

A background of a network graph with grey nodes and lines connecting them, creating a complex web-like structure.

TACTILE
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INVESTING IN VIRTUAL & AUGMENTED REALITY

THE NEXT EVOLUTION OF COMPUTING

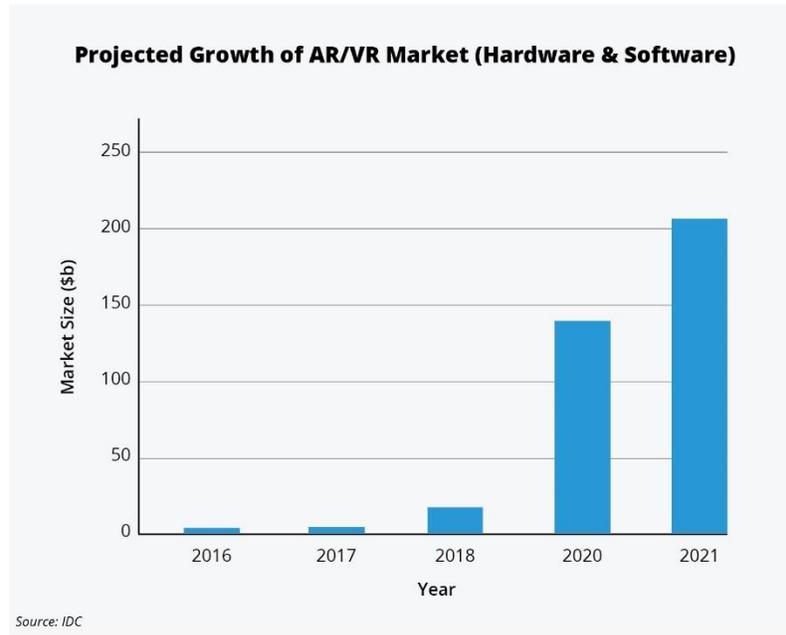
tactile-arvr.com

// THE NEXT EVOLUTION OF THE PERSONAL COMPUTER

We are surrounded by examples of how virtual reality (VR) (total immersion in a virtual world) and augmented reality (AR) (the overlay of digital information onto the physical world) can change the way people interact with data and the world around them – from a student interacting with objects in a digital classroom to an engineer working on a remote project to a person walking down the street with easy access to information about their environment. This technology possesses the power to transform lives much like mobile phones significantly and irreversibly changed the way we do things.

Since their creation, computers have been progressively miniaturized. Initially born as bulky, immobile boxes attached to large, heavy displays, computers have since evolved into portable laptops and mobile devices that can fit in your pocket. All these changes brought increasingly powerful computing into frequent, direct contact with the user. The next evolutionary stage will be AR/VR platforms that further increase that connection and accessibility allowing humans to interact directly and naturally with reality, both real and virtual.

With the proliferation of AR and VR technology, many markets and industries will be disrupted, creating substantial economic opportunity. Those companies investing in the AR/VR value chain stand to benefit from the wave of change ahead. Industry analysts believe the market for AR/VR could grow to over \$200 billion by early 2020s, and the combined size of industries disrupted could be many times larger.

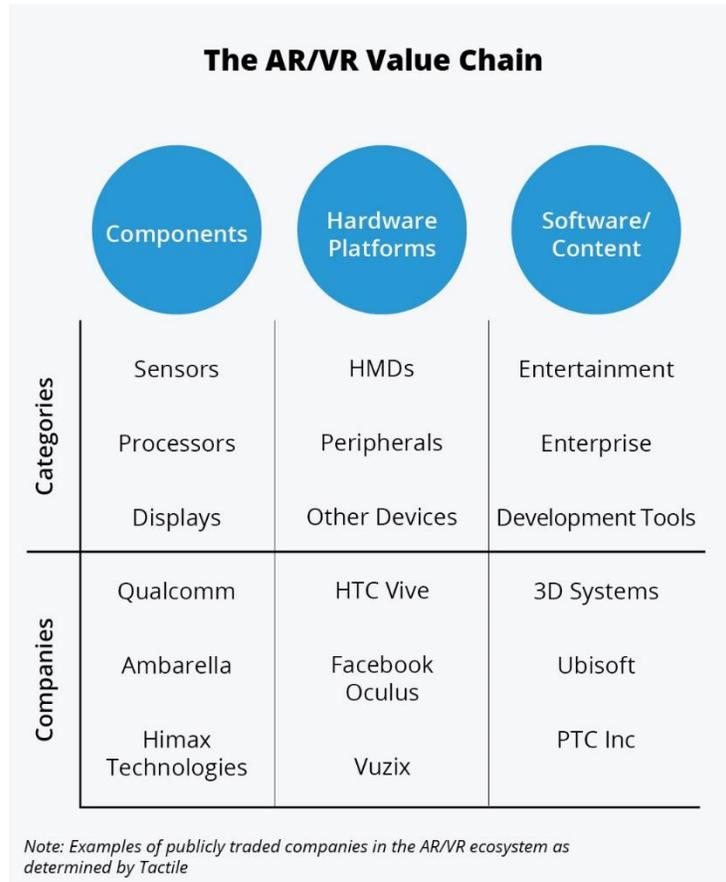


// WHAT IS AR/VR?

VR and AR are two similar, yet different, technology applications:

- VR immerses users in artificial or virtual worlds (such as video games, simulations, or movies) or simulates experiences in the real world (such as watching sports). Major hardware platforms in VR include Facebook Oculus, Sony PlayStation VR, HTC Vive, and Samsung Gear VR.
- AR overlays digital imagery onto the real world (with devices such as Google Glass, or through mobile apps such as Pokémon Go). Major hardware platforms in AR include Microsoft HoloLens, Google Glass, and Magic Leap.

VR immersion is typically achieved through opaque headsets known as Head Mounted Devices (HMDs), while AR is typically offered through transparent headsets or glasses, as well as in mobile apps. In both cases, users can interact with the digital environment through a combination of motions (moving one's head, physically walking across a room), using a hand-held controller, or through speech. This deep immersion and interaction with the digital environment is what defines AR/VR technologies as the next generation of computing.



// THE NEXT EVOLUTION OF COMPUTING

The history of the computing industry is viewed as a constant evolution in the ways in which users interact with machines. In the beginning, mainframes required punch cards to input data. The keyboard came next, followed by the mouse paired with a graphical user interface (becoming mainstream with Windows 95). The advent of the smartphone put computing power directly in users' hands, opening a multitude of new applications (Google Maps, Instagram, mobile gaming). In fact, Generation Z (those born in the mid-1990s to the early 2000s) is being branded the Mobile First Generation, with mobile devices being the primary point of computing access.

AR/VR is taking the next step by putting users' in direct contact with the digital world. Mobile screens become 360-degree interactive landscapes. Virtual keyboards are replaced with intuitive gestures and movements.

Computing has moved from the desktop to the back pocket and now directly in front of our eyes. The insights and information we are accustomed to accessing will become part of the world we interact with rather than being restricted to a fixed-size display.

// THE VIRTUAL REVOLUTION IS HERE

The idea of Virtual Reality has been around for decades, but the industry was beset by early failures.

The 1990s saw the introduction of 3D video games, with companies such as Virtuality producing VR arcade games and Nintendo releasing the Virtual Boy VR system. However, the technology available at the time could not keep up with the hype it created. Both the cost to produce these systems and the flat user experience kept consumers away.

So why is the outlook for AR/VR different today? There are four reasons why we are entering the inflection point for mass acceptance:

- **Computing Power** - The ability to create virtual worlds requires a confluence of technology. Thankfully, massive strides have been made in the last 20 years. For example, Nvidia graphics processing units (GPU's) could perform on the order of 100 million operations per second in the late 90's, whereas their current GPU's can perform on the order of 1000 billion operations per second, creating vast, interactive digital worlds that were out of reach even half a decade ago.
- **Cultural acceptance** - The early 90s VR experiences were jarring for the public who were unaccustomed to interacting with a three-dimensional video game. Decades later, consumers, particularly the younger generations, are well acquainted with 3D environments on computer screens. AR/VR is merely bringing those environments to life.
- **Wide Reaching Applications** - Video games were the first and only application of VR initially, due to closed world nature of early environments and the expected interest from the gaming demographic. Today, applications of virtual and augmented technologies span the gamut of real world industries and use cases, from education to medicine to sports. This is enabled by both the increases in computing power as well as the benefit of being in a networked world, where users can be in different times zones yet still interact within the same virtual environment.
- **Declining Costs** - None of the applications would be viable however without cost effective solutions. Today's AR and VR hardware are increasingly borrowing

components from the mobile phone ecosystem, which itself has seen a precipitous drop in component costs of the last 10+ years.

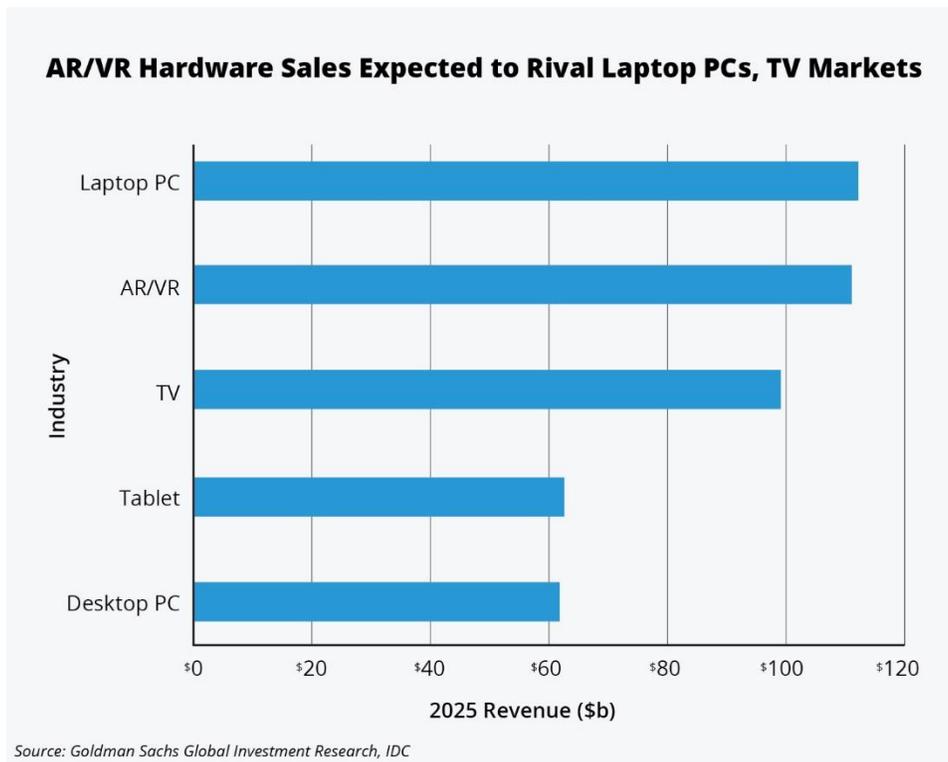
// HOW BIG IS THE MARKET FOR AR/VR?

Given the intuitive and immersive nature of AR/VR and the potential for the technology to emerge as a new computing platform, many research analysts have high expectations for the industry’s growth.

Assuming adoption curves and growth rates like the laptop and mobile phone markets, along with improvement in batteries and mobile connectivity, industry analysts expect the market to grow exponentially, with IDC forecasting AR/VR to be a \$215 billion market by 2021.

Goldman Sachs expects the AR/VR hardware market to potentially reach \$110 billion by 2025, on par with laptop (\$111 billion) and TV (\$99 billion) markets. On the software side, the same analysts expect software sales to top \$72 billion in the same timeframe.

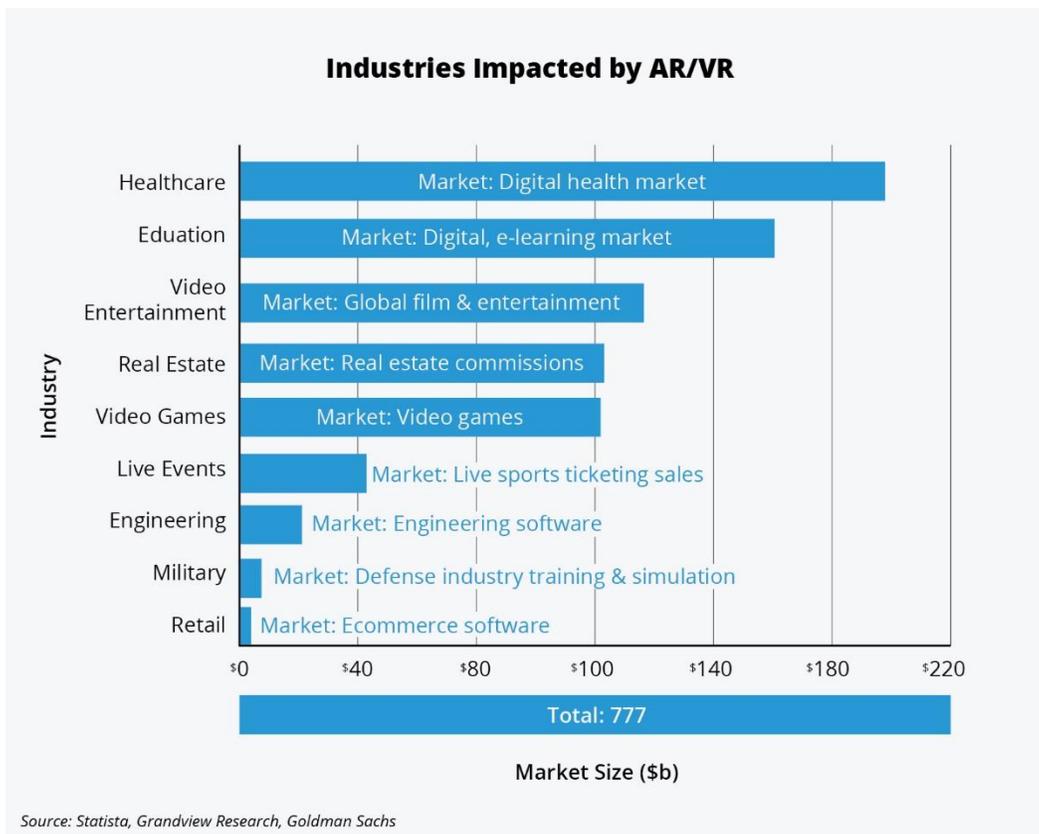
Near-term growth prospects are high as well. IDC forecasts the combined AR and VR headset market to reach 13.7 million units by the end of 2018, growing to 81.2 million by 2021 with a compound growth rate of 56 percent.



// INDUSTRY DISRUPTION

The range of potential applications spans across almost every known industry, and we are still in the early innings of determining just how far this technology will change, disrupt, and improve our global society.

Near-term, we expect increased AR/VR adoption in video games, live entertainment, medicine, real estate, and manufacturing—all industries currently using the technology. Longer-term, if technological advancements continue, just as we have seen with computers and mobile phones, AR/VR has the potential to become ubiquitous, disrupting many different existing industries, and effectively replacing smartphones, computers, televisions, and other displays.



// THEMATIC INVESTING IN AR/VR

AR/VR is a developing and growing technological trend with the potential to transform industries and society at large. Investors should consider this trend when positioning their portfolios.

Most technology ETF's are dominated by the performance of large conglomerates (think Google, Apple, Facebook). While these companies are pursuing AR/VR as part of their strategy, such investments only provide partial exposure to the full industry value chain. Furthermore, such large cap focus disproportionately weights a handful of companies, potentially ignoring small but fast-growing innovators.

A potentially better way to invest is through an equal-weighted portfolio of companies that are actively involved across the industry value chain. The Tactile Analytics AR/VR Index seeks to provide such exposure across the AR/VR industry by including companies involved in AR/VR hardware, components, content, and software. We believe such diversified exposure is crucial to achieving superior returns in such a rapidly changing industry.

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