

 PitchBook

VIRTUAL REALITY

2015 ANALYST REPORT

10 MARKET APPLICATIONS

15 VC FIRMS AND OTHERS BETTING BIG

18 HOW WILL THE MARKET ADOPT THE NEW TECH?

Including data from the PitchBook Platform, which includes more than 20,000 valuations of VC-backed companies.

Contents

Analyst Note	3
Introduction & History	4-6
Key Components & Characteristics	7
Head-Mounted Displays	8
Computing Hardware	9
Control Inputs	9
Software	10
Market Applications & Sector Briefs	10
Gaming	10-11
Digital Entertainment & Media	12
Enterprise	13
Military	13-14
Healthcare	14
Private Investment & Corporate M&A Activity	15
Deal Flow & Capital Invested	15
Most Capitalized Companies	15
Most Active Investors	15
Active/New Investor Growth	16
Investor Type	17
Market Development & Adoption	18
Technology Advancements	18-19
Addressable Market Analysis & Concerns	19-20
Content Creation	20
Adoption Risks	20-21
Mobile VR Adoption	21-22
Peripheral Equipment & Ecosystem	22
Select Company Profiles	23-26
Special Thanks	27

CREDITS & CONTACT

PitchBook Data, Inc.

JOHN GABBERT Founder, CEO

ADLEY BOWDEN Vice President, Analysis

Content, Design, Editing & Data

NIZAR TARHUNI Analyst

GEORGE GAPRINDASHVILI Editor

JENNIFER SAM Senior Graphic Designer

JESS CHAIDEZ Graphic Designer

Contact PitchBook

pitchbook.com

RESEARCH

reports@pitchbook.com

EDITORIAL

editorial@pitchbook.com

SALES

sales@pitchbook.com

COPYRIGHT © 2015 by PitchBook Data, Inc. All rights reserved. No part of this publication may be reproduced in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, and information storage and retrieval systems—without the express written permission of PitchBook Data, Inc. Contents are based on information from sources believed to be reliable, but accuracy and completeness cannot be guaranteed. Nothing herein should be construed as any past, current or future recommendation to buy or sell any security or an offer to sell, or a solicitation of an offer to buy any security. This material does not purport to contain all of the information that a prospective investor may wish to consider and is not to be relied upon as such or used in substitution for the exercise of independent judgment.



Analyst note

Attempts at creating a device that can really take a user into a completely immersive virtual world have been made several times over the past couple of decades. After multiple failures, a new device came along that opened the door for VR development today: the smartphone. These phones became ubiquitous, and with their mass production, the technology components that previously held back VR evolved—and became cheap. VR players have been able to re-purpose smartphone components such as GPUs and CPUs to create outstanding new devices that we'll begin seeing now and through 2016. There are doubts about how “real” a VR experience can be, but put a headset on, even the inexpensive cardboard models that use your smartphone as a display, and what you'll see will shock you. We know gamers will be able to utilize these headsets to enhance their gaming experiences, but these devices will do so much more. One of the biggest drivers of a consumer's behavior is personal emotion and experience, and what VR does is provide a fully encompassing experience that can touch the

consumer on a personal level. These devices can take you as close as possible to a war-torn Syria, or to the edges of Mount Everest, without actually physically being there.

The VR movement is stronger than ever today, and we've seen that show up in the numbers. Close to \$4 billion of capital has been invested in the space since 2010, with more than half of that in the last two years. There's also a diverse range of investor types deploying capital. VCs have led the way, but strategic capital has followed, and we've even recently seen private equity players become involved. As awareness has risen, the technology is enjoying a renaissance, and in this report you will find a deep dive into the present-day landscape of the technology and the private investors helping drive the emerging tech theme forward. Will we end up with a headset in every home five years from now? Probably not. But as this thing continues to grow, especially with the rate of capital flowing into the space, the newest tech set to shake the world appears to be here.

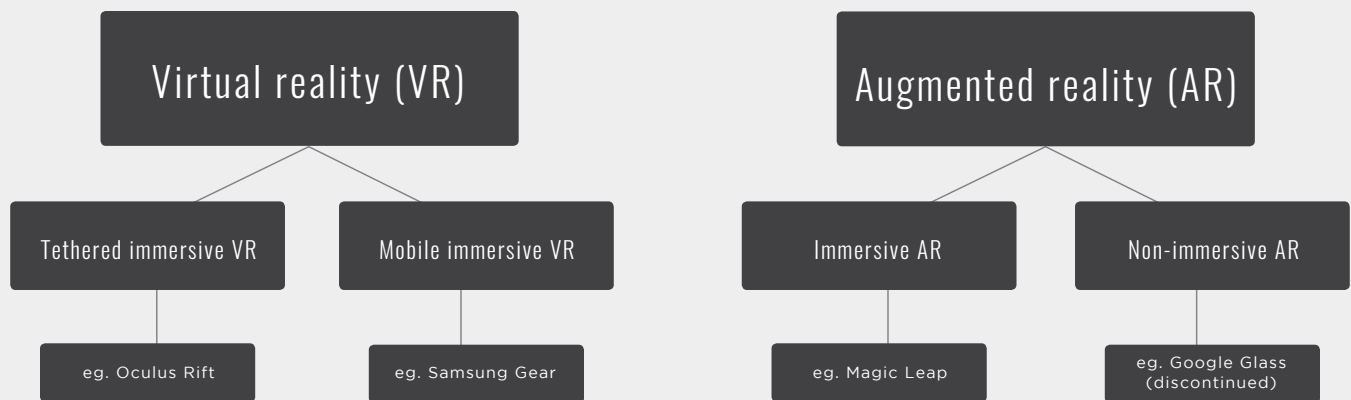
Introduction & history

Virtual reality pertains to the ability to place users in a fully immersive, computer-generated alternative environment. In recent years, developers and product manufacturers have created extensive and impressive hardware devices to accompany sophisticated software, giving users a genuine sense of presence in a virtual world. When trying to understand a VR experience, imagine being fully disconnected from your present environment. All you are experiencing, feeling and processing is a world brought to you through a device you are physically wearing, which we will describe later. With the emergence of VR, we have seen a simultaneous surge into the development of augmented reality experiences. While similar, there is certainly a difference between the two. AR experiences focus on providing computer-generated artificial overlays into a user's real-world environment. Certainly, some AR platforms and devices can provide a more immersive experience than others, but the basic premise is that AR experiences do not block out the real environment.

VR and AR serve as the umbrella heads of developing virtual technology, and while we will focus predominantly on VR in this report, we note that we expect newer companies to come to market with technologies that blend both VR and AR. What we saw with Google Glass, which has been removed from retail distribution for now, provided an introduction and example of the potential AR has. The glasses themselves did not dislodge the user from their day-to-day activities; they rather provided virtual elements in the form of maps, messages and photos, among other visuals, that appeared similar to a hologram in one's line of sight. Other companies, such as Magic Leap (profiled later), provide similar technologies, yet their experiences are more engaging, so much so that a user wouldn't be able to tackle daily tasks in certain uses of the tech—an immersive AR experience.

VR is associated with the removal of the real-world environment from the user's experience. In contrast, AR pertains to the overlay of virtual elements onto the user's real-world environment.

VR and AR applications serve as the umbrella heads of developing virtual technology. The two applications can be integrated and iterations from budding companies aiming to combine the two techs will emerge as the VR/AR platform continues to build out.



The concept of VR is not new and can actually be traced back over a century ago. As touched on in a Piper Jaffray report, think about the simple concept of storytelling or narration. The conveying of events through a story, whether fictional or real, prior to the invention of various technologies such as the radio or TV, was a method that individuals used to place themselves in an alternate reality. Stories can provoke various emotions and thought processes. The mind can wander out of reality through the lens of a story, and VR technology will only help amplify this experience. Furthermore, many sorts of entertainment, including but not limited to theater, film, photography, graphical depictions or comics all serve as similar mediums that can be amplified via VR or AR. As the applications and use cases for the tech have grown tremendously outside of just entertainment, the renewed interest in the space isn't surprising. Technology has also grown alongside the potential use cases, so the resurgence can be attributed more to the necessary pieces aligning better today than in previous decades.

Take a look below at a few historical milestones that have helped lay the groundwork for VR to re-emerge.

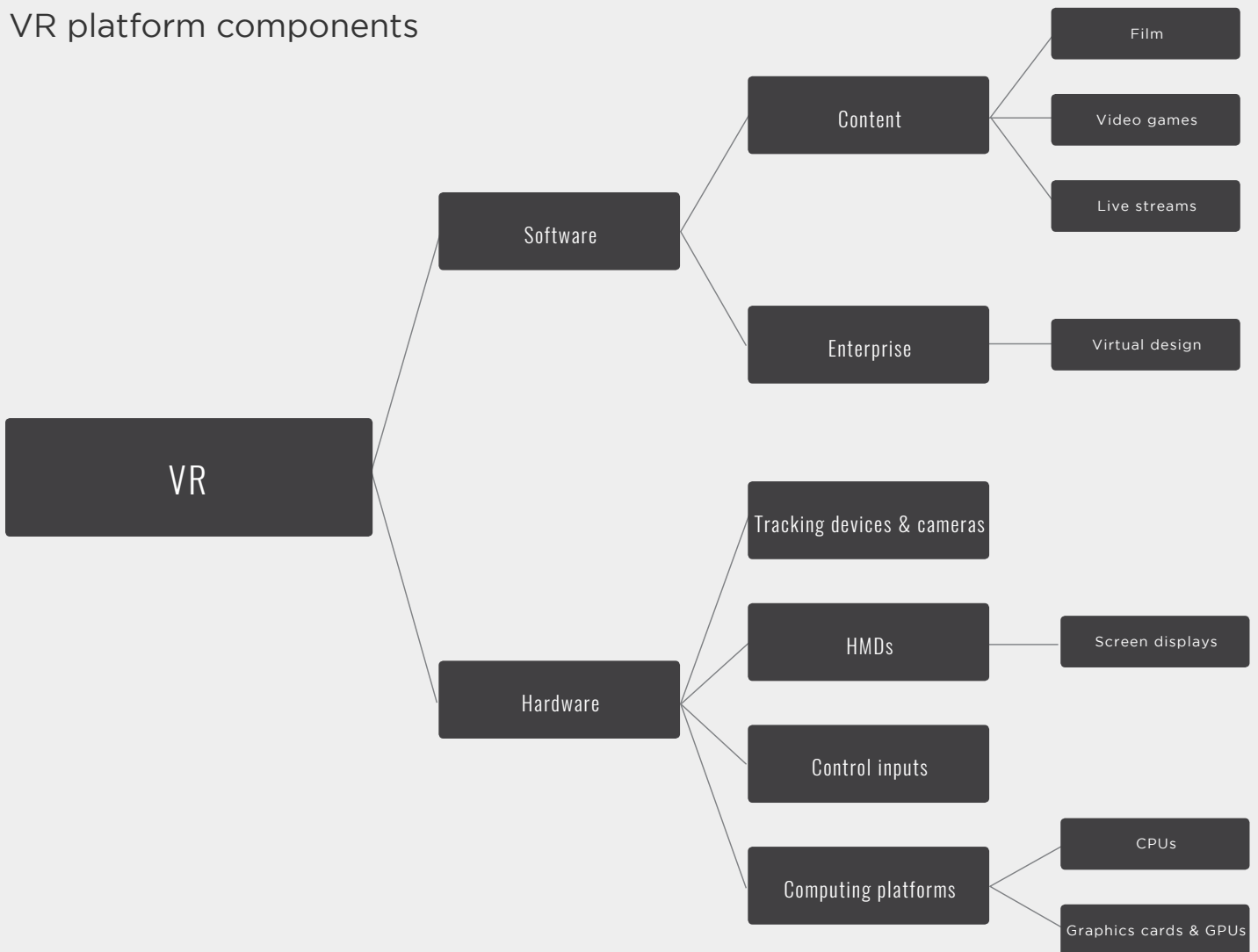
1800	1970	1980	2007	2014
<p>1838 Wheatstone Stereoscope, which utilizes a pair of mirrors to reflect separate images to each eye, is invented.</p>	<p>1968 Ivan Sutherland develops what is widely considered the first VR head-mounted display (HMD), the Sword of Damocles.</p> <p>1966 Thomas Furness develops first visual flight simulator for U.S. Air Force.</p> <p>1972 The Magnavox Odyssey, the first commercial video-game console, is introduced.</p>	<p>1977 The TRS-80, Apple II and Commodore PET computers are released. These are among the first successful computers to usher in the personal computing age.</p> <p>1984 VPL Research is founded. Its founder, Jaron Lanier, is widely credited with coining the term "virtual reality." The company went on to create VR-related products such as the Data Glove and the EyePhone.</p>	<p>1991 Sega announces plans for Sega VR, a head-tracking VR headset for arcades and consoles. The arcade version was released, but the home-console version was canceled.</p> <p>1995 Nintendo releases Virtual Boy, a VR-style home gaming console. While launched in both Japan and North America, the console did not achieve commercial success.</p> <p>2007 Apple introduces the iPhone. Notable (from a VR perspective) for its screen quality, a multi-touch interface and a combination of sensors used for proximity, light and orientation, among other purposes.</p>	<p>2012 Google announces the Google Glass optical HMD. An "Explorer Edition" was released in 2013 but the device is no longer for sale.</p> <p>Palmer Lucky launches a Kickstarter campaign to fund the "dev kit" version of Oculus Rift, raising \$2.4 million—the initial goal was to raise just \$250,000.</p> <p>2014 Facebook announces an agreement to acquire Oculus VR for \$2 billion.</p> <p>Sony announces the Project Morpheus virtual reality system, intended for use via the PS4.</p> <p>Google announces Google Cardboard, a low-cost, do-it-yourself HMD that accepts various smartphones as displays.</p> <p>Samsung announces the Gear VR, developed in collaboration with Oculus. The device is an HMD that utilizes select Samsung phones as displays.</p> <p>Google invests in Magic Leap, an AR startup believed to be developing an HMD that directly projects images into a user's eyes.</p> <p>2015 HTC & Valve announce the Vive VR headset, which couples with a base station to track a user's movements to navigate the virtual environment</p>

Source: UBS, company reports

Key components & characteristics

Before we delve deeper into present-day adoption, use cases and the investment landscape, we'll break down the "how" in this section. VR experiences are complex with many moving pieces involved. From the computing platforms used to power applications to the hardware required to actually view and engage with VR, these moving pieces must come together near perfectly in order to provide the most realistic experience.

VR platform components



HEAD-MOUNTED DISPLAYS

Head-mounted displays (HMDs) serve as the visual medium for VR experiences. In order to provide the most authentic experience, HMDs are built with a large field of view (FOV) and encompass an individual's normal vision range. The human binocular FOV spans about 120 degrees—VR HMDs are built to come as close as possible to that range. For example, the Oculus Rift (profiled later) has a 110-degree FOV, not far off from what the natural human eye set has. For comparison, Sony's Project Morpheus has a 100-degree FOV, while the Oculus-powered Samsung VR headset employs a 96-degree FOV.

These displays use stereoscopic 3D, projecting a separate image to each eye, which is how the actual human eye takes in information. Many AR experiences are able to perform well with just a single display as the user is not intended to be removed from their actual environment, but the majority of VR experiences perform better with two separate image displays to provide the most realistic experience.

When users move their head in a VR HMD, their vision moves at a rate equivalent to their motion. In previous HMD iterations, this was nearly impossible without causing motion sickness from lag. Newer headsets utilize a combination of low-persistence displays and extremely high refresh rates to remove motion blur, made possible by organic light-emitting diode (OLED) panels, such as those in the Oculus Rift headset. Oculus founder Palmer Luckey highlighted the use of low persistence at CES 2014. When a frame is rendered and brought to a screen, a full-persistence display only shows the proper scene orientation at one point in time. Pixels can only refresh once per frame, so using full persistence, pixels in the frame stay lit for an entire scene, even though the scene orientation becomes outdated until the next frame kicks in. Using a low-persistence display, the pixels remain lit only while the scene orientation is actually correct and immediately go dark after. With a high refresh rate, new frames kick in at a much faster pace and thus the image remains continuous for the user, eliminating much of the motion blur that full-persistence displays would contain.

The refresh rate typically occurs hundreds of times per second to ensure the utmost quality for users, and to minimize latency, motion blur and motion sickness. In a company blog, Oculus explains that its consumer-facing HMD (set to be released in 1H 2016) runs at a resolution of 2160x1200 with a refresh rate of 90Hz; Sony's Project Morpheus has a refresh rate of 120Hz. Contrasting this to a traditional 1080p game at a 60Hz refresh rate, we can better understand the heightened technology and rendering requirements needed to ensure VR experiences are authentic.

The Oculus Rift employs a 110-degree field of view, fairly close to the human FOV of 120 degrees. Sony's Project Morpheus headset utilizes a 100-degree FOV, while the Oculus-powered Samsung Gear has a 96-degree FOV.

The use of stereoscopic 3D, low-persistence displays and extremely high refresh rates have allowed for the most immersive VR experiences, while also mitigating motion sickness.

Traditional video games are displayed at a refresh rate of 60Hz. With VR, we'll see HMDs run with a minimum refresh rate between 90Hz and 120Hz.

Motion and positional tracking are also pivotal parts of VR experiences and thus the appropriate components must be built into HMDs to address this. Tracking allows for user actions in the real world to be mirrored and seamlessly translated into the virtual environment. In general, an external camera monitoring a user's head movement is used for this. Going forward, we will likely begin seeing a hybrid approach in which a camera attached to an HMD is utilized to track the environment while an external stationary camera is used to track user movement.

COMPUTING HARDWARE

In order to power and run VR experiences and applications, a computing platform is necessary. For tethered VR experiences, this comes in the form of PCs (Oculus) or gaming platforms such as the PlayStation 4 (Project Morpheus). For mobile (untethered) VR experiences, such as that of the Oculus-powered Samsung Gear, a smartphone can be used. When looking at certain AR experiences, such as what Microsoft is looking to accomplish with its HoloLens technology, the computing platform is actually built into the tech.

CONTROL INPUTS

To accompany impressive visual applications, control inputs are needed in order for user experiences to be interactive. Technology is already developed for motion control, where sensors are placed on body parts to translate real-life movements into a virtual character, but other comprehensive techs are being developed, as well. For example, Virtuix, a company backed by Scout Ventures, is developing a treadmill that tracks motion in a fixed place. As the first flurry of consumer-facing VR headsets begin coming to market, we'll likely see video game-type controls come to market alongside HMDs. In June 2014, Oculus acquired the Carbon Design team, which is responsible for designing the Xbox 360 controller and the Kinect. Oculus will package an Xbox One controller with each HMD sold, and purchasers will also have the option to buy Oculus Touch, a new pair of tracked controllers that should allow for more liberated movement as a separate controller is used by each hand.



Oculus Rift



Project Morpheus



Xbox One Controller



Oculus Touch

SOFTWARE

In order for the hardware to mean anything, clearly a user needs applicable content to engage with, which can be viewed through various HMDs. Video games will likely be the most widely available form of VR content for the first consumer iterations of headsets, yet content related to films, concerts, live streams and much more will play a pivotal role in the market, as well. Pre-rendered content will drive the market forward at the onset, but moving forward, companies such as Vectr Ventures-backed NextVR will be able to provide live VR experiences including concerts and sporting events. Interactive content will also be important for software developers in order to allow users to engage with experiences and remain fully immersed.

Market applications & sector briefs

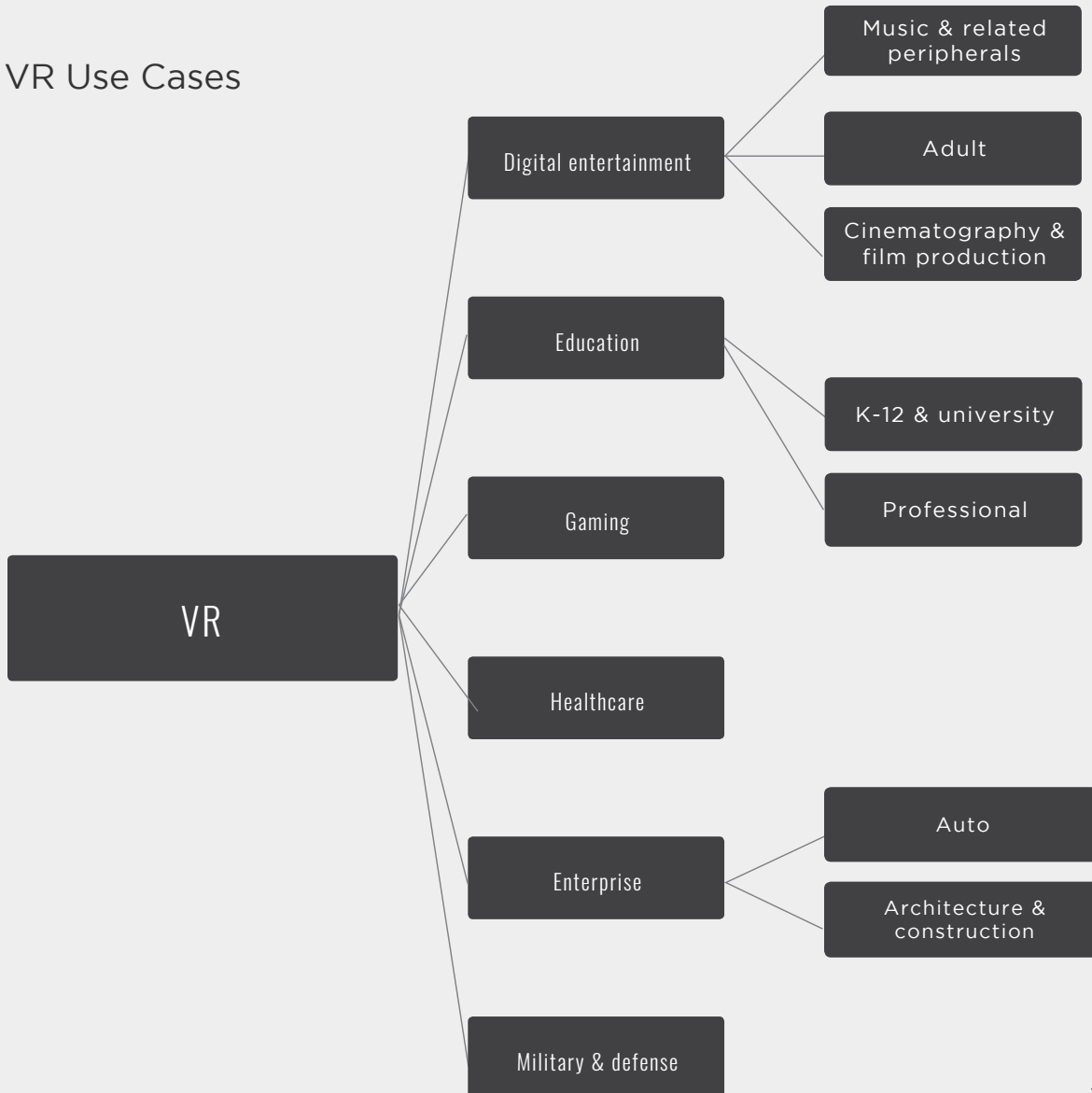
One of the primary reasons VR technology should be able to hit its critical mass in this most recent resurgence is due to the increased quantity of applications and use cases. In previous attempts to develop the tech, the advanced gaming market was by far the largest audience that displayed interest in VR, in addition to being one of the only groups that could find value in the experience it offered. However, as society has become more technology driven, enterprises have been forced to adapt in order to continue better serving customers and to also find efficiencies in their own development initiatives. Today, some of these efficiencies can be found using VR, which will continue as its platform builds out. Use cases currently range from gaming to healthcare and various enterprise applications, among many other areas, helping to underpin an increased level of acceptance and adoption as the space grows.

GAMING

The first iteration of consumer-facing VR applications will be geared toward the gaming community. Typically the early adopters in technology, these users are more likely to already be receptive to VR concepts as they search for the most realistic interactive experiences. Gamers are also more likely to already have the sophisticated hardware necessary to power VR applications. For example, individuals who

already own a PS4, which serves as the computing platform for its Project Morpheus headset, are more likely to purchase the device than those who don't own the gaming console. Historically, video game manufacturers have already made strides in the space, as evidenced by various arcade-style games, along with previous consoles such as the the Nintendo Virtual Boy System released in the early 1990s or even the Sega VR prototype that was displayed over two decades ago. From a content angle, game developers should be able to benefit tremendously from this use case. The global video game software market is expected to reach around \$56 billion in 2015, according to Statista, compared to just over \$27 billion on the hardware side. Further, the gaming engines, which are able to process 3D graphics fairly well, will be the types of engines used to power VR experiences and environments, so the parallels are available for this use case much more than others.

VR Use Cases



DIGITAL ENTERTAINMENT & MEDIA

Digital entertainment will certainly drive the market further as hardware continues to get built out. Heavily funded companies are already in the market looking to provide immersive content, from VC-backed players such as Jaunt to traditional Hollywood studios. We hear the chatter of the size of investments these studios have made into VR-focused projects and think the incentive is growing to make sure these projects succeed, and if not, that these studios are able to leave these efforts better informed for the next go-around. In addition to film, professional sports leagues and associations have displayed significant interest in the space. The Golden State Warriors of the NBA experimented with technology from NextVR to stream their 2015 regular-season opener to individuals using Samsung Gear headsets. As mentioned by the NBA's commissioner, the majority of fans never actually make it into an arena, and thus VR allows for an exhilarating experience that was previously unavailable. The efforts we've begun to see from Hollywood, along with the push from professional sports leagues to incorporate VR is exciting, and moving forward, other adopters in the space will likely include players in the music industry, as well as the adult entertainment space, as they too look to monetize their respective content. Another interesting movement to watch will be that of the traditional newspaper business. The New York Times partnered with Google to provide VR viewers to subscribers, allowing users to watch an empathetic film related to children in war-torn countries. As newspapers look to continue to provide content on the digital side, other prominent papers could follow suit, and The New York Times has announced its intent to continue releasing other short films via the same medium.

The music industry has struggled in recent years, and VR has the potential to provide a new monetizeable revenue channel. Without addressing advertisement applications, an example of this may include labels providing already-popular music video content via VR, and the ability to charge for these types of enhanced experiences seems fairly reasonable. Independent artists can also find that same revenue channel to bring more immersive content to their fans. Similar to what we'll likely see with sports applications, in-app purchases to provide enhanced viewing angles in, say, concert settings, should also allow for widening revenue paths.

Further, the adult entertainment industry has also taken a liking to VR. While potentially taboo, the adult space provides content nonetheless, and it, too, will look to enhance customer experiences. Outside of its

Digital entertainment will certainly drive the market further as hardware continues to get built out. This content may span traditional film, music applications, or live sporting events.

content, the adult space encompasses a sizeable product market, and it can create an ecosystem of its own, packaging complementing products with VR-focused content.

ENTERPRISE

From an enterprise perspective, various sectors can utilize VR to provide a better retail experience to a younger and more tech-savvy consumer base. Through VR, you can take customizable programs such as NIKEiD, where users are able to develop their own shoes online, and apply them to other spaces in a more immersive setting—auto manufacturers, architectural firms and more will utilize similar offerings. Audi has experimented with this technology, allowing users to use HMDs to see what the interior of their vehicles may look like when adding or subtracting certain options or changing the interior color schemes. Looking at architectural and construction applications, firms will be able to show clients what their mock-ups will look like before deploying large amounts of capital to complete projects. As the business use case continues to grow, VR will help enable better business-to-consumer relationships by allowing enterprises to provide the best products with matching customer experiences.

MILITARY

The military and defense space has already adopted commercial VR applications, and as sophisticated consumer HMDs begin coming to market, the military use case should continue to grow. One of the primary places we expect continued military applications is in combat training. Through HMDs and tracking inputs that translate user movement, VR can place soldiers in dangerous and life-like situations they may face abroad without actually putting them in harm's way. The use of VR can also significantly bring down costs over the long run. As the expenses to physically transport trainees into certain environments and to conduct training routines in those locations can mount, VR will be able to provide realistic training sessions at a fraction of the cost. Post-traumatic stress disorder (PTSD) is also a significant issue for those returning from combat, and VR may be able to provide a safer environment to ease those suffering from the disorder away from their symptoms. The technology will likely be used to allow for certain triggers to be introduced while being monitored, in turn helping soldiers gradually adjust to day-to-day life following active service. Other military applications include immersive flight simulations and battlefield medical training.

It is interesting to note that many services and products offered to government-backed entities are brought forward through longer-term contracts. Thus, if VR players are able to push their technology to the government in the same manner, these partnerships can prove very lucrative, while also providing stable and predictive cash flows.

HEALTHCARE

VR has been widely implemented by the healthcare space for years, a notion that may be under-recognized by many. Certain medical procedures are expensive to perform, and the costs associated with mitigating risk and adequately addressing procedures that do not go as planned can be even more costly, especially when factoring in the legal implications. The use of VR to provide zero-risk environments to conduct training can be invaluable. Surgeons can work through mock surgeries without the use of cadavers, and VR can supplement this with an impressive amount of immersiveness and reality. Although haptic feedback (form of interaction involving touch) is not quite there yet, it is certainly an input being worked on. Coupling accurate haptic implications with the software and hardware components of VR currently being developed will allow for the healthcare space to adopt the technology in many facets. Further, healthcare use cases will include rehabilitation initiatives for the treatment of phobias. Similar to how the military may use VR for PTSD treatment, common phobias such as fear of flying or heights can be addressed using VR to help mitigate these concerns for individuals in their day-to-day lives.

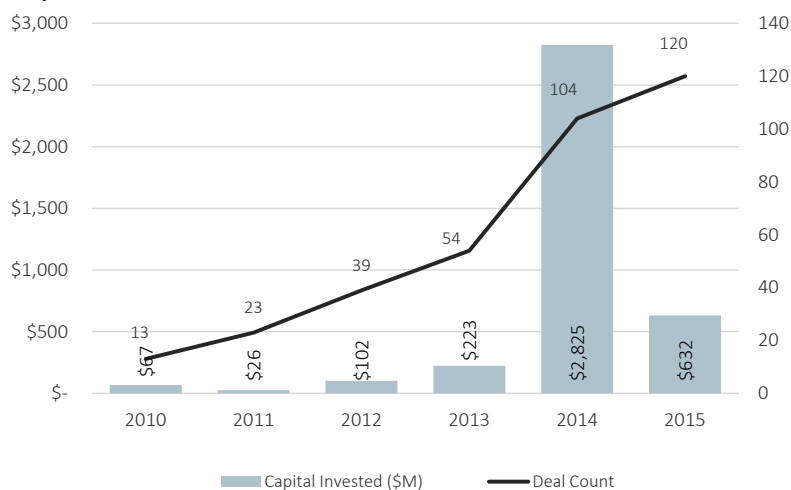
Private investment & corporate M&A activity

DEAL FLOW & CAPITAL INVESTED

Technological advances in recent years have helped underpin a renewed interest in VR, and we've seen an increasing amount of funding enter the space to help push growth in the budding sector. Participating investors don't only include traditional venture capitalists looking to make bets on emerging technologies, but corporations, corporate VC arms, hedge funds and private equity investors, as well. Since the start of 2010, nearly \$3.9 billion has been deployed into the VR space across 353 completed deals. 2014 set a rather impressive record with over \$2.8 billion invested in the space, though that was skewed heavily by the \$2 billion+ Facebook acquisition of Oculus. But even if we back out the Oculus deal, aggregate 2014 transaction value in the space was impressive at over \$825 million.

Thus far in 2015, we've seen approximately \$632 million invested across 120 deals, the latter representing a 9.2x jump from 2010 deal flow. Aggregate deal value was highest in 2014, yet we've seen more VR transactions so far this year than any other year historically. Notable transactions in the sector, outside of the Oculus buy, include AR-focused Magic Leap, which raised a \$542 million round in 2014; hardware and content-focused Jaunt, which closed a \$65 million round in September; and NextVR, which secured \$35 million in Series A funding in November to advance its technology that delivers live and on-demand VR content in true broadcast quality.

VR/AR DEAL FLOW AND CAPITAL INVESTED



MOST CAPITALIZED VR COMPANIES

Rank	Company	Total amount raised
1	Oculus VR	\$2.1B*
2	Magic Leap	\$593.7M
3	LENSAR**	\$191.1M
4	Jaunt	\$101.3M
5	Blippar	\$70.1M
6	Vuforia	\$65M
7	Matterport	\$57.7M
8	Avegant	\$37M
9	NextVR	\$36M
10	Playful	\$33M

Notable: Metaio acquired by Apple for \$32M in May 2015

*Includes FB acquisition

**Agreed to \$59M acquisition on 11/16/2015

MOST ACTIVE VR INVESTORS

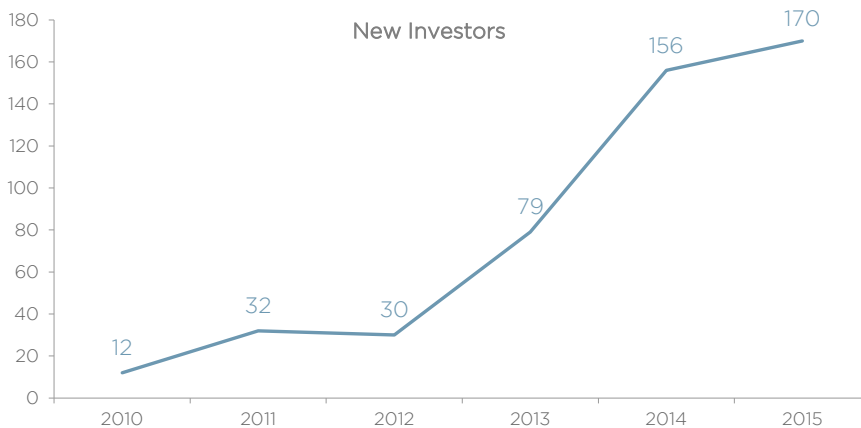
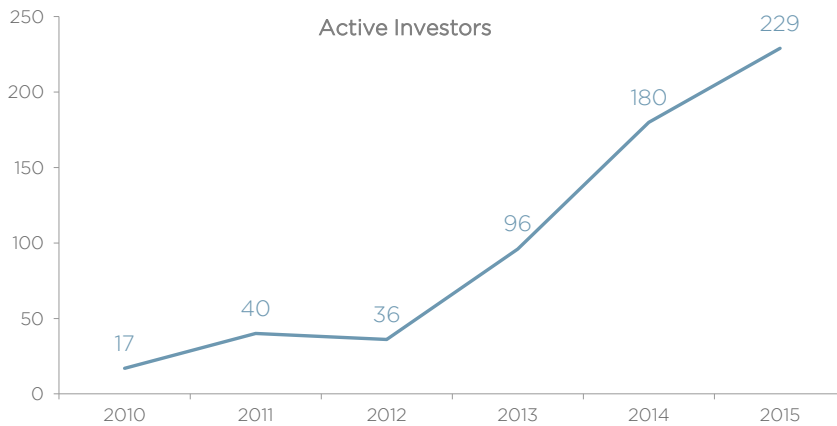
Rank	Investor	Number of investments
1	Rothenberg Ventures	12
2	River*	11
3	Intel Capital	10
4	Google Ventures	6
5	Partech Ventures	5
6	Qualcomm Ventures	5
7	Dolby Family Ventures	4
8	Formation 8	4
9	JAFCO	4
10	Andreessen Horowitz	3

*River is a program of Rothenberg Ventures

ACTIVE & NEW INVESTOR GROWTH

As we look to gauge investor interest in VR, both active investor and new investor counts have continued to rise over the past five years. 2015 has seen 229 investors close deals in the space thus far, a 27% rise over what we saw in 2014, and that number could move a bit higher by year close. Out of the 229 investors participating in 2015, 170 are actually new investors, a bump from the 156 new investors we saw involved in VR transactions in all of 2014. Since 2010, active investors have increased 13.5x while the quantity of new investors entering the space has jumped more than 14x. The figures re-emphasize the growing interest forming around the VR space. As total investors have grown exponentially over the past five years, the consistent up-tick in new investors is telling, pointing to the desire of investors looking to establish a presence in the space before values potentially skyrocket down the road.

229 investors have participated in VR transactions in 2015 to date, representing a 27% rise over the same measure in 2014 and a 13.5x jump from the quantity of investors active in 2010.



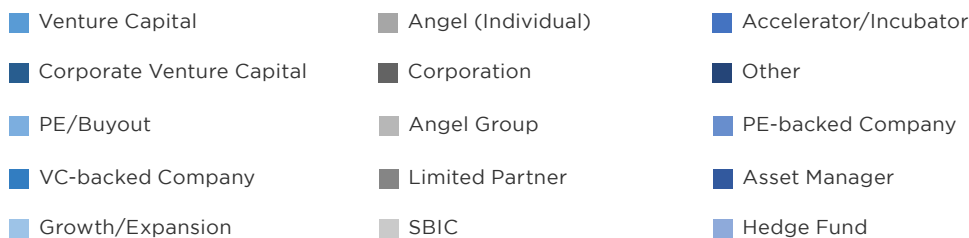
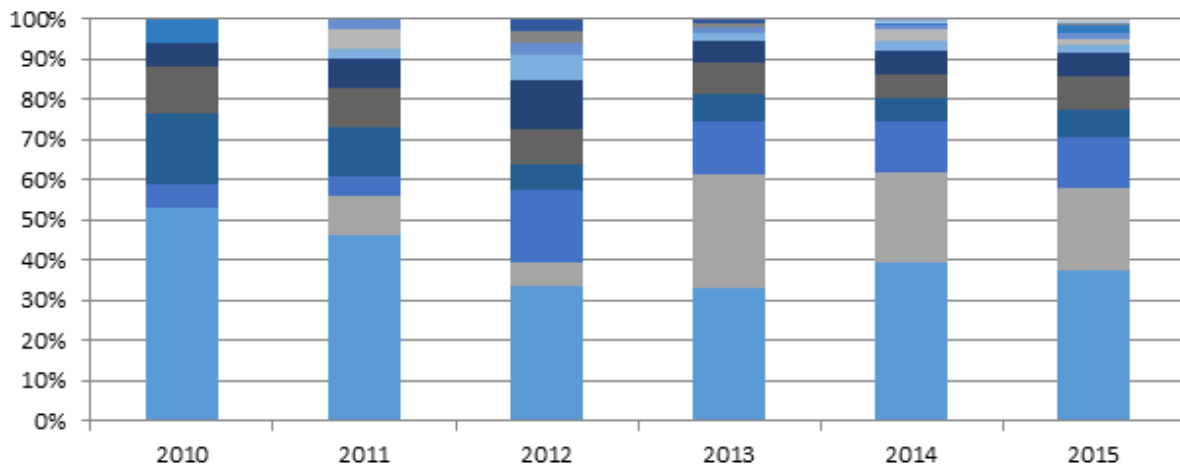
156 new investors participated in VR deals thus far in 2015, an 14x jump over 2010 figures.

INVESTOR TYPE

VCs certainly account for the majority of investors backing VR companies, yet corporate involvement has risen a noticeable amount. So far in 2015, corporations have accounted for 10.3% of all new participants making deals in the space, a noteworthy jump from the 6.7% of new investors corporates represented in 2014. Looking at active investors, growth has increased across various asset classes, with transaction counts from both traditional VCs and corporates growing by at least 8x since 2010, along with corporate VC activity jumping approximately 5x. VR is still an up-and-coming technology, and with that, it comes as no surprise that accelerators and incubator programs have also played a fairly significant role in helping these companies and founders build out. With only one company entering such a program in 2010, these investor types have been involved in no less than 26 deals in 2015.

In 2010, private equity firms did not play any part in VR deals, yet they too have begun to show signs of interest in the space. PE firms have been part of four deals in 2015 and invested in five in 2014. Participation from this asset class will be interesting to watch moving forward. As VR iterations improve, PE firms may be able to step in with an operational eye to help companies develop into prominent businesses, instead of only serving as technology developers. The most notable example of PE's involvement in the space is KKR's participation in the massive 2014 funding of Magic Leap.

PERCENTAGE OF ACTIVE INVESTORS



Market development & adoption

As we've surveyed players in the industry and continued to dive deeper into the current state of VR, the notion we keep hearing is that the recent and renewed interest in VR today holds more ground than ever before. In addition to early-enthusiast adoption and the traditional VC model of backing new and emerging techs, the groundwork appears to have finally been laid for VR to prosper and gain mass-market adoption. With that, the use cases, as touched on previously, have grown and VCs are ready and willing to deploy capital into the space. Various technology developments have allowed VR to be a realistic endeavor to chase, yet the growth of its content arm and ecosystem is what will allow it to take hold. Concerns and threats to the tech becoming adopted across mass markets are present, however, and we'll delve a bit into how VR as a platform will evolve in the coming years below.

TECHNOLOGY ADVANCEMENTS

During the 1990s, the hardware specs for an attractive and immersive VR experience simply weren't available. Latency was relatively high, the graphics were basic, and display resolutions certainly didn't allow for a truly authentic experience. As we've progressed, new products—primarily smartphones—have provided the necessary hardware components needed for a powerful experience to grow to a more than adequate performance and price level.

Mobile computer processing units (CPUs) have improved tremendously in recent years and will only continue to advance. Processing speed is vital in order for VR experiences to remain unbroken, which also helps protect against motion sickness that stems from increased latency. The faster the CPU helping to power an experience, the lower the lag, and thus experiences can remain immersive and realistic. We can see rapid improvements of mobile CPUs in the iPhone 6s that recently came to market. The phone contains Apple's third-generation A9 chip with 64-bit desktop-class architecture. According to the company, the A9 improves overall CPU performance by up to 70% compared to the previous generation.

Graphics processing units (GPUs) are also much faster today, and with the evolution of smartphones, GPU components are being mass produced at declining prices. As these components have become better and faster, VR developers are now able to re-purpose these parts to dramatically improve VR applications and mitigate against motion sickness and broken experiences. While the new A9 chip is designed to

Technology advancements have driven the VR resurgence, allowing for interactive and realistic experiences previously not possible.

A combination of better resolution screen displays with much-improved processing power and better GPUs are at the root of technological advancements supporting VR.

boost iPhone CPU performance significantly, GPU performance for the new iPhone is said to have improved by up to 90%. Apple also claims that the GPU in its last A8 chip was up to 84x faster than the original iPhone released in 2007. Clearly, the total technology of a smartphone and its related user experience is much different than that found in immersive VR, yet the rapid improvements Apple has been able to realize in both CPU and GPU speed only help support the ability of VR developers to utilize these components to provide better image rendering, faster refresh rates and better graphical experiences.

ADDRESSABLE MARKET ANALYSIS & CONCERNS

Various factors will prove significant in VR technology finally garnering mass-market adoption. We've seen addressable market figures span a wide range, encompassing either the entire VR/AR platform; single platform components such as hardware or software; and even narrower scopes that address just headset sales. We understand these are only estimates, but we think the market remains too premature to accurately predict average sales prices (ASPs) for certain products. Further, as ASPs will surely change over the next three to five years, these addressable market figures may not adequately account for these types of shifts. From a software perspective, developers and content creators are working hard to develop new and adaptive VR-friendly content. Outside of traditional sales and marketing efforts, however, new monetization schemes better suited for the VR experience are yet to be introduced, and before seeing these schemes, we believe it's too early to accurately gauge that market size. That being said, we do view current estimates valuable in attempting to gauge the monetary potential VR may have moving forward. Using a mean ASP of \$200, UBS has forecasted that annual device sales will reach roughly 34 million units by 2020, amounting to a VR hardware market of \$6.7 billion; the bank estimates VR software sales will grow to around \$3.3 billion by 2020. In another forecast, Piper Jaffray estimates the VR software market will reach \$5.4 billion by 2025, while the hardware market will grow to \$62 billion during that same period, estimating that close to 500 million headsets at a mean ASP of \$125 will be sold during that period. Both estimates were released in May 2015 reports.

From an investor's perspective, market sizes can be significant for more established industries that have comparable performance statistics, but again, that's just not there yet for VR. What we've gathered from VCs is that there is still uncertainty about precisely how large the VR market will become, but the pieces for a proper ecosystem to build out, along with the proper technology to make VR experiences what they're made

Hardware has paved the way for VR, yet content will drive mass-market adoption.

out to be, is legitimately present today. With that conviction, VCs believe the future market size will be big enough to justify significant investment into the space.

CONTENT CREATION

The growth and evolution of hardware components have clearly paved the way for VR today, yet we believe the software and content component of the platform is what will drive mass-market adoption going forward. Most analysts, journalists and others covering the space agree that gamers and early-adopter enthusiasts have driven the initial wave of interest, but that market certainly does not constitute the “mass.” Further, the associated costs with the first wave of tethered VR experiences targeting the gaming market will price out many individuals interested in the tech. As the platform builds out, pre-rendered or pre-produced content across traditional fields such as film, music videos and concerts, among other forms of entertainment, will be able to draw interest from groups looking to complement their passions in those categories via VR. Further, the ability to stream live content through HMDs is also available today as we’ve seen with the initiatives brought forward by NextVR. Fans will be able to sit courtside at an NBA game, midfield at a UEFA Champions League match, or front row at a Coldplay concert for a fraction of the price. Content creators will be able to monetize these experiences uniquely, as well. As mentioned, examples can include in-app purchases in order to view an event from a different viewing angle, or the option to purchase certain visual overlays. The industry is working hard to provide these content offerings, and as they continue to get better, VR will draw significant interest from various target audiences who will view VR as a necessary complement to enjoy their existing passions and interests.

Computing platform specifications may hinder adoption in certain use cases due to cost.

ADOPTION RISKS

As 2016 comes around, we see the total experience costs hindering adaptation and mass-market acceptance through the year. The audience has to grow past the gaming community, but VR technology is currently best equipped and suited for that market. If you consider the specs recommended for computing platforms powering tethered and immersive VR experiences, the graphics cards alone cost around \$300 to \$400 at the low end—this translates into sophisticated computers costing easily over \$1,000 to support VR. According to a recent Valve hardware survey, only roughly 8% of its users currently meet or exceed those recommended specs. Valve’s gaming engine, Steam, boasts approximately 125 million users, thus, doing the math, you

end up with just 10 million individuals that can adequately utilize a VR headset. As is often the case with new technologies, many will choose to upgrade their computing platforms to support VR applications, but many won't, and just because certain individuals currently meet the computer specs recommended, that won't necessarily translate into HMD purchases. Oculus has mentioned, however, that it intends to keep the recommended specs the same moving forward, so over the next two to five years, component prices should continue to decline and the necessary computing platforms will also decline in price. As that unfolds, we should see more interested parties transform into paying users.

Oculus is certainly the darling of the industry right now, yet HMDs such as Sony's Project Morpheus may actually allow for better acceleration of VR adoption due to their respective computing platforms. Project Morpheus is powered by Sony's PlayStation 4, which has sold over 20 million units worldwide. If 15% of PS4 owners were to purchase a PM headset as the first iteration comes to market—which would be extremely impressive and unlikely—that would equate to around 3 million units sold next year. However, for new users, paying \$350 versus over \$1,000 for a VR-supportive computing platform (Oculus and Vive) is much more reasonable and certainly an important factor in driving sales of Sony's HMD.

We think mobile and untethered experiences will drive VR adoption forward at a faster rate than traditional tethered VR applications, but not until major consumer-ready HMDs hit the market in 2016.

MOBILE VR ADOPTION

Untethered VR experiences will be significant in driving the technology forward for a variety of uses on its own. Pricing is the first. For example, the Oculus-powered Samsung Gear was introduced last year at a price point of \$199. Users were able to purchase that headset and use their Galaxy 5 mobile phone as the display and computing platform. Only one year later, the price point on that same headset has already dropped to \$99 and can now be used across multiple Samsung smartphones. In addition to price, untethered experiences allow for increased user flexibility and mobility. A user sitting on a plane or train can easily use a mobile headset, not so much a traditional tethered HMD with various cords needing to be attached to a nearby computing platform. Marriott experimented with the Samsung Gear in certain properties last year, allowing guests to check out a headset and immerse themselves in another environment. Logistics for that type of service would be fairly difficult using tethered headsets.

Mobile, untethered VR experiences will be vital, but the challenge will be developing the technology to a point where mobile phones, or built-in computing platforms, can allow for lowered latency, faster image

processing and other features that sophisticated computers handle much better. Further, content creators on the gaming side (the early adopters) could find struggles developing for mobile, not from a technological perspective but from a sales and margins perspective. Mobile applications can cost between nothing and a few dollars in the U.S., while video games today are selling for well over \$40 to \$50. With market penetration still uncertain, gaming companies may remain hesitant for some time before making any significant capital investments into mobile development, instead choosing to develop for console-powered experiences and tethered VR use cases. Over time, however, this will shift. While tethered VR applications will likely remain of strong interest for the enthusiast-focused market, the casual user base and consumer group will certainly drive the mobile side of VR due to reduced barriers from price and accessibility.

Looking outside of the gaming lens, mobile content players able to develop, create or host interactive pre-rendered content, or power live streams, will be able to penetrate the consumer market at a faster pace. “Content is King.”

PERIPHERAL EQUIPMENT & ECOSYSTEM

A testament to the growing VR ecosystem is the increased level of peripheral equipment being built and developed to accompany HMDs. Typically in the form of control inputs, products such as the motion-tracking treadmill by Virtuix, or the sensor-driven Myo Armband, which monitors arm muscles to enable the hand to act as a control input, provide better total user experiences than headsets alone. For investors looking to enter the complementary space of VR peripheral equipment, risks are certainly still present, primarily as it pertains to general production. With these components, companies are looking to not only perfect a physical product but also an attached user experience. As these companies continue to iterate and improve from both perspectives, this can become a fairly capital-intensive process and additional expenses should be expected.

As users begin adapting to VR, another market opportunity that will be interesting to monitor relates to the development of tools that allow for content creation or increased engagement once in a VR environment. This can be especially important for niche enterprise use cases such as construction or architectural applications. An example of this comes from Tilt Brush, a Google-backed company that has developed a VR tool that allows users to paint in 3D. Tilt Brush is compatible with the rudimentary but still-impressive Google Cardboard headset and serves as a great example of the types of tools that can be formed.

Select company profiles

OCULUS VR

Location: **Menlo Park, CA** | Year Founded: **2012** | Capital Raised to Date: **\$2.1B***
First Funding Date: **September 2012** | First Funding Amount: **\$2.4M**
Latest Funding Date: **June 2014** | Latest Funding Amount: **\$2.24B**

Acquired by Facebook in a \$2 billion+ cash-and-stock deal, Oculus put the resurgence of VR in the limelight. Emerging out of an initial \$250,000 Kickstarter campaign that ended up raising nearly 10x that target, Oculus has developed a fully immersive tethered VR HMD that will likely be the most heavily used and most capable headset in the consumer market, the Oculus Rift. Although the computing platform specifications needed to adequately power experiences in the rift may create barriers to entry for the casual user, Oculus has also invested to build out a complete VR platform spanning control inputs, content creation and partnerships, along with its own proprietary headset. At the beginning of this year, Oculus announced Oculus Story Studio in order to develop VR films, an effort “designed to inspire and educate—inspire by making awesome movies and educate by sharing our information with the community,” as stated by Story Studio producer Edward Saatchi in a WSJ interview. On the partnerships front, Samsung’s Gear VR, a mobile and untethered HMD, is powered by Oculus. Shortly after the FB acquisition, the company acquired the makers of the Xbox controller and has since developed a new set of control inputs, used by each hand independently. Oculus has also maintained a relatively open platform from the beginning and sold over 175,000 software developer kits across its DK1 and DK2.

*includes FB acquisition amount

MAGIC LEAP

Location: **Dania Beach, FL** | Year Founded: **2012** | Capital Raised to Date: **\$593.72M**
First Funding Date: **July 2012** | First Funding Amount: **\$20.42M**
Latest Funding Date: **October 2014** | Latest Funding Amount: **\$542M**

“Anything you can do on your smartphone, on your computer, you’ll be able to do on Magic Leap,” said chief content officer Rio Caraeff in a WSJD Live interview. While secretive in nature, the company appears to be the leader in augmented reality, developing a headset or device able to project holographic image overlays onto the user’s real-world environment. According to demos the company has posted recently,



Magic Leap is gearing toward overlaying not only everyday necessities such as email, or video streaming onto one's natural environment. It is also looking to tackle gaming experiences in the same realm. Job postings for the company consist of manufacturing managing directors and senior/lead gaming engineers, pointing to the company's focus on hardware, software and content. However postings for an experienced licensing attorney and a director of government relations responsible for providing consultancy on a broad range of federal legislative, regulatory and policy issues affecting the company point to uncertain initiatives and boundaries the Magic Leap's tech is looking to push. The AR player is reportedly in talks with Alibaba and other undisclosed investors to raise an estimated \$1 billion in new funding.

JAUNT VR

Location: **Palo Alto, CA** | Year Founded: **2013** | Capital Raised to Date: **\$101.34M**
First Funding Date: **April 2014** | First Funding Amount: **\$6.8M**
Latest Funding Date: September 2015 | Latest Funding Amount: **\$66.7M**

Focused on cinematic virtual reality, Jaunt has created an end-to-end solution for creating and distributing premium live-action VR. Their latest \$65 million funding round will be used to help the company scale VR production and advance their professional-grade camera hardware and software production tools used to deliver content to the wide array of mobile devices and VR hardware in the industry. Jaunt recently announced the launch of a series of professional-grade camera systems specifically designed for capturing fully immersive, 360-degree cinematic VR experiences codenamed "NEO." The company looks to supplement this hardware with its own content arm, Jaunt Studios, which seeks to develop professional-grade VR content.



NEXT VR

Location: **Laguna Beach, CA** | Year Founded: **2009** | Capital Raised to Date: **\$36M**
First Funding Date: **September 2014** | First Funding Amount: **\$5.5M**
Latest Funding Date: November 2015 | Latest Funding Amount: **\$30.5M**

NextVR aims to enable the transmission of live, long-form virtual reality content in broadcast quality. The California-based company has more than 26 patents granted or pending, and is seeking to transform live and on-demand VR into a mainstream experience for sporting events, concerts, cinematic productions and more. NextVR's platform allows for fully immersive content to be streamed with pristine quality using current home and mobile internet connections, while also seeking to offer content via all major consumer HMDs, including the Oculus Rift, Samsung Gear and HTC-Valve's Vive.

VIRTUIX OMNI

Location: **Austin, TX** | Year Founded: **2013** | Capital Raised to Date: **\$7.88M**

First Funding Date: **June 2013** | First Funding Amount: **\$300,000**

Latest Funding Date: August 2015 | Latest Funding Amount: **\$880,000**

Similar to many other VR-focused companies, Virtuix emerged out of a successful Kickstarter campaign. After raising \$1.1 million via Kickstarter, it has gone on to receive nearly \$8 million in funding from various private investors including Scout Ventures and Mark Cuban. The company has developed the Virtuix Omni, a VR interface and treadmill that allows users to move freely and naturally while in a virtual environment. In addition to the treadmill, which can be pre-ordered for \$699, Virtuix also offers Omni Shoes that have a proprietary low-friction shoe sole with an engineered sole configuration that stabilizes the foot and enables a natural gait when using the Omni. The shoes retail for \$59 and are required to use the treadmill. Other products include IMU-based tracking devices named Omni PODs (\$79) that attach to the Omni Shoes and aim to track the movement of each foot without noticeable latency. As we've noted that control inputs will be vital in the growth of the VR ecosystem, Virtuix is making a compelling argument to be one of the front runners in that sub-space, as the company has not only built an input that can accompany a wide array of VR content, but is on the right path of building its own respective ecosystem and platform, offering additional inputs (shoes, harness, tray, etc.) that complement its flagship treadmill. Pre-orders are being accepted.



AVEGANT

Location: **Redwood City, CA** | Year Founded: **2012** | Capital Raised to Date: **\$37M**

First Funding Date: **November 2013** | First Funding Amount: **\$2.1M**

Latest Funding Date: August 2015 | Latest Funding Amount: **\$24M**

Avegant has developed a virtual retinal display technology that interacts with the eye the way that it naturally functions. Utilizing micro mirror technology, the virtual retinal display projects images directly onto the retina, creating a much more vivid and lifelike image. Its flagship product, The Avegant Glyph, combines the technology along with a combination of optics to reflect an image directly onto the retina, effectively using the back of the eyeball as a screen. It uses an HDMI input to display anything in the user's content library, including already owned movies and games to streamed content, over smartphone or computer. Initially intended for military use, the company later realized a plethora of other use cases and the ability for developers to develop both VR and AR experiences for the headset. Avegant has estimated a consumer-ready beta version of its device to be ready in the fall of this year, but we've still yet to see the product shipped—pre-orders are being accepted.



HTC VIVE (HMD)

The Vive is an HMD developed in conjunction with game developer Valve and consumer electronics manufacturer HTC. The device is powered by Valve's SteamVR, a full-featured, 360-degree, room-scale VR experience. The Vive is comprised of a 1200x1080 pixel screen in front of each eye and has a refresh rate of 90Hz. The collaborations comprised of the hardware expertise of an HTC with the content creation expertise of a Valve allows for an interesting and likely efficient partnership. The two are also already working with a wide range of partners such as HBO, Lionsgate and Google to develop intriguing Vive-specific experiences. With over 125 million active accounts on the company's traditional Steam entertainment and gaming platform, SteamVR will look to leverage a pipeline direct to its customers to allow for similar connectivity to power and enjoy VR applications on the Vive as Steam does for existing Valve games.



ALTSPACEVR

Location: **Redwood City, CA** | Year Founded: **2013** | Capital Raised to Date: **\$15.7M**
First Funding Date: **September 2014** | First Funding Amount: **\$5.2M**
Latest Funding Date: July 2015 | Latest Funding Amount: **\$10.3M**

AltspaceVR is a VR software company bringing two-dimensional web content into shared virtual spaces and extending the web to create fully holographic experiences. In AltspaceVR, users can meet from any remote locations to play games, stream content or share various webpages. The company announced the availability of its SDK in September, which seeks to simplify the creation of VR applications for developers by allowing them to convert existing 3-D websites or to create new experiences using JavaScript and three.js.

LENSAR

Location: **Orlando, FL** | Year Founded: **2004** | Capital Raised to Date: **\$191.1M***
First Funding Date: **February 2005** | First Funding Amount: **\$350,000**
Latest Funding Date: January 2015 | Latest Funding Amount: **\$16M**

Lensar provides femtosecond laser technology for refractive cataract surgery. The company's imaging system collects a wide spectrum of biometric data and then reconstructs a 3-D model of the true anatomy of each individual patient's eye using proprietary augmented reality technology. Lensar then uses that AR image to categorize the cataract density.

*Excludes \$59M acquisition agreement

Special thanks

This is the first of a series of analyst reports we are looking to bring forward on young and emerging technologies, among other topics. We were able to connect with a number of clients and other contacts to help better inform our understanding of the VR space, and we'd like to give a special thanks to VCs including Sapphire Ventures, Vectr Ventures, Andreessen Horowitz, Scout Ventures and Kleiner Perkins, as well as Schell Games and Presence Labs for their contributions. We hope this report has helped influence your understanding of this young and upcoming sector and please feel free to reach out with any comments, questions or suggestions.

