



# INTRODUCTION TO VIRTUAL AND AUGMENTED REALITY

## Lecture 1

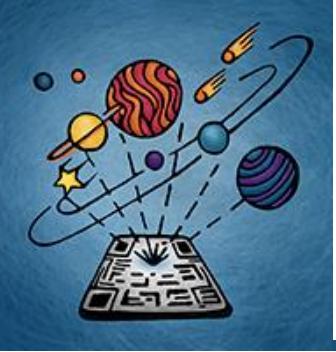
RVAU - Realidade Virtual e Aumentada - EIC0070

2019/2020 - 1S

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(adaptado de slides Rui Nóbrega, A. Augusto Sousa)

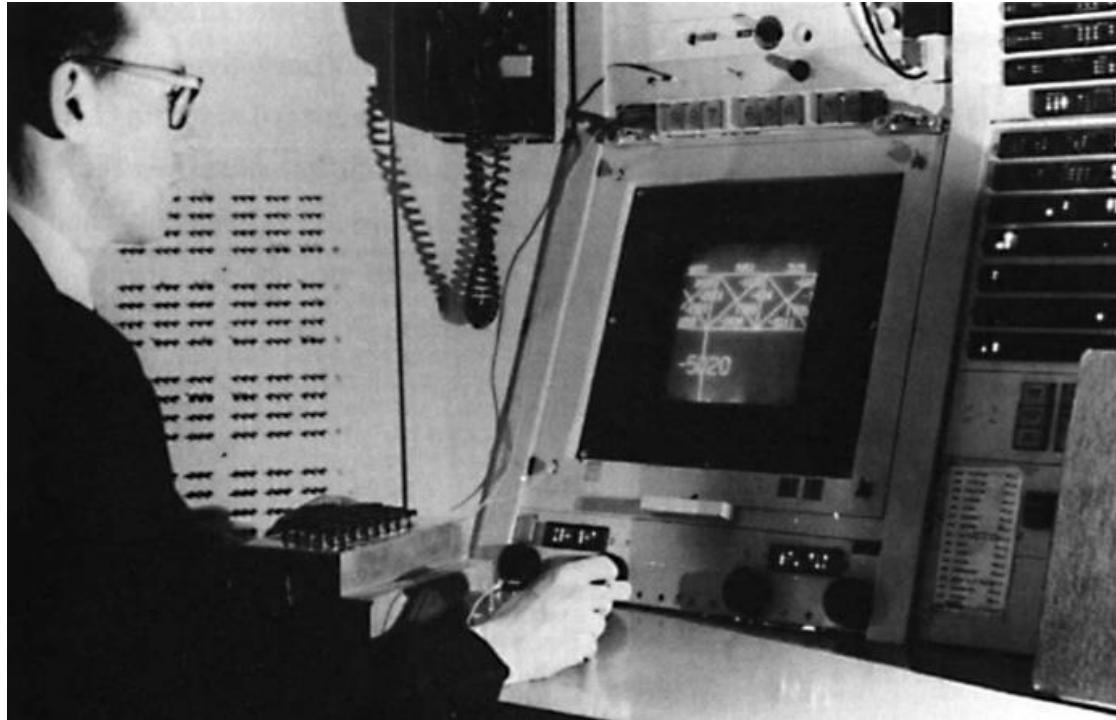


# VIRTUAL REALITY

- Slides based on Mark Billinghurst's slideshare
  - The VR Book chapter 1



# Ivan Sutherland (1963)



- Sketchpad (PhD thesis) – first interactive graphics program
- Pioneered the way for HCI
- The Graphical User Interface (GUI) was derived from the Sketchpad
- <https://youtu.be/YB3saviltTI>



# The Ultimate Display

*“The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal”.*

Ivan Sutherland, 1965



# Holodeck (1974)

The ultimate display in sci-fi



- First shown in Star Trek; The Animated Series



# HoloDeck Video



- <https://www.youtube.com/watch?v=oZwtVz7z0wM>



# Modern computers – turning point

## IBM-1401 (1959)



- In mid-1960s IBM-1401 type systems represented **half of the computers in the world**
- “**low-cost**” – US\$2,500 rental cost (around \$21,000 today)
- Mass-produced: over 12,000 units produced
- Internal architecture similar to modern computers



# The Disappearing Computer



1960-70's

Room



1970-80's

Desk



1980-90's

Lap



1990-2000's

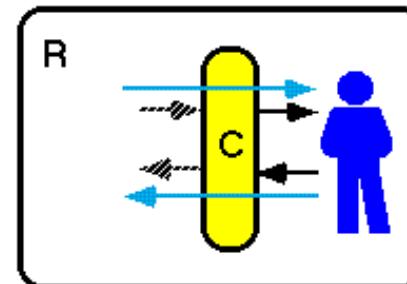
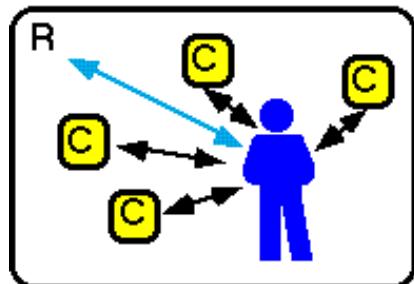
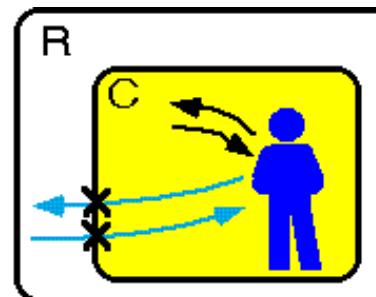
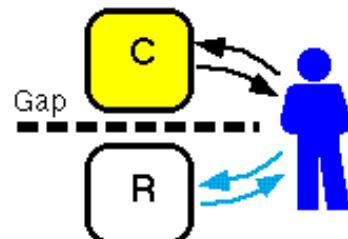
Hand





# HCI Styles

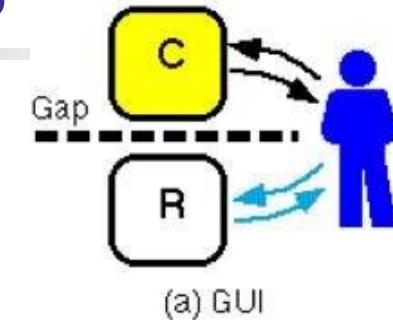
## Making Interfaces Invisible



Rekimoto, J. and Nagao, K. 1995. The world through the computer: computer augmented interaction with real world environments. In *Proceedings of the 8th Annual ACM Symposium on User Interface and Software Technology. UIST '95*. ACM, New York, NY, 29-36.



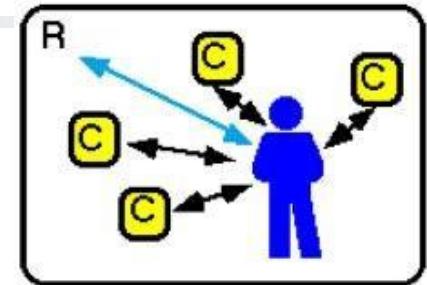
# Graphical User Interfaces



- Separation between real and digital worlds
- WIMP (Windows, Icons, Menus, Pointer) metaphor



# Ubiquitous Computing/IoT



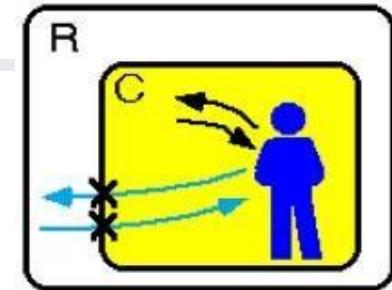
(c) Ubiquitous Computers



- Embed computing and sensing in real world
- Smart objects, sensors, etc..



# Virtual Reality



(b) Virtual Reality

- Users immersed in Computer Generated environment
- HMD, gloves, 3D graphics, body tracking



# What is Virtual Reality?

## virtual reality

*noun*

### Simple Definition of VIRTUAL REALITY

Popularity: Bottom 40% of words

: an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it

Source: Merriam-Webster's Learner's Dictionary



# What is Virtual Reality?

- VR is commonly used by popular media to describe imaginary worlds that only exist in computer and our minds
  
- “Virtual Reality is defined to be a computer-generated digital environment that can be experienced and interacted with as if that environment were real”,  
The VR Book



# Typical VR System



<https://www.youtube.com/watch?v=eJCIyf8Kn9w>



# Many Other Definitions

**Virtual reality is..**

*...a computer technology that replicates an environment, real or imagined, and simulates a user's physical presence and environment to allow for user interaction.* (Wikipedia)

*...electronic simulations of environments experienced via head mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations.* (Coates, 1992)

*...an alternate world filled with computer-generated images that respond to human movements.* (Greenbaum, 1992)

*...an interactive, immersive experience generated by a computer* (Pimental 1995)

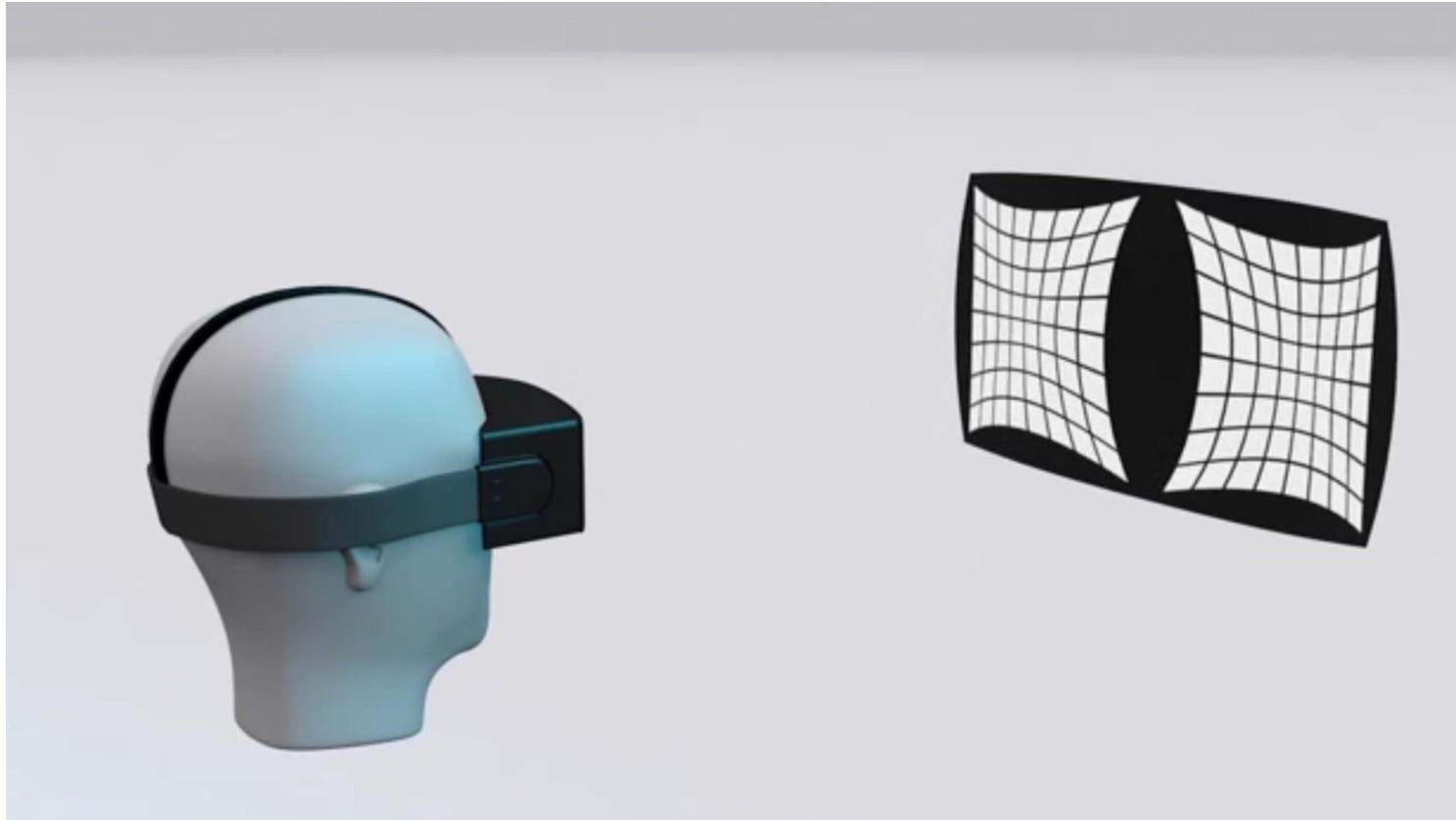


# Key Characteristics for VR

- Virtual Reality has three key characteristics
  1. 3D stereoscopic display
  2. Wide field of view display
  3. Low latency head tracking
- When these three things are combined they provide a compelling immersive experience



# Defining Characteristics



- <https://www.youtube.com/watch?v=FPcbBJbGhmk>



# VR Experience



- “ELDERS REACT TO OCULUS RIFT”
- [https://www.youtube.com/watch?v=hZ8Xj\\_I3aNU](https://www.youtube.com/watch?v=hZ8Xj_I3aNU)



# Defined in Terms of Presence

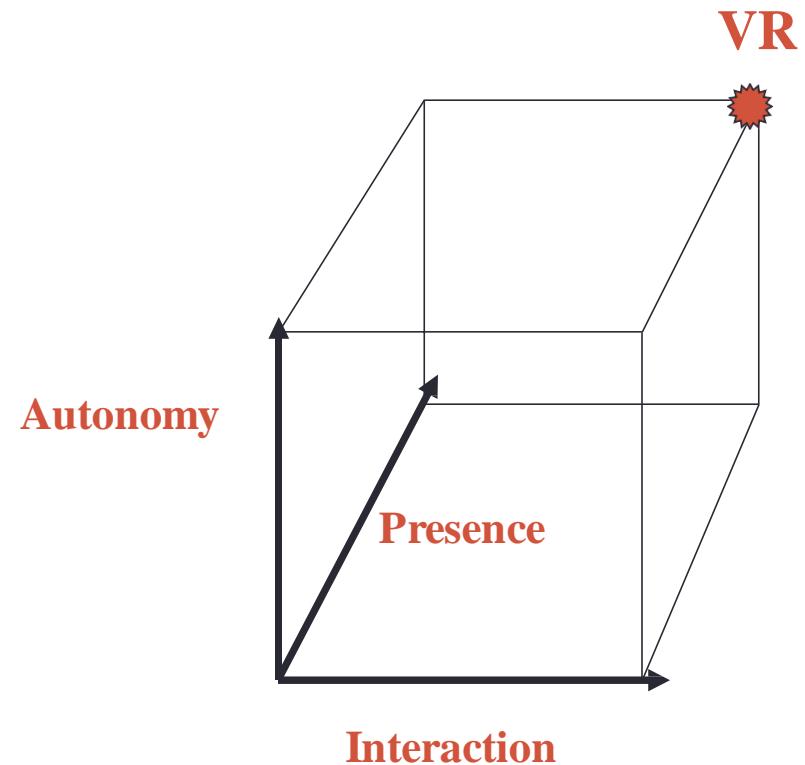
Presence is the key to defining VR in terms of experience

- Presence is defined as the sense of being in an environment
- Telepresence is defined as the experience of presence, or sensation of being elsewhere, created by a set of technologies
- A “virtual reality” is defined as a real or simulated environment in which an observer/perceiver experiences telepresence.



# David Zeltzer's AIP Cube

- **Autonomy** – User can react to events and stimuli.
- **Interaction** – User can interact with objects and environment.
- **Presence** – User feels immersed through sensory input and output channels



Zeltzer, D. (1992). Autonomy, interaction, and presence. *Presence: Teleoperators & Virtual Environments*, 1(1), 127-132.



# Types of VR



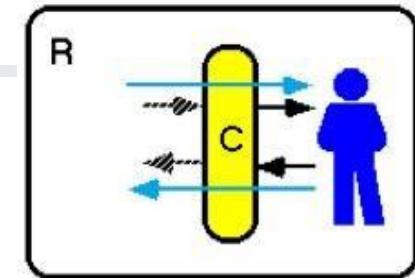


# AUGMENTED REALITY

- Slides based on Mark Billinghurst's slideshare
- Azuma, A Survey of Augmented Reality - UNC Computer Science



# Augmented Reality



- Virtual Images blended with the real world
  - Computer screens, See-through HMDs, handheld display, glasses, etc...



# Augmented Reality in Science Fiction



1977 – Star Wars

[https://youtu.be/8N\\_Cj3ZS9-A](https://youtu.be/8N_Cj3ZS9-A)



# Augmented Reality in Science Fiction



Screenshot from the movie "Who Framed Roger Rabbit?" blending the real character and background with computer generated cartoon characters



# Augmented Reality in Science Fiction

## Now inside the movie lore

Featuring:

- Markerless AR
- Image Processing: Real-time image-feature detection (edges and blobs perhaps)



1991 – Terminator 2

<http://youtu.be/9MeaaCwBW28>



# Augmented Reality Definition

- Defining Characteristics [Azuma 97]
  - Combines Real and Virtual Images
    - Both can be seen at the same time
  - Interactive in real-time
    - The virtual content can be interacted with
  - Registered in 3D
    - Virtual objects appear fixed in space

Azuma, R. T. (1997). A survey of augmented reality. *Presence*, 6(4), 355-385.



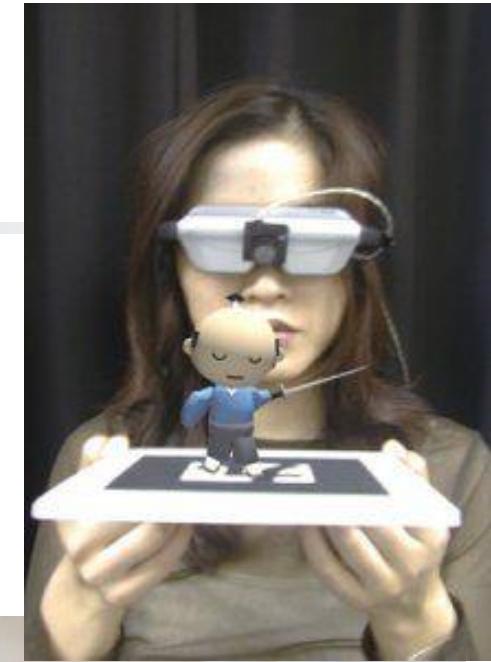
## 2008 - CNN



[https://www.youtube.com/watch?v=v7fQ\\_EsMJMs](https://www.youtube.com/watch?v=v7fQ_EsMJMs)



# Augmented Reality Examples





# AR in Marketing: Colouring Example - Quiver



<https://www.youtube.com/watch?v=aUPMDwypBkA>



# Gaming: Pokemon GO..





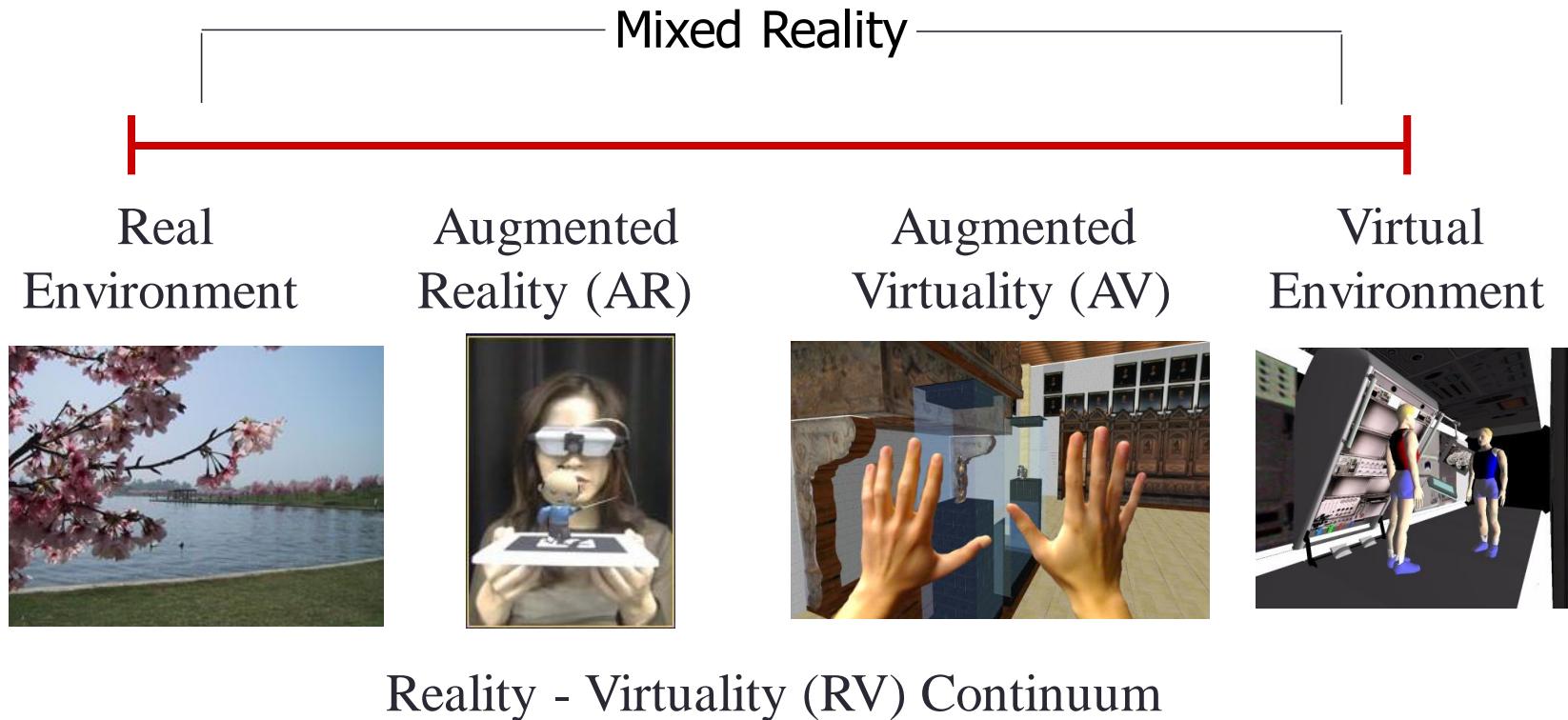
# AR vs VR

	<b>Virtual Reality</b> <i>Replaces Reality</i>	<b>Augmented Reality</b> <i>Enhances Reality</i>
<i>Scene Generation</i>	Requires realistic images	Minimal rendering okay
<i>Display Device</i>	Fully immersive, wide field of view	Non-immersive, small field of view
<i>Tracking</i>	Low to medium accuracy is okay	The highest accuracy possible



# Milgram's Reality-Virtuality continuum

"...anywhere between the extrema of the *virtuality continuum*."



P. Milgram and A. F. Kishino, Taxonomy of Mixed Reality Visual Displays  
IEICE Transactions on Information and Systems, E77-D(12), pp. 1321-1329, 1994.



# VR definition angles

- Virtual Reality can be defined in a number of ways
  - In terms of technology
  - From a Presence perspective
- VR can also be classified with other technologies
  - Natural User Interfaces (NUI)
  - Milgram's Mixed Reality continuum



# HISTORY OF VR



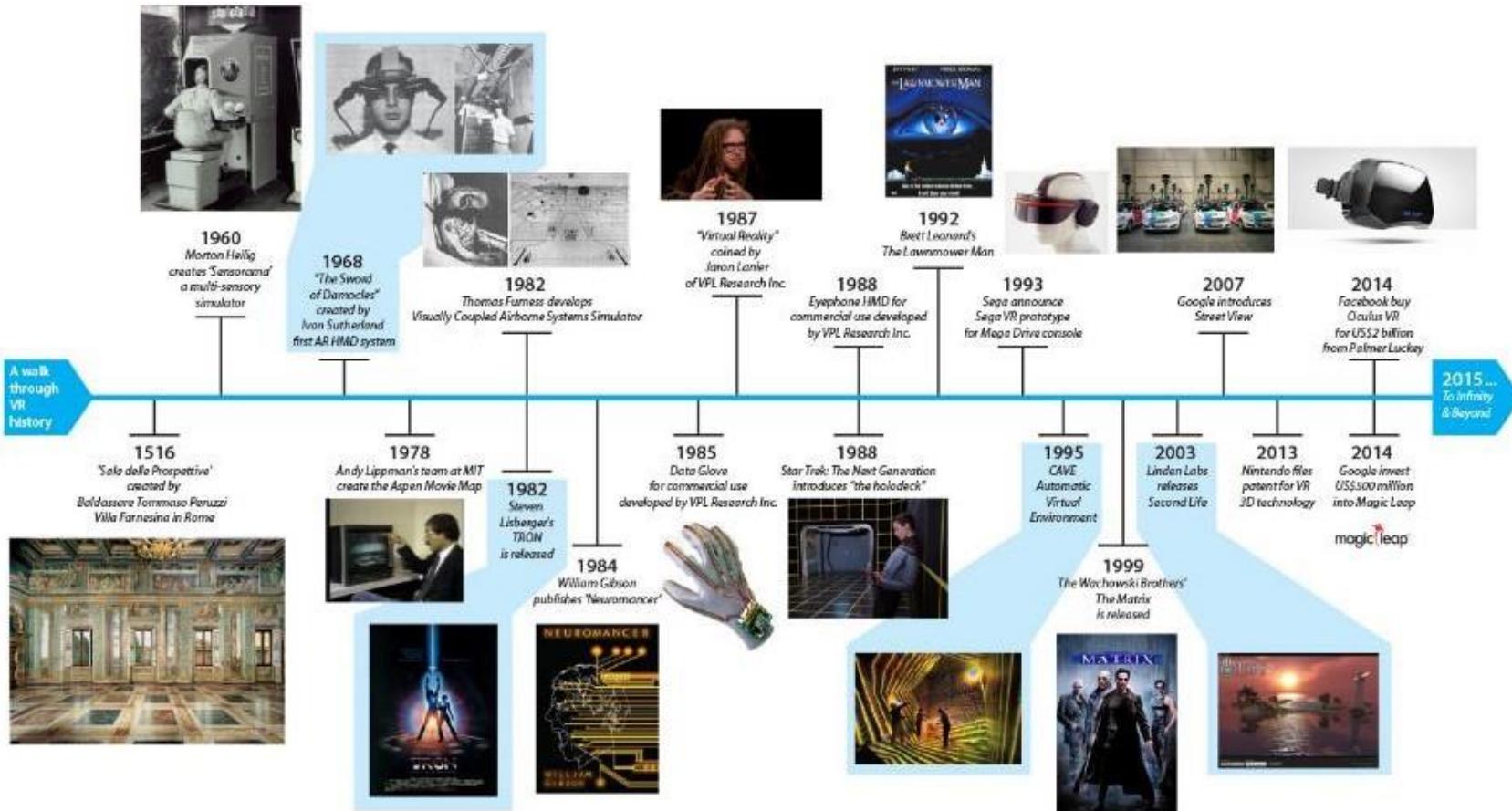
# History of VR

*When anything new comes along, everyone, like a child discovering the world thinks that they've invented it, but you scratch a little and you find a caveman scratching on a wall is creating virtual reality in a sense.*

Morton Helig (Hammit 1993)



# VR History Timeline





# Early History (30,000 BC -)

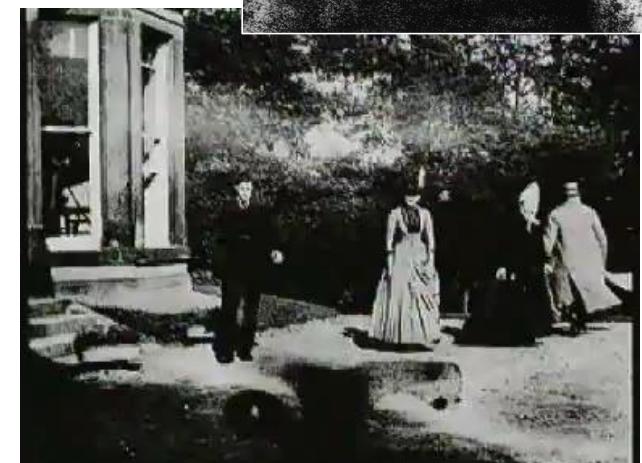


The history of VR is rooted in human's first attempts to reproduce the world around them



# 1800's – Capturing Reality

- **Panoramas (1790s)**
  - Immersive paintings
- **Photography (1820-30s)**
  - Oldest surviving photo (Niépce, 1826)
- **Stereo imagery (1830s)**
  - Wheatstone (1832)
  - Brewster (1851)
- **Movies (1870s)**
  - The Horse In Motion (1878)
    - First Motion Picture
    - Eadweard Muybridge
  - Roundhay Garden Scene (1888)
    - First Motion Film
    - Louis Le Prince





# Stereo Viewers



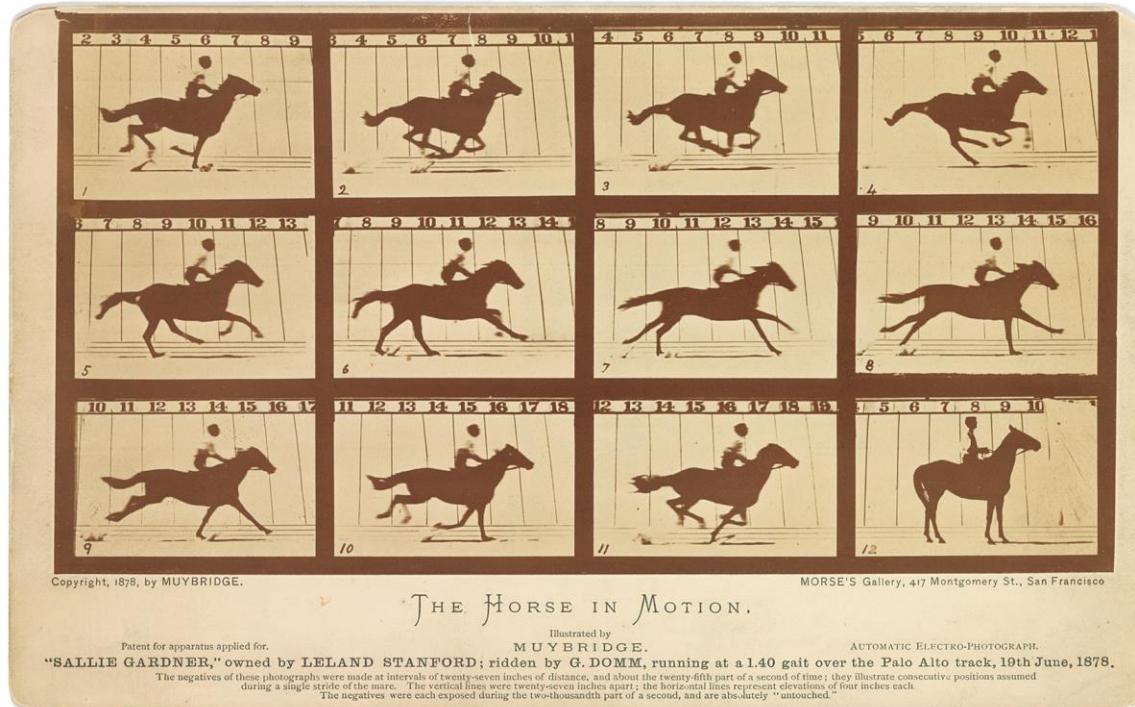
Wheatstone (1832)



Brewster (1860)

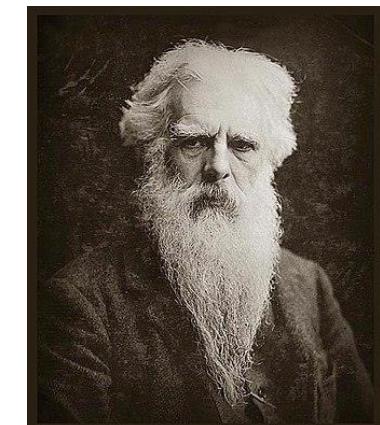


# First Motion Picture



## The Horse In Motion (1878)

<https://www.youtube.com/watch?v=heRuLp7CyTM>



Eadweard Muybridge



# Viewmaster (1939)



<https://www.youtube.com/watch?v=f9yGKzwjomc>



# 3D Cinema Golden Era (1950-60s)



*Another Famous...* **FIRST FROM U-I!**

**FIRST** with WIDE-VISION SCREEN and STEREOFONIC SOUND... on "THUNDER BAY" at the LOEW'S STATE, N.Y. - MAY 20th

NOW Universal-International brings

**THE FIRST 3-D PICTURE ON THE GIANT WIDE-VISION SCREEN WITH STEREOFONIC SOUND!**

at the RKO HILLSTREET and PAINTAGES Theatres, Los Angeles, May 27th

**THE FIRST 3-D SCIENCE-FICTION STORY**  
**THE FIRST ALL 3-D PROGRAM WITH**  
**THE FIRST 3-D MUSICAL FEATURETTE**

**NAT 'KING' COLE  
RUSS MORGAN'S ORCHESTRA AND DANCE REVUE**

**IT CAME FROM OUTER SPACE IN 3-DIMENSION**

SINCE THE DAWN OF TIME... man has never seen such sights... nor trembled before such horror!

RICHARD CARLSON BARBARA RUSH  
CHARLES VANCE KRISTIE MORRISON KATHLEEN FRANCIS JAE GAMMER  
Music by ERIC SARNETT Story by RAYMOND CHANDLER  
Directed by ROBERT LEE Produced by ROBERT LEE  
Cinematography by ROBERT LEE Story by ROBERT LEE  
Directed by ROBERT LEE Produced by ROBERT LEE

- Polarized 3D projection or anaglyph (red/blue)



# 1900s – Interactive Experiences

## Technological Foundations Began

- Early Simulators (<1960s)
  - Flight simulators
  - Sensorama (1955)
- Early HMDs (1960s)
  - Philco, Ivan Sutherland
- Military + University Research (1970-80s)
  - US Airforce, NASA, MIT, UNC
- First Commercial Wave (1980-90s)
  - VPL, Virtual i-O, Division, Virtuality
  - VR Arcades, Virtual Boy





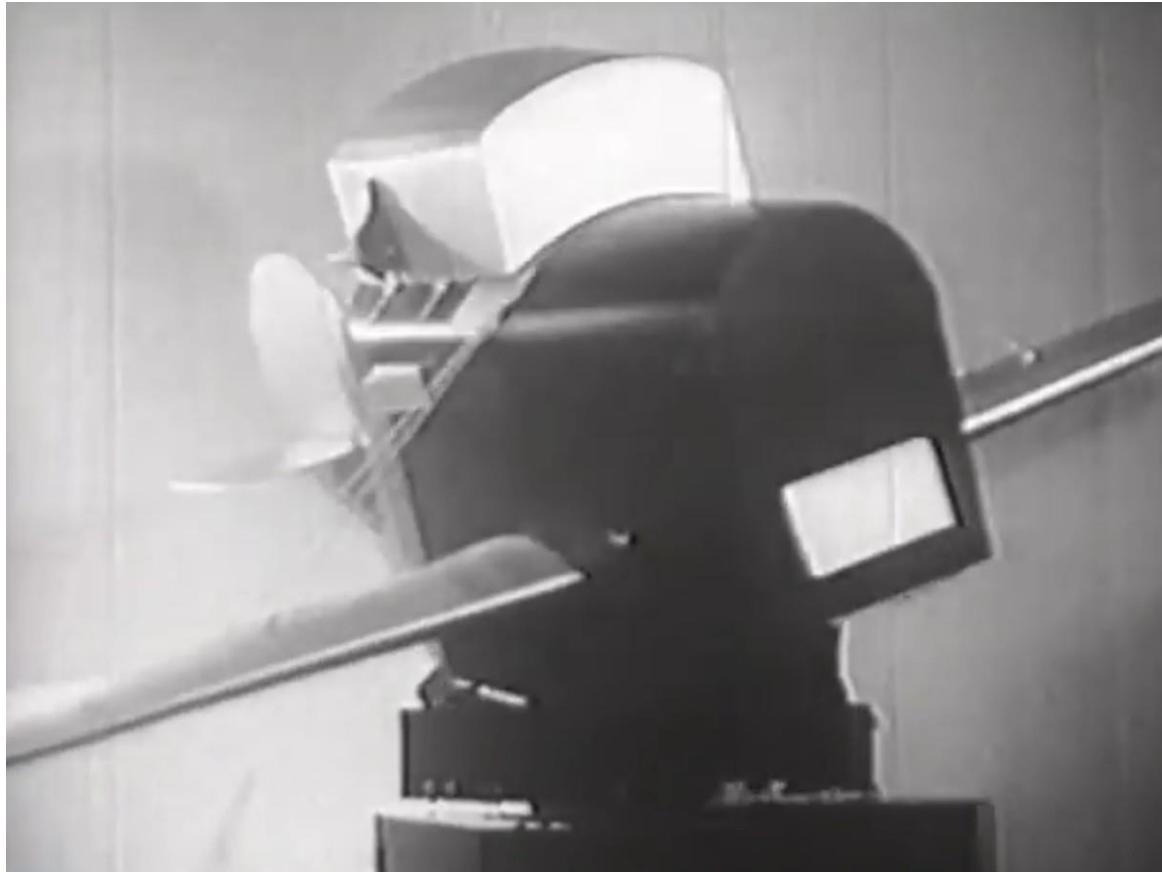
# Link Trainer (1929 – 1950s)



- Flight Simulator Training
  - Full six degree of freedom rotation
  - Force feedback and motion control
  - Simulated instruments
  - Modeling common flight conditions
- Over half a million pilots trained



# Link Trainer Video (1940's)



- <https://www.youtube.com/watch?v=5kmmKj7fbnI>



# Sensorama (1955)

- Created by Morton Heilig
  - Experience Theater
- Multi-sensory
  - Visuals
  - Sound
  - Wind
  - Vibration
  - Smell
- No financial support
- Commercial failure





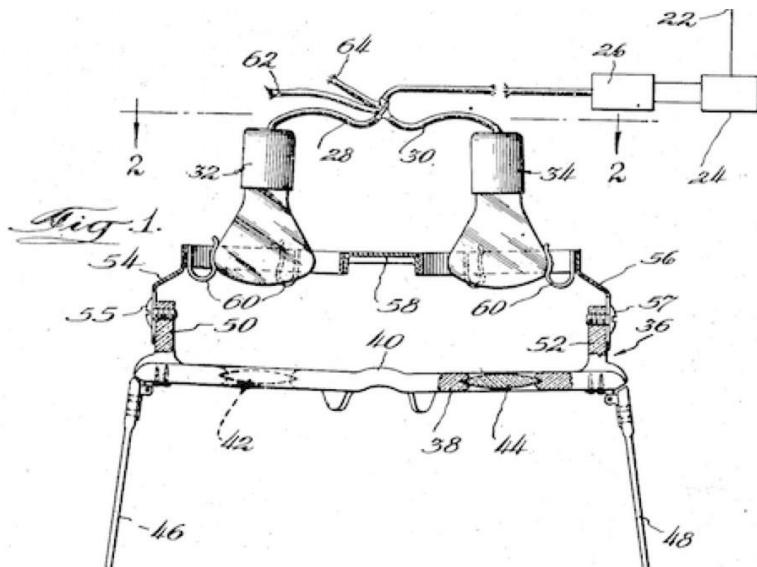
# Sensorama Video



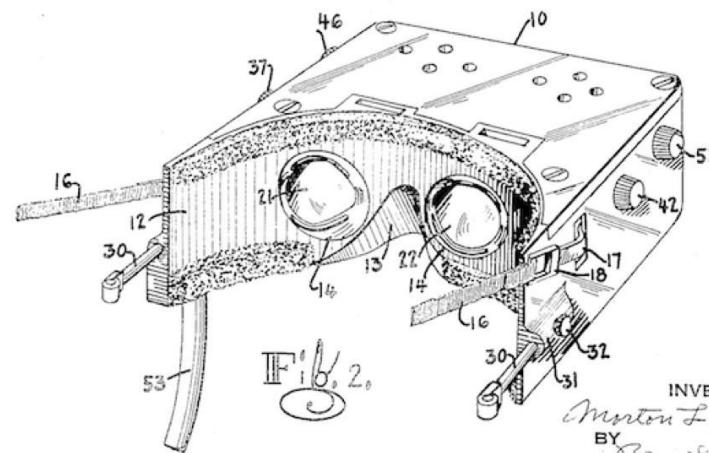
- <https://www.youtube.com/watch?v=vSINEBZNCKs>



# Early HMD Patents



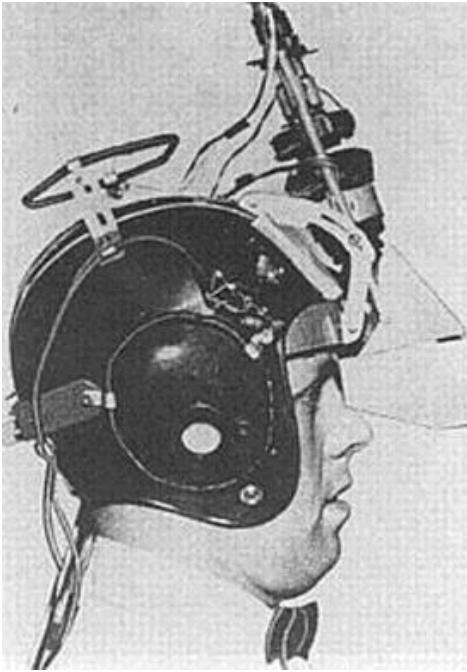
McCollum's Stereo TV HMD (1943)



Heilig's Multisensory HMD (1960)



# Early HMDs (1960s)



Philco Headsight (1961)



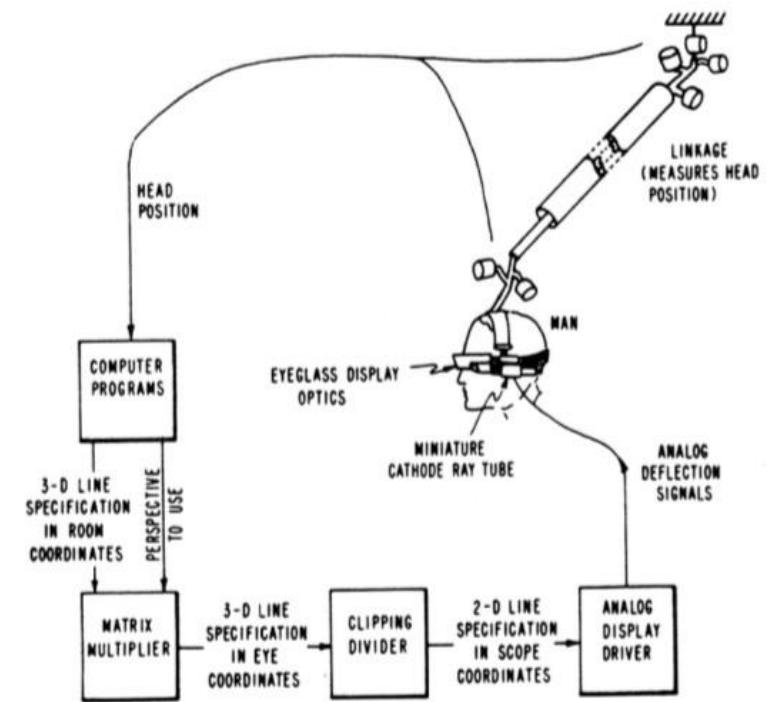
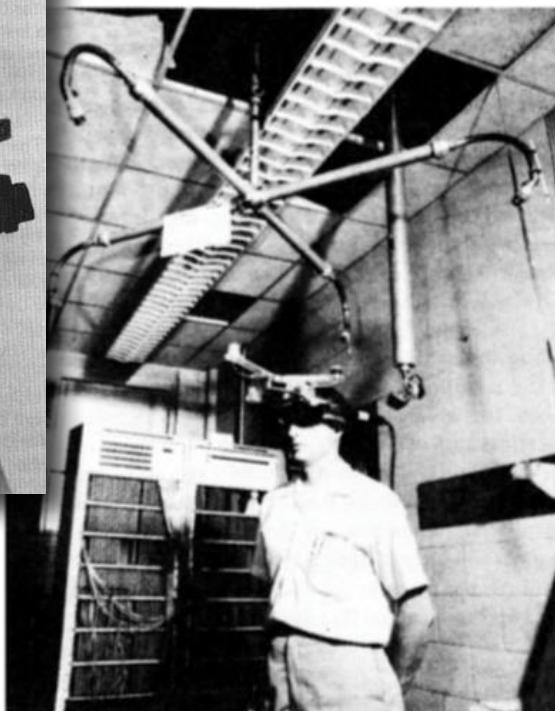
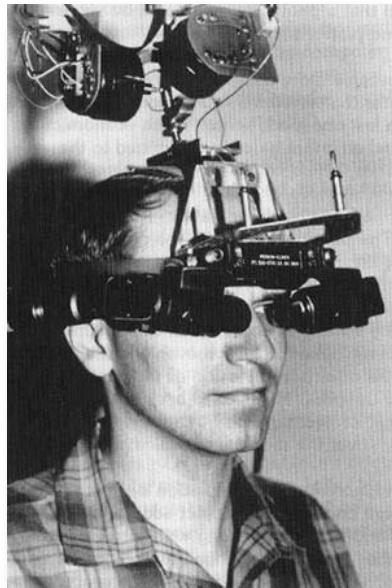
Sword of Damocles - Sutherland (1968)

- No computer generated graphics
- Magnetic head tracking
- A video telepresence solution?
  - Remote video with a CRT

- First HMD with head tracking and computer generated images



# Ivan Sutherland (1960s)



Ivan Sutherland's Head-Mounted Display (1968)



# The Sword of Damocles

## Sutherland Display – First HMD



<https://www.youtube.com/watch?v=NtwZXGprxag>



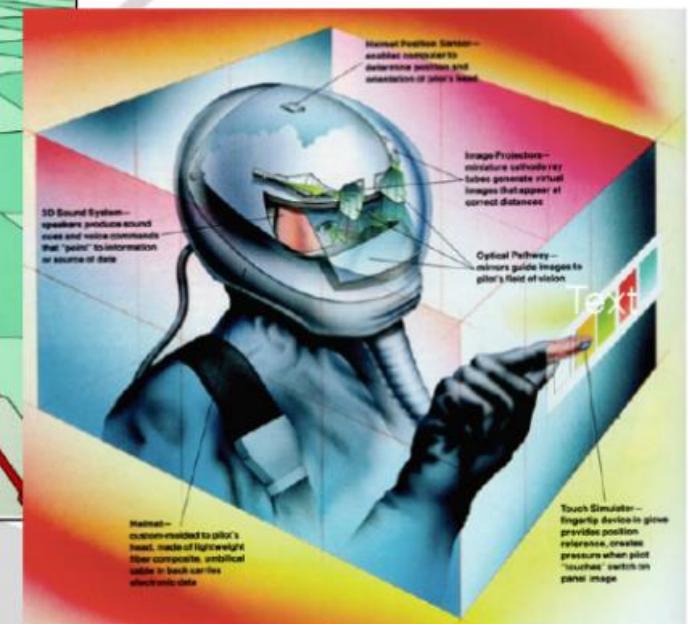
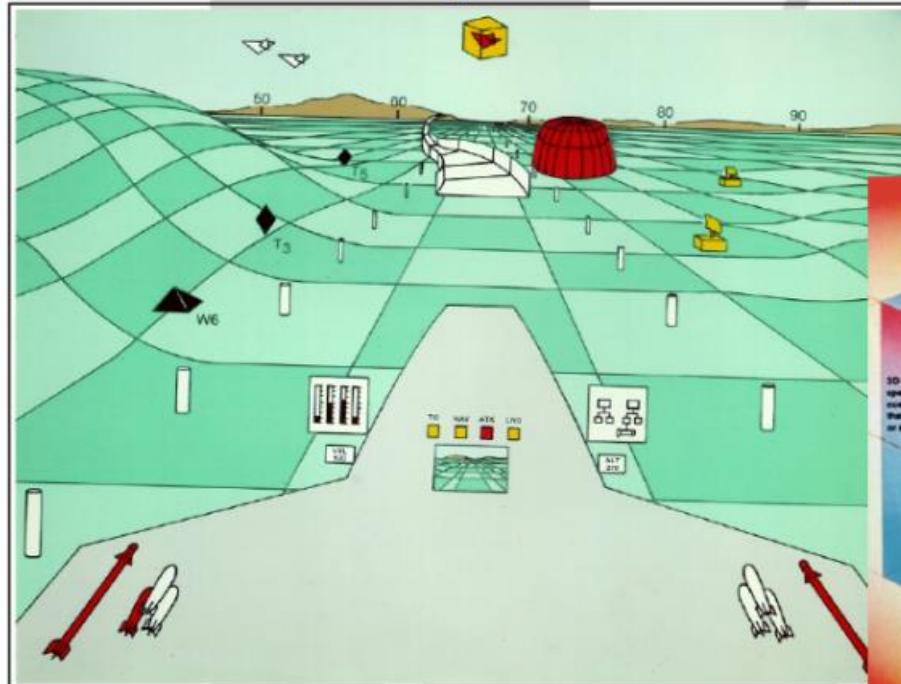
# Super Cockpit (1965-80's)

- From the US Airforce Research Program
  - Wright Patterson Air Force Base
- Created by **Tom Furness III**
  - A VR Pioneer
- Multisensory
  - Visual, 3D audio
  - Tactile recognition (gloves)
  - Speech-recognition
  - Tried to address the pilot information overload
  - Flight controls and tasks were too complicated
- Research only
  - big system, but perhaps too ambitious





# The Super Cockpit (1980's)



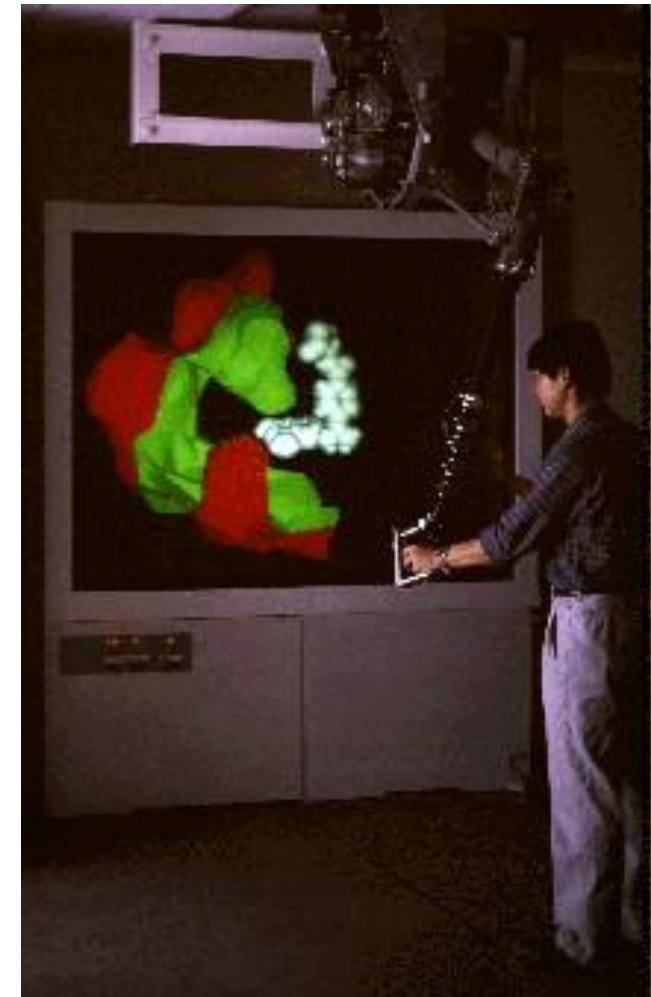
- Furness - USAF

Furness, T. A. (1986, September). The super cockpit and its human factors challenges. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 30, No. 1, pp. 48-52). SAGE Publications.



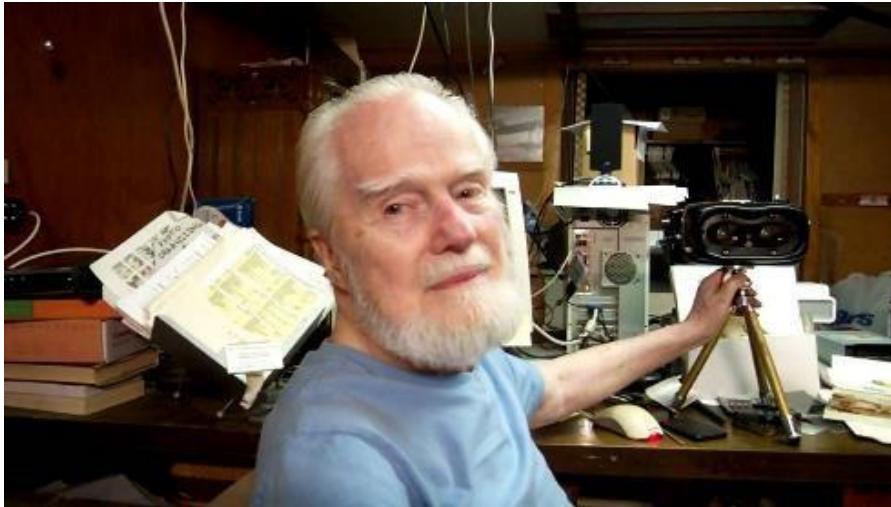
# Haptic and Force Feedback Systems (1967 – 80's)

- Haptic/kinesthetic display system
  - 6D force fields of molecular structures
  - VR for the manipulation of Nano-Structures
- Progression
  - Grope I, simple fields, particle feedback
  - Grope II, 1978, children's building blocks
  - Grope III, late 80's, Remote Manipulator
- Led to the Sarcos arm





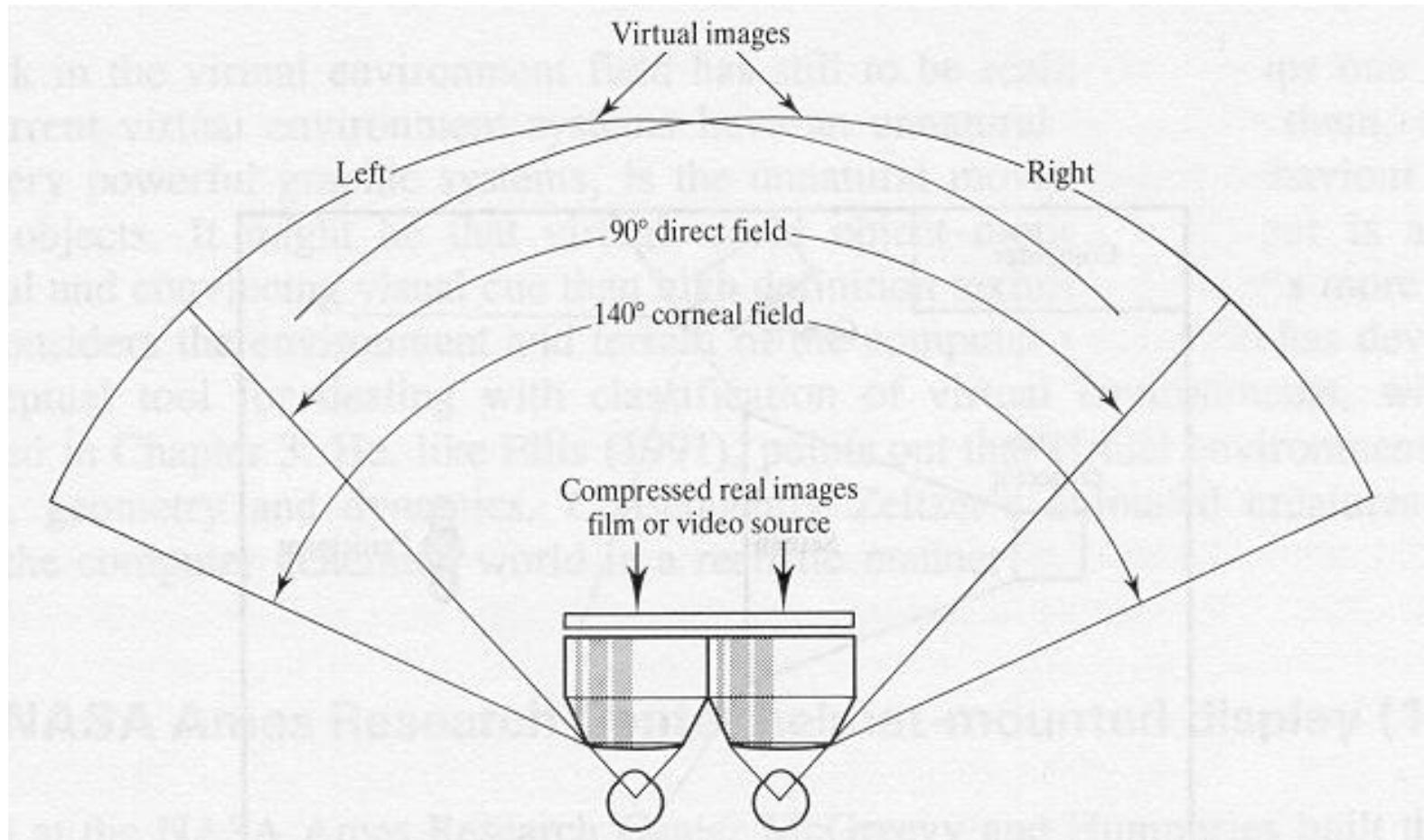
# LEEP Optics (1979)



- Large Expanse, Extra Perspective Optics
  - Developed by Eric Howlett
- Lens design for extremely wide field of view
  - High resolution in centre, lower resolution in periphery
  - 90° direct FOV, 140° corneal FOV
- Used as basis for most VR HMDs today



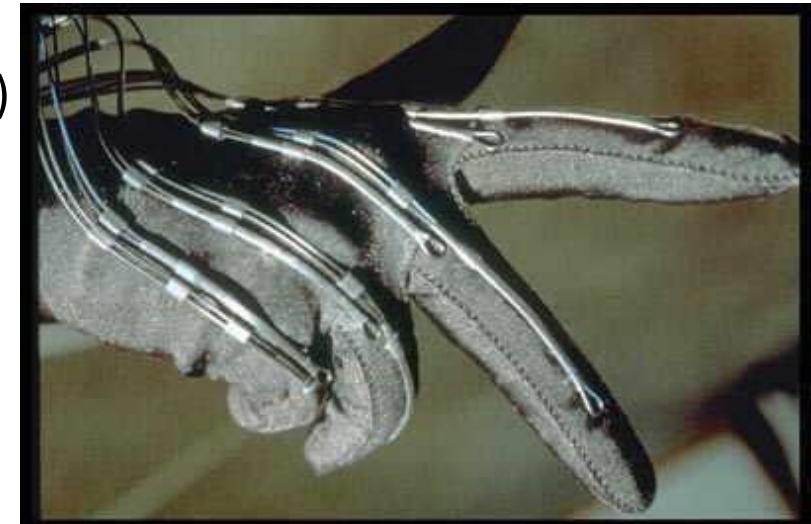
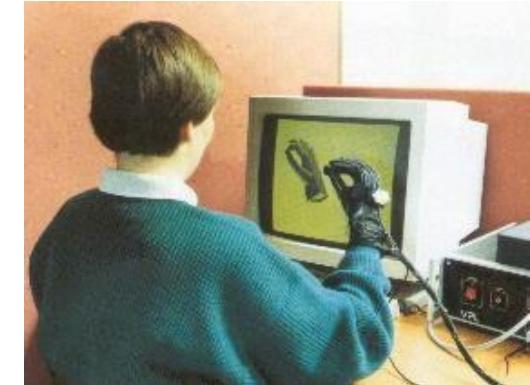
# LEEP Optics Design





# The Data Glove (1981-82)

- Precursor, Sayre Glove
  - Univ. of Illinois, 1977
- Thomas Zimmerman (1982)
- Fiber optic bend sensors
  - Detecting finger bending
- Commercialized by VPL
  - Mattel PowerGlove (1989)





# VPL DataGlove Demo



- <https://www.youtube.com/watch?v=fs3AhNr5o6o>



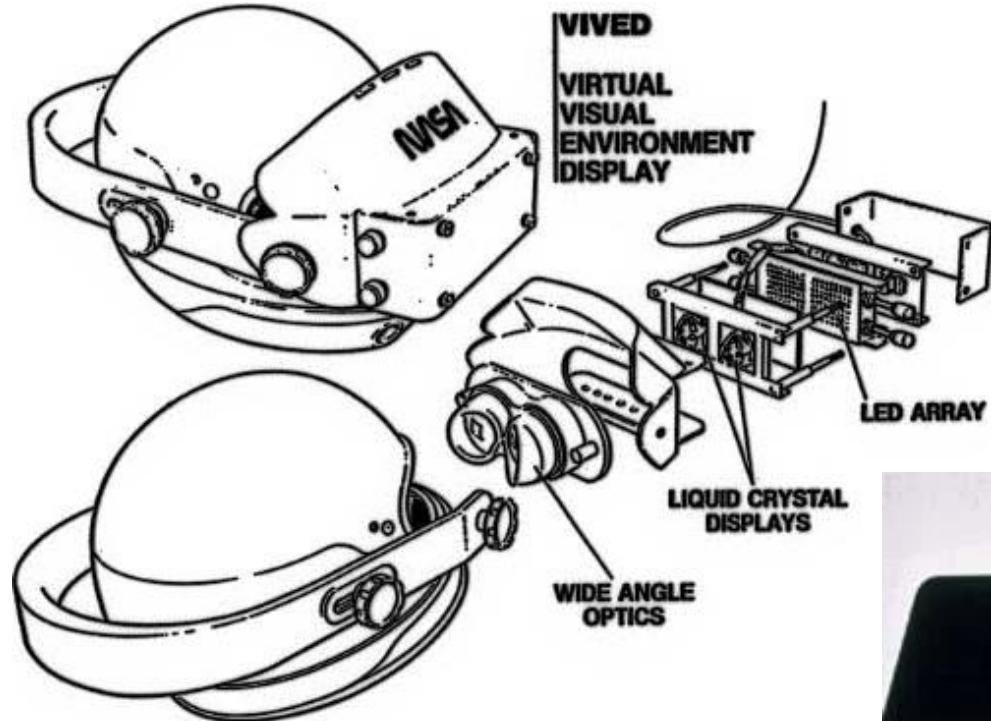
# NASA VIEW/VIVED(1981-86)

- Early HMD (McGreevy Humphries)
  - LCD “Watchman” displays
- VIEW (Scott Fisher)
  - Tracker by Polhemus
  - LEEP-based HMD
  - 3D audio (Convolvotron)
  - DataGlove gesture input
  - Simple graphics





# Virtual Interface Environment Workstation (VIEW)



- Motorbike helmet + LEEP





# Commercial Era

## VPL Research and Products (1985 – 1999)

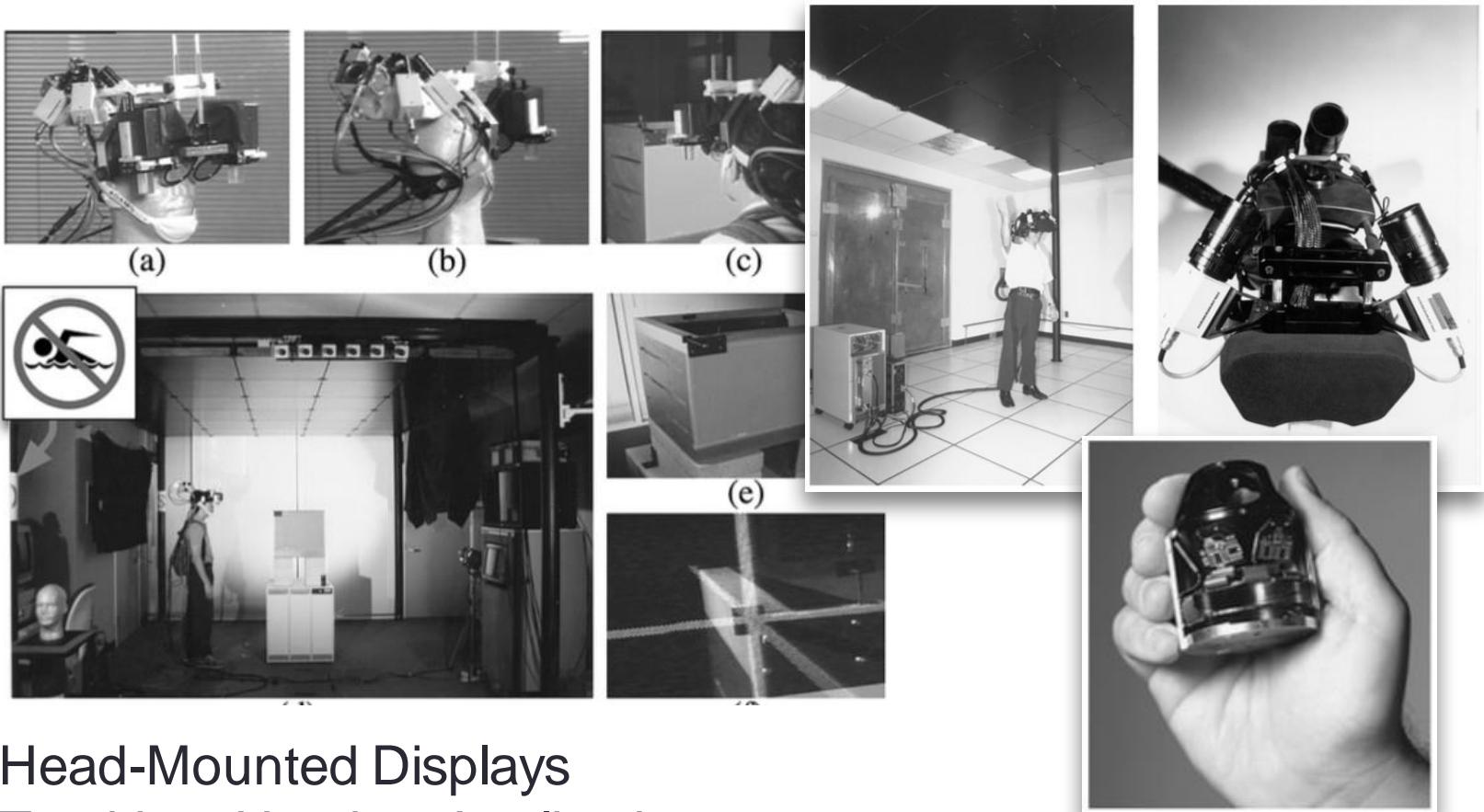


- First Commercial VR Company
  - Jaron Lanier, Jean-Jacques Grimaud
- **Provided complete systems**
  - Displays, software, gloves, etc..
  - DataGlove, EyePhone, AudioSphere





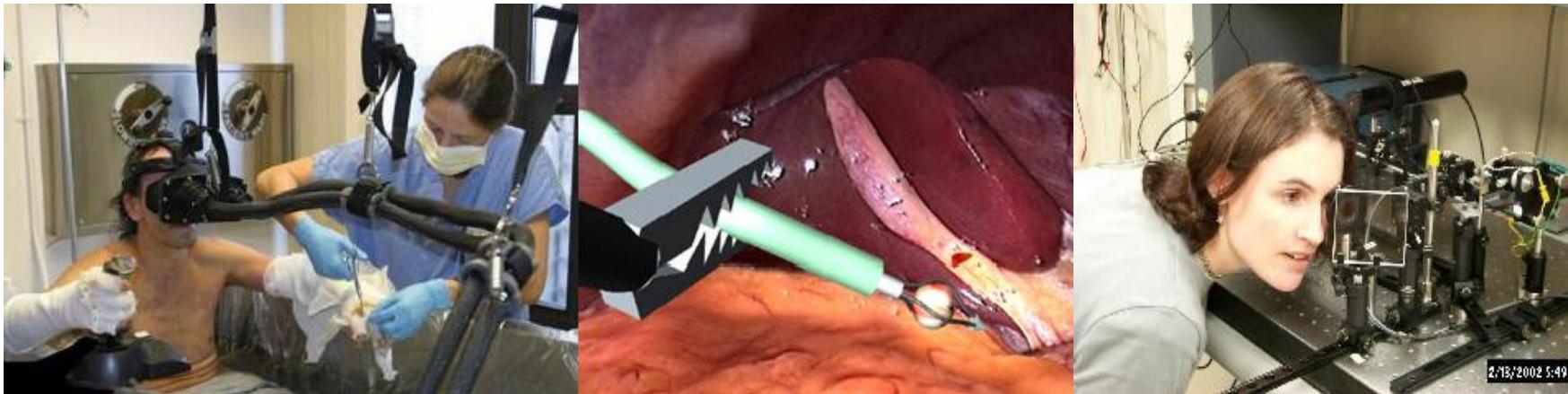
# To follow: The University of North Carolina at Chapel Hill (1980s- )



Head-Mounted Displays  
Tracking, Haptics, Applications



# To follow: University of Washington (1989 -)

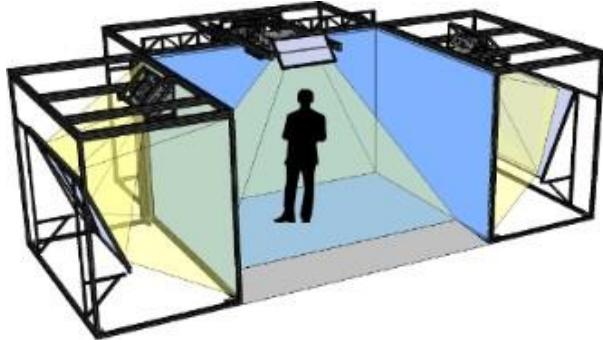


- Created the Human Interface Technology Laboratory (HIT Lab)
  - Founded by Tom Furness III (Super Cockpit)
- Many AR/VR Innovations
  - Virtual Retinal Display
  - ARToolKit AR Tracking library
  - GreenSpace shared VR experience
  - VR and pain care
  - VR and Education



# CAVE (1992)

## University of Illinois Chicago

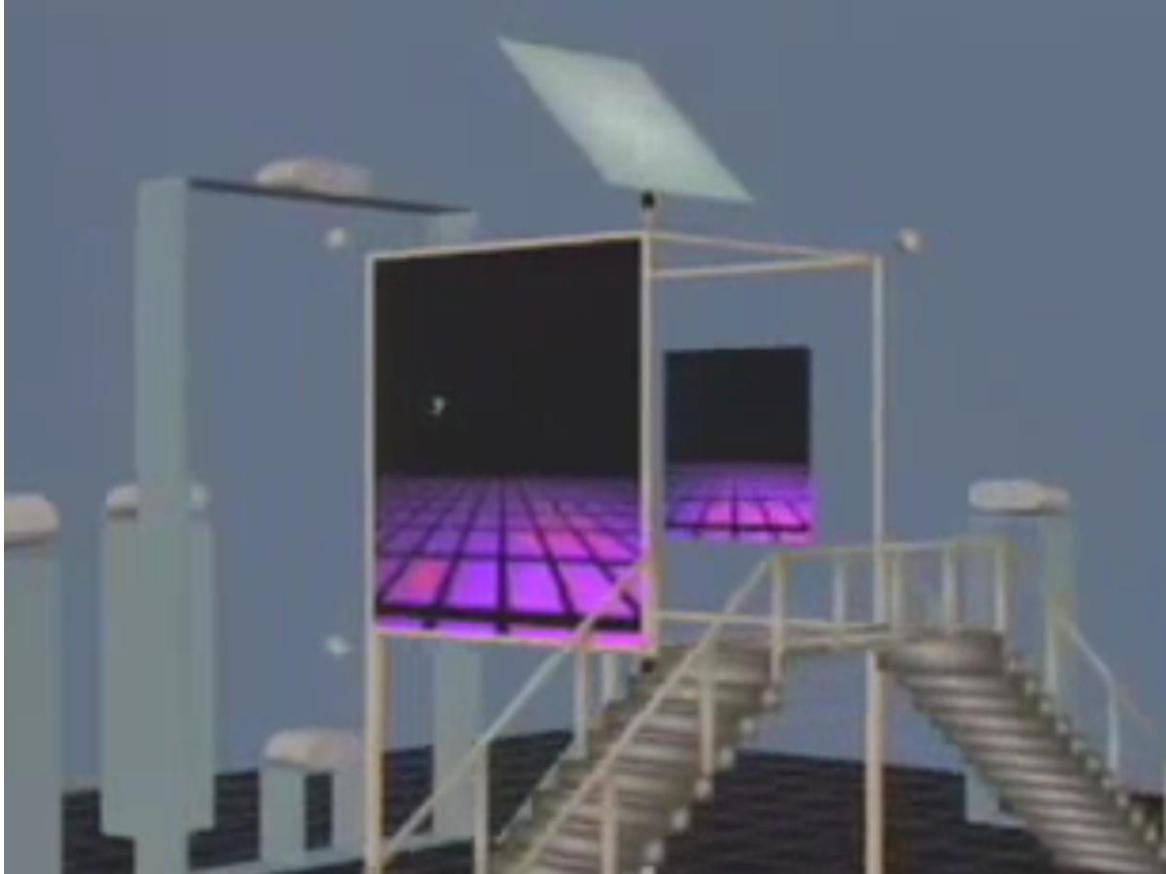


- Projection VR system
  - 3-6 wall stereo projection, viewpoint tracking
  - Developed at EVL, University of Illinois Chicago
- Commercialized by Mechdyne Corporation(1996)

C. Cruz-Neira, D. J. Sandin, T. A. DeFanti, R. V. Kenyon and J. C. Hart. "The CAVE: Audio Visual Experience Automatic Virtual Environment", *Communications of the ACM*, vol. 35(6), 1992, pp. 64–72.



# CAVE Demo Video

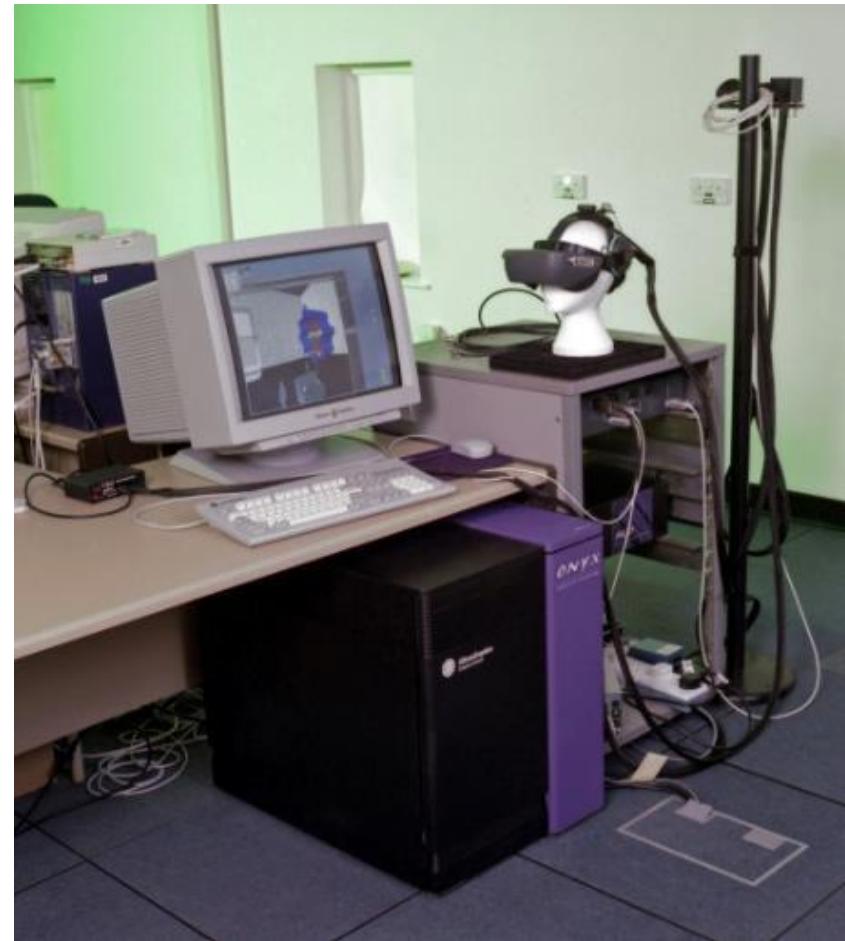
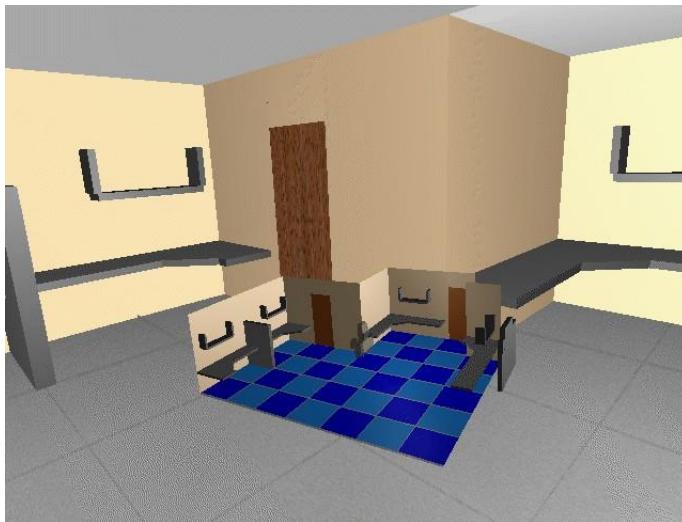


- <https://www.youtube.com/watch?v=aKL0urEdtPU>



# Desktop VR - 1995

- Expensive - \$150,000+
- 2 million polys/sec
- VGA HMD – 30 Hz
- Magnetic tracking





# Rise of Commercial VR Companies

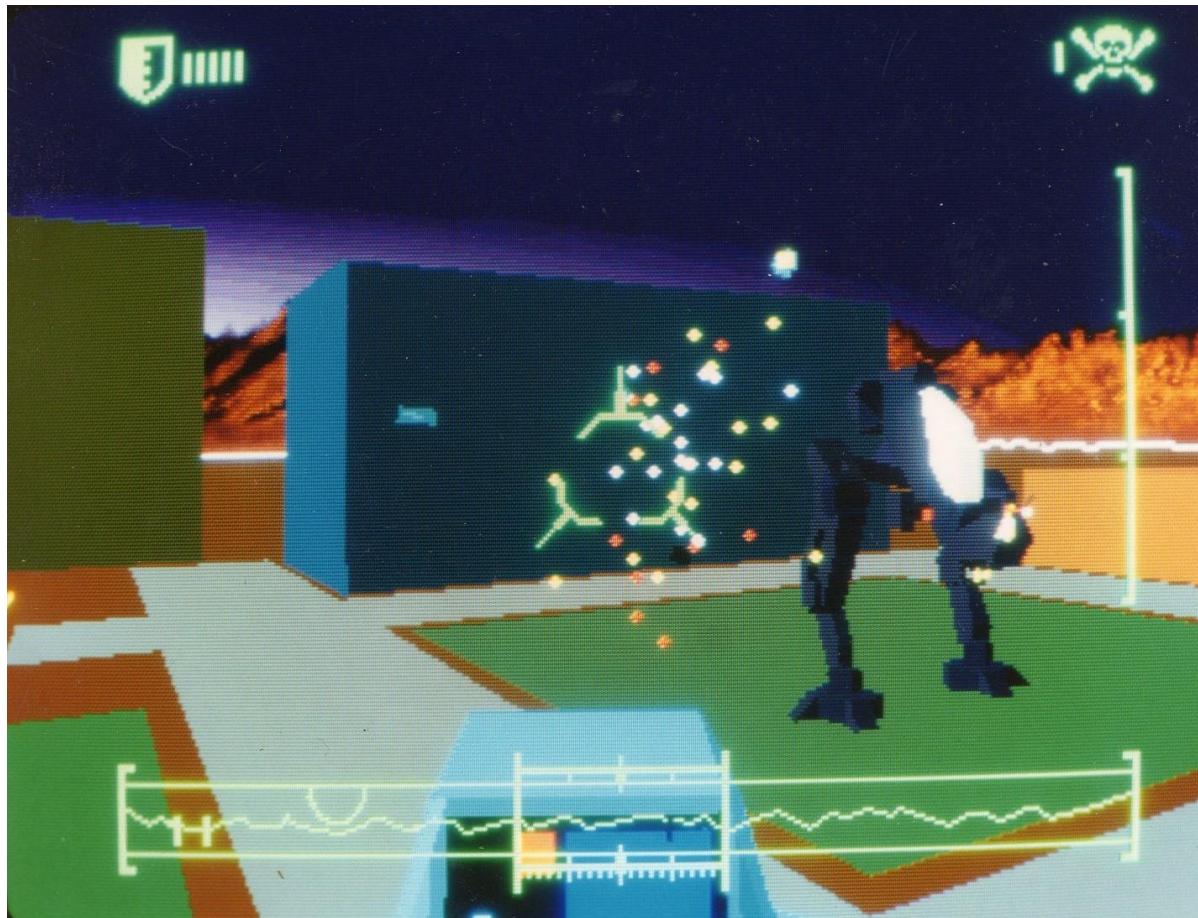
- Virtual Boy (1995 – 1996)
  - Nintendo's console
- W Industries/Virtuality (1985 - 97)
  - Location based entertainment
- Virtuality VR Arcades
  - Division (1989 – 1998)
- Virtual i-O (1993 -1997)
  - Inexpensive gamer HMDs
- Sense8 (1990 - 1998)
  - WorldToolKit, WorldUp
- VR authoring tools





# Virtuality VR (1992)

## Game: Exorex



- <https://www.youtube.com/watch?v=1Qe4suqGZmU>



SER  
ed  
bots

# COMPUTERWORLD

## Hardware

IDG

SEARCH Google™ Custom Search GO



Empowering  
People



Optimizing IT



Leveraging Info



Enabling Business  
Flexibility

## Don't Believe the Hype: The 21 Biggest Technology Flops

We fondly recall 21 overpromoted products and technologies that utterly failed to live up to their hype -- and we give you a chance to choose the biggest flop of all.

David Haskin [Today's Top Stories ▶](#) or [Other Hardware Stories ▶](#)

- April 2007 Computer World
  - VR Voted 7<sup>th</sup> on list of 21 biggest technology flops
    - MS Bob #1



# VR Second Wave (2010 - )

- Palmer Luckey
  - HMD hacker
  - Mixed Reality Lab (MxR) intern
- Oculus Rift (2011 - )
  - 2012 - \$2.4 million kickstarter
  - 2014 - \$2B acquisition FaceBook
  - \$350 USD, 110° FOV





# The Oculus Kickstarter Video



- <https://www.youtube.com/watch?v=hxptk8P15TI>



# Desktop VR in 2016

- Graphics Desktop
  - \$1500 USD
  - >4 Billion poly/sec
- \$600 HMD
  - 1080x1200, 90Hz
- Optical tracking
  - Room scale





# 2016 - Rise of Consumer HMDs



Oculus Rift



HTC/Valve Vive



Playstation VR



# HTC Vive



- Room scale tracking
- Gesture input devices



# Example Vive App – Tilt Brush



- <https://www.youtube.com/watch?v=ijukZmYFX-0>



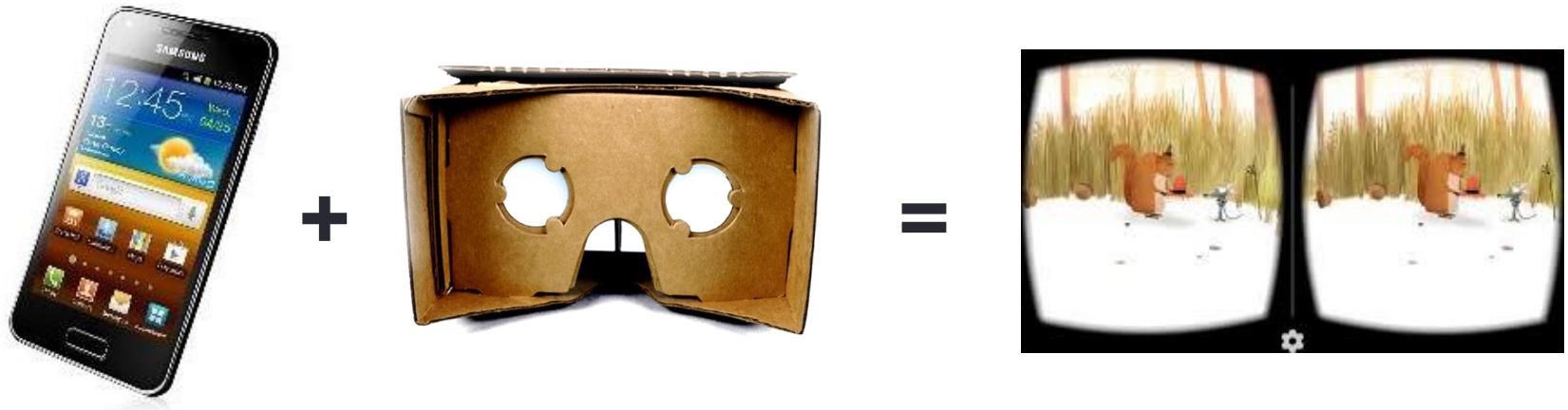
# VR2GO (2013)



- MxR Lab
  - 3D print VR viewer for mobiles
  - Open source hardware + software
  - <http://projects.ict.usc.edu/mxr/diy/vr2go/>
- Early Mobile VR viewer



# Google Cardboard



- Released 2014
  - From Google 20% side project incentive
- >5 million shipped/given away
- Easy to use developer tools





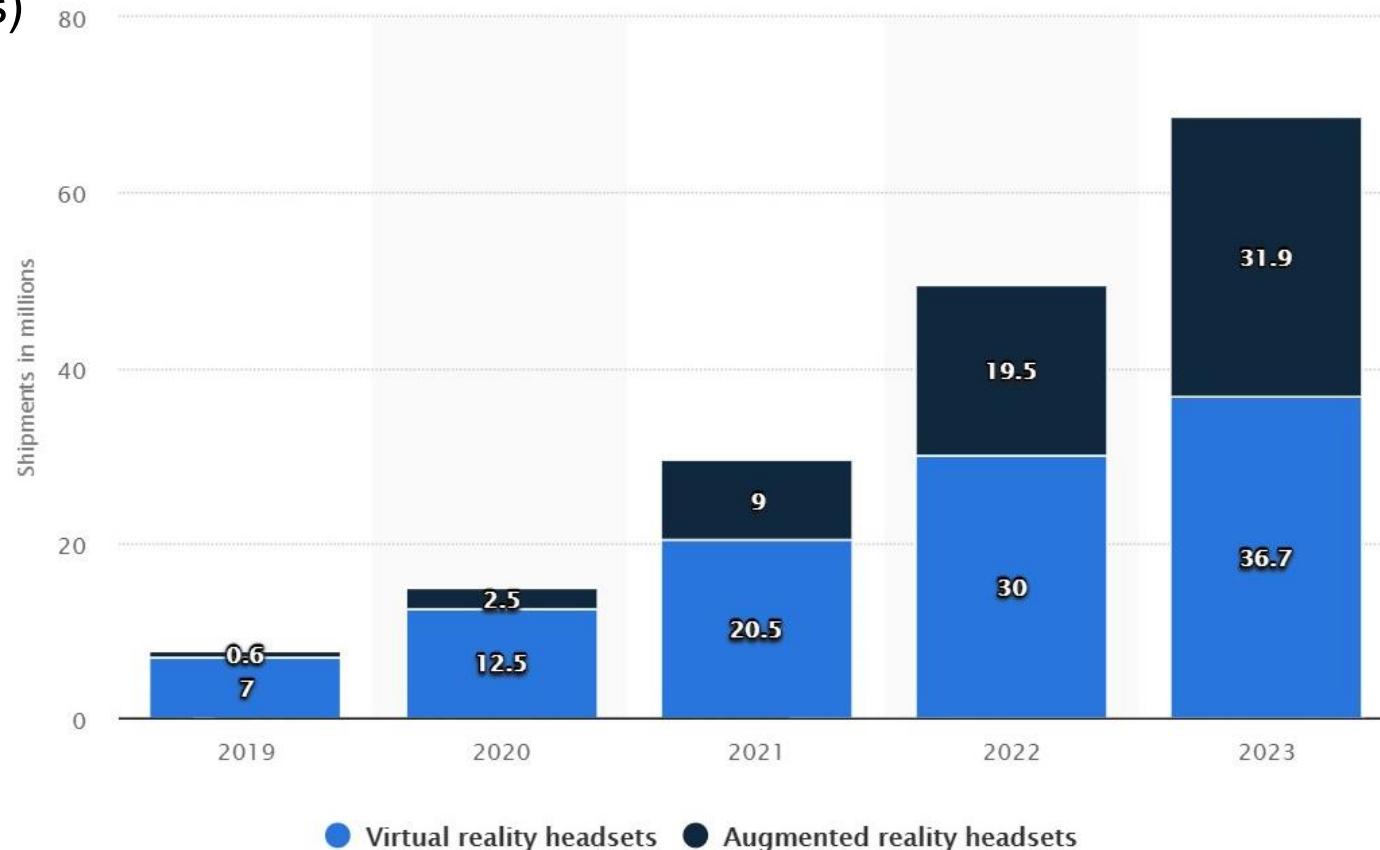
# Multiple Mobile VR Viewers Available





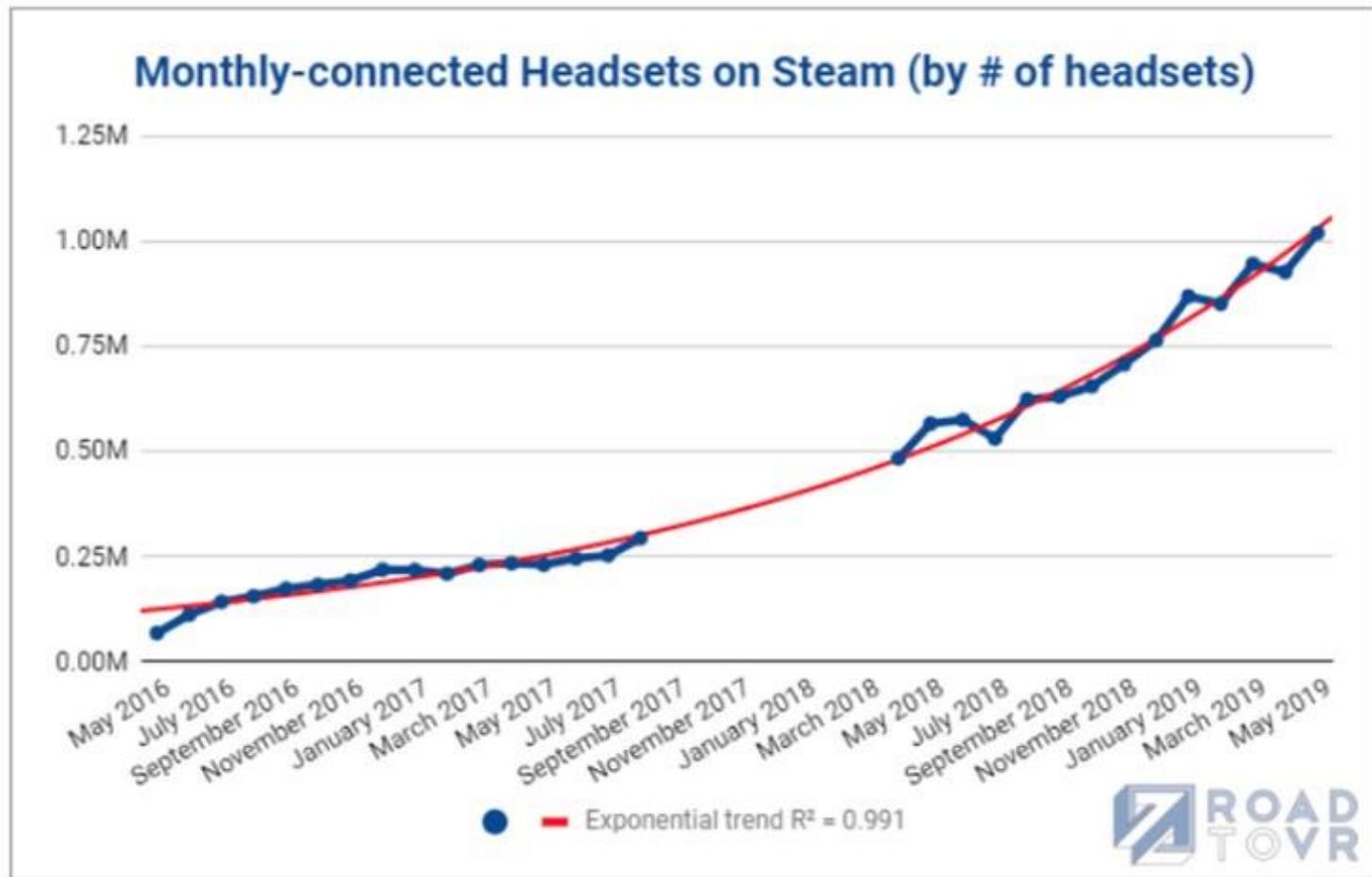
# Projected HMD Sales

Forecast unit shipments of AR and VR headsets from 2019 to 2023 (in millions)





# Market size – PC Steam



*Data gap from seven months of data misreported by Valve*



# Market size – Playstation VR



As of March 3, 2019, **PlayStation VR** has sold-through over **4.2 million units** worldwide.



## THE VR FUND H2 2017 VR INDUSTRY LANDSCAPE

LOCATION BASED	SPORTS/LIVE EVENTS	SOCIAL	GAMES	ENTERTAINMENT	ENTERPRISE	HEALTHCARE	EDUCATION
APPLICATIONS/CONTENT	IMAX <sup>®</sup>	facebook	VALVE	oculus	Google	Ovivo	Google
	ZERO	NEXTVR	survios	oculus rift	oculus rift	Reisou	VIVEarts
	BREAKAWAY VRCAFE	livelike	CRYEYE	Valve Index	oculus quest	PHOBOS	nearpod
	SEGA	intel	BETHESDA	steam	cisco	DeepStream VR	Lifelike
	PIPER JAFFRAY	bigscreen	INSOMNIAC	EA	AZCOM	AppliedVR	LABSTER
	TAKARA TOMY	DIGITAL DOWNIN	ndreams	PIXAR	level2	Limbix	VIVIENDU
	MODAL VR	MELODYVR	I-III	SECRET LOCATION	LEVEL 5	echopine	SOLIDRAX
	LONGER	vantage tv	ROBOCON	KRT GAMES	zL	TECHIECO	VC-EDUCATION
TOURISM	YU GAMES	RHAPSODY VR	ecolopl	bumi	zenvix	SOLARIS	SOULEVATED
	D-BOX	UNIVERSAL	CLIMAX	GRANMA	inContext	UNIVERSITY	UNIVERSIV
	EVR	PLUTO VR	OREMUSING	unreal engine	zlight	SECRET	CURISCOPE
	EVOLVE	cluster	OTHER SIDE	virtalis	Technologic	SUPPLY	JOURNALISM
	FIELD	HIVEDX	GYROKON	penrose	zenimax	Normal	Philips KNF
	NORMADIC	TOURAL	GYROHOT	softair	ajson	Medical Realities	OSQ
	SKYVIEW	REBEL HOUSE	READYTOWEAR	Playhouse	adventure	bioflightvr	BioflightVR
	POSITION	Live Nation	POLYARC	HANDVERS	EVOLVE	TRIPP	COGNITIVE LEAP
DISTRIBUTION (APPS/MEDIA)	VR	STRIVR	FALLOUT 4	DERIVED	MDLinking.com	MDLinking	RYOT
	AltaSense	eon sports	PERPLE	WANTO	VIRTAMED	VIRTUE	BBC RYOT
	TOURISM	TRINITY	Normal.	HANDBEANS	HOLODIA	WEARABLE	NEWSVR LIFE
	Discovery	Skratchfab	PERFORMA	READYTOWEAR	LOCKER	WIRE	VICE AP
	YOU VISIT	Google	Sketchfab	READYTOWEAR	MDLinking	RETIRED	WSJ
	DEALINESIO	RESPAWN	cluster	READYTOWEAR	reality	REFINER	Pitchfork
	DEALPORT	EA	cluster	READYTOWEAR	LOCKER	REALITY	TIME NETWORK
	YouTube	DIRECTIVE	cluster	READYTOWEAR	MDLinking	REALITY	REALITY
TOOLS/PLATFORM	Facebook	SKETCHFAB	CLIMAX	READYTOWEAR	MDLinking	REALITY	REALITY
	JAUNT	Google	GYROKON	READYTOWEAR	MDLinking	REALITY	REALITY
	WEVR	TRINITY	GYROHOT	READYTOWEAR	MDLinking	REALITY	REALITY
	LITTLESTAR	SLIVER	READYTOWEAR	READYTOWEAR	MDLinking	REALITY	REALITY
	sky VR	360SIZE	READYTOWEAR	READYTOWEAR	MDLinking	REALITY	REALITY
	PiP	CRACKLE	READYTOWEAR	READYTOWEAR	MDLinking	REALITY	REALITY
	VeeR	pixvana	READYTOWEAR	READYTOWEAR	MDLinking	REALITY	REALITY
	INCEPTION	SAMSUNG VR	READYTOWEAR	READYTOWEAR	MDLinking	REALITY	REALITY
INFRASTRUCTURE	oculus	SONY	VALVE	JAUNT	facebook	SAMSUNG	IMAX
	Google	HTC VIVE	WEVR	WEVR	WEVR	360 VR	360 VR
		Microsoft	FTBRUM	WEVR	WEVR	Canon	Insta360
	YouTube	facebook	JAUNT	WEVR	WEVR	LG	RICOH
	oculus	NEXTVR	Jaunt VR	WEVR	WEVR	Nikon	CASIO
	LITTLESTAR	SLIVER	Jaunt VR	WEVR	WEVR	GARMIN	RYLO
	sky VR	360SIZE	Jaunt VR	WEVR	WEVR	LUCID	YI
	PiP	CRACKLE	Jaunt VR	WEVR	WEVR	Polaroid	VideoStitch
HMD (TETHERED/MOBILE)	oculus	SONY	VALVE	Jaunt	facebook	SAMSUNG	IMAX
	VALVE	htc vive	WEVR	Jaunt	WEVR	360 VR	360 VR
	Microsoft	lg	WEVR	WEVR	WEVR	Canon	Insta360
		fujitsu	WEVR	WEVR	WEVR	lg	RICOH
	mindmaze	lenovo	WEVR	WEVR	WEVR	nikon	casio
	SVR	vrtd	WEVR	WEVR	WEVR	garmin	rylo
	VARJO	hyperreal	WEVR	WEVR	WEVR	lucid	yi
	HYPEREAL	pinax	WEVR	WEVR	WEVR	polaroid	videostitch
INPUT (HAND/EYE/WEARABLE/OMNI TREADMILLS/HAPTICS)	oculus	SONY	VALVE	Jaunt	facebook	SAMSUNG	IMAX
	REALSENSE	LEAP	WEVR	Jaunt	WEVR	360 VR	360 VR
	Microsoft	nod	WEVR	WEVR	WEVR	Canon	Insta360
	gestig	virtual reality	WEVR	WEVR	WEVR	lg	RICOH
	REVERIE	XIMMERSE	WEVR	WEVR	WEVR	nikon	casio
		THALMIC LABS	WEVR	WEVR	WEVR	garmin	rylo
	NEURON	Dexta	WEVR	WEVR	WEVR	lucid	yi
	Privo	Cloeeone	WEVR	WEVR	WEVR	polaroid	videostitch
REALITY CAPTURE (360 VIDEO/NEXT GEN)	QI	Cyberith	KNT	Jaunt	facebook	SAMSUNG	IMAX
	TACTICAL HAPTICS	bluebeam	Thermo Real	WEVR	WEVR	360 VR	360 VR
	bluebeam	KONTX	Striker VR	WEVR	WEVR	Canon	Insta360
	ultrahaptics	Thermo Real	Immersion	WEVR	WEVR	lg	RICOH
	MIRAISENS, Inc.	Striker VR	Immerse	WEVR	WEVR	nikon	casio
			WEVR	WEVR	WEVR	garmin	rylo
			WEVR	WEVR	WEVR	lucid	yi
			WEVR	WEVR	WEVR	polaroid	videostitch
BY TIPATAT@THEVRFUND.COM							



# Why 2020s won't be like the 1990s

- It's not just VR anymore
- Huge amount of investment
- Inexpensive hardware platforms
- Easy to use content creation tools
- New devices for input and output
- Proven use cases – no more Hype!
- **Most important: Focus on User Experience and Natural User Interfaces (NUI)**



# Conclusion

- Virtual Reality has a long history
  - > 50 years of HMDs, simulators
- Key elements for VR were in place by early 1990's
  - Displays, tracking, input, graphics
  - Strong support from military, government, universities
- First commercial wave failed in late 1990's
  - Too expensive, bad user experience, poor technology, etc...
- We are now in second commercial wave
  - Better experience, Affordable hardware, portable HMDs
  - Large commercial investment, Significant installed user base