



CAPITALX
Partners

THE RISE OF ROBOTS

INSIGHTS INTO
THE GLOBAL ROBOTICS MARKET



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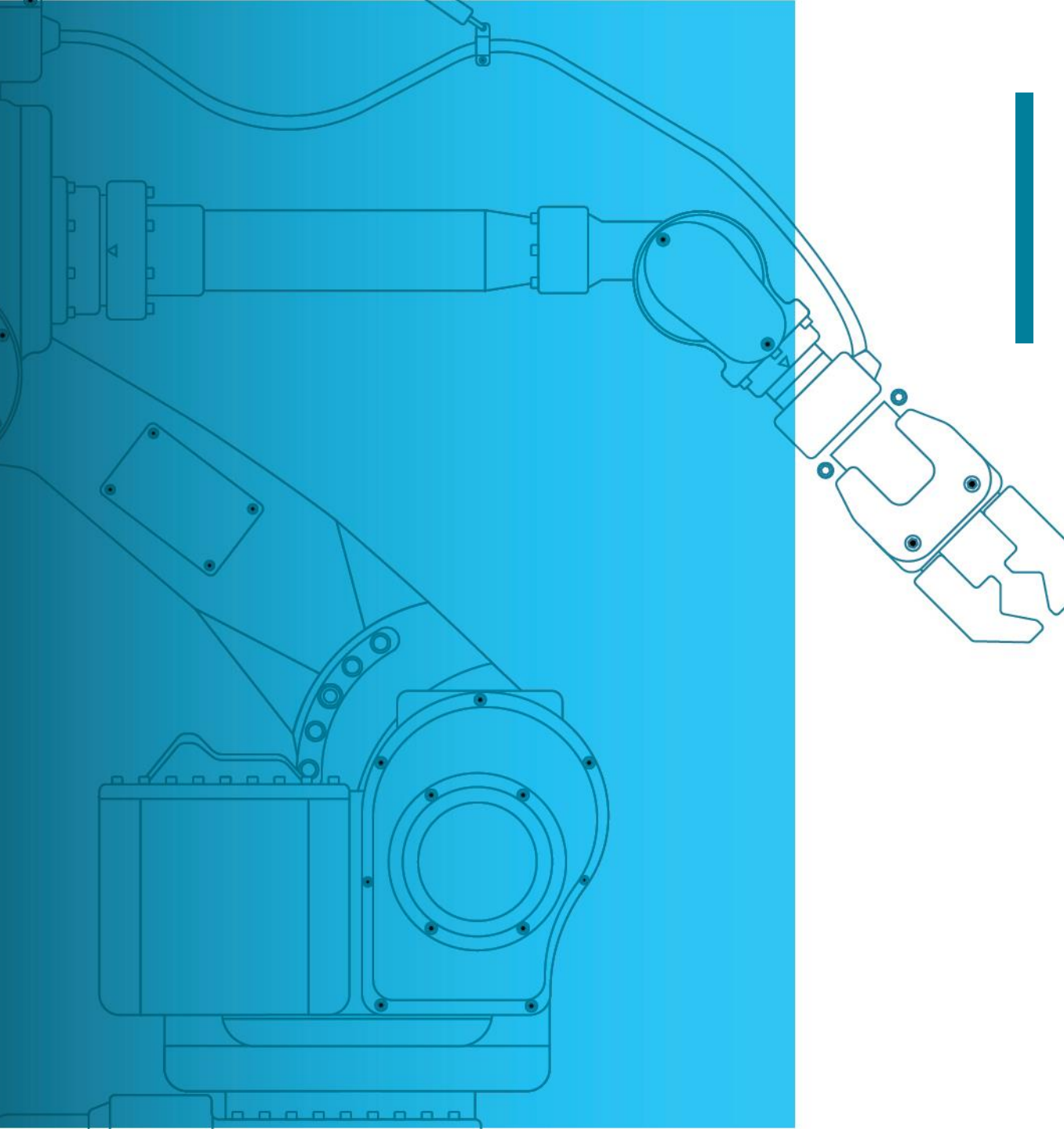
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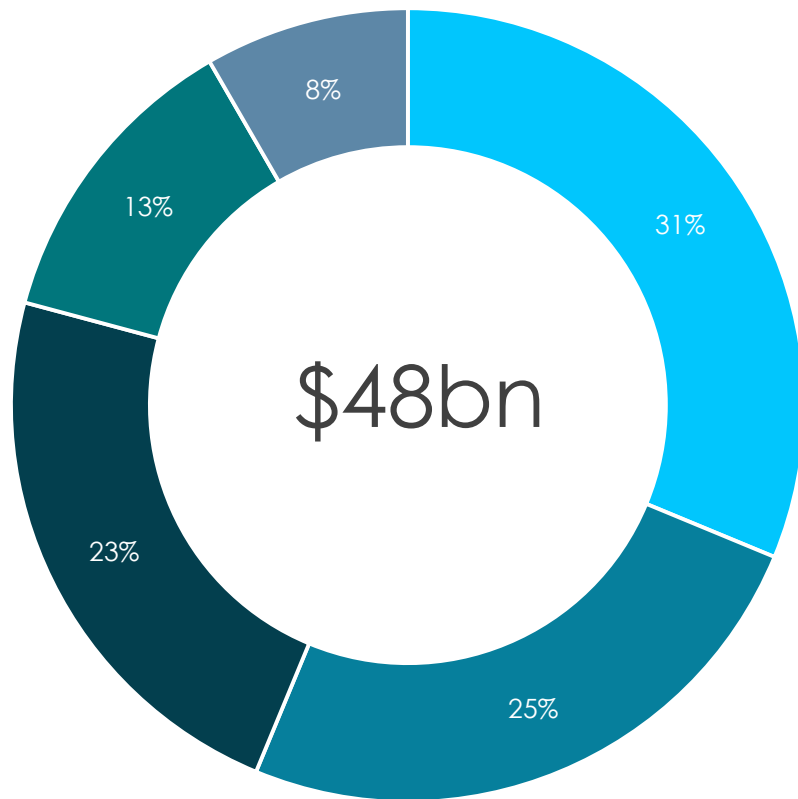
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The Rise of Robots

Industrial Robot Market ^[1] - (USD bn)



- Robot Arms
- Robot Accessories
- Auxiliary Hardware
- Installation Services
- Software

[1] McKinsey, "Industrial Robots – Insights into the Sector's Future Growth Dynamics"

Introduction

2020 marks one hundred years since the word "robot" was first coined by science fiction playwright, Karel Capek. Forty years later, in 1961, General Motors installed the world's first industrial robot, paving the way for automated manufacturing and the era of programmable machines.

Today, the global Industrial robot market is worth c.\$48bn pa and demand for robotic technology is accelerating. This on the back of the Fourth Industrial Revolution, which is revitalizing market interest and encouraging digital innovation.

In this report we analyze the growth in the global Robotics Market, identifying key trends driving demand.

In part one, we explore the impact of digital technologies and the emergence of "Advanced" Robots, which incorporates the cloud based technologies, including AI and machine vision, to fulfill increasingly complex tasks.

In part two, we analyze which industries are driving demand for Advanced Robots, taking a deep dive into smart logistics and supply chain automation. We include a case study on Amazon's robotics & a market map of key warehouse robot suppliers.

In part three, we dissect the wider robotics ecosystem, analyzing the market for robotic components, accessories and software. We include a market map on emerging technologies and key players.

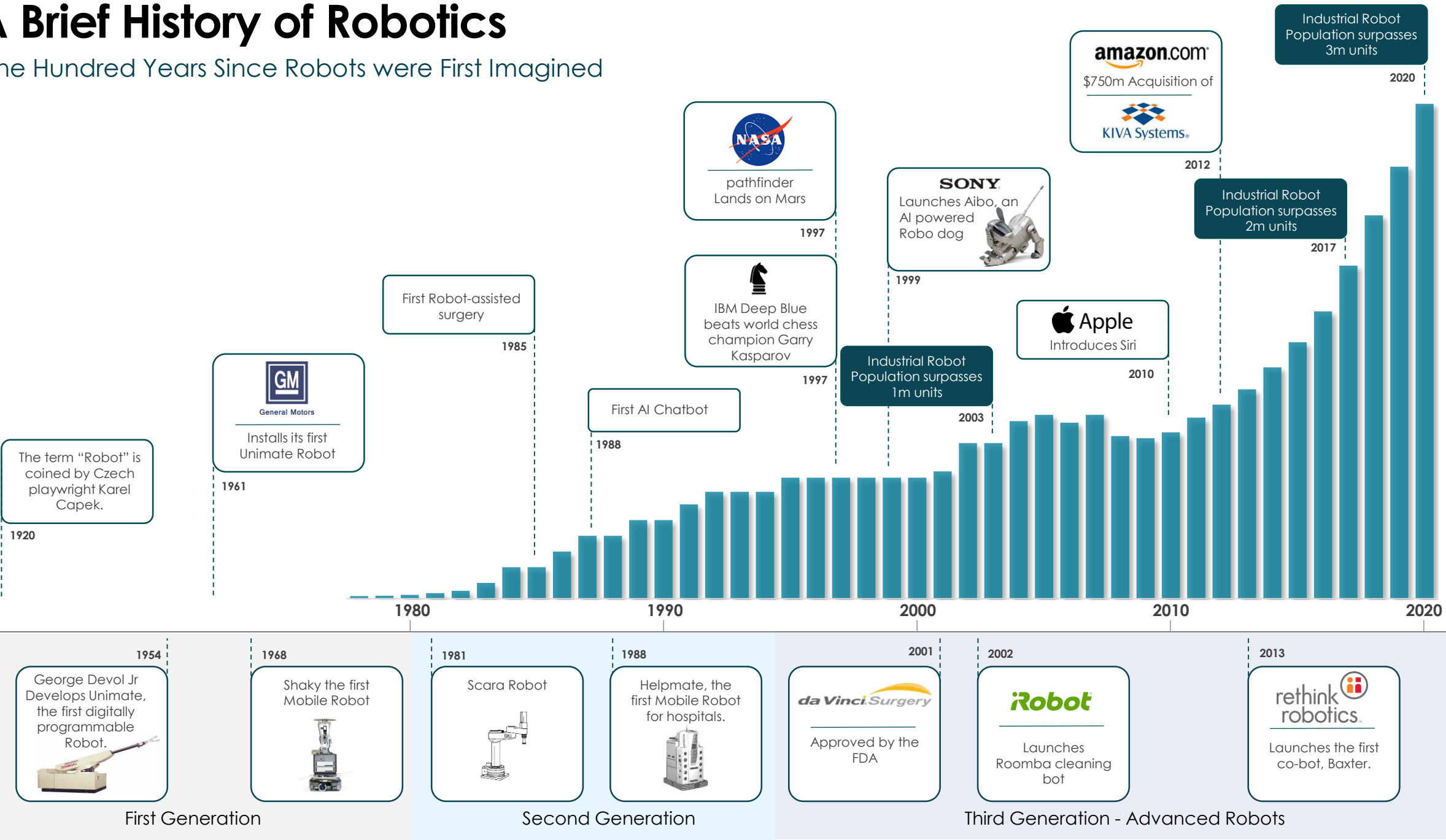
We conclude with a detailed analysis on investor activity, to determine which technologies and categories have gained widest support. We include a snapshot on notable listings, M&A activity, and VC funding.



A Brief History of Robotics

One Hundred Years Since Robots were First Imagined

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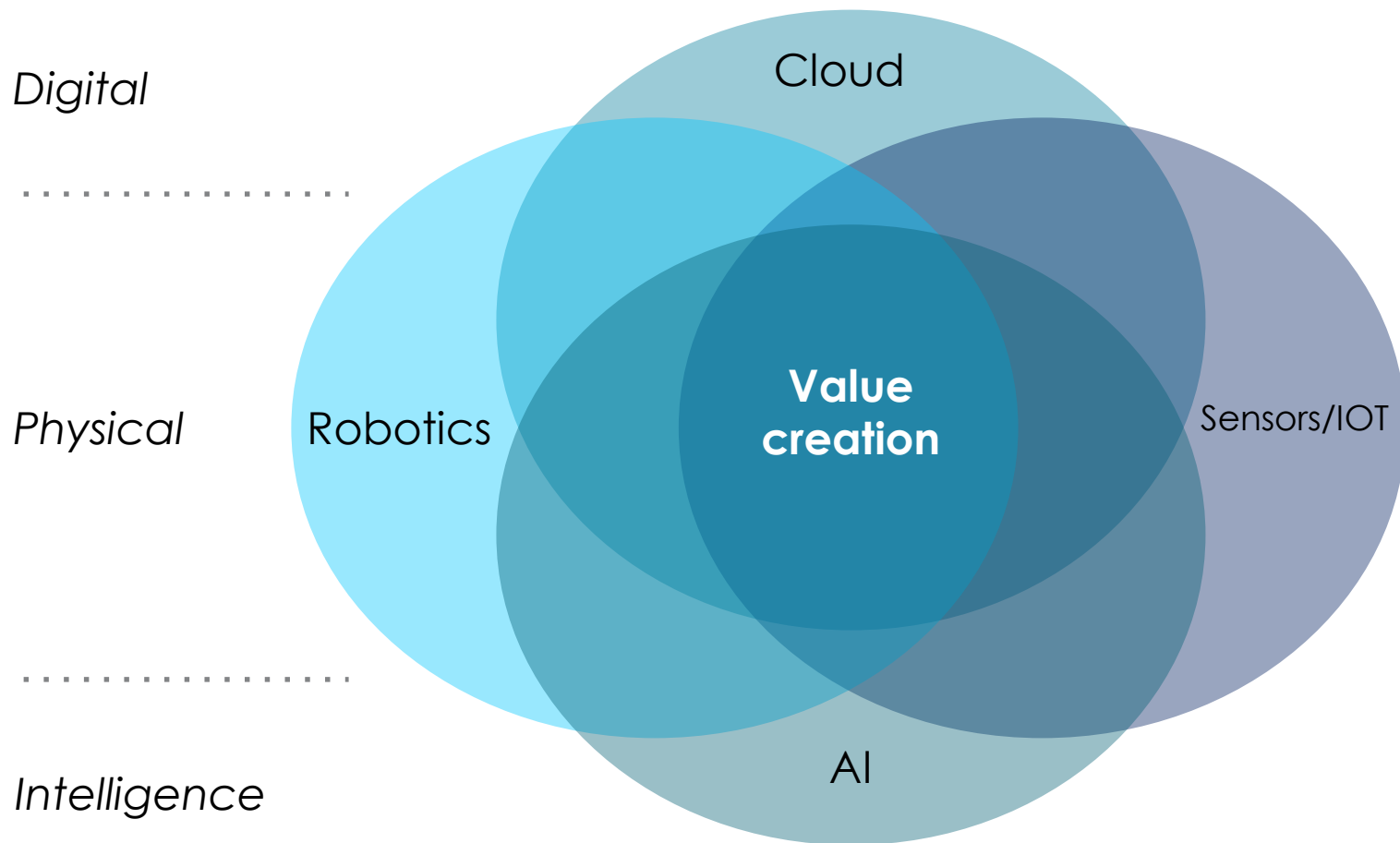
Smarter, Cheaper & Faster

Introducing a new generation of “Advanced” Robots

Digital technologies have evolved, allowing robots to marry physical automation with machine vision and intelligence. As a result, a new breed of “Smart” Robots are expanding the use case for robotic automation, driving the technology into new applications and underpenetrated markets.

Smarter: Technologies Converge

Industry 4.0: Physical technology meets digital efficiency



Robot Evolution, from Brawn to Brains:

For over 50 years, industrial robots have been used to automate physical, repetitive tasks, relying heavily on their consistency and brute strength to generate value.

These **“Traditional” Robots were expensive and lacked capabilities, effectively limiting adoption to a handful of heavy industries.**

However; the latest generation of **“Advanced” Robots incorporates the full technology stack**, combining physical automation with digital efficiency. As a result, Advanced robots are able to generate value where Traditional Robots could not.

- **Cloud Technology**, facilitates remote monitoring, real time collaboration and offsite data storage & analysis.
- **Advanced sensors and machine vision**, allow robots to develop spatial awareness and collect valuable data
- **AI and machine learning**, adds the final layer of sophistication by allowing robots to apply logic and effectively automate decision making.

Cheaper: Unit Economics

Hardware deflation & the untapped SME opportunity

Industrial robots have never been cheaper and easier to operate.

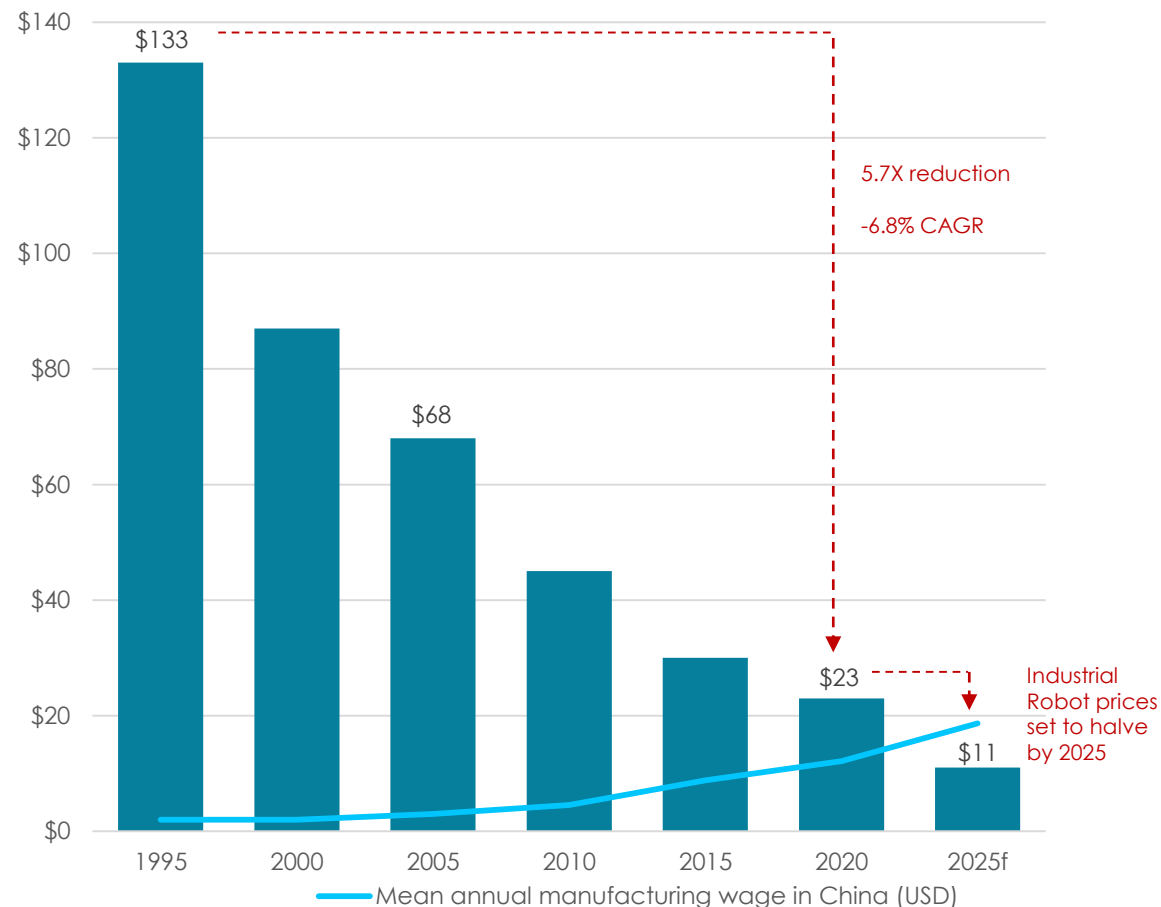
While global wages have steadily been ticking upward, industrial robot prices have fallen rapidly, reducing at a CAGR rate of 6.8% since 1995 ^[1]. This compares well with tech hardware deflation, which has tracked in a range of 5% - 7%.

At the same time, robotic systems have become easier to install, quicker to program and cheaper to operate. As a result, the **barriers to wider adoption are driven lower each year.**

According to research conducted by Ark Invest, **Industrial Robot prices could drop by as much as 50-60% by 2025**. In this scenario, as robot prices continue to decline, we anticipate two major inflection points:

1. Further deflationary pressure should **fast track interest from the Industrial SMEs**, which have traditionally avoided robotic automation due to cost and complexity. In Europe, there are over 2m SME manufacturing enterprises, which employ c.60% of the continents 17m manufacturing employees. Robot density among manufacturing SMEs stands at 6 units per 10 000 employees. This is significantly lower than the European average of 114, highlighting the market potential which has not yet been adequately addressed.
2. Over the next five years, we expect the **upfront unit cost of an industrial robot to decline below the average annual manufacturing wage in China**. As a result, China's competitive advantage in global manufacturing will likely decline, propelling a shift in global production to cheaper markets. To combat this trend, China is investing heavily in robotic automation. It is now the worlds largest market for industrial robots, accounting for c.36% of annual installations.

Industrial Robot unit costs ('000 USD) ^[1]



[1] Constant 2017 prices

[1] Ark Invest, "Big Ideas 2019", January 2019

[2] The average annual manufacturing wage in china in 2019 was CNY78k or USD11k

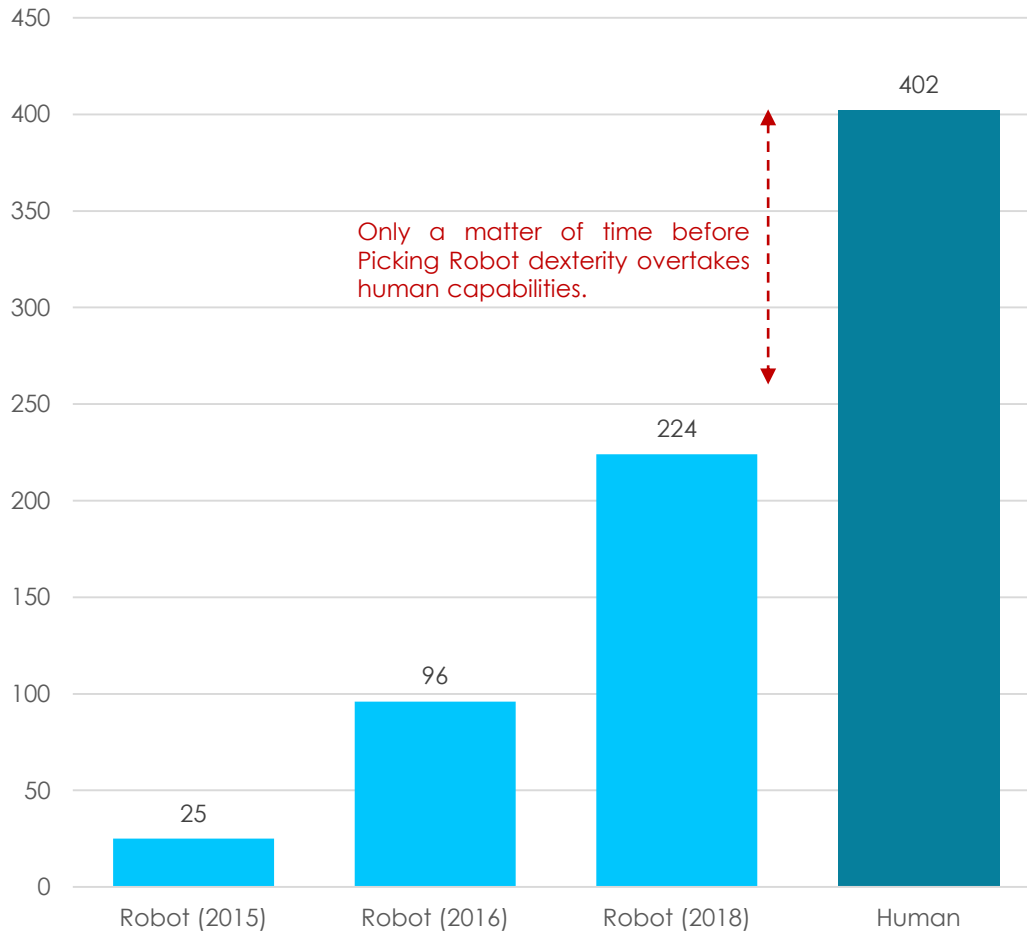
[3] China installed 154k Industrial Robots in 2018 - International Federation of Robotics

[4] Manufacturing Barometer, Robot Adoption: The SME Challenge, October 2019

Faster: Improved Functionality

Robot dexterity is quickly advancing beyond human capabilities

Items picked & placed per hour ^[1]



Advances in dexterity and sophistication are allowing industrial robots to make deeper inroads into precision roles.

When industrial robots were first introduced in the 1970's, the average robot arm utilized a relatively crude 5 axis design, which allowed limited range of motion. Fast-forward to today and most modern robot arms now utilize over 30 axis in their design.

Whilst it is clear that these improvements in hardware design have played a key role in expanding overall robot dexterity, **the real advances towards precision movement can be attributed to innovations in machine learning and sensor technology.**

This is particularly evident in the advances made in robots specifically designed for picking and sorting. In 2015, sorting robots could pick and place around 25 items per hour, however today these robots are able to pick and place well over 200 items per hour. **Further advancements in the next three to five years, should see picking speeds advance past human capabilities, which would signal a significant inflection point for industrial automation.**

One new market embracing precision robotics is the health care sector. In the US, **robot assisted surgeries have increased from c.2% to c.15%** ^[2], between 2012 and 2018. In certain applications, surgical robots are now able to achieve precision movement up to 1 micron, which is 1/50th the diameter of a human hair and 10x more precise than a human surgeon operating on their own ^[3]. With this level of accuracy and consistency, it is **only a matter of time before robot technology is utilized in most surgical procedures.**

[1] Ark Invest, "Big Ideas 2019", January 2019

[2] <https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2758472>

[3] <https://www.roboticsbusinessreview.com/manufacturing/robot-precision-evolves/>

New Market Frontiers

Expanding the addressable market for robotic automation

As robots become smarter, cheaper and faster, the technology is making deeper inroads into new industries and underpenetrated markets.

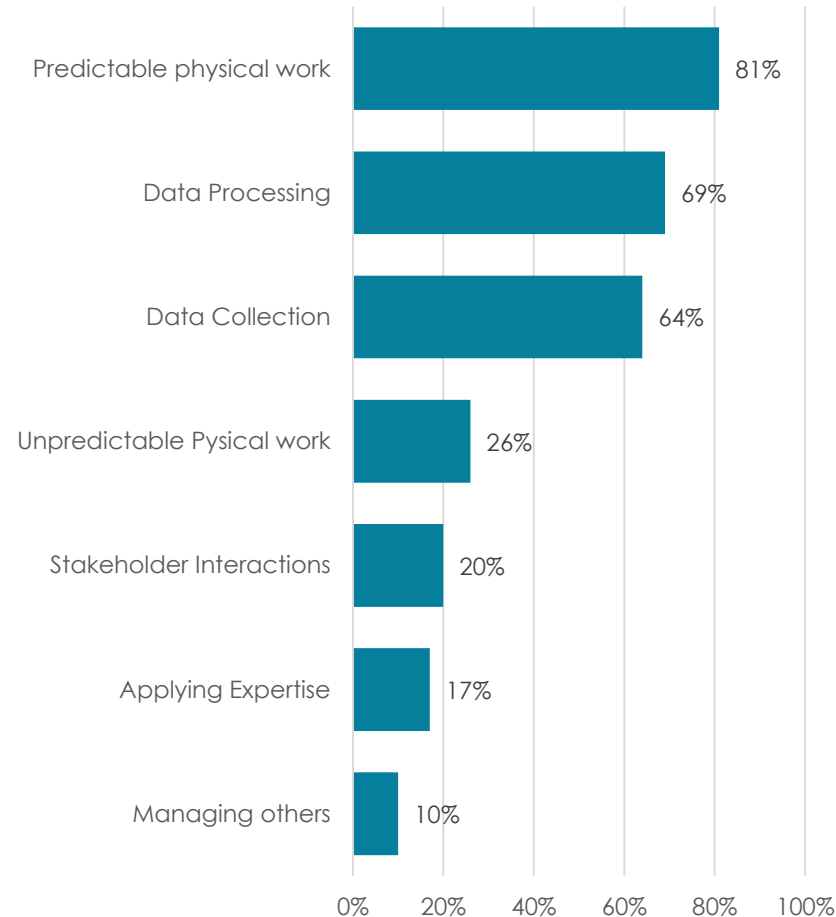
To put the opportunity in perspective, **McKinsey estimates that c.45% of work activities, could be automated using existing technologies, including AI and Robotics** ^[1].

According to the study, predictable physical work, followed by data collection and processing, stand out as the three activities most susceptible to future automation.

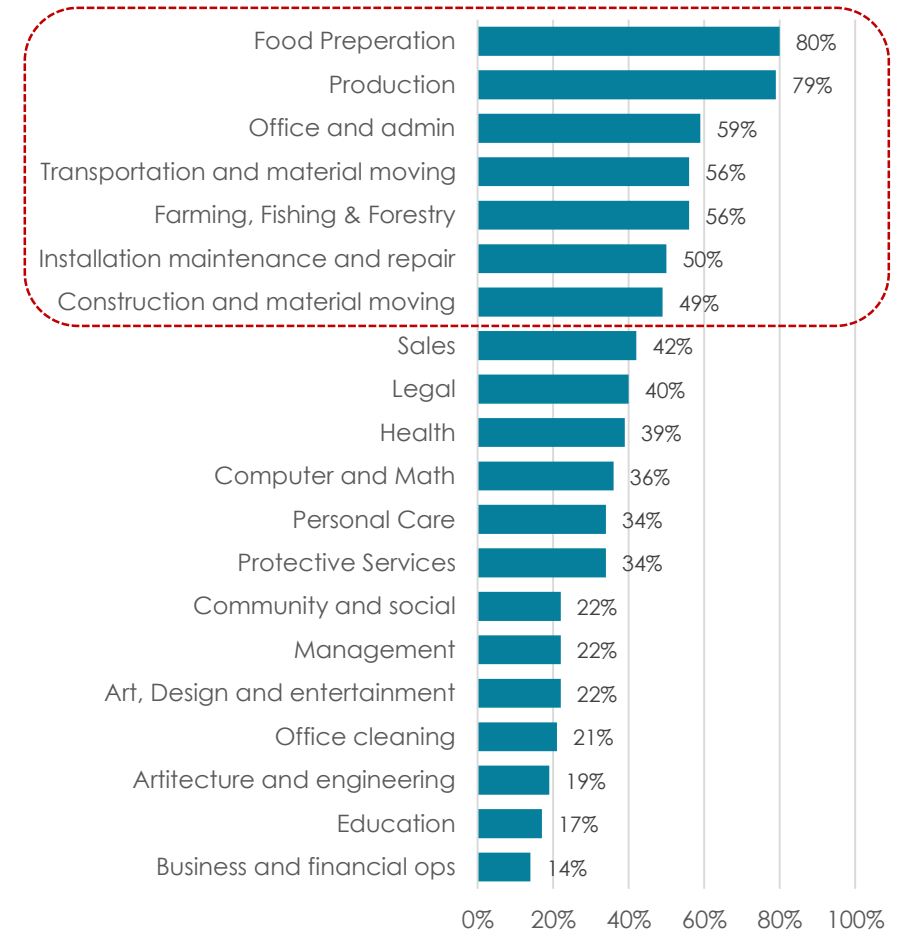
Notable industries identified to embrace physical automation include:

- **The Food Services Sector**, which is experimenting with robot technology to automate food preparation.
- **Supply chain and Logistics**, which are rapidly adopting mobile robots to automate picking & handling of goods.
- **Construction and mining sectors**, which are implementing self driving vehicles to automate material handling.
- **The Agricultural sector**, which has been an early adopter of drone technology for data collection and yield enhancement.

Percentage of work hours automatable – By activity ^[2]



Percentage of work hours automatable – By job type ^[2]



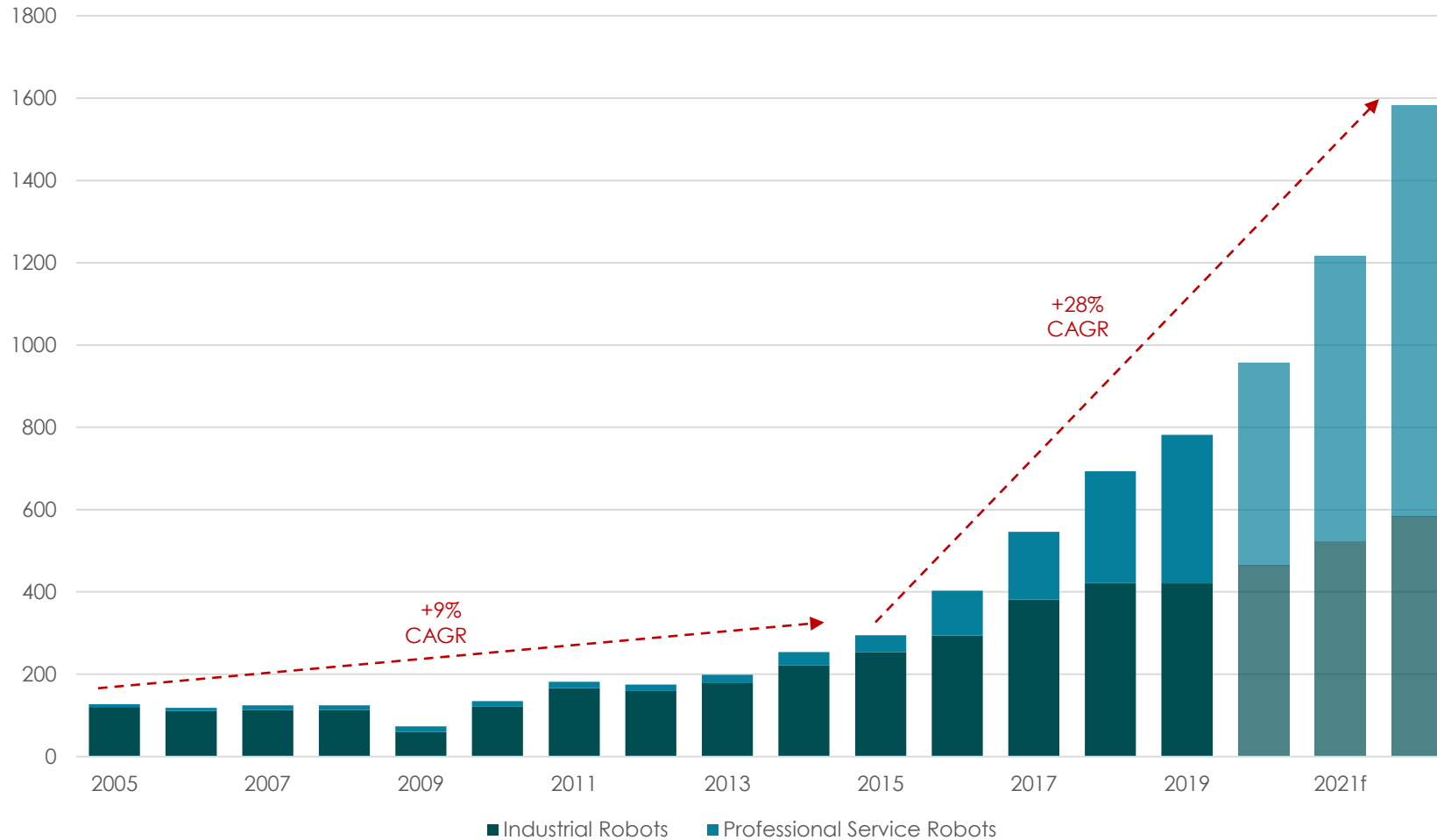
[1] McKinsey, "Four Fundamentals of Workplace Automation", November 2015

[2] McKinsey, "Where Machines Can Replace Humans", January 2017

The Rise of Advanced Robots

A clear acceleration in demand from 2015

Global Robotics Sales – '000 units



Robotics unit sales reached a key inflection point in 2015, signaling the dawn of “Advanced” Robots and a new phase of growth.

The largest growth vector has been emergence of Professional Service Robots (PSR), from a non-existent category in 2015 to a market segment that now matches Industrial Robot in unit sales.

Going forward, it is clear that we have only peeled past the first layer of potential, promised by “Advanced” Robotics.

- The full impact of the cloud is yet to be realized;
- Robot systems are getting cheaper each year;
- Picking robot dexterity is fast approaching human capabilities; &
- A wave of new industries are starting to experiment with robotic technologies.

Growth in Robot System Demand

PSR market value to overtake Industrial in the next 12-18 months.

Global Robotic Hardware Sales forecasts ^[1]

	2018	2019	2020f	2021f	2022f	CAGR 2019-22f
Global Unit Sales (000)	693	782	957	1216	1584	27%
Industrial/Manufacturing Robots	422	421	465	522	584	12%
Professional Service Robots	271	361	492	694	1000	40%
Professional Service Robots - Logistics	111	176	279	444	712	59%
Professional Service Robots - Medical	5	7	10	14	19	40%
Professional Service Robots – Field*	7	8	9	10	11	11%
Professional Service Robots - Defense	14	16	18	21	24	14%
Professional Service Robots - Inspection	106	118	132	148	167	12%
Professional Service Robots - Public Relations	11	15	21	29	41	40%
Professional Service Robots – Pro' cleaning	8	10	12	15	19	24%
Professional Service Robots - Exoskeletons	7	9	11	13	16	21%

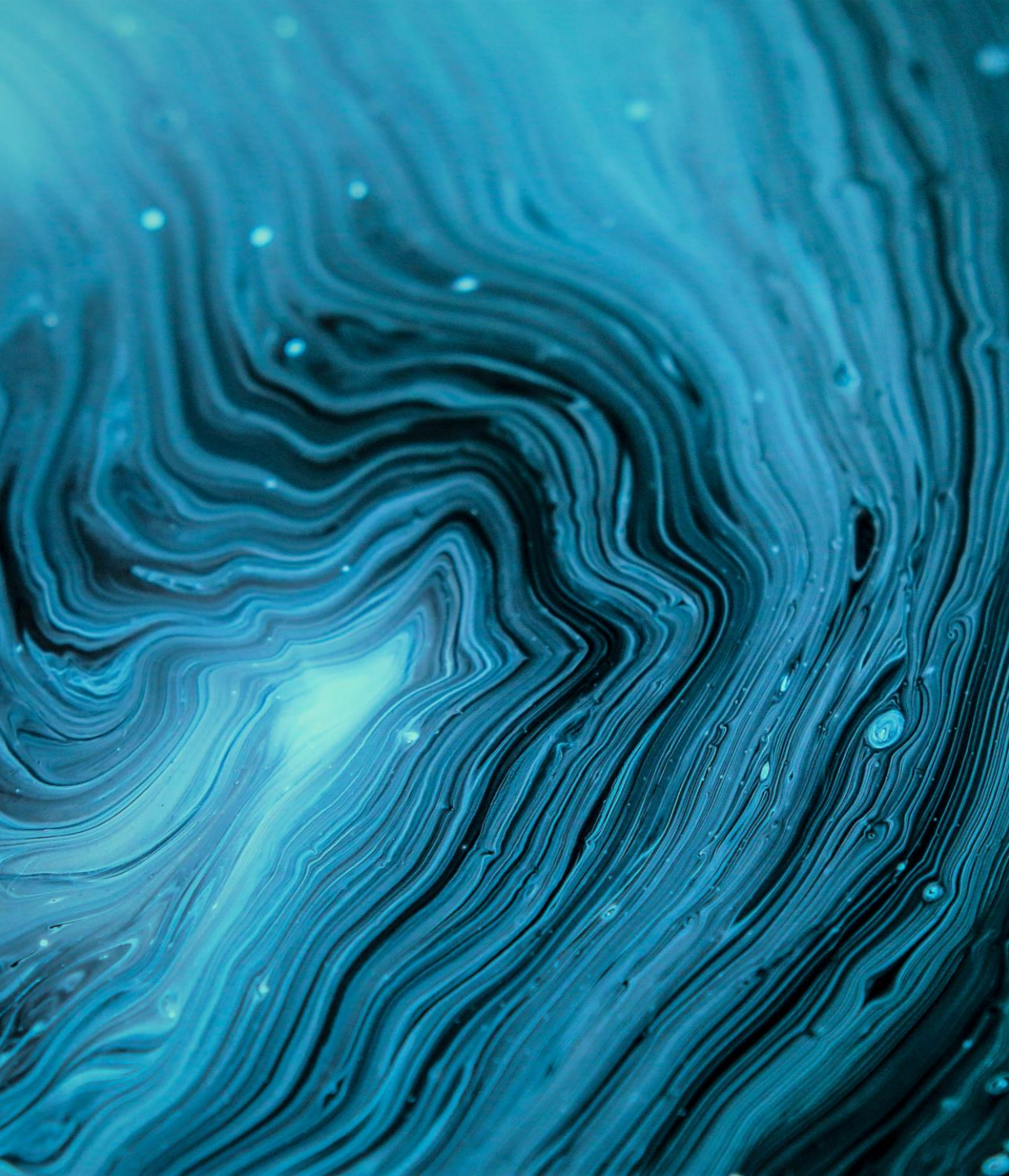
Global Value of sales (USD bn)	\$29	\$34	\$41	\$53	\$73	29%
Industrial Robots	\$16	\$16	\$18	\$21	\$23	12%
Domestic Service Robots	\$3.7	\$4.6	\$6.3	\$8.5	\$11.5	36%
Professional Service Robots	\$9.2	\$12.6	\$16.4	\$23.6	\$38	44%
Professional Service Robots - Logistics	\$3.7	\$5.7	\$9	\$14	\$23	58%
Professional Service Robots - Medical	\$2.8	\$3.7	\$5	\$6.7	\$9.1	35%
Professional Service Robots - Field	\$1	\$1.1	\$1.2	\$1.3	\$1.4	8%
Professional Service Robots - Defense	\$1	\$1.2	\$1.3	\$1.5	\$1.7	12%

The International Federation of Robotics (IFR) expects global robot shipments to increase to \$73bn by 2022 ^[1].

During this period, demand for PSR will grow at compound annual rate of c.40%, significantly outpacing growth in traditional Industrial robot shipments of c.12% CAGR.

PSR's are dominated by mobile robots, which utilize the latest self driving technology to automate material handling and delivery. The strongest source of demand for this technology will be the logistics sector, which is projected to increase from a \$6bn market in 2019, to a c.\$22bn in 2022.

In the section that follows, we take a deeper dive into robotic automation in the logistics sector, dissecting the trends driving the market and identifying which companies are positioned to benefit from this growth.



Smart Logistics

The New Growth Engine

Logistics and warehousing is one of the industries at the forefront of robotics evolution, ever looking for more efficient methods of storing, tracking and retrieving inventories.

A Shift in End Market Demand

Supply chain Automation takes center stage

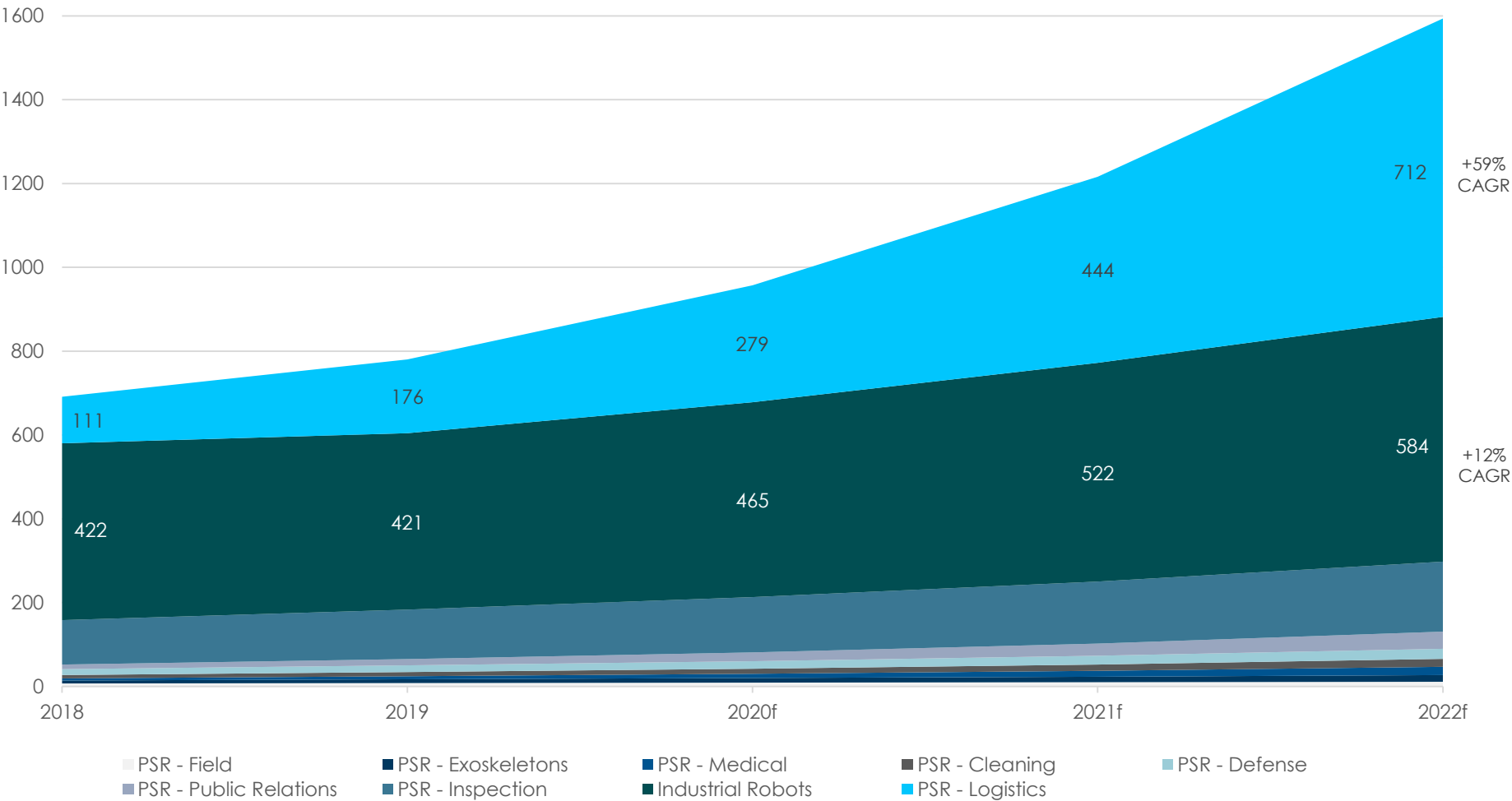
The logistics markets is set to overtake manufacturing as the largest end-market for Advanced Robots by 2022.

According the IFR, in 2018 only 16% of global robotics shipments were destined for the logistics sector. However, demand is rapidly accelerating and **by 2022 the logistics sector is expected to account for 43% of global robotic shipments.**

Underpinning this demand is the adoption of Autonomous Mobile Robots (AMRs), which are designed to automate material handling, an activity that typically accounts for c.25% of total warehouse labor expenses.

In 2018, less than 15% of warehouses in the US utilized AMRs to automate material handling, however by 2025 adoption levels are expected to rise to over 80%.

Global Robotics Sales – ‘000 units

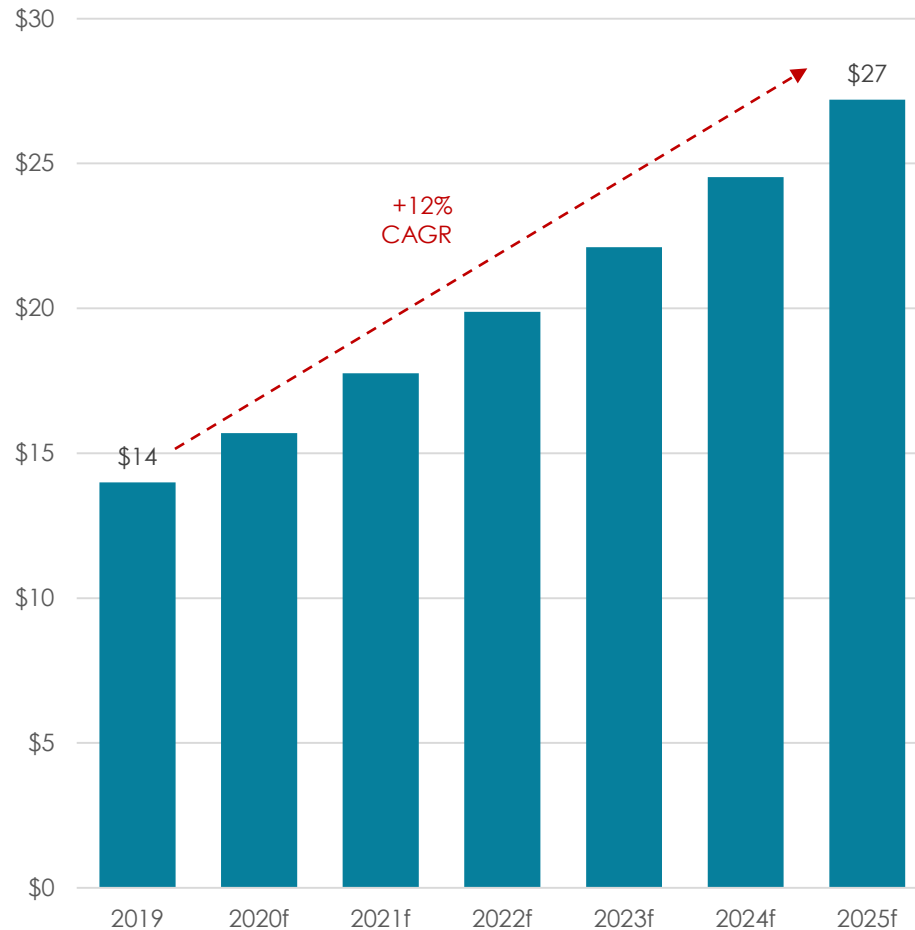


Graph Source: International Federation of Robotics, "World Robots Report 2019"

Introducing the Warehouse of the Future

Initiating Auto-Pilot

Warehouse Automation Market (USD bn) ^[1]

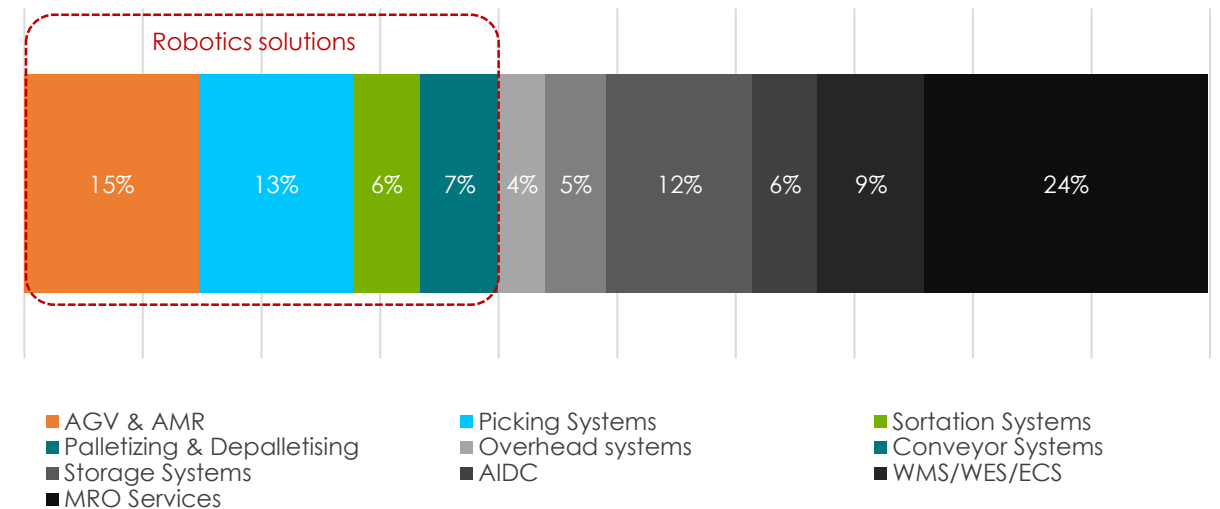


Global supply chains are set to invest heavily into warehouse automation.

Overall, penetration of warehouse automation technologies remains low. According to DHL, **80% of warehouses are still manually operated**, whilst 15% are mechanized (using conveyers and mechanized equipment) and only 5% are fully automated ^[2].

However, as global supply chains embrace the latest innovations in digital technology, a major investment cycle is on the horizon. LogisticsIQ estimates the **global warehouse automation market could double by 2025**. At that point, Advanced Robot Solutions (AMRs, Picking, Sorting and Palletizing) will feature as a key enabling technology that could account for up 41% of the \$27bn in annual spend.

Warehouse Automation Market (2025) ^[1]



[1] LogisticsIQ, "warehouse Automation : Forecast to 2025"

[2] DHL, "Logistics Trend Radar – Version 2018/19"

Warehouse Automation

Traditionally expensive to implement, costly to maintain

The introduction of Autonomous Mobile Robot (AMR) technology is disrupting the warehouse automation market through increased flexibility and lower capital cost.

Historically, warehouse automation was a capital-intensive exercise, reserved for large multinational corporations that could afford investments into big bulky conveyors and automated storage systems.

AMR technology introduces a more modular framework that's mobile, less costly and disruptive to implement and is also able to scale efficiently to both small and large operations.

These mobile robots use technologies like AI, ML, and sensors to continuously improve their own operation, significantly improving efficiency at most utilization levels and reducing overall maintenance requirements.

Traditional Ware House Automation [1]



Level 1: Conventional Picking & Process Improvements

- Implementing new WMS
- RF Picking
- Voice Picking
- Labor Management

\$500k - \$1m

(Payback 6 – 12 months)



Level 2: Mechanized Solutions

- Conveyor/Pick Modules
- Auto Stretch wrap & label
- Layer Picking

\$2m - \$5m

(Payback 1 – 2 years)



Level 3: Semi Automated Solutions

- AS/RS high density storage
- Conveyor
- WCS/WMS Software

\$10m - \$15m

(Payback 3 – 4 years)



Level 4: Fully Automated Solutions

- AS/RS
- Conveyor
- Automated Layer picking and case palletizing
- WCS/WMS software

\$40m+

(Payback 5 – 10 years)

Low

Level of Automation

High

[1] Viastore Systems 2016

Typical Warehouse Robots

Automated Guided Vehicle (AGV)

Description: Mobile delivery vehicles used to move material from point A to point B. Critically, AGVs utilize minimal on-board intelligence and rely on physical guides (wires, magnetic strips, or sensors) to navigate.

Notable Suppliers: Daifuku, JBT, Kion, Eletric80, SSI Schaefer, Swisslog



Autonomous Mobile Robot (AMR)

Description: Mobile vehicles that incorporate of on-board intelligence/sophistication to move goods as part of a dynamic process. AMRs typically rely on GPS and mapping software to navigate and optimize routes.

Notable Suppliers: Seegrid, Fetch Robotics, Otto Motors, Amazon Robots, Geek+, 6 River Systems, MIR, Grey Orange



Mobile Piece Picking Robots

Description: Mobile robotic systems focused on piece-picking and sortation applications rather than general material movement

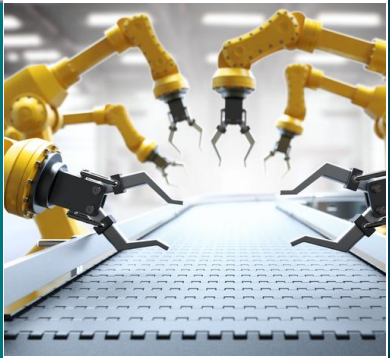
Notable suppliers: Fetch Robotics, Locus Robotics, Amazon Robotics, Locus Robotics, IAM Robotics, Geek+, GreyOrange, 6 River Systems, NextShift Robotics



Stationary Piece Picking Robots

Description: Standard fixed industrial robot arms used to pick and sort goods at various points in the production line.

Notable Suppliers: Kuka, SSI, Intelligrated, ABB, Fanuc, Yaskawa, Kion, Right Hand Robots, Kindred, Osaro, Berkshire Grey



Palletizing Robot

Description: Robots designed to strip or pack pallets as they enter a warehouse. Palletizing robots are typically comprised from standard, fixed industrial robots that are fitted with a dedicated tool to remove packages from a pallet.

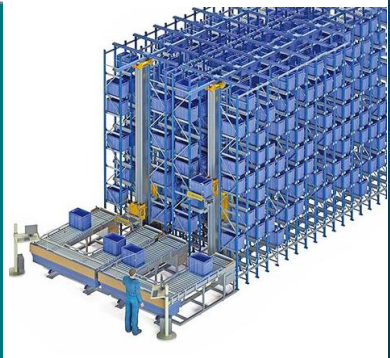
Benefits: Physical automation reduces labor costs whilst smart algorithms are used to build optimized pallets which reduce downstream shipping and storage costs.



Automated Storage & Retrieval Systems (AS/RS)

Description: Automated storage and retrieval systems operate under computerize control to maintain and organize stored items.

Benefits: These systems are able to reduce labor and inventory levels whilst achieving up to 99% accuracy tracking and retrieving inventory.



Ecommerce Demand

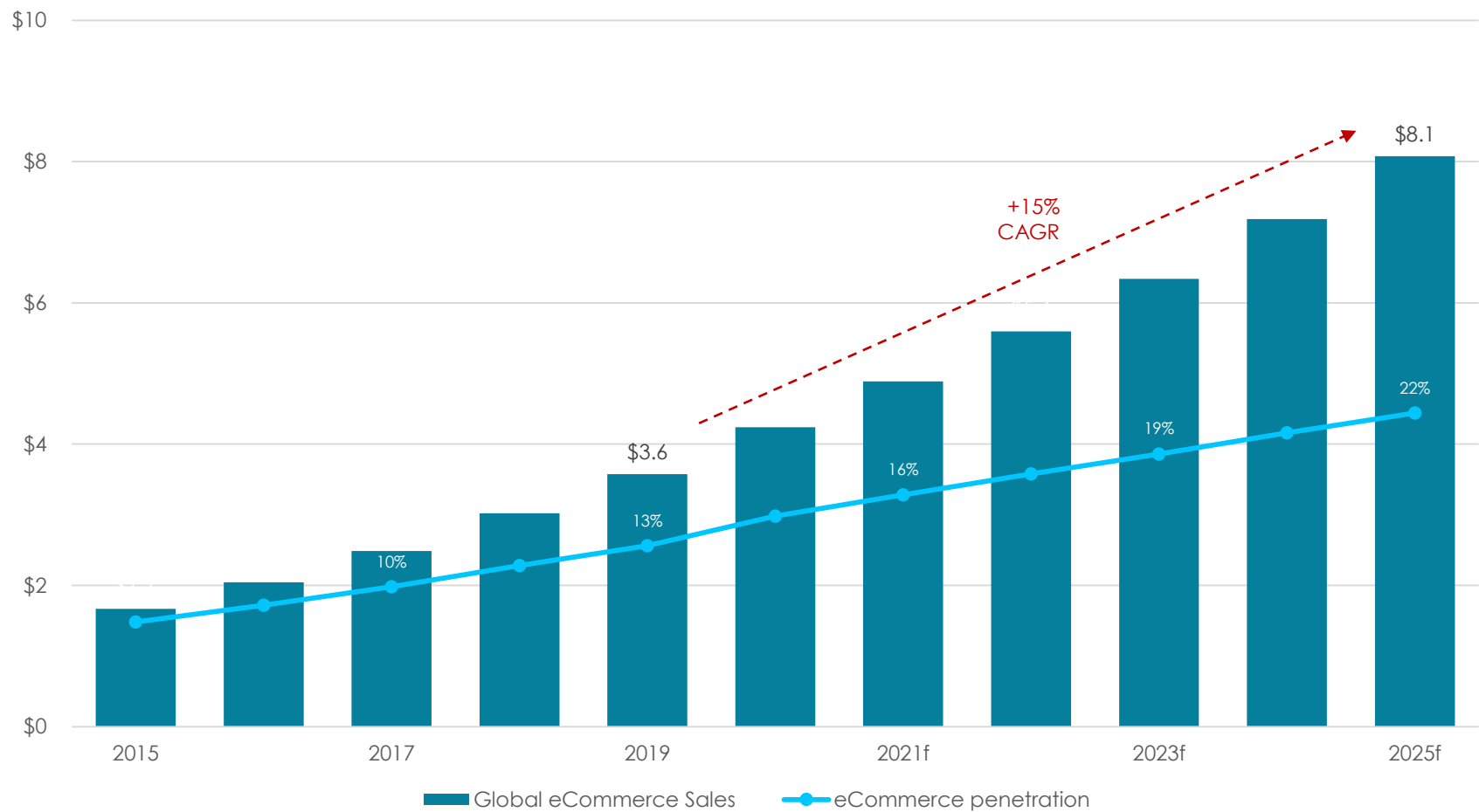
Leading the charge in Supply Chain Automation

The automation of global supply chains is being driven by the eCommerce market, an industry characterized by double-digit secular growth and relatively low levels of physical automation.

For the last two decades, success in the Ecommerce sector has been defined by topline growth and market share gains. As a result, **supply chain infrastructure was designed to accommodate growth as opposed to efficiency**, which has led to the industry becoming **heavily reliant on manual labor** for repetitive tasks.

As the race for market share matures, ecommerce firms are now investing in heavily in automation technologies and Advanced Robotics, especially as shipping cost and delivery times become an evermore important differentiating factor.

Global eCommerce Sales (USD tn) ^[1]

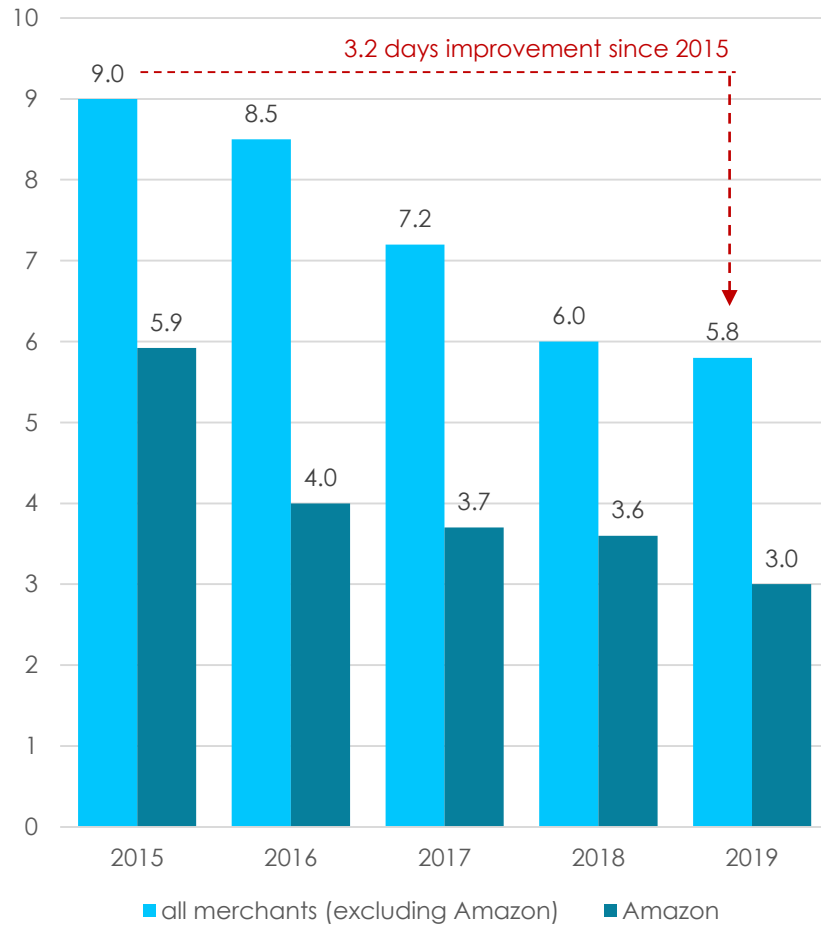


[1] LogisticsIQ, "warehouse Automation : Forecast to 2025"

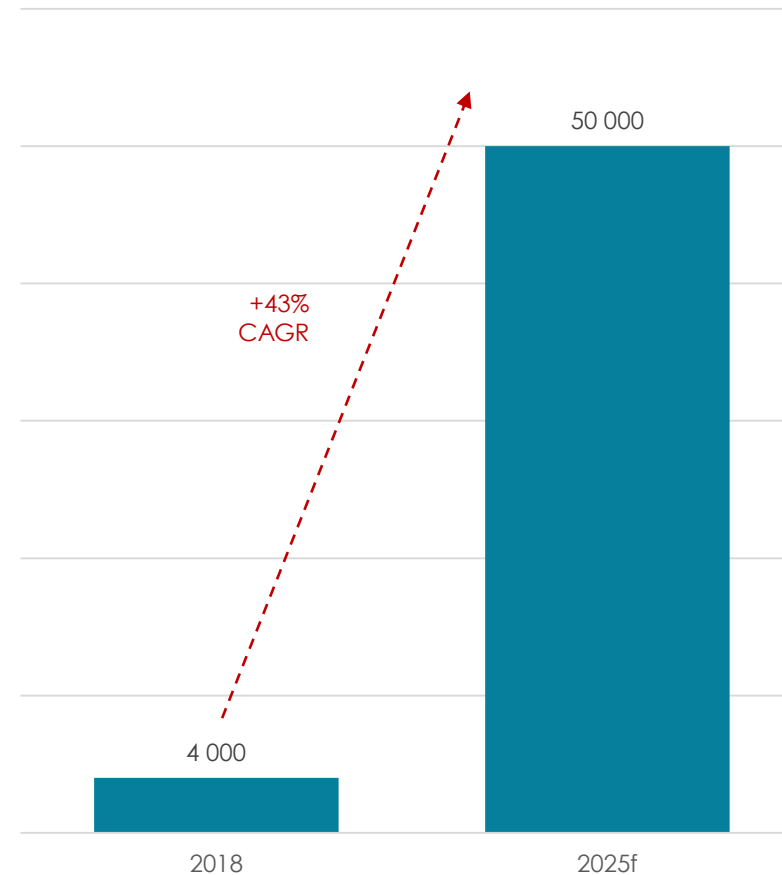
Ecommerce Automation

Demand for rapid fulfillment

US average Click-to-door Speed (Days)^[1]



Robot-powered warehouses (Global Sites)^[2]



As consumer pressure mounts, for same day delivery to become an industry standard, eCommerce companies will increasingly turn to robots to gain a competitive advantage in their supply chain.

ABI Research estimates that the number of **warehouses using robotics for automation will increase 12 fold**, from 4k to 50k sites by 2025^[2].

Leading the charge in automated fulfillment is Amazon, which holds c.50% of the online market in the US. In 2012, Amazon placed a major bet on robot fulfilment, acquiring Kiva Systems, for \$750m. Since then Amazon has grown its portfolio of Robot Enabled Fulfillment centres from 3 to 50, with its fleet of mobile robots recently exceeding 200k units globally^[3].

These investments have allowed Amazon to reduce its click-to-door lead times by three days over the last four years, which has allowed the group to maintain a three-day-lead over its peers.

Case Study: Amazon Robotics

At the forefront of Warehouse Automation

In 2019, Amazon announced its ambition to deliver packages to customers within 30 minutes of placing their order [2].

To achieve this goal, Amazon is investing billions of dollars in fully automating the handling of packages - from warehouse to customer.

Phase one of Amazon's strategy, centred on mobile robot technology to fully automate the handling of goods within the warehouse. Since 2012, Amazon have successfully implemented robotics automation systems in 27% of their 185 global fulfilment centres [1].

Phase two, shifts focus towards last mile delivery, which Amazon plans to automate using a larger form factor AMR (Amazon Scout) and a fleet of autonomous Arial drones.

Amazon Xanthus – Warehouse AMR



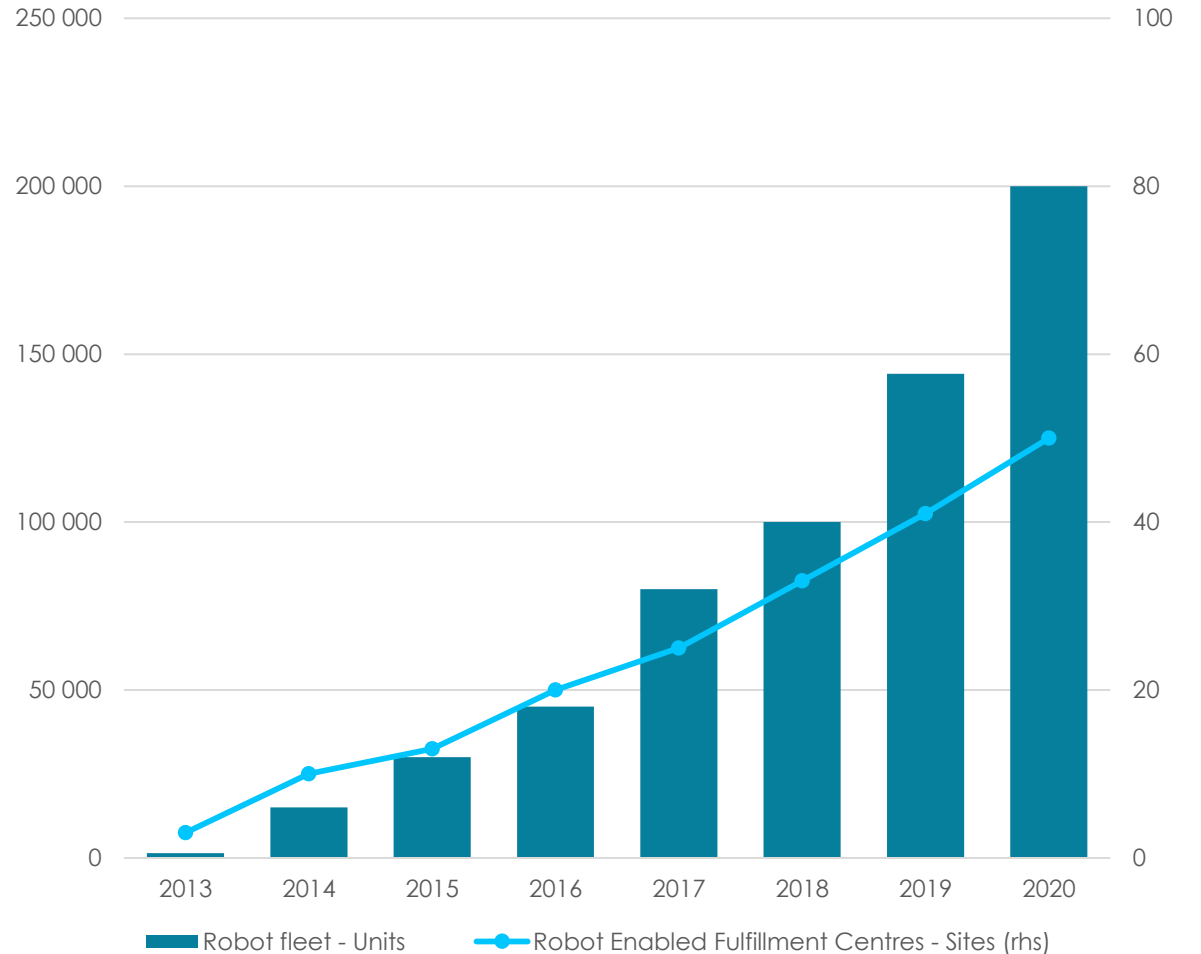
Amazon Scout – Autonomous Delivery



Amazon Prime Air – Drone Delivery



Amazon Robot Portfolio [1]



[1] Amazon Financials + Amazon Website

[2] 5lb package delivered within 10 miles in the US

Market Map: Warehouse Robotics

Market segments & growth beneficiaries

The number of warehouses utilizing robot technology is expected to grow by 43% CAGR, over the next five years ^[1].

Robotic Hardware suppliers that are in a position to benefit, can be segmented into four distinct growth categories:

- Traditional OEM's, which will need to invest heavily into new technologies to remain relevant and gain access to new growth categories;
- AMR supplies, which are on the cusp of mass adoption;
- Advanced Picking Robots, an emerging category that represents the next leg of innovation and growth; &
- Robot accessories and software, which we explore further in the next section.

Industrial Robot OEM's

Traditional robot OEMs are well positioned to benefit, from wider warehouse automation adoption. However, their product mix is weighted towards Industrial robot arms, a category that is expected to deliver relatively muted growth of c.12% CAGR ^[2].

To remain competitive, major players are investing heavily in the latest technologies and emerging categories. This strategy is complimented by strategic M&A activity, to gain access to key technologies and new markets.



Autonomous Mobile Robot (AMR)

AMR technology is the fastest growing segment within warehouse automation and robotics. According to the IFR, global AMR shipments are expected to grow c.59% CAGR ^[2].



Advanced Picking Robots

A wave of new ventures are investing heavily into advanced picking technologies.

Whilst early solutions have show strong promise, the technology is still in its infancy. However, as picking speeds improve and hardware prices drop, this category should gain mass market appeal within the next five years.





Emerging Technologies

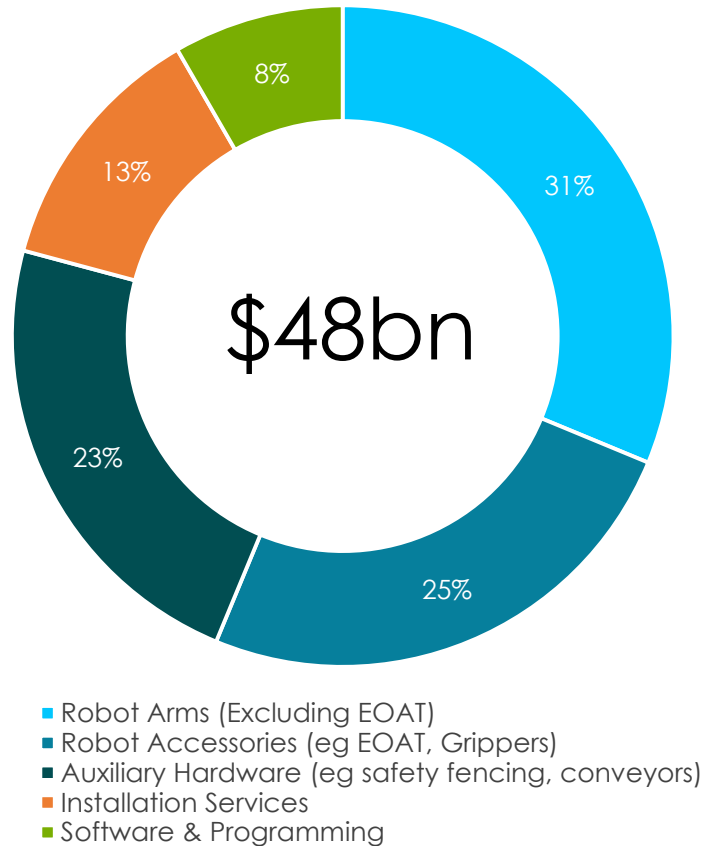
An ecosystem full of opportunities

The real advancements in Robotic technology are being driven by innovations in robotic components and software.

Robotics Components and Software

The focal points for Robotic innovation

Industrial Robot Systems Market ^[1] - (USD bn)



The real advancements in Robotic technology are being driven by innovations in Robotic Components (Sensors, batteries, EOAT) and Software.

Robot Arms

The wider Industrial Robot ecosystem is worth c.\$48bn pa, Although the robot arm itself accounts for c. 30% of annual sales, it has become a relatively commoditized piece of hardware and a minor source of innovation.

Robot Accessories

The Robot accessories market represents a major source of innovation. The market generates c.\$12bn in revenue pa. It is dominated by End-of-Arm-Tooling (EOAT) components, which serve as a pivotal interface between the robot and the material they handle. As industrial robots become more sophisticated and hardware costs are driven lower, new industries are experimenting with a variety of new robotic tools and accessories.

Robotic Software

Whilst Software & Programming currently enjoy a relatively modest share of the market, the industry is rapidly adopting new digital technologies, including Cloud Robotics, AI and Machine Vision. As this trend matures and data becomes more available, new platform based business models will emerge and software will become the focal point for innovation and productivity gains.

[1] McKinsey , "Industrial Robots – Insights into the Sectors Future Growth Dynamics"

Market Map: Advanced Robot Components & Accessories

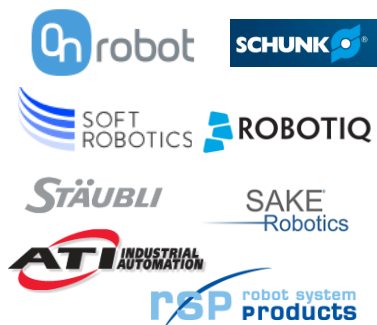
Wider value chain of opportunities

Grippers & End of Arm Tooling

Description: Companies that design and manufacture specialty tools that can be fitted to standard robot arms.

Notable applications:

- Vacuum suction
- Pick-and-place
- Palletizing
- Quality testing and inspection
- Finger grips



Motors & Motion Control

Description: Companies that design and manufacture electrical motors and motion control components used to drive mobile robots and AGV's.



Machine Vision and sensors

Description : Companies that provide the hardware (Cameras, sensors) and software that allow robots to analyze and interpret the physical environment.

Notable Applications:

- Inventory control
- Inspections
- Process control
- Automated maintenance
- Collision avoidance



Robot Battery Suppliers

Description: Companies that produce the batteries that power mobile robots and drones.



As robotic systems become more sophisticated, third party component suppliers are investing in new technologies in order to compete.

Faster, more accurate picking requirements, have directed considerable R&D spend towards innovative grips and tolling.

The ability to navigate dynamic environments safely, has been facilitated by advancements in machine vision technology and advanced sensors.

The rise of mobile robots, is developing into a major market for battery suppliers.

Robotics Software Market

The Industrial Sector is facing a wave of data that needs to be organized

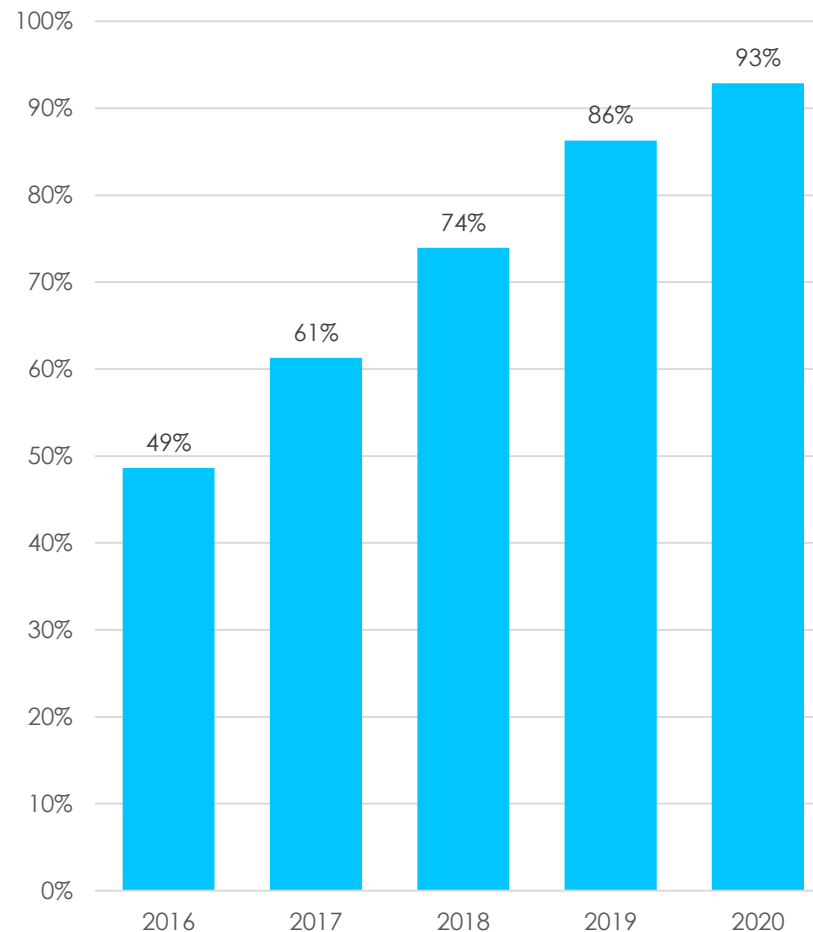
As more robots connect to the cloud, new platform-based business models will emerge.

In 2016 less than 50% of robots sold globally were connected to internet, fast-forward to today & over **90% of robot's shipped will be able to connect through the cloud** [1].

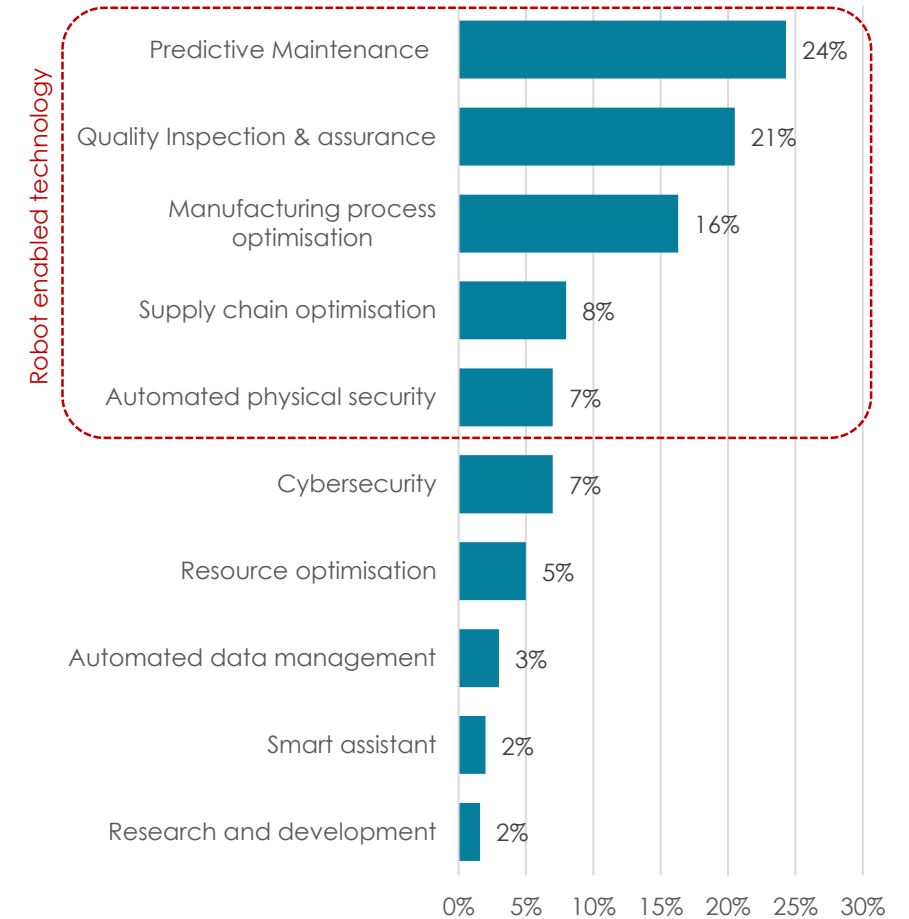
As a result, traditional industries like manufacturing and logistics, which have been slow to embrace digital technologies, are now **facing a wave of data and vast number of opportunities to leverage digital technology and AI.**

This is a challenge that will be embraced by software companies seeking to disrupt a large, established market traditionally reserved for the big global ERP providers.

Annual Robot Sales [1] - % connected to the cloud



Top ten Industrial AI use cases [2]



Market Map: Emerging Robot Services

Hardware provides mobility, but the software provides the intelligence.

The business of making robots think, see and have spatial awareness is where major investment is going.

Real-time cloud data analytics and processing are understandably targeted by the world's largest tech companies, most notably Google and Microsoft.

Google's AI projects like TensorFlow are likely to become building blocks of ever-more complex robotic implementations.

Robotics as a service are becoming more commonplace, reducing cost of ownership and enabling growth at the lower end of the market.

Digital twinning and simulation will further help reduce costs and improve usability, with simulation able to identify and correct problems before they arise.

Robot as a Service (RAAS)

Description: Providing robot hardware as a leasing option that includes the provision of software and maintenance.

Notable Benefits:

- Lower upfront costs for SMEs
- Better life time ROI's for OEMs
- Reduced risk of ownership through remote monitoring



Cloud Robotics

Description: Cloud storage & tools, designed for advanced robot applications. The market is dominated by the major cloud providers, leveraging their investments into autonomous driving technology.

Notable Benefits:

- Remote Monitoring
- Status reporting
- Intelligent visual & voice processing
- Remote software updates



Autonomy System Providers (ASP)

Description: Autonomous navigation technology that is interoperable with a range of mobile vehicles, and which is available from multiple OEMs

Notable Benefits:

- Interoperability
- Centralized control
- Process optimization
- Hardware flexibility.



Digital Twin

Description: Creating digital models of physical objects and networks to derive insights through simulation combined with real time data collected from sensors on the device.

Notable Benefits:

- Scenario planning
- Predictive maintenance





M&A Lead Generation

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M&A Activity

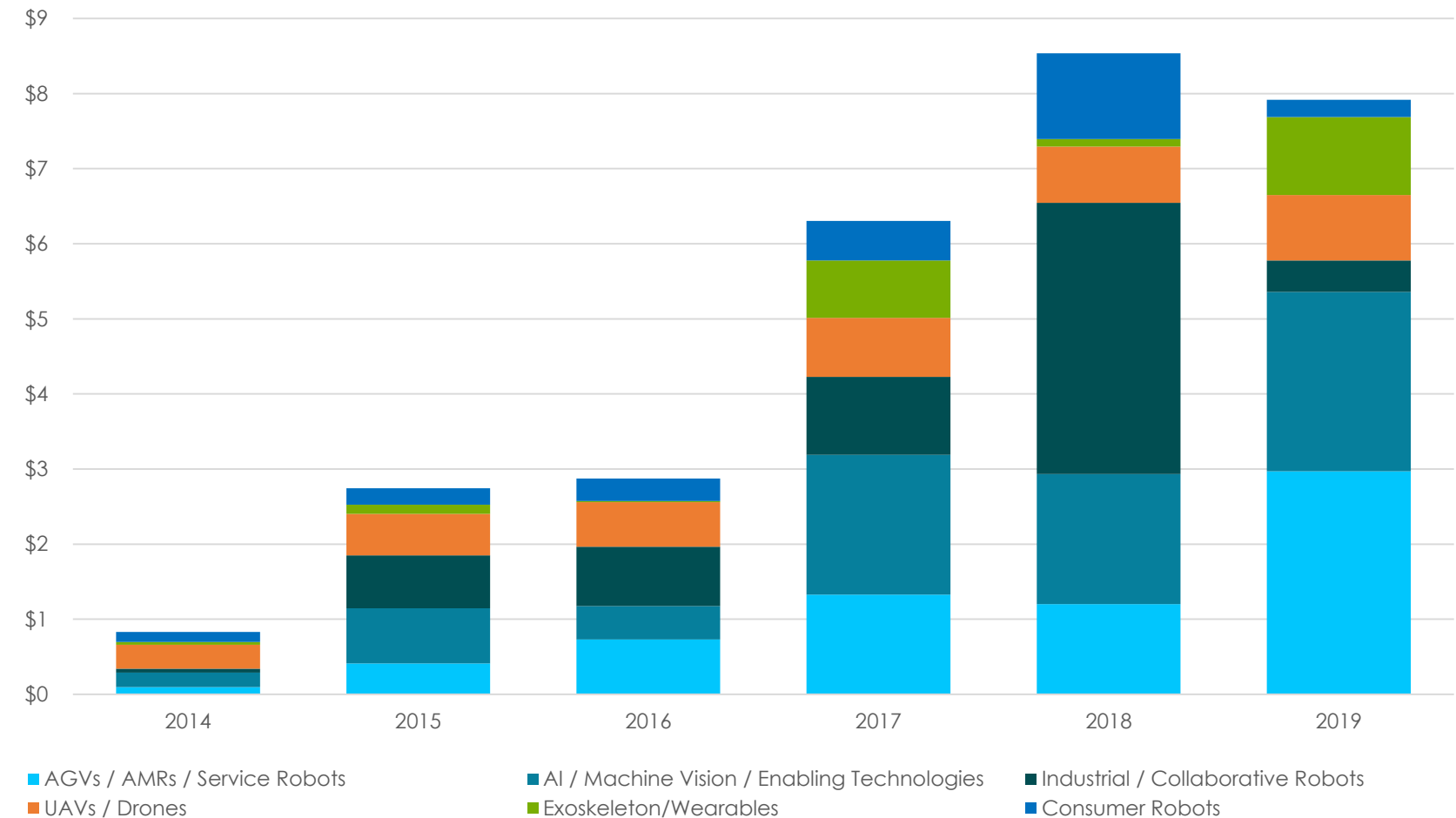
Where is the money going ?

Strong venture capital support since 2015, should sustain a healthy pipeline of M&A activity going forward.

Global Robotic Investment Activity

Demand for Rapid Fulfillment

Private Investments by Robot Category (USD bn)^[1]



Venture Capital Activity

After five years of growing support, venture capital funding saw a correction in 2019, as the number of deals fell to 66 (vs 122 in 2018). However, start-up funding has gained early momentum during the first quarter of 2020, with 24 funding rounds announced, including Berkshire Grey's c.263m Series-B round.

M&A Activity

Mobile robot ventures that were established between 2013/15, are now maturing into attractive M&A targets. Notable deals include Shopify's \$450m acquisition of 6 River Systems in 2019; Teradyne's \$273m acquisition of Mobile industrial Robots (MIR) in 2018, as well as 2019 acquisition of AutoGuide Mobile Robots for \$165m.

IPO Activity

On average, eight robotic companies have listed each year since 2017. Deal activity has been dominated by Chinese exchanges, which have accounted for over 75% of global listings.

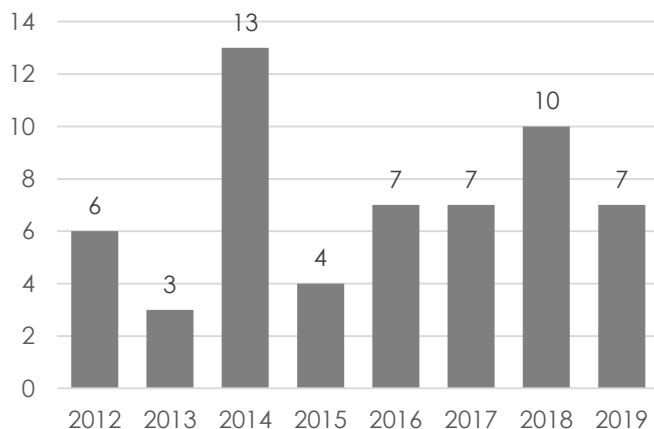
Robotic IPOs

Recent Robotic listings, concentrated in Asian Markets

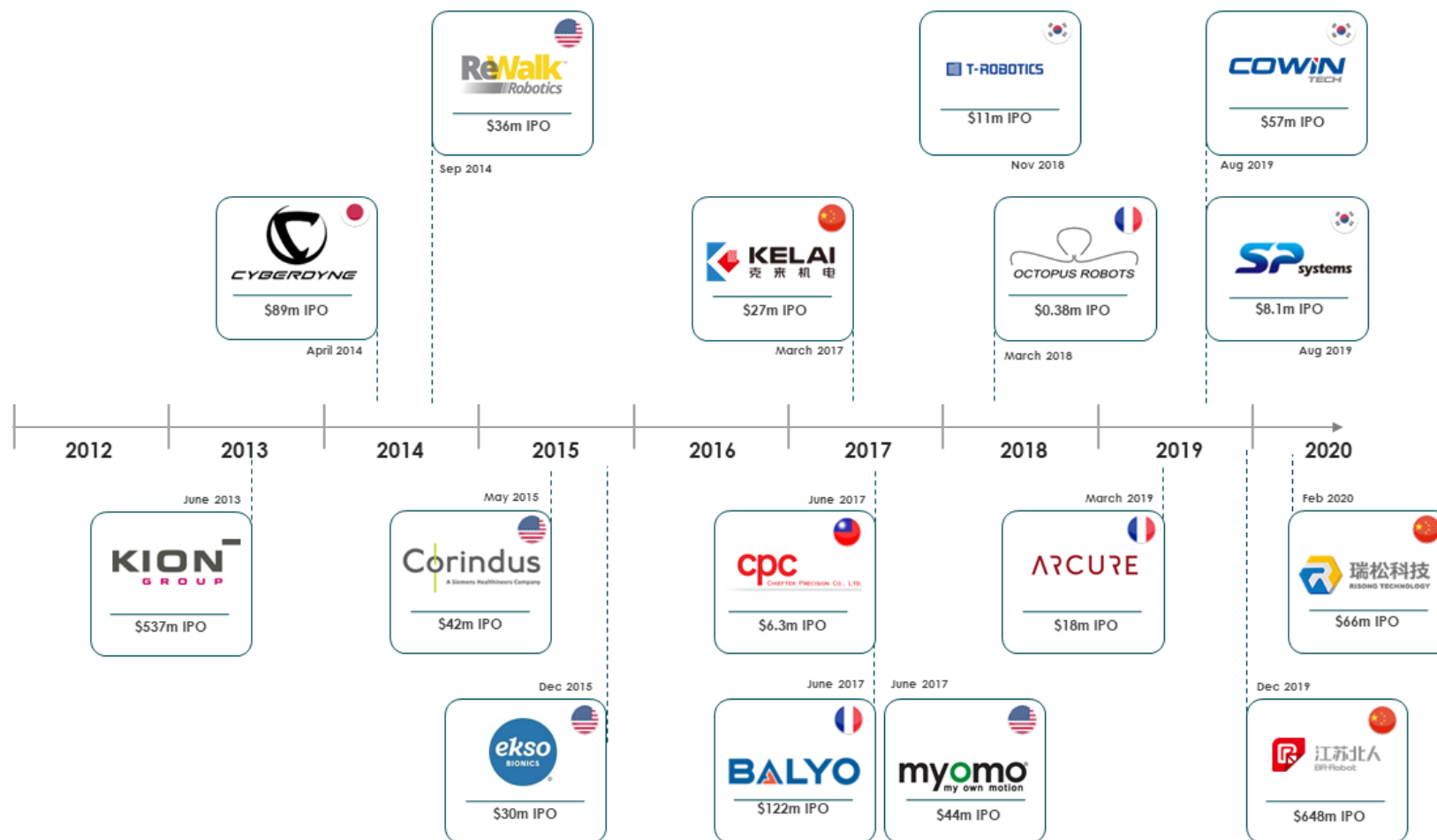
Robot IPO Snapshot – Since 2017

Number of transactions	23
Mean Transaction value	\$62m
Mean 1yr return from IPO	132%
Aggregate IPO Value	\$1.4bn
SHSE	24%
SZSE	22%
SEHK	24%
SWX	17%

IPO – Number of Deals



Notable IPOs



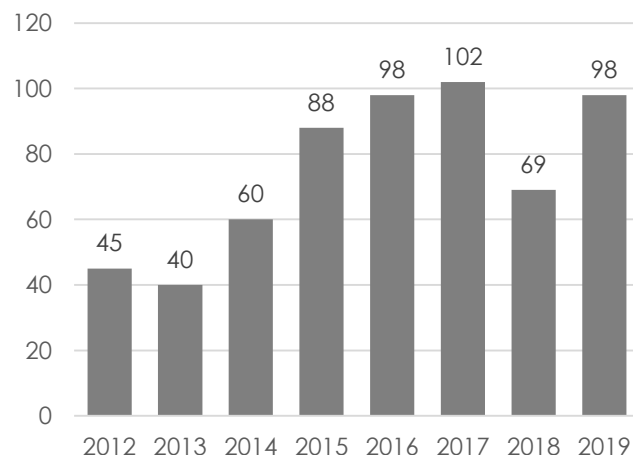
M&A Activity

Access to technology is driving consolidation

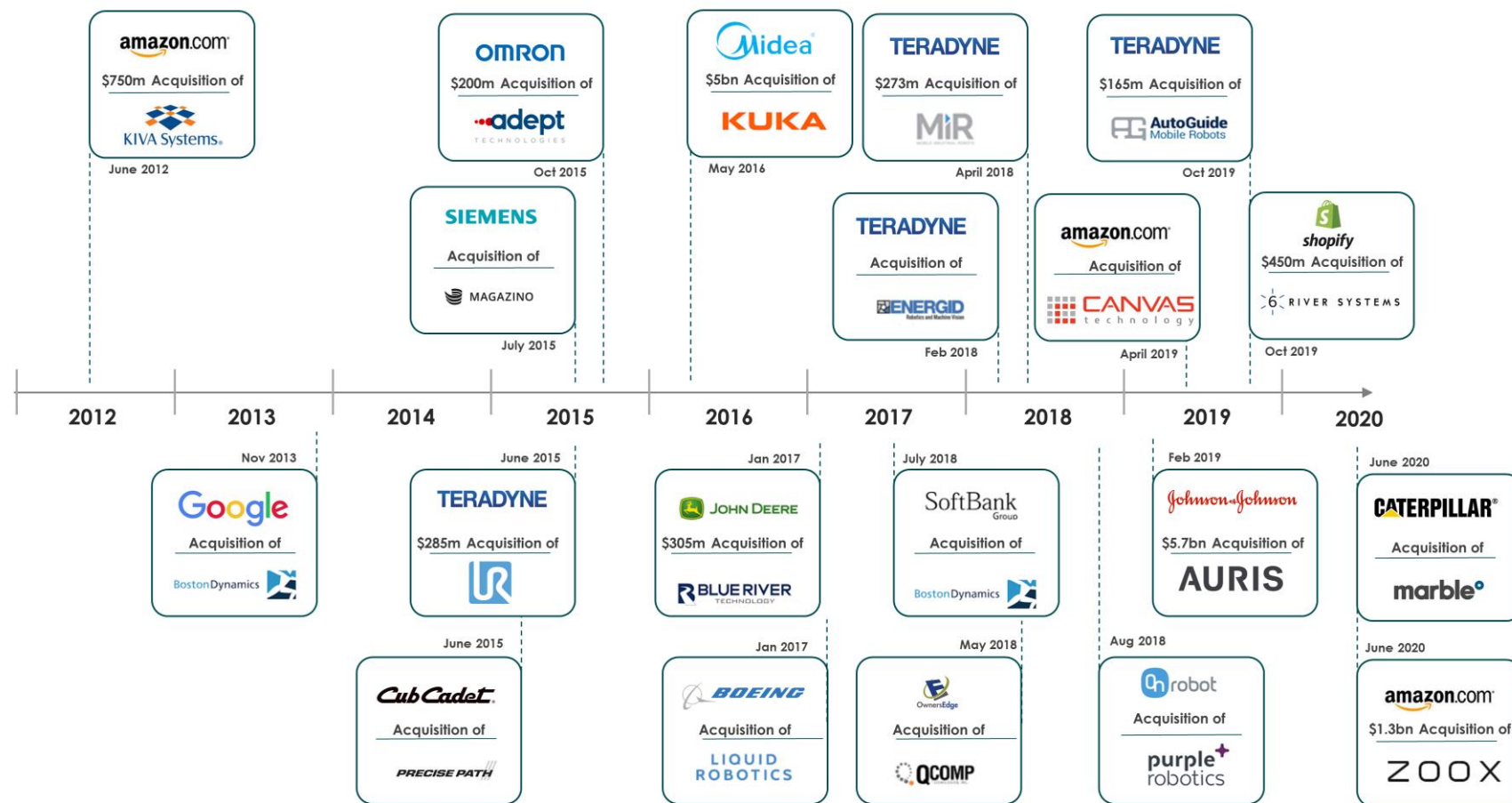
Robot M&A Snapshot – Since 2017

M&A Activity	\$14bn
Deal Count	269
Mean Transaction size	\$146m
Mean EV/EBITDA	18x
Mean EV/Sales	9x
Mean Listed Multiples^[2]	
EV/EBITDA	16x
EV/Sales	3x

M&A – Number of Deals



Notable Transactions



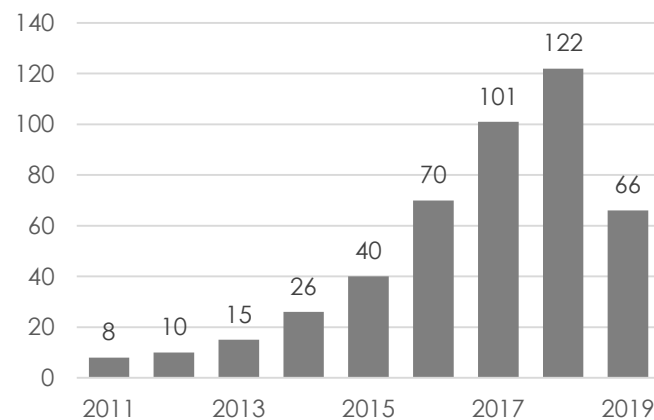
Robotics VC Funding History

Subdued support in 2019

VC Funding Snapshot – Since 2017

Total VC Funding - USD	\$24bn
Total Number of Deals	317
Mean Deal Size	\$68m
- Series A	\$25m
- Series B	\$43m
- Series C	\$55m
- Series D	\$76m
- Series E	\$53m

VC Funding – Number of deals



Notable Funding Rounds ^[1]

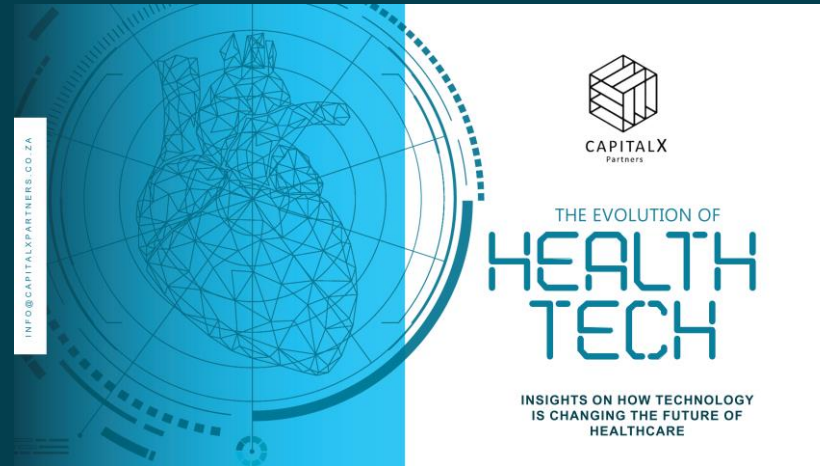
Date	Issuer	Location	Category	Funding Round	Raised (USDm)	Funding to Date (USDm)	Lead Investors
Mar-20	Seegrid	USA	AMR	Series E	\$25	\$84	G2VP
Jan-20	Berkshire Grey	USA	Industrial Robots	Series B	\$263	\$263	SoftBank
Jan-20	Soft Robotics	USA	EOAT	Series B	\$23	\$48	Calibrate Ventures,
Dec-19	Gecko Robotics	USA	Niche Robot	Series B	\$40	\$49	Drive Capital
Dec-19	Keenon Robotics	China	Niche Robot	Series B	\$29	\$29	Source Code Capital
Jul-19	Geek+	China	AMR	Series C	\$150	\$389	D1 Capital Partners, GGV Capital
Apr-19	Locus Robotics	USA	AMR	Series C	\$26	\$59	Scale Venture Partners, Zebra
Apr-19	Jaka Robot	China	Co-Bot	Series B	\$15	\$39	SAIF Partners
Feb-19	Nuro	USA	AMR	Series B	\$940	\$1032	Softbank
Feb-19	Veo Robotics	USA	Co-Bot	Series A	\$15	\$28	Baidu Ventures
Nov-18	Geek+	China	AMR	Series B	\$150	\$389	Warburg Pincus
Sep-18	GreyOrange	Singapore,	AMR	Series C	\$140	\$170	Mithril Capital Management
Sep-18	Sarcos	USA	Industrial Robots	Series B	\$30	\$56	Alex. Brown & Sons, DIG Investments
Aug-18	inVia Robotics	USA	AMR	Series B	\$20	\$29	Point72 Ventures
May-18	UBTech Robotics	China	Humanoid	Series C	\$820	\$940	Tencent Holdings
May-18	Soft Robotics	USA	EOAT	Series A	\$20	\$48	Hyperplane Venture Capital,
Feb-18	Magazino	Germany	AMR	Series A	\$25	\$25	Korber AG, Zalando
Feb-18	Miso Robotics	USA	Food Prep Bot	Series B	\$10	\$13	—
Jan-18	6 River Systems	USA	AMR	Series B	\$25	\$46	Menlo Ventures
Dec-17	Fetch Robotics	USA	AMR	Series B	\$25	\$94	Sway Ventures
Dec-17	Cobot	China	Co-Bot	Series B	\$15	\$21	GGV Capital, Lan Fund
Nov-17	Locus Robotics	USA	AMR	Series B	\$25	\$59	Scale Venture Partners
Oct-17	Built Robotics	USA	Industrial Robots	Series A	\$15	\$48	New Enterprise Associates (NEA)
Oct-17	Veo Robotics	USA	Co-Bot	Series A	\$12	\$28	GV, Lux Capital
Aug-17	Rethink Robotics	USA	Co-Bot	Series E	\$18	\$150	—
Jul-17	6 River Systems	USA	AMR	Series A	\$15	\$46	Norwest Venture Partners
Jul-17	Geek+	China	AMR	Series B	\$60	\$389	Warburg Pincus

[1] Source: Crunchbase

[1] Excludes Robotic Software Deals

CapitalX Insights

Recommended Reading

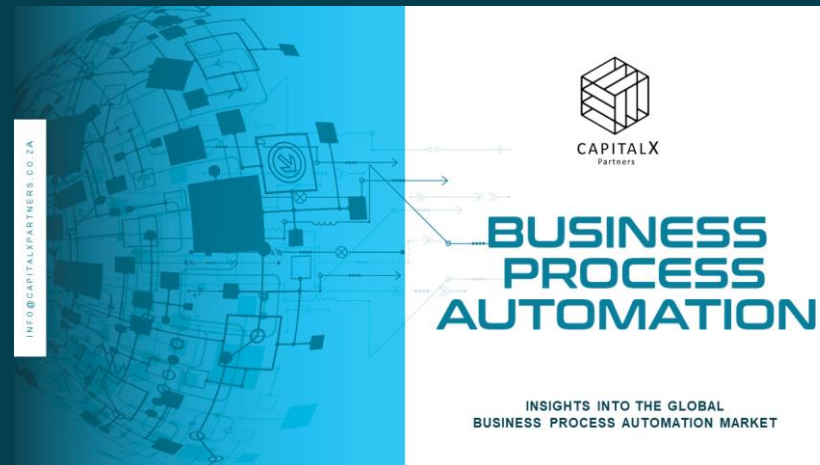


The Evolution of Health Tech

Insights on how technology is changing the future of healthcare

In this report we investigate the evolution of healthcare technology, covering aspects of telehealth, the proliferation of mobile medical devices and the future of healthcare and related services.

Of specific interest is the impact of Covid-19, which has triggered a rapid acceleration of remote monitoring and care of high-risk categories.



Business Process Automation

Insights Into The Global Robotics Sector

A platform that provides online "care coordinators" that are trained to assist Seniors with a variety of non-medical tasks, including transition advice, sourcing and vetting in-home care providers, researching senior living

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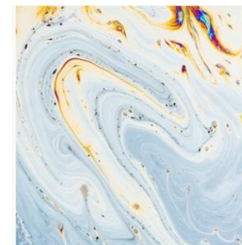
Executive Insights

Our team of analysts specialize in sourcing purpose lead data to generate key insights, which enable our clients to execute smart, informed decisions.



Corporate Strategy

We work with our clients to develop comprehensive strategies for success. We leverage our experience in market research to design strategic outcomes for our clients that is underpinned by hard data and deep fundamental analysis of underlying drivers



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We are able to assist our clients with transactional advisory services including M&A search, capital raising and deal structuring



Financial Modeling

We utilize financial analysis and forecasting to provide insights on financial standing and business health. We develop valuation models for our clients, to help them quantify the value unlock expected from growth and strategic projects

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CapitalX is a research led strategy and advisory firm, with a specialized focus on innovation and technology.

We use market research and data science to gain perspective on market opportunities and business challenges. These insights allow our clients to identify market opportunities, de-risk key decisions and execute strategic initiatives with confidence.



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