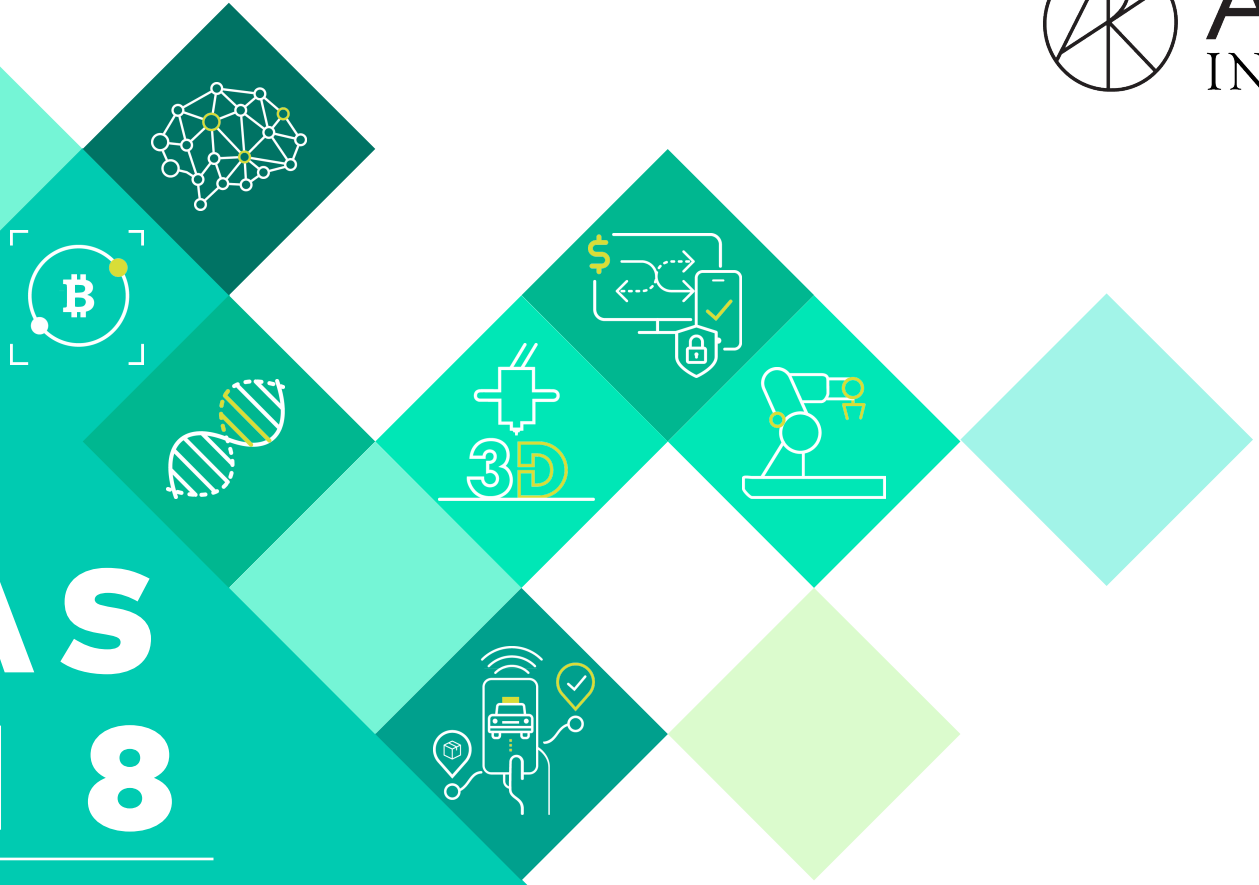
ARK INVEST

BIG IDEAS 2018

DISRUPTIVE INNOVATION



www.ark-invest.com

For informational purposes only | Updated March 19, 2018

ARK INVEST | BIG IDEAS 2018

About ARK Invest

Rooted in almost 40 years of experience, ARK Invest aims to identify large-scale investment opportunities resulting from technological change. ARK Invest focuses solely on offering investment solutions that capture disruptive innovation in the public markets.

WE BELIEVE INNOVATION IS KEY TO GROWTH.

About Big Ideas

"Big Ideas" is ARK's annual publication showcasing a selection of innovations that we believe will accelerate the pace of change. The research presented in the following slides aims to illustrate how these ideas are transforming the way the world works and delivering outsized growth opportunities across different industries.

Each section highlights a technologically enabled innovation and provides a short research analysis, before briefly sizing the investment opportunity.

Mobility-as-a-Service (MaaS)

Robotics

Deep Learning

CRISPR Genome-Editing

Cryptoassets

Frictionless Value Transfers

3D Printing

ARK's Research Team

ARK's analysts are organized by cross-sector disruptive innovation themes. Each analyst is focused on different innovation elements.

JOIN THE CONVERSATION AND GET IN TOUCH WITH ARK'S ANALYSTS.

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@juliahARK

ARK INVEST | BIG IDEAS 2018

MOBILITY-AS-A-SERVICE

Research by Tasha Keeney and Sam Korus

A Review

2004

DARPA* launches Grand Challenge, a Competition to Foster the Development of Self-Driving Ground Vehicles

(*Defense Advanced Research Projects Agency)

2009

Google Self Driving Car Project Begins

2015

Tesla Launches First Version of Autopilot Software

2016

Tesla and Chevy Launch the First "Mass Market" Electric Vehicles

2017

Large Automakers Begin Making Commitments to Phase Out Fossil Fuel Cars

Planned and Announced Global Battery Production Capacity Doubles from Previous Year to 273 GWh

Waymo Begins Testing Autonomous Cars on Public Roads Without Safety Drivers

WAYMO

Source: ARK Investment Management LLC, 2017 | A selection of events, achievements and innovation milestones.

Today, We See Two Transformations In The Mobility Space

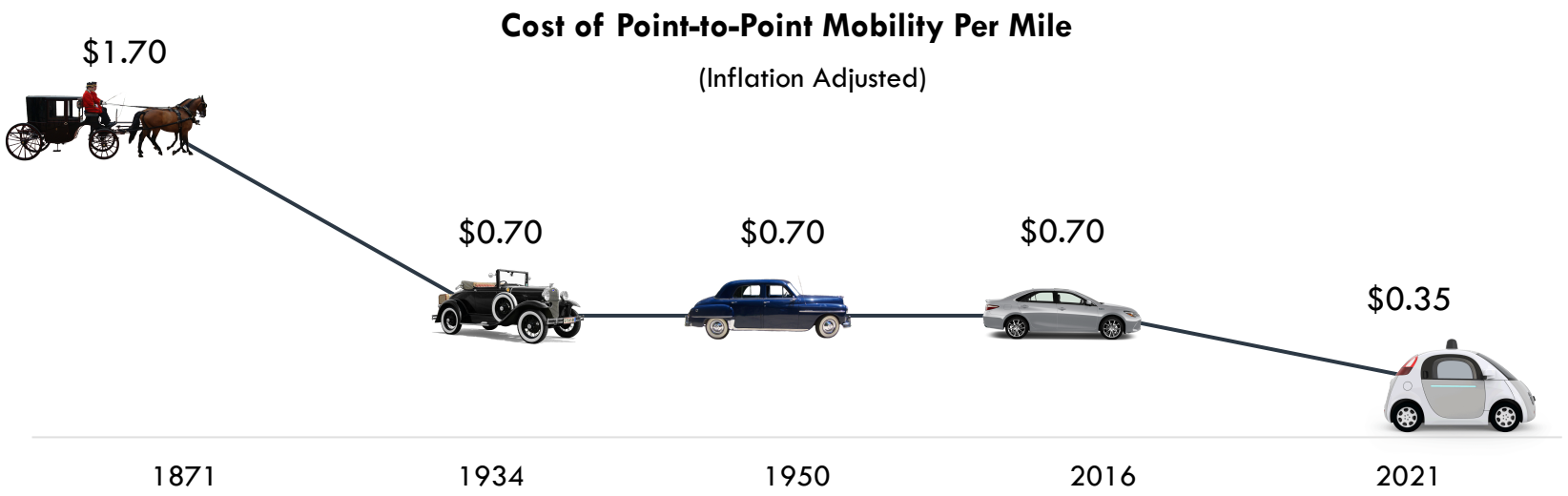
1 ..... **GAS-POWERED** → **ELECTRIC**

2 ..... **HUMAN-DRIVEN** → **AUTONOMOUS**

Autonomous platforms, or Mobility-as-a-Service (MaaS), will come in many different forms, including:

Personal Mobility Should Become More Affordable

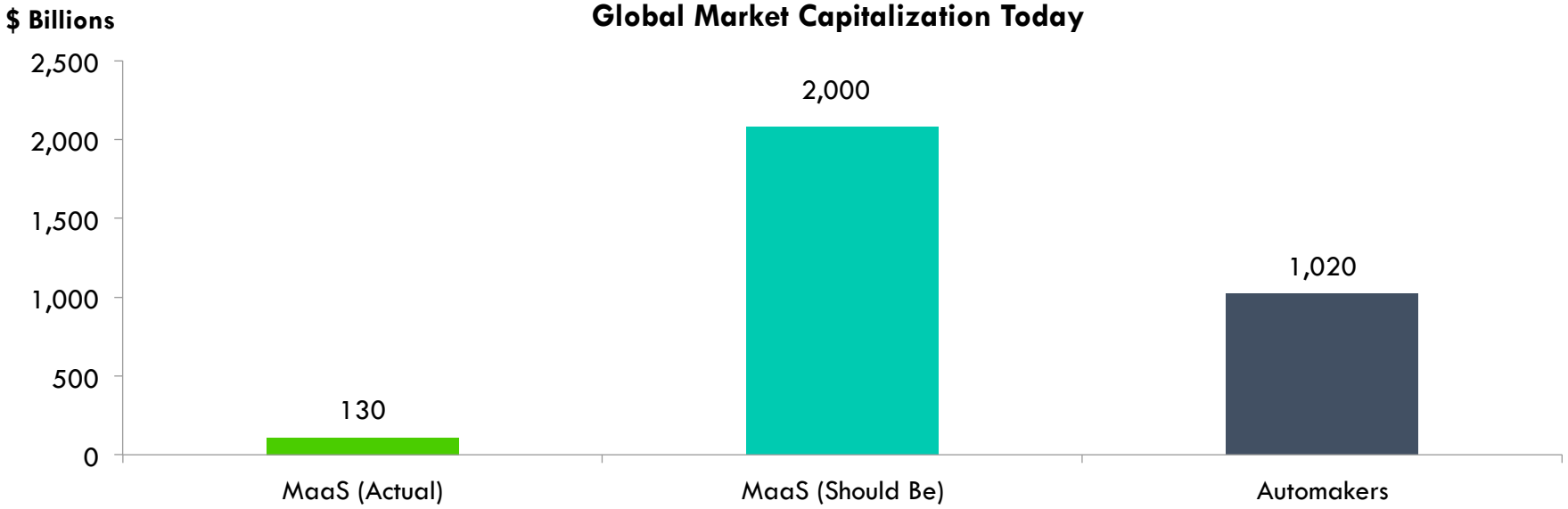
The price of personal mobility has not changed since the Model T.



Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017 | Morton Salt Company Records, American Automobile Association (AAA)

ARK's Research Shows…

…that MaaS should be valued today at $1-3 trillion dollars.

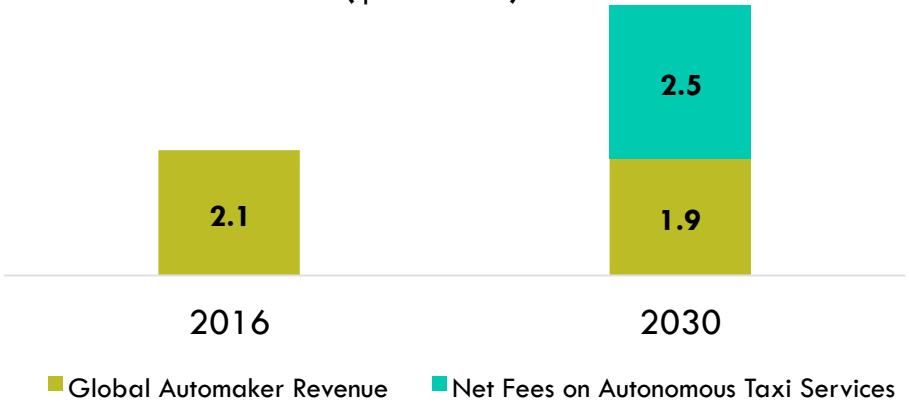


Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017

Platform Providers Could Be The Big Winners

ARK believes autonomous platform providers will be roughly 9 times more valuable than the automakers. Likely candidates are Baidu, Alphabet, and Tesla.

Revenues of Automakers and Autonomous Platform Providers ($ Trillions)



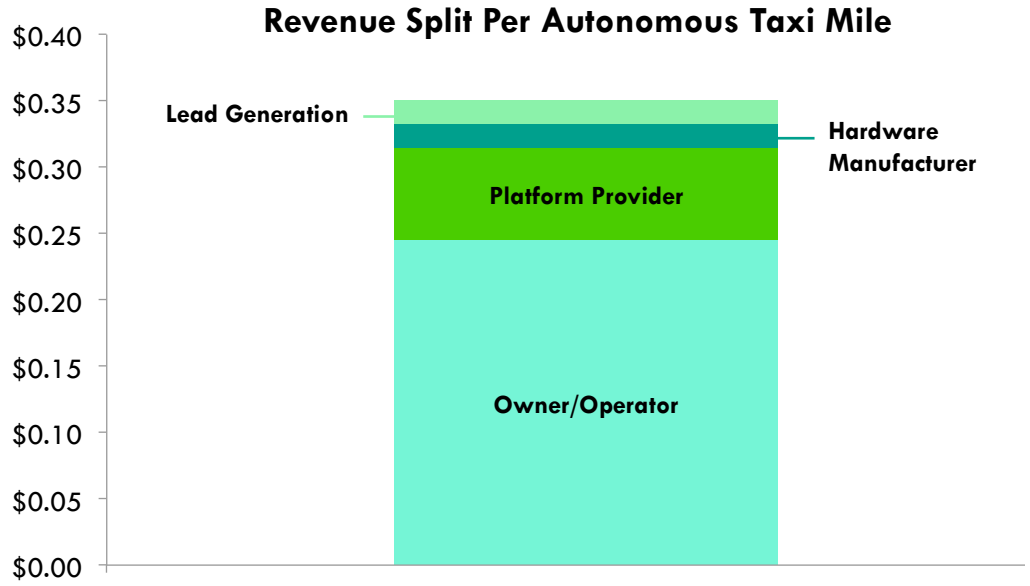
EBITDA for Automakers and Autonomous Platform Providers ($ Trillions)

Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017

EBITDA is an accounting measure calculated using a company's net earnings, before interest expenses, taxes, depreciation, and amortization are subtracted, as a proxy for a company's current operating profitability

The Revenue From Autonomous Taxi Services Will Be Shared

Autonomous MaaS revenue probably will be split among owners, platform providers, manufacturers, and lead generators.



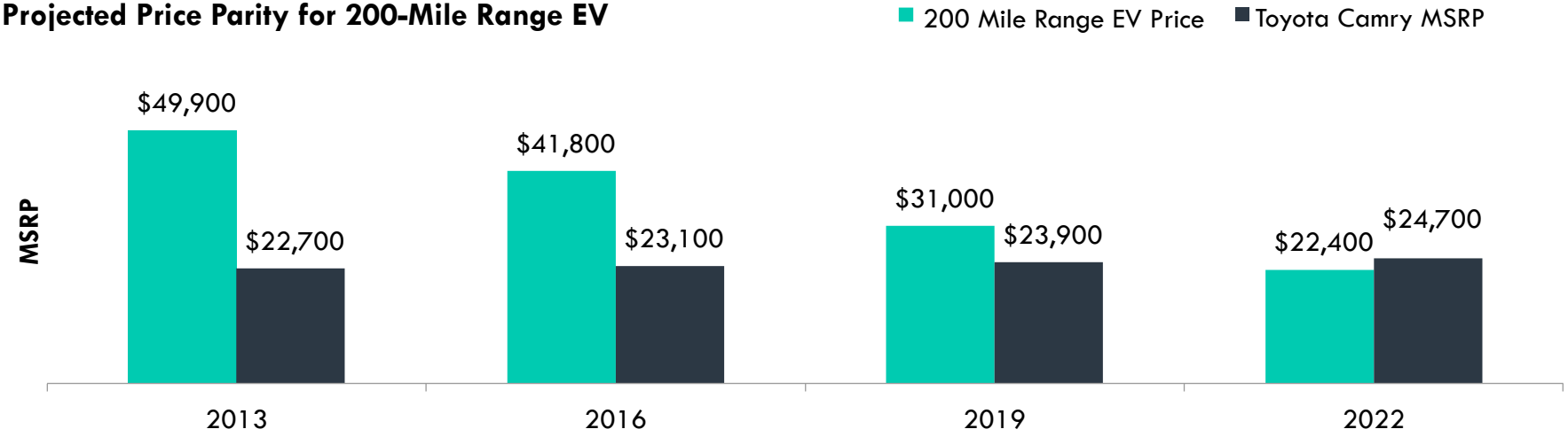
- **Lead Generation:** A share of revenue-per-mile could go towards lead generation and/or traffic acquisition.
- **Hardware Manufacturer:** Today vehicle manufacturers earn roughly 1 penny per mile traveled. In the autonomous MaaS market, hardware manufacturers should benefit either from upfront sales or a recurring revenue stream from autonomous taxis with much higher utilization rates.
- **Platform Provider:** Much like ridesharing firms take a cut of per mile revenues today, we expect MaaS platforms to take a similar, if not higher, share of revenues because they are offering more value than today's ridesharing firms. The share of revenue that MaaS platform firms will command will depend on how much of the technology stack and data pool they control.
- **Owner/Operator:** Owners of the vehicles could be individuals, auto companies, taxi firms, or commercial fleet operators. We expect them to garner most of the revenues and be responsible for most of the maintenance.

Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017

ARK Believes Electric Vehicles Likely Will Dominate Transportation

Because battery costs have declined faster than most analysts anticipated, ARK foresees a wholesale shift to electric vehicles (EVs). By 2022 EVs should be cheaper than comparable gas-powered cars.

Projected Price Parity for 200-Mile Range EV

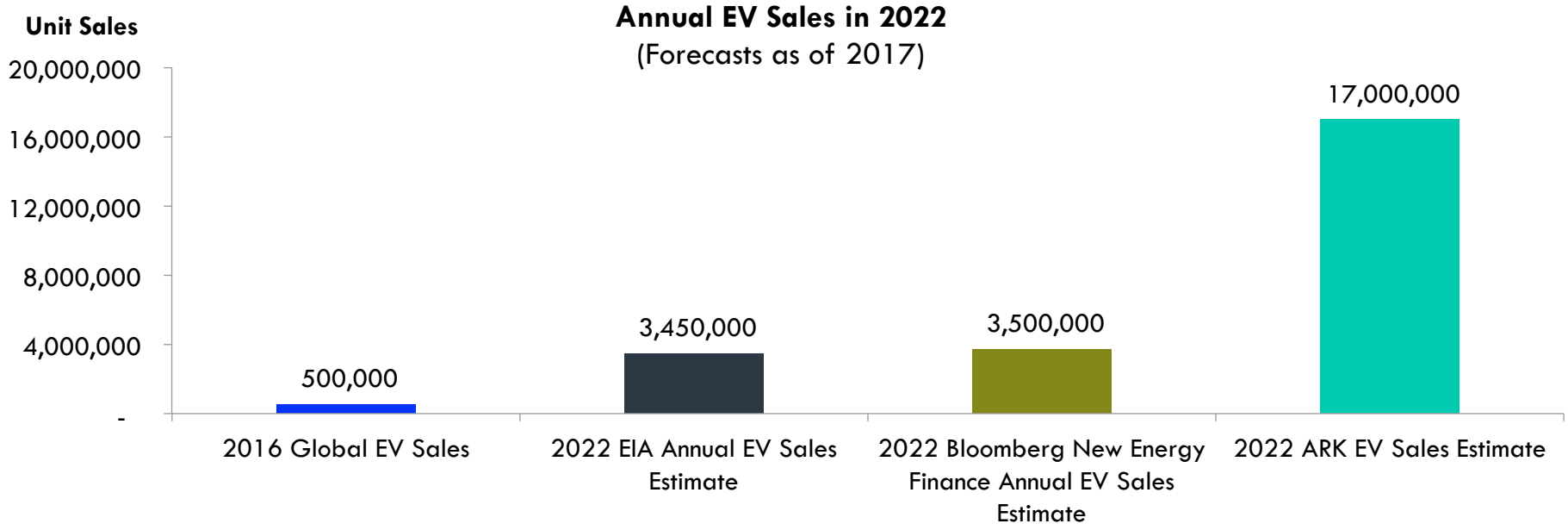


Forecasts are inherently limited and cannot be relied upon.

Sources: ARK Investment Management LLC, 2017 | ARK's expectation for EV MSRP (Manufacturer's Suggested Retail Price) parity is largely based on decreasing lithium-ion battery costs. Other factors could influence MSRP. The MSRP prices shown do not include any government subsidies.

Based On ARK's Research…

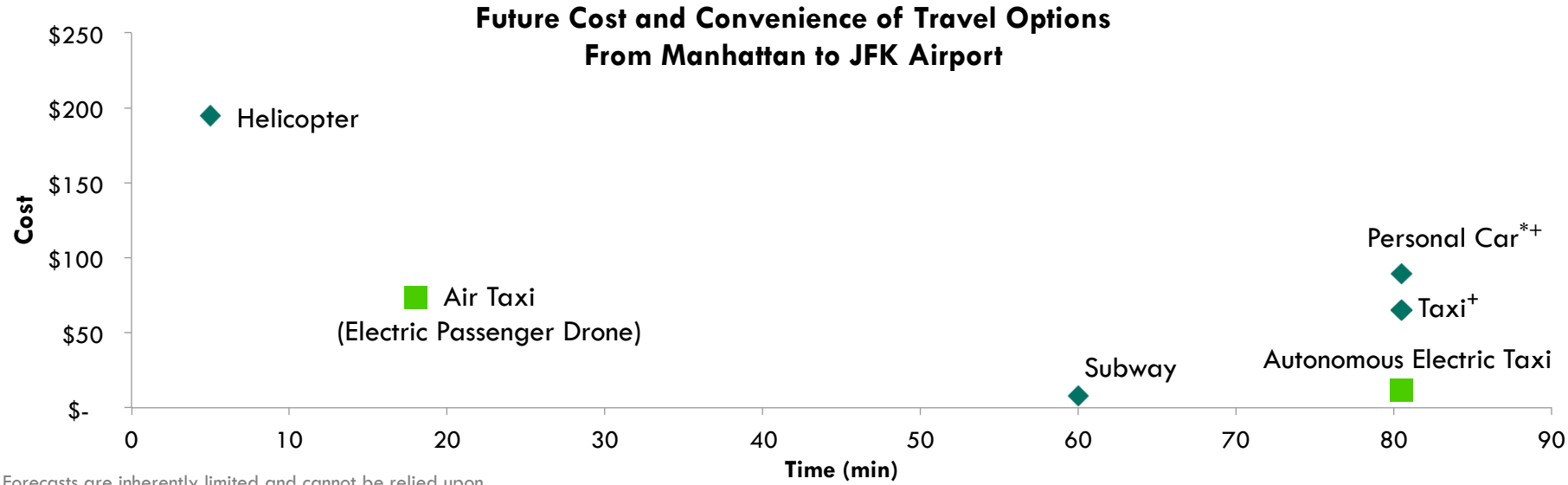
…the demand for EVs should be orders of magnitude higher than current forecasts.



Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017; Bloomberg New Energy Finance, U.S. Energy Information Administration, EV-volumes.com

Transportation By Air

By the early 2020s, ARK believes air taxis should be able to transport a passenger to the airport for the same price as a taxi, but in a fraction of the time. Alternatively, autonomous electric taxis likely will be able to transport passengers for the price of a subway ride today.



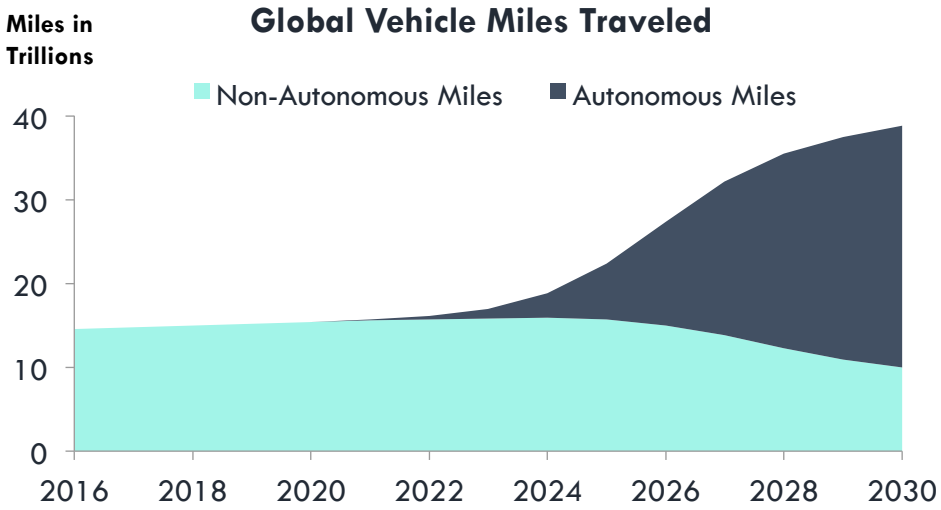
Forecasts are inherently limited and cannot be relied upon.

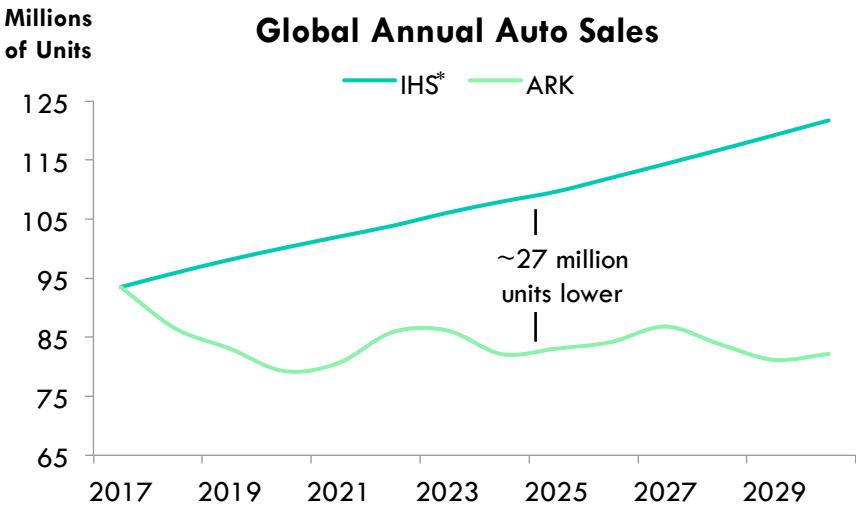
Sources: ARK Investment Management LLC, 2017 | *Includes parking for four days +15% increase in traffic due to autonomous

Data: https://blade.flyblade.com/p/bounce; https://www.panynj.gov/airports/jfk-airtrain.html

MaaS Results In More Miles Traveled And Fewer Cars Sold

While ARK expects global vehicle miles to increase two- to three-fold, auto sales should be flat to down, thanks to the higher utilization of taxi fleets.

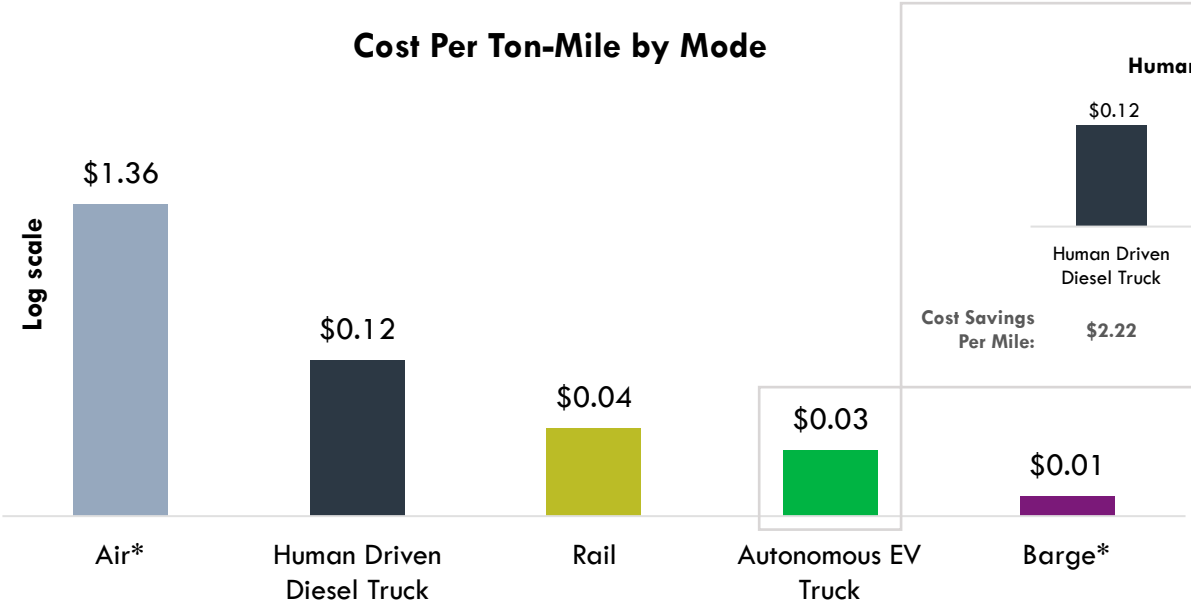


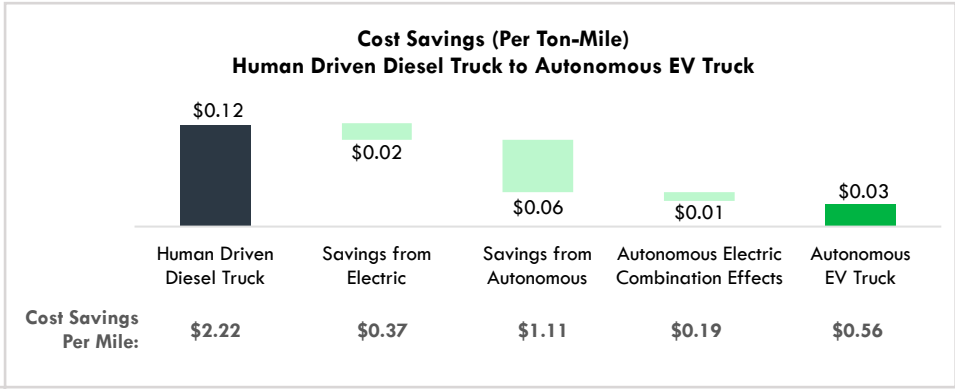


Forecasts are inherently limited and cannot be relied upon.
*IHS Markit Ltd. | Sources: ARK Investment Management LLC, 2017; IHS Markit, The Federal Highway Administration (FHWA), and the Research and Innovative Technology Administration (RITA)

Logistics-as-a-Service

ARK's research shows autonomous electric trucks should offer a shipping option less expensive than rail, on a cost per ton-mile basis.

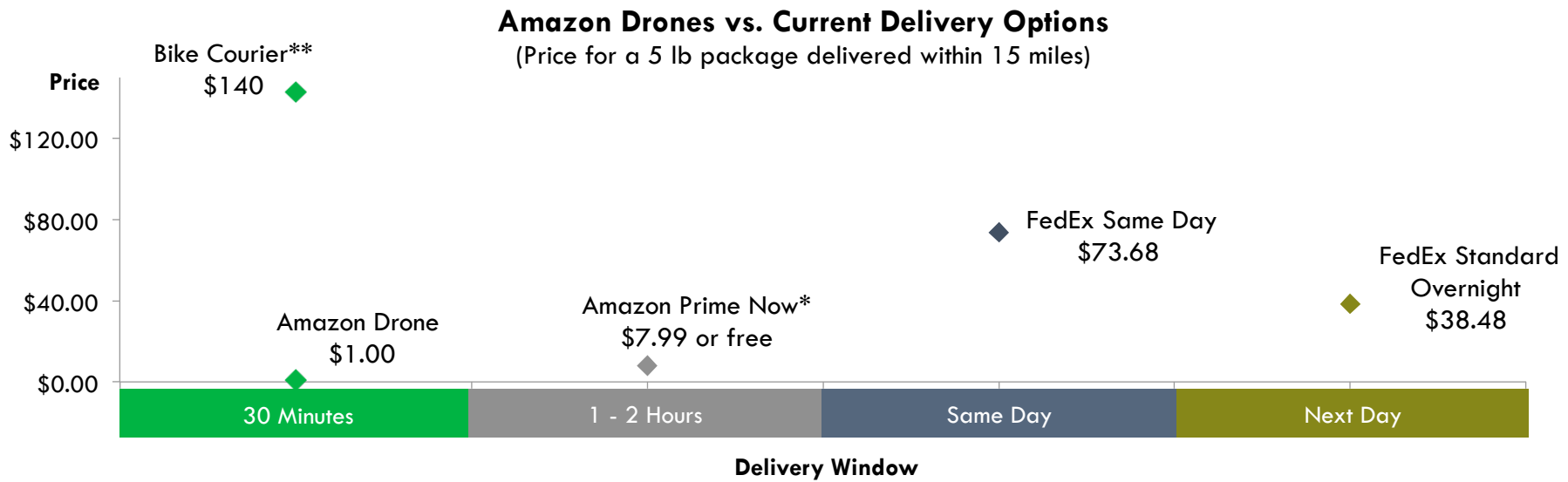




Forecasts are inherently limited and cannot be relied upon.
*Note: Cost per ton-mile for air and barge is using 2014 and 2011 data, respectively (latest available) Sources: ARK Investment Management LLC, 2017; Research and Innovative Technology Administration (RITA), Association of American Railroads (AAR), and the National Transportation Library (NTL)

Delivery By Air

ARK's research shows Amazon drones should be able to deliver a 5 lb package in 30 minutes for $1.



* Prices given are for members with a subscription. An Amazon Prime subscription is $99 per year. One hour delivery is $7.99 and two hour delivery is free.
** Most couriers do not travel more than 10 miles. This is an estimate for a 10 mile delivery.

Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017

Risks and Disclosure

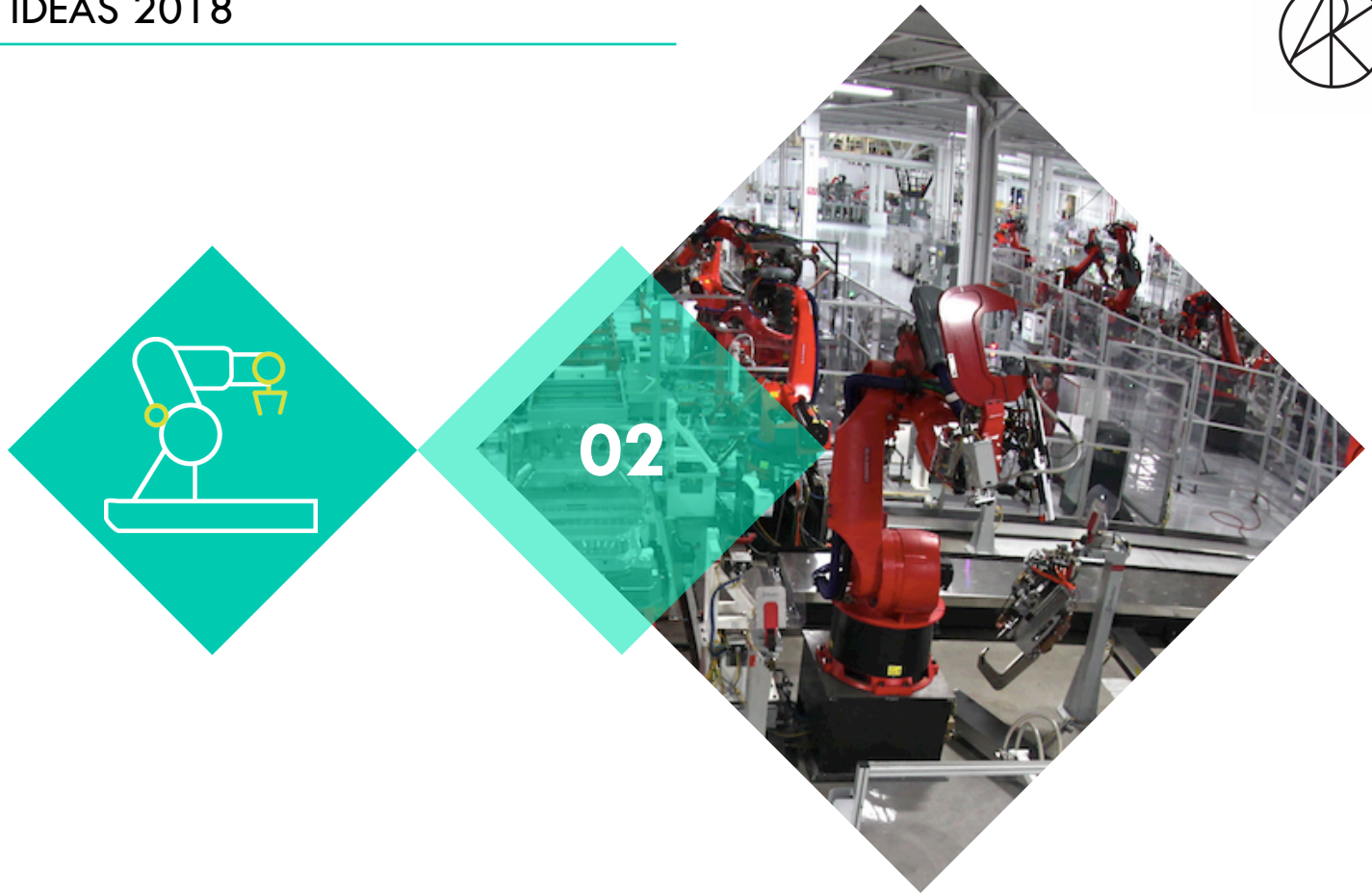
Please note, companies that ARK believes are capitalizing on disruptive innovation and developing technologies to displace older technologies or create new markets may not in fact do so and/or may face political or legal attacks from competitors, industry groups, or local and national governments.

ARK aims to educate investors and to size the potential opportunity of **Mobility-as-a-Service (MaaS)**, noting that risks and uncertainties may impact our projections and research models. Investors should use the content presented for informational purposes only, and **be aware of market risk, disruptive innovation risk, regulatory risk, and risks related to MaaS, such as:**

- **Industrials Sector Risk**
- **Information Technology Sector Risk**

Industrials Sector Risk. The industrials sector includes companies engaged in the aerospace and defense industry, electrical engineering, machinery, and professional services. Companies in the industrials sector may be adversely affected by changes in government regulation, world events and economic conditions. In addition, companies in the industrials sector may be adversely affected by environmental damages, product liability claims and exchange rates. *Aerospace and Defense Company Risk*. Companies in the aerospace and defense industry rely to a large extent on U.S. (and other) Government demand for their products and services and may be significantly affected by changes in government regulations and spending, as well as economic conditions and industry consolidation. *Professional Services Company Risk*. Professional services companies may be materially impacted by economic conditions and related fluctuations in client demand for marketing, business, technology and other consulting services. Professional services companies' success depends in large part on attracting and retaining key employees and a failure to do so could adversely affect a company's business. There are relatively few barriers to entry into the professional services market, and new competitors could readily seek to compete in one or more market segments, which could adversely affect a professional services company's operating results through pricing pressure and loss of market share. **Information Technology Sector Risk.** The information technology sector includes companies engaged in internet software and services, technology hardware and storage peripherals, electronic equipment instruments and components, and semiconductors and semiconductor equipment. Information technology companies face intense competition, both domestically and internationally, which may have an adverse effect on profit margins. These companies may have limited product lines, markets, financial resources or personnel. The products of information technology companies may face rapid product obsolescence due to technological developments and frequent new product introduction, unpredictable changes in growth rates and competition for the services of qualified personnel. Failure to introduce new products, develop and maintain a loyal customer base, or achieve general market acceptance for their products could have a material adverse effect on a company's business. Companies in the information technology sector are heavily dependent on intellectual property and the loss of patent, copyright and trademark protections may adversely affect the profitability of these companies.

ROBOTICS



Research by Sam Korus

A Review

2012

- **Amazon Acquires Kiva Robotics**

2014

- **Amazon Had 1,000 Robots in Its Warehouses at the End of 2013**

2015

- **Teradyne Acquires Universal Robots, a Collaborative Industrial Robot Company**

2016

- **Fanuc and Preferred Networks Train Robots in Parallel Using Deep Reinforcement Learning**

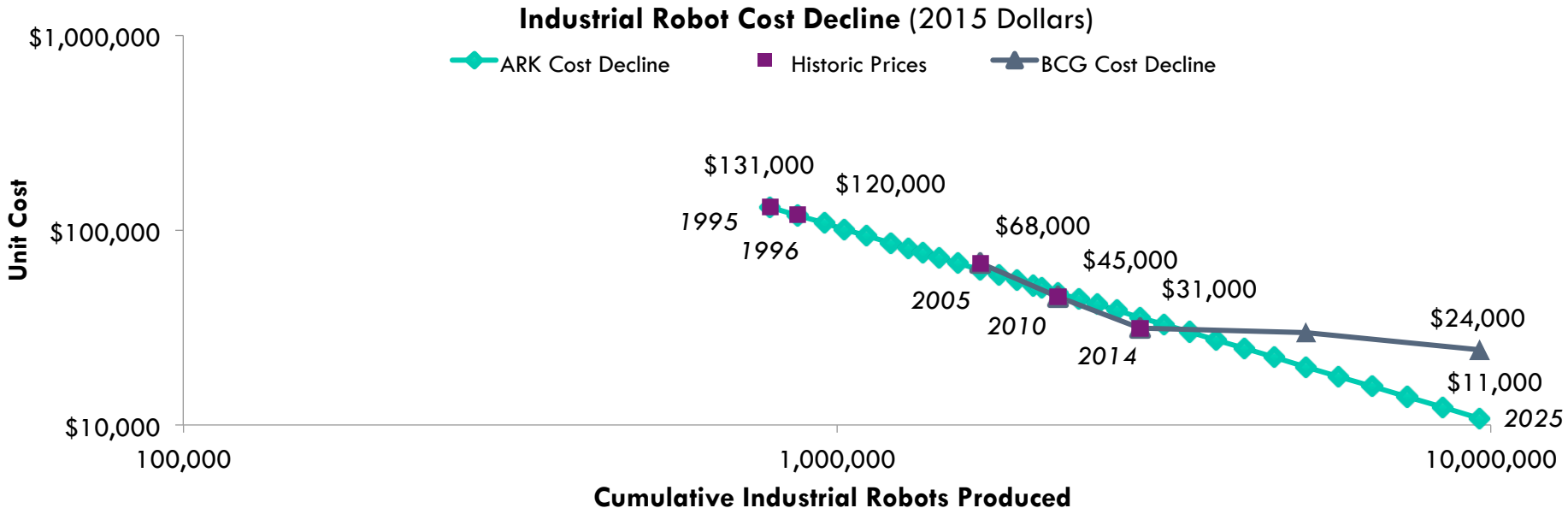
2017

- **Amazon Has Over 100,000 Robots in Its Warehouses**
- **SoftBank Acquires Boston Dynamics**

Source: ARK Investment Management LLC, 2017 | A selection of events, achievements and innovation milestones.

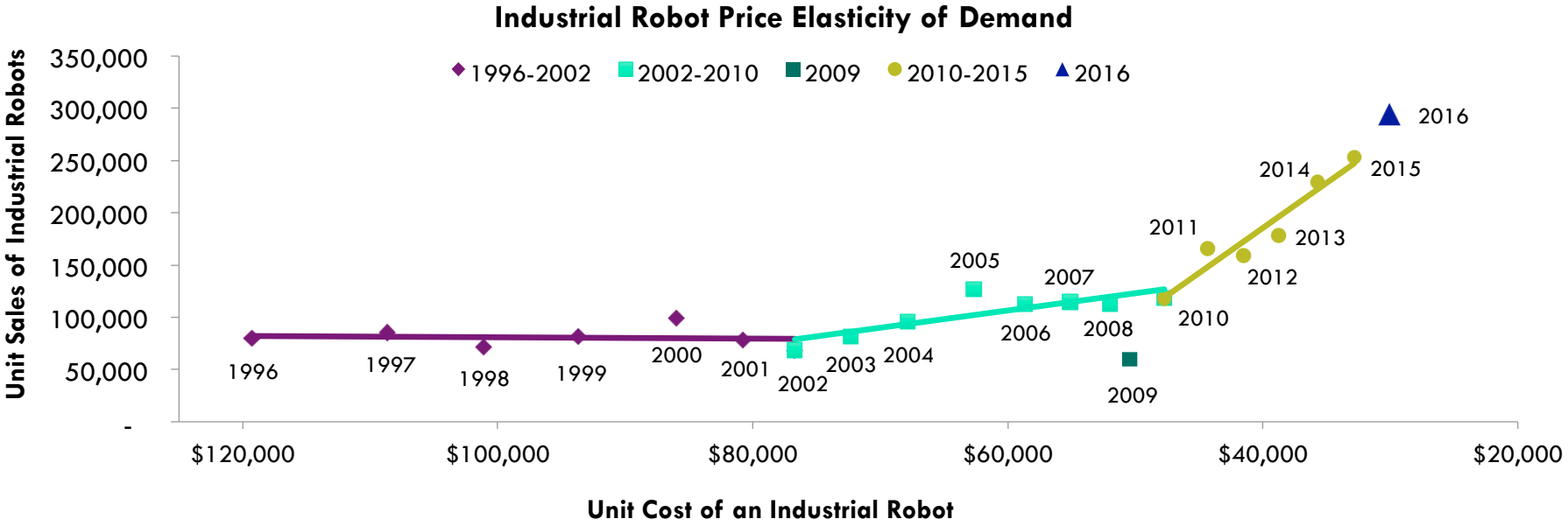
Robot Costs Are Dropping

Industrial robots are continuing to decline in cost, expanding the addressable market.



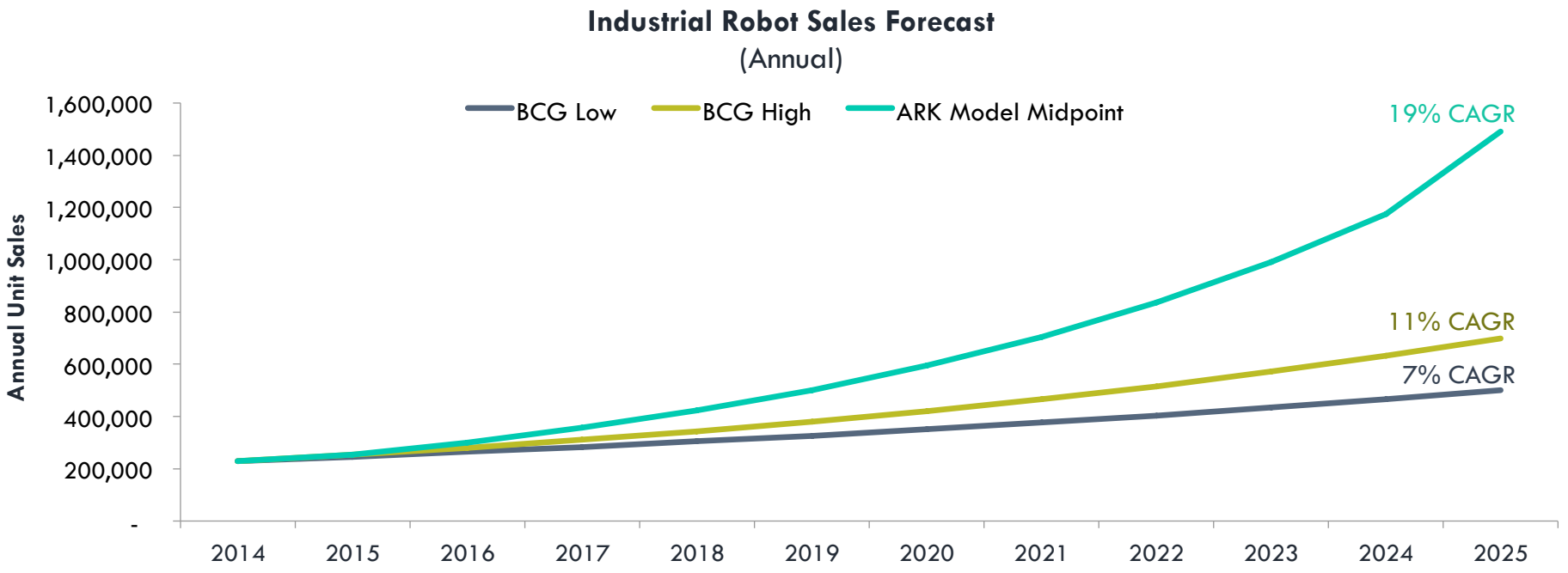
Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017
Data from: Sources: United Nations Economic Commission for Europe, International Federation of Robotics, Boston Consulting Group (BCG)

Robot Demand Is Responding To Lower Costs



Sources: ARK Investment Management LLC, 2017
Data from: Sources: United Nations Economic Commission for Europe, International Federation of Robotics, Boston Consulting Group (BCG)

Research Shows Robot Growth Should Be Sustained By More Use Cases

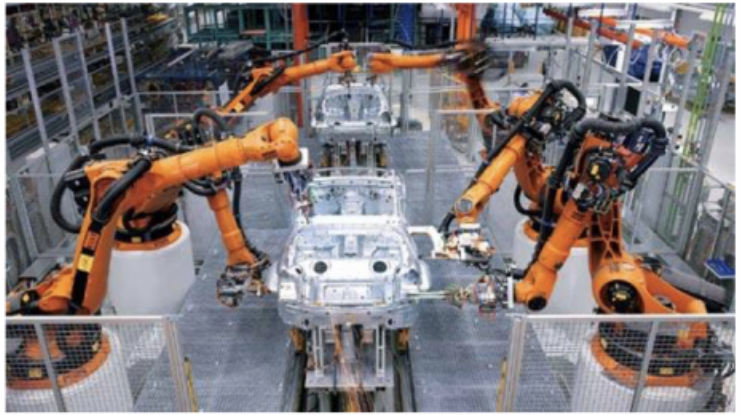


Forecasts are inherently limited and cannot be relied upon. | CAGR = Compound Annual Growth Rate

Sources: ARK Investment Management LLC, 2017; Boston Consulting Group (BCG) and International Federation of Robotics

Collaborative Robots

Traditional Industrial Robots



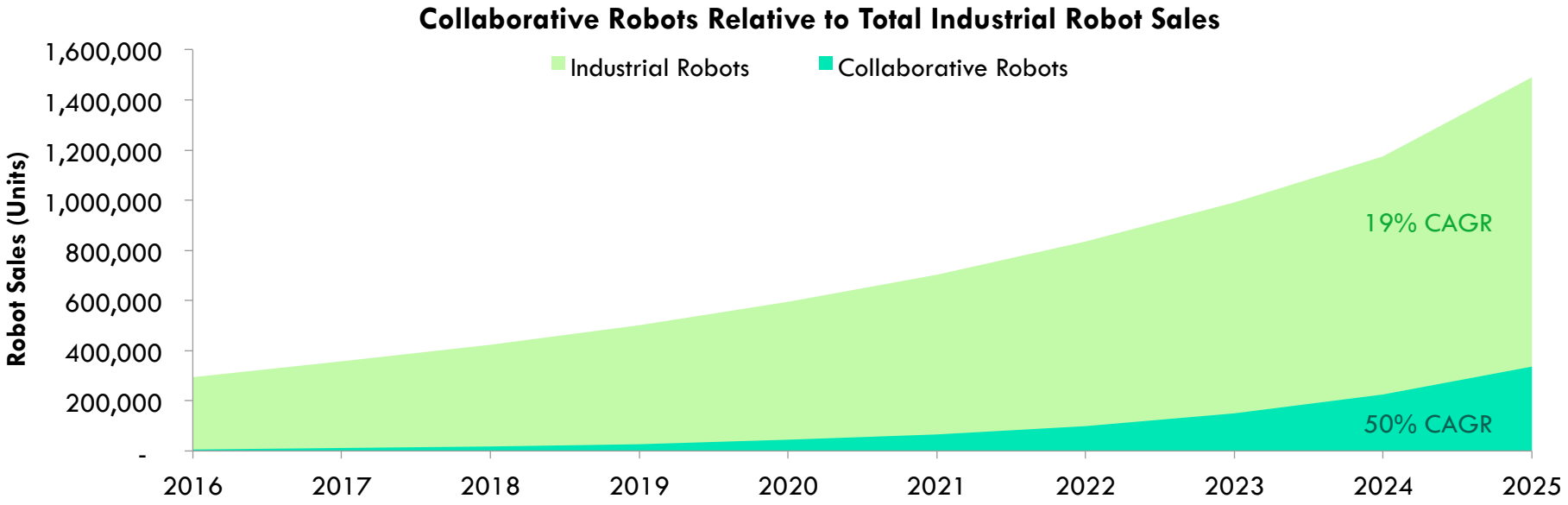
Industrial robots are defined by ISO 8373:2012 as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications.

Current Collaborative Robots

A collaborative robot ("co-bot") is a robot designed to share a workspace with humans and may have direct physical interaction with humans. (Collaborative robot can be a subset within the broader industrial robot definition.)

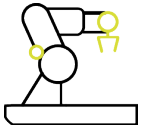
Sources: ARK Investment Management LLC, 2017; Teradyne

ARK Believes Collaborative Robots Should Gain Market Share



Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017; Teradyne

Risks and Disclosure



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DEEP LEARNING

Research by James Wang

A Review

1989

- LeCun Uses *Backpropagation* to Train Convolutional Neural Nets that Can Read Handwritten Digits with 99% Accuracy (Later Deployed in ATMs)

2012

- Deep Neural Net Wins 2012 *ImageNet* Challenge, Reducing the Error Rate by 36%

2015

- Microsoft's *ResNet* Deep Neural Net Achieves 96% Accuracy in the *ImageNet* Challenge, Reaching Human Level Performance for the First Time

2016

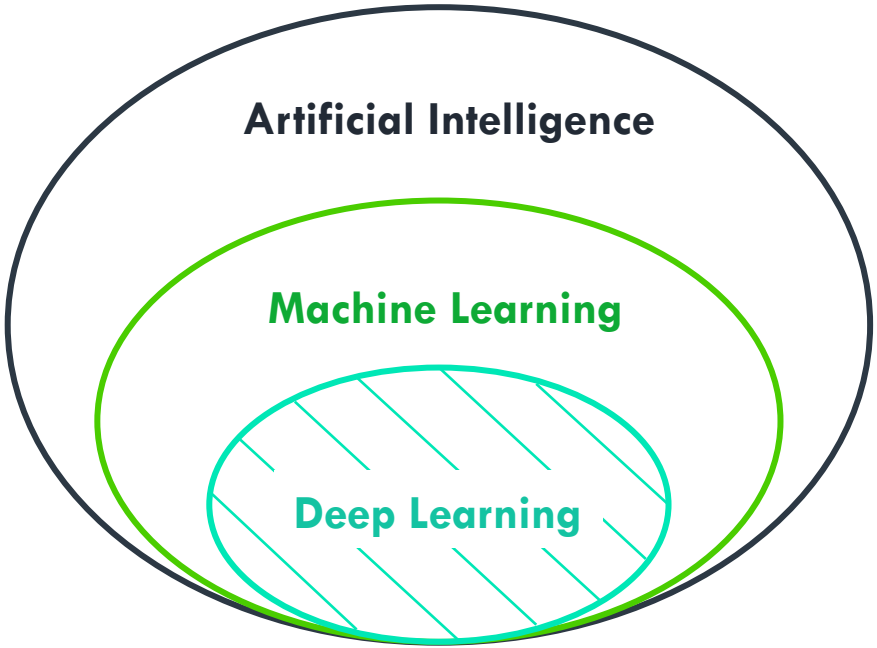
- DeepMind's AlphaGo Defeats Global Champion Lee Sedol in the Game of Go. The AI Program Combined Deep Learning with Monte Carlo Tree Search and Reached a Major AI Milestone Ten Years Ahead of Schedule

2017

- Companies Large and Small are Launching Deep Learning Products and Services. Among them are Apple, Alphabet, Amazon, Baidu, Deere, and Fanuc

Source: ARK Investment Management LLC, 2017 | A selection of events, achievements and innovation milestones.

Deep Learning Is A Subset of Artificial Intelligence (AI)

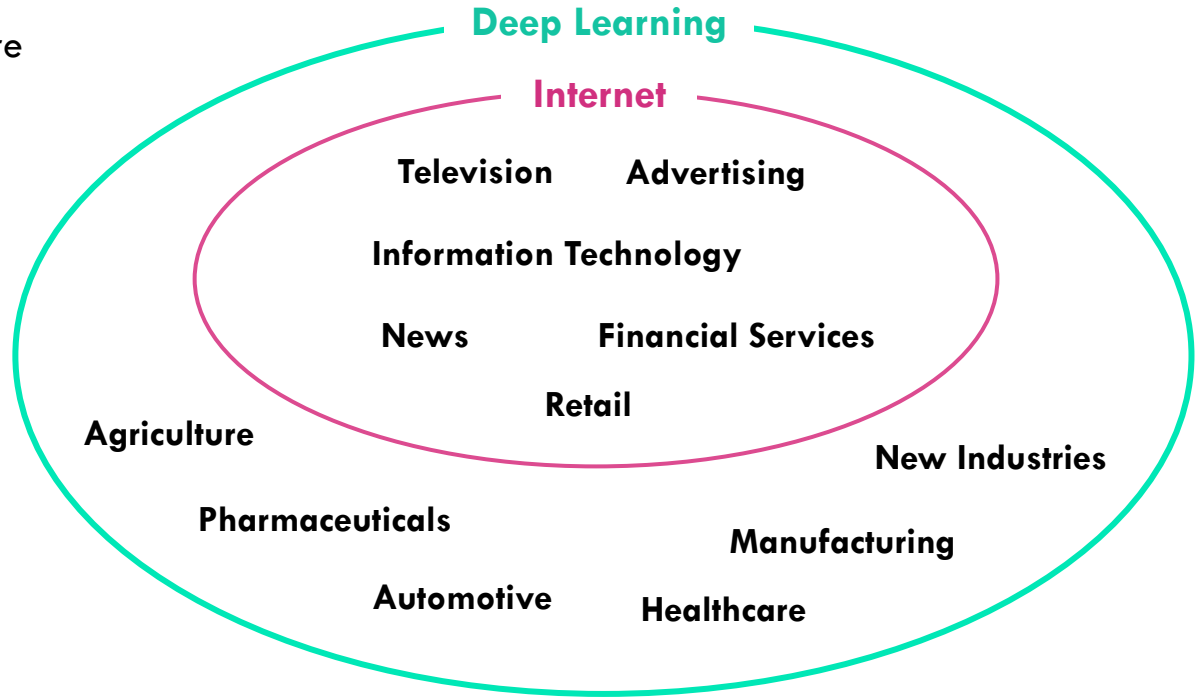


- Classic AI is based on deductive logic. Rules are based on human ingenuity.
- Machine Learning is based on statistical inference. Rules are inferred from data.
- Deep Learning is a type of Machine Learning modeled after the biological brain.

Source: ARK Investment Management LLC, 2017

Deep Learning Is A Continuation Of "Software Eating The World"

Relative to the Internet, Deep Learning could impact more sectors, causing more profound disruptive innovation across different industries.



Source: ARK Investment Management LLC, 2017

Many Deep Learning Products And Services Were Launched In 2017

SMARTPHONES

iPhone X uses AI powered facial recognition.

AGRICULTURE

Deere acquired Blue River for precision agriculture.

ROBOTICS

Miso Robotics launched AI powered burger flipping robot.

AI CLOUD

Amazon
Google
Microsoft
Alibaba
Tencent
Baidu
JD.com
iFlyTek

Every cloud provider launched AI as a service.

SOFTWARE

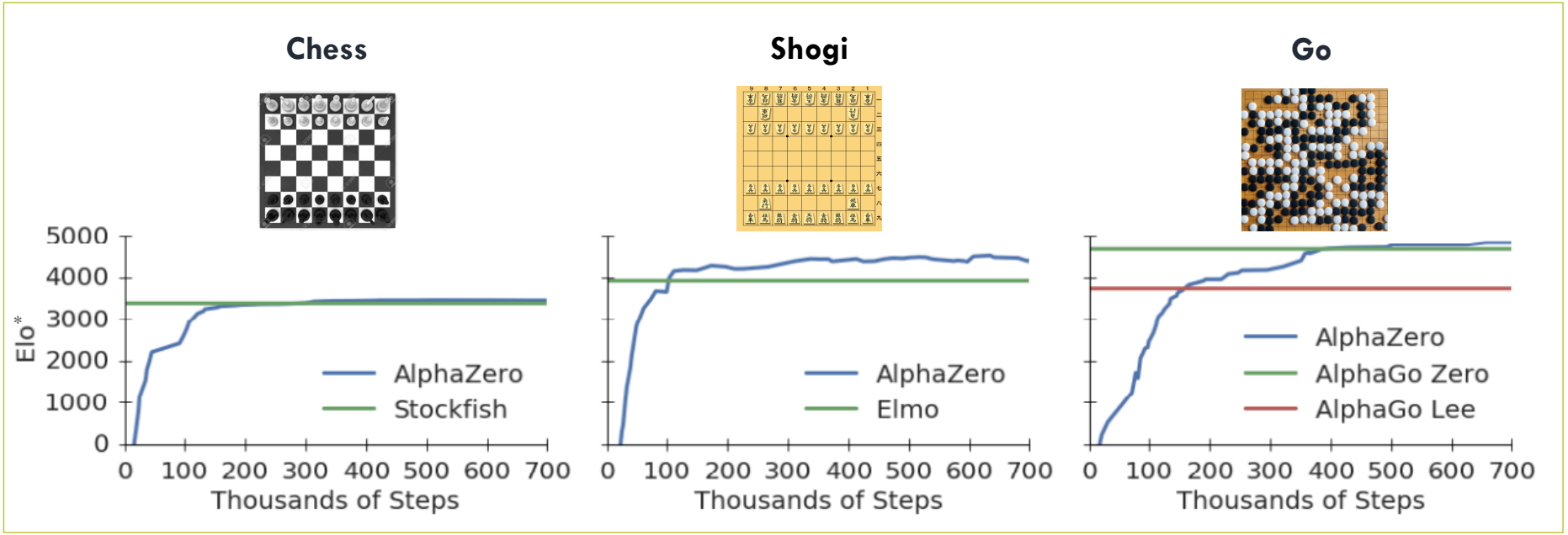
Salesforce
Box
Nuance
Adobe

Software providers use AI for classification and tagging.

Source: ARK Investment Management LLC, 2017

Deep Learning Is Now Smarter And More Adaptive

DeepMind's AlphaZero uses reinforcement learning, with no human training, to achieve world class performance across three games.



Source: DeepMind, https://arxiv.org/abs/1712.01815 | *Elo: A measure of relative skill between players

Deep Learning Achieves Photorealistic Image Generation

Deep Learning can recognize and generate images. Early results were blurry and unconvincing, as seen on the left. The latest results approach photorealism, as seen on the right.

Fake Images Generated Using Deep Learning

2016

2017

Source: Alec Radford, NVIDIA

Deep Learning Has Created A New Semiconductor Boom

Deep Learning is the fastest growing workload in data centers.

NVIDIA currently has a near monopoly on this market, but a host of companies is vying for this opportunity, which we estimate will generate $9 billion in revenue.

Companies Developing Deep Learning Chips

Company	Ownership	HQ	Story
Nvidia	Public	United States	Current market leader using GPU based deep learning
Google	Public	United States	Custom designed TPU deployed in Google Cloud
Intel	Public	United States	Nervana based chip to be released mid 2018
AMD	Public	United States	GPU based deep learning
Qualcomm	Public	United States	Developing DL silicon for mobile
Cerebras	Private	United States	Ex-AMD team backed by Benchmark Capital
Groq	Private	United States	Ex-Google TPU team backed by Social Capital
KnuEdge	Private	United States	Headed by former NASA CTO
Mythic	Private	United States	In-memory inference for IoT backed by DFJ
Thinci	Private	United States	Computer vision / auto focus
Wave Computing	Private	United States	DL server with custom chip. In customer trials
GraphCore	Private	United Kingdom	UK startup backed by top AI researchers
Bitmain	Private	China	Top maker of Bitcoin mining chips
Cambricon	Private	China	China's state-backed startup with a $1B valuation
DeePhi	Private	China	China based startup with a focus on video analysis
Horizon Robotics	Private	China	Ex-Baidu team. Embedded / computer vision focus
Tenstorrent	Private	Canada	Toronto based chip startup

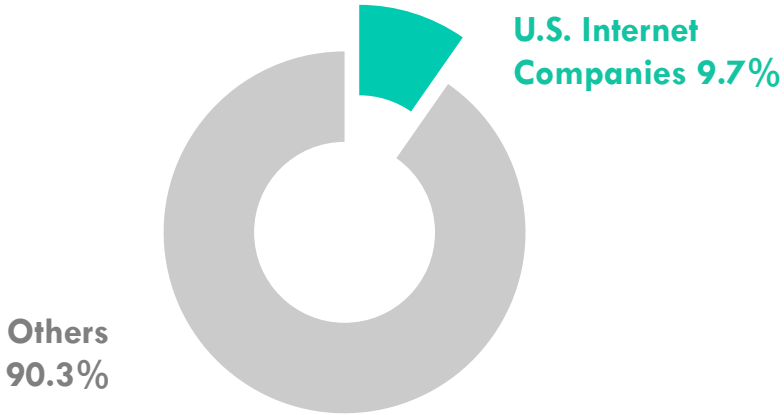
Source: Alec Radford, NVIDIA, 2017

Deep Learning Should Be An Internet Scale Opportunity

- In 1996, Internet companies made up 0% of the S&P 500
- In 2017, Internet companies made up 9.7% of the S&P 500

This foundational technology took about 10% share in roughly two decades.

Pure Internet Companies As A Percent of S&P 500



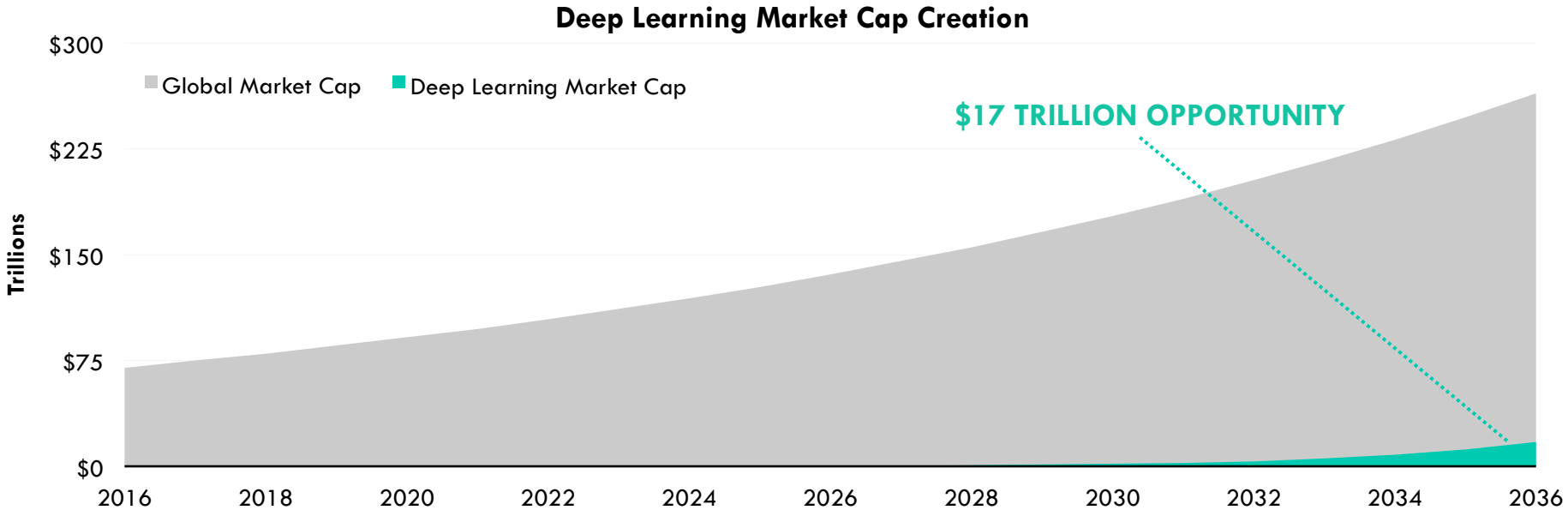
S&P 500 Market Cap Created by The Internet

Company	Market Cap ($B)
Alphabet	$727
Amazon	$563
Facebook	$513
Cisco	$189
PayPal	$88
Priceline	$85
Netflix	$83
Salesforce	$74
Ebay	$39
Expedia	$18
E*Trade	$13
Akamai	$11
Juniper Networks	$11
Verisign	$11
F5 Networks	$8
TripAdvisor	$5
Total	**$2,425**
S&P 500 Market Cap	**$25,107**
Share of Purebred Internet Companies	**9.7%**

Source: ARK investment Management LLC, as of December 2017

Based on ARK's research…

… Deep Learning could approach a global market cap of $17 trillion in 20 years.



Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2017; Deep Learning penetration adjusted for global market cap, assuming 6.9% historical growth rate of global equities, 6.6% deep learning share in 20 years.

Risks and Disclosure

Please note, companies that ARK believes are capitalizing on disruptive innovation and developing technologies to displace older technologies or create new markets may not in fact do so and/or may face political or legal attacks from competitors, industry groups, or local and national governments.

ARK aims to educate investors and to size the potential opportunity of **Deep Learning,** noting that risks and uncertainties may impact our projections and research models. Investors should use the content presented for informational purposes only, and **be aware of market risk, disruptive innovation risk, regulatory risk, and risks related to Deep Learning, such as:**

- Software Industry Risk
- Internet Company Risk
- Semiconductor Company Risk

Software Industry Risk. The software industry can be significantly affected by intense competition, aggressive pricing, technological innovations, and product obsolescence. Companies in the software industry are subject to significant competitive pressures, such as aggressive pricing, new market entrants, competition for market share, short product cycles due to an accelerated rate of technological developments and the potential for limited earnings and/or falling profit margins. These companies also face the risks that new services, equipment or technologies will not be accepted by consumers and businesses or will become rapidly obsolete. These factors can affect the profitability of these companies and, as a result, the value of their securities. Also, patent protection is integral to the success of many companies in this industry, and profitability can be affected materially by, among other things, the cost of obtaining (or failing to obtain) patent approvals, the cost of litigating patent infringement and the loss of patent protection for products (which significantly increases pricing pressures and can materially reduce profitability with respect to such products). In addition, many software companies have limited operating histories. Prices of these companies' securities historically have been more volatile than other securities, especially over the short term. **Internet Company Risk.** Many Internet-related companies have incurred large losses since their inception and may continue to incur large losses in the hope of capturing market share and generating future revenues. Accordingly, many such companies expect to incur significant operating losses for the foreseeable future, and may never be profitable. The markets in which many Internet companies compete face rapidly evolving industry standards, frequent new service and product announcements, introductions and enhancements, and changing customer demands. The failure of an Internet company to adapt to such changes could have a material adverse effect on the company's business. **Semiconductor Company Risk.** Competitive pressures may have a significant effect on the financial condition of semiconductor companies and, as product cycles shorten and manufacturing capacity increases, these companies may become increasingly subject to aggressive pricing, which hampers profitability. Reduced demand for end-user products, under-utilization of manufacturing capacity, and other factors could adversely impact the operating results of companies in the semiconductor sector. Semiconductor companies typically face high capital costs and may be heavily dependent on intellectual property rights. The semiconductor sector is highly cyclical, which may cause the operating results of many semiconductor companies to vary significantly. The stock prices of companies in the semiconductor sector have been and likely will continue to be extremely volatile.