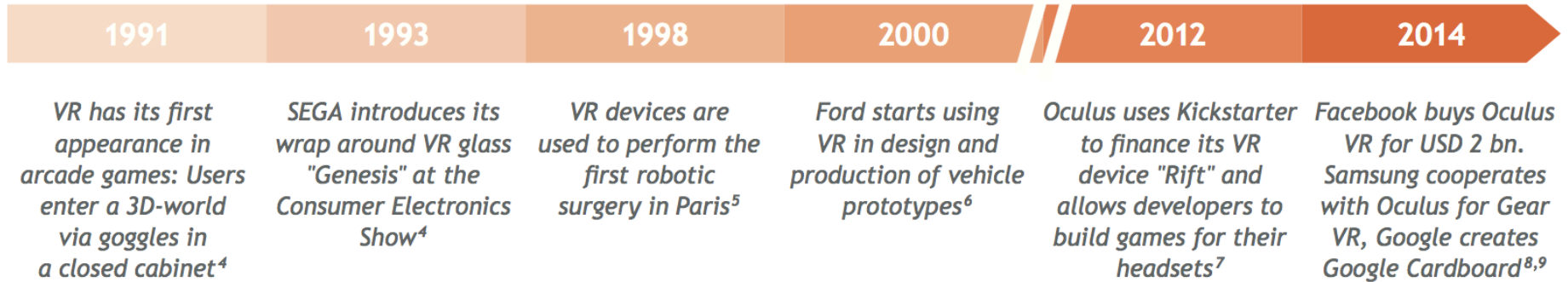


VIRTUAL REALITY HEADSETS

LILY CHIANG



VR HISTORY



- **Many companies (Virtuality, Sega, Atari, Sony) jumped on the VR hype in the 1990s; but commercialization flopped because both hardware and software failed to deliver on the promised VR vision.**
- **Any use of the VR devices in the 2000s was limited to the military, aviation, and medical industry for simulation and training.**
- **VR hype resurged after Oculus successful KickStarter campaign; subsequently acquired by Facebook for \$2.4 bn.**
- **Investments rushed into the VR industry as major tech firms such as Google, Samsung, and Microsoft and prominent VC firms bet big on the VR revolution.**

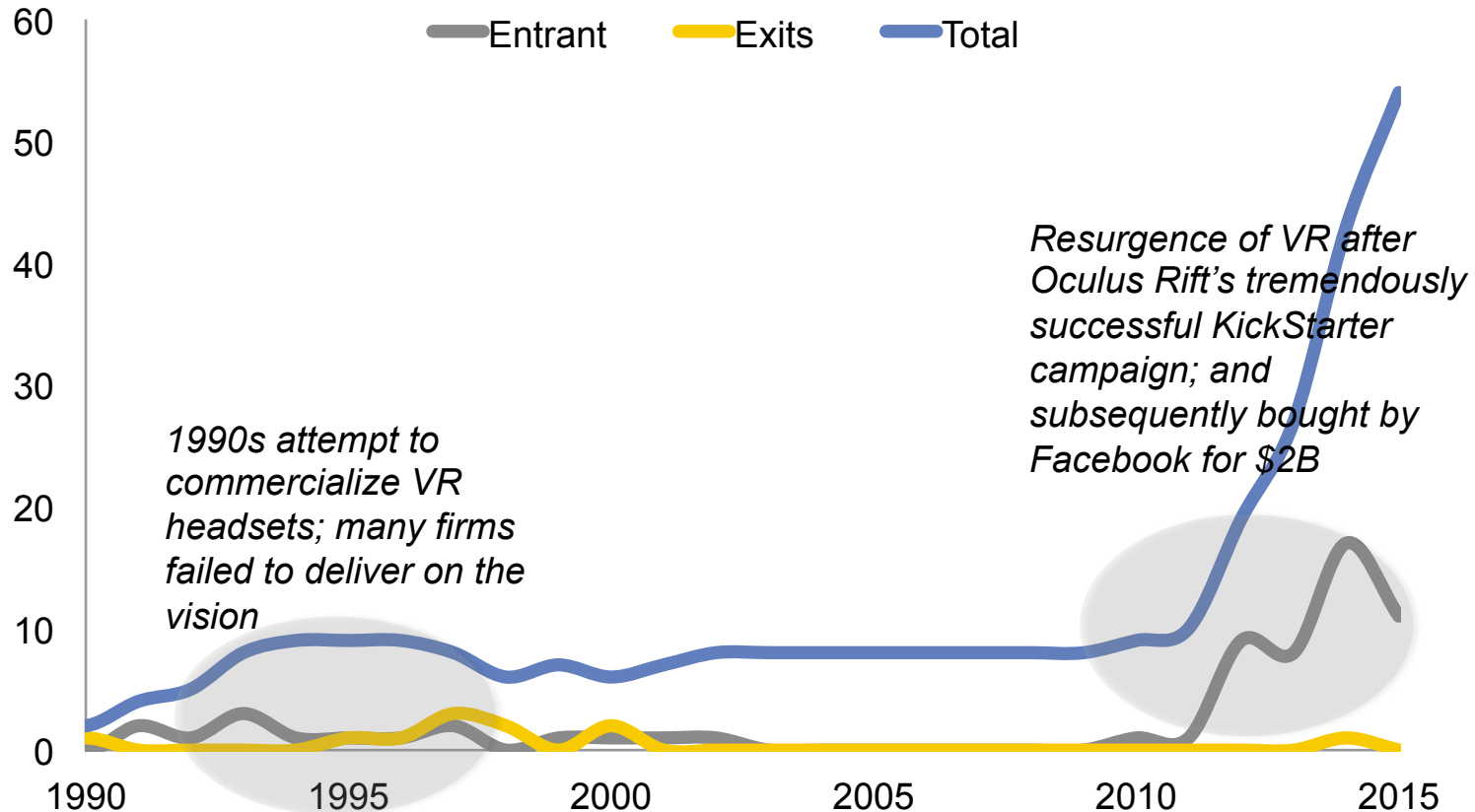
LIST OF VIRTUAL REALITY HEADSET FIRMS

Company Name	Entered	Exited	Disposition
LEEP Optics	1979	1998	Bankrupt
VPL Research Division Group LTD	1984	1990	Bankrupt
Sega VR	1989	1999	Acquired
Virtuality	1991	1994	Bankrupt
VictorMaxx	1991	1997	Acquired
Atari Jaguar VR	1992	1998	Bankrupt
Virtual I-O	1993	1996	Discontinued
eMagin	1993	1997	Bankrupt
Virtual Boy	1993		Ongoing
Forte	1994	1995	Discontinued
Sensics dSight	1995	1997	Acquired
Sony Glasstron	1996		Ongoing
Philips Scuba	1996		Ongoing
Vuzix	1997	2000	Discontinued
MindFlux	1997	2000	Discontinued
N-vision	1999		Ongoing
Cinemizer	2001		Ongoing
Pinch VR	2002		Ongoing
Light & Shadow NEO	2008	2014	Discontinued
MagicLeap	2008		Ongoing
Atheer One	2009		Ongoing
Oculus Rift	2010		Ongoing
Avegant Glyph	2011		Ongoing
Seebright	2012	2014	Acquired
MindMaze	2012		Ongoing
NeuroGoggles	2012		Ongoing
MetaVR	2012		Ongoing

Company Name	Entered	Exited	Disposition
Meta			
SpaceGlasses	2012		Ongoing
Sulon Cortex	2012		Ongoing
Epson Moverio BT-200	2012		Ongoing
i2i iPal	2012		Ongoing
Star VR	2013		Ongoing
Durovis Dive	2013		Ongoing
Vrizzmo	2013		Ongoing
CastAR	2013		Ongoing
VRase	2013		Ongoing
Yay3d VR	2013		Ongoing
Refugio 3D	2013		Ongoing
Xcope	2013		Ongoing
FOVE VR	2014		Ongoing
Zeiss	2014		Ongoing
HTC Vive	2014		Ongoing
Samsung GearVR	2014		Ongoing
Google Cardboard	2014		Ongoing
Sony Morepheus	2014		Ongoing
Visus VR	2014		Ongoing
Homido	2014		Ongoing
VRTX One	2014		Ongoing
GameFace Labs			
Mark V	2014		Ongoing
Merge VR	2014		Ongoing
Vrelia	2014		Ongoing
ANTVR Kit	2014		Ongoing
VRVANNA Totem	2014		Ongoing

Company Name	Entered	Exited	Disposition
Altergaze	2014		Ongoing
Archos VR	2014		Ongoing
AirVr	2014		Ongoing
360Specs	2014		Ongoing
Microsoft			
Hololens Systems	2015		Ongoing
Razr OSVR	2015		Ongoing
Cmoar	2015		Ongoing
Dior Eyes VR	2015		Ongoing
Impression Pi	2015		Ongoing
VR Union Claire	2015		Ongoing
Xingear XG	2015		Ongoing
Seer	2015		Ongoing
Dscvr	2015		Ongoing
Wearality Sky	2015		Ongoing
ViewMaster VR	2015		Ongoing

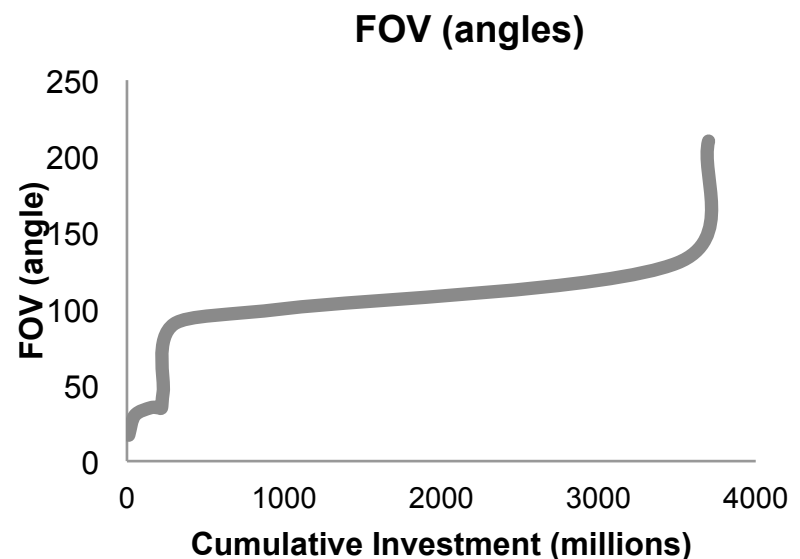
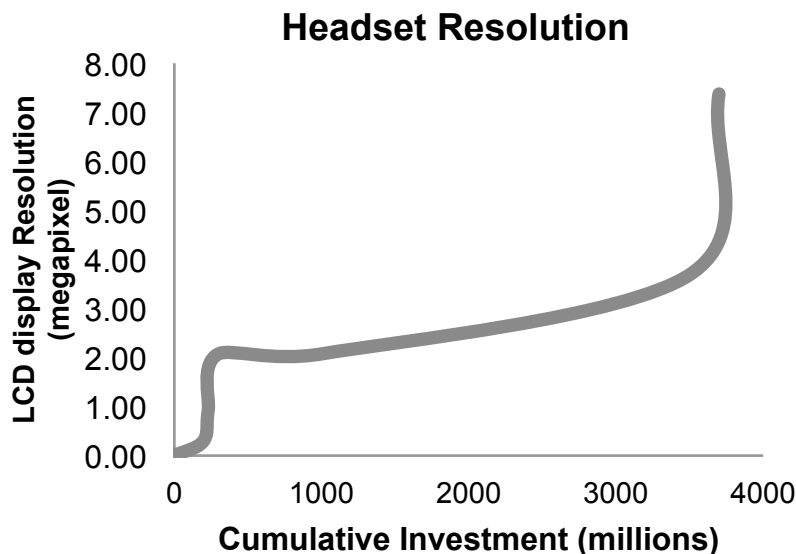
VR SHAKEOUT TO BE DETERMINED WITH RUSH OF NEW ENTRANTS



Note: The company data are gathered from various sources such as Crunchbase, Wikipedia, Kickstarter, news articles, and company websites. Since there is no publicly available free VR database and companies are constantly entering the space, the graph might not capture all the activity. However, the general shape of the graph is correct. Perhaps, the rise and fall of 1990s is more pronounced and the slope of the increase over the last 2 years is even steeper.

PERFORMANCE CURVE

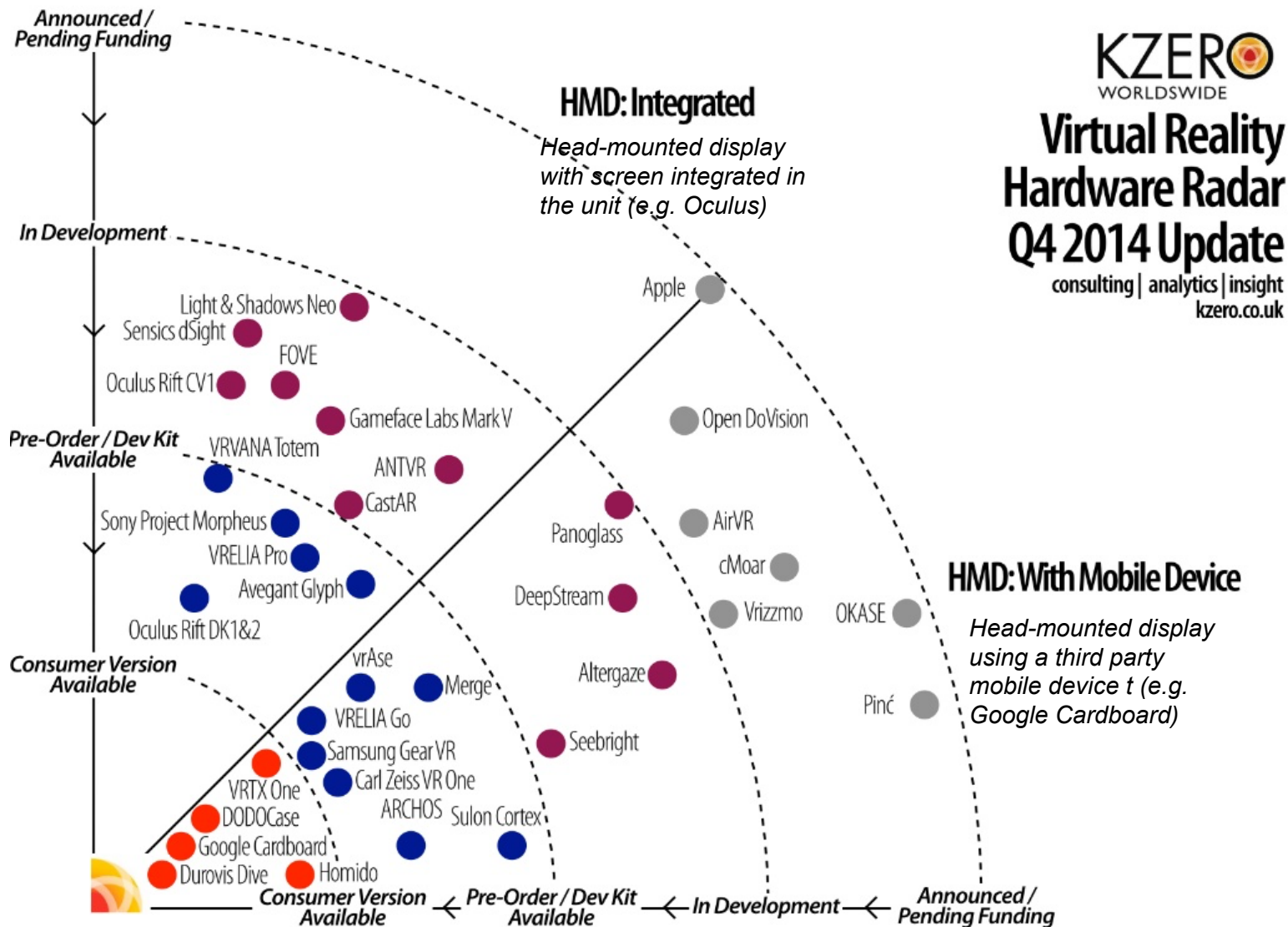
- **Performance of VR headsets are determined by number of factors such as the resolution of the screen, field of view, latency, refresh rates, and sensor accuracy**
 - Ideal performance: 10K resolution per eye, 2ms persistence pixels on screen, 20ms latency, 160 degree FOV, 120hz refresh rate, 1mm head tracking accuracy
- **Two performance measures, resolution and field of view (FOV), are shown below based on cumulative investment.**
 - Major investment by Facebook in 2014 for Oculus
 - Improvement in resolution is not limited to VR investments because there are also general investments in display resolution for use in computers and phones
 - Field of View (FOV) is the extent of the observable world is viewable. Humans has a FOV of 180 degrees`



CURRENT PERFORMANCE SPECS FOR POPULAR HEADSETS

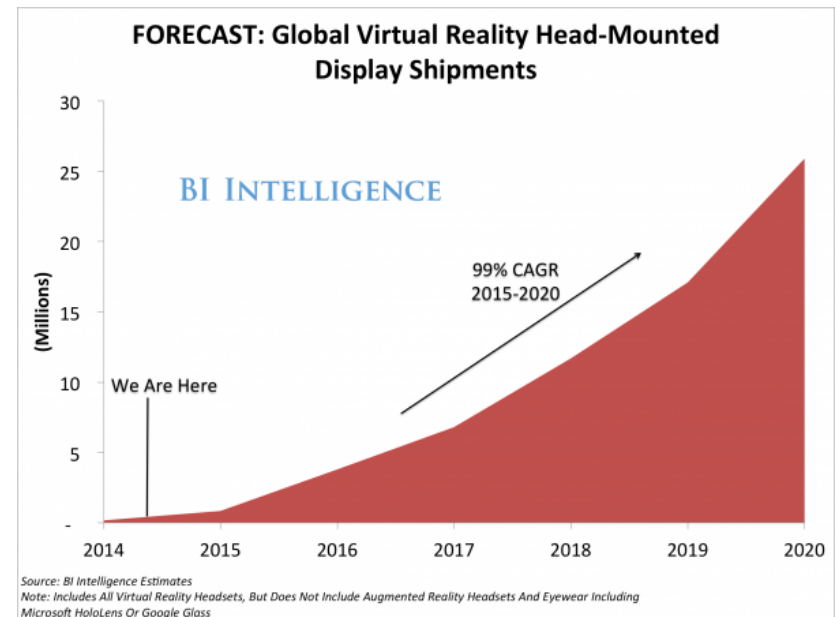
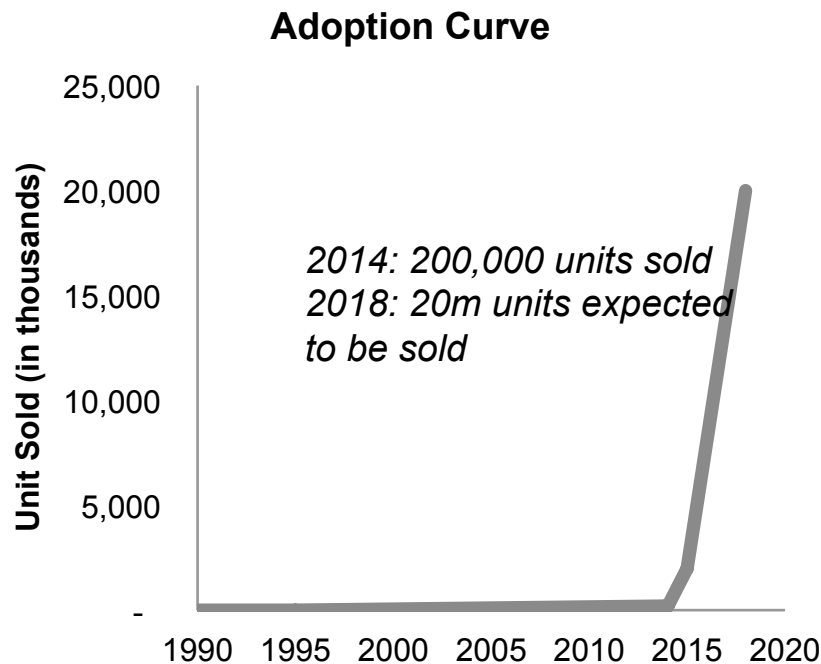
	Oculus DK1	Oculus DK2	Oculus DK3	Morpheus	Vive	Gear VR
Resolution	640x800	960x1080	1280x1440	960x1080	1200x1080	1280x1440
Screen type	LCD	OLED	OLED	OLED	OLED	Super AMOLED
Field of view	110°	100°	100°	100°	110°	96°
Persistence	3ms Full	2ms low	2ms low	2ms low	2ms low	2ms low
Motion Latency	60ms	Sub 20ms	Sub 20ms	Sub 18ms	Sub 20ms	Sub 20ms
Refresh rate	60Hz	90Hz	90Hz	120Hz	90Hz	60Hz
Tracking tech	3 Axis Orientation	90° Infrared Camera	90° Infrared Camera	360° LED Tracking	360° Lighthouse Infrared	3 Axis Orientation
Accuracy	Millimeter	Sub-millimeter	Sub-millimeter	Sub-millimeter	Sub-millimeter	Millimeter
Release date	Late 2012	Mid 2014	Mid 2015	Early 2016	Spring 2015	Late 2014
Audio	No audio	No audio	On device audio	On device audio jack	On device audio jack	On device audio jack

COMPETITION IS FIERCE TO BRING VR HEADSETS TO THE CONSUMER



ADOPTION FOR VR IS FORECASTED TO GROW SIGNIFICANTLY

- Future is very bright for the VR headset market; Business Insider estimate the market to grow at 99% CAGR, creating a \$2.8 bn hardware market by 2020.
- VR headset prices are expected to drop from \$300 to \$50 dollars to facilitate faster consumer adoption.
- Devices powered by Mobile is expected to account for 90% of all VR headset sales in 2018 according a CCS report



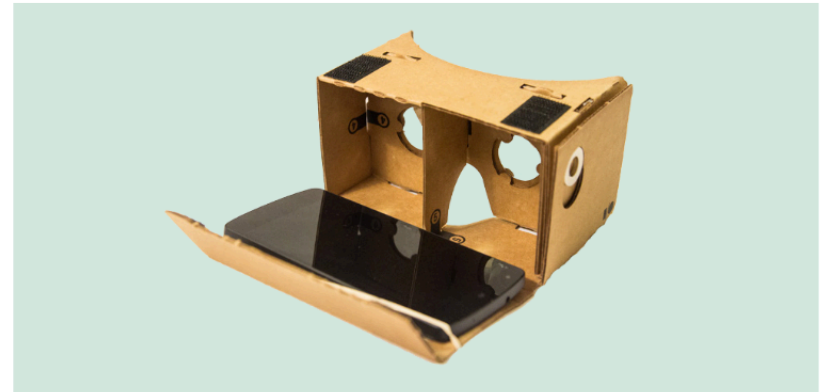
DOMINANT DESIGN HAS EMERGED FOR VR HEADSETS

HEAD MOUNTED DISPLAY



- High resolution LCD
- Head/motion sensor devices (e.g. Gyroscope, accelerometer)
- Computer to power all the graphics and support stereoscopic 3D viewing
- Strap to keep device on as goggles
- Ports to connect other devices (e.g. USB, HDMI, etc.)
- Optional audio speaker for sound

SMARTPHONE EXTENSIONS



- Contraption to hold the mobile device
- Lens for turn mobile device to a virtual reality headset
- Strap to keep device on head as goggles

VR HEADSET CATEGORY IS STILL NASCENT

- **High enthusiasm for the VR headset category**
 - High number of entrants are still entering
 - Consolidation has yet to start
- **Push Innovation**
 - No clear wide market application of VR device except for gaming
 - VR software and content need to develop concurrently in order for the VR market to realize its potential
- **No major disruptive technology to the category**
 - However, Google Cardboard could be viewed as a “disruption” because it impacts existing VR hardware firms asset and capabilities.
 - Google Cardboard is \$30 vs. Integrated headsets are \$300; The price differential could shift user adoption away from high cost integrated VR headsets.

VR HAS POTENTIAL TO CHANGE MANY INDUSTRIES

- **Gaming:** Immerse gamers with more realistic representation and improve the game experience significantly
- **Media & Advertising:** Generate new ways of interactive advertising which puts the user directly in contact with the brand
- **Entertainment:** Create new form of media that enriches the users viewing experience; potential to replace TV
- **Sales & E-commerce:** Enable new ways to sale for items that are hard to visualize remotely
- **HR & Training:** Conduct realistic training through virtual simulation
- **Tourism:** Create innovative ways for users to explore the world