PitchBook

EMERGING TECH RESEARCH

Internet of Things (IoT)

H1 2021 VC Update

Contents

Vertical overview	3
H1 2021 timeline	4
VC ecosystem market map	5
VC activity	7
Emerging opportunities	**14**
IoT/OT security	15
TinyML	19
Predictive maintenance	23
Select company highlights	**25**
Samsara	26
Ambiq Micro	28
Uptake	30

Institutional Research Group

ANALYSIS

Brendan Burke Senior Analyst, Emerging Technology

brendan.burke@pitchbook.com

pbinstitutionalresearch@pitchbook.com

DATA

Bailey York Data Analyst

bailey.york@pitchbook.com

Publishing

Designed by **Megan Woodard**

Cover by **Mara Potter**

Published on September 13, 2021

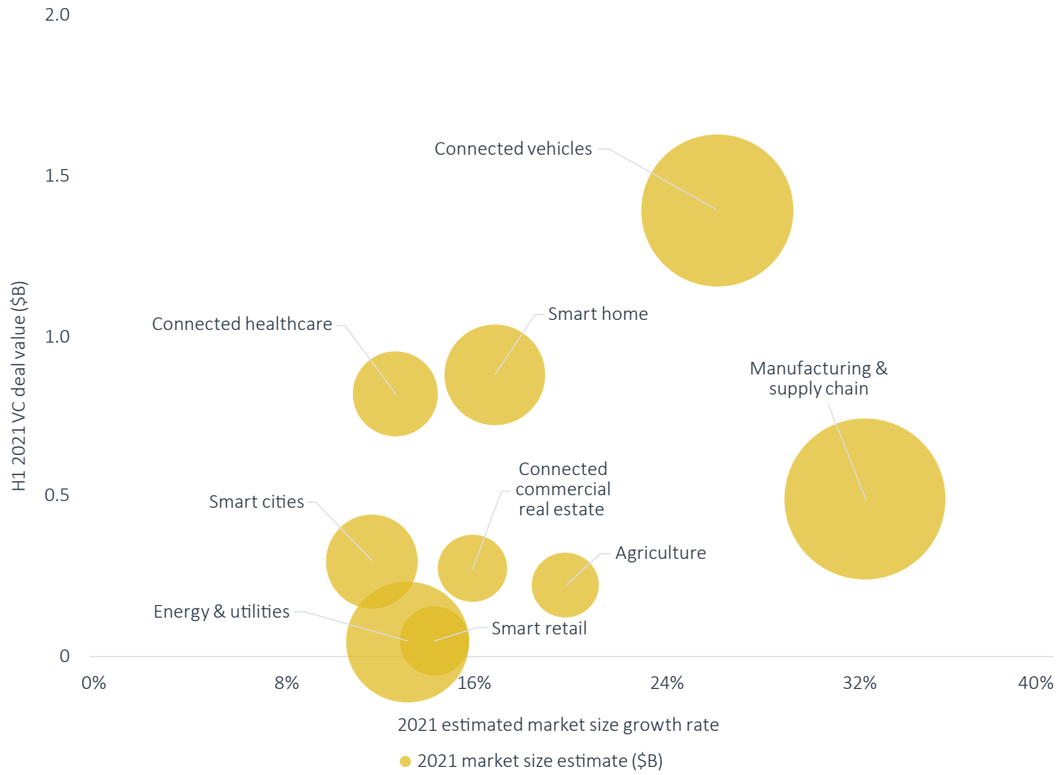
This Emerging Technology Research report is updated biannually to reflect changes in venture capital deal activity and other market related updates. The most recent comprehensive annual report can be accessed **here**.

Vertical overview

IoT remains a large and growing market with significant barriers to entry for startups. We estimate the market will reach $414.9 billion in spending in 2021, growing at a 12.6% CAGR to $592.3 billion in 2024. This estimate includes hardware, software, and services across use cases. Despite this large addressable market, VC exit momentum for pure-play IoT analytics and device companies has not continued after a strong end to 2020, suggesting that the digital transformation of industrial companies is not flowing to private companies. **C3.ai** (NYSE: AI)'s record exit for a pure-play IoT analytics platform has not produced success on public markets, with the company's share price plunging 54.9% in H1 2021 due to low growth. Challenges in achieving business value with IoT are leading to relatively higher investment in horizontal technologies including semiconductors and information security.

Manufacturing & supply chain is the largest and highest-growing use case in IoT, yet the industrial innovation ecosystem lacks funding and substantial VC investment outcomes. We estimate the market will reach $136.5 billion in 2021, incorporating heavy industry and construction use cases, growing 32.1% over 2020. Funding dipped for manufacturing & supply chain startups in H1 relative to 2020's pace, with no VC mega-deals over $100.0 million tracked in the first half of the year. Leading VC investors are generally not putting their capital into the subsegment. We believe the space remains susceptible to innovation given demand for digital analytics of industrial operations.

Figure 1. H1 2021 VC DEAL VALUE ($B) VERSUS MARKET SIZE GROWTH FORECAST (2020-2021)*



Source: PitchBook Emerging Tech Research | Geography: Global | *As of June 30, 2021

H1 2021 timeline

IPO

March 18, 2021

Tuya Smart (NYSE: TUYA) sets a record for pure-play IoT VC exit value, debuting with a $11.8 billion valuation, highlighting the scale that smart home startups can achieve. Tuya is a smart home software platform vendor, justifying its SaaS multiple of 53.9x EV/forward revenue, as well as a smart home device reseller, which compresses its gross margin below that of a typical SaaS vendor. The company claims to be the largest IoT platform vendor globally by volume of connected devices given its partnerships with **Google** Home, **Amazon** Alexa, and **Samsung** SmartThings.

NEWS

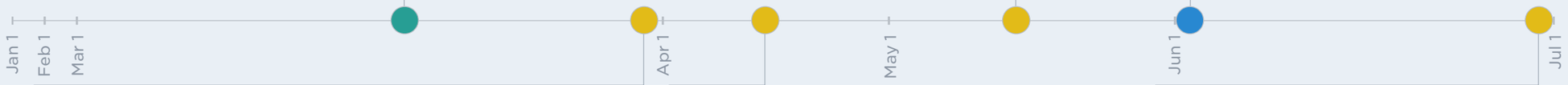
May 12, 2021

The US government's Executive Order on Improving the Nation's Cybersecurity includes consumer IoT device security labeling criteria as part of its directive to the Secretary of Commerce.

M&A

June 1, 2021

Microsoft (NASDAQ: MSFT) acquires IoT security startup **ReFirm Labs**, its second IoT security acquisition in two years. The acquisition demonstrates the value of device-level security to information security incumbents.



NEWS

March 30, 2021

Arm debuts its v9 architecture, its first new architecture in 10 years. The CPU architecture includes innovations in confidential computing for security and ML efficiency. Processors built on this platform are intended to apply to IoT and 5G use cases running compressed ML algorithms.

NEWS

April 13, 2021

Project Connected Home Over IP (CHIP), a consortium of leading smart home device vendors and the Zigbee Alliance, announces that it will begin certifying devices against its smart home connectivity standard by the end of 2021. The standards organization has since been renamed Matter.

VC DEAL

June 23, 2021

Edge AI chip startup **Hailo** achieves unicorn status with a $100.0 million Series C at a 4.4x valuation step-up. The company has designed a chip to run AI inference with high energy efficiency on IoT devices. The round featured strategic investment from ABB Technology Ventures, NEC Corporation, and Latitude Ventures.

H1 VC DEAL ACTIVITY

611
total deals

$10.9B
total raised

82.1%
half-over-half deal value growth

85.9%
YoY deal value growth

IoT VC ecosystem market map

Click to view interactive market map on the PitchBook platform

Market map is a representative overview of venture-backed or growth-stage providers in each segment. Companies listed have received venture capital or other notable private investments.

IoT VC ecosystem market map

Click to view interactive market map on the PitchBook platform

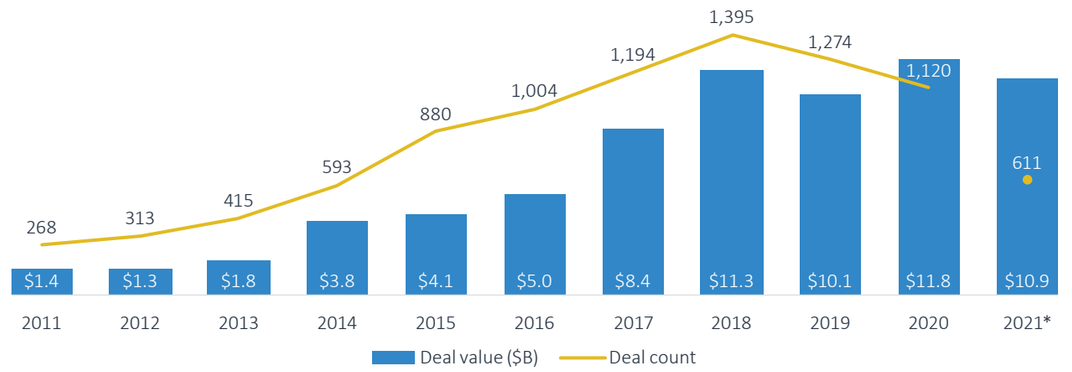
Market map is a representative overview of venture-backed or growth-stage providers in each segment. Companies listed have received venture capital or other notable private investments.

VC activity

IoT VC funding is on pace to blow past the flat deal values of the past three years, primarily fueled by IoT-inclusive security, mobility, and semiconductor companies. IoT companies raised $10.9 billion in VC funding in H1 2021, although slightly more than half of this total ($5.6 billion) flowed to chip design and mobility companies. Many of these companies only incorporate IoT as a minor use case or input to their core business. Core use cases are not on pace to match their 2020 VC funding totals including manufacturing & supply chain, energy & utilities, smart buildings, and smart retail. Little growth is flowing from horizontal IoT technologies including sensors, network infrastructure, and next-gen network protocols, although IoT software financing continues to grow. This data reinforces our thesis that IoT is better served as a use case than a primary value proposition for startups.

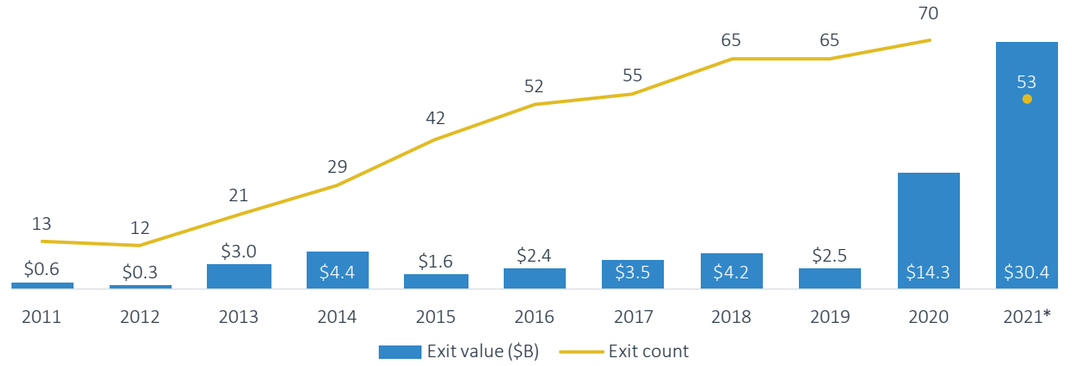
The IoT VC exit market continued to mature in H1 2021 with $30.4 billion in exit value. This total includes IoT-adjacent exits of information security companies including **SentinelOne** (NYSE: S), **Darktrace** (LON: DARK), and **Auth0**, which feature IoT security as a use case of their core products. Smart home unicorn **Tuya Smart** (NYSE: TUYA) set a record for pure-play IoT VC exit value, achieving a $10.8 billion exit size in its IPO on the NYSE. The company operates a smart device marketplace and connectivity software platform, primarily based in China. US-based pure-play IoT companies did not continue to produce venture-style outcomes after **C3.ai**'s (NYSE: AI) IPO in H2 2020. The SPAC market benefited smart building company **Latch**, which achieved a $1.2 billion valuation in its merger in Q2. Most acquisitions did not disclose their exit values, leaving uncertainty as to the value of IoT startups to acquirers. Tech giant acquirers included **Microsoft** (NASDAQ: MSFT), which acquired **ReFirm Labs**, and **Alphabet** (NASDAQ: GOOGL), which picked up **Provino Technologies**, although likely not for high acquisition values. Overall, pure-play IoT startups frequently fail to produce significant financial outcomes.

Figure 2. IOT VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of June 30, 2021

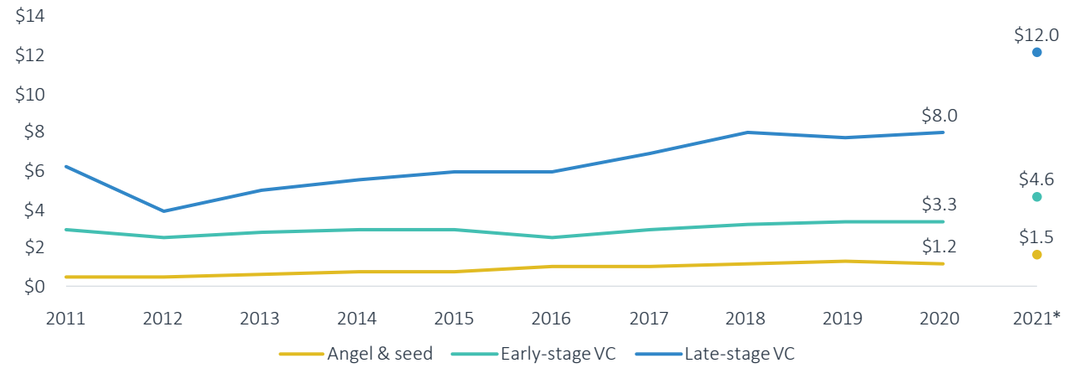
Figure 3. IOT VC EXIT ACTIVITY



Source: PitchBook | Geography: Global | *As of June 30, 2021

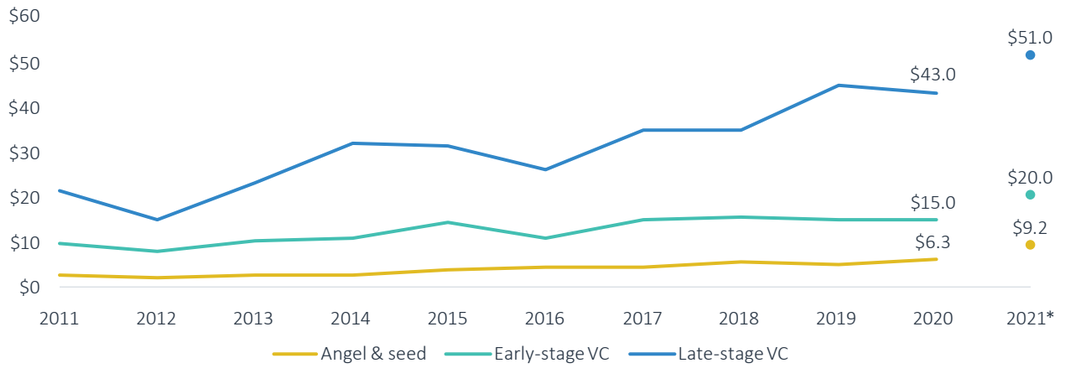
VC ACTIVITY

Figure 4. MEDIAN IOT VC DEAL SIZE ($M) BY STAGE



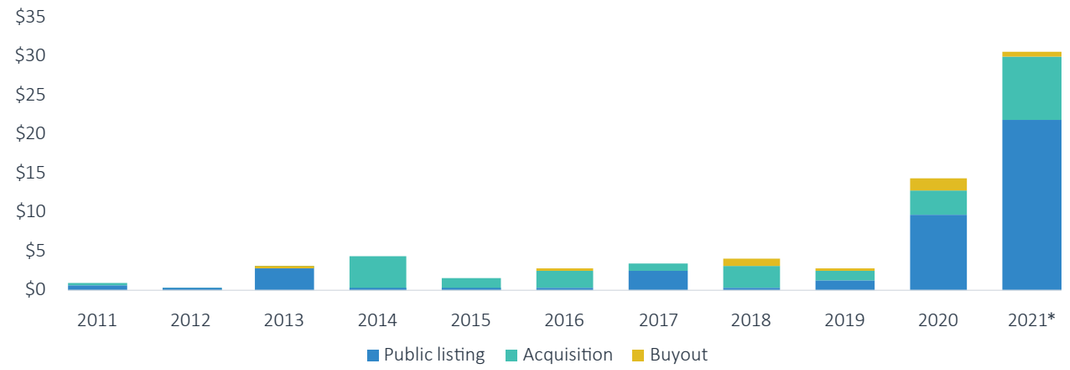
Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 5. MEDIAN IOT VC PRE-MONEY VALUATION ($M) BY STAGE



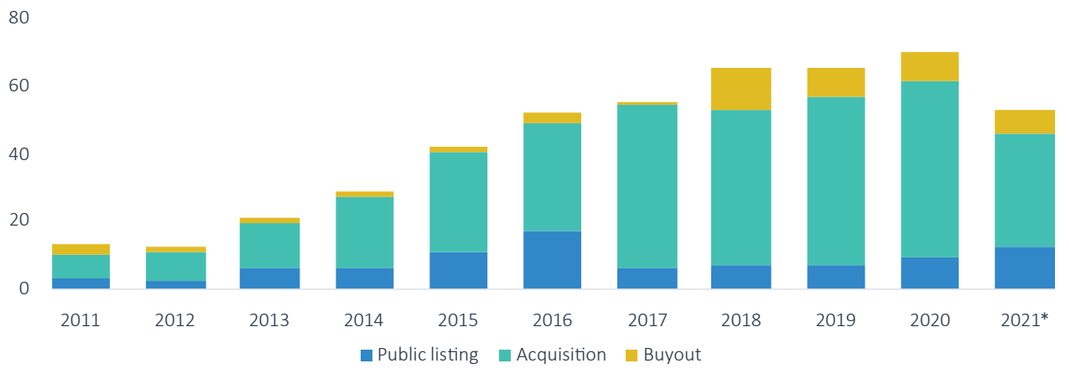
Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 6. IOT VC EXIT VALUE ($B) BY TYPE



Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 7. IOT VC EXIT COUNT BY TYPE



Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 8.

Key IoT early-stage deals

COMPANY	CLOSE DATE	SEGMENT	SUBSEGMENT	DEAL SIZE ($M)*	DEAL TYPE	LEAD INVESTOR(S)	VALUATION STEP-UP
mIQroTech	June 22, 2021	Industrial IoT	Oil & gas process optimization	$10.0	Series A	New Page Capital	7.3x
Finite State	June 18, 2021	IoT software	IoT security platforms	$30.0	Series B	Energize Ventures	2.6x
Foundries.io	June 17, 2021	IoT software	Universal platforms (PaaS)	$8.0	Series A	IQ Capital Partners	N/A
oneNav	May 20, 2021	Connected services	Biometrics & wearables	$21.0	Series B	GV	2.6x
iWire Connect	May 16, 2021	IoT software	Connectivity solutions	$34.0	Series A	Noor Capital	N/A
Birdie	May 11, 2021	Connected services	Remote patient monitoring	$11.4	Series A	Index Ventures	1.4x
Tomahawk Robotics	April 15, 2021	IoT software	Application enablement	$10.0	Series A	Southeast Investor Group, Topmark Partners, Naples Technology Ventures	2.1x
Epicmems	March 10, 2021	IoT networking	5G	$46.4	Series A	IDG Capital	N/A
Kangaroo	January 24, 2021	IoT hardware	Sensors	$20.0	Series A	Growth Technology Partners, Context Ventures, Kishore Ganji	N/A
VDOO	January 13, 2021	IoT software	IoT security platforms	$57.0	Series B	GGV Capital, Celesta Capital, Verizon Ventures, Qumra Capital	2.0x

Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 9.

Key IoT late-stage deals

COMPANY	CLOSE DATE	SEGMENT	SUBSEGMENT	DEAL SIZE ($M)*	LEAD INVESTOR(S)	VALUATION STEP-UP
Sealed	June 24, 2021	Connected buildings	Smart home platforms & devices	$16.0	Fifth Wall, FootPrint Coalition	8.2x
Hailo	June 23, 2021	IoT hardware	System on chip	$100.0	Zohar Zisapel, OurCrowd, Delek Automotive Systems	4.4x
MachineMetrics	June 16, 2021	Industrial IoT	Manufacturing platforms & devices	$20.0	Teradyne	2.6x
Claroty	June 15, 2021	IoT software	IoT security platforms	$140.0	Bessemer Venture Partners, 40 North Ventures	N/A
MacroMeta	June 15, 2021	IoT software	Cloud services	$19.4	Pelion Venture Partners	3.2x
Andium	April 8, 2021	Industrial IoT	Machine visibility and monitoring for predictive maintenance	$15.0	OGCI Climate Investments	2.5x
Flex Logix Technologies	March 22, 2021	IoT hardware	System on chip	$55.0	Mithril Capital Management	2.4x
Tink	March 12, 2021	Connected buildings	Smart home platforms & devices	$48.2	Cadence Growth Capital	2.1x
SecuriThings	February 10, 2021	IoT software	IoT security platforms	$14.0	Aleph	2.4x
Horizon Robotics	January 7, 2021	IoT hardware	System on chip	$400.0	Yunfeng Capital, Baillie Gifford, Contemporary Amperex Technology, CPE Funds Management	N/A

Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 10.

Key IoT VC exits

COMPANY	CLOSE DATE	SEGMENT	EXIT SIZE ($M)*	DEAL TYPE	ACQUIRER(S)/INDEX	VALUATION/TRAILING REVENUE
Latch**	June 10, 2021	Connected buildings	$453.0	Reverse merger	TS Innovation Acquisitions	6.3x
Maven Wireless	June 10, 2021	IoT networking	$72.2	IPO	NASDAQ	14.8x
Ngenic	June 8, 2021	Connected buildings	$14.5	IPO	STO	15.0x
Refirm Labs	June 1, 2021	IoT software	N/A	M&A	Microsoft (NASDAQ: MSFT)	N/A
Darktrace	April 30, 2021	IoT software	$2,179.9	IPO	LON	10.1x
Innoviz Technologies	April 6, 2021	Connected services	$141.0	Reverse merger	Collective Growth	262.9x
Haxiot	March 26, 2021	IoT software	$153.2	M&A	Digi International	N/A
Tuya Smart	March 18, 2021	Connected buildings	$10,839.6	IPO	NYSE	65.4x
Ouster	March 11, 2021	Connected services	$200.0	Reverse merger	Colonnade Acquisition	100.0x
Otonomo	February 2, 2021	Connected services	$172.5	Reverse merger	Software Acquisition Group Inc. II	N/A

Source: PitchBook, **Latch Exhibit 99.2 | Geography: Global | *As of June 30, 2021

VC ACTIVITY

Figure 11.

Top IoT strategic buyers & VC investors since 2018

STRATEGIC BUYER NAME	DEAL COUNT*	INVESTOR TYPE
Wireless Logic	6	PE-backed company
Bravas Group	6	PE-backed company
SECO	4	Corporation
Qorvo	3	Corporation
Digi International	3	Corporation
Apple	3	Corporation
ADT Security Services	3	Corporation
ARM	3	PE-backed company

VC INVESTOR NAME	DEAL COUNT*	INVESTOR TYPE
SOSV	63	VC
Enterprise Ireland	42	VC
Alumni Ventures Group	39	VC
Intel Capital	31	Corporate VC
Keiretsu Forum	30	VC
IDG Capital	28	VC
Right Side Capital Management	27	VC
Qualcomm Ventures	24	Corporate VC
Baidu Ventures	24	Corporate VC
Celesta Capital	23	VC

Source: PitchBook | Geography: Global | *As of June 30, 2021

Figure 12.

Top VC-backed IoT companies by VC raised

COMPANY	SEGMENT	SUBSEGMENT	LATEST RAISED VC TO DATE ($M)*
Horizon Robotics	IoT hardware	System on chip	$3,400.0
Samsara	Industrial IoT	Smart supply chain	$930.0
Terminus Technologies	Connected services	Smart city platform	$536.3
Kymeta	IoT networking	Low earth orbit satellites	$442.5
Plume	Connected buildings	Smart home platforms & devices	$422.6
SigFox	IoT networking	Low power wide area network	$341.6
ASR Microelectronics	IoT networking	5G	$333.9
Uptake	Industrial IoT	Machine visibility and monitoring for predictive maintenance	$290.0
Ambiq	IoT hardware	System on chip	$253.7
Claroty	IoT software	IoT security platforms	$240.0

Source: PitchBook | Geography: Global | *As of June 30, 2021

Emerging opportunities

IoT/OT security

Security incumbents are pursuing opportunities in device-level security via M&A

TinyML

Edge AI inferencing in IoT devices has matured from a nascent academic field to a high priority for the semiconductor industry and strategic investors

Predictive maintenance

Oil & gas startups are producing the highest valuation growth in predictive maintenance

IoT/OT security

Overview

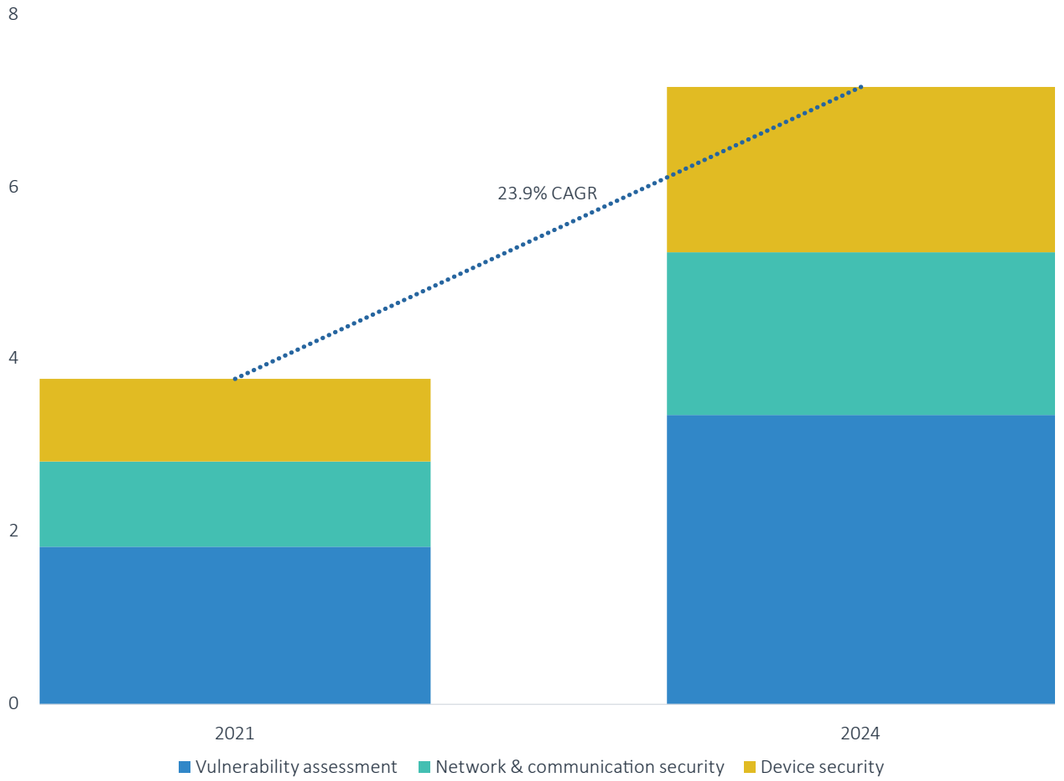
IoT/OT security software, including both internet-connected devices (IoT) and operational technology with limited connectivity (OT), has emerged as a leading opportunity in the IoT vertical given the scale of the problem. Relative to other information security categories, IoT/OT security requires a unique stack of solutions to cover the device communication chain. IoT systems generally contain devices, communications gateways, and analytics applications. In OT, this chain, which contains disconnected network layers between these assets, is referred to as the Perdue model. Given the complexity of device types in large enterprises, a stack of security solutions is required to provide defense-in-depth, including device security, network & communication security, and vulnerability assessment. For further definitions of these segments, see our **Q1 2021 analyst note on IoT/OT security**.

We estimate IoT/OT security spending will reach $3.8 billion in 2021, growing at a 23.9% CAGR to a $7.2 billion market in 2024. This estimate includes generic network and endpoint security tools with IoT use cases along with IoT-specific point solutions. IoT/OT security spending is often bundled with other security products including endpoint and network security. Device identity management and encryption carry distinct line items for OEMs and device users. We believe that similar sums are spent across segments, with vulnerability assessment comprising most of the spending.

Market direction

Critical infrastructure security will require improved network segmentation, device-level encryption, and identity management. The recent Colonial Pipeline cyberattack is pushing operators of oil & gas infrastructure to review their cybersecurity postures, which we

Figure 13. IOT SECURITY MARKET SIZE ESTIMATE BY SEGMENT ($B)



Source: PitchBook | Geography: Global | *As of June 30, 2021

believe will lead them to invest in security at all levels of their IT/OT environments. This attack demonstrated that critical infrastructure is highly connected with IT networks and faces risk from common attack vectors. The ICS (industrial control systems) opportunity for critical infrastructure is producing some of the highest growth in this market. **CyberX** achieved a positive $170.0 million acquisition from **Microsoft** (NASDAQ: MSFT) by addressing ICS/OT environments. We believe that further large companies will be created in this underserved niche.

Incumbents are pursuing opportunities in device-level security via M&A. VC investors have historically focused on network-level IoT visibility solutions, leaving less funding for device security solutions at the device firmware level. We believe that product security is gaining importance for IT incumbents as endpoints become more difficult to manage. There is significant headroom for growth in product security as recent vendor research finds that less than half of enterprises invest in hardware encryption and hardware-based operating system protection.[1] This uneven adoption means that enterprises may not yet comply with recent US federal laws on device security, including the Internet of Things Cybersecurity Act of 2020. Compliance efforts may encourage more spending in hardware product security. Public DevOps vendor **JFrog** (NASDAQ: FROG) recently acquired product security startup **VDOO** to scan binary code in embedded applications for vulnerabilities and malware. **Microsoft** (NASDAQ: MSFT) also announced the acquisition of a firmware security startup—Refirm Labs—demonstrating the strategic value of device security. This acquisition complements its earlier addition of OT/ICS-focused network & communication security startup **CyberX**. Acquisition values are increasing overall, demonstrating increased appetite for innovation in the space.

Trending startups

Industrial security is producing high valuation growth. In Q2, operational technology security startup **Claroty** achieved unicorn status with a $140.0 million Series D. The company had only raised $100.0 million previously, suggesting the round achieved a large valuation step-up. The round featured strategic investments from industrial incumbents including **Rockwell Automation**, **Siemens**, **Schneider Electric**, **Standard Industries**, and **LG**. The company enables visibility over industrial assets and vulnerability assessment. This followed a round from **Claroty's** competitor Dragos in 2020, which reached a $400.0 million post-money valuation at a 2.2x Series C valuation step-up. These companies are likely to produce independently large outcomes via acquisition or public listing.

At the early stage, secure networking startup **Elisity** increased its Series A funding by $25.6 million in Q2, reaching a $59.6 million post-money valuation. The company applies identity-based access policies across domains including users, databases, and IoT/OT devices for both on-premises and cloud traffic, while incumbents must stitch together networking appliances, proxy servers, and asset-specific point solutions to achieve similar coverage. Despite the competitive challenges from networking incumbents, this zero trust approach to IoT networking has begun to achieve customer wins in the healthcare and manufacturing industries, demonstrating the opportunity for startups in legacy industries. Further underscoring the opportunity in IoT/OT networking, early-stage startup **BlastWave** is seeking to replace VPNs with a software-defined perimeter that can encrypt both workstation and edge device traffic, eliminating the need for networking appliances.

1: "New Security Signals Study Shows Firmware Attacks on the Rise; Here's How Microsoft Is Working to Help Eliminate This Entire Class of Threats," Microsoft, March 30, 2021.

Figure 14.

Recent IoT security acquisitions

ACQUIRER	TARGET	SEGMENT	PRIMARY THREAT SURFACE	DATE	ACQUISITION VALUE ($M)
Jfrog	VDOO	Device security	IoT	July 19, 2021	$300.0
Microsoft	Refirm Labs	Device security	IoT	June 1, 2021	N/A
Akamai	Asavie	Network & communication security	Mobile	October 27, 2020	$155.0
UltraSoC	Siemens	Device security	Vehicles	July 1, 2020	N/A
Microsoft	CyberX	Network & communication security	ICS/OT	June 22, 2020	$170.0
Tenable	Indegy	Network & communication security	ICS/OT	December 2, 2019	$80.1
Palo Alto Networks	ZingBox	Network & communication security	IoT	September 20, 2019	$75.0

Source: PitchBook | Geography: Global | *As of June 30, 2021

IOT/OT SECURITY

Figure 15.

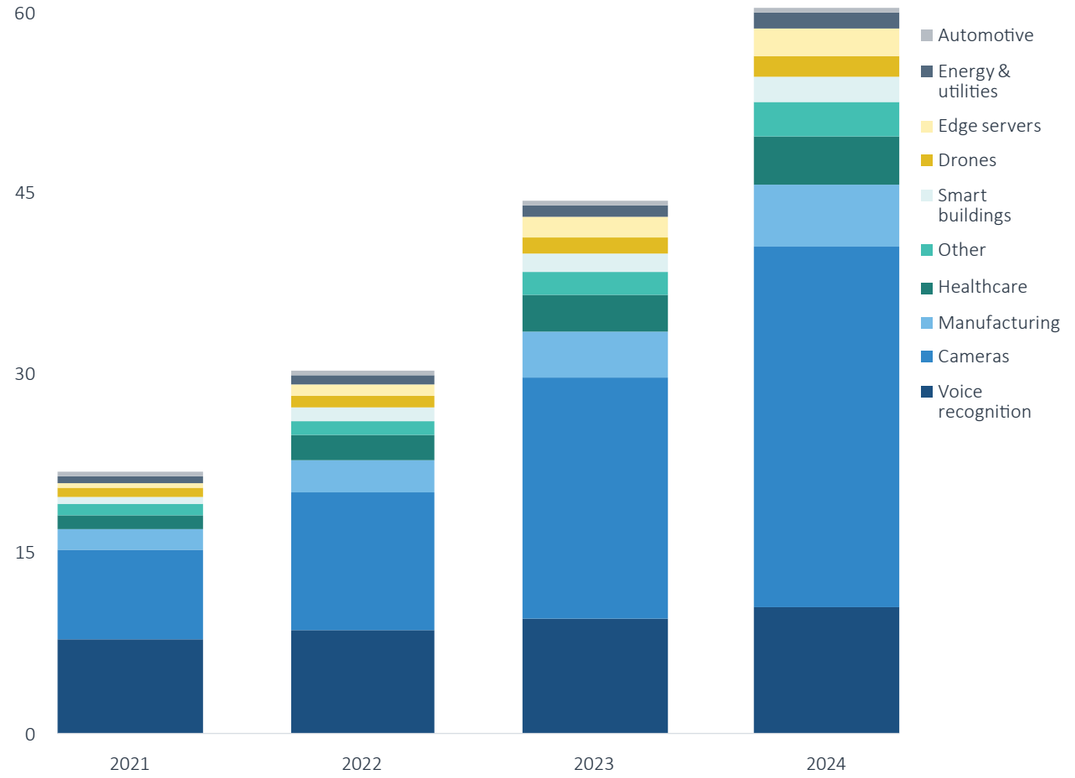
IoT/OT security VC ecosystem market map

TinyML

Overview

TinyML is a collaborative initiative to integrate low-power electronic devices with innovations in machine learning (ML) model compression. ML currently requires massively parallel processing, principally conducted in data centers using graphics processing units (GPUs), making it a power-hungry computational process. Commercialization of miniaturized ML algorithms promises to unlock value for common IoT use cases, including predictive maintenance, supply chain optimization, and connected healthcare. The initiative remains in its early stages, and we believe that fewer than 10% of battery-powered IoT devices are optimized for integration with ML models. Data centers have fueled the first wave of artificial intelligence (AI) growth, leaving edge computing as a high-growth opportunity for the next 10 years. Startups are focusing on specific use cases, so the size of each market is a critical determinant of their prospects.

Figure 16. TINYML-COMPATIBLE DEVICE MARKET SIZE ESTIMATE ($B)



Source: PitchBook Emerging Tech Research, IDC, Omdia | Geography: Global
*As of June 30, 2021

Market direction

Edge inferencing is an increasing priority for the semiconductor industry. In Q2, industry standards organization MLPerf released the first results of its Tiny v0.5 benchmark, which measures the performance of neural networks on low-power devices. MLPerf produces a definitive benchmark for training, and this new benchmark shows that edge inferencing is the future of chip design. Among a limited cohort of initial submitters, VC-backed **Latent AI** achieved leading results in image classification and anomaly detection—use cases relevant to IoT (see Figure 17). TinyML-optimized chips require high power efficiency, typically at an energy cost below one milliwatt, with the ability to last up to one year per battery charge and sufficient memory to store compressed inference models. Currently, microcontrollers can contain as little as two kilobytes in memory, while computer vision ML algorithms have only been compressed to around 10 kilobytes. Leading microcontroller manufacturers have identified tinyML as a growth opportunity, presenting barriers to entry for startups. In February 2020, **Arm** announced a chip design targeted for tinyML applications called microNPU, which integrates data memory directly on its processor to achieve 90% energy reductions for ML workloads relative to its existing Cortex microcontrollers. **NXP** has recently announced a line of microprocessors based on this platform.

Tech giants are developing packages of sensors and low-power semiconductors to enable specific IoT use cases. Among device makers, **Apple** (NASDAQ: AAPL), **Google** (NASDAQ: GOOGL), and **Amazon** (NASDAQ: AMZN) have embraced tinyML for consumer applications via R&D, M&A, and partnerships. **Google** (NASDAQ: GOOGL) integrates tinyML with its Android ecosystem via its Tensor Flow Lite framework for on-device inference. **Apple** (NASDAQ: AAPL) acquired **Xnor.ai** for $200.0 million to add TinyML to its devices. **Amazon** (NASDAQ: AMZN) partners with startups including **Syntiant** and **Sensory**, and the company recently announced a new custom neural network processor to enable on-device voice detection for its Echo speakers. We believe that the broader industrial landscape is just starting to pick up on the potential of tinyML, and startups can bring disruptive sensor packages to market in legacy industries. As an example, **Verkada** is bringing edge AI to its intelligent security cameras and has achieved an outlying unicorn valuation for the connected buildings segment of IoT.

Figure 17.

IoT-relevant results from MLPerf inference: Tiny v0.5 benchmark

SUBMITTER	DEVICE	PROCESSOR	SOFTWARE	TIME TO CONDUCT ML MODEL INFERENCE BY TASK (LATENCY IN MS)		
				VISUAL WAKE WORDS	IMAGE CLASSIFICATION	ANOMALY DETECTION
Harvard	Nucleo-L4R5ZI	Arm Cortex-M4 w/ FPU	Tensorflow Lite for Microcontrollers	603.1	704.2	10.4
Peng Cheng Laboratory	PCL Scepu02	RV32IMAC with FPU(1)	TensorFlowLite for Microcontrollers 2.3.1 (modified)	846.7	1239.2	13.7
Latent AI	Raspberry Pi 4	Broadcom BCM2711	LEIP Framework	2.6	1.1	0.2

Source: MLPerf™ v0.5 Inference: Tiny Closed v0.5 offline, entries 0.5-464, 0.5-465, 0.5-467. Retrieved from **MLCommons v0.5 Results,** August 24, 2021, entry 0.5-12.

Trending startups

Strategic investors are identifying opportunities in edge AI. In Q2, edge AI software platform **Latent AI** raised its Series A funding total to $27.0 million across three tranches from strategic and industrials-focused investors Booz Hamilton Strategic Ventures, Pegasus Tech Ventures, Autotech Ventures, 40 North Ventures, and Blackhorn Ventures. Booz Hamilton Strategic Ventures sees opportunities to sell Edge AI devices to the US Department of Defense. The company is developing ML compression training techniques that can achieve high accuracy on 2-bit processors, far below the more common 8-bit or 16-bit microcontrollers. Edge AI chip startup **Kneron** raised strategic funding from manufacturing conglomerate **Foxconn** and chipmaker **Winbond** yet did not disclose the funding total. The company has developed a neural network processing unit that can be used in manufacturing lines and added its investors as customers through the raise. At the earlier stage, Deeplite raised a $6.0 million seed round from a consortium of investors led by AI-focused investor PJC. The company was incubated at the TandemLaunch startup foundry in the AI hub of Montreal. **DarwinAI** achieved a $27.0 million valuation in its seed round led by Honeywell Ventures. The company is developing explainable AI for industrial applications, encouraging adoption from risk-averse operational technology staff.

Figure 18.

TinyML market map

Predictive maintenance

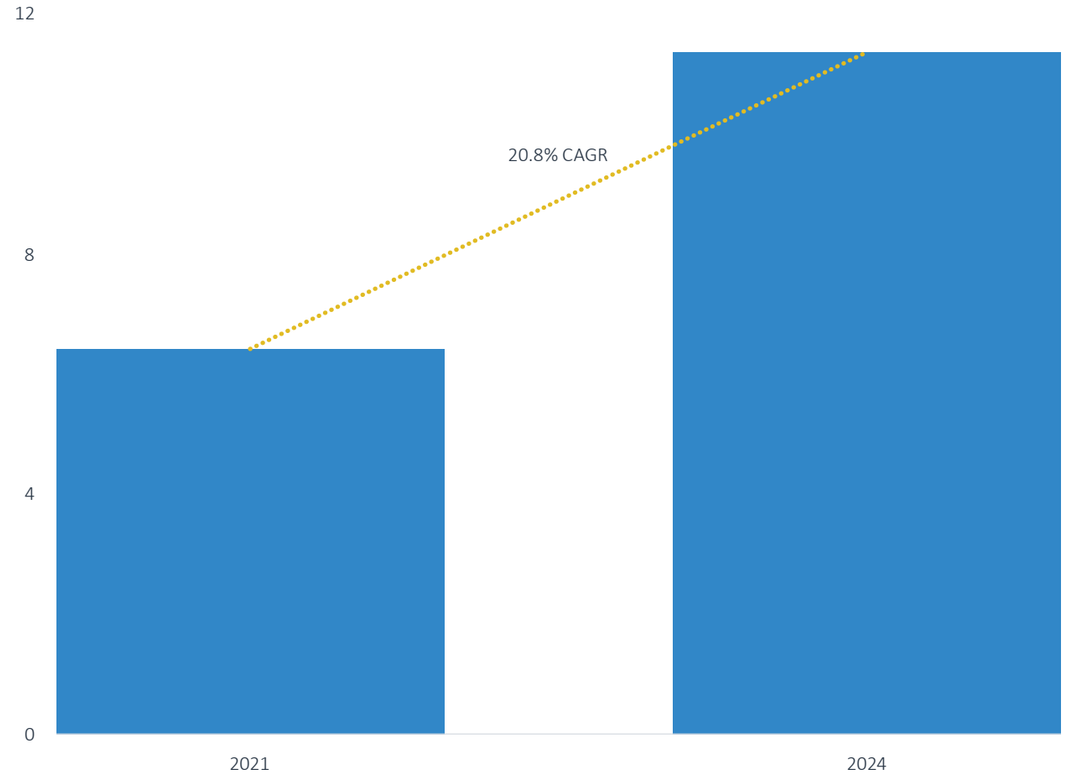
Overview

Predictive maintenance refers to the analysis of sensor data to detect signals of machine distress prior to failure. Once equipment failure is predicted, maintenance events can be automatically scheduled via computerized maintenance management systems (CMMS). These solutions require sensors, connectivity solutions, and analytics software to collect and process equipment data for early warnings. Predictive maintenance can influence several equipment KPIs including overall equipment effectiveness (OEE), frequency of planned and unplanned stops, percentage of high machine availability, and average time of disruptions. The field is shifting from simple condition-based monitoring, in which poor operating conditions trigger an alert, to continuous analytics, enabling greater optimization of performance with more complex interventions. We estimate the market will reach $6.4 billion in spending in 2021, growing at a 20.8% CAGR to an $11.4 billion market in 2024.

Market direction

Predictive maintenance has become a leading use case for industrial AI analytics vendors. Public AI vendor **C3.ai** (NYSE: AI) relies on its predictive maintenance analytics for revenue growth in oil & gas. The company earns a substantial share of its revenue from a partnership with oil services giant **Baker Hughes** (NYSE: BKR). The **Baker Hughes** (NYSE: BKR)/C3 partnership's first discrete software application was focused on predictive anomaly detection. The companies are expanding to drilling optimization and process manufacturing optimization, yet both of those use cases are more recent and less adopted by their customers. **C3.ai** (NYSE: AI), along with other venture-backed industrial analytics vendors including **Falkonry** and **Uptake**, has been able to carve out a niche in the predictive maintenance market for data

Figure 19. PREDICTIVE MAINTENANCE MARKET SIZE ESTIMATE ($B)



Source: PitchBook | Geography: Global | *As of June 30, 2021

integration from previously siloed sensors, even as original equipment manufacturers (OEMs) and asset performance management (APM) vendors incorporate predictive analytics into their product suites.

Machine learning analysis is proving successful in specific predictive maintenance use cases. Equipment maintenance efficiency in many applications has been demonstrated to improve by more than 10x due to ML algorithms—primarily random forest models—which constitutes a quantum leap for the predictive maintenance value proposition. For example, cognitive analytics developed at ML startup **SparkCognition** improved the speed of predictive analytics for pump maintenance by 20x relative to existing sensor systems, with accuracy of 99%. The company has also demonstrated the ability to detect 79% of stuck pipe failures using custom ML models. ML can also improve the frequency of inspection events, enabling more comprehensive maintenance programs. AI & ML algorithms from **Clobotics**, deployed via drone inspections, increased wind turbine inspection efficiency by 10x with 95% accuracy. We are seeing ML produce significant cost savings when companies consolidate sensor fleets with computer-vision-enabled cameras as well as reduced equipment downtime.

Trending startups

Oil & gas startups are producing the highest valuation growth in predictive maintenance. In H1, **Andium** raised a Series A at a $70.0 million pre-money valuation, the highest Series A valuation we have tracked in the space in two years. The company monitors remote oil rig operations including flare stacks. The round was led by Oil & Gas Climate Initiative (OGCI) Climate Investments, a fund managed by a CEO-led consortium of oil majors, based on the company's ability to lower emissions from drilling operations. Oil & gas pipeline sensor startup miQrotech achieved a 7.3x valuation step-up in its Series A, demonstrating outstanding results in detecting pipeline leaks using sensor fusion to combine data streams including corrosion, vibration, temperature, acoustics, and others. Further, individual oil majors have been active in strategic investment. Saudi Aramco Ventures led a Series A for predictive corrosion analytics startup **CorrosionRadar**. The company brings proprietary sensors and application software to the oil & gas market. We believe oil & gas is a necessary use case for predictive maintenance startups to support.

Figure 20.

Predictive maintenance market map

Select company highlights

SELECT COMPANY HIGHLIGHT | SAMSARA

Founded
2015

1,580 employees
in 5 offices globally

Total VC raised:
$930.0M

Winner of Business Intelligence Group's Artificial Intelligence Excellence Award for Computer Vision in 2021

Last completed financing:
$700.0M in Series F

Last financing valuation:
$5.4B

Lead investors:
Dragoneer Investment Group, Warburg Pincus, General Atlantic, Andreesen Horowitz, and General Catalyst

Overview

Samsara provides an AI-enabled industrial IoT platform that combines hardware, software, and cloud computing designed to bring real-time visibility and analytics to industrial operations. The company's suite of solutions includes vehicle telematics, driver safety, mobile workflow and compliance, asset tracking, and industrial process controls that can be managed from a single platform.

Although its core business is fleet management, the company has developed a differentiated machine vision product called the VS2 Vision System that detects abnormalities in industrial processes and communicates alerts directly to a central dashboard. VS2 can work across a host of use cases, although it focuses on commercial vehicle dashcams, and its intuitive no-code configuration platform creates a superior user experience relative to other models on the market.

The company is building a central hub for IoT data that connects to existing industrial applications via API for data integration. In Q2, its API hub, called the App Marketplace, added seven fleet management integrations, resulting in nearly 100 overall. Customer use of this hub is not robust beyond fleet management, however. The growth of integrations will determine the quality of the company's network effect. Thus far, customer data for fleet management has enabled the creation of a benchmark for fleet performance, yet it has not expanded to similar benchmarks for factory and site monitoring.

Leadership

CEO Sanjit Biswas was formerly the CEO of **Meraki**, which doubled its sales every year from inception through its $1.2 billion acquisition by **Cisco** in 2012 and beyond. CTO John Bicket was a co-founder and CTO at **Meraki**. Most of the remainder of the executive team also came from **Meraki**. In Q2, the company hired former Salesforce executive Sarah Patterson as Chief Marketing Officer. We believe additional executives with industrial automation backgrounds will be necessary to overcome barriers to entry in a mature market. In Q2, the board added former HPE executive Ann Livermore. The board previously added public company experience with former COO of **BlackRock** Sue Wagner, former CFO of **VMWare** Jonathan Chadwick, and former CMO of **Cisco** Sue Bostrom. This collective experience improves the company's aptitude for public listing and revenue growth at scale.

Competitors

Samsara is growing quickly, although it must compete with well-established incumbents such as **IBM**'s (NYSE: IBM) Watson, **SAP** (ETR: SAP), **PTC**'s (NASDAQ: PTC) ThingWorx, **Microsoft**

(NASDAQ: MSFT), and numerous industrial automation vendors. In fleet management, the company competes with telecom giants including **Verizon** (NYSE: VZ), **AT&T** (NYSE: T), and **Vodafone** (LON: VOD), each of which have automotive divisions. Telecom giants aim to integrate their 5G networks with fleet management, creating an opportunity for **Samsara**'s edge computing technology to capture market share in the short term. More broadly in IoT, **Samsara** focuses on solving the problem of disconnected process controls and analytics, which we believe incumbent vendors struggle with due to interoperability limitations. While machine vision can be a competitive differentiator in the short term, we expect AI-savvy competitors such as **Microsoft** (NASDAQ: MSFT) and **IBM** (NYSE: IBM) will be able to close the gap in this area.

Outlook

Samsara has achieved a valuation lofty enough to raise questions about its revenue potential. Leading IoT vendor **PTC** (NASDAQ: PTC) has a market cap of $7.8 billion and is a market leader in the segment. **Samsara** has nearly reached this valuation only four years post-founding. While disruptors commonly exceed incumbent market caps in high-growth segments, we believe industrial IoT will prove to be a difficult segment in which to scale due to customer stickiness and high switching costs. Both public markets and acquirers may hesitate to support the company until it removes friction from the IoT transaction, finds a recession-proof business model, and displaces incumbents.

Figure 21.

Financing history

SERIES A	SERIES B	SERIES C	SERIES D	SERIES E	SERIES F
May 19, 2015	**November 30, 2016**	**June 22, 2017**	**March 22, 2018**	**December 28, 2018**	**May 15, 2020**
Total raised ($M): $25.0	**Total raised ($M):** $15.0	**Total raised ($M):** $40.0	**Total raised ($M):** $50.0	**Total raised ($M):** $100.0	**Total raised ($M):** $700.0
Pre-money valuation ($M): $90.0	**Pre-money valuation ($M):** $240.0	**Pre-money valuation ($M):** $490.0	**Pre-money valuation ($M):** $1,350.0	**Pre-money valuation ($M):** $3,500.0	**Pre-money valuation ($M):** $4,700.0
Lead investor: Andreessen Horowitz	**Lead investor:** Andreessen Horowitz	**Lead investor:** General Catalyst	**Lead investors:** Andreessen Horowitz, General Catalyst	**Lead investors:** Andreessen Horowitz, General Catalyst	**Lead investors:** Dragoneer Investment Group, Andreessen Horowitz, General Catalyst, and Tiger Global Management

SELECT COMPANY HIGHLIGHT | AMBIQ MICRO

Founded
2010

123 employees
in 5 offices globally

Total VC raised:
$254.6M

Last completed financing:
$145.0M in a late-stage round

Lead investors:
Taiwania Capital Management, Kleiner Perkins, Tsing Capital, Fujitsu, Osage University Partners, Grand Ventures, Austin Ventures, Big Basin partners, and Q Venture Partners

Overview

Ambiq Micro is a low-power chipset company that makes microcontrollers for IoT devices. The company has developed microcontrollers with power budgets that are from 5 to 10 times smaller than those of comparable chipsets on the market—as low as 4µA/MHz. As a result, the chipset offers higher bandwidth than comparable low-power chipsets. The chipsets use circuits with transistors in the off position, which does not require them to be activated and draw a full current. This circuitry is referred to as Subthreshold Power Optimized Technology, or SPOT.

The technology has been used to power leading wearables and biometric devices. Since beginning production in 2015, the company has announced integrations with **Citizen** Smartwatches, **Huawei** fitness bands, **Valencell** biometric sensors, **Spire** health tags, **Fluent.ai** AI voice interface software products, and **DSP Concepts** voice recognition, among other applications. As a result, the company has achieved scale in the wearable microcontroller market. The company is expanding into edge AI processing, as its Apollo4 system-on-chip can power always-on battery-powered voice recognition for more than a week using **Sensory**'s embedded speech recognition technologies. This application shows how previously resource-intensive AI can be simplified at the device edge as long as power requirements are sufficiently low.

Leadership

Ambiq Micro's management team has deep experience in the semiconductor industry with substantial R&D track records. CEO and Chairman Fumihide Esaka is a long-time semiconductor executive. CTO Scott Hanson, who has a Ph.D. in Electrical Engineering from the University of Michigan, holds seven patents. The company recently hired Raghuram Tampuri as VP of Engineering. Tampuri held similar positions at engineering consultancy Altran and semiconductor startup **KnuEdge**. President Sean Chen brings business development experience from **mCube** and **Intel** (NASDAQ: INTC), among others. The board includes representatives from investors Austin Ventures, Mercury Fund, Tsing Capital, Huron Ventures, and Kleiner Perkins. The board lacks independent board members, a situation we would expect to change as the company pursues an IPO.

Competitors

Ambiq Micro competes directly against legacy chipmakers **TI** (NASDAQ: TXN), Atmel, **NXP** (NASDAQ: NXPI), and challengers such as **GreenWaves**, **Eta Compute**, and **Minima Processor**. Ambiq can succeed in use cases with high cost tolerance and requirements for extended battery life. In some cases, both **TI** (NASDAQ: TXN) and Ambiq technology can be used in conjunction. For example, at least one customer uses an Ambiq microcontroller with a **TI**

(NASDAQ: TXN) analog front end for its wearable devices. While **Ambiq Micro** will struggle with the scale efficiencies of incumbent chipmakers, partnering with them via applications could remove barriers to entry and enable cost efficiencies via larger orders.

Outlook

The high-performance chipset business has proven lucrative with the successes of **Nvidia** (NASDAQ: NVDA) and **Advanced Microdevices**, and we believe **Ambiq Micro**, along with several other low-power chipmakers, has the potential to define a new niche of the market in high efficiency chipsets. With increasing IoT applications in M2M connectivity, as well as increasing use of wearables in health insurance, we believe there is significant blue-sky opportunity for low-power chips, although low consumer uptake of wearables is a headwind for that application. The company is currently considering an IPO in the near-term and can benefit from tailwinds in semiconductor stock performance in a supply-constrained environment.

Figure 22.

Financing history

SERIES A	SERIES B	SERIES C	SERIES D	SERIES E	LATE-STAGE
November 2, 2012	**August 20, 2013**	**December 9, 2016**	**January 17, 2018**	**October 26, 2018**	**March 23, 2021**
Total raised ($M): $3.7	**Total raised ($M):** $10.0	**Total raised ($M):** $9.5	**Total raised ($M):** $34.1	**Total raised ($M):** $29.1	**Total raised ($M):** $145.0
Pre-money valuation ($M): $5.8	**Pre-money valuation ($M):** $11.8	**Pre-money valuation ($M):** $42.0	**Pre-money valuation ($M):** $100.0	**Pre-money valuation ($M):** $165.0	**Pre-money valuation ($M):** N/A
Lead investors: Big Basin Partners, Michigan Investment in New Technology Startups, and Q Venture Partners	**Lead investor:** Austin Ventures	**Lead investors:** Fujitsu, Michigan Capital Network, Osage University Partners, and Grand Ventures	**Lead investor:** Tsing Capital	**Lead investor:** Taiwania Capital Management	**Lead investors:** Trout Creek Ventures, Urban Capital Network, and Shenzhen Capital Group

SELECT COMPANY HIGHLIGHT | UPTAKE

UPTAKE

Founded
2014

288 employees
in 6 offices globally

Total VC raised:
$293.0M

Last completed financing:
$117.0M in Series D

Lead investors:
Baillie Gifford, Valor Equity Partners, Revolution, and GreatPoint Ventures

Overview

Uptake is an industrial AI & IoT software company in the asset performance management (APM) market. The company's product suite includes operational technology (OT) data integration, preventive maintenance optimization, maintenance cost analysis, condition-based monitoring, and predictive analytics. The company also offers vertical products for fleet management, energy & utilities, and equipment dealers. This product suite is almost entirely cloud-native. The company went through several rounds of layoffs in 2018 and 2019 as it reset expectations around growth.

The company defends its market position with intellectual property. In 2018, **Uptake** acquired Asset Performance Technologies for its library of equipment failure modes. **Uptake** leverages this dataset to build digital twins that evolve over time with new data. We track 22 active patents for the company. These patents relate to data science for anomaly detection and factory monitoring but do not specify advanced AI techniques such as deep learning. Its patents also cover wind turbine anomaly detection specifically, suggesting the company has a competitive advantage in that industry.

Leadership

The company was co-founded by Groupon (NASDAQ: GRPN) co-founder Brad Keywell and Eric Lefkofsky. Keywell's non-industrial background has led to increased innovation in user experience. The company remains founder-led since its inception, leading to a focus on product development. Beyond the CEO role, the company has undergone executive turnover over the past three years. In Q3 2020, the company hired Kayne Grau as President. Grau formerly led automotive marketplace startup **DRIVIN** through an acquisition. The board of directors contains only investors, including multiple representatives of Revolution Growth. The board could benefit from increased industrials experience to improve commercial strategy.

Competitors

Uptake competes with asset performance management vendors including **AVEVA** (LON: AVV), **Aspen Technology** (NASDAQ: AZPN), **GE Digital**, **IBM** (NYSE: **IBM**), **SAP** (ETR: **SAP**), and **SAS**. Other APM solutions tend to be deployed primarily on-premises. APM vendors also benefit from installed bases of pre-existing IoT platforms and devices, creating a lock-in effect. **AVEVA**

SELECT COMPANY HIGHLIGHT | UPTAKE

(LON: AVV)'s acquisition of industrial software company **OSISoft** presents a challenge to the industry given the company's high adoption in industrial data management via its PI System platform. As a result, **Uptake** will face pressure to increase its integrations with legacy control systems and data historians. For this reason, the company may consider M&A to improve its position in the market.

Outlook

Uptake has resisted an IPO and may be an acquisition candidate for an industrial incumbent or a private equity firm. The company has not raised a VC round since 2017, avoiding what would likely be a down-round. Cost-cutting and executive turnover have begun to put the company on a pathway back to growth. As a result, a VC round may be a renewed possibility. **C3.ai**'s (NYSE: AI) growth challenges indicate the inherent barriers to entry in the industrial market. Even if the company cannot achieve scale to justify its Series D valuation, the company's intellectual property carries intrinsic value that may be valuable to incumbent APM vendors lacking advanced data science capabilities. **AVEVA** (LON: AVV)'s $5.0 billion acquisition of **OSISoft** sets an upper bound for an acquisition value of an industrial data analytics platform, a figure that **Uptake** may be able to match.

Figure 23.

Financing history

SERIES A	SERIES A1	SERIES B	SERIES C	SERIES D
N/A	**March 16, 2015**	**October 27, 2015**	**April 7, 2017**	**November 30. 2017**
Total raised ($M): $3.0	**Total raised ($M):** $3.0	**Total raised ($M):** $45.0	**Total raised ($M):** $90.0	**Total raised ($M):** $117.0
Pre-money valuation ($M): $12.0	**Pre-money valuation ($M):** $50.0	**Pre-money valuation ($M):** $950.0	**Pre-money valuation ($M):** $1,800.0	**Pre-money valuation ($M):** $2,200.0
Lead investors: N/A	**Lead investors:** Caterpillar, Lightbank, and New Enterprise Associates	**Lead investor:** GreatPoint Ventures	**Lead investor:** Revolution	**Lead investor:** Baillie Gifford

About PitchBook Emerging Tech Research

Independent, objective, and timely market intel

As the private markets continue to grow in complexity and competition, it's essential for investors to understand the industries, sectors and companies driving the asset class.

Our Emerging Tech Research provides detailed analysis of nascent tech sectors so you can better navigate the changing markets you operate in—and pursue new opportunities with confidence.

PitchBook Data, Inc.

John Gabbert Founder, CEO

Nizar Tarhuni Senior Director, Institutional Research & Editorial

Paul Condra Head of Emerging Technology Research

Additional research

Agtech
Alex Frederick
alex.frederick@pitchbook.com

Artificial Intelligence & Machine Learning
Brendan Burke
brendan.burke@pitchbook.com

Cloudtech & DevOps
Paul Condra
paul.condra@pitchbook.com

Fintech
Robert Le
robert.le@pitchbook.com

Foodtech
Alex Frederick
alex.frederick@pitchbook.com

Healthtech
Kaia Colban
kaia.colban@pitchbook.com

Information Security
Brendan Burke
brendan.burke@pitchbook.com

Insurtech
Robert Le
robert.le@pitchbook.com

Internet of Things (IoT)
Brendan Burke
brendan.burke@pitchbook.com

Mobility Tech
Asad Hussain
asad.hussain@pitchbook.com

Supply Chain Tech
Asad Hussain
asad.hussain@pitchbook.com