



North America

TMT  
Internet

Industry  
**Virtual Reality**

Date  
3 March 2016

**Industry Update**

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## Has VR Finally Arrived?

### Introducing DB's VR Ecosystem

As we sit on the eve of the biggest consumer launch in VR history we observe many key trends: 1) the desktop VR pre-order period suggests demand is exceeding expectations, confirmed by Oculus/HTC comments, 2) mobile VR still looks like winning long term mass market play - fracturing into 3 subsectors: Light, Cradle and Dedicated. We could see 50m units in the market in 2017 on GearVR and Google bringing other OEMs into the picture (while Apple remains in stealth mode), 3) the industry is moving towards "full-presence" on hardware side, with mobile catching up to desktop over few years, but engagement will come down to whether content is compelling.





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In summary, the pace of innovation we see in VR reminds us of smartphone circa 2007, its going to take a few years before the pieces are in place, but we remain hugely bullish. This report is second in our VR series (see first here: [LINK](#)) and focuses on more granular details as the industry goes into consumer adoption mode.

### Unit Forecast Update – Pre-Orders Look Solid, GearVR To Break Out In 2016

We revise our desktop & console VR unit growth forecast based on granular data including the 13m installed base of VR-ready PCs according to Nvidia, the 37m current PS4 installed base, Steam's 120m+ PC gamers, and more importantly, by analyzing the content available on each platform at launch (with more announcements coming soon). We now forecast 1m Oculus, 1m HTC, 2.5m Sony and 18m mobile VR users at year-end 2016. Given the 50m PS4 installed base by year end and Sony's history of successful launches, we currently expect PSVR to have the most units in the market. Longer term, we continue to see mobile VR's low cost of ownership and rapidly improving UX as the largest opportunity. Samsung is likely to ship 10m+ GearVR in 2016, up from 250k last year, which will cement its early position in mobile. Looking to 2017, mobile VR could hit 50m units quickly as Google (and potentially Apple) brings other OEMs and experiences to the market.

### Challenges Remain In 2016 In Quest For Full Presence

Despite our optimism, there are a number of challenges today in the VR space. Full Presence is the sensation of tricking the mind to feeling completely in a new VR world. Few platforms are ready for this today. HTC Vive is arguably the closest hardware system with its motion controllers and Lighthouse tracking system. Touch will close the gap today between Oculus Rift and Vive, but doesn't ship until 2H16. Mobile VR has lots of hurdles to overcome, but should have position tracking, motion controls and higher frame rates over the next few years. Finally and most importantly, creating content in full presence requires the appropriate storyline, which few have really cracked thus far.

### Mobile VR Space Evolving

One of the most interesting development is the fragmentation of mobile VR into several key sub-categories: 1) light mobile (Google Cardboard etc), 2) cradle mobile (GearVR, LG, etc) and 3) dedicated mobile (many OEMs, OHG, etc). While GearVR has blown out expectations thus far, the frame rate, battery life, and other factors are proving somewhat sub-optimal. We see a new category of dedicated mobile HMDs with VR-specific hardware specs emerging. We also see Google and Apple making major pushes in mobile VR in 2016 and beyond. To be successful, a mobile VR ecosystem needs: 1)

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distribution - an installed base of users and a vibrant app store, 2) Developers – a healthy marketplace whereby devs can earn a living selling software, and 3) Plumbing – lots of APIs and SDKs that make sure the VR experience is on par.

#### Facebook – Out To A Strong Lead In PC and Mobile VR

Oculus management recently hinted that pre-orders are running well above the 300k dev kits that shipped, supporting our 1m unit estimate for 2016. We sense from talking to developers that gamers may opt for HTC Vive given it launches with motion controllers and SteamVR content, and that Oculus Rift is likely to be a bigger and more diverse user base and developer community. Oculus is taking a “reviewed” app store approach vs. opening it up to any app, which makes sense this early in the industry’s development. We are modeling \$600m in hardware revenue at zero gross profit in 2016 and \$35m in “net” app store revenue (FB’s 30% cut).

#### Google – VR Likely To Make A Big Splash At I/O

Google is investing aggressively in VR and we expect the company to crystalize its strategy further at this year’s I/O in May. The pieces are in place, from Cardboard SDK, developers, 5m installed viewers, YouTube 360, the Tilt Brush acquisition and the fact that Google has resisted putting any of its flagship apps into Oculus’ app store. We think Android VR (or whatever Google is going to call it) serves the higher end mobile cradle and dedicated space with SDKs/APIs, and Cardboard remains in light VR. Project Tango also looks promising on the AR side, with its first smartphone reference design coming mid-year from Lenovo.

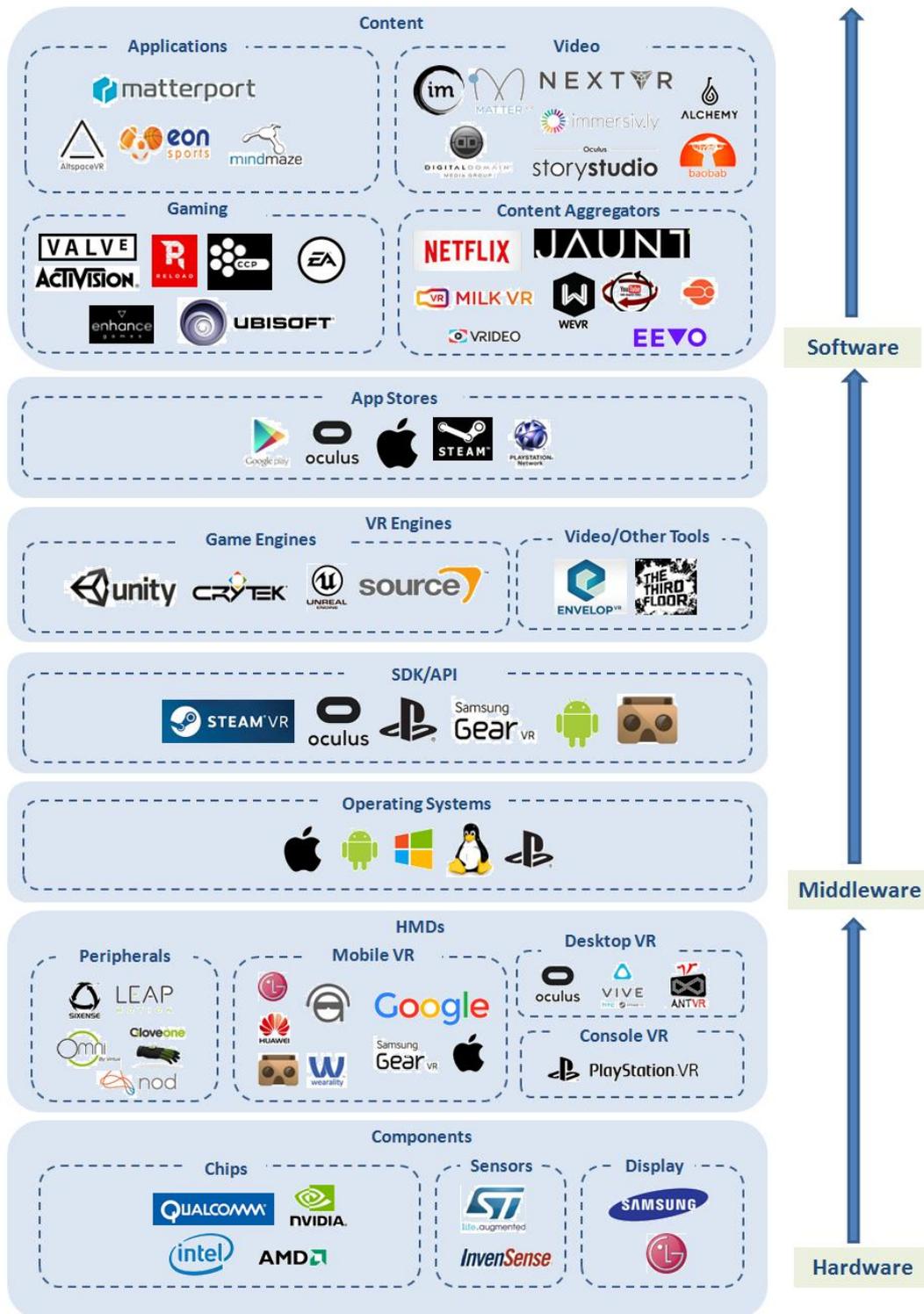


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Figure 1: Deutsche Bank 2016 Virtual Reality Ecosystem



Source: Deutsche Bank



# Current State of VR

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## VR Adoption Currently In Hardware “Adoption” Stage, But 2-3 Years Before “High Engagement” Stage

### Where Are We In the Evolution Curve

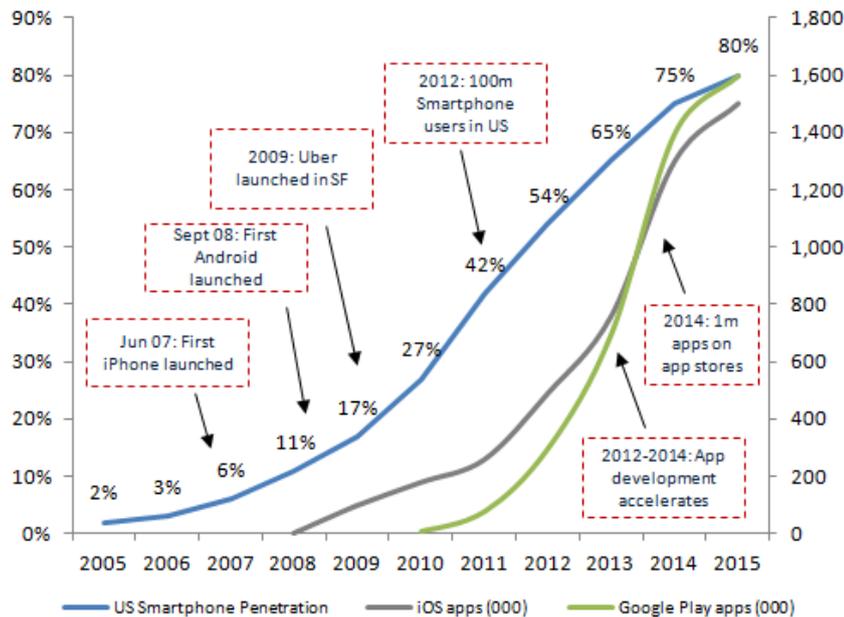
We’ve studied new technology market formation across various phases in history, the two most applicable to VR being: 1) the original internet (mid 1990’s) and 2) the smartphone adoption (2007-today). Both are good precursors for what we are likely to see over the coming decade in VR, particularly how the smartphone space has evolved (given that it’s the major smartphone apps and ecosystems that are leading the push in VR, and the content distribution mechanism looks similar).

Smartphones have been around in various forms since the early 2000’s, however we generally mark the true dawn of the smartphone era as the mid-2007 introduction of the iPhone. This is the event that started the wave of innovation that was to take place over the following decade to today.

Not surprisingly, the original iPhone was criticized heavily by the media and by competing smartphone OEMs like Nokia, Blackberry and others. The view back then was all that Apple had done was to merge an iPod and a phone, which on the surface appeared admittedly incremental vs. revolutionary. (Note - the commentary around GearVR today feels like a decent parallel). We all know the history, first was slow and steady user adoption, then everything exploded to the upside. Moore’s law started speeding up the amount of CPU and storage that smartphones could handle per dollar. Apple and Android competition spurred huge innovation in both hardware and software in annual product release cycles.



Figure 2: Evolution of Smartphone Ecosystem (Illustrated Using US Smartphone Penetration)



Source: Deutsche Bank, Company Reports, comScore

Given that there are three major desktop VR platforms emerging, and countless mobile VR HMDs, we expect a similar competitive environment. One that is characterized by rapid development cycles and product releases, on both the hardware and software sides. We've seen this already over the previous 2-3 years with each version of developer kits for desktop VR. However, the money and headcount being allocated to solve VR technical issues is 10x what it was 2 years ago, and 100x 5 years ago. Venture funding is up 4x since FB's acquisition of Oculus, and everyday more and more innovative companies are announcing funding.

In summary, we think the VR ecosystem is in its "2007-smartphone" moment in terms of the adoption cycle. It took 4-5 years for smartphones to reach 100m users in the US, we expect a slower adoption curve for VR, but still strong enough for an enormous market (see our updated unit assumptions further down below in this report).

**High Engagement and Killer Content Typically 2-3 Years After HW Adoption**

The CEO of Unity recently labeled 2016 and 2017 as potentially a "Gap of Disappointment" time period for VR whereby following all the analyst and media hype running into these major product introductions from GearVR (Nov 2015) through to PlayStation VR (late 2016), the VR space could struggle to wow users enough to keep the momentum going. There is a high likelihood that an air pocket emerges in 2017 where the media actually turns on the space and goes negative, the typical "VR is overhyped" narrative.

We've seen this pattern first hand with just about every consumer tech IPO, and it usually follows a common path. Initially there is a certain mystique around the company when it is private and growing in a new space, which can last several years. Then upon releasing its S-1 publicly, the knives start coming out with folks criticizing various aspects of the market it competes in, the



business model or previous fundraising valuations. The next phase is when the IPO and subsequent lock-up expiration period happens, and shares eventually trade down below initially allocated levels, only to see more negative press and lots of folks calling out a company or a space “overhyped”.

This was the cycle we’ve seen over the past 5 years across many companies and technology sectors. Even the best of breed companies like Facebook in 2012 and 2013 was up against a mountain of negative press and investor scrutiny, all the while the management team stayed calm and executed, and was eventually rewarded a market cap increase of around ~6x. (Some companies and spaces remain in the trough, like Fitbit, Twitter, etc).

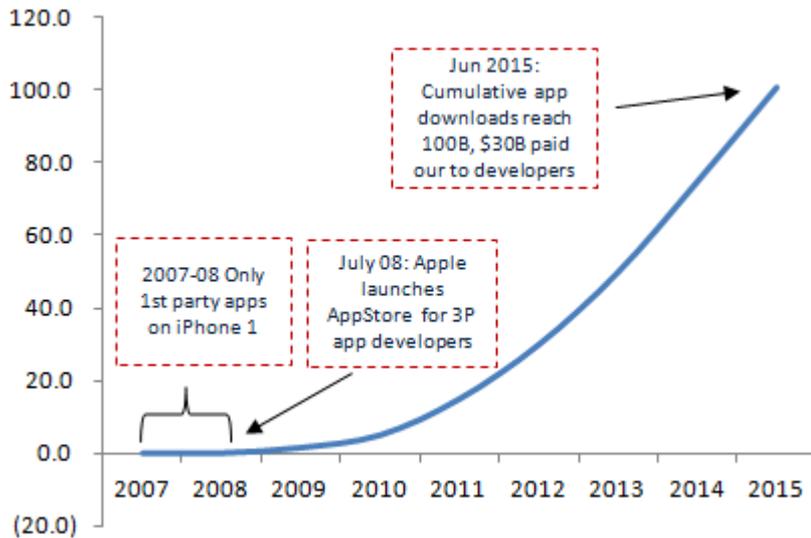
We think VR could see a similar trend, whereby after all the hardware adoption in 2016 and into 2017, media outlets and analysts may start asking “well where is the killer app?” and “why are all these VR systems collecting dust?” There is a fairly high probability that the “Gap of Disappointment” may be a theme for CES/MWC 2017.

But all is not lost. If we look at the smartphone analogy once again, it took that space several years to get to the point of a thriving ecosystem. Despite the iPhone launch in mid-2007, the iOS app store wasn’t introduced until mid-2008. The initial apps submitted to the app store were gimmicky ideas like Tetris, etc., it took years until Instagram, WhatsApp, Uber and other “killer apps” showed up with meaningful volumes and network effects. Importantly, it took developers in mobile a few years before they started to take advantage of key inputs on smartphones like GPS, mapping, cameras, etc. This point is illustrated below, whereby cumulative app store downloads only started to slope up in 2011, 4 full years following the launch of the iPhone.

A similar path can be found in Android. It took until 2009 for Android to start to catch up to the functionality of iOS, and a few more years for the market share and app download volumes to catch up. This is 4-5 years after the introduction of the first iPhone.



Figure 3: Third Party Apps Accelerated Content Consumption On Smartphones



Source: Deutsche Bank, Company Reports, Apple App Store

The key point here is that technology shifts don't happen in a linear path. They tend to come in waves or spikes. We think 2015/2016 is analogous to 2007 for the smartphone market, and similarly, VR is likely to take a few years before developers come up with apps and experiences that allow consumers to engrain VR into our everyday life.

Gaming is likely to tip first given how many early adopters are likely to buy into desktop VR and how many developers are building great experiences, but for the space to go mainstream we are likely going to need to see applications in video, social and other genres that increase daily engagement for mass market mobile VR.



# The Ultimate Goal of Achieving “Presence” VR

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## What Is “Presence”? And How Different Ecosystems Compare

Presence is an industry term that is used to describe the experience of VR tricking your brain to thinking you are actually in whatever space or scene you are looking at or engaging in. Instead of just watching a movie, you are “in” the movie, instead of playing a video game in 2D or 3D, you are actually “in” the video game, instead of watching a tightrope walk, you are “on” the actual tightrope walk. Presence is when VR tricks our primitive lizard brains into thinking we are actually in a new world vs. just wearing a HMD. And VR needs to pull all this off without causing motion sickness, which requires a certain level of technical specifications on both the hardware and software sides.

Our definition above admittedly sounds confusing, so here is Michael Abrash’s (Chief Scientist at Oculus) description of Presence:

*“This feeling of being someplace real when you’re in VR is well known to researchers, and is referred to as “presence,” and it’s presence that most distinguishes VR from 3D on a screen. Presence is distinct from immersion, which merely means that you feel surrounded by the image of the virtual world; presence means that you feel like you’re in the virtual world.”*

As mentioned above, there are a number of key technical criteria that need to come together to allow for this full-presence experience, both on the hardware and software sides. Below in **Figure 4**, we show how each of the current HMDs and peripherals stack up on these key criteria, including: position tracking, display and lens quality, calibration, haptics, audio, etc.



Figure 4: Comparison Of Presence Across Leading Virtual Reality Systems On Key Attributes

Criteria (with minimum requirements)	PlayStation VR	Oculus VR	HTC Vive	Gear VR	Auravisor
Field of View (At least 80 degrees; more is better)	🌓	●	●	🌓	🌓
Resolution (At least 1080p; higher is better)	🌓	●	●	●	🌓
Refresh Rate (At least 95 Hz; higher is better)	●	🌓	🌓	🌓	🌓
Latency (below 25ms)	●	🌓	🌓	●	🌓
Tracking (Position: mm; Orientation: 0.25 degree; Vol: 1.5m/side)	🌓	🌓	●	○	○
Pixel Persistence (no more than 3ms)	?	?	●	?	🌓
Input Controllers	🌓	🌓	●	○	○

Source: Deutsche Bank

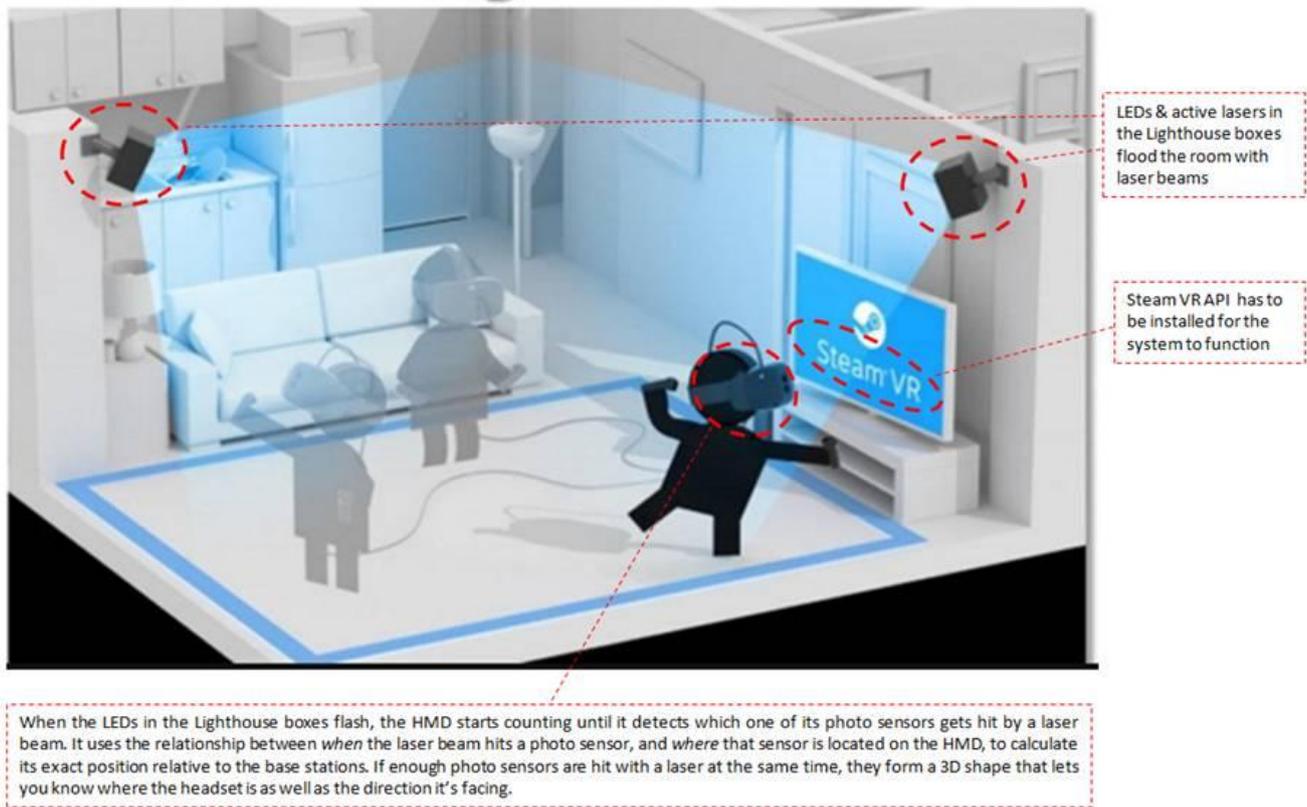
Two things stand out from this figure above: 1) the desktop and console VR systems appear ready for primetime, even if the content isn't quite there, and 2) there is still more work to be done in mobile VR before it can be labeled full-presence VR.

The HMD design is only part of the equation, the CPU/GPU, tracking system and software play a huge role in creating presence in VR. We illustrate how these factors work in concert with one another in the HTC Vive system illustrated below in **Figure 5**.

First, Vive's HMD has the technical specs noted above to deliver the content, alongside a VR-ready desktop PC. For the system to function, the Steam VR API has to be installed on the desktop, as this connects the application software to the hardware and ensures that appropriate signals are sent to the HMD and controllers. The system consists of Lighthouse Base Stations (LBS) which contain a group of stationary LEDs and a pair of active spinning laser emitters. The LEDs flash 60 times per second, followed by one of the two lasers emitting a beam of light across the room. The HMD and controllers contain LED sensors which detect these flashes and laser beams. When a flash occurs, the HMD starts counting, like a stopwatch, until it detects which of its LED sensors gets hit by a laser beam. It then uses the relationship between *when* the beam hit the LED sensor, and *where* that sensor is located on the HMD, to mathematically calculate its exact position relative to the lighthouse stations in the room. If a sufficient number of LED sensors are hit with a laser at the same time, they form a 3D shape that lets you track where the HMD is located as well as the direction it is facing.



Figure 5: HTC Vive Is the Closest To Presence Currently



Source: Deutsche Bank, HTC and Valve

The beauty of the Vive is the combination of incredible display, the motion tracking through Lighthouse, and the ability for users to move around in a wide space (as opposed to staying stationary). Oculus should have similar capabilities after it ships the Touch motion controllers this fall (but not out of the gate initially in March). PlayStation VR has these capabilities as well, but not quite at “room scale”.

#### Content Still Needs Some Work

Very little content today has been created to take advantage of full-presence VR. Games like *Eve: Valkyrie* and *Lucky Tale* that ship with Oculus are truly incredible, but don't put the user into the game fully. In *Eve Valkyrie*, movement and the field of vision are both restricted (appropriately so), with best-in-class graphics. Both use the x-box controllers vs. motion controllers, which limit the experience to some degree, or better stated, is just a different kind of VR experience that doesn't take full advantage of the technology.

Presence isn't restricted to gaming and it could be any number of experiences like concerts, fitness, business meetings, or social interactions. The experiences likely need to be slow and up-close to avoid the motion sickness issues plaguing many current VR experiences.

The best examples of full-presence VR experiences we've seen thus far are:

**Oculus' Toybox:** At Oculus Connect 2, Facebook's second developer focused conference held in September 2015, Mark Zuckerberg described Toybox as



“The craziest Oculus experience I’ve had recently”. Toybox, in addition to displaying the technical prowess of the Touch controllers, also shows off simultaneous multiplayer capabilities, countering the widely held opinion that VR is a solitary, isolating experience. In Toybox, players see each other as Rift-wearing body-less avatars playing ping pong, fighting with toys, and setting off fireworks, all in VR, nicely demonstrating the joy of accurate, naturalistic VR input.

**Tilt Brush:** Tilt Brush, the VR equivalent of Microsoft Paint, is a VR program that allows you to use controllers to paint and sculpt in 3D space. The left controller acts a tool selector, and the right controller as a brush. Hold down the right rear-trigger, and you’re suddenly doodling in 3D space with your room as your canvas. Tilt Brush seems very intuitive to learn and use, and HTC recently announced that Tilt Brush would be bundled together with pre-orders.

**London Heist:** London Heist is a first person action shooter game developed exclusively for the PS4 and the PlayStation VR headset. The software makes excellent use of the PlayStation Camera and Move controllers to allow you to aim naturally while taking cover. You have full control over your body and arms, and you’re given the feeling of being inside an action film.



# Current VR Challenges

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## Full Presence Is Hard To Pull Off

We see several challenges in the near to medium term that could prevent VR from achieving break out success. Analogous to what the smartphone space went through in the 2007-2010 era, developing large and vibrant developer ecosystems around VR experiences outside of gaming, is going to take time. It took smartphones until around 2011-2012 before they app download volumes really started to accelerate, and we think the same cadence is in place for VR.

The following are some key challenges we see:

**Mobile VR Is Not Full-Presence (Yet)** – As mentioned above, the frame rates and latency in mobile are still too low to pull off a really great immersive VR experience. Plus battery constraints, lack of motion controllers, storage, etc are temporary issues that will likely be worked out over the coming years. GearVR is the most advanced system in the mobile space today, with reference design and app store from Oculus, 60 frames per second minimum, 20ms latency, oled display and lots of custom software - yet it doesn't have position tracking or 3-D audio in place (at least not yet). Today GearVR is great for watching 360 videos and other light experiences, but falls short compared to desktop VR on full-presence. Oculus' engineering has made GearVR improvement a top priority.

We have trialed motion controllers using Sixense on GearVR already, which worked nearly as well as on Oculus Rift for certain applications, so it is only a matter of time before the mobile VR experience achieves full presence. We expect the experience to improve rather dramatically over the next few years, lots of big OEMs are throwing a lot of resources at solving mobile VR issues, and competition will certainly speed up the pace of innovation. The Dedicated mobile HMDs will start to prove this out, likely in 2017. We could see several dozen Android OEMs launch mobile VR systems in 2016/2017, and we expect the gap between mobile and today's desktop VR to converge.

**Desktop VR Is Expensive & Has Minor Technical Issues** – The biggest challenge that desktop VR is likely to face is the steep price of admission. For a new-comer to gaming or VR, it will likely require \$1500-\$2000 investment to get started in VR, before even considering content purchases. A few other smaller current challenges include the weight of the HMDs, the cord getting in the way for new users, and lens fog limiting session length. The cost should come down over time, from competition and from Moore's law. These nit-picky issues are usually overcome with time and experience in VR. The biggest challenge is likely to remain around compelling content that drives daily engagement. We are seeing more and more cool demos and experiences, but nothing that we would consider a "must own" app for non-gamers.

**AAA Content Is Temporarily Stuck In "Chicken & Egg" Scenario** - We also think today's content isn't really there yet, at least the triple AAA studios and titles. They are all watching carefully to see which desktop VR system gains the biggest audience, and hence, which one they should invest in (with the exception of Sony's 1-P titles). Presence requires new ways of thinking about



game development and other kinds of content creation. Developers can't just port PC or console games into VR, it simply won't work. Games need to have shorter session length, the players need to be more stationary or slow-moving, and other nuances. Content is going to any breakout in the space, and will improve over the coming years and decades.

**Industry Shifting From "home brew" to "competition heating up"** – The history of VR is one of a very tight and small community over the past 20 years. Many groups shared technical developments, source code, and ideas – a very open and purpose-driven community – for decades. However, we sense that now that there are huge dollars and market cap at stake, the dynamics are starting to change in the industry. Companies that were once open to collaborating are likely to think twice today. History shows that this dynamic started to change after Facebook acquired Oculus, whether it be the Minecraft fiasco (which has since been resolved and will be on Oculus), the Zenimax-Oculus lawsuit, or whether SteamVR will be accessible for Rift owners – these kinds of corporate entanglements are to be expected now that there is big money at stake. The only reason we mention this narrative is that it could have implications for future industry forecasts. If Google exerts its influence on OEM partners who it has worked with for a decade on Android smartphones, to use its SDK/app store for mobile VR - that could impact Oculus' future growth. If Oculus decides to exit hardware and provide its middle-ware and app store to many OEMs, that could impact unit estimates. When does Valve's exclusive agreement with HTC end and open it to other hardware OEMs/ODMs? If Steam's 120m+ loyal base can't play any Valve content on Oculus that could impact estimates. All of these issues are still in flux as these large corporations develop their overall strategy to compete and grow a new and exciting market.



# Facebook

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## Charging Ahead With A Big Lead

Palmer Lucky recently stated that FB shipped “over 200k” dev kits including both DK1 and DK2 (we estimate around 300k total), and also stated “but that’s nothing compared to what we plan to do this year” in 2016. Comments like these, which came a full month after pre-orders were open to the public, make us feel very good about our 1m unit estimate for Oculus Rift in 2016.

Below we revisit our model for VR’s overall impact on FB’s financial statements. We have revised the model to account for: 1) FB is likely selling the Rift hardware bundle at around break-even gross margin (ie 0%, previously we had assumed some margin on hardware), 2) we assume a consistent 30% revenue share on all app store purchases, 3) we’ve added the contribution from mobile VR, primarily the Oculus GearVR app store to the forecast, which could have meaningful app download volume in 2016 and beyond.

We think Facebook is likely to generate \$600m in revenue from Rift hardware in 2016, and another \$35m in software and in-app purchase revenue from the app store. As mentioned previously, it is admittedly difficult to imagine Facebook staying in the hardware business longer term if VR takes off. Like the Google Nexus approach in smartphone, we think Rift may continue to push the envelope and innovate at the high end, providing goal-posts for the rest of the industry including mobile VR to aspire to. But whether Facebook actually develops hardware longer term remains a key question.

Our software and content revenue estimates reflect the current global ARPU for Steam PC gamers (\$20) for desktop VR, and we’ve assumed 50% of that for mobile VR ARPU given the lower spend preference of mobile VR user. We also assume that by 2020, the ARPU will benefit from a number of non-gaming revenue streams and ARPU is likely to ramp meaningfully, as discussed below.

These estimates are likely to change over time, as more content is added to both app stores. Oculus currently has ~50 games and app-experiences in the GearVR app store, well below Cardboard VR. This is likely deliberate, with Oculus taking a “reviewed app store” approach vs. the open it up to everyone approach that Google has taken. For example, there are zero roller coaster VR apps in GearVR, while you can find a dozen or so in Cardboard. This small datapoint highlights the different strategies that each company is embarking on.



Figure 6: Oculus P&L for Facebook

Facebook VR Estimates	2016	2017	2018	2019	2020
<b>Desktop Build</b>					
Desktop VR users (m), Overall market	4.5	8.5	12.3	16.2	19.5
Y/Y Growth		88.8%	45.8%	31.2%	20.3%
Oculus Rift VR users (m)	1.0	1.5	2.1	2.8	3.6
Y/Y Growth		50.0%	40.0%	33.3%	28.6%
Oculus Market Share (of PC/Console VR)	22.3%	17.7%	17.0%	17.3%	18.5%
Oculus Rift Units Shipped (m)	1.00	1.25	1.65	2.10	2.60
Y/Y Growth		25.0%	32.0%	27.3%	23.8%
Desktop VR Hardware Revs (\$m) - Units shipped x ASP	\$599	\$749	\$988	\$1,258	\$1,557
Y/Y Growth		25.0%	32.0%	27.3%	23.8%
Oculus Desktop ARPU	\$20	\$38	\$61	\$82	\$100
Y/Y Growth		90.0%	60.0%	35.0%	22.0%
Desktop VR Software Billings (\$m) - ARPU x Users	\$20	\$57	\$128	\$230	\$360
Desktop VR Software Revs (\$m)	\$6	\$17	\$38	\$69	\$108
Take rate	30.0%	30.0%	30.0%	30.0%	30.0%
Y/Y Growth		185.0%	124.0%	80.0%	56.9%
<b>Total Oculus Desktop VR Revs (\$m)</b>	<b>\$605</b>	<b>\$766</b>	<b>\$1,027</b>	<b>\$1,327</b>	<b>\$1,666</b>
Y/Y Growth		26.6%	34.1%	29.2%	25.5%
<b>Mobile Build</b>					
Gear VR users (m)	9.6	24.6	33.8	41.5	44.8
Y/Y Growth		157.1%	37.5%	22.7%	8.0%
Gear VR ARPU	\$10	\$18	\$27	\$35	\$45
Y/Y Growth		80.0%	50.0%	30.0%	27.0%
Oculus Mobile VR Billings (\$m) - ARPU x Users	\$96	\$442	\$912	\$1,455	\$1,996
Mobile VR Software Revs (\$m)	\$29	\$133	\$274	\$437	\$599
Take rate	30.0%	30.0%	30.0%	30.0%	30.0%
Y/Y Growth		362.9%	106.3%	59.5%	37.2%
<b>Total Oculus VR Revs (Desktop + Mobile)</b>	<b>\$634</b>	<b>\$899</b>	<b>\$1,300</b>	<b>\$1,763</b>	<b>\$2,264</b>
Y/Y Growth		41.8%	44.7%	35.6%	28.4%
<b>Total Oculus VR Gross Profit (assuming 0% GM H/W), \$m</b>	<b>\$35</b>	<b>\$150</b>	<b>\$312</b>	<b>\$506</b>	<b>\$707</b>
Y/Y Growth		332.1%	108.3%	62.1%	39.8%
Oculus Headcount	600	840	1,092	1,365	1,638
Headcount	50.0%	40.0%	30.0%	25.0%	20.0%
Opex cost per employee (ex SBC) (\$000)	\$466	\$466	\$466	\$466	\$466
Opex cost per employee (GAAP) (\$000)	\$730	\$730	\$730	\$730	\$730
Oculus Opex (ex SBC), \$m	\$280	\$392	\$509	\$636	\$764
Oculus Opex, \$m	\$438	\$613	\$798	\$997	\$1,196
<b>Oculus EBIT (ex SBC), \$m</b>	<b>(\$245)</b>	<b>(\$242)</b>	<b>(\$197)</b>	<b>(\$131)</b>	<b>(\$57)</b>

Source: Deutsche Bank, company reports

Looking past the financial implications of Oculus for Facebook, the strategic path is one we observe closely. Mark Zuckerberg has stated that FB acquired Oculus because it missed out on the mobile OS race, and wants to get in front of the next major computing platform shift.



We've analyzed the critical factors for success in stitching together and more importantly, controlling an ecosystem, even if it sits on top of open source software for years, as we observe the battle between open source Android in China and emerging markets (either forks or custom ROMs) and "Certified" Android in the western markets. Google's OS is free for everyone, but the real economic control sits in the central position Google sits in between consumers (distribution) and developers (content) through its critical APIs (plumbing/SDKs/APIs). Google enforces the trusted consistency, quality and security of certified Android at all given price points through its Google Play Mobile Services API layer, and its Mobile Application Distribution Agreements (MADA) vs. the wild-west seen in open source and custom ROM variants of Android smartphones.

We think Zuckerberg's vision seems analogous to Android, if Oculus can be the control layer between distribution and content for VR by providing key SDKs/APIs, it stands to reap huge economic benefits down the road (assuming the space takes off). The app store is the consumer facing and revenue generating piece of all this ecosystem heavy lifting. Oculus' SDKs and APIs are what will ultimately lock-in consumers to the platform, same for Valve/Steam, Sony and eventually Google and Apple.

#### Rift

As stated above, we estimate 1m units for Rift in 2016, and growing from there. The hardware is best in class, alongside both Vive and Playstation VR, with technical specs that allow for full-presence VR. The challenge in the short term is the total cost of ownership for a new-to-gaming consumer (\$1500-\$2000) and the limited content. There are currently 13m VR ready PCs in the market according to Nvidia and even conservative third party estimates point to 8m PCs, so enough to get the ball rolling but far from mass market potential. We see prices coming down over time, from competition and other factors. As stated previously, we wouldn't be surprised if Oculus gets out of the hardware business eventually, choosing instead to ship reference designs to HW OEMs, the same way Valve has with HTC Vive (and similar to the Samsung GearVR relationships). This would obviously have a major impact on revenue figures for Facebook, but minimal impact to profits.

#### GearVR

We estimate GearVR shipped 250k units in 2015 and could see as many as 10m units in 2016 now that Samsung has chosen to give away a GearVR for pre-orders of Galaxy 7 (recall that Galaxy 6 had 15m pre-orders with no VR bundle). 10m units is a huge figure this early in the VR market's development, but judging by our own personal experiences with GearVR, we think daily engagement (DAUs) will be a fraction of that. Even so, at a \$10 ARPU, which seems conservative compared to Steam PC ARPU and developed market smartphone ARPU of ~\$100 in 2014. Similar to desktop VR, we expect the ARPU to expand significantly as more and more content and services are added.

More importantly, compared to Cardboard VR from Google, we estimate that GearVR has 20x the user engagement, showing a clear separation in quality between high-end cradle mobile VR and light mobile VR. We estimate there are approximately 500k (250k at the end of FY15) and Zuckerberg recently stated that over 1m hours of video have been watched in GearVR, this compares to 5m units for Cardboard and 350k hours of videos consumed on Youtube (plus some additional amount consumed on other apps like Jaunt, VRSE, etc).



### App Store & Developer Relationships

Developers are likely to prove to be critical to the success and failure of any VR ecosystem. Oculus stated its working with over 200k developers last fall at Connect in VR. This is as large a community as anywhere in VR today. We expect more and more announcements from AA and AAA content studios for games and other applications on Oculus Rift in the coming months through E3. Oculus is subsidizing some content through exclusives and other agreements.

As mentioned previously, the app store policy is a “reviewed store” where apps have to have a minimum set of requirements, much like the closed iOS app store. This makes sense at the early stages of VR development, but is in contrast to the strategy at Valve whereby some developers are granted early access and can put games up in beta for the community to help evolve (a more open, Android-like approach).

Oculus has created a ton of buzz during the pre-order period, but after the dust settles, it will need to stack up well against Steam around developer support, monetization, and speed – and Valve has a 20 year head start in gaming. It’s a new space, so we are optimistic, but we’ve heard from a number of industry experts who believe hardcore gamers will likely find their way to Vive, and Rift will likely be a more diverse set of VR enthusiasts.



# Google

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## VR Strategy To Become More Crystallized In 2016, Lots Of Interesting Developments

Google is approaching VR from multiple angles, many of which are super compelling, but the overall strategy has not been laid out as clearly as with FB/Oculus. We think i/o 2016 could be the event whereby VR comes to the fore-front for Google. Something along the lines of "Android VR" to go along with of course Cardboard VR, but also the nascent Wear, TV, Auto, Home platforms - would make a lot of sense. We presume Google is already working behind the scenes with a number of its larger Android OEM partners on various VR and AR projects. It would make sense that Google segments Android VR from Cardboard to some degree to separate the higher end cradle and dedicated mobile VR spaces from the light mobile VR lower-end. We also think the SDK, APIs and underlying technical integrations for Android VR (or whatever the company decides to call it) is going to be much more advanced than Cardboard, as on top of much higher frame rates, mobile VR in 2017 is likely to have position tracking and motion controls. Google is also likely to have many of its flagship apps (YouTube, etc) available in Android VR, which are not yet available in the Oculus App Store.

This is what the company has announced thus far:

### Cardboard VR

Google Cardboard is the highest volume light VR experience worldwide, with 5m units shipped thus far (and counting), with over 1000 apps in the store, which have been downloaded over 25m times cumulatively, the largest distribution channel in light mobile. These figures trump GearVR, but anyone that has tried the experience would agree that the two are in different sub-categories of mobile VR. Google also introduced a VR camera app in Cardboard that allows any user to shoot his or her own 360 images. Similar to the approach with the Play app store, we think Google is allowing developers more freedom to experiment and submit many different kinds of apps that may not be allowed in other VR app stores. For example, we counted a dozen roller coaster VR apps in Cardboard, a genre that Oculus has resisted from allowing into the GearVR app store to date.

### YouTube 360

YouTube has not only aggregated a massive library of 360 VR video content but it has created a vibrant content developer ecosystem whereby individual users and sophisticated studios can create incredible content. Google recently stated that Cardboard users have watched over 350k hours of video content in VR, second to only GearVR's 1m hours.

### Jump & Assembler

Google has created an open source camera rig and stitching software program to help developers create new VR experiences.



### Tilt Brush

Google acquired an awesome app called Tilt Brush that runs on HTC Vive (SteamVR) and uses the Unity game engine. It's an interactive 3D painting and creative arts app that runs in VR, similar to Medium from Oculus. It's not clear what Google's intentions are with Tilt Brush.

### What About AR? Project Tango (and Magic Leap investment)

Google is also making big strides in AR with Project Tango, which is going from concept to version 1.0 with the reference design smartphone model that Lenovo ships mid 2016. Tango uses position, GPS, and many of the chips and sensors in the smartphone to turn the device into a full functioning AR device, pulling in data about anything in the line of sight.

In addition to internally developed AR strategies, Google has laid down one of the largest corporate investments into Magic Leap. The company is building unique computer generated imagery that projects from a headset and makes objects appear in real-life spaces (hence AR). If you haven't seen any Magic Leap demos, we suggest you head over to YouTube and watch them immediately, its that amazing. The irony is that Magic Leap is almost a hedge vs. Google's own internal AR efforts, these two are likely to compete with one another, or at the very least create some conflicts.



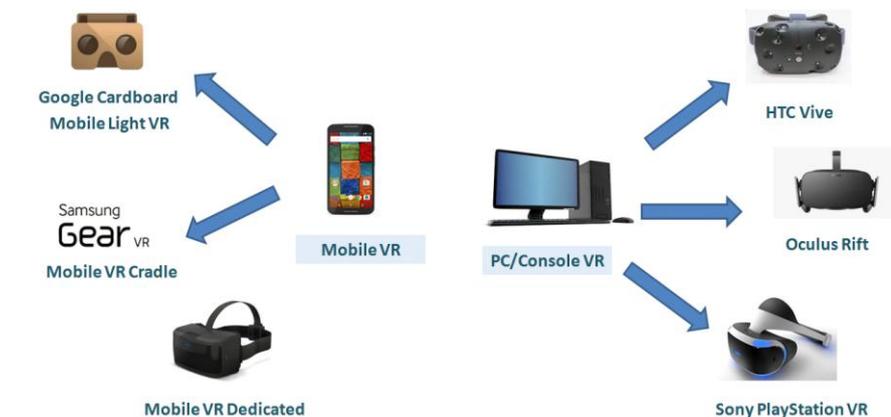
# VR Ecosystems Gaining Momentum

## 2016 Is The Year The VR Train Enters The Station

Since we published our first report in September 2015, the VR industry has seen rapid developments in mobile and desktop, on both the hardware devices and related content. In this section, we provide a detailed overview of the leading players in both mobile and desktop VR, and aim to discuss each company's competitive position.

At this early a stage, we prefer to shy away from calling distinct winners and losers on the hardware side, its just too early to predict. **Figure 7** below is a summary of the state of desktop and mobile VR on the HMDs. Desktop/Console VR is a three horse race currently, with HTC, Oculus, and Sony. In mobile, Gear VR and Cardboard are leading players today, but many new companies are expected to launch both cradle and dedicated products over the next few quarters.

Figure 7: Desktop/Console & Mobile VR Landscape Currently



Source: Deutsche Bank

## Pros vs. Cons For Each Desktop/Console VR System

We think the market for Desktop VR is very similar to that for PC and Console gaming, in the sense that companies that capture and retain the core target user base first can enjoy strong brand loyalty for a long period of time, given the high initial cost commitment and learning curve required for game play. PlayStation has a strong base of 90m+ users (35m on PS4) that have stayed with its ecosystem for a long time and regularly upgrade to new versions. Similarly, Steam has grown to become a strong community for PC gamers with over 125m active accounts currently.

While the hardware specs (discussed in detail below) appear to be relatively similar in all three VR systems, each offering a deep immersive experience, each company's competitive position varies across availability of content, developer relationships, ability to invest. **Figure 8** below highlights the key strengths and weakness we have identified for the three players in the space.



Figure 8: Competitive Strengths And Weaknesses Of Leading Desktop/Console VR Companies

	Pros	Cons
<b>PlayStation VR</b>	<ul style="list-style-type: none"> <li>- Decent hardware specs</li> <li>- Strong PlayStation ecosystem (100m)</li> <li>- Gamers don't need to invest on \$1K PC</li> <li>- Good lineup of 1P content (100+ games)</li> </ul>	<ul style="list-style-type: none"> <li>- Pricing still unclear</li> <li>- Price sensitive customer base</li> <li>- Timing of consumer launch TBD</li> <li>- Sony can't subsidize h/w too much</li> <li>- Input controls are based on PS</li> </ul>
<b>Oculus VR</b>	<ul style="list-style-type: none"> <li>- Good hardware specs</li> <li>- FB can invest heavily on Oculus</li> <li>- Building exclusive 1P gaming content</li> <li>- Content strong beyond gaming</li> <li>- Price is \$200 cheaper than HTC Vive</li> </ul>	<ul style="list-style-type: none"> <li>- v1 Shipping without Touch controls</li> <li>- Gaming currently limited to seated exp.</li> <li>- No ecosystem such as Steam/PSN</li> <li>- Initial setup cost high with \$1K+ PC</li> <li>- Limited relationship with developers</li> </ul>
<b>HTC Vive</b>	<ul style="list-style-type: none"> <li>- Best VR experience on Desktop VR</li> <li>- Closest to full presence on VR</li> <li>- Strong ecosystem of Steam (120m) users</li> <li>- Full presence VR with Vive controllers</li> </ul>	<ul style="list-style-type: none"> <li>- Requires large space to setup</li> <li>- HTC can not subsidize the h/w cost</li> <li>- Commitment from Steam for VR unclear</li> <li>- Price is expensive at \$799</li> <li>- Valve takes majority of the economics</li> </ul>

Source: Deutsche Bank

#### Hardware Specifications Are Close, And All Allow For Full-Presence

In **Figure 9** below, we have compared the hardware specifications, the differences are subtle. With full disclosure that we are not core gamers, we have tried all three devices multiple times and believe the immersive VR experience of the three are very similar and HTC might be slightly ahead with respect to ease of use and quality of experience.

As discussed previously, Oculus Chief Scientist Michael Abrash notes that in order to provide full presence immersive VR experience, VR headsets should have close to 95Hz refresh rate, 3ms pixel persistence, 110 degree view, and a minimum resolution of 1Kx1K per eye. All three desktop VR headsets have specifications close enough to offer full-presence as shown in the **Figure 9** below.



Figure 9: Comparison of Hardware Specific Across Key Criteria

	PlayStation VR	Oculus VR	HTC Vive
<b>Display</b>	OLED Display	OLED Display	OLED Display
<b>Refresh Rate</b>	120 Hz	90 Hz	90 Hz
<b>Latency</b>	18ms	20ms	22ms
<b>Pixel Persistence</b>	?	?	3ms
<b>Display</b>	?	2.35:1	16:9
<b>Resolution</b>	1920 x 1080	2160x1200	2160x1200
<b>View</b>	100 degrees	110 degrees	110 degrees
<b>Tracking</b>	9 LEDs head tracking	360 deg head position tracking	Lighthouse, front facing camera, 37 sensors
<b>Control</b>	Playstation VR Controller	Oculus Touch, xBox	Vive Controller
<b>Tracking Area</b>	?	?	15x15 feet
<b>Platform</b>	Playstation Network	Oculus Home	SteamVR

Source: Deutsche Bank, Company Reports

### Content Could Be An Important Deciding Criteria For Early Adopters

A strong lineup of content could be a critical factor in the success of early desktop VR HMD adoption. Gamers, are likely to evaluate the lineup of available titles closely before they invest \$600+ on a VR HMD. Secondly, many AAA game developers are currently waiting to see the progress of the ecosystem before committing to VR games, which makes predictions even more challenging.

In **Figure 10** below, we compare the content lineup that's announced already on the three major desktop/console VR ecosystems. At a high level, all three have been lining up games for their platform by partnering and in some case subsidizing content. We expect more announcements at GDC and E3.



Figure 10: Sample Of Games Announced Thus Far

	Sony PS VR	HTC Vive	Oculus
Partner Platform	Sony PS	Steam	xBox/PC
# of games on launch	100+**	37*	67
Free with console	TBA	TBA	2
Exclusive	TBA	TBA	20
Selected Titles	Ace combat 7	Elite: Dangerous	EVE Valkyrie
	Rez Infinite	Fantastic Contraption	Chronos
	EVE Valkyrie	Arizona Sunshine	Edge of Nowhere
	London Heist	Job Simulator 2050	Lucky's Tale
	GOLEM	Budget Cuts	P.O.L.L.E.N

Source: Deutsche Bank, Company Reports  
 \*123 games supported by Steam VR and 37 HTC Vive Ready  
 \*\*expect 100+ titles but 17 confirmed so far  
 Oculus game titles are as of Jan 25 2016 from Oculus Share

TCO Likely To Be Lower For Sony PlayStation VR Users, A Huge Advantage (But Console Gamers Are More Price Sensitive Than PC Gamers)

One of the biggest restrictions for Desktop VR to gain mainstream adoption is the high cost of companion PCs required to run VR. Both HTC and Oculus have provided detailed specifications on the computing and video accelerator capacity required by Rift and Vive (Figure 11). The technical specifications required are very similar except that Oculus requires a PC with higher RAM (8GB) for computing vs. HTC (4GB). The most important component, video display graphics card (GPU) required by Vive and HTC are identical and cost the same.

Sony PlayStation VR, on the other hand, is likely to have an install base of 50m PS4 units by the end of this year, which only need to buy a graphics box and HMD (likely bundled sub \$500) which positions Sony PlayStation VR relatively well, we believe.

Figure 11: Recommended PC Specs For Rift and Vive

Components	Rift Ready PC Specs	Vive Ready PC Specs
Graphics Card (GPU)	NVIDIA GTX 970 or AMD 290	NVIDIA GTX 970 or AMD 290
Processor (CPU)	Intel i5-4590 equivalent	Intel® i5-4590 / AMD FX 8350
Memory (RAM)	8GB+ RAM	4GB+ RAM
Video Output	HDMI 1.3 video output	HDMI 1.4 or DisplayPort 1.2
USB ports	3x USB 3.0 ports 1x USB 2.0 port	1x USB 2.0
Operating System	Windows 7 64-bit SP1	Windows 7 64-bit SP1

Source: Deutsche Bank, Company Reports

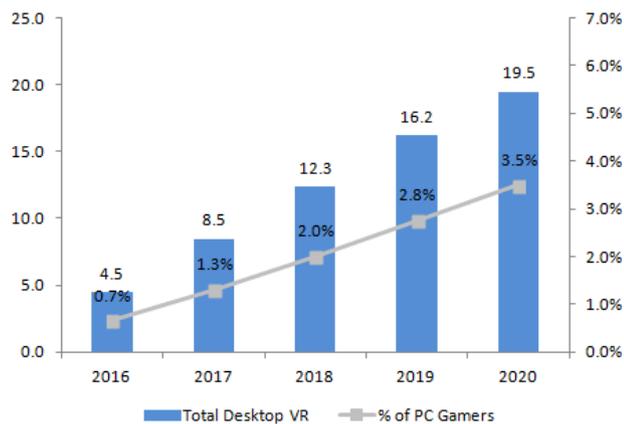


### Forecasting 20m Total Active Users On Desktop VR In 2020

As mentioned previously, accurately estimating the user base for VR is challenging due to a number of reasons: a) VR is an entirely new category and the consumer appetite rate is still unclear b) very little information is currently available on Sony PlayStation VR pricing or launch date, one of the leading players in the space, and c) Fully immersive VR experience on HTC and Oculus requires a high performance PC and Nvidia believes that there are currently only 13m such PCs active.

In **Figure 12** and **Figure 13** below, we provide a summary of our active user base forecasts for Desktop/Console VR. This is meant to be a framework for modeling the industry and will likely be revised over time (as it has since our September 2015 report). We currently estimate a total of ~20m Desktop VR devices by the end of 2020. This implies a penetration rate of ~3.5% of the total 500m gamers in the world or ~9% of the total 210m registered users on Steam & PlayStation Network. We are likely to see other players enter the space, but this is where we see things today.

Figure 12: Total Desktop VR Market Users (m)



Source: Deutsche Bank, Company Reports

Figure 13: Total Desktop VR Market By Leading Players

Total VR Users (Desktop, m)	2015	2016	2017	2018	2019	2020
Playstation VR		2.5	5.3	7.7	9.9	11.4
HTC Vive		1.0	1.7	2.6	3.5	4.5
Oculus Rift		1.0	1.5	2.1	2.8	3.6
<b>Total Desktop VR</b>		<b>4.5</b>	<b>8.5</b>	<b>12.3</b>	<b>16.2</b>	<b>19.5</b>
Y/Y Growth			89%	46%	31%	20%
% of PC Gamers		0.7%	1.3%	2.0%	2.8%	3.5%
Total Gamers WW	711.0	677.1	644.9	614.2	584.9	557.1
Y/Y Growth		-5%	-5%	-5%	-5%	-5%
Oculus Market Share		22%	18%	17%	17%	18%
Vive Market Share		22%	20%	21%	22%	23%
Sony PS VR Market Share		56%	62%	62%	61%	59%

Source: Deutsche Bank, Company Reports

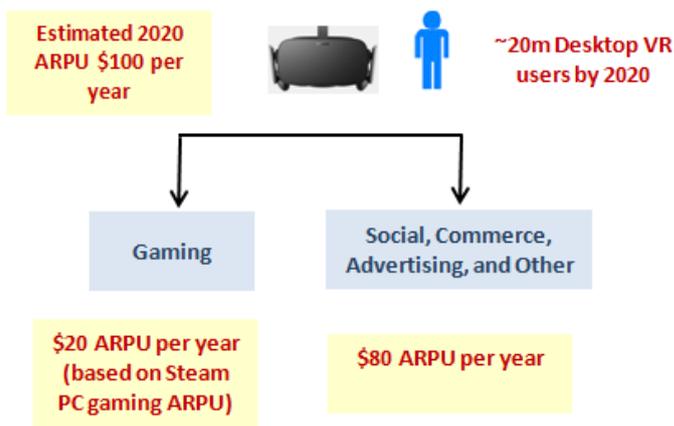
### Content ARPU Likely To Similar To Steam ARPU

On the content side, we think the desktop VR ARPU is likely to be similar to gaming ARPU on Steam Platform. Specifically, Steam's ARPU (on a gross billings basis) in 2014 was estimated at ~\$20 per user (120m currently) based on revenues reported by Valve from its 1P and 3P titles, and ARPU in western markets is likely to be higher.

Meanwhile, the monetization path for other potential VR experiences such as advertising, video, and premium subscriptions - is hard to estimate given the early stage development. We estimate \$80 in other non-gaming ARPU (reasonable compared to \$70+ PC digital advertising ARPU globally), implying a total ARPU of \$100 for desktop VR. This would imply a total software opportunity of \$2B in content gross revenues by 2020.



Figure 14: ARPU for Desktop VR Users (\$)



Source: Deutsche Bank, Company Reports, Steam for gaming ARPU

## Oculus: Rift First To Market, High Expectations

Oculus, arguably, has received the most attention from media and the investment community on the VR space over the last two years given the acquisition by Facebook, which served as a jumpstart for what we see today in terms of innovation and investment. Given that Oculus is the first VR product to reach the hands of consumers this year on March 28<sup>th</sup>, expectations are already very high around delivering a quality VR experience. The success of Oculus adoption is likely to be a barometer for future investments in the VR space, both on hardware and content development. The fact that Oculus is shipping without Touch, its motion controllers, and developers have limited access to the Touch SDK, we think HTC may have a temporary leg up.

Figure 15: Oculus Competitive Position

Strengths	Weaknesses
First to market	No gamer ecosystem currently
Works on PC across platforms	Lower immersive experience vs HTC
Price is lower than HTC	Needs \$1000+ PC
FB has resource to subsidize device cost & games	No existing relationship with game studios
Oculus Share is scaling fast as VR platform	V1 ships without Oculus Touch
Wide set of content beyond games incl. movies	Closed platform approach for third party content
FB has resources to sign exclusive game deals	

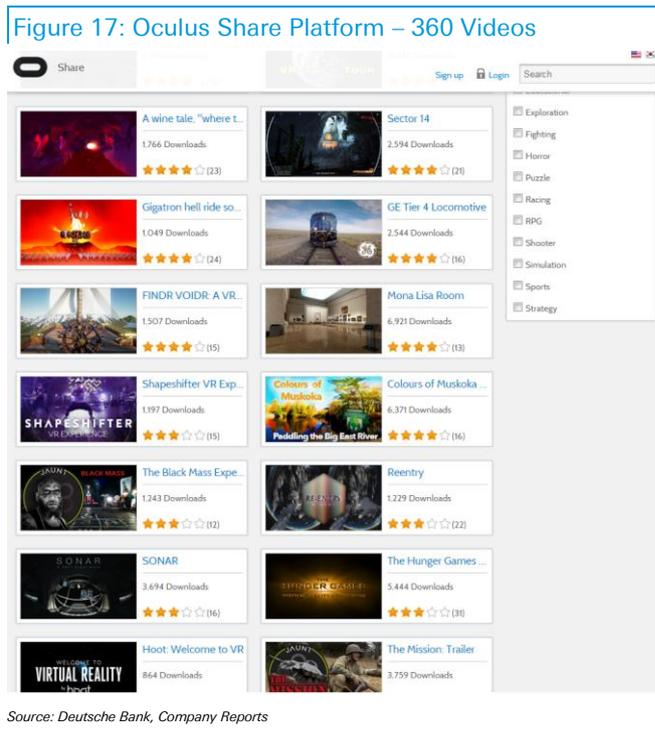
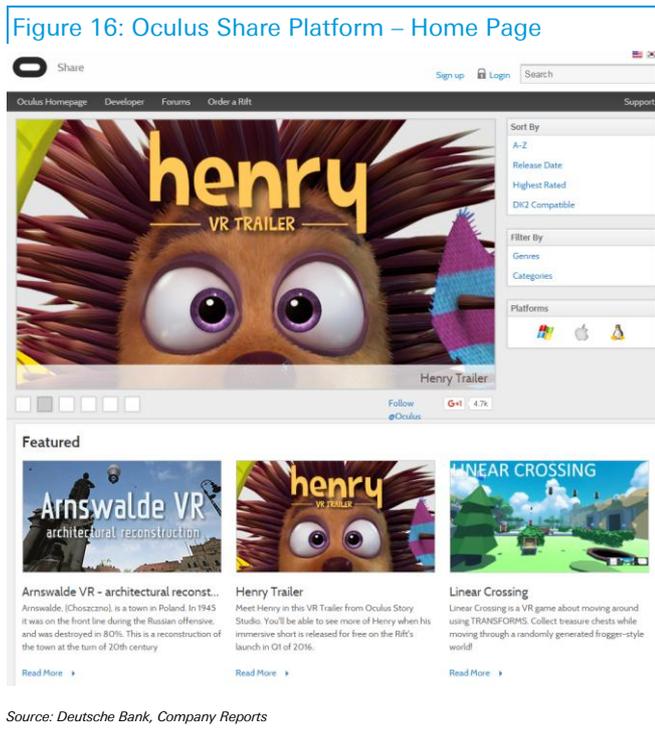
Source: Deutsche Bank

The biggest competitive advantage Oculus has over its peers is the financial support of Facebook that enables Oculus to subsidize the VR hardware sales (at 0% GM) and also invest significantly on building first party content and eventually subsidizing/acquiring third party content. Other hardware-oriented competitors (namely HTC, but also Sony to some degree) are likely looking to generate gross profits from device sales, given their expectations from public



markets, and hence cannot subsidize as aggressively. Valve should capture the lions share of the profits from the HTC Vive system (which they played a major part in designing) as it brings the 120m active gamers and the developer community (along with key flagship 1-P titles like Dota 2 and Half Life 3).

Oculus is positioning its app store as a way for developers to monetize their content, much like Steam (PC), iOS/Android (mobile), but still needs to gain traction with users and developers.



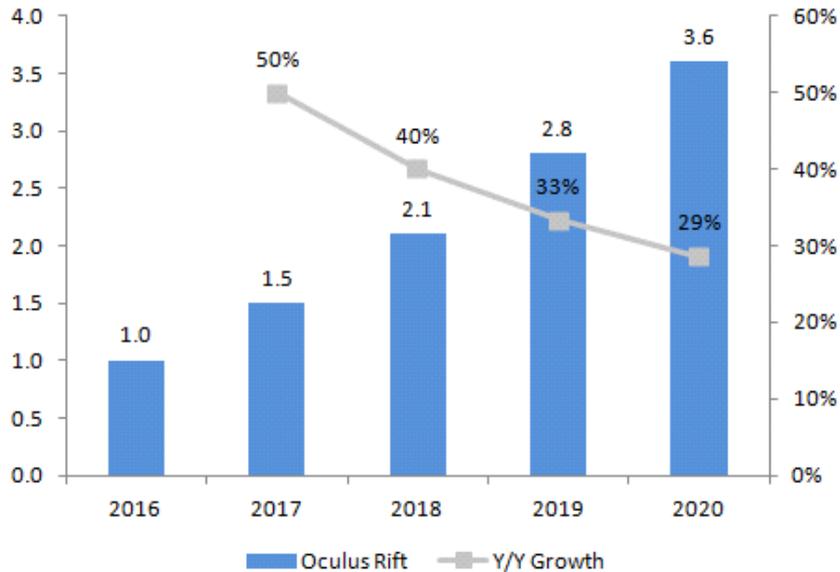
As mentioned previously, one of the biggest challenge for Oculus vs. other PC/console VR systems is its limited scale in gaming. We think consumers who are buying Oculus Rift systems are VR enthusiasts, early adopters, but gamers are likely to stick with their preferred existing systems (Steam and Playstation).

**Modeling 1m Rift Units This Year – Which Should Be Do-Able**

Our forecast is based on three key drivers a) expected growth in PC gaming community b) VR attach rate for PC gaming and c) and potential Oculus market share. As such, we forecast 1m active users for Oculus in 2016 but reaching 4m by 2020, taking 19% share of the total Desktop VR market.



Figure 18: Oculus User Base Forecasts (m)



Source: Deutsche Bank, Company Reports

### 1P Content Investments by Oculus

As noted previously, one of Oculus's greatest competitive strengths is the financial support from FB, which enables the company to subsidize device sales and also invest significantly in content. Oculus is shipping the Rift HMD with two free titles, EVE: Valkyrie and Lucky's Tale during the launch. The company also expects to have more than 100 titles for Rift by the end of 2016 and has announced partnerships with many game studios including 4A Games, Climax Studios, Glu, Harmonix, Ready At Dawn, and Signal Studios. In **Figure 19** below, we have listed details on the games that have been disclosed publicly so far.

Furthermore, Oculus Studios is also working to have 20 game titles exclusively on Oculus Store including Rockband VR, Edge of Nowhere, and The Climb. While this content might work on other VR headsets in the future, distribution is controlled exclusively by Oculus Store. The feedback on gaming blogs has been relatively positive for EVE: Valkyrie, one of the two games that Oculus is expecting to ship for free with the consumer version. But the lack of motion controllers may initially limit the full-presence nature of Oculus content.



Figure 19: Selected List of Upcoming Games Announced On Oculus (Feb 9-)

Title	Description
EVE Valkyrie	Spaceship battle game
Edge of Nowhere	Adventure game
Rockband VR	Musical instrument simulation
Keep Talking and Nobody Explodes	Adventure game
P.O.L.L.E.N.	Adventure game
Lucky's Tale	Similar to Mario 3D
Chronos	3rd person adventure game
Esper 2	Adventure game w/ puzzle solving
ALICE VR	Space exploration game
Bullet Train	Shooting game on Bullet Train

Source: Deutsche Bank, Gamesradar.com

## HTC Vive: Big Steam Installed Base To Sell To, But Expensive

HTC announced that the consumer version of Vive is on target to ship in April 2016. Similar to Oculus Rift, Vive is built to offer a full presence Desktop VR experience, targeted initially at largely PC gamers on Valve's Steam Platform. Vive was designed by Valve, manufactured by HTC. The Steam enjoys a huge ecosystem advantage with direct billing relationships with 120m gamers in many countries and a loyal following.

Figure 20: HTC Vive Competitive Position

Strengths	Weaknesses
Steam Ecosystem is big (120m gamers)	Price is higher than Oculus by \$200
Best VR Experience on Desktop VR	Needs \$1000+ PC
Vive control enables VR experiences with motion	HTC cannot subsidize hardware sales
Has good relationship with many game studios	Commitment from Valve still unclear
Lighthouse enables better motion tracking	HTC cannot invest a lot on 1P content
Valve has track-record with building game platform	Steam is highly multi-player focused
Steam is developer friendly platform	Initial slate of games are less appealing

Source: Deutsche Bank, Company Reports

Firstly, in our view, Vive offers the best desktop VR experience among all three versions of Desktop VR currently available in the market. It's unclear how the consumer version of Vive compares with other competitors, but the current



developer editions of Vive appear to provide significantly better VR experience than Oculus and PlayStation VR. Vive controllers also provide a range of motion, and its Lighthouse technology and Room Scale experience allow users to move around during game play (something which is restricted with xBox controllers on Oculus initially).

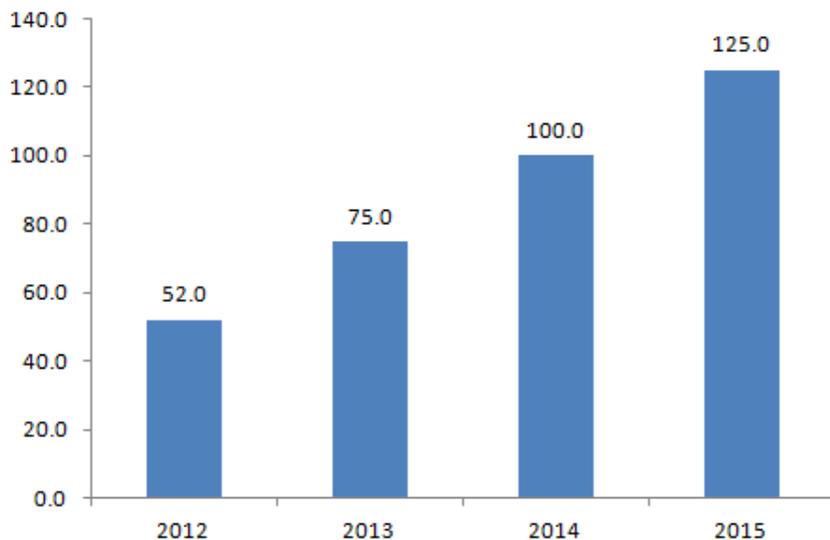
Secondly, as noted previously, Vive also enjoys immediate exposure to 120m PC gamers on the Valve's Steam platform. Valve has a strong track record in building a game developer ecosystem and has all the systems and processes in place to make it seamless for developers to start distributing their games directly on Steam and generating revenue. Our industry checks with game developers also point out that Steam will likely be a more open platform (similar to Google/Android on smartphone) compared to Oculus with respect to game review process and approvals.

On the cons side, HTC's commercial relationship with Valve still remains unclear. HTC is relying on Valve heavily for the reference design, most of the VR intellectual property, its relationships with gamers and its 1-P game studios. It is unclear how this relationship is likely to emerge over time.

#### Forecasting 1m HTC Vive Users For 2016

We forecast our estimate of HTC Vive user base over the next few years by using a penetration rate of VR among PC gamers on the Steam, which has seen strong growth over the last years, reaching ~125m users in 2015 from 52m in 2012.

Figure 21: # of Registered Users On Steam

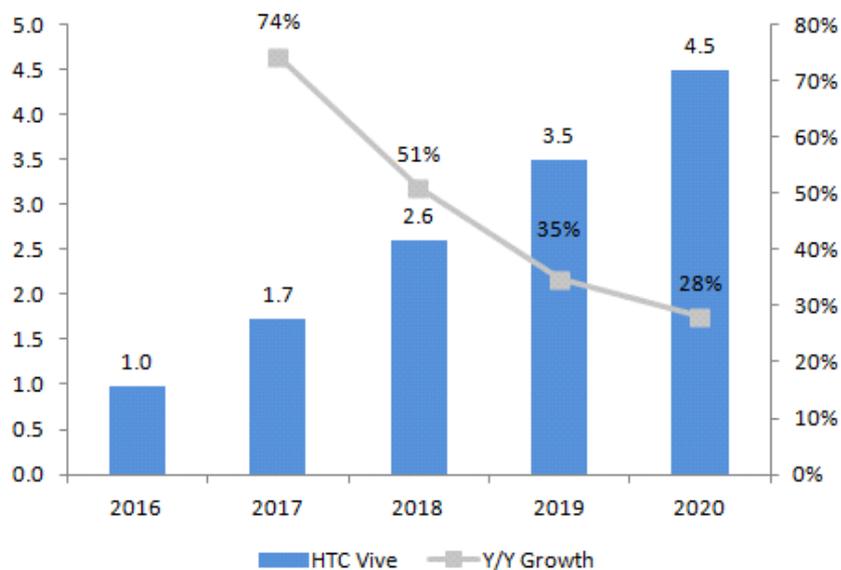


Source: Deutsche Bank, Steam

Admittedly, the \$799 price point for Vive positions it at a disadvantage compared to Oculus, which is priced at \$599, but given the slightly better VR experience, the strong ecosystem of Steam gamers behind it, we think HTC Vive is likely to see good adoption in 2016. We forecast HTC Vive user base to reach 1m units this year and grow to reach 4.5m by 2020.



Figure 22: HTC Vive Users (m)



Source: Deutsche Bank, Company Reports, Steam

#### List of Games Announced So Far

As noted above, the initial slate of content available during launch is an extremely important factor in the purchase decision of a gamer looking to buy a VR headset device. Valve and HTC showcased a line-up of 12 games in January 2016 at the content showcase, and we expect more announcements at GDC and E3. **Figure 23** below highlights a selected list of the games and their description expected during HTC Vive's launch in April 2016. This represents only the initial set of games announced so far and we expect more announcements on new titles this year. Vive also can run a number of games on its Steam Platform that are VR Ready (i.e. support VR HMD but not provide fully immersive VR experience), in addition to the 12 full-fledged games promised by Valve during the launch.

Many of the games listed below are also likely to be made available on Oculus later this year but they are launch titles for HTC Vive. For example, Budget Cuts and Hover Junkers are expected to launch on Oculus when the Touch controllers arrive later in 2016.



Figure 23: Selected List of Games On HTC Vive During Launch

Title	Description
Elite: Dangerous	Space adventure combat game
The Gallery: Call of the Starseed	Fantasy adventure game
Fantastic Contraption	Puzzle game
Budget Cuts	Adventure game
Hover Junkers	Multiplayer/Flying combat game
Tilt Brush	Paintings in 3D
Job Simulator: the 2050 Archives	Simulation game
Arizona Sunshine	Zombie shooter game
Final Approach	Management strategy game

Source: Deutsche Bank, Valve, Wareable.com

### VR Ready Games On Steam

In addition to the games announced by HTC and Valve as full-fledged VR ready, there are a number of third party games that are VR ready and available on Steam currently. The VR experience is likely not immersive on these games compared to games built exclusively for VR, but users of Vive will have access to these game titles on Steam that have support for VR HMDs. More importantly, Unity, the largest game development engine used by a number of game developers for PC and console gaming, recently announced native support to HTC Vive and Steam VR platform. This native support for HTC Vive means that game developers can now re-build their games for VR with minimum effort and investment. Unity has already been used extensively in the creation of VR games including Surgeon Simulator and Job Simulator.

Figure 24: Selected List of VR Ready Games on Steam

#	Game Name	Daily players	HTC Vive Support	Price
1	Elite Dangerous: Horizons	3,771	HMD	\$59.99
2	Train Simulator 2016	2,274	HMD	\$44.99
3	Half-Life 2: Lost Coast	1,050	HMD	\$39.99
4	Elite: Dangerous	3,771	HMD	\$29.99
5	Euro Truck Simulator 2	24,153	HMD	\$22.99
6	Don't Starve	4,958	HMD	\$14.99

Source: Deutsche Bank, Steam, As on Jan 25, 2016

### Top Developers Are Still Waiting, But Likely To Launch Soon

Many of the top game developers have not discussed their plans for VR game development publicly and observing the emergence of VR ecosystem. As shown in **Figure 25** below, of the top 10 games on Steam, only a handful have announced VR support currently, including Valve, which hasn't re-designed its



top games for VR yet. Among the large game studios, Activision and EA have not made public announcements about building or redesigning their games for VR games currently. We think this is likely to evolve and expect many of the leading game developers including Valve to launch titles for HTC Vive and potentially other HMDs over the next few months.

Figure 25: Top 10 Games On Steam

#	Daily Players (000)	Title Name	Studio
1	932	Dota 2	Valve
2	659	Counter-Strike: Global Offensive	Valve, Turtle Rock
3	76	Team Fortress 2	Valve
4	77	Football Manager 2016	Sega / Sports Int.
5	63	ARK: Survival Evolved	Instinct Games
6	76	Fallout 4	Bethesda Softworks
7	65	Garry's Mod	Facepunch Studios
8	54	Grand Theft Auto V	Rockstar Games
9	69	Sid Meier's Civilization V	Firaxis Games
10	46	Warframe	Digital Extremes

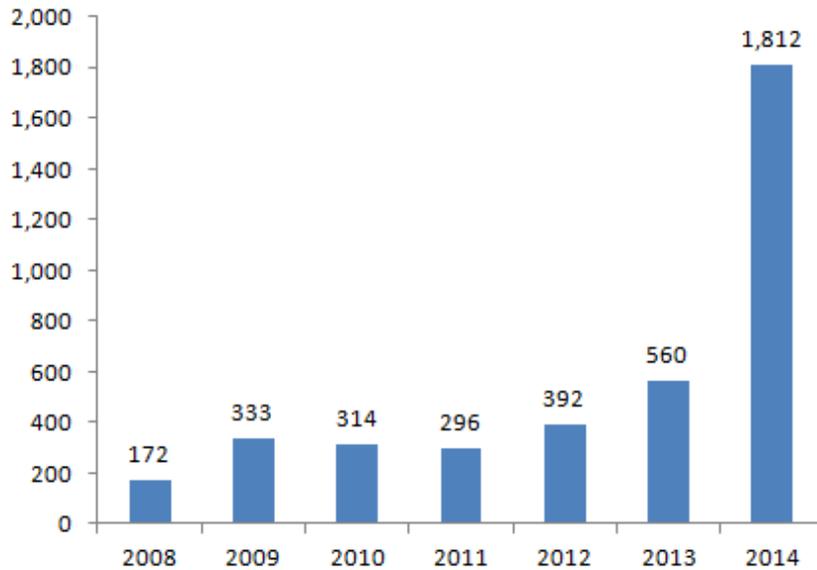
Source: Deutsche Bank, Steam

#### PC Gaming Has Grown To Be Large Ecosystem

PC gaming market has seen strong growth over many years as evident from the growth of number of gamers and the volume of content distributed. Steam has over 3700 games currently and continues to grow rapidly. Only a handful of early developers are building games for VR currently, or at least, have announced plans to build VR games.



Figure 26: Number of New Game Releases On Steam



Source: Deutsche Bank, Steam

## Sony PlayStation VR – Could Be An Early Winner If Price Is Right

Among all three Desktop VR HMDs that are launching to consumers this year, Sony PlayStation VR has been the most tight-lipped in terms of details regarding specifications or potential price point for its VR system (HMD plus graphics box). The company has sent out press invites for an exclusive VR event on March 15<sup>th</sup> but little details are known at this point.

From a competitive standpoint, we think Sony could be strong competitor to Oculus and HTC Vive in the VR market. In **Figure 27** below, we have listed the key strengths and weaknesses we have identified for Sony based on our diligence. With little information on the price point and potential launch date admittedly, there are still a number of unknown variables that could decide Sony's success in the Desktop/Console VR market.



Figure 27: Sony PlayStation VR Competitive Position

Strengths	Weaknesses
PlayStation ecosystem is big with 90m users	Price point is still unclear
PS4 is cheaper than VR ready PCs	Sony cannot subsidize HMD price
Strong line up of games during launch	Game devs aren't ready to commit w/o price
Has good relationship with many game studios	Still lots of unknowns
PS VR comes with external computing box	Console gamers are price conscious
Hardware specs appear to be slightly ahead	

Source: Deutsche Bank, Company Reports

Sony's greatest strength is the company's strong ecosystem of PlayStation users. The company currently has ~90m total PlayStation users (~50m PS4 users by end of FY16) that are committed to the PS ecosystem. This positions Sony extremely well to upsell the VR system to PS4 users, if the device is launched at the right price point.

Secondly, Sony already has existing relationship with many game developers. The company is expected to have 91 games this year for PS VR, with ~20 of them exclusive. Sony has 17 in house independent studios creating content, a staggering advantage. Sony also has years of experience launching new console systems, which will likely be a strength come holiday 2016. From a hardware spec standpoint, PlayStation VR seems similar to HTC and Oculus on a range of variables, with higher refresh rate.

Sony PlayStation VR also comes with significant cost advantages by running on PS4. PS4 costs \$400 compared to \$900+ for a VR ready PC required by Oculus and HTC. Total cost of ownership of PS VR could be lower than Oculus and HTC even if Sony prices PS VR at a small premium to both Oculus and HTC (and we are expecting the price to be below Oculus \$600 system).

On the cons side, Sony PlayStation VR hasn't announced price or availability, which should happen in short order, and will alleviate any temporary concerns in the developer community around potential installed base.

#### PS VR Appears To Stack Up Well On Hardware Specs But Early Reviews Are Mixed

Sony's hardware specifications for the PlayStation VR system seem largely comparable to both HTC and Oculus on certain key specifications. PSVR wins points on latency and speedy refresh rates, however, the resolution is slightly lower than HTC and Oculus. On input, PlayStation VR ships with the same PlayStation Move input controllers used by PS for game play.



Figure 28: Sony PlayStation Move



Source: Deutsche Bank, Company Reports

Figure 29: Sony PlayStation External Processing Box

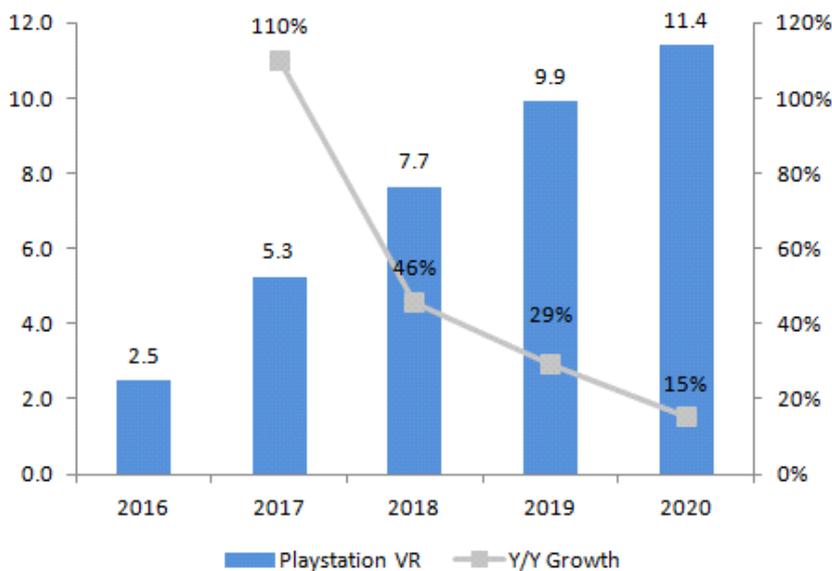


Source: Deutsche Bank, Company Reports

### Forecasting 2.5m Units for FY16, Active User Base To Reach 11m+ in FY20

Our forecast for Sony PlayStation VR users is based on a potential attach rate on existing PlayStation users. Sony currently has ~90m PlayStation users, with nearly a third on the most recent PS4 platform. As mentioned previously, industry estimates call for PS4 install base to reach 50m by the end of this year. If Sony can sell its PlayStation VR to 10% of current PS4 users, the company should be able to comfortably reach ~5m+ units for FY17.

Figure 30: Sony PlayStation VR User Base (m)



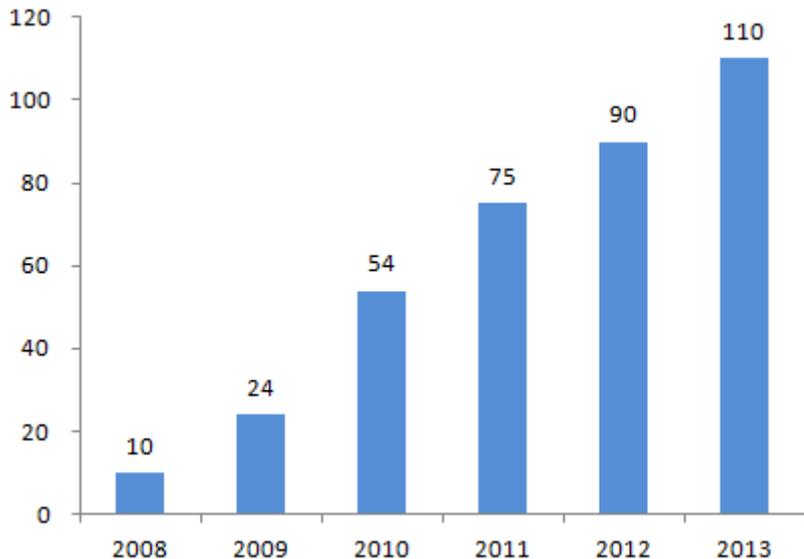
Source: Deutsche Bank, Company Reports

### Sony Has Large User Base On PlayStation Network

Similar to Valve, Sony enjoys a large install base of PlayStation users. The company stopped disclosing the user base on its PlayStation Network (PSN) in the last two years but had ~110m users in 2013. PSN is Sony's app store for distribution of games and content for PlayStation.



Figure 31: Number of Registered Members On PlayStation Network (m)



Source: Deutsche Bank, Company Reports

### Line Up of Games Looks Solid

As noted previously, Sony appears mostly likely to have a competitive line up of games already announced for PlayStation VR. The company has confirmed that over 91 games are coming to PlayStation VR in 2016 and 20 titles are exclusive for PlayStation VR. In **Figure 32** below, we have listed a few leading games that are expected to be available for PlayStation VR this year. More details on other games are expected to be announced over the next few months.

Figure 32: Mentioned Games On PlayStation VR So Far

Title	Description
Ace combat 7	Flight focused action arcade game
Rez Infinite	Musical shooter game
EVE Valkyrie	Spaceship battle game
London Heist	First person action shooter game
GOLEM	PSVR exclusive movie style game
Head master	Soccer game
Rush of Blood	Arcade style shooter game
Psychonauts	Single player platform game
Wayward Sky	Action game
Battle Zone	Tank combat arcade game
Eagle Flight	VR exclusive exploration game

Source: Deutsche Bank, PlayStation Network

Figure 33: Apps On PlayStation Network (Available On PS3 & PS4)

1st Party Apps	3rd Party Apps
PlayStation Music	Netflix
PlayStation Now	NBA Game Time
PlayStation Video	NFL Sunday Ticket
Live from PlayStation	Dish Network
UEFA Champions League	HBO Go
The Playroom	Hulu Plus
VidZone	Spotify
	YouTube
	Amazon Video
	BBC iPlayer

Source: Deutsche Bank



### [Sony PlayStation Network Already Has Apps For Other Content But Portability Into VR Is Unclear](#)

In addition to games, Sony PlayStation Network (PSN) also have a wide range of apps both 1<sup>st</sup> party and third party beyond gaming content. It's unclear how many such apps and experiences will be live at the PSVR launch, but the content includes several premium content including NBA, NFL, and HBO Go currently accessed on PlayStation. **(Figure 33)**



# Mobile VR – The Mainstream Winner

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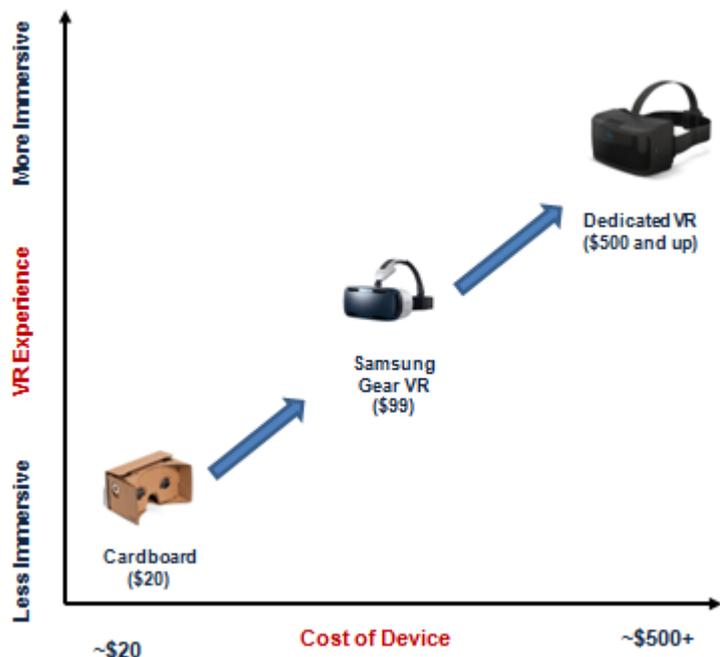
## Three Mobile VR Sub-Categories Are Emerging

On mobile VR, we see three different types of form factors, and hence ecosystems, emerging depending on the levels of immersive experiences:

- **Light Mobile VR** - which includes low-cost HMDs without position or motion tracking. The Google Cardboard space, with 5m installed HMDs and the most app volume of any category today. Google Cardboard is the early leader in Light Mobile VR but in the last few months many OEMs including Mattel, Goggle Tech, Homido, Knox Labs have built slightly advanced versions for a slightly higher price using the Google Cardboard recommended design specifications.
- **Cradle Mobile VR** - which includes smartphone-delivery of VR into the HMD through a phone port. The technical specs for cradle are superior to light mobile VR with minimum refresh rates and latency. GearVR is the leader today (we estimate 500k units today going to 10m by end of 2016), but many others likely jump into the mix in 2017. As noted previously, GearVR has nearly 20x the engagement of Cardboard measured by video consumption stats, hence this is a clear separation from the Light Mobile VR space.
- **Dedicated (or Stand-Alone) Mobile VR** - which includes companies that are building dedicated, all-encompassing mobile-specific devices for VR experience. These HMDs come with built-in CPU/GPU, wifi, oled display, extended battery, IMU and other sensors, removing the need to use the smartphone-cradle approach or an PC-HDMI port. This could be premium mobile VR market segment longer term, but its likely 12-18 months from seeing any viable product, and even further from mainstream adoption. Companies such as AuraVisor and ODG are building dedicated mobile VR devices with potentially better immersive experiences than what we see in the market today from Cradle and Light mobile VR. Several press reports are also speculating that Google and Samsung also building dedicated VR devices currently but details are still unclear, we wouldn't be surprised if nearly every major consumer electronics and smartphone OEM is looking closely at this space, including Apple.



Figure 34: Illustration of Level Immersive Experiences on Three Mobile VR Offerings



Source: Deutsche Bank, Company Reports

### Forecasting 135m Users, 4m Total DAUs In All Categories Of Mobile VR In 2020

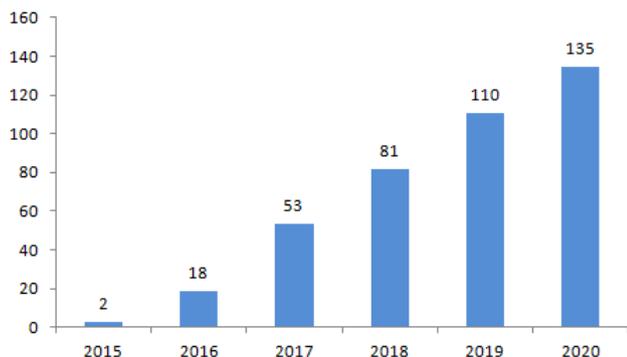
Our forecast assumes a strong ramp in 2016 for the Cradle VR market due to free shipments of Gear VR with Samsung S7. We expect several Android smartphone OEMs to launch mobile cradle VR device in 2017, supporting their smartphone sales with free bundles, which should result in a massive installed base for mobile VR by 2020.

Unlike desktop VR, we think it's important to look at mobile VR ARPU potential both on user basis (for revenue opportunities like in-app purchase, and premium downloads etc) and DAU basis (for revenue opportunities like advertising) to truly assess the software and services TAM. Based on expected gaming and video use cases, we currently think DAUs are likely to be fraction of total users on mobile VR, compared to nearly 80-100% on desktop VR. This could obviously change if social applications take off in VR, pulling in high engagement. On DAU basis, we forecast a total of 4m DAUs for mobile VR by 2020.

In **Figure 35** and **Figure 36** below, we provide a summary of our active user base forecasts for Mobile VR based on our expectations for the adoption rates of three types of mobile VR devices. We have discussed the detailed build for each category in the sections below.

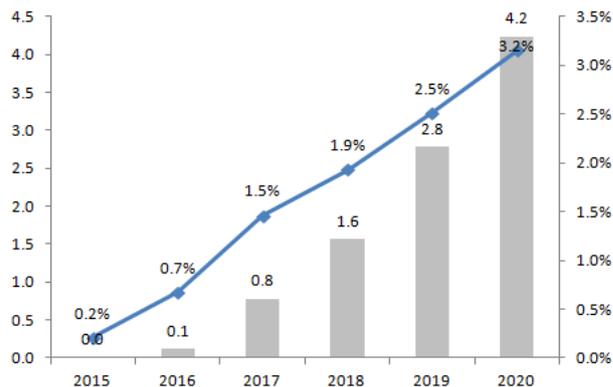


Figure 35: Total Mobile VR Users (m)



Source: Deutsche Bank, Company Reports, \* average during year

Figure 36: Mobile VR DAU (m)

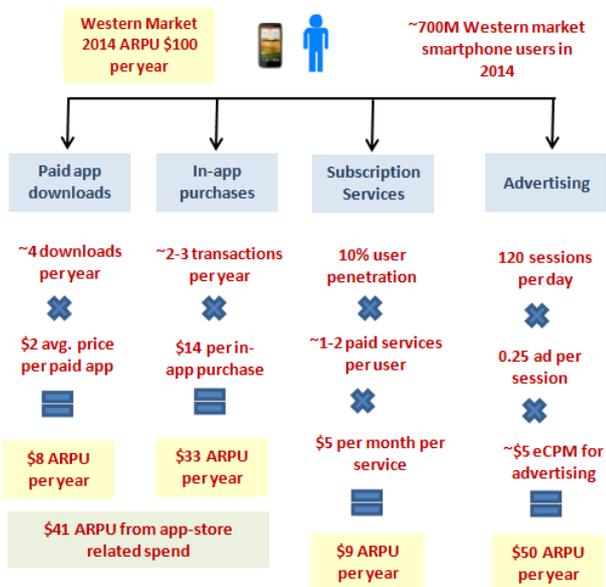


Source: Deutsche Bank, Company Reports

ARPU Of ~\$45 For Mobile VR By 2020

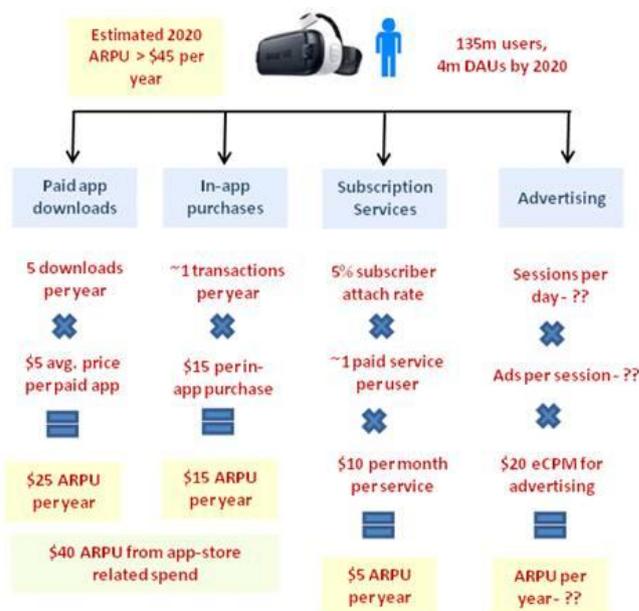
On the software and content side, we think the ARPU on mobile VR is likely to include a range of revenue models such as content, advertising, ecommerce, and in-app purchases similar to the software and service monetization models on smartphone currently. We estimate current ARPU for smartphone users in western markets at \$100 per user based on paid app downloads, in app purchases, subscription services, and advertising. For VR, we estimate \$45 per user in the out year using similar monetization calculation for smartphones (Figure 37). At an ARPU of \$45 and 135m users, we estimate the digital opportunity on mobile VR to be \$6B by 2020.

Figure 37: Western Market Smartphone ARPU, 2015



Source: Deutsche Bank, Company Reports

Figure 38: Mobile VR ARPU, 2020



Source: Deutsche Bank, Company Reports



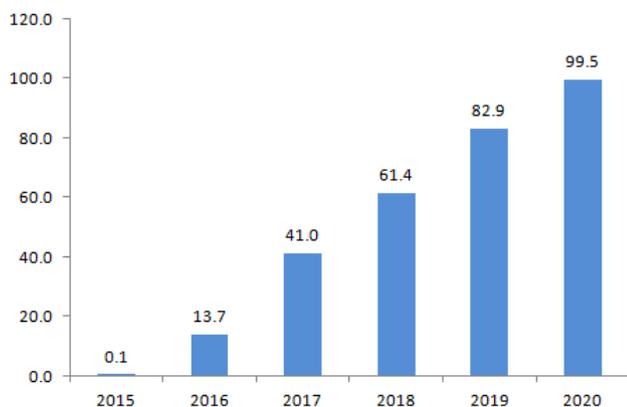
## Cradle Mobile VR – Samsung Gear VR Looks To Be The Early Break-Out Success

Cradle VR is the most popular on mobile VR currently. Samsung launched its Gear VR to consumers during holiday season 2015 and the device has seen solid adoption over the last few months.

The advantage of cradle VR devices is simple. They are very easy and comfortable to use on top of smartphones. The incremental cost of buying one of these devices for the consumer is approaching ZERO (Samsung Gear VR is priced \$99, but bundled into Samsung Galaxy 7 purchases for free during pre-orders), much lower than the financial commitment necessary for desktop VR adoption. While the experience is sub-par compared to Desktop VR, Cradle HMDs offer the best immersive experience on mobile VR currently.

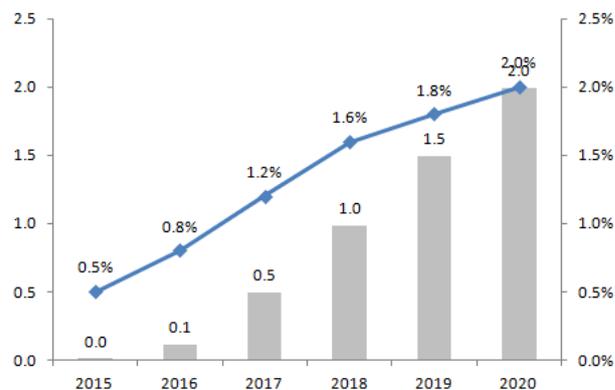
We forecast the Cradle VR market to reach 14m this year and grow to 100m by 2020 as many competitors including HTC, LG, and Hwawei introduce competing products to GearVR. Given that a vast majority of these users acquired their device free of cost with their smartphones, the engagement on the platform is likely to be lower than Desktop VR. We estimate DAUs of 2m by 2020 on cradle VR market.

Figure 39: Cradle Mobile VR Users (m)



Source: Deutsche Bank, Company Reports

Figure 40: Cradle Mobile VR DAUs (m)



Source: Deutsche Bank, Company Reports

### App Store Ecosystem Still In Development For Mobile VR But Oculus & Google Are Early Leaders

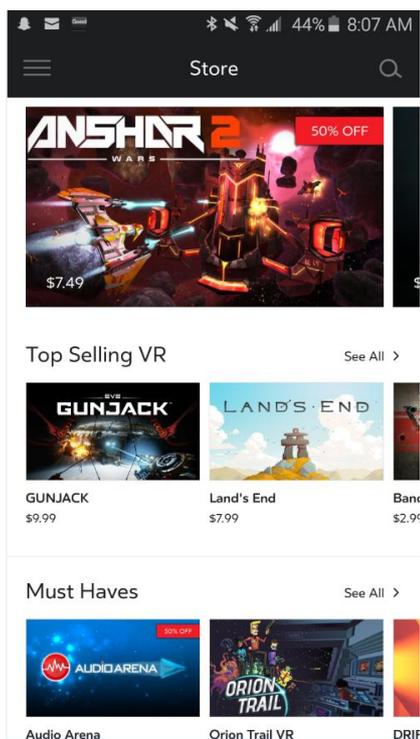
Google Cardboard/Play Store and Oculus are the leading app stores currently available for mobile VR. OEMs that are building Cradle mobile VR can chose to: A) partner with one of the existing leading app stores, or 2) build out their own ecosystem of software SDKs and developer relationships (which will likely be attempted by some but similar to the smartphone space, seems like a non-starter for anyone aside from Google, Facebook or Apple). Samsung, the early trailblazer and leader in the Mobile VR space, has partnered with Oculus for the app store powering GearVR content distribution. Oculus charges the same 30% revenue share from developers for paid content.

Meanwhile, Cardboard VR app store relies on underlying Google Play for app distribution. Users who purchase (or are gifted) Cardboard VR HMDs download the Cardboard app first from the Play store to configure their VR device with



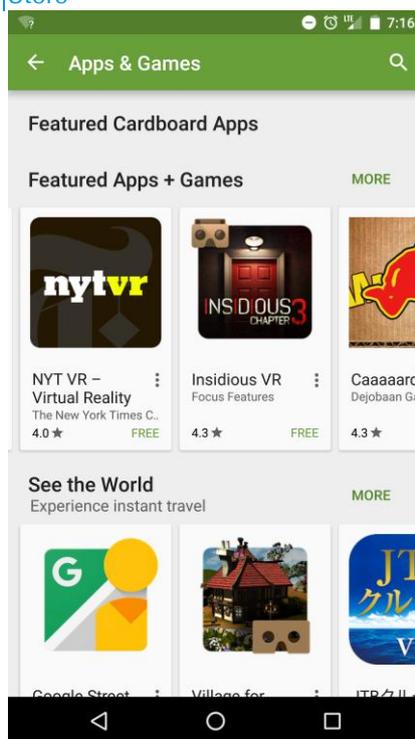
the user's account. They can then browse Google Play and download third party apps from Play for Cardboard VR. Meanwhile, Google also launched a Cardboard app for iOS platform. In iOS, users of Cardboard download VR apps from Apple App Store.

Figure 41: Oculus Store On Gear VR



Source: Deutsche Bank, Company Reports

Figure 42: Google Cardboard App Store



Source: Deutsche Bank, Company Reports

### Cardboard App Store Seems To Be Ahead Of Oculus Share On Content Volumes But Quality Is Hard To Assess

Despite the rapid growth in GearVR devices available in the market, the content on Oculus Home for Gear VR appears to be largely limited compared to apps and content on Cardboard app store. Our analysis of Oculus Home for Gear VR shows that there are 50+ apps currently. Meanwhile, Google Cardboard has over 1000 apps and nearly a dozen apps have over 500k downloads already. Oculus doesn't publish the number of downloads for the apps on its store currently but Jurassic World is most reviewed app with ~6k reviews.

OEMs are likely to partner with app stores that have the largest collection of best quality apps for their devices. Oculus seems to be scrutinizing the apps submitted by apps more thoroughly than Google before approving the app on the app store, which could partially explain the low volume on apps on Oculus store. Specifically, Oculus requires that app developers ensure that content meets the 60 frames per second refresh rate and 20ms pixel latency threshold that are required for better experience. **Figure 43** below lists a selected list of apps from both platforms. While the number of apps on Google Play is high, Oculus seems to feature more apps that are better tailored for VR experience.



Figure 43: Leading Apps On Cardboard vs. Oculus

Oculus	Google Play
Netflix	Jaunt VR
JauntVR	Insurgent VR by Lionsgate
Next VR	VRSE
Milk VR	Star Wars
Jurassic World	Jurassic VR
Dreamworks VR	VR Cosmic Rolls
Gear vr gallery	Mercedes VR
Samsung Internet beta	Volvo Reality
Shooting Showdown 2	VR Roller Coaster
Gunjack	VR Cinema

Source: Deutsche Bank

## Light Mobile VR: Google Cardboard Is Bringing Low-End VR Experience To Everyone

Light Mobile VR is the most popular form factor in VR currently in terms of number of devices out in the market but provides the least immersive experience compared to other devices. These devices are essentially manufactured with two optical lenses inside a cardboard or plastic box to prevent light intervention. Google first built the design for Mobile VR in 2014 and later made the design specifications open source for other OEMs.

As stated above, Google stated in late January that there are over 5m Google cardboard devices already and the company also noted that the app from Cardboard for Light Mobile VR has been installed over 25m times cumulatively by the end of 2015. The company is also seeing strong volume on a number of apps on Cardboard app including YouTube. Over 350k hours of YouTube videos are watched in VR already.



Figure 44: Google Cardboard



Source: Deutsche Bank, Google cardboard

Figure 45: Cardboard By POWIS



Source: Deutsche Bank, Google Cardboard

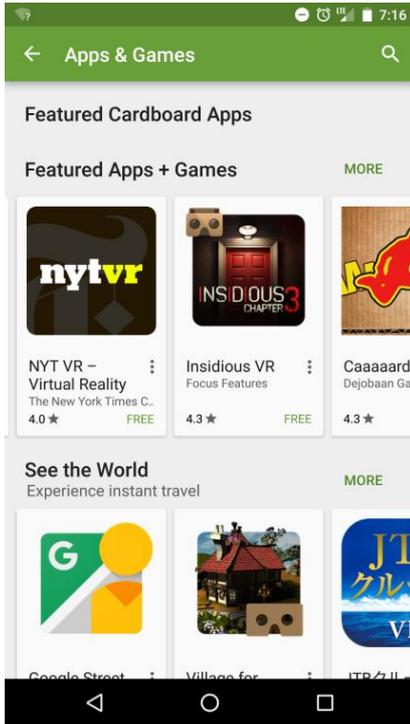
### Content Distribution on Light Mobile VR Is Similar To Cradle VR

Similar to Cradle Mobile VR, Light mobile VR devices also rely on the underlying app stores on the phone for third party content. App stores play an integral content in distribution of third party apps and content. Google is positioning its Cardboard App as the leading distribution app store for Light VR. Users of Light Mobile VR viewers that are built using Cardboard specifications are required to install the Cardboard App on their smartphone during the VR device setup using the QR code. After installing the Cardboard App, users can search for third party app from Google Play Store or the Cardboard App to download and install other apps. Cardboard app is also available on Apple App Store and to browse and search for VR content.

Apps that are submitted to Cardboard often don't meet the same standards of performance as Cradle (or certainly desktop VR). Oculus and Samsung are holding the line on minimum quality (40 frames per second refresh) for all content. This is a big reason why some are arguing that Light Mobile VR needs to have its own category and not be blended in with Cradle or Dedicated, we tend to agree.

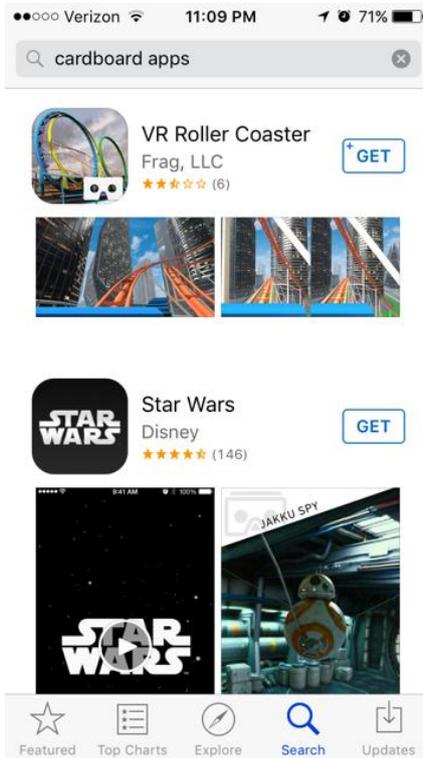


Figure 46: Cardboard App On Android Smartphone For Light Mobile VR



Source: Deutsche Bank, Google Play

Figure 47: VR Apps On Apple App Store



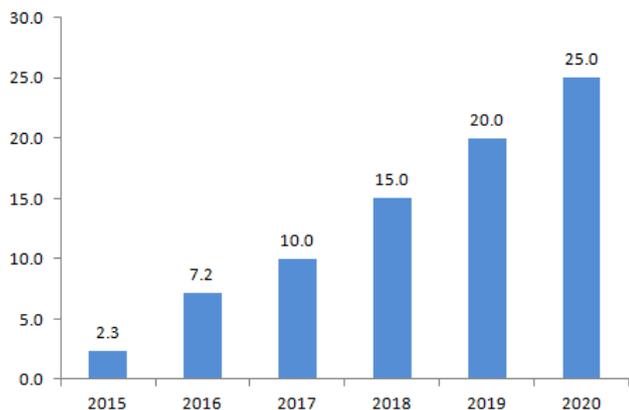
Source: Deutsche Bank, App Store

### Forecasting 25m Active Users of Light Mobile VR In 2020

Google has noted that over 5m Cardboards are shipped as of Jan 2016, in the first 19 months since launching Cardboard. The active user base and engagement of these users is unclear. For our forecast, we define user base as the average of number of people who owned the device, and DAU as the percentage of users who engage with the device on a daily basis during the period. We are forecasting the user base for Light Mobile VR to reach 25m in 2020, largely from the growth of Google Cardboard designed viewers. The growth in Light Mobile VR is likely to be slower than Cradle given the number of smartphone companies likely launching cradle offerings with free bundle promotions. We think Cardboard may be crowded out to some degree at the low-end over the coming years.

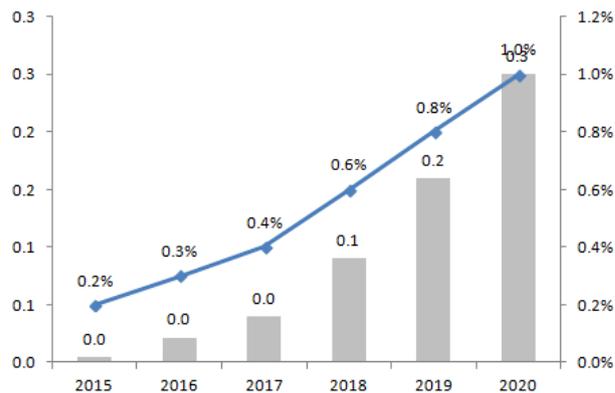


Figure 48: Light Mobile VR Users (m)



Source: Deutsche Bank, Company Reports

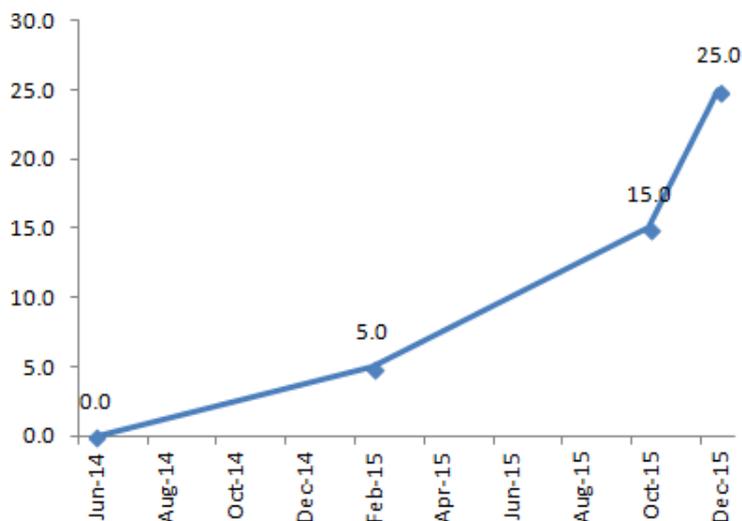
Figure 49: Light Mobile VR DAU (m)



Source: Deutsche Bank, Company Reports

App downloads from Cardboard app has grown exponentially over the last months. Google noted that over 25m cumulative apps are downloaded at the end of Dec 2015 for Cardboard from Google Play, with over 20m apps downloaded in FY15 alone as shown in **Figure 50** below.

Figure 50: Cardboard Apps Installed From Google Play



Source: Deutsche Bank, Google

## Dedicated Mobile VR: Most Compelling Long-Term, But Still In Proof Of Concept Mode

A few new emerging companies such as Auravisor, ODG, etc (likely also Samsung, Google, Apple and nearly EVERY smartphone OEM) are building dedicated mobile VR devices that function stand-alone without any smartphone-cradle system. These devices may be highly advanced technology with CPU/GPU, storage, sensors, wifi, premium glass and many other features. The aspirational goal is to create the closest experience to desktop VR without the cords and companion PC, which offers more freedom of movement. As a result, these devices are likely to be WAY more expensive than anything we see in mobile today, potentially approaching \$1000 per HMD.



Figure 51: AuraVisor Standalone Virtual Reality Headset



Source: Deutsche Bank, Company Reports

Figure 52: ODG Smart Glasses



Source: Deutsche Bank, Company Reports

### Today's Tech Specs Look Similar To Cradle – The Future Specs To Look Like Desktop VR

As noted above, the technological specifications required to create virtual reality experience on a dedicated device is very high, higher than what a smartphone can offer. **Figure 53** below highlights the key technological differences in specifications between Samsung Gear VR and Auravisor. The most significant difference is the presence of Quad Core processor for computing and 16GB integrated storage capacity in Auravisor. There is no computing capacity insider GearVR and only has capability to track positioning through sensors. Meanwhile, both the devices have relatively low refresh rate at 60Hz, compared to desktop VR devices. Auravisor also has external connectivity through Wifi, Bluetooth, and HDMI.

Auravisor also runs on Android OS compared to Gear VR that relies on the underlying smartphone for OS and content. Given the need for computing capacity and requirements, the cost of dedicated VR devices is higher than other forms of mobile VR. Auravisor is currently available for preorder for \$450 but is expected to ship only on May 2016.

We expect future versions of dedicated mobile VR HMDs to come with comparable built-in chips and sensors to what we see today in Rift and Vive, which will drive up cost and performance, and allow for a Full Presence experience in mobile VR.



Figure 53: AuraVisor Technical Specifications vs. Samsung Gear VR

Components	Auravisor	GearVR
<b>Display</b>	5 inch	Super AMOLED 5.7 inch
<b>Resolution</b>	1920x1080	2560 x 1440
<b>View</b>	100 deg	96 degrees
<b>Refresh Rate</b>	60 Hz	60 Hz
<b>Latency</b>	20ms	< 20ms
<b>Storage</b>	Built-in 16GB, MicroSD	Samsung Phone
<b>Connectivity</b>	WiFi, Bluetooth, HDMI for video	Samsung Phone w/USB
<b>Processor</b>	Quad Core Processor	-
<b>OS</b>	Android	-
<b>Weight</b>	1.05lb	~0.7lb

Source: Deutsche Bank, Company Reports

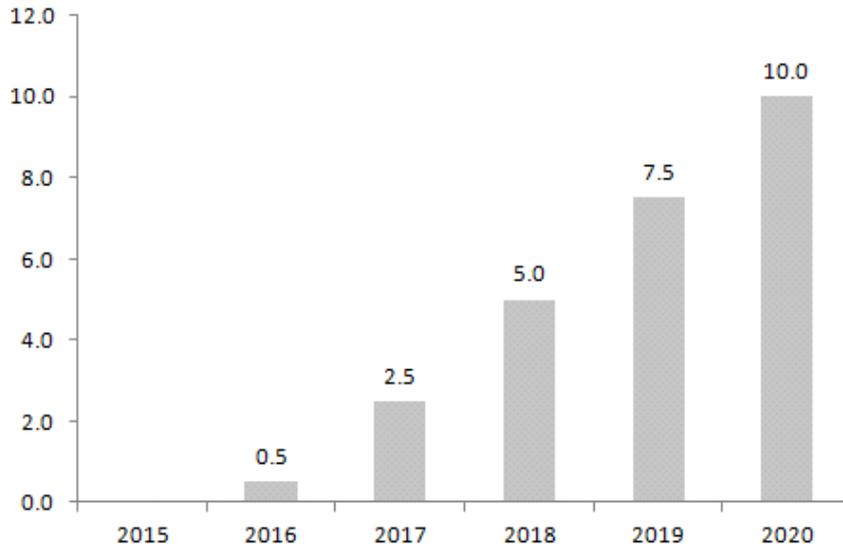
#### Connectivity A Big Tech Roadblock For Dedicated (compared to desktop VR)

From usability standpoint, the biggest advantage that dedicated VR has over desktop VR is the ability to provide mobility with VR experience, which is currently a challenge on desktop VR HMDs. With long and thick cables connecting the HMD to PC, users have limited mobility with desktop VR. However, the current wireless protocols using WiFi and Bluetooth are mature technologies without recent advancements and are largely optimized for data transfer. These technologies lack the speed of transfer required to deliver fully immersive VR experience, which exceeds the rate of over 90Hz and is currently possible only through HDMI cables. It is unclear how dedicated VR devices such as Auravisor are optimizing the user experience for this problem but the wireless technology available currently appears to be incapable to offer fully immersive VR experience with low latency and high frame rates.

Given that dedicated VR market is still largely at proof-of-concept stage, forecasting units is an extremely challenging exercise, especially before we see what companies like Samsung, Google and Apple come up with. Conservatively, our model estimates 500k units this year and likely to reach 10m units by 2020, which is obviously subject to revision.



Figure 54: Forecasting Dedicated Mobile VR Units (m)



Source: Deutsche Bank

#### Still Many Questions Remain On Dedicated VR

There are still a number of questions on the dedicated VR market. It is unclear how the dedicated VR OEMs are likely to choose app stores and content distribution platforms for their devices. Auravisor is built on top of Android OS and has a VR store integrated with the device, linked to the Google Play store.



# Virtual Reality Use Cases

## New Use Cases Emerging Every Day

Since we published our first VR report in Sept 2015, we have seen a number of new use cases emerge for VR. Many third party app developers and content studios are building new VR experiences and investments on the space is happening at an accelerated pace over the last few months. In the section below, we are highlighting a selected list of interesting VR applications.

### Gaming

As discussed above, all three desktop VR companies, Oculus, HTC, and Sony are have lined up a solid list of games already for their consumer launches this year. Many game and content studios have already launched their leading titles for VR. By platform, some of the most exciting current and upcoming VR games include: Oculus Rift – Eve Valkyrie, Edge of Nowhere, Rockband VR, Lucky’s Tale, and Chronos; Sony’s PlayStation VR – Ace Combat 7, Rez Infinite, London Heist and GOLEM; and HTC Vive – Elite: Dangerous, Fantastic Contraption, Arizona Sunshine, Job Simulator 2050 and Budget Cuts.

Figure 55: Eve: Valkyrie ships with Oculus



Source: Deutsche Bank, Company Reports

Figure 56: London Heist On Sony’s PlayStation VR



Source: Deutsche Bank, Company Reports

### Live Events

Companies like NextVR and others have built proprietary “stitching” algorithms and have unique 360-degree cameras to capture live sports and concerts, as if the user was sitting courtside. This space might be the most promising mainstream application longer term, but rights issues and quality are still being worked out. It’s not hard to envision this area as a huge winner. There is nothing in today’s live sports television viewing experience that could match the immersive VR experience of sitting sideline or courtside, while in the comfort of your living room or bedroom (or VR room!).

NextVR, whose platform allows them to transmit live stereoscopic VR content over low-bandwidth (even mobile) internet connections, is set up to work across multiple VR platforms, including Samsung Gear VR, Sony PlayStation VR, Oculus Rift and HTC Vive. The company has tested its technology with broadcasters such as ESPN and Fox Sports, and organizations like the NBA and NHL, and is now moving beyond testing to first VR market executions in sports. Dave Cole, co-founder of NextVR, believes VR technology could open up additional revenue models for sports and entertainment companies through sponsorship sales, subscriptions, and pay-for-view.



Figure 57: NBA Experience On Gear VR



Source: Deutsche Bank, Gear VR

Figure 58: Coldplay Concert On Next VR



Source: Deutsche Bank, Next VR

### Social Experiences

Companies such as Altspace VR are developing social VR apps that allow users to participate in interesting applications together with other users, through VR. The Altspace VR app enables users to talk to other people in VR and enjoy their company in real-time, and they can also participate in several multi-player games and watch Netflix in a synchronized manner with other participants through VR. The development of such social VR apps and experiences could play a key role in countering the widely held opinion that VR is a solitary, isolating experience.

Figure 59: Dungeons And Dragons By AltSpace VR



Source: Deutsche Bank, AltSpace VR

### V-Commerce

Retailers are using platforms like Sixsense and others to create virtual shopping experiences, whereby the user is immersed in a new experience similar to visiting a showroom, and a huge step up from the static look-and-feel of traditional e-commerce. Not only will the user be able to virtually try on any piece of clothing or accessories or other consumer products, but retailers can capture extremely valuable “click-stream” data on what products are interacted with, and how each user wants their virtual showroom personalized. One of the biggest reasons for the relatively low 3% conversion rate in e-



commerce is the inability of the user to really touch and feel the product, a barrier that immediately breaks down in VR.

Walker Sands Communications, an award-winning tech PR firm, surveyed more than 1,400 U.S. consumers as part of their 2015 Future of Retail Study, and identified virtual reality and drones as the two technology trends that will shape the future of retail. More than one-third (35%) of consumers said they would shop more online if they could try on merchandise virtually using a product like Oculus Rift, two-thirds (66%) said they would be interested in virtual shopping and 63% said they expect it to impact their shopping experience in the future. E-commerce is a \$1.2 Trillion market globally, so any small penetration could be material.

Figure 60: Audi Showroom On Virtual Reality



Source: Deutsche Bank, Oculus Rift

### Healthcare and Wellness

Many companies are exploring VR's potential in the areas of healthcare and wellness. Doctors and therapists are experimenting with new treatment methods for patients suffering from phobias and other disorders by creating customized VR experiences to simulate a situation in real life. Furthermore, the USC Institute for Creative Technologies recently introduced a VR exposure therapy designed to treat post-traumatic stress, while a London based company, 'Virtual Exposure Therapy', uses VR to treat phobias.



Figure 61: VR in healthcare and wellness



Source: Deutsche Bank, Washington.edu

### Fitness

VR is also finding applications in the fitness domain. Actor and former NFL football player Terry Crews recently filmed some fitness videos in 360 degrees, and is reportedly considering creating VR content of his own. Additionally, companies like VirZOOM are combining fitness apparatus with VR to create interesting experiences. The VirZOOM exercise bike with controller buttons built into the handles can be combined with a wired VR headset like the Oculus Rift, PlayStation VR or HTC Vive. The faster you pedal the bike, the faster you go in the game. Horseback riding, flying or driving a race car are among the initial titles built for the bike. The bike is expected to ship in 1H16, in time to be combined with the first consumer wired headsets. The bike includes five games as well as a month subscription to a service that includes online multiplayer and fitness tracking. It costs \$10 per month thereafter.

Figure 62: VirZoom exercise bike can be combined with VR



Source: Deutsche Bank, VirZoom



### Advertorials and Sponsored Content

Brands like Northface and Red Bull are leveraging companies like Jaunt VR to create compelling sponsored content that highlights their products in new ways that traditional advertising can't. For example, a video of a team climbing El Capitan in Yosemite with Northface equipment is a much more engaging advertising experience than a 30-second spot on ESPN.

Similarly, Volvo built an app 'Volvo Reality', the world's first virtual reality test drive on a smart phone, to promote its XC90 SUV, while Animation studio ReelFX, creator of last year's animated feature "The Book of Life", is filming commercials with a 360-degree camera rig intended for VR headsets. \$200B is spent on TV advertising globally, despite declining viewership stats in many day parts in Western markets, hence every minute spent in VR (and not on TV) may exacerbate an already challenging environment for traditional TV ad spend.

Figure 63: Real Estate Application On Oculus VR



Source: Deutsche Bank, Oculus

Figure 64: Volvo's XC90 SUV on the 'Volvo Reality' app



Source: Deutsche Bank, Google

### Entertainment & Movies

VR has made a solid progress on entertainment and movies in the last few months. Several companies both in Hollywood and in Silicon Valley are building highly immersive VR content and technology required to pioneer VR entertainment. From a quality standpoint, movie content on VR can provide better immersive experiences to users than motion picture. In film, you have to have at least 24 frames per second (fps) or the illusion of motion breaks down. VR devices can provide refresh rates as high as 60 fps (which is the minimum standard for any VR device) and therefore can give an astonishing perception of reality. The annual box office is \$10B in the US and \$40B globally, plus an additional \$25B in video on demand, so any traction in VR entertainment opens up a huge TAM. A few examples of VR related efforts on entertainment are listed below.

Oculus has created its own in-house movie studio, Story Studios, to produce native VR content, and has announced plans to create five short animated movies. The company has also struck a deal with Felix & Paul Studios, who created the VR experiences for *Jurassic World* and *Wild* for the Gear VR, to produce VR content for its own upcoming Rift headset and Samsung's Gear VR. Several other content studios are working on VR movies.



Figure 65: Virtual Reality movie "Zero Point" By Condition One



Source: Deutsche Bank, Condition One, Oculus

Samsung has partnered with David Alpert, executive producer of *The Walking Dead*, to produce a series for its Milk VR service. In 2015, Google launched a new open-source VR platform for upcoming VR filmmakers, Google Jump, based on a 16-camera set of GoPros capable of capturing 360-degree, three-dimensional pictures and video.

Star Wars director J.J. Abrams, noted director Chris Milk and the USC Institute for Creative Technologies are also working on interesting projects involving the use of VR in film. This push towards VR content creation has also resulted in VR getting a film festival of its own. The Kaleidoscope VR Film Festival is a traveling fest that hit 10 cities in the US and Canada in 2015. Each stop included a series of experiences available on Samsung Gear VR and Oculus VR headsets.

### Communication

Instead of using Skype, Facetime or a mobile messaging app for a one-to-one or many-to-many communication, we see VR experiences like Alt-Space and others becoming a viable alternative one day. The ability to bring documents, images, videos, and any other rich media into a group face-to-face private meeting setting with users scattered around the globe opens up a ton of opportunity. We don't see a lot of revenue attached to this model today, but there are many potential areas of monetization.

### Training & Education Simulations

One of the most promising cost-saving and engaging use cases for VR is around training and education. This is a broad area that could range from virtual military training simulations, to K-12 classroom settings, to B2B instructional videos on how to operate expensive machinery or make repairs, to sports training and coaching. The opportunities in this area are uncapped. Research shows that people remember 20% of what they hear, 30% of what they see and up to 90% of what they do or simulate. Virtual Reality thus has the potential to significantly improve retention of the subject matter amongst the target audience.

The same way that the consumer internet space has evolved into how-to videos, MOOCs, education marketplaces, YouTube, and many other areas, Virtual Reality could do even more. As an example, in 2015, a Bay Area company called STRIVR showed college football and NFL teams how VR can



allow quarterbacks to put on a headset and re-live games they just played, besides revolutionizing recruiting for the team. STRIVR already counts at least 7 NFL teams and 13 college programs as clients, including Stanford, Arkansas, Auburn, Clemson, Dartmouth, Rice and Vanderbilt, as well as the Dallas Cowboys, NY Jets, the 49ers and the Vikings, among others. Other companies, such as Discover Labs and Upload VR, are developing immersive and interactive technology to create compelling educational experiences across medical science, history and several other areas.

Figure 66: Football Training In VR For QBs



Source: Deutsche Bank, StriVR

### Tourism

In Mark Zuckerberg's keynote at F8 2015, he demonstrated a VR tourism video for someone looking to travel to a village in Italy. Instead of just looking at static photos/videos and reading hotel, restaurant and attractions reviews online, a user will one day be able to do all of those things while virtually walking through the market or the town square, checking out the true look and feel of a location. Beaches, jungle, waterfalls, Pyramids and other wonders of the world are now accessible to anyone with a VR system.

In British Columbia, Canada, virtual reality already allows users to hike, boat and ride through several of the country's national parks via an Oculus Rift. In Australia, Qantas has implemented VR experience in the cabins of their longhaul flights. The airlines has partnered with Samsung and Rapid VR to produce a new VR film which will allow Qantas customers the opportunity to experience a 360 degree experience of the Great Barrier Reef and Hamilton Island. Leisure travel is a \$1T TAM annually, and these use cases are already in full adoption mode online, so the leap to VR seems likely.



Figure 67: VR Tourism



Source: Deutsche Bank, Oculus Rift

Figure 68: VR Tourism



Source: Deutsche Bank, Qantas



# Appendix 1

## Important Disclosures

Additional information available upon request

### Disclosure checklist

Company	Ticker	Recent price*	Disclosure
Google	GOOG.OQ	718.85 (USD) 2 Mar 16	2,7,8,14,15
Facebook, Inc.	FB.OQ	109.95 (USD) 2 Mar 16	2

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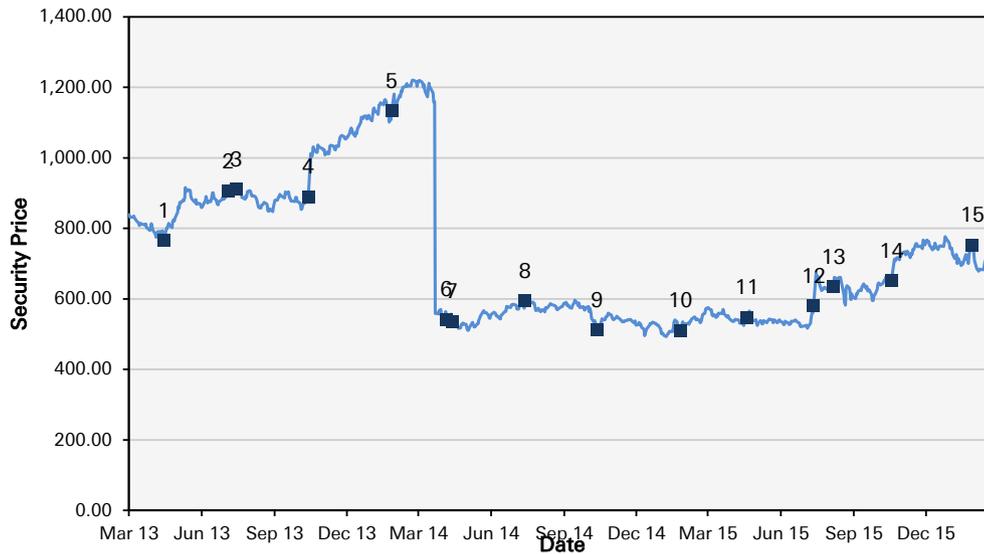
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 (as of 3/2/2016)



Previous Recommendations

- Strong Buy
- Buy
- Market Perform
- Underperform
- Not Rated
- Suspended Rating

Current Recommendations

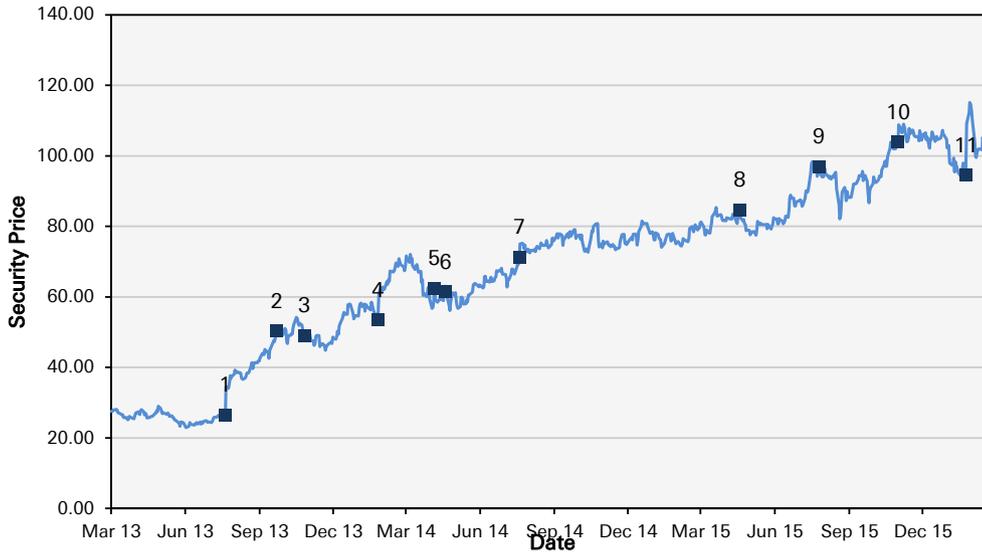
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- Hold
- Sell
- Not Rated
- Suspended Rating

\*New Recommendation Structure  
 as of September 9,2002

1.	04/19/2013:	Buy, Target Price Change USD930.00	9.	10/17/2014:	Buy, Target Price Change USD615.00
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Historical recommendations and target price: Facebook, Inc. (FB.OQ)  
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- Market Perform
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- Not Rated
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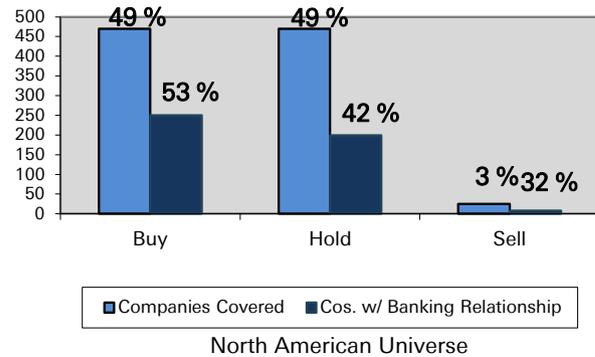
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