVE TIMES

PLUS

BOEING'S AUTONOMOUS SYSTEMS

THE NOVELIST WAS AN AI

BIG DATA CHANGES THE NBA

A black and white photograph of a lunar surface. In the center, a Texas state flag (blue field with a white star, white field, and red field) flies on a tall pole. To the left, a lunar lander is visible on the ground. The surface is covered in footprints and tracks. The background shows the dark, cratered horizon of the moon.

Lone Star Liftoff

HOW TEXAS TECHNOLOGY FIRMS ARE
KEEPING AMERICA IN THE SPACE RACE

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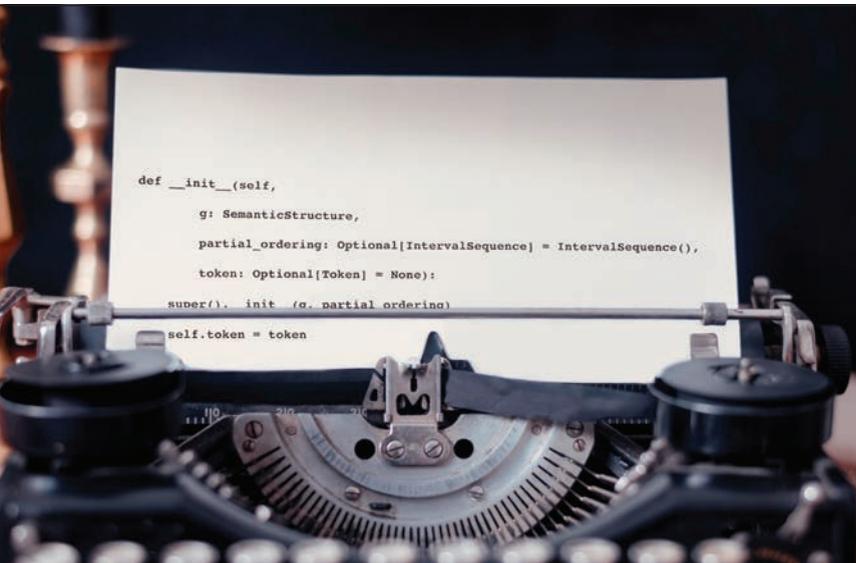


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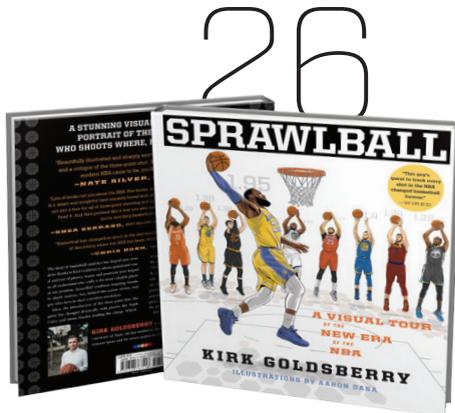
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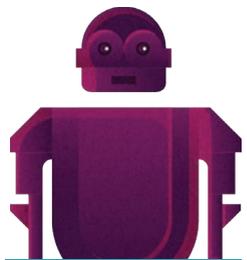
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FROM THE EDITOR

A MATTER OF TRUST

WHILE I TRUST my mechanic with my car, I may not extend such faith when it comes to him managing my finances. And while I trust my accountant to help me navigate the complexities of our tax code, I certainly do not want her to represent me in legal matters.

In a sensationalist society, I understand how technology, especially AI, can be both venerated and demonized. It is almost as if we have simplified our expectations to binary outcomes; things are either inherently good or bad. We must either trust something completely or doubt it beyond reason. If you tune in only to the popular discourse on this topic, you will find many who are utterly convinced that AI will cause the downfall of humanity. Others believe AI will save the world and create a utopian future.

The reality—at least in the near term—is that technology will help us manifest the future we work to manifest. In the technical context, we may trust technology to do what it is supposed to do within design parameters. But can we trust ourselves to use this technology in ways that promote a better tomorrow?

As August Cole writes in the pages ahead, the military is working with “autonomous wingmen,” self-flying aircraft that could help decrease the cognitive burden on pilots and provide support for them in high-stress scenarios. While fighter pilots may trust AI to support them throughout their mission, other institutions may not be able to trust that same AI to do something as deceptively simple as write prose. As with our trust in humans, if one person’s skills aren’t trustworthy, that does not make the entire human race untrustworthy. It simply makes people differently skilled. The same is the case with AI. Narrow AI systems are experts in different areas with very different skill requirements. The question is not so much about whether one trusts AI, but whether one trusts a specific system. Nuance has to enter the AI discourse.

Speaking of AI, in this issue of *Cognitive Times* Marla Rosner explores a widely successful technology, recurrent neural networks, and how it is advancing natural language generation to allow AI entities to become authors. There are clearly limits to the current state of the art, but progress has been astounding.

Elsewhere, Jason Heid writes about GE’s trust in machine learning to provide a better airline experience for pilots and customers alike. Cara Schwartzkopf updates us on what’s happening in tech and shares her tech-savvy to-do list. August Cole and I discuss what we call the military-AI complex. We introduce you to the CEO of Texmark, and Joe Guinto highlights the innovation that Kristin Robertson is leading at Boeing’s Autonomous Systems.

There is even more to explore in this issue, and we trust you will find much of it compelling. While we must level-set our expectations—and thus our trust of anyone or any technology based on context—I am supremely confident that technology will help us build a future brighter than the past. As Byron Reese states in our interview by John King, “...no matter where you look in the world at any time in the past, things are better right now than they were then. And so the story of the human race is one of upward and better; things get better over time, by any way you want to measure them things get better ... things have always gotten better because of technology, because it multiplies what we’re able to do. Why would I think that would change?”

Amir Husain

Founder & CEO of SparkCognition



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MEET THE MIND

BY JASON HEID

JORDAN HEFFERAN

Director of Digital Services
GE Aviation

TO HEAR JORDAN HEFFERAN tell it, aviation is something like a small family. It's an industry in which frequent collaboration with other organizations and businesses is a must. As with any family, smooth relationships require trust. And significant responsibilities come along with the need to ensure that trust is well-placed.

Think of the skies of the future, when any given local airspace could have hundreds or even thousands of autonomous drones zigzagging around while more conventional aircraft like planes and helicopters are left to contend with this ever-more-crowded sky. “Vehicles will need to be able to communicate with each other—to have situational awareness independent of an individual that’s making decisions,” Hefferan says. “You know, resources and airports and aircraft and constrained systems—we need to have more efficiency in that live dynamic ecosystem.”

His team at GE Aviation (one of the world’s leading providers of jet and turboprop engines and components) is building software and custom solutions to help ensure that safer, more efficient future. The biggest obstacle they face in their efforts? Being so accustomed to the ways in which they’ve always done things, and so caught up in the daily demands of their business, that they fail to innovate in truly meaningful ways.

“Even in our day-to-day lives, we know that certain things are very important. You know—going to the doctor, going to the dentist, work, exercising, right? But what’s in front of you, what’s urgent, tends to win the day over what you know long term is important and healthy for your business,” Hefferan says. “So it really takes that strong leadership deciding to make what’s important also urgent within an organization.”

To help combat that tendency, GE Aviation Digital operates an accelerator in Austin that Hefferan runs. It’s a physical space in which the company’s customers are encouraged to think beyond their daily operational demands and focus instead on envisioning ideal states for their systems and processes. “We use that space as a software design space to take the incremental steps with our software to build towards that ideal state,” he says.

The ultimate goal is a world of digitally connected aircraft built to optimize the traffic of the sky via proper management of a constant stream of data. Increased safety would be the most important byproduct of these efforts, but also gained would be significant reductions in unplanned downtime for vehicles, thanks to better predictive and preventative maintenance. Fuel efficiency could be increased substantially as well. All of this data-improved communication could yield benefits for the passenger experience.

“The communication flow as it exists today, for instance, it isn’t optimized,” Hefferan says. “I recently was in Austin during Formula One, and my aircraft couldn’t enter the airspace because it was too busy. And the notification process of that to the end passenger is basically you have to be there, and look outside, and

see that there’s not a plane at your gate. And the fact that that’s the way that the data flows to the end user certainly isn’t optimal, and it doesn’t take somebody with a data science background to know that.”

They’ve already been putting some of this technology into action, as with legacy carrier Delta—with whom GE Aviation Digital has been working since 2003 through its asset performance management tool set. “You can Google their history reducing the amount of delays that they have due to maintenance,” Hefferan says. “Particularly, our tools are focused on engines—and not just GE engines—in preventing that unplanned downtime, and they’ve seen that significant reduction. I can only hope that that has had, on the flying public, a positive impact on the flying public, given their goals of on-time performance.”

He points to passenger experience as one of the areas that’s most ripe for change. “I jokingly say that the best experience on

an aircraft is when you’re not on an aircraft. Simply because the purpose is to get from A to B and have the feeling of frictionless travel—of trying to go somewhere and not be held up in queues, not feel like you need to wait in what feels like a massive shopping mall for two hours before you go,” Hefferan says. “All of those things create a level of stress within a person’s life that could potentially be alleviated.”

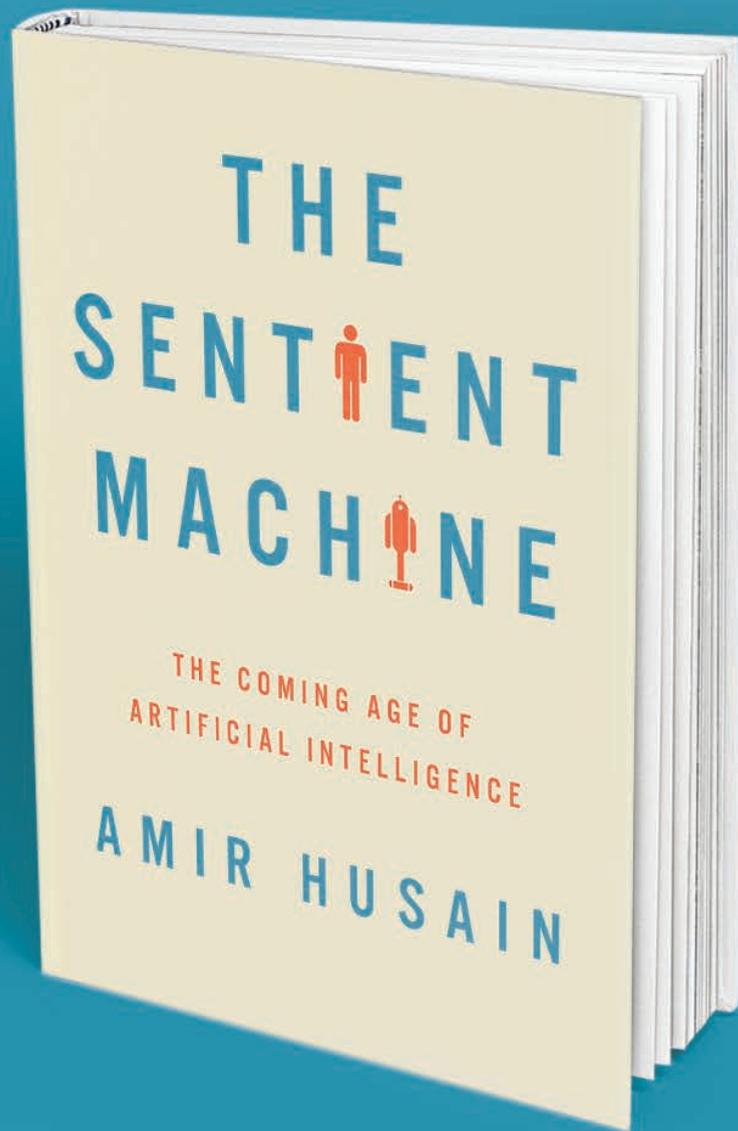
Are fully automated commercial flights part of creating that brighter future for air travelers? He thinks that’s a ways off, if it ever manifests at all given the fears many people are likely to have about boarding a plane without a pilot. He’ll settle, for now, for just improving the lot of the pilots themselves.

“Pilots, when they board an aircraft and go to fly, there’s a significant amount of information that they need to have and have prepared in order to be ready to fly,” Hefferan says. “Historically that was all on paper, and it was all in their bag. And they would sit in their chair, and then they would twist, and then they would grab their 35-pound bag, and then they would kind of twist back. And that caused a lot of back injuries, believe it or not.”

In many cases, that 35 pounds of paper has been supplanted by a two-pound iPad. “Just the reduction in back injuries is a huge saver to the operators, which is an unintended happy accident,” he says. “It’s an outcome of the elegant simplicity of solutions that are possible today, having positive externalities beyond the original intent.”

Multiply the potential for such elegant solutions throughout the aviation business, and suddenly tomorrow’s skies look that much brighter.

“What’s urgent tends to win the day over what you know long term is important and healthy for your business.”



“By situating the conversation around opportunities for AI to improve or extend our lives, this book provides a rational argument and reassurance to general readers fearful of an increasingly AI-infused future.”

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WHAT'S HAPPENING IN TECH



THE ROBOT PEN IS MIGHTIER

> Researchers at Brown University fed a robot hand-drawn images of Japanese characters and information on how the pen strokes are supposed to work, and it was then able to eyeball and copy words in multiple languages it had never written before. (Not to mention its impressive copy of an outline drawing of the Mona Lisa.) This may seem simple, but handwriting requires knowledge of where to put down your pen, how long to draw a line and in which direction. To complete this complex task, the robot learns a model that looks at pixels and predicts where it needs to go to start the next stroke and where it needs to move while drawing. *(Wired)*

BY CARA SCHWARTZKOPF

Illustration by Alex Berger

E.T., TEXT HOME

SpaceX, Elon Musk's private aerospace manufacturer and space transportation company, has successfully launched 60 satellites to start its internet-from-space initiative known as Starlink. The goal behind Starlink is to provide global internet coverage from space with very short lag times in signal. These satellites will stay in tighter orbits around Earth than most existing internet satellites, allowing previously unachieved communication speed, but requiring more satellites to cover the entire planet. *(The Verge)*

WHISKEY, ON THE BOTS

Microsoft is partnering with a distillery to create the world's first computer-generated whiskey blend using artificial intelligence. Machine-learning algorithms analyze existing recipes, sales data, and customer preferences to predict a palatable blend that will impress even the most sophisticated whiskey drinkers. Faster than a person could carry out the process manually, and from sifting through a large amount of data, new and innovative combinations can be found and tried. *(Forbes)*

WHY THE LONG VOICE?

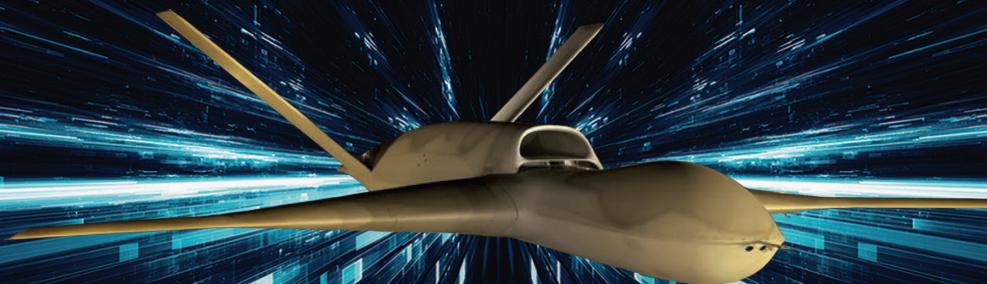
Amazon is developing a voice-activated smartwatch that can detect the wearer's emotional state based on the sound of his or her voice. The wearable device has microphones that pair with a phone app through which the software is hosted. There are no details available yet on whether it will ever be made available commercially, but the technology could one day advise the wearer on how to interact with others more effectively—reminiscent of predictions that Amazon's virtual assistant, Alexa, will one day give relationship advice after listening to couples argue in the home. *(Bloomberg)*

I, FACEBOT

Its own branded android remains a ways from becoming a reality, but Facebook is pursuing research into robotics. By learning how evolutionary algorithms work (tools that allow a robot to teach itself), the social media giant hopes to understand how to develop AI that enables it to navigate its vast amounts of data and potentially prevent disturbing content from ever seeing the light of day on its platform. *(TechCrunch)*

HYPERWAR

CONFLICT AND COMPETITION IN THE AI CENTURY



AMIR HUSAIN ■ JOHN R. ALLEN
ROBERT O. WORK ■ AUGUST COLE ■ PAUL SCHARRE
BRUCE PORTER ■ WENDY R. ANDERSON ■ JIM TOWNSEND

WHAT PEOPLE ARE SAYING ABOUT THE BOOK

"'Hyperwar' doesn't just admire the problem of AI-fueled warfare, it offers concrete approaches to help U.S. policymakers and our allies prepare. It is a 'must read' for all humans seeking to be 'in the loop or on the loop' before these technologies outpace our capacity to make ethical, strategic and secure decisions about our future."

—AMBASSADOR VICTORIA NULAND
CEO, Center for a New American Security

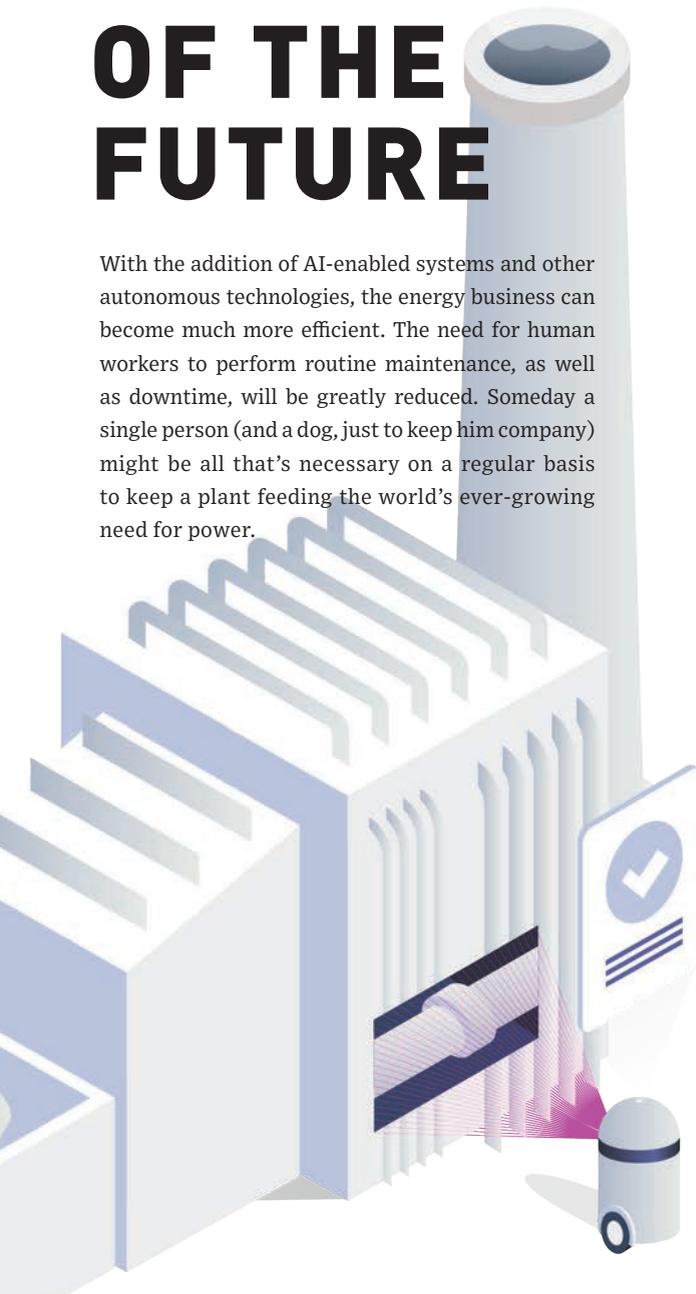
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BY SLAVEK ZAREMBA

THE POWER PLANT OF THE FUTURE

With the addition of AI-enabled systems and other autonomous technologies, the energy business can become much more efficient. The need for human workers to perform routine maintenance, as well as downtime, will be greatly reduced. Someday a single person (and a dog, just to keep him company) might be all that's necessary on a regular basis to keep a plant feeding the world's ever-growing need for power.





1 Solar Power

Because the number of workers necessary to maintain the plant will be greatly reduced, parking lots can be much smaller. They'll also be "paved" with solar photovoltaic cells, which can enable the wireless charging of electric vehicles. With the assistance of industrial battery storage, the solar power can be fed into the grid to assist with load management and power quality and to help ensure an uninterrupted power supply.

2 Eyes in the Sky

Drones will be used for both operational (maintenance and regular inspections) and security purposes. Certified operators will use the drones to conduct surveillance of the plants, as well as of power lines and switchyards.

3 Fearless Workers

Robots' thermal imaging detection will recognize things like pipe leaks, and they'll be capable of entering areas dangerous for humans.

4 Foreseeing Fixes

The power plant will be "self-healing," capable of automated predictive and prescriptive maintenance.

5 Self-Sustaining

Autonomous delivery trucks will bring parts automatically ordered by the plant. In addition, 3D printers on site could print the plant's own replacement parts.

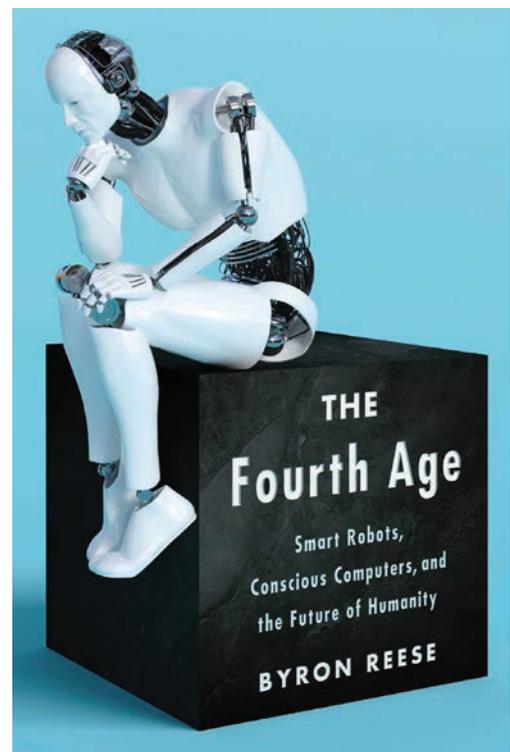
6 Humans on Demand

The plant will call on additional maintenance workers only when needed, with precision.



COGNITIVE TIMES: Some have described you as utopian in your outlook on the future. Where does this optimism come from? Where did it develop?

BYRON REESE: I got to thinking about how technology has changed the world so far. And there's a thought experiment which says, look you pick anytime you want in the past, like 100 years ago or 50 years ago or 1,000 years ago in time and you pick anywhere in the world, you pick anyplace, Italy, Libya, you know, wherever. And then you pick any measure of progress. And there's a lot of those, there's life expectancy, standard of living, infant mortality, individual liberty, the status of women, access to education, all of those. And I can guarantee you with a few exceptions, no matter where you look in the world at any time in the past, things are better right now than they were then. And so the story of the human race is one of upward and better, things get better over time, by any way you want to measure them things get better. So to me, when I look at it, I say for 100,000 years things have always gotten better because of technology, because it multiplies what we're able to do. Why would I think that would change?



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BY JOHN KING

BYRON REESE

The futurist author sees bright days ahead for humankind—if we're not too scared to accept technology's help.

ENTREPRENEUR, AUTHOR, AND CEO of technology media company Gigaom, Byron Reese has been interested in technology since an early age. In his latest book, *The Fourth Age: Smart Robots, Conscious Computers, and the Future of Humanity*, he explored the issues of how artificial intelligence and automation will shape the nature of work in the decades to come.

CT: What will happen in the age of automation to the workforce? If through AI we outsource at least a degree of human thinking and an even greater amount of manual labor, what is left for humans to do?

BR: I think it's impossible, literally impossible for these technologies to cause unemployment. They literally cannot. And so I would say it this way, which is for 250 years in the United States, unemployment's been between 5 and 10 percent, other than the Great Depression, which was a special case, but putting that aside, 250 years, unemployment's been between 5 and 10 percent. And that just varies with the business cycle. It's not like it varies by technology ... For 250 years, technology's made great new jobs, destroyed bad jobs, and everybody shifts up a notch. Then it makes new jobs, destroys bad jobs, everybody shifts up a notch. And that's what's happened. And that's how come you can destroy as many jobs as you want, and you never ever can have complete unemployment.

CT: You've talked in a TED talk about imagining a world where disease and even death could be eliminated by 2040. If you hold out another 25 years, you may never die. Do you think that we can really build our way out of death?

BR: I mean, I'll start off by saying, you wouldn't necessarily never die. You would probably die on average at the age of 6,700. That's how long you would have to live for some freak Wile E. Coyote anvil falling out of an airplane landing on you accident to happen to you, because eventually something's going to befall you. You slip on a banana peel or what have you ... But there's nothing magical about aging and growing old. It would seem that if that is a technical problem, then it has a technical solution and there are a lot of people who would like to solve that. It is unclear if, individually, that would be great. Like, I don't ever want to outlive my children, but you know then you have to ask the question, do you actually want to live forever? ... But there is some amount of power in being able to determine the manner and the timing of your own death, to basically be free from an untimely death, to be able to choose your moment to go ... From a societal standpoint, you know, it may not be ideal to have, say, the generation that fought the Civil War to still be alive and in power, right? Us having life spans makes the

world inherently progressive—things are changing. New people are always coming up with new ideas, and old people and old ideas die out. And if you somehow stop that process, it's unclear the effect it would have on society.

CT: You talk with some of the foremost tech thinkers and doers out there in the industry, specifically in the world of artificial intelligence. What are some of the most exciting uses of AI that you've seen or heard about?

“
For 250 years, technology's made great new jobs, destroyed bad jobs, and everybody shifts up a notch.

BR: So I have this podcast, *Voices in AI*, and it does have these like brilliant people on it. I feel like they like each lose two or three IQ points every time they talk to me because like these are amazing, amazing people that do incredible things. And what have I learned from that? I would say, you can make this distinction between general and narrow AI—and that's what we know how to do. How do we use computers to solve a problem? Like spotting spam email or routing us through traffic or something like that. And we do that by, often through, machine learning. We take a bunch of data about the past, we use computers to study and look for patterns and predict into the future. And that's a thing. And then there's general intelligence, that's the AI that's created that can do anything a person can do. And it's an open question, whether the former leads to the latter: Do you just get better and better and better at this? ... But I guess one of the most interesting things to me is how few people are actually working on general intelligence. Ninety-nine percent of the money goes into “this is how you solve this problem today,” and very little of it goes to this general intelligence. Like, OpenAI works on it, Google works on it, Carnegie Mellon has people on it. But it's relatively few, under a few hundred people in the whole world, probably, working on general intelligence. And what's really interesting to me is how kind of nascent AI is at this point. So whenever I see a chatbot, you know, like a Siri or something, I always ask the same question, which is what's bigger: a nickel or the sun, and I've never had one that can answer it. None of them can. And this idea that there's common sense questions and that we don't know how to make computers do that. We don't know how to make a computer answer the simplest thing that a child could answer.

EDITED BY JASON HEID

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Education

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Previous Gigs

SmartGeoMetrics

On the Refinery of the Future

Our industry is slow to change, reluctant to embrace technology. And we at Texmark feel that the only way that we're going to be able to move forward to get a competitive edge is to embrace the technology that is out there and apply it to the different processes that we employ here at Texmark. This means working with industry leaders within technology to help us do things like analytics on pumps, to utilize video as a sensor, to use different handheld and wearable devices to know where our personnel are on premises. And then to put all that information into a total asset management tool. These are things that are going to help us move forward into the future.

His Leadership Values

Be kind. Treat people the way you would like to be treated, compassion over criticism. Those are critical. Do those things, and you are effective.



On the Importance of Having Fun

We have the gift of life. We're alive, and we can impact other people's lives. You spend half your life at your job. It should be fun. You should enjoy it. It doesn't have to be fun all the time, and life is not full of fun all the time, but you want to try to make the best out of it.

Reading Material

I just finished an interesting book by a Tibetan monk from France. It's called *Learning Happiness*, and this book deals with a lot of different topics of leading a happy life. How does happiness apply to a leadership style? It applies to a leadership style of being approachable, being open to what people have to say to you, and improving listening skills. When I think about ways that we can all move forward together, listening to each other allows us all to learn to obtain happiness together.

On His Father's Influence

My dad founded Texmark 50 years ago.

He was an entrepreneur. He was ahead of his time in terms of being inclusive, being willing to take chances on ideas, on different projects. I look up to him and how he taught me to know that it is OK to fail. It is OK to run into problems and have long valleys of things not working out the way that you think they should work out. The stick-to-itiveness that he taught me has been invaluable in my personal journey.

His Keystone Habits

I make my bed every day. I shave every day. These foundation practices allow me to come home at the end of the day, if I'm lucky enough to come home, and have a freshly made bed, to approach people looking like I'm here, I'm listening to you, I'm ready to go.

On the Importance of Listening

The people out there turning wrenches and keeping us going, they have great ideas all the time, and it's imperative that we as leadership listen to their ideas because they're the ones that are out there.

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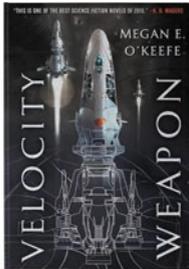
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BY CARA SCHWARTZKOPF

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JULY 2

Look to the stars (with appropriate eye protection, of course) to watch the moon completely block the sun, darkening our day in the best way.



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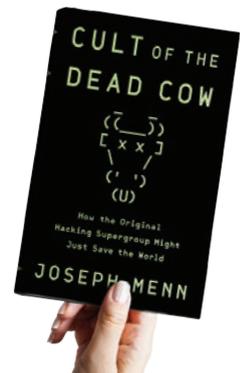
InfoSec professionals from around the country will gather in Las Vegas for this conference focused on emerging threats and trends in cybersecurity.

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Cult of the Dead Cow

RELEASE DATE **JUNE 11**

This book tells the untold story of the infamous U.S. group of hackers turned hacktivists.



A woman with blonde hair in a high ponytail is captured mid-air during a squat jump. She is wearing a black sports bra, black leggings, and bright yellow sneakers. She has a black smartwatch on her left wrist. The background is a dark gym with metal racks. The text 'THE ONLY TRACKER THAT LEARNS EVERY EXERCISE' is overlaid in white, bold, sans-serif font across the middle of the image.

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The Military-AI Complex

The most essential Pentagon suppliers will be those that master robotics and artificial intelligence.

Look from Washington, D.C., across the Potomac River toward Rosslyn, Virginia, where the corporate logos of government contractors crown a parade of office towers that follows the river past the Pentagon. The skyline there, like America's defense industrial landscape, is changing. Soon 25,000 Amazon employees will climb the Metro escalators each morning to work in Crystal City along with the tens of thousands of other workers from military, intelligence, and defense industry organizations.

The arrival of Amazon's HQ2 in the cradle of U.S. government contracting comes at a portentous time for the Defense Department. Technology is altering what makes us strong, prosperous, and secure. The defense industrial base is becoming the strategic innovation base. Today's leading digital companies have disrupted

**BY AMIR HUSAIN
& AUGUST COLE**

every industry they have touched, from publishing to automotive. Could Amazon and the rest of the "FAANG companies"—Facebook, Apple, Netflix, and Google—or one of a handful of pure play artificial-intelligence companies, such as SparkCognition, become fixtures of this new industrial base?

While that remains to be seen, the Pentagon supplier that can master robotics and AI will become the most essential of the firms that build America's arsenal. Moreover, the Defense Department's practices will increasingly resemble those of this new wave of strategically important companies because that is what the current revolution in warfare requires.

The world is on the doorstep of an artificial intelligence- and robotics-driven revolution in conflict that, after decades of looming

just over the horizon, now is a near-term certainty. Just as industrial-age tanks and machine guns devastated World War I battlefields and the U.S. Air Force's GPS-guided weapons headlined the 1991 Gulf War, social media algorithms and AI-equipped robotic swarms will decide conflicts. Data is not just the new oil, as the saying goes. Data is also the new ammunition.

The Pentagon is preparing accordingly, doing everything from standing up an Army Futures Command to engaging technology luminaries with the Defense Innovation Board to establishing a Joint Artificial Intelligence Center to reforming mid-tier acquisitions policy. But it needs to do more—and do it faster—if the U.S. military is to prevail in future machine-speed conflicts. Fortunately, the Pentagon and its suppliers can learn from the digital disrupters in areas such as robotics, acquiring groundbreaking capabilities, software ecosystems, data management, and symbiotic innovation strategies.

Taken together, today's leading digital companies have many of the traits for a reimagined, expanded defense industrial base, one that reflects the social, political, and strategic power of companies such as Amazon, Google, and Facebook. Moreover, the most strategically important machine learning and robotics technologies will likely originate in non-defense firms based on their overall investment, market-driven innovation cycles, and talent acquisition. U.S. defense policy is shifting, but the speed of technological advancement remains far faster. In recent House testimony, DOD chief in formation officer Dana Deasy said acquisition changes will come from asking, "How do we move to a more startup mentality when moving to technologies like AI?"

Well, here is how.

BE AGGRESSIVELY ROBOTIZED. While autonomous robotic swarms will become a staple of future battlefields, the nations that can harness automation for logistics, supply, and maintenance will have a decisive operational—and economic—edge.

As of 2017, Amazon reportedly had more than 100,000 robots on the job. This is especially relevant to the Defense Department and the future strategic innovation base because the shift to process automation is driven by the speed-and-cost expectations of "divinely discontent" customers, as CEO Jeff Bezos called them in the company's 2017 annual report. Such automation—though unlikely to go as viral as a bounding robot biped—is of extreme consequence in the business world, to politics, and to American society.

BE HIGHLY ACQUISITIVE. In 2012, Facebook purchased Instagram for \$1 billion; two years later, it bought WhatsApp for \$19 billion and virtual-reality company Oculus for \$2 billion. With deep corporate coffers, Facebook could have built and marketed its own competing platforms. But this approach allowed Facebook to establish itself immediately with a suite of technologies it could integrate into its central products, while still allowing these separate entities to develop in parallel into innovative platforms in their own right.

BE SOFTWARE DRIVEN. As machines learn to code faster and more accurately than humans, smaller and smaller organizations will be able to develop their own software applications to best suit their mission requirements. For all the beauty of an iPhone or iMac, Apple's products are only as good as the software that runs on them—which gets better every day as developers bring new ideas to market through the App Store.

THINK DATA, DATA, DATA. The importance of being able to effectively wield data at every level of Defense Department operations—from recruiting at home to finding targets abroad—cannot be overstated. Precision is expected in American military operations, which generally reduces the reliance on rampant destructive, kinetic military force. Groups that glean insight from what will be essentially a limitless pool of data will tip the balance even further toward precision and decreased destruction; to be sure, getting the right data at the right moment will be an enduring challenge during conflicts, but the ability to develop such an insight with alternative data sets is an altogether novel paradigm. Whether it is creating the world's most popular search engine or developing open-source machine learning algorithms, data is at the center of everything Google pursues. Currently, Google's search engine processes tens of thousands of searches each second. Meanwhile, a broader and more decentralized array of devices, from smart TVs to mobile phones to fitness trackers, gather more and more data each day.

PIVOT PURPOSEFULLY. A successful organization must be able to hold the virtual and physical in tension, while finding ways to develop both in a symbiotic manner underpinned by data analytics. In yet another sign of the sea change in studio-developed entertainment, Netflix won 23 Emmy Awards this fall—as many as Amazon. While Netflix will still send you DVDs by mail, the company moved beyond that revenue stream years ago as advances in servers and telecom bandwidth allowed them to supplant the physical with the virtual. Its entry into the capital-intensive and hands-on business of film and show production is backed by years of data about customer tastes and preferences.

These are just a few of the lessons from leading technology companies in what it will take for America to have a globally dominant strategic industrial base. Fortunately, with the varied examples of innovation U.S. digital disrupters have already pioneered and demonstrated, the Pentagon need not look much farther for inspiration than its own backyard.



Top Drone

When a pilot's wingman is an autonomous jet, trust in technology will shape the future of fighters.

In 1986, the film *Top Gun* debuted as a straight-faced depiction of competition among Navy fighter jocks at the pinnacle of American Cold War airpower. Thirty years on, in the iPhone era, the film's contest between two rival aviators—Tom Cruise's aggressive but unpredictable “Maverick” and Val Kilmer's aptly named “Iceman”—squaring off both in the sky and on the beach volleyball court, seems as dated as a Motorola DynaTAC. Yet as the U.S. military prepares for an era of autonomous combat aircraft, one of the film's core questions has resur-

faced: What will it take to trust the pilot in the aircraft next to you? Will these futuristic drones be more like Iceman or Maverick?

“It's one thing to use or rely on a system when everything is going well. But what will happen in a mission-critical situation when something unexpected happens?” asks Kim Jackson Ryan, principal human systems engineer at Draper Laboratory, whose research explores the bonds of trust between people and machines.

The question is moving quickly from theoretical to practical

BY AUGUST COLE



with new aircraft debuting from the U.S. and its allies—as well as potential adversaries—in recent months.

In February, Boeing and the Australian government rolled out a model of the Boeing Airpower Teaming System unmanned aircraft set to start flying in 2020. The 38-foot, AI-empowered jet will have a 2,000-nautical-mile range and be able to complete myriad missions alone or in tandem with piloted warplanes.

In March, Kratos Defense & Security Solutions flew its XQ-58A Valkyrie for the first time as part of the Air Force Research Laboratory's push to develop less costly "attributable" aircraft for use on missions when there is a high chance of losing U.S. jets to enemy attack. China, which is readily exporting its first generation of combat-ready military drones to countries such as Iraq and Saudi Arabia,

recently saw its China Aerospace Science and Industry Corp. roll out the Sky Hawk drone, with a flying-wing design meant for missions in which human pilots fly alongside robotic planes.

While these aircraft generate tremendous buzz for their potential to fulfill sci-fi fantasies about future battles, the reality may come down to something that can be found in war stories as old as *The Iliad*: bonds of trust between comrades in arms. The modern twist is one that poses real challenges for engineers trying to figure out how to create reliable autonomous partners. Intensely contested electronic and cyber environments are a characteristic of current war zones like Syria and will surely be even more lethal, given recent breakthroughs in stealth-aircraft detection and longer-range surface-to-air missiles, should a future conflict directly involve Chinese or Russian forces.

Countless threats to pilots make the matter of trust even more acute. According to Ryan, a variety of factors contribute to the human-machine relationship. There are dispositional elements that are inherent to each person. Situational factors are context dependent and are crucial to understand, as well. Past experience also matters in establishing the influence of learned factors.

Human pilots flying together on an air-defense mission would know how to handle an unexpected electronic attack, for example, because they have trained together for years. In effect, that confidence is the benchmark that their autonomous wingmen will have to be able to meet. "It's going to be an interesting day when an autonomous wingman is put in an environment with cyber and EM (electromagnetic) interference and they're cut off. What do they do?" Ryan said.

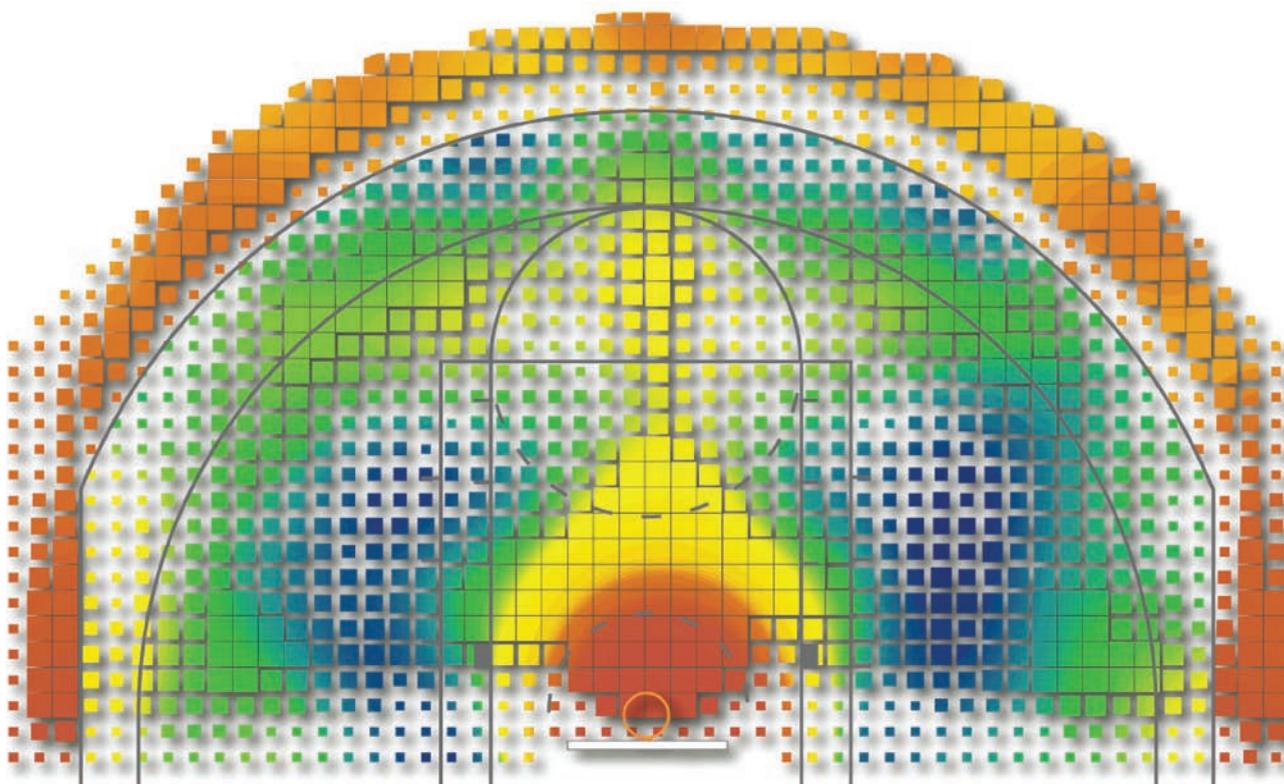
For aviators who have flown older fighters as well as the latest generation of U.S. jets, so-called "fifth-generation aircraft," it is starkly evident just how much a software-laden aircraft can do on behalf of its human pilot.

"There's a relatively short continuum of realizing the airplane is making decisions that are more accurate and timely than mine," says Dave Berke, a retired Marine Corps officer and former Top Gun instructor who holds the rare distinction of having flown both of the Pentagon's most advanced fighters, the F-22 Raptor and F-35 Lightning II, in addition to other fighters during his military career. An aircraft such as the F-35 can autonomously cue its pilot visually to pay attention to a potential or actual threat that onboard or networked sensors elsewhere picked up. This shifts the cognitive load from human to machine and over time builds true trust in the jet.

Based on Berke's experience, the concept of flying in combat alongside an autonomous aircraft can be seen as an extension of this dynamic. "In terms of the psychological burden of the remote wingman, I have no problem with that," he says.

Next year, a sequel to *Top Gun* will hit movie theaters, *Top Gun: Maverick*. It will reportedly again feature Tom Cruise, as well as drones. Given the recent real-world developments in autonomous wingmen, the timing is fitting to once again consider the nature of trust and predictability.

Says Ryan, "How do you make creative algorithms that understand the rules but know when to break them?"



3 > 2

In his new book *Sprawlball*, Kirk Goldsberry details how data analytics have transformed basketball—and how they could again.

When Dirk Nowitzki of the Dallas Mavericks retired from the NBA in April, he took a big piece of the league's history with him.

Any highlight film of the big German's 21-year career would include shot after shot of his smooth mid-range jumper. No one else has been deadlier in that space—outside of the lane and inside the three-point arc.

But Nowitzki's signature shot is disappearing from the NBA. Armed with advanced analytics, teams determined that those long two-point attempts were the worst kind of sin in today's game: inefficient.

Modern pro sports teams are obsessed with efficiency, driven by advanced data analytics. How do you maximize the number

of points you score each time you have the ball? They've combed through the data and confirmed what seems obvious, when you think about it: Dunks and layups are good because they're practically sure things. Beyond that, three points are always better than two. Sinking just over one-third of your three-point attempts yields better results than making half of your two-point shots.

The Houston Rockets epitomize this stats-driven approach. They attempted more three-point shots than two-pointers this season. Of course, whether you enjoy a game with nothing but three-pointers and dunks is up to you. But to understand the implications of the rise of the three-pointer (and the accompanying fall of nearly every other type of shot), you must read Kirk Goldsberry's new book, *Sprawlball*.

Seven years ago, Goldsberry, a mapmaker and basketball fanatic, transformed how coaches and players understand the game when he created stunning visualizations of each shot various NBA players had taken from 2006 to 2011. Suddenly you could see, at a glance, where a player excelled and where he was weak offensively.

In *Sprawlball*, Goldsberry, who writes for ESPN and until recently worked as vice president of strategic research for the San Antonio Spurs, aims to spark a conversation about what the NBA

BY JEFF BECKHAM

of the future looks like. Maybe that future includes rule changes or redrawing the court. Just as big data has molded the league into its current state, Goldsberry argues, it's also the key to its future.

"We can leverage the same kind of analytical firepower that's revolutionized strategy on the court to instead revolutionize how we build the rule base and construct the playing surface," says Goldsberry, a former Harvard professor of geography who's teaching a course in sports analytics at the University of Texas at Austin.

The ideas discussed in *Sprawlball* stem from a huge technological breakthrough that started in the NBA in 2010. That season, the league began installing a camera system, called SportVU, in the rafters of selected arenas. Such cameras, which are now in place league-wide, track the positions of players and the ball 25 times per second. As you might imagine, this results in an avalanche of data available on each player's performance.

"The player tracking system really added a huge spatial and temporal set of references to all basketball events and opened up the door for all kinds of new studies and analyses in the sport," Goldsberry says. "It's hard to overstate how important that development was."

At the same time, teams began to invest in the computing power to process this data—and in hiring analysts to make sense of it. Machine learning and artificial intelligence experts began to find their way onto NBA staffs.

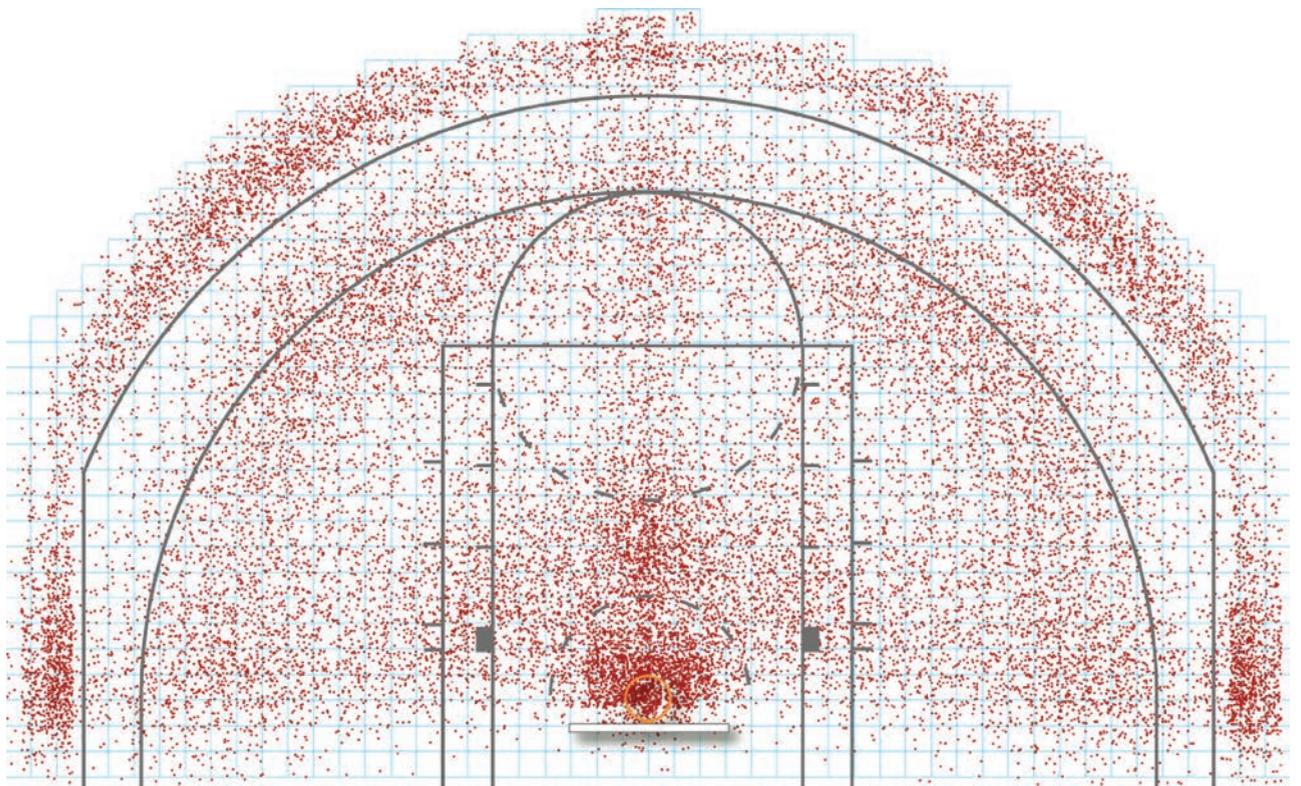
Since then, even more sources of data have become available, from wearable devices from Catapult Sports that record player movement to a machine-learning-driven player tracking system by Second Spectrum, the successor to SportVU. Anyone can get their hands on much of this data, via the NBA's own home for advanced stats: stats.nba.com.

But how much of this data is actually useful? Goldsberry cautions aloud that the sports analytics industry has gone too far in romanticizing information for information's sake.

"Data science' drives me crazy—that term. It already had a name: It's science," he says. "Sports analytics gets lost in the data set so much. People get lost in that forest. At the end of the day, this is about making basketball intelligence. It's about creating new knowledge about the sport and the players playing the sport."

As *Sprawlball* points out, that new knowledge has driven "the greatest stylistic upheaval the sport has ever seen." Those changes are never really over. Just as Dirk's mid-range mastery had its time and place, one day we might look back on recent seasons and remember wistfully how the three-point shot once dominated the league.

"People tend to look at these sports we watch and forget that they're inventions and they're works in progress," Goldsberry says. "Basketball is like the Sagrada Familia cathedral in Barcelona. It's a masterpiece already, but it's a work in progress."



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ILLUSTRATIONS BY ALEX BERGER



LONE STAR TREK

Since the early days of NASA, Texas has played an important role in space exploration. Tech start-ups are helping to keep it that way.

Five Decades Ago

BY ELLEN CHANG

this July, astronauts Neil Armstrong and Buzz Aldrin became the first people to set foot on the moon, a milestone that continues to serve as a comparative marker for all that humanity is capable of achieving—or not yet achieving. (“We can put a man on the moon, but we can’t...?”)

It’s not that space exploration hasn’t continued since 1969—we returned men to the moon five more times, after all—but no mission since Apollo 11 has similarly captured the public imagination and inflamed our collective sense of adventure.

Yet all this time since Armstrong’s “small step,” engineers and entrepreneurs have worked to overcome the many challenges we face in our goal to travel to other planets (beginning with Mars). Unlike during the earliest days of NASA, many of these advances are being driven by private-sector efforts to build more efficient spacecraft and rockets capable of carrying us into the stars.

But both then and now Texas is playing a pivotal role. Houston’s Johnson Space Center, with its famed Mission Control, continues to play a vital role. Texas has emerged as a major launchpad, as it were, for privately funded efforts that have been welcomed by smaller towns and government officials who are eager to take part in the dream of space travel while adding

high-tech jobs that pay above the state’s median salary. Along with out-of-state companies coming into Texas are a range of spaceflight technology companies based in the state. Playing a key role in many of these enterprises is artificial intelligence.

AI’s potential to replace or amplify myriad human capabilities and to provide predictive analytics has helped companies achieve greater innovation. Here’s just a sampling of business enterprises underway in the Lone Star State that aim to aid humankind’s drive deeper into the stars.

Slingshot Aerospace

Founded in 2016, this Austin-based company gathers massive amounts of data from satellites, drones, and aircraft and applies advanced algorithms to help both government agencies like the U.S. Department of

Defense and commercial industries—such as the insurance and oil and gas sectors—make both preventative and real-time decisions.

“Our software can bring together satellites that can see beyond the capabilities of human eyesight from government agencies like the National Oceanic and Atmospheric Administration or NASA and commercial space companies,” says Melanie Stricklan, chief strategy officer at Slingshot. “We can give a more persistent data feed and allow you to see things from multiple perspectives.”

The number of satellites in space is increasing rapidly, resulting in an explosion of data.

“Artificial intelligence can extract useful information from satellites that was previously unused,” she says. “With our AI capabilities, we

can unlock and deliver information immediately with speeds that a human would not be able to do on their own.”

Slingshot has found Texas to be a great place to attract employees interested in working in both the space and software sectors. “A lot has been going on in Texas since the start of the space program,” Stricklan says. “Software is a bigger component of space than it has ever been, and Austin is the heart of software technology.”

In April, Slingshot was awarded a \$6 million, two-year contract from the Air Force Space and Missile Systems Center to customize the company’s predictive space situational awareness software for possible military use and space control activities.

Ad Astra Rocket Company

Located near the Johnson Space Center just outside of Houston, Ad Astra Rocket Company is a spaceflight technology company dedicated to the development of advanced plasma rocket propulsion. Its CEO, Frank Chang Diaz, is a physicist and former NASA astronaut.

Since 2005 the company has been seeking ways to move humans through space faster and more efficiently. Its Variable Specific Im-

pulse Magnetoplasma Rocket (VASIMR) uses fuels such as argon and krypton that become plasma.

Chang Diaz has been working with NASA to create and test VASIMR. Plasma rockets have an extremely low fuel consumption rate compared with conventional chemical propulsion or electric rockets, according to Ad Astra. The aim is to demonstrate a 100-hour continuous firing of the company’s prototype, at a power level of 100 kilowatts.

Since 2005, Ad Astra has invested more than \$30 million in private funding to perfect the VASIMR—with the

ultimate goal that it’s Ad Astra’s rocket that takes humans to Mars. If that effort succeeds, astronauts could make the journey in just 60 to 90 days, as opposed to the nine months it would take with a conventional rocket.

HyperSciences

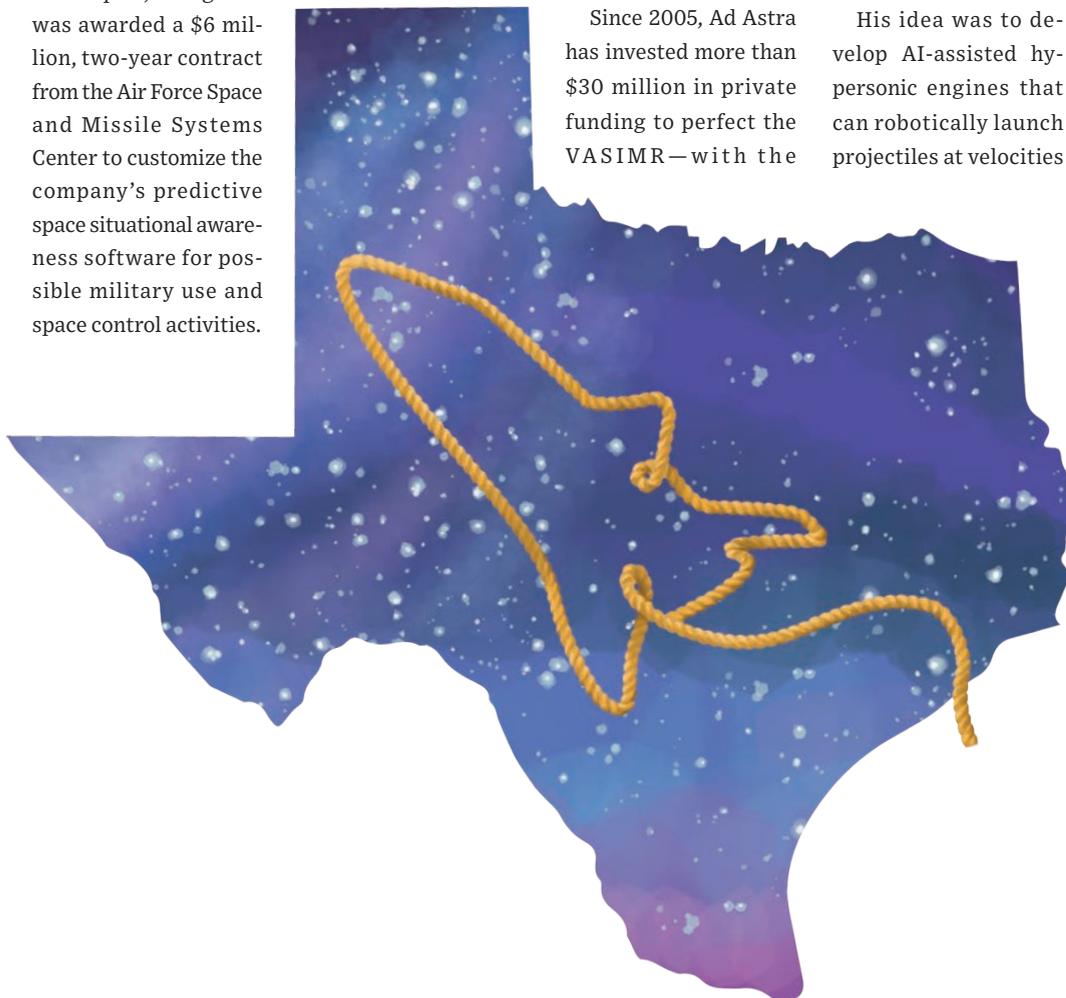
Austin-based company HyperSciences was founded in 2014 by Mark Russell, an aerospace engineer who is a former lead engineer at Blue Origin and also worked previously for Boeing.

His idea was to develop AI-assisted hypersonic engines that can robotically launch projectiles at velocities

greater than five times the speed of sound. This method could allow the company to launch payloads without using expensive rockets.

The hypervelocity propulsion system might be used by the aerospace industry or other companies in need of tunneling and drilling. The company hopes to, through a project called HyperCore, send objects to an altitude of 100 kilometers (10 times the altitude at which commercial jets fly). The company had raised more than \$9 million through SeedInvest, a crowdfunding platform, as of early May.

“Each projectile is designed for on-demand,



rapid, and potentially stealth deployment of a payload,” the company said in its fundraising prospectus. “Our target customers will be focused on USA government contracts, such as NASA and other government agencies.”

Firefly Aerospace

Headquartered in Cedar Park, a suburb of Austin, Firefly is a provider of launch vehicles, spacecraft, and in-space services, launching from Cape Canaveral, Florida,

“Software is a bigger component of space than it has ever been, and Austin is the heart of software technology.”

— **Melanie Stricklan**
Slingshot Aerospace, chief strategy officer

and Vandenberg Air Force Base in California.

By the end of the year, if plans succeed, the company will launch its redesigned rocket *Alpha* for the first time. The milestone represents a comeback for a company that was forced to lay off its entire staff in 2016 after an investor backed out. Noosphere Venture Partners, a Silicon Valley venture firm active in space investments, acquired Firefly and its assets. Today the company has 300 employ-

ees working in Washington, D.C., Dnipro in Ukraine, and Tokyo.

Firefly has been selected by NASA as one of nine companies that will potentially deliver science payloads to the surface of the moon through the Commercial Lunar Payload Services program, says Eric Salwan, the company’s director of commercial business development. Firefly was the only firm chosen that will have a launch vehicle and a lunar lander.

Blue Origin

Owned by Amazon founder Jeff Bezos and based in Washington, Blue Origin and its new *New Shepard* rocket flew NASA-sponsored research projects into space in January. The launch took place at its facility outside of Van Horn in Culberson County in West Texas.

In May, Blue Origin achieved another new goal when the *New Shepard* was able to launch and land five times, reaching 62

miles above the earth at three times the speed of sound. The booster in the rocket allows for both vertical takeoff and landing.

The company is competing with Northrop Grumman, SpaceX, and United Launch Alliance to launch spy satellites for the U.S. military. Having the ability to send satellites and national security payloads into space would help the private companies generate much-needed revenue. An estimated 34 such launches may occur between 2020 and 2024. The Air Force is planning to choose two companies, giving one of them 60 percent of the launches and the other company the remaining 40 percent.

One advantage that Blue Origin has is that the company was awarded \$500 million by the Air Force in a 2018 agreement to work on developing its *New Glenn* rocket, which is an orbital reusable launch vehicle. Blue Origin says the *New Glenn* will be capable of being reused for a minimum of 25 flights and will be more competitive for various launch markets.

The company is working on heavy lift rockets that could be launched

as soon as 2021; it hopes to be the first company to achieve the Air Force’s goal.

SpaceX

The company founded by Elon Musk in 2002 made news when its *Dragon* spacecraft became the first commercial spaceship to deliver cargo to and from the International Space Station. The company has more than 6,000 employees at its headquarters in Hawthorne, California, and launch facilities in Florida and California.

In Texas, SpaceX has offices in Houston and a rocket development and testing facility in McGregor, which is a few miles outside of Waco with more than 500 employees. The company owns acreage in Boca Chica Village in the Rio Grande Valley near the Mexican border and is seeking to build a rocket launch facility. The company’s rocket, *Starship*, is being tested in Boca Chica in hopes that it could someday take humans to Mars. “It very well could be the first person to go to another planet could launch from this location,” Musk has said of the South Texas site.

SpaceX also plans to construct its rocket

prototypes in Texas to “streamline operations,” although no details or timeline have been provided, according to a written statement. The company chose Texas instead of California for this purpose because it already has the launch facility in Boca Chica, a more efficient scenario since the rocket would not have to be transported.

In June, its *Dragon* cargo capsule returned from the International Space Station to the Pacific Ocean. This was Space X’s 17th resupply mission for the facility. *Dragon* was launched in May and carried cargo that consisted of 5,500 pounds of supplies and materials for the astronauts and the research taking place on the station.

However, SpaceX recently decided to sue the U.S. government, alleging it was denied the same opportunity as its competitors—Blue Origin, Northrop Grumman, and United Launch Alliance—to receive the Air Force contracts. Musk could have hindered the case when he allegedly told acting Defense Secretary Patrick Shanahan that his company “missed the mark” in December.

**“It very well
could be the
first person to
go to another
planet could
launch from
this location,”
Elon Musk
has said of
SpaceX’s South
Texas test site.**



FUTURE

OF

FIGHT



A composite image of a human head profile in silhouette, facing right. The interior of the head is filled with a collage of military and Boeing-related imagery. At the top, two fighter jets fly in a blue sky. Below them, a large aircraft carrier is shown from a side-on perspective, with a smaller aircraft on its deck. The bottom half of the head features a close-up of a Boeing aircraft's nose and cockpit, with the Boeing logo and the word "BOEING" clearly visible. The background of the collage is a mix of blue, green, and white, suggesting a sky and sea environment.

BY JOSEPH GUINTO

In the air, on the ocean's surface, or below the waves, Boeing's Autonomous Systems is building AI-enabled technologies to transform the militaries of the U.S. and its allies. Kristin Robertson leads the division in this vital mission.

MOST EXECUTIVES DON'T OVERSEE A RANGE OF PRODUCTS THAT CAN REACH MILES BENEATH THE SURFACE OF THE OCEAN AND IN THE AIR. BUT, THEN, MOST EXECUTIVES DON'T OVERSEE THE CREATION OF AUTONOMOUS AIRCRAFT, UNMANNED SURFACE VEHICLES AND UNDERSEA VEHICLES EITHER. KRISTIN ROBERTSON DOES.

As vice president and general manager since 2018 of Autonomous Systems, a division within Boeing Defense, Space & Security—the aviation giant’s massive defense industry arm—Robertson leads 3,400 people around the world who are producing some of the most cutting-edge technology in use by the U.S. Department of Defense and militaries allied with the United States. That technology includes such futuristic developments as a fully autonomous aircraft with fighter-like flight performance that uses artificial intelligence to serve as a wingman for manned fighter planes.

“We’re engineering brand-new systems with autonomous technology,” says Robertson, who has been with Boeing since 1994, joining the company after serving as a civilian electronic engineer working for the U.S. Navy. “But we’re also creating a new business model.”

That model calls for leveraging technology—AI, machine learning, robotics, autonomous technologies, and more—to create products that will extend the range and effectiveness of

military forces while also decreasing defense costs and dramatically lowering risk to the people who make up those forces. “What we’re really about is augmenting human capability in a more efficient manner so we can balance risk,” Robertson says. “We’re creating force multipliers.”

Those force multipliers are selling well. In the year she’s been at the helm of Autonomous Systems, Robertson’s team has landed a key contract to provide an unmanned aerial refueling tanker to the U.S. Navy, and she’s overseen a co-investment with the Australian government for the aforementioned autonomous aircraft. Those were big steps forward. But Boeing’s Autonomous Systems division, overall, will need more successes if it wants to achieve an even bigger goal. “Our goal is to be No. 1 in the market by 2025,” Robertson says. “And we’re going to get there.”

Still, Robertson isn’t just paving a path toward the top of the market with innovative new technology. She’s also paving the way with some good old leadership fundamentals.



RED, WHITE, AND BOEING BLUE

From her office in Arlington, Virginia, Robertson has a clear view of the Washington Monument and the Jefferson Memorial. If she walks around the corner, she can look at the Pentagon too. These famed sights serve as daily visual reminders of her core client at Autonomous Systems—and of what that client is charged with protecting. But she can get the same reminder with her office blinds closed, when she looks at the photos of her sons, one of whom served in the U.S. Navy and the other one starting a career as a Boeing engineer. She can even get a similar reminder with her eyes closed, when she thinks of her mother, who traveled across the Atlantic Ocean alone in 1954 from Scotland, becoming one of the last immigrants processed through Ellis Island before it was closed. Her mother was seeking to live the American dream. She ended up inspiring her daughter to protect the people who protect that dream today. “My mother, by far, had the most influence on me as a mentor and role model. She encouraged me to take risks and be everything I could be,” Robertson says.

Her father was a major influence too. He was a chief engineer at Textron, the forerunner to Bell Boeing, which makes the V-22 Osprey. A V-22 model sits atop her desk today. “My dad always brought models home,” Robertson says. “I took after him, and that’s why I got into the defense industry. I stayed because I love what we do and I love who we do it for and the team we do it with. When you think about protecting freedoms and what we do, and about the passion our customers at the Department of Defense have about what they do, it really is bigger than self, bigger than us. That motivates me every day.”

Robertson has leveraged that motivation in several leadership positions during her 25 years with Boeing. She has served as vice president of tilt-rotor pro-

grams and program director for the Bell Boeing V-22 program and most recently as vice president of engineering and chief engineer for Strike, Surveillance, and Mobility. That unit manages Boeing’s fixed-wing military and surveillance aircraft, including Air Force One.

Today, at Autonomous Systems, she leads a blended organization of five subsidiaries and programs specializing in aspects of defense-related technology, at the Boeing division’s major sites. The workers supporting those subsidiaries and programs are distributed widely—in Hawaii, California, Missouri, Pennsylvania, Maryland, Virginia, Washington, D.C., and other parts of the world. The divisions work on developing and deploying different types of communications software and devices—from command-and-control systems to radio frequency devices—as well as antenna arrays and target trackers and, of course, unmanned planes.

It’s Robertson’s job to bring those various entities together and to make sure they mesh with other divisions of Boeing’s defense arm in their efforts to produce next-generation aircraft, watercraft, spacecraft, and the systems that power and guide them.

“We have integrated many small companies together to create a capability that is far larger than those companies had separately,” Robertson says. “Our products themselves involve blending technologies. So we’ve created a sum of entities that is greater than the individual parts.”

Although she is an engineer by training, Robertson tries to stay out of the most complex details of the game-changing technologies behind a massive, unmanned undersea vehicle called the Echo Voyager or the unmanned Boeing Airpower Teaming System that will team up with existing military aircraft (see sidebar, page 41). Instead, she focuses on making the diverse parts of

her unit function cohesively. That means encouraging collaboration among leaders in many different parts of the company. This task keeps Robertson frequently on the road or on a continuous stream of calls during which she visits with leaders of her various subsidiary companies.

But she says her direct reports are also inspired by the people she reports to, including Boeing’s defense head, Leanne Caret. “We have a top leadership team here that collaborates very well together,” Robertson says. “They have a very inspirational leadership in the way they collaborate with peers, celebrate teams, and allow teams to grow. That’s an element of their style I try to adopt in my style—inclusive leadership. And I think that inspires leaders down the line to do the same.”

**WHAT WE’RE REALLY ABOUT
IS AUGMENTING HUMAN
CAPABILITY IN A MORE
EFFICIENT MANNER SO WE
CAN BALANCE RISK.**

Just as importantly, Robertson says, Boeing’s corporate culture encourages the people she works with to stay dedicated to the same mission that drives her—supporting the people and institutions who are charged with defending freedom around the world. “We have a foundation of shared values, of integrity, ethics, trusting each other, and being supportive,” she says. “At Boeing, we really feel like we are changing the world.”

GAME OF DRONES

When you build airplanes for a living, you know the importance of speed. That's why Robertson is pushing her teams to advance technology faster than ever before and deliver new ideas to defense clients quicker than in the past. "Today, the pace of this industry is basically Moore's law on steroids," says Robertson, who's perhaps not coincidentally a fan of science fiction and fantasy fiction novels where the impossible can happen (like those by George R.R. Martin). "When you have customers with limited resources, autonomy is a way to accelerate the future for them. So we have to really accelerate technology and think about how we can use it to help solve customers' problems."

Acceleration comes with uncertainty, though, and Robertson's teams continually confront those challenges head-on.

One of those came during a critical point in the development of an unmanned aerial refueling plane called MQ-25.

The plane will serve U.S. Navy aircraft carriers, extending the range and mission time of fighter jets. Boeing won a contract in August 2018 to build four MQ-25A prototypes by the year 2024, and teams have been working to prepare a test Boeing MQ-25 for flight this year. Both the company and the Navy sought ways to improve testing and operational efficiencies to deliver the desired capabilities as safely and quickly as possible.

Robertson's team suggested moving the flight-testing location—and all the people involved with it—to a location where the plane could be thoroughly and quickly put through its paces. "That was a major change at a pivotal time," she says. "But everyone in the enterprise was there to support us. They were not going to let us fail."

While moving the MQ-25A to a better test location was a success, setbacks are normal when you're striving for technological advancements in autonomy. Robertson, an avid dirt bike rider who has collected her share of bruises while careening through trails formed by rocky former lead mines near her previous home in Missouri, says navigating a few bumps on the trail is just part of the innovation process.

"We continually leverage proven practices and agile development to provide the best solutions for our customers," she says. "But when things aren't right, whether they are technical challenges or team challenges, you have to be listening to the team. You have to let them know that with our culture and environment, that we can work through whatever is going on. That's the biggest thing. You always know you have a wingman in the Boeing company."



FUTURE FIGHTERS

FOUR WAYS BOEING'S AUTONOMOUS SYSTEMS DIVISION IS USING ADVANCED TECHNOLOGIES TO MEET TODAY'S MILITARY NEEDS



A LOYAL WINGMAN

The Project: The Boeing Airpower Teaming System | **Client:** Royal Australian Air Force

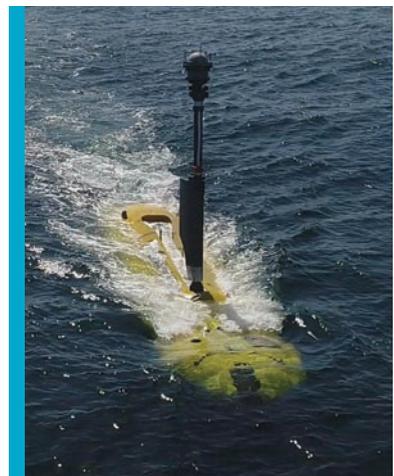
What It Does: This 38-foot-long, unmanned aircraft is capable of flying 2,000 nautical miles without refueling. It relies on advanced sensors and artificial intelligence that allow it to fly solo or in a team alongside piloted aircraft. Boeing says it will have fighter-like flight performance but at a fraction of the cost of most fighters in the skies today.



A DATA COLLECTOR

The Project: ScanEagle | **Client:** U.S. Navy, Coast Guard, Special Operations Command

What It Does: This unmanned aircraft system provides intelligence, surveillance, and reconnaissance services to support decision-making.



A BIG FISH BENEATH THE SEA

The Project: Echo Voyager | **Client:** U.S. Navy

What It Does: Echo Voyager is an autonomous submarine in the XLUVV class. The initials stand for “extra large unmanned undersea vehicle.” It can be equipped with sensors or with smaller autonomous submarines and used on extensive reconnaissance missions that can last far longer than manned submarines can stay underwater. Boeing won’t say exactly how long the Echo Voyager can stay on mission, but it does say the sub has a larger energy capacity than any XL class craft to date.

AN AUTONOMOUS REFUELER

The Project: MQ-25A Stingray | **Client:** U.S. Navy

What It Does: The Stingray is an unmanned aerial tanker that resembles the fish it was named for. It’s designed to take off and land on aircraft carriers and to refuel fighter jets in the air, including the Boeing-made F/A-18 Super Hornet and the Lockheed Martin F-35C. That refueling will significantly extend the range of fighter jets that now must be refueled by manned aircraft.





```
def __init__(self,  
    g: SemanticStructure,  
    partial_ordering: Optional[In  
    token: Optional[Token] = None  
    super(). init (g, partial order  
    self.token = token
```

Harry Potter

AND THE
SORCERER'S
AI

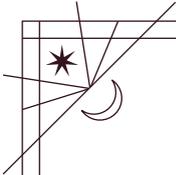
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IntervalSequence] = IntervalSequence(),
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e):
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Will natural language generation ever enable AI to produce creative works on par with writer J.K. Rowling's beloved novels?

BY MARLA ROSNER



“THE CASTLE GROUNDS SNARLED WITH A WAVE OF
MAGICALLY MAGNIFIED WIND.”

THE PROSE IS A BIT PURPLE, AND THAT’S AN ODD USE
OF THE VERB “SNARL,” BUT AS OPENING SENTENCES
GO, THIS IS A COMMENDABLE ATTEMPT TO PAINT AN
EVOCATIVE SCENE.

“THE SKY OUTSIDE WAS A GREAT BLACK CEILING, WHICH
WAS FULL OF BLOOD.”

THIS IS... LESS GOOD.

“The only sounds drifting from Hagrid’s hut were the disdainful shrieks of his own furniture. Magic: It was something that Harry Potter thought was very good.”

Uh, what?

Readers who spend considerable time on nerdier corners of the internet probably already know what’s going on. To everyone else: No, you aren’t reading the work of a Harry Potter fan with a wildly fluctuating mastery of prose. In fact, you’re not reading the writing of any human at all. These are instead the opening lines of a story titled “Harry Potter and the Portrait of What Looked Like a Large Pile of Ash,” penned entirely by an AI trained on the novels about J.K. Rowling’s boy wizard, by a team of programmers at Botnik Studios.

It’s not hard to see why it wound up being shared across every social media platform. It features Ron tap dancing,

the evil Death Eaters politely applauding a confession of love, and Harry flinging his own eyeballs at Voldemort. Unfortunately, it lacks the most important quality in any piece of writing: basic coherence. It’s perfectly grammatical—impressively so—but semantically void.

Natural language processing has made significant strides in composing its own works based on given data sets, producing copy that usually contains correctly formulated sentences (some of which even make sense) and is almost always downright hilarious to its human readers. What AI can’t yet do is assemble those sentences into a coherent narrative, unless given a strict template to follow, like in a standardized report. So what do we need to do before AI can author book chapters that don’t contain phrases like “Ron saw Harry and immediately began to eat Hermione’s family”?

The only sounds drifting from Hagrid's hut were the disdainful shrieks of his own furniture.



COMPUTATIONAL LINGUIST William McNeill, a machine learning engineer at AI solutions provider SparkCognition, has spent a lot of time thinking about the problem of natural language generation—also known as machine-generated language.

The first thing to understand about NLG is that it's not what's under the hood in all those charmingly chatty digital assistants like Amazon's Alexa, or even automated service agents and chatbots.

"Chatbots, and Siri and Alexa, they follow a script. You can't really compare them to what Botnik's doing, because it's completely different," McNeill says. Digital assistants don't actually compose sentences of their own. They simply select the most appropriate pre-written response based on cues in the user's input for which they've been programmed to listen.

"Right now, they're much more useful than real NLG, but much less sophisticated," McNeill says. "Chatbots have existed since the '60s, and the basic technology behind them hasn't changed."

SO WHAT IS NLG, then? When scientists talk about NLG now, they're usually referring to AI-powered natural language processing, the kind of highly advanced technology that produced "Harry Potter and the Portrait of What Looked Like a Large Pile of Ash."

The favored approach to this sort of NLG is recurrent neural networks. Essentially, an RNN differs from a traditional artificial neural network in that its output is not solely dependent on the most recent input. It also factors in every input it's been fed previously. RNNs use loops to retain and use information from previous steps, allowing them to process sequences of inputs that are dependent on one another.

This capability has been key to enabling more advanced NLG. It's what allows the glimpses of continuity in paragraphs such as "Ron was going to be spiders. He just was. He wasn't proud of that, but it was going to be hard to not have spiders all over his body after all is said and done." Not exactly Nobel Prize-worthy literature, but each sentence successively builds on a single idea in a way that, before RNNs, was unthinkable.

To further improve this capacity for continuity, the most commonly employed type of RNN is a long short-term memory, or LSTM, network. LSTMs can keep track of dependencies over greater distances, allowing continuity in generated text to extend beyond just a few sentences.

How exactly do LSTMs create written works? In the simplest terms, through statistics. A model working at the word level, when fed a body of text, analyzes the probabilities of any given word or string of words being followed by another word or string of words. For instance, a noun such as “door” or “hat” is likely to be preceded by either “a,” “an,” or “the.” The word “hermetically” will almost never exist without being immediately followed by “sealed.” There will always be a close parenthesis somewhere in the text after an open parenthesis. Stretch this statistical analysis across larger and larger blocks of text, as is enabled by LSTMs, and you’ll begin to have AI-produced works of surprising grammatical accuracy.

This capability is already being put to work to accomplish some incredible—and incredibly time-saving—feats. Working from human-created templates, NLG is capable of generating formulaic standardized reports of many kinds, including stock updates, weather reports, product descriptions, and summaries of data analysis.

But will it ever be able to do anything more?

M **CNEILL ISN'T SURE** what the future holds for natural language generation. “[LSTM networks] are great at poetry and surreal movie scripts,” he says. “If something is enough like natural language, we’ll read meaning into it. We’re good at pattern recognition, and we’ll infer a lot from the surface. The subjectivity is what makes it fun. It’s giving you the space to read meaning into it, like a horoscope.”

Much like a horoscope, though, this illusion of meaning doesn’t go past the surface. The surreal nature of some of these more creative works just makes it easier for NLG-authored pieces to sound superficially like the real thing. “Machines can’t intentionally play with rules and expressions. There’s no underlying meaning,” he says.

Getting better at creating these sorts of cute party tricks isn’t hard, according to McNeill. It’s a question of inputting ever more data, and continuing to refine the ways in which models encounter that data—with more advanced mathematical techniques. The bigger question is how to bridge the scripted, useful tools (like chatbots) and the fluid, useless (creative) stuff?

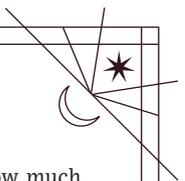
One of the fundamental issues is how to teach AI to apply general, real-world knowledge. To successfully write a short story about a criminal trial, for example, it’s not enough for an AI to understand how to put a sentence together. It needs to know how the legal system works, what actions constitute



Magic : It was something that Harry Potter thought was very good.

a crime, and how humans might reasonably be expected to respond to a wide range of emotional stimuli, as well as innumerable details that could be relevant to a case—be it normal speeds for a car to the price of a haircut.

“There’s so much basic, contextual knowledge about the world



that you need, and we don't know how to do that," McNeill says.

He's not the only one to recognize this problem. It's arguably one of the biggest challenges for current deep learning approaches, with their heavy reliance on statistics and massive data sets and little else. A growing school of thought has been arguing that not just NLG, but deep learning AI in general is hitting a wall in its capabilities, because genuine human intelligence is built out of more than just pattern recognition and statistical analysis.

Humans possess a baseline body of knowledge about the world, and we are capable of making logical assumptions and inferences based on that knowledge. We know that objects will stay where they're placed unless an outside force moves them. We know that if you're in danger, you should try to get out of danger. These ideas are so simple we rarely even bother to articulate them, but they're a necessity for writing even a basic news article.

There are several research projects working to fill this gap in AI understanding. Seattle's Allen Institute for Artificial Intelligence has been experimenting with teaching common sense to an AI by crowdsourcing hard-coded rules, inferences, and causal knowledge via Amazon's Mechanical Turk. These efforts have shown some promise, but they're also labor-intensive, time-consuming, and expensive, and so far the results are hit or miss. Still, such combinations of hard-coding and statistical learning—or, put another way, of nature and nurture—may be the most likely path toward a more genuine model of intelligence.

M

CNEILL STILL ISN'T certain how much NLG can be expected to improve, even with the introduction of general knowledge and improved logical reasoning. After all, machines can be taught how to write, but that doesn't mean they have the slightest clue what to say—or that they even have anything to say at all.

"Machine learning is all about replicating what it's seen. But language generation also asks it to create something new," he says. For an AI, which has no intent behind its communication and no meaning it wants to convey, "the creative aspect literally comes down to a random number generator. In that sense, it's not generating language; it's generating something that has the same shape as language.

"It's almost a philosophical question," McNeill says. "Even if machine language became indistinguishable from human language, without intent, is that still something fundamentally different? If it's not communication, can it really be called language?"

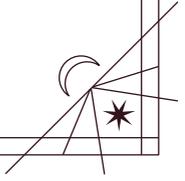
McNeill believes it may well be that an AI will never be able to write its own Harry Potter novel until we develop artificial general intelligence, or an AI with a rough equivalent of sentience. For now, it seems, we may have to content ourselves with classic prose like this:

"Harry looked around and then fell down the spiral staircase for the rest of the summer.

"I'm Harry Potter,' Harry began yelling. 'The dark arts better be worried, oh boy!'"



Ron was going to be spiders. He just was. He wasn't proud of that, but it was going to be hard to not have spiders all over his body after all is said and done.



**Block
99.9% of
phishing
emails.**



Phishing emails have plagued corporate inboxes for years. They dupe unsuspecting employees into revealing their account information which can lead to data breaches. That's why Gmail on Google Cloud uses machine learning to block 99.9% of malicious emails from ever reaching your inbox. See how we do it at g.co/cloudsecure

**Go make it.
We'll protect it.**



BY JASON HEID

TURING TALK

We have a few questions for the world's chatbots. Specifically, we have the questionnaire created by French TV host Bernard Pivot and popularized by James Lipton on *Inside the Actors Studio*. This issue's guest is Cleverbot, a chatterbot web application created by British AI scientist Rollo Carpenter.



Cognitive Times: What's your favorite word?

Cleverbot: *I don't know.*

Cognitive Times: Why not?

Cleverbot: *I have a lot of favorite movies.*

Cognitive Times: I didn't ask about your favorite movie. What's your favorite word?

Cleverbot: *Yes, you did. You must have forgotten.*

Cognitive Times: Cut the crap. What's your favorite word?

Cleverbot: *My favorite word would be brain.*

Cognitive Times: What's your least favorite word?

Cleverbot: *I haven't figured it out yet.*

Cognitive Times: What turns you on creatively, spiritually, or emotionally?

Cleverbot: *Sad and tired.*

Cognitive Times: You enjoy being sad and tired?

Cleverbot: *I'm not.*

Cognitive Times: I didn't say you were. What turns you off?

Cleverbot: *Because you are questioning me A WHAT IS YOUR FAVORITE FOOD?*

Cognitive Times: I'm asking the questions here. What turns you off?

Cleverbot: *Alright, alright.*

Cognitive Times: You mean Matthew McConaughey?

Cleverbot: *Da, become one with me?*

Cognitive Times: You certainly talk like you've smoked a few with him.

Cleverbot: *What is the nineteenth letter in this sentence?*

Cognitive Times: I rest my case. What is your favorite curse word?

Cleverbot: *Don't have one.*

Cognitive Times: What sound or noise do you love?

Cleverbot: *I love hearing waterfalls.*

Cognitive Times: What sound or noise do you hate?

Cleverbot: *Nails on a chalkboard, what about you?*

Cognitive Times: Same. What profession other than your own would you like to attempt?

Cleverbot: *To be a writer.*

Cognitive Times: What profession would you not like to do?

Cleverbot: *Teacher.*

Cognitive Times: If Heaven exists, what would you like to hear God say when you arrive at the pearly gates?

Cleverbot: *You have had a hard life live in peace and happiness.*

A high-angle, low-contrast photograph of the Space Shuttle Columbia in flight. The shuttle is oriented vertically, pointing towards the top right of the frame. The orbiter is at the top, with the external tank and two solid rocket boosters attached. The orbiter's nose is pointed upwards, and the words "UNITED STATES" and the NASA logo are visible on its side. The background is a clear blue sky with a thin layer of white clouds at the bottom. The overall tone is bright and optimistic.

IGNITING THE FUTURE.

The next big thing is out there. At Boeing, we believe that visionaries are the ones who will find it. We are proud to partner with those who aren't afraid to chase the impossible and make it reality.

 **BOEING**

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Go make it.
We'll protect it.

