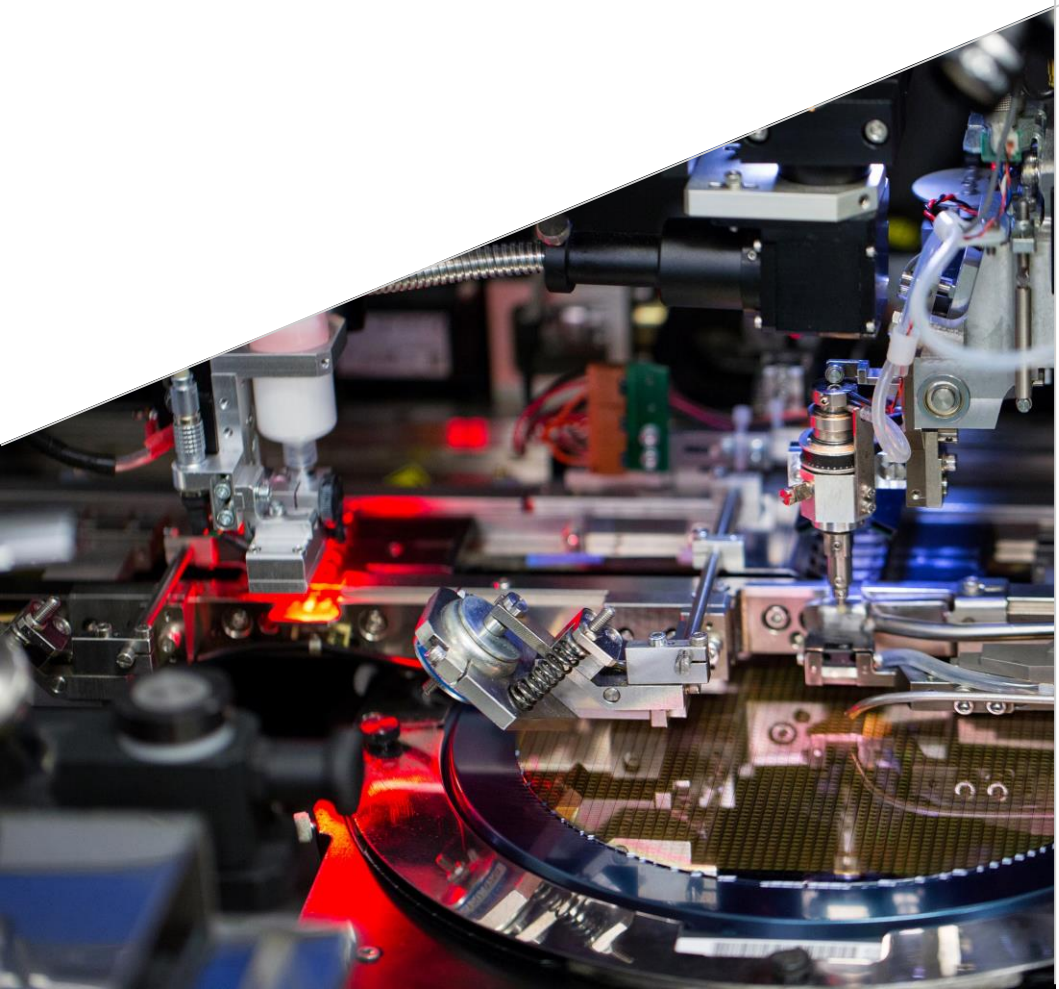
BloombergNEF Technology Radar

The Robotic Process Automation Edition

April 10, 2019



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Section 1. Introduction

Each month the Digital Industry team publishes a review of recent projects, partnerships, product launches, policy and fundraising. As well as providing this overview of events from the previous month, the Technology Radar includes an analysis of selected new technologies, business models, startups and investor strategies – and their impact on industries including electricity, oil & gas and mining. Readers should expect to see a combination of the following.

- ***Technology coverage***: Industrial internet-of-things, advanced materials, blockchain, cybersecurity, robotics, automation, drones, data privacy and security.
- ***Company coverage:*** Industrials, technology and IT, telecoms, cities, government, utilities, oil and gas, mining and others.
- ***Startup coverage***: A profile of a selected startup in the technology world, its business model, technology, partners and potential.
- ***Financing data***: Investment data for relevant technologies, investor profiles of incubators, accelerators, VC, PE, and corporate venture capital.
- ***Recent BNEF publications***: A review of BNEF reports published in the past month of relevance to our technology coverage.

The theme each month will change based on topics that have had recent activity or on particular news events. The choice of startup or investors profiled is made based on the theme for the month and on recent news. It is not an indication of company rankings. This month's technology theme is robotic process automation (RPA).

Section 2. News and fundraising

March news

Cyberattack

Norsk Hydro sustained a cyberattack in March that required a shift to manual production.

On March 19, Norsk Hydro, the Norwegian aluminum smelter, sustained an extended cyberattack that resulted in production losses and a switch to manual operations. Most critical activities were able to continue operating with workarounds and isolated IT systems. However, the financial impact during the first week of the attack was estimated between $35 - 41 million, though Norsk Hydro has (capped) cyber insurance that will cover some of the damages.

Industrial AI startups sign some big names in March

Codelco, the world's largest copper producer, said on March 26 that the company will deploy Uptake's asset performance management software to monitor and predict the future health of its mining assets. Uptake, an industrial IoT startup and one of BloombergNEF's 2019 New Energy Pioneer winners, uses artificial intelligence and an extensive library of asset models to help customers reduce operations and maintenance expenditure.

Similarly, Aker BP, an independent offshore oil producer, will deploy startup SparkCognition's AI applications to monitor installations and predict maintenance issues before they occur. SparkCognition's AI will operate both topside and sub-surface at 30 of Aker BP's offshore rigs.

On March 20, Cemex, a global building materials firm, announced a global agreement with Petuum, another industrial AI company focusing on industrial, financial services and health care. Petuum's Industrial AI Autopilot specializes in optimizing energy use, autonomous operation of manufacturing asset, emissions reductions, and maximizing production. Autopilot will use AI to learn over time with the eventual goal of fully autonomous operations.

A Berkshire Hathaway insurance firm, Guard, will offer its customers discounted IoT devices from Triple+ to monitor water leaks and prevent damage. The wireless sensors can alert the customer of abnormal water usage, freezing temperatures and open valves. The system can also remotely shut off the water main in the event of a leak or flood.

On March 11, C3, another industrial AI company, announced partnerships with 10 systems integrators including BGP, Ortec, Neal Analytics and CGI. Integrators can help C3's customers connect disparate IT systems in order to aggregate their data onto C3's enterprise-AI platform.

Volkswagen is partnering with both Amazon Web Services and Microsoft Azure for its cloud computing.

Japan's industrial and electronics conglomerate, Kyocera, has partnered with LO3, an energy blockchain startup. The two companies will test how renewable resources can be aggregated and traded using a peer-to-peer, decentralized blockchain. This virtual power plant will optimize and record transactions for Kyocera's solar and battery storage systems situated within a microgrid. The companies will use IoT sensor data to increase the accuracy with which power is aggregated and distributed from decentralized energy sources. For more on VPPs, see *Virtual Power Plant 101* (web | terminal).

Cloud companies make inroads into industry

On March 27, Volkswagen announced it will turn to Amazon Web Services to build digital manufacturing operations to connect its 122 plants worldwide. Operational data on equipment will be used to optimize production. Volkwagen will use not only AWS's data storage and structure but

also the company's IoT products: IoT Greengrass, IoT Core, IoT Analytics and IoT SiteWise. As recently as September 2018, Volkswagen had inked an agreement with AWS's rival, Microsoft Azure, to provide connected-car services but allegedly wants to keep Amazon at an arms distance from its customer relationships. Volkswagen has also said it may try to commercialize these products to sell to other industry participants.

ExxonMobil hopes to deliver 50,000 barrels per day of additional oil through the use of IoT and cloud computing.

ExxonMobil said on February 22 that it will use Microsoft Azure's cloud computing services and analytics to boost its production in the U.S. Permian Basin. Projects will include developing mobile apps and employing artificial intelligence to improve well performance by 50,000 barrels per day by 2025. ExxonMobil joins Chevron, Equinor, Shell and others that have announced multi-year deals with Microsoft for its cloud computing and IoT capabilities.

Nexcom, an industrial computing hardware company, has partnered with Google Cloud to use Google's edge computing technology stack. Nexcom has developed an IoT gateway that integrates hardware including Google's Tensor Processing Unit (TPU), a computing chip dedicated to machine learning, with other communication capabilities. Nexcom's industrial customers will be able to not only collect data but analyze it and make real-time decisions at the edge of the network.

On February 28, IBM launched Maximo Asset Performance Management, a suite of software and IoT tools for the oil and gas, manufacturing and heavy industry sectors. The product will include asset health analytics based on real-time data, predictive maintenance, and tools to help technicians identify and fix repairs. IBM will launch customized products for specific industry verticals, starting with energy and utilities. It is one of many technology companies competing with startups and industrials for industrial IoT applications.

More projects and partnerships for the industrials

GE is working with A2A Group, an Italian utility, to modernize and deploy IoT to four combined-cycle gas plants through a combination of hardware and software solutions. A2A Group hopes to increase the flexibility, reliability, and operational life of assets in competitive Italian wholesale markets that are seeing an influx of renewables. Through a combination of hardware and software, GE's operations performance management has improved the ramping rate of the Chivasso power plant by two and a half times the normal rate. For more, see *EU Power Weekly: Digital Enhancement for Europe's Gas* (web | terminal).

To deliver new digital services to the chemical and refining industries, Haldor Topsoe announced a new digital product, ClearView, to sit atop Honeywell's Connected Plant cloud-based platform. Data gathering and cleansing will occur within Honeywell's platform, then ClearView delivers analytics to help optimize output, achieve energy savings and improve reliability. Haldor Topsoe can build on Honeywell's existing Connected Plant customer base.

Software talent is global

The government of France is making it easier for foreign employees to work in the French startup scene. The new visa program, announced on March 1, allows more than 10,000 startups to recruit outside of France. Employees can work for four years on the visa, even if they move companies. As data science and software development talent remains scarce, France hopes the visas will develop and expand its startup landscape.

Focus on: Digital at BNEF's New York Summit

This year's BloombergNEF Summit in New York held on 25-26 March gathered 1,000 executives and strategists, hailing from utilities, oil companies, manufacturers, and governments. The Digital Industry team held a plenary session on 'Utilities in the age of the Industrial Internet of Things' as well as an Innovation Forum that ran both days.

Soundbites

Rethinking the Energy Internet – Michael Wilshire, Head of Strategy, described the history of networks and the evolution of the decentralized network that makes up the electricity system. Machine learning techniques like neural nets and deep learning have become important tools for optimizing and controlling complex systems such as the electricity grid. See the presentation (web | terminal) and the video.

> "Utilities should embrace machine learning to achieve operational efficiencies - not just thinking about retrofitting them to your existing business but thinking about how you can use them more fundamentally to create new types of business… The strategy choices for these technologies are no longer *whether and when* to use them but *how and how fast*."

In Images

Utility Digitalization Panel (video)

- Claire Curry, Head of Digital Industry, BloombergNEF
- Drew Murphy – Senior Vice President, Strategy and Corporate Development, Edison International
- Dr Jiong Ma – Senior Partner, Braemar Energy Ventures
- Emmanuel Lagarrigue – Chief Innovation Officer, Schneider Electric

Innovation Forum

The Innovation Forum is an opportunity for BNEF's technology-focused teams to present short talks that highlight upcoming research. This year we spoke about the storage, advanced transport, digital industry and advanced materials. The Digital Industry team presented on the following research that is in the pipeline (web | terminal):

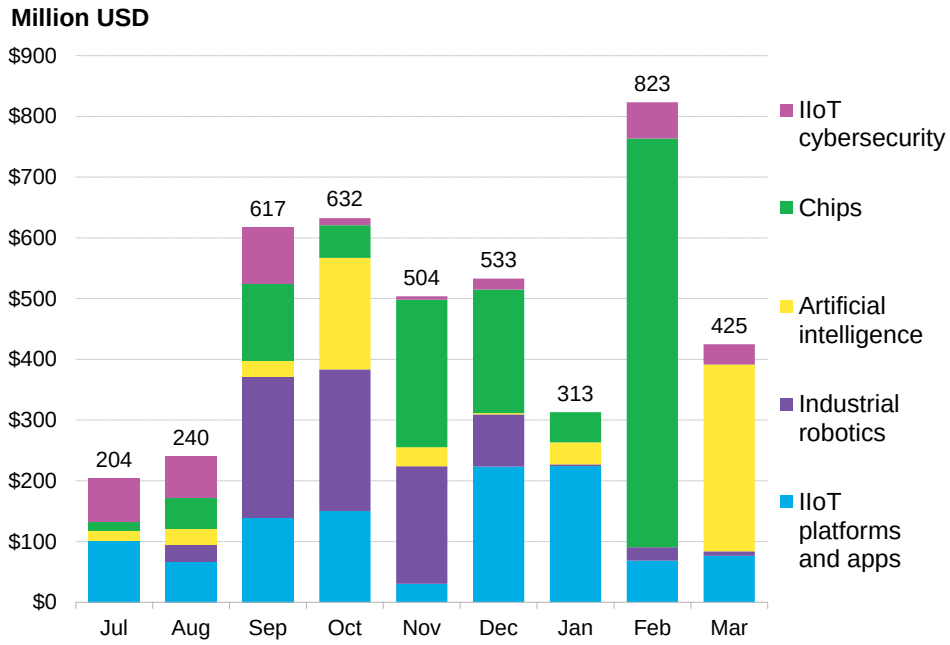
- Cloud computing companies' new focus on industrial IoT
- Oil and gas digitalization strategies
- Startups: strategies, services and strengths

Watch out for next month's tech radar, where we will profile the winners of our New Energy Pioneers startup competition!

Investments and acquisitions

In March, BNEF's Digital Industry team tracked 55 startup funding deals, totaling $425 million. The largest deal of the month, at $297 million, went to MiningLamp. This Chinese company sells AI software and is positioning itself to become a one-stop-shop for enterprise AI.

Figure 1: VC/PE startup fundraising in IIoT, industrial cybersecurity, artificial intelligence, robotics & automation, 2H 2018 to April 2019



Source: BloombergNEF, CB Insights

Table 1: March VC/PE investment for Industrial IoT, industrial robotics

Startup	Sector	Description	Date raised	$m raised	Investors	$m raised to date*
Iguazio	Artificial intelligence	Industrial AI and data science delivered as a platform-as-a-service	6 March	N/A	Samsung Ventures	48
Determined AI	Artificial intelligence	Tools and management platform for deep learning model development	13 March	11	GV; Amplify Partners; CRV; Haystack; SV Angel; Specialized Types; The House	13.6
Adagos	Artificial intelligence	Automatically fits deep learning models to clients' learning data sets	26 March	N/A	Continental Startup Challenge	N/A
MiningLamp	Artificial intelligence	Enterprise AI services including human-robot interaction and big data analysis	28 March	297	Tencent; Huaxing Growth Capital; China Renaissance; AVIC Trust	487
Glartek	AR/VR	AR/VR software for industrial maintenance	6 March	1.7	EDP Ventures; H-Farm; HCapital Partners; Novabase Capital	1.9
Ario Technologies	AR/VR	Augmented reality software as a service for industrial workers	19 March	1	757 Angels; Center for Innovative Technology; Plug and Play Ventures	1
Scope AR	AR/VR	Industrial AR content creation platform	20 March	9.7	AngelList; Haystack Fund; New Stack Ventures; Susa Ventures	11.8

Startup	Sector	Description	Date raised	$m raised	Investors	$m raised to date*
ManoMotion	AR/VR	Software that tracks and recognizes hand gesturing for AR/VR applications	27 March	2.5	European Commission	6.5
Insightness	Chips	Computer vision chips and software for spatial awareness in drones and robots	18 March	0.02	Hello Tomorrow	0.02
SpaceTouch	Chips	AI and IoT chips, specializing in voice and touch processing	21 March	N/A	Volcanics Ventures	N/A
Intellifusion	Chips	AI chips for computer vision	22 March	N/A	BOC International; China CITIC Bank	N/A
Charging Ledger	IIoT (blockchain)	Blockchain-based demand response software for grid operators	13 March	0.1	AngelPad	N/A
Elements Technology Platform	IIoT (data aggregation & visualization)	Digital documentation and workflow management software for manufacturers	21 March	0.33	Northern Powerhouse Investment Fund	N/A
idatase	IIoT (data analytics)	Build IIoT digital twins using language not code, for asset analytics	4 March	0.12	Techstars	0.15
Zinier	IIoT (data analytics)	AI-based field service management software for scheduling field technicians	5 March	22	Founders Fund; Qualcomm Ventures; NGP Capital; Accel; NewFund Capital	22
KoBold Metals	IIoT (data analytics)	Using AI on geological data to find sources of ethical cobalt	5 March	N/A	Breakthrough Energy Ventures; Andreesen Horowitz	N/A
Enerzai	IIoT (data analytics)	AI-based software that automates oil and gas drilling	6 March	N/A	Springcamp	N/A
Yundao Zhizhuang	IIoT (data analytics)	Simulation software for manufacturing	6 March	N/A	Zhongchuang Hongxing; Zhongguancun Development Group	N/A
Earth Science Analytics	IIoT (data analytics)	AI software that predicts subsurface rock and fluid properties for oil and gas	8 March	N/A	Saudi Aramco Energy Ventures	N/A
EroNkan	IIoT (data analytics)	Software that monitors industrial equipment efficiency and manufacturing workflows	11 March	N/A	GVFL Ltd	N/A
Okra	IIoT (data analytics)	Software for managing distributed energy resources on rural microgrids	12 March	N/A	Smart Axiata Digital Innovation Fund	N/A
Eigen Innovations	IIoT (data analytics)	AI-based IoT data analytics for manufacturers	13 March	0.08	Atlantic Canada Opportunities Agency	4.94
Ferntech	IIoT (data analytics)	Software to monitor and control off-grid power systems	13 March	N/A	Factor(e)	N/A
FireVisor Systems	IIoT (data analytics)	Analytics for manufacturers to detect and analyze product defects	19 March	0.74	500 Startups; Acequia Capital; Entrepreneur First; SGI	0.8

Startup	Sector	Description	Date raised	$m raised	Investors	$m raised to date*
Overview	IIoT (data analytics)	Cameras and AI that visually monitor industrial machines for anomalies	19 March	0.15	Y Combinator	N/A
Enging	IIoT (data analytics)	Predictive maintenance software for motors and power transformers	20 March	1.14	EDP Ventures	1.14
Transport Hub	IIoT (data analytics)	Analytics and dashboards for logistics digitization	22 March	0.5	N/A	0.5
Presenso	IIoT (data analytics)	AI-based predictive maintenance software for industrial machines	25 March	N/A	EDP Ventures	2
Geospock	IIoT (data integrator)	Aggregates multi-sensor data for big data analysis and visualization	26 March	2.6	Parkwalk Advisors	28.6
Edgemicro	IIoT (edge computing)	Modular data centers for edge computing	6 March	3	N/A	6
Edjx	IIoT (edge computing)	Microservers for running applications at the edge	15 March	2	6fusion	N/A
Boranet	IIoT (platform provider)	IIoT platform and cloud manufacturing execution software	7 March	N/A	Gobi Partners; Yuanlai Investment	N/A
NeuCloud	IIoT (platform provider)	Industrial IoT platform focusing on oil, power, rail and manufacturing	8 March		Huangshan Fengying Equity Investment Fund; Tianjin Huacheng Oulun Investment Management Partnership	N/A
GearBuddy	IIoT (sensors & connectivity)	IoT connectivity for construction equipment	4 March	0.1	Urban-X	0.1
Vortex IoT	IIoT (sensors & connectivity)	IIoT sensors and networks for harsh environments	4 March	N/A	Development Bank of Wales	0.67
Rail Vision	IIoT (sensors & connectivity)	Thermal sensors for trains that can identify hazards and alert operators	6 March	10	Knorr-Bremse Group	10
Enertive	IIoT (sensors & connectivity)	Self-powered sensors that identify sources of industrial heat loss	6 March	0.15	First Ventures	0.15
Zaphiro Technologies	IIoT (sensors & connectivity)	Sensors for real-time voltage and current monitoring on smart grids	11 March	1.5	AtmosClear Investments	N/A
Sofar Ocean Technologies	IIoT (sensors & connectivity)	Developer of underwater drones and sea sensors	27 March	7	Craft Ventures; Peter Rive; True Ventures	7
Cassia Networks	IIoT (sensors & connectivity)	Long-range Bluetooth networks for IIoT connectivity	29 March	10	Wu Capital	21
Mocana	IIoT cybersecurity	Cybersecurity software that embeds into IoT device firmware	4 March	15	ForgePoint Capital; Shasta Ventures; Sway Ventures	101

Startup	Sector	Description	Date raised	$m raised	Investors	$m raised to date*
Sepio Systems	IIoT cybersecurity	Software that uncovers rogue hardware attacks	4 March	N/A	EDP; Founders Group; Mindset Ventures; PICO Venture Partners	N/A
Levl Technologies	IIoT cybersecurity	Identity authentication for low-power IoT devices	5 March	N/A	Ubiquity Ventures	N/A
Shoonya	IIoT cybersecurity	Cybersecurity software for Android-based mobile IoT devices	5 March	N/A	Ubiquity Ventures	2
Chang Yang Technology	IIoT cybersecurity	Industrial IoT network security provider	11 March	N/A	Vinno Capital	N/A
IoT.bzh	IIoT cybersecurity	Open source software for continuous verification of IIoT system safety	13 March	N/A	BPI France	N/A
Attivo Networks	IIoT cybersecurity	Network cybersecurity using deception techniques to detect threats	21 March	N/A	Energy Impact Partners	46
CyberX	IIoT cybersecurity	Software for protecting IIoT networks and industrial control systems	25 March	18	Qualcomm Ventures; Northwest Venture Partners; OurCrowd; Flint Capital; INVEN Capital	47
Kespry	Robotics (hardware & software)	Drones-as-a-service for industrial applications	27 March	N/A	Salesforce Ventures	59
Automata Technologies	Robotics (hardware)	Portable robotic arms that can be programmed in a few minutes	19 March	7.4	ABB Technology Ventures; Entrepreneur First; Hardware Club	7.4
AirMap	Robotics (software)	Air-traffic data and flight-management software for drones	6 March	N/A	Temasek Holdings; Honeywell Ventures	43.6
Skysys	Robotics (software)	Software for launching, scheduling and flying autonomous drones	11 March	N/A	China Materialia; LightHouse Capital Management	N/A
Aerodyne	Robotics (software)	Drones-as-a-service and analytics software for industrial inspection	11 March	N/A	Drone Fund	N/A
Linx Robot	Robotics (software)	Control systems for intelligent robots that use computer vision	14 March	N/A	Xiyi Asset Management	N/A
FlytBase	Robotics (software)	Application development platform for commercial drones	20 March	N/A	Nippon Telegraph and Telephone Corporation	N/A

*Source: BloombergNEF, CB Insights. *Note: Where there is no value available for this months' raise, the 'total raised to date' does not include the latest funding round.*

Table 2: March 2019 mergers & acquisitions

Startup	Industry	Description	Date acquired	$m amount	Acquirer	$m raised to date
Entic	IIoT (data analytics)	Predictive analytics to optimize building energy use	26 March	N/A	Acquicore	21.47
Mellanox	IIoT (comms)	Ethernet and interconnections for data servers	11 March	6,900	Nvidia	Public

BluVector	IIoT cybersecurity	Network security software using AI and ML	4 March	N/A	Comcast	N/A
NexDefense	IIoT cybersecurity	Cybersecurity software for industrial control systems	18 March	N/A	Dragos	8.19
Endeavor Robotics	Robotics (hardware)	Ground robots for defense, security and industrial markets	4 March	382	FLIR Systems	N/A
Cyberhawk	Robotics (software)	Software for drone inspections and asset visualization	28 March	N/A	Magnesium Capital	4.73

Source: BloombergNEF, CB Insights

Section 3. Technology Spotlight: Robotic Process Automation

Each month, we profile an emerging technology that BloombergNEF believes will benefit the power, oil & gas, mining and manufacturing industries. This section outlines the technology, highlights key players and policies, and provides an opinion on its future trajectory and impact.

BNEF Take: Robotic process automation (RPA) can perform repetitive back-office tasks using so-called 'bots', cheaper, faster and often more accurately than humans. Built upon technologies such as screen scraping, RPA can also help integrate siloed business systems and software products. New developments in bots include the ability to interact directly with interfaces to existing software to improve reliability and toolkits that allow users to develop new bots with no coding background. Accounting, human resources (HR) and customer billing are three processes where RPA is having an immediate impact and utilities and manufacturers can use RPA to integrate legacy systems, reduce costs and adapt to new challenges. RPA vendors partner with technology companies on application development and leverage the distribution channels of consulting companies.

Figure 2: SWOT analysis of robotic process automation (RPA)

Strengths	Opportunities
• Easy integration of multiple systems • Low business disruption • High flexibility to adapt to process changes	• Wide applications • Address rising cost of human labor • Integrating AI to build bots (reducing consulting work)
Weaknesses	**Threats**
• Low reliability in some cases • Heavy coding still required for complicated tasks • Extensive consulting work upfront	• Backlash from human workforce • Less incentive for IT upgrade or innovations

Source: BloombergNEF

What is robotic process automation?

Robotic process automation uses software bots to simulate repetitive, rule-based tasks that humans perform via screens and keyboards.

Robotic process automation (RPA) is the term for a process that uses software 'bots' to simulate repetitive, rule-based tasks that humans usually perform via computer screens and keyboards. These tasks are often time-consuming, costly in terms of labor costs and prone to human errors, due to their repetitive nature. Software bots can perform these tasks more efficiently and accurately, running 24/7 and with lower costs.

RPA has some significant advantages over conventional automation software. Conventional software can cost a lot of time and resources to develop, particularly when the tasks being automated span different business processes. Traditional approaches often require background codes of different applications to be integrated and may need new user interfaces. RPA is easier to develop, can integrate different applications without touching the background codes, and is flexible in accommodating changes.

RPA is widely used in automating back-office tasks such as accounting, customer management, IT testing and expense handling. Tasks that are standardized, process driven, repetitive and spanning across different systems are most likely to benefit from RPA. For example, utilities can adopt RPA to manage customer records and billing, reduce the manual work of data entry, generate invoices, and send emails to customers.

Programming approach: how are the software bots built?

There is a wide variation in terms of how much explicit, manual coding is required to build the bots. The industry is increasingly moving towards a low code or even no code approach, where users only need to drag and drop blocks of codes from a library, rather than having to write everything from scratch. Another common approach is to use a "process recorder", which observes what humans do at the user interface level (e.g. on a screen or with a keyboard) and automatically transforms these activities into codes. However, these low-code approaches can only handle simple and straightforward tasks. Automatically generated codes are also prone to error and redundancies, and can involve high maintenance costs.

RPA is moving toward a future where bots are built with little code and become more intelligent.

In the past, RPA developers had not used artificial intelligence (AI) techniques to a great extent. However, many are increasingly integrating AI to make the bots more intelligent. Self-learning bots are now able to mimic and potentially optimize business processes, based on machine learning derived, for example, from videos of humans performing the tasks as well as system logs. This is a step beyond conventional RPA, in which bots mimic human actions dynamically and learn, improve and adapt to new scenarios rather than needing to be pre-programmed in advance. While a fully self-learning bot is still more of a concept than a real product, cognitive bots that integrate machine learning capabilities have already been put into commercial use. Optical character recognition (OCR) for digitalizing paper work and natural language processing (NLP) for chatbots are the two most common machine learning technologies used in RPA.

How does system integration happen?

For the software bots to interact with different software and websites in the same way as humans, they need to figure out a way to access those systems. For example, a bot for automated billing might need to read smart meter data from a web-based software, enter the data in Excel, generate billing files, and send them through emails to customers. This requires integration of the web-based software, the Microsoft applications, and email systems. This form of system integration is something that conventional automation software struggles to achieve.

Screen scraping is the method most commonly used by software programmers to extract data, where they write codes to access the systems and request certain data at the user interface level. However, it is not a very reliable approach. If the interface or back-end structure of the website changes, the codes may break. Some websites might also identify frequent requests for data as malware and block them. Although screen scraping is evolving to be more dynamic and adaptable to changes in the interface, reliability is still a major issue.

System integration is a major function of RPA, which can be done through screen scraping or API integration.

An alternative to screen scraping is to obtain direct access to the application programming interface (API) of the software or website. An API is a set of rules and protocols upon which the software is built. Instead of having to obtain data through the user interface as screen scraping, programmers can access the underlying database through APIs, if these are open. Although software companies are increasingly open to sharing their API, most still remain cautious.

Industry applications

Robotic process automation is used mostly for different back-office functions, such as finance, operations, IT maintenance and human resource management. These functions usually involve highly standardized and periodic processes that are scattered across different systems. Tasks that require expertise, knowledge and human judgment, such as drafting investment memos, are not something RPA targets, nor are tasks with limited scope that existing software already manages perfectly well such as payroll automation. See the table below for detailed tasks involved.

RPA is used to automate accounting, HR, IT and operation, but not for tasks that require expert knowledge.

Table 3: Application cases for RPA

Function	Process to automate	How RPA helps
Finance	Order-to-cash, procure-to-pay	Integrating data from multiple systems such ERP, CRM, banks and logistics companies to reduce the turnover time
Finance	Financial reporting	Automatic data entries, generating financial reports, and disseminating to relevant stakeholders
Operations	Supply chain management	Updating vendor records and inventory records,
Operations	Customer management	Handling customer onboarding faster, updating customer records and resolving simple customer issues
Operations	Invoicing and billing	Conducting massive email dissemination of billings
Operations	Business intelligence collection	Extracting industry news from the internet periodically and updating databases
IT	IT testing	Testing new software by mimicking user interaction
IT	IT maintenance	Running regular diagnosis of software to spot issues
HR	Hiring	Sorting candidate resumes, arranging interviews and updating employment records
HR	Expense handling	Extracting fields from receipts automatically and updating expense forms

Source: BloombergNEF

Utility sector applications

The utility sector is one of the sectors that can benefit the most from RPA. Utilities operate in a market with some unique challenges:

- Utilities have a huge customer base and a massive amount of transactions to handle every day. State Grid, the largest utility in China, has 1.1 billion customers in its territory.
- They are struggling to hire a new and young workforce. The U.S. Department of Energy has reported that 77% of energy companies find it difficult to hire qualified employees.
- Utilities often need to adjust internal business processes for compliance or regulatory reasons. For example, changes in tax credits or tax reliefs on depreciation for clean energy assets might require changes in accounting methods.
- Utilities in some countries might need to adopt new technologies to manage the increasing penetration of distributed resources. For example, Innogy, a utility in Germany, uses distributed energy resource management (DERM) software to control and integrate assets on the grid. RPA could help with integrating DERMs to legacy software (we are not aware of any commercial projects doing this today).

RPA can help solve some of the challenges utilities face in managing customers and adapting to technological changes.

RPA can help to solve these challenges for utilities. It can automate the massive amount of work in customer management and billing, thereby improving operational efficiencies. It may help to attract and retain new talent by automating more routine tasks and allowing workers to focus instead on more knowledge-based and creative assignments. It can help companies adapt to compliance changes and build them into the automation process. RPA is also good at bridging between legacy IT systems and the new software that utilities are deploying, such as DERMs, automated demand response software, and smart home software.

Manufacturing sector applications

The manufacturing sector has also rapidly adopted RPA in recent years. Over the past three decades, the manufacturing sector has been through the process of factory automation and has learnt the organizational and cultural changes that are needed. With the cost of human workforces rising and the margin of manufacturing goods tightening (for example, Foxconn, the biggest assembler of smartphones, had a profit margin of 1.7% in 2018 compared to 8.5% two decades ago), this sector is increasingly looking into automating back-office functions as well.

Product lifecycle management (PLM), the process of tracking product-related information through the stages of design, manufacturing, service and disposal can benefit significantly from RPA. Conventional PLM software is usually costly, and still requires a high level of manual work to move data across different software systems such as enterprise resource planning (ERP) and manufacturing execution systems (MES). RPA can cut the software cost, reduce the amount of customization and integration required, and automate the “last mile of manual work”.

Player landscape

Unicorns in the RPA industry were founded over a decade ago.

UiPath, BluePrism, and Automation Anywhere are the market leaders and among the first batch of RPA vendors founded in 2000s. Newer players such as WorkFusion and Kryon integrate intelligent functions such as character recognition into their products. Even more recently, early-stage startups, such as FortressIQ and Automation Hero have appeared, specializing in innovative RPA with advanced machine learning capabilities. Traditional software vendors such

as VisualCron and Softmotive with expertise in Windows automation have also expanded their business into RPA. See Table 4 for more details.

Table 4: Representative RPA technology vendor comparison

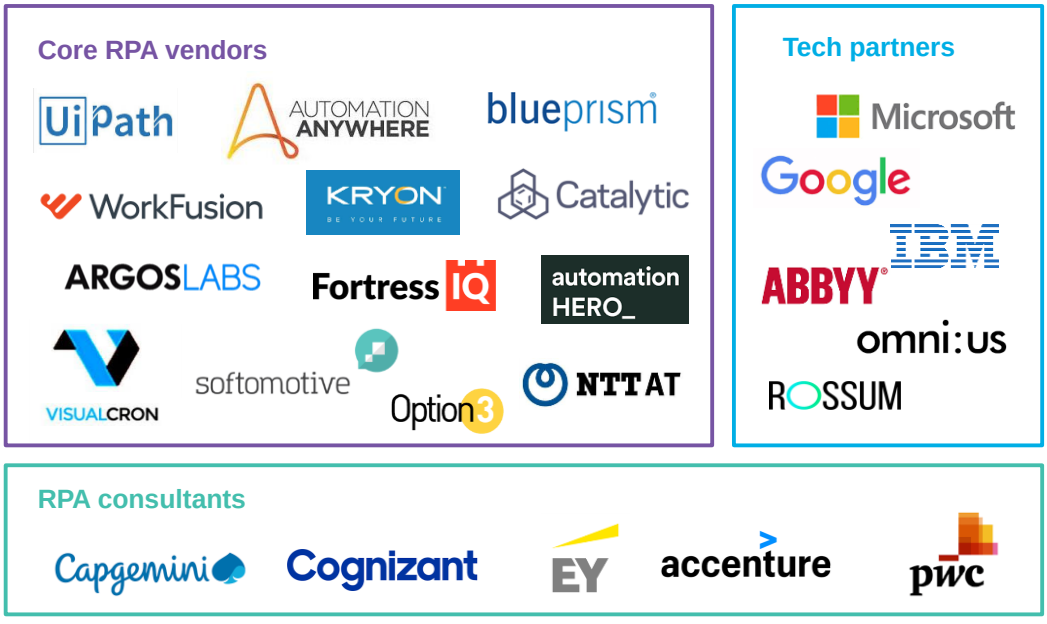
Vendor	Year founded	Funding	RPA features
Blue Prism	2001	$59 million (IPO)	RPA marketplace
Automation Anywhere	2003	$550 million (Corporate)	RPA marketplace
UiPath	2005	$448 million (Series C)	RPA marketplace
Kryon	2008	$53 million (Series C)	AI for process discovery
WorkFusion	2010	$121 million (Series E)	Cognitive functions
Argos Labs	2012	None	No code RPA
Catalytic	2015	$47 million (Series B)	N/A
FortressIQ	2017	$16 million (Series A)	Self-learning RPA
Automation Hero	2017	$19 million (Series A)	Automated AI modelling

Source: BloombergNEF

RPA providers partner with other companies on programming or application development.

Leading RPA providers tend to offer a bot development platform and partner with other companies to develop specific bots or applications. They might outsource the programming to external vendors, or work with their customers to build bots using process recorders or other low-code techniques. Most of the leading players charge by the number of bots that run on their platform or per process automated. This business model allows RPA vendors to quickly scale their business without putting constraint on internal resources.

Figure 3: RPA player ecosystem



Source: BloombergNEF

Some RPA providers have also launched a bot marketplace (similar to an application store), where customers can buy bots from certified application providers or third-party developers. For example, UiPath and Automation Anywhere have brought on board big technology companies including Microsoft, Google and IBM to open up their APIs, so that developers can make RPA bots that automate jobs and tasks for users of these enterprise software products. Specialized technology vendors are also partners of RPA companies – such as ABBYY in image character recognition and Rossum in invoice data extraction.

RPA providers distribute their products through a network of consultants.

Core RPA providers usually distribute their products through a network of consultants. They include accounting service providers such as the large accounting and consulting firms, management and technology consultants such as Accenture, as well as some smaller specialized players. These partnerships can give RPA providers access to a broader customer base.

Technology outlook

Robotic process automation is already a mature technology, deployed at a commercial scale. Future innovations will mainly be around making the bots more reliable and intelligent:

- While the industry is empowering users to develop bots with little code, it needs to figure out a way to ensure the robustness and reliability of the bots. As process recording might generate convoluted codes that can break easily if the process or the interface changes, companies are exploring ways to integrate machine learning or other programming techniques to adapt the codes automatically. Better integration with standardised software APIs is another approach to ensure reliability.
- Extracting or even optimizing business processes is another area where AI can greatly enhance RPA. Currently, extensive consulting and manual work is required to identify which processes to automate and for which tasks. This is time consuming, and in the process some inefficiencies might be built in. Using AI to observe the different ways in which many people perform the same task, and thereby determine the most efficient approach is a potential solution. This could involve the use of reinforcement learning, where AI optimizes the system through repeated learning methods.

Section 4. Startup profile: Fortress IQ and Argos Labs

This Section showcases companies related to the theme of the month that have innovative technologies or business models. The profile will outline the main characteristics, customer base and products, before analyzing areas of distinctiveness.

This month we profiled two startups tackling the "last mile" of manual work for the robotic process automation (RPA) technology: consulting and coding. FortressIQ applies artificial intelligence (AI) to learn from existing business processes and design tailored RPA plans for the customers. Argos Labs develops tools for customers to build their own bots that it says can perform as reliably as those that are manually coded. The two companies have innovative business models: FortressIQ partners with downstream RPA vendors to integrate their services, and Argos Labs hosts a marketplace to engage customers and third-party experts. They also share a similar vision in terms of the relationships between humans and bots: they are not primarily replacing people, but instead helping them to perform their work more efficiently and strategically.

FortressIQ

FortressIQ is a startup that uses AI to determine which business processes to automate. Instead of building RPA bots, FortressIQ tackles the upfront design of RPA projects, usually done by human consultants. It uses computer vision to observe human activities, and advanced machine learning algorithms to decide how best to automate processes and achieve the project. The company was founded in 2017 and has raised a total of $16 million.

Product: AI for process recording and analytics

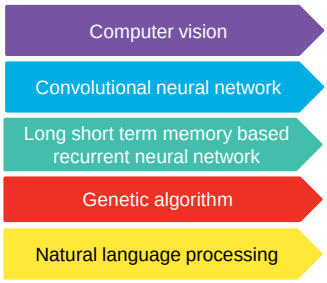
FortressIQ is a startup that uses AI to identify which business processes to automate.

FortressIQ's product uses AI for both data collection and process analytics, minimizing human errors and limiting biases in the process. Conventional RPA projects usually involve hiring $1,500-per-day business consultants to interview different stakeholders and come up with a plan for automation. The data collected might not be accurate, as it depends on stakeholders recalling what they did, and it might be biased, with analysts disagreeing on what is an "optimized" process. This consulting process is expensive, time-consuming, and often not adaptable to new changes that might occur in the future. The vision of FortressIQ is to replace this RPA consulting process with a more accurate, optimizable and scalable tool, powered by AI. FortressIQ claims that its bots can achieve a 90% reduction in cost and a 40% increase in the accuracy of process documentation, compared to typical consulting projects.

For Fortress IQ, computer vision algorithms perform the data collection. It trains the algorithm to recognize different features on the screen, for example buttons, scrollbars, list boxes, and tabs. By observing what the human does on the screen, the algorithm can then turn a series of screenshots into a sequence of actions. The computer vision algorithms, called "observer agents", work unobtrusively in the background without consuming much IT resource, taking less than 3% of CPU, and only 256 Kbps of bandwidth, according to the company.

Advanced machine learning algorithms then analyse these observations, solving the challenge of identifying the optimal path in a business process – for example:

Figure 4: FortressIQ AI collections



Source: FortressIQ, BloombergNEF

- *Noise removal.* When a worker performs a process, she might be distracted by other tasks not relevant to the process, for example checking emails while processing an invoice, or messaging co-workers while talking to a customer. Long short-term memory recurrent neural networks (LSTMs) are algorithms that are able to recognise patterns in sequences of activities and are therefore particularly useful in solving this kind of problem. They have a form of memory and a temporal dimension that allows them to take time and sequence into account. The algorithm can use these capabilities to identify and reinforce useful actions that occur frequently and screen out the 'noise' that happens less often or more randomly.
- *Dimension reduction.* Different people have different habits when performing the same task, for example, whether to enter the customers' first or last name first in the database. A simple algorithm might think these are separate processes, resulting in an explosion of the total possible paths. Classification algorithms are able to identify similar paths and group them together, reducing the complexity or 'dimensions' of the processes captured.
- *Path calculation.* After merging similar paths, there might still be some distinct paths within a single process, for example, whether to extract customer names from the order form, or the Salesforce system. The problem is then to decide on the optimal path to automate. Genetic algorithms, a methodology inspired by natural selection in which the algorithm evolves, are used in this case to find the best path for performing a task.

Business model: consulting service priced per bot deployed

FortressIQ adopts a pricing model that aligns with RPA implementation.

FortressIQ prices its services per bot deployed, or per process observed, together with a continuing platform fee. While traditional consulting services charge hourly rates, FortressIQ's product may be more cost efficient for enterprises with ambitious automation schemes. The pricing approach can also make the integration with downstream RPA implementation smoother as that is also priced per process automated. FortressIQ's vision is to become the automation partner of the customer, providing continuous insights into their business processes rather than one-off consulting reviews. These insights can go beyond just RPA, as automation may not always be the best or only route to improved efficiencies.

FortressIQ develops algorithms that can be transferred across different processes and projects, lowering the cost of AI deployment. Since many tasks such as extracting data or accessing email systems are similar across different business, FortressIQ can sometimes deploy its algorithms without any retraining. The software can run in the cloud or in the customers' local servers.

FortressIQ is trying to deploy AI so that it incorporates human feedback and judgment. The project cycle is as follows:

- Deploying "observer agents" (computer-vision enabled software bots) to record activities
- Creating a list of applications involved in the processes
- Generating the optimized process through machine learning algorithms
- Integrating feedback from employees through surveys
- Exporting the optimized process diagram as a product development document (PDD) that RPA implementation companies such as UiPath can use to build bots.
- Assessing the process through scorecards to prioritize tasks for automation

Customers, partners and use case

FortressIQ believes its product is industry agnostic, with customers spanning the finance, retail and supply-chain industries. It does not reveal any public information about its customers. In

addition to working directly with customers, FortressIQ is working to integrate its product with those of major RPA vendors, so that the process diagrams that FortressIQ generates can best support the bot development process. The company has raised $16 million so far from U.S. venture capital firms Lightspeed Ventures, Eniac Ventures and Comcast Ventures.

Argos Labs

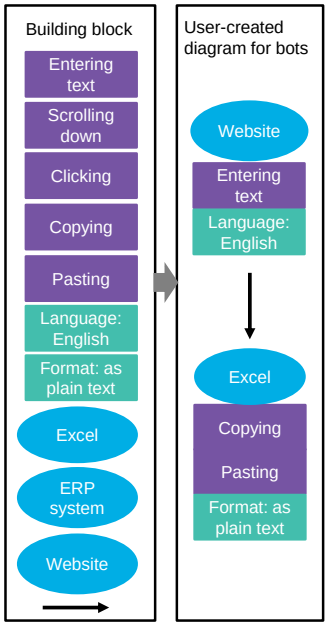
Argos Labs is a company that develops tools for customers to easily build bots.

Argos Labs develops tools for customers to build RPA bots without codes. The company believes the future of RPA is one where everyone can easily build, modify and enhance their own bots. This can reduce deployment costs, facilitate scale-up, and more importantly, establish a better understanding of what bots can do, helping to build stakeholder buy-in which is sometimes the biggest hurdle for RPA projects. Argos Labs was spun off from a Korean IT monitoring company Vivans in 2016, and has been fully self-funded. The company inherited 11 years of software monitoring and IT testing competence from its original parent and moved into RPA in response to client requests and the opportunity that it perceived in RPA. Argos Labs is headquartered in California and has most of its operations and clients in Asia.

Product: a robust and easy-to-use bot building tool

Argos Labs sells an application for customers to build and manage RPA bots. The package includes a software development kit for bot building, and a supervisor platform for orchestrating and managing bots in operation.

Figure 5: How building block interface works



Source: BloombergNEF

Argos Lab's bot building tool takes two approaches: a process recorder and a building block interface. Process recorders are used to capture simple user behaviors, where codes are automatically generated in the background. The building block interface, on the other hand, builds customized RPA by showing users pre-programmed code blocks visualized as icons representing different actions (Figure 5). Users can drag and drop these into a diagram to address processes that are more complicated. Although many RPA vendors are building such tools, Argos Labs aims to be distinctive by achieving reliability of codes in the background while being user friendly at the front end. There are some particular technical features of note in its tool:

- *Using bots to test and improve bots.* RPA was first developed to mimic user activities and test software performance, which can in turn be used to test the bots themselves. The biggest issue with creating pre-programmed generic actions (as in the building block interface approach) is how to make sure they work consistently in different situations. For example, the simple action of right clicking a mouse can mean different things to different software programs. By using bots to perform actions across different software and test the robustness of codes, Argos Labs is able to improve consistency in bot performance.
- *Simplifying the process of bot building.* Some RPA tools have over 500 building blocks for users to select and put together different action streams. However, people can easily get lost in the massive library of possibilities and are prone to make mistakes. Argos Labs' tool instead has less than 50 core building blocks that represent the most basic user actions. These are flexible enough to allow customers develop variations of functions that can handle a range of tasks, equivalent in scope to the remaining 450 building blocks that others use.

Argos Labs can run its bots on a wide range of operating systems, including Windows, Android, iOS and Linux, which distinguishes it from other RPA vendors that usually only support deployment in Windows. As many IoT devices, such as smart refrigerators, run on the Android system, and most cloud-based software runs on the Linux system, Argos Labs is able to integrate

applications from the edge to the cloud. For example, the bots can extract data from smart home devices, enter them in the utility's Excel database, and then report this data to a cloud-based analytics platform, without the need for any other integration or intermediary software.

Business model: aggressive pricing and bot marketplace

Argos Labs uses competitive prices to penetrate the Asian market, and hosts a bot marketplace to drive additional revenue.

Argos Labs charges $50 per month per bot. This price is competitive against not only other RPA products, but also human labor in some low-wage countries. Argos Labs is able to adopt this pricing model because of the plug-and-play nature of its product: the company only needs to give a one-hour training session to the users before they can start to build and manage bots on their own.

Similar to the big RPA vendors such as UiPath and BluePrism, Argos Labs is also trying to launch a marketplace in the second half of 2019. The marketplace is both for bots and building block codes. The bot marketplace aims to incentivize customer engagement: customers can build bots for internal use and then sell them for additional revenue. Building-block marketplaces are designed to leverage the expertise of third-party developers to enrich the code collection customers can use. In return, Argos Labs charges a 10%-20% administration fee for any agencies that register to trade on its platform. In recent years similar marketplaces for digital products, including algorithms, applications and datasets, have become popular among technology companies. This is in line with the overall transition of tech companies toward a "platform-driven" business that hosts and integrates different products, rather than developing specific products of their own.

Customers, partners and use case

Argos Labs has expertise in integrating edge applications and enterprise software.

Most of Argos Labs' clients are in the manufacturing and telecom industry in Korea and Japan. These include Softbank, SK Telecom, Toyota, Posco (Korean steel manufacturer), Line (Japanese messaging app).

Argos Labs covers varied back-office tasks including accounting, operations and HR, but a particular expertise is in the integration of edge devices and applications. As companies are increasingly moving their customer-facing functions to smartphone apps, integration between edge applications and enterprise software becomes critical. Below are a few examples of the projects that Argos Labs has done.

Table 5: Argos Labs case studies

Client	Tasks automated	Benefits
A steel manufacturer	Automating the steel production management process	Annual savings of millions of dollars
A furniture manufacturer	Integrating e-commerce software with the existing software such as CRM, ERP and PLM	Eliminating the need to hire additional personnel which could have cost $100,000 annually in total
A telecom carrier	Integrating customer feedback from apps, websites and other channels	Saved money by reducing manual data consolidation efforts

Source: ArgosLabs, BloombergNEF

Section 5. Accelerator strategy profile: high value manufacturing, Catapult

2,032

SME clients of the HVM program in 2017-2018

£116.4m

Value of collaborative R&D secured with SMEs, by HVM

68%

Portion of U.K. business R&D investment that goes into manufacturing

Figure 6: High Value Manufacturing centers

Source: Catapult HVM

The Catapult is a U.K. government initiative to boost economic performance, tying startups, corporates, academia and government players together. The Catapult groups institutions, organisations and programs to accelerate time to market for new research in digital, energy, industry, biotech & medicine, and transport sectors. One of the programs encourages high value manufacturing in the U.K. BNEF spoke with Rosa Wilkinson, Head of Communications for Catapult's high value manufacturing program. *The Q&A has been edited for sense and flow.*

Can you introduce high value manufacturing Catapult to us?

Catapult is an entity aimed at translating research ideas into commercial use. It has developed organizations that bring business, academic and government communities together to source stronger ideas. The high value manufacturing program (HVM) was Catapult's first initiative in 2011, bringing together seven existing centers of excellence (Figure 6). Catapult's HVM is active in all areas of manufacturing such as construction, new materials, process engineering, food and drink and also the traditional manufacturing sectors we think about such as cars, airplanes, ships.

What is your strategy and aim?

The HVM Catapult exists to accelerate growth across the manufacturing sector and, in turn, the contribution it makes to the U.K. economy. We develop the capabilities needed to translate the output from the U.K.'s science base into commercially viable products and processes. We bring together the expertise, facilities, equipment and collaborations needed to shape the markets of the future. We play a leadership role in removing industry-wide barriers to innovation and commercialization. Our work involves support for both startup companies and existing businesses. In 2017-2018, HVM Catapult worked with 3,763 private sector clients, including 2,032 SMEs (Figure 8). We also had 498 engagements with academic institutions. The work we do focuses on helping manufacturers grow through harnessing new technologies or adapting to changing customer demand. An example of that is the work we do to help manufacturers reduce their impact on the environment.

What are your focus topics?

From conversations with manufacturing contacts throughout our network, the HVM Catapult has identified five areas where we see real opportunities for the U.K.:

1. **Digital manufacturing:** Using digital technologies to connect to customers and to monitor production-line health.
1. **Robotics and automation:** Robotic and automation technologies offer potential to manufacturing industries to transform their work practices, boost productivity and increase safety while improving the service levels they offer to customers.

2. **Materials processing and new materials:** New materials and approaches to processing them allow for products that are lighter, stronger, more resilient, less environmentally damaging, more recyclable and cheaper.
3. **Process engineering, biotechnology and biologics:** The process industries includes food and drink, chemicals, pharmaceutical, biotechnology sectors. We guide companies through the steps needed to take their next generation formulated products to market.
4. **Product design and verification:** The HVM Catapult is working to develop next generation software tools and processes that will help manufacturers condense design and product lead times and improve productivity. Our work includes simulation tools to enable manufacturing for metallic and composite components thanks to rapid design, simulation and building of prototypes.

Figure 7: HVM revenue sources 2017/2018

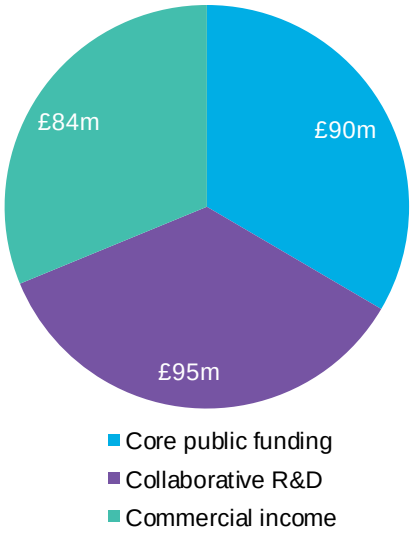
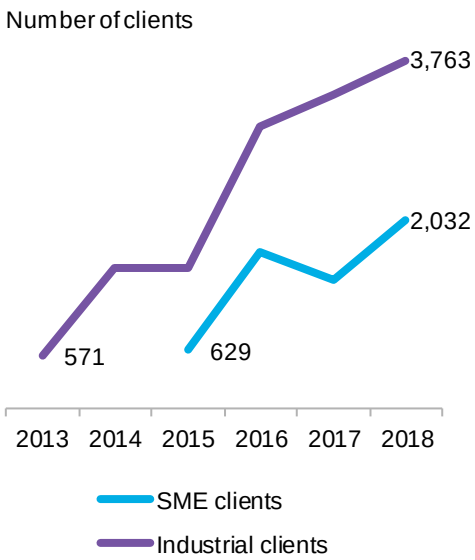


Figure 8: HVM clients growth



Source: Catapult HVM annual review, BloombergNEF

How do you select the projects you work with?

HVM works on a variety of projects from very early-stage to commercially ready products.

We deliver a service – and we are open to any innovative idea. When we review startup proposals, we look for the capabilities of the business to carry out the project. Some companies are not ready, even with great innovations – it is easier to have a good idea than to deliver it. We look for the right commitment, time and balance sheet. Concerning the technology itself, we take on a variety of projects, from very early stage development to commercially ready products (Table 6).

The government also fuels some of our work (Figure 7). The Government's determination to end sales of new conventional petrol and diesel cars and vans by 2040 spurs out work on electric vehicle batteries. The HVM Catapult has played a key role in producing the Government's Faraday Challenge a £246 million commitment on battery development for the automotive electrification market. Our WMG team was instrumental in the award of £80 million of Faraday funding to establish a new National Battery Manufacturing Development Facility.

Table 6: Selected example projects

Name	Innovation	HVM contribution
Char.gy	Retrofit lamp posts with EV charger	Warwick WMG center helped design and develop the product
A Step Ahead	Rungless ladder mechanism for construction	AFRC center helped with product design, structural integrity, tolerance limits and materials advice
Solar-Polar	Solar cooling for vaccines	Design assistance from AMRC
Harris RCS	Computer controlled machinery parts for aviation	MTC support on production planning, productivity, scheduling

Source: HVM Catapult, BloombergNEF

How do you support projects, what is your value add?

Business development - We first have our business development team talk through the main ideas of a project. From experience, we know to look at the entire supply and business line. We question the project: does this make sense? Is this opportunity worthwhile? Our team can really help figure out the plan to bring the right innovation to market.

HVM highlighted that the most valuable insight they provide startups comes from having hundreds of conversations with all players in their network.

Networking – Perhaps one of our greatest strengths lies in our ability to make connections. That might be about connecting a small business with a brilliant idea to sources of funding, or it might be about building connections through the supply chain. Crucially we can help to connect firms with the latest knowledge flowing up from the U.K.'s research base and help them to understand how to apply that knowledge.

Skills – New technologies only have real impact when combined with people that have the skills to use them. The Manufacturing Technology Center in Coventry and the Sheffield Advanced Manufacturing Research Center both have training centers and apprenticeship programs that encourage new manufacturing skills and machinery specific technical knowledge. Our student cohorts are a combination of company employees and students looking for placement opportunities. We are focused on growing our efforts in this area.

Facilities – We also provide facilities in the form of laboratories and technical equipment. Innovation can be an expensive and risky journey. We provide access to equipment and expertise to develop ideas and test them at a commercial scale without disrupting existing operations. That allows manufacturers to hold off from making major investments in new equipment or premises until they have proof that their plans will work.

Section 6. BNEF research review

This section provides links to the most recent BNEF publications relevant to our technology coverage.

Table 7: March 2019 Digital Industry and related published content

Publication Date	Research Note	Links
March 1	Consumer adoption S curves for power and transport	web | terminal
March 7	BNEF Watchlist: Dash Cams, Semisolid Batteries	web | terminal
March 11	1Q 2019 Decentralized Energy Strategy Trends	web | terminal
March 14	BNEF Watchlist: Engie's Cool Basement, Hydrogen From Air	web | terminal
March 15	Signposts for Energy and Mobility Transition, 1Q 2019	web | terminal
March 19	Technology Radar: March 2019	web | terminal
March 25	BNEF Watchlist: Flying Batteries, Round-Trip Fuel Cells	web | terminal
March 25	BNEF New York Summit presentation: Intelligent Mobility	web | terminal
March 26	BNEF New York Summit presentation: Virtual Power Plants	web | terminal
March 26	BNEF New York Summit presentation: Rethinking The Energy Internet	web | terminal
March 26	BNEF New York Summit presentation: Digital Industry	web | terminal
March 26	BNEF New York Summit presentation: Advanced Materials	web | terminal
March 28	Metals Monthly: 201,000 Tonnes of Lithium Delayed	web | terminal

Source: BloombergNEF

Podcast Alert!

BloombergNEF is launching a weekly podcast, **Switched On**. The client-only podcast features BNEF analysts discussing the findings in their reports, what their assumptions are and the stories that hold it all together. Switched On will soon be available on the BNEF App, but you can access the preview episode here.

In this episode, Diego Marquina, lead author of 'Flexibility Solutions for High-Renewable Systems - U.K.', is joined by BNEF Head of Research Albert Cheung. They discuss the challenges and surprises in their work on the future power system, one that solves for grid flexibility using tools such as energy storage, demand response, flexible EV charging and grid interconnections.

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