Gartner

**Testimony of Brian Blau, Research Vice President, Gartner
Before the Senate Committee on Commerce, Science and Technology
Hearing: "Exploring Augmented Reality"
November 16, 2016**

Chairman Thune, ranking member Nelson, and the Members of the Committee:

Thank you for inviting me to testify today about augmented reality.

I'm Brian Blau, Research Vice President at Gartner, the world's leading information technology market research company. I'm here today because my background in immersive technology spans 25 years including in my current position where I advise technology providers, CIO's, businesses and investors across many industries and geographies on aspects of designing, marketing and using personal devices, apps and services.

Let me begin by saying, if immersive technologies, and by that I mean, augmented reality, virtual reality, and mixed reality are to achieve their potential, several important issues need to be understood.

First, using AR to blend the real world and virtual world in a seamless way can have novel and beneficial implications across a myriad of industries. This nascent technology is about to achieve a critical milestone – practical and affordable viewing devices entering the market. Now is our unique opportunity to foster its innovation and growth.

Second, the market for AR technologies might be small today but interest, over the long term, remains high and the potential for growth is significant.

Finally, for AR technology to flourish, innovation needs to be supported and accelerated without undue restrictions.

The result will be a plethora of new computing experiences that drive increased productivity across many industries, improved effectiveness of individuals in their work, and exciting new developments in the leisure, entertainment and retail sectors.

The 50-year plus history of computing can't be told without including the technology that addresses how humans, using their senses, interact with computers, each other and the world. With AR technology, users will perceive the physical world in new, richer ways, ones that are visually augmented to whatever best suits the needs of its users.

The technologies brought before you today provide a prime example of American invention, innovation and opportunity. Augmented reality, virtual reality and mixed reality, follow from a taxonomy of visual and sensory display types. AR devices are centered around a transparent smart display; which can be worn on your head, held in your hand, or seen through a wall.

Business use cases are broad. In coming years, field service workers, those that maintain utilities, infrastructure, machines, and equipment, will benefit because their work is often "hands-busy" tasks. An AR headset can provide visual overlays of diagrams, complex instructions, event recording, or enable "see-what-I-see" remote collaboration. Using AR can improve workforce productivity by removing time-wasting behaviors, or improving the efficiency of tasks.

The market for AR is mainly business today. We estimate the number of AR HMDs (head-mounted display headset) sold in 2016 to be around several hundred thousands. We forecast that in 5 to 10 years there will be hundreds of millions of HMD devices in the hands of users; split between see-through transparent display devices and those that provide full immersion such as VR. There are many technology vendors competing for this opportunity, Microsoft, Google, ODG, Epson, Daqri and many others. First generation devices are available now. Next generations will exceed these capabilities, and improvements over the coming years will solve and optimize many perceptual computing challenges.

Not only will there be intense competition in hardware – the devices and headsets – but there is also a great need for new core technologies as well as apps, services, infrastructure, and components; all of which need healthy digital ecosystems and business opportunities to flourish.

When will consumer AR become common? It may not be far off, and it's possible it will come in many form factors including handsets and headsets. Use cases for consumer AR are quite compelling because the visual overlay technology can show realtime and instant information when we look out into the physical world. Imagine turning your backyard into a video game, or going to a movie theater that is an individualized entertainment experience.

For the market to grow it's critical that you carefully consider any actions that would restrict or limiting AR's innovation process. AR needs development and maturity in many areas and will for many years to come. A particular focus should be around usability, safety and security. The requirements are higher here; AR –is– the experience and it could falter if the technology is restricted in ways that don't allow for experimentation, invention, testing, and ultimately broad use in many aspects of the consumer and business markets.

Thank you again for the the opportunity to share our knowledge and guidance on this exciting application of technology, and for the leadership of the US Senate to take such a high level of interest.

Brian Blau, Research Vice President, Gartner
United States Senate | Committee on Commerce, Science and Transportation
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Competitive Landscape: HMDs for Augmented Reality and Virtual Reality

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Analyst(s): Brian Blau, Annette Jump

Head-mounted displays and their use in AR and VR are quickly becoming a target of businesses due to their ability to enhance work and customer experiences. Ecosystem battles and years of fast device changes mean product managers should be selective and identify key verticals for immersive solutions.

Key Findings

- Ecosystem battles over the next five years mean that approximately five global players will dominate the market, but business verticals provide significant opportunities for value-added players.

- Diverse opportunity exists due to wide-ranging HMD capabilities. However, volume shipments will be small and less than 15 million units in the midterm and will ramp up to 35 million units by 2020.

- Devices are maturing quickly, but significant challenges remain. New product iterations are expected to be released constantly, so differentiation means specializing for a target audience.

- Selling to enterprise means educating IT about HMDs, the overall technical solution, support and services, and proof HMDs provide significant benefit to enhance the work process or improve customer scenarios.

Recommendations

For product managers:

- Aggressively build and market solutions, such as for field service, maintenance, training, design or medicine, which improve business functions using HMD technology.

- Become one of the top five ecosystem players, either globally, or in a specific use case, or in a vertical market segment, to gain and maintain market share.

- Work with ISV providers to enable a solutions channel to better help businesses integrate immersive technology enabling smart workplace environments.

- Create compelling user experiences for customers through great devices, but also help improve their technical expertise and design, and implement and continually refine solutions.

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Strategic Planning Assumptions

By 2020, 50% of the 50,000 largest businesses globally will have piloted or integrated immersive head-mounted displays (HMDs) for enterprise and customer use.

By 2020, there will be five HMD ecosystem providers that sell 80% of all devices.

By 2020, the market for HMD devices will exceed 35 million devices and generate $75 billion in revenue.

Analysis

The landscape for HMD for use in augmented reality (AR) and virtual reality (VR) solution spaces is quickly evolving, and the first ecosystems of devices, platforms and content are emerging in 2016. Gartner's definition of an HMD is a head-worn device that integrates small displays or projection technology. It is worn or mounted on or near the head so that its displays can be seen by the wearer at an ideal viewing distance, and aspects of the visual content will be contextual information that translates the wearer's state into visual cues.

The market for devices today is nascent but vibrant, and competition for the first deployment of devices into the market was well underway at mid-2016. Vendors are offering devices for augmented reality and virtual reality solutions, and these are typically defined as either having a transparent display (for AR) or one that is opaque (for VR). Form factors play heavily in how the devices are used and who would best benefit from them, and functionality greatly varies as devices are matched with software and services. Common form factors for VR include a facemask-style device that blocks the user's entire visual field of view, and AR devices can be found in glasses, helmets and clip-on form factors. Benefits range from entertainment experiences to enhancing the work process, but challenges in creating technology to integrate with the human perception of capabilities mean years of trial and development are needed before a high level of effectiveness is reached.

By mid-2016, the HMD vendor landscape was quickly gaining diversity. It spans from the largest technology providers, such as Google, Microsoft and Facebook, but also includes consumer electronics firms such as Samsung, Sony and Epson, and startups such as Atheer and Meta.

This report will reveal that while the market is new, it is already hypercompetitive and many of the biggest technology providers have announced or are planning on supplying or supporting HMD devices and ecosystems as part of their product portfolios. The unique nature of HMDs means many providers will use new and optimized OSes, and the associated hardware and software platforms, as well as enabling or supplying apps, services and content. Vendors that excel will be the ones that cover the entire HMD technology stack, as well as those that provide an ecosystem of solutions, that offer these devices and apps globally, or that partner to gain needed functionality.

This document will help product managers within HMD and other hardware providers to understand the evolution of HMD for different immersive solutions, the competitive landscape and major player positioning, as well as provide Gartner's view on the future of competition. This will enable them to decide on what parts of the HMD market they want to compete/enter, as well as better position and differentiate their products versus existing competition.

Competitive Situation and Trends

The Landscape for HMDs Coalesces in 2016

Outside of a few vendors, early access programs and smartphone VR (Google Cardboard or Samsung Gear VR), the sale of HMD devices to businesses and consumers started in 2016 to buyers that have been excited about their arrival. The devices, their content and apps greatly range in capability, price and performance, as vendors move quickly to provide solutions for a wide range of use cases.

By mid-2016, Gartner estimates that more than 7 million devices have made it into the hands of users, but overall usage has been limited to watching traditional flat-screen video, playing video games and businesses that are piloting HMD projects for future use cases. Business use of HMDs is less advanced than consumer use. This is due to fewer enterprise-ready devices being available compared with the consumer-ready VR headsets that are already in users' hands. The gap between the adoption of business use of HMD and consumer use will close, and by 2019 we will see HMD penetration rates where both segments of the market are well-established, and that business adoption could exceed consumer adoption.

Table 1 describes the main categories of devices and their market characteristics.

Table 1. HMD Market Description in mid-2016

Form Factor	Description	Type	Target User	Examples
Fully immersive facemask style	**Smartphone VR —** an accessory; requires a smartphone for operation	VR	Consumer with mixed business use	Samsung Gear VR, Google Daydream and Cardboard
	All-in-One — self-contained; mobile/wireless	VR	Consumer and business	Intel Project Alloy, Sulon Q
	Wired/Tethered — connected to a PC with capable CPU/GPU or game console	VR	Consumer with mixed business use	Oculus Rift, HTC/Valve Vive, Sony PlayStation VR
Partially Immersive with transparent display	Glasses, helmet, clip-on; all are mobile/wireless	AR	Business	Microsoft HoloLens, Daqri Smart Helmet, Vuzix M300
GPU = graphics processing unit				

Source: Gartner (October 2016)

Overall, Gartner predicts that the market for HMD across all form factors — such as smart glasses, helmets, facemask style and others that enable AR and VR solutions — will see strong growth in a 10-year or more time frame, reaching $72 billion in device revenue in addition to apps and services. Through 2020, the market will see only modest growth, and acceleration of adoption will occur later once better consumer devices are made available. During this time period, we will see HMD adoption move from enthusiast levels to ones that show market maturity and global availability, and have sustaining business models. Based on Gartner's latest wearable forecasts, 477.8 million units of wearables devices will be shipped in 2020, which includes 39.9 million HMDs. More details around these forecasts can be found in "Forecast: Wearable Electronic Devices, Worldwide, 2016."

During our HMD forecast period through 2020, we expect technical functions of AR and VR to merge into a mixed reality feature set, and by then many midrange and premium HMDs will support a wide variety of immersive experiences. It is likely that the future HMD market linked with AR will be much bigger versus VR, mainly due to AR's horizontal applicability as a business tool. Additional factors, such as device and ecosystem maturity, cost of implementation, availability of vertical-specific solutions, and advancement of see-through display technology, will push forward a future type of immersion called "mixed reality." Superseding AR but still maintaining VR capabilities is this mixing of the real and virtual. This excites businesses and brands due to its ability to create hyperpersonal experiences. Getting to that mixed reality advanced point will require a mass market consumer see-through display solution, which we expect to see made available within five years.

Finally, by 2020, the number of market-share-leading HMD providers will diminish to approximately five, mainly due to the high technical requirements needed to make advanced transparent displays. The small group of two or three market share leaders will be the global companies that can create
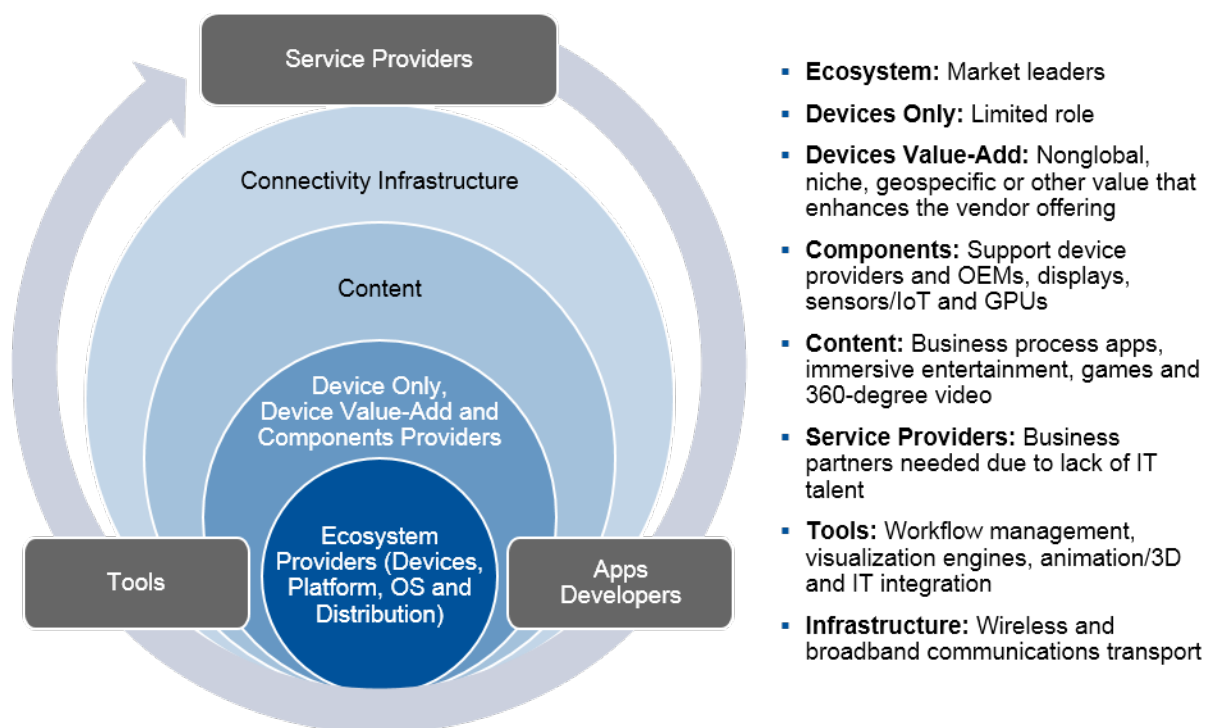
compelling consumer and business solution sets, namely ecosystems, where most of the list includes businesses that are already ubiquitous with consumers and business. In addition, we will see several providers that come from China, or that only focus on the market in Asia. There are opportunities to specialize in content and local technology ecosystems, such as ISPs or other digital content providers.

Supporting Different Ecosystems Is Key to Successful HMD Business Models

The successful HMD businesses will either be or support an ecosystem of devices, developer hardware and software platforms, operating systems, and content, similar to the Google Android and Apple iOS ecosystems we see today, or are ones that tightly integrate with them. That horizontal approach means flexibility in configuring HMD solutions, and controlling the technology and transaction flow, or being a platform for others to build on.

Other areas, such as providing content creation and management tools, professional services, infrastructure, components or being a geospecific provider in any of these areas, will be needed to support HMD providers or businesses that adopt HMD solutions. Figure 1 describes the layout of the HMD market for the next five years:

Figure 1. HMD Market Layout

- **Ecosystem:** Market leaders
- **Devices Only:** Limited role
- **Devices Value-Add:** Nonglobal, niche, geospecific or other value that enhances the vendor offering
- **Components:** Support device providers and OEMs, displays, sensors/IoT and GPUs
- **Content:** Business process apps, immersive entertainment, games and 360-degree video
- **Service Providers:** Business partners needed due to lack of IT talent
- **Tools:** Workflow management, visualization engines, animation/3D and IT integration
- **Infrastructure:** Wireless and broadband communications transport

Source: Gartner (October 2016)

Business Models: Most HMD providers will focus on device sales directly to end users as their main business model, but we will see exceptions as provisions are made to allow businesses to purchase in volume. The largest HMD providers, those that will likely be the ecosystem leaders, will

directly offer devices at no or low profit margins. An example is Oculus, which has previously stated it won't focus on profits for its device, but wants to enable its ecosystem and will provide the device at or near cost. Some HMD ecosystem leaders will provide OEM opportunities for others, such as the recently announced partnership between Intel and Microsoft (Intel Developer Forum [IDF] 2016), where each company will bring technology (Intel's Alloy HMD OEM specification) and Windows Holographic (Microsoft's OS for immersive devices). Ecosystem providers will also tax app developers for platform access, which is a typical type of revenue sharing we see in app stores such as those from iOS and Android.

Business Focus Is About Process Enablement and New Behavior Facilitation

We expect HMD technology to enable businesses to change how they manage individual work functions and to also empower employees in specific verticals. Businesses will use HMD technology to improve employee productivity, such as being used for training, in product design, when collaborating with others, in remote work situations, and other activities that can benefit from the use of head-worn displays.

In the short term to midterm, AR see-through display devices will be adopted by enterprises with consumer devices coming in several years at the earliest. A limited number of smart glasses and other HMDs for AR is available, but most are only for early adopters, and many HMDs have yet to ship their first commercially available units. We expect HMD product managers to select and focus on business verticals by offering their own cloud-based solutions, or that they will partner with third-party solution providers or independent software vendors (ISVs) to fill in product gaps.

For now, the focus for business-immersive HMD solutions is mostly on see-through AR devices targeted at basic work tasks, taking pictures, scanning codes or providing basic work process data. In mid-2016, there are many pilot projects underway for AR in logistics/warehousing, medical and healthcare, product design, business operations, retail, manufacturing, architecture, and more. If these pilots ultimately are successful, we will see greater adoption of HMDs in business verticals starting in 2017 and 2018.

Lack of IT HMD Talent Enables New Class of Professional Services to Help Integrate Immersive Technologies

Immersive AR and VR solutions require a different level of sophistication and enhanced user experience than other digital technologies to be effective. The success of HMD systems is heavily reliant on the experiences they enable, and IT's overall lack of engineering talent in 3D or graphics technology means services, not IT, will play an important experience design role for the next three to five years.

Some HMD systems, especially AR solutions for business, offer ecosystems and customization solutions — such as Atheer's AiR Suite — but few businesses are prepared from a technical or talent perspective to create and manage their own custom-made integrations and apps. Service providers in this sector, on the other hand, have that needed experience; for example, APX Labs, WorldViz and Eon Reality, each of which has been creating immersive content for businesses for more than 10 years. Service providers are adding to their knowledge arsenal with each new

implementation, and as a result there is a growing cadre of providers that is becoming an important aspect of the market.

Where else can IT find examples of good HMD experiences and talent? The earliest consumer HMD adopters will be video game players who are avid buyers of the sophisticated graphics that make games attractive. These game developers are best prepared today to support AR and VR apps as they have the most experience working with graphical simulations and complex user experiences necessary for HMDs. Look to the consumer HMD experience for examples of best practices and expectations of better HMD apps and services.

The challenge for businesses and IT is threefold:

- They don't have the knowledge base to create effective solutions that can best leverage HMD devices

- They don't have IT staff that has experience in creating visualization or real-time graphics apps

- They are not familiar with example solution sets they can mimic and recreate for themselves

HMD product managers should focus on solving all three of these challenges by offering IT-friendly user interfaces, extended support and design consulting services, and advanced integrations with other IT systems to facilitate out-of-the-box data exchange. Until this advanced product feature stage is reached, build partnerships and solutions channels as there is a clear opportunity for solution providers to act as technical and design resources for IT.

Market Players

The following chart (broken into two parts as Figures 2 and 3) provides a high-level look at a cross section of the HMD provider landscape. Not all HMD solutions are listed, but ones representing all of the popular form factors are included. Some of the providers in this chart are further detailed in the Vendors to Watch section later in this document.

Figure 2. Sample Market Player Overviews

Company	Picture	Portfolio	Release Status	OS	API	Example Vertical	Support	Region
Microsoft		HoloLens	Business/enterprise developers only	Windows 10	Yes	Manufacturing and operations, design, aerospace, automotive, space exploration, healthcare, education, retail	Through partners	U.S. and Canada
Google		Cardboard Daydream View Glass at Work	2014 October 2016 2016	Android/iOS Android Glass OS	Yes	Cross-vertical support	None For OEMs Direct	Global U.S., U.K., DE, CA, AU U.S.
Oculus		Rift	March 2016	PC	Yes	Gaming and entertainment, retail	Direct, online community	U.S. and selected mature markets
Daqri		Daqri Smart Helmet	Developer edition	Daqri 4D OS	Yes	Manufacturing, oil and gas, transportation, utilities	Direct	U.S. and U.K./Ireland
Atheer		AiR Glasses	Prerelease, ships in 3Q16	AiR OS (Android based)	Yes	Field service, insurance, healthcare, oil and gas, warehousing/logistics	Direct	U.S.
Sony		PlayStation VR SmartEyeGlass	October 2016 2016	PlayStation Android	Yes	Video games Business applications	Direct Direct	U.S. and select mature markets
Epson		Moverio BT-200 and BT-300	BT-200 since 2014, BT-300 ships in 2016	Android	Yes	Business applications	Through partners	U.S. and select mature markets

DE = Germany; CA = Canada; AU = Australia

Source: Gartner (October 2016)

Figure 3. Sample Market Player Overviews, Continued

Company	Picture	Portfolio	Release Status	OS	API	Example Vertical	Support	Region
ODG		R7	2016	Reticle OS, based on Android	Yes	Military and government, automotive, medical and entertainment, consumer (in future)	Directly and via partners	U.S. and select mature markets
Samsung		Gear VR	2014, last update in August 2016	Requires Samsung Android phone	Yes	Games and entertainment	Directly to users	Worldwide
HTC		Vive	2016	SteamOS	Yes	Games and entertainment	Online community	Worldwide
Meta		Meta 2	Prerelease	PC	Yes	Business applications	Direct, online community	U.S.
Vuzix		M100 M300	Available now Select enterprise developers	Android Android and iOS	Yes	Warehousing/logistics, utility/field services, manufacturing, medicine, business apps, consumer (in 2017)	Directly and via partners	U.S., Europe and Japan
Baofeng		Mojing, in various configurations	2015	Android	Yes	Games and entertainment	Online community	China

Source: Gartner (October 2016)

Many other vendors have announced or offer HMD products, and it is thought that there are more than 100 vendors that have announced or are already shipping devices. Other vendors not listed above are Zeiss, Archos, LG, Razer, GameFace Labs, Fove, Recon Instruments (an Intel company), Optinvent, Kopin, Avegant, castAR, Canon, Innovega, Seebright, Lumus, Sulon, Avegant Glyph, Mattel, Vrvana, Brilliantservice, Scully and Starbreeze.

Magic Leap is included in this report due to its announced HMD and the large investment it received. More than $1.4 billion was invested in the company by 2Q16. There is a high level of interest surrounding Magic Leap in the technology community due to the large investment amount and patent filings that indicate an advanced level of HMD capability, but it has yet to demonstrate its devices so any claims of quality haven't been verified publicly.

The Future of Competition

One aspect of both AR and VR, and as mentioned several times, devices and systems will be advancing at a fast pace over the next five years. During this time, the basic functionality won't change, but the capabilities of HMDs will. One of the most profound changes will be the merging of device capabilities between AR and VR. Advances in transparent display technology as well as cameras and other sensors will be integrated into future HMD devices. The resulting data will provide more than enough data to allow developers to create both transparent and opaque apps on all types of devices. An important point for HMD product managers is to understand how AR and VR will merge functionality, and build that use case into future plans to allow for more flexible and useful systems.

HMDs Require Quality Experiences, or Risk Abandonment

Creating quality and effective immersive experiences aren't easy or intuitive, but can be achieved through an ongoing iterative design-test-release-improve process. HMD product managers need to enable a quality experience by providing robust ecosystems and platforms as well as devices that can fully enable these experiences. Without the combination of advanced device technology, the HMD market won't develop, and the likely cause will be due to user abandonment because of poor-quality experiences. Business demands for return on investment won't materialize if HMDs and their associated apps and services don't bring the benefits that are being advertised by providers today.

The Success of HMDs Relies on the Realization of Its Novel User Experience and Perceived Value

The hype around HMD technology has existed for decades, and vendors must deliver on the promises of an improved computing experience if users are trying and trusting that vendors can deliver on these promises.

It is unlikely that we will see a specific "killer app" for HMD linked with AR, as many implementations will be vertically targeted. In the midterm, we will see AR used around more advanced tasks in specific verticals (aerospace, medicine, universities, architecture/design and real estate), communication and collaborative work among mainstream business users and for remote work (oil/gas, repair workers in the field and car repairs/car accidents). Advanced capabilities, such

as accurate overlays, simultaneous location and mapping (SLAM) or computer vision-assisted object identification, are available today for experimentation but won't be deployed in HMDs until a more advanced stage of development.

This change of the user interface, from flat to immersive, is a long-term challenge, and if the past is any indication of the future, it will take many years of advancement before these user interfaces will be refined to a point they can positively impact users at a reasonable cost. There is little real experience in the market for designing these immersive experiences, especially with IT, which seldom focuses on how its business users experience software systems.

Long-Term Value of HMD in Business Will Be Due to Democratization

Over the next two to three years, HMD quality will rise, out-of-the-box business systems will emerge, and prices of devices will decrease. This democratization of AR and VR will enable its adoption with affordability and functionality over time, then will match the ROI equation that businesses require.
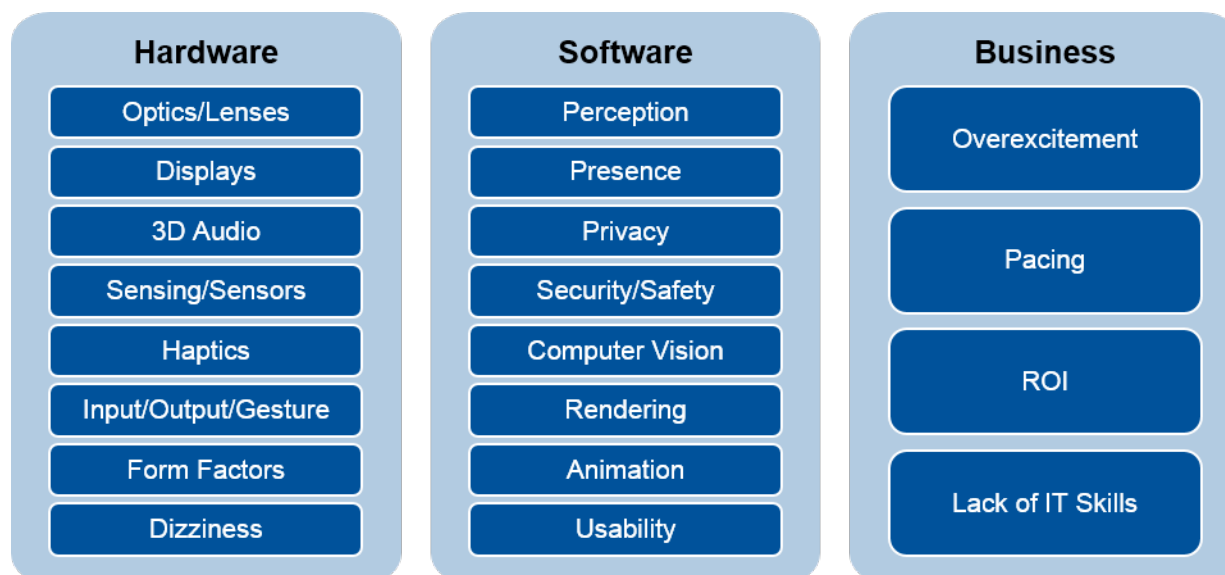
Today, this means businesses will be identifying how they can integrate AR and VR solutions as a beneficial aspect of their workflow and process. They are accomplishing this goal by first working through pilot programs, which is how most HMD deployments start out. In future years, these pilots will become more robust and eventually lead to full-scale deployments, which will start in 2018 and 2019.

HMD product managers should facilitate pilot programs to help convince customers the value proposition of immersive use cases, such as by looking at ways to improve or change individual and physical workplace behaviors and actions into ones that can leverage HMDs. Solutions will likely need to be purpose-built for a single task, but this can be accomplished with standardized devices and systems. Most businesses will not need purpose-built or ultra-expensive VR, but will be able to create prototype and deployable VR solutions for less than $100,000 by 2018.

Hurdles Remain Before Devices and Their Systems Become Robust

The HMD available today is usable. While advanced in nature, it is considered an entry-level product compared with what will be available in just a few years. There are many areas of development needed before HMD devices can better match a human perceptual system, or provide core business value. Figure 3 lists many areas of development and research that are ongoing at device vendors and content developers.

Figure 4. HMD Technical and Business Challenges

Hardware	Software	Business
Optics/Lenses	Perception	Overexcitement
Displays	Presence	
3D Audio	Privacy	Pacing
Sensing/Sensors	Security/Safety	
Haptics	Computer Vision	ROI
Input/Output/Gesture	Rendering	
Form Factors	Animation	Lack of IT Skills
Dizziness	Usability	

Source: Gartner (October 2016)

One area of particular concern is the ability of the HMD to best match the human perceptual system. One physical reaction to HMD use is dizziness or headaches, and users simply won't continue wearing an HMD if these conditions persist. Solving this problem requires better technology, including improving the display, optics or even adding eye-tracking. Ultimately, though, it is the combination of device and app that drives each experience, and when done correctly most people won't have a negative response, such as being dizzy.

Issues such as human factors and perception are long-term concerns for HMD providers, and as much as they can create great technology, product managers must work with content providers in unison to create the best devices possible. As AR and VR are complex solutions, not individual technology pieces, each must work well together to overcome these challenges as we have yet to see any one single device or system component be dominant.

Competitive Profiles

Microsoft

Market Overview

Microsoft is a relatively new player in the HMD market with its HoloLens product. It announced the prototype HoloLens in January 2015, and the Development Edition was launched in March 2016. Microsoft HoloLens is a fully self-contained holographic computer that is able to deliver an AR experience, which Microsoft calls "mixed reality." It is also the only HMD device that is running on Windows 10. Windows Holographic OS was recently updated with AR-specific versions of Microsoft

Outlook Mail and Calendar, allowing users to interact with emails and calendar appointments in a virtual world. For now, Microsoft's focus with HoloLens is only on the business segment, but inclusion of video game demos indicates its focus may include consumers in the next two to three years.

How This Provider Competes

A mobile and wireless head-mounted display, Microsoft HoloLens is available to developers in the U.S. and Canada, with some broader availability across selected mature markets expected in 2017. The device has an optical system that integrates a variety of sensors to capture information about user actions and the surrounding environment. It also understands gestures and is able to generate multidimensional full-color images using a special transparent display. The device has more processing power than the average notebook and its holographic processing unit (HPU) is able to process the large volume of data required to deliver a smooth virtual experience. This enables users to move freely and naturally interact with virtual data and content.

The biggest current limitation of Microsoft HoloLens is around its field of view, which is limited to approximately 30 degrees. The company is now proactively building its developer community to create apps for a wide variety of business verticals. Microsoft's strategy is to provide best-of-class immersive technology, and to work with partners to enable a growing ecosystem of devices, apps and services, which gives Microsoft some advantages in the HMD market due to its existing influence in business.

Google

Market Overview

Google offers three classes of HMD devices: Cardboard, Daydream and Glass at Work.

Cardboard was launched in 2014 as a technical commentary piece indicating that VR didn't need to be complicated or expensive. The idea caught on, and today there are dozens of smartphone-based VR systems that use the Cardboard app standard. By mid-2016, Cardboard-style devices dominate the HMD market by unit volume, and while it is not a significant revenue generator for Google, the devices are accessible to many, including a special version that is made available to elementary school teachers.

Google's latest push into VR is Daydream, first announced in May 2016 with follow-up details in October 2016. Daydream is a VR platform that includes a smartphone VR HMD, a handheld controller for VR user interactions, an operating system tailored to support VR experiences, a developer platform and content distribution. Google's new Pixel smartphone is the first marketed as Daydream-ready, and device specifications let OEMs offer their own HMD devices, the first of which are expected in late 2016. Partners that are expected to release devices include Samsung, HTC, Huawei, LG, ZTE, Asus, Alcatel, Xiaomi and others. Google's YouTube, Play Movies, Photos and Street View — plus games and apps such as Netflix and Hulu — will be part of the initial content at the device launch in October 2016.

Glass Explorer Edition prototypes had an initial limited release beginning in April 2013, followed by a public release in May 2014. The project received a mixed reaction from both consumers and enterprises. The intense media coverage generated by this initiative uniformly raised awareness for HMDs, as well as AR and VR. Glass operates through a wireless connection to a smartphone. Google's Glass at Work is an update to the original device and is available to select developers that focus only on enterprise solutions. Its small screen, limited battery life and lack of a true AR experience, as well as public backlash over privacy concerns, ultimately limited the appeal of Glass.

How This Provider Competes

Google's overall approach to HMDs is focused on being a global ecosystem of devices, content, OSes and developer tools. In addition, Google has invested significant funds into Magic Leap, which could mean that Google will have access to yet more HMD technology in the future. Google's other efforts, such as overall development of Android, and Project Tango's computer-vision-driven sensor technology, will influence and enhance their HMD efforts. Their approach is broad and extensive, and represents the most diverse strategy and offering of any other player in the market.

Oculus/Facebook

Market Overview

Oculus was acquired by Facebook in April 2014, and since then the company has invested heavily in its technology and talent. The much-anticipated HMD Oculus Rift was released in March 2016. The device's $599 price is lower than others, but it also requires a PC to operate, significantly raising the cost of an entire Rift system to approximately $1,500, and it is supported only in Windows PCs. Oculus Touch, an ergonomic gesture controller, will sell for $200, and additional cameras for room-scale VR raise the cost of an overall system.

Additionally, Facebook has been working with Samsung on a smartphone VR, the Samsung Gear VR, which is powered by immersive software from Oculus. Samsung Gear VR has been available since late 2014, and while the unit price is $99, it is often given away free with a new Samsung smartphone purchase. Oculus powers Gear VR software, and in October 2016 it announced that more than 400 apps and games are available.

How This Provider Competes

While the Oculus Rift is available for sale to any type of user, its focus is concentrated on consumers, gaming and entertainment. Facebook's recently announced studio works to enable VR games and content production for its HMD. It has also created the Oculus Store, which offers Rift-compatible games and content. All of its games come with an "intensity" rating based on how much motion there is in the game to help users judge the possible impact of VR, especially for novice players. There is also a growing list of movies and apps that are supported for the VR experience on the Oculus Rift.

Oculus is being challenged by competition from traditional technology providers such as Microsoft and Google. Outside of Samsung, Facebook has no hardware partners that could challenge it, as developers will want to limit the number of systems they support as the market continues to expand. Oculus announced in October 2016 that it will spend another $250 million to support content and app developers to help seed the market.

Daqri

Market Overview

The main HMD product of Daqri, a U.S. company, is the Daqri Smart Helmet, which enables workers via AR experiences to get more information about their environment. In the form factor of a safety helmet, the device is meant for on-site workers and offers build-in optimized work instructions and other hands-busy tasks. The HMD runs Daqri 4D OS, and the company also offers software to help businesses integrate the helmet functionality into their workflows.

How This Provider Competes

The Smart Helmet device is for enterprise users. The targeted verticals are manufacturing, oil and gas, transportation and utilities. The idea is to use AR to deliver specific work instructions and reduce errors in quality, and reduce unnecessary movement of employees in factories and production facilities, as well as increase efficiency through data visualization. Customers are able to use Daqri 4D Studio to create custom work packages and then use them with the Smart Helmet. It is possible to integrate data from ERP systems with both 4D Studio and its HMD device. The company is also offering Melon, an activity monitor for your brain (electroencephalography [EEG] monitoring) that can help users to track and train focus and related behaviors.

The Daqri Smart Helmet is currently available only to approved businesses, and Daqri's formal developer program opens in November 2016. With few selected customers and partners on board, there is no commercial availability yet.

Atheer

Market Overview

Atheer created its first prototype of 3D AR glasses in 2013, and has been shipping Atheer AiR Glasses since December 2014. The focus of the company is making users of selected verticals more productive through an AR-like interface. The currently available product is AiR Glasses, mobile 3D AR glasses with touch-free gesture control. The device uses an Android variant, which means it is compatible with a large number of apps. It also has a medium-wide field view (50 degrees) and offers eight-hour battery life, which gives it an advantage over others that can't yet provide these same capabilities.

How This Provider Competes

Atheer aims to empower workers to interact with the digital world similarly to how they do it in the real world. Atheer AiR Glasses allow users to visualize and interact with data via gestures, and do it touch-free and precisely. Atheer is able to provide immersive and wide-field computing, as well as personalized binocular image optimization. The company is focused on enterprise with the following vertical focus: field service, insurance, healthcare, oil and gas, and warehousing/logistics. The company also offers an enterprise-ready cloud solution — the Atheer AiR Suite platform. It provides collaboration, task-flow management and remote expert communication.

Its software suite is able to support the company's own-branded smart glasses, as well as those from other providers, such as Epson, Osterhout Design Group (ODG), Recon and Vuzix. This unique approach means flexibility in providing devices themselves, or supporting those from other vendors.

Sony

Market Overview

Initially announced at GDC 2014, Sony's PlayStation VR will connect to the PlayStation 4 (and Pro) and provide VR games and entertainment content. Sony's device is based on a helmet and straps to the head so that the fully immersive display rests on the forehead and is counterbalanced with a weight on the back, versus being strapped from the rear as seen in other VR HMD solutions. Sony has a long-standing history with game players through the PlayStation platform, and these players are Sony's intended audience at launch. Devices became available in October 2016.

Sony's SmartEyeglass devices are AR-style smart glasses and run on the Android operating system. SmartEyeglass uses a prism to bend the image around the headpiece, but it is small enough to fit comfortably into a glasses-like package.

How This Provider Competes

Sony's approach to HMDs is concentrated on its PlayStation game console and consumers. The PlayStation is the leading game console with more than 40 million devices in the hands of consumers, which is far ahead of its main competitor, Microsoft Xbox, which is not yet offering any HMD or VR solutions. Due to the large installed base, it is expected that the PlayStation VR will become the market leader by unit volume in the months after the device makes it to the hands of game players.

Sony's HMD SmartEyeglass device competes with the others that are targeting business users, which is an increasingly crowded market.

Epson

Market Overview

The company started developments around HMD (smart glasses, specifically) in 2009 and introduced its first product, Moverio BT-100, in 2011. Since then, the company has expanded its offering to smart glasses (Moverio BT-200/BT-300) and a smart headset (Moverio Pro BT-2000). Epson's BT-2000 headsets cost $2,999 and are targeted at industrial verticals. Epson's BT-200 smart glasses have been in the market from 2014 and cost $699. Its price is much less expensive versus newer models, 20% heavier versus newer models, has only a video graphics array (VGA) camera, and won't fit over regular glasses, which are some of the differences. The next-version BT-300 is claimed to be the lightest smart glass device in the market, and has been announced for preorders, but no pricing or availability date has been released.

How This Provider Competes

Epson's product portfolio of HMDs is targeted specifically at enterprise users. Its smart glasses allow users via a transparent display to seamlessly blend digital content into the physical world around them. A front-facing camera enables AR, while via head-tracking sensors users can have a 360-degree digital canvas. Epson's smart headset is specifically designed for industrial working environments (logistics, construction, remote workers and airspace), so it features an adjustable headband, allows motion tracking with 3D mapping and gesture control, and is dust and water resistant. All of Epson's HMDs are built on the Android OS, which provides a familiar OS development platform for many app developers.

Osterhout Design Group (ODG)

Market Overview

The HMDs from ODG are AR devices fashioned in the form of electronic glasses. Its latest product is R-7 smart glasses, priced at $2,750. The R-7 model incorporates sensors typically found in most AR glasses devices, such as gyroscopes, magnetometers and accelerometers, have a voice recognition system, a front-facing camera and global navigation satellite technology. They include stereoscopic see-through displays in which the user sees graphics overlays or other contextual information. This way, the user is able to maintain awareness of the surroundings. In January 2016, ODG reached an agreement with 21st Century Fox to acquire a minority stake in the company. The main benefit for ODG will be the access to huge media content and apps through its integration of the Android operating system.

How This Provider Competes

ODG's background as an HMD supplier to the U.S. Department of Defense has given it years of experience creating immersive devices for a very focused customer. The company's smart glasses are targeted at verticals such as automotive, medical and entertainment, as well as its traditional customers in the military and government. For now, the company is only playing in the business segment and plans to expand into the consumer market in the future.

Samsung

Market Overview

Samsung's partnership with Oculus has resulted in the Gear VR, a smartphone-based HMD that relies on a specific set of Samsung Galaxy smartphones, such as the Note 7, for its functionality. Software powering the Gear VR is from its partner Oculus, which provides the VR user interface, app store and developer platform. The Samsung Gear VR is the global leader of this type of HMD, but Chinese Baofeng has more devices in the hands of users and it can use many types of smartphones for its operation.

How This Provider Competes

Samsung's strategy with the Gear VR is more than just its HMD, as it is the top provider of smartphone devices worldwide. Samsung now offers a suite of devices that support its overall VR efforts. The Gear 360 is a spherical camera that takes pictures and video that can be seen in VR experiences. Also a partner of Google's Daydream, it is expected that its next generation of devices will include phones that support Google's new VR headset.

Vuzix

Market Overview

Vuzix has HMDs available for purchase by enterprises or consumers. Its long history in the HMD market (since 1999) gives it experience in creating devices, as well as brand recognition in the market. For the enterprise space, the company offers several smart glasses (the M100, which is available now, and the M300, which is available to select enterprise developers). The currently available M100 smart glasses cost approximately $983. In January 2015, the company received a $25 million investment to accelerate the development of fashion-oriented smart glasses for the consumer space. Currently, Vuzix offers iWear Video, which is a wearable display for gaming, mobile video and VR. The approximate cost of iWear Video is $590.

How This Provider Competes

The vendor's catalog of HMD devices comprises two categories: AR glasses for enterprises and iWear for a wearable display. The M100 is different from other smart glasses in that it supports a single screen (monocular), and the unit can attach to any pair of consumer prescription glasses or conforming safety glasses. The display is not transparent, but a front-mounted camera adds some realism to the imagery.

iWear is a VR device in a visor-like form factor. It can play back movies or be used as an HMD for VR experiences, similar to Oculus. Vuzix M100 smart glasses are running Android OS, so they are compatible with many of the existing Android apps. The next generation of Vuzix smart glasses (M300) will be able to operate on both Android and iOS.

The company also announced plans to release in Fall 2016, M3000 smart glasses with advance waveguide optics. The upcoming Vuzix device will have features and capabilities similar to a smartphone, but in a hand-free wearable form factor.

References and Methodology

This report was prepared using primary and secondary resources extensively. The research uses additional industry sources to verify the accuracy of the information. Sources of data used by Gartner include, but are not limited to, interviews with HMD and solution providers, media reports and general trade press, published HMD provider statements and documents, estimates from reliable industry sources, and the Gartner analyst community.

Various companies, government agencies and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between information provided by Gartner and information provided by other research organizations.

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

"Forecast: Internet of Things — Endpoints and Associated Services, Worldwide, 2015"

"Forecast: Wearable Electronic Devices, Worldwide, 2016"

"Top 10 IoT Technologies for 2017 and 2018"

"Hype Cycle for Personal Technologies, 2016"

"Enabling Future Smart Workplaces With IT"

"Predicts 2016: Know Your Customer to Capture Opportunities in the Personal Technologies Market"

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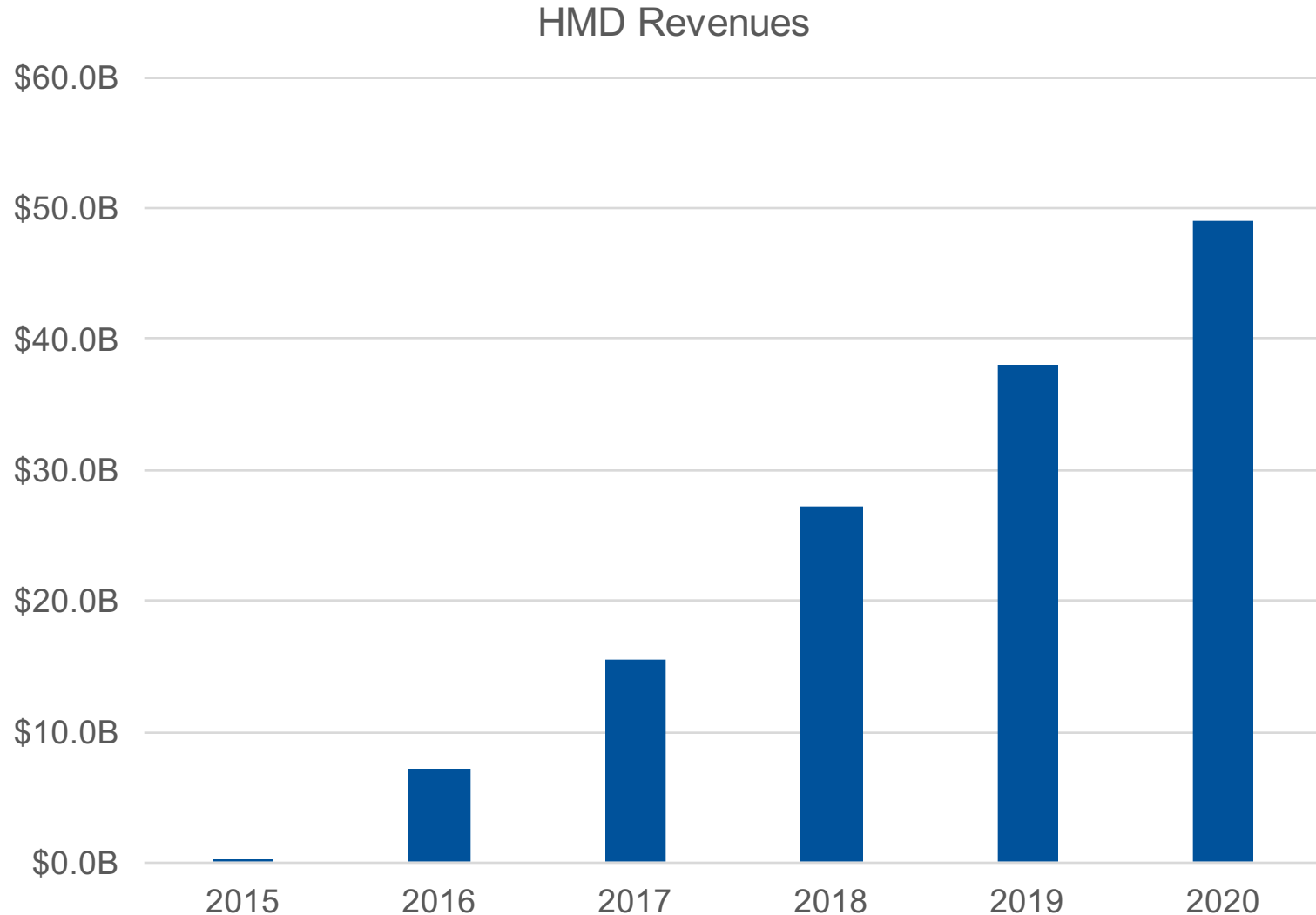
Gartner: AR/VR HMD Devices Market Forecast

HMD Unit Sales (millions)
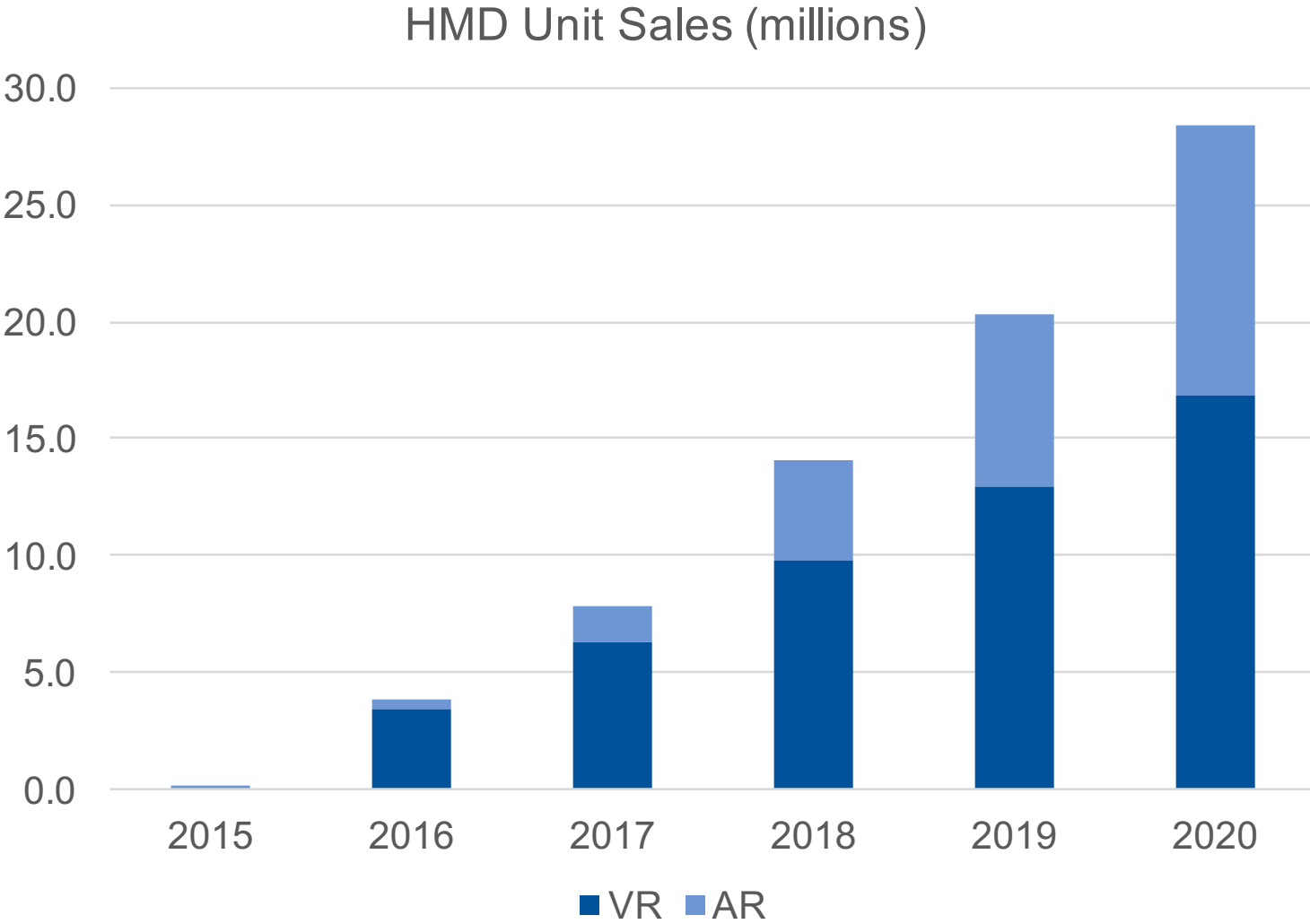
- Availability of devices starts in 2016
- Quality HMD's for VR, AR lacks maturity
- Adoption accelerates at modest pace through 2020
- Not a large market, consumer AR not yet a factor

VR ■ AR

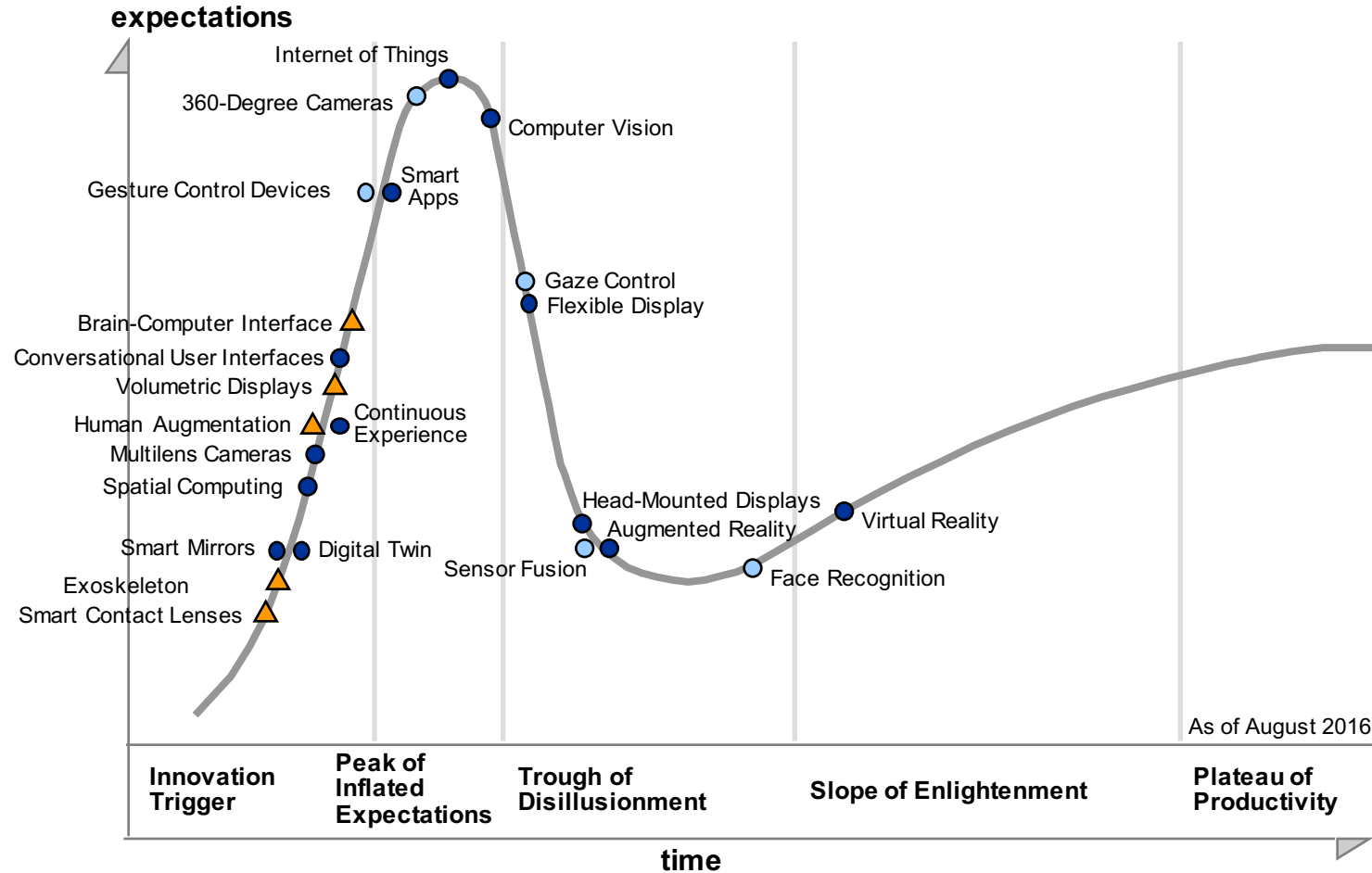Source: Forecast: Wearable Electronic Devices, Worldwide 2016

Gartner®

Gartner: AR/VR HMD Revenue Forecast

HMD Revenues

- US: design and develop
- Asia/China: components and assembly
- Display technology for AR isn't robust. Sensor data fusion lacks scale
- Critical R&D investment period
- Apps/services revenues to exceed HMD revenues as much as 2x-5x

Source: Forecast: Wearable Electronic Devices, Worldwide 2016

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Gartner Hype Cycle 2016: Example AR Technologies