



# CB DIGEST FOR TECHNOLOGY

JAN 11, 2020

Every week CB DIGEST scours many of newspapers, magazines, and websites, searching for the most intriguing tech stories and the most thoughtful things – left, right, and in-between. The CT DIGEST also reports on what the smartest people are saying about the world.

**CHAMBIZ** 

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### **Commerce Zooms in on AI Software for Geospatial Imagery Analysis**

On Monday, January 6, 2020, the US Department of Commerce's Bureau of Industry and Security published an interim rule that places additional export control restrictions under the Export Administration Regulations on certain automated geospatial imagery analysis software. The specific software that is subject to the interim rule is defined as follows:

Geospatial imagery software specially designed for training a Deep Convolutional Neural Network to automate the analysis of geospatial imagery and point clouds, and having all of the following:

1. Provides a graphical user interface that enables the user to identify objects (e.g., vehicles, houses, etc.) from within geospatial imagery and point clouds in order to extract positive and negative samples of an object of interest
2. Reduces pixel variation by performing scale, color and rotational normalization on the positive samples
3. Trains a Deep Convolutional Neural Network to detect the object of interest from the positive and negative samples
4. Identifies objects in geospatial imagery using the trained Deep Convolutional Neural Network by matching the rotational pattern from the positive samples with the rotational pattern of objects in the geospatial imagery

Technical Note: A point cloud is a collection of data points defined by a given coordinate system. A point cloud is also known as a digital surface model. Notably, to be caught by the rule, the subject software must be specially designed for training a Deep Convolutional Neural Network and satisfy all four of the listed criteria. The term "specially designed" is broadly defined and can in some cases capture software capable merely of use in or with Deep Convolutional Neural Networks. The determination of whether software is specially designed ultimately requires a fact-specific analysis, including a review of other intended uses of the software.

Under the interim rule, an export license will be required from BIS to export such software subject to the interim rule to every country except Canada. There is a 60-day comment period, ending March 6, 2020, during which interested parties may submit comments regarding the new export controls for BIS to consider in its final implementation of the rule.

### **Asana said to plan direct listing**

Project management software unicorn Asana is reportedly expected to go public via a direct listing next year, which would make it the latest prominent technology company to favor that approach over a traditional IPO. The San Francisco-based company, led by Facebook co-founder Dustin Moskovitz, may also raise money with a private share

### **5G and Autonomous Driving to Headline CES 2020, Says Wedbush's Ives**

5G and autonomous driving technologies are likely to be the two main themes of next week's Consumer Electronic Show (CES), Wedbush analyst Dan Ives wrote in an investor note on last Friday. With major wireless carriers such as Verizon and AT&T rolling out their initial 5G offerings over the last few months, CES attendees will be anxious to get their hands on new 5G-compatible devices from phones to laptops, and more. Ives said he expects announcements from chip makers Qualcomm and Intel about their 5G technology, as both are set to have a large presence at the show. Conference goers will also be able to see the latest in autonomous and connected vehicle technology from major automakers like Toyota, BMW, and Hyundai, which will reportedly show off its flying car concept.

Interestingly, Ives pointed out that Apple will be attending CES for the first time in decades. According to Bloomberg, Apple will be showcasing HomeKit, its system for controlling home devices such as motion sensors and

smart light bulbs. Smart speakers and home devices from Amazon and Google, as well as new AR and VR products, should also be a focus, Ives said.

### **CES 2020 Opens to the Media, Chock-Full of Smart Devices**

The showroom doors for the Consumer Electronics Show (CES) don't officially open until Tuesday morning, but on Sunday, the media was given a sneak peak at some of this year's gadgets from companies not named Google or Amazon. Perhaps not shockingly, the booths at Sunday's event—named CES Unveiled—were full of all things “smart.” Smart makeup mirrors let users ask Alexa about the weather. Smart pantry shelves notify users when their peanut butter jars are running low. Smart adult diapers are helping hospitals and nursing homes provide better care for patients. My favorite of the night was probably a smart mailbox called the “Parcel Guard,” which acts like a personal Amazon locker to protect against packages getting stolen from front porches. There were plenty of more traditional smart home devices as well, like door locks and security cameras. Monitoring water leaks in homes seemed to be a hot topic among these companies, including Alarm.com.

**Samsung shows off bizarre fitness exoskeleton and rolling robot at CES 2020.** Samsung unveiled a friendly home robot named Ballie that can roll around your house and has cameras on it. The electronics giant also showcased an exoskeleton system called GEM that works with augmented reality glasses. Samsung did not provide the launch date for the two products. Samsung's press conference was riddled with buzzwords when the company talked a lot about future experiences it hopes to deliver to consumers, but provided little detail on whether any of it is coming to the market anytime soon.

### **Infineon and PMD Present 5th Generation REAL3 Sensor**

Infineon has collaborated with software and 3D ToF system company pmdtechnologies to develop the world's smallest 3D image sensor measuring just 4.4 x 5.1 mm. It can be incorporated into even the smallest devices with just a few elements.

“With the fifth generation of our REAL3 chip we are once again demonstrating our leading position in the field of 3D sensors,” says Andreas Urschitz, President of the Power Management and Multimarket Division at Infineon, which also includes sensor business. “It's robust, reliable, powerful, energy efficient and at the same time decisively small. We see great growth potential for 3D sensors, since the range of applications in the areas of security, image use and context-based interaction with the devices will steadily increase.” The 3D sensor also allows the device to be controlled via gestures, so that human-machine interaction is context-based and without touch.

The new 3D image sensor chip (IRS2887C) was developed in Graz, Dresden and Siegen and combines the expertise of Infineon's and pmdtechnologies' German and Austrian locations. Series production will begin in the middle of 2020. In addition, Infineon Technologies offers an optimized illumination driver (IRS9100C) that further improves performance, size and cost as a complete solution.

**Apple's App Store platform grossed around \$50 billion in 2019, paid \$155 billion to developers since 2008.** Tech giant Apple reported around \$50 billion in sales from its App store last year, the company made the revelation during an [interview](#) with CNBC. The company also announced Wednesday that it has paid \$155 billion to developers since 2008, up from \$120 billion disclosed in January 2019. That means the company's App Store had total sales maxing out at \$50 billion in 2019, assuming developers take 70% of app sales, and generated about \$15 billion in revenue for Apple.

Healthtech startup ClassPass raises \$285M Series E to fuel global expansion and scale corporate wellness program. [ClassPass](#), a New York-based healthtech startup and leading global fitness and wellness marketplace, announced today it has closed \$285 million Series E investment to continue rapidly scaling its proprietary reservation and booking technology across the globe. The round, which was led by L Catterton and Apax Digital, with additional participation by existing investor Temasek, follows the successful expansion by ClassPass into 28 countries and the

signing of more than 1,000 leading employers into its corporate wellness program. Founded in 2013 by Payal Kadakia, ClassPass provides a flexible network of fitness and wellness experiences.

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**Union Square Ventures led a \$5M Series A funding in legal tech startup Juro.** London-based [Juro](#) announced it has raised a \$5m Series A to double-down on its data proposition, triple the size of its product team and continue to expand its growing customer base in the EU and US. The round was led by Union Square Ventures (USV) – the backers of Twitter, Twilio, Etsy and Kickstarter – in a rare US-to-Europe investment in legal tech. USV was joined in the round by existing investors including Point Nine Capital, Seedcamp, Taavet Hinrikus (co-founder of TransferWise) and Paul Forster (co-founder of Indeed). In conjunction with the funding, Juro also announced that John Buttrick, partner at USV, will join its Board.

**Cloudflare buys S2 Systems Corporation, the developer of patented browser isolation technology.** [Cloudflare](#), a San Francisco, CA-based provider of solutions that protect and accelerate any Internet application online, acquired S2 Systems Corporation, a Kirkland, Washington-based developer of patented browser isolation technology to improve the web browsing experience. The amount of the deal was not disclosed. As part of the acquisition, the S2 team has joined Cloudflare and is located at Cloudflare's new office in the Seattle metropolitan area. Cloudflare also expects to add S2's technology to Cloudflare Gateway, part of Cloudflare for Teams, a new security suite designed to protect corporate employees.

**Perch rebrands as Orchard; scores additional \$36M Series B to scale home buying marketplace.** [Orchard](#), the home buying marketplace startup that makes purchasing a home stress-free, fair and simple, announced today it has changed its name to Orchard. In conjunction with the rebranding, the startup also announced it has raised \$36 million in new equity funding to further invest in product innovation, hiring, and growth. The round, which was led by Navitas with participation from FirstMark, Juxtapose, and Accomplice, brings the company's total equity capital raised to \$69 million. Founded in late 2017 Court Cunningham and Phil DeGisi, the New York City-based Orchard is transforming the way people buy and sell their homes by bringing simplicity, convenience, and certainty to the process.

**HighRadius Raises \$125M in Series B Funding to Accelerate Growth.** [HighRadius](#), a provider of Artificial Intelligence-powered Order-to-Cash and Treasury Management software, raised \$125m in Series B growth funding to accelerate continuing platform development and expansion of its geographic reach. The round was led by Iconiq Capital, with participation from existing investors Susquehanna Growth Equity and Citi Ventures. Founded by CEO Sashi Narahari, the Houston, Texas-based HighRadius provides a SaaS AI powered integrated platform for accounts receivables and treasury management to more than 400 clients including more than 200 of the Forbes Global 2000.

**Healthtech startup Allurion Technologies raises \$34M to develop a medical device for ballon weight loss without surgery or endoscopy.** [Allurion Technologies](#), a healthtech startup developing a medical device for weight loss that can be delivered and removed without surgery or endoscopy, has raised \$34M in new funding to continue growing internationally and, subject to obtaining approval of the U.S. Food and Drug Administration (FDA), launching their revolutionary weight loss program in the United States. The new round, which came through a securities financing and a growth capital term loan, was led by Novalis LifeSciences and Romulus Capital with participation from IDO Investments and ex-Covidien CEO Jose Almeida. The financing also includes a growth capital term loan from Bridge Bank. Founded in 2009 by Samuel Levy and Shantanu Gaur, Allurion Technologies is dedicated to helping people realize their full potential with innovative, scalable and trusted experiences.

## **HP to Xerox: Drop Dead**

If Xerox thought that it could get HP a little more interested in talking about a merger by lining up financing commitments, HP has made clear that is not the case. In a short and to-the-point letter sent to Xerox's CEO on Wednesday afternoon, HP's board said the "financing does not address the key issue—that Xerox's proposal significantly undervalues HP—and is not a basis for discussion."

Xerox said earlier this week it had lined up the financing to cover the cash it needs for its \$33 billion cash-and-stock takeover offer for HP. Xerox made an offer to buy HP last November for \$22 a share, several dollars above HP's stock price that had hit a low of \$16.96 in early October. But HP, which is several times Xerox's size, has dismissed the offer as too low and also said it had concerns about Xerox's financial health. Despite the letter, HP stock was up slightly to \$20.93 on Wednesday (and a tad more after hours), a sign that investors at least expect the two sides to start talking.

## **mmWave auction adds another \$1 billion in bids**

The Federal Communications Commission's ongoing millimeter wave auction has added another billion in bids, bringing the total to more than \$6.1 billion. Bidding resumed yesterday after a break for the holidays. More than 14,100 licenses are up for grabs across three mmWave bands in Auction 103: the upper 37 GHz band (37.6-38.6 GHz), the 39 GHz band (38.6-40 GHz) and the 47 GHz band (47.2-48.2 GHz). The licenses are based on a Partial Economic Area geographic basis which divides the country into 416 sections.

There is more spectrum available at 39 GHz than in the other two bands, with 14 blocks of 100 megahertz available, or 5,824 individual licenses. The 47 GHz and upper 37 GHz bands each have 4,160 licenses available, or 10 blocks of 100 megahertz in each PEA. The FCC has authorized either fixed or mobile use in the bands, and the commission has emphasized the sheer amount of spectrum available: at 3,400 megahertz, it's the largest amount of spectrum ever offered in an auction.

The FCC has divided the spectrum into two categories of licenses: 24 100-MHz licenses in the 37 and 39 GHz frequency blocks, the MN or M/N licenses, and ten 100-MHz licenses in the 47 GHz frequency block, the P licenses.

Of the 832 total spectrum "products" (the MN and P licenses in each of the 416 PEAs), 305 had more demand than supply as of the close of round 29, another 127 had demand equal to supply, and 400 had more supply than demand.

## **Water-from-air startup awarded Smart Home Mark of Excellence at CES Las Vegas**

Israeli startup Watergen, which has developed a technology to make water from air, has been named winner of the Energy Efficiency Product of the Year in the 2020 Smart Home Mark of Excellence Awards at CES in Las Vegas for its GENNY product. The annual award, presented during CES by the Consumer Technology Association (CTA), recognizes the industry's top smart home innovations. The GENNY was also awarded a CES Best of Innovation Award in 2019.

**Facebook takes steps to remove 'deepfake' videos from its social media networks.** Yesterday, we wrote an article about Samsung researchers developed an AI system to convert an image into a Deepfake video. Today, Facebook announced that it would remove "deepfake" and other manipulated videos from its website to stop the spread of false information ahead of the 2020 presidential race, but U.S. lawmakers said those and other changes it has recently announced do not go far enough. "Why wouldn't Facebook simply take down the fake Pelosi video?" Florida Congressman Darren Soto, a Democrat, said. However, Facebook's vice president of global policy management, Monika Bickert, pointed out that Facebook recognizes the risks of manipulated media and that "its latest policy is designed to prohibit the most sophisticated attempts to mislead people."

**This California tech startup just unveiled 'Reverse microwave' that can chill bottle of wine in just three minutes at CES 2020.** An amazing 'reverse microwave' that can chill a beer, bottle of wine or soft drink in seconds has been unveiled at CES 2020. The Juno has been developed by California-based Matrix Industries, which specializes in body

heat-powered smartwatches. The ‘chiller’ uses a thermoelectric cooling engine that spins water around the beverage at high speed, rapidly decreasing the temperature of the can. As the container itself is held still, the contents will be ready to drink as soon as it comes out of the machine and won’t ‘fizz up’ and, according to Matrix.

### **WeWork Sells Software Firm Teem**

WeWork sold workplace management software firm Teem to enterprise software competitor iOffice on Friday, two people familiar with the matter said. WeWork bought Teem in September 2018 for more than \$90 million in cash. The sale to iOffice is believed to be for less than \$50 million, the people said. It’s the second sale that WeWork completed since announcing last fall it would try to sell or spin off at least five of its previously acquired companies. WeWork needs the cash and wants to focus on its office leasing business. It previously sold ad-tech firm Conductor. Other potential deals to watch include Meetup.com and Managed by Q, which has featured a bidding war between competitor Eden and a group fronted by Managed by Q’s departed founder. Teem sells software that lets employees book conference room space manage visitors, while giving companies analytics tools showing how people use their workspaces. It was founded in 2009 and originally raised about \$21 million from the likes of GV and Greycroft.

**Rivian raises \$1.3 billion in funding led by Amazon, others, for its electric utility and adventure vehicles.** Amazon among investors again as electric vehicle maker [Rivian](#) raises another \$1.3 billion. Back in February, we wrote about Rivian when Amazon led \$700 million investment in electric truck startup Rivian. With millions of gas guzzlers on the roads, Rivian believes it can reduce the Carbon dioxide emissions into the atmosphere, lower the carbon footprint world.

**BigID lands \$50M for data privacy**

BigID, a provider of machine learning and identity intelligence technology to protect enterprise customer and employee data, announced it has raised \$50 million in new funding from Tiger Global. The fundraising comes just four months after the New York- and Tel Aviv-based company secured its last round, also for \$50 million.

**The Guild raises \$25M for luxury suites**

The Guild, an Austin-based startup that turns upscale apartments into tech-enabled luxury suites, has raised \$25 million in a Series B round backed by a syndicate of venture and real estate investors. The 4-year-old startup plans to use the financing to launch in new markets and develop technology that will allow guests to personalize their stays.

**One Medical files for \$100M IPO**

Healthcare provider One Medical has filed to go public on Nasdaq, with plans to raise \$100 million in the offering. Founded in 2007, the San Francisco-based company offers a membership model for patients to access care virtually or at one of its clinics. The business, which has raised over a half-billion dollars in private funding, has been growing at a brisk pace but continues to lose money.

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**MedRisk Buys boutique specialty network provide Select Provider Networks.** [MedRisk](#), a King of Prussia, Pennsylvania-based managed care organization, has acquired Select Provider Networks, Inc. (SPNet), a provider of a boutique specialty network of physical and occupational therapists to the workers' compensation industry, from Select Medical. The amount and terms of the deal were not disclosed. Founded in 2008 by Select Medical, SPNet offers payers a prospective, managed rehabilitation solution to control physical medicine costs that includes a proprietary peer-to-peer utilization management system.

**BigID kicks off 2020 with \$50M to help companies secure customer data and satisfy privacy regulations.** New York-based identity management startup [BigID](#) kicks off 2020 with \$50 of new funding to further accelerate global sales, channel and product expansion. The round, which was led by Tiger Global, was secured less than four months after previously raising a \$50M Series C. The new capital will be used to deliver new products in privacy and protection of personal data along with expansion of go-to-market strategies across the globe. Founded in 2016 by Dimitri Sirota and Nimrod Vax. The startup consists of a team security industry veterans spanning the identity, data security, big data and governance markets. BigID develops a software that helps companies have a secure customer data and satisfy privacy regulations. Organizations are facing record breaches of personal information and proliferating global privacy regulations with fines reaching 4% of annual revenue.

**Alitheon secures \$14.9 million in funding led by BMW and others.** [Alitheon](#), a Bellevue, Wash.-based machine vision software startup, has closed a \$14.9 million in venture capital financing to expand its FeaturePrint technology across the defense, aerospace, aviation services, automotive, semiconductor, luxury goods, additive manufacturing, pharmaceutical and government sectors. The round was backed BMW i Ventures, IPD Capital and Shasta Ventures alongside current and former senior management from Accenture, Boeing and Fidelity. Co-founded by CEO Scot E. Land, Alitheon is a leader in advanced machine vision and artificial intelligence and creator of FeaturePrint™, a patented system that connects the physical and digital worlds via a secure and immutable link.

#### **Bain Capital wants billions for public equities**

Bain Capital is seeking to raise between \$5 billion and \$7 billion for a new fund that would pursue long-term investments in public equities, according to Bloomberg, a strategy that would continue the Boston-based firm's diversification away from its traditional buyout business.

#### **Insight Partners values Swiss software specialist at \$5B in latest takeover**

Software-focused Insight Partners has agreed to acquire Veeam in a deal that values the Swiss startup at \$5 billion. It's not the firm's first investment in Veeam, which offers a cloud-based data-backup platform and boasts annual sales exceeding \$1 billion. Insight made a minority investment in 2013 and participated in a \$500 million round last year.

**SaaS startup Docket raises \$1.5 million in seed funding to grow its team.** Docket, a cloud startup and a provide of SaaS platform for managing intelligent meetings, has secured \$1.5M in seed funding to grow the team in engineering, marketing and customer success, continue to invest in platform growth, adding new native solutions and expanding its library of integrations. The round was led by Allos Ventures with participation from High Alpha Capital, Elevate Ventures and Simon Equity Partners. Co-founded by CEO and SaaS veteran Darin Brown, the Indianapolis-based Docket is a meeting intelligence platform that enables and enhances every stage of the meeting by providing tools that create good habits.

**Corvus raises \$32 million to transform commercial insurance with AI.** [Corvus](#), an insurtech startup that offers Smart Commercial Insurance policies and innovative technology that utilizes new forms of data to predict and prevent claims, announced it has raised \$32 million Series B to predict and prevent losses for its corporate customers in the food and pharmaceutical industries. The latest round brings the Boston-based firm's total raised to \$46 million, following the \$10 million series A round in September 2018. The round was led by Telstra Ventures, with participation from Obvious Ventures and existing Corvus investors .406 Ventures, Bain Capital Ventures, and Hudson Structured Capital Management. Founded in 2017 by by a team of veteran entrepreneurs from the insurance and technology industries, Philip Edmundson, James McElhiney, and Mike Lloyd, and Corvus uses data across more than 50 criteria to predict and prevent losses for its corporate customers in the food and pharmaceutical industries.

**Quibi raises \$400M for its mobile-first video streaming service built for Millennials, launches April 6 at \$4.99 per month.** [Quibi](#) just raised \$400 million in funding from 49 investors, according to a filing with the Securities and Exchange Commission. The funding will be used for content and marketing, according to the Los Angeles Times. The names of the backers were not disclosed. In conjunction to the funding, Quibi also announced Wednesday, that it's launching April 6 at \$4.99 per month with ads or \$7.99 per month without ads. As part of the launch, Quibi will introduce more than 175 original shows and 8,500 short episodes in the 12 months following its launch, CEO Meg Whitman announced Wednesday during a keynote speech at CES in Las Vegas, with three hours of fresh content debuting daily. Unlike other streaming services out there, Quibi is differentiating itself by focusing on short-form videos, about ten minutes or less, across a mix of entertainment and news.

#### **North American startup funding dipped in Q4, but 2019 still outperformed**

The fourth quarter delivered a slight downer of an ending to a bullish year for North American startup investment. Overall, Crunchbase projects funding for the region totaled around \$31.6 billion across all stages in Q4, down slightly from the prior quarter and well below year-ago levels. For all of 2019, meanwhile, startup funding totaled roughly \$132 billion.

**The drumroll for 5G got louder at this year's big consumer electronics show in Las Vegas, where companies promised that everything from augmented reality glasses to autonomous vehicles to mobile streaming services will get a boost from the new wireless technology.**

By Nick Bastone

Predicting which technologies at CES—the giant consumer electronics show taking place here this week—will become part of our lives and when is always a crapshoot.

Personal robots, 3D television sets and a long list of operating systems and devices that debuted at the show in past years all ended up flopping. If there is one technology that attendees at this year's show regard as a sure bet, though, it is 5G, which promises to be more than just a mere generational change in wireless networking. It could well end up being the cornerstone upon which other consumer electronics—such as augmented reality and autonomous vehicles—build because of its promised speed and minimal networking delays.

“This CES is the drumroll to the introduction of 5G,” Daniel Ives, an analyst at Wedbush Securities, told us at the show. “I think now you realize that it's real and it's at this conference; it's not just a fluff theme.”

But signs of uneasiness loomed over the show, which sprawled across cavernous exhibition halls at the Las Vegas Convention Center and hotels down the Las Vegas Strip. The Consumer Technology Association—the electronics trade group that puts on CES—has been a vocal opponent of the trade war between the U.S. and China, saying that it threatens the rollout of new technologies, including 5G. President Donald Trump is scheduled to sign a phase one portion of a trade agreement with China next week that could postpone a new round of tariffs on imported laptops, smartphones and other devices, but the trade group is [still pressing](#) for a broader resolution of trade disputes between the nations.

In the meantime, the show gave a coveted keynote spot on Tuesday to Ivanka Trump, daughter of and senior adviser to the president. She used the opportunity to speak about the future of work. The speech [sparked controversy](#), including the Twitter hashtag #BoycottCES, among critics who felt there were much more qualified women to speak about technology. But Trump received a polite reception at her speech. Extending the speaking invitation to her couldn't have hurt the CTA's relations with the White House.

Here are the trends that caught our eye at CES this week:

- **5G is around the corner.** While mobile carriers in the U.S., including Verizon, AT&T and Sprint, have begun rolling out their 5G offerings in recent months, network coverage is still sparse. That hasn't mattered a whole lot so far since most people don't have 5G-ready devices, but that will change soon, proponents of the new wireless technology say.

Steve Koenig, vice president of research for the CTA, told reporters at the show that the organization estimates around 12% of new phones shipped in the U.S. this year will be able to run 5G, a figure that will jump to 63% by 2022.

Samsung, the world's largest smartphone maker, said that it shipped more than [6.7 million 5G-enabled smartphones last year](#) and in the coming months will release a 5G tablet, the first in the market.

The biggest reason device makers are so bullish about 5G is that it offers extremely low latency, promising

almost imperceptible transit times for data over the network. The upshot is that mobile devices can now push some of the computing functions they used to handle onto the cloud. That should translate into lower power consumption, smaller batteries and lighter devices.

At least that's the idea. Industry watchers expect some of the initial 5G phones to have [worse battery life](#).

We saw an interesting example of the possibilities of 5G from a startup called Orbi Prime, which will soon begin testing a technology with Verizon that could allow it to stream virtual reality video from the helmets of NFL players via 5G stadium antennas to consumers at home with VR headsets (Orbi Prime doesn't have an NFL deal, though Verizon has a relationship with the league).

- **Augmented reality is building steam.** Techies looking for the next big thing have earnestly started talking up AR, which overlays digital imagery on lenses inside glasses or headsets.

At CES, some executives, such as Paul Travers, CEO of AR startup Vuzix, argued that the technology will be appealing to consumers sooner than that. While Vuzix currently makes AR glasses for enterprises—which have generally been more tolerant of bulky headgear than consumers are—Travers believes 5G will soon enable mass-market product designs with better battery life and lower prices.

“It's not years,” Travers said. “It's not this week, but it's not far away.”

Vuzix has partnered with Verizon and Sprint, and plans to use 5G from their networks to move computing functions into the cloud.

The prospect of Apple and Facebook invading AR should, in theory, be worrisome for smaller companies like Vuzix. But Travers insists that the arrival of headsets from those large companies will be positive for his company. “The minute any one of those is off to the races, all the other guys that didn't figure it out are going to be like, ‘We gotta get going. We gotta solve this problem.’ And we are a great partner for them,” he said.

- **An explosion in streaming services.** Entertainment executives used CES to pitch a wave of new internet streaming services that will arrive in the coming months. Executives from WarnerMedia and NBCUniversal headlined conference talks at the posh Aria hotel where they discussed HBO Max and Peacock, their respective new services. And DreamWorks co-founder Jeffrey Katzenberg and former HP CEO Meg Whitman officially unveiled their new short-form, mobile-only video service, Quibi, in a keynote at the show.

The expansion of 5G could help the adoption of services like Quibi by greatly accelerating mobile streaming speeds. However, Quibi, which will launch on April 6, doesn't have to wait for the technology to catch up. In an interview, Quibi's chief technology officer, Rob Post, said the streaming service is a “perfect use case” for 5G. But when we asked if 5G would help spur user adoption, Quibi's chief product officer, Tom Conrad, said it won't be essential for Quibi.

“I think Quibi adoption is going to be faster than 5G adoption, so it'll be a tailwind, but I don't think it'll be the thing that defines our success,” Conrad said.

- **Vehicles get a wireless boost.** Automakers are already beginning to plot ways they can exploit 5G in their vehicles. The German luxury automaker BMW announced that it will equip its new iNext electric SUV with 5G when it hits showroom floors in 2021. James Mallinson, the head of vehicle connectivity at BMW, told me that the technology will provide better entertainment options for riders, such as streaming 4K videos and enabling on-board gaming (cloud gaming services like Google's Stadia could be especially good fits for 5G).

In the future, 5G connections will enable more-advanced forms of autonomous driving. For instance, if a vehicle

has an accident, it will be able to alert the cars behind it via 5G so they know to reroute, Mallison said. And when traffic signals have the proper sensors, they will alert cars that they'll be turning red in 10 seconds so the autonomous vehicles won't have to slam on the brakes. Realizing these capabilities will require infrastructure investments, though. Mallinson said China especially has been investing heavily in this area.

BMW is also rethinking the interior design of its cars as its self-driving technology progresses. When cars are fully autonomous, drivers will want more comfortable seating options for long-distance road trips, Ernst Fricke, BMW's vice president of Requirements, Concepts and Integration, told me. To address that need, at CES this year BMW introduced the ZeroG Lounger, a reclinable car seat that's meant to give passengers the sensation that they are floating in space. We sat in a ZeroG Lounger, which will be ready for production vehicles in a few years, and we didn't want to get out of it, especially after hoofing it around CES for three days.

- **The wacky side of CES lives on.** Part of the charm of CES is the wild technology ideas that seem half-baked, weird or just unlikely to ever succeed. Samsung, for instance, at this CES introduced [Ballie](#), a small, round robot that follows people around their homes, helping them raise their curtains in the morning or activating a Roomba vacuum cleaner when spills happen.

Ballie is also supposed to act as a pet-like companion to its users, without the hassles of pet ownership. Other personal and therapeutic robots were scattered throughout the show, including my favorite, [Qoobo](#), a furry cushion that wags its tail when rubbed.

The South Korean electronics maker LG, meanwhile, showed off a new refrigerator-size [gardening appliance](#) that allows people to grow fresh herbs and vegetables inside their kitchens, automating light, temperature and water settings.

CES has always been one of the first places where exotic new designs for television sets show up. Samsung caused a stir this year with its Sero TV, which rotates to a vertical orientation—helpful for Gen Zers who are looking for ways to watch their TikTok videos on big screens.

By Dean Bublely

**Predictions include power-shaming indicators, bonded 5G/6G and Wi-Fi 9, multi-network software-defined connectivity, contextual communications in IoT devices and Alexa bots.**

While everyone is doing their predictions for 2020, here's my look into 5-10 years out to consider what telecoms, wireless and related technologies will look like in 2030. A decade from now, we could see things like power-shaming indicators, bonded 5G/6G and Wi-Fi 9, multi-network software-defined connectivity, contextual communications in IoT devices and Alexa bots.

If you read my articles and tweets, you probably know what I think about 2020 already. Private cellular networks will be important (4G, initially). 5G fixed wireless is interesting and will grow the FWA market – but won't replace fiber. 5G is "just another G" and is overhyped, especially until the new core matures.

So, at the start of the 2020s, what about the next decade? Assuming I haven't retired to my palatial Mars-orbiting private moon in 10 years' time, what do I think I'll be writing, podcasting (or neural-transmitting) about in 2030? Let's have a few shots at this more-distant target...

- **6G:** In 2030, the first 6G networks are already gaining traction in the marketplace. The first users are still fixed connections to homes, and personal devices that look a bit similar to phones and wearables, but with a variety of new display and UI technologies, including contact lenses and advanced audio/haptic interfaces. 6G represents the maturing of various 5G concepts (such as the new core), plus greater intelligence to allow efficient operation.
- **Details, details:** Much of the 2020s will have been spent dealing with numerous back-office problems that have stopped many early 5G visions becoming real. Network-slicing will have thrown up huge operationalisation and security issues. Dealing with QoS/slice roaming or handoff, at borders between networks (outdoor / indoor / private / neutral / international) will be hugely complex. Edge computing scenarios will turn out to need local peering or interconnection points. All of these will have huge extra complexities with billing, pricing and monitoring. mmWave planning and design tools will need to have matured, as well as the processes for installation and operation.
- **Device-network cooperation:** By 2030, mobile ecosystems and control software will break today's silos between radio network, devices and applications much more effectively. Sensors in users' devices, cell-towers and elsewhere will be linked to artificial intelligence (AI) which works out how, why, and where people or Internet of things (IoT) objects need connectivity and how best to deliver it. Recognize a moving truck with machine-vision, and bounce signals off it opportunistically. Work out that someone is approaching the front of a building, and pre-emptively look for Wi-Fi, or negotiate with the in-building neutral host on a marketplace before they enter the door. Spot behavioral patterns such as driving the same route to work and optimize connectivity accordingly. Recognize a low battery and tweak the "best-connected" algorithm for power efficiency, and downrate apps' energy demand. There will be thousands of ways to improve operations if networks stop just thinking of a "terminal" as just an endpoint and look for external sources of operational data – that's a 20th century approach. Expect Google's work on its Fi MVNO & Android/Pixel phones, and similar efforts by Samsung and maybe Apple, Qualcomm and Arm, to have driven much of this cross-domain evolution.

- **Energy-aware networks:** Far more energy-awareness will be designed into all aspects of the network, cloud and device/app ecosystem. How best to optimize wired/wireless data for power demand, where best to charge devices, “scavenging” for power and so on. Maybe even “nudge” people to lower-energy applications or consumption behaviors by including “power-shaming” indicators. If 3GPP and governments get their act together, as well as vendors, overall 6G energy use will be a higher priority design-goal than throughput speed and latency.
- **Wi-Fi:** We’ll probably be on Wi-Fi 9 by 2030. It will continue to dominate connectivity inside buildings, especially homes and business premises with FTTX broadband. It will continue to be used for primary connectivity on high-throughput / low-margin / low-mobility devices like TVs and display screens, PC-type devices, AR/VR headsets and so on. It will be bonded together with 5G/6G and other technologies with ever-better multi-path mechanisms, including ad-hoc device meshes. Fairly little public Wi-Fi will be delivered by “service providers” as we think of them today. We’ll probably still have to suffer the “6G will kill Wi-Fi” pundit-pieces and hype, though.
- **Spectrum:** The spectrum world changes slowly at a global level, thanks to the glacial 4-year cycle of ITU WRCs. By 2030 we will have had 2023 and 2027 conferences, which will probably harmonize more spectrum for 5G/6G, satellites & high-altitude platforms (HAPS) and Wi-Fi type unlicensed use. The more interesting developments will occur at national / regional levels, below the ITU’s role, in how these bands actually get released / authorized – and especially whether that’s for localized or shared usage suitable for private networks and other innovators. I think we’ll be closer to some of the “spectrum-as-a-service” models and marketplaces I’ve been discussing over the last 24 months, with more fluid resale and temporary usage permits. International allocations will still differ though. We will also see much more opportunism and flexibility in band support in silicon/devices, and more sophisticated approaches to in-band sharing between different technologies. I’m less certain whether we will have progressed much with commercialization of mmWave bands 20-100GHz, especially for mobile and indoor use.
- **Private/neutral cellular:** Today, there are around 1,000 MNOs globally (public and private). By 2030, I’d expect there to be between 100,000 and a million networks, probably with various new types of service provider, aggregation hubs and consortia. These will span industrial, city, office, rural, utility, “public venue” and many other domains. It will be increasingly hard to distinguish private from public, eg with MNOs’ campus networks with private cores and hybrid public/private spectrum. Some networks will look like micro-telcos (eg an airport providing access to caterers & airlines) and will need billing, management & security tools – and perhaps new forms of regulation.
- **Security & privacy:** Both good and bad guys will be armed to the teeth with AI. We’ll see networks attacked physically as well as logically. We’ll see sophisticated thefts of credentials and what we quaintly term “secrets” today. There will be cameras and mics everywhere. Quantum threats may compromise encryption – and other quantum tools may enhance it, as well as provide new forms of identity and authentication. We will need to be wary of threats within core networks, especially where orchestration and oversight is automated. I think we will be wise to avoid “monocultures” of technologies at various levels of the network – we need to trade off efficiency and scale vs. resilience.
- **Satellite / HAPS:** We’ll definitely have more satellite constellations by 2030, including some huge ones from SpaceX or others. I have my doubts that they will be “game-changers” in terms of our overall broadband use, except in rural/remote areas. They won’t have the capacity of terrestrial networks, and signals will struggle with indoor penetration and uplink from anything battery powered. Vehicles, planes, boats and remote IoT will be much better-connected, though. Space junk and cascading-collision scenarios like the movie Gravity will be a worry, though. I’m not sure about drones and balloons as HAPS for mass-market use, although I suspect they’ll have some cool applications we don’t know today.

- **Cloud & edge:** The bulk of the world’s computing cycles and data storage will continue to occur in massive data centers (perhaps heading towards a terawatt of aggregate power by 2030) and on devices themselves, or nearby gateways. But there will be a thriving mid-market of different sorts of “edge” as I’ve covered in many posts and presentations recently. This will partly be about low latency, but not as much as most people think. It will be more about saving mass data-transport costs, protecting “data sovereignty” and perhaps optimizing energy consumption. There will be a lot of value in the overall orchestration of compute tasks for applications between multiple locations in the ecosystem, from chip-level to hyperscale and back again. The fundamental physical quantum of much edge compute will be mundane: a 40-foot shipping container, plonked down near sources of power and fiber.
- **Multi-network:** We should expect all connectivity to be “software-defined” and “multi-network”. Devices will have lots of radios, connecting simultaneously, with different paths and providers (and multiple eSIM / other identities). Buildings will have multiple fibers, wireless connections and management tools. Device-to-device connections and relaying will be prevalent. IoT will use a selection of LPWAN technologies as well as Wi-Fi, cellular and short-range connections. Satellite and maybe LiFi (light-based) connections will play new roles. Arbitrage, bonding, load-balancing will occur at multiple levels from silicon to OS to gateway to mid-network. Very few things will be locked to a single network or provider – unless it has unique value such as managed security or power consumption.
- **Voice & messaging:** Telephony will be 150 years old in 2026. By 2030 we’ll still be making some retro-style “phone calls” although it will seem even more clunky, interruptive, unnatural and primitive than today. (It won’t stop the cellular industry spending billions upgrading to Vo6G though). SMS won’t have disappeared, either. But most consumers will communicate through a broad variety of voice and video interaction models, in-app, group-based, mediated by an array of assistants, and veracity-checked to avoid “fake voice” and man-in-the-middle attacks of ever-increasing subtlety.
- **Enterprise comms:** Collaboration tools will progress steadily, if unspectacularly – although with ever more cloud focus. There will be more video, more AI-enriched experiences for knowledge management, translation, whispered coaching and search. There will be attempts to reduce travel to meetings and events as carbon taxes bite, although few will come close to the in-person experience or effectiveness. Ever more communications will take place “contextually” – within apps, natively supported in IoT devices, or with AI-based assistants. Contact centers and customer interactions will be battlegrounds for bots and assistants on both sides. (“Alexa, renegotiate my subscription for a better price – you have permission to emulate my voice”). Security and verification will be highly prized – just because something is heard doesn’t mean it will match what was originally spoken
- **Network ownership models:** Some networks of today will still look mostly like “telcos” in 2030, but as I wrote in [this post](#) the first industry to be transformed by 5G will be the telecom industry itself. We’ll see many new stakeholders, some of which look like SPs, some which are private network operators, and many new forms of aggregator, virtual operator, wholesale or neutral mobile/fiber provider. I think regulations will favor more sharing of assets where it makes sense. Individual industries will take control of their own connectivity and communications, perhaps using standardized 5G, or mild variations of it. There will be major telcos of today still around – but most will not be providing “slices” to companies and offering deep cross-vertical managed services.

By Maurizio Di Paolo Emilio

A processor that allows control of many qubits simultaneously and will facilitate the development of larger and more complex quantum computing systems.

Intel has unveiled a new hardware solution focused on quantum computing: Horse Ridge is the first cryogenically-controlled processor designed to accelerate the development of full-stack quantum computing systems.

Quantum computers promise to address problems that conventional computing solutions cannot handle. The underlying technology is quantum physics; since a quantum bit (or qubit) can exist simultaneously in multiple states, it can be used to conduct a large number of calculations at the same time, significantly speeding up the resolution of complex problems.

At the beginning of the development of quantum computing, scientists focused on the realization of qubits. If we imagine the bit like a coin that, once launched, can reveal its face with the value 1 or 0, a qubit (quantum bit) is a coin that spins like a spinning top — allowing it to have more values simultaneously — until it is stopped to read the measured value. Those organizations pursuing silicon quantum processors (there are several other than Intel) that measure the property of electron spin.

Quantum computers can perform a large number of calculations at the same time, but in doing so, they generate excessive amounts of heat. Consequently, to be effective, they must operate at temperatures close to absolute zero (i.e., very close to  $-273.15\text{ }^{\circ}\text{C}$ ).

These devices, which are often custom-designed, tend to require hundreds of cables in and out of the cryogenic fridge to control the quantum processor, making many quantum computing systems look like weird steampunk machines, with cables popping out from all sides (Fig. 1).

Researchers are in a furious race to build quantum computers. In the early years of quantum hardware development with testing and characterization, Intel identified a significant bottleneck toward the realization of quantum processing on a commercial scale: interconnections and control electronics.

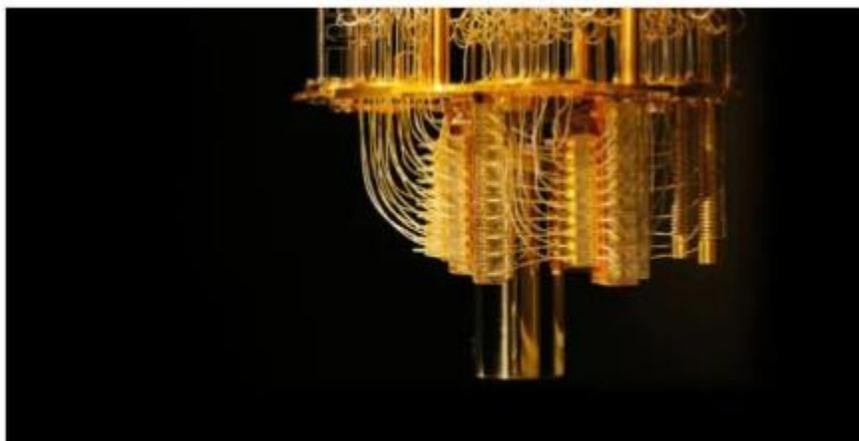


Figure 1: Google quantum computers

Horse Ridge, named after one of the coldest places in Oregon (where Intel has some of its most extensive operation), was developed together with QuTech researchers, a partnership between TU Delft and TNO (Netherlands Organization for Applied Scientific Research). In the race to create quantum computers, many are focusing on implementations in silicon, in large part because silicon quantum computers can be made using common CMOS silicon processing. Horse Ridge was manufactured using Intel's 22-nanometer FinFET process. This should dramatically accelerate Intel's ability to design, test, and optimize a commercial quantum computer.

Jim Clarke, director of quantum hardware at Intel, explained that, until now, much emphasis has been placed on the qubit itself, but one of the main challenges is the simultaneous control of multiple qubits. Intel's new chip simplifies the design and size of quantum computers.

Horse Ridge is a highly integrated mixed-signal system on chip (SoC) that reduces the complexity of quantum control engineering. It is programmed with instructions that correspond to basic qubit operations. The SoC translates these instructions into electromagnetic microwave pulses that can manipulate the state of the qubits.

A quantum computer works in the milliKelvin range, which is only a fraction of a degree above absolute zero. Silicon spin qubits have properties that could allow them to operate at 1 Kelvin or higher temperatures, which would drastically reduce the cooling challenges of quantum technology.

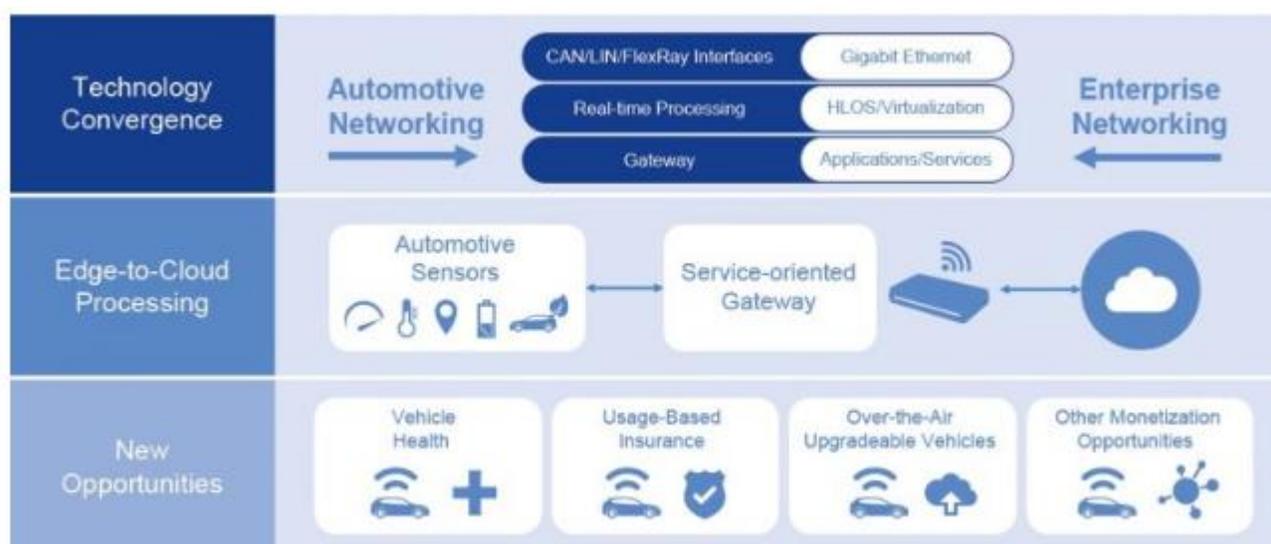
Intel aims to ensure that cryogenic controls and qubit spindles operate at the same temperature level to create more advanced and compact solutions. By making it easier to control multiple qubits, Horse Ridge is helping to define a path toward scaling more complex systems. Intel expects the result to be more easily manipulated quantum computers that will also allow the company to leverage its expertise in advanced packaging and interconnected technologies.

Intel's investment in research and development ensures a complete hardware and software base in the development of an efficient and commercially viable quantum system. It is necessary to stress the importance of small-scale quantum systems to demonstrate the absolute potential of qubits. In Horse Ridge, Intel has developed a scalable control system that should accelerate the testing and the potential of quantum computing.

By Junko Yoshida

NXP Semiconductors is coming to the Consumer Electronics Show to launch a new “Automotive Network Processor.”

NXP’s S32G is “a single-chip version” of two processors — an automotive microprocessor and an enterprise network processor — combined, said Ray Cornyn, vice president and general manager, Vehicle Dynamics Products. The S32G functions as a gateway processor for connected vehicles, as it offers enterprise-level networking capabilities. It also enables the latest data-intensive ADAS applications while providing vehicles with secure communication capabilities, he explained.



*What NXP S32G entails (Source: NXP Semiconductors)*

A closer look inside the S32G reveals a car OEM wish list for next-generation vehicles in 2021 and beyond.

Among the wishes are: over-the-air software updates — à la Tesla — to make vehicles “software upgradeable,” a shift to new domain-based vehicle architectures (i.e., consolidation of ECUs), beefed-up security features (including intrusion detection/monitoring), the vehicle’s ability to analyze data on the edge without constantly depending on the cloud, and upgraded safety to ASIL D.

In “connected vehicles,” car OEMs are looking for new business opportunities, including subscription models and usage-based insurance.

“It is a worldwide trend among car OEMs to bring all these new business opportunities and capabilities to next-generation vehicles,” said Brian Carlson, director, product line management for vehicle network processors at NXP.

If a software-upgradeable car is the automotive industry’s objective, the S32G seems designed to bring car OEMs a step closer.

Phil Magney, Founder and Principal at VSI Labs, observed that S32G “is designed to serve as the gateway to

centralized domain processing, which is the supporting architecture of the software-defined car. Furthermore, new vehicle architectures must support tremendous volumes of data through multiple interfaces.”

He noted, “Up until this point, networking has been a bit of an afterthought. But in reality, it is quite critical since there is so much data moving around the vehicle. The S32G can handle all the plumbing and associated security, timing, and safety requirements.” He added that there are many network controllers designed by major chip suppliers and Tier Ones. But among existing network processors, “I have not seen anything that aggregates everything into one chip like the S32G.”

The new processor is already sampling, and car OEMs are currently testing S32G, said Carlson. To demonstrate the appeal of S32G among key automotive players, NXP, in its press release, shared a quote from Bernhard Augustin, Audi’s director of ECU Development Autonomous Driving: “We found the unique combination of networking, performance, and safety features of the S32G processor to be ideal for use in our next-generation ADAS domain controller.”

### S32 family of processors

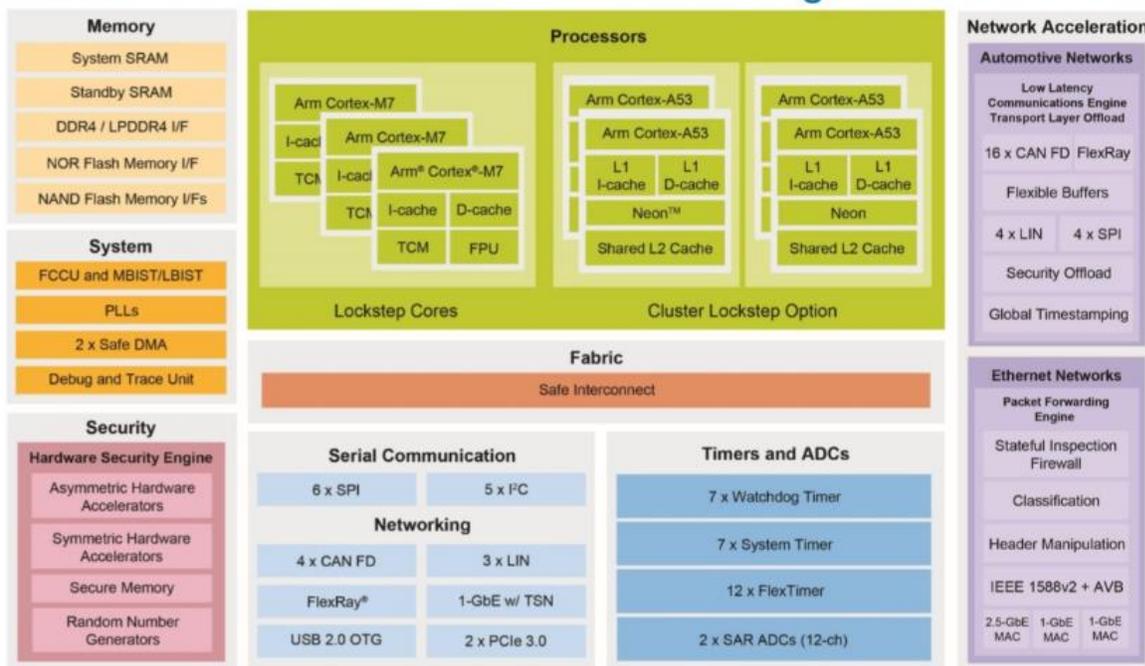
S32G is part of NXP’s S32 family of processors based on a unified architecture of high-performance MCUs, MPUs, application-specific acceleration, and interfaces. The S32 family, designed to be scalable, allows developers to create software in a uniform environment across application platforms. The goal is to let developers reuse their expensive R&D work, shortening time to market as the automotive industry copes with rapid changes in vehicle architectures over the next several years.

NXP noted that the platform maintains “automotive quality, reliability, and ASIL D performance across multiple application spaces throughout vehicles.”

### Vehicle network processor

First and foremost, S32G provides an unprecedented level of networking and processing capabilities. Shown in the block diagram below, the S32G processor incorporates lock-step Arm Cortex M7 microcontroller cores and an industry-first ability to lock-step clusters of Arm Cortex-A53 application cores.

## S32G274A Vehicle Network Processor High-level Block Diagram



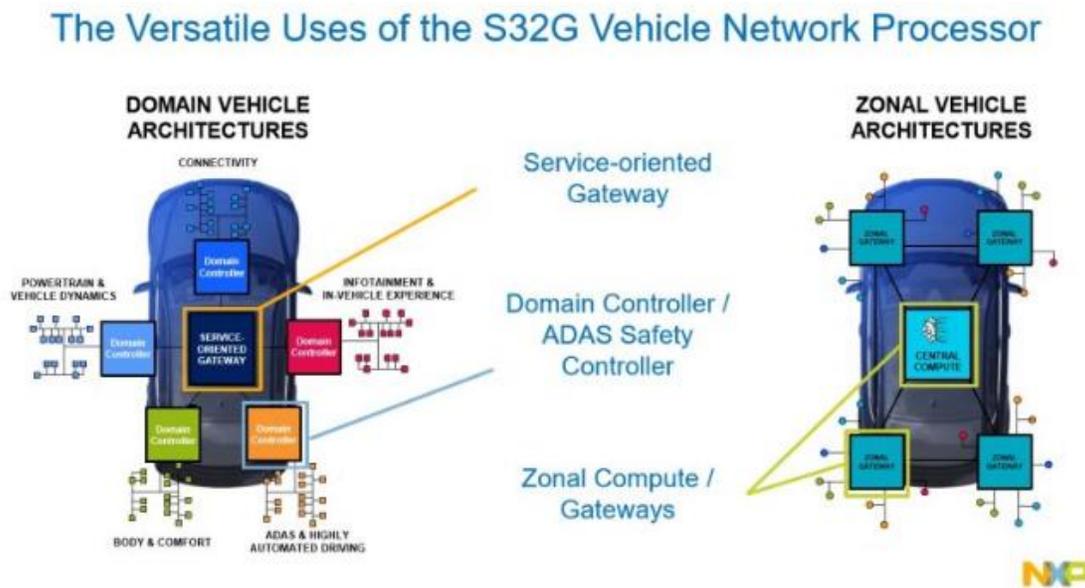
As the amount of data collected and transported inside a vehicle grows exponentially, the processor’s ability to accelerate automotive networks and Ethernet packets becomes increasingly critical, Carlson explained. It’s one thing to tout a networking processor’s ability to handle large data. But it’s a whole different story if the chip can actually accelerate data processing. Without acceleration, the vehicle network can easily bog down, said Carlson, making it impossible for the new vehicle to offer critical services with the deterministic network performance demanded by car OEMs.

S32G processors are designed to offload transport layers so that its communication engine can achieve low latency, he noted. S32G features “network acceleration blocks” designed for automotive and Ethernet networks. Included in S32G network features are 20× CAN/CAN FD Interfaces, 4× Gigabit Ethernet Interfaces, and a PCI Express Gen 3 Interface. As a comparison, Magney noted that Tesla “supports six CAN channels, four Ethernet channels, and eight serial lines for the cameras.” Calling Tesla “a proxy for future vehicle architectures,” Magney said, “Not surprisingly, NXP supplies Ethernet and CAN controllers to Tesla.” Other key features integrated inside the S32G are security and safety.

The S32G, like all other S32 platform processors, embed high-performance hardware security acceleration, along with public key infrastructure (PKI) support for trusted key management, enabled by its Hardware Security Engine (HSE). The firewalled HSE is the root of trust supporting secure boot, providing system security services, and protecting against side-channel attacks. As for safety, S32G processors offer full ASIL D capabilities, including lock-step Arm Cortex M7 microcontroller cores and an industry-first ability to lock-step clusters of Arm Cortex-A53 application cores, allowing new levels of safety performance with high-level operating systems and larger memory support.

### Versatility of S32G

NXP’s Carlson made the point that the beauty of S32G lies in its versatility. The S32G can be used in many different places inside a vehicle — ranging from a gate processor to a domain controller and ADAS safety processors.



Where in a vehicle S32G can be used (Source: NXP)

VSI Labs’ Magney observed, “The S32G appears complementary to many of the AV or ADAS domain controllers because it consolidates a handful of chips into one.” He added, “Otherwise, the functionality of the S32G would be scattered with multiple transceivers and controllers to handle all the data traffic. The S32G also contains all the critical timing elements, memory, security, and network accelerators necessary to support all the data being passed around inside the vehicle.”

**The trend of investment in and acquisition of mobile robotic companies seeking to automate the movement of goods within warehouses, fulfillment centers, and manufacturing facilities is still rising. Only in recent months, IDTechEx has seen three notable activities: Amazon, Shopify, and Teradyne acquired Canvas Technology, 6 River Systems, and AutoGuide, respectively.**

The following discussion is based on our report "Mobile Robots, Autonomous Vehicles, and Drones in Logistics, Warehousing, and Delivery 2020-2040". This report provides a comprehensive analysis of all the key players, technologies, and markets. It covers automated, as well as autonomous carts and robots, automated goods-to-person robots, autonomous and collaborative robots, delivery robots, mobile picking robots, autonomous material handling vehicles such as tuggers and forklifts, autonomous trucks, vans, and last-mile delivery robots and drones.

IDTechEx provides technology roadmaps and 20-year market forecasts, in unit numbers and revenue, for all the technologies outlined above (13 forecast lines). IDTechEx built a 20-year model because their technology roadmap suggests that these changes will take place over long timescales. In their detailed forecast, IDTechEx clearly explains the different stages of market growth and outlines the key assumptions/conditions, as well as data points that underpin their model.

### Recent acquisitions: why companies pay such high multiples

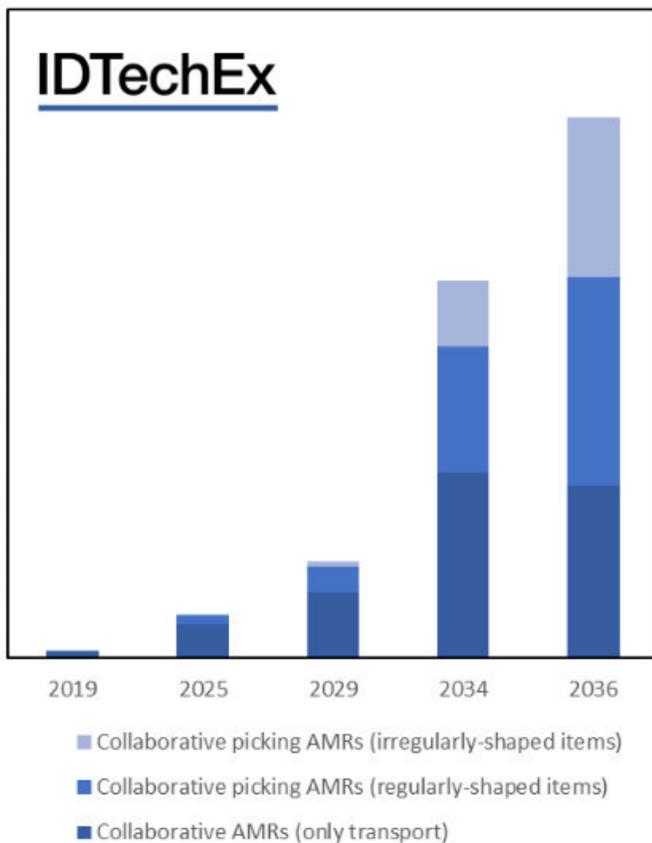
Canvas Technology, a company based in Colorado, had developed an advanced navigation technology, enabling its mobile platforms to achieve intelligent autonomous mobility. The company had developed navigation algorithms based on high-definition RGB cameras, enabling the robot to detect and classify objects. This is an advancement

over earlier generations in which the navigation was achieved using only 2D ranging lidars. The additional object detection and classification capability enable the robot to operate in more dynamic, complex, and challenging environments and to achieve more intelligent path planning in response to different objects and environments. In short, it puts the company on a technology roadmap with ample room for development and improvement.

Previously, Amazon famously acquired Kiva Systems in 2012 for a huge \$775 million. This technology has allowed Amazon to boost the productivity of the latest generation of its fulfillment centers by automating the goods-to-person step. The robot fleet is estimated to have increased at an approximate rate of 15k or so robots per year and was estimated to have recently reached 100k units.

The latest acquisition should be seen within the same trend of automating fulfillment. The technology of Canvas allows automation to be implemented in existing centers whose infrastructure cannot be readily altered to enable Kiva-like goods-to-person autonomy. Furthermore, this technology gives an excellent pathway towards autonomising larger

Collaborative AMR



vehicles, such as forklifts and tuggers. As such, it extends Amazon's capability to all manner of vehicles and situations found in fulfillment automation. Amazon considers this a core strategic competence.

Shopify acquired 6 River Systems for \$450 million (60% cash), which represents a huge multiple, probably in excess of 20-23. 6 River systems had previously raised \$45 million, and in the summer of 2019, their robots were deployed in 30 customer sites (some using the eight-robot start kits and some having as many as 50 robots in a building). It did have a strong sales pipeline, which could result in >500 robot unit sales in 2020. However, this uptick in sales on its own does not justify the valuation.

6 River also had an interesting technology. The majority (70% or so) of its 150-person team were focused on the software aspects. Within the software team, the smaller sub-team focused on autonomy algorithms and the larger sub-team on cloud-based fleet and task management software.

On the autonomy side, 6 River used both lidars and cameras. The lidar map, built during the initialization phase, would be curated by engineers, uploaded onto the cloud, and used by the fleet within that specific environment. Camera technology could also enable it to detect and classify objects, thus achieving more responsive path planning algorithms. On the higher-level software, they developed algorithms to optimize the movement of the fleet to achieve reliability and speed in fulfilling multi-item requests. They could also share learnings amongst the entire fleet via the cloud, setting in place a learning loop that could enable the algorithm to be constantly improved. These technology choices - with regards to both autonomy and cloud-based fleet/task management - placed 6 River in a good position in the short and long terms.

Shopify was motivated to make this acquisition, as in June 2019, it announced the Shopify Fulfillment Network. 6 River's vertically integrated full-solution approach allowed Shopify to bring the entirety of a key strategic competence inhouse. The technology will likely be initially rolled out at select 3PLs before Shopify puts in place its own infrastructure.

The taking off the market of another mobile robotic company through acquisition will put third part fulfillment center operators in a difficult position as to which technology to adopt in the future. This suggests that system interoperability and ease of integration with an existing automated system will become important in the future, as operators do not want to be blind-sided again

Another acquisition this year was that of Teradyne, paying \$165 million (\$58 million in cash and the rest if certain performance targets are reached) for AutoGuide, a company with barely \$4 million in revenue in 2018. Teradyne 1.5 years ago acquired Mobile Industrial Robots (MiR) for \$148 million. MiR developed SLAM-based mobile platforms, mainly acting as low-payload deck-load mobile conveyors. Teradyne had also acquired Universal Arms (UR) for \$227 million in 2015. UR is the pioneer and leading supplier of collaborative arms. Teradyne also owns Energid.

This acquisition - if the entire \$165 million is realized - represents a huge multiple, even when considering the projected doubling of the revenue of the target company. This acquisition enables Teradyne to expand its product portfolio in the warehouse and logistics automation business. In particular, it complements MiR's product line-up, bringing it to the AGV (Automated Guided Vehicle), as well as SLAM-based, high-payload vehicles such as tuggers. As such, it exposes Teradyne to every sector of the market, even if the acquired firms are operated as stand-alone concerns.

The SLAM-based navigation is lidar-based. This technology based on natural feature extraction can also be used in forklifts, giving the firm the chance to expand its product portfolio further. Indeed, an interesting choice made by AutoGuide was to design its own platforms in a modular way, enabling one tool to be changed into another in a short time. The choice to make its own platforms also give the company vertical control, eliminating the risk that a third-party supplier unexpectedly changes a feature in the platform which would put the autonomous fleet at risk.

Many firms in this space have also raised notable funds. One prominent example is Geek Plus (China), which has raised \$389 million since 2015. The firm is pursuing an aggressive expansion strategy. It has delivered over 7K units of its fiducial-based goods-to-person robots, which operate in the same way as Amazon's Kiva Systems. The company is now expanding its production capability and tipping its toes into the area of autonomous forklifts. The additional capital is justified on the basis that there is significant merit in having a large installed fleet (market share). Furthermore, the capital is required to invest in production capacity.

Another firm in the same field that has raised notable sums is GreyOrange. It raised \$140 million in 2018, bringing its total to \$170 million. This Indian firm, with offices in Singapore and now the U.S., has a well-engineered product and has recently announced winning large-scale deployment orders.

We assess that the market for how such autonomous mobile robots (AMRs) will grow. There have also been prominent investments and acquisitions this year, e.g., by Shopify and Amazon. Overall, we forecast that more than 200k robots could be sold within the 2020-2030 period (this figure includes those that can perform picking of regularly or irregularly shaped items). To learn more about various companies, market and technology trends, and to access our detailed market forecasts, please see the report "Mobile Robots, Autonomous Vehicles, and Drones in Logistics, Warehousing, and Delivery 2020-2040".

### **Picking mobile robots to dominate AMRs?**

Picking or grasping technology is an essential component of warehouse automation. Today, many firms and research groups are deploying deep learning to enable robots to pick novel and irregularly shaped items rapidly and with high success rates. To this end, various strategies for data collection/annotation and for DNN training are being followed.

A limited number of firms have integrated picking arms on mobile platforms. Today, these mainly pick box-shaped items in known environments. However, technology progress will bring these technologies to more varied items. It will also allow better integration of the robotic arm with the mobile platform.

We forecast that picking mobile robots able to pick regularly shaped items will be in the learning and low volume deployment phase until 2024. Thereafter, the sales will pick up. However, only after 2030 do we forecast significant annual sales volumes. As for robots able to pick irregularly shaped items, we consider that the development and low-volume deployment phase could last until 2030. In the longer term though, we forecast that 36% and 38% of AMRs in warehouses sold in 2040 will be able to pick regular - as well as irregular-shaped items, respectively. This points towards a major technology transformation, requiring automation beyond just autonomy of movement.

The report "Mobile Robots, Autonomous Vehicles, and Drones in Logistics, Warehousing, and Delivery 2020-2040" provides a comprehensive analysis of all the key players, technologies, and markets. It covers automated as well as autonomous carts and robots, automated goods-to-person robots, autonomous and collaborative robots, delivery robots, mobile picking robots, autonomous material handling vehicles such as tuggers and forklifts, autonomous trucks, vans, and last-mile delivery robots and drones.



By Mike Wheatley

Semiconductor maker Qualcomm Inc. is making a play for the automotive sector with the launch of its first self-driving car platform.

Announced at the Consumer Electronics Show today, Qualcomm's Snapdragon Ride Platform is designed to make it easier for automakers to transform their vehicles into self-driving cars. The platform includes everything needs to run an autonomous vehicle, including the artificial intelligence software needed to avoid collisions, and compact, power-efficient hardware.

Qualcomm said the platform will be able to assist with tasks such as automatic emergency braking, lane keeping assist functions, automated highway driving, urban driving situations, driving in heavy traffic and traffic sign recognition. It will also be able to perform fully autonomous driving for things such as robo-taxis by the time it hits the market in 2023, the company said.

The Snapdragon Ride Platform is Qualcomm's first effort at creating a fully autonomous car system. Qualcomm has actually been a major supplier to the automotive sector for years, but its primary focus has always been on the modem chips needed to power infotainment systems and connect vehicles to the internet.

Unlike rivals Intel Corp. and Nvidia Corp., which have been very public about the millions of dollars they've invested in their autonomous driving systems, Qualcomm's effort has been very much under the radar.

In an interview with Reuters, Patrick Little, senior vice president and general manager of Qualcomm's automotive business, said the company had applied the expertise it gained from making mobile phone processors to build powerful hardware that consumes very little electricity. He said Qualcomm's new computers are tiny and can fit into the palm of a hand, and that they do not require cooling systems to prevent them from overheating. He said low power consumption would be critical for self-driving cars.

"Many of these cars have a supercomputer in the back. It looks like your kid's gaming PC," Little told Reuters. "Now imagine you're putting that in the trunk of an electric vehicle. Now your range anxiety is just doubled."

Qualcomm explained that the Snapdragon Ride Platform can also be broken down into specific components that can be scaled up according to car maker's needs. For example, customers might want to use a smaller version of the platform for simpler tasks such as lane-control, while others may want a more comprehensive self-driving experience that requires the full platform. The company has also created its own self-driving algorithms for customers that want to use them.

Constellation Research Inc. analyst Holger Mueller told SiliconANGLE that separating hardware from software in this way is a smart move that has worked well with other platforms.

“What is different this time is that the self-driving car is likely not going to be an autonomous operating platform, but a connected platform that depends on surrounding platforms,” Mueller said. “That makes the stakes and adoption prediction harder, and also more exciting.”

“Qualcomm's Snapdragon Ride puts it in direct competition with Nvidia and Intel's self-driving tech efforts,” said Patrick Moorhead, an analyst with Moor Insights & Strategy. “I am super-impressed with the AI performance per watt. Qualcomm has been shipping into automotive for nearly 20 years now, so this isn't its first rodeo.”

Qualcomm also announced a new Car-to-Cloud Platform at CES that enables automakers to offer on-demand services to drivers both before and after they purchase a vehicle. The platform uses data analytics to show automakers which features their customers are using, so they'll be able to pitch more advanced capabilities and services based on that information.

Possible services include health monitoring, a Wi-Fi hotspot, movie downloads and advanced safety features, Qualcomm said.



By Maria Deutscher

Now that Alexa is firmly established as a fixture of the smart home appliance market, Amazon.com Inc. is trying to bring its voice assistant to other parts of consumers' lives.

That includes, among others, their cars, which the company made the center focus of its announcements today at the Consumer Electronics Show in Las Vegas.

### **'Alexa, pay for gas'**

Amazon's push to make Alexa part of users' morning commute and road trips relies heavily on partnerships with automakers. The company added two more such alliances today. Automobili Lamborghini S.p.A will integrate Alexa into its upcoming Huracan Evo sports car to let drivers perform actions such as adjusting climate control settings using their voice. Heavily funded auto startup Rivian Automotives Inc., in turn, is set to ship the assistant with its two debut consumer vehicles when they launch later this year. Rivian was recently tapped by Amazon to supply 100,000 electric vans for its delivery fleet.

The online retail giant is adding more automotive-specific features to Alexa in anticipation of the assistant being used more often inside cars. A partnership with Exxon Mobil Corp., also announced this morning, will enable people to purchase fuel at more than 11,500 gas stations in the U.S. using the command "Alexa, pay for gas." The assistant will ask buyers to confirm the station location and the pump number, then process the transaction using payment details from their Amazon account.

Lastly, Amazon is adding more navigation features. The company is enhancing Alexa Auto SDK, the development toolkit automakers use to integrate the assistant into their vehicles, with integrations for connecting to navigation services from Bosch GmbH, Here Global N.V., TomTom N.V. and other mapping providers.

Amazon Web Services Inc. naturally has a part to play in Amazon's auto strategy as well. A newly revealed deal with Blackberry Ltd. will see the phonemaker-turned-cybersecurity provider develop a vehicle analytics platform on top of AWS. This platform, the companies said, will enable car manufacturers to collect data from vehicles' sensors and build cloud applications to process the information.

### **Fire TV**

Alexa wasn't the only star of Amazon's CES presentation. The other focus was Fire TV Edition, the version of the company's streaming platform of the same name that TV manufacturers can embed into their devices.

Amazon will now make Fire TV Edition available for automakers as well to let users watch shows while they're on the go. The inaugural partners are BMW AG and Fiat Chrysler Automobiles NV, which plan to integrate the service into unnamed future auto models. Amazon said that in-vehicle displays powered by Fire TV will provide hands-free voice control via an Alexa integration, as well as the ability to save content locally for times when there's no reliable internet access in the car.



By Mark Albertson

Behind the connected underwear, smart trash cans and a mood harness for dogs, a more significant confluence of trends emerged this week at the Consumer Electronics Show in Las Vegas: The technology industry is moving en masse to embrace 5G, artificial intelligence and edge computing.

Amid the noise surrounding an array of mind-numbing gadgets at CES is an inescapable fact: Data now runs the world and new technologies for the 5G wireless standard, AI and processing information on edge devices will be essential to make it all work.

As Andreas Schaaf, chief customer officer of the automaker Byton Co., put it in his company's CES press conference on Sunday, "For consumers today, it's more about data power than horsepower."

### **Qualcomm sees 5G emergence**

One year ago, the lack of concrete evidence that 5G would be widely deployed in 2019 became a key story to emerge from CES. This week, a top executive for smartphone processor supplier Qualcomm Inc. offered a more convincing argument that 2020 will be the year of 5G.

"2020 is the year we expect 5G to scale, it's really moving faster than 4G," Qualcomm President Cristiano Amon said during his company's press conference Monday. Amon indicated that he expected 200 million 5G smartphones to ship over the next 12 months. "And that number is conservative," he added.

The company also teamed up with Lenovo to announce what was billed as the world's first 5G laptop, called Yoga, that will run on the Qualcomm Snapdragon 8cx platform.

While Qualcomm may be seeing early evidence of the 5G rocket beginning to lift off in the PC and smartphone markets, researchers from the Consumer Technology Association, which produces the annual CES event, believe that the enterprise will lead the 5G charge.

In CTA's long-term view, 5G deployment will be fueled by a combination of lots of endpoints in environments such as smart buildings generating small amounts of data, and fewer endpoints churning out massive streams of information such as traffic safety systems.

"5G will be led by enterprise applications," said Steve Koenig, vice president of research at CTA. "This 5G narrative is going to continue to unfold as we move into this decade."

### **Intel launches AI solutions**

Processing that rapidly expanding mountain of data facilitated by the faster, more robust 5G pipeline will require increasingly sophisticated intelligence tools. It's in this area where another key processor company – Intel Corp. – has made a significant investment as part of its overall data center strategy.

"How do we embed intelligence into everything that we make?" Intel Chief Executive Bob Swan (pictured) asked at his company's press conference on Monday afternoon. "Everything needs to be processed to make the data more relevant and useful."

The answer to Swan's question in Intel's case was to make a range of announcements this week designed to bolster the company's position in autonomous driving and mobile computing. Intel demonstrated advancements in its Mobileye automotive navigation technology and revealed a lineup of Tiger Lake mobile processors with AI-embedded accelerators.

Company executives indicated on Monday that AI now accounted for \$3.5 billion in revenue for Intel, fueled by its flagship Xeon processors. "More data center AI runs on Xeon than on any other platform," said Navin Shenoy, executive vice president and general manager of the Data Platforms Group at Intel. "We believe that AI hardware will be a massive opportunity for the industry."

Indeed, the enterprise march toward the AI landscape is already pushing deep into the consumer market as well. LG Electronics devoted the first 20 minutes of its press conference Monday to a lengthy discussion of AI before making a single new product announcement.

LG's ThinQ intelligence platform has been integrated across its vast portfolio of consumer products and services. Air conditioners sense the number of people in a room and automatically adjust the temperature accordingly. A washing machine identifies the type of fabric inside sets the correct wash cycle as it continuously processes information.

"It's a transformation of the very nature of our business, of our relationship with our customers," said I.P. Park, president and chief technology officer of LG Electronics.

### **Preparing for massive edge processing**

A consequence of the need for AI at the device level is the growing demand for processing at the edge. On Monday, Qualcomm introduced an intelligent edge box for 5G connectivity in AI processing.

According to Amon, the new edge product will be deployed commercially at scale in the second half of this year. "It's the result of a design win with a major hyperscaler company," he said.

Driving these major moves by key chipmakers such as Qualcomm and Intel is a sobering forecast of a data-centric future. Swan cited Intel's own statistics indicating that 175 zettabytes of data will be created by 2025. That's the equivalent of 6.5 billion years of high-definition video content, according to Swan, who also said half of that data will be created at the edge.

"Increasingly everything looks more and more and acts more and more like a computer," Swan said.

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## *Skin-like sensors bring a human touch to wearable tech*

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By University of Toronto

University of Toronto Engineering researchers have developed a super-stretchy, transparent and self-powering sensor that records the complex sensations of human skin.

Dubbed artificial ionic skin—or AISkin for short—the researchers believe the innovative properties of AISkin could lead to future advancements in wearable electronics, personal health care and robotics.

"Since it's hydrogel, it's inexpensive and biocompatible—you can put it on the skin without any toxic effects. It's also very adhesive, and it doesn't fall off, so there are so many avenues for this material," Professor Xinyu Liu, whose lab is focused on the emerging areas of ionic skin and soft robotics.

The adhesive AISkin is made of two oppositely charged sheets of stretchable substances known as hydrogels. By overlaying negative and positive ions, the researchers create what they call a "sensing junction" on the gel's surface.

When the AISkin is subjected to strain, humidity or changes in temperature, it generates controlled ion movements across the sensing junction, which can be measured as electrical signals such as voltage or current.

"If you look at human skin, how we sense heat or pressure, our neural cells transmit information through ions—it's really not so different from our artificial skin," says Liu.



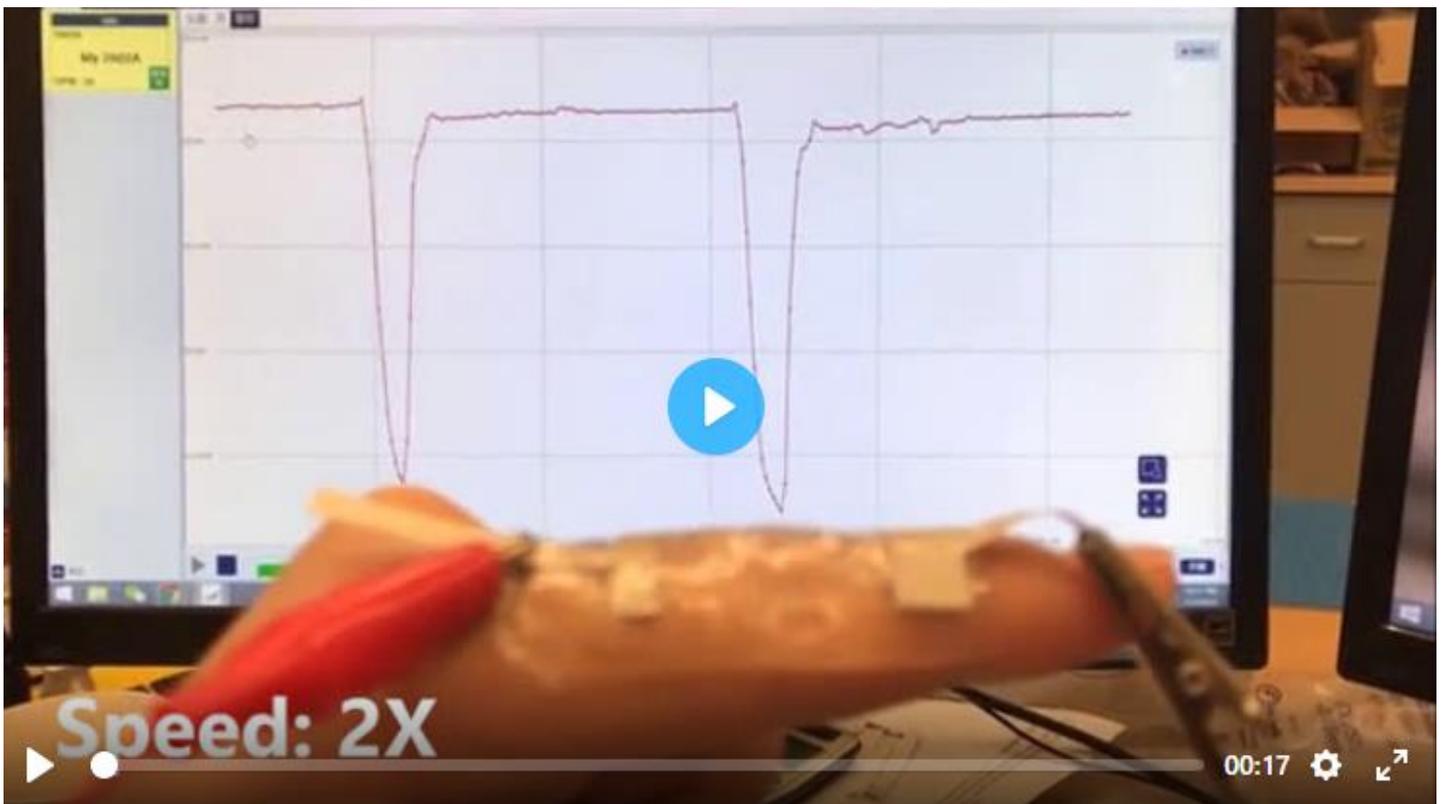
Human skin can stretch about 50%, but our AISkin can stretch up to 400% of its length without breaking. Credit: Daria Perevezentsev

AI-Skin is also uniquely tough and stretchable. "Our human skin can stretch about 50 percent, but our AI-Skin can stretch up to 400 percent of its length without breaking," says Binbin Ying, a visiting Ph.D. candidate from McGill University who's leading the project in Liu's lab. The researchers recently published their findings in *Materials Horizons*.

The new AI-Skin could open doors to skin-like Fitbits that measure multiple body parameters, or an adhesive touchpad you can stick onto the surface of your hand, adds Liu. "It could work for athletes looking to measure the rigour of their training, or it could be a wearable touchpad to play games."

It could also measure the progress of muscle rehabilitation. "If you were to put this material on a glove of a patient rehabilitating their hand for example, the health care workers would be able to monitor their finger-bending movements," says Liu.

Another application is in soft robotics—flexible bots made completely out of polymers. An example is soft robotic grippers used in factories to handle delicate objects such as light bulbs or food.



*Binbin Ying demonstrates how AI-Skin could be used to measure the progress of muscle rehabilitation. Credit: Binbin Ying*

The researchers envision AI-Skin being integrated onto soft robots to measure data, whether it's the temperature of food or the pressure necessary to handle brittle objects.

Over the next year, Liu's lab will be focused on further enhancing their AI-Skin, aiming to shrink the size of AI-Skin sensors through microfabrication. They'll also add bio-sensing capabilities to the material, allowing it to measure biomolecules in body fluids such as sweat.

"If we further advance this research, this could be something we put on like a 'smart bandage,'" says Liu. "Wound healing requires breathability, moisture balance—ionic skin feels like the natural next step."



**Lidar technology company Velodyne Lidar (San Jose, CA) has introduced its smallest sensor, which it says brings new levels of versatility and affordability to 3D lidar perception and advances its mission to make high-quality 3D lidar sensors readily accessible to everyone.**

The Velabit lidar sensor leverages the company's lidar technology and manufacturing partnerships for cost optimization and easy high-volume production. It delivers the same technology and performance found on the company's full suite of state-of-the-art sensors and, says the company, will be the catalyst for creating endless possibilities for new applications in a variety of industries.

The compact Velabit can be embedded almost anywhere within vehicles, robots, unmanned aerial vehicles (UAVs), infrastructure and more. It is engineered, says the company, to be an optimal automotive grade lidar solution for Advanced Driver Assistance Systems (ADAS) and autonomous vehicles.

"The Velabit democratizes lidar with its ultra-small form factor and its sensor pricing targeted at \$100 in high-volume production, making 3D lidar available for all safety-critical applications," says Anand Gopalan, Chief Executive Officer, Velodyne Lidar. "Its combination of performance, size, and price position the Velabit to drive a quantum leap in the number of lidar-powered applications. The sensor delivers what the industry has been seeking: a breakthrough innovation that can jump-start a new era of autonomous solutions on a global scale."

The Velabit includes the following key features:

- Integrated processing in a compact size of 2.4" x 2.4" x 1.38" – smaller than a deck of playing cards – to be easily embedded in a wide range of solutions
- Range up to 100 meters
- Outstanding field of view (FoV): 60-degree horizontal FoV x 10-degree vertical FoV
- Highly configurable to support a range of applications
- Proven, Class 1 eye-safe 903 nanometer technology
- Bottom connector with cable length options
- Multiple manufacturing sources scheduled to be available for qualified production projects

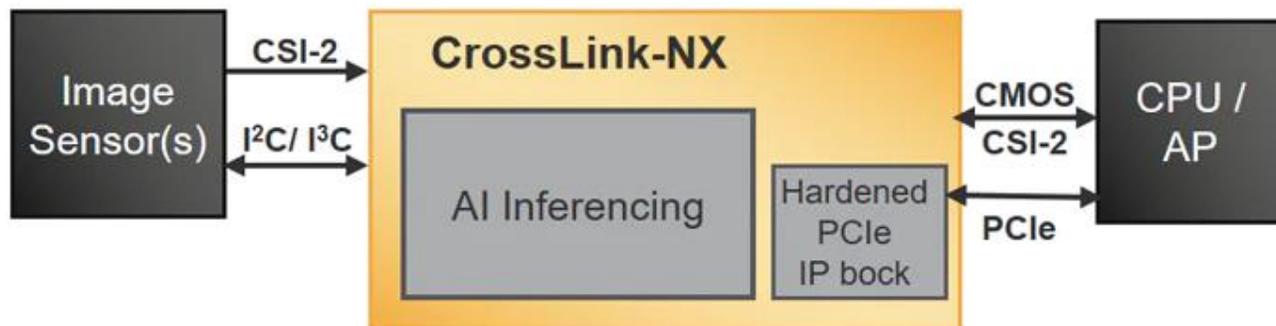
The Velabit will be available to customers mid-2020.

**Need to go beyond just bridging between devices? Lattice Semiconductor's CrossLink-NX could very well be the solution.**

By William G. Wong

Lattice Semiconductor is well-known for its low-power, flash-based FPGAs. One of the applications the company has targeted is interfacing between devices. The CrossLink-NX FPGA is designed to provide such bridging support with built-in, hard IP serial interfaces supporting devices like digital cameras. The FPGA fabric can be used to handle protocol conversions, but it's also capable of implementing more complex machine-learning (ML) models to process data (Fig. 1).

## Edge AI Processing



1. CrossLink-NX FPGAs include efficient, hard interfaces and provide enough FPGA fabric support to implement a range of machine-learning algorithms. Thus, bridging applications can process data as it flows through the system.

This type of implementation can be very useful in automotive applications where radar, LiDAR, or vision sensor data streams can be processed by the FPGA instead of having it done on the host. Of course, hosts with ML support are being used as well, but the low-power nature of the CrossLink-NX enables designers to build more power-efficient systems.

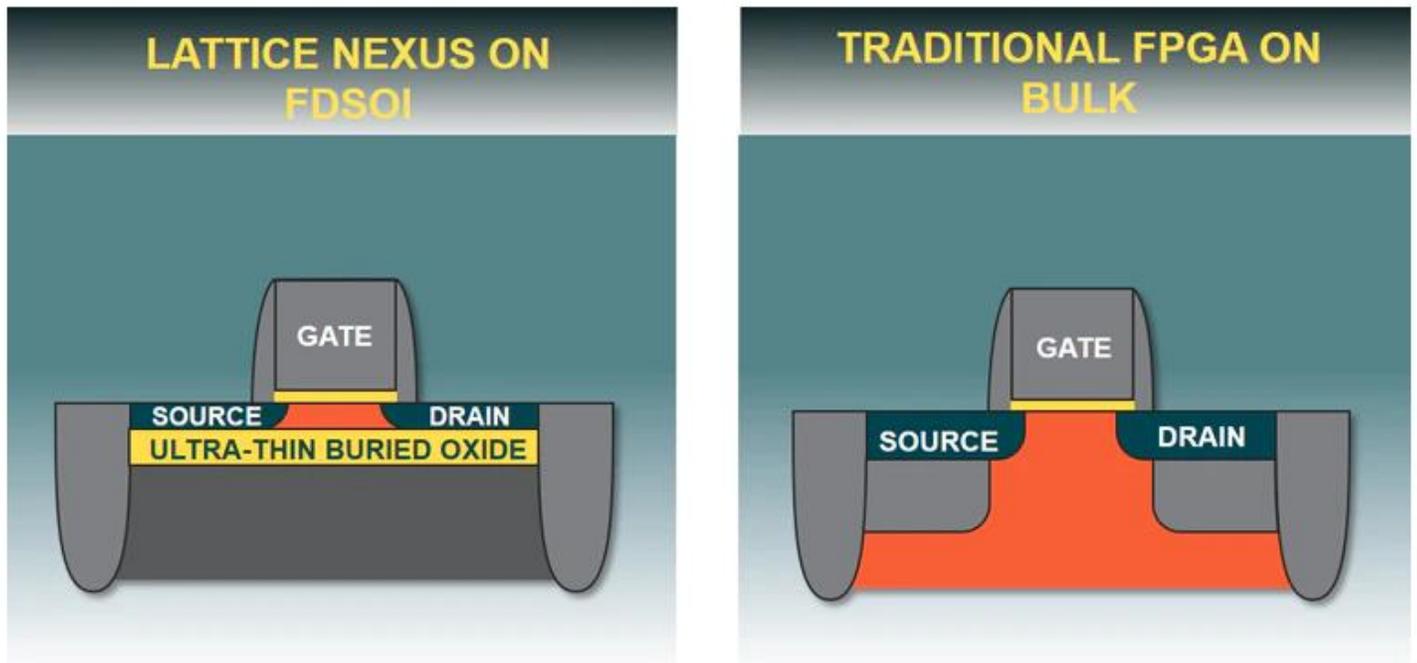
CrossLink-NX and Lattice's FPGAs in general have a soft error rate (SER) that's up to 100X lower than similar FPGAs in its class due to two factors: they are flash-based, and the implementation of Lattice's transistor technology. This is important for safety and high-reliability applications. The initial set of CrossLink-NX devices targets ruggedized environments found in outdoor, industrial, and automotive applications.

The design of CrossLink-NX is built around three key elements. The chips include hard IP blocks that deliver fast I/O support to handle interfaces such as MIPI, PCIe, and DDR3 memory. The flash-based nature of Lattice's FPGA families allows for instant-on operation. CrossLink-NX I/O configuration can be done in less than 3 ms and total device configuration takes less than 15 ms. Finally, the CrossLink-NX family has a high memory-to-logic ratio. This is designed to address ML inferencing. The family features 170 bits of memory for every logic cell.

The CrossLink-NX family comes in a very small form factor—devices are available in 6- × 6-mm packages.

CrossLink-NX is built on Lattice's new Nexus platform that's based on 28-nm, fully depleted silicon-on-insulator (FD-

SOI) technology. The FD-SOI support from Samsung cuts transistor leakage in half compared to bulk CMOS (Fig. 2).



2. Lattice Semiconductor’s Nexus platform brings low power, FD-SOI transistor technology to its FPGA line, including CrossLink-NX.

“We are excited to collaborate with Lattice to bring the benefits of our Samsung Foundry 28FDS manufacturing process technology to the low-power FPGA market,” said Ryan Lee, Vice President of Marketing at Samsung Foundry. “By combining their innovation and expertise in FPGA fabric design with our industry-leading and differentiated foundry technology, Lattice will continue its leadership in low-power FPGAs for years to come.”

### **Radiant 2.0**

Also included in Lattice’s latest announcements is release of Lattice Radiant 2.0, their FPGA software design tool. Radiant supports all of Lattice’s FPGA families including the CrossLink-NX. Roger Do, Senior Product Line Manager, Software, at Lattice said, “Lattice Radiant 2.0 design software gives developers an easy-to-follow user experience; the tool leads them through the design flow from design creation, to importing IP, to implementation, to bitstream generation, to downloading the bitstream onto an FPGA. Developers with little to no experience working with FPGAs should be able to quickly leverage the automated features of Lattice Radiant. For experienced FPGA developers, Lattice Radiant 2.0 allows for more granular control over FPGA settings if specific optimizations are required.”

The new release includes on-chip debug for real-time examination and manipulation of the system. It enables insertion of virtual switches or LEDs in the FPGA code to provide control and feedback. It can even be used to change hard IP block settings to test different operating modes without having to recompile and download a new configuration.

The software has improved timing analysis that delivers more accurate trace-and-route planning and clock timing to avoid design congestion and thermal issues. Developers will also appreciate the built-in engineering change order (ECO) editor. It allows developers to make incremental changes to a completed design without recompiling the entire FPGA database.

A Simultaneous Switching Output (SSO) calculator is available for analyzing the signal integrity of individual pins. This helps ensure that performance isn’t adversely affected by a pin’s proximity to another pin.

By Tanmay Tiwary

Alibaba DAMO Academy, the global research initiative of China-based conglomerate Alibaba Group, has published its forecast of the leading trends that would gain pace in the tech industry in 2020.

Founded in October 2017, the DAMO Academy is a research and development institute dedicated to exploring the unknown through scientific and technological research and innovation.

“We are in an era of rapid technology development. In particular, technologies such as cloud computing, AI (artificial intelligence), blockchain and data intelligence are expected to accelerate the pace of digital economy,” Jeff Zhang, head of Alibaba DAMO Academy and president of Alibaba cloud intelligence, said.

The academy believes that more technology advancements and breakthroughs are expected to gain momentum and have a big impact on our daily lives. “In addition to exploring the unknown through scientific and technological research, we are also working with industry players to foster the applications of innovation in different industries, making technologies more accessible for businesses as well as the society at large,” Zhang said.

The following are highlights from the academy’s predicted top 10 trends in the tech community:

1. AI has surpassed humans in areas of perceptual intelligence such as speech-to-text, natural language processing and video understanding, but cognitive intelligence requires external knowledge, logical reasoning and domain migration, and is still in its infancy. Cognitive intelligence is set to draw inspiration from cognitive psychology, brain science and human social history, combined with techniques such as cross-domain knowledge graph, causality inference and continuous learning to establish effective mechanisms for stable acquisition and expression of knowledge.
2. Innovation in processing-in-memory will drive development of AI. The memory and processor are separate, and computation requires data to be moved back and forth in the currently-used von Neumann architecture. However, in the PIM (processing-in-memory) architecture, memory and processor are fused and computations are performed where data is stored, with minimal data movement. Therefore, innovation in the PIM architecture holds the ticket to next-generation AI.
3. IoT (internet of things), 5G, cloud computing and edge computing will accelerate the fusion of information system, communication system and industrial control system in 2020. Through advanced industrial IoT, manufacturing companies will achieve automation of machines, in-factory logistics and production scheduling as a way to realise consumer-to-business smart manufacturing.
4. Traditional single intelligence cannot meet the real-time perception and decision of large-scale intelligent devices. The development of collaborative sensing technology of IoT and 5G communication technology will realise the collaboration among multiple agents -- machines cooperate with each other and compete with each other to complete target tasks. The group intelligence brought by the cooperation of multiple intelligent bodies will amplify the value of the intelligent system -- for example, warehouse robots will work together to complete cargo sorting more efficiently and driverless cars can perceive the overall traffic conditions on the road.
5. The traditional model of chip design cannot efficiently respond to the fast-evolving needs of chip

production. This is set to be replaced by the open-source SoC (system on a chip) design based on RISC-V, high-level hardware description language and IP-based modular chip design methods, which have accelerated the rapid development of agile design methods and the ecosystem of open-source chips.

6. BaaS (Blockchain-as-a-Service) will reduce the barriers to entry for enterprise blockchain applications. In the future, a large number of innovative blockchain application scenarios with multi-dimensional collaboration across different industries and ecosystems will emerge, and large-scale production-grade blockchain applications with more than 10 million daily active items will gain mass adoption.

7. In 2020, the field of quantum computing will receive more investment, which comes with enhanced competitions. The field is also expected to experience a speed-up in industrialisation.

8. Until now, major semiconductor manufacturers have not had a clear answer and option to chips beyond 3 nm. Usage of new materials will make new logic, storage and interconnection devices through new physical mechanisms, driving continuous innovation in the semiconductor industry.

9. Compliance costs are increasing due to the recent data protection laws and regulations related to data transfer. Therefore, there has been growing interest in using AI technologies to protect data. Such technologies promise to solve the problems of data silos and lack of trust in today's data-sharing practices.

10. Cloud computing technology has grown far beyond the scope of IT infrastructure. It creates new technologies like serverless computing, cloud-native software architecture, software-hardware integrated design, as well as intelligent automated operation. Cloud computing is set to redefine every aspect of IT, making new technologies more accessible to the public.

**From the evolution of pure-play e-commerce to the purpose of brick and mortar, the Retail Dive team serves up its predictions for 2020.**



By Kaarin Vembar

The on-again, off-again, maybe-on-again of tariffs that got on retailers' last nerve in 2019 serve as a neat metaphor for the industry as a whole — in retail, things are complicated, swiftly changing and sometimes contradictory.

The U.S. consumer, for example, seems confident, yet remains picky. Stores need e-commerce, yet e-commerce needs stores. It's complicating the business from merchandising to fulfillment, shaking up the c-suite, and landing ill-prepared or debt-heavy retailers in the financial dust.

That 2020 is an election year will only make an already complex environment more bewildering. Here is a look ahead to 10 of the trends Retail Dive is watching most closely.

### **1. Pure-play retail is less "pure"**

We've witnessed the grand entrance of direct-to-consumer brands over the years, but now they're solidly here, introducing the next stage of growth (or reckoning) for digital natives. Some of the most popular direct-to-consumer (DTC) brands achieved unicorn status in 2019, indicating a \$1 billion valuation and their status as a hard-to-ignore presence in their markets. At the same time, signs of a DTC shakeout have emerged, with some brands, including Wayfair and Chewy, posting large losses even as sales rise. As these brands grow up, more successful expansion, and risk of failure, are on the horizon.

In their rise, DTC brands have continued to learn from traditional retailers, first by recognizing the potential in e-commerce and now by opening up physical stores to complement it. Brick and mortar is now a key part of their strategies, with footprints that vary from a handful of stores for brands like Everlane, to Casper's plans for 200. In many cases, the brands have come to see brick and mortar as an essential piece of the puzzle, though with very different goals for the spaces than other retail sectors have had during their times of expansion.

In turn, DTC brands have taught pure-play physical retailers that the e-commerce experience is just as essential to their strategy as storefronts are. That's led to a blurring of channels and even stalwart brick-and-mortar retailers like Costco finally building out e-commerce. It's also primed consumers to look directly to brands for product, rather than to the retailers they often sell through. That's perhaps best evidenced by Nike's commitment to its Direct strategy, which came to a head with the November announcement that it would stop selling on Amazon.

## **2. Executive teams shift**

Last year saw the highest number of CEO departures through November since Challenger, Gray & Christmas started tracking the numbers in 2002. The firm's November report recorded that 1,480 CEOs had left their posts up to that point in 2019, 12% more than during the same timeframe the prior year and just four short of the previous full-year record, from 2008.

The departures in retail are happening at a variety of companies, including distressed retailers like Destination Maternity and David's Bridal as well as better-positioned brands like Nike. The retailers that lost CEOs last year include Tapestry, Gap, Under Armour, Best Buy, Away and Bed Bath & Beyond, among others. The C-suite shuffling extends beyond just the top role, with Bed Bath & Beyond and J.C. Penney building up whole teams around new CEOs — and getting rid of those that didn't stack up.

Expectations for the C-suite, and the CEO in particular, have also risen. They must not only keep the ship from sinking, but also bring new ideas to float it ever higher. In some ways, that explains Nike's choice to replace Mark Parker with John Donahoe, a former eBay CEO, given that the brand is looking to build out digital even more. Likewise, J.C. Penney hired Jill Soltau, an executive with a long history of merchandising experience, to solve a slew of problems at the department store, not least a lackluster assortment.

On top of all that, CEOs are being held accountable for bad company culture and other personal transgressions, including undisclosed relationships or otherwise failing to meet company standards. By November, 14 CEOs had left their positions due to professional misconduct, Challenger, Gray & Christmas noted. "Any behavior unbecoming to a company's brand is pretty quickly followed by a resignation announcement," Andrew Challenger, vice president of the firm, said in a statement.

## **3. The purpose of stores changes**

Both direct-to-consumer brands and legacy retailers are re-evaluating the purpose of a store.

Casper in 2018 announced it planned to open 200 stores across North America. Prior to that its foray into physical retail had been through partnerships with Target and West Elm. Warby Parker now has more than 100 stores and Bonobos has more than 60. All told, digitally native brands are set to open 850 stores in the next five years, according to a report from Real Estate firm JLL.

It isn't simply a trend; it's become necessary for survival. Ray Hartjen, marketing director at RetailNext, told Retail Dive in an earlier interview that DTC brands are pressured into opening brick-and-mortar locations because the cost of customer acquisition when operating solely online is so high.

At the same time, legacy players, especially those in malls, are finding it necessary to shrink their store footprints. Store closures in 2019 exceeded 9,000 in the U.S., far surpassing openings, according to Coresight Research.

Nordstrom launched Local, its merchandise-free retail concept, in 2017 and pushed the boundaries of what is considered a store. As consumer habits evolve, companies are searching for ways to evolve their stores to best serve customers' needs.

## **4. BOPIS packs a punch**

While buy online, pick up in-store (BOPIS) services aren't new, they will continue to help the bottom line of those retailers that can deliver on logistics and speed.

This past holiday season shoppers took advantage of BOPIS services in order to save money. Additionally, 49% of consumers stated that in-store pickup is quicker than at-home delivery. That's an advantage when delivery is going through a time of upheaval. In December, for example, Amazon banned third-party sellers from shipping Prime orders with FedEx Ground or Home, citing a "decline in performance." In a move that highlighted those woes, FedEx announced that the company would cut air freight capacity after a 50% margin loss.

BOPIS services may benefit traditional brick-and-mortar retailers, by cutting down on last mile expenses and turning stores into a competitive advantage over online retailers, including Amazon. In a November interview with CNBC, Target CEO Brian Cornell noted that the retailer's costs drop 90% when customers utilized BOPIS.

## **5. Apparel struggles — except for secondhand**

While retail as a whole struggled during 2019, a number of companies that filed Chapter 11 are in the apparel category. Additionally, there are companies that are teetering on the edge with either a high or elevated risk of bankruptcy including Ascena, J. Crew, RTW Retailwinds, Tailored Brands, Express and J. Jill. Department stores are largely in the same boat, too, because they have heavily favored apparel in their product mix in recent decades.

In 1987, the average consumer allocated 5.9% of their spending to apparel, but by 2017 that number had decreased to 3.1%, according to a Deloitte report. A number of factors, including a dressed-down workforce, a shrink in the middle class and increased competition means that retailers are fighting for fewer apparel dollars.

The one part of the industry that may prove to be the segment's saving grace — at least temporarily — is secondhand clothing. Resale has grown 21 times faster than the wider apparel market over the past three years. Secondhand retailer ThredUp recently forged partnerships with more traditional retailers including Macy's, J.C. Penney and Madewell. Additionally, luxury resale company TheRealReal made a splash when it launched an IPO during the summer of 2019. The rise of secondhand apparel comes as Gen Z shoppers have largely refused to pay full price on clothing, citing affordability as their top value when making purchasing decisions.

## **6. More retailers enter distressed territory**

Major retail bankruptcies surged in 2019, surpassing 2018, though not 2017's record numbers. Retail liquidations contributed heavily to a flood of store closures, which according to Coresight Research hit a record of more than 9,000 last year.

There are still plenty of retailers with sagging sales, large debt loads and fragile or deteriorating finances. That's a recipe that raises the risk of bankruptcy. But even retailers that can avoid restructuring will likely still need to shutter a big chunk of their store base.

Mass closures might slow in 2020, but don't expect a sudden halt. Retailers are still overstored. E-commerce penetration is still growing. There is still a price war ongoing among the largest players. As retailers rightsize their footprint, and new retailers grow theirs, equilibrium between store closures and openings is still about five years out, says A.T. Kearney's Michael Brown.

## **7. Amazon loses its halo**

Amazon is one of the most highly valued companies in the world. That probably won't change in 2020, but there is risk that the company's political and legal headaches could start to compound.

In 2019, the company was the subject of numerous stories that alleged it forced third-party sellers to lower their prices against competitors, tailored its algorithm to promote profitability, allowed dangerous products and salvaged goods onto its sites, and rushed to build a delivery network that poses a public safety risk while avoiding legal

responsibility for crashes. Privacy issues with the company's voice technology have also been exposed. (Amazon has largely denied such claims or says they represent a small portion of the activity in question.)

Amazon, moreover, is reportedly facing a broad federal antitrust inquiry into its market power. Meanwhile, plaintiffs have challenged whether Amazon can avoid liability over products sold on its site. Brands and retailers, too, have pushed back against Amazon, filing lawsuits over counterfeits and other issues. Others, perhaps most notably Nike, have left the site altogether, deciding they can fare online better without the e-commerce giant's platform. For the company that wants to sell everything on its site, that could be an ominous portent. And the possibility of more unflattering stories pose a potential threat against the company's incredibly valuable brand in 2020.

### **8. A disappearing middle class impacts retail**

While it may seem obvious to note that retailers' fortunes generally depend on the ups and downs of the economy, in recent years in the U.S. that correlation really hasn't been all that hard and fast. Instead of thriving in the post-Great Recession, for example, department stores, malls and others catering to middle-income shoppers have struggled and slid, even amid signs of consumer confidence and other harbingers of economic stability.

That's part of a greater decades-long trend, a stubborn wealth gap in the U.S. that appears to be worsening. In fact, as 2019 trailed to a close, that divide was "the biggest it's ever been," according to Kasey Lobaugh, chief retail innovation officer and omnichannel retail practice leader for Deloitte Consulting. "The winners and losers, if history and trends continue to play themselves out, are a reflection of the continued bifurcation of the consumer and the retail environment," he told Retail Dive in an October interview.

The situation led Kantar to spotlight the "demise of the middle class" as one of its top trends that will bridge the prior decade and carry over into 2020. It "will continue to affect everything from shopper preferences and political leanings to media consumption platforms and the rise and celebration of new 'moments,'" according to a Dec. 19 email to Retail Dive.

In fact, the reality may become even more stark, considering that the economy could take a few dips that are poised to hit the middle class especially hard. Growth in GDP, employment and retail sales is expected to slow in 2020 compared to the past three years, and fundamentals in the housing market, including home sales and prices, are also expected to moderate, according to a Dec. 19 note from Telsey Advisory Group.

Add to that the political uncertainty ushered in by the Presidential campaign itself: "[T]he upcoming US presidential election could create volatility and uncertainty for the financial markets, and distract consumers," Telsey analysts warned.

### **9. Department stores face a reckoning**

The retail model that perhaps thrived best when the middle class thrived — and began a slow, inexorable decline as the middle class faltered — is the department store. Macy's in recent years finished its planned closure of 100 stores, with CEO Jeff Gennette in November strongly hinting there may be more to come. Barneys New York is emerging from bankruptcy as a brand more than a retailer. Sears has all but disappeared. J.C. Penney is struggling.

In fact, in 2019 the segment stood out as deteriorating "the most of all the retail sectors," with discounts increasing to the point where nearly three-quarters of department store merchandise was on sale, according to a Dec. 30 note from Refinitiv emailed to Retail Dive. Despite ongoing consumer confidence, the sector is likely to face further pressure to close stores, according to the Refinitiv StarMine Combined Credit Risk (CCR) model.

But it's not clear that the American consumer has utterly given up on the department store. This past holiday, half of the 189.6 million who shopped during the Thanksgiving through Black Friday weekend visited one. And new retail concepts like Showfields and Neighborhood Goods tout themselves as "the new department store." The question is,

can department stores themselves evolve? Nordstrom, for one, with its emphasis on service and experimentation with concepts like its merchandise-free Local shops, seems to believe so.

"Department stores have a tremendous opportunity to redefine who they are," Doug Stephens, author of *Doug Stephens, author of "Reengineering Retail: The Future of Selling in a Post-Digital World"* (and a consultant to department stores, including Macy's) told Retail Dive in an interview previously. "But they have to stop stuffing every inch of their stores with product. The stores are a mess, the stores are boring, and products are table stakes now. This notion of staging experiences — it should be what department stores are good at."

#### **10. The circular economy expands**

From rental services to resale, the circular economy really took hold in 2019. More brands are jumping on the trend, joining apparel services like Rent the Runway and e-commerce platform ThredUp and furniture rental companies like Fernish and Feather.

According to ThredUp's 2019 Resale Report, which cites research from GlobalData, the secondhand market is projected to reach \$51 billion by 2023, with \$28 billion of that coming from thrift and donations, and \$23 billion from resale. Additionally, the secondhand market is expected to grow to nearly 1.5 times that of fast fashion (\$64 billion versus \$44 billion) by 2028.

The lines between rental, resale and traditional retailers continue to blur. Lord & Taylor in November was acquired by subscription apparel rental service Le Tote. Bloomingdale's formed a partnership with CaaStle to launch "My List," a subscription rental service. Urban Outfitters entered the apparel rental space with Nuuly. Nordstrom in November announced it was expanding its partnership with Rent the Runway. And ThredUp formed partnerships with Macy's, J.C. Penney and Madewell to sell used apparel in stores.

As consumers become more environmentally conscious, adapting a circular model may become particularly viable for retailers. Fifteen percent of Gen Z shoppers said they are dedicated to reducing the amount of waste they create, in addition to reducing their carbon footprints and single-use plastic consumption, according to a 2019 OC&C Strategy Consultants study.

**The former chief economist of Microsoft and the founders of the startup Aible explain why AI needs to solve business problems, not math problems.**

By R. Preston McAfee, Arijit Sengupta and Jonathan Wray

When it comes to making businesses run better, artificial intelligence has shown more promise than performance.

AI, which refers to algorithms that learn from and find patterns in huge quantities of data, is fundamentally about giving the right actionable information to someone at the moment of making a decision. Only AI can do that at scale. AI can be used all across the enterprise, in sales, marketing, customer retention, customer support, fraud reduction—anything that requires a prediction based on data and actionable recommendations in order to make an informed business decision.

But a recent International Data Corporation survey of global organizations that are already using AI solutions found only 25% have developed an enterprise-wide AI strategy. Most organizations reported failures among their AI projects, with a quarter of them reporting up to a 50% failure rate.

Why? Too many times, AI fails to deliver the positive impact that businesses really want from the technology, like more revenue, lower cost, fewer customers lost to churn, higher manufacturing quality, and lower waste and fraud. The mathematics behind today's AI is impressive (just ask any data scientist). But when it comes to making businesses more profitable, somehow the numbers don't add up.

One key reason that AI underperforms for business is that most AI used by businesses today has been trained to maximize model accuracy—or the percentage of “correct” answers. But in many real-world business cases, the most accurate AI models aren't the ones that result in the best business results. If the AI provides only five good sales recommendations, it's of little value to a sales rep needing to close 100 deals per month. After nearly two decades working in AI, we've heard a lot of frustrated business users say that their AI is never wrong—it's just completely useless for the business improvement they're trying to achieve. It tells them things they already know.

AI often fails to respect fundamental business principles, chief among them the Efficient Frontier, a term borrowed from economics and finance. The Efficient Frontier refers to trade-offs and the balance of risk and reward. It's the set of portfolios or assets that offer the highest expected return for a defined level of risk, or the lowest risk for a given level of expected return. For example, when the price of oil goes up, an energy company may add more resources—employees, drilling sites, advanced equipment—because the reward is high. But the company can't add unlimited capacity—it has resource constraints that limit its ability to expand, even during a price surge.

Businesses are constantly calculating and recalculating the Efficient Frontier for every aspect of their operation, from manufacturing capacity and sales team size to inventory levels, marketing budget, and geographic location. That means they're always seeking the optimal risk-reward trade-off for a given asset under current circumstances.

Today, there needs to be an Efficient Frontier for AI models. The models must change as business realities change, with many small models constantly re-computing the Efficient Frontier. Models can be specialized by geography—one model for sales in Germany, another for China, and a third for the U.S. Models can also be customized according to current business opportunities and constraints. There might be one model for when a company has a lot of sales leads that week, and a different model for when there are relatively few leads.

As new data is generated, some models that performed well may start to decay, while some poor-performing models may show surprising improvement. The Efficient Frontier of models is all about using the right model at the right time.

Unfortunately, most AI today is generated by off-the-shelf machine learning platforms from companies like Amazon, Google, and DataRobot that often fail to take into account the sort of cost-benefit trade-offs and resource constraints that businesses face every day. Many models assume that all costs and benefits are equal, but that's almost never true in business. What if the benefit of winning a deal is 100 times the cost of pursuing a deal? In that case, you might be willing to pursue and lose 99 deals for a single win. An AI that finds only 1 win in 100 would be very inaccurate. But it would boost your net revenue. An AI trained for accuracy would never recognize this cost-benefit trade-off.

Similarly, most AI fails to respect resource constraints. If your company's current sales capacity is restricted to only 10 leads you can effectively pursue, an AI that tells you to go after 100 leads is worthless. In business, operational constraints such as marketing budget and sales capacity matter—a lot.

Models rarely go out of tune for everything all at once—they first go out of tune in specific subgroups. A company may experience a big spike in customer complaints in the Boston area; then it quickly becomes a Massachusetts-wide problem, and before long, it permeates the entire enterprise. Specific subgroups going out of tune can act as canaries in a coal mine, a signal that the entire model may be starting to break.

AI needs to incorporate the fact that businesses are subject to constant change, and are not a vast collection of numbers that generally follow predictable patterns. AI optimized for business impact must adjust, enabling a company to continually run experiments and find new ways to be efficient.

Above all, companies need AI that solves business problems rather than math problems. Accuracy matters less than business impact. It doesn't pay to have an AI that's trained to learn more and more about things that aren't going to make the company money. Too much of today's AI gets lost in the complex data science metrics—every number, it seems, except profit.

The gap between AI's promise and payoff has become a canyon of disappointment for business. AI needs to, and can, do a much better job at responding to the problems that businesses face every day. Businesses shouldn't have to learn how to speak AI. AI needs to speak business.

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*R. Preston McAfee most recently served as chief economist at Microsoft, and is an advisor to Aible, an AI startup headquartered in Silicon Valley. Arijit Sengupta is the founder and CEO of Aible. Jonathan Wray is the cofounder of Aible.*

By Mitch Wagner

Network Virtualization & SDN Americas -- AT&T is concentrating on the middle of the edge to build the network intelligence needed for emerging 5G apps, Josh Goodell, AT&T VP of Edge Solutions, said Wednesday.

AT&T is focused on building virtualization and intelligence into the customer edge and network edge for 5G applications, Goodell said, kicking off the Network Virtualization & SDN Americas conference here.

"This is not science fiction for us. We are in the process of delivering it today," Goodell said.

Putting intelligence in the customer edge means moving compute to the customer location, which allows for local processing of data on site, providing privacy for companies that need it, and application level controls, Goodell said. Manufacturing is one application demanding customer premises intelligence.

Intelligence at the customer edge is integral to a project where AT&T is working with Rush Medical, a connected hospital, to enable real time image processing and analysis by medical staff at the location. Additionally, facial recognition monitors patient pain thresholds to alert doctors and nurses to change their therapeutic approach to the patient. And the hospital is using AR and VR for doctor training. "This is happening today. We are deploying this solution as a real example, as we speak right now," Goodell said.



AT&T's Josh Goodell.

Light Reading wrote about AT&T's collaboration with Rush Medical previously.

The other part of the network middle is putting compute in the network itself. "We call this network edge compute," Goodell said. AT&T is pushing compute deeper into metros, in central offices, to optimize wireless and wireline networks, enabling 5G low latency.

"The big difference between this approach and on-premises is that this will span an entire metro, whereas the other approach is centralized to a location," Goodell said. Network edge compute can bring roughly 20 millisecond latency to a 200-300 mile radius.

As an example of the type of application that can be permitted by network edge compute, Goodell cited AT&T's partnership with Vorpai, a company developing technology to monitor rogue drones to track their location, and also triangulate back to find the

operator. Goodell said that seemed to him at first like a niche application, but drones are an emerging security threat, piloted by saboteurs and terrorists. Goodell noted that drones may have played a role in the recent attacks on Saudi Arabian oil facilities.

AT&T started its transformation to virtual networking by laying out a vision in 2015, Goodell said. And we've followed AT&T's virtualization transformation closely over the years. Most recently, last week we reported that AT&T is on

track for 100% core network traffic virtualization next year, with 75% of MPLS tunnel traffic on the core network now controlled by SDN. AT&T is leaning on open source to implement virtualization -- it says it has no choice.

Today, AT&T is moving to a virtualized network in over 70 countries. The next step is to make the network "truly intelligent," Goodell said.

5G is the big change driver today, Goodell said. 5G provides great benefit over existing technology: 100 times the throughput of LTE, providing multiple gigabits per second. 5G also provides for "ultra responsiveness" -- in other words, low latency.

That network performance permits revolutionary applications, Goodell said.

"In the not too distant future it will be possible for a surgeon sitting in Boston to operate on a patient in Boise, Idaho, 2,000 miles away in an operating room using 5G technology," Goodell said.

Massive device connectivity is another new capability of 5G transformation, Goodell said. While WiFi can support hundreds of devices per access point, and LTE can support thousands, 5G can support millions. That may sound like overkill, but emerging applications need that kind of connectivity. A single manufacturing location might support 35 million sensors in one building.

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## Mobileye's self-driving car on streets of Jerusalem

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**At CES in Las Vegas, Intel Corp. releases video of autonomous car navigating streets of the capital using cameras, but no other sensors**

By Shoshanna Solomon

Intel Corp. has released a video showing a Mobileye self-driving car navigating the streets of Jerusalem using cameras but no other sensors.

The video was released by Intel, which acquired the Jerusalem-based Mobileye in 2017 for a whopping \$15.3 billion, at the 2020 Consumer Electronics Show (CES) in Las Vegas, where Mobileye also announced two new partnerships, with a South Korean city and a Chinese automaker for the deployment and testing of its autonomous-vehicle technologies.

The unedited video shows the self-driving vehicle navigating intersections, turning into streets with heavy traffic, changing lanes and stopping for pedestrians. A driver sits behind the steering wheel, which turns by itself to navigate the car.

At the event, Mobileye's CEO and co-founder Prof. Amnon Shashua talked about the car's use of camera sensors — the firm's so-called VIDAR solution — alone, and no other sensors, such as radar and lidar, that are typically used in autonomous vehicle technologies. Shashua also explained how the technology can create 3D models from 2D camera images, and how the technology achieves pixel-level scene segmentation that can be used to detect tiny fragments of "road users" such as wheelchairs or open vehicle doors, Intel said in a statement.



At the event, Mobileye also announced two new partnerships, the first with Daegu, South Korea, to deploy and test robotaxis that use Mobileye's self-driving systems.

As part of the agreement, Mobileye will integrate its self-driving technologies into vehicles, to enable a driverless mobility-as-a-service operation. Daegu Metropolitan City partners will ensure the regulatory framework to support the establishment of robotaxi fleet operation, the statement said.

Mobileye's other new agreement is with China's SAIC Motor Corp., a car manufacturer, to use the firm's mapping technology on SAIC's vehicles to gather information on China's roads, creating a high definition map of the country that can then be used to navigate autonomous cars.

The agreements follow other recent announcements by Mobileye, including: an agreement with RATP in partnership with the city of Paris to bring robotaxis to France; a collaboration with NIO, a Chinese maker of electric vehicles, to manufacture Mobileye's self-driving system and sell consumer autonomous vehicles based on that system, and to supply robotaxis exclusively to Mobileye for China and other markets; a joint venture with UniGroup in China for use of map data; and a joint venture with Volkswagen and Champion Motors to operate an autonomous ride-hailing fleet in Israel.

Mobileye also said that sales of its systems were close to a record \$1 billion in 2019, and are expected to rise to double digits in 2020.

By Gabriel Brown

For 5G in 2020, we're now at the "show me, don't tell me" stage. This isn't the time to amplify grand visions and hype future services that are still years from being technically and commercially viable. It's the moment to set about scaling up the 5G ecosystem in earnest to generate product volume in network technology, devices and chipsets and to demonstrate to enterprises and consumers that 5G really can make a difference to them.

The five major 5G network themes I identify for 2020 are:

**1. Extending 5G coverage** – This is the single biggest challenge and I'm excited about the potential for progress. The good news is there are lots of options – from low-band frequencies (including dynamic spectrum sharing), small cell densification, and in-building systems, through to RAN software features such as downlink carrier aggregation – that can improve coverage. This is going to cost a lot of money, however, so it's about being smart and bold in RAN choices.

**2. Standalone (SA) 5G and 5G core** – Advanced operators will introduce 5G SA (standalone), alongside non-standalone (NSA), with the first commercial terminals available from mid-year. We generally expect 5G core to be deployed on NFV infrastructure using virtual network functions (VNFs), with cloud-native network functions (CNFs) starting to make an appearance later this year. It's probably too soon to go full "cloud native" on a 5G core production deployment.

**3. Transport network investment** – Operators have started investing in 5G-specific transport, most obviously by upgrading the backhaul connections to cell sites to 10 Gbit/s or higher and by running fiber to small cells. In 2020 we should also start to see transport network architectures that can support fronthaul, network slicing and edge connectivity, all areas of significant network planning research in recent years.

**4. Cloud and edge** – US operators, in particular, are emphasizing the importance of edge computing for 5G and are highlighting their nascent edge infrastructure deployments. Everyone is watching to see what that means in practice for application performance. In the meantime, expect the wave of partnerships between operators and cloud companies to continue. I can see this emerging as quite a dynamic part of the market, albeit focused more on announcements than actual services and revenues at this stage.

**5. Proving the end-to-end architecture** – It's important for the industry to demonstrate a working end-to-end 5G architecture that is capable of supporting at least some of the advanced services envisioned for 5G. Ultra-reliable low-latency communication (URLLC) services and network slicing are of particular interest and it would be encouraging if the industry can get beyond the proof-of-concept phase in 2020 and into small-scale pilots in the field.

On the standards front, expect to hear quite a bit about 3GPP Release 17 work, which has just been approved but which is not scheduled to be completed until second half 2021. And remember, work on Release 16 specifications is still ongoing and not set to "freeze" until March 2020: Expect R16 to make a major impact from 2021 onwards.

To take stock, the industry has sold a great story on 5G and started fast in 2019. Now, in 2020, the sector needs to stick to plan, not waver in its commitment, and start to scale 5G in every dimension.

By Jeff Baumgartner

The CES show floor is brimming with connected, one-off Internet of Things (IoT) products, but the next generation of the ever-evolving smart home market will be defined by software platforms that can stitch those products together to create useful services and "experiences" for the consumer, execs in the sector insisted here this week.

Creating experiences is the "next horizon" for the smart home business, Fahri Diner, CEO of Plume Design, said on Monday at a press event held here at the Mirage hotel. While smart home and IoT remains a solid play at retail, the shift to platforms plays right into the hands of cable operators, telcos and other service providers that are building out smart home services and forging integrations with a focused blend of outside partners.

Plume, which works with major service providers such as Comcast, Charter, J:COM in Japan and Bell Canada, cut its teeth on providing whole-home WiFi products, but has since evolved its business with OpenSync, an open-source software/cloud platform that serves as an abstraction layer that can support a wide range of connected IoT devices from third parties.



Using a common software platform driven by the cloud to create smart home experiences represents the 'next horizon' for the market, Plume CEO Fahri Diner says.

"In order to get scale, you have to be open," Diner said, noting that Plume's technology is live in 12 million homes today, with about 130 million homes under contract. He estimates that about 600 million devices are connected to Plume's cloud platform and that another 15 million to 20 million devices are being added to the mix each month.

Those efforts, part of what the company likens to a broader movement toward "Smart Home 2.0," are also opening the door to new smart home services. Along those lines, Plume this week introduced Plume Motion, a motion detection enhancement developed in partnership with AI specialist Cognitive Systems.

Rather than requiring new cameras and other types of gear purpose-built to detect motion, Plume is using existing WiFi radios and compatible OpenSync nodes to detect motion in the home by analyzing the WiFi waves between those devices. The AI component of Plume Motion Aware will, for example, will be able to detect pets and avoid

false alarms, the company said. Plume said the new service will become available to all US Plume users on February 27 as part of their membership, but has yet to announce any commitments from its service provider partners.

### **Common thinking**

Plume isn't alone in its thinking about how the smart home market is evolving.

As the market pivots away from end-point solutions, platforms, driven by software, are rapidly becoming the "brain and nerve center" for the smart home and other forms of IoT products, Brad Russell, Research Director, Connected Home, at Parks Associates, said at a session held on Tuesday morning.

That next phase is also entering the picture as the smart home market continues to grow and establish some true scale. According to new Parks Associates research, 38% of US broadband households owned a connected device (a category that includes pure smart home/automation products and not products such as smart speakers and video streamers) at the end of 2019, up 19% from 2018. About 18% of those homes now own a home control system, up 38% year-over-year, Russell said, calling that a "sleepy category" that has been waking up over the past four to five years and appears to have reached a tipping point.

Comcast has also taken the platform approach, using it to build on new smart home services, including a cybersecurity product that the operator is now rolling out to about 18 million qualified broadband customers for no added charge. Comcast, which got into the home security and automation game back in 2012, now has about 1.4 million subscribers for those products.

In addition to using that platform to build and launch a curated and integrated mix of smart home products and experiences, another aim is to help simplify things for the consumer, said Derrick Dicoi, VP, of strategy and product management at Comcast, noting that customers can access and manage those services on the TV (also supported by Comcast's voice remote) as well as through mobile apps.

### **Avoiding an IoT free-for-all**

At the same time, industry execs warned that while there is a need to build platforms and new services based on deep integrations with third parties, some limits should be set around that openness.

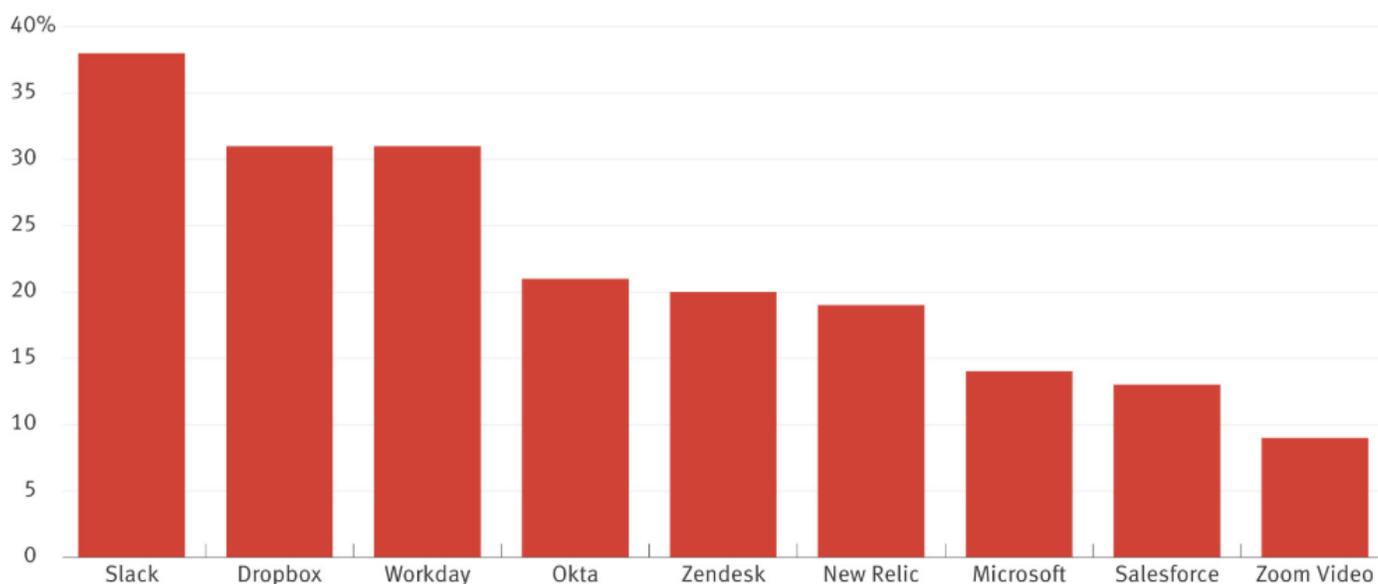
"Don't conflate open with a free-for-all," warned Amber Kappa, VP of platform partnerships and business development at Samsung SmartThings. Platform providers, she added, need to remain vigilant about what partners are doing with the data they do have access to and to create strong protections around what data those partners have access to and how they are using it.

The goal should be to create a "highly curated platform" with best-of-breed partners rather than one that allows consumers to bolt on any IoT product, said Anne Ferguson, VP of marketing at Alarm.com. That more focused integration work will help to ensure that the consumer experience is both "easy and reliable," she added.

By Kevin McLaughlin

## Research Effort

R&D spending as a percentage of revenue



Notes: The figures reflect the first nine months of the 2019 fiscal year for most companies, although some run to Oct. 31 and others to Sept. 30; Microsoft figure is the first quarter of its 2020 fiscal year; New Relic figure is the first six months of its 2020 fiscal year

Source: The companies

When it comes to tech companies arming themselves against competition, Slack may be hard to beat. At least, that is, when it comes to spending on research and development, the route to new product development.

Slack spent the equivalent of 38% of its revenue on R&D in its first three quarters of last year, a percentage that was significantly higher than for other subscription software firms we surveyed. The closest were Dropbox and Workday, each of which spent 31%. (See above chart.) That's likely no coincidence. Slack and Dropbox are essentially single-product companies fighting intense competition from bigger rivals such as Microsoft and Google. Workday, which provides business applications for human resources and financial management, also faces intense competition from giants like Oracle and SAP.

"If you are not constantly innovating and improving your products, that's a problem, because your competitors are improving theirs," said Sammy Abdullah, co-manager at Blossom Street Ventures, an investment firm that focuses on subscription software companies. "Initially you'll fall behind, and then, in a worst-case [scenario], you'll be overtaken, become obsolete and die."

Taking a different approach is Zoom Video Communications, one of the hottest tech IPOs of last year, which provides videoconferencing services to companies. Its spending on R&D was the equivalent of just 9% of its revenue in the first nine months of last year. That's partly because Zoom does a significant amount of R&D in China, where the cost of hiring engineers is less than in the Bay Area, said a person close to the company. Zoom also prioritizes investment in sales and marketing, the person said, which was 49% of revenue in the period. A Zoom spokesperson didn't have a comment.

Abdullah said the median level of R&D spending as a percentage of revenue is 28% among 19 subscription software companies that have gone public since 2017. (By comparison, bigger tech companies like Microsoft and Alphabet spend a percentage in the mid-teens of their revenue on R&D).

Abdullah notes that subscription software companies have more incentive to invest in R&D than traditional software providers. When companies bought software the old way, as an outright purchase, they'd hold onto the software for a few years before upgrading. Constant improvements weren't vital. But now, as companies are subscribing on an ongoing basis, it's relatively simple to switch to a different software provider. That means subscription software firms must continually add new features to prevent customers from defecting.

To put together our chart, we looked at data on nine subscription software companies, including startups and well-known older firms across a range of software industry segments. Some, like Slack, Zoom and Dropbox, sell software that lets different teams in companies work together more effectively. Others, like Zendesk, Workday, Microsoft and Salesforce, sell business and productivity applications. The last two, Okta and New Relic, develop software for monitoring and managing access to corporate applications and data.

Both Slack and Dropbox are under particular pressure to innovate because they each offer a free version of their product in order to attract users, and they charge for more advanced features like data protection and support services.

Last year, the fruits of Slack's and Dropbox's R&D spending showed up in new products aimed at getting companies to open their wallets. In September, Slack launched Shared Channels, which lets different companies work together through a private connection. The same month, Dropbox launched Spaces, which lets teams of users inside companies collaborate on files stored on local machines and in the cloud.

In a statement, Slack co-Founder and CTO Cal Henderson said that Slack's "ambitious, strategic R&D has yielded unique features which continue to set our product experience apart, such as Shared Channels and Workflow Builder."

Zoom also uses the "freemium" model. Shan Sinha, founder of videoconferencing startup HighFive and angel investor focused on subscription software companies, said the disparity between Zoom on the one hand, and Slack and Dropbox on the other, is due to the different competitive forces the companies are facing.

"Zoom is in a category where none of the major technology companies are competing with them meaningfully, while Dropbox and Slack are being heavily targeted by competitors," Sinha said. "At the end of the day, all three companies primarily rely on product-driven growth through new user conversions and by adding new capabilities."

Among the older business application providers, Microsoft spent 14% of revenue on R&D and Salesforce spent 13% during the three-quarter period surveyed. While both companies are established leaders in the segments in which they compete, the amount of their R&D spending is still significant in the scope of their overall revenue. The companies are also rivals in customer management software, so at least some of their R&D spending is likely aimed at competing with each other.

To put together the chart, we looked at R&D spending disclosures in each of the companies' SEC filings. Workday categorizes its spending as "product development" rather than R&D. We deducted stock compensation expense related to R&D except in the case of Microsoft, which doesn't disclose stock expense related to R&D specifically.

By Taylor Soper

Parallel reality is becoming actual reality.

The mind-bending technology — in which a single display shows different images to multiple people at the same time, tailoring the information to each person — will be tested in a real-world environment later this year when Delta Air Lines rolls out a beta experience at Detroit Metropolitan Airport.

The airline is partnering on the futuristic project with Misapplied Sciences, a Redmond, Wash.-based startup that developed the technology.

It might sound like science fiction. But GeekWire, along with thousands of attendees at CES this week in Las Vegas, had a chance to test out the experience. The installation lets travelers look at a digital screen and see only their personalized information, rather than a big list of all arriving and departing flights. No more scanning through tiny font to find your gate number and destination.

The airport scenario was one of the potential examples that Misapplied Sciences CEO and co-founder Albert Ng described when GeekWire first uncovered the stealthy startup in April 2018.

Delta's in-house startup team found out about Misapplied and made an equity investment last year. The companies are working side-by-side on the airport project.

“When we met the Misapplied team, we were looking at ways to reduce stress in the airport environment,” explained Nicole Jones, Delta's global innovation leader.

Delta had a huge presence at CES this year. It's the first airline ever to rent a booth on the show floor. Attendees waited in long lines to try the “parallel reality experience,” marking the first time the technology was demonstrated in public.

“We knew that people need to see the technology to truly believe it,” Ng said.

Ng took my group through two demos on Wednesday.

“Welcome to the international airport of the future,” he said, as we entered the experience.



The first was something I saw at Misapplied's headquarters last year: An array of mirrors that shows how a single “parallel reality” display looks from many different vantage points. The images below are reflected from just one display, behind where I was standing while taking this photograph.



The underlying technology is powered by a new type of display, enabled by a “multi-view” pixel. Unlike traditional pixels, each of which emit one color of light in all directions, Misapplied says its pixel can send different colors of light in tens of thousands or even millions of directions. They call it a “magic pixel.”

The next demo showed what Delta travelers in Detroit can expect later this year.

Each guest scanned a personal boarding pass — Las Vegas to Seoul was our faux trip — before stepping into the room. That enabled an overhead camera to track our location in space as an anonymous blob, and display a personalized image on the screen. Ng said in the future that smartphones, facial recognition tech, or wearable devices could be used for tracking individual travelers.

The demo went through a few examples of messages, such as personalized gate and departure information, or a baggage claim carousel number, with the ability to switch to the viewer’s preferred language.



CEO Ed Bastian and Jones on stage.

It all worked as described. I was impressed to see everything out of the lab and in use by an actual company. There’s a “wow” factor to the technology, but the real world implementation seemed a ways off when we demoed it in 2018.

Delta, which showed off other innovations at CES such as its mobile app and an exoskeleton designed to boost employees’ physical capabilities, is bullish about the potential of parallel reality. It spotlighted Misapplied during the company’s CES keynote speech, where Ng joined Delta



*From left to right: Delta's global innovation chief Nicole Jones; Delta CEO Ed Bastian; and Misapplied Sciences CEO Albert Ng at Delta's CES keynote.*

Bastian called it “astonishing new technology.”

“This is a great combination of how we’re combining Delta’s strength and scale with innovative startups to advance the future of travel,” he added.

The privacy implications of parallel reality could be significant. Jones said the pilot in Detroit will be opt-in. The company is still finalizing details of how exactly travelers will be tracked. “All of the information will be protected and secure in Delta systems.”

Misapplied is aiming to get its technology not only in airports but stadiums, theme parks, retail stores, and more. “We would like to see parallel reality in all sorts of public venues,” Ng said.

The startup was founded in 2014 by Ng; former Microsoft Research leader Paul Dietz; and Dave Thompson, who previously worked at Walt Disney Imagineering.

Dietz, who is widely recognized in engineering circles for his early work on multi-touch screen technology, ran the company as CEO until March 2018. He was CTO and chairman when he stepped down in June 2019. Dietz is now a technical fellow at Tactual Labs, and Ng said he left the company to pursue other interests. We’ve reached out to Dietz for comment about his departure.

Ng is a Stanford University and Caltech alum recognized for his work in areas including low-latency touchscreens. He was a research intern at Microsoft Research during Dietz’s tenure at the company.

Misapplied has raised \$11.4 million to date, in addition to \$1.5 million in grants from the National Science Foundation. In addition to Delta, investors include Carl Ledbetter of Pelion Venture Partners and Ginger Alford, an expert in computer graphics.

Other companies are also working on different ways to show personalized information to people using a single display. MirraViz, for example, is another startup that uses projectors to display different content to multiple people on the same screen.



By University of Birmingham

Engineers need to get more creative in their approach to design and additive manufacturing (AM) systems, by taking inspiration from the way humans grow and develop, say researchers at the University of Birmingham.

In a new paper, published in *The International Journal of Advanced Manufacturing Technology*, teams from the University's School of

Engineering and Centre for Reproductive Science have proposed a design approach for AM, otherwise known as 3-D printing, which opens a world of potential for the development of new materials and products.

Dr. Lauren Thomas-Seale, lecturer in Engineering Design and Principle Investigator of the project, explains: "Although we refer to it as additive manufacturing, traditionally engineers learn to design parts based on a long history of subtractive manufacturing. This leads to well-acknowledged constraints in design creativity. Additive manufacturing has to break out of this inertia if it is to reach its full potential in both design and as a fundamental technique."

Dr. Jackson Kirkman-Brown, Reader in Human Reproductive Biology, and co-author on the paper, says: "Whilst using biological inspiration in engineering design is commonplace, studying the growth of humans and translating this to advanced manufacturing systems offers a whole new perspective. The way in which biological systems develop from incrementally adding cells to form tissues and organs, which both grow and modulate each other to function in synergy, is the epitome of sophisticated AM."

The study outlines how growth processes of the foetus change over time i.e. the duration of pregnancy. These processes are fundamental to the development of the human. Yet, the "growth" of an AM part during manufacture, is limited to where the material is deposited or fused. Therefore time can be considered an unutilised variable in design for AM. The authors propose Temporal Design for AM as a new approach that will unleash the potential of time through the additive build, to create new materials and parts for AM.

Dr. Thomas-Seale elaborates "Looking towards radically different avenues for inspiration, is required not only to create real change in the way we approach design but also represents a more holistic approach, which is important to avoid the fragmented development of the technique that ultimately mean new products face a much more difficult and costly route towards commercialisation."

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**More information:** S. Saliba et al, *Temporal design for additive manufacturing*, *The International Journal of Advanced Manufacturing Technology* (2020). DOI: [10.1007/s00170-019-04835-3](https://doi.org/10.1007/s00170-019-04835-3)

**Air cargo facilities are undergoing rapid digital transformation via the adoption of automation technologies. - the most recent one being fully autonomous drones. At the leading edge of this innovation in inventory management is IAG Cargo, part of the same group that owns British Airways.**

*Case Study from FlytWare*

Air cargo facilities are undergoing rapid digital transformation via the adoption of automation technologies. - the most recent one being fully autonomous drones. At the leading edge of this innovation in inventory management is IAG Cargo, part of the same group that owns British Airways. With a vision to fully automate inventory counts at its air cargo facilities, IAG Cargo has been working closely with FlytBase on aerial inventory scans at its Madrid facility.

Inventory counting, while a critical business activity, consumes thousands of man-hours each year across IAG Cargo's hubs in the UK, Spain, and Ireland. Increasing the frequency of such counts, a necessity in the age of global e-commerce and same-day delivery, is important - but impractical if done manually. Drones, however, can make this a reality - thanks to cost-effective hardware, intelligent automation software, and continuing advances in indoor autonomous navigation using machine vision and AI/ML techniques - all packaged in the form of FlytWare, an autonomous aerial inventory scanning solution from FlytBase.

FlytBase's engagement with IAG Cargo involved stakeholders from innovation, continuous improvement, warehouse operations, inventory management, digital transformation, and business analysis. After prioritizing the key requirements for aerial inventory counts, FlytWare was trialed and tested carefully by running dozens and dozens of indoor drone flights - the barcodes thus scanned were automatically mapped to their locations; making available the 'ground truth' data that could then be filtered for empty slots, compared with WMS data and analyzed for location accuracy.



Having thus been tested at IAG Cargo via proof-of-concept trials, and further refined during the pilot project, FlytWare is now being readied for production deployments at multiple IAG Cargo facilities. The reality of inventory management is that each warehouse, distribution center, and air cargo facility is unique in terms of storage

configurations, key operating metrics, cycle count frequency, etc. Scanning one-deep, front-facing bar codes on full pallets is obviously much simpler than counting case reserve in VNAs, scanning pallets stored in bulk areas or enabling automatic ‘first counts’ of multi-deep pallet/case reserve that are then followed by manual ‘second counts’.



Nitin Gupta, CEO, FlytBase, explained: “Flytware’s trials at IAG Cargo have been successful in uncovering the significant opportunities and key challenges of deploying fully autonomous drones for inventory counts in warehouse rack storage. Not only can aerial inventory scans provide cost-effective and high frequency cycle counts, but they can also measurably impact productivity and support regulatory audits. The availability of live video feeds and location-wise image data, coupled with capabilities such as precision landing and WMS integration make FlytWare a highly compelling alternative to not only manual counts, but also RFID, AGVs and other methods that remain expensive and difficult to scale. Needless to say, we look forward to deploying FlytWare across IAG Cargo, a leading advocate for aerial inventory counts.”

The trials of FlytWare at IAG Cargo’s Madrid warehouse have also reinforced the importance of user-friendly operator dashboards, auditable inventory data and live video feeds. These underpin the intangible benefits of drone-based barcode scans - in addition to the time, cost & safety benefits versus manual counts. In fact, from a safety perspective, the ability to detect and avoid obstacles during autonomous flights turned out to be a key success factor for adopting FlytWare - even though the SOPs may require that the aisles be closed off during drone flights.

In an age of high-velocity supply chains and consumer expectation w.r.t. instant delivery, automation is becoming the silver bullet for inventory stakeholders at air cargo facilities - with fully autonomous drones expected to play a central role.

**Here's what happened at the biggest product show of the year that you actually need to know about.**

By Mark Wilson

Every January, the annual Consumer Electronics Show snaps the tech press out of its holiday stupor to fly to Las Vegas and walk through aisle after aisle of new televisions, robots, and plain old weird gadgets that are all billed as the next big thing.

I've been to CES. Many times. And I can tell you, the sheer corporate thirst on display is exhausting. But I'll also admit, there is almost no better portrait of our times than when businesses reflect our values back at us in the form of must-have products. No year was that more clear than it was this year, with gadgets that have been designed, not just with normal iterative improvements in mind, but with the promise to filter our unbreathable air or critique our self-pleasure.

Here are the big trends lurking in the new products of CES 2020.

### **Dystopian design**

Talking to experts across food, architecture, and design late last year, they all agreed that the environment would be the chief focus of design for the next decade. We're seeing that play out at CES this year in a variety of dystopia-ready products—the sorts of things that would have been hard to imagine even existing a few years ago.



Take the Atmos mask. It's a \$350 personal air filter, worn on your face, that uses filters and fans to give your mouth and nose its own clean air bubble in a polluted world. And in an effort to reduce plastic bottle consumption, companies are promising big countertop machines to improve water—from your tap. We saw this late last year with a \$555 filter from the Swiss company Lang, and now, with the New York company Rocean. Another company called Hydraloop wants to make sure you don't waste extra water, so for \$4,000, the refrigerator-sized device promises to recycle your used "grey water" from sources such as your shower into nondrinking applications such as your washing machine or toilet. And of course, no dystopia would be complete without a new way to eat: Impossible debuted a new pork product at the show, which will be slowly rolling out at restaurants and grocery stores over the

next year (though most analysis points out that this is Impossible's play for the Chinese market, which consumes 50% of all pork globally each year). In any case, it apparently tastes pretty good.



### Foldable everything

In theory, a phone or tablet that folds in half is better than one that doesn't, and it allows you an ergonomic flexibility that was lost in the iPhone era of hard, glass devices that feature big, rigid screens.

Now, after years of companies showing off wonky tech demos, the foldable screen revolution is finally, really here. Late last year brought the new folding Razr, and Samsung is rumored to be announcing its second foldable phone in about a month. At CES, we saw a duo of folding laptop concepts from Dell. Sure, these are still concepts, so who knows if they'll ever be produced? But Dell is not exactly known for cutting-edge design so the company likely sees the writing on the wall: Folding screens will become ubiquitous. Lenovo debuted the ThinkPad X1 Fold, a foldable 13.3-inch laptop that will be available later this year for \$2,500. The entire thing is one big display, and the interface looks well-articulated, with a screen that can pop up a virtual keyboard like a laptop when it's folded halfway. Finally, TCL—the company you probably know best for making the super cheap 4K TVs that you see advertised on Black Friday—debuted a series of smartphones that will all cost under \$500 this year. A folding concept shown alongside them won't come out in 2020. But if TCL is eyeing this market, it means folding displays will go from premium devices to budget-friendly products fast.

### Design that whitewashes privacy invasions

Invisible design and inclusive design have been some of the most important design trends of the past five years. Inclusive design has enabled companies such as Microsoft to build products that work for everyone, not just the able-bodied, and invisible design, which rests on seamless user experiences, has helped disrupt everything from retail to transportation.

But technologies that we've equated with these approaches—vision and voice, in particular—have come with a cost to our privacy. I'm beginning to doubt that any company, no matter how righteous, can protect the data it collects, and at CES, I get the sense that the tech industry is leveraging the halo of inclusivity to whitewash the surveillance state.



The OrCam Hear is an AI-infused wearable camera that links to a Bluetooth headset. The idea is that it can see who is talking to you and boost just their frequency so that you can hear them. It's clever and could truly help people who are hearing impaired. But it also means that someone will be wearing the equivalent of a Ring doorbell around their neck, watching you even as you merely walk by.

We see this happening in travel too. You have Delta promising custom “parallel reality displays,” which, in a pilot project in Detroit, will magically aim pixels right at your eyes, to show people their individual flight information instead of a big board of hundreds of flights. The tacit promise is that no one will have to squint at tiny lettering on the big board ever again. But you'll have to scan your ticket to opt in (for now—Chinese airports are already scanning your face for checking in). American Airlines announced it will begin using the Google Assistant's interpreter mode to translate languages for flyers in their Admirals Club. Conversations with the airline's concierge who checks you in and can assist with flights will get easier, sure—but a portion of this private space will be recorded.

Click below image:



Finally, there's what's happening in the intimacy industry. The Lioness 2 vibrator tracks your orgasms, measuring their strength, comparing them to orgasms from other people, and offering tips for maximizing intensity. “Which is cool,” one of my female colleagues scoffed, “because then it's another way for women to be rated and judged or maybe have some shame about if their number isn't high enough?” Not to be outdone, men are getting a “taint bandaid” from a company called Morari, which uses localized electrical signals to delay premature ejaculation. For \$25 next year, the device can be controlled with an accompanying smartphone app or, apparently, even a Fitbit. I can't imagine what could possibly go wrong.

By Rahul Joshi

The last decade saw an unprecedented adoption of digital transformation initiatives. Technologies such as cloud, mobility, analytics, automation, AI (artificial intelligence) and the likes enabled enterprises to reimagine everything from customer experience to business growth. These technologies came, they reigned and they transformed. Every facet of enterprise strategy bears the sweeping impact of these technologies and their transformative touch. Digital innovation is reaching new heights and ushering in digital maturity and adoption at scale.

Technology is taking huge strides in the areas of hardware, software/services and human experiences. These developments are inter-related and their intersection compounds their impact on transformation. Here are the top trends set to make a mark in 2020:

### **Quantum computing, 5G and autonomous things top the list of advancements in hardware**

- **Quantum computing:** With the competition for quantum supremacy becoming intense, 2020 should see advances in quantum computing where it begins contributing to the real life by powering complex AI applications.

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*AI and quantum computing will emerge as two sides of the same coin. For instance, a quantum computer could help enterprises that process voluminous transactions at super speed to develop virtual assistants that have high contextual awareness and almost human-like sensitivity towards customers.*

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- **5G:** Although 5G has gained significant momentum, and some operators have begun offering high-speed services in dense urban locations in some countries, challenges persist. When it comes to the scale of deployment, operators can deploy 5G at a larger scale, but with low band. A combination of 5G+4G (nonstandalone deployment) facilitates optimal coverage without compromising on the data demands of customers. Moreover, most devices in the market are illprepared to support 5G yet. In 2020 and the years ahead, manufacturing companies will catch up to build devices that support 5G.
- **Autonomous things:** AI, ML (machine learning) and deep learning are equipping robots, drones and autonomous vehicles to act and control their environment. Gartner stated that the leaders of enterprise architecture and technology innovation are gearing up to take advantage of the opportunities presented by autonomous things. Amazon's package delivery through drones and automated warehouses are prime examples. The year 2020 will see the introduction of many more autonomous devices to empower humans.

### **In the software/services area, expect hyper-automation, digital workforce and AI-based security to mature**

- **Hyper-automation:** Hyper-automation goes beyond desktop automation to integrate systems and automate core business processes to amplify the organisation as a whole. It involves everyone in the organisation to be part of the transformation journey. With RPA (robotic process automation) at the core, hyperautomation

will leverage people, processes and tools such as AI, analytics and deep-process mining to scale up automation capabilities and unlock unforeseen efficiencies.

- **Digital workforce:** With the power of RPA, AI and ML, digital workers have incredible potential to augment the human workforce.

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Digital workers can analyse like humans, and execute with the speed and accuracy of robots. A digital worker can automate the entire process without any supervision. As digital workers become mainstream in 2020, it will usher in a new future of work.

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- **AI-based cybersecurity:** With the growing number of interconnected systems, the threat of cybersecurity looms large. AI-based attacks have increased significantly and enterprises are turning towards highly-sophisticated AI cybersecurity (offensive AI) to counter the advanced attacks in the modern threat environment.

#### **A focus on amplifying experiences for both customers and employees will drive conversational commerce, ambient experience and citizen access**

- **Conversational commerce:** This offers a convenient and smart way for customers and businesses to interact. Conversational commerce is possible through AI-powered chatbots coupled with cognitive intelligence to deliver an augmented and personalised customer experience. Enterprises can shorten the time it takes to satisfy customer needs, right from the first greeting to the final payment, and redefine customer experiences through conversational commerce.
- **Ambient experience:** Enterprises are swiftly moving towards offering ambient experiences across omnichannel. The rise of AR (augmented reality), VR (virtual reality) and MR (mixed reality), along with a cohesive integration of knowledgebase and CRMs have made ambient experiences a high possibility — especially in environments with high customer interactions. AR, VR and MR have emerged as compelling options to provide premium customer experience by harnessing the power of AI to merge the virtual and real-world seamlessly in real time.
- **Citizen access:** Building reusable applications through low-code or no-code platforms, or drag-and-drop interfaces is the new norm. The industry will witness rapid democratisation of technology, which will allow people to access technical expertise easily and create technical solutions without any extensive training on the necessary skills, eg: citizen data scientists and citizen programmers. Organisations would rely on AI-driven development and automated testing so that all employees can contribute to it.

Technological advancements across hardware, software/services and experiences, and their controlled collision are pushing the envelope of innovation with every passing year. These technologies are high in value, maturity, or both, and together they are redefining the way organisations operate and create value in the ecosystem.

By Graham Jarvis

**Alphabet’s report, *What moves Britain?* finds that 73% of British workers believe their vehicles are essential for their daily commuting.**

Cars often freedom of choice of where to go, and they don’t wish to lose this benefit. However, within corporate circles, there is much interest in mobility solutions. Pressure will also be put on the use of cars within urban environments as new policies are emerging to encourage alternative modes of transport.

There is a push for better air quality, reduced traffic congestion and improved safety. While decision-makers and employees are interested in mobility solutions, they are seen as being either supplementary or as a partial alternative to the traditional fleet. This is because employees value the benefits that a fleet vehicle brings them. In some cases, it’s also because cars are the only practical option.

**Time to prepare**

Even so, the general view in the industry is that fleet managers should be preparing to adopt new, cleaner technologies – designing their driver policies with eligibility criteria that consider charging infrastructure for electric vehicles and employee responsibilities. Fleet telematics will in some circumstance that they’ll inevitably need to consider, not just for delivery vans and lorries because telematics is a fundamental cornerstone of usage-based insurance (UBI).

Ptolemus Consulting’s December 2019 email newsletter says fleet insurance telematics premiums will reach \$22Bn globally, by 2030. It reports that it has seen “rapid growth of connected fleet solutions in commercial vehicles and company cars: from 37 million in 2016 to **64.1 million** in 2019”. It also finds that connected fleet UBI policies will reach 10.95M in 2030, with the US retaining its lead, followed by China and Japan.

Meanwhile, in the US logistics sector, there is also a need to look at future-proofing – not just telematics but fleets themselves. Samantha Thompson, fleet telematics and customer manager at Penske reminds us why telematics is so important. She asks: “Where is my fleet, and what is it doing?” Even for car and van fleets this information can often be crucial, and so for fleet managers generally it is essential to have it at hand.

**Connectivity is crucial**

Connectivity across fleets, therefore, plays a role – particularly where there is an unprecedented amount of data to be collected. This data can be used to improve productivity and efficiency. Thompson adds: “It’s more about the outliers versus the status, the part of my fleet that I need to manage. It can point out the areas I need to focus on. There are also safety programs, validating that drivers are conforming with their training. It can also ensure that they are compliant with regulations.”

Over the last few years, truck fleets have adopted electronic logging devices (ELDs) to comply with regulations. Nowadays ELDs are supplemented with dashboard cameras or back-up cameras. “It’s less about Big Brother and more about protecting their fleet,” she says. In essence, they offer fleet companies cover against losses and she finds that some insurance companies are either suggesting or requiring them before giving discounts on insurance premiums – much like they offer whenever UBI is used in cars.

**Investing in telematics**

This still leaves the question of whether investing in the future-proofing of fleet telematics is worth it from a return-on-investment standpoint. Thompson says this is a complex question but the answer is that investing in fleet

telematics is worth it. ELDs and cameras will inevitably have an impact – particularly if they are used to their full extent. Yet people will often buy things and then not use them.

She therefore explains: “Many software technology providers have that struggle, so they need to help them to use it to manage their fleet better. This will hopefully help them to justify the cost.” She subsequently advises that it’s vital to have a good on-boarding and customer success program to ensure “the solution does what the customer is expecting it to do. We try to be a full-service provider here at Penske.”

### **Understanding pain-points**

To future-proof fleets and telematics, there is also a prerequisite to consider the potential future pain-points that may affect them. Data security is one of them but there is also the issue created by shifts in hardware, which is leading carmakers to jump into the telematics space.

Thompson adds: “Many of our customers have adopted third party technologies. It’s becoming more about the platform, software and data. The hardware is becoming a gateway to it. We are seeing trends where the device is becoming moot, and the installation of third-party black boxes that can pull off the data from the vehicles.”

She reveals that some fleets have put their own boxes in the trucks. This is creating more competition between telematics service providers (TSPs) automakers. However, she explains that there is also reason for them to work together: “If I am a fleet operator and I use the same OEM across the fleet, that won’t be much of a problem – unless several different OEMs are used across the fleet, which would make it more complex.”

### **ELD uses**

However, ELDs can be used for “a ton of stuff” besides tracking hours of service (HOS). They can provide fault code monitoring and GPS. So, in essence ELDs are not just for recording HOS, and Penske is seeing more consolidation in the marketplace. “Five years ago, TSPs needed to integrate with several other providers to provide add-on services, and even in the driver’s truck they would have different devices”, says Thompson.

This consolidation isn’t so much about one company buying another. It’s about providing more services from one provider, rather than from several providers. This consolidation can reduce complexity and make it easier for fleets to use the same solutions. Yet, besides cyber-security and driver objections, there are still some obstacles and technical issues that need to be overcome as a result of the ELD Mandate.

Thompson explains what they are: “Not all vehicles are capable of providing the data that the US government needed and many drivers often work for many firms, which means they may use several different ELDs. It, therefore, behooves the industry to make the different systems to be able to work together.”

### **Offer interoperability**

There needs to be a core set of data to offer interoperability. “In one fleet they could have one or two ELDs or telematics systems: A fleet may be owned by the same company but they operate using different systems in different locations,” she says. As part of the ELD Mandate there is a need for each driver to have their previous seven days of hours of service data. So, in terms of future-proofing telematics and fleets, the industry isn’t there yet. Thompson concludes that it’s about device stability, regulatory compliance and cyber-security is also something that concerns fleet customers. Cyber-security is increasingly being seen as a crucial aspect of regulatory compliance, and the penalties for data breaches can be severe – much depending on which jurisdiction the data resides.

Nevertheless, Shell’s *Future of Fleet Report* suggests that there is an exciting road ahead. It’s a future where telematics will play a key role for fleet cars, trucks and vans.

***These electromagnetic waves have a unique ability to see through and identify materials; Tel Aviv University scientists manage to produce them in a lab***

By Shoshanna Solomon

A group of researchers at Tel Aviv University say they have developed a new way to produce and control terahertz waves, an elusive type of electromagnetic wave, using nanometric materials.

These waves can be used to create devices with advanced imaging abilities that can see through opaque materials like plastics or paper, identify small structures and their composition, or look through paint layers in works of art, the researchers said.

Terahertz waves are considered by scientists to be very important due to their unique ability to interact with materials: this makes them useful in accurately identifying different materials. In addition, terahertz waves can pass through materials and objects that appear opaque to other wavelengths, and thus can be used to detect hidden objects and even reveal their composition.

Despite their great importance, however, the ability to produce and control terahertz waves has been very limited compared to other forms of radiation.



Now, researchers at TAU’s Center for Nanoscience and Nanotechnology say they have created nanometric surfaces known as meta-surfaces, which enable the “groundbreaking” and “unprecedented production and control of terahertz waves.”

The nanometric materials were developed at the Nanoscale Electro-Optics Laboratory at TAU’s Department of Physical Electronics, by its head, Prof. Tal Ellenbogen, and research students Shay Keren-Zur, May Tal and Eviatar Minerbi, in collaboration with Prof. Daniel Mittleman of Brown University in the US and Dr. Sharly Fleischer from TAU’s School of Chemistry. The lab for nanoscale electro-optics at the university focuses on the interaction between light and nano-materials.

The results were recently published in both Nature Communications and Nano Letters and will be presented at the beginning of February in the SPIE Photonics West international photonics and laser exhibition in San Francisco.



*left to right: Shay Keren-Zur, May Tal, and Prof. Tal Ellenbogen. (Tel Aviv University)*

Radio waves and microwaves are long electromagnetic waves; light, X-rays and infrared rays are short electromagnetic waves. Between the short and the long waves on the electromagnetic spectrum reside another kind of electromagnetic waves — the terahertz waves, shorter than radio waves and longer than infrared waves.

The short and long electromagnetic waves already have many uses, thanks to the ability of technology to produce them and control them. But while current technology can create optical waves or radio waves, it cannot create terahertz waves.

The nano-structured materials engineered by the TAU researchers are activated by shining ultra-short pulses of infrared light at them, and these metamaterials then generate terahertz waves.

By generating application-tailored terahertz waves, the metamaterials provide a promising new tool for terahertz science and applications, the university said in a statement.

The researchers created chips paved with millions of nanometric gold antennas (1 nanometer = 1 billionth of a meter), that get light from lasers emitting ultrashort infrared pulses, and then convert the energy and transmit terahertz pulses instead. By controlling the antennas on the meta-surfaces, the researchers showed that they can control the spatial and temporal shape of the terahertz pulse in a way that had never before been possible.

“The demonstration we performed in the lab breaks new ground, because the use of nanometric materials and the ability to produce light from them in a controllable manner,” said Ellenbogen in a statement. This adds “important technological tools and new abilities, taking research in this field a big step forward.”

“The ability to fully control the spatial shape and other properties of terahertz waves, as demonstrated in the study, enables the development and implementation of advanced imaging methods and new techniques of microscopy and spectroscopy,” he added. “Thus, for example, they will improve the ability to detect from afar, without chemical lab tests, the composition and spatial structure of materials. This will enable, for instance, the easy detection of fake medications and explosives.”

The project received funding from the European Research Council (ERC) and from Israel’s Ministry of Science & Technology.

**Wireless carriers around the world are accelerating the buildup of 5G network infrastructure with major investments in spectrum, base stations, microcells, and hotspots.**

By Jack Browne



Mobile telecommunications carriers around the world have proclaimed 5G cellular wireless networks as the next major step in communications technology. They will do what cellular network generations before them could not, operating at frequencies and data rates never possible. They will serve billions of users worldwide (if not just in China) and provide the bandwidth required for a

future filled with Internet of Things (IoT) devices for smart homes, smart factories, and smart cities, as well as the near-zero-latency signals for autonomous vehicles on smart highways.

The future of 5G certainly looks bright but what about the present? The hyperbole about 5G New Radio (NR) networks and technology is enormous, but how close is it to becoming reality?

The primary need for 5G is additional wireless capacity: it will provide service for more cell phones and other wireless devices. The global demand for wireless devices and services continues to grow, eclipsing the capacities of the first four cellular generations. 5G will add capacity along with enhanced performance in support of emerging applications powered by IoT devices. Its extended frequencies, bandwidths, and associated technologies are not meant to replace earlier cellular wireless network generations, such as 3G and 4G Long Term Evolution (LTE), but to work alongside them.

### **FR1 and FR2**

While a great deal of the novelty associated with 5G networks is their reach into millimeter-wave (mmWave) frequencies, much of their operation will be performed within a frequency range that has come to be known as “FR1” for signals below 6 GHz, compared to higher-frequency signals (above 6 GHz) within a range known as “FR2.” More specifically, 5G networks are being designed for multilayer spectrum coverage, occupying licensed and unlicensed frequencies in three bands: low-band signals below 1 GHz, mid-band signals from 1 to 6 GHz, and high-band signals above 6 GHz at centimeter-wave (cmWave) and millimeter-wave (mmWave) frequencies.

Spectrum sharing will allow current wireless applications to coexist with low- and mid-band 5G network signals. As an example, China is experimenting with sharing frequency bands below 1 GHz (470 to 806 MHz) between existing broadcast television systems and emerging 5G multimedia mobile communications applications. Depending on 4G/5G network configurations, some shared spectrum may even involve uplinked versions of sub-1-GHz signals within crowded spectrum to take advantage of available wireless connections at higher frequencies, such as from 3.3 to 3.8 GHz in Europe.

Frequency spectrum around the world is being allocated and, in some cases, auctioned for use by 5G carriers. The costs of licensing frequencies and bandwidth can vary widely by region, from the FCC’s high-cost auctioning of frequencies according to its 5G Facilitate America’s Superiority in 5G Technology (5G FAST) plan, to China’s allocation of frequency bandwidth to its four government-owned 5G carriers.

Spectrum auctions by the FCC in the U.S. include FR1 bands of 3.100 to 3.550 GHz and 3.7 to 4.2 GHz, and FR2 bands of 27.50 to 28.35 GHz and 37 to 40 GHz. In contrast, in China, FR1 bands of 3.3 to 3.6 GHz, 4.4 to 4.5 GHz, and 4.80 to 4.99 GHz, and FR2 frequencies of 24.25 to 27.50 GHz and 37.00 to 43.50 GHz are being deployed. And in Japan, 5G will operate within FR1 bands of 3.6 to 4.2 GHz and 4.4 to 4.9 GHz, and FR2 frequencies of 27.50 to 28.28 GHz.

### Proper Infrastructure

Standards for 5G performance and protocols—established by organizations such as the IEEE and Third Generation Partnership Project (3GPP) and its TS 38.104 V15 specifications for 5G base stations—are essential for creating wireless networks and UE devices that will be compatible within a given operating region. In some locations, such as downtown Beijing, China, 5G network infrastructure has been deployed to investigate the limits of higher-frequency 5G signals compared to earlier-generation cellular wireless networks (Fig. 1).



1. Aggressive infrastructure buildup in highly populated areas such as Beijing, China is making commercial 5G network service available. (Courtesy of Qualcomm)

Many carriers have been aggressive in their claims of providing 5G network coverage, offering computerized coverage maps that indicate availability by frequency. The use cases for 5G coverage include enhanced mobile broadband (eMBB) applications like smartphones, massive machine-type communications (mMTC) such as in automated factories, and ultra-reliable low-latency communications (URLLC) such as in robotic surgery and vehicle-to-vehicle (V2V) communications for autonomous vehicles.

Infrastructure for 5G networks is being built “on top of” earlier cellular wireless generations, with 5G base stations being added whenever possible to 3G and 4G installations as non-standalone (NSA) 5G base stations. For voice and noncritical data applications, such installations can provide service by means of 3G or 4G networks, reserving 5G at its highest frequencies for low-latency, high-speed-data applications.

Transfer of data at high rates requires large amounts of contiguous bandwidth, which can be found with the lack of applications at 24 GHz and above. However, the higher path losses of those higher-frequency signals mean that they

will not be as freely available in wireless networks without additional hardware and software assistance compared to lower-frequency signals.

To fill holes in the signal coverage between NSA base stations using mmWave signals, smaller 5G standalone (SA) base stations will be constructed. These will have much closer spacing between them because of the high path losses for cmWave and mmWave signals.

Both SA and NSA base stations will be important parts of 5G wireless networks. However, the two types of sites will have different functionality and capabilities requiring, for example, different test strategies to characterize 4G LTE equipment in NSA base stations compared to the higher-frequency transceivers in 5G NSA base stations. Due to the challenge of achieving coverage with mmWave signals, 5G networks will employ higher-frequency signals (and their support of high data rates) where they do the most good, such as in office buildings and heavily populated areas.

### **Investing in 5G**

With its higher frequencies and technologies to support their use, investment in 5G wireless networks is not trivial—it's required the rapid growth of wireless users through 3G and 4G LTE networks. The adoption rate of 5G UE devices and services throughout the world is expected to quickly eclipse the rates at which customers took to 3G/4G devices and services.

South Korea, the first country to commercialize 5G wireless networks and UE devices, already has over 2.5 million 5G mobile broadband users. The South Korean government is very involved in the commercialization, subsidizing the sales of UE devices and cutting taxes on network infrastructure construction for service providers. That government feels 5G will have many vertical business branches that will boost its economy, such as autonomous driving in smart cities and digital wireless healthcare, and the technology is well worth its involvement and investment.

Throughout the U.S., for example, 5G service providers such as AT&T, Sprint Nextel, T-Mobile, and Verizon have made major investments in their wireless networks, adding frequencies, capacity, and performance. AT&T, for example, quotes an investment of \$145 billion in its wireless network over the past five years, while T-Mobile has invested over \$30 billion in 5G network infrastructure that involves 25,000 new cell sites and towers. For all carriers and networks, performance will improve over time with the addition of bandwidth at higher frequencies. Some offer “offshoots” of full-featured 5G technology based on network availability, such as Verizon's broadband internet Home 5G Service.

At present, 5G coverage in the U.S. is limited to select major cities and to performance levels that only begin to scratch the surface of 5G's ultimate performance capabilities. As coverage extends to more rural areas, networks will evolve with functionality and services provided as needed. The networks support 5G smartphones from several major manufacturers, such as the Galaxy S10 5G phone from Samsung. Within a 5G network, it's capable of the fast upload/download data rates promised by 5G technology. Outside 5G coverage, it operates according to a network's capabilities, serving largely as a fully functional 4G LTE smartphone.

Customers for 5G smartphones are getting an idea of the much higher costs of those devices compared to 4G phones—and this is with limited service. Service providers worldwide are in the process of constructing their 5G networks, currently offering very limited coverage mostly at lower frequencies and with some experimental or “pilot” cells operating at mmWave frequencies.

Very little is known about signal frequencies at 24 GHz and higher in actual use and these test cases provide the means to discover the effects of real-world operating environments, such as rainfall attenuation, on mmWave signals. Signals at mmWave frequencies used in 5G systems for high-data-rate transmission and reception suffer much higher path loss than lower-frequency signals with longer wavelengths. They can be attenuated by a building, foliage, or even a user's hand placed too close to the antenna array within a 5G smartphone.

Many service providers are learning a great deal from their users of these early 5G network sites, reporting positive results from the use of multiple-input, multiple-output (MIMO) antennas and active antenna systems (AAS) on extending coverage with mmWave signals. Antennas in  $4 \times 4$  MIMO configurations have been successfully applied in 4G LTE networks. Much larger antenna arrays are typically being used in 5G networks. These are often  $8 \times 8$ , 64-element active antenna arrays capable of controlling the phase and amplitude of each element to form a beam of directed energy between a base station and a user at mmWave frequencies.

Most 5G carriers expect about a five-year buildup period for their networks with major investments in hardware, since the cost of RF/microwave components tends to increase with increasing frequency. Leading device manufacturers such as Intel, Qualcomm, and Texas Instruments are working to reduce the costs of RF/microwave components such as radio transceivers at higher mmWave frequencies. They're accomplishing this through the dense integration of components within ICs and multilayer circuit modules that can serve both 5G UE devices and base stations. In general, 5G UE devices and base stations will be highly integrated, which is notable at higher frequencies where array antennas are tightly integrated with radio electronics, making it difficult to characterize 5G radio circuits using traditional test methods.

### Testing the Future

In 5G SA base stations, the multiple-band radio equipment will operate on its own, while in NSA base stations, it will share real estate with earlier-generation wireless base stations. The radio portion of a 5G base station will be a separate unit than the controller electronics, a remote radio head (RRH), with the two units interconnected by optical cables. Due to the propagation characteristics of mmWave signals (poor penetration of solid objects such as building walls), RRHs will be mounted where needed for maximum coverage, such as on building rooftops and within buildings (Fig. 2). However, such locations may make access with test equipment difficult.



2. Compact base stations like the Nokia Airscale Base Station will add 5G coverage to areas already served by 3G and 4G LTE networks. These modular base stations make it possible to add 5G frequencies and spectrum as available to enhance performance and coverage.

Due to the many hundreds and thousands of base stations and microcells that will be needed and constructed during the next five years, different measurement approaches will be required to characterize and maintain the

performance of 5G RRHs. This includes over-the-air (OTA) testing for locations where it's impractical to make a physical (coaxial cable) connection between the RRH and a signal analyzer.

OTA testing performs measurements of a UE device or base station at some distance from the antennas in the device under test (DUT) using a calibrated measurement antenna connected to the signal analyzer. In the case of a smaller DUT such as a smartphone, OTA measurements are performed within a shielded room or enclosure. Once installed, 5G base stations can also be checked for performance levels and coverage within an area using OTA measurements.

Clearly, 5G wireless network coverage is in its infancy in many locations. Some locations, such as China, Japan, and South Korea, are further along in constructing the 5G network infrastructure needed to meet the bold claims of 5G service providers. However, the investments and the commitments to building 5G wireless networks are strong.

It's clear that the next five years will be active times for suppliers of UE device chipsets, for infrastructure radio equipment suppliers in both FR1 and FR2 frequency ranges, for suppliers of test hardware and software in support of OTA measurements, and even for suppliers of the potentially millions of kilometers of fiber-optic cables needed in the integration of 5G base-station subsystems. It's important to remember that 5G networks will be multilayered systems operating in basically three different frequency bands and wireless functionality and performance will grow as 5G infrastructure builds up.

Many functions remain well-served by 4G LTE systems. As 5G networks expand, they will add to the possibilities of 5G technology especially in vertical markets, such as autonomous vehicles, wireless and IoT-enabled robotic factories and warehouses, and wireless healthcare and remote medical care.