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GAM releases GSL robotic strain wave gearboxes
GAM released its new GSL series of strain wave gearboxes. The new gearboxes provide zero-backlash and high torque in a small gearbox for robotic and motion control applications. The GSL gearbox uses harmonic gearing for a very compact design that easily integrates into applications requiring high ratios and high precision in a small form factor. The GSL series is available in frame sizes 14 to 40 and reduction ratios 50:1 to 160:1.

"GAM has always been known for our breadth of products," said Craig Van den Avont, president, "and with the introduction of the GSL strain wave gearbox, we bring that breadth of product to our zero-backlash gearbox offering including our GCL series cycloidal gearbox and our revolutionary GPL zero-backlash planetary gearbox."

Options for the GSL series include the "hat" and "cup" type with keyed bore, hollow, or shaft inputs. The GSL is also offered in basic component form for fully integrating into applications. The GSL series can be used in a wide variety of applications, such as robot joints, autonomous remote vehicles, antenna positions, or any other applications requiring zero-backlash and high torque in a small gearbox.

Game world star PewDiePie signs exclusive deal with YouTube
YouTube on Monday announced that streaming star PewDiePie will make the Google-owned video platform his exclusive online stage. PewDiePie, whose real name is Felix Kjellberg, has 104 million subscribers at YouTube, where his videos have racked up more than 25 billion views. No details were disclosed regarding any financial incentives involved in his decision to go exclusive at Google-owned YouTube, which competes with rival platforms such as Amazon-owned Twitch and Microsoft Mixer.

Solar and wind energy sites mapped globally for the first time
Researchers at the University of Southampton have mapped the global locations of major renewable energy sites, providing a valuable resource to help assess their potential environmental impact. Their study, published in the Nature journal Scientific Data, shows where solar and wind farms are based around the world—demonstrating both their infrastructure density in different regions and approximate power output. It is the first ever global, open-access dataset of wind and solar power generating sites.

The study authors used data from OpenStreetMap (OSM), an open-access, collaborative global mapping project. They extracted grouped data records tagged 'solar' or 'wind' and then cross-referenced these with select national datasets in order to get a best estimate of power capacity and create their own maps of solar and wind energy sites. The data show Europe, North America and East Asia's dominance of the renewable energy sector, and results correlate extremely well with official independent statistics of the renewable energy capacity of countries.

Gore Launches New Online Microwave/RF Assembly Builder
W. L. Gore & Associates has launched its updated GORE® Microwave/RF Assembly Builder, a step-by-step tool that allows the user to configure and request a quote for an assembly with a variety of connector & cable options, assembly lengths, and frequencies.

The new GORE Microwave/RF Assembly Builder is designed to aid those working in Test & Measurement, Spaceflight, Aerospace or Defense industries. Once the assembly has been designed, the visitor can download custom datasheets for the assemblies within minutes, as well as submit the builds for a quote. A Gore specialist will then review the submitted designs and application requirements and provide a quote on each design.

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Cooley: #1 in US for IPOs by Operating Companies Year-to-Date
Cooley's capital markets practice continues to lead the nation in partnering with innovative companies and their investment banks through the IPO process, despite the numerous challenges faced in light of the COVID-19 pandemic. From the start of the year, Cooley is the #1 law firm nationwide for IPOs by US operating companies and is also the #1 law firm nationwide for IPOs by life sciences companies.

Additionally, Cooley advised on numerous recent notable securities transactions involving already public issuers – either on the company- or bank-side – including Shake Shack's $140 million public offering of Class A common stock and $75 million "at-the-market" equity offering program, NVIDIA's $5 billion investment grade note offering, Health Catalyst's $260 million convertible senior notes offering, Invitae's $184 million public offering of common stock, Immunovant's $139.4 million public offering of common stock and Crinetics' $115.1 million public offering of common stock.

Cooley has been the #1 law firm advising companies going public across all industries since 2014 and the #1 law firm for all venture-backed IPOs across all industries for 15+ years, according to IPO Vital Signs and PitchBook. This year, the firm earned a three-time Capital Markets Practice Group of the Year distinction by Law360 and was named one of the decade's top IPO legal advisors by Bloomberg Law.

Game Makers EA, Activision See Business Surge During Outbreak
One part of the entertainment business—videogames—is showing resilience amid stay-at-home orders related to the Covid-19 outbreak. For the quarter ended March 31, Electronic Arts—which owns FIFA, Madden and other popular game franchises—said its net income more than doubled to $418 million while its net revenue jumped 14% to $1.39 billion from the same period a year earlier. Meanwhile, Activision Blizzard—known for its Call of Duty and World of Warcraft brands—said its net income rose 13% to $505 million revenue from a year earlier while its net revenue slid 2% to $1.79 billion.

Both companies said they were seeing significant increases in usage of their games as people depend more heavily on in-home sources of entertainment. The true test of their business models will come in the next quarter. Both companies sounded bullish notes for the future. Activision, for example, raised its revenue forecasts for its full fiscal year to $6.8 billion from an earlier prediction of $6.45 billion.

Airbnb, Uber announce steep layoffs
Layoffs continue for companies in the transportation and travel spaces, both hit hard during the COVID-19 pandemic. Among the latest to announce steep reductions are Airbnb, which is cutting about 1,900 jobs, and Uber, which is laying off 3,700 employees.

Lyft Ride Business Now Down About 70% From Last Year
Lyft appears to have recovered from the worst of the decline in ride-hailing. Ride volumes are now down 70% compared to the same time a year ago, a slight improvement from the middle of April when rides were down around 75% compared to the same time a year ago, the company said Wednesday amid its first-quarter earnings report. Lyft is now handling about 500,000 rides per day. Before Covid-19 shutdowns, Lyft was handling about two million rides a day. Lyft's prospects could improve as more U.S. states allow some businesses and offices to reopen, but CEO Logan Green said social distancing and corporate cost cutting will have a long term negative impact. A second wave of virus infections and deaths also could cause another retrenchment.

Lyft last week cut 17% of its employees, or nearly 1,000 people, as it adjusts to the depressed state of its industry. That move will save the company several hundred million dollars annually. The company said it had $2.7 billion in cash at the end of March and that it wouldn't need more than that to get to a point where it breaks even from a free cash flow basis in the future. The Covid-19 impact on Lyft's ride hailing business only began in the last two weeks of March, but the lockdowns pulled down the company's first quarter revenue by at least $100 million versus what it would have been otherwise. That meant Lyft's first quarter revenue grew 23% compared to a year ago versus at least

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36% if Covid-19 hadn't arrived. Lyft appears to have made strides towards shrinking the cash burn from its operations. While its cash burn more than doubled to $242 million in the first quarter compared to a year earlier, that increase was due to a one time payment that helped resolve car insurance claims in 2018 and earlier. If the increase in Lyft's share price following first quarter results holds to the next trading day, it will still be down 43.5% from February.

Qualcomm excited about Wi-Fi 6E, has device silicon ready
Qualcomm has more than 70 Wi-Fi 6-enabled devices and more than 200 AP and gateway designs
Last month, the FCC opened up the 6 GHz frequency band for use by Wi-Fi 6 technology, a decision that is receiving substantial industry praise. Qualcomm is no different, as the company's Senior VP and GM of Connectivity Rahul Patel told RCR Wireless News.

"The last time spectrum was opened for Wi-Fi was 20 years ago. We are very excited about Wi-Fi 6E," Patel said. "For us and our customers, we all are very enthusiastic and eager to launch [compatible devices]as quickly as possible."

The ability to leverage the 6 GHz band for unlicensed Wi-Fi operation — referred to as Wi-Fi 6E — will deliver faster connectivity speeds and improved capacity when compared to both 2.4 GHz and 5 GHz Wi-Fi, making it ideal for smartphones, tablets, laptops and, perhaps most exciting, virtual/augmented devices. Further, the MU-MIMO capabilities of 802.11ax, or Wi-Fi 6, combined with 6 GHz will create a number of use cases both in the home and in the enterprise space. According to Patel, Qualcomm already has more than 70 Wi-Fi 6-enabled devices and an additional 200 or so access points (APs) and gateway designs. He also said that while the expectation is for Wi-Fi 6E to launch sometime around the end of this year or the beginning of next, some companies, Qualcomm being one of them, will enable customers to launch sooner than that.

Scientists from MIT and Broad Institute have developed rapid CRISPR-based test for coronavirus; the at-home test could cost as little as $6
A team of scientists from MIT, the McGovern Institute, and the Broad Institute has developed a gene-editing technology CRISPR-based test for the coronavirus that could work as simply as a pregnancy test. Dubbed STOPCovid, the goal of the effort is to develop point-of-care and at-home tests for COVID-19.

The STOPCovid kit and protocol are currently not to be used for clinical purposes. Although the kit has been validated on patient samples, the test is not FDA authorized. The test is based on a gene-editing technology known as Crispr, and the researchers estimated that the materials for each test would cost about $6.

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Goldman Sachs and ClearSky Security invest in cybersecurity startup White Ops to protect enterprises from sophisticated bot attacks
White Ops, a New York City-based cybersecurity startup that protects enterprises and the largest internet platforms from sophisticated bots, today announced the completion of an investment by Goldman Sachs Merchant Banking Division and ClearSky Security to support the Company in its next phase of growth. The company did not disclose the total amount of funding. In conjunction with the investment, White Ops announced that a member of the Goldman Sachs team will join representatives from previous investors Paladin Capital Group and Grotech Ventures on the its board of directors. The investment will also enable White Ops to further accelerate its growth and expansion on a global basis, support product development, and expand into new vertical markets. The Company's core mission is to protect enterprises from sophisticated bot attacks and fraud across the domains of cybersecurity, digital advertising, and marketing, serving some of the largest enterprises and internet platforms.

Founded in 2012 by Ash Kalb, Dan Kaminsky, Michael Tiffany, and Tamer Hassan, White Ops protects enterprises all over the globe, including the largest internet platforms, from sophisticated bots by verifying the humanity of more than one trillion online interactions every week. The most sophisticated bots look and act like humans when they visit websites, click on ads, fill out forms, take over accounts, and commit payment fraud.

Industrial AI startup Covariant raises a $40M Series B
Covariant this week announced that it has raised a $40 million Series B, led by Index Ventures. The funding brings the three-year-old Berkeley startup's total funding up to $67 million. Co-founded by top UC Berkeley professor Pieter Abbeel, the company is dedicated to building autonomy for industrial robotics. It's a category that's growing hotter than ever as more companies look toward robotics and automation as potential ways forward amid the COVID-19 pandemic. Covariant came out of stealth in January, announcing that it had already deployed its technology to real-world facilities in Europe and North America. In March, the company announced a partnership with top industrial robotics company ABB.

Healthtech startup Medable raises $25M funding to drive global adoption of decentralized clinical trials
With research institutions and pharmaceutical companies in a race to develop vaccine to cure the deadly coronavirus, the need to accelerate clinical drug development is more needed than ever. That's why Medable, a Silicon Valley healthtech startup, is on a mission to reduce clinical trial timelines by 50 percent. Medable announced it has secured $25 million in venture funding to accelerate clinical drug development with digital technology, enabling effective new therapies to reach patients faster. The round, which was led by early-stage healthcare and AI investor GSR Ventures, brings Medable's total capital raised to more than $45 million. PPD, Inc. also participated in the round.

Founded in 2012 by Fernando Waigandt, James Sas, Michelle Longmire, and Tim Smith, Medable is transforming healthcare by enabling patient generated data to drive healthcare delivery and clinical research. The company has become a leader in the movement to digitize and virtualize clinical trials. Over the past several years, Medable's team has built a modular digital platform-as-a-service that streamlines clinical trials with direct-to-patient technologies. The platform is now used by leading biopharma sponsors and clinical research organizations worldwide, and has been used for trials in 30+ countries and 26 languages.

KlearNow raises $16 million to bring customs clearance industry into the digital age
Silicon Valley-based KlearNow has developed a platform that aims to bring customs clearance into the digital age. Now, with $16 million new funding, KlearNow aims to expand its geographic reach and improve its product to cover increasingly complex export-import verticals and time-sensitive shipments. The company has certification to handle

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any import into the U.S., no matter what the commodity is. KlearNow is close to getting certified in Canada and the U.K., and plans to expand to Netherlands, Belgium, Spain and Germany. KlearNow has about two dozen customers.

The Series A funding round was led by GreatPoint Ventures, with additional participation from Autotech Ventures, Argean Capital and Monta Vista Capital . Ashok Krishnamurthi, managing partner at GreatPoint Ventures, will join KlearNow's board. Daniel Hoffer from Autotech Ventures is joining as a board observer.

Silver Lake to Invest $750 Million in Indian Mobile Provider Jio

Reliance Industries, the Indian conglomerate owned by Asia's richest man, said U.S. private equity firm Silver Lake will buy a $750 million stake in Jio Platforms, a telecom subsidiary. The investment comes after Facebook said last month it would invest $5.7 billion for a nearly 10% stake in Jio, which is India's largest mobile network by subscribers.

Intel buying Moovit for $900M

Intel is acquiring Moovit, developer of an app for planning local journeys primarily using public transit, in a deal valued at around $900 million. Founded in 2012, Israel-based Moovit previously raised over $130 million in venture funding from Intel and other backers.

Qwilr raises $9M for snazzy sales docs

Sydney-based Qwilr, a document design and automation tool, closed on a $7.25 million Series A funding round led by AirTree Ventures, Skip Capital, and Typeform co-founder Robert Muñoz. The company's software enables users to create interactive sales documents.

Nvidia acquires Cumulus Networks

Nvidia today (May 4, 2020) announced its plans to acquire Cumulus Networks, an open-source-centric company that specializes in helping enterprises optimize their data center networking stack. Cumulus offers both its own Linux distribution for network switches, as well as tools for managing network operations. With Cumulus Express, the company also offers a hardware solution in the form of its own data center switch. The two companies did not announce the price of the acquisition, but chances are we are talking about a considerable amount, given that Cumulus had raised $134 million since it was founded in 2010.

Mountain View-based Cumulus already had a previous partnership with Mellanox, which Nvidia acquired for $6.9 billion. That acquisition closed only a few days ago. As Mellanox's Amit Katz notes in today's announcement, the two companies first met in 2013, and they formed a first official partnership in 2016. Cumulus, it's worth noting, was also an early player in the OpenStack ecosystem.

Trading App Robinhood Raises $280 Million at $8.3 Billion Valuation

The stock-trading app Robinhood confirmed on Monday that it had raised a $280 million Series F funding round led by Sequoia Capital which values the company at $8.3 billion. Early indication of the round was first reported by Bloomberg in April. To date, Robinhood has raised around $1.1 billion, according to a company spokesperson. Its previous raise last July for $323 million valued the company at $7.6 billion.

In an interview with Fortune on Monday, co-CEO Vlad Tenev said Robinhood had added three million funded accounts since the beginning of the year, and that daily trading volume was three times higher in March than the company's average during last year's fourth quarter. In early March, Robinhood had a series of outages (one for an entire day) that left users unable to make trades. At the time, the company said the outages were caused by "stress to its infrastructure" due to "unprecedented load." Later in March, the company reportedly started offering credits to those impacted by the outages.

Silver Lake values Jio Platforms at $65B

Silver Lake has agreed to invest nearly 56.6 billion rupees (about $750 million) into Jio Platforms, a budding internet services giant in India. The deal gives the company an equity valuation of some $65 billion, a 12.5% increase from the

valuation assigned to Jio last month when Facebook acquired just shy of 10% of the business. Jio is a subsidiary of Reliance Industries, the largest business conglomerate in India.

Altaris seals $650M deal for 3M's drug delivery unit
Altaris Capital Partners has completed a previously announced deal to acquire a majority stake in the drug delivery business of 3M for roughly $650 million. 3M will retain a 17% stake in the St. Paul, Minn.-based company, which has been rebranded as Kindeva Drug Delivery. The business specializes in drug delivery services for the pharmaceutical and biotech sectors.

Riverwood Capital backs Sensor Tower
Sensor Tower has received a $45 million growth investment from Riverwood Capital—its first fundraise since a $1 million seed round in 2013, according to TechCrunch. The San Francisco-based company is the developer of a mobile app analytics platform that's used by The Wall Street Journal, Reuters, Bloomberg and other publications.

Robinhood banks $280M at $8.3B valuation
Robinhood, the developer of a commission-free trading platform, has raised a $280 million Series F led by Sequoia, pushing the online brokerage's valuation to $8.3 billion. The latest round also includes participation from existing investors NEA, Ribbit Capital, 9Yards Capital and Unusual Ventures. The company was valued at $7.6 billion after a $373 million financing in October, according to PitchBook data.

Based in Menlo Park, Robinhood also operates in locations including Colorado, Florida and the UK. The company plans to use the new funds in part to hire employees, scale its platform and create new products. It has added more than 3 million accounts to its customer base in 2020, half of which are first-time investors.

Database Startup Cockroach Gets $87M in New Funding
Cockroach Labs, a database startup founded by former Google engineers, announced an $87 million Series D financing round led by Altimeter Capital and Bond Capital. The startup, valued at $550 million after its last round in August, didn't disclose a new figure. The financing shows that startups that help companies store and analyze data are still able to attract investors in the uncertain economic times brought on by the Covid-19 pandemic. It also underscores investors' confidence in startups built around open source software.

Another factor helping companies like Cockroach is the overall growth of data that companies are generating from their operations. Outside of hard-hit industries like travel and retail, that trend seems unlikely to be significantly altered by the pandemic.Tehama nabs $10M for virtual work platform
Tehama, a SaaS platform that aims to offer a secure way to deploy a virtual workforce, has raised $10 million in a Series A round. Toronto-based OMERS Ventures led the investment in the Ontario company, which provides services around virtual rooms that provide a secure lock on data.

Orca Security closes on $20M
Israel-based Orca Security raised $20 million in a Series A round led by GGV Capital. The company's technology aims to provide frictionless tools to quickly analyze all cloud assets for risks within minutes.

Postal.io emerges from stealth with $9M
Postal.io came out of stealth mode Tuesday with a $9 million Series A round to launch its direct mail platform for sales and marketing teams. This is the San Luis Obispo, California-based company's first investment and was led by Mayfield.

Instabug nets $5M to keep apps from crashing
Instabug, which provides mobile developers with real-time contextual insights, has raised $5 million in a Series A led by Accel. The company, which has dual headquarters in Cairo, Egypt, and San Francisco, focuses on helping mobile developers more quickly identify and fix bugs within apps.

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LetsGetChecked lands $71M for home tests
At-home testing startup LetsGetChecked raised $71 million in a Series C round led by Illumina Ventures and HLM Venture Partners. The New York-based company plans to use much of the funding to increase its supply, manufacturing and testing capabilities for COVID-19.

Covariant raises $40M for AI robotics
Berkeley, California-based Covariant, an AI-enabled robotics company, raised $40 million in a Series B round led by Index Ventures. The company says warehouse operators have been early adopters of its technology, but it foresees greater use of its robots in other industries, such parcel mail, manufacturing, agriculture and recycling.

Peanut lands $12M for women's network
Peanut, a London-based social network for women, has raised a $12 million Series A round led by EQT Ventures. The startup aims to provide a community where women can seek support and advice from those in similar life stages, such as trying to conceive or parenting.

Treasury Prime secures $9M to power banks
Fintech startup Treasury Prime raised $9 million in a Series A round led by Amias Gerety of QED Investors, SaaStr founder Jason Lemkin, and Hans Morris of NYCA Partners. The San Francisco-based company makes software that reduces certain labor-intensive processes for banks and connects them with fintech companies.

N26 extends Series D to $570M
German fintech startup N26 has secured more than $100 million in additional funding for its Series D from existing investors, bringing the round total to $570 million. N26 has more than 5 million customers and is valued at $3.5 billion. It is backed by investors including Allianz X, Insight Partners and Tencent.

Ninja Van picks up $279M
Ninja Van has raised $279 million from investors including GeoPost and Grab Holdings, according to Bloomberg. Founded in 2014 and based in Singapore, the company offers logistics services across six countries in Southeast Asia.

Paris-based Back Market lands $120M
Back Market, the provider of a refurbished electronics marketplace with more than 1,000 sellers, has raised $120 million from Goldman Sachs, Aglaé Ventures and Eurazeo Growth. Founded in 2014, the company operates in eight countries. It was valued at €217 million (around $235 million at today's conversion rate) in 2018, according to PitchBook data.

L Catterton devotes $400M to cruise line subsidiary
L Catterton has agreed to invest as much as $400 million in NCL, a subsidiary of Miami-based Norwegian Cruise Line Holdings, through a private placement of exchangeable senior notes due in 2026. As part of the transaction, L Catterton will nominate one person to the company's board of directors, assuming certain ownership thresholds are met. The terms of the deal are also subject to NCL raising $1 billion in proceeds.

TPG-backed Adare Pharma buys Orbis Biosciences
Adare Pharmaceuticals, a clinical-stage drug developer backed by TPG Capital, has acquired Kansas-based pharmaceutical tech company Orbis Biosciences. The add-on deal is intended to bolster Adare's oral and over-the-counter medicine businesses.

PE-backed Sauer Brands snags seasonings manufacturer
Sauer Brands, a Virginia-based provider of condiments, spices, flavorings and other food products, has acquired Chicago Custom Foods, an Illinois-based provider of branded seasonings. Highlander Partners had owned CCF since early 2018, when it acquired the business from VMG Partners. Falfurrias Capital Partners has backed Sauer Brands since August.

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BV Investment Partners Announces Investment in StraighterLine
BV Investment Partners, a middle-market private equity firm focused on the tech-enabled business services, software and IT services sectors, announced today that it has made a significant investment in StraighterLine, an education technology company that provides scalable solutions to deliver affordable, effective and accelerated learning pathways to formal degree programs and widely recognized industry credentials.

SIP secures $400M to future proof infrastructure
A new entity called Sidewalk Infrastructure Partners (SIP) has raised a $400 million Series A round with the goal of "future proofing" infrastructure through technology. The startup is actually a holding company spun off of Alphabet's Sidewalk Labs, with backing from Alphabet and Ontario Teachers Pension Plan.

Symend raises $52M for debt resolution
Symend, a developer of tools for customer debt resolution, announced a $52 million fundraising round led by Inovia Capital. The Calgary-based company's platform uses artificial intelligence and behavioral science to provide insight into the situation of a customer who has a payment past due.

Runa Capital closes $157M fund for deep tech
VC investor Runa Capital closed a $157 million third fund, its largest to date. The firm will use the capital mostly to invest in early-stage deep tech (specifically quantum computing) and digital transformation in cloud infrastructure businesses.

Dtex lands $17.5M for cybersecurity
Insider threat cybersecurity company Dtex raised $17.5 million in a Series D round led by Northgate Capital. The San Jose, California-based company targets Fortune 1000 companies, many of which are looking for a cybersecurity solution for specific use cases, including how to secure employees while they work from home.

Hydrant soaks up $5.7M to quench thirst
New York-based Hydrant, developer of a line of hydration and daily wellness products, has raised $5.7 million in a Series A round led by Coefficient Capital. The company plans to use the new funding to expand its team, work on its go-to-market strategy, new product innovation and invest in analytics.

UNMET pitch event goes virtual
When startups and investors interact at the upcoming UNMET Arizona 2020, they will be doing it through an app rather than in person. Organizers decided to move the conference to the Thumbraise video pitch app as a result of COVID-19.

Data was pulled from Pitchbook and Crunchbase.

By Kareem Aly, a principal at Thomvest Ventures–a $500 million cross-stage venture capital fund based in Silicon Valley and Toronto.

When the economy takes a turn for the worst, a few things usually take place. Market multiples contract. Unemployment rises. Cash dries up. For many startups, this will mean death. For others, by clamping down on burn rates quickly, becoming hyper efficient, and continuing to execute—even at reduced growth rates—they will make it out on the other side.

Over the past 12 years, many companies received funding due to an increase in the number of funds, which were raised relatively easily with the lower cost of capital. In the coming years, however, startups and venture firms will be severely challenged. As a result, Darwin's survival of the fittest will come to fruition, and only a limited number will survive.

With the emergence of the COVID-19 pandemic, funding dollars, funding rounds, and private company valuations will decline. Given the uncertainty emanating from Silicon Valley and the venture community, we thought it'd be fascinating to go back in time and track valuations of companies that raised around the 2008-2009 time frame and ended up becoming successful.

Who are the fittest?
Granted, this analysis is biased for upside and not illustrative of the long list of companies that failed and closed shop during this period. It also is not encompassing of every company that generated a return for its founders and investors. However, the results remain intriguing, with far more companies successfully emerging from the 2008-2009 downturn than we had anticipated:

Company	2007	Pre-money	2008	Pre-money	2009	Pre-money	2010	Pre-money	Exit	Valuation at exit	Valuation at current
Anaplan	--	--	Seed	NA	--	--	Series A	$8m	IPO, 2018	$1.8B	$5.1B
AppDynamics	--	--	Series A	$7m	--	--	Series B	$35m	M&A, 2017	$3.7B	--
Facebook	Series C	NA	Series C	$15B	Later stage	$10B	Later stage	$24B	IPO, 2012	$65.2B	$436B
Mulesoft	Series B	$32m	--	--	--	--	Series C	$182m	IPO, 2017	$1.9B	Acq, $6.5B
Benefitfocus	Series A	NA	--	--	--	--	Series B	$585m	IPO, 2013	$565m	$272m
Groupon	--	--	Series A	$23m	Series B	$263m	Series C	$1.4B	IPO, 2011	$12.1B	$320m
Chegg	Series A-1	$6m	Series B, C	$16m, $29m	Series D	$509m	Series E	$635m	IPO, 2013	$834m	$3.7B
Brightcove	Series C	$143m	--	--	--	--	Series D	$285m	IPO, 2012	$235m	$239m
AppFolio	Series A	$11m	Series B	$50m	Series C	$60m	--	--	IPO, 2015	$315m	$3.1B
Tableau	--	--	Series B	$105m	--	--	--	--	IPO, 2013	$1.5B	Acq, $15.7B
Coupa	Series A	$4m	Series B	$15m	Series C	$6m	--	--	IPO, 2016	$730m	$9.1B
Box	--	--	Series B	$13m	Series B-1	$19m	Series C	$51m	IPO, 2015	$1.5B	$1.8B
Cornerstone	Series D	$40m	--	--	Series E	$58m	--	--	IPO, 2011	$508m	$1.5B
Procore	Series B	$10m	Bridge	$6m	--	--	--	--	IPO (ann)	NA	$3-4B (exp)
Carbon Black	Series C	$41m	--	--	--	--	Series C-1	$5m	IPO, 2018	$1.1B	Acq, $2.1B

(Note: Red font denotes flat/down rounds, decreases in valuation, or subpar exits. Green font denotes up rounds, increases in valuation, or positive exits.)

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Suffice it to say, you would have been hurting in the short-term if you were an investor that came in on the Series B for Coupa or the Series C for Carbon Black and witnessed valuations take a nosedive in the subsequent round. Valuations and pricing require extra consideration in economic downturns.

However, it's also evident that both of those companies—and many of the others in the above image—went on to become quite successful. With companies like Mulesoft, AppD, Tableau, Box and Facebook generating outsized returns, investors would be remiss to close their doors.

Company	2007	Pre-money	2008	Pre-money	2009	Pre-money	2010	Pre-money	Exit	Valuation at exit	Valuation at current
Twilio	--	--	--	--	Seed, A	NA, $9m	Series B	$40m	IPO, 2016	$1.1B	$13.5B
Bill.com	--	--	--	--	Series B	$12m	--	--	IPO, 2019	$1.3B	$3.0B
Cloudflare	--	--	--	--	Series A	$4m	--	--	IPO, 2019	$3.9B	$6.8B
Twitter	Series A, B	$.1m, $23m	Series C	$87m	Series D, E	$250m, $1.1B	Series F	$3.4B	IPO, 2013	$12.3B	$20.2B
Zynga	--	--	Series A, A1, B	$17m, $50m, $197m	Series B1	$3.2B	Series B2	$4.3B	IPO, 2011	$6.0B	$6.1B
Docusign	Series B	$29m	--	--	Series B1	$47m	Series C	$166m	IPO, 2018	$4.0B	$15.3B
Lending Club	Series A	$16m	--	--	Series B	$24m	Series C	$76m	IPO, 2014	$4.7B	$775m
RingCentral	Series A	$23m	Series B	$103m	--	--	Series C	$179m	IPO, 2013	$690m	$17.9B
Yelp	--	--	Series D	$204m	--	--	Series E	$455m	IPO, 2012	$791m	$1.5B
Zscaler	--	--	Series A	$4m	--	--	--	--	IPO, 2018	$1.7B	$8.0B
Zuora	--	--	Series A, B	$12m, $39m	--	--	Series C	$140m	IPO, 2018	$1.3B	$960m
Cloudera	--	--	--	--	Series A, B	$9m, $19m	Series C	$137m	IPO, 2017	$1.7B	$2.1B
ServiceNow	--	--	--	--	Series C	$61m	--	--	IPO, 2012	$2.0B	$51.6B
Roku	--	--	Series A, B	$4m, $33m	Series C	$40m	--	--	IPO, 2017	$1.2B	$11.7B
Redfin	Series C	$36m	--	--	Series D	$45m	--	--	IPO, 2017	$1.1B	$1.5B

Here we see flat/down rounds with companies such as Lending Club and DocuSign, as well as up rounds with companies such as Twitter and Zynga. Investing at the same valuation as an investor two years prior to the 2008-2009 downturn would seem to have been a well-placed bet. On the contrary, valuation at current (depicting today's contracted market conditions) would seem to signify the importance of picking the right companies above all else. Lastly, in our final set of companies below, we see that several seed rounds were completed in the midst of the last recession, including Airbnb, Slack, Lyft, Pinterest and Okta.

Company	2007	Pre-money	2008	Pre-money	2009	Pre-money	2010	Pre-money	Exit	Valuation at exit	Valuation at current
Airbnb	--	--	--	--	Seed	NA	Series A	$60m	NA	NA	$30.0B
Slack	--	--	--	--	Seed	NA	Series A	$15m	IPO, 2019	$23.3B	$15.7B
Lyft	--	--	--	--	Seed	NA	Seed-2	$5m	IPO, 2019	$21.7B	$8.0B
TrueCar	--	--	Series B	$44m	Series C	$85m	--	--	IPO, 2014	$569m	$256m
Square	--	--	--	--	Series A	$35m	--	--	IPO, 2015	$2.7B	$23.3B
Pinterest	--	--	--	--	Seed	$2m	Seed-2	$5m	IPO, 2019	$8.6B	$8.7B
LinkedIn	Series C	$237m	Series D	$984m	--	--	--	--	IPO, 2011	$3.9B	Acq, $26.2B
Mindbody	--	--	--	--	Series C	$19m	Series D	$37m	IPO, 2018	$448m	Acq, $1.9B
Acacia Comm.	--	--	--	--	Series A	$8m	--	--	IPO, 2016	$717m	Acq, $2.8B
A10 Networks	--	--	Series C	$55m	--	--	--	--	IPO, 2014	$750m	$418m
ChannelAdvisor	Series C	$130m	Series D	$171m	--	--	--	--	IPO, 2013	$206m	$198m
SailPoint	Series B	$21m	Series C	$43m	--	--	--	--	IPO, 2017	$855m	$1.5B
Veeva	Series A	$2m	Series B	$16m	--	--	--	--	IPO, 2013	$1.9B	$23.1B
Okta	--	--	--	--	Seed	NA	Series A	$24m	IPO, 2017	$1.4B	$15.1B
Uber	--	--	--	--	--	--	Seed	$4m	IPO, 2019	$67.6B	$47.0B

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Additionally, Veeva was able to make $7 million in total funding last through the downturn to its eventual IPO in 2013. The epitome of vertical software, Veeva's tailored features and highly targeted marketing efforts within life sciences led to improved SaaS metrics, such as lower CAC and best-in-class retention, and a $20B+ valuation today.

No one investment strategy fits all situations

VCs will need to focus on portfolio companies, maintain reserves and increase rigor around diligence and post-investment execution. Beyond that, however, the above data would suggest VCs should continue to invest in companies in the following three types of investment situations:

1. Early-stage works. These are companies with scrappy teams that can keep their burn rate low while focusing on product and UI/UX. Examples include Slack (seed in 2009), Twilio (seed and Series A in 2009) and Zscaler (Series A in 2008).
2. Later-stage works. These are companies that are attractively repriced category winners, which excel at alleviating massive pain points. Examples include Coupa (Series C in 2009), Box (Series B-1 in 2009) and Carbon Black (Series C-1 in 2010).
3. Be price-sensitive albeit flexible. Some companies have the leverage to abstain from valuation haircuts, even in economic downturns. Investors who remain dogmatically rigid in pricing may miss these opportunities. Examples include Tableau (acquired by Salesforce for $15.7 billion), LinkedIn (acquired by Microsoft for $26.2 billion) and ServiceNow (current market cap of $50 billion-plus).

Doing our part as a VC community

As we enter this period of uncertainty, many VCs will be focused on their portfolio companies, modifying plans via reductions in the topline, headcount and burn rates. Difficult decisions will be carried out as a result, and we empathize with those individuals negatively impacted by this pandemic. The inevitable constant, however, is startups will continue to need additional funding.

Rather than shut our doors, the VC community should embrace this uncertainty by investing in and helping grow the next generation of category creators and disruptors. Investors must stay amenable, adjust on the fly and look to deploy. In getting this next set of great ideas funded during this downturn, we'll have helped create the foundation for a new set of leaders to thrive and tackle pain points in a variety of categories we so direly need to be solved in the future.

We will inevitably be on the cusp of another bull cycle in due time. Let us seize the opportunity to help drive that cycle forward, help guide life back to normalcy, and support the courageous innovators and entrepreneurs enabling a better tomorrow for us all.

Note: An increase in pre-money is not always indicative of an increase in share price. Thus, pre-money can increase while a subsequent round is still considered a flat or down round.

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By Anke Zeidler-Finsel, Fraunhofer-Gesellschaft

Battery test bench at Fraunhofer LBF. Credit: Fraunhofer LBF

Thorough testing is paramount to the safety and reliability of the batteries that power electric vehicles. However, the lab tests conducted to date have been anything but realistic. Fraunhofer researchers have developed a new type of testing environment that combines physical components with mathematical simulations of vehicles. This setup is the first to enable lab trials under real-world conditions.

Electric vehicle batteries, often called traction batteries, are key components of e-cars. Storing the energy supplied by charging stations and providing that motive power on demand is just one side of their performance equation. The other is to hold up to the wear and tear of electrical, mechanical and thermal stress when negotiating hairpin bends, bouncing over gravel roads strewn with potholes and motoring in the sweltering summer heat. This is why new battery systems have to prove their mettle in various tests before they may be installed in vehicles. However, conventional lab tests are a far cry from reality, and real-world trials have to wait until engineers deliver a drivable prototype of the vehicle. If undetected problems surface at that late a stage, then the necessary modifications can cost a lot of time and money.

The crossroads where the simulation and test bench meet
Researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt have developed an alternative in a project called MEF-BILL, which is short for Battery in the Loop @ LBF. "We are now bringing the road into the laboratory and combining our multi-physical testing rig with a computational vehicle simulation. This means we can test batteries under realistic conditions before a prototype vehicle physically exists," says Dr. Riccardo Bartolozzi, the resident expert on numerical system simulation at Fraunhofer LBF. "This way, we gain a lot of time in the development process and significantly improve the quality of results." The loads placed on batteries can be broken down into three domains—the electrical loads primarily attributable to current flows, the vehicular motion, and the climatic aspects. The conventional approach has been to test these three factors separately in lab with trials that have standard runtimes. In the real world, however, these factors are interdependent and affect each other in complex ways. Experts test these loads and their interaction simultaneously in the Fraunhofer LBF testing environment. They have also integrated a real-time-enabled, computerized model of the vehicle into this environment. This way, the researchers can simulate the vehicle and its performance on very different types of roads. This simulation enables them to determine the loads that would also affect the battery in the actual conditions prevailing out there in the real world.

In the past, lab tests have usually been carried out with a battery current profile that follows an idealized curve. This curve looks a lot different in reality. Its trajectory is highly dynamic with random variations, spiking unpredictably as the load peaks. This is why researchers first have to determine the test conditions. What type of vehicle is this battery powering? How heavy is its payload? At what speed does it travel? Is the road's surface flat and smooth or dotted with potholes? The simulation factors all this information into the equation as it calculates the loads placed

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on and the current fed into the tested battery. The experts who conduct these trials also take complex interactions into account. For example, the amount of initially required power can vary as the temperature in the battery or other parameters change. The researchers constantly track the battery's actual parameters and feed these readings appinto the simulation. This circular give-and-take is why trials like this have come to be know as hardware-in-the-loop tests. The input data does not remain static throughout the duration of the test. Instead, it is adjusted on the fly based on data sourced from the simulation and readings taken from the battery. "We can reproduce realistic driving maneuvers in our test scenarios, for example driving uphill or downhill or around sharp bends," says Bartolozzi. The researchers can investigate how other variables affect performance, for example, to determine what happens when an added load increases the vehicle's mass by 20 percent. Shake tests are also performed, using a vibration table actuated by six hydraulic cylinders that can move it in any direction, to mimic the impact on the battery of movements of the vehicle chassis.
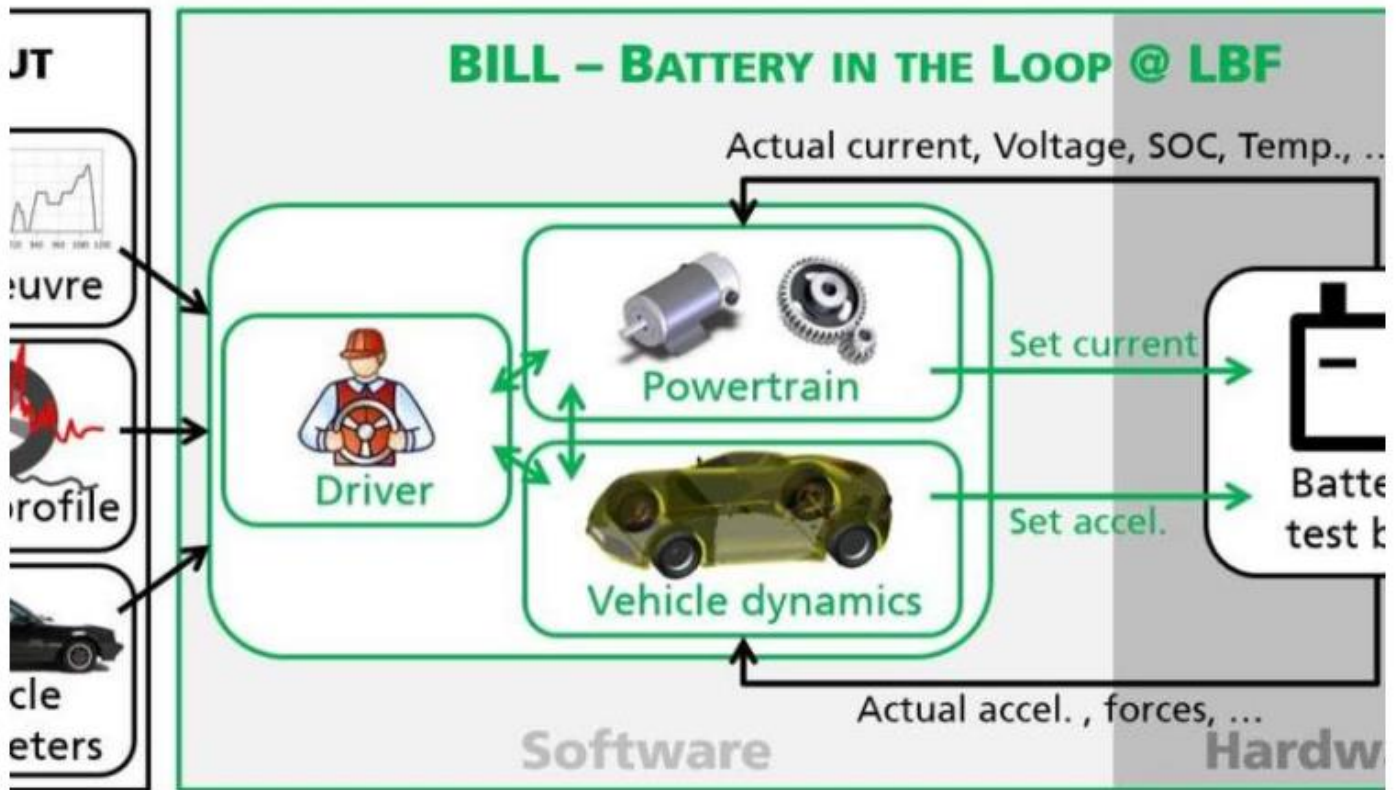
How the HiL-based (hard-ware-in-the-loop) test environment for traction batteries works.

The real-time challenge

One of the great challenges for hardware-in-the-loop tests is that the simulation has to run in real time. For example, if a test is conducted to investigate ten seconds of operation, the entire simulation may not take a moment longer than ten seconds. After all, this is a loop where the results of the simulation have to be plugged right back into the test to update the simulation on the fly as the trial progresses. The researchers have fine-tuned the calculation's complexity for this to work. "We ran the simulations at varying levels of complexity to strike the best balance between complexity and computing time," says Bartolozzi. The system is ready for use and preparations for the final demonstration are underway.

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By Sean Kinney

Microsoft confirmed acquisition of Affirmed Networks in March

Microsoft made big telco moves ahead of its earnings call last week with the acquisition of Affirmed Networks and announcement of Azure edge products for both carriers and enterprises. And, on the April 29 call with analysts, CEO Satya Nadella provided commentary on Microsoft's ambitions around supporting 5G applications at the network edge.

On March 31, Microsoft announced Azure Edge Zones and Azure Private Edge Zones, the former an Azure cloud service meant to connect directly to 5G networks and the latter a private LTE/5G network combined with on-prem Azure Stack Edge.

According to a transcript of the earnings call, Nadella said Microsoft has "the only cloud that extends to the edge, with consistency across operating models, development environments, and infrastructure stack." He said Azure Edge Zones and 5G will "enable immersive, real-time experiences that require ultra-low latency. And our acquisition of Affirmed Networks will help operators deploy and maintain 5G networks and services cost effectively and securely."

For some time now, Microsoft has been working with operators on integrating edge computing capabilities with 5G networks and Azure cloud services, with AT&T being one of the company's most notable 5G partners. At last year's MWC, AT&T announced its partnership with Microsoft for the development of a proof of concept to integrate network edge compute capabilities using its 5G network in conjunction with Azure cloud services, and solution that both company's stated would prove important for IoT use cases in a number of industries including retail, healthcare, public safety, entertainment, and manufacturing.

Nadella said the edge zones initiative and Affirmed acquisition "speaks to I think what is going to be the secular infrastructure architecture going forward. It's not just about migrating off-premise, but it's going to be able to have an architecture that supports the needs where edge compute is increasingly going to be very important."
Analyst Jim Patterson posed the question, "Is Microsoft the new Ericsson?" in the most recent installment of his recurring The Sunday Brief.

But beyond its new edge focus and the Affirmed acquisition, "There's a lot more to do to compete with Ericsson," Patterson wrote, "and it's unlikely that Microsoft would focus its energies on integrating LTE into 5G (they might start with private networks that only interoperate at the 5G level using the 5G standalone or SA standard). But Microsoft is definitely taking steps to replace traditional telecom infrastructure providers and firmly detach operating systems from hardware. And they have $137 billion in cash and marketable securities on their balance sheet, a global presence, and the ear of every Fortune 1000 Global CIO."

Azure Edge Zones for carriers and enterprises

In a blog post on the Azure Edge Zones strategy, Microsoft Corporate VP, Azure Networking, Yousef Khalidi laid out the big picture. "Cloud, edge computing, and IoT are making strides to transform whole industries and create opportunities that weren't possible just a few years ago. With the rise of 5G mobile connectivity, there are even more possibilities to deliver immersive, real-time experiences that have demanding, ultra-low latency, and connectivity requirements. 5G opens new frontiers with enhanced mobile broadband up to 10x faster, reliable low-latency communication, and very high device density up to 1 million devices per square kilometer."

For carriers, Microsoft called out opportunities around online gaming, remote meetings and events and smart

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infrastructure. The commercial offering is based in part of earlier work done with AT&T. In addition to AT&T, named operator partners include Etisalat, NTT, Proximus, Rogers, SK Telecom, Telefonica, Telstra and Vodafone Business. Target verticals for the Azure Private Edge Zones, as delineated in the blog post, include IoT for smart factories, logistics and operations, and connected health care.

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Sourced by BioAge Group

The Australian Government has established funding to support hydrogen-powered projects. The A$300 million (US$193 million) Advancing Hydrogen Fund will be administered by the Clean Energy Finance Corporation (CEFC).

As an early priority, CEFC will seek investment in projects included in the ARENA Renewable Hydrogen Deployment Funding Round. The ARENA round is a $70-million grant program aiming to demonstrate the technical and commercial viability of hydrogen production at a large-scale using electrolysis.


Hydrogen has the potential to make a substantial contribution to our clean energy transition, reducing emissions across the economy while underpinning the development of an important domestic and export industry.

Renewable hydrogen can enable the deep decarbonization of notoriously difficult-to-abate sectors, particularly in transport and manufacturing, while accelerating the contribution of renewable energy across the economy.

CEFC finance remains central to filling market gaps, whether driven by technology, development or commercial challenges. We are confident we can use our capital to help build investor confidence in the emerging hydrogen sector, which is an exciting extension of our investment focus.

—CEFC CEO Ian Learmonth
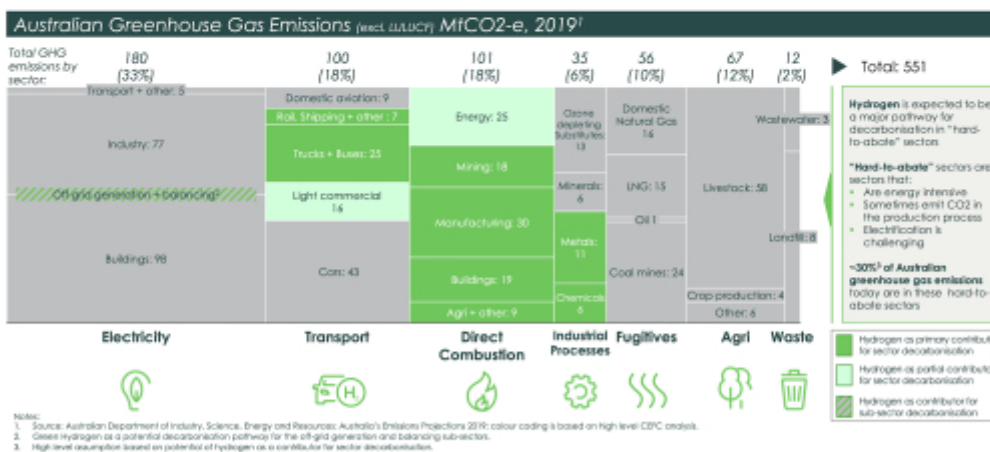
Emissions reduction potential. Current hydrogen technologies represent the most credible pathway to the decarbonization of "hard-to-abate" sectors—including those which produce emissions in the production process and/or lack scaleable electrification options. Together, these sectors are responsible for driving approximately 30% of Australia's greenhouse gas emissions. Source: CEFC

The CEFC Advancing Hydrogen Fund will draw on existing CEFC finance. In line with the CEFC Act, projects seeking CEFC finance through the Advancing Hydrogen Fund are required to be commercial, draw on renewable energy, energy efficiency and/or low emissions technologies and contribute to emissions reduction.

Through the Advancing Hydrogen Fund, the CEFC expects to provide either debt or equity finance to eligible larger-scale commercial and industrial projects, typically requiring $10 million or more of CEFC capital. CEFC investments typically include co-financiers and/or equity partners where possible.

Hydrogen is currently used mainly for ammonia production in Australia, accounting for approximately 70% of total hydrogen use nationally. The current ammonia production process is a material carbon emitter, accounting for almost 1% of total Australian greenhouse gas emissions.

> *Accelerating the transition to green ammonia, produced using renewable energy, represents a sizeable abatement opportunity for Australia, with the potential to position Australia as a leading global producer and exporter of green ammonia.*
>
> *Hydrogen is an extremely versatile energy carrier which is gaining significant support worldwide as the fuel of the future. We see green hydrogen as offering the most credible pathway to decarbonisation for high emitting sectors and those which lack scaleable electrification options. Together, these sectors are responsible for driving some 30 per cent of Australia's greenhouse gas emissions.*
>
> —Ian Learmonth

In considering investment proposals for the Advancing Hydrogen Fund, the Mandate directs the CEFC to prioritize projects that promote the objectives of the National Hydrogen Strategy and that focus on one or more of the following:

- Advancing hydrogen production projects;
- Developing export and domestic hydrogen supply chains, including hydrogen export industry infrastructure;
- Establishing hydrogen hubs; and
- Other projects that assist in building domestic demand for hydrogen.

CEFC finance for the hydrogen sector has the potential to deliver significant benefits:

- Drive large-scale deployment of electrolyzer technologies, leading to technology cost reductions, improved supply chain expertise, increased industry expertise and offtake opportunities.
- Catalyze the hydrogen industry to accelerate the deployment of large-scale renewable energy hydrogen technologies, including demand-side projects to achieve price discovery, increase transparency of current and projected economies of scale, and increase skills and market knowledge.
- Access to tailored finance providing investing support to project proponents as they seek to accelerate hydrogen developments.
- Support the implementation of the National Hydrogen Strategy including its aims to create jobs, especially in regional areas, contribute to a cleaner environment, increase prosperity and enhance Australia's fuel security.

The ARENA Renewable Hydrogen Deployment Funding Round is receiving expressions of interest for projects which: demonstrate electrolysis and associated renewable hydrogen technologies at scale; facilitate a pathway to technical and commercial viability of renewable hydrogen in Australia and provide price discovery and transparency in relation to the current and projected economics for renewable hydrogen technologies.

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ARENA and the CEFC have previously worked together to accelerate clean energy developments, including through the successful large-scale solar funding program. The program delivered grant and/or debt finance to 12 developments contributing to large-scale solar becoming cost competitive with wind energy and cheaper than new build coal and gas.

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By Kevin McLaughlin

Not long ago, Google and Zoom Video Communications had cordial relations. In 2018, several thousand Google employees were using Zoom as an alternative to Google's own videoconferencing product, said a person with direct knowledge of the situation. The popularity of Zoom within Google even prompted some Google Cloud engineers to discuss acquiring Zoom late that year.

They went so far as to evaluate what would be a reasonable price to pay and calculated the unit economics for the service if it ran on Google's servers, according to a person who has worked at Google Cloud. Zoom was one of several companies the Google engineers evaluated in this way, said the former Google Cloud employee. The internal discussions didn't get very far.

A spokesperson for Google Cloud said the company "has never seriously evaluated acquiring Zoom" and there has never been a "large-scale agreement" for Google employees to use Zoom. A spokesperson for Zoom had no comment on the matter.

Zoom likely wouldn't have been receptive to a serious Google overture anyway. Zoom CEO Eric Yuan was resistant to the idea of selling the company, said a former Zoom employee. Recode has previously reported that Microsoft sought unsuccessfully to acquire Zoom.

But now, Google has emerged as one of the companies most determined to snatch away some of Zoom's rocket-fast momentum—and at a time when Zoom is facing scrutiny about the security of its product. Recently, Google Cloud announced a series of upgrades to make its videoconferencing service, Meet, a more compelling alternative to Zoom while also making it free to everyone. That's a change from the past when the service was only available to users of its G Suite applications.

"For the first time, they're offering a head-to-head experience," said Patrick Moorhead, an analyst at Moor Insights & Strategy, of Google's efforts to compete directly with Zoom.

No tech company has seen its profile change so radically during the coronavirus pandemic as Zoom, which has become a household name in a matter of weeks. The number of daily Zoom meeting participants has skyrocketed to 300 million from 10 million at the end of December, Zoom has said. Its stock price has soared 32% since the pandemic sparked a stock market plunge, giving the company a market capitalization of nearly $40 billion.

The huge increase in usage has also spotlighted the product's security shortcomings. Those issues allowed uninvited mischief-makers to easily hijack videoconferences, sometimes by showing pornographic videos. In early April, Yuan apologized for the security "missteps," and in late April Zoom released an update with improved encryption and other features aimed at stopping malicious users.

Meanwhile, Zoom's bigger rivals in the tech industry have taken more-determined steps to keep Zoom from walking away with the videoconferencing market. In a blog post in early April, Microsoft said usage of the videoconferencing feature of Teams more than doubled in March, implying that the product was becoming more competitive with Zoom. Verizon acquired BlueJeans, a videoconferencing service aimed at companies. And last month Facebook announced a free service that lets users launch video calls from within its Messenger service.

Google, meanwhile, has in recent months told resellers of its services that it was stepping up its efforts to compete against Zoom. It has in particular highlighted Meet's security features, according to three people who do business

with Google Cloud. Its recent upgrades to Meet include a grid view that displays up to 16 meeting participants, noise cancellation and a feature that compensates for poor lighting conditions.

Google has also clamped down on internal use of Zoom. Its security team recently told employees they can't use Zoom's desktop application anymore because it doesn't meet Google's security standards for employee apps, a Google Cloud spokesperson said. The spokesperson added that employees can still use Zoom through a web browser and mobile phones.

Zoom has found a way to push back. Its decision late last month to sign up for Oracle's struggling cloud computing service was a snub directed at Google as much as an endorsement of Oracle's offering. Zoom was already using the two top public cloud-service providers, Amazon Web Services and Microsoft Azure.

Google Cloud is the No. 3 player, whereas Oracle is an also-ran in the cloud computing market. It has so little market share that most research firms don't even bother breaking out Oracle from the "other" category of cloud providers.

But Oracle has cozied up to Zoom. Last month, Larry Ellison, Oracle's founder and chief technology officer, lauded how critical Zoom's tools have become for companies working from home.

"Zoom has become an essential service for Oracle, for companies in the United States, for companies around the world," Ellison gushed in a rare testimonial video posted to YouTube. "It has allowed the economy to continue to function even though we're facing a Covid-19 pandemic."

Oracle was an early high-profile customer of Zoom's service, although—in an irony that has become apparent now—it was Thomas Kurian who led the group at Oracle that cut the deal to use Zoom, according to a person with direct knowledge of the matter. Kurian, a former longtime Oracle executive, is now CEO of Google's cloud computing division.

Zoom is currently only using Oracle's cloud service to help it handle the surge in demand it is seeing from people using a free version of Zoom's service, The Information has learned. For the videoconference needs of its paying customers, Zoom handles traffic through its own private data centers. The company also buys cloud computing capacity from AWS and a smaller amount from Microsoft's Azure, said a person close to Zoom.

The Zoom relationship with Oracle could get deeper over time. The companies have had preliminary discussions about enabling customers of both companies to run the paid version of Zoom on Oracle's cloud.

A spokesperson for Oracle didn't respond to requests for comment.

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By Peter Dizikes @ MIT

In many parts of the U.S., robots have been replacing workers over the last few decades. But to what extent, really? Some technologists have forecast that automation will lead to a future without work, while other observers have been more skeptical about such scenarios.

Now a study co-authored by an MIT professor puts firm numbers on the trend, finding a very real impact—although one that falls well short of a robot takeover. The study also finds that in the U.S., the impact of robots varies widely by industry and region, and may play a notable role in exacerbating income inequality.

"We find fairly major negative employment effects," MIT economist Daron Acemoglu says, although he notes that the impact of the trend can be overstated.

From 1990 to 2007, the study shows, adding one additional robot per 1,000 workers reduced the national employment-to-population ratio by about 0.2 percent, with some areas of the U.S. affected far more than others.

This means each additional robot added in manufacturing replaced about 3.3 workers nationally, on average.

That increased use of robots in the workplace also lowered wages by roughly 0.4 percent during the same time period.

"We find negative wage effects, that workers are losing in terms of real wages in more affected areas, because robots are pretty good at competing against them," Acemoglu says.

The paper, "Robots and Jobs: Evidence from U.S. Labor Markets," appears in advance online form in the Journal of Political Economy. The authors are Acemoglu and Pascual Restrepo Ph.D. '16, an assistant professor of economics at Boston University.

Displaced in Detroit
To conduct the study, Acemoglu and Restrepo used data on 19 industries, compiled by the International Federation of Robotics (IFR), a Frankfurt-based industry group that keeps detailed statistics on robot deployments worldwide. The scholars combined that with U.S.-based data on population, employment, business, and wages, from the U.S. Census Bureau, the Bureau of Economic Analysis, and the Bureau of Labor Statistics, among other sources.

The researchers also compared robot deployment in the U.S. to that of other countries, finding it lags behind that of Europe. From 1993 to 2007, U.S. firms actually did introduce almost exactly one new robot per 1,000 workers; in Europe, firms introduced 1.6 new robots per 1,000 workers.

"Even though the U.S. is a technologically very advanced economy, in terms of industrial robots' production and usage and innovation, it's behind many other advanced economies," Acemoglu says.

In the U.S., four manufacturing industries account for 70 percent of robots: automakers (38 percent of robots in use), electronics (15 percent), the plastics and chemical industry (10 percent), and metals manufacturers (7 percent).

Across the U.S., the study analyzed the impact of robots in 722 commuting zones in the continental U.S.—essentially metropolitan areas—and found considerable geographic variation in how intensively robots are utilized.

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Given industry trends in robot deployment, the area of the country most affected is the seat of the automobile industry. Michigan has the highest concentration of robots in the workplace, with employment in Detroit, Lansing, and Saginaw affected more than anywhere else in the country.

"Different industries have different footprints in different places in the U.S.," Acemoglu observes. "The place where the robot issue is most apparent is Detroit. Whatever happens to automobile manufacturing has a much greater impact on the Detroit area [than elsewhere]."

In commuting zones where robots were added to the workforce, each robot replaces about 6.6 jobs locally, the researchers found. However, in a subtle twist, adding robots in manufacturing benefits people in other industries and other areas of the country—by lowering the cost of goods, among other things. These national economic benefits are the reason the researchers calculated that adding one robot replaces 3.3 jobs for the country as a whole.

The inequality issue
In conducting the study, Acemoglu and Restrepo went to considerable lengths to see if the employment trends in robot-heavy areas might have been caused by other factors, such as trade policy, but they found no complicating empirical effects.

The study does suggest, however, that robots have a direct influence on income inequality. The manufacturing jobs they replace come from parts of the workforce without many other good employment options; as a result, there is a direct connection between automation in robot-using industries and sagging incomes among blue-collar workers.

"There are major distributional implications," Acemoglu says. When robots are added to manufacturing plants, "The burden falls on the low-skill and especially middle-skill workers. That's really an important part of our overall research [on robots], that automation actually is a much bigger part of the technological factors that have contributed to rising inequality over the last 30 years."

So while claims about machines wiping out human work entirely may be overstated, the research by Acemoglu and Restrepo shows that the robot effect is a very real one in manufacturing, with significant social implications.

"It certainly won't give any support to those who think robots are going to take all of our jobs," Acemoglu says. "But it does imply that automation is a real force to be grappled with."

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Sourced by Sequoia

We distinctly remember the day in 2012 when Nir Erez and Roy Bick pitched Moovit's plan to improve public transportation. Nir's evangelism was as powerful then as it is today. The picture he drew remains vivid: Public transportation is a large and underserved market. There are nearly 8 billion people in the world and fewer than 1 billion passenger cars. For the vast majority of the global population, public transportation is not a want, but a need. At the same time, public transportation information is fragmented and service levels vary depending on providers and geographies. Moovit is building a global informational and navigational service for public transportation.

We loved the mission and the founding team's charisma left a lasting impression. Unfortunately, we initially failed to dream of a viable business model so we passed. A year later, with more support for the vision and the conviction of the founders even stronger, we corrected our mistake and invested in Moovit's Series A from both our Israel and US funds.

Today, Moovit is one of the world's best-known Israeli-based companies, with over 800 million people using its public transit navigation app, available in 45 languages, 3,100 cities, and 102 countries. In addition to the free mobile app, Moovit provides public transportation information and mobility-as-a-service solutions to mobility and ridesharing companies, and municipal authorities to help improve public transportation.

It wasn't straightforward and it was never easy. The problems Moovit found and set out to solve were devilishly complex. Public transportation is controlled by opaque and slow-moving municipalities. There is a web of private mobility providers, such as bike, scooter, and ride-sharing companies. Layered on top are the competing interests of map services.

But methodically and creatively, Moovit began putting the pieces together. First, the company found product-market fit by starting small and focusing on consumers in Tel Aviv. Second, it built a community of local editors and tools for them to help self-manage the ongoing changes and update transit information in cities around the world. Third, it grew the user base, mostly organically. Fourth, it found a distinctive business model after much trial and error. Eventually, we came back to the core information asset Moovit built over the years. We found revenue-market fit by providing information and multi-modal trip planning to mobility and ridesharing companies and municipal authorities. That made it possible to quickly scale the company's revenue.

Moovit's high-performing and enduring culture allows the team to keep adapting to changing conditions. When the coronavirus outbreak created a significant global reduction in public transportation services, Moovit's team adjusted to providing a customizable platform to help operators and cities around the world adhere to local regulations and provide on-demand mobility services to essential employees, automatically determining their optimal route.
It's remarkable to think that starting small and focusing intensely on the travel needs of a single city (Tel Aviv) allowed Moovit to solve problems that have vexed the world. By sharing information and making day-to-day travel

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simpler, the company has improved the lives of hundreds of millions of people around the globe and that's just the beginning.

Today's (May 4, 2020) announcement is a testament to Moovit's commitment to turning its mission into reality and to the wonderful company that they built along the way. On behalf of Team Sequoia, congratulations to Nir, Roy, and the entire Moovit team. We're excited to see how you will take Moovit's mission to the next level.

CHAMBIZ

By Leah Hodgson

Göran Marby, CEO of the Internet Corporation for Assigned Names and Numbers.

Ethos Capital's bid to buy control of the .org domain was blocked by the Internet Corporation for Assigned Names and Numbers (ICANN), the nonprofit that oversees internet domain registries, but the possibility of a private equity purchase could remain.

The firm agreed to acquire .org owner Public Interest Registry (PIR) from its nonprofit parent the Internet Society for $1.1 billion in November. When the deal was announced, Andrew Sullivan, CEO of the Internet Society, said the deal offered an "endowment of sustainable funding," and Ethos would provide the necessary capital to expand PIR's services. In February, Ethos announced it would further support the .org community through a $10 million community enablement fund.

The deal was met with a backlash from nonprofits, advocacy groups and politicians concerned about the lack of transparency around Ethos and its investors. ICANN's rejection of the deal cited the removal of PIR's nonprofit status, pointing out that the group's focus would shift from protecting the .org community to serving its shareholders. It added that the deal would have saddled PIR with $360 million of debt.

"We see this certainly as a positive step, but essentially half of what needs to happen," said Amy Sample Ward, CEO of NTEN, a group that led a public pressure campaign opposing the acquisition. "I wouldn't be surprised if [Ethos Capital] introduced a new proposal."

Indeed, Ethos Capital has not ruled out a new attempt to buy the .org domain. It did not respond to multiple requests for comment but released a statement that it was evaluating all options. The firm had already tried to assuage concerns by proposing price controls on the domain registry, which would limit registration fee increases to 10% a year for eight years, as well as creating an independent stewardship council with the ability to veto policy changes regarding issues such as censorship and user data. For its part, ICANN made clear that its ruling should not be read as any kind of ban on PE firms controlling registry operators.

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Though disappointed by ICANN's ruling, PIR currently maintains it is not up for sale. Meanwhile, in a statement, the Internet Society said that it would have been irresponsible not to consider Ethos' unsolicited bid, which could mean that a similar situation might arise in the future.

Sample Ward said ICANN blocking the transaction may not be enough, adding that any possible future sale of PIR should be done through a public open bid overseen by ICANN. Private equity firms, she said, do not fit the bill, because investors typically place profit-making considerations ahead of considerations that drive nonprofits.

Nevertheless, PE investors have a history of backing businesses in the domain sector. Abry Partners owns Washington-based Donuts, which holds one of the world's largest portfolios of new top-level domains such as .ltd and .company. And European web domain provider Host Europe received an undisclosed investment from Idinvest Partners in 2017. Sample Ward added that in order to avoid a similar situation, PIR should stay within the nonprofit world and look for a buyer there.

By Morris Lore

A 5G radio plan "excluding China" sounds about as sensible as a sportswear business that excludes athletes. The country dominates the global market for existing 4G infrastructure and is expected to erect about half a million 5G basestations this year alone.

But that phrase littered Nokia's first-quarter earnings report after the Finnish vendor was spurned by China's operators in recent 5G tenders. On the upside, it can focus on other 5G markets with less exacting requirements. "Excluding China," Nokia claims, it has already won 5G deals where it did not previously supply 4G products – a tricky feat for any vendor. Its 5G R&D investments have grown, it says.

Overall R&D spending has not, however. Indeed, that figure has been falling since 2017, and the decline on the networks side continued in the first quarter of 2020. Last year, Nokia spent about €500 million ($545 million) less on R&D than it did in either 2016 or 2017. That means its annual investments have dropped a tenth over this period.

R&D spending ($M)

(Source: companies)
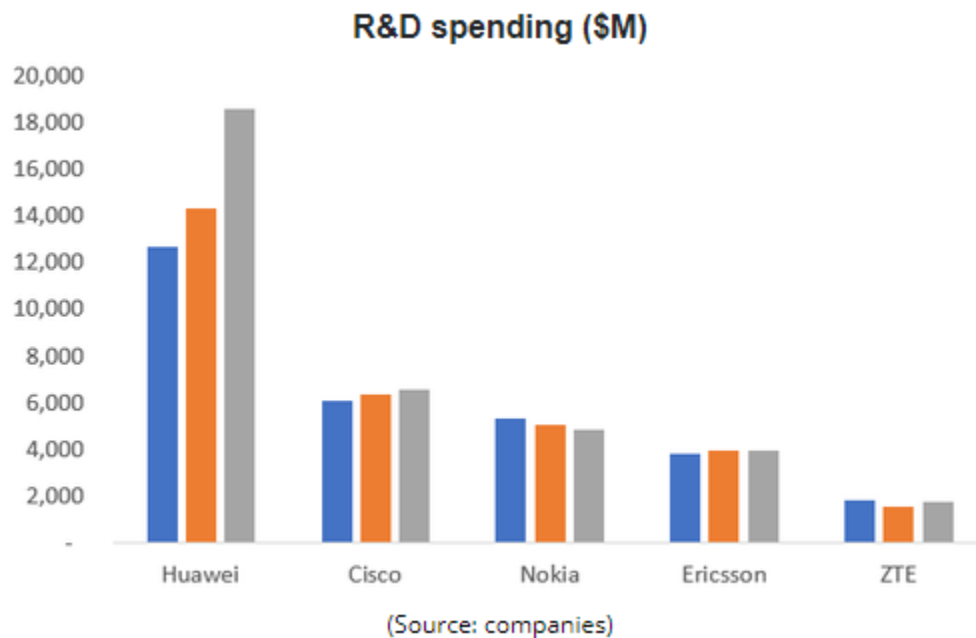
Along with most other equipment vendors, Nokia does not break out details of spending on particular technologies. But investments outside the 5G business have evidently been squeezed from two directions – the increase in 5G spending, and the overall budget cuts.

This squeeze has received little attention from an industry currently fixated on 5G. Before the COVID-19 pandemic, equipment vendors had been counting on this hyped technology for a sales boost in 2020. The mobile radio market also attracts attention because it is so much bigger than other equipment sectors. Last year, mobile access products accounted for about 64% of all network sales at Nokia, and for about half of total company revenues. Lose its way in 5G, and the consequences could be devastating.

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The risk is that spending cuts upset Nokia's competitiveness in other areas. Those include several of the product divisions it acquired with its takeover of Alcatel-Lucent in 2016, such as fixed access, IP routing and optical networks. IP routing had an especially weak first quarter, with sales down 11% year-on-year, although Nokia blamed this unfavourable comparison on its unusually strong performance in early 2019. Supply chain constraints linked to COVID-19 were largely responsible for the 2% drop in optical equipment sales, it said.

Certainly, there is no evidence that Nokia is slashing R&D investments in IP routing or optical, where its reputation is solid. Obvious targets for cutbacks would include older mobile and fixed-line technologies, such as 3G and DSL. Yet this still implies an overall decline in some broad categories.

Of the different product groups, Nokia has an abundance. No other company apart from China's Huawei ticks as many boxes in the catalogue of telecom and enterprise network goodies. But Huawei's R&D investments dwarf Nokia's. Last year, the Chinese company spent about $18.6 billion on R&D, using today's exchange rate. Nokia managed just $4.8 billion. Even accounting for Huawei's massive devices business and other interests, the Finnish vendor looks thinly spread by comparison.

In its defense, Nokia has probably realized some efficiencies through its takeover of Alcatel-Lucent. In 2015, the year before the deal happened, combined R&D spending at Nokia and Alcatel-Lucent came to about €4.5 billion ($4.9 billion), just €100 million ($109 million) more than Nokia's budget last year. More recently, it attributes R&D savings at its fast-growing software business to investment in a common software platform, allowing it to phase out other systems.

But it remains the only one of the "big five" (Cisco, Ericsson, Huawei, Nokia and ZTE) whose R&D investments have markedly declined in the last couple of years, even though it spent a higher percentage of revenues than any of its rivals. Ericsson, its main non-Chinese competitor, also looks more focused. With a budget of roughly $3.9 billion last year, the Swedish firm invested about $900 million less in R&D than Nokia did. But Ericsson has sold off TV assets and concentrates almost entirely on mobile technology these days.

R&D spending as percentage of sales

(Source: companies)

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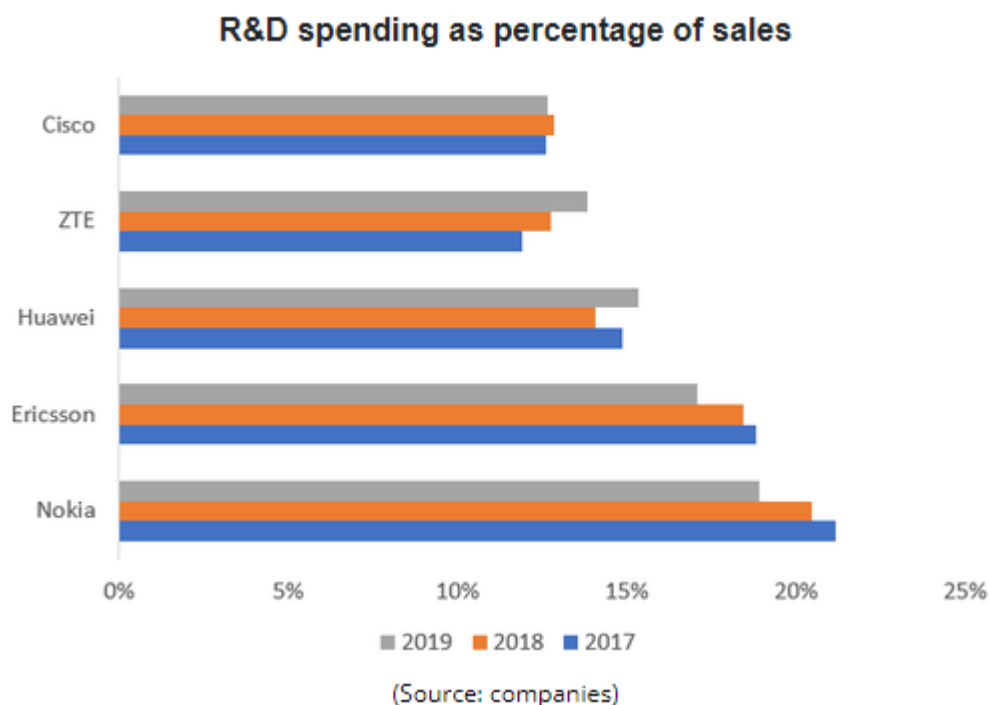
Nokia CEO Rajeev Suri has fiercely denied talk of R&D constraints. "We have a better mix of low-cost countries after looking at where talent is available," he told Light Reading during an interview in June 2019. "It has helped to not have everything in Finland but use Poland, Greece and other parts of Europe."

Even so, other suppliers would seem to have the same opportunity, and the Chinese vendors have a huge talent pool on which they can draw. "There are so many people in China to hire," said Earl Lum, an analyst with EJL Wireless Research, during a recent conversation with Light Reading. "It doesn't matter that everyone you are hiring isn't an Einstein. One of them will be." Last year, Huawei had 96,000 employees in R&D, up from 80,000 in 2018. ZTE's R&D function included 28,300 employees, an increase of about 2,300 on the 2018 figure.

Table 1: Annual costs at Nokia (€M)

	2017	2018	2019
Cost of sales	14,008	14,117	14,989
Research and development expenses	4,916	4,620	4,411
Sales, general and admin expenses	3,615	3,463	3,101
Other	592	422	329
Total	23,131	22,622	22,830

Source: Nokia.

While Nokia does not break out employee numbers by division, its overall workforce shrank by about 5,000 employees in 2019 as the company made cost savings a priority. Its investments in 5G have already forced it to lower its target for annual cuts to €500 million ($545 million), from an original figure of €700 million ($763 million), between 2018 and 2020. Nokia insists its revised plan is on track, with overall costs down about €200 million last year, to roughly €22.8 billion ($24.9 billion). Yet profitability has been elusive.

All that puts Nokia in a difficult position. Boosting R&D investments could threaten profits, aggravating investors already upset that margin targets have repeatedly been lowered. But further cuts will expand the gap between Nokia and Huawei, which insists it will spend about $20 billion on R&D this year. No wonder Nokia's strategy is the subject of so much speculation.

Startup company CoreTigo brings wireless products to end users and technology suppliers and delivers IO-Link Wireless capabilities to legacy systems and new devices.

By David Greenfield

Less than 20 years ago, there was no shortage of engineers who were highly skeptical about the use of Ethernet on the plant floor. Though few engineers today doubt Ethernet's use in industry, there remains a good deal of skepticism about the use of wireless in plants. Much of this doubt is based on experience with Wi-Fi networks. But we are now seeing the rise of industrial wireless technologies that do not use traditional wireless networks.

One prominent player in this relatively new industrial wireless field is CoreTigo *(*Chambiz DF &1ˢᵗ Memo – 11 Aug 2018)*, a startup based in Israel and backed by Qualcomm Ventures, Sierra Ventures, and Lenovo, among others.

At the center of CoreTigo's products is IO-Link Wireless—a wireless technology developed for factory automation applications. IO-Link Wireless reportedly provides a deterministic latency of up to 5msec with reliability that is better than 1 e-9 packet error rate (PER)—or .000000001 PER. To give you an idea of how that stacks up to wireless standards like Wi-Fi, Bluetooth, and Zigbee, those technologies have a PER that is 6 orders of magnitude less reliable (i.e., 1 e-3).

This level of reliability enables IO-Link Wireless to claim that it is deterministic and suited for industrial automation use. CoreTigo notes that IO-Link Wireless is designed as a deterministic protocol. It is based on time and frequency slots and guarantees that each data packet will be delivered within a bounded delay.

"We worked with the IO-Link consortium to create this deterministic, cable grade wireless product that offers a level of reliability on par with the quality of wired IO-Link," says Gabi Daniely, chief strategy and marketing officer at CoreTigo.

Daniely adds that IO-Link Wireless can co-exist with other Wi-Fi networks already in place in a factory. CoreTigo's products can "be configured not to operate on channels used for Wi-Fi," he says, explaining that the technology

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uses "adaptive hopping to move between channels designated for its use to maintain deterministic levels of communication. This is a key part of the IO-Link Wireless standard."

Like wired IO-Link, the IO-Link Wireless standard is not proprietary; it's an extension of the IO-Link IEC 61131-9 standard. Major automation technology suppliers in the IO-Link ecosystem include: Balluff, Bosch Rexroth, Festo, ifm, Hilscher, Mitsubishi Electric, Omron, Rockwell Automation, Schneider Electric, Sick, and Siemens. In total, more than 250 industrial technology companies support IO-Link.

Products
CoreTigo adds that IO-Link Wireless is designed to support a large number of devices while still maintaining its low latency and high reliability. The company says a single IO-Link Wireless Master can support up to 40 IO-Link Wireless Devices divided onto five tracks.

Each track in a Wireless Master can support up to eight IO-Link Wireless Devices. All tracks of a Wireless Master communicate at the same time on different frequencies, providing an optimal medium utilization. An IO-Link Wireless Cell can support up to three Masters with 120 IO-Link Wireless Devices.

The company supplies its IO-Link Wireless embedded modules for technology suppliers to incorporate into their own devices as well as supplying its own CoreTigo-branded products. For example, the embedded modules offered by CoreTigo include the TigoMaster 2T for building a two-track IO-Link Wireless Master, which is used in Hilscher's TigoMaster 2TH IP67 technology platform. Daniely notes that this product features Hilscher's NetX chip for handling communications at both the operations technology and IT levels. Other products offered by CoreTigo for technology developers are the TigoBridge module for retrofitting legacy sensors and actuators for use with IO-Link Wireless, and TigoAir for newly developed sensors, actuators, or I/O hubs. Products ready for application by end users from CoreTigo include the TigoBridge with IP67 enclosure, which converts IO-Link and digital data to IO- Link Wireless, and the TigoEngine, software for system setup and configuration of network analytics, diagnostics, and monitoring.

Applications
Major applications of the technology are already underway in robotics and transport track systems, as well as for industrial energy conservation.

In robotics, the TigoBridge has been embedded in grippers to eliminate the use of cable and cable accessories formerly needed to connect the gripper for communication with the robot controller. Enabling the grippers to communicate wirelessly reduces cabling costs and allows for full flexibility of the robot. Daniely adds that a large automotive manufacturer is using CoreTigo products to reduce data cabling on robots in the plant in their press shop.

For transport track system applications (an area that has been growing rapidly, as seen in the introduction of new technologies from B&R and Beckhoff, for example), Daniely says CoreTigo products are being used to convert the shuttles on these systems into smart shuttles.

"The shuttles on these track systems are not smart in terms of communication because the inductive power rail can't communicate with the shuttles in a stable manner beyond the motion control of the shuttle," he says. Therefore, to control anything on the shuttles, you have to do it manually. But with IO-Link Wireless, devices attached to the shuttles can communicate and be controlled wirelessly. For example, a vacuum pump or gripper on a shuttle can be equipped with IO-Link Wireless so that changeovers can be handled automatically via commands from the PLC. This is key when changing out product or packaging types. This also means you can add sensors, equipped with IO-Link Wireless, to the shuttles for predictive maintenance.

SKF, a global supplier of bearings, seals, mechatronic components, and lubrication systems, is using CoreTigo's technology to reduce its use of compressed air use at its St. Cyr plant in France. Daniely says that typically

compressed air accounts for 30%-40% of such plants' energy use. SKF sought a wireless approach to monitoring its compressed air use because cabling of the sensors from the machines to the network would be, needless to say, challenging in terms of cost and deployment effort.

CoreTigo's TigoBridge

In this application, SKF is using the TigoBridge to connect to ifm flow sensors on its machines. TigoMaster platforms communicate with the TigoBridges to relay data from the machines to TigoInsights software (part of TigoEngine) to track flow data and communicate the machines' operational and availability status. According to Daniely, the combination of real-time flow and operational data enables improved analytics to detect leakages and non-optimal flow. The TigoInsights dashboards and analytics tool enables SKF to view the data anywhere in the factory for analysis and receive real-time alerts.

Daniely adds that SKF is already seeing energy conservation trends in certain machines based on detected air leakages.

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By Ben Marcus

Below is an opinion piece by Ben Marcus, co-founder and chairman of AirMap, a solutions provider for unmanned airspace and fleet management.

The drone industry has come a long way in the last five years. Numerous innovative drone manufacturers and applications have emerged around the globe, and according to the Federal Aviation Administration (FAA), there are now over 1.5 million drones registered in the U.S. alone. The industry has designed, tested and launched the fundamental technologies for UAS Traffic Management (UTM).

The FAA's Low Altitude Authorization and Notification (LAANC) program, which offers automated digital airspace authorization for access to fly in controlled U.S. airspace, has enabled over one hundred thousand missions, reduced flight authorization time from up to 90 days to just a few seconds, and is now available to recreational operators. Switzerland became the first nation to implement a national UTM system called U-space, and aviation authorities around the globe are working hard to safely integrate drones into their national airspace.

We've put the building blocks in place, and the drone industry is now ready to scale in a big way. So get excited about drones becoming part of your daily life, and be on the lookout for these five major developments I predict we'll see in the 2020s.

Welcome to the decade of the drone.

Prediction #1: Advanced Capabilities
We won't be able to reap the societal benefits of drones until they're able to fly safely over people, beyond-visual-line-of-sight (BVLOS) and at night. These advanced capabilities will enable complex drone operations and unlock a broader drone economy—but only if proper rules and regulations are in place. Authorities around the globe are creating those regulations now. On December 26, 2019, the FAA released a proposed Remote ID rule allowing authorities to identify nearly all drones operating in U.S. low-altitude airspace. The rule lays the groundwork for other advanced operations, including BVLOS.

BVLOS capabilities are key to further drone enablement and have been the subject of government-sponsored research projects by NASA and the FAA in the United States, and SESAR Joint Undertaking in the European Union. I anticipate that we'll see the culmination of those studies in the coming year.

Prediction #2: Enterprise Enablement
PwC estimates that the total addressable market for commercial drones is $127.3 billion. That includes $45.2 billion in infrastructure, $32.4 billion in agriculture, $13 billion in transport and $10.5 billion in security. As more corporations look to capitalize on these commercial opportunities, investment continues to grow.

 According to Drone Industry Insights' *Drone Market Report 2019*, energy is the largest industry participating drone market, but transportation and warehousing use of drones is growing fast. When it comes to applications, inspection remains the leading use for drones, although drone deliveries will accelerate as we move into the second half of the decade.

The business case for drones is strong. As the World Economic Forum (WEF) notes, drones have the potential to transform business models and revolutionize how people and goods are transported. That's why I predict that in the 2020s, enterprise use of drones will skyrocket and major corporations will invest in drones in a big way.

Prediction #3: Increased Automation
Automation is already revolutionizing the drone economy. Just look at the FAA's Low Altitude Authorization and Notification (LAANC) program: by automating airspace authorization, it has enabled over 100,000 drone flights.

Enterprises are also using automation, taking advantage of automated data capture and processing workflows to support their activities. Drones are fantastic flying sensors that capture high-precision data, spot defects, and track changes over time—and using drones is much cheaper and safer than conducting manual inspections.

According to Goldman Sachs Research, pipeline inspections that used to require a $2,500 per hour helicopter crew can now be done by drone. According to CB Insights, following the destruction of Hurricane Harvey in 2017, telecommunication companies like AT&T and Verizon used drones to inspect towers—a process that would have been too dangerous and time-consuming to do manually.

As drone automation continues to increase, enterprises will start creating and updating comprehensive digital twins of their assets. We'll see automation play a big role in the drone industry in the coming decade: it will make high-volume, complex operations possible, increase safety, and enable the drone economy to scale to greater heights.

Prediction #4: Urban Air Mobility
Whether for last mile delivery, public transportation or air taxis, electric vertical takeoff and landing vehicles (eVTOLS) hold enormous promise. By ferrying people through the low-altitude sky, Urban Air Mobility (UAM) will likely serve as an airborne alternative to crowded freeways.

According to the Vertical Flight Society's World eVTOL Aircraft Directory, there are already over 200 aircraft concepts currently in development. Industry powerhouses Volocopter, Boeing, Airbus, Bell, Lilium, Beta Technologies and Joby are all working on their own eVTOL concepts. Uber plans to run initial test flights in 2020 and debut commercial aerial services in Dallas, Los Angeles and Melbourne in 2023.

By the end of the decade, NASA estimates that there will be approximately 23,000 air taxis transporting around 740 million passengers worldwide. With UAM, we can reduce fossil fuel emissions and open the door to using airspace to provide emergency services to people in crisis.

The only way to unlock these benefits at scale is with a robust, safety-first and automated air traffic management system designed for autonomous aerial vehicles. The UTM system we're building today will serve as the bedrock for Urban Air Mobility. By creating a new air traffic management paradigm that allows drones to fly safely, autonomously and at scale, we pave the way for a future where Jetsons-style flying taxis will be the new normal.

Prediction #5: A New Era of Aviation

For a long time, we've thought of aviation as just one thing: planes flying into airports. But in the coming decade, the skies will be different. We'll see drone missions increase in scope and scale: there will be delivery drones, recreational drones, enterprise drones, public safety drones, and more. Urban air mobility will become a reality. We'll expand what aviation means, usher in a new era of flight and reap the societal benefits drones provide (think lower carbon emissions, better information about our assets, and increased access to global markets).

Exciting developments are in store—and the Decade of the Drone is just getting started.

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By Luke Laumann

The COVID-19 pandemic has caused a steep decline in US M&A activity in the first quarter of 2020, compared to Q1 2019—with volume down 25% to 3,686 deals and value down 39% to US$563.70 billion, largely due to the drop in the value of megadeals. Unsurprisingly, the number of deals declined at an accelerating rate throughout the quarter as the COVID-19 pandemic worsened, with volume in March at only about half the level it was in January.

US deal volume dropped as the crisis deepened
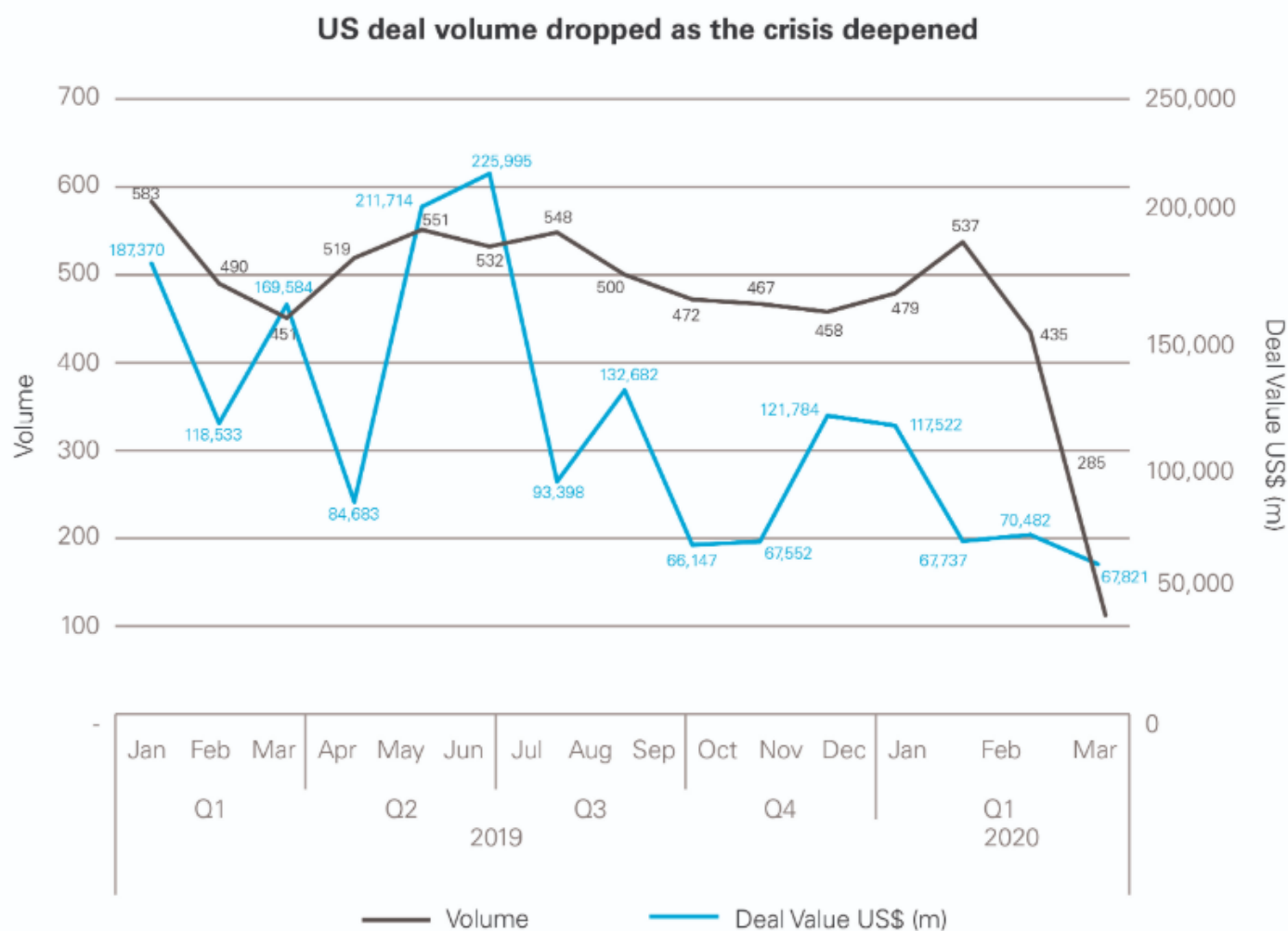
So activity is down, but are announced deals still closing? While there have been numerous publications relating to the failure to close, or disputes arising from, pending transactions due to the COVID-19 pandemic, our analysis indicates that the impact of the COVID-19 pandemic on pending transactions may be overstated.

Just considering large deals, there were 57 announced M&A transactions that were valued at US$1 billion or more and that involved a US acquirer or target in the first quarter of 2020. Six of these transactions have already closed, and 49 are currently pending without publicly announced changes to their terms. That leaves only two large transactions that are already terminated or in dispute this year. The US$6.4 billion merger of Woodward and Hexcel was mutually terminated without liability. BorgWarner's US$3.3 billion acquisition of Delphi Technologies is in

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dispute, with BorgWarner having delivered a notice of breach asserting that BorgWarner has the right to terminate the agreement if the breach remained uncured.

Will the number of delayed, disputed, renegotiated or terminated deals increase?
Several factors could affect the outcome of pending transactions, the most obvious of which include the duration of the COVID-19 pandemic, related remedial measures (including social distancing measures), and the resulting market volatility and macroeconomic trends. The longer these effects last, the greater the likelihood that parties will seek to delay, renegotiate or terminate pending transactions.

With that in mind, we are monitoring changes to pending transactions to understand which strategies have yielded desirable outcomes and the factors that have influenced them. Of course, actions taken in connection with any deal are affected by the particular facts and circumstances of the deal and the companies involved.
We have seen a number of actions taken in response to the current market situation, most prominently including the following.

- **Delayed shareholder votes to approve deals.** Parties in at least four transactions have delayed shareholder votes by more than a month. For the merger between special purpose acquisition company (SPAC) Gordon Pointe and HOF Village (US$390 million), the Gordon Pointe shareholder meeting was delayed to May 4, 2020. Mylan's shareholder meeting to approve its combination with Upjohn, a division of Pfizer, was moved from April 27, 2020 to June 30, 2020. For the Lantheus Holdings acquisition of Progenics Pharmaceuticals (US$500 million), both sides agreed to delay their shareholder meetings to June 16, 2020. For Montagu Private Equity LLP's acquisition of RTI Surgical Holding's OEM business (US$490 million), RTI delayed its meeting to June 15, 2020.

- **Purchase price adjustments.** We are aware of private deals in which parties are adjusting the purchase price of their transactions, but know of no deals where price adjustments have been made public.

- **Mutual terminations.** Since March 30, 2020, several transactions have been terminated by mutual agreement, including the merger of Woodward and Hexcel (US$6.4 billion); an acquisition by the SPAC Allegro Merger Corp. of TGI Fridays (US$380 million); and an acquisition by the SPAC HL Acquisitions Corp. of Chi Energie (Singapore).

- **Payment of reverse termination fee.** On March 24, 2020, Asbury Automotive Group terminated its acquisition of Park Place Dealerships (US$1 billion) by paying US$10 million in liquidated damages.

- **Unilateral terminations or delays by buyers.** From March 30, 2020 to April 16, 2020, buyers in at least seven transactions delivered a notice of breach or termination, refused to close, or delayed closing. In six of these transactions, the sellers filed claims or motions to enforce the buyers' obligations to close. (For details, see the sidebar "Six attempted terminations or delays by buyers" at the end of this article.)

On what bases are buyers unilaterally terminating or delaying transactions?
We have reviewed sellers' allegations and buyers' arguments set forth in press releases, SEC filings and court filings to get a sense of the variety of justifications asserted by buyers to support their decisions not to close transactions due to effects of the COVID-19 pandemic. Five reasons currently stand out (though, again, actions taken in connection with any deal are affected by the particular facts and circumstances of the deal and the companies involved).

- **The occurrence of a material adverse effect (MAE).** We have identified only one complaint suggesting that a buyer intended to assert the occurrence of an MAE to justify termination. This complaint was filed by Oberman, Tivoli & Pickert in Delaware Chancery Court against Cast & Crew Indie Services and its parent, but, according to court filings, the parties have since reached an agreement in principle to resolve the dispute.

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Courts have generally been reluctant to find an MAE, and we expect this to remain generally true, at least in the near term, in cases related to the COVID-19 pandemic. Presently, the long-term effects of the pandemic are unclear—though as weeks turn into months, the effects will become more durationally significant, which could make courts more likely to consider whether an MAE has occurred. However, depending on the specific language and facts of a transaction, several customary carve-outs to what could be considered an MAE could hinder buyers' ability to successfully establish an MAE claim. For example, it is customary to include carve-outs for changes affecting industries in which the target operates, changes to general economic or financial market conditions, changes in law and force majeures.

- **Failure to operate in the ordinary course.** Level 4 Yoga, in its complaint filed in Delaware Chancery Court against CorePower Yoga, alleges that CorePower views Level 4's temporary closure of certain studios as a breach of its obligation to operate in the ordinary course consistent with past practice. In recent years, a thread of argument suggests that it may be easier for buyers to terminate a transaction by claiming a breach of the ordinary course covenant than claiming an MAE. A few years ago, buyers in both the *Akorn* and *Cooper Tire* cases successfully argued that the sellers did not operate in the ordinary course of business between signing and closing their transactions, and thus were able to terminate the contracts. But case law on this issue is not fully developed, and it remains an open question as to whether the risk allocation reflected in the carve-outs to the definition of MAE should be considered in assessing whether a company has complied with its obligation to operate in the ordinary course of business.

  Like the defendant in *Cooper Tire*, buyers may argue that the ordinary course covenant is a concept completely separate from an MAE. However, sellers may try to point to dicta in the *Cooper Tire* decision that could support the position that operational changes made in response to the COVID-19 pandemic are not breaches of the ordinary course covenant if the effects of COVID-19 are carved out of the definition of MAE. Additionally, in the Level 4 case, there are sure to be competing views of what is considered ordinary course. Sellers such as Level 4 may claim that, in the ordinary course, they comply with law, including the current government ordinances to close businesses, and that they adjusted their operations to deal with the current environment.

  Note also that the outcome of disputes involving the ordinary course covenant could be affected by the inclusion or absence of any carve-outs to a seller's obligation to operate in the ordinary course. For example, it is not unusual for an agreement to provide that a seller can operate outside the ordinary course if required by law or permitted under the agreement, or as necessary in the event of an emergency.

- **Breach of an expressly enumerated operational restriction.** On March 30, BorgWarner delivered a notice of breach to Delphi Technologies after Delphi drew down its full US$500 million credit facility in apparent contravention of a covenant that restricted Delphi from incurring debt in excess of US$5 million without BorgWarner's consent (not to be unreasonably withheld). In response, Delphi has asserted that BorgWarner's consent was sought and unreasonably withheld in breach of the agreement. However, both parties have publicly stated that they are working to find a solution and have not yet sought relief in court.

- **Doctrine of impossibility.** In the dispute between the seller of Star Cinema Grill and Cinemex USA Real Estate Holdings, which is pending in the Southern District of Texas, Cinemex claimed (in correspondence between the parties filed as exhibits to the seller's complaint) that, as buyer, it is entitled to protections under Delaware law, including protections related to impossibility, impracticability, illegality, frustration of purpose, and commercial frustration. Under Delaware law, a buyer would need to establish that the COVID-19 outbreak was not foreseeable by the parties, that the risk of COVID-19 was not expressly or impliedly allocated to the buyer, and that the pandemic has rendered performance objectively impossible. Generally, courts have held that impossibility is a high bar to establish, but the outcome of any such defense will be vastly fact-intensive.

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- **Failure to provide access to information or facilities.** Based on the filed complaints, we expect some buyers to take the position that the seller breached its obligation to provide adequate access to information or facilities for inspection. However, even if such breaches have occurred, a buyer would need to establish that the breaches were material enough to cause the buyer's closing conditions to be unsatisfied.

Drafting considerations for companies considering entering into an agreement

Given the effects of the COVID-19 pandemic, the carve-outs to the definition of MAE will likely continue to be an area of focus for parties during negotiations. Until very recently, many transaction agreements did not expressly address the impact of "pandemics," "epidemics" or "COVID-19" on MAE definitions. However, there were a number of deals signed in the first quarter of 2020 that specifically excluded the effects of pandemics (often specifically naming COVID-19) from what can be taken into account in determining whether or not an MAE has occurred, thereby shifting risk to the buyer. We have not seen any provisions (such as closing conditions) that specifically allocate the risk of pandemics or COVID-19 to the seller.

Considering the outcomes in *Akorn* and *Cooper Tire*, parties will also be paying special attention to interim operating covenants. Sellers may want to consider ways to soften their obligations to operate in the ordinary course. This could involve implementing a "commercially reasonable efforts" standard, carving out actions required or requested by a government authority, only requiring compliance "in all material respects," or replacing the "consistent with past practice" standard with one that compares a target's actions to the actions of other similarly situated companies (e.g., "consistent with commercially reasonable custom and practice associated with companies engaged in similarly situated businesses").

Another approach that has not often been used but may become more prevalent is to specifically incorporate MAE exclusions into the covenant. In so doing, as a matter of contract, operational changes made outside of the ordinary course that are in line with changes made by other market participants and that arise from the pandemic or any other MAE exclusion would not be considered a breach of covenant by the seller or target company. Buyers should pay close attention to the list of expressly enumerated interim operating restrictions to ensure they adequately protect against the risk of material changes in the target's operations, whether caused by COVID-19 or not.

Buyers will also want to fully understand the potential liability to which they can be exposed in the event of a wrongful termination. In the event of a termination, many agreements eliminate a party's liability except in the instance of fraud or willful breach. A buyer's potential liability can be significantly affected by the way "willful breach" or fraud are defined (if defined at all), so buyers should negotiate to remove the willful breach and fraud carve-out or define those terms in a way to limit liability in the event that they have chosen to terminate the transaction and a court determines that the termination is a breach.

Six attempted terminations or delays by buyers as of April 16

There are four complaints pending before the Delaware Court of Chancery:

- On April 3, 2020, Bed Bath & Beyond filed a complaint against 800-Flowers after 800-Flowers unilaterally decided to delay the closing of its acquisition of PersonalizationMall.com by a month. The defendant's answer is due on the date of this publication.
- On April 2, 2020, Level 4 Yoga filed a complaint against CorePower Yoga after CorePower refused to close the acquisition of certain studios.
- On April 6, 2020, The We Company, by direction of a special committee of independent directors, filed a complaint against SoftBank Group in the Delaware Court of Chancery after SoftBank terminated its US$3 billion tender offer.
- On April 6, 2020, Oberman, Tivoli & Pickert filed a complaint against Cast & Crew Indie Services and its parent Camera Holdings in the Delaware Chancery Court to enforce their obligations to acquire the assets of Media

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Services. However, according to court filing from seller requesting to withdraw its motion to expedite, the parties have since reached an agreement in principle to resolve the matter.

There is one complaint pending before the Southern District of Texas: On April 2, 2020, Omar Khan filed a complaint against Cinemex USA Real Estate Holdings after Cinemex failed to close the acquisition of Star Cinema Grill. The defendant's answer is due on the date of this publication.

A motion has been filed in US Bankruptcy Court for the Southern District of Texas: On April 6, 2020, Approach Resources Inc. filed a motion to enforce Alpine Energy Acquisitions, LLC's obligations as the stalking horse bidder in connection with a sale under Section 363 of the United States Bankruptcy Code.

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By Meagan Simpson

Kitchener-Waterloo-based ApplyBoard has raised a $100 million CAD Series C round of funding, with the company claiming that its post-money valuation now sits at $2 billion CAD.

If accurate, ApplyBoard's new valuation makes it the latest Canadian tech company to reach Unicorn status: a private company with a market value over $1 billion USD. Prior to 2019, Canada had struggled to produce Unicorns, with the Narwhal List reporting no new Unicorns since Kik Interactive in 2015 (later disputed). That changed last year with Quebec City's Coveo and Montreal's Nuvei both surpassing $1 billion valuations.

The $100 million raise comes just shy of a year since ApplyBoard announced its $55 million CAD Series B.

ApplyBoard's Series C round was led by Ohio-based venture firm Drive Capital, with participation from Fidelity Investments Canada ULC and Business Development Bank of Canada (BDC), as well as existing investors Anthos Capital, Artiman Ventures, and Plug and Play Tech Center. ApplyBoard told BetaKit that the $100 million raise was all primary capital and equity investment.

The Kitchener-Waterloo based startup was founded in 2015 and offers an artificial intelligence-enabled recruitment platform helping international students apply to post-secondary education abroad.

The $100 million raise comes just shy of a year since ApplyBoard announced its $55 million CAD Series B. The new funding brings the company's total funding to date to $172 million CAD, including a $17 million Series A in June 2018.

ApplyBoard's co-founder and CEO Martin Basiri had previously told BetaKit the company expected to raise double its Series B after seeing solid financial growth over the past year. Speaking with BetaKit last year, Basiri claimed ApplyBoard had seen consistent growth over the past couple of years, with 12,000 percent growth in 2019.

Currently, the five-year-old startup works with more than 1,200 educational institutions and 4,000 recruitment partners around the world and claims to have directly assisted over 100,000 students.

"We are excited about [reaching Unicorn status]," Basiri told BetaKit this week. "More from the point of view that money for us is a resource to hire more people, but also [we are] able to do our vision."

ApplyBoard's new funding and unicorn status comes as many of Canada's top startups are reeling from the effects of COVID-19.

"One thing that's important to us is the fact that we will be able to help more people and have all the resources to do so," the CEO added. "Other than that, valuations is just a number, like you're on a good footing, and we are happy to be in this situation and we can help more people."

The Series C round notably closed in late March, with Drive Capital partner Nick Solaro noting massive societal changes between signing the term sheet in February and officially closing the deal.

"We went through almost the entire diligence period being physically unable to go visit the company because we're all in 'shelter in place,'" Solaro told BetaKit. "So the world changed quite a bit between the time we signed that term sheet and the time that we closed the deal."

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ApplyBoard helps international students apply for post-secondary schooling in North America and the United Kingdom. Despite open questions across the education sector on the long term effects of COVID-19, and on international students specifically, Solaro said he is confident that the fundamental thesis of Drive's investment is intact.

"Do we have questions about the fall semester of 2020, yeah, sure, of course we do. But this isn't a quick flip or a trade," he said. Solaro noted that Drive sees the opportunity for ApplyBoard to lead in a virtual, global recruitment market with what he said has hundreds of billions of dollars in tuition and hundreds of millions of students.

International students make up around 20 percent of the overall student body in Canada and are becoming an increasingly important revenue source for universities. This reliance has raised concerns about a drop-off in September enrolments given the current global pandemic.

For his part, Basiri told BetaKit that one report he saw noted 90 percent of international students do not plan on making changes to their international studies.

Noting the financial importance international students have for post-secondary institutions, Basiri sees the recruitment sector growing post-COVID. "More and more universities are wanting to diversify their student body, more and more universities are going to be diversifying for their financial needs," he said.

Social distancing measures have seen most post-secondary institutions move students out of residences, creating challenges for international students to either find new places to stay locally or get back home. Universities have also faced challenges moving online, with Basiri noting that ApplyBoard saw an influx of thousands of inquiries from students and institutions alike.

ApplyBoard has recently worked with government and university bodies to ensure that international students are not left behind in emergency measures. While the Canadian government had originally been criticized for leaving international students out of measures, it later removed restrictions, allowing international students to work 20 hours per week while classes are in session.

"In the long term, I think [this crisis] would be very positive for our industry," said Basiri. "Because now that the universities can also do online, in the future this gives them a huge flexibility of delivering programs both offline and online or in a hybrid manner. I think this is very positive for our industry."

ApplyBoard plans to use its newfound capital to "invest heavily" in its technology, with the goal of serving more customers. The startup recently launched in the United Kingdom, announcing the move on March 30. Basiri told BetaKit ApplyBoard is looking to use a portion of the $100 million to strengthen its position in that region.

The move follows shortly after the company saw Jo Johnson, the brother of current United Kingdom (UK) prime minister Boris Johnson, join as chairman of its advisory board. A former member of parliament himself, Jo served as minister of state for universities, science, research, and innovation.

ApplyBoard also plans to grow its team. The startup has been scaling quickly, expanding its team from 180 in May 2019 to around 400 employees now. The company spans 20 countries, with around 300 of those employees working out of the startup's Kitchener-Waterloo office.

With this latest funding round, ApplyBoard plans to bring on at least 100 more employees. Basri noted that the majority of those positions are currently open.

"The whole company started because of [mine and my brother's] personal experience," said the CEO. "We are really happy that we can support more and more people to be able to get a good education … our campaign is to build a better future for people and I'm so happy that in our life we can have a positive reinforcement on that."

Basiri highlighted that ApplyBoard's goal is to make education accessible for students around the world and feels like it is well-positioned to help the international recruitment sector during COVID-19.

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By Natasha Mascarenhas

A month ago, we asked several venture capitalists if they planned to change the way they invest or lead rounds during COVID-19 — most said no, but they noted that valuations were coming down and founders in their portfolio companies were responding to the crisis.

Northzone's Paul Murphy predicted fewer FOMO rounds because investors will "take more time to get to know and diligence the business… and it might also take a bit more time to close deals," adding that he would "continue to lead rounds and back great founders." But, as other investors call their bluffs, firms are looking for tangible ways to show they are open for business.

First Round Capital
At least that was the case with First Round Capital. On Thursday, the seed-stage firm announced that when it leads a first round in a company, it will always take pro rata in the next outside-led venture round with a commitment of up to $3 million.

Pro rata is a clause in an investment agreement that gives the investor a right to participate in future financings. If investors don't invest in a company's pro rata, that might negatively signal they don't believe in the company's future. I asked Brett Berson, a partner at First Round, to offer more context about the announcement.

"The question 'is your investor taking their pro rata' is not necessarily a checkbox answer," Berson said. "And I think in a time of maximum uncertainty, what a given investor was doing 12 months ago might not be what he or she is doing today."

In an upmarket, there's "euphoria and most people are taking pro rata," he said. Now, as markets oddly tip back and forth, the future becomes more confusing.

First Round, said Berson, has long invested in the pro rata of its portfolio companies internally. The public announcement was the firm's way of being "clear about our overall stance, and ideally other investors will follow." A less public anecdote, Berson said, is that First Round Capital has seen more investor collaboration through passing deals. "It's becoming more proactive."

Accelerators
Last month, Y Combinator changed its policy on automatic pro-rata investments and will now invest on a case-by-case basis. 500 Startups has not changed its case-by-case thesis either, the accelerator confirmed.

Beyond pro rata, some VCs are launching programs to keep their eye on trends (and potential deal flow).

NextView VC, which closed a $75 million fund in January, launched an accelerator for the first time ever. It will invest $200,000 for an 8% stake in fewer than 10 startups. "During this current COVID crisis, we have seen many VCs publicly saying that they are 'open for business,' but we wanted to put our money where our mouth is," partner David Beisel told TechCrunch.

Cleo Capital, founded by Sarah Kunst, is launching a fellowship for laid-off workers, free of charge. It is not taking any equity, but Kunst noted that she hopes any startups that are born as a result of a fellowship will give Cleo the chance to invest.

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Signaling
Signaling happens when a VC chooses to not do follow-on investing in an existing portfolio company. If someone who knows you well isn't willing to invest in you in your next phase of growth, it "signals" to the venture market that the deal might not be worth your time. And boom, negative perception means others get cold feet and then your Series A or B falls apart.

Signaling has always been a wary problem for early-stage founders. These initiatives are an attempt at removing some of that signaling.

For example, NextView, alongside its accelerator announcement, was upfront in saying it will not lead follow-on investment for its future cohort. Same story, different approach with First Round's choice to lead a minimum investment in future pro rata, across all (not some) investments. Now future investors will not judge cohort companies by a lack of investment and won't be able to separate which First Round startups got pro rata and didn't. Both firms are trying to avoid negative signaling by oversharing.

What would have been a marketing play a few months ago is now more noteworthy to us because it is a tangible way to understand how venture capitalists are spending money these days. It's important to see firms being transparent and consistent in the way they invest. Clarity, amidst a pandemic, is always good news.

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By Peter Grad

It was in 1901 that an author of children's books imagined an electronic image that could float over people and provide information about them. L. Frank Baum, who a year earlier penned "The Wonderful Wizard of Oz," referred to that image as a character marker. In fact, it is the first known reference to what 120 years later would commonly be referred to as augmented reality.

From SnapChat's whimsical face filters to daily evening weather forecast maps on TV, digital overlays upon real world scenes have become ubiquitous.

The pace of advances in augmented reality will only increase in coming months and years.

Some of those advances will be relatively simple. One such example was unveiled last month. Cyril Diagne, a designer and programmer currently in residence at the Google Arts and Culture Lab in Paris, showed that as mundane an operation as cut-and-paste can be turbocharged in the era of augmented reality.

He posted demonstration videos of his smartphone camera process that singles out an object, isolates it from the background and, when pointed to a desktop computer, inserts the image into a document. This is all done in under 10 seconds.

Diagne explained that he utilizes BASNet to trace the outline of an image and smoothly wipe out the background. He uses other image-tracking technology to determine precisely where the phone's camera is pointing.

"This is a prototype that uses the phone camera to capture, extract and paste objects from your surroundings directly to Photoshop," Diagne explained. "Thanks to OpenCV SIFT, an image-tracking technology, the app is able to detect where the phone is pointing at the screen, making it a seamless experience. It's part of a series of experiments I'm doing every weekend to explore how machine learning and AI can help create more digital interactions that are more natural."

His demonstration video shows him pointing his camera at three items in succession—a plant, a book and a blouse—and in each instance pointing the camera at a desktop computer, where each image flies into the document.

Images require 2.5 seconds to capture and 4 seconds to paste.

Other video examples show him capturing still images hanging on a wall transferred to a computer where they initiate video clips, and capturing the logo of hard rock band Iron Maiden on the T-shirt of his wife that, when transferred to the computer, instantly plays "Drifter" from their "Killers" album.

Diagne says there is room for improvement, including a reduction in times needed for transfer. But for now, he offers AR Cut and Paste only as a prototype and has uploaded all details and code on GitHub. A local server must be established to link the smartphone to Photoshop on the desktop computer.

Augmented reality fuels some of the most intriguing apps available today. Aside from its obvious application to innumerable games, it offers many practical uses for personal, educational and commercial needs.

Froggipedia projects a lifelike 3-D frog on any surface you point your camera at, offering a highly detailed—and pain-free—step-by-step dissection, conducted with your fingertip motions. HairStyle Pro captures your image and presents you with hundreds of hairstyles and differing colors precisely positioned over your face (including beards and sideburns for men). YouCam Makeup-Magic does the same for women seeking the perfect shade of cosmetics.

For the craftsmen or craftswoman in the home, AR Measure Kit lets you point your camera at any two targets and returns a precise measurement. If you prefer to purchase ready-made furniture, IKEA allows you to project images of its inventory of furniture and other home accessories right into your living room or kitchen.

And perhaps best of all, with an AR Visualizer, you can check out that Porsche 911 Carrera 4S that you always wanted, listing at a mere $120,600 today, and place its image on your own driveway in front of your home as you select colors, interiors and rim style and then watch the car drive off and down the road.

More information: *www.theverge.com/2020/5/4/2124 … world-photoshop-demo*

A new Stanford technology could one day make it possible for electric cars to recharge themselves as they speed along futuristic highways built to "refuel" vehicles wirelessly.

Provided by Stanford University

Stanford engineers have taken a big step toward making it practical for electric cars to recharge as they speed along futuristic highways built to "refuel" vehicles wirelessly.

Although wireless charging pads already exist for smartphones, they only work if the phone is sitting still. For cars, that would be just as inconvenient as the current practice of plugging them in for an hour or two at charging stations.

Three years ago, Stanford electrical engineer Shanhui Fan and Sid Assawaworrarit, a graduate student in his lab, built the first system that could wirelessly recharge objects in motion. However, the technology was too inefficient to be useful outside the lab.

Now, in Nature Electronics, the two engineers demonstrate a technology that could one day be scaled up to power a car moving down the road. In the nearer term, the system could soon make it practical to wirelessly recharge robots as they move around in warehouses and on factory floors—eliminating downtime and enabling robots to work almost around the clock.

"This is a significant step toward a practical and efficient system for wirelessly re-charging automobiles and robots, even when they are moving high speeds," Fan said. "We would have to scale up the power to recharge a moving car, but I don't think that's a serious roadblock. For re-charging robots, we're already within the range of practical usefulness."

Wireless chargers transmit electricity by creating a magnetic field that oscillates at a frequency that creates a resonating vibration in magnetic coils on the receiving device. The problem is that the resonant frequency changes if the distance between the source and receiver changes by even a small amount.

In their first breakthrough three years ago, the researchers developed a wireless charger that could transmit electricity even as the distance to the receiver changes. They did this by incorporating an amplifier and feedback resistor that allowed the system to automatically adjusts its operating frequency as the distance between the charger and the moving object changed. But that initial system wasn't efficient enough to be practical. The amplifier uses so much electricity internally to produce the required amplification effect that the system only transmitted 10% of the power flowing through the system.

In their new paper, the researchers show how to boosts the system's wireless-transmission efficiency to 92%. The key, Assawaworrarit explained, was to replace the original amplifier with a far more efficient "switch mode" amplifier. Such amplifiers aren't new but they are finicky and will only produce high-efficiency amplification under very precise conditions. It took years of tinkering, and additional theoretical work, to design a circuit configuration that worked.

The new lab prototype can wirelessly transmit 10 watts of electricity over a distance of two or three feet. Fan says there aren't any fundamental obstacles to scaling up a system to transmit the tens or hundreds of kilowatts that a car would need. He says the system is more than fast enough to re-supply a speeding automobile. The wireless transmission takes only a few milliseconds—a tiny fraction of the time it would take a car moving at 70 miles an hour

to cross a four-foot charging zone. The only limiting factor, Fan said, will be how fast the car's batteries can absorb all the power.

The wireless chargers shouldn't pose a health risk, said Assawaworrarit, because even ones that are powerful enough for cars would produce magnetic fields that are well within established safety guidelines. Indeed, the magnetic fields can transmit electricity through people without them feeling a thing.

Though it could be many years before wireless chargers become embedded in highways, the opportunities for robots and even aerial drones are more immediate. It's much less costly to embed chargers in floors or on rooftops than on long stretches of highway. Imagine a drone, says Fan, that could fly all day by swooping down occasionally and hovering around a roof for quick charges.

Who knows? Maybe drones really could be practical for delivering pizza.

CHAMBIZ

Commentary: We still spend far too much time training machine learning models rather than deploying them. Could MLOps--which brings data scientists and DevOps together--be a solution?

By Matt Asay

We're definitely beyond the science project years of artificial intelligence (AI) deployments, and we've got work to do before we get past the "brittle" phase. Some retailers, like Walmart, have used machine learning (ML) to improve forecasting while reducing their cost of inventory. But many others spend lots of time building models that never get deployed, said Tony Paikeday, director of product marketing for the NVIDIA DGX portfolio of AI supercomputers and NVIDIA accelerated data science platform, in an interview.

What we need, he said, is to "industrialize AI," in part by bringing together data scientists with DevOps. NVIDIA seems to be all in on this new approach, called "MLOps," and the company might be onto something.

Not just a box
But first, an admission, one that I'll offer in case you've made the same mistake. I've always thought of NVIDIA as a chip company--you know, that company that created a graphics chip way back when that made video games cool. Since then, NVIDIA and others have expanded the use of these graphics processing units (GPUs) for areas like high-performance computing and artificial intelligence.

But still, hardware, right?

According to Paikeday, in the past customers would buy a GPU, stick it in a server, and apply open source (like TensorFlow) to it. This worked (sort of), but broke down as the size of data sets grew. It became ever more difficult to parallelize such workloads across processors. It became obvious that these customers needed cluster-aware software.

Even more, NVIDIA figured out it needed a full stack that is optimized from the driver level so the company could parallelize across not just a few GPUs, but rather across multiple systems. NVIDIA simply couldn't afford to delay on a training run--the company needed its models fast.

With all this as context, for years Nvidia has been developing software. Indeed, NVIDIA now spends more time on software-related development with its customers than working on the hardware by itself.

Not just a bunch of boxes
This brings us to another part of NVIDIA's AI-related business: Where does the customer run NVIDIA hardware/software? The short answer is "wherever they want to," since NVIDIA is somewhat agnostic to where its solutions run. The customer, however, is not.

According to Paikeday, most of its customers start in the public cloud--whether customers will stay there depends on a few factors. Using the adage "Train where your data lands," Paikeday said, customers who create data in the cloud will tend to run their AI training models there. Customers may also keep training runs in the cloud so as to be able to iterate and fail fast. Given how new AI remains for so many, the cloud is a great place to explore.

But as a customer's data set size or models grow, and they have more sophisticated prototypes, "the impact of data gravity starts to be felt," he said, making it cost effective to avoid data transit fees by keeping the data local. For some of these, he says, they may feel they can get better results from fixed-cost infrastructure as well as centralizing

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operations in an "AI center of excellence" of sorts, where they can cross-pollinate expertise across teams, groom new talent, and more.

Not a box at all
Wherever enterprises opt to run their training models, companies quickly need to figure out how to operationalize their data science. One problem is that data scientists tend not to be trained engineers, and don't necessarily follow good DevOps practices. Worse, data scientists, engineers, and IT operations often work in isolation. All of this contributes to make AI brittle and immature within the enterprise.

The Holy Grail, at least to some, is MLOps, a bringing together of AI and Operations, similar to what has been done between Development and Operations (DevOps). The goals? As articulated by Kyle Gallatin, an ML engineer at Pfizer:

- Reduce the time and difficulty to push models into production
- Reduce friction between teams and enhance collaboration
- Improve model tracking, versioning, monitoring, and management
- Create a truly cyclical lifecycle for the modern ML model
- Standardize the machine learning process to prepare for increasing regulation and policy

Sounds straightforward, right? Well, of course it isn't, or we wouldn't have the brittle AI that we do today. NVIDIA, said Paikeday, is building a platform that allows data scientists to work closely with DevOps folks and thus reduce the friction between these sparring groups.

It's a good goal. It's also not what you'd expect from a chip company that helps to make video game graphics sing. But then, that's not really what NVIDIA does anymore. At least, not completely. It's even more focused today on building the software that will serve as connective tissue for data scientists and DevOps within the enterprise so that AI moves from artisanal to industrial.

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By Paul Sawers

A five-year European Union (EU) project to develop a collaborative humanoid that helps workers in industrial environments has concluded, with the participants touting breakthroughs in "AI learning, natural language processing, and robotic manipulation."

The SecondHands project, born from the EU's €80 billion ($87 billion) Horizon 2020 research program, set out back in 2015 to develop what it called a "second pair of hands" for workers in factories, warehouses, and other industrial locations. The aim was to create a robotic assistant that is "proactive" in helping technicians lift or carry objects, acting as an apprentice-like helper that carries out the less-skilled facets of a job. The project was developed under the auspices of a consortium of researchers and computer scientists from a number of organizations, including Ecole Polytechnique Fédérale de Lausanne (EPFL); Karlsruhe Institute of Technology (KIT); Sapienza, University of Rome; University College London (UCL); and Ocado Technology, the technology division of the U.K.'s online-only grocery giant Ocado.

The culmination of the program was a robot called ARMAR-6, which was developed at KIT in Germany to advance research into human-robot interaction in a structured, supervised environment.

Collaboration
Over the past couple of years, ARMAR-6 has been tested at Ocado's automated customer fulfillment centers in the U.K. to perform maintenance on its conveyor belt system — essentially trialing the use of robots to help fix other robots. The idea is that a maintenance technician could be at the top of a ladder with a tool in their hand, and as they stretch their arm out to place the tool down, the robot would observe their action and take it from them.

Moreover, ARMAR-6 was designed to learn and adapt to real-world situations, such as grasping an object when someone wants to move it from one location to another.

ARMAR-6 sports a range of sensors and cameras, along with a telescopic torso and rotatable arms, hands, and fingers that can grasp. Crucially, it can interact with its environment using just visual data, detecting where humans are and estimating their posture purely from real-time images.

ARMAR-6 using real-time visual data for pose estimation

A major part of the project was also showcasing how ARMAR-6 could avoid collisions in a fast-moving industrial environment, where static and dynamic obstacles — including humans — are common.

Among other notable developments from the project is the creation of a speech interface based entirely on neural models, including all-neural speech synthesis and all-neural speech recognition. Such breakthroughs, according to KIT's Dr. Sebastian Stüker, will lead to "better acceptance of 'cobots' by humans" and facilitate a more natural interaction between humans and robots.

Transition
SecondHands' broader goal was to help transition humanoid assistants from research labs to industry settings, with Ocado the first stepping stone on that journey. With the project now officially concluded, plans are in place to apply findings to other sectors and use cases, including autonomous vehicles and the oil and gas industry.

Ocado won't be deploying ARMAR-6 at is fulfillment centers, which suggests it's not quite ready for a commercial environment. But various undisclosed ARMAR-6 projects are underway in other industries, so it could help accelerate the use of humanoid assistants in the real world.

"The results of this project have shown categorically how robots can amplify the benefits of human expertise," said Graham Deacon, robotics research fellow at Ocado Technology. "We'll continue to build on these learnings, looking forward to a future when we can use these breakthroughs to apply them in a real-world setting."

This project also highlights the need for academia and industry to work in tandem. There's no point developing AI-infused robots in a laboratory setting if they fail at the first hurdle in the real world.

The timing of SecondHands' conclusion is also notable, as countries are embracing more automation due to social-distancing measures enforced by the COVID-19 crisis. In the future, the technologies that underpin ARMAR-6 could be redeployed in other environments, such as "helping to reduce contamination, or in assisted living," according to Deacon.

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By Eugene Demaitre
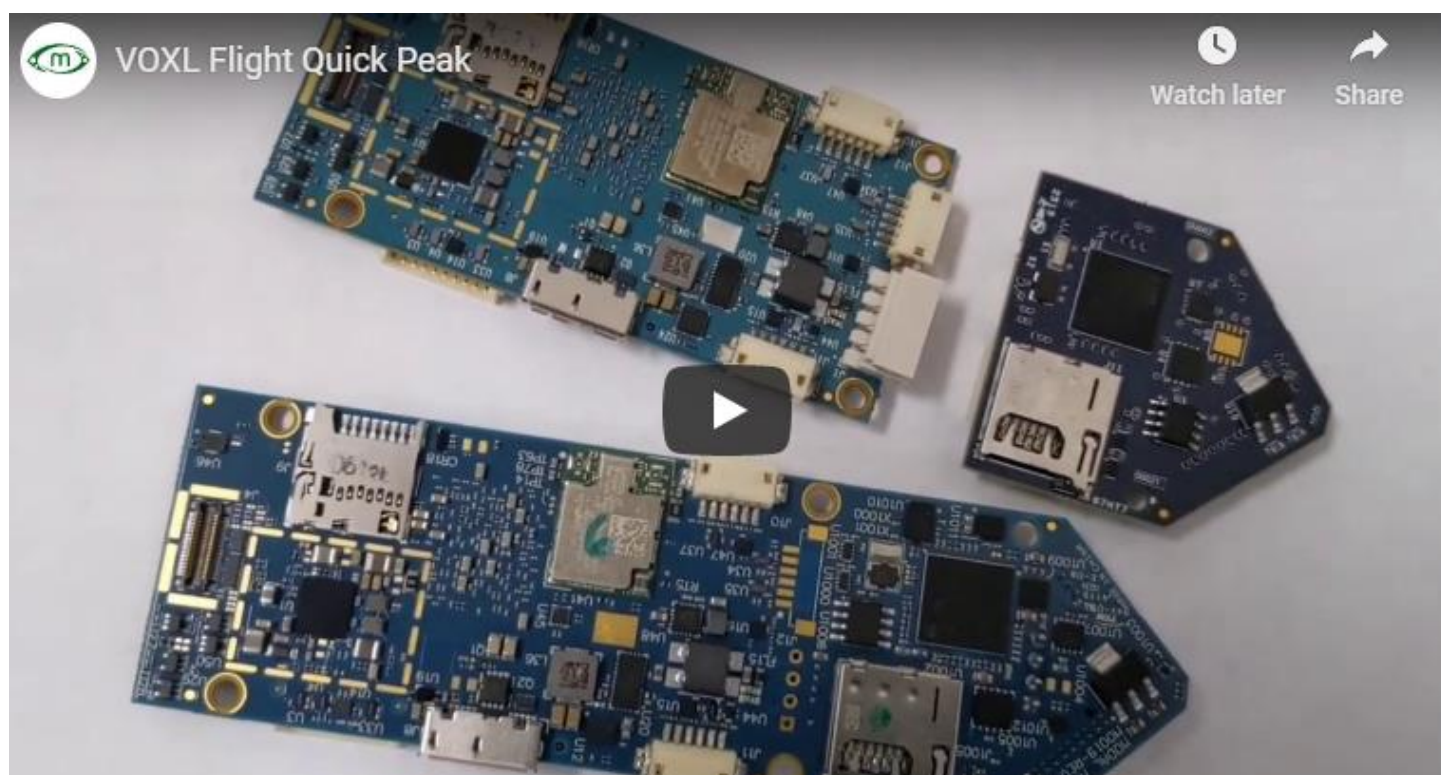
The aerial drone industry has had its ups and downs, as startups interested in the consumer market pivoted to commercial applications a few years ago. More recently, the U.S. government and others have expressed concern over China's dominance in the technology. VOXL Flight, an open development platform for autonomous drone navigation, addresses both of these issues.

In late March, San Diego-based **ModalAI** announced the release of VOXL Flight, which it said combines a PX4 flight controller and a companion computer on a single circuit board. Not only does this design reduce weight, cabling, and cost, but it also enables drone makers to get their products to market more quickly, according to the company.

ModalAI spun out of Qualcomm Technologies Inc. in 2018, and its technologies are intended to help aerial and ground robots autonomously navigate while communicating over 4G and 5G networks.

"I led robotics research and development at Qualcomm for 20 years, and we had built a full stack of technology," said Chad Sweet, CEO of ModalAI. "Qualcomm was a generous partner, giving us a running start to advance the technology and productize it."

VOXL Flight capabilities
VOXL Flight use artificial intelligence and smartphone networks to enable autonomous drones to fly beyond the visual line of sight (BVLOS). It includes Simultaneous Localization and Mapping (SLAM), has deep-learning object recognition for obstacle avoidance, and can support for up to four image sensors. The system can operate in GPS-denied and "challenging" outdoor environments, said the company.

VOXL Flight uses Qualcomm Flight Pro UAS processors for camera, security, and communications. It is also compatible with open-source technologies including the Robot Operating System (ROS), Linux, and PX4.

"It's more than a DIY flight controller," Sweet told The Robot Report. "It's a sophisticated open development platform for SUAS [small unmanned aerial systems]."

In addition, VOXL Flight supports LTE-based BVLOS capabilities to avoid obstacles and operate autonomously on the wireless network. It has a Digital Data Link (DDL) radio modem for industrial applications operating on private networks. The system can also support video encoding of 4k h.264 for MIPI, USB, and HDMI camera payloads.

"After developers install and configure VOXL Flight, the drone can navigate autonomously indoors, outdoors, and around obstacles," Sweet stated. "VOXL Flight accelerates autonomy by reducing the most difficult parts of hardware and software design for autonomous systems – a true out-of-the-box solution."
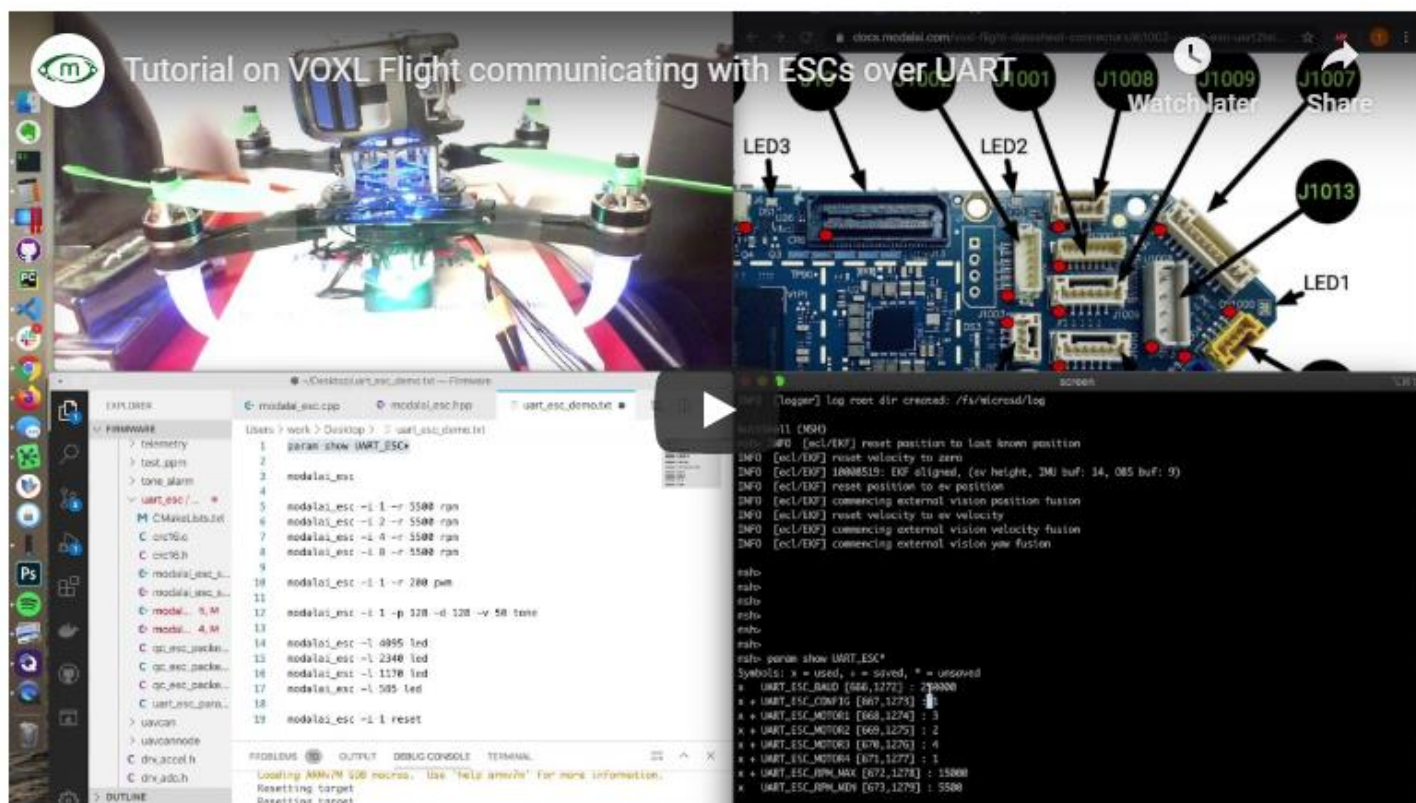
VOXL Flight is made in America

Last year, the U.S. Department of Homeland Security (DHS) last year warned that systems made by DJI (Shenzhen Dà-Jiāng Innovations Technology Co.), the global market leader in SUAS, could be sending location data to China. The U.S. Department of the Interior stopped flying more than 800 drones in October. The National Defense Authorization Act of 2020 (NDAA) prohibited U.S. Department of Defense (DoD) personnel from buying SUAS components from China.

The Drone Origin Security Enhancement Act, which has passed in the U.S. House of Representatives, would ban the DHS from buying or using foreign-manufactured drones. ModalAI manufactures all of its printed circuit-board assemblies in Southern California.

"Qualcomm invested in cellular-based communications for SUAS. From designing circuit boards to full-level application software, our goal is to make as much as possible here," Sweet said. "We use contract manufacturers, which is not as cheap or easy as buying something from China. We're the only ones doing it."

"We teamed up with the Defense Innovation Unit in late 2018, and VOXL Flight is a culmination of a lot of that work," he added. ModalAI said it plans to provide the U.S. armed forces "with state-of-the-art technology for Group 1 unmanned aerial systems."

ModalAI sees more commercial drone applications

ModalAI said its products can also support applications such as delivering packages or medical supplies, as well as precision agriculture and infrastructure inspections. VOXL, the predecessor to VOXL Flight, participated in tests of Uber Eats for drone deliveries of food last year.

"We see two drone markets — enterprise and military," Sweet said. "It's of course been very up and down, from consumer hype to industrial, but the enterprise market is growing quickly, with new applications and companies coming online very day. Things have shifted in the market, creating opportunities."

"The first is the NDAA. Government agencies are very big customers, which trickles into interest in using domestic products for information and product security," he explained. "The second is that the FAA started its Part 107 licensing program in 2017. It was not perfect, but it opened things from 'You can't do anything with SUAS,' to 'Now you can do it in a limited fashion.'"

"There are now hundreds of thousands of pilots for news stations, utility inspections, and real estate," said Sweet. "Once you find something that is useful and saves time, lives, and money, growth happens automatically. It might not match the early hype, but there is certainly a growing base of activity. We've had a lot of interest from the military and delivery services and about indoor navigation inside warehouses."

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"Our system is also applicable to autonomous vehicles and ground robots," he added. "VOXL Flight's predecessor didn't have built-in flight, and the motor controller was more vision-based guidance. VOXL Flight can also be used for tunnel exploration, like in the DARPA Subterranean Challenge, but as a startup, we had to stay focused on our customers."

Lessons for developers

"It's hard for big companies to make technology accessible," acknowledged Sweet. "We learned that this market needs open platforms. ModalAI has lots of multi-decade veterans from Qualcomm, and we wanted to reach a broad set of customers."

"VOXL Flight is a synthesis of everything we've learned, with expandable features, developer support, and documentation," he said. "When the DoD banned DJI, people thought it would be easy to replace, but it turned out to be a lot harder to find something equivalent."

"Our advantage was that we could move quickly and do sophisticated things that others couldn't do toward monetization," Sweet said. "We see ourselves as R&D folks, every day investing in new technologies. The sky's the limit — until you see robots everywhere, which I do think is going to happen."

CHAMBIZ

By Peter Cade

Enterprise tartups UIPath and Scale have drawn huge attention in recent years from companies looking to automate workflows, from RPA (robotic process automation) to data labeling.

What's been overlooked in the wake of such workflow-specific tools has been the base class of products that enterprises are using to build the core of their machine learning (ML) workflows, and the shift in focus toward automating the deployment and governance aspects of the ML workflow.

That's where MLOps comes in, and its popularity has been fueled by the rise of core ML workflow platforms such as Boston-based DataRobot. The company has raised more than $430 million and reached a $1 billion valuation this past fall serving this very need for enterprise customers. DataRobot's vision has been simple: enabling a range of users within enterprises, from business and IT users to data scientists, to gather data and build, test and deploy ML models quickly.

Founded in 2012, the company has quietly amassed a customer base that boasts more than a third of the Fortune 50, with triple-digit yearly growth since 2015. DataRobot's top four industries include finance, retail, healthcare and insurance; its customers have deployed over 1.7 billion models through DataRobot's platform. The company is not alone, with competitors like H20.ai, which raised a $72.5 million Series D led by Goldman Sachs last August, offering a similar platform.

Why the excitement? As artificial intelligence pushed into the enterprise, the first step was to go from data to a working ML model, which started with data scientists doing this manually, but today is increasingly automated and has become known as "auto ML." An auto-ML platform like DataRobot's can let an enterprise user quickly auto-select features based on their data and auto-generate a number of models to see which ones work best.

As auto ML became more popular, improving the deployment phase of the ML workflow has become critical for reliability and performance — and so enters MLOps. It's quite similar to the way that DevOps has improved the deployment of source code for applications. Companies such as DataRobot and H20.ai, along with other startups and the major cloud providers, are intensifying their efforts on providing MLOps solutions for customers.

We sat down with DataRobot's team to understand how their platform has been helping enterprises build auto-ML workflows, what MLOps is all about and what's been driving customers to adopt MLOps practices now.

The rise of MLOps
As enterprises adopt auto-ML workflows, one of the issues they're commonly seeing is that many of the models built by data scientists never make it into production. There are a number of issues that can stop deployment, including models that underperform in pre-production environments, incompatibilities between production environments and the model-training environment, or inconsistencies with production infrastructure.

This is where MLOps comes in.

The world of MLOps has been shaped a fair bit by the evolution of DevOps, which has rocketed to popularity the past few years. The role of DevOps is to efficiently integrate and deploy source code, and it's typically managed by a DevOps engineer who works as a bridge between IT and developers.

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MLOps is similar, but focuses on the ML model and data sets as opposed to code. These days, data engineers run MLOps, but it's likely the specialized role of MLOps engineer will come about soon.

There are four components to the modern MLOps workflow:

- **Continuous Integration**: In DevOps, this refers to synchronizing new code with the existing code base, whereas in MLOps, this process refers to synchronizing the data and models. This involves checks such as confirming that a model mathematically converges, making sure it does not result in data-type errors, and running tests on sub-methods within the model to ensure they're working as expected.
- **Continuous Deployment**: In DevOps, this refers to moving code into production, and it's the same with MLOps, except with models instead of code. This involves checks such as ensuring that the libraries required for a model to run exist in the production environment, testing the model with sample input data to verify it's producing the expected outputs and testing performance metrics in pre-production.
- **Monitoring**: Once a model has been deployed, it needs to be actively evaluated to ensure that it's working as desired, both in terms of accuracy and runtime speed. MLOps solutions look at metrics such as data drift (assessing whether a model is losing its accuracy as input data changes) and performance around run time and latency.
- **Governance:** For an enterprise company that would likely have many algorithms in production at once, issues can crop up requiring a data scientist to look into what's causing a model to not work as expected. Having an end-to-end system that enables tracking by model of which data it was trained on, who built the model and when, and other such factors, can be helpful. Further, maintaining this data is helpful for compliance purposes.

How companies like DataRobot have driven the need for MLOps
DataRobot's enterprise AI platform helps customers streamline the full ML life cycle across data preparation, model building and model deployment. H2o.ai offers a similar solution to DataRobot called H2o Driverless AI, which provides end-to-end automated AI capabilities. One of the key differences between the two platforms lies with their target users, as H2o.ai tends to cater to more technical users, whereas DataRobot serves business and IT folks along with data scientists.

Beyond end-to-end AI workflow platforms, the auto-ML market has been flooded with many companies providing tools for various parts of the enterprise AI stack. Cloud providers, including Amazon, Microsoft and Google, have innovated by developing auto-ML capabilities for cloud customers. Specialized platforms such as Domino Data Lab offer solutions for advanced users, and many tools such as TensorFlow and pre-built classifiers are readily accessible to developers for model building.

In the case of end-to-end AI workflow platforms such as DataRobot, some of the key benefits for enterprises have included the automation of various parts of the workflow, particularly around feature engineering and model generation, and the efficiency that comes with consolidating the entire workflow onto a single platform.

That's perhaps a lot of buzzwords, so let's consider the case of a security team at a credit card company assessing fraud risk for users. Let's assume the input data consists of rows pertaining to end customers, with each row containing metadata including the day the customer's card was activated, the day it expired and the number of fraudulent events identified in that time frame.

In order to effectively model the fraud risk, the security team would need to take the difference between the card activation and card expiration days and tie that to the number of fraudulent events identified. This is called feature engineering, which involves combining the input features in such a way that helps an ML model learn the underlying patterns as best as possible.

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This may look simple, but problems often have a large number of input data columns that can greatly increase the number of combinations one has to try — and the relations between different data points may not be easy to discern, either.

Automated feature engineering makes this process simpler by auto-testing many different combinations of input features, quickly and at scale, to help the user pick the best one.

Once a user has finalized the set of features, DataRobot's automated model generation capability lets them run many different types of models on the data, and see which ones perform best. This saves users the time of building models from scratch, and also gives them the benefit of seeing how different models perform.

Moreover, in situations where the data is rapidly changing, it gives users the ability to rerun the full set of models and re-determine which ones work best based on new data. In the case of the security team at the credit card company, consider a model that was developed in a particular region. If the security team is tasked with understanding fraud risk in another region and further receives some new data columns specific to that region, it's possible the initial models won't perform as well as new models that take all the available data into account.

The consolidation of the entire workflow into a single platform also provides several benefits for users. On the model building side, the coupling of data to a variety of models can make experimenting easier and help debug any issues that come up with the models much quicker. On the model deployment side, it helps with tracking source data and model attributes for models in deployment, both for any changes that become necessary and for governance.

Though companies like DataRobot and H20.ai offer end-to-end AI workflow platforms, the drive toward automating these workflows has not solely been confined to a single vendor solution. Given the modularity between data prep, feature engineering and model development, enterprises are often using permutations of a number of different solutions to satisfy their requirements.

In DataRobot's case, use of their products alongside Snowflake and Tableau has been a popular ask by customers. Customers commonly tend to use ML tools offered by cloud providers in conjunction with DataRobot and H20.ai's products as well, and both of them provide tight integration with the major cloud providers.

The rapidly expanding MLOps solutions market
The market for MLOps solutions has been growing over the past year as enterprises focused their efforts on model deployment and governance following the widespread adoption of auto-ML tools.

DataRobot recently acquired ParallelM, one of the early entrants in the MLOps space back in 2017, which enables customers to deploy models to infrastructure such as Kubernetes and Spark, either on-premise or on one of the major cloud providers. H20.ai partnered last year with ParallelM's MLOps solution, as well.

The MLOps space is also seeing open-source solutions prop up. KubeFlow is an open-source tool that enables MLOps capabilities for deploying to Kubernetes, and, similar to TensorFlow, it began as a project based on Google's internal ML pipelines. DataBricks has released an open-source tool called MLFlow, which provides full life cycle workflows for ML development, including MLOps with deployment capabilities to Apache Spark.

The major cloud providers have also made their own forays into this category. Amazon SageMaker has introduced MLOps capabilities by helping customers leverage AWS Lambda and Step Functions for deploying models. Microsoft Azure has enabled tight integration between its auto-ML platform Azure Machine Learning and its Azure DevOps platform to enable MLOps functionality. Google Cloud has similarly moved to providing MLOps capabilities by outlining use of TensorFlow and KubeFlow along with Google Build.

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Enterprises deciding on which MLOps solution to use will likely consider the following two factors: the auto-ML platform they're using, and the orchestration framework to which they plan to deploy. For enterprises using a cloud auto-ML platform such as Amazon SageMaker, the default choice will likely be to use the associated integrations from the cloud provider and string together an MLOps workflow. The same will likely be true for standalone platforms such as DataRobot, which provide auto-ML tools with an associated MLOps capability.

Kubernetes has increasingly been a popular scalable orchestration platform for ML workloads. MLOps solutions such as KubeFlow, which help deploy to Kubernetes, and ParallelM's MCenter product, which also supports Kubernetes, are likely to see growing adoption, given the widespread use of Kubernetes. Another advantage of Kubernetes is its ability to help streamline hybrid deployments across on-prem and cloud, which many companies demand, such as OpenAI, which uses Kubernetes across on-prem, and Microsoft Azure.

The MLOps market will not likely be a winner-take-all. We'll likely see continued effort on part of auto-ML providers to create tight integrations that enable MLOps capabilities for their customers, and we'll also see select deployment practices such as the use of Kubernetes continue to grow as developers begin to prioritize deployment possibilities from the outset as they consider different ML workflow platform providers.

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The debut of Wi-Fi 6 and the explosion of AI hardware, networks, and tools will open new markets and spur future technology trends.

Published by Electronic Design

The innovations of connectivity and AI are about to shift into full gear as new advances—edge computing, Wi-Fi 6, and Bluetooth Low Energy (BLE) v5.2, to name a few—arrive in full force. These developments are quite significant. Wi-Fi 6 will improve robustness and performance, while Bluetooth audio sharing will make it possible for multiple consumers to personally enjoy the audio of a single device. In addition, edge computing will give a significant boost to the Artificial Intelligence of Things (AIoT).

This is a win-win for those wishing to utilize these technologies, but not everyone will feel like a winner in 2020. The year could bring hardship to AI hardware startups that have risen up after years of long-term and highly intensive R&D. In many ways, this process has led to incredible results, including complex, high-value products. But those products also bring forth a strong patent portfolio, which can act as landmines to competitors. Many firms have failed to keep up, inevitably leading to a decline—and soon, a contraction—within the space.

Let's take a closer look at these and other notable innovations to watch for as 2020 unfolds.

The Power of Wi-Fi
Wi-Fi has changed the world as we know it, but the biggest criticisms are that it often doesn't work or it's too slow. Networks are often strained by the number of users on board, a pain point that's particularly prevalent at airports and other public venues or events. Even the 2012 Olympic Games in London was bogged down by internet access of just 100 kB/s at the opening ceremony. This was on a network that was supposed to offer several hundred megabits per second! But when overloaded, the network failed to deliver a quality experience.

One of the key challenges is simply the way Wi-Fi works. When a mobile device connects to your router at home, for example, it does something called association. The access point sends out messages every few seconds. In the case of the Olympic Games opening ceremony, the devices were in fact "talking" to the access points, saying, "I'm here and I want to send." However, nothing could actually send, since so many people were on the network simultaneously.

Thus, the most exciting part of Wi-Fi 6 is that it will eliminate this pain point. It will effectively improve robustness and performance with two techniques: colors and orthogonal frequency-division multiple access (OFDMA). The former involves the use of different access points, which are a problem with current Wi-Fi. Now it's possible to have different Basic Service Set (BSS) "colors," or numbers between 0 and 7 that will allow devices to ignore signals from the AP it's not associated with. In other words, if you're in an apartment in New York City, your devices will be able to ignore what your neighbors are doing next door and provide a stronger signal. OFDMA helps speed up our connectivity by breaking the spectrum into smaller chunks, enabling more devices to communicate.

Wi-Fi 6 can also help reduce battery drain for small devices. This may not necessarily apply to mobile phones, but for sensors in the home (such as a thermostat), it will be quite significant. Instead of being required to charge the device or change its batteries on a regular basis, Wi-Fi 6 will make it possible to leave them be for a year or longer.

Finally, Wi-Fi 6 will get an additional boost now that the 6-GHz band (1,200 MHz of spectrum) has been opened to unlicensed uses. The latest version of Wi-Fi, known as Wi-Fi 6E, uses the newly available spectrum to enable devices

to connect quicker and for data to transfer faster. It hasn't received approval just yet, but it looks like Wi-Fi 6E could become a reality in 2021, if not sooner.

Sharing is Caring (and Aural Bliss)
The hidden brilliance of Bluetooth Low Energy (BLE) v5.2 can't be denied—it offers one of the most impressive changes since the technology was introduced: audio sharing. While this has been possible with Bluetooth Classic, which is quite power-hungry, this is the first time it can be done with BLE. As a result, you'll receive the same benefits but with much lower power consumption. That means smaller devices with smaller batteries (such as hearing aids) now can take advantage of this impressive feature.

Computing at the Edge of Innovation
At the same time, artificial intelligence will get a boost as edge computing becomes a major factor and a prominent focus within the market. Powerful accelerators will enable devices to run neural networks at the edge of the network. This could present a host of interesting opportunities, particularly for AIoT. As low-cost edge compute nodes make it possible to do more on a tighter budget, the potential will be limitless.

AI Hardware Startups Face the Music, but AI Apps Will Come to the Rescue

AI hardware startups have relied on a multi-year and highly intensive process involving near-endless research and development. This has been effective in getting them to where they are today, but it could come at a price. As every company under the sun rushed to take every dollar available from venture capitalists (VCs), they may not have considered how difficult it would be to demonstrate the value of that investment. If they can't show the fruits of their labor in 2020, VCs might not be interested in returning for another investment round.

While AI hardware could be challenged this year, AI apps will have their moment to shine. Two primary kits—Apple's Core ML and Google's ML—have opened the door to thousands of developers, allowing them to incorporate machine-learning models into their software. This will enable AI-centric apps to reach the mainstream, propelling the technology as users come to recognize its incredible value. This will surely get the interest of VCs, who might be intrigued by apps that can offer features that were once limited to very specific hardware.

The Best is Yet to Come
This year will prove to be an outstanding opportunity for some of our most important technologies, such as Bluetooth and Wi-Fi, to shine while giving future innovations like AI software an opportunity to flourish. AI hardware companies could face increasing pressure if they aren't able to show that their VC money was worth the investment, but it's clear others will be waiting to take their place.

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*Posted by Yuxiang Yang and Deepali Jain, AI Residents, Robotics at Google*

Recent advancements in deep reinforcement learning (deep RL) has enabled legged robots to learn many agile skills through automated environment interactions. However, the lack of sample efficiency is still a major bottleneck for many algorithms, and researchers have to rely on using off-policy data, imitating animal behaviors, or performing meta learning to reduce the amount of real world experience required. Moreover, most existing works focus on simple, low-level skills only, such as walking forward, backward and turning. In order to operate autonomously in the real world, robots still need to combine these skills to generate more advanced behaviors.

Today we present two projects that aim to address the above problems and help close the perception-actuation loop for legged robots. In "Data Efficient Reinforcement Learning for Legged Robots", we present an efficient way to learn low level motion control policies. By fitting a dynamics model to the robot and planning for actions in real time, the robot learns multiple locomotion skills using less than 5 minutes of data. Going beyond simple behaviors, we explore automatic path navigation in "Hierarchical Reinforcement Learning for Quadruped Locomotion". With a policy architecture designed for end-to-end training, the robot learns to combine a high-level planning policy with a low-level motion controller, in order to navigate autonomously through a curved path.

Data Efficient Reinforcement Learning for Legged Robots
A major roadblock in RL is the lack of sample efficiency. Even with a state-of-the-art sample-efficient learning algorithm like Soft Actor-Critic (SAC), it would still require more than an hour of data to learn a reasonable walking policy, which is difficult to collect in the real world.

In a continued effort to learn walking skills using minimal interaction with the real-world environment, we present a model-based method to learn basic walking skills. Instead of directly learning a policy that maps from environment state to robot action, we learn a dynamics model of the robot that estimates future states given its current state and action. Since the entire learning process requires less than 5 minutes of data, it could be performed directly on the real robot.
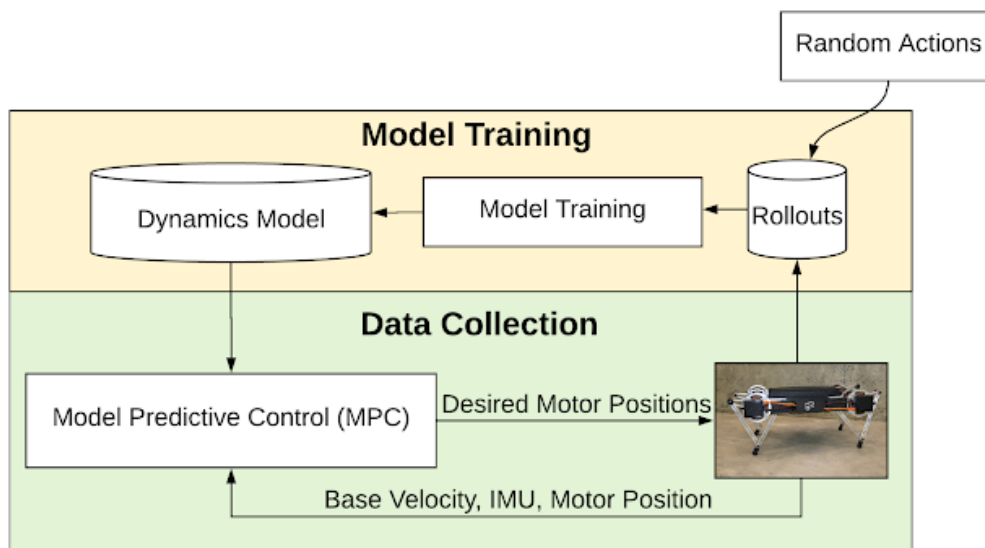
We start by executing random actions on the robot, and fit the model to the data collected. With the model fitted, we control the robot using a model predictive control (MPC) planner. We iterate between collecting more data with MPC and re-training the model to better fit the dynamics of the environment.

Overview of the model-based learning pipeline. The system alternates between fitting the dynamics model and collecting trajectories using model predictive control (MPC).

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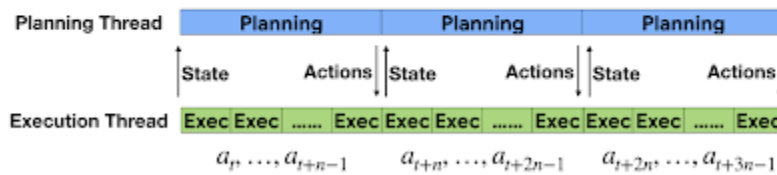In standard MPC, the controller plans for a sequence of actions at each timestep, and only executes the first of the planned actions. While online replanning with regular feedback from the robot to the controller makes the controller robust to model inaccuracies, it also poses a challenge for the action planner, as planning must finish before the next step of the control loop (usually less than 10ms for legged robots). To satisfy such a tight time constraint, we introduce a multi-threaded, asynchronous version of MPC, with action planning and execution happening on different threads. As the execution thread applies actions at a high frequency, the planning thread optimizes for actions in the background without interruption. Furthermore, since action planning can take multiple timesteps, the robot state would have changed by the time planning has finished. To address the problem with planning latency, we devise a novel technique to compensate, which first predicts the future state when the planner is expected to finish its computation, and then uses this future state to seed the planning algorithm.
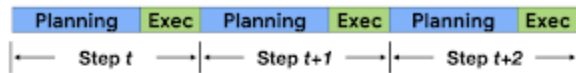
We separate action planning and execution on different threads.

Although MPC refreshes the action plan frequently, the planner still needs to work over long action horizons to keep track of the long-term goal and avoid myopic behaviors. To that end, we use a *multi-step loss* function, a reformulation of the model loss function that helps to reduce error accumulation over time by predicting the loss over a range of future steps.

Safety is another concern for learning on the real robot. For legged robots, a small mistake, such as missing a foot step, could lead to catastrophic failures, from the robot falling to the motor overheating. To ensure safe exploration, we embed a stable, in-place stepping gait prior, that is modulated by a trajectory generator. With the stable walking prior, MPC can then safely explore the action space.

Combining an accurate dynamics model with an online, asynchronous MPC controller, the robot successfully learned to walk using only 4.5 minutes of data (36 episodes). The learned dynamics model is also *generalizable*: by simply

After 3 Episodes   After 12 Episodes   After 36 Episodes

The robot learns to walk using only 4.5 minutes of data.

changing the reward function of MPC, the controller is able to optimize for different behaviors, such as walking backwards, or turning, without re-training. As an extension, we use a similar framework to enable even more agile behaviors. For example, in simulation the robot learns to backflip and walk on its rear legs, though these behaviors are yet to be learned by the real robot.

Combining low-level controller with high-level planning
Although model-based RL has allowed the robot to learn simple locomotion skills efficiently, such skills are insufficient for handling complex, real-world tasks. For example, in order to navigate through an office space, the robot may have to adjust its speed,

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direction and height multiple times, instead of following a pre-defined speed profile. Traditionally, people solve such complex tasks by breaking them down into multiple hierarchical sub-problems, such as a high-level trajectory planner and a low-level trajectory-following controller. However, manually defining a suitable hierarchy is typically a tedious task, as it requires careful engineering for each sub-problem.

In our second paper, we introduce a hierarchical reinforcement learning (HRL) framework that can be trained to automatically decompose complex reinforcement learning tasks. We break down our policy structure into a high-level and a low-level policy. Instead of designing each policy manually, we only define a simple communication protocol between the policy levels. In this framework, the high-level policy (e.g., a trajectory planner) commands the low-level policy (such as the motion control policy) through a latent command, and decides for how long to hold that command constant before issuing a new one. The low-level policy then interprets the latent command from the high-level policy, and gives motor commands to the robot.

To facilitate learning, we also split the observation space into high-level (e.g., robot position and orientation) and low-level (IMU, motor positions) observations, which are fed to their corresponding policies. This architecture naturally allows the high-level policy to operate at a slower timescale than the low-level policy, which saves computation resources and reduces training complexity.
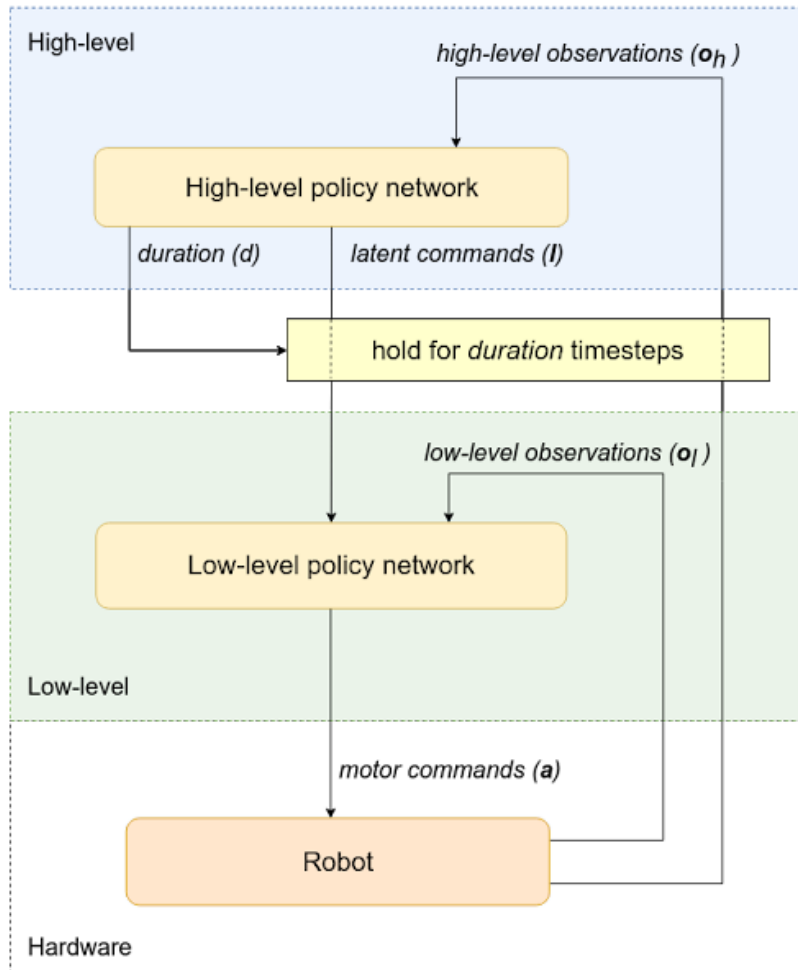

Framework of Hierarchical Policy: The policy gets observations from the robot and sends motor commands to execute desired actions. It is split into two levels (high and low). The high-level policy gives a latent command to the low-level policy and also decides the duration for which low-level will run.

Since the high-level and low-level policies operate at discrete timescales, the entire policy structure is not end-to-end differentiable, and standard gradient-based RL algorithms like PPO and SAC cannot be used. Instead, we choose to train the hierarchical policy through augmented random search (ARS), a simple evolutionary optimization method that has demonstrated good performance in reinforcement learning tasks. Weights of both levels of the policy are trained together, where the objective is to maximize the total reward from the robot trajectory.

We test our framework on a path-following task using the same quadruped robot. In addition to straight walking, the robot needs to steer in different directions to complete the task. Note that as the low-level policy does not know the robot's position in the path, it does not have sufficient information to complete the entire task on its own. However, with the coordination between the high-level and low-level policies, steering behavior emerges automatically in the latent command space, which allows the robot to efficiently complete the path. After successful training in a simulated environment, we validate our results on hardware by transferring an HRL policy to a real robot and recording the resulting trajectories.

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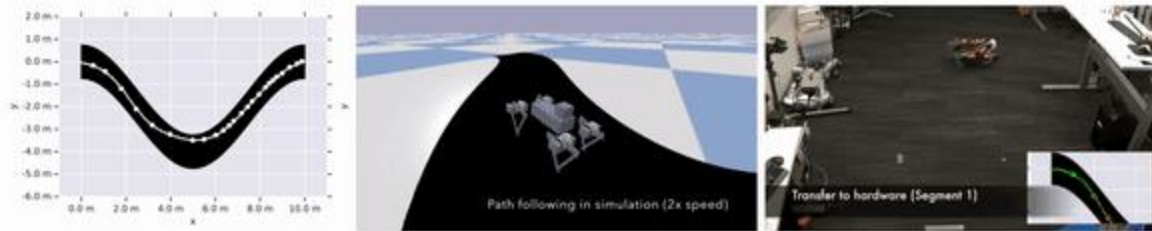
Successful trajectory of a robot on a curved path. **Left:** A plot of the trajectory traversed by the robot with dots along the trajectory marking the positions where the high-level policy sent a new latent command to the low-level policy. **Middle:** The robot walking along the path in the simulated environment. **Right:** The robot walking around the path in the real world.

To further demonstrate the learned hierarchical policy, we visualized the behavior of the learned low-level policy under different latent commands. As shown in the plot below, different latent commands can cause the robot to walk straight, or turn left or right at different rates. We also test the generalizability of low-level policies by transferring them to new tasks from a similar domain, which, in our case, includes following a path with different shapes. By fixing the low-level policy weights and only training the high-level policy, the robot could successfully traverse through different paths.
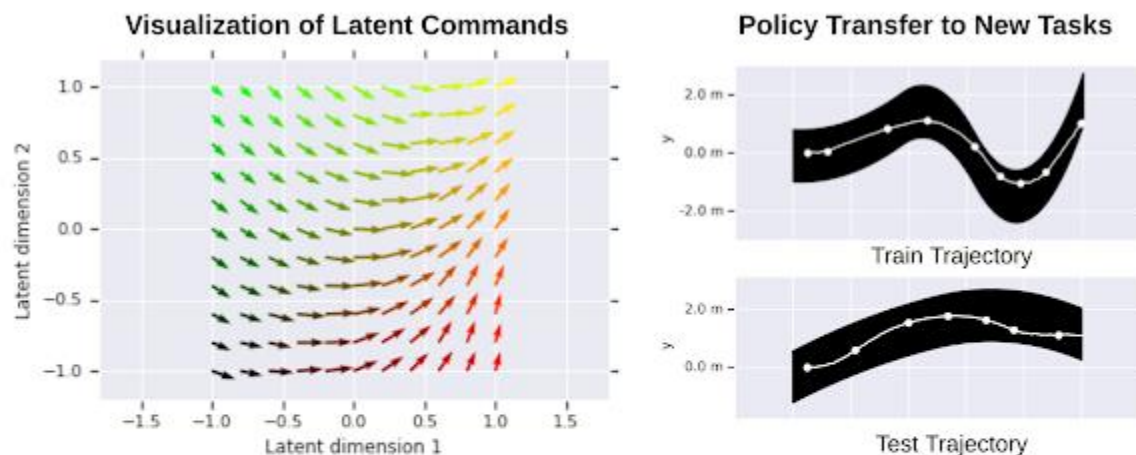
Left: Visualization of a learned 2D latent command space. Vector directions correspond to the movement direction of the robot. Vector length is proportional to the distance covered. Right: Transfer of low level policy: An HRL policy was trained on a single path (right, top). The learned low-level policy was then reused when training the high-level policy on other paths (e.g., right, bottom).

Conclusion

Reinforcement learning poses a promising future for robotics by automating the controller design process. With model-based RL, we enabled efficient learning of generalizable locomotion behaviors directly on the real robot. With hierarchical RL, the robot learned to coordinate policies at different levels to achieve more complex tasks. In the future, we plan to bring perception into the loop, so that robots can operate truly autonomously in the real world.

Acknowledgements

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Sheltering in place has driven up demand for deliveries, but machines still have trouble confronting the unpredictability of the real world.

By Aarlan Marshall

AMERICANS CHOOSING TO —or forced to—stay inside during the Covid-19 pandemic are leaning heavily on food delivery. Instacart sales soared 98 percent, and Amazon Fresh sales 68 percent, in March, compared with February, according to the consumer analytics firm Second Measure.

Restaurants that can't open their doors are tapping delivery services to preserve some revenue. But many delivery workers say they don't feel safe. Workers for Instacart have said they lack the gloves, face masks, and disinfectant to do the job safely; others who have received equipment complain it's subpar. And restaurant owners chafe at the high commissions of app-based services like DoorDash, Postmates, and Uber Eats.

So it would appear to be the perfect time for the swarms of delivery robots funded by more than $1 billion in venture capital in recent years. But it turns out that the tech isn't quite ready to always operate without human help, and it will need serious additional cash to get there. Some business models remain opaque. And robot makers must learn to navigate not just US streets, but the complex rules that govern their use.

Some robot makers are using the surge of interest during the pandemic to test and demonstrate their tech in new ways. Starship Technologies says it has launched its smallish, sidewalk-traversing delivery robots in five new places in the US since shelter-in-place orders hit, bringing its total number of deployments to 12.

Henry Harris-Burland, Starship's vice president of marketing, says his company already knows how to make money. Its 55-pound robots are built to run at slower speeds on sidewalks, carry about 20 pounds, and cost no more than a high-end laptop, he says. A robot needs to travel an area just once before it is sufficiently well-mapped to start service.

Starship typically strikes deals with local government officials, university campuses, or retailers before it enters a market, the company says. That may include taking a cut of each delivery. In Fairfax, Virginia, the 42-year-old Greek and Italian restaurant Havabite Eatery launched robot delivery with Starship in mid-April. Since then, the company

has fulfilled five to 15 orders per day through the service. Like others who have partnered with Starship, restaurant owner Ida Beylee says customers are delighted by the robots. But she's not excited to pay Starship's fee, after a one-month free trial. "Twenty percent is big money," Beylee says, more than what she pays GrubHub for its delivery service. She doesn't think the Havabite can afford it, especially because it was not approved for a government-backed small business loan.

Starship and others building robots for sidewalks have faced criticism for operating there, where they compete with pedestrians and people in wheelchairs for space. San Francisco, for example, has only approved one company's robots—cheery yellow ones built by delivery app Postmates—to temporarily operate on a limited number of sidewalks. (One local politician suggested the things would be more useful picking up needles than delivering food.) As a result, sidewalk-bound robots must be cautious and slow, moving no faster than a human jog. Still, Starship robots have been okayed to operate in at least eight states.

Another startup, Nuro, has shifted its modus operandi during the pandemic, away from home deliveries. Nuro was founded by pedigreed veterans of Google's self-driving car project, and it received a $940 million infusion by Softbank last year. It had signed delivery deals with Domino's and grocery chain Kroger prior to the pandemic; its toaster-like bot is built to travel in the street at speeds up to 25 mph. Earlier this year, it gained a rare permit to operate its driverless vehicle on public roads in California, and an exemption from the US Department of Transportation to take to the streets.

> **"Fundamentally, it's that the technology is not ready at scale to deploy. We're trying hard, I promise."**
>
> – DAVE FERGUSON, NURO PRESIDENT AND COFOUNDER

But today, Nuro is operating a few robots at two temporary field hospitals in California, the Sleep Train Arena in Sacramento and the San Mateo County Event Center—both self-contained campuses. There, the robots are delivering food and medical supplies like fresh linens and protective equipment, traveling at max speeds of 5 mph outdoors and 2 mph indoors. Health care workers can open the robots with a contact-free thumbs-up.

Even Nuro's president and cofounder, Dave Ferguson, says the bot isn't yet suited for unassisted delivery to American homes. Nuro's robots face the same technical hurdles as other autonomous vehicles—ensuring that their software can handle not just finding their way through a neighborhood, but any number of unlikely situations they may confront. For now, each robot is typically followed by a chase car with two workers monitoring its movements. But that's a social distancing no-go.

"Fundamentally, it's that the technology is not ready at scale to deploy," says Ferguson. "We're trying hard, I promise."

Ann Arbor, Michigan-based robotic-tech maker Refraction AI has also had to consider its humans during the pandemic. Like many other autonomous vehicle companies, the startup employs teleoperators to monitor its nascent technology remotely and to intervene if something goes wrong. "The tech is not necessarily good enough right now that you can do it without having someone watching it," says Matthew Johnson-Roberson, the company's CEO and cofounder. After Refraction closed its office last month, the company had to ensure that its teleoperators had the equipment—and importantly, the steady Wi-Fi—to monitor the not-quite-self-driving bots from their homes. To scale up the business, the company will need to sharpen the robots' software so that one person can monitor several bots at once.

Refraction, which has built about 20 of its nearly-5-foot-high robots meant to travel in bike lanes, makes money by charging restaurants and grocery stores a 15 percent commission on deliveries, a rate equal to or lower than that charged by human-powered delivery apps. But Johnson-Roberson says the robotic delivery industry still needs deep pockets to become ubiquitous. "I think at this point it's really a question of, 'Do people want to commit the money

required to make that happen?'" he says. "My sense is that if we and others can do enough to convince people that it makes sense, and do it at some sense of scale, we can." With $100 million, he says, Refraction could launch thousands of robots in eight to 15 cities.

For now, though, the company is experimenting. On Monday, it launched a free grocery delivery service in Ann Arbor, without a store partner. Residents order via the company's app, and an employee decked out in protective gear selects and purchases items before placing them into robots curbside.

Samuel Sullivan, a driver for Uber and Uber Eats, says he's not particularly nervous about robotic competitors. He happened upon a Starship robot while delivering food in Fairfax last week. He watched as the robot paused a long while at the corner of a quiet street. ("The robots will pause at busy road crossings and only cross when it is safe to do so," says Starship spokesperson Janel Steinberg. "The robot will wait at a road crossing longer than when it is traveling on the sidewalk.")

"People have been telling me for five years now that, 'Oh you're not going to have a job next year because all the cars are going to be self-driving,'" Sullivan says. Yet here he is. To be honest, he kind of loved the little thing. "I find it so adorable," he says.

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By John Cook

Pacific NW Tech Startup Funding Totals (in millions)
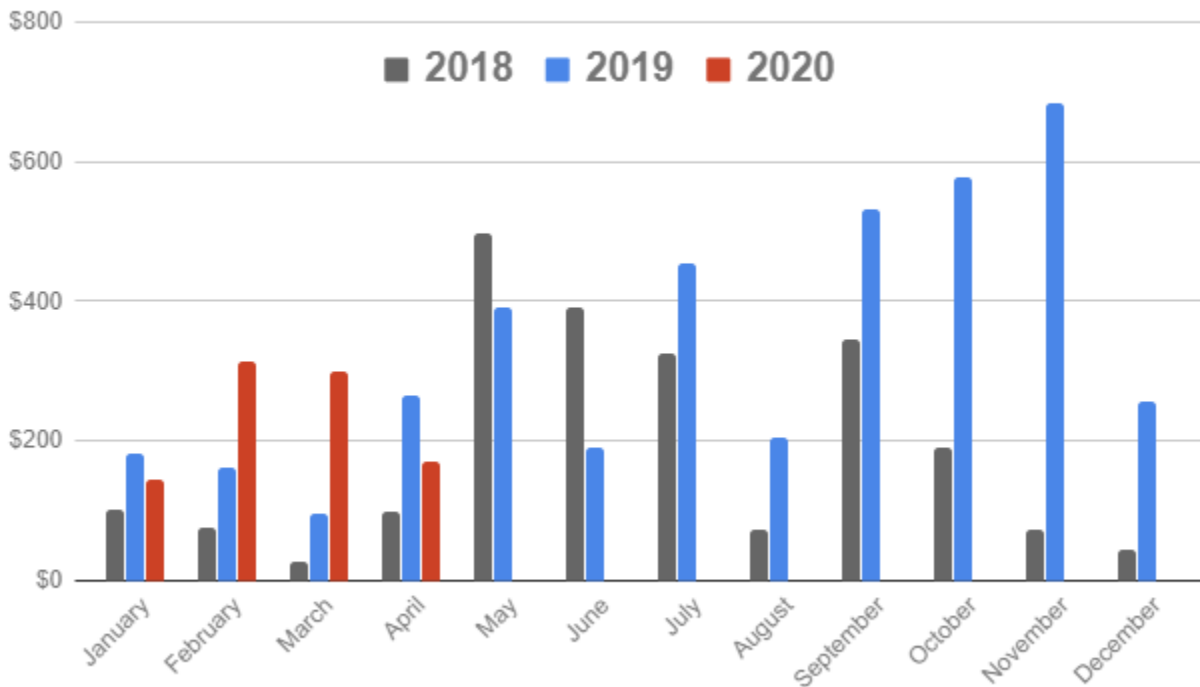
Source: GeekWire reporting, SEC filings.   geekwire.com/fundings

After reaching record levels in late 2019, VC funding for Pacific Northwest startups fell moderately in April, but not as much as it did nationally.

Venture capitalists are typically known for their optimism. But that core belief was shaken during the month of April as COVID-19 forced startup investors to tap the brakes on investing.

As the chart below shows, U.S. venture capital investments fell a whopping 46% from March to April. April's total of $7.3 billion in investments nationally was down 43% compared to April of last year. The number of deals also slowed, dropping to 600 deals in April. That compared to 867 deals in March, and 1,060 deals in April 2019, according to PitchBook data.

US VC deal activity in 2020

	Jan	Feb	Mar	Apr
Deal value ($M)	$11,302.6	$10,449.0	$13,728.9	$7,333.5
Deal count	936	830	867	600

*As of 4/30/2020

Washington State VC deal activity in 2020

	Jan	Feb	Mar	Apr
Deal value ($M)	$152.6	$145.7	$281.1	$190.6
Deal count	20	40	29	21

*As of 4/30/2020

The national numbers confirm a recent report from the National Venture Capital Association, which predicted a "bumpy ride" ahead for startups seeking venture capital funding.

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In Seattle and Washington state, the picture wasn't quite as bleak. In fact, April's totals — $190 million invested in 21 deals — outpaced the months of January and February, prior to the coronavirus pandemic taking root in the U.S. Of course, it is difficult to discern trend lines on a month-to-month basis with such a small sample size. But looking behind the Washington state numbers for April actually points to an interesting data point.

The top three companies raising money last month — 98point6, Avalyn and Blaze Bioscience — operate in the health or life sciences arena. Together, those three Seattle companies raised $101 million, or more than half of the month's entire haul.

Avalyn, led by noted biotechnology entrepreneur Bruce Montgomery, is developing therapies for severe respiratory diseases. 98point6 is creating new telemedicine products, and Fred Hutch spin-out Blaze Bioscience is using a novel approach to identifying brain tumors.

GeekWire's funding tracker of Pacific Northwest deals, which includes companies in Washington, Oregon and British Columbia, shows a relatively stable level of funding, $171.5 million invested across 18 companies for April. That was down from April 2019 ($265 million) but ahead of April 2018 ($100 million). It was also down compared to February and March of this year, but up slightly compared to January.

The challenge is likely ahead. It's unclear how many companies rushed to close financing deals in March and April, sensing that funding sources would be drying up in the coming months. Some investors also may go into triage mode, cutting losses on startups that have yet to show traction and doubling down on those startups gaining momentum.

As the chart at top shows, massive amounts of money flowed into startups in the Pacific Northwest in the latter half of 2019. It seems unlikely that those levels will be reached given the current state of the economy.

As we've written in the past, COVID-19 does not treat all industries or companies equally. While travel-dependent companies like Rover and Airbnb are cutting staff, the disruption is creating huge opportunities for a host of others who are seeing a quicker shift to digital offerings, telehealth services, online education products or medical innovations.

Venture capitalist Bill Gurley summarized that sentiment, responding to a Recode story titled *"The layoffs at Airbnb cast a dark shadow over Silicon Valley."*

Bill Gurley ✓
@bgurley

"Dark shadow over Silicon Valley" is inaccurate. Unlike 2001 & 2009, this pandemic so far has only hit a few sectors extremely hard, & just as many companies are seeing their results improve (Zoom, Discord, Nextdoor). The real dark shadow is over SMBs all over America, not S.V. twitter.com/Recode/status/…

Recode ✓ @Recode
The layoffs at Airbnb cast a dark shadow over Silicon Valley
bit.ly/35zUD1M

♡ 1,348   3:26 PM - May 5, 2020

💬 196 people are talking about this

Almost nine in 10 manufacturing businesses in the world's industrial heartlands want their own private LTE and 5G networks to drive forward Industry 4.0 initiatives and digital transformation. Three quarters are set to upgrade their communications networks in the next two years. Wi-Fi and wireless LAN will hardly get a look in.

These are the conclusions from a new survey by ABI Research of 600-odd 'decision-makers' in the manufacturing sector, commissioned by Finnish vendor Nokia to assess investment strategies related to 4G and 5G, and to other Industry 4.0 technologies.

The resulting poll found 74 percent of manufacturing companies – in frontline industrial markets – are looking to upgrade their communications and control networks by the end of 2022. More than 90 percent are investigating the use of 4G and/or 5G in their operations, 88 percent are familiar with private 4G and 5G networking, and 84 percent are "considering" installing their own local private 4G and 5G wireless networks in their manufacturing operations.

Ryan Martin, principal analyst at ABI Research, said: "Research findings indicate a preference for deploying private fully-owned and operated wireless networks, with manufacturers favouring in-house management to allay security concerns. It's evident respondents are not entirely committed to Wi-Fi/WLAN and will consider latest generations of wireless technologies."

The survey, completed at the end of 2019, polled protagonists in developed countries. The sample was split between the automotive, consumer goods, and machinery markets, and roughly between the United States and Canada in North America, and the major industrial centres in Europe (Germany, France, UK) and Asia (China and Japan), with a smattering from Australia as well.

Half of respondents (52 percent) said advanced LTE and 5G will be necessary to meet their transformational goals. The research also sought to identify key business use cases that would drive investment in 4G or 5G.

Respondents cited the need to improve existing infrastructure (63 percent), automation with robotics (51 percent), and employee productivity (42 percent). Priority buying areas are automation and machine upgrades (47 percent), industrial IoT initiatives (41 percent), with cloud infrastructure following at (37 percent).

Buying decisions for new industrial IT systems is focused reducing downtime (53 percent), improving operations efficiency (42 percent), and enhancing security (36 percent). Buying decisions for new OT (operations technology) gear is focused on replacing ageing infrastructure (43 percent), improving efficiency (40 percent), and increasing capacity (38 percent).

Martin said: "2020 is a critical year for networking suppliers to educate the market regarding the merits of 4G and 5G. We also observe a pan-industry need to quantify not only the potential ROI of investing in private wireless, but also to clearly indicate the cost of inaction – vendors need to make the case for investing in Industry 4.0 today to gain a clear competitive advantage over those who choose to wait."

Manish Gulyani, vice president for marketing at Nokia's enterprise unit, said: "We have reached an inflection point in Industry 4.0 transformation as the fast, secure, low latency connectivity underpinning its implementation now becomes available. This research indicates the strong marketplace appetite for industrial-grade wireless networking to capture the transformational benefits of digitalisation and automation."

By Jonathan Shieber

During the waning days of the first dot-com boom, some of the biggest names in venture capital invested in marketplaces and directories whose sole function was to consolidate information and foster transparency in industries that had remained opaque for decades.

The thesis was that thousands of small businesses were making specialized products consumed by larger businesses in huge industries, but the reach of smaller players was limited by their dependence on a sales structure built on conferences and personal interactions.

Companies making pharmaceuticals, chemicals, construction materials and medical supplies represented trillions in sales, but those huge aggregate numbers hide how fragmented these supply chains are — and how difficult it is for buyers to see the breadth of sellers available.

Now, similar to the way business models popularized by Kozmo.com and **Webvan** in decades past have since been reincarnated as Postmates and DoorDash, the B2B directory and marketplace rises from the investment graveyard.

The first sign of life for the directory model came with the success of GoodRX back in 2011. The company proved that when information about pricing in a previously opaque industry becomes available, it can unleash a torrent of new demand.

"GoodRX did this to huge success," said Shaun Maguire, a partner at Sequoia Capital, who invested in Knowde, a marketplace that follows a similar model. "The idea of crawling the public internet and creating structured data and winning SEO or doing SEO for the first time for something so you get a lot of traffic from buyers so you have something to offer sellers so you can get the sellers to cooperate with you... that playbook can be taken to many different industries."

Indeed, these kinds of SEO-driven market makers are cropping up across the board.

Andreessen Horowitz invested in Tomorrow Health, which offers a twist on the model for home medical equipment purchasers.

"[The founders] mapped out all the components of the end-to-end home health service delivery model and identified the key areas where a grounds-up rebuild was both needed and possible: namely, the logistics side of home healthcare, which is a combination of real-time supply-demand matching and end-to-end supply chain management; the reimbursement side, which means aggregating and streamlining complex medical policies and reimbursement rules across hundreds of health plans nationwide; and last but not least, the customer experience side, for both providers and patients," **Julie Yoo** href="https://a16z.com/2020/04/28/investing-tomorrow-health-home-care/"> in a blog post explaining the firm's investment.

For Andreessen Horowitz, an opportunity presented itself in durable home medical equipment, a $60 billion market, according to the Centers for Medicare and Medicaid Services. "Not only does this category keep rising in spend, it also has significant downstream cost and outcome implications when its processes are poorly managed," wrote Yoo. "For example, discharges from hospitals are often delayed because of the inability to reliably order DME for the patients who need it in their homes."

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Bain Capital Ventures is also trying its hand in the marketplace world with an investment in Material Bank. Announced earlier this week, the **Material Bank** deal — a $28 million investment that the firm led — shows the breadth of opportunities in the B2B marketplace.

As Bain Capital Ventures' growth investor, Merritt Hummer, noted in her Medium post describing the investment, the business-to-business world is only just waking up to digital sales. She points to the comparative size of Amazon's business and consumer marketplaces as an indicator. **Amazon** Business, Hummer noted, saw $10 billion in sales in 2019, up from $1 billion in 2015. Meanwhile, Amazon's consumers sales platform reached $300 billion in gross merchandise volume in 2019.

The difficulty cracking business-to-business sales stems in part from the scale of the transactions and the different requirements businesses have from a one-off consumer purchase.

"B2B transactions may involve price negotiations, special payment terms, a variety of payment methods, detailed product specifications, complicated SKU proliferation, consultation with a sales rep, unique shipping requirements, and the list goes on," wrote Hummer. "A retailer buying 10,000 TVs from a wholesaler is a fundamentally different transaction than a consumer buying 1 TV from a retailer."

That specialization can go a long way to explain why there's such a demand — and so many opportunities to scale — for vertical marketplaces.

"Take, for example, the highly specialized procurement processes in medical supplies, pharmaceuticals, and construction equipment. Whereas consumers in their everyday lives purchase across numerous verticals, business buyers operate in silos according to the idiosyncrasies of their individual verticals," Merritt wrote. "This makes it more difficult for a B2B marketplace to achieve category expansion. Every time a B2B marketplace enters a new vertical, it faces the challenge of onboarding a new set of vertical-specific buyers and sellers."

Hummer's assessment means there's likely not going to be a single marketplace that wins in every vertical. The specialization requirements mean that for each of these billion-dollar-plus industries, at least one or two startups may find a foothold and a way to succeed.

Savvy investors can find these kinds of marketplace mechanics nearly anywhere.

H1, a recent **Y Combinator** graduate, is bringing this transparency to pharmaceutical companies that need to find information on doctors who specialize in areas where drug makers need expertise (or potential sales channels). That company managed to snag $12.9 million in funding mere months after leaving the accelerator program; Menlo Ventures led that investment.

Meanwhile, Maguire and **Sequoia Capital** placed their bet on Knowde and its attempt to bring transparency to the $5 trillion chemicals market.

Just the breadth of industries covered above point to a vast potential opportunity set. What's needed is an old industry that's going through the demographic shift of a professional managerial class coming online that's comfortable with online buying and selling.

"We believe the next ten years will be characterized by the rise of B2B commerce and platforms that support it," wrote Hummer. "It will look different this time: verticalized online marketplaces will emerge, and the landscape is unlikely to be dominated by one behemoth like Amazon."

CHAMBIZ

The latest in energy-storage systems demand high-performance safety components and sophisticated circuit-protection solutions that can provide the critical levels of protection to ensure both safety and reliability.

By Markus Beck

Electric vehicles have been around since the mid-19th century and were quite popular until cheap gasoline from Texas oil fields changed the dynamic. Those early EVs had serious issues with energy density and powertrain efficiency, yet an electric vehicle held the land speed record until the turn of the last century. The greatest safety issue with those first-generation vehicular battery systems mostly revolved around shipping and the storage of acids in the electrolyte (Fig. 1).

1. Early battery systems suffered from low energy density and the caustic materials that were used.

A modern EV battery pack has a significantly higher power density and capacity than those antique systems, and the safety issues and processes needed to address them have migrated to more advanced core technologies. Managing the high currents involved in today's EVs has become a major safety issue, as a mismanaged short-circuit event can become a catastrophic failure situation.

Safety and Performance

The same demands for efficiency and energy density apply to an EV's power electronics, which also require extremely high levels of safety and functionality. Only by having both advanced battery systems and power-management electronics can today's EVs address the needs for range, performance, and safety. The migration to advanced materials like wide-bandgap semiconductors in power systems is a double-edged sword, increasing both performance as well as the need for safe operation.

Better Batteries

The demand for improved energy storage has been steadily growing in almost every market sector. From devices as small as medical wearables to systems as large as the power grid, today's solutions require high-density batteries. These applications need a variety of methods to safely and reliably operate, as the power levels leave no room for error. From grid peak-shaving and other load-shifting methodologies in the power grid, to the fast-charging electronics serving the EVs attached to it, ensuring the safety of the batteries involved is critical (Fig. 2).

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Fusing for Safety

To ensure these high-density power-management systems are safe over a vehicle's operational lifetime, it's critical to integrate robust, high-performance protection components into their designs. Fuses or similar devices are required circuit-protection components, protecting the car from short-circuit conditions by breaking the power link under very specific conditions. Many of these myriad types of fuses share a primary aspect, a piece of engineered conductor.

This tailored link, usually metal, is rated to break the connection by melting (or vaporizing) in a controlled manner. This usually happens under the higher temperature conditions created by a short circuit, ensuring the safety of the system by completely cutting it off from the power source. A few drawbacks exist, though, among them being that a circuit under load will not always exhibit a regular and smooth flow of current.

For example, in designs that experience high-power pulses, the wide current variation that results means using a higher-value fuse to avoid nuisance tripping. The problem is that this solution leaves the circuit more exposed to overheating and thermal failure. In addition, the disposable aspect of fuses has led to more use of advanced safety devices like circuit breakers, which are resettable and don't have parts that burn out.

Contactors Connecting

Contactors are electromechanical protection devices that, while similar to circuit breakers, differ in that they don't stop a short. Rather, they act as high-performance switching devices that connect directly to high-current loads. Operated by an external control, power contactors serve demanding circuit-resetting tasks where high current levels are present. Similar in operation to relays, contactors also offer features to control and suppress the arcs created when switching.

High-voltage contactors ensure safety and circuit continuity in hybrid- and electric-vehicle power storage, battery chargers, and high-power industrial systems, quickly and securely connecting and disconnecting power while managing arcing and inrush issues. One example is in EVs, where normally open contactors manage the connection between the battery pack and the system, automatically disconnecting when the car isn't being used.
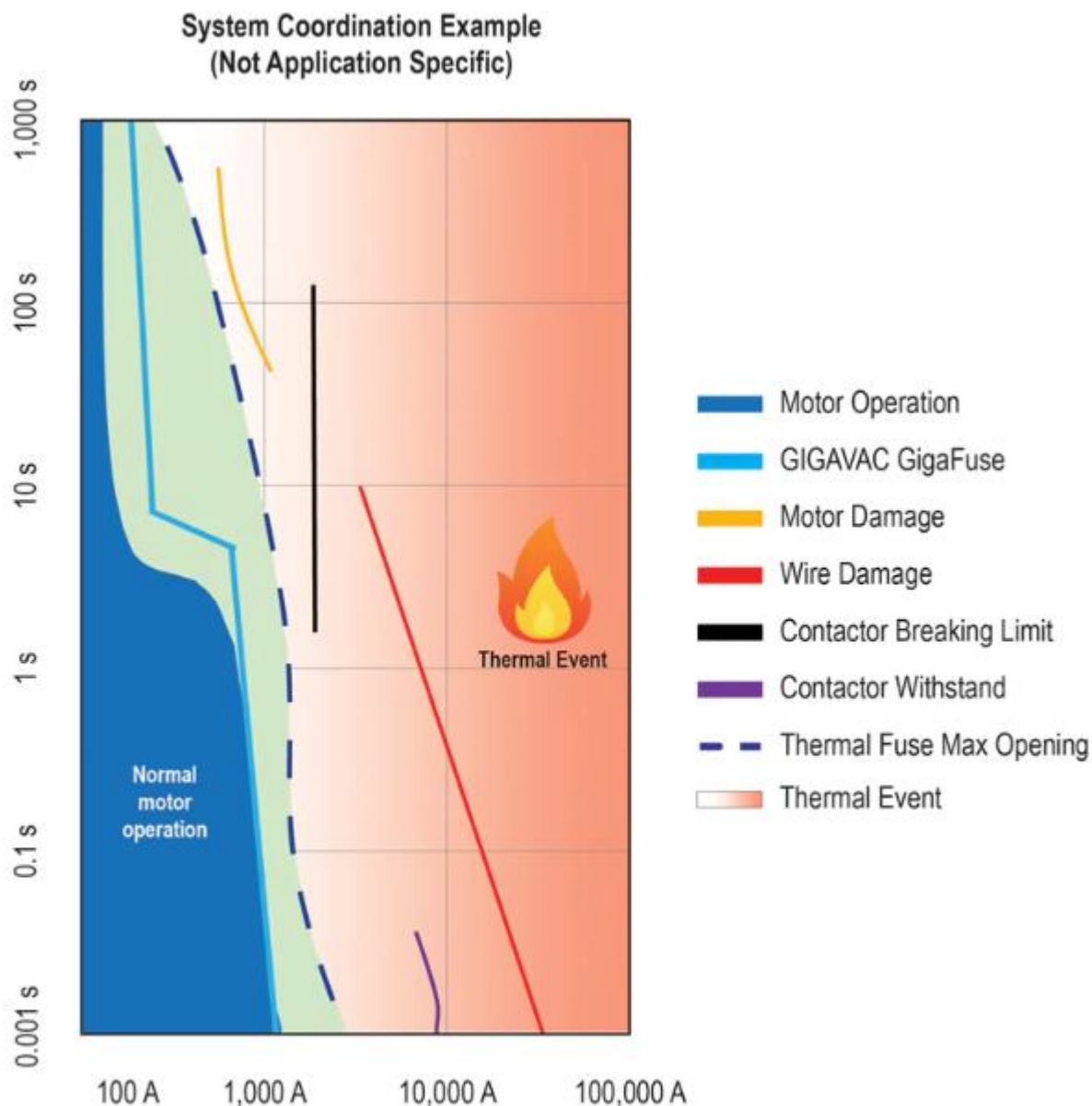
Next-Generation Protection

Other circuit-protection solutions exist that can open a circuit faster than a fuse and are more resistant to nuisance tripping. This and other advanced features ensure a lower risk of damage than thermal fuses. An example of such a solution can be found in the GigaFuse developed by GIGAVAC, a Sensata Technologies brand (Fig. 3).

3. Targeted at EVs, the Sensata GigaFuse is a fast-acting electromechanical device with low heat generation.

The hermetically sealed, fast-acting electromechanical device has low heat generation and trips at an exact current. Features include highly reduced resistance, no thermal aging, and increased system efficiency. Provided in both passive and passive-active variations, the devices use the current flow's magnetic field (Lorentz force) to trigger the device. Figure 4 shows how it operates, with the blue line in the chart showing the triggering threshold.

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System Coordination Example
(Not Application Specific)

Legend:
- Motor Operation
- GIGAVAC GigaFuse
- Motor Damage
- Wire Damage
- Contactor Breaking Limit
- Contactor Withstand
- Thermal Fuse Max Opening
- Thermal Event

4. This diagram demonstrates the operation of circuit-protection solutions like the GigaFuse. The blue line indicates the triggering threshold, showing that the device can open the circuit faster than a fuse and closer to the desired operating conditions.

This chart shows the device can open the circuit faster and closer to the desired operating conditions than a fuse. Available in a continuous range of ratings from 200 to 500 A, the path of its triggering threshold is also adjustable. Generating little heat in operation, it's immune from both thermal aging and nuisance tripping caused by hot and cool operational cycles, which over time, causes brittleness of the conductor.

The GigaFuse is claimed as the industry's first hermetic fuse that trips at exact currents. It's designed to significantly reduce resistance, install time, complexity and cost, helping to increase system efficiency.

Extending the system's operational life by ensuring the physical and operational integrity of the connection, the fuse has fast and consistent clear times regardless of ambient temperatures. This is increasingly important in high-powered EVs, where any addition to the thermal impact of the drivetrain electronics can affect the performance of other thermally sensitive subsystems.

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Fast operation also improves contactor performance. A contactor can levitate during operation, dissipating energy that should be available to trigger the fuse, and instead, loading the current on the contactor. This can prevent the fuse from "seeing" the short and potentially lead to catastrophic failure. Looking at a situation with a 500-A contactor and 500-A fuse, such a configuration would take a second or two at 1,000 A to trip, whereas a fast-tripping solution can be set at 1,000 A, for example, and trip within 3 ms.

In the case of thermal fuses, there's an area of operation where current levels may overwhelm the contactor, foiling its ability to interrupt the load by blocking it from reaching the thermal point for a fuse to trigger. This risk is eliminated with products that offer a very low contact resistance of less than 0.15 mΩ, which also leads to less power loss and increased system efficiency.

Considerations
Precise and rapidly tripping protection devices address circuit safety in high-power systems, but their benefits aren't restricted to just serving advanced batteries. A myriad variety of applications, including industrial robotics and alternate energy systems, can benefit from such a solution's efficiency, thermal features, and operational speed. These fast-acting, hermetically sealed electromechanical devices are well-suited for applications where thermal aging or nuisance tripping are problematic.

Power protection solutions like the GigaFuse aid contactor coordination and provide protection under short-circuit conditions. Next-generation energy-storage systems demand equally high-performance safety components and sophisticated circuit-protection solutions that can provide the required critical levels of protection to ensure both safety and reliability.

CHAMBIZ

By Natasha Mascarenhas, Alex Wilhelm

Chris Lynch, a founder and former general partner at Boston-based seed-stage fund Accomplice, remembers "VC Mountain in Waltham."

Back then, entrepreneurs on funding quests would visit a building overlooking the Waltham Reservoir near Boston where they pitched to a few investors: Matrix Partners, Charles River Ventures and Highland Capital Partners.

"And if they didn't invest in you, you weren't getting money to start your company," Lynch said.

Since then, Lynch has watched the area's startup ecosystem reach the point where seed-stage firms are ubiquitous, but in a city populated with firms waiting to make first bets, the scene is unsurprisingly undergoing a funding drought. Crunchbase data indicates that the city's Q2 venture capital pace slowed dramatically, with April seeing far fewer rounds and dollars invested in 2020 than in 2019.

Boston saw just seven known equity funding rounds in April, investments worth a hair under $60 million. In the year-ago April, Boston recorded 24 equity funding rounds worth more than $500 million.

Yet, while the numbers are slow, some Boston tech leaders think seed startups will continue to thrive thanks to accelerators and a healthy base of local early-stage investors. And Lynch, who left Accomplice in 2017, says the venture slowdown might help firms recalibrate their appetite for new deals to a more healthy pace.

"The advantage of more access to capital without a proportional increase in great ideas really waters down the fort," he said, referring to upmarkets. "A lot of money has been invested in companies before they even proved their ideas were right, and I think even I fell into a trap of competing so hard for deals that I lost sight of a good deal." He estimates that in our COVID-19 world, investors will start to again take three months for due diligence on a deal, versus three weeks to a signed term sheet.

If Boston's seed investors becomes more conservative, that means that accelerators — homes of the brightest founders, often before they even have their first customer — will be pressed to react.

Accelerators
Venture Lane, a co-working space and startup incubator for early-stage companies, was nearing its one-year anniversary in the heart of Boston when COVID-19 hit the city.

The incubator, which traditionally hosts 10 startups at a time, made its whole program virtual and reworked existing content to help navigate the climate. Plus, per founder Christian Magel, its tips and workshops were opened up to any early-stage founder, not just the ones enrolled with Venture Lane. Hundreds have signed up, he said.
Venture Lane solves an interesting niche in the early-stage world: It helps companies right after they leave an accelerator, of which Boston has a ton: Harvard iLabs, Techstars, Greentown Labs, MassChallenge and others. Instead, Venture Lane helps companies seeking seed and Series A rounds that still want the help of networks and microecosystems.

The fact that it is up and running — and now accepting two more startups to join its cohort — tells us that Boston isn't shutting down in the face of this crisis.

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Another accelerator that's come to our attention is Petri, which provides capital, guidance and — pre-COVID-19, at least — lab space for startups that need it. Its year-long program is funded in part by Pillar VC, a Boston-area venture capital firm. Even more, Petri announced this week that it's working with Pillar on a new effort called Breakout, a six-week virtual series for individuals interested in building companies.

Given how active Pillar is in Boston's early-stage scene, we caught up with its founder, Jamie Goldstein.

Seed and survival
Goldstein said the city has more seed-focused firms than Series A and B-focused firms, which could lead to a bottleneck, or what was once called a Series A or B "crunch."

With travel impossible and VCs cutting their risk profile, the Silicon Valley and New York firms that helped fill out Boston's middle-stage rounds might not be as ready to write checks to companies that they can't meet in person, he noted.

Goldstein told TechCrunch that from a "comparative health" perspective, Boston's startups are in sectors that "are going to do pretty well." The Pillar investor also cited how academic institutions bring a regular flow of new companies, and while there will be a difficult period for them, they will "come out the downturn strong."

But not all companies in the city will make it, and Goldstein has a perspective on which will survive — and which won't.

"There's a lot of discussion out there right now about months," the venture capitalist told TechCrunch, advising that every startup should "have at least 12 months or 18 months or 24 months" of cash. In his view, runway expectations miss the point.

What, then, should startups focus on? The critical question for young companies to answer is, "what do you need to do to position yourself to raise your next round of funding on attractive terms?" That's a different question than how to survive until December of 2021, he noted, adding that nothing magical happens if a startup merely endures until a certain date.

That said, Goldstein did note that as investor expectations grow, it's smart to "give yourself extra time to be able to survive and then grow into some really meaningful run rate so you can get a healthy financing done."

It's not enough to just survive, then; startups will need to thrive in order to make it through the downturn.

Don't think that Goldstein is being overly harsh, mind; we've been reminded by other investors that the startups that survive this downturn won't just have to compete against each other for capital on the other side. They'll also have to jockey with new companies that were born after the winter.

The Boston startups that make it are going to be a hardy bunch.

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By Amir Efrati

Zoox, one of the most ambitious self-driving car developers that was valued at $2.7 billion in 2018, is contemplating a sale.

The startup, which has raised $1 billion in equity, has hired Qatalyst Partners to help it find a buyer, said two people familiar with the situation. At the same time, however, it is also trying to raise fresh equity in a deal that would allow it to remain independent, at least for the moment. Zoox executives have talked to representatives of several automakers about a potential deal or financing, one of the people said.

Its latest financing efforts come at a tough time for the self-driving vehicle development industry. Development of vehicles reliable enough to operate as taxis is taking longer than some major companies projected, which means many firms need more money. Within the past year, well-known startups Drive.ai and Starsky Robotics have shuttered, while others including Kodiak Robotics and Ike have cut staff. Public companies including Alphabet's Waymo and General Motors' Cruise, meanwhile, have raised billions of dollars from outside investors. The Covid-19 economic downturn has made fundraising particularly difficult for many startups.

Zoox is in a particularly tight spot. Its technological approach to self-driving vehicles—creating a brand-new type of electric-powered car with no pedals or steering wheel—is seen as more expensive than that pursued by other companies. Until last month, when it laid off 100 employees, Zoox had a workforce of 1,000, bigger than other self-driving car startups not owned by a big company. Few companies may be willing to take on the risk of buying a startup with such high costs and long-term investment requirements right now. The company, which does not yet generate revenue, appears to need more cash to keep going.

It's unclear which direction Zoox will go in striking a deal now. The firm has tried to raise fresh equity over the past year, so far without reaching a deal. Most auto companies have already placed big bets in the self-driving car race, which could make it tough for Zoox to strike a partnership.

Zoox in a statement confirmed it hired Qatalyst to evaluate interest in the company from potential "strategic investors" as well as from potential buyers and that it expects to "finalize the [financing] round soon."

Costly Approach
Zoox vehicles promise to look different from other self-driving cars. Zoox has some shuttle-like vehicle prototypes. They don't have a steering wheel and are bidirectional, so they can drive in both directions on the road (meaning they don't have a front or back). Zoox will need a lot more time and money to develop a robotaxi business and manufacture vehicles at scale. The company has kept the prototype under wraps but has hinted it would unveil the vehicle later this year.

"The first time I saw Zoox's patent application for their bidirectional car…I believe I audibly gasped," said Reilly Brennan, a partner at Trucks.vc, which invests in transportation-related companies. "From a hardware point of view, it was unlike anything I'd ever imagined. It was audacious to design new hardware to benefit the software, and this meant to me that they were going to need a lot of money."

People who have experienced demonstrations of Zoox's automated driving software in a retrofitted Toyota SUV, with a human backup driver behind the wheel, say it shows impressive capabilities. But one of the only true measures of software quality is the ability to carry real passengers in a driverless, fully automated vehicle.

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Some people involved in the process view Zoox as akin to a pharmaceutical company whose drug has shown progress in trials, needs more money for development, and carries risks until it is commercially viable.

Any acquisition of Zoox or of its software would be a bet on the ability to improve its existing technology rather than pair it with another software stack. Engineers in the field say it's next to impossible to merge autonomous vehicle software developed by different companies.

The two most advanced and best-capitalized robotaxi developers, Waymo and Cruise, pursued the opposite strategy, retrofitting existing passenger vehicles. But Zoox executives have argued that it would be better to build a new type of vehicle made especially for automated driving than to retrofit an existing passenger vehicle with automated driving software and special hardware and sensors.

As a result, in the first few years of Zoox's life, under its founder and former CEO Tim Kentley-Klay, the company steered clear of partnering with existing automakers. But it fired Kentley-Klay in 2018 and installed former Intel executive Aicha Evans as CEO. She has spent the past 15 months trying to improve relations with automakers.

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