

AUGMENTED AND VIRTUAL REALITY

Visualizing Potential
Across Hardware,
Software, and Services



AUGMENTED REALITY AND VIRTUAL REALITY

REALITY SPECTRUM



MEETING A NEED FOR VISUALIZATION

Over the past decade, the prevalence of new enabling technologies in numerous marketplaces has grown significantly. Any market examined will point to new applications and use cases being enabled through novel technology adaptations and expanding product portfolios. This has consisted of significant digitization in the enterprise sector: basic connectivity added to an implementation enabling new things. This gave rise to analytics, automation, Artificial Intelligence (AI), and more.

One element to this digitization that has been missing is visualization. For these millions of new connections and resulting applications, all value was realized in the background. While the value of these applications is strong, there are more still that either could be improved with a visual element, or novel applications altogether that require visualization of data. Anything human-facing often falls into the latter category when discussing digitization.

This is also true on the consumer side, although the conversation is different. There were novel uses of visualization capabilities not yet realized, spanning content types. Media & entertainment is the most prevalent, but consumer-facing opportunities in retail, education, fitness, and more were ripe for this visualization boost. Improvements in user devices, such as Three-Dimensional (3D) Televisions (TVs) or Blu-Ray players, were only ever iterative; while the advancements are impressive on their own, nothing really new had been shown.

Immersive technologies in Augmented Reality (AR) and Virtual Reality (VR) have presented and, to some extent, already proven to be more than iterative improvements to existing tech in both consumer and enterprise domains. A level of immersion not possible before was introduced with VR, while AR offered an entirely unique way of accessing and overlaying data without removing a user from the world. Applications in both consumer and enterprise markets have been trialed, deployed, and proven Return on Investment (ROI).

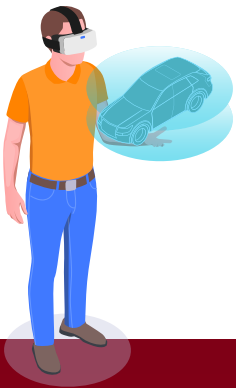


BARRIERS STANDING IN THE WAY

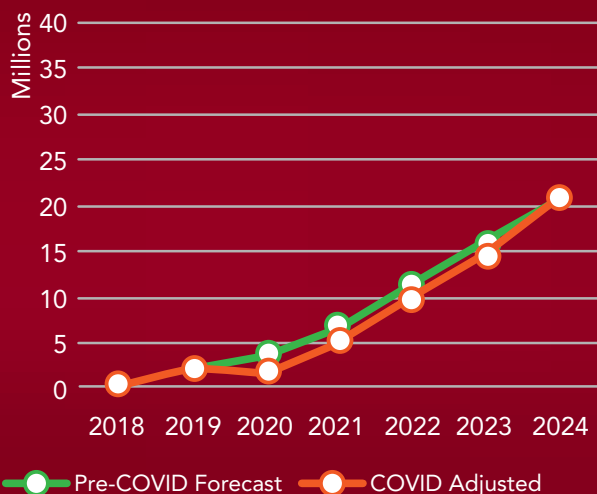
These markets have not been without their barriers. High prices for head-worn devices plague both markets across the user spectrum. Struggles with systems integration for complex enterprise deployments delayed discussions and roadmaps. Uncertainty around content value, especially in VR, kept potential buyers hesitant.

After about 6 years of iteration for both AR and VR (with two keystone products, Google Glass launched in 2013 and Oculus Rift in 2014), many of these barriers have been reduced and some outright eliminated. The introduction of mobile device-based AR, with first-party support from Apple and Google, offered a low-cost and low-risk opportunity for developers, implementers, and end-users to experiment with AR and understand the value. Improvements in standalone VR devices—those not requiring any external tether or compute device—have delivered on improved ease of use, while keeping prices acceptable. Significant numbers of pilot phases and case studies have proven value for AR and VR devices across use cases and company types, providing investment confidence in an admittedly tricky market.

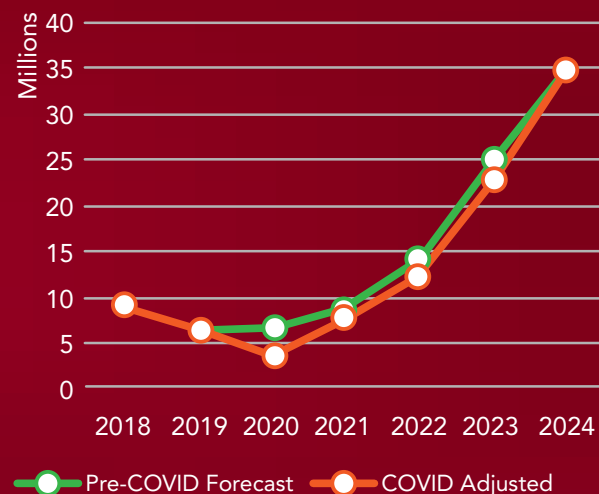
Capturing some of these trends requires a holistic look at the markets across hardware, software, and services. ABI Research has already built on top of a broad and deep database for AR and VR hardware, and will be expanding that breadth and depth to properly account for the software and services side as well. The two are linked, of course, with advances in one almost always leading to advances in the other.



Augmented Reality Shipments Forecast Impact



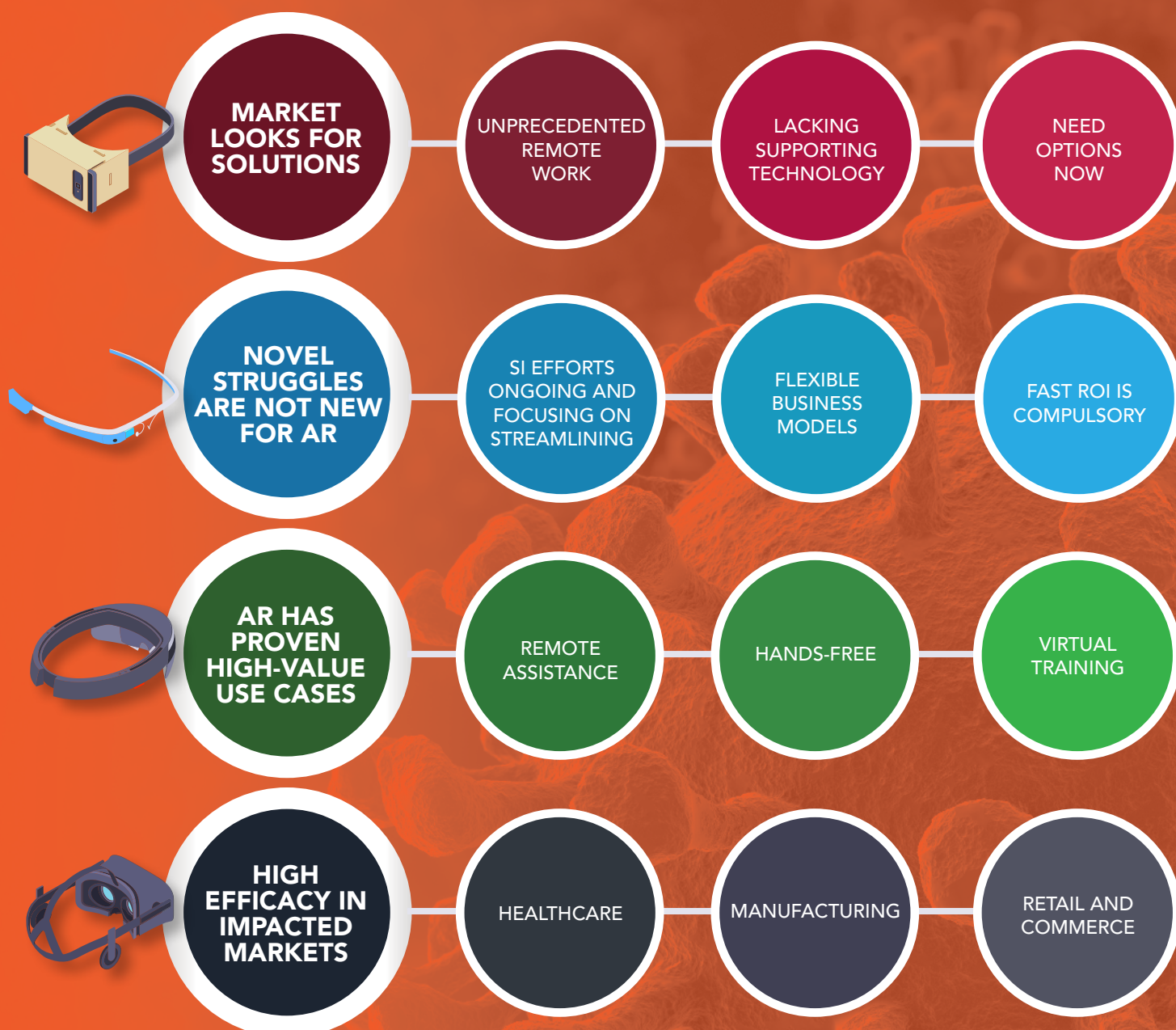
Virtual Reality Shipments Forecast Impact



UNCERTAIN MARKETS SEEK PROVEN VALUE

The COVID-19 pandemic has changed the world forever, and the impacts from this are far-reaching. Globally, companies have been forced to adopt strict work-from-home policies whenever possible, and outright cessation of operations when social distancing and remote work were not possible. Uniquely, this was true in every market in every nation. Today, some markets and regions are returning to normalcy, while others are continuing to adapt to the new normal of work.

Interestingly, COVID-19 did not present many new challenges for AR and VR implementations, but instead emphasized potential and value. When examining the changes necessitated by the pandemic, many overlap significantly with high value-added solutions within AR/VR that have existed for years.



REMOTE WORK



Remote assistance has been the leading use case in AR for years. Quick and reliable ROI, through both direct travel cost reduction and increased efficiency through instant knowledge access (and, secondarily, reduced downtime). Adding value to a process that, at best, was a video call on a mobile device or, at worst, a traditional telephone call or an asynchronous support ticket, has been straightforward for AR on both head-worn and mobile devices. Annotation, spatial awareness, automatic data capture and creation, visualization integration, and step-by-step instruction all have proven value on both device types.

Remote work is unique in its universal applicability. Internal usage for the enterprise sector is relatively straightforward, but customer-facing use cases are growing. Post-sales support for devices or services has been an increasingly valuable use case, with AR providing a level of visualization and easy-to-follow guidance not possible with existing means. Telehealth and telemedicine fit in a similar way.

TRAINING



Related to remote work and assistance, training in AR and VR has been a powerful value driver for companies. Realistic simulation has had a home in VR, while more real-world training and knowledge transfer fits well in AR. The capability for in-situ training, where training and workflow accomplishment happen simultaneously, thanks to AR, allows instantaneous employee ramp-up. With a renewed focus on off-site capabilities, training content can be delivered and consumed wherever a user is located, with proper visualization and simulation of the target workflow environment available through the device.

DATA CAPTURE



Again tying into remote work and training, data capture in AR has not seen as much direct activity as training and remote assistance, but it is being positioned as a promising longer-term approach to content capture, creation, and distribution. Today, there is an increased emphasis on the quick and easy capture of data and, more broadly, workflows to maintain efficiency with a reduced workforce and enable more seamless knowledge capture and transfer.

Capturing and logging data through AR serves as a connection point between data-driven Internet of Things (IoT) platforms and human workers: data from workers, who without that connection point would be lost, can now be fed into the system and fully leveraged for analytics and other uses.

HANDS-FREE



With head-worn devices, hands-free data access and interaction is possible. Input methods like voice, gesture, and gaze can completely eliminate hands-on interaction for both the AR/VR device and anything the device can access. Prior to the pandemic, hands-free was a valuable assurance of an uninterrupted workflow and employee safety. Today, there is an added layer of sanitation potential anywhere head-worn devices are leveraged.

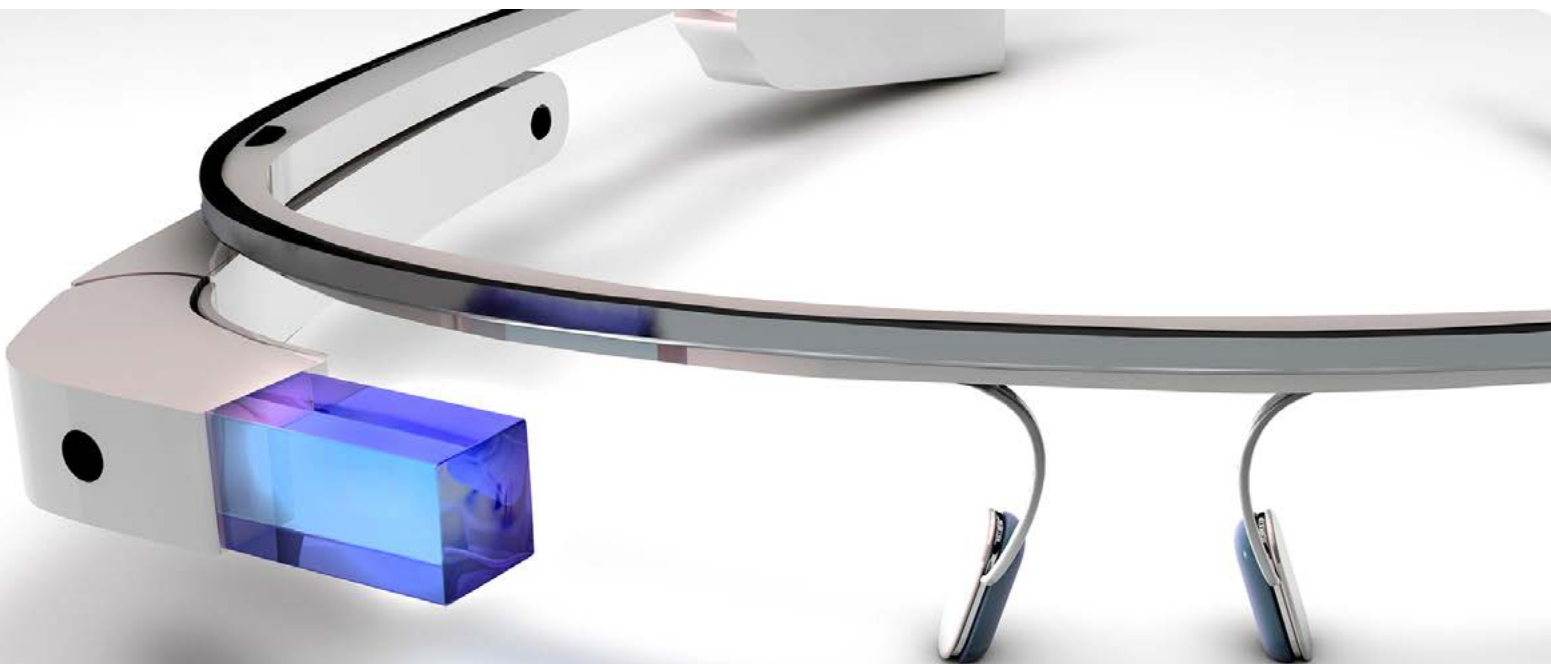
CONSUMER AND ENTERPRISE: NOT BLACK AND WHITE

While the value of AR and VR in the enterprise market has been proven, the consumer market is more complicated. Some early attempts at consumer-targeted AR glasses have never taken off, with high prices and limited value for most consumers. An upcoming wave of glasses is more promising, with companies like nReal and North offering lower-cost devices, but the question of value for consumers remains.

Right now, the AR market is like the smartphone before Apple. The value of the device is recognized, but some barriers to adoption and the lack of a driving force for adoption hold it back from true ubiquity. There is some general hesitation and curiosity around how the market will develop, but as soon as a major Original Equipment Manufacturer (OEM) does something, which many are rumored to do soon, hype and investment will skyrocket again.

All the heavy-hitting tech names today are involved in AR in some form already:

- Apple has the mobile device Software Development Kit (SDK), ARKit, for Operating System (OS)-level AR enablement. Hiring, patents, and rumors abound surrounding an eventual Head-Mounted Device (HMD) from the company coming in the next couple of years.
- Google has Google Glass and ARCore (similar to ARKit). Glass launched as a consumer product, but was quickly pivoted to the enterprise market, where it is still showcasing value for many enterprise customers.
- Facebook has AR development tools, direct AR support in Instagram for filters, and plays in retail and commerce.
- Amazon has had AR options in its retail platform for years. Amazon Web Services (AWS) is a powerhouse behind the scenes that touches nearly every aspect of every technology market, and AR is no different.



As these players ramp up their involvement—both direct and indirect—in AR and VR, growth will cascade through markets, applications, and end-users. Efforts in cloud delivery and compute, for instance, will enable low-latency content delivery applicable both to enterprise and consumer applications.

The consumer market becomes an increasing growth driver over the next few years. Interestingly, this positively impacts even the enterprise market; consumer-targeted AR and VR devices can be leveraged in enterprise implementations, and, in fact, cater to many of the same desires that enterprise customers often have: cost, ease of set-up, and ease of use. Standalone VR devices have seen growth in both consumer and enterprise markets. Many hardware players directly cater to both markets with things like content houses and enterprise/corporate implementation programs. Over 70% of VR shipments in 2024 are expected to be standalone devices.

What is positive for one market is often positive for another, and this dynamic will drive growth for both the consumer and enterprise AR/VR markets over time. Early on, consumer VR was expected to be a driving factor, with 360° video and VR gaming attracting a significant audience. Still, adoption barriers in price, ease of use, and amount of content prevented the full potential market size from happening. Now, VR usage in education, healthcare, retail, and industrial markets is seeing growth, leveraging once consumer-targeted devices.

Software and services play an integral role here as well; flexible solutions for the enterprise sector allow for broader hardware adoption and easier scale. This can be enabled through more inclusive device management paradigms, greater connectivity and content delivery options (both from a security and an efficiency point of view), and adaptable business models that scale with a company as needed, both in terms of user base and use case demands. Platform and licensing revenue is a significant chunk of the total AR market value chain for this reason; nearly US\$20 billion in revenue is expected for AR platform and licensing revenue in 2024.

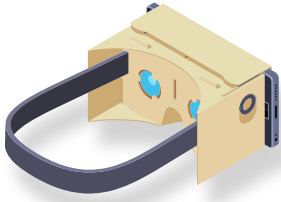


CHALLENGES AND RECOMMENDATIONS

AR and VR have been unique in their ability to deliver objective value and differentiation compared to existing devices and experiences, while still being a problematic investment decision for enterprises and purchase for consumers. The objective and defined value does not immediately make investment decisions easy. There are plenty of challenges in the AR and VR markets across decision areas, groups, and responsibilities.

- **Cost, both upfront and ongoing, is one of the most impactful challenges for adoption.** For enterprises, hardware Capital Expenditure (CAPEX) paired with high platform Operational Expenditure (OPEX) can be a difficult combination, even with high confidence in the likely return. For consumers, high device costs across the board, paired with the lack of a strong thread of valuable content and experiences for most, again limit adoption. This is where more flexible and varied business models can help; an increase in as-a-Service offerings has been seen over the past year, often bundling hardware and platform into one transaction and allowing for easier integration and scaling in the future.
- **Complexity can snowball for both AR and VR** as devices become more capable and integration into existing systems becomes more commonplace. Enterprises can extract maximum value from immersive devices by directly integrating them into existing infrastructure, be it Customer Relationship Management (CRM), Product Life Cycle Management (PLM), the IoT, etc. Leveraging content, data, and analytics from those systems and presenting AR/VR as a novel visualization option offers easy-to-understand value for investors and users. Early examples of value through immersive devices often pointed to the most capable but also the most expensive and most complex devices to accomplish very impressive tasks. However, the difference between these high-complexity opportunities and simpler, quicker-to-deploy options, such as basic hands-free remote assistance, was smaller than once anticipated.
- **User experience is a challenge that has not received enough attention in the AR and VR markets.** Complexity also filters down to end-user experiences, where the more complicated the device is, the higher the chance of a user growing disinterested. If an implementation does not account for things like User Interface (UI) design, target environment, and target user, disconnects between these areas can disrupt workflows and create new inefficiencies that did not exist before AR/VR. Confusing experiences for a user can make them less efficient than without AR or VR. Proper UI design, leveraging the inherent strengths of a device (e.g., pass-through displays, hands-free input methods, high immersion, etc.), can mitigate some of this, as can proper selection of device form factor (AR versus VR, mobile versus head-worn).





Some guidelines and best practices are already in place, again thanks to significant Research and Development (R&D) and testing done over the past 5 years for both AR and VR:

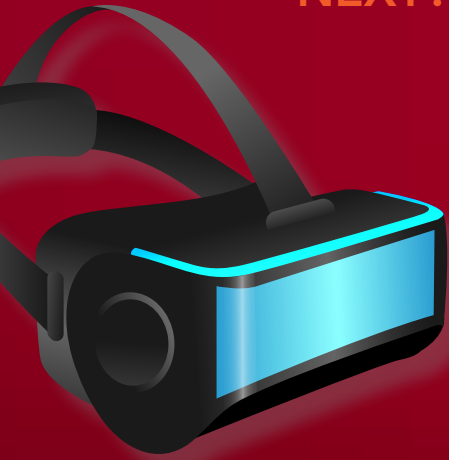
Investment and Implementation: Identify pain points and areas of weakness in current implementations. Increases in efficiency and employee safety are common for AR, as is downtime reduction. Quick ROI is possible, but it is impacted significantly by the complexity of implementation: mobile devices offer lower cost and faster implementation time, but are more limited compared to head-worn. Spatial compute, object recognition, etc. through a mixed reality system adds both capability and complexity, increasing time to ROI for most. The target environment also dictates best practices, with hands-free versus handheld and viable input method options dictating hardware choice.

Content: Leveraging existing content whenever possible lessens the burden of novel and upfront content creation. This is true for enterprise and consumer content. Optimizing Computer-Aided Design (CAD) and 3D models whenever possible in an enterprise reduces time to implementation and realizes ROI quicker. Even so, new content is almost always required to make use of immersive devices. Familiar content creation tools like Unity, AutoCAD, Blender, and others either directly support AR/VR development or support it through plugins for many programs. This offers a less daunting starting point.

Usage: Understand the real value in immersive usage. Not every use case needs AR or VR, and some may even be negatively impacted by forcing it. Users are more receptive to devices when impact on their normal workflow is as minimal as possible, and the device has not only a notable increase in their bottom line, but also to their morale. Churn is very easy with new tech, especially AR/VR, and nothing destroys ROI quicker than devices collecting dust.



WHAT'S NEXT?



Looking ahead, things become both more clear-cut and more complicated. Proven value in work-from-home and remote collaboration extends beyond the COVID-19 impact. A consistent increase in remote work and telepresence usage overall naturally includes AR/VR, and as companies and customers return to normal, much of this adaptation will persist.

The pandemic forced pilots for remote assistance and other AR use cases for many previously hesitant to adopt immersive technology. These forced programs will prove ROI under stress, which informs and encourages future investment, serving as a kickstart for the market that had been occurring slowly but surely over time.

Consumer trends are interesting as well. The desire for digital content is at an all-time high, with video and gaming markets setting records in users and revenue. VR certainly was part of this growth, but the total installed base of consumers is still small and not yet notable in the broader scope of these markets. Going forward, this can shift, with efforts in cloud gaming and more accessible VR hardware making its way into the market, along with operators and content houses looking for new revenue streams. On the AR front, nearly all consumer activity is on mobile devices. Some of the broader market shifts seen in the enterprise sector make their way to the consumer side, with opportunities in retail, media & entertainment, education, and healthcare permeating consumer devices. Again, actual AR usage is not significant yet, but the trends in the ecosystem, combined with foundational support for AR going forward, present the ingredients for a strong inflection point.

The overlap between the enterprise and consumer markets is not discussed as much as it should be today. Preparation for these devices before they are market-ready will ensure a streamlined implementation; look to those flexible business models and scalable architectures for best practices around current and future AR/VR action.

Many of the barriers to adoption seen in the enterprise market come down to device cost and ease of use; these issues are the same in the consumer market. Many of the first wave of consumer AR devices have prioritized keeping prices down, while delivering on promised value. Google Glass was technically launched as a consumer product, but the price and lack of clarity around value quickly pushed the device to the enterprise market where it found purchasers.



ABI Research has already seen this trend continue, with consumer-targeted products like Magic Leap pivoting to find an enterprise audience. Going forward, lower-cost devices (ideally US\$500 and less for the consumer space) will cross over into the enterprise space, thanks to inherent value and advantages over more expensive options supposedly tailored to the enterprise market. The enabling of these devices requires software and services that are flexible enough to support devices for their intended use case, not necessarily their target market. Device-agnostic platforms and flexible business models will be an essential first step.

Despite hardware being a key component in the end-to-end AR and VR ecosystem, a wider approach covering immersive content/services/applications more broadly better bridges near-term value with longer-term visions and applicability. This also means a greater variety of companies are involved in these discussions: of course, hardware and software remain at the core of the market, but support from telcos, cloud service providers, retailers and brands, and more will show greater interest and more direct involvement and investment in the space. The role of telcos and cloud service providers is substantial as content moves toward the edge for low-latency and localized delivery.



ABI Research has targeted coverage across hardware, software, and services, with deep insight into ROI, use cases, and value chain differentiation. The impact of trends across all of these areas continues to be an important focus as well, as does the intersection with other enabling technologies like AI, the IoT, and connectivity.

IN THE POST-COVID-19 LANDSCAPE, HAVING ACCESS TO THE RIGHT INFORMATION AND STRATEGIC GUIDANCE IS MORE CRITICAL THAN EVER. ABI RESEARCH CAN DELIVER IT.

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ABI Research's Augmented and Virtual Reality Service covers enterprise and consumer applications, services, hardware, and platforms related to digital visualization. It focuses on technologies and use cases that provide value through data visualization and immersive experiences. It quantifies market opportunities across the value chain for both AR and VR, and head-worn and handheld form factors, while identifying enabling technologies within and across markets that include the smart industry, edge compute, machine learning, and 5G.

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