sabre labs

RADAR 2017 REPORT

Sabre

FOREWORD

Sabre Labs is the travel and technology innovation team within Sabre devoted to exploring how new capabilities will impact travel over the next decade. Each year, as we research, create prototypes and talk with partners, we end up with a long list of trends and technologies. A handful are selected for our annual Emerging Technology in Travel Report, but we run out of space to share everything.

The Radar Report is an opportunity for us fill in some of the gaps and share nine of the trends and technologies we're most excited about. Each has recently experienced some significant growth or achieved a milestone. You may recognize some of the technologies, like virtual reality or space tourism; others you may know less about.

As with everything we do in Sabre Labs, we frame our thoughts through the lens of travel: what will these trends mean to how people move through and engage the world? We hope you find this report interesting, informative and inspiring!

If you have feedback or want to discuss the future of travel and technology, please reach out via SabreLabs@Sabre.com.

Sincerely,

Philip Likens
Director, Sabre Labs

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ARTIFICIAL **INTELLIGENCE**

DEFINING A COLLABORATIVE FUTURE

In a field without clear definitions, Star Wars' R2-D2 and C-3PO are among the most universally recognized depictions of artificial intelligence. The iconic pair's appearance in 1977 helped set expectations for a future where AIs are capable assistants: personable, independent and exceptional at specific kinds of tasks. Now we're experiencing the first stage of what may evolve into a ubiquitous, collaborative future for humans and AIs.

WHAT IS AI?

Virtually every discussion of AI circles back to definitions. "Artificial" is the easy part–in the context of AI it means "digital" or "computer." Defining "intelligence" is the hard part–and a problem which existed long before computers. Defining intelligence in animals has many of the same issues. Dogs and dolphins seem intelligent; flatworms and mosquitos… not so much. R2-D2 and C-3PO seem intelligent; calculators and microwaves… not a chance.

Since humans set the terms of discussion, we tend to use ourselves as the benchmark for intelligence. The essential traits of human intelligence are: acquiring knowledge and applying knowledge. Both are necessary to live in an unpredictable world, whether navigating traffic or an emotionally complex conversation.

In Labs, we define an AI as any program with the capacity to learn new information and apply it to new problems as they emerge. Learning and innovation are the two lenses through which we measure all intelligence, whether biological or digital.

AI RISING

For the past few years, we've seen headlines touting the rise of artificial intelligence as superior to humans in various domains: first chess, then Jeopardy, Go, video games, and poker. But the standards for superiority gradually shift as computer complexity becomes normalized.

As computers master more complex games, the relative "intelligence" factor increases. Excelling at a game like poker is exceedingly challenging because there is never perfect information; every game you have to learn about your opponents and adapt your strategy based on what they do and how they play. As the adage goes, "play your opponent, not the cards." Poker is a very human game that can never be solved.

Of course, every headline touting the victory of AI over humanity in another domain serves to reinforce the incredible complexity of human intelligence. Most of our world is not lived in head-to-head competitive board or card games. Yet to date, AIs are niche intelligences: excellent at one thing but limited or useless at almost everything else. The ultimate test of intelligence—applying knowledge in novel ways to situations as diverse as poker, happy hour small talk and disaster relief—is an area in which humans are unmatched.

But even our apex status for broad-based intelligence may be challenged in the future. AI experts differ wildly in when they believe AI will demonstrate intelligence across a broad array of problems instead of just in niche domains. In a recent survey of more than 350 global experts, the average estimate for the first

human-level machine intelligence is 45 years away, but individual responses ranged from 20 to more than 100 years.

THE HUMAN OPPORTUNITY

Regardless of the timeline for AI growth, we are seeing AI have a significant impact in every niche to which it's applied. In many cases, AI is being brought alongside humans to produce more effective outcomes than either could achieve alone.

In some industries, robots are being "hired" to replace humans in certain kinds of roles. For instance, "picking" is the lowest tier of work in large shipping warehouses. It usually involves moving quickly through a huge space, picking out items, and carrying them to a central location for packing and shipping. It's known to be physically demanding, often low-income work. E-commerce retailer Boxed is one of many companies in the process of replacing pickers with robots. Boxed estimates the change will produce a 600% increase productivity. But rather than laying off human pickers, the company is retraining all its workers, usually into higher skill level, higher paying jobs.

Though some AIs will be designed for physical bodies—like warehouse robots or the fictional Star Wars duo—the majority of AIs will exist only as software, helping streamline tasks across digital domains.

Among the most widespread examples of software-only AIs are the bots helping companies provide service and support. Back in 2011, Gartner research predicted that by 2020, customers will manage 85% of their interaction with companies without interacting with a human. Servion consulting released a more recent figure, predicting that AI will power 95% of customer interactions by 2025.

The most effective service and support teams have an AI layer capable of understanding and responding to most basic questions, paired with humans available to step in when the AI isn't confident it has an answer. For travel, the AI layer might provide hotel checkout times or local restaurant recommendations and the human might take over if a customer has a special request or wants to share a personal experience.

In both warehouse and service and support cases, AIs can drastically reduce the load of repetitive tasks—whether physical or digital—freeing humans up for higher value, more creative work. As this transition happens, the major challenge across industries will be to rapidly retrain the human workforce to take advantage of these new opportunities.

Wall Street finance is experiencing the beginning of significant disruption as AIs replace humans at choosing stocks to buy and sell. Hundreds of thousands of white collar jobs will be displaced,

but these are representative of the kinds of jobs that are inherently difficult for humans but easy for AI. The financial system is too complex and fast moving for humans to intelligently and quickly respond to all the minutiae—we can't physically learn and act on all the information we need. But this kind of multivariate analysis is an area where AIs excel.

Similar kinds of traditionally complex jobs have similar risks, but may also have great opportunities. For instance, AIs are rapidly improving in the area of language translation, which is helping to flatten the world economy, streamline travel and make it easier for people to connect with one another. We might need less translators in the future, or we might see translators moving from rote translation of documents to high-engagement, face-to-face roles as tour guides or diplomats, or to more artistic roles like translating literature with a nuance for idiom and poetry.

PREPARING FOR THE FUTURE

The biggest change in AI right now is the opening up and growth of AI platforms, providing "AI as a service." The vision is for everyone to be able to tap into existing AIs, building new functionality on existing services. The ability of small companies and individuals to utilize the incredible AI tools and resources of giant companies like Amazon, Google and IBM will exponentially grow the space. It also means improvements in AI can scale very rapidly—if a company's natural language processing AI gets 10% more accurate, then every service built using that AI instantly realizes the improvement.

Opening up AI platforms also creates radically more opportunities for humans to capitalize on one of the things our intelligence does very well—innovate to disrupt the existing status quo. In a very real sense, artificial intelligence is inevitable because it is an outgrowth of our humanity. Our curiosity demands we venture into the unknown, sail uncharted seas, open Pandora's Box, create machines in the image of ourselves.

The question of the evolution of AI isn't "if" but "when." AI progress is disruptive. The challenge for our industry and for others is to ensure AI's disruption is a net positive. It is essential that we build a world in which humans and AIs work together. In Labs, we're optimistic about the potential gains of a collaborative future—one in which we are more creative, have more leisure, have more bandwidth to travel and richly experience the world.

AUGMENTED **REALITY**

DIGITAL IMMERSION IN PHYSICAL SPACE

Augmented reality (AR) is turning the world we live in into a multiverse—countless simultaneous, overlapping realities. With the right lens, the right window, we can seamlessly move between worlds or even create our own. And AR doesn't just provide new worlds; as the lines blur between the digital and physical, there are a growing number of opportunities for AR to enrich our three dimensional spaces.

LOOKING AT TODAY

Augmented reality has become trendy in Hollywood. Movies such as Iron Man and Minority Report, have taken advantage of computer graphics to envision how AR might look in the future. But where movies often fall short is by depicting AR as merely a high-tech substitute for today's flat displays. AR is developing to be far broader and deeper, adding layers of digital content to every part of the real world.

Last year saw the launch of three foundational AR efforts: Microsoft HoloLens, Google Tango, and Pokemon Go—a trio of radically different projects, each demonstrating a different element of AR's potential. It also saw the proliferation of real-time video filters and interactive selfie animations added to Snapchat and Facebook. But the big news in augmented reality this year is Apple's release of ARKit, a tool for developers to build AR apps in preparation for the launch of iOS 11 this fall. Taken together, these products provide a framework for understanding what's happening now and what we can expect over the next few years.

PROXIMATE AR

AR depends on having some awareness of a user's location. Proximate AR knows rough location, but lacks the sensors to accurately map a physical space in 3D, so nearby objects may jump around, but can still exist in an approximate location. Proximate AR is sufficient for many kinds of tasks and is cheap and easy to implement into everyday devices such as smartphones and tablets.

Pokemon Go is the most widespread touchpoint for proximate AR. It dominated a cultural moment, catapulting the term "augmented reality" into the public consciousness. To date, Pokemon Go's use of AR is very limited—it's inclusion of digital creatures overlaid on a cellphone camera feed is the most primitive form of adding digital content to the real world. What's far more interesting about Pokemon Go is its success in normalizing the idea of location-based digital content. The game adds a layer of digital information mapped to the real world—it is its own separate Earth, coexisting with the world around us. And players are often willing to walk hundreds of miles over the course of play to collect digital objects and visit virtual locations.

PRECISE AR

Precise AR involves sensors that can accurately map a 3D environment and seamlessly integrate virtual objects into that physical space. With precise AR, virtual objects can have a sense

of permanence—existing and behaving as if they were real. With precise AR, if you place a virtual coffee cup on a physical table, it will rest exactly on top of the table—not partially inside the table, not floating above it. Precise AR is what's necessary for the AR multiverse to fully realize its potential.

The Microsoft HoloLens headset was released as a developer kit in March 2016 (still not marketed to the general public) and is the standard bearer for precise AR. Wearers look through clear lenses and see fully three-dimensional virtual objects embedded in the real world. The most impressive part of the HoloLens is its ability to map and remember physical spaces with incredible precision. If you walk out of a room, digital objects in it will remain exactly where you left them—a virtual TV on the wall, a virtual chessboard on the table, a virtual window displaying a live view of the beach. Persistence and visual immersion make the HoloLens the best current experience of what will be possible in the future.

Google Tango is a design standard for precise AR in smart phones, using spatial sensors similar to those in the HoloLens; the phone becomes a window through which you can see into other worlds. For instance, on a museum tour, a Tango device could allow you to see inside a sarcophagus or put flesh over dinosaur bones. Businesses from BMW to Gap to Lowes are actively using Tango technology to help sell products, allowing people to find and envision products in their personal spaces and at scale. For now, Tango is primarily being marketed to businesses and there is currently only one Tango-capable phone on the market (though a second is on the way). If Tango starts being integrated widely into Android phones, it will likely accelerate development and use of precise AR applications.

WORLDS OF TOMORROW

Apple's ARKit is the X-factor in the current AR landscape—from the information released to date, it appears to achieve some advantages of precise AR without the need for the spatial sensors present in HoloLens and Tango devices. ARKit allows programmers to create iOS 11 apps with integrated AR functionality using the standard iPhone/iPad camera as the only visual sensor. But what Apple lacks in sensor complexity it makes up for in user volume… with the launch of iOS 11, hundreds of millions of iPhones and iPads will have access to ARKit apps. This incredible user base should jumpstart interest and funding for real world

applications. ARKit will help establish an ecosystem and talent pool ready to grow in capability whenever Apple decides to launch more sophisticated, sensor-rich hardware.

Back in February, Apple CEO Tim Cook said, "I view AR like I view the silicon here in my iPhone, it's not a product per se, it's a core technology."

Looking at AR as a core technology, the overlap of the four efforts highlighted point to what AR may look like a few years out: Precise AR, available in both headset and smartphone forms, broadly supported through rich Android and iOS ecosystems, providing access to a multiverse of countless overlapping worlds. But what will some of those worlds be?

For many people, Pokemon Go helped create the idea that AR is first about gaming, and while gamification of the real world is happening, AR worlds are far broader. AR is already being used for things like translation—the ability to read every sign or document in your preferred language in real time. And it's easy to imagine all kinds of other functionalities, like visual Wikipedia for the real world… every building, street and landmark mapped to layers of rich content. Walk around a sculpture and watch a time lapse of the sculptor carving the piece; look down a street and see all the businesses and reviews; look up in the sky and see through the clouds to the satellites and stars soaring above. Or, closer in, look at a flower or listen to bird and learn what it is and where it thrives. Or in social spaces, never forget a name or an interaction; businesses could greet every passenger or hotel guest by name and know their customer history at a glance.

The real potential of AR is not just in making information ubiquitous and easy to access, it's in creating new functionalities, new kinds of content and ways of augmenting the real world to engage more deeply with it and with one another. We have infinite worlds to discover and create, and it's up to us to imagine what those worlds will be.

AUTONOMOUS **DELIVERY**

ANYTHING EVERYWHERE

Homing pigeons were the first autonomous delivery system, used across the world to deliver messages, including the results of the first Olympics almost 3,000 years ago. Drones are the pigeon's modern day functional successors, capable of delivering goods across great distances without the need for human intervention.

On a global scale, regional differences in regulation and infrastructure are showcasing different future paths for an always and everywhere on-demand economy of physical things.

LEAPFROGGING INFRASTRUCTURE

Through most of history, transportation infrastructure has been closely aligned with resources: areas with rich resources and dense populations are strongly connected; areas with few resources or people are largely isolated. Mountains, lakes, rivers, forests, etc., act as natural barriers to building roads and other infrastructure. Yet flying drones, like homing pigeons, are not limited by terrain.

In the developed Western world, we see headlines of Amazon, Google, UPS, etc., promising drones delivering everything from pizza to diapers to asprin. Meanwhile, in Africa, drones are in daily use throughout Rwanda. There, Zipline's fixed-wing drones are lifesavers for rural areas, delivering medical supplies in minutes that would otherwise have taken hours. Orders can be placed by text, deliveries are parachuted into a designated landing area and medical staff receive a text notification of delivery.

Zipline's fixed-wing drones (similar to small airplanes) have much greater speed and range than quadcopter drones, and are also more resistant to weather. The small size of Rwanda (~10,000 square miles, similar to Massachusetts or Belgium), makes it possible for Zipline to provide service to the entire country from just two distribution centers. Centralized storage of sensitive and expiration-dated medical supplies also has the potential to greatly reduce waste and ensure supplies are at their most effective for treatment.

The use of drones in Rwanda is being scrutinized globally as a test case for autonomous delivery. In many countries, regulatory concerns over safety and airspace are the factors limiting drone implementation. But the Zipline business model–lifesaving supplies on demand–makes a compelling case for accelerating global drone adoption.

URBAN ROLLOUT

Drones in rural and even suburban areas are relatively easy to envision becoming a near-term reality. Drones in urban areas present a totally different set of logistic and regulatory challenges. Which is why delivery by ground is still being viewed as the best near-term option for high density areas.

Earlier this year, Starship Technologies and delivery service Postmates launched a robotic delivery service in Washington,

D.C. The robots look like medium-sized coolers on six wheels and have special approval to travel exclusively on sidewalks in the District and in neighboring Virginia. They use GPS and an array of nine cameras to help navigate their environments. They can't bring all your groceries yet, but they can bring quick takeout meals or a bag of items from a local convenience store.

Postmates estimates autonomous delivery robots will be able to drive down costs of short-range deliveries by 80-90 percent compared to current human delivery charges… and they won't expect a tip. Several other states are considering legislation allowing autonomous delivery vehicles, and in the next few years robots may become commonplace on sidewalks around the world. Indoors, similar kinds of robots like the Savioke Relay are at work in hotels and offices, providing concierge-like services and delivering items. Savioke says its robots have already completed over 100,000 autonomous deliveries in hotels, freeing up staff for more important tasks.

Back on the street, Matternet (in partnership with Mercedes-Benz) and UPS are independently experimenting with hybrid solutions, using drones launched from the roofs of delivery vans. In these scenarios, drivers see increased delivery efficiency and cost savings by having a drone as an assistant.

SCALING UP

It's tough to envision autonomous delivery scaled to current delivery demand. UPS alone delivers 16 million packages in just the U.S. on a normal day with holiday season days doubling that number. And as online sales continue to grow, delivery volume climbs; faster delivery options made possible by drones are expected to further accelerate demand.

It's reasonable to imagine fleets of thousands of delivery drones being needed to meet consumer demand. A robust air traffic control system will be needed specifically for drones in order to meet eventual regulatory issues as well as to ensure safety of people and property. U.S. and U.K. governments are actively working to develop ATC systems for autonomous drones; simultaneously Amazon and Google's Project Wing are independently working on their own ATC systems for autonomous drones to help ensure there are no technological barriers once regulatory approval is in place.

Weather is the other critical factor to be addressed for drone delivery to ever become widespread. For drones (quadcopters and the like) to be quiet, urban-friendly and power-efficient, they have to be light and have limited payloads, 2-3 pounds for most models, as much as 10 pounds for others. The shape and mass

of these small drones make them vulnerable to extreme weather. Area-level forecasting is not granular enough to be of much help in block-level flight planning. For instance, some streets of Chicago are often canyons howling with high winds–strong enough to take out a quadcopter–but the area forecast might be for a light breeze. Contrast that with the unofficial motto of the US Postal Service, "Neither snow nor rain nor heat… [shall stop the mail]." It's expected that block-by-block weather forecasting may be necessary in order for drones to be put into widespread use.

For a delivery system to be sustainable, it can't be based solely on airborne drones; if it were, every weather event would disrupt and backlog commerce. What appears much more likely is for drones and delivery robots to co-evolve as part of a broader delivery ecosystem, with each device occupying an appropriate niche.

HANDS FREE TRAVEL

When combined with other technologies, like biometric identity, it's easy to imagine a world in which travel becomes a virtually hands free process, thanks in large part to autonomous delivery technologies. An autonomous suitcase and an autonomous personal porter are already in production—it may soon be commonplace to see small robots following their owners through airports, train stations and city streets. Luggage may even check itself in and come find you after you debark. It might even be possible to retask your luggage to run errands once you're at a destination—drop off the dry cleaning or pick up a snack. If you're out in the city and left your phone or sunglasses in the hotel, no worries… those can be delivered.

And when work is done and you're ready to relax, we're not too far from flying taxis taking off, able to carry you down the coast to a favorite secluded beach. Once you're stretched out on the sand, soaking in the sun, a drone-delivered margarita shouldn't be too far behind.

BLOCK**CHAIN**

BEYOND THE HYPE

In the past two years, “blockchain” has become a magic word, able to open doors and investor wallets, panic industry juggernauts, and guarantee headlines. But much of its power comes from mystery and misunderstanding—we all know it’s important, but not how to talk about it. And meanwhile, we see headlines touting all the ways blockchain is transforming whole spheres of society: finance, security, transportation, public information and beyond.

BLOCKCHAIN BASICS

Blockchain is self-descriptive: blocks of data are sequentially added to a chain of similar blocks. All blocks in a chain must follow the same set of rules, established from the first block. As each new block of information is added, the entire chain is tested to make sure nothing is out of place. Chains are unbreakable or "immutable"—once a block is in place, it can't be moved or changed without taking the whole chain apart. At its core:

- **Blockchain is a framework optimized for immutable, distributed, public ledgers.** It allows the direct transfer of value between parties without requiring those parties to trust each other. The value can be any digital record—currency, property, identity, loyalty, votes, media, etc.
- **Blockchain is not a single thing; it's a set of ideas.** Blockchain protocols (like those defined by Bitcoin, Ethereum, Hyperledger, etc.) are essentially programming languages—each has various strengths and weaknesses.
- **Blockchain is nascent in its development.** At an MIT-hosted conference on blockchain in April, blockchain was compared to the 1989-1990 Internet—a time when today's protocols (like HTML) were still being figured out. This comparison suggests: 1) blockchain could have a powerful and widespread future; 2) blockchain still has a very long way to go; and 3) blockchain is ripe for experimentation.

Gartner Inc. has placed blockchain on their Hype Cycle near the "peak of inflated expectations." According to their model, this means blockchain may slide into the "trough of disillusionment" for a period of years before it comes into its own and has a transformative and lasting impact.

GLOBAL IMPACT

The number of companies working on blockchain is increasing exponentially. The Ethereum protocol alone has over 500 decentralized applications live or under way, and new blockchains are being launched weekly. At present, an array of governments, businesses, non-profits and ad hoc collectives are using blockchains in a breadth of ways hinting at its future potential.

- **Businesses are committed to and experimenting with blockchain platforms and protocols.** The two most significant concentrations are around the open-source Hyperledger project and the Enterprise Ethereum Alliance.
- **Blockchain-based currencies have the potential to bring the entire world into a digital economy.** Governments, banks and non-profits are testing blockchain-based cryp-

tocurrencies, with the potential to bring digital financial services to everyone, including 2 billion people in developing nations who have never had access to a bank or credit card.

- **Every good—physical or digital—can have a unique permanent record (a 'passport') stored in blockchain.** Outside finance, the hottest growth area for blockchain seems to be transforming supply chains to better track goods between businesses and across borders, helping guarantee authenticity and eliminate counterfeiting.
- **Blockchain has the potential to change the shape of public information.** Blockchain-powered projects providing services similar to Facebook, YouTube, Twitter and countless other major platforms are proposed or in development with the goal to return ownership of assets to the individual and assure freedom from censorship.

TRUST ISSUES

Blockchains are being hyped as the end to silos, corruption, lack of transparency and insecurity. But in taking a wider look at the tech landscape, it's still unclear in which cases blockchains will offer a favorable value proposition over other kinds of ledgers, including traditional databases.

The touted immutability of blockchains is both a pro and a con. If the data is correct and the protocol is secure, then immutability is a tremendous benefit. But whenever something is recorded incorrectly, or a loophole is found and exploited in the original protocol of the blockchain, those problems are very difficult to resolve. With nodes as partners, there is no "higher authority" to appeal to if/when something goes wrong.

Private blockchains "solve" the higher authority issue, since every node within a blockchain is controlled by a business, coalition or government. But in many of these cases, it's unclear why blockchain is necessary. Existing database solutions can be built with most of the same features as blockchain and can often be implemented at lower costs with existing infrastructure.

Since the rules for a blockchain are established from the first block, what effectively occurs in a public blockchain is a shift in trust: instead of trusting an institution to create and maintain data records, participants are asked to trust that whatever entity creates the initial block does so in a clear and secure way, that data is then entered correctly, and that the majority of nodes remain committed to the original goals of the system. In a private blockchain, trust is similar to today: you trust whatever entity (or entities) controls the network.

TRAVEL RELEVANCE

Blockchain appears to excel when you need a clear and immutable record of any type of information (such as location or ownership) to be accessible to multiple parties who may not trust one another. We're beginning to see blockchain prototypes emerging in the travel space:

- **Webjet is piloting hotel room inventory on blockchain**, to collect exponentially more data with each booking and ensure prompt and complete payment to all parties.
- **Startups are eyeing digital identity management on blockchain**. Combining biometric identification with blockchain may provide more secure digital proof of identity, over traditional identity measures like a passport.
- **Hotel and airline loyalty programs may transition to blockchain** to help streamline tracking of loyalty points and simplify conversion and redemption across all players.
- **Airbus has brainstormed blockchain possibilities**, and is part of the Hyperledger blockchain consortium; their test project is to use blockchain to create industry-wide tracking of pilot diplomas, certifications and qualifications.
- **Moog Aircraft group is using blockchain for parts tracking**, as well as to digitally authenticate and provide rights management for 3D printed airplane parts.

Even the most bullish blockchain proponents acknowledge the need for some centralized or trusted authorities within complex business systems. In travel, centralized players are necessary to help ensure proper identity, policy compliance, reporting and security. The cost and potential regulatory liability of moving billions of transactions to a new and barely-tested ecosystem is extremely prohibitive, as is the challenge of consensus around a new platform.

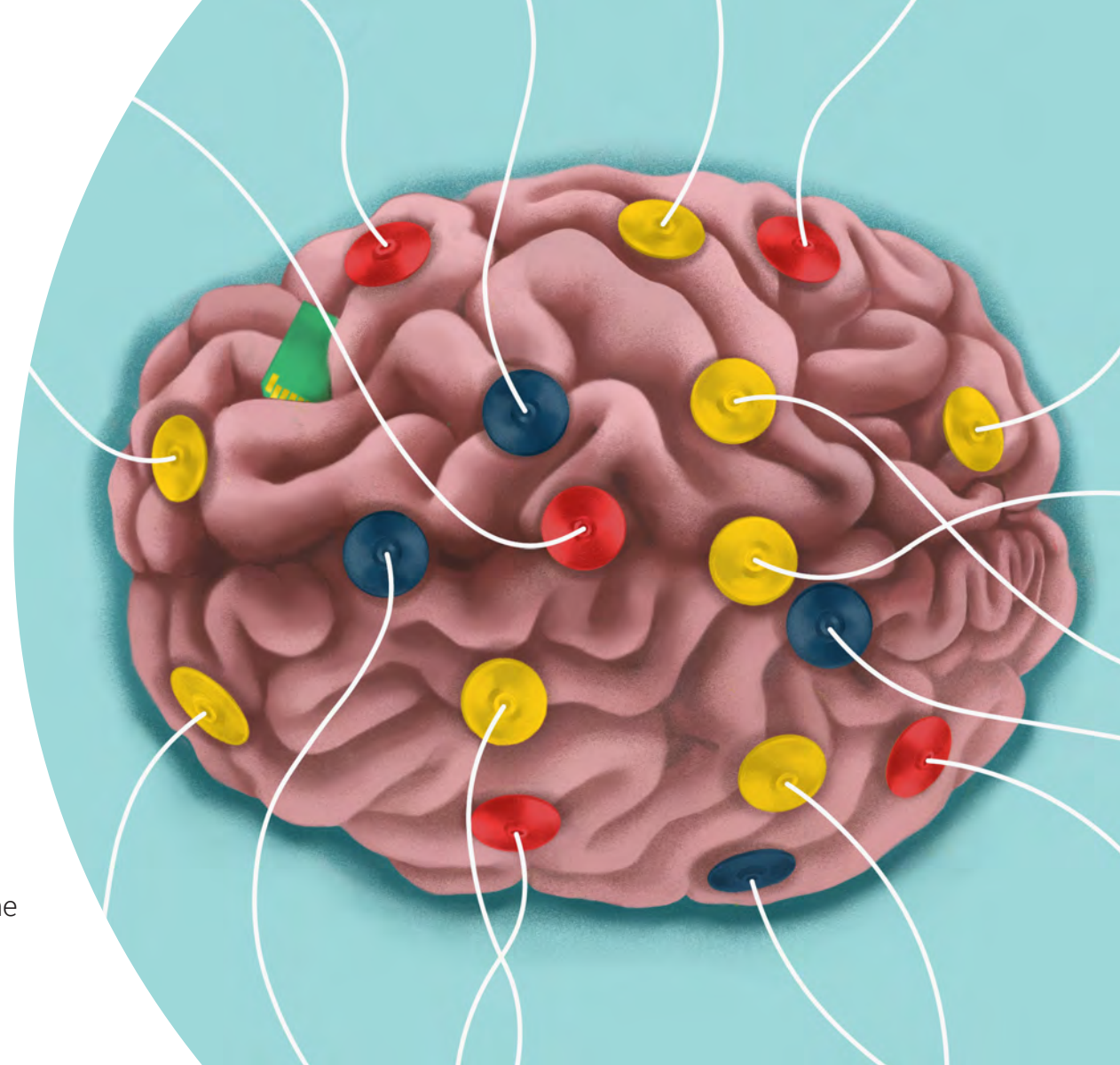
This is not to say that travel distribution functions will never be provided via a blockchain. But when these develop, they will most likely be on a private blockchains, and implemented only after extensive testing and validation of the security and safety of the platform. And there would still be a central, trusted authority, helping manage compatibility and compliance within the blockchain system.

Regardless of which projects get off the ground, blockchain looks to have significant long term impact inside and outside the travel industry.

NEURAL **INTERFACES**

MERGING MIND AND MACHINE

There's an old story of a king who has a dream he doesn't understand. He brings in his wisest advisors and magicians, demanding they explain his dream or die. But there's a catch: to prove their power, they also have to read the mind of the king and tell him the pictures he saw in his dream.



In the story, the wise men fail; no magic on earth could see inside the mind. Yet today, peeking into the images in the brain is only one of many capabilities envisioned for neural interfaces. Research is also under way on telepathy, telekinesis (moving objects with thoughts), expanded memory, and a whole array of medical applications.

THE AMAZING BRAIN

It's become a trope that "the human brain is the most complex object in the known universe." (Granted, we haven't explored much of the universe yet, but our limited reach shouldn't diminish the awe-inspiring complexity of the supercomputer between our ears.)

Our brains have 80-100 billion neurons, each with ~10,000 synaptic connections, running off just 20 watts of energy. It's estimated that in computing terms our brains process around a billion billion calculations per second (yep, that's 1,000,000,000 squared). There's a name for this level of complexity—exascale computing—and the race to achieve the exascale milestone is being run in earnest by the world's largest governments and technology companies. In June, the U.S. Department of Energy infused an additional $258 million into the race in a bid to keep up with China, which promises to have an exascale computer functional by 2020.

Complexity and speed aren't ends unto themselves, but as supercomputers approach the complexity of a human brain, it becomes possible to perform deeper simulations of the inner workings of the brain, to better understand how they work.

HACKING THE MIND

When it comes to the mind, there are two very different challenges: extracting information from the brain and transferring new information in. Neural interfaces attempt to address one or both challenges, and can do so in either an invasive or non-invasive way.

Invasive neural interfaces—implanting something inside the body—have been in development and use for decades in medicine, helping people with disabilities or neural conditions to function more normally. Medical work on neural interfaces is advancing to control specific nerves to help immune responses and muscle control. This field, often referred to as "bioelectric medicine," is being supercharged by a handful of companies including GE, GlaxoSmithKline and Alphabet which together have committed almost $1 billion over the next few years to advancing the field.

In a new study demonstrating the potential for neural interfaces, highly accurate facial images were extracted from the brains of monkeys by using electrodes to read signals from just a few hundred neurons. The study claims to "reveal the brain's code for facial identity," helping change the way researchers approach translating neural signals into images.

In the human realm, the most news-grabbing invasive neural interface effort is Elon Musk's Neuralink, which aims to develop a neural lace, a brain implant creating a seamless interface between mind and machine. Neuralink's vision mirrors an earlier startup, Kernel, whose founder Bryan Johnson is emphatic that neural interfaces are essential to human evolution. Kernel is focused on advancing human intelligence by exploring how memory can be edited and augmented with implants.

A more down to earth neural implant is under development as part of the BRAIN Initiative, an effort launched in 2013 which brings together the U.S. government, academic and commercial institutions. As part of the initiative, DARPA is leading a 4-year project to develop a neural interface that will "communicate clearly and individually with any of up to one million neurons in a given region of the brain." While only a tiny fraction of the brain, this would still be a monumental achievement.

Many experts believe the timelines are overly optimistic for non-medical neural implants due to safety concerns and regulatory issues surrounding physical augmentation.

OUTSIDE THE SKIN

Non-invasive neural interface technologies have the potential for rapid adoption if they can be made useful. Staying outside the skin avoids most of the safety and regulatory pitfalls of invasive devices and has basic advantages like being able to demo a device without needing surgery to try it!

At a hackathon last fall, Sabre Labs built an EEG-based flight shopping app for iOS. Wearing an EEG headband, users undergo a quick training session looking at images of beaches and mountains to establish baseline brainwaves. After training, a person can simply think of a destination—mountain vs. beach—to launch the appropriately themed flight search.

EEG readers are the most well-established neural interface. They provide a very basic scan of electrical activity, but the limited amount of data they provide can be used to do far more than just travel shopping. EEG is great for simple movement, such as moving an on-screen cursor, navigating in virtual reality, operating a drone, or moving a prosthetic limb.

Going beyond EEG, Facebook has a team of more than 60 engineers working on a neural interface to allow people to type using just their minds. The team plans to be able to scan a brain more than 100 times per second, translating words spoken silently into text. It also aims to use a neural interface to provide a hands-free way to control digital experiences, including virtual and augmented reality.

Of course, reading data from the brain in a non-invasive way is easier than transmitting data into the brain in a non-invasive way. Non-invasive computer-to-brain interface projects are few, but one research project achieved limited telepathy, using an EEG to read signals paired with magnetic stimulation to transmit simple binary signals into another person's brain.

NEURAL INTERFACES IN ACTION

Computer interfaces have evolved—from punchcards to keyboards to mice to touch to voice—but neural interfaces are the obvious endpoint of interface evolution. Mind and machine is becoming synchronous, with thoughts translated directly into action.

Close in, neural interfaces are leveling the technology playing field and providing new capabilities, helping overcome human disabilities, restore function and enable exciting new ways of exerting control over the world. When combined with advances in robotics, this could eventually allow independent mobility and travel for everyone, regardless of physical limitations.

The next few years will see a host of different neural interfaces attempting to make sense of the signals in our brains. Control will be limited, but applications as simple as directing your autonomous luggage to move with just a thought could have practical, everyday functionality.

Further out, computer-to-brain neural interfaces will allow thoughts and sensations to be implanted in the brain. The most immediate capabilities will likely be simple: syncing GPS routing to your brain so you know when to turn without looking at a map; notifications for meetings and appointments; syncing to your circadian rhythms so you are woken up at the right moment without an audible alarm, regardless of time zone.

Eventually, we'll be capable of greater creative control and sensory immersion. Our thoughts controlling the machines in our environment; the ability to translate our dreams and imaginings into visible and audible forms; greater immersion in VR-type environments, where we can have the implanted sensation of sun on our faces and sand between our toes.

Neural interfaces promise a rich and exciting future, and the process of getting there will stretch our minds and our dreams.

QUANTUM **COMPUTING**

PAPER TO PROTOTYPES

Quantum computers have long been the stuff of spy thrillers and conspiracy theories, promising to make passwords and encryption obsolete. But as quantum computers get closer and we better understand their potential, it appears their first “killer app” is likely to be optimization--finding the most efficient way to chart a path or engineer a system. And this has tremendous potential for travel!

SUPERPOSITIONS & SIMPLICITY

Quantum computers are on track to hit a milestone this year, demonstrating their superiority over traditional computers for certain kinds of niche tasks. Google, NASA, Microsoft, IBM, HP, Bell Labs, D-Wave, MIT and many other tech players are working on different approaches to create a quantum computer stable enough and powerful enough to conclusively demonstrate a new kind of computing.

To understand what kinds of tasks quantum computers will be good for, it helps to have a basic understanding of how they work. Conventional computers store and process information as 1's and 0's—on and off states. Quantum computers utilize "qubits," which have a state of superposition that is both 1 and 0 at the same time. Think of superposition like a spinning coin—until a spinning coin lands, it's both heads and tails. (Or, in the classic thought experiment of Schrödinger's Cat, the cat in the box is both alive and dead.) Until a qubit is read, it's both 1 and 0.

Because bits in superposition are both 1 and 0, an array of qubits can hold exponentially more possibilities than traditional bits. Two traditional bits can represent one of four possibilities: 00, 01, 10, 11; two qubits represent all four possibilities at once. Similarly, 30 bits can represent one of over a billion combinations; 30 qubits represent all billion combinations at once. It's estimated that somewhere around 50 qubits, quantum computers will begin to surpass traditional computers for many kinds of tasks. Researchers anticipate computers with thousands of qubits being built in the near future (whether years away or decades is uncertain).

Of course, holding every possibility at once isn't helpful without a way for the computer to simplify down to a traditional answer, represented by 1's and 0's. This is where the study and discovery of quantum algorithms is useful—specific ways of using quantum systems to solve niche kinds of problems.

Quantum algorithms rely on the tendency of quantum systems to fall into a state of lowest possible energy. If you drop a box of ball bearings onto the floor of an old house, you'll quickly discover how the floor slants and where the low spots are based on how the ball bearings roll and where they come to rest. Quantum computing works much the same way: for an optimization problem, like the most efficient route from Sydney to San Francisco—the array simultaneously tries every possible route. But the inefficient routes would quickly fall away, like a ball bearing rolling downhill; it takes too much energy for a quantum system to maintain inefficient solutions. So after a very brief

wait for the system to settle to a state of low energy, it's possible to read the position of qubits as a string of 1's and 0's.

Settling into a state of low energy isn't exact—at this point in development, there are too many variables that can affect quantum systems to be certain any solution is perfect. This is similar to how ball bearings dropped on an old floor won't ever end up in exactly the same configurations twice, but will end up in similar areas. However, solving the same problem multiple times and comparing the low energy states for commonalities can quickly produce a solution that has a high probability of being near optimal.

With enough qubits in an array, it's possible to find near-optimal solutions in systems far too complex for any traditional computer.

OUT OF THE BOX

Yes, quantum computers will be able to crack most traditional encryption algorithms very quickly, but cracking passwords will be a very small footnote to actualized quantum computing.

New encryption protocols are being developed that are "quantum-proof," and it's just a matter of adopting new security protocols before quantum computers scale up.

The most obvious need for quantum computers is to address problems of scale. Huge data sets are tough to analyze. The rapidly growing Internet of Things is already generating troves of data too large for traditional computers to analyze efficiently. And data generation is increasing exponentially.

Much of travel—along with other common things like internet search and social media—relies on optimization across large data arrays. Flight scheduling, crew allocation, aircraft routing, traveler itineraries, etc., are all optimization problems with countless variables. Traditional computers work on these problems with limited toolsets; quantum computers may be able to find entirely new solutions and efficiencies.

But the more interesting problems are ones almost impossible to tackle now, such as: simulating the properties of matter at the atomic level to create new materials, chemicals and medicines; better understanding weather patterns and celestial phenomena; predicting finance trends and mapping the interrelationships of global economies. New materials may change the kinds of transportation we can build, the kind of structures we can create. New medicines may change how we are able to travel in certain parts of the world, helping eradicate disease and forestall epidemics. New understanding of weather systems may not only

change the accuracy of weather modeling, but may provide us tools to influence weather.

ASKING NEW QUESTIONS

Quantum computers will not replace traditional computers any more than space shuttles will replace cars. Cars are better than space shuttles for almost every common earthly task—running errands, commuting, delivering goods, etc.—but all the cars in the world will never get you to another planet. Similarly, traditional computers are better for social media, Web browsing, word processing, etc.—but all the computers in the world will never solve the kinds of problems quantum computers can address.

Both space shuttles and quantum computers open up new worlds and new areas of exploration. And in both cases, we're not sure what we'll find. A key role for the next few years is figuring out the best questions to ask a quantum computer to solve. And we're excited to see what kinds of questions—and solutions—emerge.

SPACE TOURISM

CALLING FROM MARS

The human journey into the unknown ignites the imagination. Stories of exploration and adventure fuel the advance of science, focusing resources into new technologies. Now, for the first time since the last moon landing in 1972, we're poised to see human beings set foot on extraterrestrial soil: Mars. Forget Antarctica or Everest—this is the new ultimate destination!

SIGHTS ON THE RED PLANET

Most of the Mars-centric headlines right now are for a company named SpaceX, which generates press through a combination of impressive technology, bold claims, and the halo of futurism surrounding anything Elon Musk is involved in. But SpaceX is far from the only player aiming for Mars, though it has set out the most ambitious timeline: to put a human on Mars by 2025.

Boeing publicly challenged SpaceX for the Mars crown last October and is working with NASA on its mission. NASA has set a goal of putting humans on Mars "in the 2030's," but to-date, Boeing is less specific… it doesn't claim to know when it will get a human to Mars, it just claims it will be there before SpaceX.

Outside the US, China has plans to start exploring Mars, with probes on the planet's surface by 2020, but no date has been set for a manned mission to Mars. UAE is taking a longer view, with a hundred-year goal of having a 600,000 person city on Mars by 2117. In Europe, the non-profit Mars One, partnered with US-based Lockheed Martin, has a goal of having humans on Mars by 2032 as the first step in establishing a permanent settlement.

These entities are part of a much broader pool of competitors eyeing space ventures closer to home.

FROM EARTH TO THE MOON

Commercial space flight, hotels in low earth orbit and lunar fly-bys are all inching towards viability, bringing the dream of space tourism much closer to reality.

The most basic form of space tourism involves reaching an altitude above the Karman Line, generally agreed as the barrier between the earth's atmosphere and space. For several years, companies like Blue Origin and Virgin Galactic have been promising commercial flights just into the edge of space. From more than 62 miles above the earth's surface, passengers are promised a few minutes of weightlessness and a stellar view of the curve of the earth. To date, no company has been able to bring an offering safely to market, but Virgin Galactic has redoubled its efforts to start flights by the end of 2018. At that point, they can start working through the backlog of ~500 passengers who have already prepaid, at a cost of roughly $250,000 each.

Anything more than a quick jaunt into space causes costs to increase dramatically. The International Space Station orbits at roughly 220 miles above the earth. Between 2001 and 2009, seven civilians visited the International Space Station, with trip

costs rising from $20 million to $40 million during that time. These men and women are the first true space tourists.

NASA currently pays ~$80 million per astronaut for a round trip ticket on a Russian spacecraft. NASA's new contracts with SpaceX and Boeing are expected to reduce the costs to less than $60 million per passenger. In the near term, round trip tickets to any low-earth orbit space hotels (private space stations) would probably have similar transportation costs. But with more than 2,000 billionaires in the world, there's enough of a potential market to expect at least one privately-owned, tourist-friendly space station to open in the next few years.

To go past low earth orbit out to the moon is another jump in cost, likely due in part to the scarcity of available tickets. The planned SpaceX trip around the moon in 2018 is expected to have two private passengers at a cost of somewhere between $175 million and $300 million each, and deposits have already been paid for both seats, though the identity of the passengers has not been disclosed.

If you're short on funds for these extraterrestrial adventures, start saving your Bitcoins now. Space flight prices are anticipated to drop dramatically in the coming decades, with the long-term goal of $200,000 round trip tickets to Mars.

TRICKLE-DOWN TECHS

The race to make new space stories a reality is accelerating a host of ancillary research and technologies, many with potentially huge terrestrial effects. The transfer of space techs into daily life is nothing new—NASA technologies alone are responsible for more than 2,000 commercial products since its Technology Transfer Program started in 1976. But the growth of new and significant commercial players in the 21st century has resulted in a radical increase in the number of launches, scope and ambition; we're witnessing the new "space race." In this race, no matter which players come out on top, all of mankind is poised to benefit.

Some of the aircraft technologies being developed—particularly for near space flights—may see broader commercial applications within the next decade. Various patent filings and prototype tests for hypersonic aircraft are under way. Hypersonic craft travel at Mach 5 and above—at least 7 times faster than the top speed of an Airbus A380 or Boeing 787. These speeds could shorten Atlantic-crossing times to an hour, and London to Sydney times to as little as 2 hours, radically shrinking the world and changing the shape of global business.

The privatization of space flight is also serving to bring satellite launch costs down, opening the doors for a host of new space-

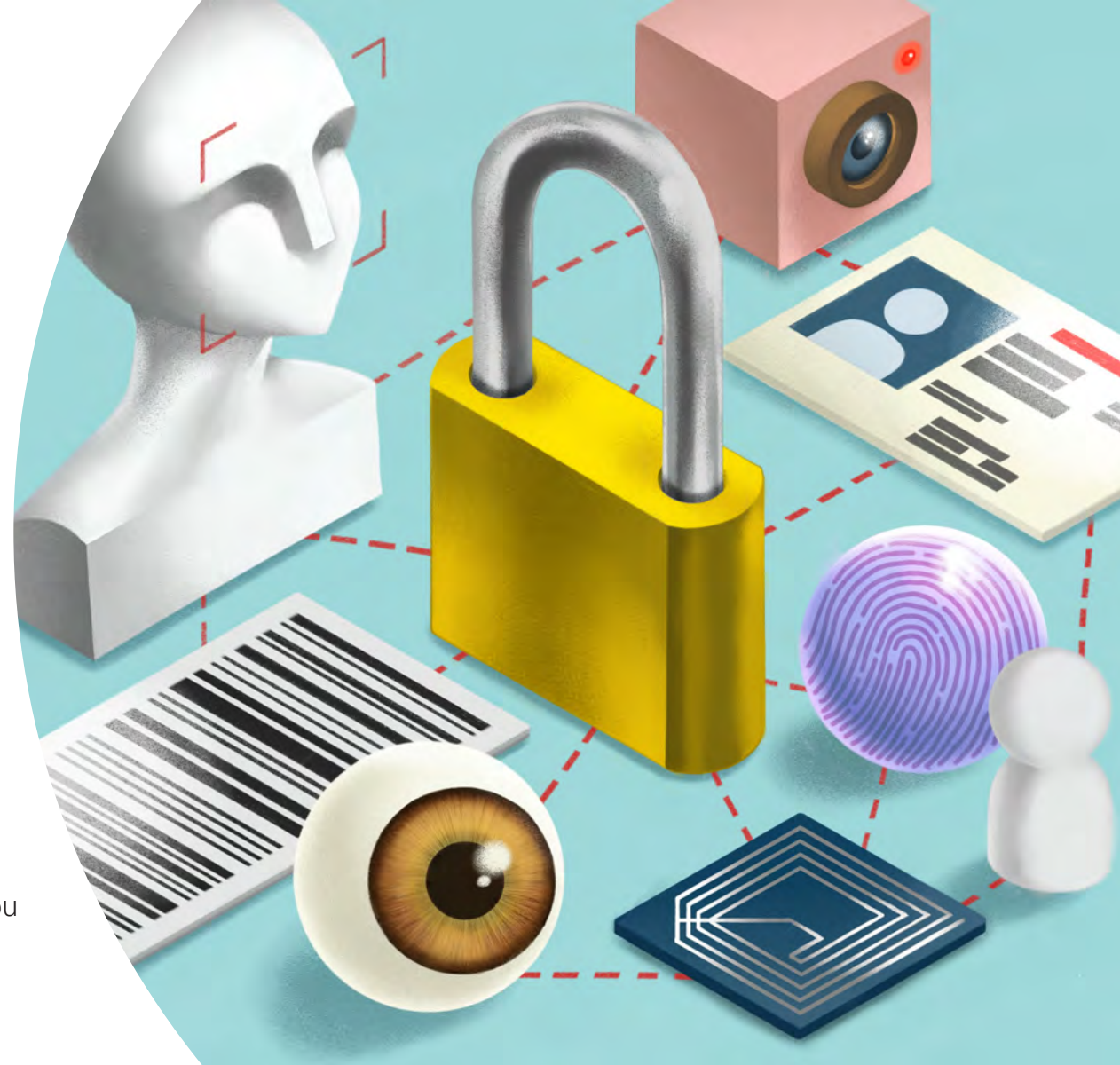
based research and businesses. Access to cheaper and more frequent space launches is also accelerating competition among satellite internet companies. ViaSat and EchoStar are already operational and Boeing, OneWeb and SpaceX have announced plans to launch more than 1,000 satellites each. Regardless of the company, constellations of high speed satellites will eventually have clear line-of-sight to every point on earth, theoretically making hi-speed Internet ubiquitous. The downstream effects of having hi-speed, wireless Internet everywhere in a seamless mesh are profound, particularly as it eases barriers to travel.

The possibility of space tourism becoming viable in our lifetimes is pretty astounding, and the certainty of how the 21st century space is poised to shrink our world is exhilarating!

TRUSTED **PRESENCE**

GOING SEAMLESS

"Grab and go" has been a retail dream for decades. The idea is encapsulated in a 1999 IBM ad called "The Future Market." It's a 60-second depiction of a man walking through a grocery store, tucking items inside his trenchcoat. As he exits, a security guard stops the man, but it isn't an arrest. Instead, it's setup for the only line of dialogue: "Excuse me sir, you forgot your receipt."



The ad shows shopping without registers, checkout lines, or credit card scanners. Instead, every item and identity is tracked, providing instantaneous verification and resolution when a customer walks out the door. At its root, the narrative is not just about seamless commerce—it's about trusted presence as a fundamental shift in security, privacy and identity.

NEED FOR TRUST

The travel industry is in the business of establishing trust—knowing the location and identity of people and objects is one of its most important responsibilities. And the technologies to make that possible mirror the retail world. Going through airport security is very similar to checking out at a grocery store: put everything on a conveyor belt, every item is analyzed, and identity is verified.

Unfortunately—for both travel and retail—vetting trust via these processes is a common pain point for people, bottlenecked by finite physical space and staffing. And both queues are similarly unpredictable: the same process can be 10X faster one day versus another, depending on the balance between demand and resources.

REINVENTING RETAIL

In a real world attempt at the kind of grab and go commerce depicted in the IBM ad, Amazon Go was launched in December at the corner of 7th Ave. and Blanchard St. in downtown Seattle. The store is still in beta testing, serving as a proof of concept for bringing together a range of complex technologies to increase efficiency and eliminate pain points for an everyday activity. Amazon is using pre-vetted individuals—in this case, its employees—as shoppers during the beta period while it refines the technologies used to make grab and go a reality.

Amazon is vague about how it's trying to achieve seamless commerce, chalking it up to a combination of "computer vision," "deep learning algorithms" and "sensor fusion"—the usual buzzword suspects. But presumably what these mean is that Amazon Go uses a network of cameras, RFID readers and other sensors to feed data into a set of algorithms focused on pattern recognition and classification, comparing the live stream of data with proprietary data sets (such as shopping histories and demographic profiles) to achieve a high certainty of billing the right people for the right items.

STREAMLINING TRAVEL

Trust is transactional—we choose to share information about ourselves to gain a measure of trust from another entity. The more information we share, the more trust we are given, the more streamlined our experience is likely to become.

Travel programs like EasyPASS (Germany), Smart Entry System (Korea), Global Entry (US), among others, aim to streamline travel through pre-vetting. Questionnaires, background checks and interviews establish trust for individuals, so that once identity is established a high degree of trust is automatically present.

The trick to going seamless is establishing identity quickly and accurately at every point in a journey. Today, clusters of technology similar to those in place at the Amazon Go market are in various stages of development and deployment to help expedite identity authentication in the travel process. The most rapid inroads are in airports. Australia has outlined the most ambitious goals of any country, planning to automate 90% of incoming international air travel processing by 2020, using a combination of facial recognition, fingerprints and iris scanning to identify passengers without the need to show passports.

In Germany, EasyPASS eGates scan passports and take photos of faces to ensure IDs and travelers match. For program enrollees, this almost completely automates border control (a human still stamps passports). Charles de Gaulle Airport in Paris is taking a similar approach, testing use of facial recognition and fingerprinting to expedite European Union citizens through border control.

Airlines are also looking to expedite proof of identity. In London, British Airways is using facial recognition for boarding. In Amsterdam, it's KLM. In the US, it's JetBlue. By testing facial recognition for boarding instead of for security clearance, all three airlines are starting with a high degree of trust—their passenger pool has already been vetted by security. Finnair is taking a different approach in Helsinki, using facial recognition for check-in; it's using a pool of 1,000 frequent fliers as its trusted trial group.

For many people, sharing information in exchange for convenience is an easy decision—particularly if they trust the recipients of their information. And this is a key part of trust; it goes both ways. Corporations and governments need to be able to trust individuals' identities, and individuals need to be able to trust corporations and governments to be responsible stewards of their personal information.

SEAMLESS BIOMETRICS

It's a beautiful truth that every person is unique. It's a relevant fact that the base implementations of virtually every biometric security measure have been shown to have flaws.

Some facial recognition systems can be fooled by photos, some voice identification systems can be triggered by recordings,

some fingerprint scanners can be bypassed by gummy bears. But as you add complexity, biometric systems quickly increase in security.

Facial recognition—key to most of the airline and retail initiatives—becomes exponentially harder to hoodwink when set up to require multiple camera angles for each profile. Instead of just needing a color printer, forging identity suddenly requires 3D modeling, facial masks and/or prosthetics. This alone is enough to deter all but the most determined and capable miscreants.

And when multiple technologies are used together identity is virtually assured. Common biometrics like facial recognition are being joined by newer biometric measures like breath, sweat, gait analysis, vein pattern recognition and body odor to add additional layers of security. It's one thing to mimic someone's face or voice or fingerprint or iris or sweat, but to do all five is Mission Impossible territory!

Travel is going seamless. But that future isn't based on any one proof of identity or single technology—it's in sensors and algorithms that account for multiple proofs of identity, aggregating in complete trust that you are you.

VR GETS **PHYSICAL**

TOUCHING NEW WORLDS

Virtual reality is about more than just immersing users in the sights and sounds of other places. The incorporation of tactile environments and sensory feedback is blurring the lines between VR and the physical world, becoming less “virtual” and more “reality.”

VR aims to engage as many senses as possible in the experience of another world. Its ultimate goal is to become like the Star Trek Holodeck—a space that can be anything, any when, anywhere, yet feels totally immersive, totally real. As VR technology matures towards this goal, the kinds of experiences available are diverging down two paths—stationary VR and room scale VR. Both paths are finding ways to increase engagement by bringing physical objects and tactile sensations into VR environments and by bringing people together to make VR a more social space.

When we enter into a virtual world, we bring with us our real experiences from the physical world. The closer the virtual experience aligns to physics and our human perspective, the more "natural" the experience feels, and the stronger the immersion. As we explore this new medium of VR, it's important to leverage the forms and functions we know as reality, while simultaneously stretching the realms of possibility.

TRAVEL WITHOUT MOVING

Stationary VR is what it sounds like – a user's body remains in one place, though they can freely look around within a 360-degree environment. For form and function to align, stationary VR works best when built around experiences that are largely stationary in the physical world.

The simplest kinds of immersive stationary VR experiences are for seated activities like watching movies, sports, concerts and theater. These don't require any physical sensation, and can be done from anywhere with very limited equipment. A growing number of events, performances, speeches, etc., are offering VR livestreams, allowing virtual attendance. Some platforms even allow social interaction—you and a friend watching the same event half a world away.

Many stationary experiences aim to be active, not passive. And VR has widely varying degrees of success in creating active stationary experiences. Some kinds of video games work really well from a stationary position, even in VR. If players are used to a gaming controller for navigation of simulated 3D environments, then moving from 2D screens to VR headsets isn't a significant leap.

On the other hand, when controllers are used for non-gaming immersive experiences—particularly for people not already accustomed to similar controls, the results can be disconcerting. One recent VR demo places users on the summit of a mountain. To see different views, users point a controller at predefined spots and click a button to move. In practice, the experience is like teleporting—a totally unnatural way to explore a mountain. It may be a great way to show different views, but the

experience of teleporting instead of walking or hiking breaks the illusion of being there.

In contrast, a growing number of VR experiences are based on activities that can be stationary in the real world, like cycling. Last year, a man cycled the entire 900 mile (1,500 km) length of the United Kingdom from an exercise bike in his living room, using Google Street View images as his 360 scenery for the trip. In his blog and videos, he speaks as if he's been to all the small towns and villages he biked through over the course of his 8 month trip; the experience felt real. And as mapping sophistication and photo quality continues to improve, it's easy to imagine a cycling experience that lets you ride any road on earth without ever leaving your home or gym.

Similar kinds of experiences for walking, running, rowing, sky-diving, etc., make sense for other pieces of stationary equipment, and also provide the chance for social engagement. Syncing audio and creating shared spaces could allow for anything from leisurely cycling trips through Italian wine country to head-to-head boat races down the Thames, to walking tours of Easter Island.

ROOMS TO MOVE

Room scale VR experiences are growing in number and complexity, split between home experiences, like the HTC Vive and Oculus Rift, and more sophisticated entertainment-driven commercial experiences. In room scale VR, a variety of sensors (mainly infrared sensors and cameras) are fixed throughout a room to track objects and people as they move within the space. Incorporating tracking sensors enables objects from the physical world—tennis racquets, swords, skateboards—to be incorporated into the virtual world. This makes it possible to walk, run, crawl, climb and use everyday objects within virtual experiences in a very natural way.

The challenge of room scale VR in homes is twofold: it requires a lot of open space (at a premium in most homes) and the specialized gear is expensive. These factors are giving rise to a new generation of arcades focused on shared VR experiences. There are thousands of VR arcades in Asia—more than 3,000 in China alone, and a growing number are opening in western countries. Many are focused on shared experiences, and tie-ins with Hollywood studios are helping cross-promote and engage more users.

But arcades aren't going to be the only places to experience high end VR outside the home. Oculus is installing 100 VR systems in libraries throughout California. The VR experiences will be free and preloaded with a breadth of educational content, like various space exploration titles and Google Earth VR, so

users can virtually explore almost any corner of this world and beyond. Schools, both public and private at all levels of education are also starting to make VR opportunities part of education. We hope to see similar experiences grow; VR has the potential to make amazing experiences and adventures available to everyone, regardless of background.

VR IN TRAVEL

With VR growing in prominence, the question many people ask is: [when] does VR replace travel?

There are plenty of questions about VR we don't know the answers to yet: How will VR storytelling evolve alongside film? What are the best ways to distribute VR content? How will people use collaborative VR platforms, like Facebook Spaces, to engage socially with one another?

We may not have all the answers, but in Labs, we firmly believe VR will never replace travel, but instead will augment and inspire travel experiences.

VR is a natural technology for inspiring real world travel and upselling premium experiences. In part, because VR helps make new kinds of experiences possible, especially around education. For instance, a VR tour through a simulated Rome at the height of the Roman Empire can provide deep historical context to make visiting modern Rome even more meaningful. VR can also help inspire local travel opportunities like diving with sharks or paragliding off a cliff—the VR experience is more accessible and can help people mentally prepare for real world experiences that may be at the edge of their comfort zone.

But the most important reason travel in the physical world is here to stay is authenticity. Authentic experiences matter, especially to rising generations of Millennials and Gen Z. And as VR experiences grow in number and prominence, the value of physical—real—experiences is likely to increase in value.

It is impossible to undervalue scarcity, and travel offers the opportunity to take people to countless unique places and experiences. Even if future neural interfaces make it difficult to project all five senses directly into the brain, it won't replace the luxury of really being present. Presence is a gift, and one we don't believe people will ever willingly give up. And that's great news for travel!

THANK **YOU**

We hope you enjoyed reading the Sabre Labs' Radar 2017 Report!

For questions, media inquiries and speaking requests, contact us at SabreLabs@Sabre.com.