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Global Technology

Can Augmented Reality Drive the Next Big Smartphone Upgrade Cycle?

Our view is that Augmented Reality (AR) is the next killer app, extending the life of the smartphone market and accelerating upgrades over the next three years. We see Apple leading the charge with Alibaba, Amazon, Google, and Tencent benefitting from increased eCommerce and mobile app adoption.



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Can Augmented Reality Drive the Next Big Smartphone Upgrade Cycle?

Our view is that Augmented Reality (AR) is the next killer app, extending the life of the smartphone market and accelerating upgrades over the next three years. We see Apple leading the charge with Alibaba, Amazon, Google, and Tencent benefitting from increased eCommerce and mobile app adoption.

We view AR as a revolutionary technology trend.

Forty years ago, the personal computer

equipped with keyboard and mouse brought computing into the home. Thirty years later, mobile devices led by iOS introduced touch input that transferred the power of compute to your hand. With the introduction of dual camera and 3D sensors, a new revolution is underway which allows mobile devices to capture 3D images of your surroundings and overlay additional images or information, making the camera a new input technology. Examples of AR use cases include replicating a mobile game in the user's current environment, accurately measuring depth and distance between objects, trying out furniture or clothing before purchasing online, and providing a "real life" view of digital maps. We expect consumer apps to dominate near-term with enterprise apps taking longer to develop but creating even more value.

We liken the impact of AR to the launch of the Apple App Store in 2008. While the iPhone introduced a user-friendly touch interface that revolutionized mobile phones, it was the app store that allowed users to consume and create information in a way that was optimized for the smaller form factor, expanding the range of computing func-



IT Hardware
North America Industry View

Cautious

tions and therefore demand in the market. We see new camera technology along with Apple's ARKit as similarly accelerating both device upgrades and services growth. We don't expect the Android ecosystem to stand still in response. In fact, Google recently announced ARCore, a developer platform similar to Apple's ARKit. However, compatibility with only two handsets – the Samsung Galaxy S8 and Google's Pixel – limits adoption.

We size the incremental AR opportunity as \$404B over the next three years, driven by accelerated device upgrades (\$286B) and AR-related services (\$118B). Combined device and services revenue grows at a 20% CAGR over the next three years in a scenario of meaningful AR adoption, compared to our current base case estimate of 15% growth. We also see \$38B of revenue from 3D-related smartphone components, although it is unclear how much is incremental given ongoing pricing pressure in smartphone components.

What's changed? We introduce an Apple AR bull case of modest revenue growth, largely driven by Services acceleration, and \$14.05 EPS in FY19 which drives our new bull case valuation of \$253 and assumes an 18x P/E – a slight premium to the market but a discount to other platform companies. Our colleague Charlie Chan, who covers Greater China Semiconductor stocks, also launches coverage of [Win](#)

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Semi with an Equal-weight rating, and forecasts 25% revenue exposure if our Augmented Reality bull case plays out. Additionally, our colleague Yunchen Tsai raises her price target for AAC as growing AR applications should drive greater adoption of haptics, with 3D sensing serving as upside.

Who benefits? **Apple** is the clear leader, with **Google** and **Tencent** also well-positioned to capture incremental services revenue long-term. We see interesting use cases that increase eCommerce penetration benefitting **Alibaba** and **Amazon**. Our preferred component supplier stocks with AR exposure include **Win Semi**, **TSMC**, **Himax**, and **Mediatek**. A full list of clear and potential beneficiaries can be found in [Exhibit 4](#) and [Exhibit 5](#).

Exhibit 1:

Ratings and Valuation Changes Made in Conjunction with Our AR Note

Stock Rating / Valuation Changes			
Company	Ticker	Rating	Action
AAC	2018.HK	OW	Increase Price Target to HK\$170 (from HK\$150)
Apple	AAPL	OW	Increase Bull Case Valuation to \$253 (from \$203)
Win Semi	3105-OT	EW	Initiate EW with NT\$199 Price Target

Source: Morgan Stanley Research

Exhibit 2:

Clear Beneficiaries of an AR-Driven Smartphone Upgrade Cycle

Clear Beneficiaries of Mobile AR Cycle		
Devices \$286B TAM	Services \$118B TAM	Components \$38B TAM
Apple	Alibaba	AAC
Samsung	Alphabet	AMS
	Amazon	Chroma Ate
	Apple	Himax
	Tencent	Largan
		LG Innotek
		Lumentum
		Mediatek
		STMicro
		Sunny Optical
		TSMC
		Tong Hsing
		Viavi
		Win Semi

Source: Morgan Stanley Research



Portfolio Manager Summary

Why are we bullish on AR? We see the camera becoming the main input/output function on smartphones, allowing everyday smartphone users to create and experience rich images/video with the special effects of professional film. This has the potential to revolutionize applications, including social media, search, gaming, and eCommerce. If we're right, both smartphone upgrades and mobile app revenues should accelerate.

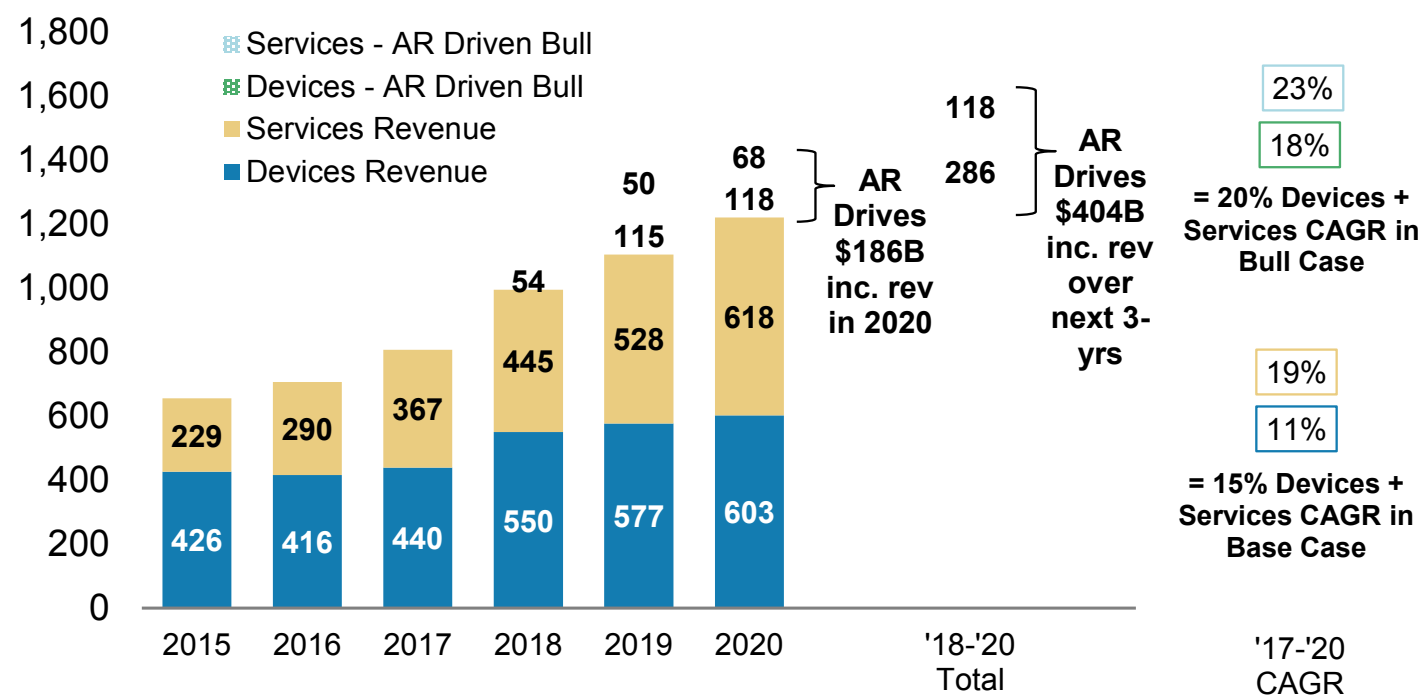
What are AR use cases? Niantic's Pokemon Go and Snapchat 3D effects are early use cases of AR, both overlaying content on real world images to take applications to the next level. Retailers, like Ikea and Wayfair, are leveraging AR-based technology to view product in real world environments reducing the friction of buying online. We expect other retailers, like apparel brands and car manufacturers, to follow suit. Potential business applications include collaboration, training, remote diagnostics, and more dynamic marketing campaigns.

What's the impact on the technology market? We see a bull case of AR adding \$404B to our smartphone device and services revenue forecasts over the next three years. Accelerating device upgrades push smartphone shipment revenue CAGR to 18% 2017-20E, from our current base case of 11%, representing \$286B of incremental revenue over the three years. We believe mobile app revenue growth will accelerate much like after LTE and large screen smartphone adoption, adding \$118B of revenue over the next three years. In this scenario, we see services growing at a 23% CAGR compared to 19% based on current Morgan Stanley forecasts. While not included below, we see an addressable market of \$38B for AR-related smartphone components though note that falling prices for other components may fund some of this spend which is why we don't view it as entirely incremental.

Exhibit 3:

AR Adds \$404B of Incremental Revenue to Devices and Services Over Next 3 Years

Annual Revenue (\$B)



Source: Company Data, IDC, Morgan Stanley Research. Incremental devices assumes ASP of \$330



Who will benefit? Given the history of commoditization in the component supply chain, we see device makers and mobile app services as the best way to capture sustainable value creation. **Apple** is clearly in the lead but the Android ecosystem isn't far behind - Apple's ARKit for developers launched in June 2017, and Google's ARCore launched in late August 2017. However, Apple benefits from uniform upgrades to new operating systems while Android faces the challenge of fragmentation. For perspective, two-thirds of iPhone users upgraded to iOS 10 in the first thirty days post release compared to low single-digit adoption of Android 7.0 over a similar time period.

We see mobile games driving early AR use cases, but with start-ups often creating many of the innovative games, **Apple**, **Google**, and **Tencent** are best positioned to monetize increased mobile game spend. Additionally, we see eCommerce benefiting from a more dynamic view and real-life experience with the product whether it be trying out furniture in your own home or clothes on a given body type. As a result, **Alibaba** and **Amazon** can further penetrate large markets. Dual camera and 3D sensor component stocks⁽¹⁾ are up 55% YTD, suggesting adoption outside of Apple is generally needed to unlock more value. As is the case historically, the risk with component stocks is commoditization as smartphone vendors ramp multiple suppliers, making us prefer stocks with more of a services angle. We see **Himax**, **MediaTek**, **TSMC**, and **Win Semi** as the best-positioned component suppliers with additional share price upside.

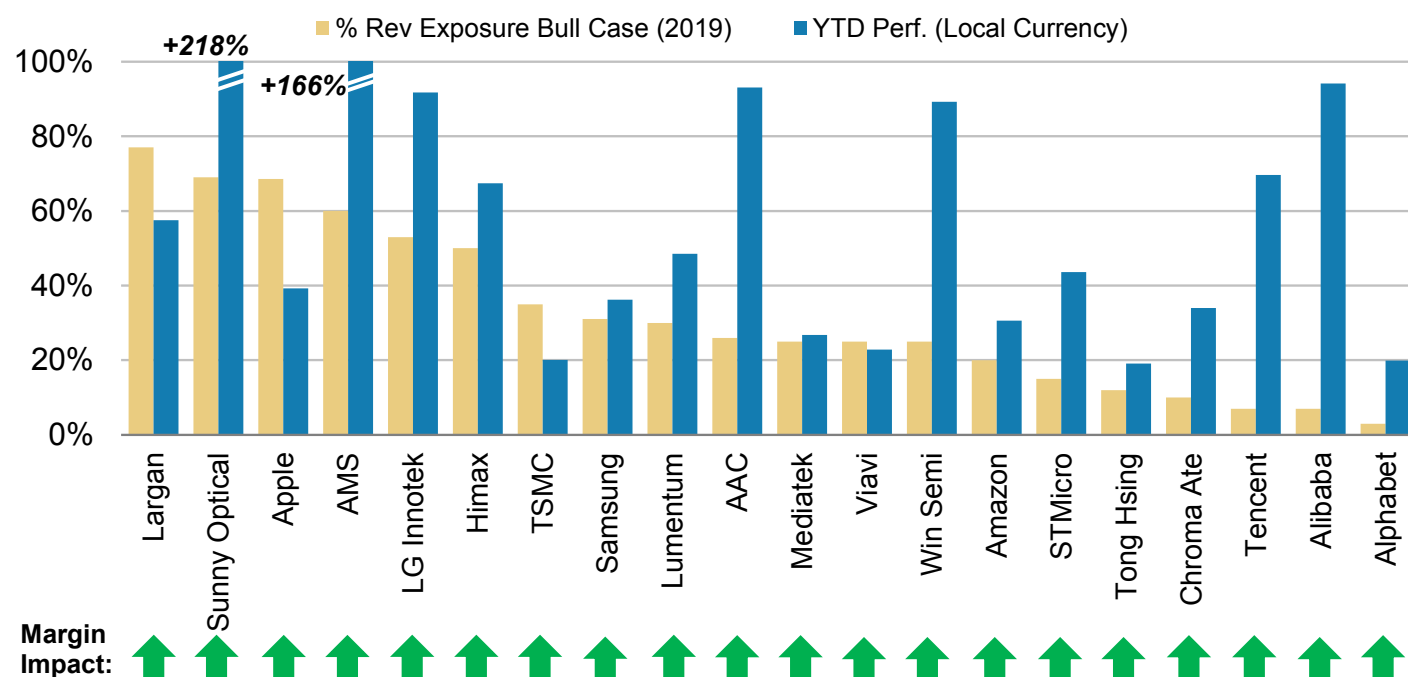
What is the timeline and what are the key signposts? While it likely will take years for AR applications to mature, Apple's recently launched ARKit allows developers to build early use cases for launch starting in fall 2017 with the release of iOS 11. The pace at which smartphone competitors follow Apple in adding dual camera and 3D sensors to their new devices is also key to monitoring traction of the technology. Based on recent supplier conversations, we expect Android based technology adoption to unfold in 2H18 and 2019. Dual camera penetration is 3% today and passing 20% tends to represent a key inflection point, which we forecast should happen in 2018. Further, we see meaningful commitments from mobile gaming and eCommerce companies to develop AR-based experiences as another tipping point in adoption.

Where could we be wrong? Augmented reality use cases may not be compelling enough near-term to drive mainstream adoption. Developers may take a wait and see approach given they don't want to take away resources from traditional mobile apps experiencing high growth. Android smartphone makers may choose not to follow in Apple's footsteps in the absence of clear consumer adoption. Apple's 3D sensing technology could face quality issues or production ramp issues that limit early adoption.

Exhibit 4:

Clear Beneficiaries of the Mobile AR Cycle: Bull Case AR Revenue Exposure vs. YTD Performance

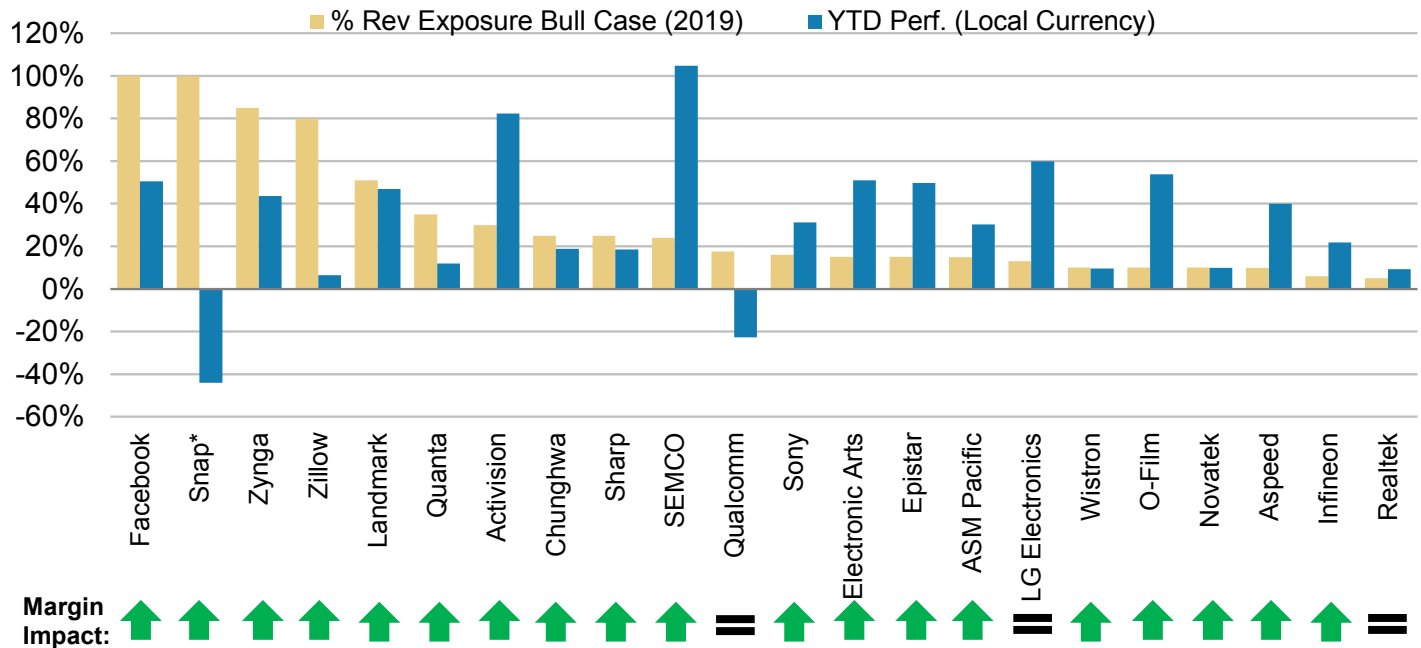
Bull Case AR Exposure vs. YTD Performance: Clear Beneficiaries



Source: Morgan Stanley Research, Thomson Reuters; YTD Performance is as of Sept. 7th, 2017

**Exhibit 5:**

Potential Beneficiaries of the Mobile AR Cycle: Bull Case AR Revenue Exposure vs. YTD Performance

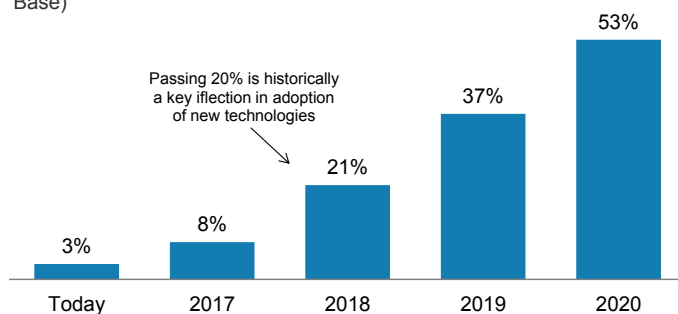
Bull Case AR Exposure vs. YTD Performance: Potential Beneficiaries

Source: Morgan Stanley Research, Thomson Reuters; YTD Performance is as of Sept. 7th, 2017; *Note: Snap YTD performance is for the period March 3, 2017 - September 7, 2017

Exhibit 6:

We See Dual Camera Penetration Hitting 20% Inflection Point in 2018

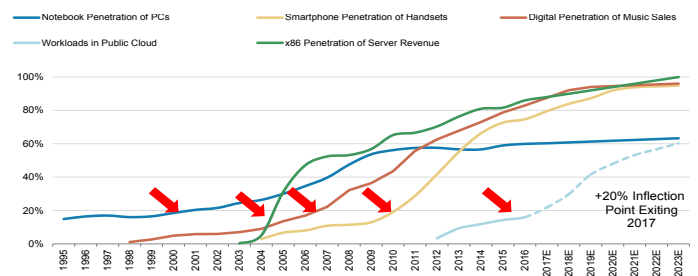
Dual Camera Penetration (% of 3-Yr Smartphone Install Base)



Source: IDC, Morgan Stanley Research. Install base assumes 3-yr useful life. Today reflects data through 2Q17.

Exhibit 7:

20% Represents a Historically Important Penetration Level for Tech Trends



Source: IDC, Gartner, US Census Bureau, CIO Survey, Morgan Stanley Research

⁽¹⁾ Average YTD performance of AMS, Epistar, Himax, LG Innotek, Lumentum, Sharp, ST Micro, Tong Hsing, Viavi, and Win Semi.



What Is Augmented Reality?

Blurring the line between the real world and digitally generated images.

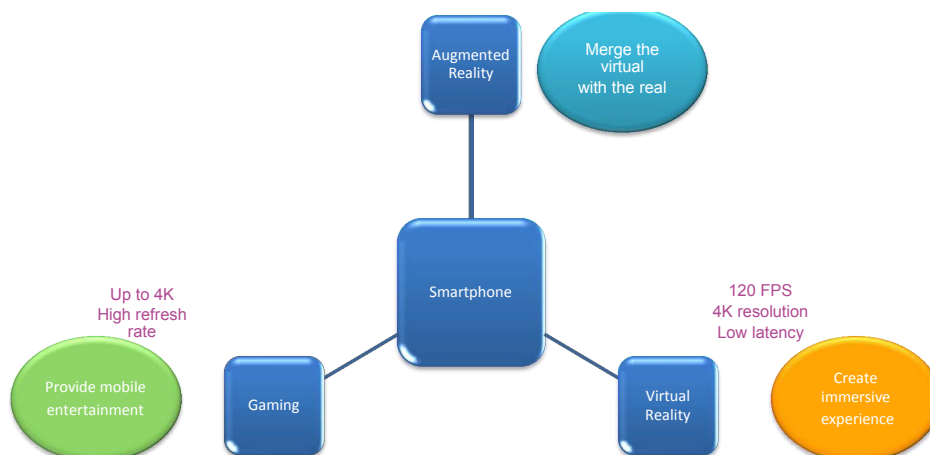
Augmented Reality, the younger cousin of Virtual Reality, is defined in the Oxford Dictionary as "a technology that superimposes a computer-generated image on a user's view of the real world." In recent years, technology companies such as Microsoft, Google, Samsung, and HTC, among others, attempted to push the boundaries of reality by incorporating multiple cameras and sensors into a headset to display Augmented Reality visuals. Application of the technology ranges from simply superimposing a computer-generated image onto a screen in front of your eyes to a more complex high-resolution, digitally created army of characters that move, talk, and explore within your actual real life environment. However, good quality AR headsets cost thousands of US dollars, and typically come with large, bulky hardware, making mass adoption unlikely. Then, in 2016, a 20-year-old game originating from Japan was revived on a smartphone, and the concept of Mobile AR was brought to the mainstream.

Pokemon GO was the first true use case of mass mobile AR adoption.

In July 2016, Nintendo (covered by Masahiro Ono) and Niantic Labs (privately held) launched the first mainstream mobile AR application, Pokemon GO, which allowed users to locate, battle, and capture digitally created Pokemon avatars overlayed on a real world backdrop captured by your phone's rear-facing camera. In order to find these avatars, users leveraged their smartphone's location-based GPS services to search around their neighborhoods, pointing their camera in the direction of where each digitally overlayed Pokemon character could be found. The game received more than 500M downloads within two months after its launch with 650M downloads by February 2017. In October 2016, market research firm App Annie estimated it took Pokemon GO 90 days to generate \$600M in revenue, more than 2x faster than any other mobile game in history. And in early January 2017, Apple acknowledged that Pokemon GO was the most downloaded iOS app in all of 2016. However, the popularity of Pokemon GO faded in early 2017 as concerns about draining battery life arose and teenagers shifted their attention to newer games. We acknowledge the issue with battery life could limit adoption as it did with Pokemon GO (and Google Tango),

Exhibit 8:

Mobile AR Combines the Key Features of Digital Gaming with Virtual Reality



Source: ARM, Morgan Stanley Research

but the point is, Pokemon GO dramatically demonstrated the significant revenue potential of leveraging existing smartphone features like dual camera and GPS in innovative ways for both device and services vendors.

Why, then, does mobile AR in particular have such great potential? Due to the widespread (and increasing) penetration of smartphones around the world, we believe mobile AR has the potential to be the next revolutionary technology trend. Mobile AR provides a high level of entertainment and usability in a low-cost, convenient fashion. Current use cases span consumer and commercial applications (**Exhibit 11**). For example, beyond the plethora of games and entertainment-focused apps being previewed on the internet, companies from Ikea to Wayfair to Hyundai have begun incorporating AR into their businesses. Just recently, Hyundai Motor introduced a [Virtual Guide](#) for its Genesis G80 and G90 models (available on the App Store and Google Play), eliminating the need for a standard car manual. As Tim Cook said during Apple's recent F3Q earnings call in early August, "We believe AR has broad mainstream applicability across education, entertainment, interactive gaming, enterprise and categories we probably haven't even thought of." We detail the most compelling announced use cases in **Exhibit 11**.

**Exhibit 9:**

Comparison of AR/VR Hardware Environments

	Mobile AR	Mobile VR	AR smart glasses	Wired VR
Incremental cost (US\$)	0	150	2,000	1,000
Mobility	High	Mid	Mid	Low
Cost items	Normal smartphone can play	Need a simple headset and controller	Gesture sensor, high-performance CPU/GPU, micro projector costs are still high	VR headset+controller, VR capable graphic card
Level of virtualization	Low Nothing real outside of smartphone screen	High Immersive, but hard to play high-end gaming	Mid Mixed with reality from one's perspective	Very high High performance VR
End products	Pokemon Go, Ingress, Sony Xperia Z1 AR camera	Gear VR, LG G5 VR, Daydream VR	HoloLens, Google Glass, Meta, Magic Leap	Oculus Rift, Sony VR, HTC Vive

Source: Company Data, Morgan Stanley Research

Mobile AR Is About Creating an Ecosystem

Google was the first to create an AR platform. As with the laptop, smartphone, portable music players, and smart speakers, Apple is rarely the first to market with emerging technology. In fact, three years ago Google introduced the Tango Platform, which promotes the expansion of mobile AR development on Android devices utilizing motion tracking, area learning, and depth perception. However, fast forward three years and Google Tango is only available on two devices (according to the Google Tango website, get.google.com/tango): the Lenovo Phab 2 Pro and the Asus ZenFone AR, relatively unknown phones to many consumers.

So why is it that an operating system with an installed base of over 2.5 billion devices can only muster minor adoption? We believe the reason lies in the concept of "fragmentation", which centers on the slow pace of how smartphone vendors and cellular networks adopt OS software updates. While Android is the most widely adopted mobile OS in the market, the hardware upon which Android is installed is developed by many different hardware vendors around the world. This means that in order for Tango (and ARCore) to be compatible with the hardware, the hardware and software vendors need to be perfectly in sync with their latest updates. However, this doesn't appear to be the case. According to a Bloomberg report from August 2017, there are seven different versions of Android OS running on mobile devices and only 11.5% of Android devices are running the latest version of Android OS. Therefore, widespread adoption of Google Tango will be hard to come by as third-party developers look for a more widely adopted platform to build their following.

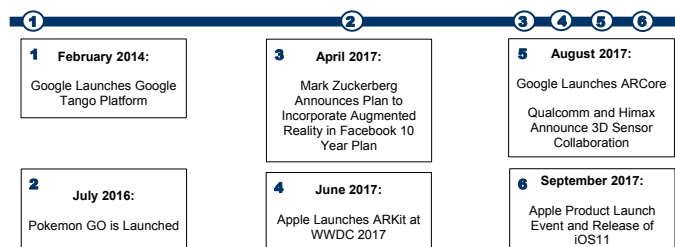


The launch of Apple's ARKit. At its Worldwide Developers Conference (WWDC) in June 2017, Apple introduced ARKit, a development platform for creating AR applications solely on iOS11, viewed on your iPhone and/or iPad and available to the general public this September. During the presentation, Apple demonstrated a handful of AR use cases developed on ARKit, displayed on the new 10.5" iPad Pro. These use cases ranged impressively, from games where digitally created planes buzzed around the San Jose Convention Center to digital furniture shopping where 3D models of goods were overlaid on a real world table. Nevertheless, we believe they only represent the tip of the iceberg because none take advantage of the new camera and sensor technology that is expected to launch with the new iPhones this fall.

Google's response: ARCore. On August 29, Google debuted a preview of ARCore, the Android-based AR developer platform that will compete directly against Apple's ARKit on iOS (official launch is planned for this winter). In comparison to Google Tango, ARCore is less powerful, as it doesn't require the dual cameras that Tango needed, but will have wider distribution and will be initially available on the Samsung GS8 and the Google Pixel (Google is also in conversations with Huawei, Asus, and LG about including ARCore on future phone launches). We understand ARCore likely will contain similar capabilities as ARKit, such as motion tracking, light estimation, and environmental understanding, but will not initially be focused on human or facial recognition, and initial use cases are currently limited given the smaller limited preview.

Exhibit 10:

Timeline of Augmented Reality Adoption



Source: Company Data, Morgan Stanley Research

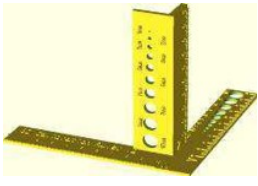
We believe ARKit completes the Apple software and hardware ecosystem and gives Apple a significant first mover advantage.

With the launch of ARKit, Apple now controls both the hardware upon which AR applications can be run and the software platform for which the third-party applications can be created. As a result, we expect much more widespread adoption of AR on the iOS system vs. Google Tango and ARCore (at first) as developers realize the potential for broad distribution across the iOS platform. In fact, Apple released the first beta version of iOS11 to third-party developers this summer, and in the weeks following, new AR use cases sprung up on a daily basis (see [Exhibit 11](#)). However, it's important to highlight that all of these use cases only utilize a single or dual-cam setup on Apple's current smartphone and tablet offerings. What if there were other components that could be installed in Apple hardware to take AR to the next level? With the highly anticipated introduction of the 10th anniversary iPhone, we believe this question will be answered.

**Exhibit 11:**

Smartphone Mobile AR Use Cases Developed With Apple's ARKit

List of Consumer and Commercial Smartphone AR Use Cases

Use Cases	Scenarios		
Measurement Measure the real world distance between two points	• Turns your phone camera into a virtual ruler capable of calculating the distance between two points in a 3D space • Use a virtual on-screen ruler to measure objects like furniture, carpets, interiors, etc.	 	
Gaming/Entertainment Play smartphone-based VR games (e.g. PokemonGO), 3D animation, facial lenses/filters, create virtual worlds	• Play your favorite game or recreate virtual fantasy scenes overlaid on a real world environment • Turn a 2D drawing into a 3D image or animation • Simulate a real world situation or environment (e.g. Flight Simulator) in a virtual 3D space • Bring your life simulation video game into a realistic first person environment		
Volumetric Capture / VR Video Using a single multi-lens camera shooting in 360 degrees, you can film a scene that can then be dropping to a virtual 3D environment where the viewers can walk around and see different angles of the scene	• Instant replay - review a play from your favorite game at any angle right on your desk • Watch a scene from your favorite new movie	 	
Physically Based Rendering Import virtual content into into a real world environment to allow for virtual tracking	• Architecture/Real Estate: Create a virtual home tour; tour an empty lot and place a virtual home to see how it would aesthetically look and fit, without ever having to break ground; Use 3D images of furniture to see how they would fit in actual home • Automotives: View 3D model of car to compare interiors and adjust accessory options; replace car manual with a virtual guide; virtual showroom • Food: Menu visualization would allow customers to view menu items prior to ordering, thereby reducing food waste • Retail: View physically rendered images of products (e.g. counter tops, appliances) in your home prior to purchasing • 3D Model Viewing	  	
Mapping Overlay directional advice from a mapping app into your real world environment	• Instead of looking at a virtual map while getting driving directions, your directional advice app will overlay arrows and signs virtualized in the real world • Follow paths while hiking or biking using real world overlaid guidance		
Education Recreate historical or educational events (especially important given the prevalence of iPads in K-12 schools)	• Explore the solar system within your classroom • Recreate historical events such as D-day or the building of the Panama Canal in a 3D virtual environment • View different important historical scenes or places without having to physically travel there	  	

Source: Company Websites, Morgan Stanley Research



What changes with the 10th anniversary iPhone 8/X? Beyond the anticipated adoption of power efficient OLED panels, a larger full screen display, a new form factor (bigger than the iPhone 7, smaller than the iPhone 7 Plus, with a larger display than both) and the potential for wireless and/or fast charging capabilities, the new iPhone is expected to contain 3D sensors, possibly on the front and rear of the new phone. We believe that by combining 3D sensors and greater processing power in the iPhone 8/X with Apple's ARKit platform, mobile AR app development will increase at an exponential pace, unlocking a new wave of smartphone upgrades (a "supercycle") – driven not only by OLED screens, a new form factor, or wireless charging, but also by augmented reality.

How Does 3D Sensing Work?

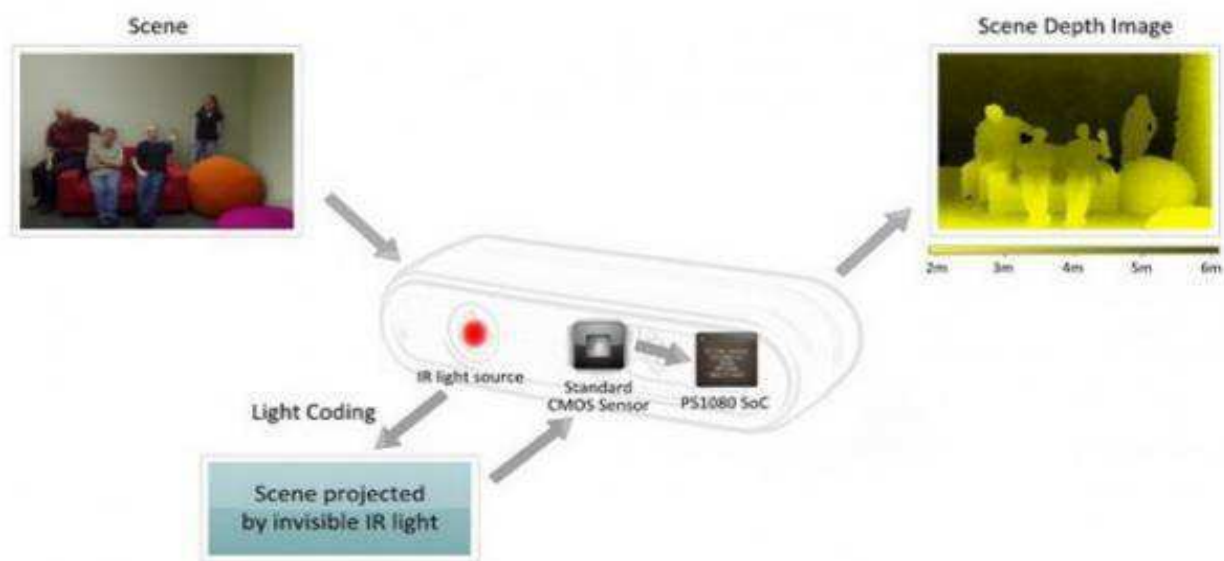
What is 3D sensing? 3D sensing is a rather new hardware application in consumer devices that has the ability to detect image patterns, enable better depth perception, and improve the accuracy of distances and shapes in certain objects or environments. While a conventional smartphone camera takes a 2D snapshot of the environment, and a dual cam adds depth perception, 3D sensing can provide close to exact measurements of objects that can then be incorporated into smartphone use cases. While facial recognition is likely the primary use case for a front facing 3D camera (i.e. the "selfie" camera), we believe AR is the primary use case for a rear facing camera (combined with the dual cam). And keep in mind this technology is still relatively new on smartphones, so we would expect additional applications as the 3D/AR ecosystem is adopted into future iPhone models and other smartphone vendor hardware.

How does 3D sensing work? To date, 3D sensing features have been installed in a handful of game consoles, PCs, and smartphones, such as Microsoft's Kinect, Intel's RealSense, and Google's "Project Tango" smartphones. However, these 3D sensors are based on different technologies, including infrared depth image sensor and Time-of-Flight (ToF) technology. Back in 2010, Microsoft, in cooperation with PrimeSense, released a structured-light (SL)-based range sensing camera for the Kinect. The module includes: 1) a laser diode, which sends out the infrared light, 2) an optical path, which helps to focus the reflected light into the sensor while filtering out ambient light, 3) an image sensor that matches the impact of the IR beams with the image direction information, and 4) a processing chip that maps out and calculates the exact measurements of the 3D image ([Exhibit 13](#)). Incorporating these components in a smartphone allows third-party developers to access this data for use in their AR (or other) application. In 2015, the new Kinect One changed to a real-time range sensing device based on the Time-of-Flight principle, which we explain fully in a later section.

Previous generation 3D sensing solutions are bulky and consume a lot of power. Now the industry is adopting wafer level optic (WLO) technology to reduce the form-factor of optical elements. The advancement of vertical cavity surface emitting laser (VCSEL) performance and chip packaging technology (system in packaging, or SiP) should also reduce the size of the module. As a result, the new generation of 3D sensing solutions (such as Apple's 3D sensing) can be based on time-of-flight or structure light sensing technologies, and are smaller, use less power, and cost less.

Exhibit 12:

3D Sensing Snapshot - How Does It Work?



Source: PrimeSense

**Exhibit 13:**

Key Components within the 3D Module

Component	Description
Laser Source	The solution generally use laser diodes (VCSEL) sending infrared photons towards the object. LED based solutions could also be used but IR is preferred due to better performance at difficult surfaces (i.e. materials effectively absorbing light) and minimal degradation over time.
Optical Path	Lenses help focus the reflected light into the sensor while effectively filtering out unnecessary ambient light. Filters/optics can be applied above the module focusing on reducing ambient light and/or at wafer-level focusing primarily on directing light to the sensor.
Image Sensor	The detector is usually a CMOS sensor that matches the impact of the IR beams with the image direction information to be computed by the logic component (IC).
Logic IC	The processing chip will map out and calculate the exact measurements of the 3D image making it accessible for third-party apps run by the main application processor. Apple acquired PrimeSense in 2013 for \$360m, which design similar application into the Microsoft Kinect.

Source: Morgan Stanley Research

Understanding the difference between "time of flight" and "structured light" in 3D sensors. With their ability to transmit high band frequency from 1 to 10 GHz with low power consumption, vertical cavity surface emitting lasers (VCSELs) are a great fit for high-speed communications and precision sensing applications, making them a popular technology in the midst of the 3D sensing and AR story for mobile handsets. Another favorable trait is their ability to emit concentrated light efficiently at a much smaller die size, making it very powerful to create VCSEL arrays to achieve objectives. With the above characteristics, plus favorable performance, cost savings, and power consumption attributes, VCSEL makes mobile 3D sensing possible in the next generation of handsets.

There are currently two ways to create 3D images. One is "time of flight" (ToF). Time of flight is a method of measuring the time that a photon takes to hit an object and reflect back to the sensor, similar to how a radar works. A simple version of the technology has already been implemented in existing smartphones for proximity sensing (such as when one picks up a phone and puts it near one's ear, the touch screen function will be disabled once sensed).

The other method is structured light (SL). Structured light uses a diffractive optical element to split a beam of light into multiple beams in order to create a pattern of speckles that are then projected

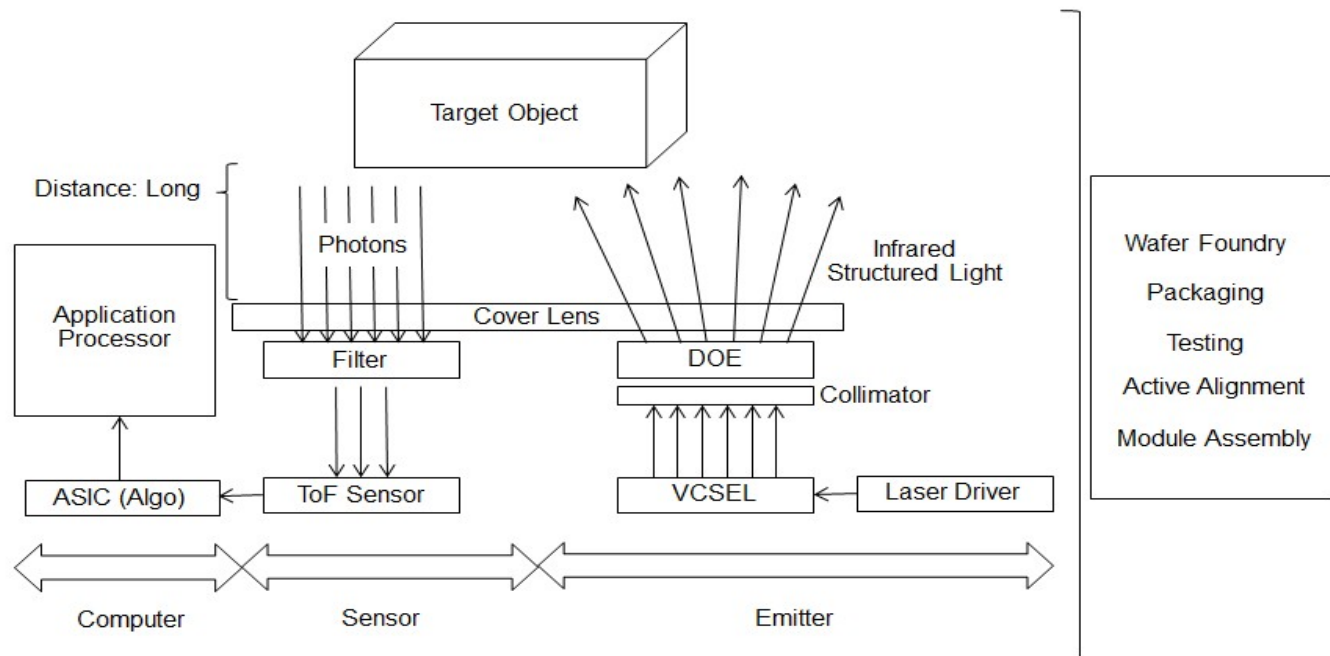
onto an object using arrays of VCSEL dies with higher intensity and near-infrared (NIR) spectrometer sensors to capture the distorted pattern formed through contoured lines to then calculate depth and create 3D images.

Based on our checks with Himax, both methods of 3D sensing use infrared structured light as the emitters but the difference between the two is in the way the structure (based on the type of sensor) analyzes the light. For example, if there is an obstacle (let's say a rock) in a well-lit cave, a bat would use echolocation to calculate the time it takes for the sound it makes to bounce back to tell the distance to the rock (similar to ToF), while a person would use visual images that he or she sees (similar to Android Structured Light) to determine the distance. The difference is in what technology interprets the returning signal.

Factors in favor of Structured Light are 1) better resolution, 2) higher precision, 3) ease of integration with RGB CIS (contact image sensor) sensors, and 4) smaller form factor. Disadvantages include shorter operational distance and higher power consumption. The incumbent solution that is currently used in smartphones is a 3D depth camera solution module (such as Project Tango in ZenPhone AR), which is priced at \$20-30. The structural light 3D sensing cost around \$15-20, with a form factor that is much smaller.

**Exhibit 14:**

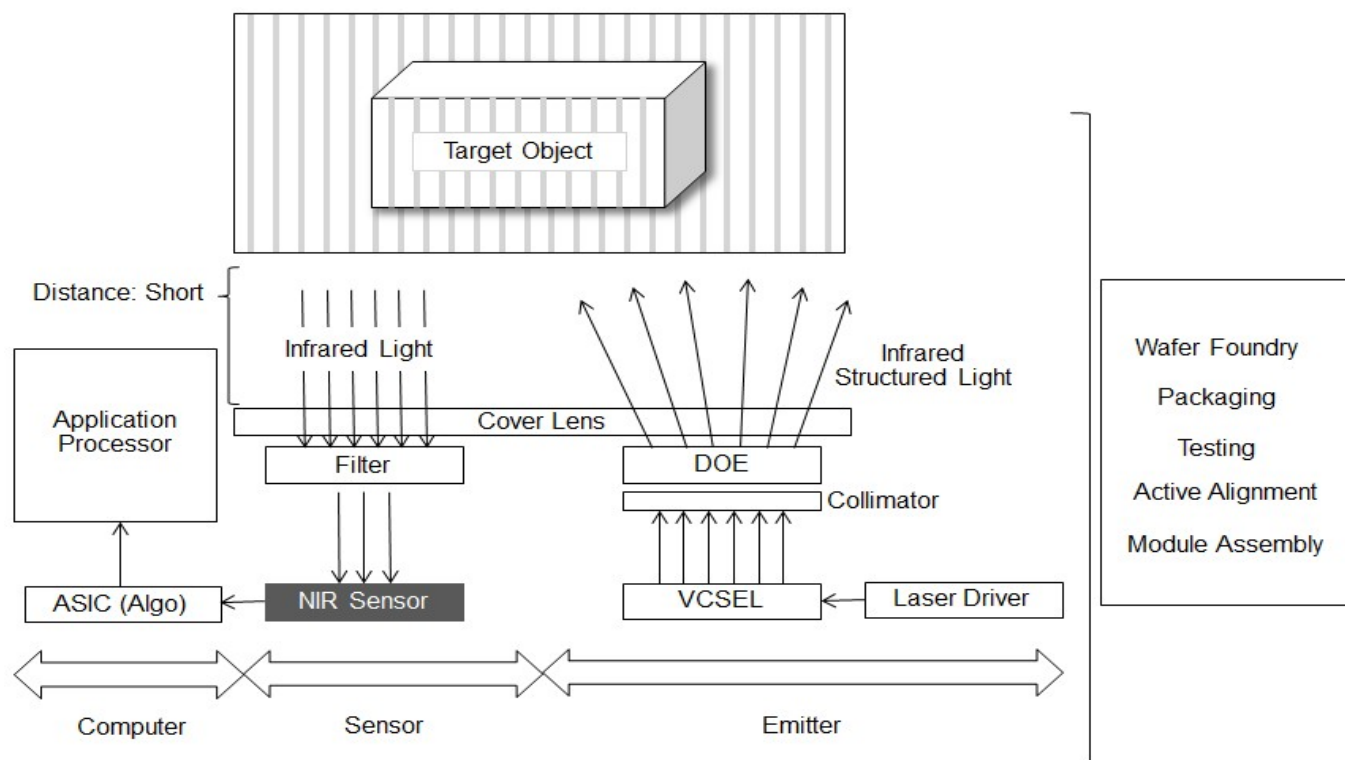
Apple 3D Sensor Time of Flight (ToF) Diagram



Source: Company Data, Morgan Stanley Research

Exhibit 15:

3D Sensor Structured Light Diagram



Source: Company Data, Morgan Stanley Research

**Exhibit 16:**

Apple 3D Sensor Vendor List

Apple iPhone 8 3D Sensor	Company
VCSEL (High Power)	
IDM	Lumentum (main), Finisar, II-VI
Wafer Processing	Win Semi (for Lumentum outsourcing)
Wafer epi	IQE
Base Substrate	Sumitomo
WLO (Collimator and DOE)	Himax
Filter	Viavi
Sensor	
ToF Sensor IDM	STM
Wafer Redistribution Layout	Tong Hsing
Algorithm/ASIC	Apple (PrimeSense)
Camera Cover Lens	Largan, Genius
Module Assembly	LG Innotec
Test Equipment	Chroma

Source: Company Data, Morgan Stanley Research

Exhibit 17:

Android 3D Sensor Vendor List

Android Smartphones 3D Sensor	Qualcomm & Himax Camp	Other Vendors
VCSEL (High Power)	Lumentum	SanAn, Epistar
Laser Driver	Himax	
WLO (Collimator and DOE)	Himax	ams, AAC
Sensor		ams, STM
NIR Sensor Design	Himax	
Wafer Foundry	TSMC	
Algorithm/ASIC	Himax	ams
Active Alignment		ams
Knowhow	Himax	
Equipment	ASM Pacific	
Camera Cover Lens	Largan	Genius
Module Assembly	Truly	Sunny Optical; O-Film; Q-Tech
Smartphone Processor & Firmware	Qualcomm	MediaTek

Source: Company Data, Morgan Stanley Research

**Exhibit 18:**

3D Sensor Component Mapping

3D Sensor Supply Chain Mapping

Company Name	Ticker	Rating	Market Cap (>\$350M)	Product Offering	2018E Revenue Exposure	Covering MS Analyst
Light Source						
Lumentum	LITE.O	UW	3,559	VCSEL	30-40%	Meta Marshall
II-VI	IIVI.O	NC	2,307	VCSEL	N/A	
Finisar	FNSR.O	NC	2,514	VCSEL	N/A	
Epistar	2448.TW	OW	1,239	VCSEL	< 3%	Sharon Shih
ams	AMS.SW	EW	6,377	VCSEL	61%	Francois Meunier
IQE	IQE.L	NC	1,369	VCSEL Wafer	N/A	
Himax	HIMX.O	OW	1,908	Laser driver	1%	Charlie Chan
Wafer Foundry						
Win Semi	3105.TWO	EW	2,281	VCSEL Wafer Foundry	10%	Charlie Chan
TSMC	2330.TW	OW	186,974	Wafer Foundry	2%	Charlie Chan
Packaging/Testing						
ams	AMS.SW	EW	6,377	Module Packaging	61%	Francois Meunier
eLaser	3450.TW	NC	462	VCSEL Packaging	N/A	
Controlling Optics						
Viavi	VIAV.O	EW	2,314	Filter	15-20%	Meta Marshall
II-VI	IIVI.O	NC	2,307	Filter	N/A	
ams	AMS.SW	EW	6,377	Filter	61%	Francois Meunier
Himax	HIMX.O	OW	1,908	Diffraction Optics Element	15%	Charlie Chan
Image Sensor						
ams	AMS.SW	EW	6,377	CMOS Imaging Sensor	61%	Francois Meunier
Tong Hsing	6271.TW	OW	706	Reconstruction Wafer	5-15%	Sharon Shih
STMicroelectronics	STM.PA	UW	16,402	CMOS Imaging Sensor	7%	Francois Meunier
Melexis	MLXS.BR	NC	3,761	CMOS Imaging Sensor	N/A	
Himax	HIMX.O	OW	1,908	CMOS Imaging Sensor	4%	Charlie Chan
Sony	6758.T	OW	49,472	CMOS Imaging Sensor	9%	Masahiro Ono
Infineon	IFXGn.DE	UW	26,854	CMOS Imaging Sensor	< 1%	Francois Meunier
Algorithm						
Himax	HIMX.O	OW	1,908	Structural Light Algorithm	3%	Charlie Chan
Mantis Vision	Private	NC	Private	Algorithm for Project Tango	N/A	
Module						
LG Innotek	011070.KS	EW	3,616	Laser emitter module	10%	Shawn Kim
Sharp	6753.T	UW	15,157	CCD/CMOS imagers	9%	Masahiro Ono
STMicroelectronics	STM.PA	UW	16,402	Module Packaging	7%	Francois Meunier
ams	AMS.SW	EW	6,377	Module Packaging	61%	Francois Meunier
Infineon	IFXGn.DE	UW	26,854	Module Packaging	< 1%	Francois Meunier
Truly	0732.HK	NC	858	Camera Module	N/A	
O-Film	002456.SZ	EW	8,803	Camera Module	5%	Sharon Shih
Sunny Optical	2382.HK	OW	15,560	3D sensing camera module	5%	Yunchen Tsai
Testing Equipment						
Chroma Ate	2360.TW	OW	1,350	LD/GPU Testing Equipment	5-10%	Melrose Chiu
ASM Pacific	0522.HK	OW	5,660	Active Alignment Tool	10%	Charlie Chan
Iris Scan						
Osram	OSRn.DE	UW	8,497	Light Source	7%	Lucie Carrier
Epistar	2448.TW	OW	1,239	Infrared LED	< 10%	Sharon Shih

Source: Morgan Stanley Research

**Exhibit 19:**

Mobile AR/VR Supply Chain Mapping

Mobile AR/VR Supply Chain Mapping

Company Name	Ticker	Rating	Market Cap (>\$350M)	Product Offering	2018E Revenue Exposure	Covering MS Analyst
Quick Charging Technology						
MediaTek	2454.TW	OW	14,324	Express 3.0 quick charge IC	2%	Charlie Chan
Silergy	6415.TW	OW	1,909	Qualcomm quick charger 3.0	2%	Charlie Chan
On-Bright	4947.TW	NC	426	Mid-to-low power power management IC	N/A	
Power Banks						
MediaTek	2454.TW	OW	14,324	Realtek offers power management IC	1%	Charlie Chan
Silergy	6415.TW	OW	1,909	Power management IC	3%	Charlie Chan
Simple	6121.TWO	NC	1,096	Battery packs for power banks	N/A	
Cloud Data Center						
Aspeed	5274.TWO	EW	744	Server BMC	90%	Daniel Yen
Landmark	3081.TWO	OW	1,147	Silicon Photonics	43%	Sharon Shih
Quanta	2382.TW	OW	8,702	Datacenter hardware	26%	Melrose Chiu
Wistron	3231.TW	EW	2,435	Datacenter hardware	7%	Melrose Chiu
Inventec	2356.TW	NC	2,825	Datacenter hardware	N/A	
Wireless Connectivity						
MediaTek	2454.TW	OW	14,324	GPS / WiFi / Bluetooth combo chip	10%	Charlie Chan
Realtek	2379.TW	EW	1,846	Bluetooth	20%	Daniel Yen
CSR	Private	NC	Private	Bluetooth	N/A	
AR Related Device						
Himax	HIMX.O	OW	1,908	DOE, Micro display for AR smart glasses	30%	Charlie Chan
Lenovo	0992.HK	UW	5,891	Google Tango-enabled AR Smartphone	< 5%	Melrose Chiu
Smartphone Chipset Design						
MediaTek	2454.TW	OW	14,324	Mid-to-high end smartphone chipset	30%	Charlie Chan
Qualcomm	QCOM.O	EW	74,468	High-end smartphone chipset	< 5%	James Faucette
Samsung	005930.KS	OW	274,965	High-end smartphone chipset	< 5%	Shawn Kim
Smartphone Chipset Supply						
TSMC	2330.TW	OW	186,974	Leading-edge foundry vendor	30%	Charlie Chan
ARM	Private	NC	Private	CPU/GPU core IP	N/A	
Chunghwa Precision Test Tech	6510.TWO	OW	1,443	Smartphone AP test board	70%	Charlie Chan
High Resolution Display						
Novatek	3034.TW	EW	2,325	High resolution driver IC	20%	Daniel Yen
Himax	HIMX.O	OW	1,908	AMOLED driver IC	1%	Charlie Chan
Samsung	005930.KS	OW	274,965	AMOLED display	15%	Shawn Kim
AUO	2409.TW	EW	3,902	AMOLED display	< 3%	Sharon Shih
Tianma	000050.SZ	EW	4,896	AMOLED display	< 3%	Sharon Shih
LG Display	034220.KS	UW	10,068	AMOLED display	5-10%	Shawn Kim
Mobile DRAM						
Samsung	005930.KS	OW	274,965	LPDDR4x at 18nm for power consumption	5-10%	Shawn Kim
SK Hynix	000660.KS	OW	45,777	Mobile DRAM	25-30%	Shawn Kim
Nanya Tech	2408.TW	EW	5,695	Mobile DRAM	15%	Charlie Chan
Mobile VR Headset and Controller						
Samsung	005930.KS	OW	274,965	Gear VR headset	< 3%	Shawn Kim
ZTE	0763.HK	EW	2,008	Axon 7 Mobile VR phone	< 3%	Yunchen Tsai
ELAN	2458.TW	NC	630	Touch pad controller technology	N/A	
Daydream VR Smartphone OEM						
HTC	2498.TW	NC	1,747	Daydream mobile VR smartphone	N/A	
ZTE	0763.HK	EW	2,008	Axon 7	< 3%	Yunchen Tsai
Samsung	005930.KS	OW	274,965	Galaxy S9 Series	10-15%	Shawn Kim
LG Electronics	066570.KS	UW	12,293	Daydream mobile VR smartphone	< 5%	Shawn Kim
Asustek	2357.TW	EW	6,047	VR Headset	< 5%	Melrose Chiu
Xiaomi	Private	NC	Private	Daydream mobile VR smartphone	N/A	

Source: Morgan Stanley Research



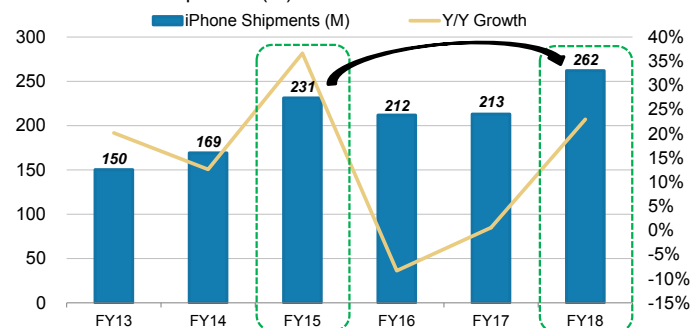
Why Is Mobile AR Important?

We believe mobile Augmented Reality has the potential to be a revolutionary technology trend and reignite smartphone growth. Similar to the App Store in 2008 and new, larger smartphone displays in 2012, we see the potential for AR to drive a multi-year period of accelerated smartphone shipment growth as consumers upgrade to mobile AR capable hardware. *Why?* Because we view AR as allowing consumers to create, view, and share content in a 3D, rather than 2D context. We believe that by combining 3D sensors and greater processing power in the new iPhone along with Apple's ARKit platform on iOS 11, mobile AR app development will increase at an exponential pace, unlocking new use cases and a new wave of iPhone upgrades (a "supercycle"). While we view Apple as the first mover, we don't expect the Android ecosystem to stand still, similar to the introduction of Google Play after the Apple App Store. Google recently launched ARCore, a similar AR development platform to Apple's ARKit. Our supply chain conversations suggest that other leading smartphone vendors, including Samsung and Huawei, will incorporate 3D sensors in new smartphones during 2018, following on Apple's introduction of the technology in September 2017.

Exhibit 20:

Augmented Reality Is the "Killer App" that Can Help Accelerate Smartphone Shipment Growth

Annual iPhone Shipments (M) vs. Y/Y Growth



Source: Company Data, Morgan Stanley Research

Commercial use cases are a potential upside to unlocking growth. While games, eCommerce, and entertainment-focused AR applications have the potential to unlock widespread adoption of mobile AR, we believe commercial use cases could unlock even more value long-term. For example, the smartphone can become the primary tool used by real estate agents showing new properties, architects designing homes, technologists designing hardware, cinematographers creating content, and many more. This would dramatically change the landscape of the smartphone market, as commercially focused smartphones could become just as common as a computer in an office. And with increased commercial adoption comes additional investment, which would likely lead to a broadening of use cases over time. In other words, while we see the potential for mobile AR to re-accelerate consumer smartphone upgrades, we believe widespread commercial adoption could lead to a considerable expansion of the device market.

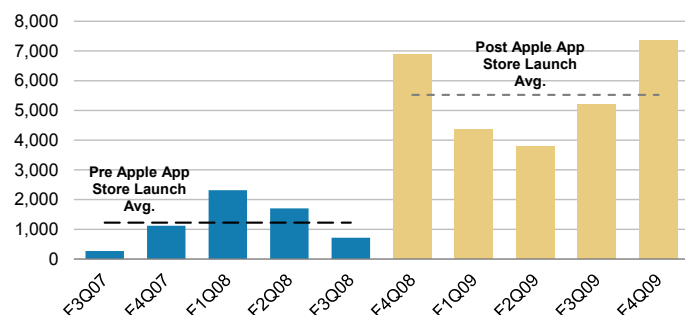
Case Study: The 2008 Launch of the Apple App Store

Flashback to 2008 and the launch of Apple's App Store.

While the January 2007 launch of the first generation iPhone introduced a simple user-friendly touch-screen interface that would revolutionize mobile phone design, it was the July 2008 launch of the Apple App Store that really kick started smartphone penetration. This was because the App Store allowed users to consume and create information and entertainment in a way that was optimized for a small, handheld form factor accessible 24/7. As a result, the range of computing functions on a smartphone expanded dramatically and drove an exponential increase in demand. In the five quarters prior to the launch of the Apple App Store, Apple averaged 1.2M iPhone shipments per quarter. Yet in the first quarter after the App Store launched, Apple sold 6.9M iPhones, more than all the prior five quarters combined. We believe the introduction of Augmented Reality on mobile phones could have a similar effect in accelerating the pace of upgrades, bringing new users into the market, and gaining share against competitors that lag in adopting AR technology.

**Exhibit 21:**

The Introduction of the Apple App Store Drove an Acceleration in iPhone Demand

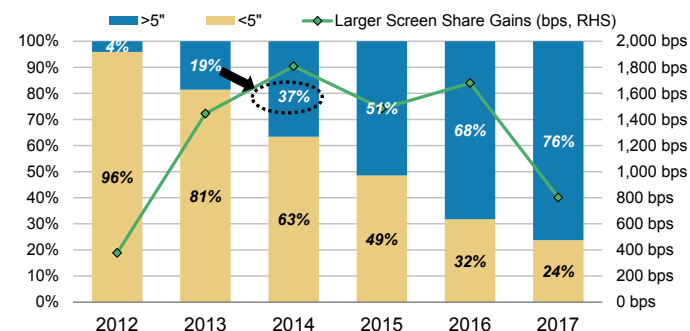
Apple iPhone Shipments (Thousands)

Source: Company Data, Morgan Stanley Research

We use the 2014 smartphone upgrade cycle as a guide for how AR could impact smartphone sales in 2017-2019. Between 2010 and 2013, there were over 2.5 billion smartphones shipped globally, with 2.3 billion of those containing a screen size smaller than 5". However, this mix dramatically shifted in 2014 with accelerated adoption of large screen, higher-end smartphones such as the iPhone 6 and 6 Plus, the Samsung Galaxy Note 4, the Google Nexus 6, and the HTC One M8, which all had screens ~5". As a result, smartphone shipments for larger screen phones grew over 150% in 2014, while shipments for phones with a screen smaller than 5" declined 1%, driving an 1800bps mix shift between the two categories of phones. At the same time, the rapid roll-out of 4G networks around the world amplified these new product introductions, with IDC estimating that shipments of 4G connected smartphones doubled from 272 million in 2013 to ~550 million in 2014. And in China, the world's largest smartphone market, 2014 was the first year in which the Chinese government awarded FDD-LTE 4G trial licenses to Chinese mobile carriers and the first time the iPhone was available on the China Mobile platform. Combined, these events drove a wave of smartphone upgrades that condensed the smartphone replacement cycle by 1.8 months, which we calculate using annual smartphone shipment data from IDC and smartphone installed base estimates from consultancy group Ovum ([Exhibit 24](#))

Exhibit 22:

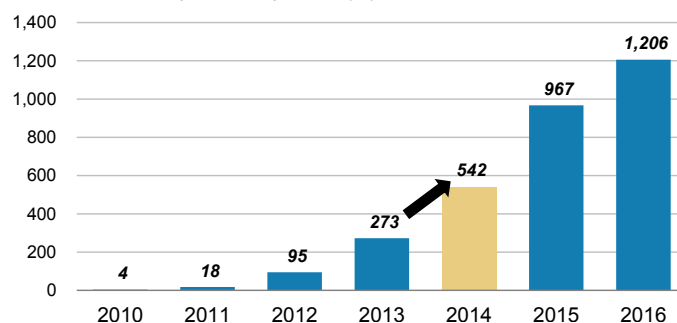
Shipments of Smartphones with 5"+ Screens Grew 152% in 2014...

Mix of Larger Screen Smartphones as % of Total

Source: IDC, Morgan Stanley Research

Exhibit 23:

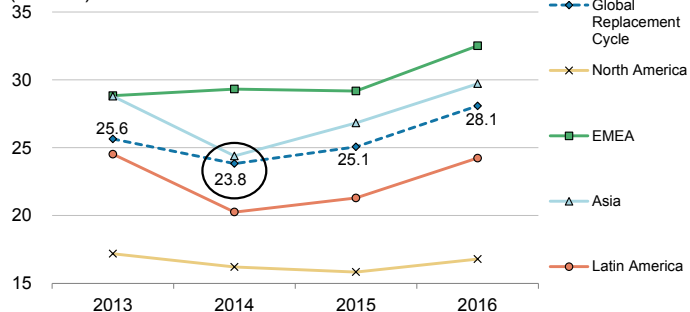
...While 4G Connected Smartphone Shipments Grew ~100% in 2014...

4G Enabled Smartphone Shipments (M)

Source: IDC, Morgan Stanley Research

Exhibit 24:

...Driving a 1.8 Month Drop in the Global Smartphone Replacement Cycle to 23.8 Months

Smartphone Market Replacement Cycle - By Region (Months)

Source: IDC, Ovum, Morgan Stanley Research

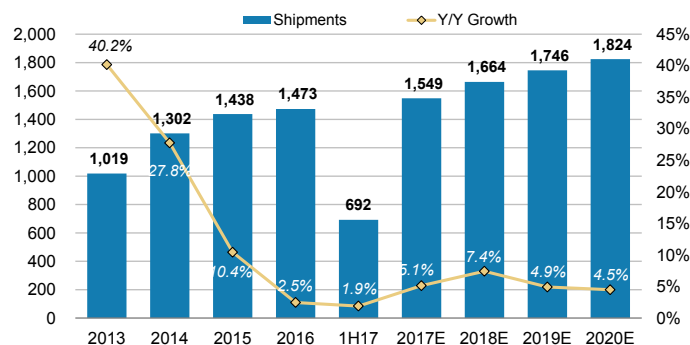
The current state of the smartphone market. Through the first half of 2017, smartphone shipments rose 2% Y/Y, a continuation of the growth deceleration experienced in the smartphone market over the last three years. However, a slowdown is to be expected as smartphone penetration reached 50% in 2013 and as higher quality devices help extend the useful life. Nevertheless, we expect key product introductions from the likes of Apple (iPhone 8/X), Samsung (Galaxy Note 8), Google (Pixel 2), and LG (V30) in 2H17 to drive a resurgence in smartphone shipments and, in our base case, model a re-acceleration of shipments to 5% for 2017, followed by growth of 7% in 2018.

Our base case assumes Apple's adoption of 3D sensors, power-efficient OLED screens and wireless/fast charging capabilities drives an iPhone supercycle, or a period of accelerated upgrades and share gains, in 2018 and model total CY18 iPhone shipments growing 23% (or 50M incremental Y/Y unit shipments). However, our base case forecast assumes a less robust upgrade environment for non-Apple vendors with growth of 5% in 2018 on the back of more limited adoption of AR capable technology and longer-tailed Android AR ecosystem roll-out. Net, our base case model assumes smartphone replacement cycles continue to lengthen next year.

Exhibit 25:

In Our Base Case, We Expect 2H17 Smartphone Launches From the Likes of Apple and Samsung To Drive 5.1% and 7.4% Growth in 2017 and 2018, Respectively...

Base Case: Global Smartphone Shipments (M) & Y/Y Growth

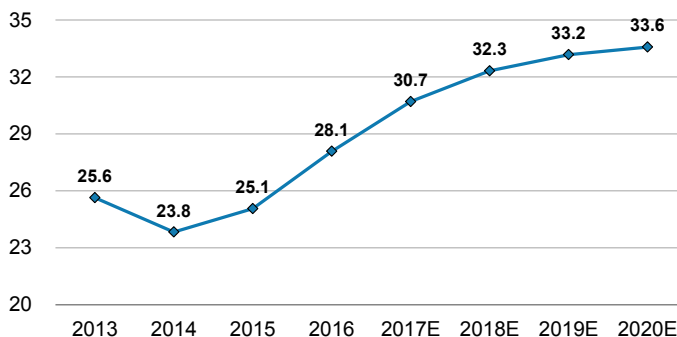


Source: IDC, Morgan Stanley Research

Exhibit 26:

...Which Would Imply a Further Lengthening of the Smartphone Replacement Cycle to ~33 Months

Base Case: Smartphone Replacement Cycle

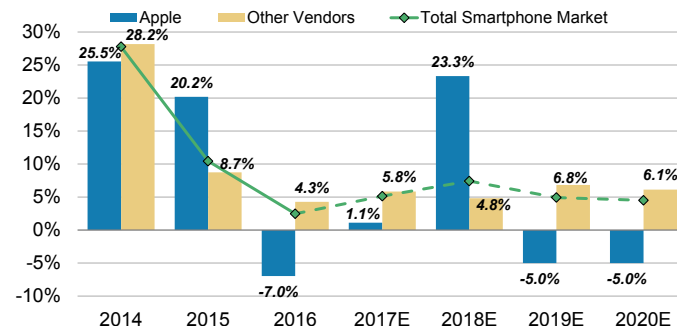


Source: Ovum, IDC, Morgan Stanley Research

Exhibit 27:

Base Case: Smartphone Shipments Grow 7.4% Y/Y in 2018...

Smartphone Shipment Growth (Base Case)

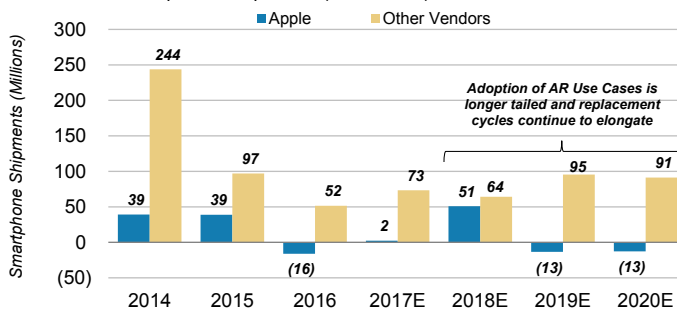


Source: IDC, Morgan Stanley Research

Exhibit 28:

...as Apple Adoption of 3D Sensors Takes Longer to Migrate to Other Vendors and Smartphone Replacement Cycles Continue to Elongate

Incremental Smartphone Shipments (Base Case)



Source: IDC, Morgan Stanley Research

Introducing Our Bull Case, AR-Driven Smartphone Market Forecast

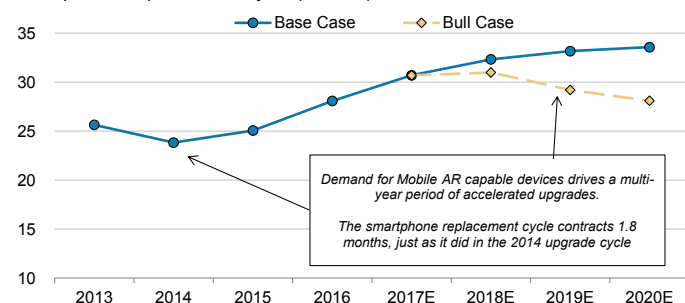
Our bull case assumes accelerated smartphone upgrades on increasing penetration of AR technology, driving a supercycle for both Apple and the market overall.

In our bull case forecast, we assume that the global smartphone replacement cycle contracts by 1.8 months by 2019, similar to the 2014 upgrade cycle ([Exhibit 29](#)). We believe this is a fair comparison because the characteristics of each cycle have the potential to be quite similar. The 2018-2019 cycle would be driven largely by smartphone owners looking to upgrade to a newly released technology that we believe will become a staple of all smartphones over time, similar to app stores, larger screens and 4G connectivity in the past. The 2014 smartphone supercycle is especially pertinent to our forecast period as both cycles were more about upgrading to new technology given the maturity of smartphone penetration which is 75% today versus 66% in 2014. While we believe mobile AR-capable devices have the potential to attract new smartphone users, it will take time for the technology to filter to the lowest-end devices, which are typically the first devices non-smartphone owners purchase when switching from feature (or no) phones.

Exhibit 29:

AR Adoption Across Smartphone Vendors Accelerates Upgrade Cycles in Our Bull Case, Driving Down Replacement Cycles Similar to the 2014 Smartphone Cycle

Smartphone Replacement Cycle (Months)



Source: Ovum, IDC, Morgan Stanley Research

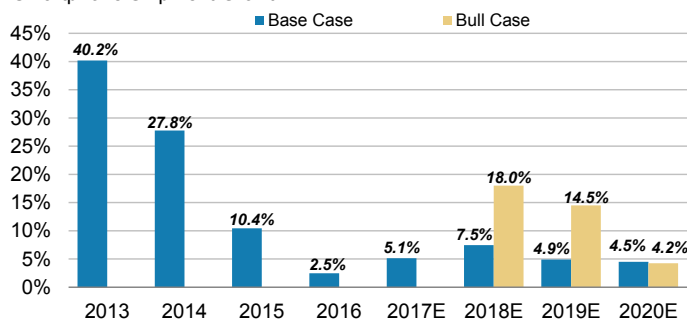
Key to our bull case is the proliferation of mobile AR ecosystems beyond Apple. While Apple has yet to formally announce the launch of the iPhone 8/X and general availability of iOS 11, we believe it will help bring mobile AR to the masses. In our bull case, we model iPhone shipments accelerating 30% to 283M units, 670bps above our base case estimate, resulting in 140bps of global market share gains in 2018, similar to Apple's 130bps market share gain in 2014-2015 ([Exhibit 33](#)). However, we think it is unrealistic to expect Apple to be the only vendor to capitalize on the growth of AR. It's our belief that many smartphone vendors, including those in China, the world's

largest smartphone market, are waiting to see Apple's approach to and success with AR. Once the device hits the market, we expect vendors to aggressively pursue the technology needed to drive an expansion of the ecosystem. At the same time, we expect the software and app developers to also aggressively experiment with expanding the AR ecosystem. This means that rapid adoption of non-Apple smartphones will likely lag the iPhone 8/X, resulting in more widespread Android adoption towards the end of 2018 and into 2019. This is why, in our bull case, we forecast non-Apple shipment growth accelerating to 16.2% in 2019, driving most of the incremental Y/Y demand for smartphones and resulting in Android share gains of 130bps in 2019.

Exhibit 30:

In Our Bull Case, Accelerated Smartphone Upgrades Drive 18% Smartphone Shipment Growth in 2018, with Continued Adoption Driving 2019 Smartphone Shipment Growth of 14.5%

Smartphone Shipment Growth

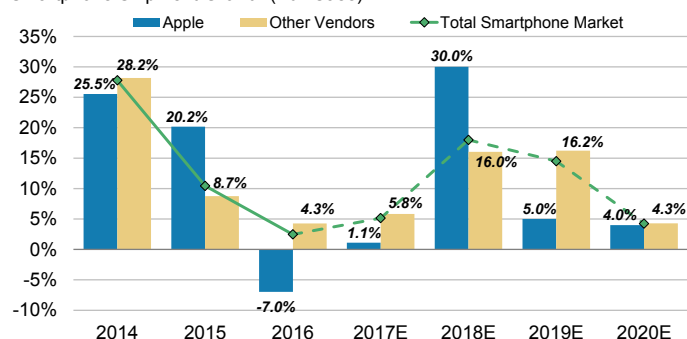


Source: IDC, Morgan Stanley Research

Exhibit 31:

Bull Case: The Rise of Mobile AR Ecosystems Drives 18% Smartphone Growth in 2018 and 14.5% Growth in 2019...

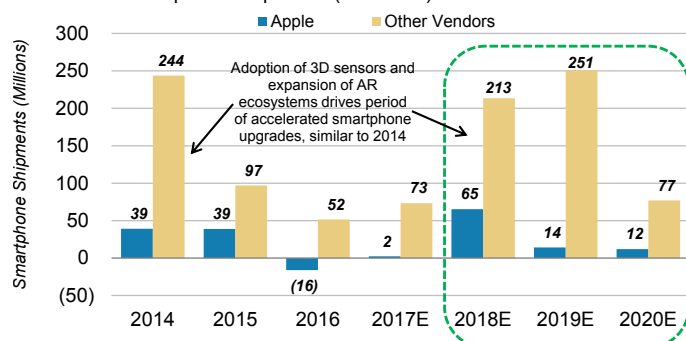
Smartphone Shipment Growth (Bull Case)



Source: IDC, Morgan Stanley Research

**Exhibit 32:**

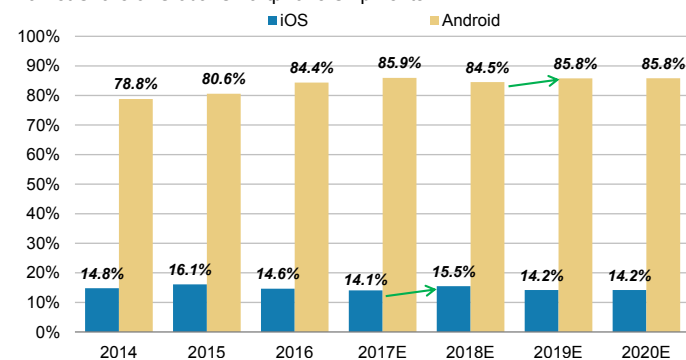
Resulting in 633M Incremental Shipments During 2018-2020 vs. 2017

Incremental Smartphone Shipments (Bull Case)

Source: IDC, Morgan Stanley Research

Exhibit 33:

Our Bull Case Points to Apple Gaining Share of the Global Smartphone Market in 2018, While Non-Apple Vendors Gain in the Following Year as Android AR Penetration Expands

Market Share of Global Smartphone Shipments

Source: IDC, Morgan Stanley Research

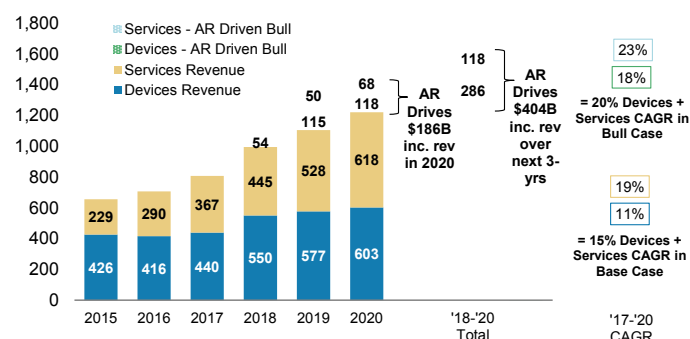


Sizing the Incremental Mobile AR Opportunity

We size the incremental AR opportunity at \$404B over the next three years, driven by accelerated device upgrades (\$286B) and AR-related services (\$118B).

Exhibit 34:

\$404B Incremental AR Opportunity Driven by Accelerated Device Upgrades (\$286B) and Additional AR-Related Services (\$118B)
Annual Revenue (\$B)



Source: Company Data, Morgan Stanley Research

Devices

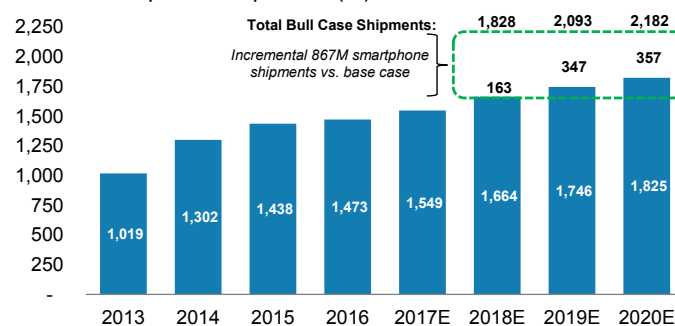
Accelerated upgrades drive \$286B incremental smartphone device revenue versus our base case over the next three years.

Our bull case smartphone market forecast implies that an incremental 867M smartphones will be sold in the 2018-2020 period relative to our base case, driven by demand for AR-capable mobile devices that shortens smartphone replacement cycles by 1.8 months through 2019, similar to the 2014 cycle. Given the fact that the majority of these shipments are likely to be AR-capable devices, which will have more robust components and therefore a higher bill of materials, we assume the ASP for these devices is ~\$330, in line with YTD 2017 ASPs for developed markets (including China) and 13% higher than the global smartphone ASP of \$292 though June 2017. This translates to \$286 billion of incremental smartphone device revenue over the next three years 2018-20E (Exhibit 36) in the bull case, driven by AR-related upgrades.

Exhibit 35:

Bull Case Reflects 867M Incremental Smartphones Shipped in 2018-2020 Relative to Base Case

Global Smartphone Shipments (M)



Source: Company Data, Morgan Stanley Research

Exhibit 36:

Driving the Incremental Device Opportunity from Mobile AR to \$286 Billion

Sizing The Incremental Device Opportunity			
	Base Case	Bull Case	Difference
2017 Shipments (M)	1,549	1,549	-
2018 Shipments	1,664	1,828	163
2019 Shipments	1,746	2,093	347
2020 Shipments	1,825	2,182	357
Incremental 2018-2020 Shipments			867
(*) Developed Markets (incl. China) ASP			\$ 330.38
Incremental Device TAM (\$M)			\$ 286,463

Source: IDC, Morgan Stanley Research; Note: ASPs are calculated by taking the market average of ASPs in North America, EMEA, and Asia

Services

AR drives \$118B incremental revenue for services companies over the next three years. We expect new dual camera and 3D sensor modules incorporated in smartphones to enable users to consume, create, and share content in new ways, accelerating mobile app revenue.

Historically, the introduction of new technologies such as LTE and larger screen smartphones drove an acceleration in the growth of Apple Services revenue (Exhibit 37) as well as the broader services industry (Exhibit 38). We believe AR can drive a similar acceleration, resulting in Apple Services revenue growth accelerating to 31% Y/Y in 2019, from 19% in 2018, relative to our base case estimate of 19% growth Y/Y (Exhibit 39). This translates to incremental Apple App Store revenue of \$8.6B over the next three years. While we recognize the benefit to Apple is small relative to the

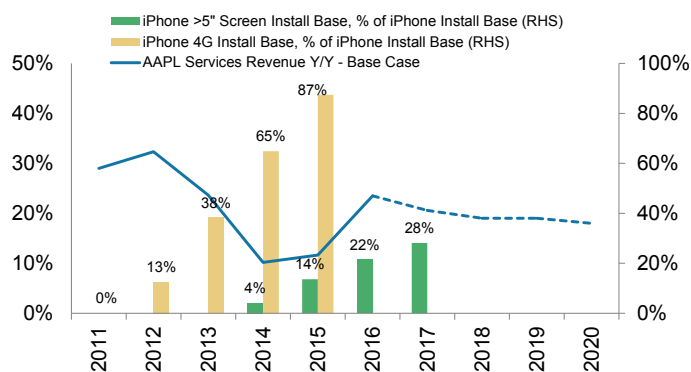


company's overall revenue base, the incremental margin is near 100%, helping drive a more meaningful EPS impact of over \$1/share over the three year period.

We see an even larger opportunity for the broader mobile services ecosystem, including Google, Facebook, Amazon, Netflix, Pandora, Activision, EA, and Tencent ([Exhibit 40](#)). We similarly look to the acceleration in revenue growth from these companies in 2016 on the back of large screen smartphone adoption as a guide to the potential impact of new AR applications increasing user engagement and total services spend. Collective revenue from these companies accelerated 9pts Y/Y to 27% in 2016, and a similar inflection implies revenue growth accelerates to 30% Y/Y in 2019 from 21% in 2018, as forecasted by the base case estimates of Morgan Stanley Research. We expect the AR-fueled growth acceleration to drive combined incremental services revenue of \$118B over the next three years with services growing at a 23% CAGR compared to 19% based on current Morgan Stanley forecasts.

Exhibit 37:

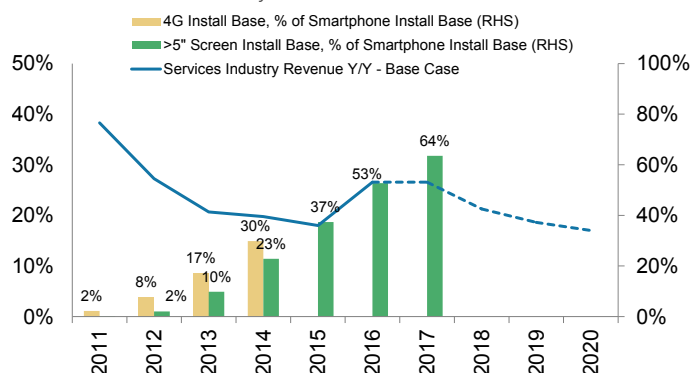
Revolutionary New Technologies Historically Accelerate Apple Services Growth...



Source: Company Data, IDC, Morgan Stanley Research

Exhibit 38:

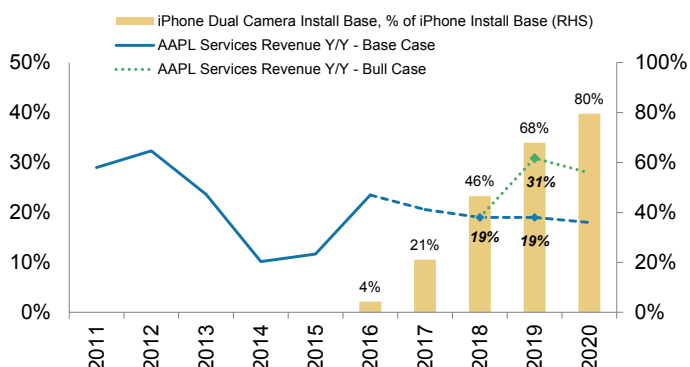
...as Well as Total Industry Services Growth



Source: Company Data, IDC, Morgan Stanley Research. Services Industry include AAPL (services), Google (ex Bets), AMZN (ex AWS), NFLX (streaming only), Pandora, ATVI (mobile and other), EA (mobile), Tencent

Exhibit 39:

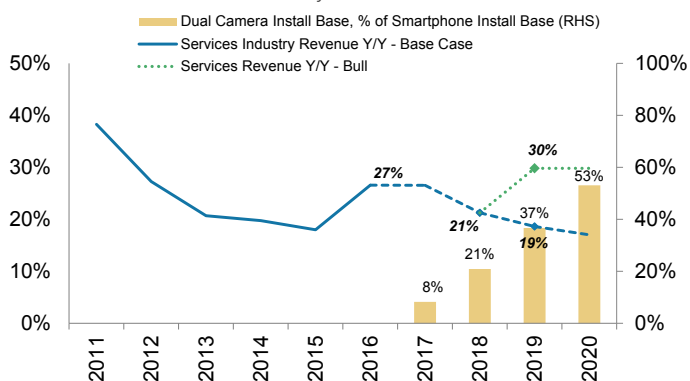
We See an Opportunity for AR to Accelerate Apple Services Revenue Growth...



Source: Company Data, IDC, Morgan Stanley Research.

Exhibit 40:

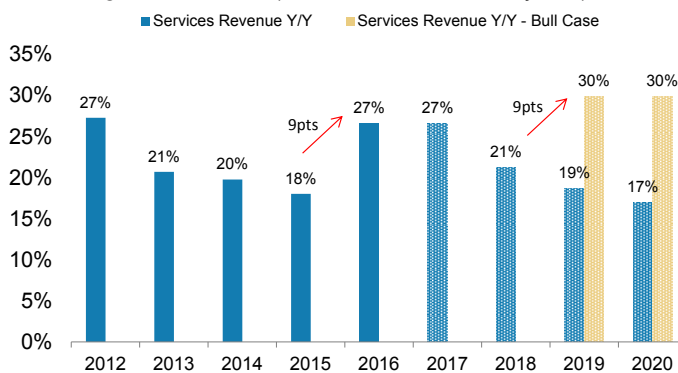
... and Broader Services Industry Revenue Growth



Source: Company Data, IDC, Morgan Stanley Research. Services Industry include AAPL (services), Google (ex Bets), AMZN (ex AWS), NFLX (streaming only), Pandora, ATVI (mobile and other), EA (mobile), Tencent

Exhibit 41:

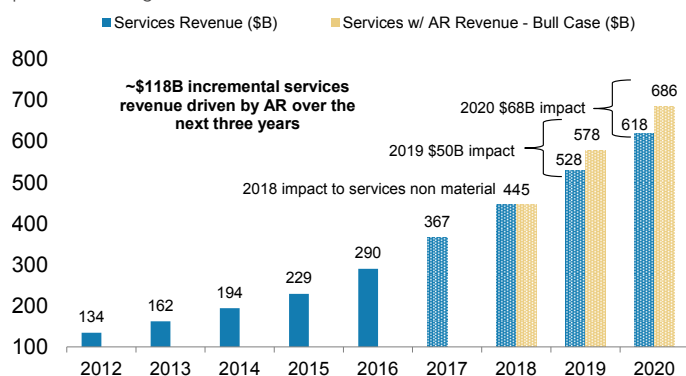
Bull Case: AR Drives Service Revenue Inflection Similar to 9-Point Bump When Larger-Screen Smartphones Were More Widely Adopted



Source: IDC, Morgan Stanley Research. Services Industry include AAPL (services), Google (ex Bets), AMZN (ex AWS), NFLX (streaming only), Pandora, ATVI (mobile and other), EA (mobile), Tencent

**Exhibit 42:**

Bull Case: AR drives ~\$118B Incremental Revenue for Services Companies Through 2020



Source: IDC, Morgan Stanley Research. Services Industry include AAPL (services), Google (ex Bets), AMZN (ex AWS), NFLX (streaming only), Pandora, ATVI (mobile and other), EA (mobile), Tencent

Components

New component opportunity driven by upgraded chip, memory, display, and sensor suite. We see incremental opportunity in mobile AR trends from potential upgrades in feature phones/ultra low-end smartphones, and in smartphones that are Pokémon GO-ready. We estimate 25% of global handsets (mainly feature phone) today cannot run the Mobile AR app, and that each of these handsets would require \$10/device in upgrades to do so. Upgrading 200M units of feature phones would create a \$2 billion TAM. However, greater upside could come from smartphones that add 3D sensing and force touch features, which will require greater computing power within the smartphones, primarily in the form of more robust AP and DRAM. We don't think higher resolution display or AMOLED are necessary to utilize mobile AR, but screen resolution is an accompanying spec for higher-end phones.

In our bull case upgrade cycle, we assume 607M units of low-end smartphones will add one rear-facing 3D sensing module (at a cost of around \$12/device), which would also trigger an upgrade of the processor to an 8-core A53 process, DRAM to 2GB, and display resolution to HD720. In total, we see US\$30/device incremental component costs, and by timing the incremental volume, this would represent around \$18 billion in TAM over the 2018-2020 period.

For a smartphone to reach a perfect Mobile AR user experience, we believe there will be additional component upgrades required beyond the typical AR-capable smartphone discussed above. The high-end AR-enabled device would have a higher resolution and more power-efficient display, criteria which the QHD AMOLED display (2,560 x 1,440 pixels) currently fits. The combination of a 3D sensor suite (for upgrading depth perception), dual camera module (increase resolution), and haptic design (for tactile feedback) are the major additional components that would enhance AR applications and user experience. In total, these upgrades would require \$62 of incremental component costs per device vs. mid-end smartphones. Upgrading 260M units of mid-end smartphones to these "high-end" AR phones would result in our \$18 billion incremental high-end smartphone component TAM.

Bringing together the incremental component requirements for low, mid, and high-end smartphone drives the total incremental component opportunity for AR capable devices to \$38B in our 2018-2020 bull case smartphone upgrade period. However, given the current fragmented supply chain dynamics and innovation needed for cost reduction as AR reaches a greater volume of smartphones, it is important to monitor the progress of additional component technology development and their associated costs.

**Exhibit 43:**

New Component Sales Reach \$38 billion in the 2018-2020 Upgrade Cycle

Sizing The Incremental Component Opportunity for Mobile AR							
	Low-End Smartphone	Cost (USD) - A	AR Capable Smartphone	Cost (USD) - B	High End AR Capable Smartphone	Cost (USD) - C	Total
Retail Price	\$50 - \$250		\$250 - 500		>\$500		
% of Total Smartphone Market (2016)	55%		21%		19%		
2016 Annual Volume	~800M units		~300M units		~285M units		
Key Component Changes							
Chipset (AP + Connectivity)	4-Core	\$ 6	8-core A53	\$ 12	8-core, with A73/A75 as BIG cores	\$ 25	
DRAM	1GB	\$ 7	2GB	\$ 14	4GB	\$ 28	
Display	HD720 LCD	\$ 15	Full HD LCD	\$ 20	AMOLED/Full Screen	\$ 40	
3D Sensor Suite	N/A		Rear Facing	\$ 12	Front and Rear Facing	\$ 24	
Haptics	N/A		N/A		Force Touch	\$ 9	
Subtotal		\$ 28		\$ 58		\$ 126	
Incremental Cost for Key Components		\$ 10		\$ 30		\$ 68	
Assumed Mix of Incremental 2018-20 Shipments in Bull Case				70%		30%	
Incremental 2018-20 Shipments in Bull Case (M)		200		607		260	
TAM for Key Components (\$M)		\$ 2,000		\$ 18,209	+	\$ 17,688	\$ 37,897

Source: Company Data, Morgan Stanley Research estimates



Who Is Best Positioned?

Devices

Best Positioned: Apple followed by Samsung

Apple is the clear device leader in the push to bring Mobile AR mainstream, and we believe they are best positioned to capture sustainable value creation as a result of Mobile AR Adoption. Why? Because Apple is the first to roll out AR-focused mobile hardware, the first to launch an AR platform for developers, and benefits from a customer base that upgrades to new versions of iOS at a rapid pace. Apple will be the first smartphone vendor to introduce 3D sensors in their smartphones in fall 2017 with 650M+ users that will upgrade to this technology over the next several years. Apple already has the second highest mix globally of dual cam smartphones as a % of total shipments at 31% (2nd to Huawei). Combined with AR features available with iOS 11 and new apps developed on ARKit over the last several months, Apple will have the most robust AR user base entering 2018. While competition is sure to heat up after Google recently launched their ARCore AR development platform for Android, we believe most smartphone vendors will take several quarters to fully adopt ARCore technology (currently only on Samsung GS8 and Google Pixel phones), thereby limiting the breadth of the Android platform vs. Apple in the eyes of the consumer.

Exhibit 44:

We Raise our Apple Bull Case Valuation to \$253 (from \$203) on the Back of our AR Work

Apple Inc. (AAPL)	2018		2019	
	Base	Bull	Base	Bull
Revenue Growth	27%	33%	-4%	6%
iPhone Unit Growth	23%	33%	-5%	4%
Services Growth	20%	20%	19%	31%
EPS	\$ 11.80	\$ 12.37	\$ 11.38	\$ 14.05
P/E Multiple	15.4x			18.0x
Valuation Target	\$ 182			\$ 253
Upside	15%			59%
Current Price (9/8/17):	\$ 158.63			

Source: Company Data, Morgan Stanley Research

We see Samsung as the next best positioned in the device market to capture incremental value from AR. Samsung has adopted the dual cam for the first time in the recently unveiled Note 8 phablet. We expect the adoption rate will grow meaningfully from next year, as the company's next-generation flagship Galaxy S9 will likely be equipped with dual cam and potentially all 100mn Galaxy phones as

well as mid-end A-series smartphones which could add another ~35mn units. As such, we believe more Samsung devices will be able to support ARCore next year. In addition to Gear VR headsets launched in 2015, Samsung is in the process of developing 'Monitorless' glasses, which can be paired with a PC or a smartphone to show the device's display on a virtual screen. Monitorless uses a specially built pair of glasses, made from electrochromic glass, that connect wirelessly to a device, which also enables VR and AR interactions, including gaming. Its current VR apps include TraVRer (a 360-degree platform that allows travel to places virtually, capturing noises, moods and events in the streets), VuidUs (VR for home buyers furniture - more of an IKEA type catalog app) and Relúmiño, a visual aid which allows visually impaired to read books and watch TV "with new levels of clarity."

Services

Best Positioned: Apple, Alphabet and Tencent followed by Snapchat, Facebook and Amazon

We believe large platforms likely to be the biggest beneficiaries as mobile AR becomes more mainstream. To look at the potential winners in the Mobile AR market, we look to mobile gaming, which contributes the lion's share of revenues to the Apple App Store and Google Play (App Annie estimates that in 2016 games generated 75% of AppStore revenues and 90% of Google Play revenues).

With this as a backdrop, we see the large platforms (Apple, Alphabet, Tencent) driving and benefiting from AR gaming given they control platform operators 1) the software 2) the marketplace and payments and 3) discovery and the user interface. As users download more mobile games and make more mobile purchases the platforms monetize. The high margin revenue streams of the marketplaces drive results too, as we estimate that in 2017 the Apple App Store could generate \$12bn (39% of services revenue), Google Play ~\$7bn (~6% percent of revenue), and Tencent \$5.5bn (15% of revenue).

What about gaming publishers? We note that while mobile gaming has been a tremendous contributor to growth in the global gaming market (we estimate 80% of growth in global gaming software spend has come from mobile...now representing nearly half of annual gaming software revenues), it is not necessarily intuitive which publishers are best positioned to benefit from augmented reality.



The quality of the content and games will matter...and the long tail of successful mobile-specific publishers is, well, long. No question the traditional large gaming publishers (ATVI, EA, TTWO and UBI) have strong intellectual properties that could be leveraged into augmented reality. But their success in augmented reality will down to execution and their ability to port the content to the new mobile ecosystem. That can be difficult and mobile game competition is high and wide spread. Indeed, consider that 10 of the top 10 mobile games in 2016 were made by publishers that focus purely on mobile gaming ([Exhibit 45](#)).

Exhibit 45:

The Top 10 Mobile Games in 2016 Were Produced and Developed by Mobile First Publishers

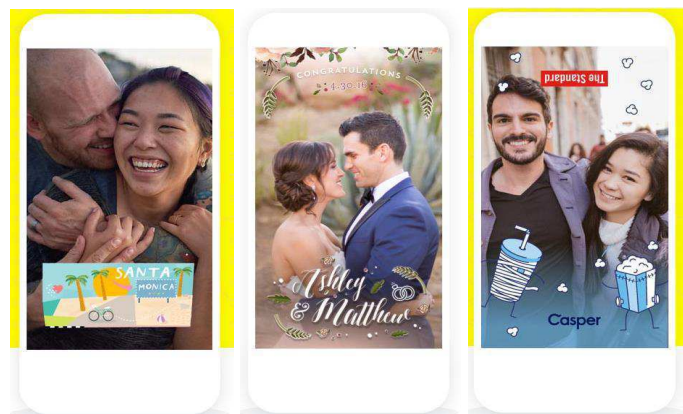
2016 Apple App Store Rank	Game	Publisher
1	Monster Strike	Mixi
2	Puzzle and Dragons	Gungho Online
3	Fantasy Westward Journey II	NetEase
4	Clash of Clans	Supercell
5	Game of War - Fire Age	Machine Zone
6	Clash Royale	Supercell
7	Mobile Strike	Machine Zone
8	Pokemon Go	Niantic
9	Candy Crush Saga	King
10	Honour of Kings	Tencent

Source: Sensor Tower, Morgan Stanley Research

We see Snapchat, Facebook and Amazon as the best positioned in the services space to capture incremental value from augmented reality. Snapchat has been an early leader in augmented reality with sponsored lenses and other creative geofilters ([Exhibit 46](#)). Some of these include sponsored lenses such as by Pokemon, Taco Bell, and X-Men.

Exhibit 46:

Snapchat Geofilters Can Center Around Community, Personal Events, and Businesses



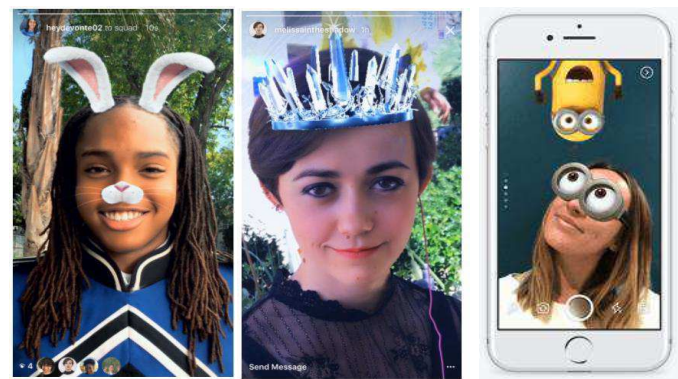
Source: Snapchat

These are already material to Snapchat monetization as we estimate that creative lens and geofilters made up 50 percent (~\$200mm) of Snapchat's 2016 ad revenue. Augmented reality drives engagement too as Snapchat recently said that users that engage with creative lenses spend over 3 minutes doing so daily.

Facebook and Instagram are similarly offering users new and fun lenses to use and share with friends ([Exhibit 47](#)) as well as offering sponsored lenses for advertisers. Ultimately, these filters serve to engage audiences and connect users, but can also be used to drive ad revenue growth.

Exhibit 47:

Facebook Recently Added Lenses and Sponsored Lenses for both Facebook and Instagram



Source: Facebook.com

We view Amazon as an enabler and winner within augmented reality as well. More specifically, we see the potential for Amazon to re-imagine the online shopping experience in certain categories that require more tangibility and/or have been relatively more difficult to move online. We see Amazon's engineering and investment focus as well as its budding Echo business (the hardware to likely enable Amazon's long term augmented reality capabilities) enabling to company to drive augmented e-commerce.

Consider fashion and apparel, where the photo recognition and 3D imaging with Echo Look ([Exhibit 48](#)) and augmented reality capabilities can show users how they would look wearing different sizes and types of clothes. Increased tangibility could drive higher purchase behavior. We see similar opportunities in home furnishing and appliances and other categories too...as 3D conceptual imaging could enable users to see how potential purchases would look/fit in their rooms. In all, we see Amazon's augmented reality capabilities bringing more tangibility and personalization to ecommerce...which will likely enable Amazon to continue to drive ecommerce and overall personal consumer expenditure.

**Exhibit 48:**

Amazon's Echo Look Can Show Users How They Look in Clothes Before They Buy



Source: Amazon.com

Components

Best Positioned: AAC, Tong Hsing, LG Innotek, Himax, Win Semi, MediaTek and TSMC

AAC is best positioned for its leading position in haptic supply in terms of both technology (electromagnetic know-how and ability to upgrade haptics design for better user experience) and scale (ability to expand capacity per customers' requirement). Haptics enhance what we can feel in the AR environment. A key application of haptics in an AR context will most likely be in gaming, to simulate the sensation of shooting, or bumping into a wall in car racing, to enhance the gameplayer's sense of immersion beyond sound and vision.

Tong Hsing should benefit from the AR-enabled phone adoption growth with its unique CMOS sensor wafer restructuring, testing and packaging work. Its newly set up integrated CMOS sensor wafer processing fab should allow it to capture incremental potential from increased functionality within 3D sensor suite design. It has exposure to both the Apple and non-Apple camps. For iPhones, it can provide

reconstruction wafers (RW) for image sensors, and for non-Apple smartphones, ceramic substrates for high-power lasers. Both are within its core expertise, accounting for 75-80% of its revenues. However, we think Tong Hsing may be able to provide image sensor RWs for non-Apple smartphones as well, which would drive additional earnings upside.

LG Innotek (LGI) specializes in module assembly, namely camera modules and 3D sensing modules for smartphones. As a key supplier of such modules for iPhones, LGI generates ~80% of its total profit from Apple. We believe LGI will take roughly 70% share in the 3D sensor and dual cam business for Apple this year, thanks to the company's strong production yields. Given the company's strong customer relationships with Apple as well as LG Electronics (it is a 41% stakeholder in LGI), we believe LGI is a key beneficiary of the rising trend of mobile AR.

Himax is the key supplier to Apple's 3D sensing optical component, and the structured light solution to the Android camp.

Himax should have started volume shipments of diffractive optics element (DOE) components for Apple in 3Q17. We forecast Himax will ship around 100mn units of DOE components to Apple in 2017, and around 250mn units in 2018. 3D sensing contributes 5% of Himax's revenue in 2017, mainly from the DOE shipment to Apple. On August 30, 2017, Qualcomm and Himax jointly announced a 3D sensing total solution, and target shipments in 1Q18. This reaffirms our thesis that Android camp smartphones will adopt 3D sensing features earlier than expected. We assume Himax ships 13mn units of 3D sensing solutions to Android smartphones in 2018 with ASPs of around US\$12, and expect 3D sensing to contribute 25% of Himax's total revenue in 2018, up from 5% in 2017. If Apple decides to adopt 3D sensing in more camera modules, we think there could be upside risk to our 2018 revenue forecast.

Win Semi realizes the lower-cost 3D sensing VCSEL for smartphones via its competitive 6-inch wafer foundry capacity.

Apple has said that it is integrating a VCSEL into the upcoming iPhone 8/X. Lumentum, the main supplier of the new iPhone's 3D sensing laser diode, has selected WIN Semi as a key foundry vendor given the latter's competitive cost structure and better scalability versus peers. In 2017, 3D sensing has become a new growth driver for WIN Semi, and we estimate that the segment will account for 10% of the company's overall revenues in 2018 and 16% in 2019, up from 5% in 2017.

MediaTek could benefit from the potential smartphone upgrade cycle.

The company owns 50% market share in the emerging markets smartphone chipset. For MediaTek, the sweet spot should be the mainstream smartphone's product cycle, which we think could be triggered by Mobile AR trend in 2019. Although going into 2018 MediaTek's chipsets cannot support Himax's structural light 3D sensing solution, its customers can still adopt the 3D depth camera technology provided by Google's "Project Tango," which costs US\$20-30 per module. We believe MediaTek's chipsets in 2019 will start to support 3D sensing technologies when those solutions get commoditized, and become more affordable for EM smartphone users.

TSMC benefits from more smartphone chipset features and shipments.

Our positive thesis on TSMC is based on the growing revenue contribution from HPC (high performance computing), and our belief is that HPC could surpass the smartphone chipset as the main growth driver as soon as 2019. However, smartphone chipsets (including Apple iPhone processors and Android smartphone chipsets) still account for half of the company's revenue today. Thanks to the Mobile AR trend, if TSMC's smartphone chipset revenue also grow thanks to high semiconductor content and/or better shipments, that would provide additional upside to our long-term growth forecasts for TSMC.

**Exhibit 49:**

Clear Beneficiaries of the Mobile AR Cycle

Clear Beneficiaries of the Mobile AR Cycle					
Product	Company	Ticker	Rating	Market Cap (\$M)	Product Offering
Devices	Apple	AAPL	OW	819,360	Smartphone OEM
	Samsung	005930.KS	OW	282,428	Smartphone OEM
Components	AAC	2018.HK	OW	21,274	Haptic Engine; Wafer Level Optics
	AMS	AMS-EB	EW	6,850	3D Sensor Componentry
	Chroma Ate	2360.TW	OW	1,375	Laser Diode Testing Equipment
	Himax	HIMX.O	OW	1,753	3D Sensor Controlling Optics
	Largan	3008.TW	OW	26,719	Smartphone Lens
	LG Innotek	011070.KS	EW	3,558	3D Sensor Laser Emitter Module
	Lumentum	LITE.O	UW	3,469	3D Sensor Light Source
	Mediatek	2454.TW	OW	14,488	Smartphone Chipset Design
	STMicro	STM.PA	UW	17,052	3D Imaging Sensor
	Sunny Optical	2382.HK	OW	15,166	3D Sensor Module
	TSMC	2330.TW	OW	188,607	3D Sensor Light Source
	Tong Hsing	6271.TW	OW	712	3D Imaging Sensor Wafer Processing
	Viavi	VIAV.O	EW	2,271	3D Sensor Controlling Optics
	Win Semi	3105-OT	EW	2,311	3D Sensor Light Source
Services	Alibaba	BABA	OW	432,835	eCommerce
	Alphabet	GOOGL	OW	280,582	Internet-Related Services & Products
	Amazon	AMZN	OW	463,999	eCommerce
	Apple	AAPL	OW	819,360	App Store Platform
	Tencent	700-HK	OW	391,282	Internet-Related Services & Products

Source: Morgan Stanley Research

Exhibit 50:

Potential Beneficiaries of the Mobile AR Cycle

Potential Beneficiaries of the Mobile AR Cycle					
Product	Company	Ticker	Rating	Market Cap (\$M)	Product Offering
Devices	LG Electronics	066570.KS	UW	11,953	Smartphone OEM
Components	ASM Pacific	0522.HK	OW	5,590	3D Sensor Testing Equipment
	Aspeed	5274.TWO	EW	748	Cloud Data Center - Server Mgmt
	Chunghwa Precision	6510.TWO	OW	1,450	Smartphone Chipset
	Epistar	2448.TW	OW	1,259	3D Sensor Light Source
	Finisar	FNSR.O	NC	2,504	3D Sensor Light Source
	II-VI	IIVI.O	NC	2,310	3D Sensor Light Source
	Infineon	IFXGn.DE	UW	27,440	3D Imaging Sensor & Module
	Landmark	3081.TWO	OW	1,191	Cloud Data Center - Silicon Photonics
	Novatek	3034.TW	EW	2,369	High Resolution Displays
	O-Film	002456.SZ	EW	8,806	3D Sensor Module
	Osram	OSRn.DE	UW	8,631	3D Sensor Iris Scan
	Qualcomm	QCOM.O	EW	74,364	Smartphone Chipset Design
	Quanta	2382.TW	OW	8,675	Data Center Hardware
	Realtek	2379.TW	EW	1,873	Wireless Connectivity
	SEMC	009150.KS	OW	6,878	3D Sensor Module
	Sharp	6753.T	UW	14,704	Display Panel, 3D Sensor Module
	Sony	6758.T	OW	50,112	3D Image Sensor
	Wistron	3231.TW	EW	2,429	Data Center Hardware
Services	Activision Blizzard	ATVI	OW	49,696	Gaming Developer
	Electronic Arts	EA	OW	36,717	Gaming Developer
	Facebook	FB	OW	410,565	Online Social Networking
	Snap	SNAP	EW	18,137	Online Social Networking
	Zillow	Z	EW	4,858	Online Real Estate Marketplace
	Zynga	ZNGA	OW	2,866	Mobile Gaming Developer

Source: Morgan Stanley Research



Morgan Stanley Global Smartphone Model

We update our global smartphone model for IDC's 2Q17 reported data. While shipments in 2Q grew only 0.4% Y/Y, and below our prior forecast, we view the recent weakness as a pause in purchases ahead of the expected iPhone 8/X smartphone launch on September 11th. As a result, our full year CY17 estimate is unchanged at 5%.

Exhibit 51:

Morgan Stanley Global Smartphone Model

	1Q15	2Q15	3Q15	4Q15	1Q16	2Q16	3Q16	4Q16	1Q17	2Q17	3Q17e	4Q17e	1Q18e	2Q18e	3Q18e	4Q18e	2014	2015	2016	2017e	2018e	2019e	2020e
Smartphone Units Shipments (mln)																							
PRC	101	106	109	114	103	113	116	136	104	111	126	147	111	121	136	157	423	430	467	488	526	552	574
Rest of Asia/Pacific	47	46	43	55	43	47	44	55	48	45	48	59	51	50	52	65	166	190	189	200	217	233	247
EMEA	89	91	100	111	90	86	92	111	89	83	97	115	91	90	104	122	322	391	378	384	407	415	423
North America	42	38	43	55	41	39	44	62	41	43	48	65	42	45	52	69	173	179	187	198	208	213	217
Latin America	34	34	35	40	32	34	35	42	36	36	38	45	35	38	42	49	136	144	143	156	164	168	173
India	22	27	29	26	23	28	32	26	27	28	38	30	31	34	43	34	80	104	109	123	142	166	191
Total	335	342	359	401	333	346	363	431	344	348	396	462	361	378	428	496	1,302	1,438	1,473	1,549	1,664	1,746	1,824
Mix																							
PRC	30%	31%	30%	29%	31%	33%	32%	32%	30%	32%	32%	32%	31%	32%	32%	32%	33%	30%	32%	32%	32%	32%	31%
Rest of Asia/Pacific	14%	13%	12%	14%	13%	14%	12%	13%	14%	13%	12%	13%	14%	13%	12%	13%	13%	13%	13%	13%	13%	14%	
EMEA	26%	27%	28%	28%	27%	25%	25%	26%	26%	24%	25%	25%	25%	24%	24%	25%	25%	27%	26%	25%	24%	24%	23%
North America	13%	11%	12%	14%	12%	11%	12%	14%	12%	12%	12%	14%	12%	12%	12%	14%	13%	12%	13%	13%	12%	12%	
Latin America	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	9%	
India	7%	8%	8%	6%	7%	8%	9%	6%	8%	8%	10%	7%	9%	9%	10%	7%	6%	7%	7%	8%	9%	10%	
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Y/Y Growth																							
PRC	-4%	2%	3%	5%	3%	6%	6%	19%	1%	-1%	9%	8%	7%	9%	8%	7%	20%	2%	9%	4%	8%	5%	4%
Rest of Asia/Pacific	37%	22%	4%	2%	-7%	3%	2%	1%	10%	-4%	9%	8%	7%	10%	9%	9%	27%	14%	-1%	6%	9%	7%	6%
EMEA	28%	27%	18%	15%	1%	-6%	-8%	0%	-2%	-3%	6%	4%	3%	8%	7%	6%	31%	21%	-3%	1%	6%	2%	2%
North America	17%	1%	1%	-3%	-3%	2%	3%	12%	0%	11%	9%	5%	2%	4%	7%	7%	21%	3%	4%	6%	5%	2%	2%
Latin America	20%	7%	-1%	0%	-7%	0%	1%	3%	13%	6%	9%	9%	-3%	5%	8%	8%	36%	6%	0%	9%	5%	3%	3%
India	35%	44%	25%	15%	5%	4%	11%	0%	15%	2%	17%	17%	14%	20%	14%	14%	83%	29%	5%	13%	15%	17%	15%
Total	15.9%	13.4%	7.9%	6.1%	-0.6%	1.1%	1.1%	7.4%	3.4%	0.4%	8.8%	7.2%	4.9%	8.7%	8.3%	7.6%	27.8%	10.4%	2.5%	5.1%	7.4%	4.9%	4.5%
Q/Q Growth																							
PRC	-8%	6%	2%	5%	-10%	9%	3%	17%	-23%	7%	13%	16%	-24%	9%	12%	15%	-12%	-2%	-8%	27%	-21%	9%	25%
Rest of Asia/Pacific	-12%	-2%	-6%	27%	-21%	9%	-7%	25%	-13%	-4%	5%	24%	-14%	-2%	4%	24%	-8%	3%	10%	11%	-19%	-5%	7%
EMEA	-8%	3%	10%	11%	-19%	-5%	7%	21%	-20%	-6%	17%	19%	-21%	-2%	16%	18%	-25%	-9%	12%	28%	-25%	-5%	13%
North America	-25%	-9%	12%	28%	-25%	-5%	13%	39%	-33%	5%	11%	34%	-35%	7%	15%	34%	-15%	0%	2%	15%	-21%	8%	3%
Latin America	-15%	0%	2%	15%	-21%	8%	3%	18%	-13%	1%	5%	18%	-23%	9%	9%	18%	1%	19%	10%	-12%	17%	17%	-20%
India	1%	19%	10%	-12%	-8%	17%	17%	-20%	5%	4%	35%	-20%	2%	9%	29%	-20%	1%	19%	10%	-12%	17%	17%	-20%
Total	-11%	2%	5%	12%	-17%	4%	5%	18%	-20%	1%	14%	17%	-22%	5%	13%	16%	-11%	2%	5%	12%	-17%	4%	5%

Source: IDC, Morgan Stanley Research



AAPL Risk Reward

Upcoming iPhone Supercycle combined with potential cash repatriation and tax reform make AAPL our top pick in 2017



Source: Thomson Reuters, Morgan Stanley Research

Price Target \$182

Derived from base-case scenario.

Bull \$253

18x Bull Case FY19e EPS of \$14.05

Demand for mobile AR technology extends iPhone supercycle beyond FY18. iPhone units grow 4% in FY19 after 32% growth in FY18. Services demand better than expected and investors focus on platform valuation. iPhone supercycle extends into FY19 as units grow 4%+ off a much larger base and Services growth accelerates to 30%+ on the back of increased demand for new AR-centric applications. Gross margins move closer to 40% due to more beneficial iPhone and Services revenue mix. Investors focus on monetization of Apple's 1.2B+ and growing device base and value Apple closer to that of a platform company. We assume an 18x P/E multiple (or 15.4x ex-net cash) on FY19 EPS of \$14.05, which is approx. ½ turn above the market multiple and ½ turn below the average of large cap platform companies such as Coke, Alphabet, Nike, P&G, etc. which we believe is warranted given the extended iPhone growth, expanding device installed base, increasing high margin services mix and larger cash balance. Additional upside could also come from repatriation leading to increased share repurchases, a lower corporate tax rate, and/or potential for investment in new categories.

Base \$182

15.4x Base Case FY18e EPS of \$11.80 or 12.5x Ex-Net Cash

Upcoming iPhone supercycle drives 23% unit growth and valuation multiple back to 2014 peak range. Starting in late 2017, we see an iPhone supercycle driven by accelerating upgrades due to new augmented reality applications, better battery life and new form factors. Revenue grows 27% in FY18 driven by 40% iPhone revenue growth (23% unit growth) and 20% Services growth. Gross margin is up 20 bps with favorable mix more than offsetting lower iPhone margins. We assume a 15.4x P/E multiple, which is in line with the high-end of the peak multiple during the iPhone 6 supercycle. This assumes 12.5x adjusting for Apple's \$34/shr of net cash in twelve months, which is closer to mature technology companies.

Bear \$120

12x Bear Case FY18e EPS of \$10.00

iPhone growth disappoints due to limited OLED supply, weak demand, and/or trade war with China, with slower than expected EPS growth. US protectionist measures and OLED availability only at the high-end of the iPhone line limits revenue growth. Apple continues to invest in future products and services, driving negative operating leverage, offset by continued share repurchases. EPS grows in the mid-teens. P/E multiple falls to 12x, or 9x after adjusting for Apple's net cash balance, close to low-end of large cap IT hardware peers.

Investment Thesis

■ Apple has the world's most valuable technology platform with over one billion active devices, and is best positioned to capture more of its users' time in areas such as health, autos and home. Near-term, we see pent-up demand heading into a significant form factor change that is likely to accelerate iPhone unit growth, led by China. Furthermore, accelerated Services growth, tax reform / cash repatriation, and increased appetite for M&A are catalysts that can help sustainably re-rate shares.

Key Debates

■ Can Apple sustainably grow revenue and EPS? Yes, the combination of increased services mix, higher share repurchases, potential M&A, and investments in new categories like augmented/virtual reality, artificial intelligence, health, and autos are drivers of sustainable growth longer-term.

■ Can Apple accelerate innovation? Yes, we expect FY17 to be the fifth year in a row that R&D growth outpaces revenue growth, translating to new products and services over time. Over the past three years, Apple spent an incremental \$10B+ on R&D compared to less than \$1B ahead of iPhone and iPad. This compares to minimal incremental spend at top auto makers (ex-Tesla) and \$11B incremental spend at Alphabet on far more projects.

Potential Catalysts

- New AMOLED iPhones with 3D sensors, improved battery technology, and new form factor accelerate upgrades globally, with meaningful pent-up demand in China.
- Tax reform increases probability of cash repatriation and a lower corporate tax rate
- Expanding the platform to new industries, for example healthcare, autos or homes, drives "halo effect" across Apple's businesses
- Expanding points-of-sale, especially in emerging markets like India
- Increasing services mix could more sustainably re-rate shares.
- Accelerated share repurchase and/or large M&A contribute to earnings growth and multiple expansion

Risks to Achieving Price Target

- Weak global consumer spending and strong US dollar create headwinds
- Maturing markets, and Android competition in smartphones and tablets
- Lack of traction with new product categories and/or services limit multiple expansion
- Carriers lengthening replacement cycles and/or lower subsidies
- Political, regulatory and legal risk as Apple gains profit share in mobile devices and remains dependent on Asian suppliers and consumers to deliver results
- Rising memory costs could pressure gross margins near-term



Disclosure Section

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Global Stock Ratings Distribution

(as of August 31, 2017)

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For disclosure purposes only (in accordance with NASD and NYSE requirements), we include the category headings of Buy, Hold, and Sell alongside our ratings of Overweight, Equal-weight, Not-Rated and Underweight. Morgan Stanley does not assign ratings of Buy, Hold or Sell to the stocks we cover. Overweight, Equal-weight, Not-Rated and Underweight are not the equivalent of buy, hold, and sell but represent recommended relative weightings (see definitions below). To satisfy regulatory requirements, we correspond Overweight, our most positive stock rating, with a buy recommendation; we correspond Equal-weight and Not-Rated to hold and Underweight to sell recommendations, respectively.

Stock Rating Category	Coverage Universe		Investment Banking Clients (IBC)			Other Material Investment Services Clients (MISC)	
	Count	% of Total	Count	% of Total IBC	% of Rating Category	Count	% of Total Other MISC
Overweight/Buy	1164	36%	306	41%	26%	555	37%
Equal-weight/Hold	1425	44%	349	46%	24%	701	46%
Not-Rated/Hold	61	2%	6	1%	10%	10	1%
Underweight/Sell	606	19%	91	12%	15%	242	16%
Total	3,256		752			1508	

Data include common stock and ADRs currently assigned ratings. Investment Banking Clients are companies from whom Morgan Stanley received investment banking compensation in the last 12 months.

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Overweight (O or Over) - The stock's total return is expected to exceed the total return of the relevant country MSCI Index or the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis over the next 12-18 months.

Equal-weight (E or Equal) - The stock's total return is expected to be in line with the total return of the relevant country MSCI Index or the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis over the next 12-18 months.

Not-Rated (NR) - Currently the analyst does not have adequate conviction about the stock's total return relative to the relevant country MSCI Index or the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

Underweight (U or Under) - The stock's total return is expected to be below the total return of the relevant country MSCI Index or the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

Unless otherwise specified, the time frame for price targets included in Morgan Stanley Research is 12 to 18 months.

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Attractive (A): The analyst expects the performance of his or her industry coverage universe over the next 12-18 months to be attractive vs. the relevant broad market benchmark, as indicated below.

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Cautious (C): The analyst views the performance of his or her industry coverage universe over the next 12-18 months with caution vs. the relevant broad market benchmark, as indicated below.

Benchmarks for each region are as follows: North America - S&P 500; Latin America - relevant MSCI country index or MSCI Latin America Index; Europe - MSCI Europe; Japan - TOPIX; Asia - relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.



Stock Price, Price Target and Rating History (See Rating Definitions)

LG Electronics (066570.KS) - As of 9/11/17 in KRW
Industry : S. Korea Technology



Stock Rating History: 9/1/14 : O/I; 11/25/14 : E/I; 5/12/16 : U/I; 3/14/17 : E/I; 7/10/17 : U/I

Price Target History: 10/25/13 : 87000; 11/25/14 : 76000; 2/5/15 : 68000; 5/27/15 : 63000; 7/13/15 : 52000;
8/28/15 : 51000; 12/16/15 : 53000; 2/19/16 : 58000; 5/12/16 : 45000; 8/9/16 : 44000; 1/26/17 : 50000;
2/7/17 : 52000; 2/15/17 : 54000; 3/14/17 : 65000; 5/30/17 : 85000; 7/10/17 : 62000; 9/6/17 : 70000

Source: Morgan Stanley Research Date Format : MM/DD/YY Price Target --- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) --- Stock Price (Covered by Current Analyst) ---
Stock and Industry Ratings (abbreviations below) appear as ♦ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

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Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.



LG Innotek (011070.KS) - As of 9/11/17 in KRW
Industry : S. Korea Technology



Stock Rating History: 9/1/14 : O/I; 10/30/14 : E/I; 11/25/14 : U/I; 5/23/16 : E/I; 2/22/17 : O/I; 5/30/17 : E/I

Price Target History: 6/23/14 : 158000; 10/30/14 : 120000; 11/25/14 : 95000; 8/12/15 : 74000; 12/16/15 : 73000;
4/7/16 : 72000; 5/23/16 : 84000; 9/22/16 : 80000; 2/15/17 : 110000; 2/22/17 : 150000; 5/30/17 : 130000;
7/7/17 : 148000; 8/9/17 : 160000

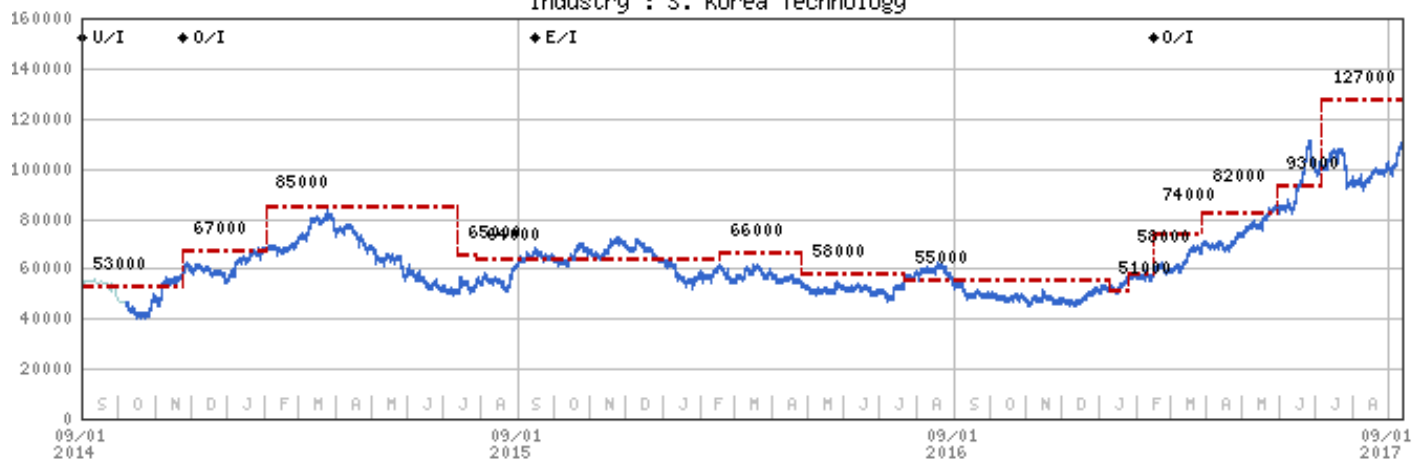
Source: Morgan Stanley Research Date Format : MM/DD/YY Price Target --- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) — Stock Price (Covered by Current Analyst) —
Stock and Industry Ratings (abbreviations below) appear as ♦ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

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Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.



Samsung Electro-Mechanics (009150.KS) - As of 9/11/17 in KRW
Industry : S. Korea Technology



Price Target History: 7/29/14 : 53000; 11/25/14 : 67000; 2/2/15 : 85000; 7/13/15 : 65000; 7/29/15 : 64000;
2/18/16 : 66000; 4/27/16 : 58000; 7/22/16 : 55000; 1/9/17 : 51000; 1/25/17 : 58000; 2/15/17 : 74000;
3/29/17 : 82000; 5/30/17 : 93000; 7/7/17 : 127000

Source: Morgan Stanley Research Date Format : MM/DD/YY Price Target --- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) — Stock Price (Covered by Current Analyst) —
Stock and Industry Ratings (abbreviations below) appear as ♦ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

Effective January 13, 2014, the stocks covered by Morgan Stanley Asia Pacific will be rated relative to the analyst's industry (or industry team's) coverage.

Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.



Source: Morgan Stanley Research Date Format : MM/DD/YY Price Target --- No Price Target Assigned (NA)
 Stock Price (Not Covered by Current Analyst) — Stock Price (Covered by Current Analyst) —
 Stock and Industry Ratings (abbreviations below) appear as ♦ Stock Ratings/Industry View
 Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
 Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

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INDUSTRY COVERAGE: IT HARDWARE

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/08/2017)
Katy L. Huberty, CFA		
Apple, Inc. (AAPL.O)	O (05/26/2009)	\$158.63
CDW Corporation (CDW.O)	E (08/06/2013)	\$58.96
Electronics for Imaging Inc (EFIL.O)	U (08/03/2017)	\$38.20
Hewlett Packard Enterprise (HPE.N)	E (11/11/2015)	\$13.12
HP Inc. (HPQ.N)	O (03/18/2013)	\$19.12
IBM (IBM.N)	O (02/18/2016)	\$142.45
NCR Corp. (NCR.N)	E (09/25/2011)	\$35.45
NetApp Inc (NTAP.O)	U (03/24/2014)	\$38.63
Nutanix Inc (NTNX.O)	E (05/10/2017)	\$21.73
Pure Storage Inc (PSTG.N)	E (05/18/2017)	\$14.42
Seagate Technology (STX.O)	E (07/11/2016)	\$31.99
Teradata (TDC.N)	U (12/03/2013)	\$30.74
Tintri Inc (TNTR.O)	E (08/23/2017)	\$4.55
Western Digital (WDC.O)	O (04/28/2017)	\$87.00
Xerox Corp (XRX.N)	O (01/12/2017)	\$31.56

Yuuji Anderson

Fitbit Inc (FIT.N)	E (07/30/2017)	\$6.29
Garmin Ltd (GRMN.O)	E (01/07/2015)	\$52.26
GoPro Inc (GPRO.O)	E (07/30/2017)	\$10.26

Stock Ratings are subject to change. Please see latest research for each company.

* Historical prices are not split adjusted.

INDUSTRY COVERAGE: INTERNET

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/08/2017)
Brian Nowak, CFA		
Activision Blizzard Inc (ATVI.O)	O (09/23/2016)	\$64.93
Alphabet Inc. (GOOGL.O)	O (08/11/2015)	\$941.41
Amazon.com Inc (AMZN.O)	O (04/24/2015)	\$965.90
Blue Apron Holdings Inc (APRN.N)	E (07/24/2017)	\$5.38
Care.com Inc (CRCM.N)	E (06/29/2016)	\$14.49
Criteo SA (CRTO.O)	E (01/26/2016)	\$44.88
eBay Inc (EBAY.O)	U (04/19/2016)	\$37.79
Electronic Arts Inc (EA.O)	O (09/23/2016)	\$118.28
Etsy Inc (ETSY.O)	E (05/11/2015)	\$16.88
Expedia Inc. (EXPE.O)	E (01/10/2017)	\$141.41
Facebook Inc (FB.O)	O (04/27/2016)	\$170.95
Groupon, Inc. (GRPN.O)	U (04/23/2017)	\$4.38
GrubHub Inc. (GRUB.N)	O (08/06/2017)	\$56.08
Priceline Group Inc (PCLN.O)	O (06/30/2016)	\$1,838.57
Rubicon Project Inc (RUBI.N)	U (09/12/2016)	\$3.98
Snap Inc. (SNAP.N)	E (07/11/2017)	\$15.34
TRIVAGO NV (TRVG.O)	O (01/10/2017)	\$10.96
TrueCar Inc (TRUE.O)	U (09/12/2016)	\$16.81
Twitter Inc (TWTR.N)	U (10/21/2015)	\$17.45
Yelp Inc (YELP.N)	E (07/29/2015)	\$43.75
Zillow Group Inc (Z.O)	E (01/13/2017)	\$37.80
Zynga Inc (ZNGA.O)	O (06/08/2017)	\$3.68

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* Historical prices are not split adjusted.



INDUSTRY COVERAGE: CHINA INTERNET AND OTHER SERVICES

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/11/2017)
David Sun		
58.com (WUBA.N)	U (06/30/2017)	\$63.97
Changyou.com (CYOU.O)	E (02/23/2017)	\$40.04
Cheetah Mobile Inc. (CMCM.N)	U (05/23/2016)	\$9.26
NetEase, Inc (NTES.O)	E (09/24/2015)	\$273.04
Sohu.com Inc (SOHU.O)	E (08/01/2017)	\$54.22
Grace Chen		
Alibaba Group Holding (BABA.N)	O (12/08/2016)	\$169.00
Baidu Inc (BIDU.O)	E (01/17/2017)	\$229.23
JD.com, Inc. (JD.O)	O (12/17/2015)	\$41.15
Tencent Holdings Ltd. (0700.HK)	O (01/09/2017)	HK\$330.80
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* Historical prices are not split adjusted.		

INDUSTRY COVERAGE: S. KOREA TECHNOLOGY

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/11/2017)
Shawn Kim		
Hanwha Techwin (012450.KS)	O (06/13/2016)	W38,200
LG Display (034220.KS)	U (02/06/2017)	W31,900
LG Electronics (066570.KS)	U (07/10/2017)	W83,100
LG Innotek (011070.KS)	E (05/30/2017)	W171,500
Samsung Electro-Mechanics (009150.KS)	O (02/15/2017)	W109,000
Samsung Electronics (005935.KS)	O (12/12/2016)	W2,036,000
Samsung Electronics (005930.KS)	O (10/31/2014)	W2,490,000
Samsung SDI (006400.KS)	O (05/30/2017)	W202,500
Samsung SDS (018260.KS)	E (06/23/2017)	W171,500
Seoul Semiconductor (046890.KQ)	E (05/30/2017)	W22,400
SK Hynix (000660.KS)	O (06/27/2017)	W73,800
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* Historical prices are not split adjusted.		

INDUSTRY COVERAGE: GREATER CHINA TECHNOLOGY SEMICONDUCTORS

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/11/2017)
Charlie Chan		
Advanced Semi Engineering (2311.TW)	O (05/22/2014)	NT\$36.60
ASM Pacific (0522.HK)	O (10/27/2016)	HK\$106.80
Chipbond Technology Corp (6147.TWO)	O (07/20/2017)	NT\$50.20
Chunghwa Precision Test Tech (6510.TWO)	O (08/09/2016)	NT\$1,335.00
Himax Technology, Inc (HIMX.O)	O (03/27/2017)	\$10.19
Jiangsu Changjiang Electronics Tech (600584.SS)	U (09/22/2015)	Rmb17.46
MediaTek (2454.TW)	O (05/23/2017)	NT\$279.00
Nanya Technology Corp. (2408.TW)	O (12/08/2016)	NT\$64.20
Nationz Technologies (300077.SZ)	U (09/22/2015)	Rmb14.85
Powertech Technology (6239.TW)	E (07/26/2017)	NT\$88.80
Shenzhen Huiding Technology Co Ltd (603160.SS)	U (11/28/2016)	Rmb97.10
Silergy Corp. (6415.TW)	O (03/27/2014)	NT\$665.00
Silicon Motion (SIMO.O)	O (11/07/2014)	\$47.14
Siliconware Precision Industries Co. (2325.TW)	E (08/21/2015)	NT\$47.60



SMIC (0981.HK)	O (06/24/2013)	HK\$7.67
TSMC (2330.TW)	O (02/18/2016)	NT\$217.00
UMC (2303.TW)	U (07/27/2016)	NT\$16.05
Unigroup Guoxin Co Ltd (002049.SZ)	U (08/25/2017)	Rmb29.26
Universal Scientific Ind. (Shanghai) (601231.SS)	O (08/04/2015)	Rmb14.71
Vanguard International Semiconductor (5347.TWO)	U (08/02/2016)	NT\$54.60

Daniel Yen

Aspeed Technology (5274.TWO)	O (03/31/2017)	NT\$661.00
Egis Technology Inc (6462.TWO)	O (11/28/2016)	NT\$315.00
Macronix International Co Ltd (2337.TW)	O (06/01/2017)	NT\$48.30
Novatek (3034.TW)	O (07/20/2017)	NT\$116.00
Realtek Semiconductor (2379.TW)	E (07/31/2017)	NT\$107.50
WPG Holdings (3702.TW)	O (07/31/2017)	NT\$40.75

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: COMMUNICATIONS SYSTEMS AND APPLICATIONS

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/08/2017)
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James E Faucette

A10 Networks, Inc. (ATEN.N)	E (08/28/2014)	\$6.55
Arista Networks (ANET.N)	E (12/05/2016)	\$172.68
BlackBerry Ltd (BBRY.O)	E (07/28/2015)	\$9.01
Brocade Communications Systems (BRCD.O)	E (07/12/2016)	\$12.31
Cisco Systems Inc (CSCO.O)	O (05/15/2017)	\$31.48
Corning Inc (GLW.N)	E (12/11/2014)	\$28.54
F5 Networks Inc (FFIV.O)	E (06/17/2014)	\$115.56
Juniper Networks Inc (JNPR.N)	U (11/01/2016)	\$26.62
MobileIron (MOBL.O)	E (04/23/2015)	\$3.90
Qualcomm Inc. (QCOM.O)	E (11/10/2016)	\$49.64
Trimble Inc. (TRMB.O)	E (09/21/2015)	\$38.87
Zebra Technologies Corporation (ZBRA.O)	E (05/31/2017)	\$99.76

Meta A Marshall

Acacia Communications Inc (ACIA.O)	E (05/11/2017)	\$43.58
Arris International plc (ARRS.O)	O (09/20/2016)	\$26.42
Calix Inc. (CALX.N)	E (05/20/2015)	\$4.65
Ciena Corporation (CIEN.N)	E (09/02/2016)	\$21.72
CommScope Holding Company Inc (COMM.O)	O (08/17/2017)	\$33.04
Infinera Corp (INFN.O)	E (02/22/2016)	\$8.19
Lumentum Holdings Inc (LITE.O)	U (08/11/2016)	\$56.40
Viavi Solutions Inc (VIAV.O)	E (05/20/2015)	\$9.98

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: GREATER CHINA TECHNOLOGY HARDWARE

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/11/2017)
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Gill Yin

GIS (6456.TW)	E (03/30/2017)	NT\$331.50
Ningbo Joyson Electronic Corp (600699.SS)	O (09/26/2016)	Rmb35.27
Shenzhen Sunlord Electronics Co. Ltd. (002138.SZ)	E (05/26/2016)	Rmb21.43
TPK Holding (3673.TW)	U (04/15/2016)	NT\$117.50



Howard Kao

Flexium (6269.TW)	O (04/11/2017)	NT\$127.00
Kinsus Interconnect Tech. (3189.TW)	U (04/11/2017)	NT\$81.60
Tripod Technology (3044.TW)	E (04/11/2017)	NT\$103.50
Unimicron (3037.TW)	O (04/11/2017)	NT\$17.25
Zhen Ding (4958.TW)	U (01/21/2016)	NT\$70.30

Melrose Chiu

Acer Inc. (2353.TW)	U (07/11/2013)	NT\$16.05
Adlink Technology Inc (6166.TW)	E (03/09/2017)	NT\$64.80
Advantech (2395.TW)	O (08/20/2015)	NT\$222.50
Airtac International (1590.TW)	O (08/20/2015)	NT\$415.00
Asustek Computer Inc. (2357.TW)	E (07/20/2016)	NT\$248.00
Chroma Ate Inc. (2360.TW)	O (04/29/2016)	NT\$101.00
Compal Electronics (2324.TW)	E (08/30/2009)	NT\$21.95
Dawning Information Industry (603019.SS)	E (05/02/2017)	Rmb32.27
Ennoconn Corporation (6414.TW)	E (04/05/2017)	NT\$476.00
Hiwin Technologies Corp. (2049.TW)	O (08/10/2017)	NT\$276.50
Inspur Electronic Information (000977.SZ)	E (11/17/2016)	Rmb18.20
Lenovo (0992.HK)	U (06/01/2016)	HK\$4.24
Pegatron Corporation (4938.TW)	E (09/29/2016)	NT\$92.80
Quanta Computer Inc. (2382.TW)	O (04/20/2011)	NT\$67.70
Wistron Corporation (3231.TW)	E (05/08/2017)	NT\$26.90

Sharon Shih

AU Optronics (2409.TW)	E (08/15/2017)	NT\$12.30
BOE Technology (000725.SZ)	E (06/25/2015)	Rmb3.97
Casetek Holdings (5264.TW)	U (01/10/2017)	NT\$105.50
Catcher Technology (2474.TW)	O (01/10/2017)	NT\$359.50
Delta Electronics Inc. (2308.TW)	O (07/13/2017)	NT\$161.00
Epistar (2448.TW)	O (05/17/2016)	NT\$38.10
Foxconn Technology (2354.TW)	E (08/16/2016)	NT\$95.70
Hon Hai Precision (2317.TW)	E (07/13/2017)	NT\$116.00
Innolux (3481.TW)	E (03/19/2014)	NT\$14.25
LandMark Optoelectronics Corporation (3081.TWO)	O (06/02/2017)	NT\$397.00
Lens Technology (300433.SZ)	E (06/13/2016)	Rmb31.06
Lite-On Technology (2301.TW)	E (07/13/2017)	NT\$43.90
MLS Company Limited (002745.SZ)	O (04/07/2016)	Rmb39.01
Sanan Optoelectronics (600703.SS)	E (08/22/2014)	Rmb21.20
Shenzhen O-film Tech (002456.SZ)	E (10/23/2016)	Rmb21.24
Tianma Microelectronics (000050.SZ)	E (05/08/2017)	Rmb23.39
Tong Hsing (6271.TW)	O (02/22/2017)	NT\$133.00

Yunchen Tsai

AAC Technologies Holdings (2018.HK)	O (08/28/2017)	HK\$139.60
BYD Electronics (0285.HK)	E (03/29/2017)	HK\$20.60
Dahua Technology Co. Ltd. (002236.SZ)	O (07/25/2016)	Rmb25.27
Everwin Precision Technology (300115.SZ)	E (09/25/2014)	Rmb35.79
GoerTek Inc (002241.SZ)	E (01/18/2017)	Rmb21.57
HIKVision Digital Technology (002415.SZ)	O (11/02/2015)	Rmb32.60
Largan Precision (3008.TW)	O (09/11/2015)	NT\$5,825.00
Luxshare Precision Industry Co., Ltd. (002475.SZ)	O (10/24/2016)	Rmb21.10
Merry Electronics Co Ltd (2439.TW)	O (10/24/2016)	NT\$232.00
Shenzhen Sunway Communication Co. Ltd. (300136.SZ)	E (11/17/2016)	Rmb42.73
Sunny Optical (2382.HK)	O (01/04/2017)	HK\$110.90
Sunwoda Electronic Co., Ltd. (300207.SZ)	E (06/25/2015)	Rmb12.99
ZTE Corporation (0763.HK)	U (03/28/2017)	HK\$21.70
ZTE Corporation (000063.SZ)	U (03/28/2017)	Rmb25.30

Stock Ratings are subject to change. Please see latest research for each company.

* Historical prices are not split adjusted.

INDUSTRY COVERAGE: TECHNOLOGY - SEMICONDUCTORS

COMPANY (TICKER)	RATING (AS OF)	PRICE* (09/11/2017)
Andrew Humphrey		
AIXTRON SE (AIXGn.DE)	E (12/18/2015)	€10.83
Francois A Meunier		
Ams AG (AMS.S)	E (05/23/2017)	SFr 78.25
ASM International NV (ASMI.AS)	E (08/01/2017)	€51.26
ASML Holding NV (ASML.AS)	O (07/31/2014)	€135.35
Dialog Semiconductor PLC (DLGS.DE)	O (10/07/2016)	€41.05
Imagination Technologies Group (IMG.L)	E (12/19/2016)	142p
Infineon Technologies AG (IFXGn.DE)	U (07/30/2014)	€20.35
STMicroelectronics NV (STM.PA)	U (01/04/2017)	€15.78

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* Historical prices are not split adjusted.

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