



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.

Brett Winton

Director of Research
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James Wang, Analyst

Artificial Intelligence, Mobile, Cloud
[@jwangARK](#)

Manisha Samy, Analyst

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Agricultural Biology, Stem Cells
[@msamyARK](#)

Bhavana Yarasuri, Analyst

Payments, Blockchain, Bitcoin,
Cryptocurrencies
[@bhavanaARK](#)

Catherine D. Wood

Founder, CEO/CIO
[@CathieDWood](#)

Tasha Keeney, Analyst, CFA

3D Printing, Autonomous Vehicles,
Mobility-as-a-Service
[@tashaARK](#)

Sam Korus, Analyst

Robotics, Energy Storage, Electric
Vehicles, Alternative Energy
[@skorusARK](#)

Julia Hemmendinger, Analyst

Big Data and Analytics, Cloud
Computing, Lending and Insurance
[@juliahARK](#)

MOBILITY-AS-A-SERVICE



1. Mobility-as-a-Service

A Review



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

(*Defense Advanced Research Projects Agency)

- Google Self Driving Car Project Begins



- Tesla Launches First Version of Autopilot Software

2015

- Tesla and Chevy Launch the First “Mass Market” Electric Vehicles

2016

- 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

2017



2004



2009



1. Mobility-as-a-Service

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:

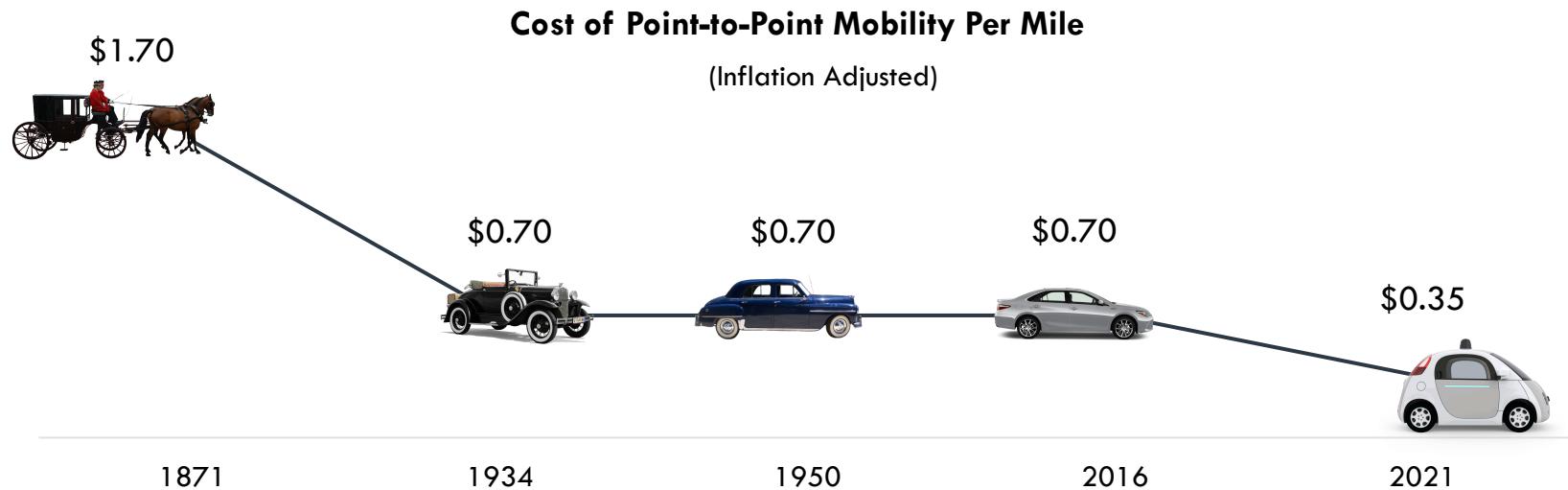


1. Mobility-as-a-Service

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.

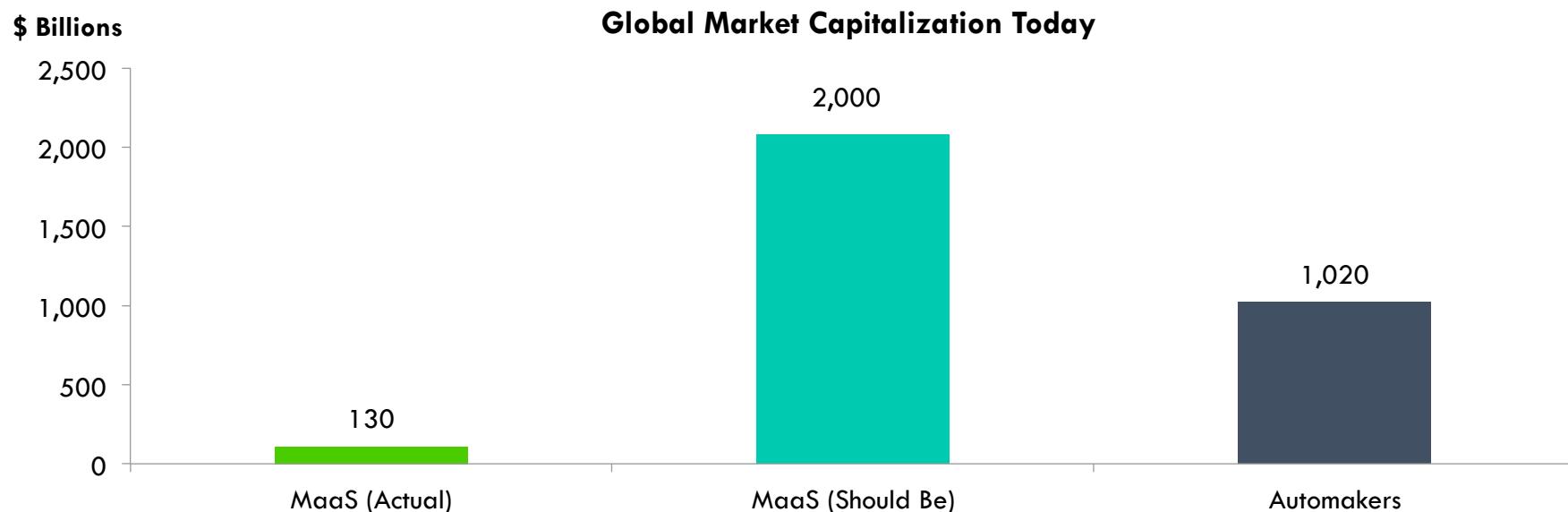
Sources: ARK Investment Management LLC, 2017 | Morton Salt Company Records, American Automobile Association (AAA)

1. Mobility-as-a-Service

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

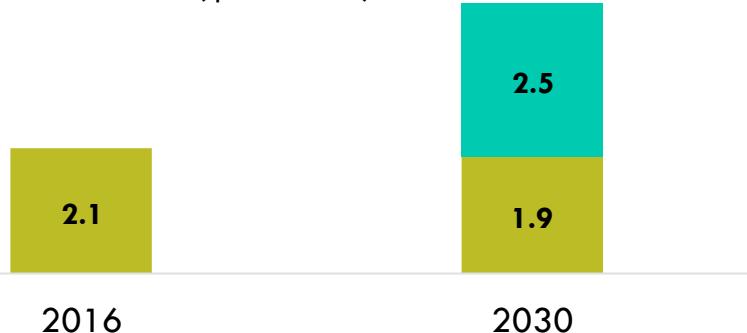
1. Mobility-as-a-Service

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)**



■ Global Automaker Revenue

■ Net Fees on Autonomous Taxi Services

**EBITDA for Automakers and Autonomous Platform Providers
(\$ Trillions)**



■ EBITDA on Autonomous Taxi Services

■ Global Automaker EBITDA

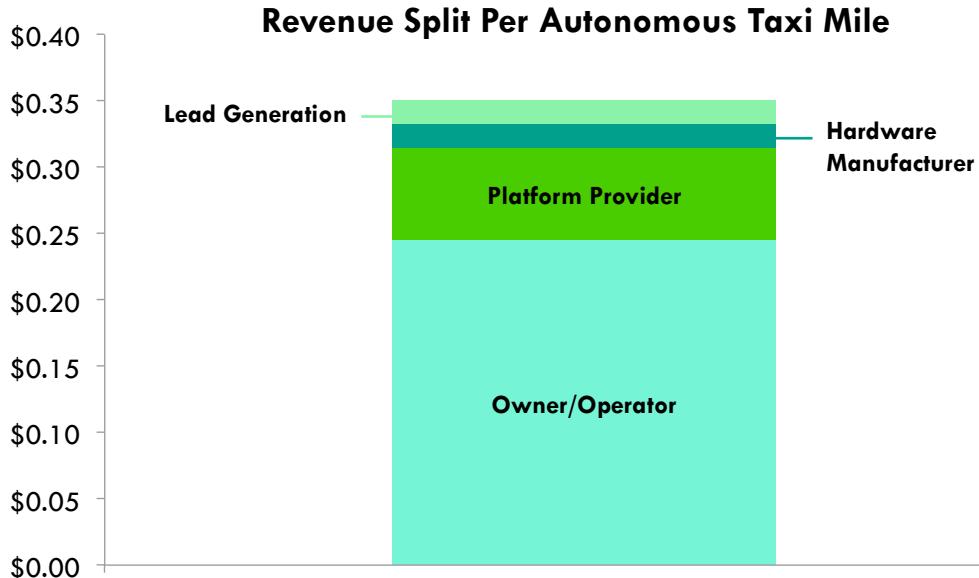
Forecasts are inherently limited and cannot be relied upon.
Sources: ARK Investment Management LLC, 2017

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

1. Mobility-as-a-Service

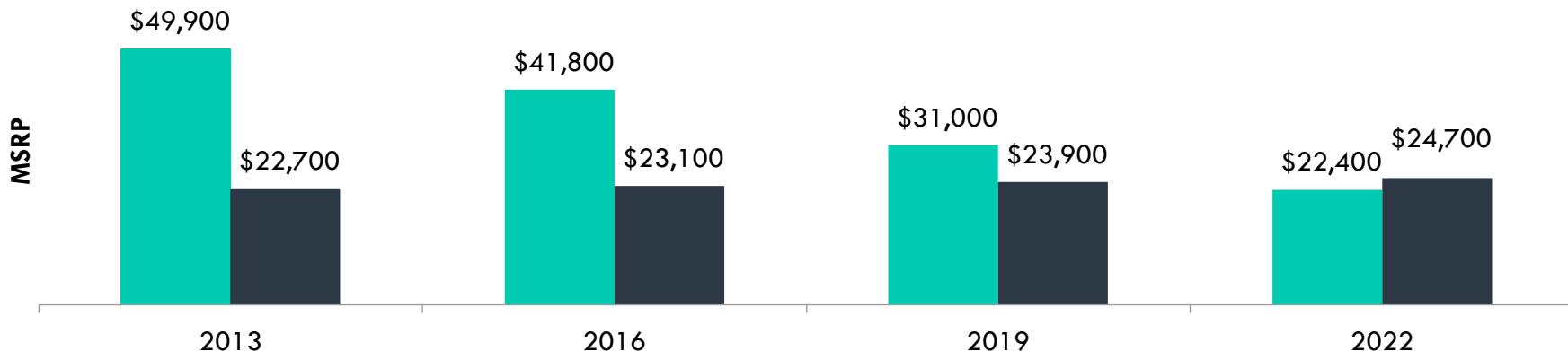
ARK Believes Electric Vehicles Likely Will Dominate Transportation



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

■ 200 Mile Range EV Price ■ Toyota Camry MSRP



Forecasts are inherently limited and cannot be relied upon.

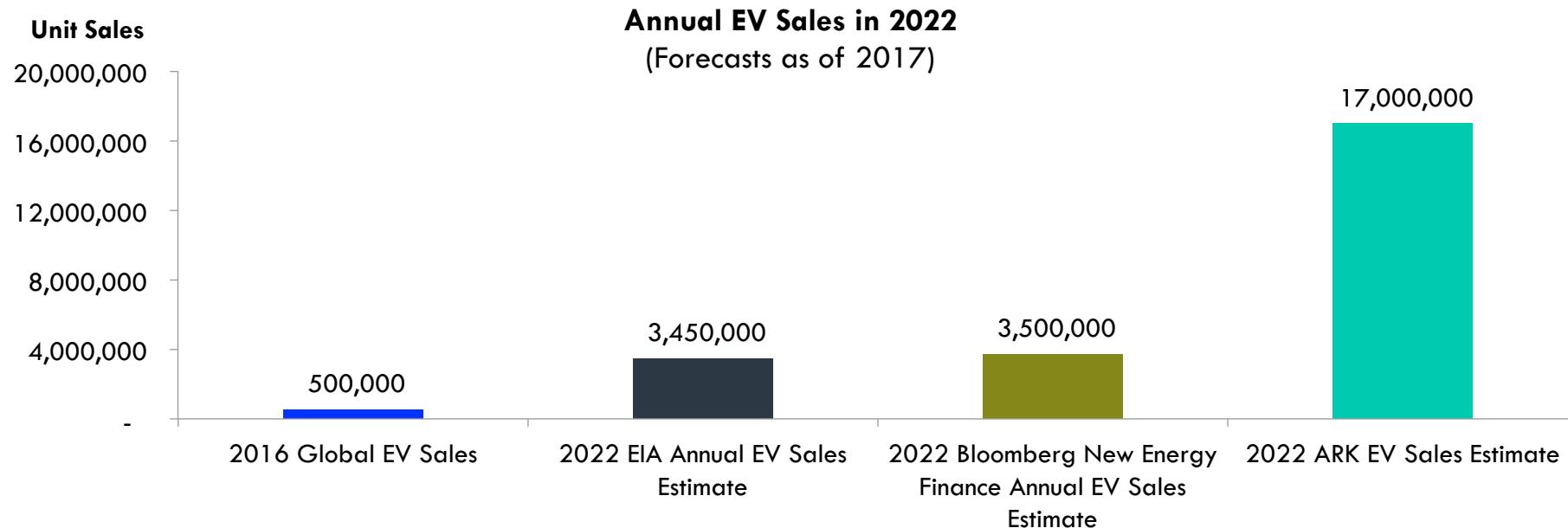
Sources: ARK Investment Management LLC, 2017 | ARK's expectation for EV MSRP (Manufacturer's Suggested Retail Price) parity is largely based on decreasing lithium-ion battery costs. Other factors could influence MSRP. The MSRP prices shown do not include any government subsidies.

1. Mobility-as-a-Service

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.

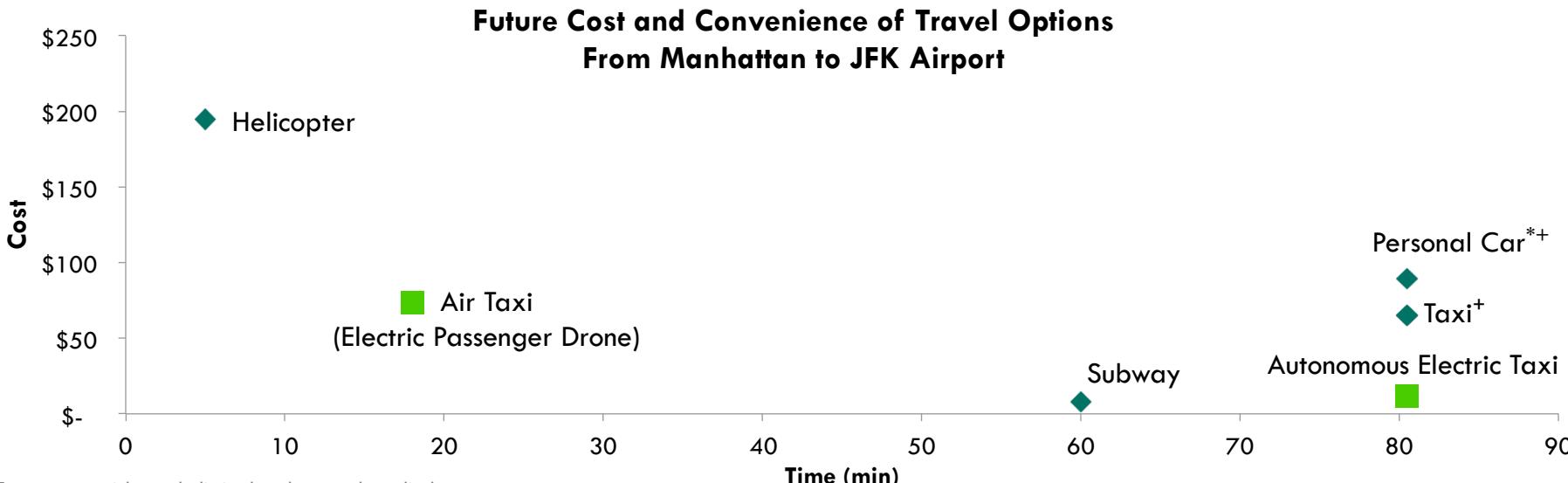
Sources: ARK Investment Management LLC, 2017; Bloomberg New Energy Finance, U.S. Energy Information Administration, EV-volumes.com

1. Mobility-as-a-Service

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.

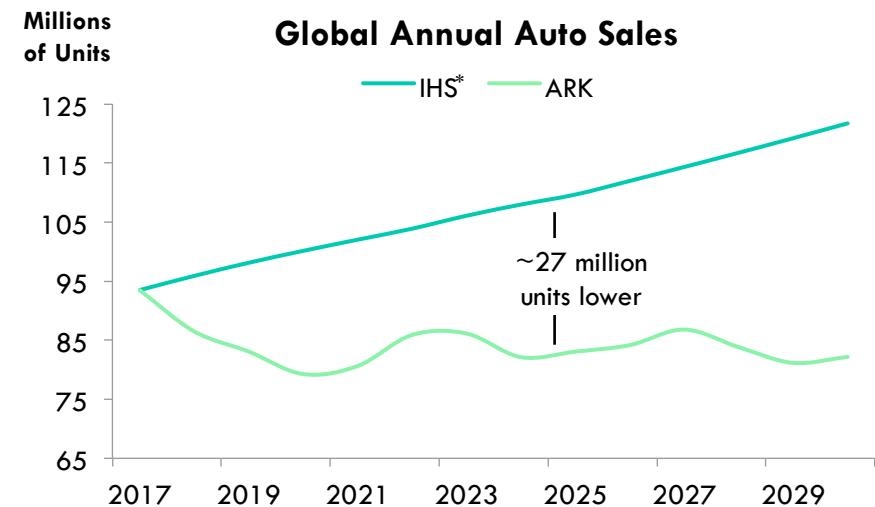
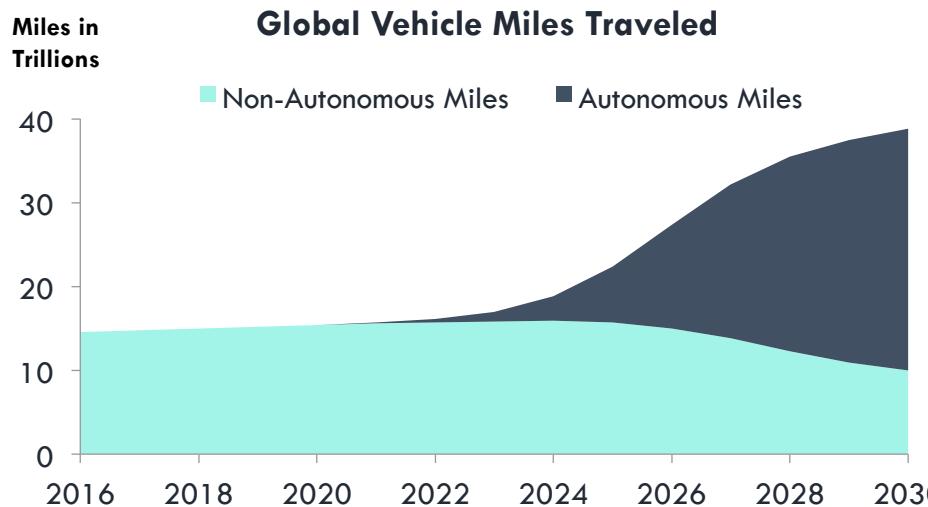
Sources: ARK Investment Management LLC, 2017 | *Includes parking for four days ⁺15% increase in traffic due to autonomous
Data: <https://blade.flyblade.com/p/bounce>; <https://www.panynj.gov/airports/jfk-airtrain.html>

1. Mobility-as-a-Service

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.

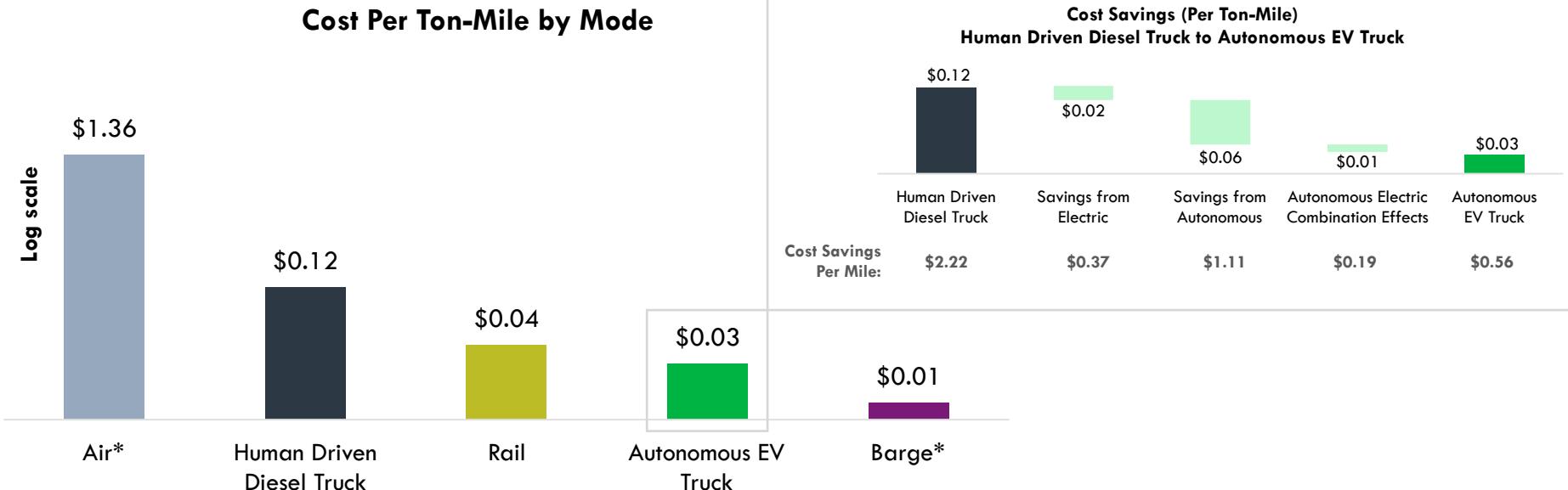
*IHS Markit Ltd. | Sources: ARK Investment Management LLC, 2017; IHS Markit, The Federal Highway Administration (FHWA), and the Research and Innovative Technology Administration (RITA)

1. Mobility-as-a-Service

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)

1. Mobility-as-a-Service

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

1. Mobility-as-a-Service

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.

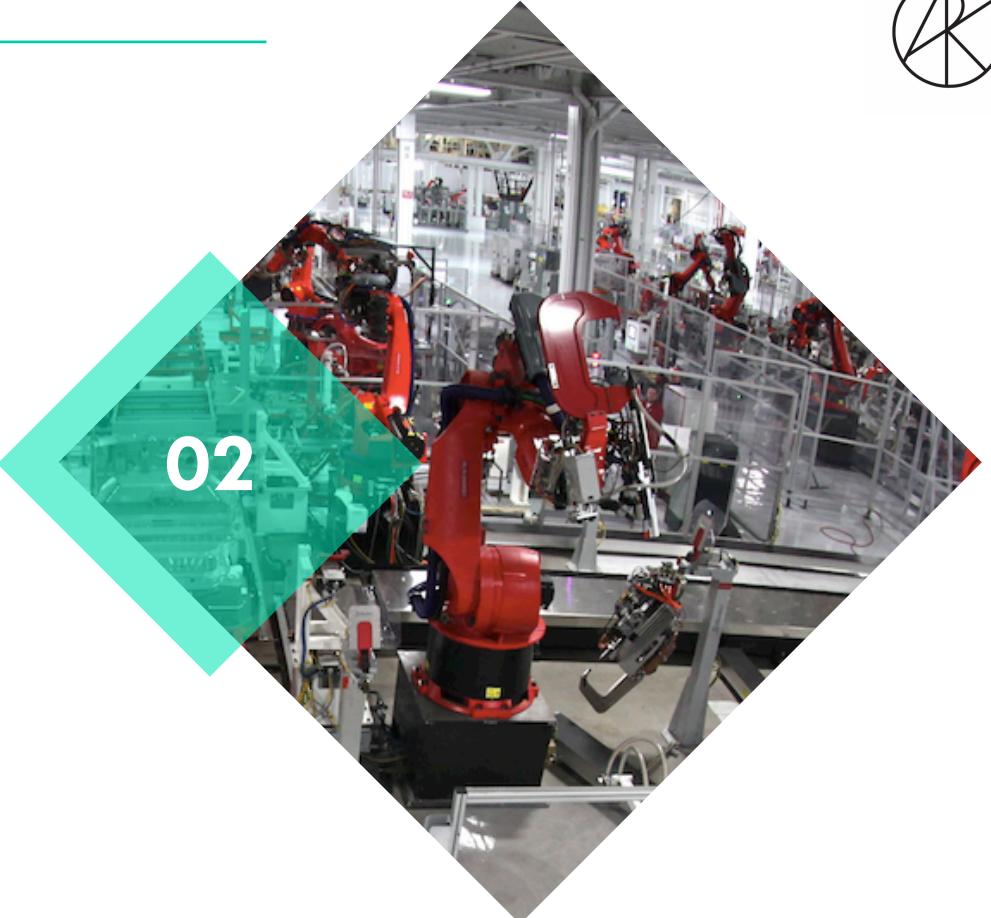
ARK aims to educate investors and to size the potential opportunity of **Mobility-as-a-Service (MaaS)**, noting that risks and uncertainties may impact our projections and research models. Investors should use the content presented for informational purposes only, and **be aware of market risk, disruptive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

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

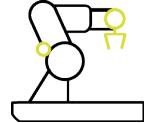
Industrials Sector Risk. The industrials sector includes companies engaged in the aerospace and defense industry, electrical engineering, machinery, and professional services. Companies in the industrials sector may be adversely affected by changes in government regulation, world events and economic 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



A Review



- Amazon Acquires Kiva Robotics



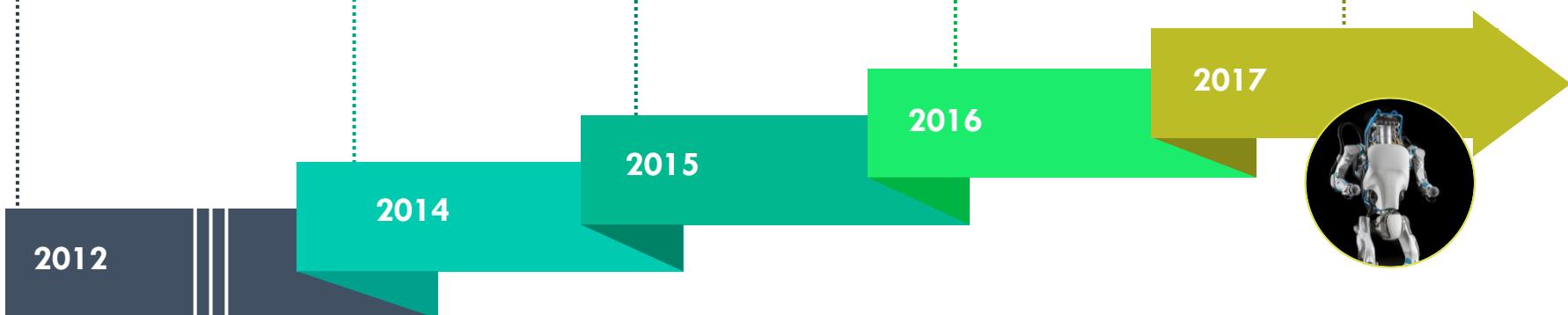
- Amazon Had 1,000 Robots in Its Warehouses at the End of 2013

- Teradyne Acquires Universal Robots, a Collaborative Industrial Robot Company

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

- Amazon Has Over 100,000 Robots in Its Warehouses

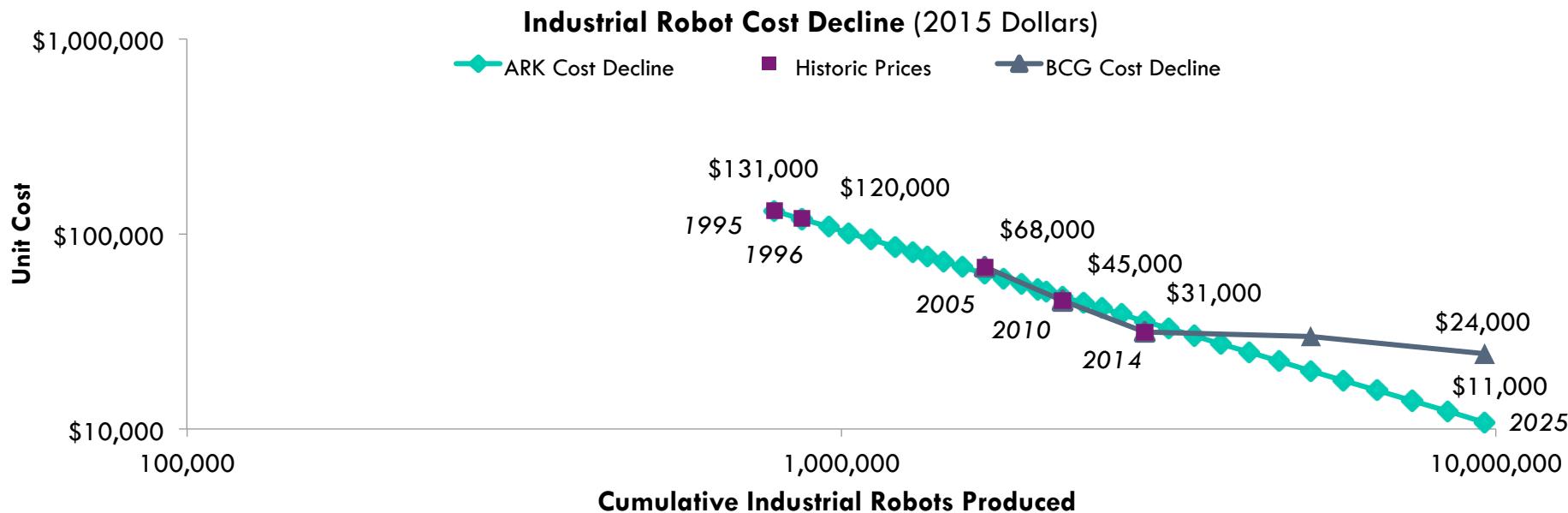
- SoftBank Acquires Boston Dynamics





Robot Costs Are Dropping

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



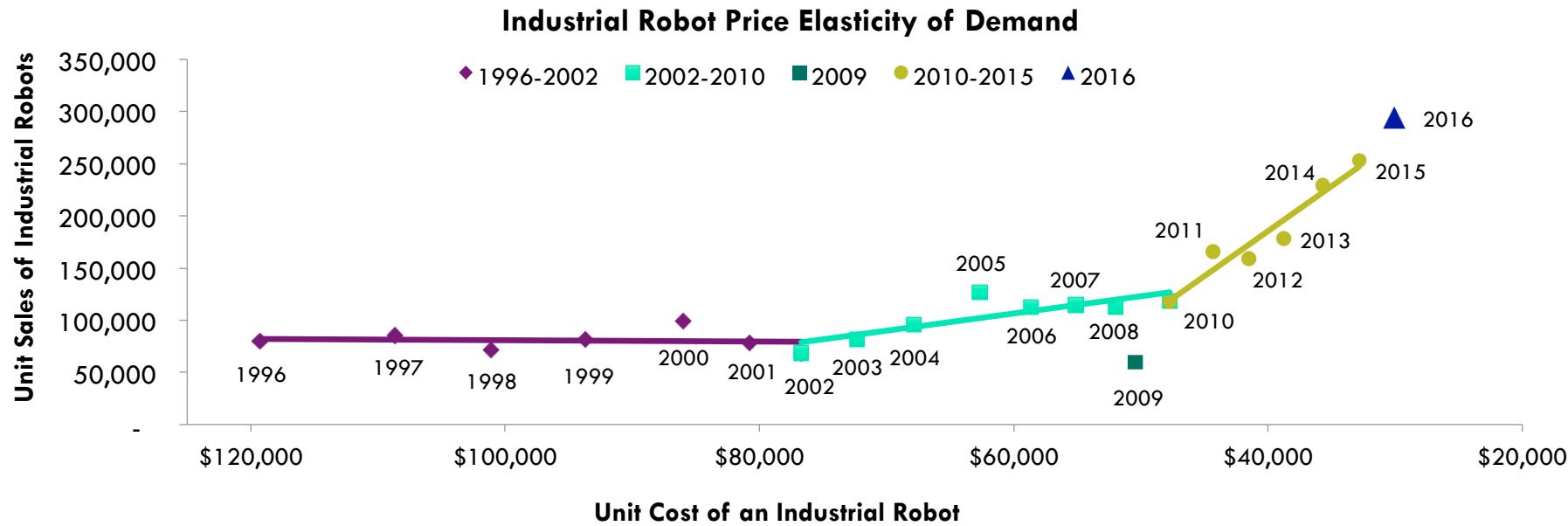
Forecasts are inherently limited and cannot be relied upon.

Sources: ARK Investment Management LLC, 2017

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

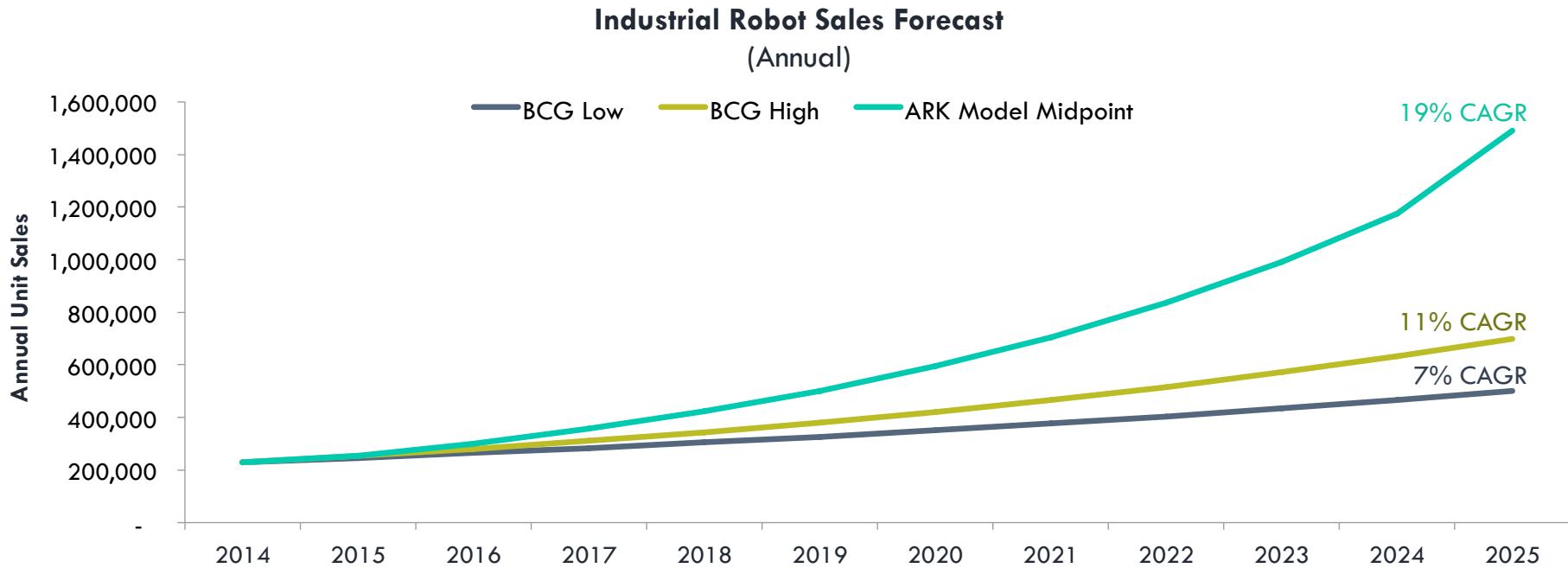


Robot Demand Is Responding To Lower Costs





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.

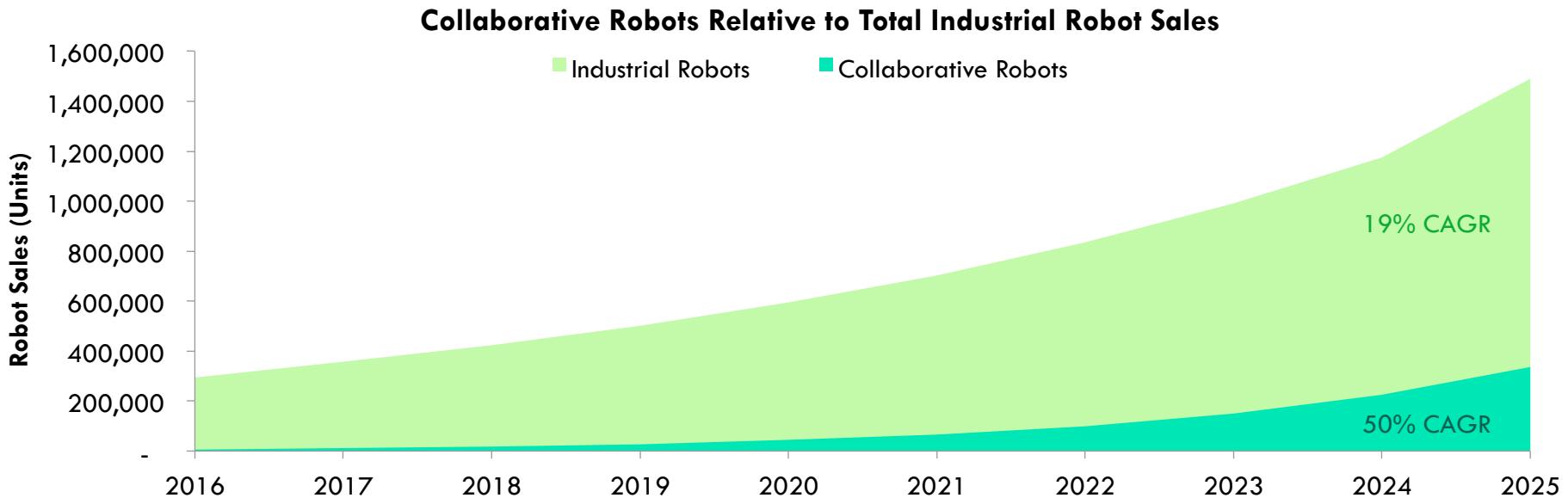
Current Collaborative Robots



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.)



ARK Believes Collaborative Robots Should Gain Market Share



Risks and Disclosure



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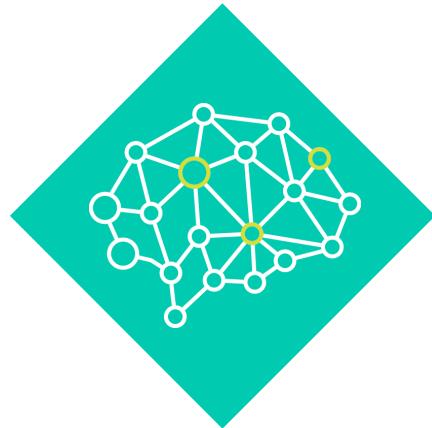
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- **Industrials Sector Risk**
- **Information Technology Sector Risk**

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.

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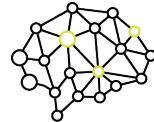
DEEP LEARNING



03



A Review



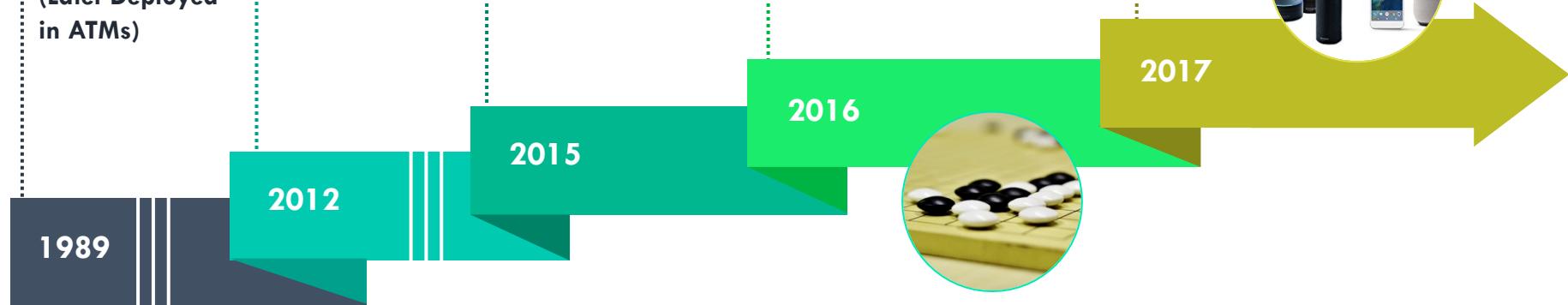
- LeCun Uses Backpropagation to Train Convolutional Neural Nets that Can Read Handwritten Digits with 99% Accuracy (Later Deployed in ATMs)

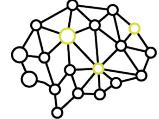
- Deep Neural Net Wins 2012 ImageNet Challenge, Reducing the Error Rate by 36%

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

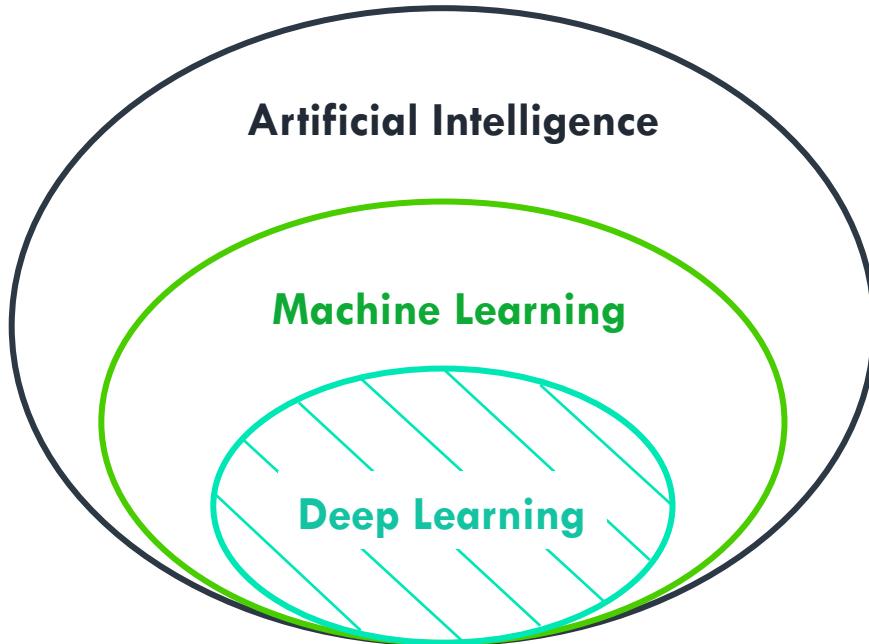
- DeepMind's AlphaGo Defeats Global Champion Lee Sedol in the Game of Go. The AI Program Combined Deep Learning with Monte Carlo Tree Search and Reached a Major AI Milestone Ten Years Ahead of Schedule

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

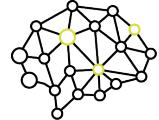




Deep Learning Is A Subset of Artificial Intelligence (AI)

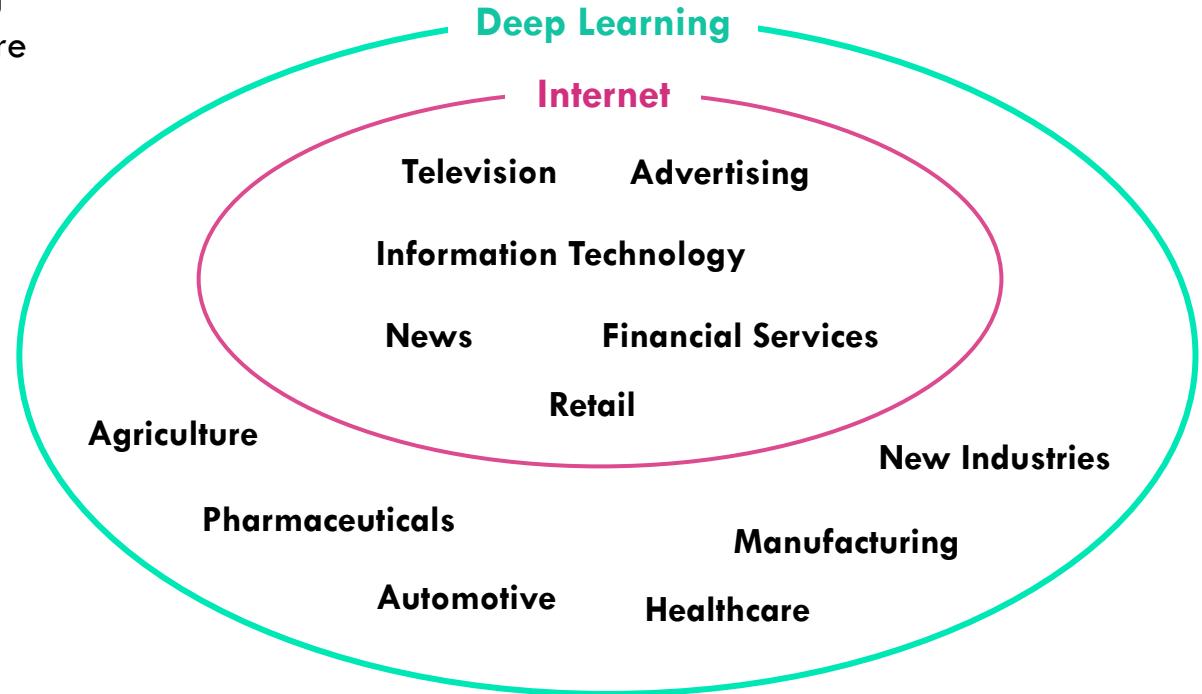


- Classic AI is based on deductive logic.
Rules are based on human ingenuity.
- Machine Learning is based on statistical inference. Rules are inferred from data.
- Deep Learning is a type of Machine Learning modeled after the biological brain.

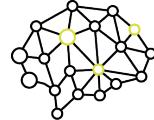


Deep Learning Is A Continuation Of “Software Eating The World”

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



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

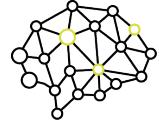
Amazon
Google
Microsoft
Alibaba
Tencent
Baidu
JD.com
iFlyTek

Every cloud provider launched AI as a service.

SOFTWARE

Salesforce
Box
Nuance
Adobe

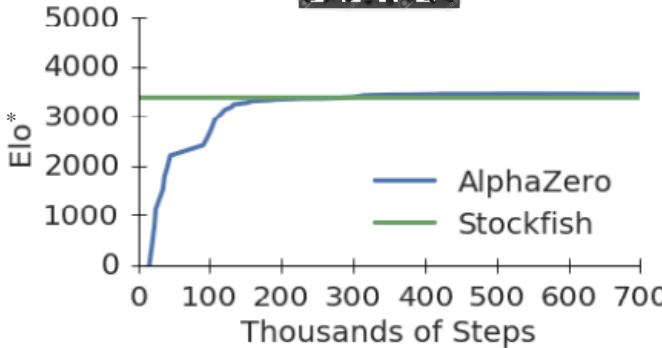
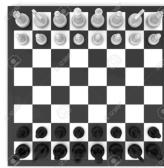
Software providers use AI for classification and tagging.



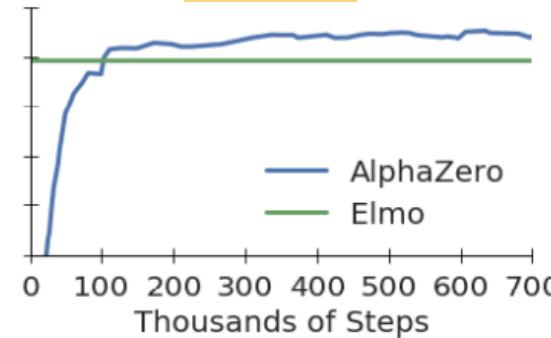
Deep Learning Is Now Smarter And More Adaptive

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

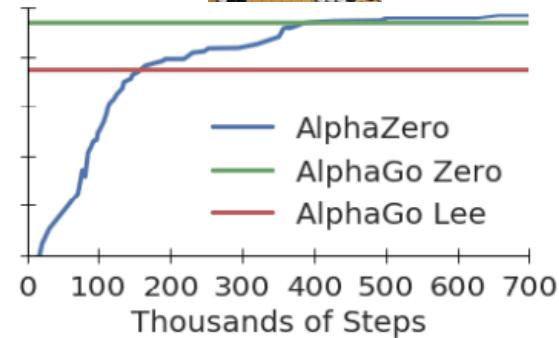
Chess

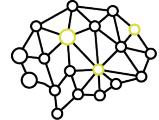


Shogi



Go





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

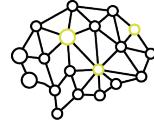


2017



3. Deep Learning

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

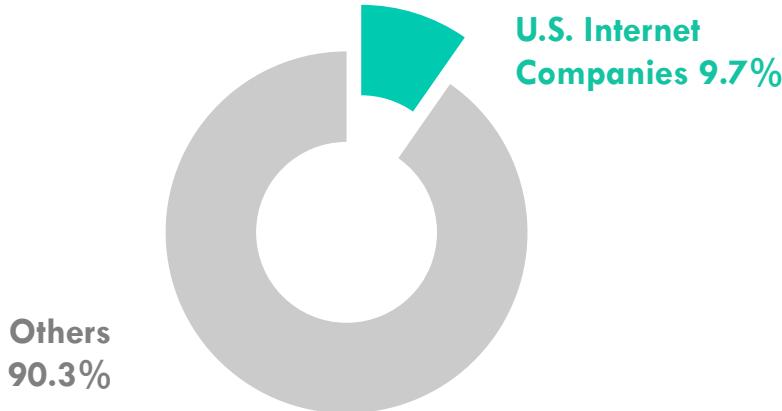


Deep Learning Should Be An Internet Scale Opportunity

- 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.

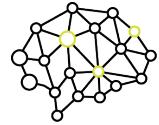
Pure Internet Companies As A Percent of S&P 500



S&P 500 Market Cap Created by The Internet

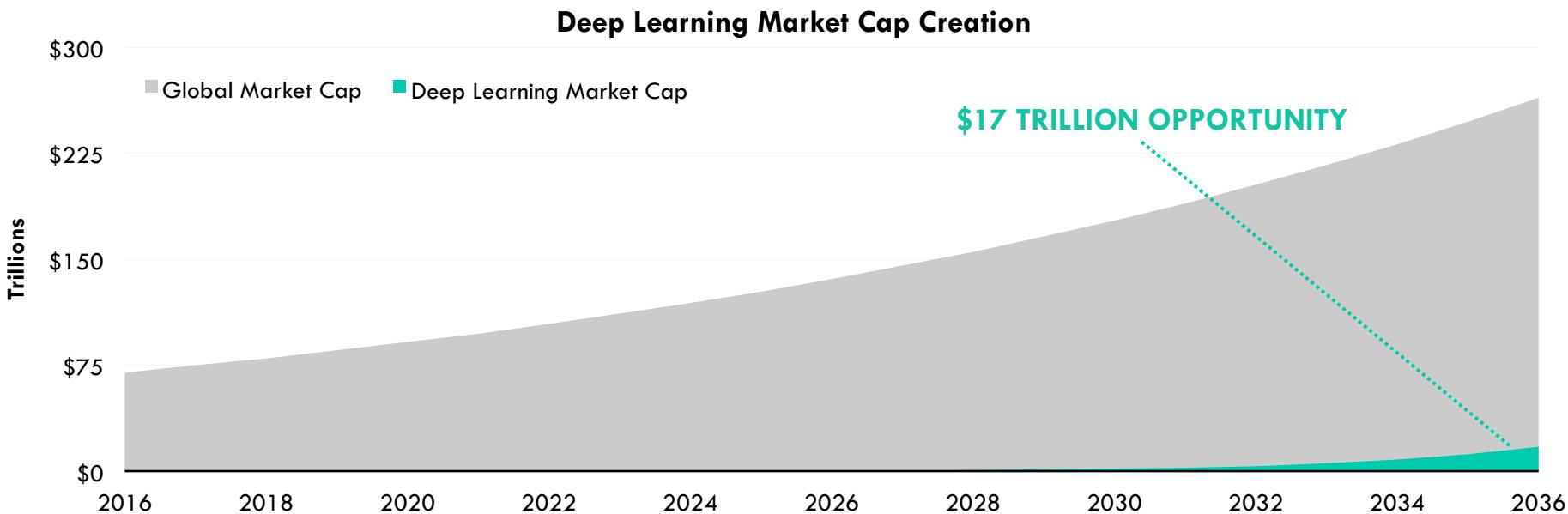
Company	Market Cap (\$B)
Alphabet	\$727
Amazon	\$563
Facebook	\$513
Cisco	\$189
PayPal	\$88
Priceline	\$85
Netflix	\$83
Salesforce	\$74
Ebay	\$39
Expedia	\$18
E*Trade	\$13
Akamai	\$11
Juniper Networks	\$11
Verisign	\$11
F5 Networks	\$8
TripAdvisor	\$5
Total	\$2,425
S&P 500 Market Cap	\$25,107
Share of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

3. Deep Learning



Based on ARK's research...

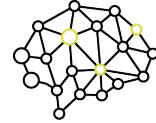
... Deep Learning could approach a global market cap of \$17 trillion in 20 years.



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



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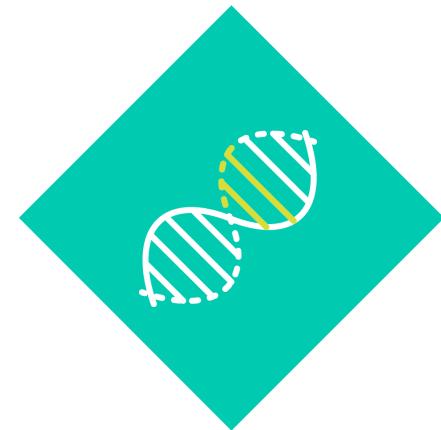
ARK aims to educate investors and to size the potential opportunity of **Deep Learning**, noting that risks and uncertainties may impact our projections and research models. Investors should use the content presented for informational purposes only, and **be aware of market risk, disruptive innovation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

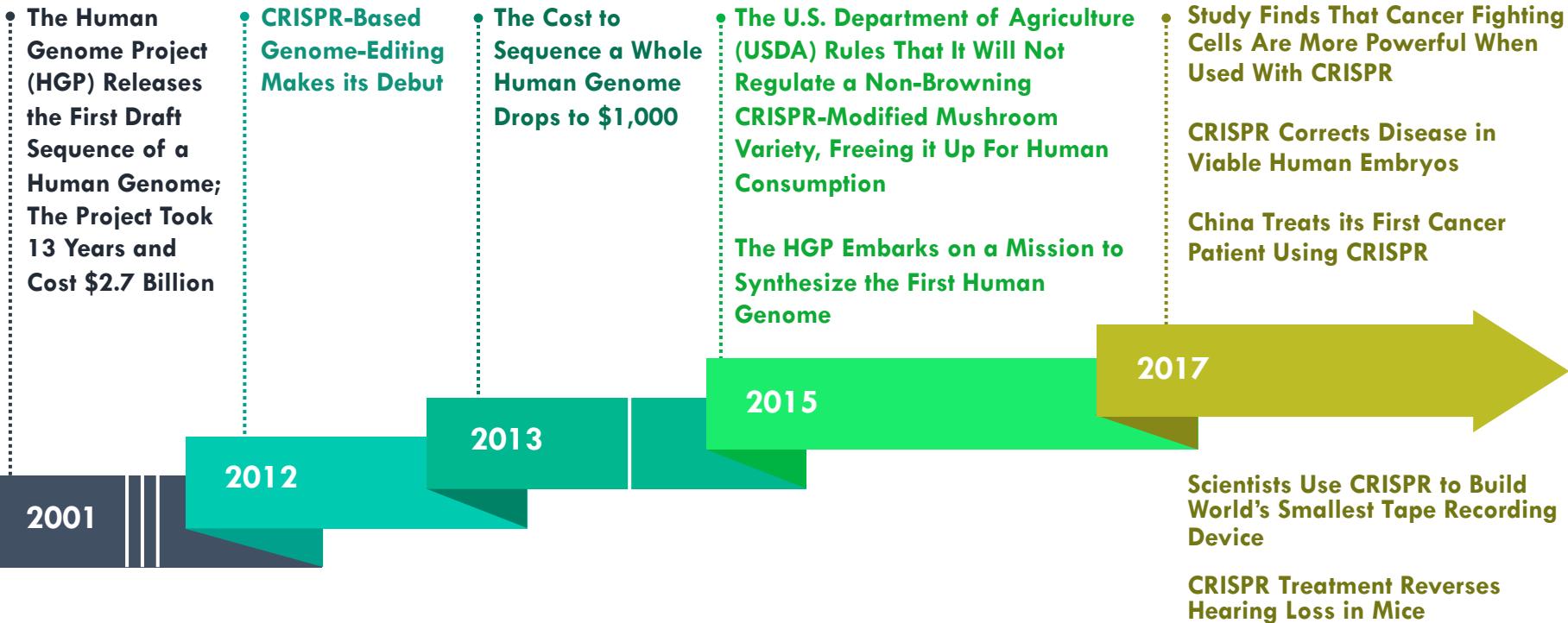


CRISPR GENOME-EDITING



4. CRISPR Genome-Editing

A Review

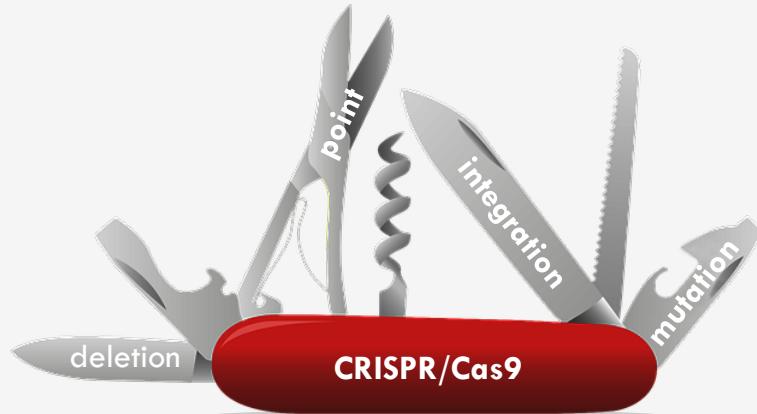


Cheap And Rapid “Write” Capabilities Enable Genome Modification



ARK believes that CRISPR is a genome-editing platform that will address the world's most salient health issues. It is like a “molecular swiss army knife” with a rapidly expanding number of tools that perform different functions:

Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)



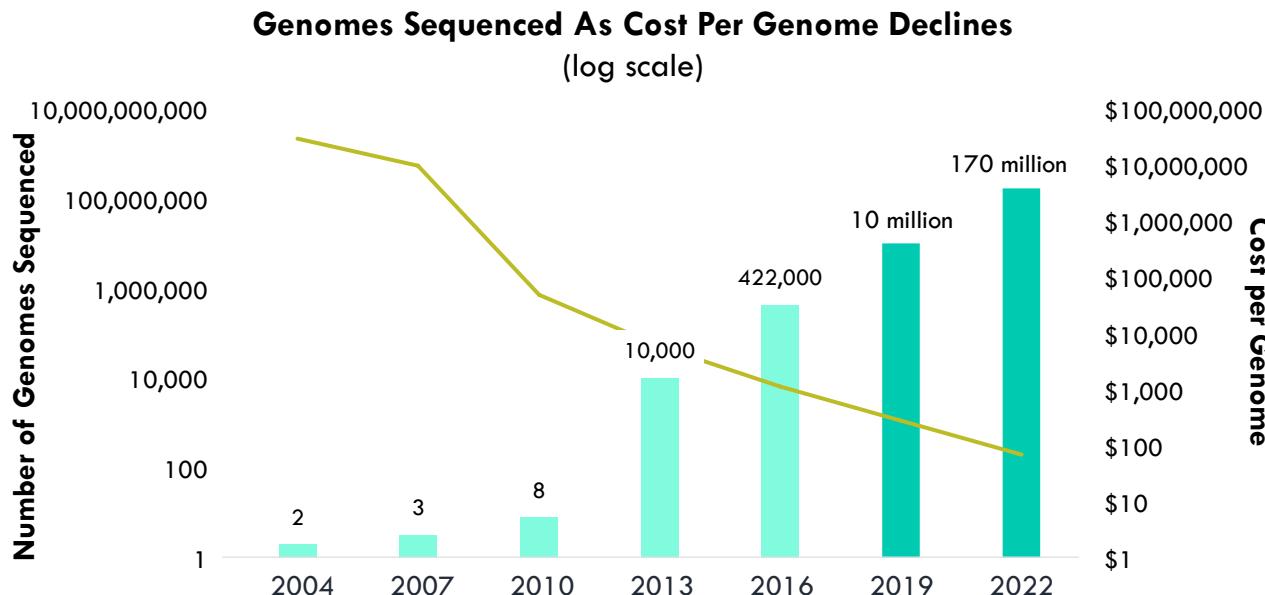
- **Cut** DNA/RNA at a single point or in stretches
- **Insert** DNA/RNA and create novel gene sequences
- **Activate and Silence** genes without making permanent changes
- **Regulate** protein expression levels epigenetically
- **Record and Timestamp** biological events
- **Track** the movement of specific biological molecules
- **Identify** the presence of specific cancer mutations and bacteria
- **Locate** molecules without making changes
- **Target and Destroy** specific viral and bacterial DNA and RNA
- **Interrogate** gene function multiplexed
- **Activate** drug release at a specified trigger

4. CRISPR Genome-Editing

Research Shows The Number Of Human Genomes Sequenced Should Soar



By 2022, the cost of sequencing or “reading” the DNA of a full human genome should drop below \$100, creating an explosion in the number of whole human genomes sequenced.



KEY EXPECTATIONS

- 2018-2021: NovaSeq instruments and chemistries should drive sequencing costs down by ~40% per year
- 2021: Cost/Genome ~\$100
- 2022: ~170 million human genomes should be sequenced

Forecasts are inherently limited and cannot be relied upon.

Source: ARK Investment Management LLC, 2017

4. CRISPR Genome-Editing

The Cost Of Editing DNA Mutations Is Dropping Precipitously



The cost of CRISPR, or “editing” DNA, is dropping, as is its time-to-manufacture, accelerating the pace of innovation.

	ZFNs*	TALENs**	CRISPR
Year of First Human Cell Modification	2003	2009	2012
Time to Manufacture (days)	22	10	5
Cost (per pair of nuclease)	~\$5,500	~\$360 per pair	~\$30 per pair

Newer Genome-Editing Techniques

THE CRISPR ADVANTAGE

- Increases research thanks to lower costs and ease of use
- Reduces manufacturing time thanks to operational efficiencies
- Re-invigorates opportunities in regenerative medicine, such as stem cell research

*ZFNs: Zinc Finger Nucleases **TALENs: Transcription activator-like effector nuclease

Source: ARK Investment Management LLC, 2017

Use Case: Agriculture



CRISPR should increase the yields of livestock, crops, and aquaculture in different ways:



- Breed TB- and other disease-resistant cattle
- Shift breeding practices from random to more scientific techniques
- Raise pigs with lower fat content
- Increase the milk yield of cows



- Yield more productive, pesticide-free, and weather/bug resistant crops
- Enhance taste and nutritional value
- Surface new seed variants for hard-to-modify crops like wheat and rice



- Cut gestation periods in half
- Increase the conversion of feed into weight
- Sterilize farmed fish to protect wildlife
- Breed disease-resistant fish to avoid food poisoning

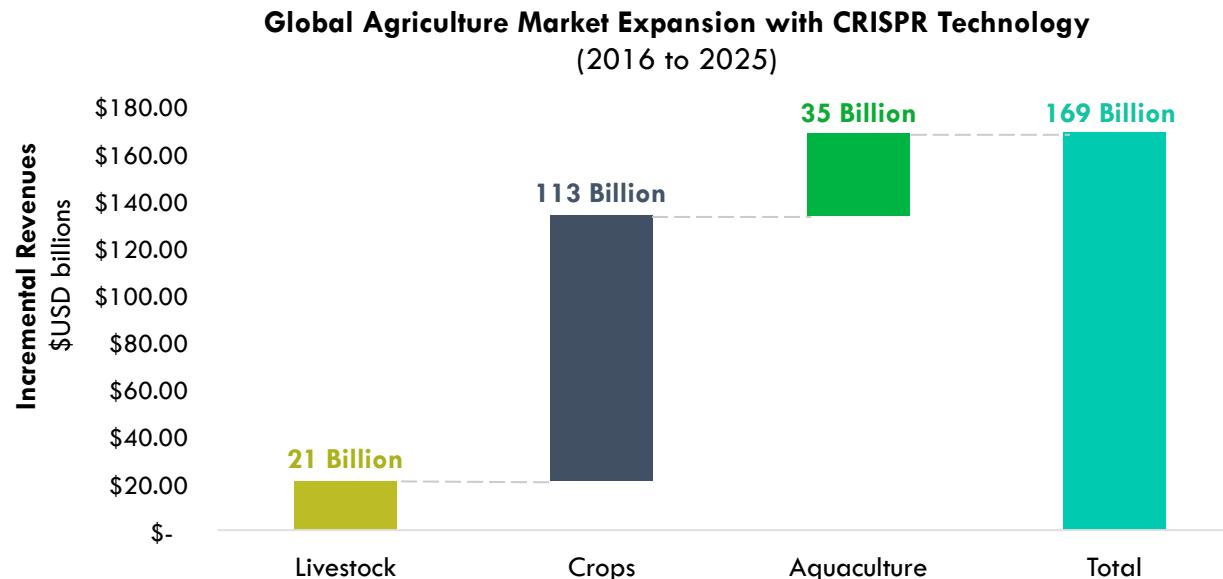
CRISPR

- Minimizes environmental footprint
- Avoids traditional GMO's in which foreign DNA infiltrates genes
- Aids small, family-owned farms with breeding techniques that lower the risk of disease
- Meets global demand for a diversified diet
- Reduces energy consumption associated with inefficient farmed fishing methods

Use Case: Agriculture



By 2025, CRISPR could expand the agricultural market by an estimated \$170 billion, sustaining projected growth in the global population.



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

CRISPR should have the first commercial impact in agriculture:

- 2020: CRISPR could enable the first commercial waxy corn variety
- 2025: CRISPR may increase food yield by an estimated 585 trillion calories
- 2025: CRISPR may increase agricultural productivity enough to feed an additional 800 million people

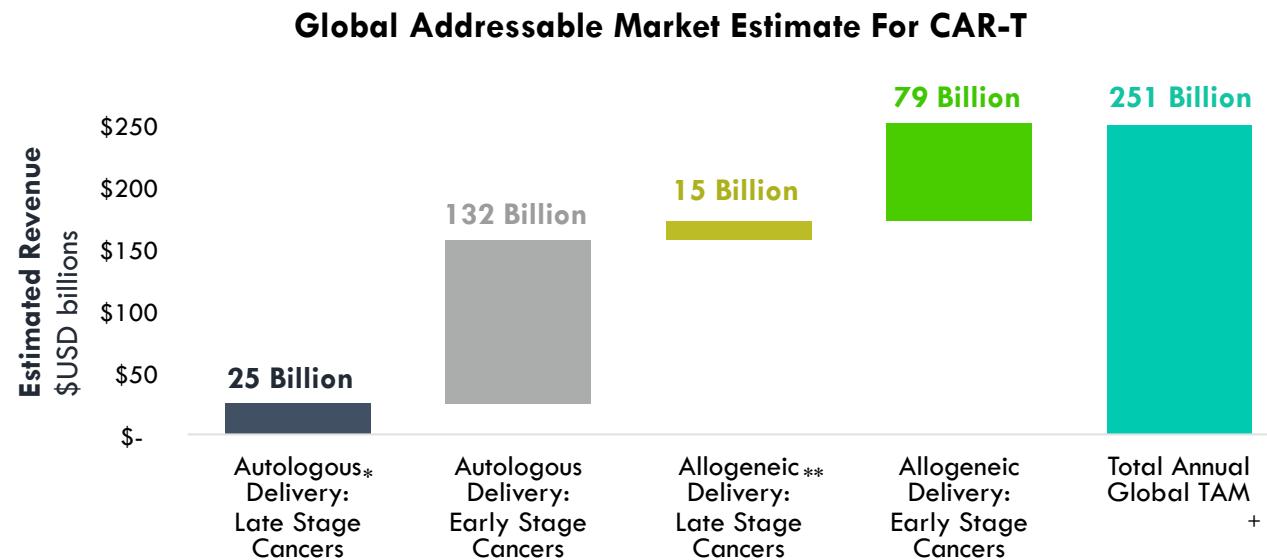
4. CRISPR Genome-Editing

Use Case: CAR-T



Globally, CAR-T cancer therapy could generate \$250 billion per year in revenues, with royalties payable to CRISPR companies.

- Chimeric Antigen Receptor T-cell (CAR-T) therapy is a novel immunotherapy that modifies a patient's own T-cells to target and kill malignant cells while keeping healthy cells intact.
- CAR-T therapy is in its infancy: CRISPR could enhance the safety and efficacy of next generation CAR-T therapies.



Forecasts are inherently limited and cannot be relied upon.

*Autologous: involves one individual as both donor and recipient. **Allogeneic: involves different individuals of the same species

+TAM: Total Addressable Market | Source: ARK Investment Management LLC, 2017

4. CRISPR Genome-Editing

Use Case: Monogenic Disease



CRISPR should dominate the \$75 billion annual addressable monogenic disease market. Only 5% of diseases caused by a single gene have any available treatment today.

CRISPR's Total Addressable Market: Monogenic Diseases

(prices based on cures, \$USD billions)



- CRISPR can address 10,000 monogenic diseases, of which only 5% have any treatments today
- 1 in 100 live human births results in a monogenic disease
- ARK expects CRISPR to enter human trials in 2018

Forecasts are inherently limited and cannot be relied upon.

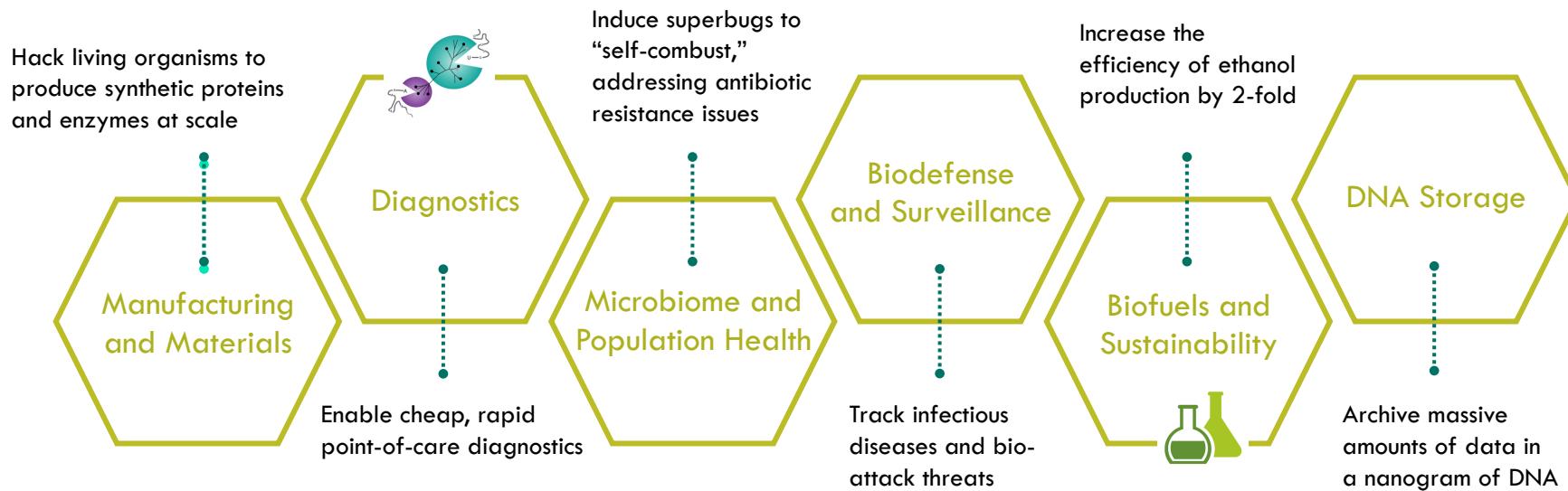
Source: ARK Investment Management LLC, 2017; Genetic Explanation: Sense and Nonsense. Gruber, Jeremy & Krimsky, Sheldon. 2013

4. CRISPR Genome-Editing

Based On ARK's Research...



CRISPR's toolbox should disrupt more than therapeutics and agriculture.



4. CRISPR Genome-Editing

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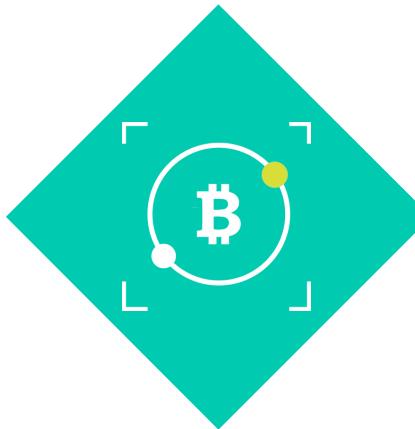
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- **Health Care Sector Risk**
- **Biotechnology Company Risk**
- **Pharmaceutical Company Risk**

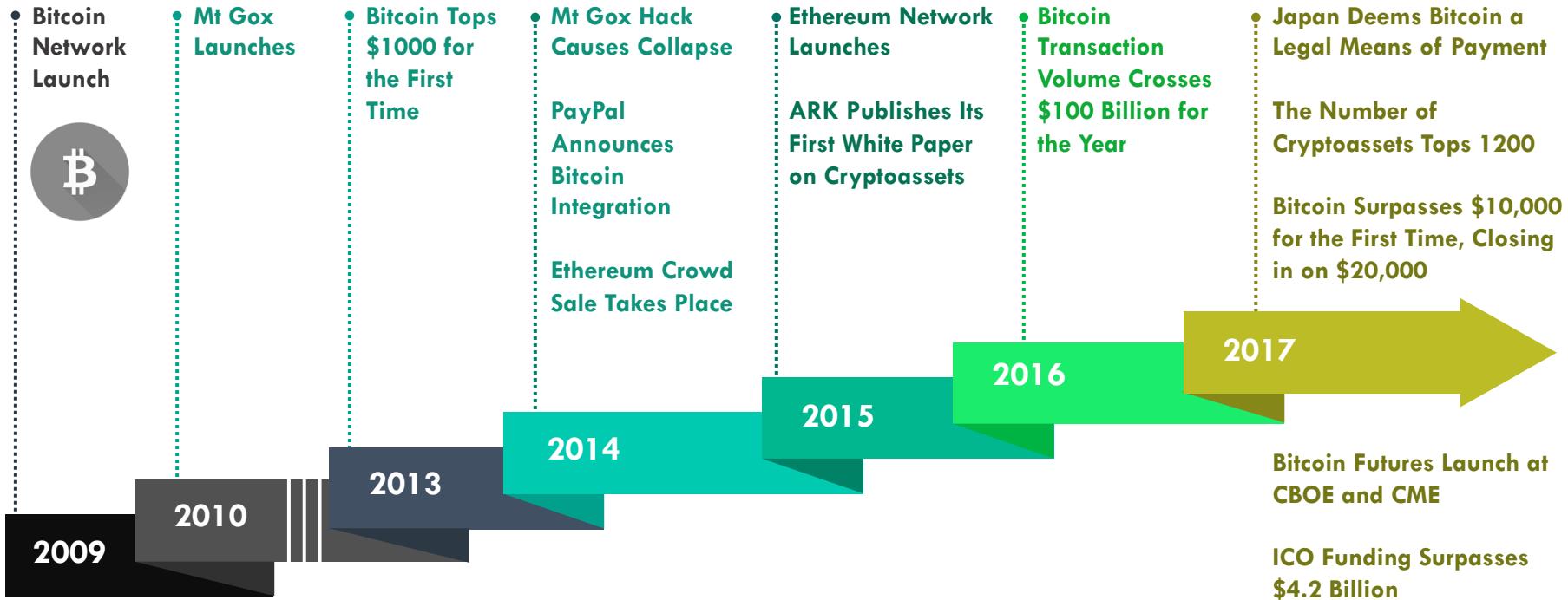
Health Care Sector Risk. The health care sector may be affected by government regulations and government health care programs, restrictions on government reimbursement for medical expenses, increases or decreases in the cost of medical products and services and product liability claims, among other factors. Many health care companies are: (i) heavily dependent on patent protection and intellectual property rights and the expiration of a patent may adversely affect their profitability; (ii) subject to extensive litigation based on product liability and similar claims; and (iii) subject to competitive forces that may make it difficult to raise prices and, in fact, may result in price discounting. Many health care products and services may be subject to regulatory approvals. The process of obtaining such approvals may be long and costly, and delays or failure to receive such approvals may negatively impact the business of such companies. Additional or more stringent laws and regulations enacted in the future could have a material adverse effect on such companies in the health care sector. In addition, issuers in the health care sector include issuers having their principal activities in the biotechnology industry, medical laboratories and research, drug laboratories and research and drug manufacturers, which have the additional risks described below. **Biotechnology Company Risk.** A biotechnology company's valuation can often be based largely on the potential or actual performance of a limited number of products and can accordingly be greatly affected if one of its products proves, among other things, unsafe, ineffective or unprofitable. Biotechnology companies are subject to regulation by, and the restrictions of, the U.S. Food and Drug Administration, the U.S. Environmental Protection Agency, state and local governments, and foreign regulatory authorities. **Pharmaceutical Company Risk.** Companies in the pharmaceutical industry can be significantly affected by, among other things, government approval of products and services, government regulation and reimbursement rates, product liability claims, patent expirations and protection and intense competition.



CRYPTOASSETS



A Review



Bitcoin Can Play The Roles Of Currency And Store of Value



Bitcoin →

Money over IP*

+

Digital Gold

ARK believes that through blockchain technology, bitcoin can act as “money over IP”, allowing for value transfer at a lower cost for consumers. For example, it could allow much simpler and cheaper cross-border money transfers for migrant workers.

*IP: Internet Protocol

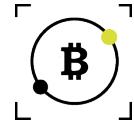
Bitcoin’s supply is mathematically metered to level out at 21 million units.⁺ As it moves toward this limit and becomes scarce, ARK believes bitcoin will hold its value, if not appreciate. For instance, increasingly bitcoin is serving as a “store of value” in countries, like Zimbabwe and Venezuela, which are plagued with hyperinflation

⁺Unless its core-software developer community agrees to lift the limit.

Cryptocurrency: A digital currency (i.e. bitcoin) in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds independently of a central bank within a decentralized network via the internet.

Source: ARK Investment Management LLC, 2017

Bitcoin As Money Over IP



In the 1980s, communicating across the world was expensive.

Voice over IP (VoIP)

Instant communication everywhere without relying on expensive telecom providers

➡ *The Internet enabled “free voice”*

Today, transferring funds across the world is expensive.

Money over IP (MoIP)

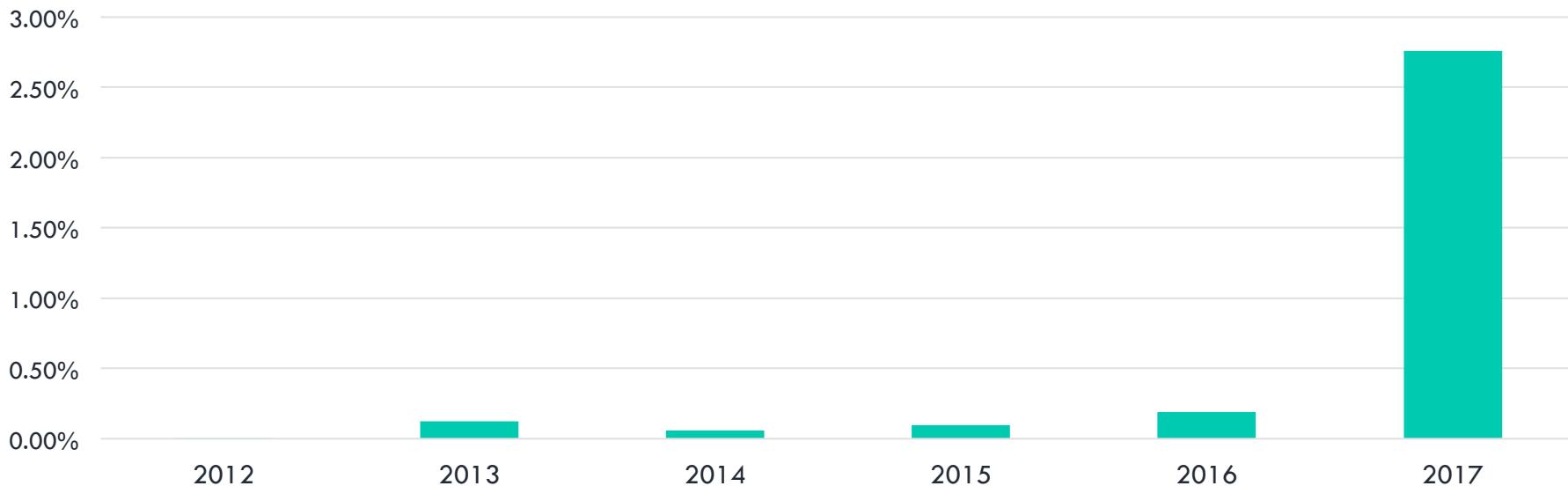
Instant value transfer of any amount to any person anywhere at almost no cost

➡ ARK believes blockchain technology will enable fee-less transfers

Bitcoin As Digital Gold



Year End Dollar Value of Bitcoin Outstanding as a Percentage of Above Ground Gold

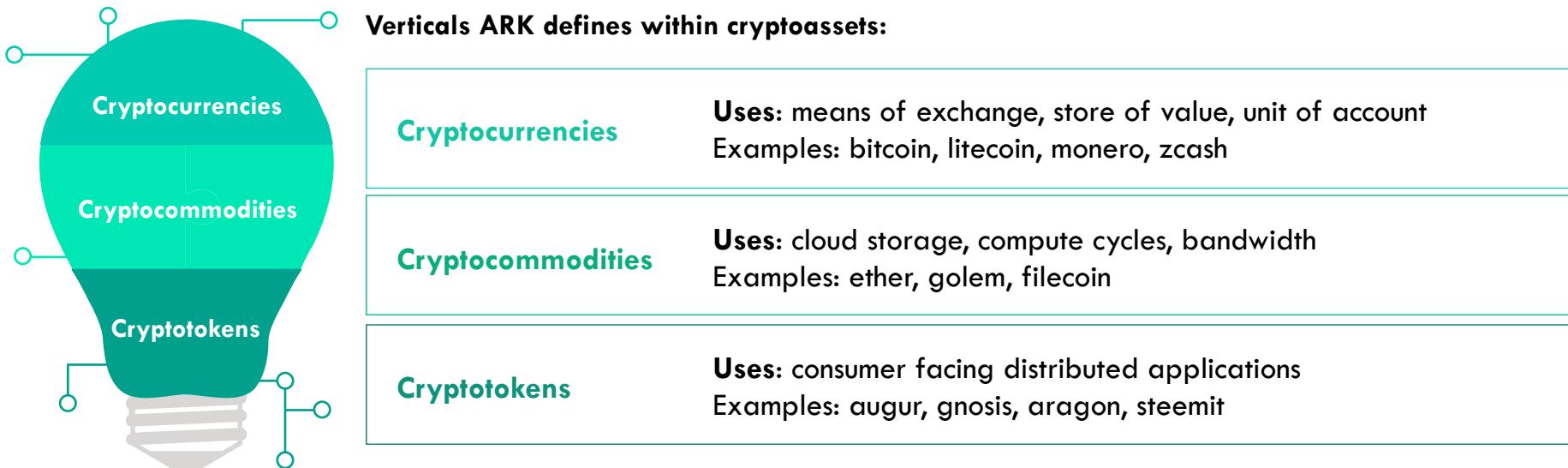


Bitcoins price is volatile and since the end of 2017 has lost substantial value. Bitcoin outstanding as a percentage of above ground gold as of 02/28/2018 was 2.2%.

Blockchain Technology Has The Potential to Create A New Asset Class



ARK believes that bitcoin and other cryptocurrencies are not just “currencies”, but could be considered part of a new asset class: **Cryptoassets**. The definition of an asset class was addressed by Robert Greer¹ in 1997. Greer differentiates asset classes in three ways: politico-economic features, correlation of price movements, and risk-reward profiles. ARK believes the same differentiation can be applied to cryptoassets when comparing them to other asset classes such as equities, bonds, or currencies.



5. Cryptoassets

How Cryptoassets Compare To Other Asset Classes



	Collateral	Basis of value	Provenance
Equities	Voting rights	Cash flows in excess of fixed income obligations	1600s
Bonds	Fixed assets; Legal position in the capital structure	Interest payments, recovery value of fixed assets	1200s
Income-producing real estate	Underlying land and buildings	Rents	500 BC
Physical commodities (i.e. Grains, Coal)	Physical goods	Supply/predictable demand	100,000 BC
Precious metals (i.e. Gold)	Metal	Supply/unpredictable demand	3000 BC
Currency	The credibility of the monetary authority	Manipulated supply to stabilize demand	600 BC
Fine art	Paint on canvas	Aesthetics/scarcity/unpredictable demand	400 BC
Cryptoassets	Bandwidth in a digital network	Digital scarcity / mathematically metered supply ⁺ / unpredictable demand	2008

Unlike traditional currencies or other asset classes, bitcoin has no physical form and is not backed by tangible assets. A virtual currency like bitcoin is not insured or controlled by a central bank or other governmental authority, cannot always be exchanged for other commodities, and is subject to little or no regulation. Consequently, there is significant more risk for potential fraud and manipulation.

⁺Some cryptoassets may not be mathematically metered (i.e. Ripple) and follow a different approach.

Sources: ARK Investment Management LLC, 2017;

Data Sources: The Ascent of Money; Land Tenure in Ancient Greece, The Canadian Journal of Economics and Political Science; Britannica.com; The history of money from barter to bitcoin, the Telegraph

5. Cryptoassets

Cryptoassets Are Still Small Compared To Other Asset Classes.



Asset Classes	Global Value (USD Trillions)	As a Multiple of Cryptoassets
As of Feb 28, 2018		
Cryptoassets	\$0.4	1x
Gold	\$8.1	20x
Money Supply (Narrow)	\$37	92x
Equities	\$80	200x
Money Supply (Broad)	\$90	225x
Bonds	\$108	270x
Real Estate	\$240	600x

Cryptoassets: Represented by the sum total of assets listed on coinmarketcap.com

Gold Outstanding: Represented by the current value of all above-ground gold

Money Supply Narrow: M1 outstanding according to the CIA Fact Book

Money Supply Broad: M2 outstanding according to the CIA Fact Book

Equities: Reflects total value of equities outstanding per SIFMA Fact Book adjusted for incremental appreciation

Bonds: Total debt securities outstanding from the March 2018 BIS quarterly review plus estimates of incremental issuance

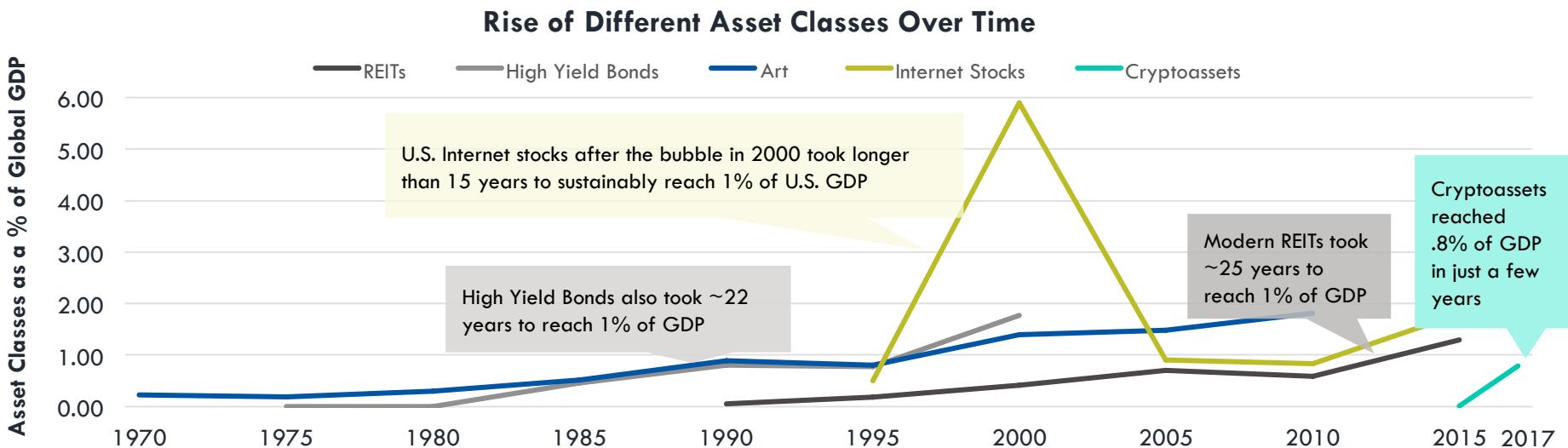
Real estate: Estimate of total value of privately held real estate

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Cryptoassets Have Appreciated Rapidly

It typically takes decades before an asset class's value rises sustainably above 1% of global GDP. The total value of bitcoin, ether, litecoin, and other cryptoassets listed on coinmarketcap.com hit 0.8% of global GDP in late 2017—less than a decade.



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Sources: ARK Investment Management LLC, 2017; Data Sources : ART: "Size of Distressed Debt Market and Default Outlook for 2005 - 2006", NYU Stern, "Art as an Asset and the underperformance of the Masters" by Mei and Moses REITs: <https://www.reit.com/data-research/reit-market-data/us-reit-industry-equity-market-cap> Internet Stocks: "The valuation and market rationality of internet stock prices", 2002, NY Stern

5. Cryptoassets

Are Cryptoassets In A Bubble?



Many thought that cryptoassets were in a bubble in 2013 when bitcoin peaked around \$1,000. Financial “booms and busts” are normal in technological revolutions. ARK believes the value proposition of blockchain technology is profound.



What We Expect In The Future For Cryptoassets

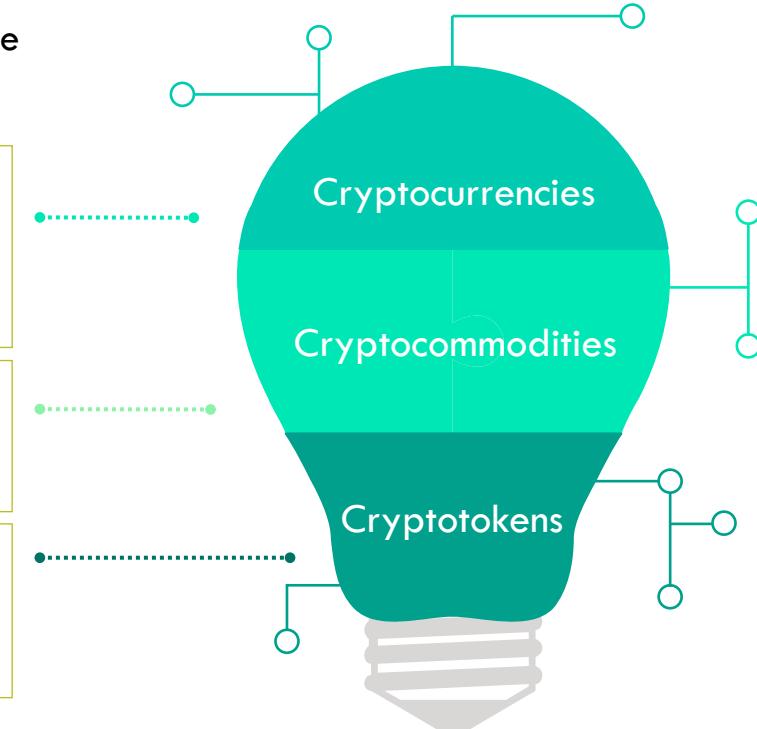


As the cryptoasset market evolves, each category will have a unique utility and value proposition.

- 01 A store of value, particularly in emerging markets.
- 02 A means of payment, particularly in emerging markets.
- 03 A reserve currency for all other crypto-assets.

- 04 Computing power, storage, bandwidth, and other digital commodities will become securitized products that trade on financial exchanges.

- 05 Just as bonds are claims on fixed assets and equities are claims on excess cash flows, tokens will be claims on the utilization of assets and could become a part of corporate capital structures.



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- **Cryptocurrency Risk**
- **Cryptocurrency Tax Risk**

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Cryptocurrency Tax Risk. Many significant aspects of the U.S. federal income tax treatment of investments in bitcoin are uncertain and an investment in bitcoin may produce income that is not treated as qualifying income for purposes of the income test applicable to regulated investment companies, such as the Fund. GBTC is expected to be treated as a grantor trust for U.S. federal income tax purposes, and therefore an investment by the Fund in GBTC will generally be treated as a direct investment in bitcoin for such purposes. See “Taxes” in the Fund’s SAI for more information.



FRICTIONLESS VALUE TRANSFERS



06



6. Frictionless Value Transfers

A Review



- Alipay Launches



- Bitcoin Network Launches

2009

- Apple Pay Launches

2014

- WeChat Pay Reaches 1 Billion Active Users

Mobile Payments Hit \$5.8 Trillion in 2016



2016

- Square Cash App Launches Bitcoin Purchasing Function

Over the 3 Months Ended December 6th, Bitcoin's Blockchain Facilitated More Than \$1.5 Billion Worth of Value Transfer on Average Per Day

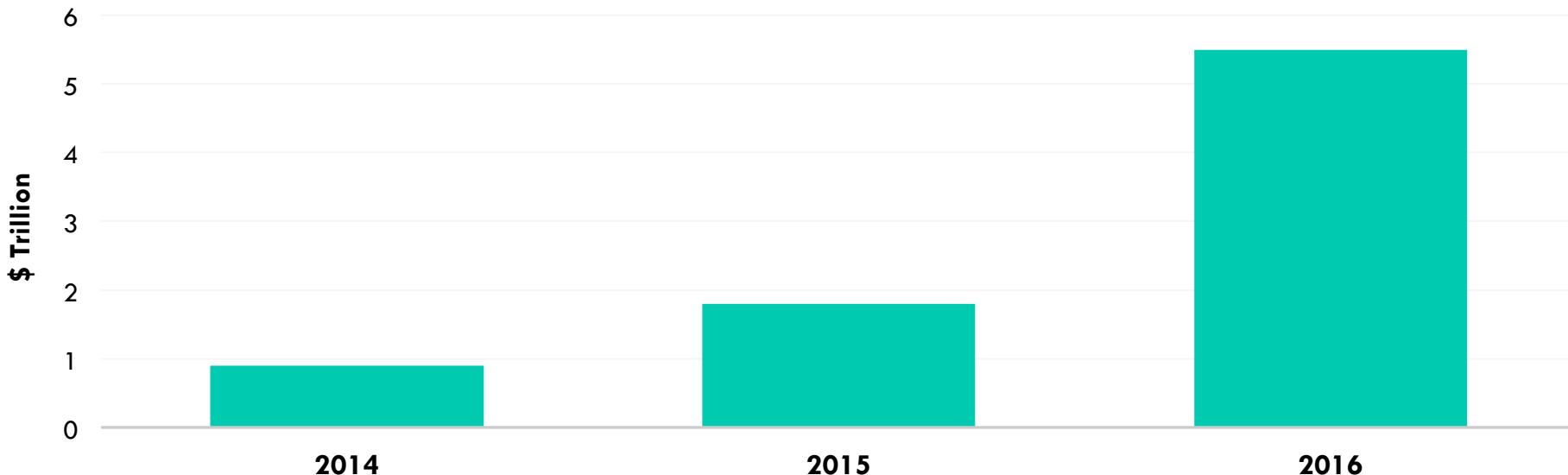
2017





China Points To The Potential Of Mobile Payments

ARK believes that frictionless value transfers, enabled by technology, make transactions and exchanges (i.e. money, digital commodities, etc.) as simple and seamless as possible within a user's everyday life. Today, one of the most common forms is mobile payments. In China, mobile value transfers jumped 5-fold in two years, reaching \$5.5 trillion in 2016.

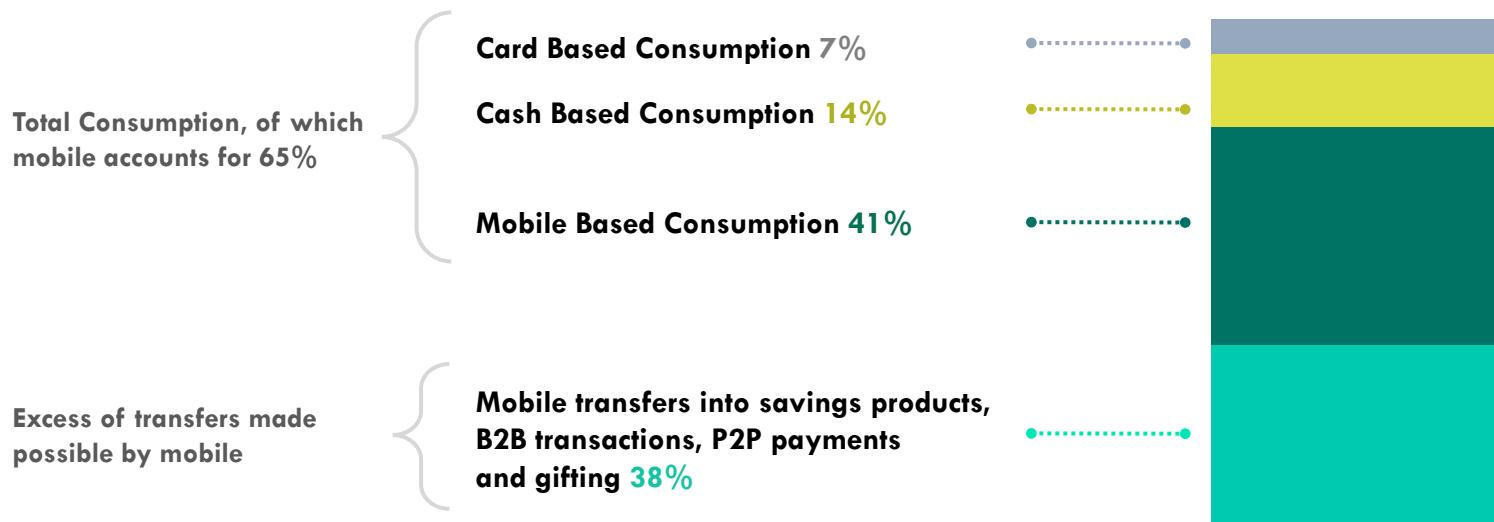




China Points To The Potential Of Mobile Payments

Mobile enables 65% of the consumption in China as well as other financial transfers like gifts and business-to-business transactions.

Mobile as a % of Total Value Transfers in 2016



China Points To The Potential Of Mobile Payments



ON-DEMAND BIKE SHARING

- 25 Billion Transactions in 2017
- Average Value of \$0.15



TIPPING FOR CONTENT

- 1.2 Trillion Transactions in 2016
- Average Value of \$0.01



RED ENVELOPES & GIFT GIVING

- 290 Billion Transactions in 2017
- Average Value of \$1.50

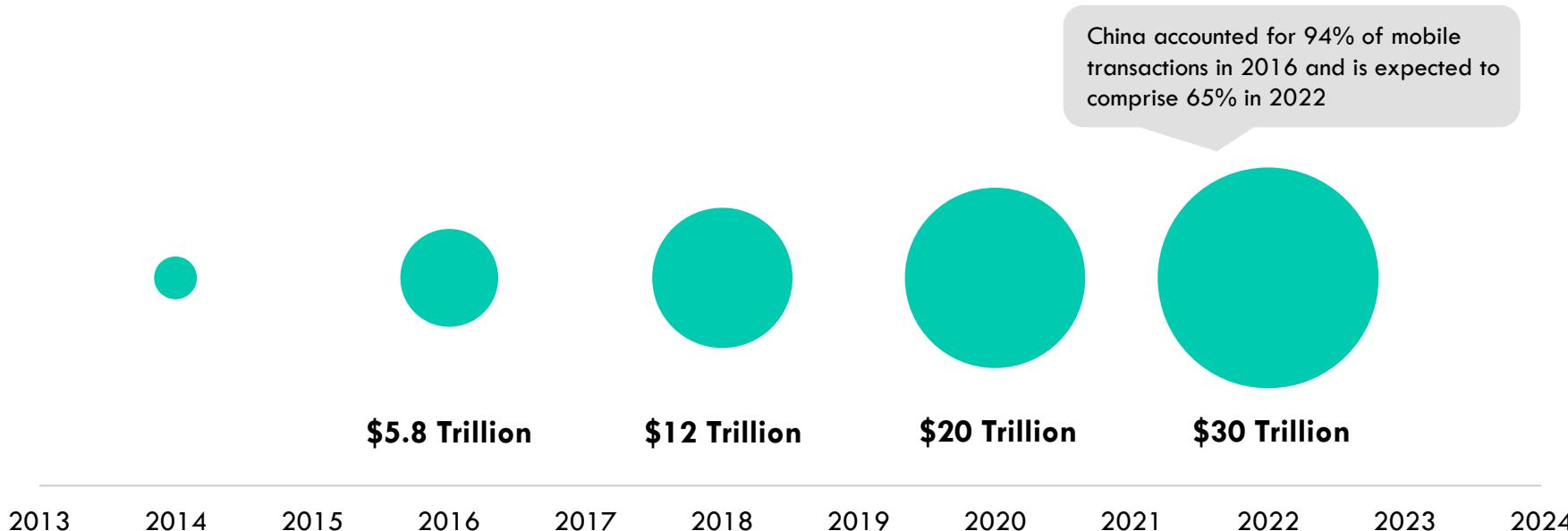
Sources: <https://www.economist.com/news/business/21731675-one-answer-would-be-ofo-and-mobike-merge-chinas-bicycle-sharing-giants-are-still-trying>,
<https://www.reuters.com/article/us-lunar-newyear-wechat-redpackets/wechat-users-send-46-billion-digital-red-packets-over-lunar-new-year-xinhua-idUSKBN15J0BG>

6. Frictionless Value Transfers

China Points To The Potential Of Mobile Payments



ARK's research shows globally, mobile value transfers are expected to grow 5-fold and to reach **\$30 trillion** by 2022.



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

The Evolution Of Frictionless Value Transfers Has Accelerated



ARK believes the number of transactions should increase significantly as technology enables programmatic value transfers.

Cash

Bank Notes

Demand Drafts

Credit & Debit Cards
VISA, MASTERCARD

Wire Transfers
WESTERN UNION

ATMs

Mobile Payments
WECHAT PAY, ALIPAY

Social Payments
VENMO, SQUARE CASH

Digital Wallets
APPLE PAY, PAYPAL

Embedded Payments
AMAZON ONE CLICK

**Machine to Machine
Programmatic Value
Transfers**

BITCOIN, LITECOIN

Digital Commodities

**Real Time Insurance
Contracts**



6. Frictionless Value Transfers

Risks and Disclosure



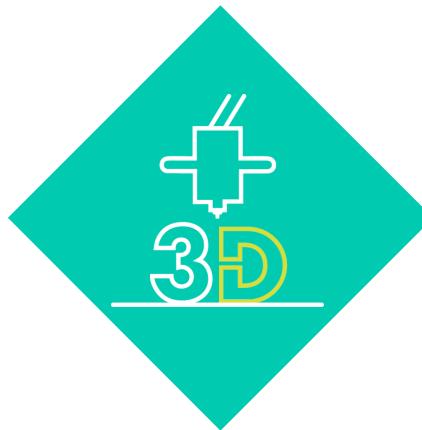
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- **Internet Company Risk**
- **Software Industry Risk**
- **Cryptocurrency Risk**

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3D PRINTING



A Review



- Invention of First 3D Printing Methods



- First Patent for 3D Printed Human Cells

- Consumer 3D Printing Hype

- 3D Printing Companies Restructure, Placing Less Emphasis on the Consumer Market

GE Acquires Metal 3D Printing Companies, Arcam and Concept Laser

HP Begins Selling Multi-jet Fusion Printer

- Adidas and Carbon 3D Partner on 3D Printing Shoe Midsoles

FAA Drafts Guidance on Additive Manufacturing in Aerospace

FDA Provides Guidance on Additive Manufacturing for Medical Devices

2003

2014

2016

2017

1980



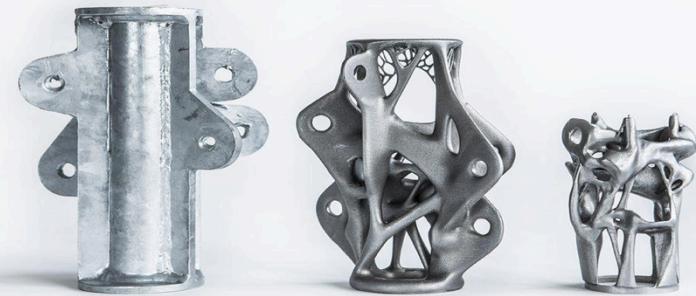


3D Printing Should Revolutionize Traditional Manufacturing

By building objects layer-by-layer, instead of removing material from a larger block or using a mold, 3D printing offers a range of benefits:

- **Shortens design-to-production time**
- **Shifts power to the designers**
- **Creates products with less waste**
- **Enables radically new architectures**
- **Reduces the cost of manufacturing significantly**

Traditional Manufacturing → 3D Printing and Machine Learning



For example, these structural nodes all support the same weight, but the part on the right weighs 75% less and is 50% smaller than the original part on the left.



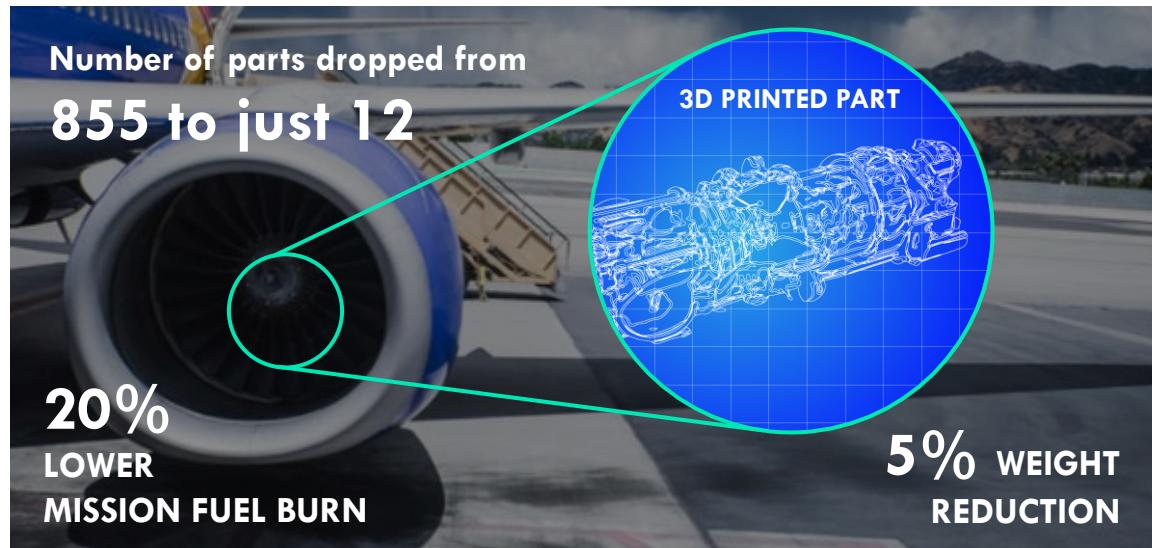
Use Case: Aerospace & Aviation

General Electric expects its additive manufacturing efforts to generate \$1 billion in revenues and save \$3-5 billion in costs by 2020.

Thanks to 3D printing, GE is reducing costs and producing better performing parts for jet engines.

PROOF OF CONCEPT: ADVANCED TURBOPROP ENGINE (ATP)

- Number of parts dropped from 855 to just 12
- Fuel burn lowered by 20%
- Weight reduced 5%
- Test schedule dropped from 12 to 6 months
- Structural casting eliminated



Sources: GE Additive Oppenheimer Annual Industrial conference 2017, https://www.ge.com/investor-relations/sites/default/files/GE%20Additive_Oppenheimer%20Annual%20Industrial%20Growth%20Conference.pdf
<https://www.geglobalresearch.com/blog/3d-printing-creates-new-parts-aircraft-engines>



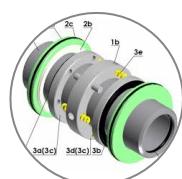
3D Printing Is In Its Infancy

ARK's research shows that 3D printing for end use parts should be the next frontier.

3D Printing Market Potential And Its Current Penetration

Design for Manufacture

Prototypes



Molds & Tools



Consumer Products
End Use Parts



Non-Consumer
End Use Parts



	\$12.5B	\$30B	\$260B	\$230B
Market size:	\$12.5B	\$30B	\$260B	\$230B
1st Applications:	1980's	1990's	-----	Early 2000's
Current Penetration:	30-40%	5%	-----	<1%

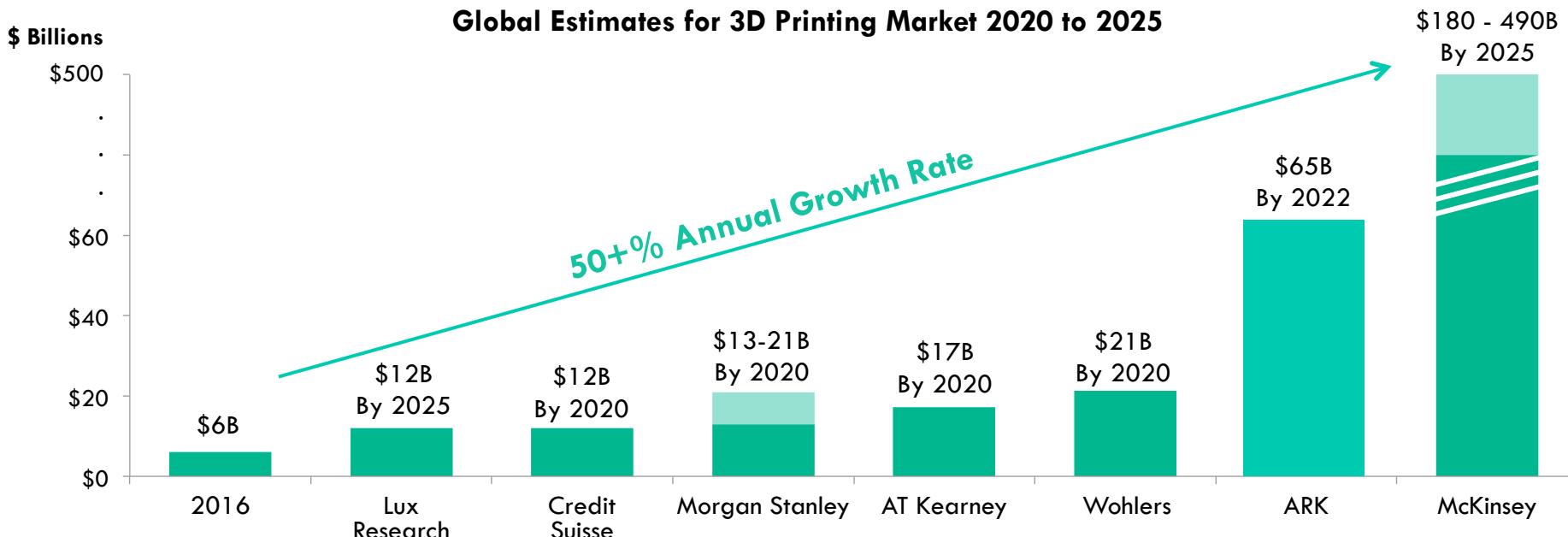
Forecasts are inherently limited and cannot be relied upon.

Sources: ARK Investment Management LLC, 2017; McKinsey; Stratasys; <http://www.avplastics.co.uk/3d-printing-history/>



The 3D Printing Market Could Increase Nearly Ten-Fold By 2022

ARK's research predicts the 3D printing market could grow to \$65 billion by 2022.



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



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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.

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- **Industrials Sector Risk**
- **Machinery Industry Risk**
- **Software Industry 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.

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