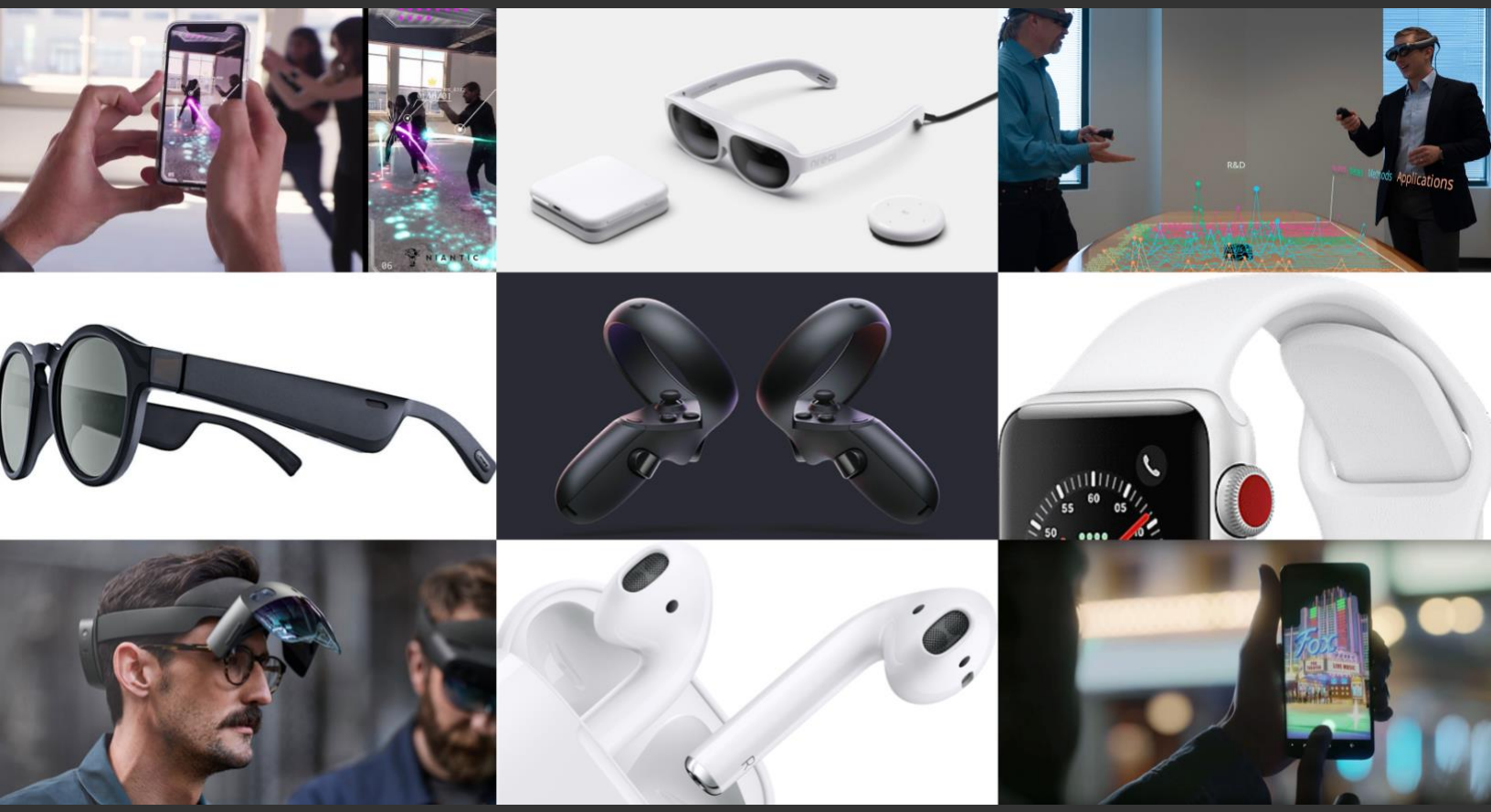
ARtillery Intelligence



ARtillery Intelligence Briefing

Spatial Computing: 2019 Lessons, 2020 Outlook

December 2019

ARtillery Intelligence

Table of Contents

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Key Takeaways

- 2019 was a rebuilding year for AR and VR in the aggregate, while some positive steps were taken.
  - Continuing a trend from 2018, the sector's under-developed status was reinforced in 2019.
  - Though this was discouraging and involved an industry shakeout, it follows a common pattern.
  - As was seen in the eCommerce bubble, a shakeout can be followed by slow but healthy growth.
  - Eventual industry revenues can exceed early/ambitious projections, but not until several years later.

- This is where we now sit in the AR and VR sectors as we enter 2020. A long road lies ahead.
  - Though discouraging signals abound, such as dissolved companies, we see confidence signals.
  - This includes revenue performance and momentum in certain sub-sectors such as AR advertising.
  - Advertising is AR's revenue leader, projected to grow from $1.58 billion to $2.6 billion in 2020.
  - Levels of investments from tech giants is another signal in our exercise of "following the money."

- The outcome of Apple's rumored AR glasses will have a large impact on industry health.
  - Apple's track record in mainstreaming emerging tech could "rise all boats" for AR glasses.
  - Signals we track indicate a product launch in 2022, deviating from rumors of a 2020 launch.
  - Apple could start with an entertainment wearable to tap into consumers' existing comfort levels.
  - Like the iPhone 1, this could then evolve including the move towards an "all-day" wearable.
  - Apple IP, such as variable-opacity lenses, signal multi-modal glasses for entertainment and utility.

- Until AR glasses become more ubiquitous, Mobile AR is the near-term play for reach & scale.
  - There are currently 3.3 billion smartphones globally, a growing share of which are AR compatible.
  - The common industry rallying cry is that there are 1 billion AR compatible phones globally.
  - This number is correct if measuring ARkit and ARCore, but is much larger with other platforms.
  - Facebook Spark AR, Snap Lens Studio and Web AR are increasingly important platforms.
  - The most relevant figure is the number of global *active* users which is 334 million today.

- With all of the above consumer AR platforms, a key tactic is to tap into existing behavior and comfort.
  - The broader wearables movement is well-underway and could accelerate AR comfort levels.
  - This is Apple's strategy with AirPods & Watch, as well as Snap's strategy with Spectacles 3.
  - AR lenses so far succeed by building on the popular activity of sharing multimedia socially.
  - Instagram's AR efforts will tap into a camera-forward audience and fashion-discovery use case.

- Enterprise AR continues to hold significant promise, but adoption has been slower than expected.
  - Industrial AR can provide strong ROI in visualizing assembly and maintenance, but is challenged.
  - Organizational inertia and human resistance are the biggest pitfalls where strategies should focus.
  - Beyond industrial settings, "enterprise AR" hold promises in retail, commerce & entertainment.
  - These consumer-facing enterprise AR implementations (B2B2C) will be a major revenue category.
  - Enterprise AR in total is projected to grow from $3.2 billion this year to $5.6 billion in 2020.

- VR likewise had a slow year with an industry in retraction... but there were pockets of momentum.
  - The catalyst will continue to be Facebook's investments to accelerate adoption and network effect.
  - Oculus Quest is a beacon of hope in hitting the sweet spot on the price/quality sliding scale.
  - Facebook's Beat Games acquisition signals exit potential and incentivizes further innovation.
  - VR revenues will grow to $7.4 billion in 2020 with a cumulative installed base of 18.5 million units.

Executive Summary

They say that patience is a virtue. This applies to the current state of the spatial computing industry. After passing through the boom and bust cycle of 2016 and 2017, the last two years were more about measured optimism in the face of industry shakeout.

At the precipice of 2020, that leaves the question of where we are now? Optimism is still present but AR and VR players continue to be tested as high-flying prospects like ODG, Meta and Daqri dissolve. These events are resetting expectations on revenue outcomes.

But more than the 'how much?" is a question of "when?" Market timing is quickly becoming a prominent factor to determine success of spatial computing players. This is a common factor in tech cycles historically. Spatial computing will be no different.

Speaking of history, spatial computing follows a pattern similar to the early 2000's eCommerce bubble. Exuberance is followed by market correction, followed by slow progression that eventually meets and exceeds early projections… but not until years later.

The good news is that this slow uphill progression has already started, and we believe the worst is behind us. Though the broader tech and media worlds have shrugged off AR and VR as fads that died in 2017, Industry subsectors are signaling growth by quietly gaining traction and revenue.

This includes AR-based advertising. ARtillery Intelligence projects it to grow from $453 million last year to $8.8 billion by 2023. This outlook follows the momentum of advertiser adoption, as well as the continued investment of tech leaders like Facebook and Snap.

There's also a robust support industry germinating, including "building blocks" which are endemic to this period of any tech sector. Represented by tools such as Unity, Adobe Aero, and 8th Wall, AR-as-a-Service (ARaas) will be a major AR revenue category.

AR's health also hinges on the outcome of Apple's rumored AR glasses. Apple has a track record of mainstreaming emerging tech, and the AR industry is hoping for that halo effect. But based on signals we track, this will come a few years past the rumored 2020 launch.

Meanwhile, adjacent sectors will accelerate AR adoption and development. The broader wearables segment is growing rapidly, and will benefit AR by acclimating consumers to wearing tech on their bodies. 5G, self-driving cars and other areas will likewise feed into AR.

There are also lots of positive signals for market growth in VR. Facebook/Oculus continues to invest in hardware subsidies and loss-leader pricing to jumpstart a network effect. The result of this investment is high quality and consumer-friendly price points for Oculus Go and Quest.

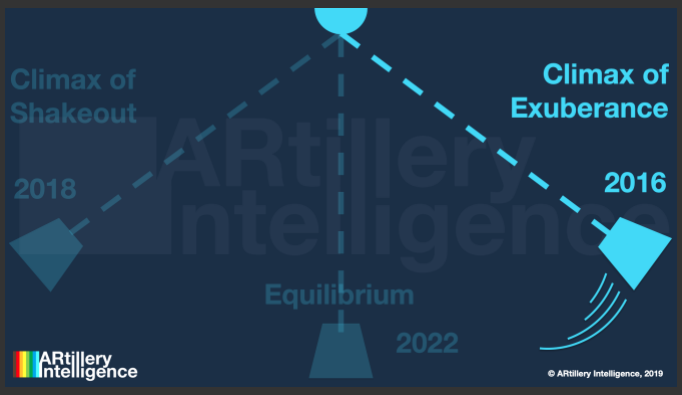
What do all of these signals collectively tell us? And where do they point for 2020 outcomes? We'll unpack the full list of market factors and 2019 lessons in this report, pursuant to illuminating likely paths for spatial computing in 2020. A robust ecosystem is (slowly) building.

Introduction: The Backswing

Spatial computing, represented by AR and VR, has seen its ups and downs. The excitement and expectations that consumed 2016 and 2017 were followed by a bad hangover in 2018 and 2019. Where does that leave us now and, more importantly, where are we headed?

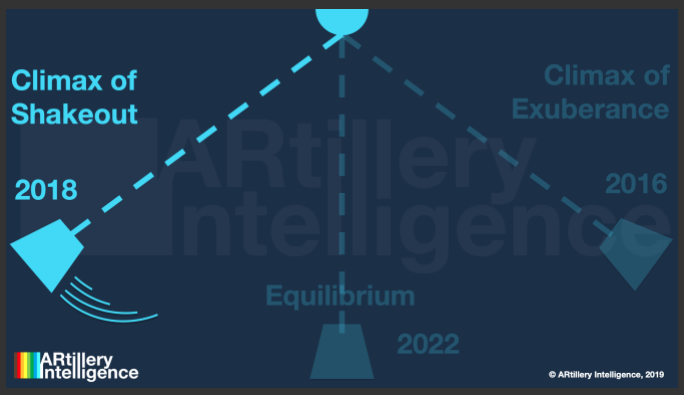
Whenever this question arises, the go-to explanation is AR's period of repentance in the "trough of disillusionment," of Gartner's Hype Cycle. This is a perfectly valid construct but it's arguably overused as fodder in nearly every conference presentation on AR and VR status.

So we've begun to think about industry life cycle using a different construct: that of a pendulum. Often in early-stage sectors, a pendulum metaphorically swings in one direction that represents overblown expectations, supply-side saturation and an abundance of venture funding.

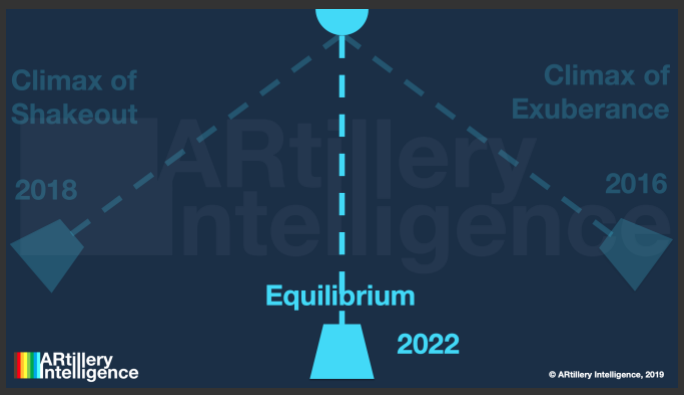


Then, it swings in the other direction as a backlash to that abundance. This period is defined by sobering realizations that the technology isn't ready, or that it's not gaining the traction previously expected. A shakeout ensues as venture funding pulls back.

But after that backswing hits its peak, things move towards a happy medium. Markets progress at a healthy pace, while supply and demand grow in step. Just like gravity compels the pendulum to the center, market forces compel supply/demand equilibrium.



What follows is a more measured and realistic period of market growth. Previous hockey-stick growth charts give way to slower, but more reliable, industry revenue projections. ARtillery Intelligence has recently released AR[i] and VR[ii] forecasts where this thinking is represented.



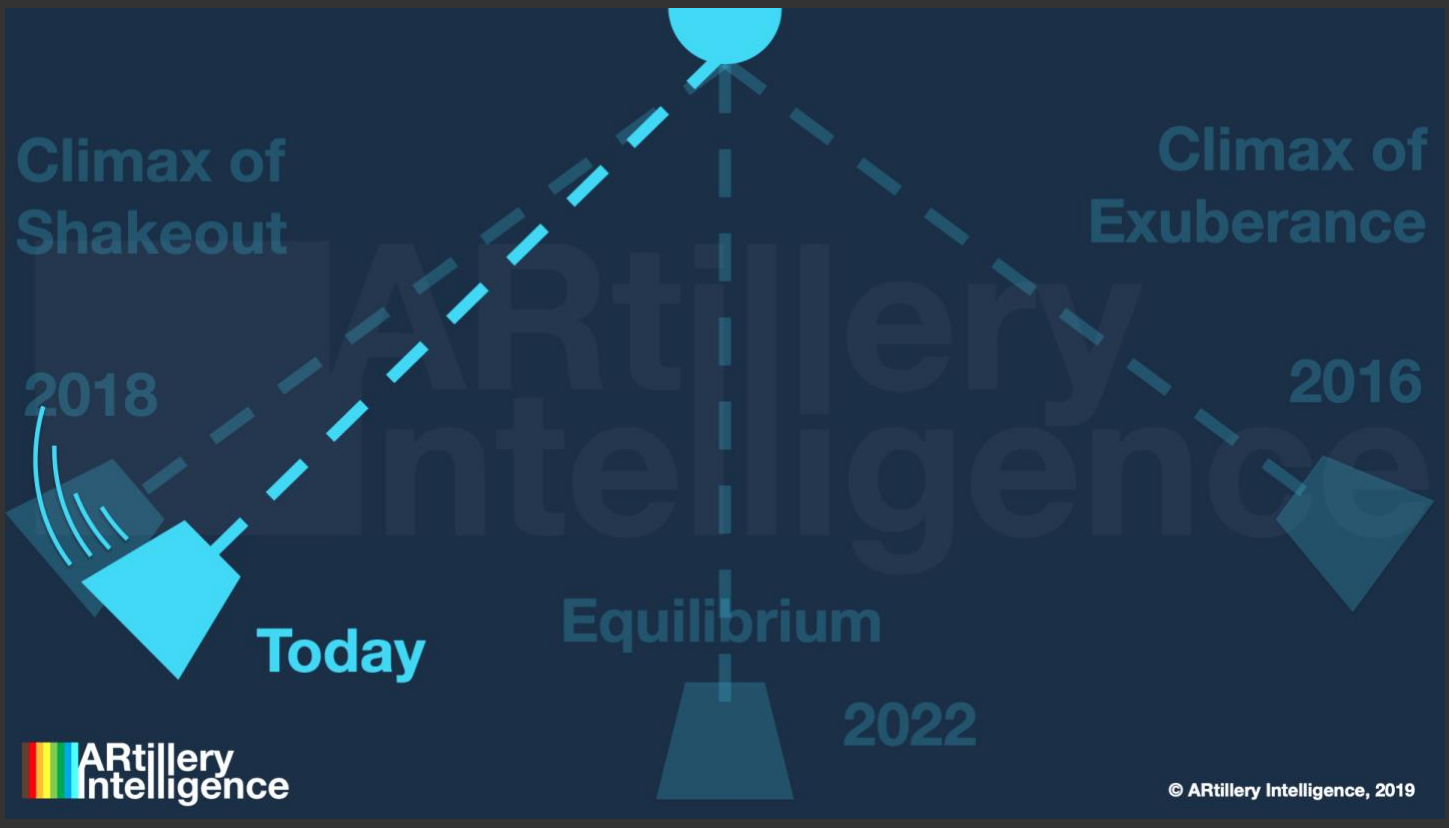
Historical Lessons

A historical example of this cycle is the 2000's dot-com bubble. Overblown expectations gave way to a recessionary period. But then in 2002, things moved slowly towards measured progress, and the rise of tech giants like Google, Facebook, and the web 2.0 era.

That goes back to the question of where we are now with AR. Though the extent of the pendulum swing in either direction may be smaller, we believe AR is in that 2002 spot where the worst is behind us, and AR is moving (slowly) towards healthy growth and equilibrium.

What makes us say that? There are lots of signals that AR's 2018-2019 hangover has hit its high point, and that the sector is beginning to recover. There's still a ways to go, but we're starting to see meaningful signals for consumer AR traction and, more importantly, revenue.

What are those signals? We'll outline them throughout this report, starting with the biggest confidence signal of all: money. Tech giants' investments in AR signals a level of self-serving motivation that will accelerate the technology, and move markets. There, the story starts with Apple.



Apple: The Halo Effect

By now, you've likely read about Apple's rumored move into AR glasses. This would bring legitimacy, mainstream penetration and Apple's signature "halo-effect". After disappointing AR products (including ARkit apps) and consumer traction over the last two years, the sector needs a win.

Backing up for the sake of context, what are the rumored Apple Glasses? Based on a string of patent filings, acquisitions and reports, AR glasses are rumored to be in design at Apple for a market launch in the next few years. It's been a rallying cry for the AR industry.

The "Why?"

First, it's important to look at what's driving Apple. Given AR's challenges, there must be ample motivation. This goes back to the aforementioned exercise of "following the money." As examined in our ongoing analysis,[iii] financial motivations can reveal directional signals for tech giants' AR moves.

How does this principle apply to Apple's AR Glasses? Among other things, it's about supporting and succeeding an aging iPhone. Given maturing global smartphone sales and innovation cycles, AR can make the iPhone sexy again and justify premium pricing.

Source: Apple

At the same time, it will increase reliance on the iPhone — and thus its value — by shouldering compute needs of phone-tethered AR glasses. The unanimous market sentiment is that these AR glasses will utilize the iPhone for connectivity and compute power.

Add it all up and there's too much on the line for Apple to not release AR glasses. A supporting role to the iPhone could make AR glasses' overall revenue impact in the tens of billions. Equally important, they could also prop up Apple's next big play: a wearables suite.

iWear

AR glasses could be a key component in a wearables line that succeeds the iPhone as Apple's cash cow. In concert with AirPods, Watch and others, it could augment several senses and comprise the ultimate personal computing touchpoint to our lives.

That could include line-of-sight AR (Glasses), biometric tracking and info delivered to your wrist (Watch), and textured/intelligent audio delivered to your ears (Airpods). The latter is the area we call "hearables" and "audio AR," and could be a massive revenue category.[iv]

Overall, this would fit the profile and align with a longstanding staple of the Apple playbook: platform lock-in. In other words, a wearables suite could incentivize multi-device ownership through functional advantages.

That's what Apple has done for years in pushing multiple interlocking devices. The pitch is to own the full suite of devices to get the best functionality. But in this case, the maturing Mac, iPhone & iPad give way to the next generation of Watch, AirPods & iGlasses.

For Apple, these are all roads to greater revenue per user (ARPU) -- another key metric in its playbook. The same playbook may define Apple glasses' eventual target as part of a comprehensive wearables line that succeeds the current suite of rectangular iThings.

In further support of this theory, Apple's motivation for wearables was quantified in its Q4 earnings. iPhone sales were down 9 percent year-over-year to $33.36 billion while wearables were up 54 percent to $6.52 billion. This is similar to where the iPhone once sat relative to maturing Mac sales.

The “When?”

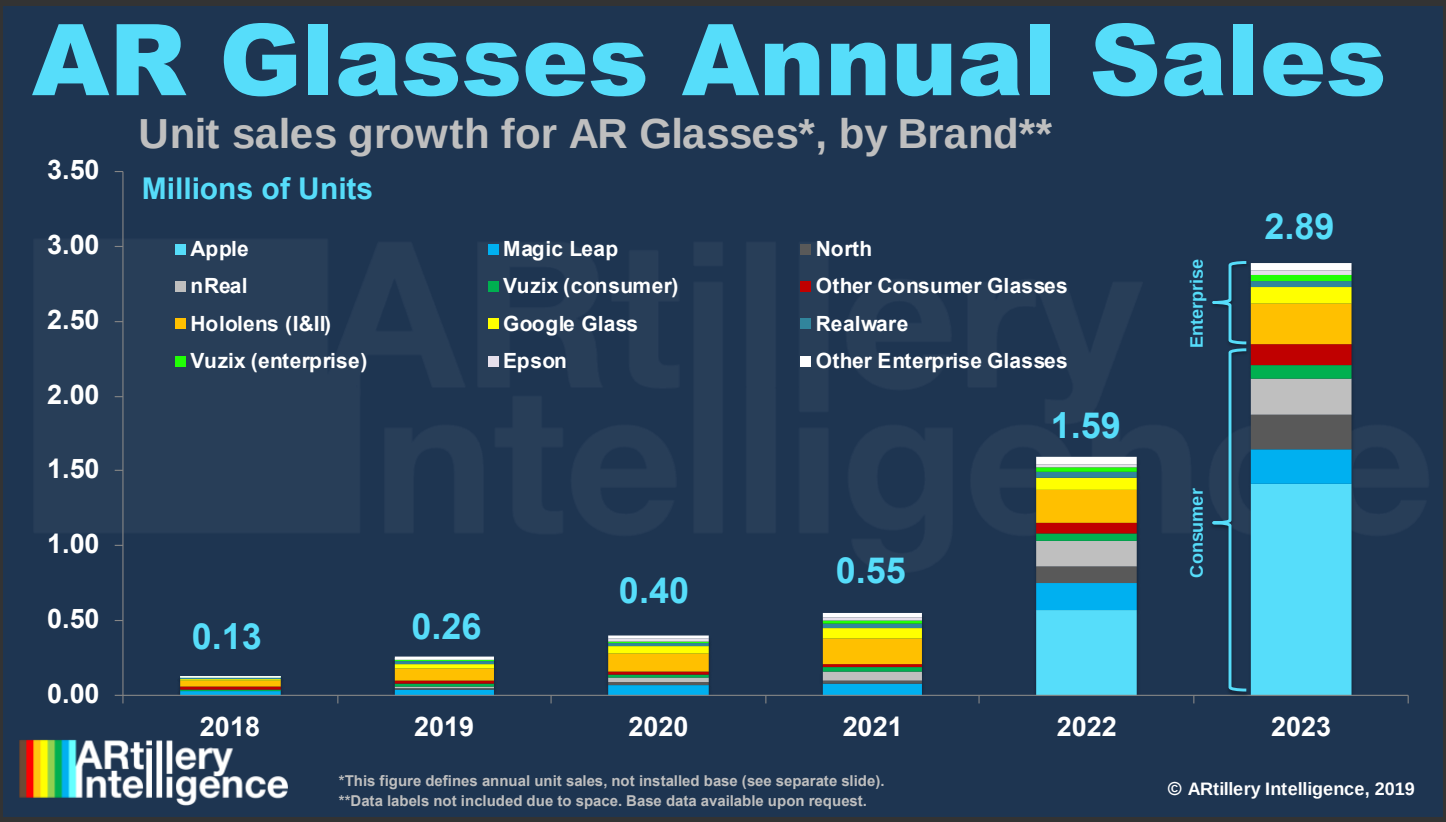
The next question is when? Rumors point to 2020, but we’re doubtful. We’ve based the projections in our AR Revenue Forecastv on Apple’s mid-2022 market entrance. This would involve a fall 2021 unveiling and following-year launch, as Apple product cycles often go.

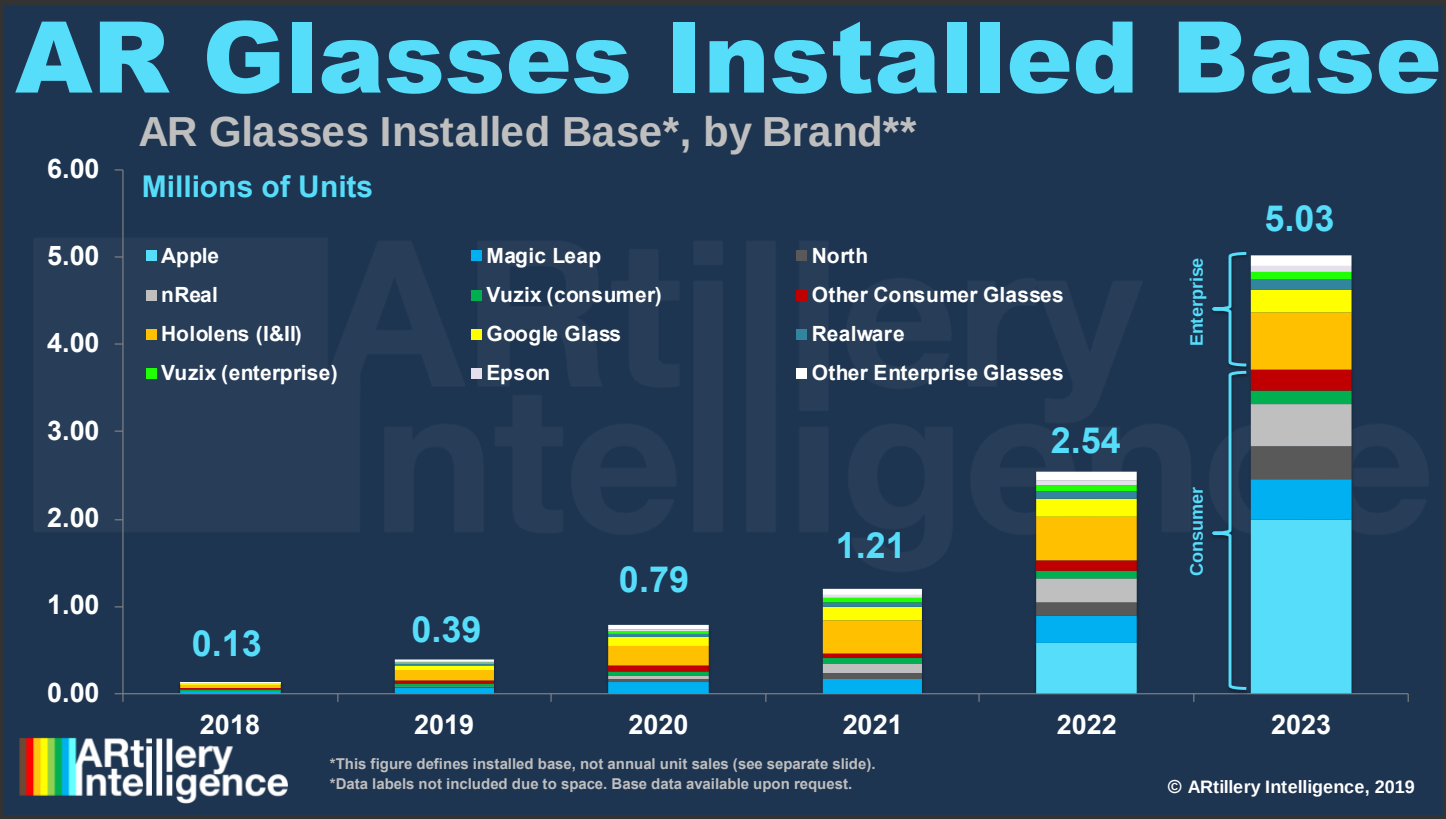
As shown in the revenue projections below, this will cause the market to inflect starting in 2022 and more so in 2023. The effect will not only be for Apple’s own AR glasses, but to mainstream the product category (a la halo effect), thereby raising all boats.

We base this 2022 prediction on a few factors. For one, the underlying technology isn’t yet there for a compelling-enough UX that fits Apple’s high bar for style and design. It has world-leading industrial design, and anything launched in 2020 wouldn’t meet that standard.

Apple is also rarely early to market, which 2020 certainly would be. Its signature move is to arrive late and outperform earlier entrants with superior design, mainstream appeal, marketing and supply-chain economies of scale (see: Mp3 players, smartphones, tablets… etc.).

These theories about timeline were validated by early-November reports that Apple will launch limited-functionality AR glasses in the 2022 timeframe. These will iterate over time and have a parallel track for a sleeker and more multi-purpose model in 2023. Signals for this device progression are starting to be seen.





The "What?"

After examining the "why?" and the "when?" for Apple's AR Glasses initiatives, that leaves the question of "What?" As indicated above, internal Apple documentation has leaked which signals hybrid AR/VR glasses in 2022, followed by sleeker AR glasses in 2023.

These clues potentially carry more weight than other rumors that are based on supply chain indicators. In this case, the report comes from an announcement made to an assembly of more than 1,000 Apple employees. This provides some additional veracity.

Triangulating this clue with others we've tracked, Apple could release a "lean back" entertainment wearable in 2022. This will be for isolated/occluded uses like watching movies. Then it will launch a more fashionable (though less-spec'd) "all-day" wearable in 2023.

Best of Both Worlds

What gives us this idea? If we look elsewhere in Apple's IP, there's a patent filing for variable-opacity lenses. Similar to some prescription glasses, these are meant to dynamically shift opacity and shade level based on factors like ambient light, or manual controls.

According to the patent, they "selectively darken portions of the real-world light from view." This involves tiny mirrors that direct ultraviolet light to individual pixels to dim or block light and "allow improved contrast when displaying computer-generated content over the real-world objects."

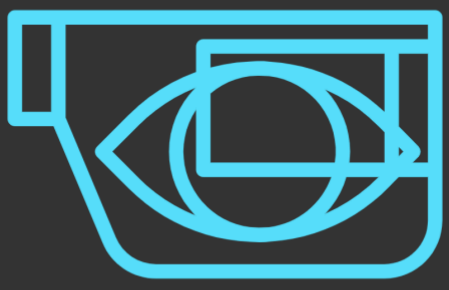
The reason this would align with an entertainment wearable is that opacity would make glasses optimized for high-contrast

entertainment like watching a movie. This sidesteps AR's inherent challenge that optical combiners can't show the color black, and other colors are washed out.

At the same time, entertainment won't be a silver bullet, so opacity ranges could accommodate variable use cases that include utilities. Low opacity ranges could be optimal for a heads-up notification layer for iOS content (messages, email and opt-in alerts).

Synthesizing these use cases, imagine you're at the airport, where it's fitting for low-opacity AR notifications like flight info and messaging. But then when you board the flight and reach 30,000 feet, you can zone out and watch a movie at high opacity ranges, all without fumbling with several screens and tray tables.

In addition to the above clues, other factors support the outcome for a potential variable-opacity multimodal device. One, there's still no killer app for AR — something Apple hoped to jumpstart with ARkit. This will inhibit consumers' motivation to buy AR glasses.



So it makes sense to acclimate the world to AR through the training wheels of a familiar use case… watching TV & movies. Apple is also motivated to create more viewing time for iTunes, TV+ and other digital content as it diversifies revenue due to falling iPhone sales.

In total, this multimodal approach could be compelling while allowing Apple to acclimate consumers to AR glasses through utility, convenience and familiar activities. Once everyone is comfortable with the hardware, it could activate world-immersive AR in 2023.

Lastly, this aligns with observations of other influential market watchers. Most notably, Charlie Fink predicted at the May AWE conference that Apple will introduce the first version of its AR glasses as an entertainment wearable. This aligns with the above clues that have subsequently leaked.

"What if it's not really AR the way we're thinking about it… maybe it's a media consumption machine… it's like you just bought the most high-definition big-screen TV in the world even though you might live in a 600 square foot apartment. So I think it's very possible that this is where Apple is going and they will iterate their way out of it as 5G improves."

All of the above is qualified by the caveat that it's speculative, and doesn't address variables like field of view and heat. But clues align conceptually. In the end, Apple's eventual play will be something none of us speculated but could have shards of disparate predictions.

Wearables: AR's Forbearer

Beyond Apple's influence in mainstreaming AR acceptance, a broader trend could do similar: wearables. As the sector continues to inflect, it could accelerate AR, given that its endpoints are headworn, and by generally acclimating consumers to wearing tech on their bodies.

But before going into the AR implications, let's step back and look at the broader wearables sector. Wearables sales this year are projected to hit $41 billion, up 28 percent from $32 billion last year.[vi] Responding to that growth is a blitz of market activity and product launches.

Apple is far ahead given the success of Watch and Airpods. Google acquired Fitbit to buttress its wearables play. Amazon and Microsoft launched wearables lines in the past quarter and smaller players like Bose and Snap are planting seeds for a wearables future.

Hardware's Next Era

There's an underlying driver for this activity that goes back to our "follow the money" exercise. It's is all about extrapolating product roadmaps based on tech giants' motivations. This is often to future-proof their core businesses or diversify revenue as products mature.

The poster child is Apple, as explored in the previous section. It's leaning into wearables as a near-term diversification play and long-term succession plan. Both vectors are compelled by iPhone (and smartphones in general) market saturation and declining revenue.

Google meanwhile acquired Fitbit to accelerate its lingering WearOS platform with some hardware in the game. Its motivation, beyond wearables' rising tide, is the same that drives Android: to maintain a direct touchpoint with consumers to support its core search business.

Speaking of direct consumer touchpoints, Amazon blitzed the wearables market last month as a delivery system for Alexa. Its Echo Buds are AirPod-like Bluetooth earpieces; Echo Frames are Bose Frames-like audio glasses. And Echo Loop is an odd little ring with a mic and speaker.

Its motivation? When Amazon failed to market the Fire Phone last decade, it lost a consumer touchpoint, thus ceding years of pole position to Google and Apple. It now sees smartphone and wearables trendlines on intersecting paths, and wants to redeem that mistake for the next era of hardware.

Microsoft is in a similar spot. Its Windows Mobile OS licensing model lost share to Android's more compelling price tag (free) last decade. It thus missed out on pole position in the mobile revolution, which it now wants to redeem with a vertically-integrated approach.

That can be seen in Surface Laptops (a vessel for Windows and Office products), as well as the category-leading Hololens. More recently, it applied this hardware-forward approach to its Surface Earbuds which have native integration with Microsoft Office productivity functions.

Acclimation Play

This trend stretches beyond the big five (and let's not forget Facebook). Samsung has its own wearables play. And the strength of the category will attract commodity hardware players to fill gaps at the lower end of the market, thus scaling up global access.

We'll also see specialty players such as Bose. It's leaning into a hearables strategy with its BoseAR platform. In addition to a strong brand, it's the only player to open up a developer platform to scale up the creation of intelligent and sensor-informed audio apps.[vii]

Snapchat is another dark horse. Its advantages include high engagement, product focus and it's not afraid to experiment with hardware in the wild. It's zeroing in on elegant UX with Spectacles 3, pursuant to feeling out and advancing consumer comfort with glasses.

This all goes back to AR acclimation. Like Apple could do with an entertainment wearable, the idea is to condition users to AR through known activities. Wearables could do this by warming up mainstream users to faceworn tech through the stepping stone of hardware that goes on your wrist and ears.

While that's underway, a separate AR vector continues to progress: Mobile AR.

Source: Apple

Mobile: The Near-Term Play

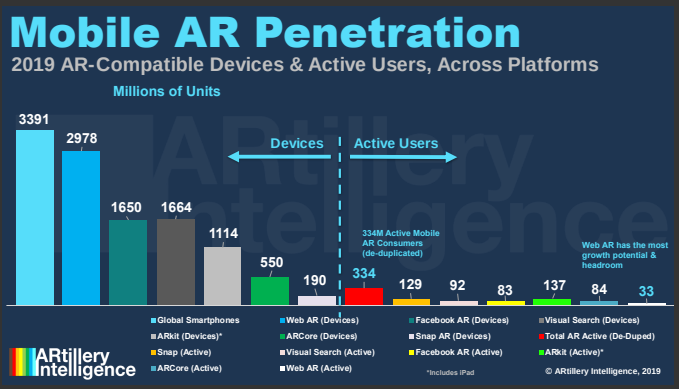
While all of the above factors converge to bring us consumer-grade AR glasses over the next 3-5 years, AR glasses' older brother has reached ubiquity and global scale. We're talking of course about smartphones, and the less-evolved form of AR that will be a stepping stone to its fully-realized vision.

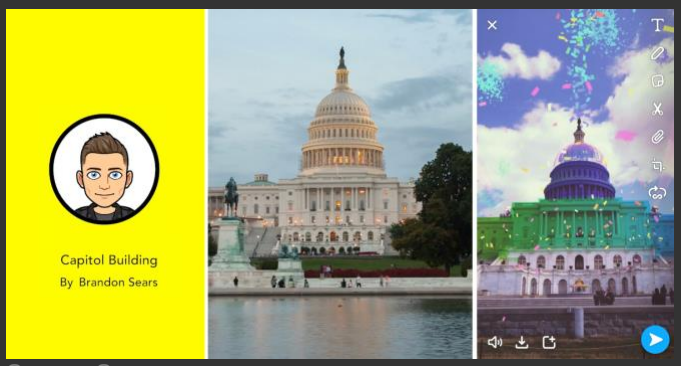
To provide some initial high-level figures to put this scale into perspective, there are about 3.39 billion global smartphones today, growing to more than 3.4 billion by 2023. The latter is 700x the 2023 projection for AR glasses' installed base shown earlier.

This mobile scale has been a rally cry for the AR industry's potential reach until AR glasses arrive in earnest. However, it's more relevant to examine mobile AR compatibility and active use, as opposed to the overall universe of global smartphones. That number is smaller but still considerable.

One Billion Served

Mobile AR's installed base is often cited as "1 billion units." This is true if counting Apple (ARkit) and Google (ARcore) compatibility. However, an increasingly-fragmented set of mobile AR platforms creates a more complex picture, and a larger installed base.





Source: Snap

According to ARtillery Intelligence's latest AR revenue forecast,[viii] of the 3.39 billion smartphones on the planet, those that are AR-compatible include web AR (2.97 billion), Facebook's Spark AR (1.6 billion) Snap's Lens Studio (190 million) and several others represented on the chart at the lower left.

But the above figures measure total devices and AR compatibility. The number that matters more is *active AR users*. That total comes to 334 million, growing to 1.076 billion by 2023. This figure tallies and de-duplicates active users across all of these platforms.

As an important qualifier, this doesn't include platforms endemic to China. Such platforms are significant, but their sizing is done separately in terms of addressable market analysis. That's because users of these platforms aren't always addressable to companies outside of China.

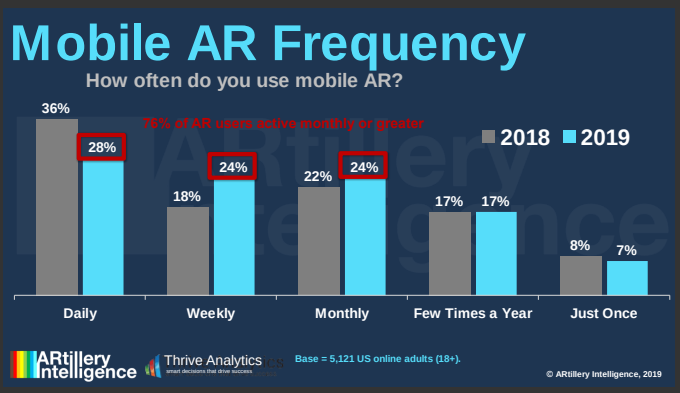
Confidence Signals

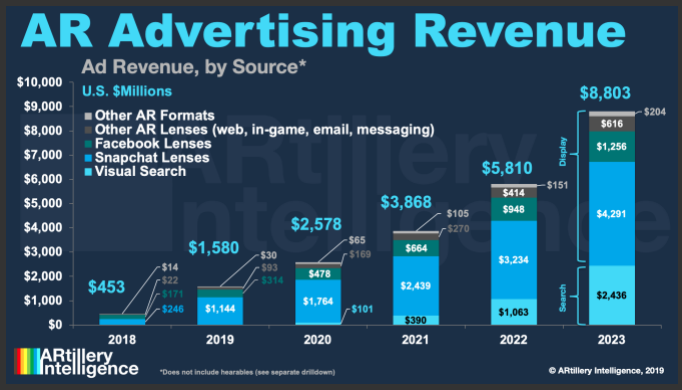
Though the above figures are strong, Mobile AR is more of a layover than a final destination. Smartphone-based AR doesn't live up to AR's true promise, but is warming the world up for it. That goes for consumers as well as developers, who must condition their thinking for natively building immersive experiences.

This involves several formats that are taking shape as developers and tech companies feel out consumer demand. The two forms of AR that have gained the most traction are object visualization (placing objects in your space) or selfie lenses and filters to dress up one's appearance.

The former involves the rear-facing camera to augment the world, while the latter involves the front-facing camera to augment people. As Snap's Carolina Arguelles said at AWE Europe in October,[ix] AR content has to be relevant… and there's nothing more relevant to people than their own faces.

This principle has driven lots of high frequency and deep engagement for lens use. ARtillery's consumer AR survey with Thrive Analytics shows that 67 percent of users reported monthly or greater frequency and 78 percent reported high or very high satisfaction.





Facebook meanwhile has served one billion AR lens engagements over the past year across News Feed, Portal and Messenger. The biggest sleeping giant could be Instagram, where it just opened up AR development. This could be a winning formula with Instagram's camera-forward audience.

Snapchat has shown even more scale with 15 billion AR lens engagements over the past year, 142 million daily AR lens users and 500,000 total lenses created. And the ad dollars are following, given strong performance for immersive product try-ons with branded AR lenses.

Specifically, ARtillery Intelligence projects AR advertising revenue to grow from $453 million last year to $8.8 billion by 2023. That consists mostly of brand-sponsored AR lenses in the above channels but will grow into other channels like messaging and formats like high-intent visual search.

This so far is the biggest source of revenue in AR, followed by in-app-purchases, mostly from Pokémon Go, and AR as a Service (ARaaS developer tools).[x] This revenue mix will evolve greatly over the coming years, especially as mobile AR user experiences and expectations likewise evolve.

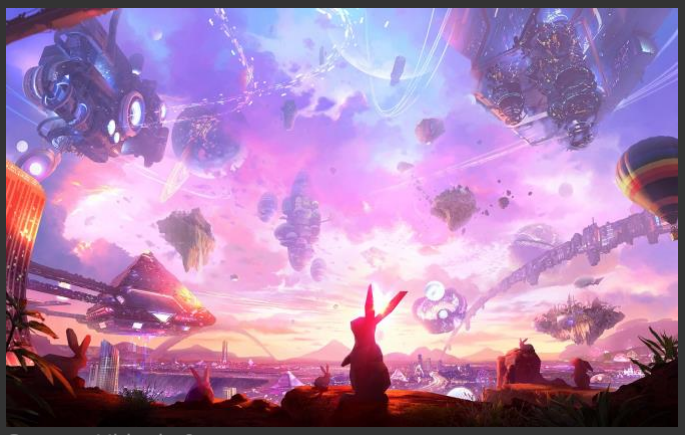
The Internet of Places

How will the above AR trends advance and inflect? There's currently a large missing piece in the AR puzzle. It's currently under construction and will represent a key enabling entity for the vision we all have for AR's future. We're referring to the AR cloud.

This is the missing piece for the vision we all have for AR that "just works." As an invisible data layer that coats the physical world, it will empower AR devices to place graphics in the right spots. Also known as "Mirrorworld," "Magicverse," and the "Internet of Places," it's AR's lynchpin.

But the challenge is building it, given that it happens on the scale of the inhabitable earth. This has led to lots of creative approaches such as crowdsourcing (6d.ai), visual databases for object recognition (Google & Apple), satellite imagery (Sturfee) and compositions of images (Scape).

In most cases, it involves scanning the physical world using cameras and advanced software, which creates spatial maps and point clouds. These then become the foundation for data that can feed AR devices on the fly – enabling them to overlay graphics with positional and contextual accuracy.



Source: Ubiquity6

The crowdsourced approach is interesting in that it scales. But its downside is reliance on humans to participate in an activity that may not be familiar. Panning your phone around to scan physical spaces is a deliberate behavior that has to be conditioned. It's not culturally a thing yet.

Training Wheels

6D.ai is tackling this in interesting ways with SDKs for developers who utilize its spatial mapping in return for sharing back data that their users capture, a la Waze. Apps like Babble Rabbit have found creative ways to get users to pan their phones around a space in gamified ways.

Ubiquity6 is likewise addressing this challenge. Its display.land app lets users create 3D scans of their physical spaces to then upload, augment and share with friends. This isn't AR in that the shared file is viewed on one's phone and not overlaid on the physical world.

But the point is to introduce a new behavior that piggybacks on users' conceptual understanding of an old one. In other words, one of today's most popular mobile activities is capturing photos and videos, then sharing to a social graph. Dislplay.land, taps into that sense of familiarity.

This could advance user acclimation towards the somewhat unnatural act of scanning physical spaces, thereby accelerating the construction of the AR cloud. This "training wheels" approach will be a key theme in getting users into AR activities by piggybacking on things they're already familiar with.

AR at Work: The Enterprise

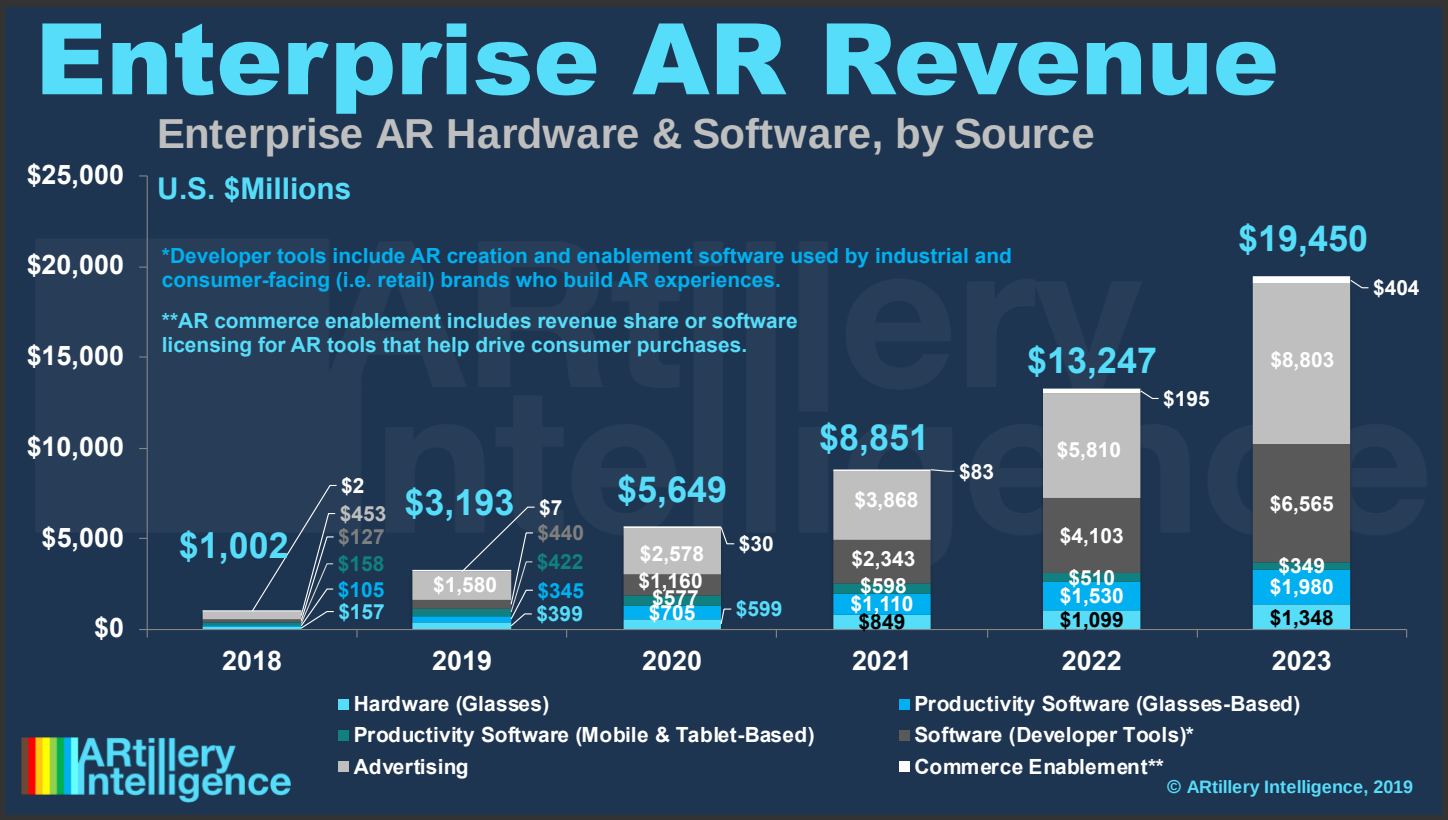
Everything examined so far in this report relates to consumer-facing AR. But what about the enterprise opportunity? Enterprise AR, particularly in industrial settings, has been positioned as AR's saving grace while consumer adoption lingers. But it's also seen its fair share of challenges.

Before diving in, it's important to first define and delineate "enterprise AR." Often, the term is used in reference to industrial uses. But "enterprise" is a much broader market segment. Think of the "enterprise software" market which addresses corporate, retail, industrial and other segments.

This is the same way we think of enterprise AR. Of course, there are use cases in industrial settings, such as automation and visualization. But there are also lots of opportunities in corporate settings (data visualization), retail (product visualization) and brand advertising (examined earlier).

Some of the above classifications fall into a category we've begun to call "B2B2C." Though the end user of a given AR experience is a consumer, it is enterprises that are adopting and deploying AR. This is usually consumer-facing companies that are using AR to engage their customers.

This category also includes developer tools such as Unity. It includes AR democratization and creation tools such as Amazon Sumerian or Adobe Aero. This is also known as AR-as-a-service (ARaas)[xi]. Similar to SaaS in the enterprise software world, and as mentioned earlier, it will have a major impact on AR.



Heavy AR

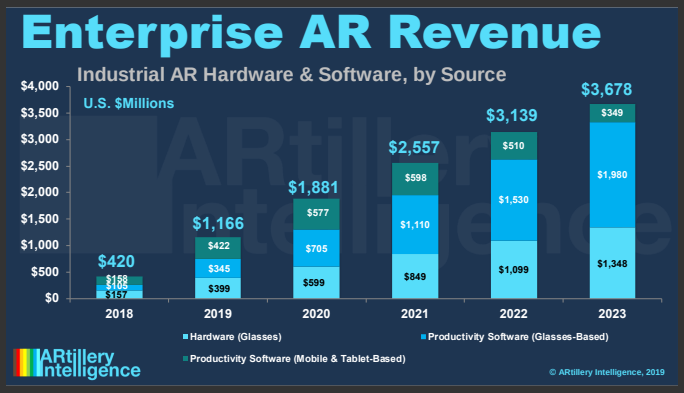
Zeroing in on industrial AR, it continues to hold lots of promise. But like many AR sub-sectors, it's taking longer than expected to get off the ground. This has less to do with the technology's efficacy (which is strong) and more to do with roadblocks from human and organizational issues.

First, what are its benefits? Industrial AR's target areas include assembly and maintenance in manufacturing. The idea is that line-of-sight visualization can guide front-line workers. Compared to the "mental mapping" they otherwise do with 2D instructions, AR support boosts productivity.

This plays out through speed, effectiveness, error reduction and safety. These micro efficiencies add up to worthwhile bottom-line impact in large-scale operations. Macro benefits meanwhile include lower strain and turnover, leading to higher morale and institutional knowledge retention.

But even though all of these advantages are well-validated, it's challenging to get to the point of realizing them. Practical and logistical barriers stand in the way such as organizational inertia, politics, change management and fear of new technology among key stakeholders.

Source: Microsoft



The biggest symptom of these stumbling blocks is the dreaded "pilot purgatory." As its name suggests, and as you may have heard in AR industry narratives, this is when AR is adopted at the pilot stage, but never progresses to full deployment. It's the biggest pain point in industrial AR.

ARtillery Intelligence has identified sources and solution areas for these challenges, which we've classified as the *Three P's*. Comprising People, Product & Process, they're the top areas where effective AR implementation strategies should focus in order to avoid pilot purgatory.

For *people*, it's about customizing AR's ROI story to individuals at all levels of the organization. For *product*, it's all about addressing real operational pain points, uncovered through ground-level research. For *process*, it's about multi-disciplinary prototyping rather than top-down innovation.

But the most important of the three is likely *people* (the reason it comes first). Because organizations are comprised of people, the points of adoption (and resistance) lie with people. And it's with people that AR's value proposition should be customized and optimized for maximum results.

More can be seen in the ARtillery Intelligence report *Industrial AR Benefits & Barriers*.[xii]

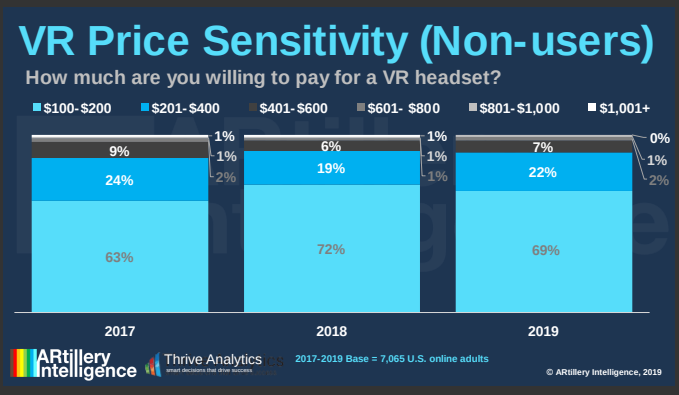
VR's Long Road

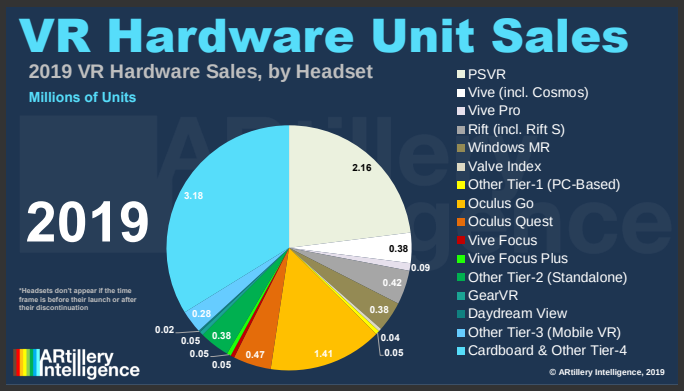
Though the majority of this report has focused on AR (reflective of ARtillery Intelligence's main focus), there are applicable learnings and market development for its cousin, VR. The VR market made strides in 2019, but they were more about positioning and "table-setting" than sales inflections.

Among these positioning moves was the continued success of the tier-1 VR hardware leader Playstation VR. Building on an installed base of 100,000+ Playstation 4 consoles and a compelling "experience sell" (rather than focusing on specs), it reached 5 million lifetime unit sales in June.[xiii]

But perhaps more significant for the VR industry was the May launch of Oculus Quest. The long-awaited device didn't disappoint, hitting the elusive sweet spot on the quality/price sliding scale. This includes six-degrees of freedom tracking, platform compatibility via Oculus Link, and rave reviews.

Zeroing in on price, It's a big factor at this early and unproven stage of VR. ARtillery Intelligence consumer survey data with Thrive Analytics (n=1,959) indicate that demand inflects at $200 and $400. Those happen to be the all-in price points for base-model Oculus Go and Quest, respectively.





500K Strong

As background, Facebook's long-game strategy compels aggressive pricing. This involves a sort of loss-leader approach to establish its platform. Early market share is the name of the game in platform wars as it attracts developers, which grow the content library to attract more users – a virtuous cycle.

"This is Facebook accelerating adoption by subsidizing and selling these at very little margin," said Tested's Jeremy Williams. "That's something the competitors can't necessarily do, but we as consumers can take advantage of it. This is a device that probably shouldn't exist at this price."

With these factors in mind, our 2019 predictions pegged Quest's sales this year at about a quarter of a million units. Lower than other projections that exceeded 1 million units for the same time frame, our rationale took into account only six months of sales runway and other market demand signals.

It now appears that 2019 Quest sales will be closer to 470,000 units. This considers several factors including extrapolations based on Facebook's disclosures about Quest's content sales. To put this into perspective, it's equivalent to the longer-tenured Oculus Rift's annual sales, but in half the time.

One Good Reason

Perhaps more important than today's market performance is panning back to examine how Quest will tee up VR's growth and mainstream consumer demand in the coming months and years. As examined above, Quest (along with Oculus Go) are long-term investments to bring more people into VR.

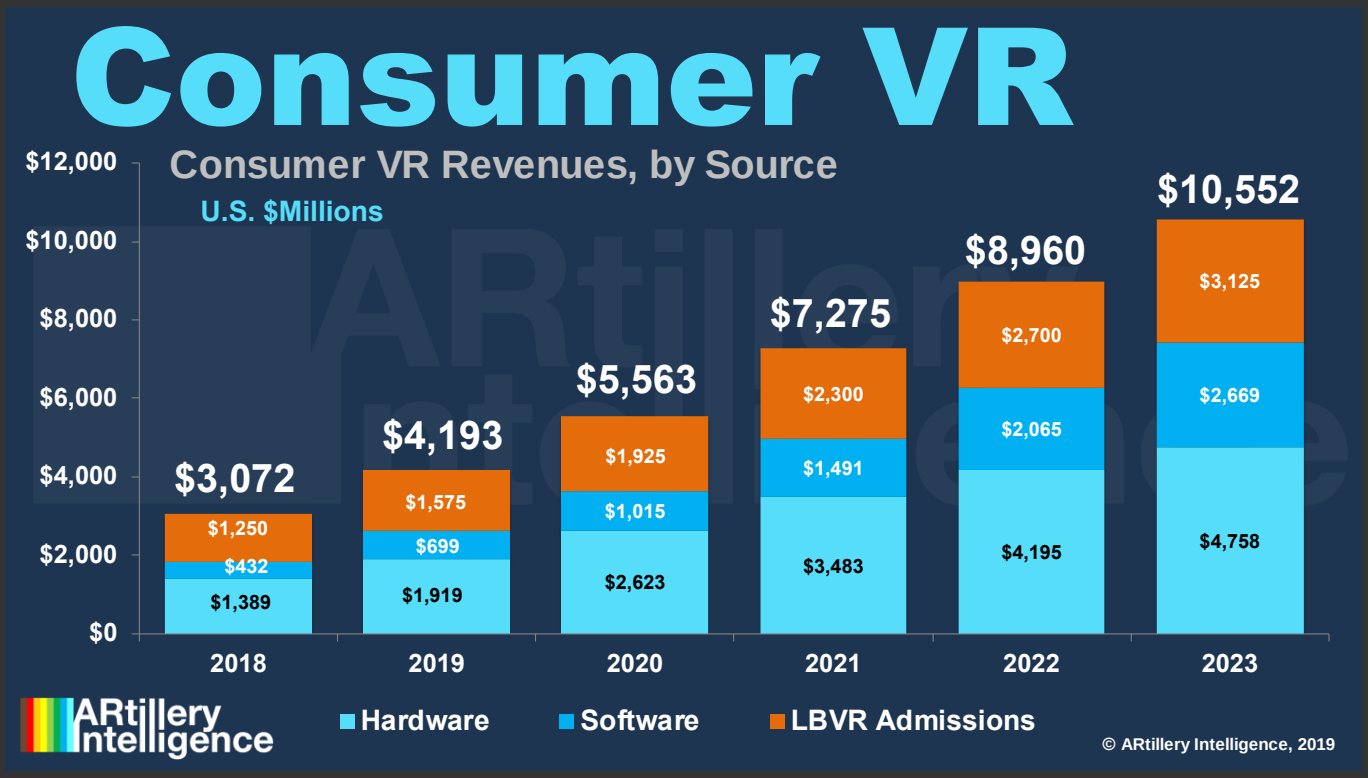
Based partly on Quest's impact and halo effect, ARtillery Intelligence projects consumer VR to grow from $4.2 billion in 2018 to $10.6 billion by 2023.[xiv] That's led by hardware in the near term, with software's revenue share increasing as it builds on a larger installed base.

Meanwhile, aggregate hardware unit sales for tier-1 (tethered) and tier-2 (standalone) VR headsets will grow from 3.8 million units last year to 19.8 million annually by 2023. This correlates to a cumulative installed base of in-market devices of 8 million in 2018 and 48.5 million in 2023 (see chart on next page).

But this growth requires more than just compelling and competitively-priced hardware. VR needs a better reason to buy, or a killer app. Outside of VR circles, there's not really one solid answer to the question of why one should buy VR. There are lots of little answers, but that's not going to cut it.

Fortunately, Quest is advantaged in its versatility. Out of the gate, it was somewhat limited to low processing power and thus a limited range of games (think: low-poly graphical styling). But with the surprisingly adept Oculus Link, Quest can be tethered to PCs to play a wider range of Rift titles.

Meanwhile, Oculus Quest ports have performed well, including the closest thing yet to a killer app: Beat Saber. Congruent with its long-term investments in VR examined above, Facebook last month acquired Beat Saber developer Beat Games, which should be another stimulant for the VR sector.



VR's Palm Pilot

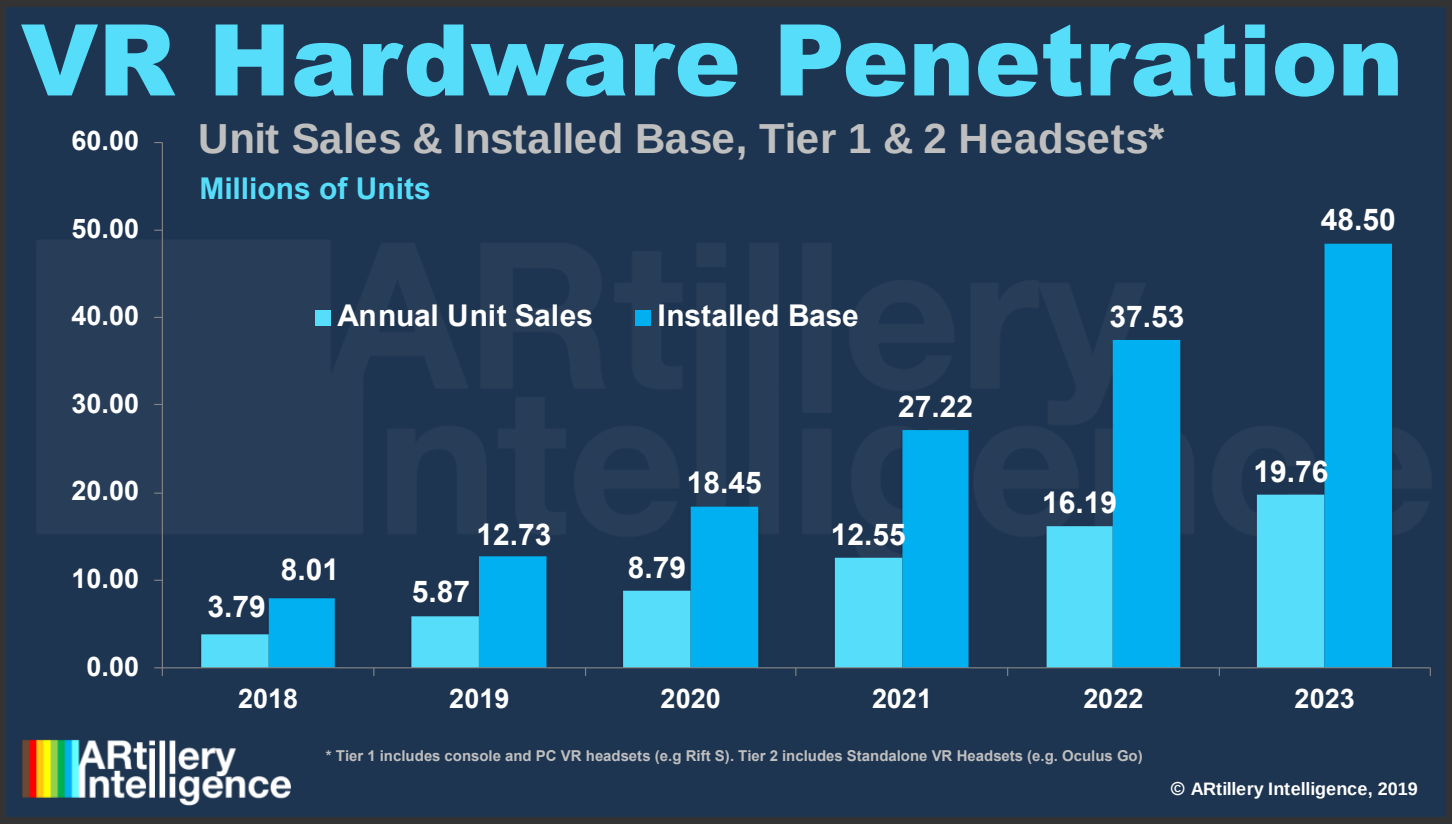
Based on these developing factors, some have labeled Oculus Quest as VR's iPhone moment. We appreciate that optimism but a more appropriate analogy is the Palm Pilot. Quest is a design feat that will be appreciated for years, but is more of an evolutionary step towards VR's iPhone moment.

Source: Facebook

Source: Facebook

Meanwhile, Quest is what VR needs at this stage. Along with the Beat Games acquisition, which signals exit potential for developers, Quest's growing installed base will attract more developers to build content. Expanding content libraries will in turn attract more users… and the flywheel effect is closer to being achieved.

VR Hardware Penetration



Boiling it Down: 5 Predictions

Synthesizing all of the above lessons to illuminate the path forward for AR and VR in 2020, we've boiled it down to 5 predictions. These are laid out in the following pages, including rationale, data and concrete market projections. We'll be watching these throughout 2020 and holding ourselves to task.

1. Apple Glasses Don’t Arrive in 2020

A longstanding rumor in the AR industry has pegged 2020 as the year that Apple will launch AR glasses. We believe that won’t happen.

Our reasons go back to the state of the underlying technology, which is not ready for marketable AR glasses. That factor is amplified by Apple’s standard playbook of launching products late, rather than being first to market.

Combining these two factors, the technology isn’t yet at the stage where it’s possible for Apple to release something that is up to its standards of product style, mass-market viability and industrial design.

Based on these factors, we believe Apple will spend 2020 in behind-the-scenes work on AR glasses as it works towards a 2022 release. Expect more technology acquisitions and acquihires as Apple assembles its capabilities to achieve market-leading AR glasses.

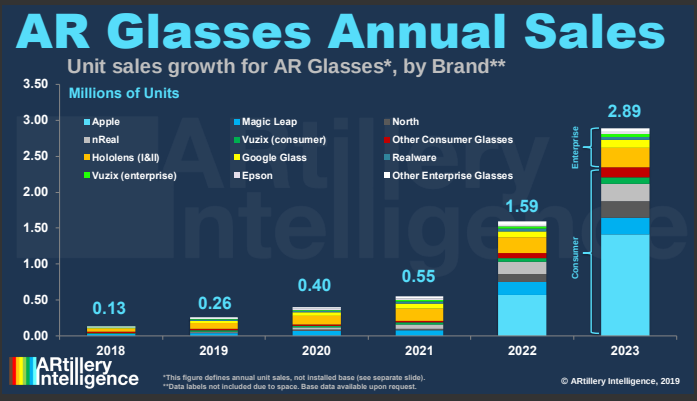
As for the glasses themselves, they’ll likely start as entertainment-centric glasses that are meant for stationary use, as opposed to an all-day wearable for world-immersive AR.
The latter will be something Apple works towards as the underlying technology – and supporting technologies like 5G – enable it. This can be thought of like the iPhone 1, which was followed by years of evolutionary steps.

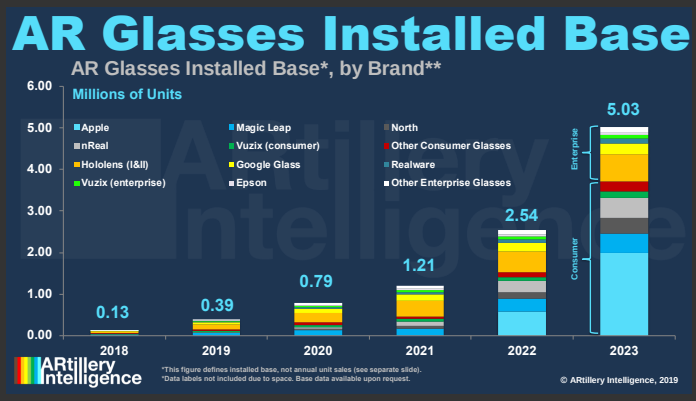
The eventual target will be an all-day wearable that utilizes Apple’s recently-patented variable-opacity lenses, which enable multimodal use. That includes lean back entertainment when glasses are opaque/occluded; and utility-driven content (iOS notifications, etc.) when in transparent mode.

For all of the above, Apple’s standard hardware cycle should be considered. So a 2022 release could be announced in Fall 2021.

Importantly, these glasses will impact consumer AR acclimation and growth which will inflect in 2022. This means that Apple’s AR glasses won’t just grow aggregate sales on their own, but by rising all boats and boosting sales of competitors.

Concrete prediction: Apple will sell less than one million AR glasses in 2022 but exceed one million by 2023. This will drive overall AR glasses sales of almost 3 million by 2023, correlating to an installed base of 5 million units.





2. AR Wins With "Training Wheels"

The spatial computing industry is learning that its circa-2016 ambitions aren't translating to mainstream adoption. This is causing a sobering realization that mainstream consumers aren't as excited about AR (or don't understand it) as its proponents are.

This is mostly due to confusion over the technology, or the fact that its proposed use cases are a mismatch with mainstream interest levels. Therefore, any potential killer apps will have to meet users halfway in terms of their existing interests or understanding. This product strategy will be critical in 2020.

This means a few things: AR providers that can acclimate consumers to AR by tapping into existing behavior will succeed in boosting adoption. One example is Ubiquity6's strategy to condition users to scanning their environments by giving them a free tool to capture and share 3D models.

This taps into an existing area of interest (social sharing), and will represent the types of training wheels that AR needs. Support of this concept can be seen in the most popular form of AR today – selfie lenses. These are shared with friends in the same channels as photo sharing, and build on existing behavior.

Instagram will be a sleeping giant in AR, and in driving AR commerce by incorporating it in organic ways to a camera-forward user base. It will succeed in driving AR ad revenue by adding the technology to product and fashion discovery, including seamless in-app transactional functions.

Another example of this "training-wheels" principle will be the growth in wearables as a consumer product category. The sector's existing growth will feed into AR by acclimating users to wearing sensors on their bodies.

Apple is already conditioning this use case (AirPods & Watch), as is Snap (Spectacles).

Speaking of Apple, it will further exercise this training-wheels approach in the ways described in the previous prediction. To get users accustomed to AR glasses, it will start with a use case that they're already familiar and comfortable with: watching TV and movies. It will then ease them in to "true AR."

Another way that AR will get over the adoption hump is with utilities that provide tangible value to consumers – in addition to the social and entertainment use cases that have erstwhile ruled AR. This includes most notably visual search (e.g. Google Lens) and navigation (e.g. Google Live View).

Concrete Prediction: Apple will invest heavily in its wearables line to offset iPhone sales declines, and to condition the world for a wearable-tech future (including AR glasses). Snap will do the same with Spectacles. Google will accelerate the adoption of its AR "flavors" (e.g. visual search) by incubating AR in search and increasing the calls to action for AR experiences in existing search products.

Source: Apple

3. Advertising Keeps the AR Revenue Crown

Advertising is currently AR's revenue leader, with $453 million spent last year, growing to $8.8 billion by 2023 according to our projections. This is dominated by AR lenses in social channels today, but other formats like visual search will gain market share over time as Google pushes the technology.

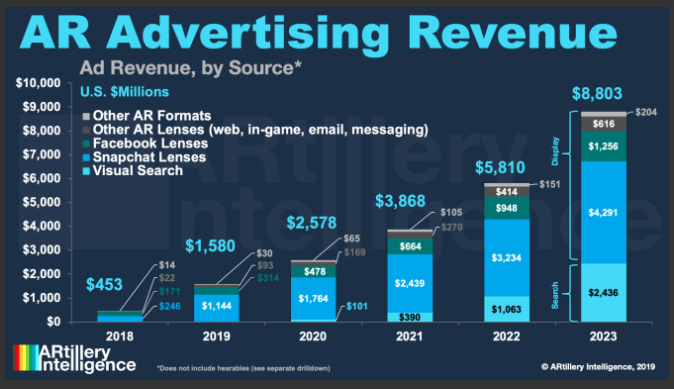
Based on its current momentum – and the continued barriers faced by other AR sub-sectors – Advertising will continue to hold the revenue crown in 2020. Snapchat will maintain its leading position among AR lens providers, despite Facebook's greater global scale and reach.

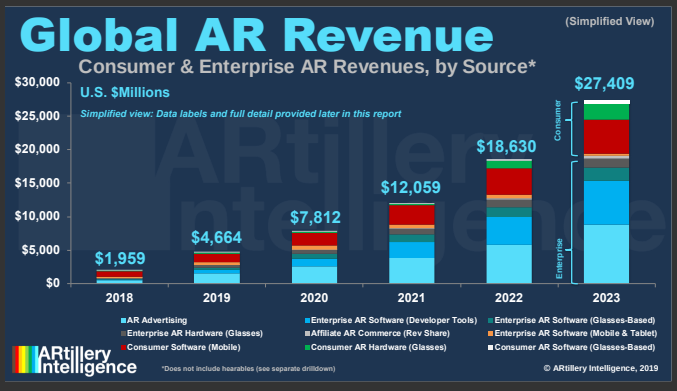
Snapchat's lead results from dedicated focus on lenses as a user engagement feature, and a tool for advertisers to demonstrate products in immersive ways. Lens formats will continue to be dominated by front-facing camera (selfie) activations, but rear-facing (world-immersive) lenses will gain share.

Facebook's AR advertising ambitions will be boosted by Instagram's entrance to the AR lens competitive field. This will be a natural activity for camera-forward Instagram users, and will dovetail well with Instagram's existing use case as a product and fashion discovery tool.

Instagram's edge in AR advertising will be this existing user behavior, combined with its execution in combining AR user behavior with transactional capability. The latter is a phenomenon that's already growing on Instagram and is on a convergence path with AR. Instagram will lean into this synergy.

Concrete Prediction: It will be revealed in 2020 that AR advertising revenues reached $1.58 billion in 2019. 2020 revenues will meanwhile reach $2.58 billion. AR lenses will maintain their leading position in that revenue mix but Google will begin to monetize visual search as a high-intent (and thus high-premium) ad format. The latter will take much more time to develop but will advance in 2020.





4. Enterprise AR Lingers One More Year

Industrial enterprise adoption of AR has been much slower than industry proponents had hoped or predicted. This is due mostly to the common difficulties in implementing new technologies in large organizations. Regardless of the efficacy and ROI, there is inertia with any large paradigm shift.

This factor will continue in 2020, including the dreaded “pilot purgatory” that has been the biggest source of stalled implementations for industrial AR. Though the successful case studies get disproportionate attention, panning back to the larger market’s resistance is required for a full view.

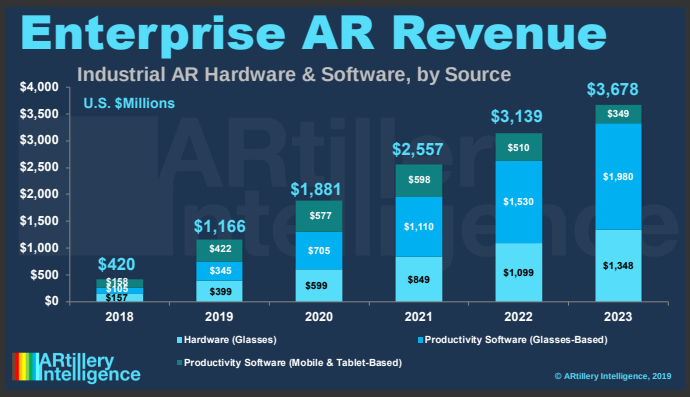
There will be a tipping point for industrial AR, after which adoption accelerates in a sort of herd mentality. This is the common industry-adoption cycle, which can be seen in past paradigm shifts such as enterprise smartphone adoption. Industrial AR will be no exception but the question is when?

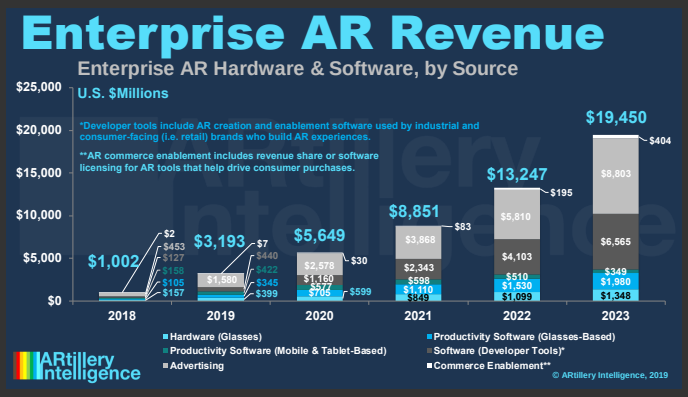
We believe the tipping point won’t come in 2020 but momentum will be gained so that it can come in 2021. 2020 will meanwhile see continued ROI proof points and case studies as companies like Lockheed Martin and Caterpillar continue to see and demonstrate real ROI gains.

Until that tipping point comes, Enterprise-targeted AR technologies will succeed in other areas outside of industrial and manufacturing-based implementations. For example, AR developer tools will be a leading source of enterprise AR spending, including authoring AR experiences.

The leading category of enterprise AR will in fact have a consumer endpoint. In other words, the area we track and define as “B2B2C” will outspend industrial AR by 2023. This includes software to lower barriers to consumer AR experience creation for brands, retailers and other consumer-facing enterprises.

Concrete Prediction: Industrial AR spending will grow from $1.17 billion in 2019 to $1.88 billion in 2020. That includes hardware and software, such as visualization support for industrial assembly and maintenance. Meanwhile, developer tools for AR experience creation will grow from $440 million in 2019 to $1.16 billion in 2020.





5. VR's Evolutionary 2020

VR will continue to make important strides and hit important milestones in 2020. But it will be a long, slow road, rather than the revolutionary cultural takeover that proponents expected in the circa-2016 hype cycle. The catalyst will continue to be Facebook's VR investments to accelerate adoption.

This includes continued momentum of Oculus Quest, which includes the device itself as well as additional investments such as content libraries and supporting tech (e.g. Oculus Link, and hand tracking). These moves will attract more users to Quest, and VR by association, given more reasons to adopt.

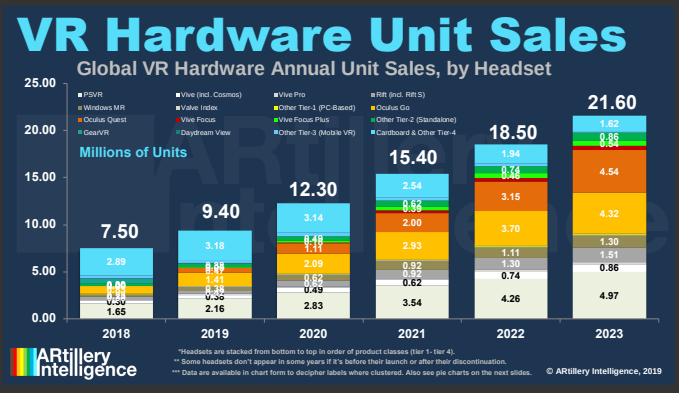
The market will also continue to diverge, with Oculus' market share growing in the product classes where it competes. That includes tier-1 tethered (Rift), tier-2 standalone (Quest) and lean-back 3DoF VR (Go). Its aggressive loss-leader pricing approach will gain share from margin-dependent competitors.

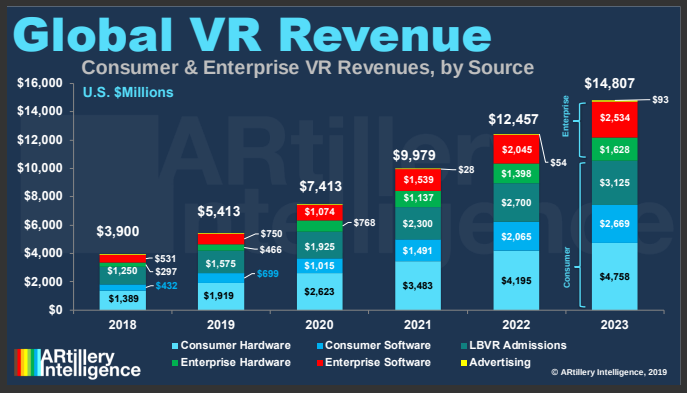
The exception will be hardware that has specialized functions in certain use cases – such as Vive PRO's and Varjo's focus on enterprise-grade specs. But those market-share wins will be smaller in quantity than Oculus's consumer-based VR growth in 2020. Oculus will pull ahead in the aggregate.

Oculus will also continue to invest in content, including buying rather than building, as it did with Beat Games. This represents a divergence from its previous strategy with Oculus Story Studio. This means exit potential for AR startups and will stimulate innovation and seed investments.

These factors will result in more robust VR content libraries, more users, and greater software spending per user (ARPU). This virtuous cycle will take a while to ratchet up, but is the process that Oculus will continue to accelerate through its platform-driven long-term investment approach.

Concrete Prediction: VR will grow from $5.4 billion in 2018 to $7.4 billion in 2020 and $14.8 billion in 2023. Oculus Quest will impact aggregate VR unit and revenue growth, reaching 470,000 units sold in 2019 and 1.11 million in 2020. That correlates to revenue of $178 million in 2019, growing to $399 million in 2020.





ARtillery Intelligence

Key Takeaways

- 2019 was a rebuilding year for AR and VR in the aggregate, while some positive steps were taken.
  - Continuing a trend from 2018, the sector's under-developed status was reinforced in 2019.
  - Though this was discouraging and involved an industry shakeout, it follows a common pattern.
  - As was seen in the eCommerce bubble, a shakeout can be followed by slow but healthy growth.
  - Eventual industry revenues can exceed early/ambitious projections, but not until several years later.

- This is where we now sit in the AR and VR sectors as we enter 2020. A long road lies ahead.
  - Though discouraging signals abound, such as dissolved companies, we see confidence signals.
  - This includes revenue performance and momentum in certain sub-sectors such as AR advertising.
  - Advertising is AR's revenue leader, projected to grow from $1.58 billion to $2.6 billion in 2020.
  - Levels of investments from tech giants is another signal in our exercise of "following the money."

- The outcome of Apple's rumored AR glasses will have a large impact on industry health.
  - Apple's track record in mainstreaming emerging tech could "rise all boats" for AR glasses.
  - Signals we track indicate a product launch in 2022, deviating from rumors of a 2020 launch.
  - Apple could start with an entertainment wearable to tap into consumers' existing comfort levels.
  - Like the iPhone 1, this could then evolve including the move towards an "all-day" wearable.
  - Apple IP, such as variable-opacity lenses, signal multi-modal glasses for entertainment and utility.

- Until AR glasses become more ubiquitous, Mobile AR is the near-term play for reach & scale.
  - There are currently 3.3 billion smartphones globally, a growing share of which are AR compatible.
  - The common industry rallying cry is that there are 1 billion AR compatible phones globally.
  - This number is correct if measuring ARkit and ARCore, but is much larger with other platforms.
  - Facebook Spark AR, Snap Lens Studio and Web AR are increasingly important platforms.
  - The most relevant figure is the number of global *active* users which is 334 million today.

- With all of the above consumer AR platforms, a key tactic is to tap into existing behavior and comfort.
  - The broader wearables movement is well-underway and could accelerate AR comfort levels.
  - This is Apple's strategy with AirPods & Watch, as well as Snap's strategy with Spectacles 3.
  - AR lenses so far succeed by building on the popular activity of sharing multimedia socially.
  - Instagram's AR efforts will tap into a camera-forward audience and fashion-discovery use case.

- Enterprise AR continues to hold significant promise, but adoption has been slower than expected.
  - Industrial AR can provide strong ROI in visualizing assembly and maintenance, but is challenged.
  - Organizational inertia and human resistance are the biggest pitfalls where strategies should focus.
  - Beyond industrial settings, "enterprise AR" hold promises in retail, commerce & entertainment.
  - These consumer-facing enterprise AR implementations (B2B2C) will be a major revenue category.
  - Enterprise AR in total is projected to grow from $3.2 billion this year to $5.6 billion in 2020.

- VR likewise had a slow year with an industry in retraction... but there were pockets of momentum.
  - The catalyst will continue to be Facebook's investments to accelerate adoption and network effect.
  - Oculus Quest is a beacon of hope in hitting the sweet spot on the price/quality sliding scale.
  - Facebook's Beat Games acquisition signals exit potential and incentivizes further innovation.
  - VR revenues will grow to $7.4 billion in 2020 with a cumulative installed base of 18.5 million units.

About ARtillery Intelligence

ARtillery Intelligence chronicles the evolution of spatial computing. Through writings and multimedia, it provides deep and analytical views into the industry's biggest players, opportunities and strategies.

Run by analysts and former journalists, coverage is grounded in a disciplined and journalistic approach. It also maintains a business angle: Though there are lots of fun and games in spatial computing, cultural, technological and financial implications are the primary focus.

Products include the AR Insider publication and the ARtillery PRO research subscription, which together engender a circular flow of knowledge. Research includes monthly narrative reports, market-sizing forecasts consumer survey data and multi-media, all housed in a robust intelligence vault.

Learn more **here**.

About Intelligence Briefings

ARtillery Intelligence Briefings are monthly installments of spatial computing analysis. They synthesize original and third-party data to reveal opportunities and dynamics of VR and AR sectors. A layer of insights is applied to translate market events and raw figures into prescriptive advice.

More information, past reports and editorial calendar can be seen **here.**

About the Author

Mike Boland was one of Silicon Valley's first tech reporters of the Internet age, as a staff reporter for *Forbes* (print) starting in 2000. He has been an industry analyst covering mobile and social media since 2005, and is now Chief Analyst of *ARtillery Intelligence* and Editor-in-Chief of *AR Insider.*

Mike is a frequent speaker at industry conferences such as AWE, VRLA and XRDC. He has authored more than 120 reports and market-sizing forecasts on the tech & media landscape. He contributes regularly to news sources such as *TechCrunch*, *Business Insider* and the *Huffington Post*.

A trusted source for tech journalists, his comments have appeared in A-list publications, including *The New Yorker*, *The Wall Street Journal* and *The New York Times*.

Further background, history and credentials can be read **here**.

Methodology

This report highlights *ARtillery Intelligence* viewpoints, gathered from its daily in-depth coverage of spatial computing. To support narratives, data are cited throughout the report. These include *ARtillery Intelligence* original data, as well as that of third parties. Data sources are attributed in each case.

For market sizing and forecasting, *ARtillery Intelligence* follows disciplined best practices, developed and reinforced through its principles' 15 years in tech-sector research and intelligence. This includes the past 4 years covering AR & VR exclusively, as seen in research reports and daily reporting.

Furthermore, devising these figures involves the "bottom-up" market-sizing methodology, which involves granular revenue dynamics such as unit penetration, pricing and growth patterns. More on ARtillery Intelligence market-sizing research and methodologies can be read **here.**

Disclosure and Ethics Policy

ARtillery Intelligence has no financial stake in the companies mentioned in this report, nor was it commissioned to produce it. With respect to market sizing, *ARtillery Intelligence* remains independent of players and practitioners in the sectors it covers, thus mitigating bias in industry revenue calculations and projections.

ARtillery Intelligence's disclosure and ethics policy can be seen in full **here.**

Contact

Questions and requests for deeper analysis can be submitted **here.**

References

[i] See ARtillery report: Global AR Revenue Forecast, 2018-2023 (sign-in required)
[ii] See ARtillery report: Global VR Revenue Forecast, 2018-2023 (sign-in required)
[iii] See ARtillery report: AR Business Models: The Top of the Food Chain (sign-in required)
[iv] See ARtillery report: Hearables: Broadening the Definition of AR (sign-in required)
[v] See ARtillery report: Global AR Revenue Forecast, 2018-2023 (sign-in required)
[vi] See AR Insider article: Begun, the Wearables Wars Have
[vii] See ARtillery report: Hearables: Broadening the Definition of AR (sign-in required)
[viii] See ARtillery report: Global AR Revenue Forecast, 2018-2023 (sign-in required)
[ix] See AWE Talk: Camera Native Gen: Snapchat
[x] See ARtillery report: Mobile AR Strategies & Business Models (sign-in required)
[xi] See ARtillery report: Mobile AR Strategies & Business Models (sign-in required)
[xii] See ARtillery report: Industrial AR: Benefits & Barriers (sign-in required)
[xiii] See AR Insider article: Data Point of the Week: 5 Million PSVRs?
[xiv] See ARtillery report: Global VR Revenue Forecast, 2018-2023 (sign-in required)