ARtillery
Intelligence

ARTILLERY INTELLIGENCE BRIEFING
XR 2018 LESSONS, 2019 OUTLOOK
JANUARY 2019

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Table of Contents

Executive Summary

2018 was a reflective year for XR. After an exuberant 2016, followed by a corrective 2017, XR industries settled into a moderate pace. This includes reset expectations on the size and timing of AR & VR markets, as well as an overall acceptance that 2016's aspirations will take longer to materialize.

But we saw deep-pocketed tech giants charge ahead with XR. With strong contention that XR represents the next computing shift, they're investing in the future of their platforms by gaining early market share and technological edge. And they're each attacking XR from different angles.

Apple is investing in AR to fertilize the ground for the future of its hardware business: AR glasses. Google is cultivating visual search, a close cousin of AR, as a future search modality. Amazon is embracing AR to boost e-commerce, and Facebook is spending billions to position a VR powerhouse.

Despite XR market softness, it was these moves from tech giants that provided confidence in 2018 for the eventual market arrival. Indeed, there's no bigger vote of confidence in a technology and a market than billions of dollars in long-term bets. We believe this will continue into 2019.

One of those key investments will be Facebook's continued subsidization of VR headsets, through aggressive price competition. It's executing a classic loss-leader approach to gain early market share and build up the installed base of Oculus headsets. This is already accelerating consumer adoption.

We also learned important lessons in 2018 about AR adoption and behavior. Mobile AR, despite its potential scale, is gated by consumer AR interest and app quality. And these factors need more time in the oven. The half-baked quality of many ARkit apps hasn't sold the masses on AR just yet.

But though the scale is relatively low, mobile AR users are showing strong engagement in terms of frequency of use and other behavior. In formats where engagement is measured heavily, such as AR ads (branded AR lenses), performance indicators and advertiser ROI are already quite strong.

Meanwhile, there were wild cards played in 2018. Magic Leap One finally launched, coupled with even more ambitious promises. Apple's acquisition spree and patent filings point to its AR glasses in the 2021 timeframe. And the AR Cloud's importance emerged into the collective consciousness.

So the question is, where are we now with these and other XR sub-sectors? And what can we expect in 2019? Drawing from ARtillery Intelligence's deep XR coverage, we ventured to answer these questions. We'll look back at 2018 to extract measurable lessons, and predict XR's directions in 2019.

Key Takeaways

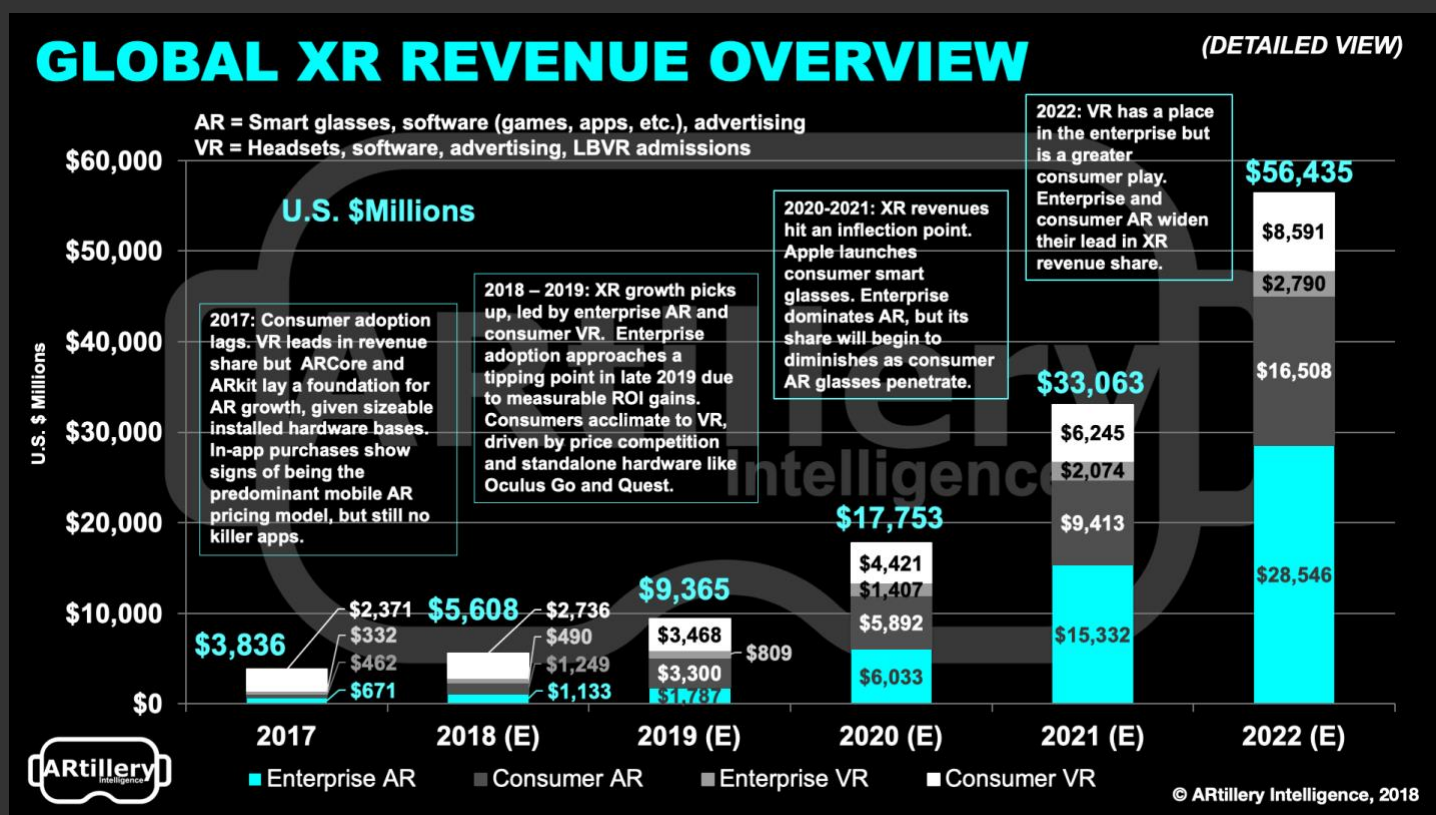*Key takeaways are also highlighted throughout the main body of this report.*

- XR and its sub sectors had a reflective and corrective 2018, due to continued market softness.
    - Previous optimism will turn out to be well placed, but in a much longer fulfillment timeframe.
    - Confidence for XRs long-term health and opportunity is reinforced by tech giants' investment levels.

- Mobile AR became the focus in 2018, due to the installed base of 2.6 billion global smartphones.
    - Mobile holds the *capacity* for AR scale, but not yet the reality of sizeable active usage volume.
    - Evolution is required in underlying technology, developers' native footing and consumer acclimation.
    - Native development is particularly important to achieve novel AR, but novelty alone isn't enough.
    - The combination of novelty and utility will strike the right balance for mainstream AR appeal.
    - A killer app could be released in late 2019 – a historically-validated timeframe after ARkit's launch.
    - AR killer apps will be communications, social or utility-oriented, due to recurring/active use cases.
    - "AR as a feature," emerged as a success factor for AR in 2018, as opposed to standalone apps.
    - The dominant business model for AR apps has and will continue to be In-App Purchases (IAP).
    - IAP has been validated by Pokemon Go's $2 billion cumulative revenue, as well as our user survey data.

- The AR cloud came into the collective consciousness in 2018 as a critical but missing puzzle piece.
    - Key attributes include delivering geo-precise spatial mapping and object recognition data.
    - Several AR Cloud startups launched in 2018 and tech giants formulated AR cloud strategies.
    - AR cloud data sources will diversify, including startups and non-AR entities like autonomous vehicles.
    - AR as a service (ARaaS) emerged (e.g. Niantic) to democratize AR cloud functionality for developers.
    - Like the AR cloud, a breakout category in 2019 will be enabling-technologies or "building blocks."
    - These democratize XR creation and distribution, such as creative tools for 3D graphics production.

- Amidst long-term market building, some XR sectors are driving revenue today, such as AR advertising.
    - AR ads made $418 million in revenue in 2018, projected to reach $761 million in 2019.
    - This has mostly been branded AR lenses from social apps like Snapchat and Facebook.
    - Advantages include immersive product interactions, high consumer engagement, and direct response.
    - Disadvantages include relatively low reach and short AR sessions, which diminish ad inventory.
    - AR ads will evolve to include visual search, a user behavior with potentially high commercial intent.

- Wild cards in 2018 include Magic Leap One's launch and rumors of Apple AR glasses on the horizon.
    - Apple will continue to drive ARkit as a developer training ground for an eventual AR glasses era.
    - Despite 2020 rumors, we don't believe world-immersive Apple AR glasses will arrive until 2021-2022.
    - Magic Leap One received mixed reviews and won't have a large commercial impact in 2019.

- Enterprise AR is a sleeping giant in terms of potential for scale and impact, but growth will be slow.
    - Despite continued ROI validation, AR deployments are commonly stuck in "pilot purgatory."
    - This is mostly due to failure to win over stakeholders like risk-averse IT departments and employees.
    - A tipping point will come, followed by accelerated adoption and a herd mentality… but not in 2019.
    - Resistance will break down in 2020, then will follow historical enterprise smartphone adoption patterns.

- Consumer VR leads XR revenues today, but is flattening while other XR sub-sectors trend upward.
    - 2016 and 2017 early adopters have plateaued in volume, while new segments weren't penetrated.
    - With that realization, price competition took over in 2018 to appeal to mainstream consumers.
    - ARtillery Intelligence consumer survey data indicate that demand inflects at $200 and $400.
    - Standalone VR leaders will align with these price points including Oculus Go and Prime.
    - Oculus' loss-leader approach to seed its platform will drive its unit sales growth and contract the market.

Introduction: History Repeats

One word that characterizes the tone of 2018's XR industry is *moderation*. The industry and its sub-sectors settled into acceptance that the exuberance that defined 2016 (and backlashed into 2017) was ill-devised. The market will arrive, the feeling goes, but it will take longer than initially expected.

It is indeed a matter of timing. This has parallels to the pre-bust 2000's. Despite its bad wrap, e-commerce revenue forecasting at that time wasn't overblown. In fact it ended up being too low. But the problem was it was off by about five years. That's sort of where we are now with AR & VR.

We're witnessing a classic market correction and a funding crunch. We're also confident that immersive computing will make its way back to those 2016 lofty aspirations, but not until the tech and the cultural acclimation go back in the oven for a few years. Market building is the name of the game.

GLOBAL XR REVENUE OVERVIEW *(DETAILED VIEW)*

AR = Smart glasses, software (games, apps, etc.), advertising
VR = Headsets, software, advertising, LBVR admissions

U.S. $Millions

2017: Consumer adoption lags. VR leads in revenue share but ARCore and ARkit lay a foundation for AR growth, given sizeable installed hardware bases. In-app purchases show signs of being the predominant mobile AR pricing model, but still no killer apps.

2018 – 2019: XR growth picks up, led by enterprise AR and consumer VR. Enterprise adoption approaches a tipping point in late 2019 due to measurable ROI gains. Consumers acclimate to VR, driven by price competition and standalone hardware like Oculus Go and Quest.

2020-2021: XR revenues hit an inflection point. Apple launches consumer smart glasses. Enterprise dominates AR, but its share will begin to diminishes as consumer AR glasses penetrate.

2022: VR has a place in the enterprise but is a greater consumer play. Enterprise and consumer AR widen their lead in XR revenue share.

Year	Total	Consumer VR	Enterprise VR	Consumer AR	Enterprise AR
2017	$3,836	$2,371	$332	$462	$671
2018 (E)	$5,608	$2,736	$490	$1,249	$1,133
2019 (E)	$9,365	$3,468	$809	$3,300	$1,787
2020 (E)	$17,753	$4,421	$1,407	$5,892	$6,033
2021 (E)	$33,063	$6,245	$2,074	$9,413	$15,332
2022 (E)	$56,435	$8,591	$2,790	$16,508	$28,546

■ Enterprise AR ■ Consumer AR ■ Enterprise VR ■ Consumer VR

© ARtillery Intelligence, 2018

Big Bets

The confidence to make the previous statements comes from a few places. Chief among them is the level of investment being made by influential tech giants that will pave the roads. That includes major platforms and most notably, tech's "four horsemen": Apple, Google, Facebook and Amazon.[i]

For example, Google has a vested interest in AR-based visual search to boost monetizable search query volume. Facebook wants to keep us in its walled garden through visually-immersive content sharing like AR camera effects. It also sees VR as a prominent future modality for social interaction.

Similarly, Apple wants to make the iPhone – its cash cow – sexy again through AR apps. It also wants to seed AR app development to pre-empt its post-iPhone flagship: AR glasses. And Amazon wants consumers to use AR to visualize products in-home to boost e-commerce and reduce returns.

Why is all of this important? Knowing these players' course headings and motivations can start to paint a picture of our AR future or "where the puck is going." Gaps in the value chain will accordingly open up for startups and other players that hope to play a role in emerging XR markets.

Driving Forces

To further illustrate the level of motivation driving XR, consider the event that jumpstarted the current wave of immersive computing: Facebook's 2014 acquisition of Oculus. Why did it acquire the company? And why did it pay so much – a sum that's since multiplied in internal R&D?

Facebook's VR motivations stem from a desire to own the direct touch point (hardware) for the next era of digital connectivity. It learned this lesson after failing to market a hardware product in the smartphone era. This ceded direct consumer ownership to Apple and Google.
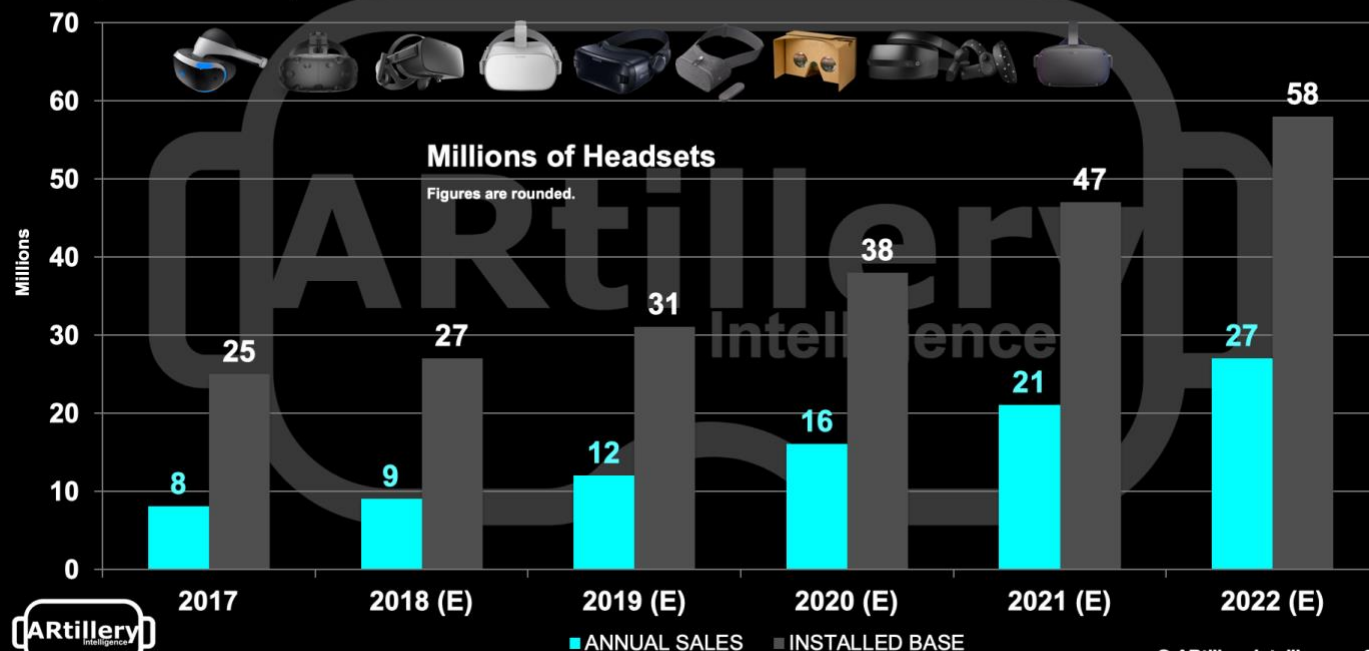
Given Mark Zuckerberg's vision of a VR future, that's not a barrier he wants to face again. Though smartphones are highly conducive to social engagement and connectivity, he sees VR as an even greater bedfellow for the future of digital social interaction. Facebook wants to be on your face.

And it continues to double down on this vision. Oculus Go was dispatched as a $199 loss leader to seed an installed base that drives Facebook's long-game platform strategy. Oculus Rift and Quest pricing followed suit, making margin-dependent VR companies unable to compete on price.

The key difference is that Facebook can afford the loss leader approach with an eye on the larger prize: Owning the hardware that's essentially a trojan horse for that privileged spot on your face. But that will be a long-term bet. VR's global installed base is 27 million units, with a long ways to go.

GLOBAL VR HEADSET INSTALLED BASE

(DETAILED VIEW)

Millions of Headsets
Figures are rounded.
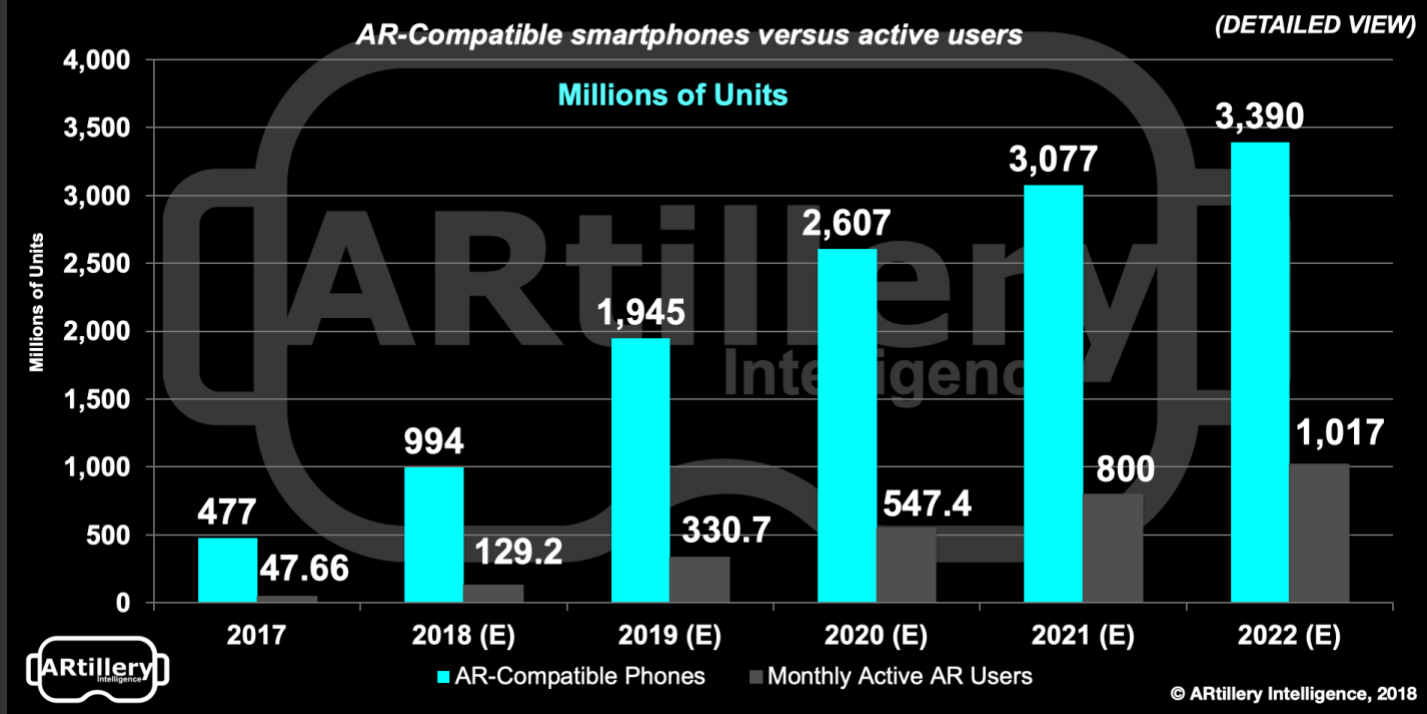
ANNUAL SALES ■ INSTALLED BASE

© ARtillery Intelligence, 2018

Year	Annual Sales	Installed Base
2017	8	25
2018 (E)	9	27
2019 (E)	12	31
2020 (E)	16	38
2021 (E)	21	47
2022 (E)	27	58

AR Rises

While investing for the future, Facebook also wants to wage battles for nearer-term revenue with VR's technological cousin: AR. That opportunity is here today, thanks to mobile AR formats that are compatible with about 900 million global smartphones. This makes the opportunity scale today.

This is an opportunity that Apple jumpstarted with ARkit and continues to cultivate in its own strategy. Like Facebook, it has short and long-term plans. The former involve mobile AR apps, which drive its central iPhone profit center. The latter involve its post-iPhone device: AR glasses.

2018 saw a string of acquisitions, patent filings and rumors that point to a 2020 AR Glasses launch. This could be aggressive given the cycles of Moore's Law needed for meaningful leaps in size, cost and power efficiencies for stylistically-marketable glasses. We believe it will be more like 2021-2022.

Meanwhile, ARkit apps will be a sort of training ground for developers to build AR skills. Apple has given them a few years to do so and is hoping that this lead time will seed apps and content libraries that can drive AR glasses appeal and utility. It's a big bet for Apple's presumptive iPhone successor.

ARCORE + ARKIT INSTALLED BASE

AR-Compatible smartphones versus active users — *(DETAILED VIEW)*

Millions of Units

	2017	2018 (E)	2019 (E)	2020 (E)	2021 (E)	2022 (E)
AR-Compatible Phones	477	994	1,945	2,607	3,077	3,390
Monthly Active AR Users	47.66	129.2	330.7	547.4	800	1,017

© ARtillery Intelligence, 2018

Revenue Today

Another short-term mobile AR strategy feeds into the business models of social giants like Facebook and Snapchat: advertising. Their revenue correlates to the time we spend in their apps. AR brings more ammunition to keep us there longer through visually immersive content to share with friends.

AR ads also drive revenue directly. AR lenses are developing in ways that let consumers plant and visualize products in their immediate surroundings. These can be demonstrable and highly engaging ad experiences on Facebook and Snapchat, such as trying on fashion accessories.

Using Facebook's Camera Effects platform, Michael Kors built a campaign that lets users jump from a News Feed ad to a front-facing camera activation that virtually tries on sunglasses. Nike spotlighted a new shoe release by letting users place it virtually in their space then walk around (and buy) the shoe.

Foot Locker and Jordan Brand similarly devised an AR campaign to run on Snapchat. Using Snapchat's "Ad to AR" format, users swiped up on a related story to reveal a branded lens. In this case, the lens featured an AR animation for a new shoe release, and ability to buy the shoe.

This makes AR a rare "full funnel" ad format including brand awareness and direct-purchases. The latter demonstrates advertiser ROI through real conversions (see figure below). This attracts increasingly data-hungry and ROI-oriented advertisers, and breaks down AR adoption barriers.

Figure: AR Ad Campaigns & ROI

Advertiser	App/Publisher	Campaign Dynamics	Results
Home Depot	Yahoo Mail	AR sequence launched from static email banner ad.	2+ minute average engagement time. 12.5 percent CTR to shopping page.
Kia	Facebook Messenger	Car visualization via AR overlay, launched from Kia's Facebook Messenger Bot.	46 percent boost in dealer inventory searches; 20 percent boost in phone calls.
Nike	Facebook Messenger	Kyrie 4 shoe release available exclusively through Facebook Messenger after users launched AR visualization feature.	Shoe sold out in less than an hour
Asus	Facebook Messenger	Customers "virtually unbox" latest ZenPhone 5 via AR visualization launched from Messenger.	Achieved 10x engagement compared to non-AR campaigns.
Foot Locker	Snapchat	The latest Jordan sneaker visualized through AR animations, launched from Snap Stories.	45-second average play time, 4 million impressions.
N/A	Houzz	In-home furniture visualization of a large portion of Houzz's online catalogue.	11x increase in purchase intent. 2.7x increase in time-in-app.
N/A	Snapchat	Branded Lenses, Shoppable AR and Ad to AR comprise its current range of paid AR offerings.	Overall 15 percent boost in purchase intent and a 9 percent boost in conversions from branded AR lenses.

Visual Search

Most AR ad campaigns so far involve ads that are programmatically *pushed* to users in a targeted way. This is analogous to digital display ads today. Indeed, many of those AR activations piggyback on existing display ad channels and networks mentioned above, such as Facebook and Snapchat.
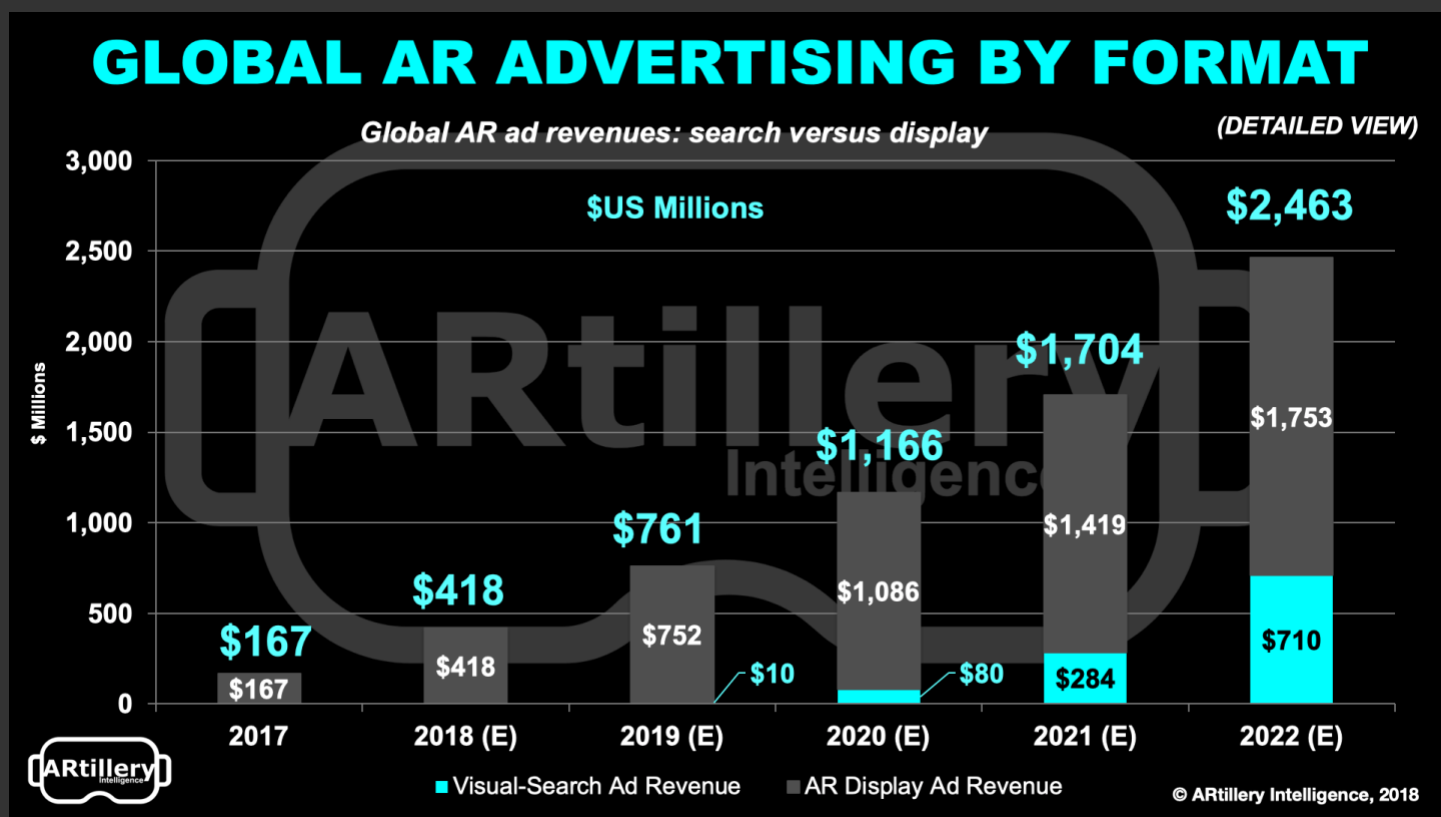
But beyond that push format, what about the advertising world's other modality: *pull*. We're of course referring to search. It's a $90 billion per year industry,[ii] whose success has a lot to do with its contextual relevance and alignment with user intent. That's because users explicitly indicate a need.

This *push* versus *pull* delineation will play into AR advertising's evolution. Just as the web started with display ads before search was introduced. a similar progression will happen in AR. That's why the above examples are display-heavy in AR's early days, and market share will shift over time to search.

If you think about it, AR is inherently a form of search. But instead of typing search queries in the traditional way, the search input is your phone's camera and the search "terms" are physical objects. These dynamics will cause search to gain prominence in AR in user adoption and ad revenue.

The way this is taking shape so far is "visual search." Represented best by Google Lens, users point their phones at items to retrieve information (or transact). Its use cases and product categories will materialize over time, leaning towards commercially-oriented searches like fashion and apparel.

Specifically, we project AR advertising to grow from $167 million in 2017 to $2.46 billion in 2022. This is dominated by display-oriented AR advertising like the examples in the previous section. But over time, visual search-based advertising will gain share as it's developed by Google and others.

GLOBAL AR ADVERTISING BY FORMAT

Global AR ad revenues: search versus display

(DETAILED VIEW)

$US Millions

Year	2017	2018 (E)	2019 (E)	2020 (E)	2021 (E)	2022 (E)
Total	$167	$418	$761	$1,166	$1,704	$2,463
AR Display Ad Revenue	$167	$418	$752	$1,086	$1,419	$1,753
Visual-Search Ad Revenue			$10	$80	$284	$710

■ Visual-Search Ad Revenue   ■ AR Display Ad Revenue

© ARtillery Intelligence, 2018

Consumer adoption has to come first, but we believe that will happen over the next 24 months. Among AR use cases, visual search has the best shot at sustained consumer engagement. Its combination of frequency and utility could make it the first mass-scale, albeit mundane, AR use case.

It can also be thought of as an extension to Google's mission statement to "organize the world's information." But instead of a search index and typed queries, AR delivers information about an item *on that item*. And instead of a web index, this works towards a sort of "internet of places."[iii]

Video Companion: AR Advertising
(click URL to open)

https://youtu.be/naJ9MEeb0Ws
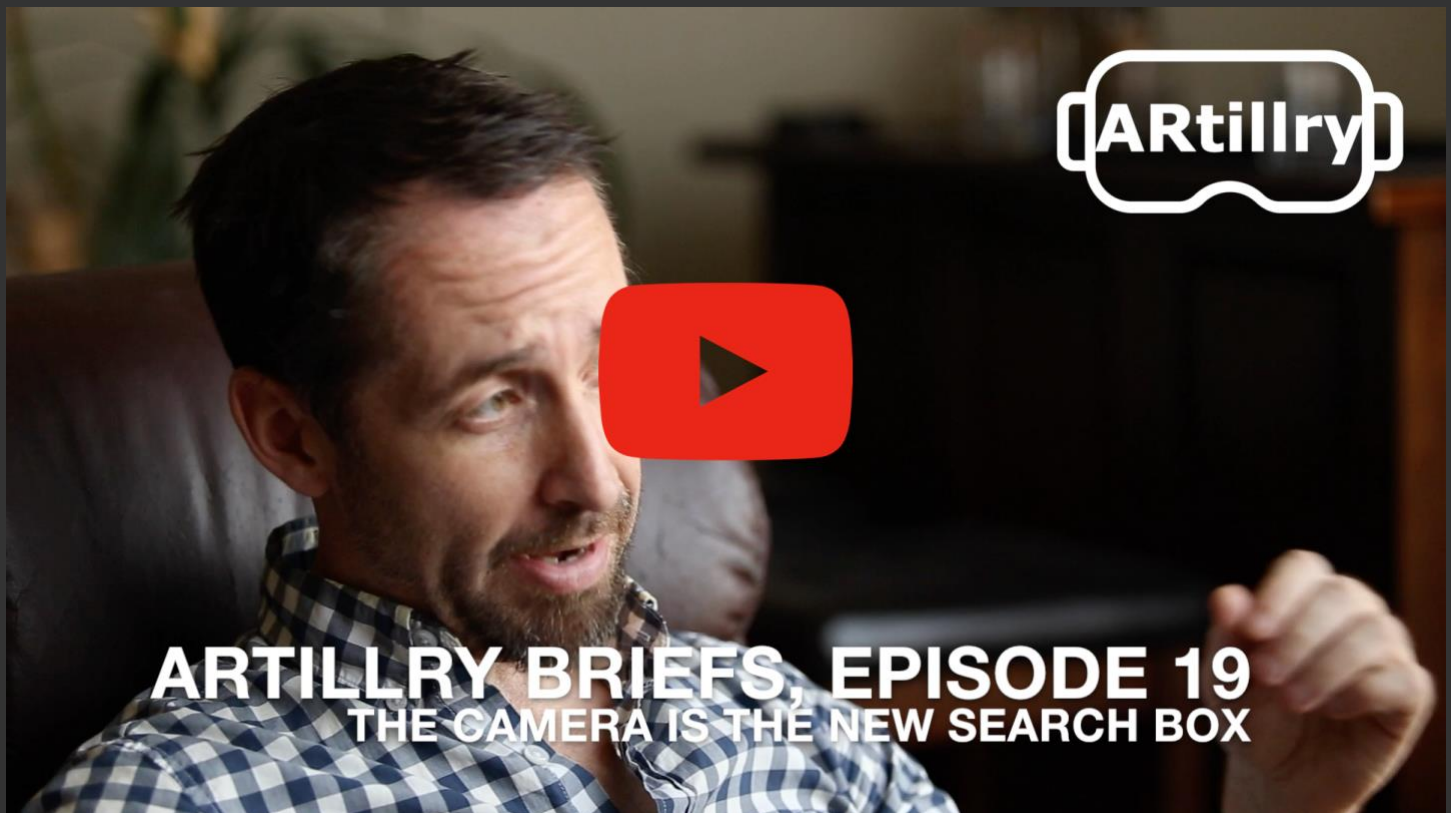
The AR Cloud

In order for Google to accomplish visual search, or for other AR use cases to work, it requires the AR cloud. It's a cloud data repository that enables AR devices to do things like identify items or anchor graphics properly.[iv] These actions require geo-relevant data and object-recognition blueprints.

ARCore and ARkit perform well in individual AR sessions including mapping a given space using surface detection, localization and inertial odometry. But to map large (outdoor) areas, or come back to previously mapped areas requires more computational muscle than smartphones offer.

That's where the AR cloud comes in. It will help AR devices to "recognize" scenes, rather than exhaust computational muscle (and battery life) mapping already-chartered territory. It will register devices' location dynamically, then serve mapping and object recognition data tagged to that location.

Another AR cloud benefit, like cloud computing generally, is offloading computational burden. Because, mapping and object-recognition data for the entire world is too extensive to store on-device, smartphones can tap the AR cloud to conserve computational muscle – a precious resource in AR.
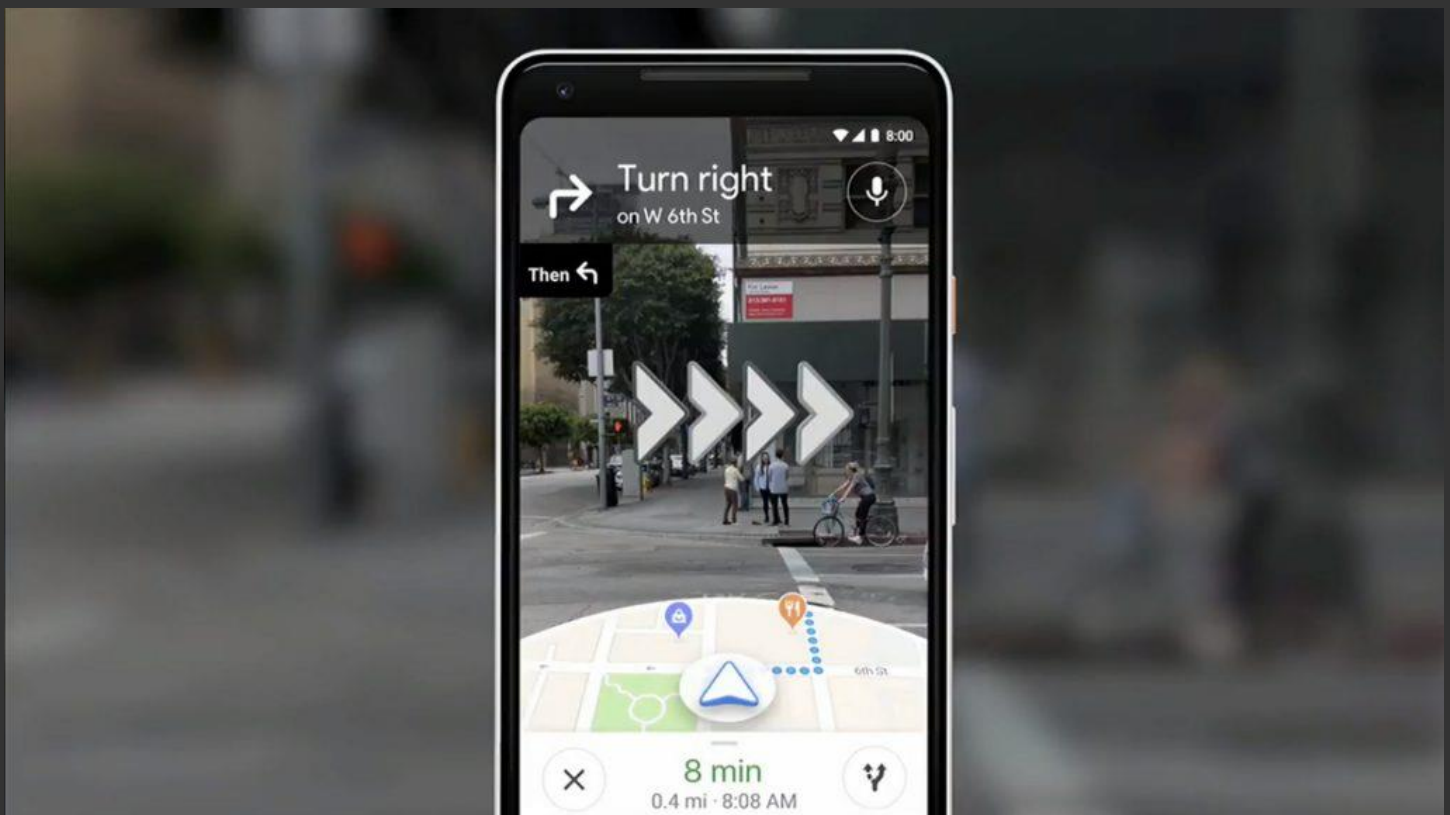

Image Source: Google

The AR cloud will also enable a key function: image persistence. This refers to AR graphics that remain in place across separate AR sessions, and between users. The latter is key for social AR experiences and multiplayer support — both projected to drive AR's killer apps.

"What occurred to me as an entrepreneur is that these are must haves, not nice to haves that make AR apps a bit better," said 6D.ai CEO Matt Miesnieks. "If you assume persistence and multiplayer are fundamental for AR, you need some sort of computer vision cloud infrastructure to support that."

Video Companion: AR Advertising
 (click URL to open)

https://youtu.be/_UTq8K_wbSM

The Magicverse

One take on the AR cloud that emerged in 2018 was Magic Leap's construct of the "Magicverse," presented at the L.E.A.P. Conference. Following the long-awaited release of Magic Leap One, the Magicverse characterizes the company's philosophy for the device's software user experience.

One of the underlying constructs of the Magicverse is "verses." Not a completely new concept, these are data sets that represent thematic layers of content that one might want to see overlaid on their world. There can be layers for entertainment, art, sports, work, utility/safety, etc..

"Maybe there's going to be a director who creates a week-long comic adventure over Los Angeles," posed Magic Leap CEO Rony Abovitz at L.E.A.P.. "That may be the entertainment layer. Other folks might want to work on the communication layer or health and wellness layers."

Furthering the analogy, Magic Leap Chief Futurist and Snow Crash author Neil Stephenson referenced a recent lunch where the restaurant had both pleasing decor and eyesores like exit signs. These represent functional layers that could be activated in a Magicverse construct.

"Most of the time you may want to just see the beautiful stuff, but in an emergency, what you want to know is where to find the exits," he said. "So the idea of layers that serve different purposes that we can toggle on and off as we need them is a key element to the Magicverse concept."
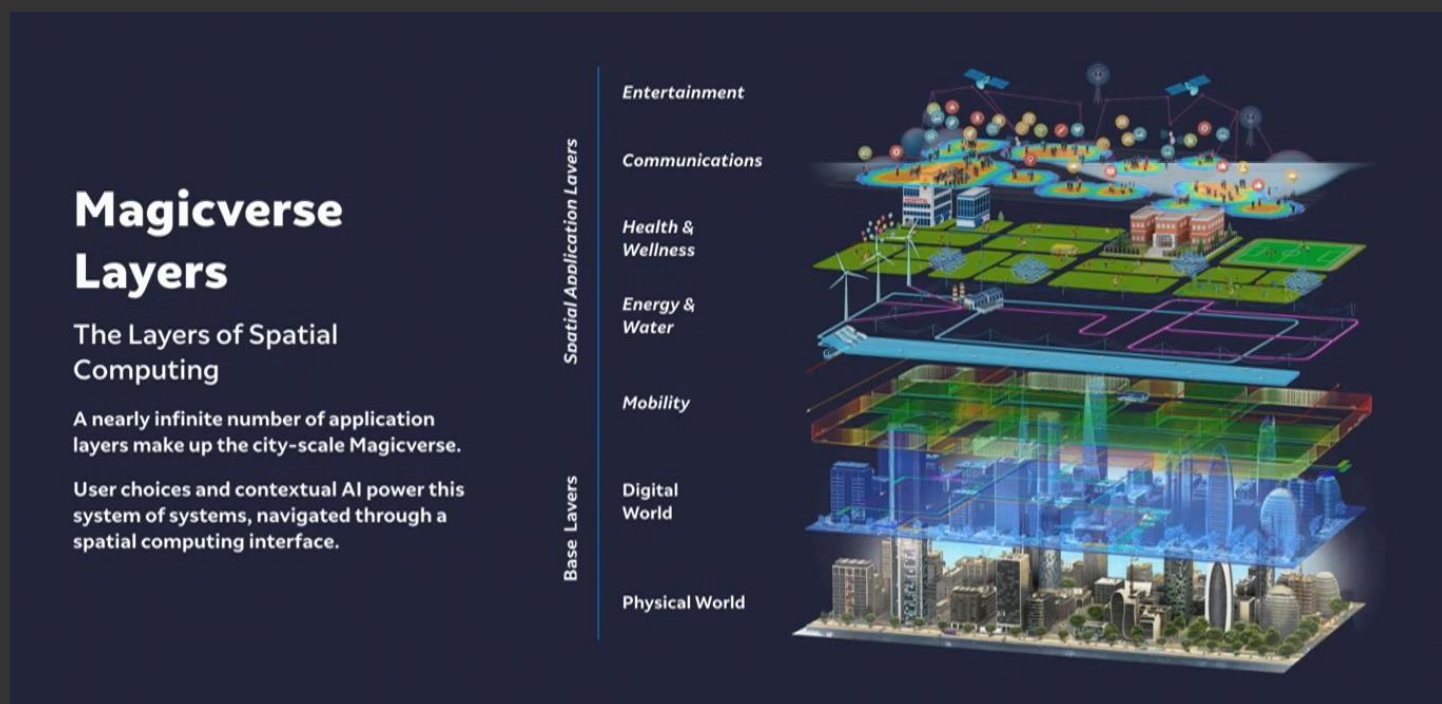

Image Source: Magic Leap

As for the hardware, the long-awaited Magic Leap One was met with mixed feelings when it launched in August. Developers mostly like it, but formal reviews from tech writers couldn't get past the divergence between two years of hype and what they now perceive as an unspectacular product.

One of Magic Leap's challenges is that it's a victim of the hype that surrounded it — a metaphor for XR's current stage. Another challenge is the same challenge for immersive technology in general: you can't really capture and share the experience through 2D video or verbal descriptions.

This represents a marketing challenge for Magic Leap. In addition to pushing against classic price elasticity — rampant in something that is new/non-vital and pricey — it has to sell new users directly through experience. And that's a logistical/distribution challenge (think: retail installations).

Marketing challenges aside, Magic Leap One is a key milestone in AR's evolution. But it shouldn't be viewed as an end-point; that will only further industry "disillusionment." If Google Glass was the Apple Newton of AR glasses, Magic Leap One could be the Palm Pilot on the way to the iPhone.

5G + Edge

Joining the AR Cloud, another key enabling-technology whose absence became apparent in 2018 is 5G wireless networks. XR's heavy computing and graphics will benefit from bigger pipes. Related to that is the arrival over the next few years of edge computing, which likewise boosts XR capabilities.
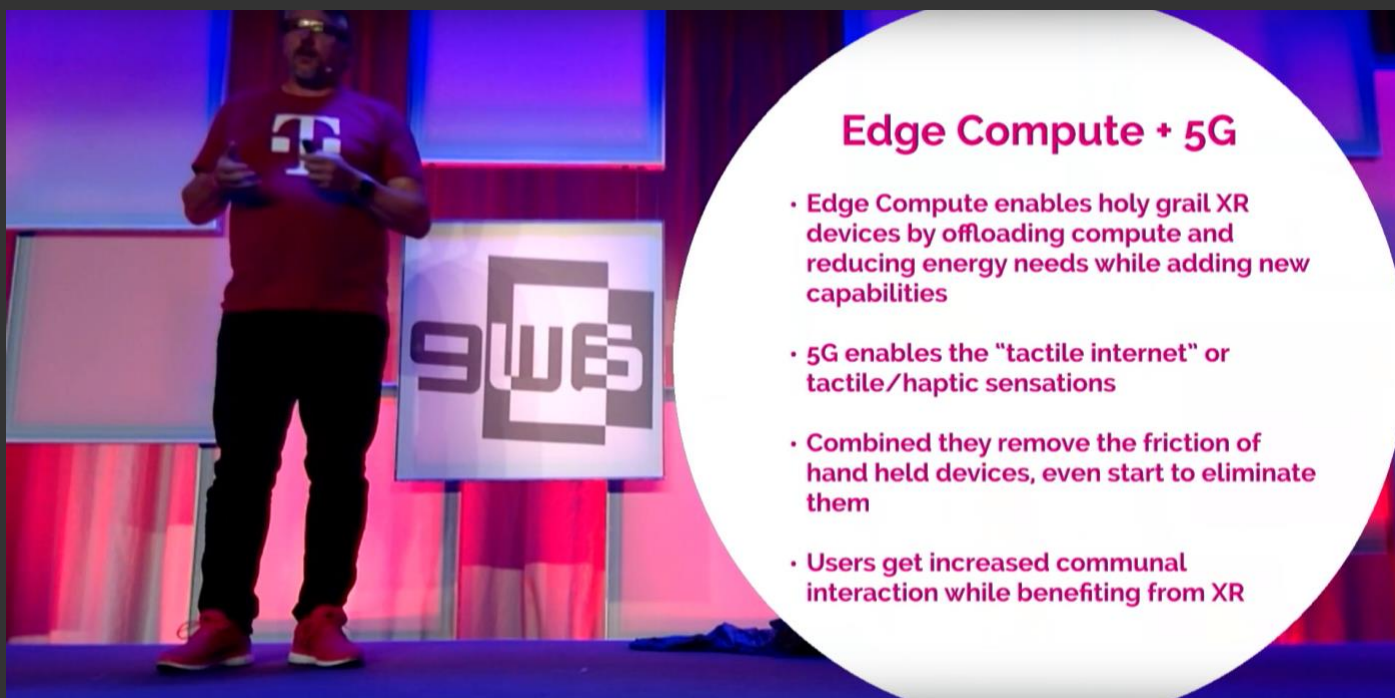
But first of all, what is edge computing? 5G is clear in terms of bandwidth and other benefits, but edge is less familiar. It essentially brings compute and connectivity closer to devices, using a mesh network of stations placed strategically in places like commercial districts, campuses or 5G base stations.

"It's not that edge will replace the cloud, it's just going to move the cloud closer to the user," said Deutsche Telekom's Terry Schussler at AWE Europe. "We control data transfer at the speed of light, so if we shorten the distance from the data center to the user, we can reduce milliseconds of latency."

Similar to a mesh router network, edge computing will be able to have several base stations that work intelligently in unison to provide the most efficient compute and connectivity transfers to nearby devices. The ultimate goal is for this to work even to optimize connectivity to moving vehicles.

Where this plays out in practical terms is to power the dream of "pervasive AR." Currently AR glasses are mostly used for a single purpose, often in the enterprise, with a single app loaded onto a device. Pervasive AR will give us much more functionality and optionality for a range of uses.

"We want to move to a more pervasive time-duration extended experience," Schussler said. "We will see a transition into next year where we'll have experiences that last for one to two hours such as a sports or entertainment experience at a stadium, or watching television shows at home."

Building Blocks

Technologies examined so far, such as AR Cloud and Edge, support XR development and delivery. Also known as "building blocks," it will be a key theme as we move into 2019. Another emerging sub-sector that falls into that category is creative tools that democratize graphical assets for AR & VR.

These are literally the building blocks of immersive experiences. Game engines like Unity have already democratized 3D creations with tools and graphical elements for 3D worlds. Google Blocks lowered the barrier even further for creating such assets with limited programming skills.

Google also launched Poly, which is an online library of graphical assets that can be used by AR and VR creators. Sketchfab is another such tool, which has a marketplace for creators to display and sell 3D graphical assets. In November, it announced that it passed one billion cumulative page views.

Arctic Fox (Sitting)
by Naomi Chen   89 likes

Image Source: Google Poly, Naomi Chen

Creative Muscle

Other important creation tools include Amazon Sumerian. This is a platform, run under Amazon's AWS, which lets developers and brands create and run VR and AR apps, or 3D graphics. It boasts drag & drop functionality and not requiring specialized programming nor 3D graphics expertise.

One example is an early prototype built on Sumerian by Fidelity Labs, a division of Fidelity Investments. It's a 3D virtual persona that provides voice-guided visualization for investment data. In fact, virtual hosts are one of Sumerian's early and demonstrative use cases.

"Hosts are probably the biggest building block of Sumerian that's obvious right now," Sumerian GM Kyle Roche told us. "Having a character that you can make eye contact with, set up in the same way you'd set up an Alexa skill, just drag and drop in a browser, is super attractive for some customers."

This will be especially useful in functions like customer service and brand marketing. In these cases, XR creation can be enabled or accelerated if it can be built in-house. Or even in the case of outside help from creative agencies, they're going to need tools like Sumerian to build XR apps for clients.

"A lot of enterprises or smaller shops want to get into XR," said Roche. "As they see it come to life, they're thinking 'Okay, I need to get a 3D game engine, learn how to sculpt, animate, rig and all these complex things.' They just want something that's easy to use in a familiar environment."

There's also Adobe Aero, a tool to similarly provide a drag & drop creation environment for AR, VR and 3D graphics. One of its biggest advantages is that it plugs right into Adobe Creative Suite, which is a ubiquitous platform for creative professionals, including tools like Photoshop and Premier.

"Adobe has always embraced new mediums from print and PC to web and mobile," said CTO Abhay Parasnis at the recent Adobe MAX conference. "We've always looked around the corner to figure out the next creative medium. We truly believe that we're at a similar inflection point with AR."
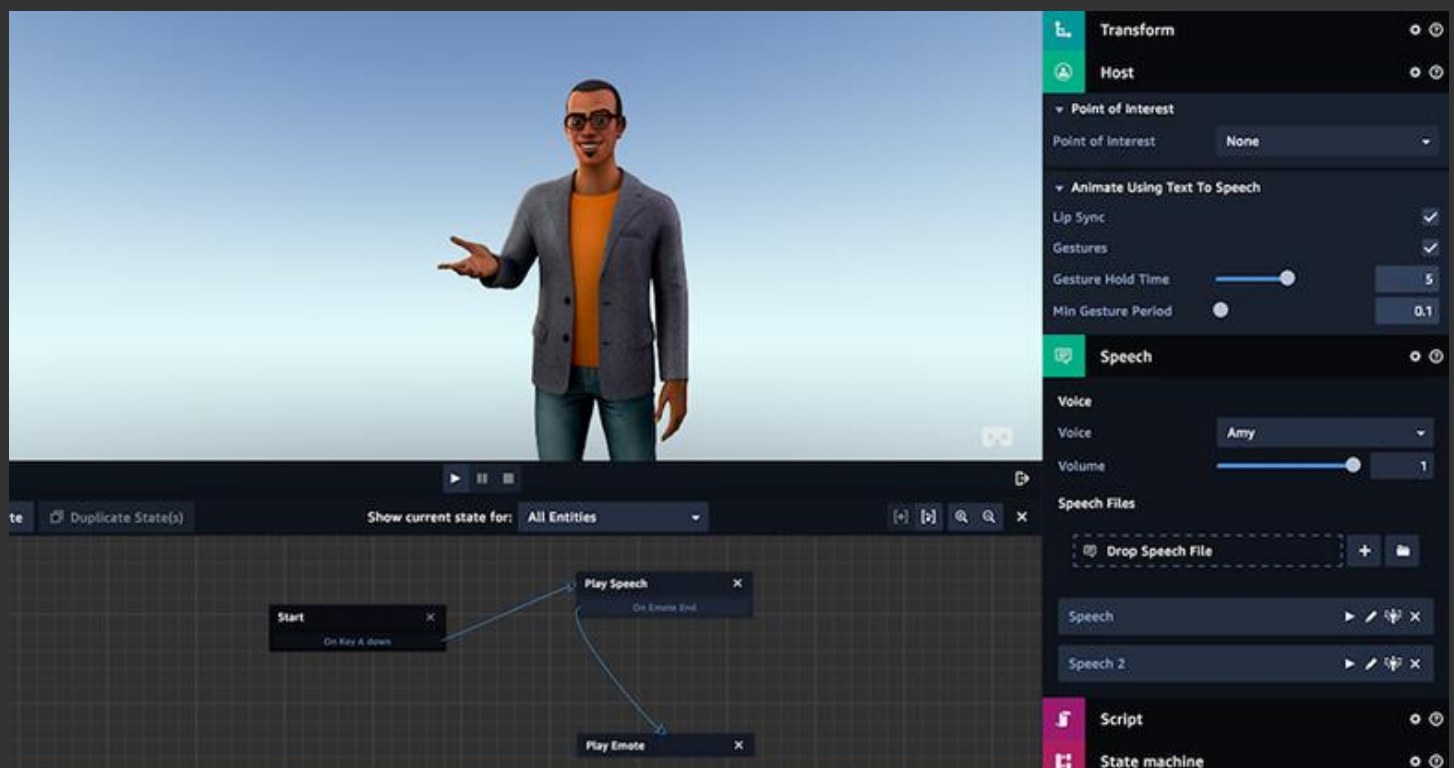

Image Source: Amazon Sumerian

Aero integrates with Photoshop and other Creative Cloud programs to output 3D graphics that are AR-ready. It's also working with Apple and others to standardize the USDZ file format for AR project workflows. This makes exported 3D graphics compatible with Apple's "Quick Look" web AR feature.

The Business Case

Speaking of Quick Look, one key use for 3D graphics is product visualization. This popular AR function requires 3D scans that have dimensional accuracy to fulfill the intended purpose of simulating in-home product placement. But it requires AR-ready scans for vast libraries of products.

"Whenever anyone asks what they need to do to get ready for the future, I say make digital twins of everything in your inventory," Unity's Timoni West told ARtillery. "A lot of companies don't have that right now or they have CAD files for 3D printing that are way too big and won't work for mobile."

In the near term, IKEA, Wayfair and others offering AR visualization apps rely on individual solutions to scan products. But the real opportunity is for specialized and standardized methods that can help them scale up 3D image libraries, and bring it within reach of smaller down-market players.

E-commerce platform Shopify has done similar by bringing AR product visualization to 600,000 businesses. Using the aforementioned USDZ file format, Shopify merchants can create 3D graphics that are immediately usable in Apple's "Quick Look" AR feature. This is a key area of opportunity

"Larger players like Wayfair and IKEA have their own means and methods they've created in-house, because there's nothing out there that's scalable, affordable and easy," said Super Ventures Partner Tom Emrich at a recent event. "These are startup opportunities that, as an investor, I'm looking at."
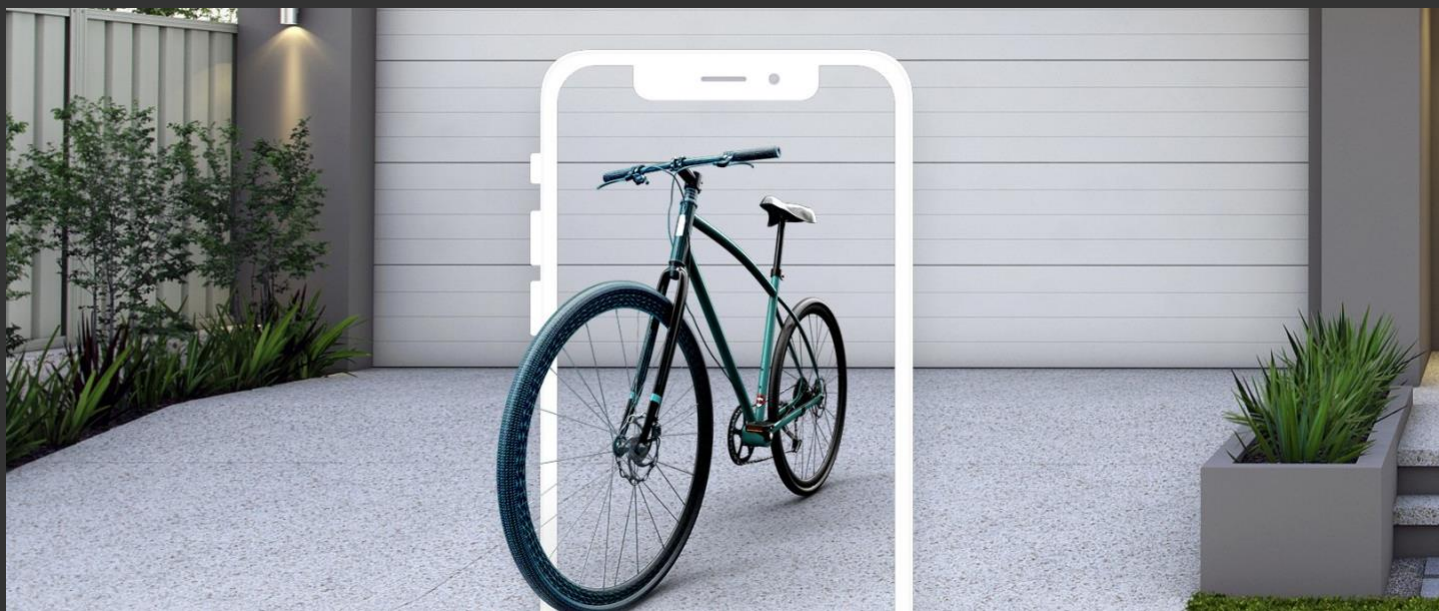

Image Source: Shopify

AR as a Service

Sticking with the theme of building blocks and enabling-technologies, a key concept that emerged in 2018 was AR as a Service (ARaaS). Like software as a service began to do a decade ago, ARaaS democratizes advanced AR functionality and architecture to lower the barriers for AR developers.

The company that introduced this concept to us in 2018 was Niantic. The Pokemon Go and Ingress creator recently turned its AR architecture into a platform on which others can build apps. Known as Real World Platform, it productizes the underlying code base for Niantic's popular AR games.

Similar to Amazon Web Services' (AWS) inception, Niantic built its engine primarily to drive its own product. But then came the realization that it can be its own platform. And like AWS, it could be a highly scalable revenue stream, making it opportunistic for Niantic and transformative to the industry.

"AWS and GCP weren't built as compute platforms for everybody," said Niantic CTO Phil Kelsin at AWE in May. "They were built to support the applications of Amazon and Google. Then they decided 'we have excess capacity let's turn it into something that our users can use.'"

Of course, this is all conceptual: The real value of Niantic's Platform will lie in its execution and functionality. And there, the question is capability. In other words, Pokemon Go is a primitive form of AR, so will it spawn a valuable platform? That's where Niantic's acquisition spree comes in.

Image Source: Niantic

Real World Platform is strategically timed to incorporate IP that Niantic has been scooping up and adding to its already-scalable infrastructure. That includes Escher Reality (multi-player & social AR) and Matrix Mill (occlusion and computer vision), which contribute to its "Planet Scale AR."

The idea is to have more robust computer vision and machine learning to contextualize real-world items. Then, scene mapping IP from Matrix Mill can infuse graphics in dimensionally accurate ways, and Escher's social AR capabilities bring collaborative features. Niantic will keep building this stack.

But before developers get the chance to build AR apps and games using the Real World Platform, we'll get to see its first proof of concept: *Harry Potter, Wizards Unite*. Niantic's follow-up to Pokémon Go will be an important test for the platform, and for AR's mass appeal in 2019.

"One of the things we had to do along the way was respond to player behavior and things that happened in the game," said Keslin. "Network problems, system problems, and fixing those in real time. We're going to take all of that and we're going to pour it into *Harry Potter, Wizard Unite*."

Image Source: Niantic

Think Native

All of the above transformation and "enabling-technologies" for AR and VR are only half the battle. Companies and individuals that are building immersive experiences still have to follow a set of standards and best practices. And those are a moving target in such a nascent field.

But one key success factor is to "think native." This means build experiences that are fitting to unique attributes of the new technology, rather than porting experiences from legacy technology. Also known as "AR-first," we learned a similar lesson in "mobile-first" app design principles of the past decade.

But it goes deeper than native thinking. There are other best practices and success factors we've observed over the past decade. For example the "if it ain't broke" test: If a given AR app fills a gap that wasn't really a pain point for anyone, it could be a solution in search of a problem.

Mobile payments are a historical example. Despite lots of excitement and investment, they faced a tough road to ubiquity because paying by cash or credit was never really a pain point for anyone. These are entrenched behaviors whose proposed replacement was only slightly better.

AR-First, AR-Only

With AR, one example is tabletop games that let you hold your phone up to a flat surface to initiate a battle/strategy game or board game. This is certainly intriguing but physical board games or mobile apps work fine. And they let you play in a more comfortable range of positions and contexts.

Put another way, the tabletop aspect makes it novel and native, but crouching and holding up your phone isn't ergonomic nor conducive to long/repeat sessions. The latter could overpower the former as novelty wears off while gravity doesn't. So the bar is set high for compelling game play.

Speaking of novelty versus sustained value, some AR experiences lack replay-ability. Google's AR animations that place animated characters in your space is novel, but it wears off quickly. Stickiness comes from ongoing utility, such as Google's potential with Lens and VPS, explored earlier.

Going beyond whether something's better in AR (AR first), another target is if it's *only* possible in AR (AR only). This principle drove the killer apps of the iPhone era like Waze, Uber and Foursquare. The common element: they weren't possible on the previous form factor, the PC.

"You couldn't make an Uber-style app when it was on a PC," said Escher Reality CEO Ross Finman on stage at TechCrunch Disrupt. "It only made sense after a mobile platform came out. Now it's about understanding what the new things are you can do with the mobile platform for AR."

Where and When

Additional AR lessons learned in 2018 include fundamentals like reducing access friction. With apps, consider "AR as a feature." It worked for Snapchat Lenses and Amazon's AR View. These are essentially AR training wheels: native AR, but delivered in the apps people already use.

Acclimating users in these low-friction ways will pave the way for AR's killer apps, which we could see emerge sometime in late 2019 when AR developers truly gain their native footing. We believe that will be communications, social, or utility experience, all of which are conducive to active usage.

As for killer app timing, there are historical lessons. It took 2-3 years after the first iPhone before we saw killer apps, such as Waze and Uber in the 2009 timeframe. We could see killer apps in that same elapsed time from last year's ARkit launch, which would mean the end of 2019 or 2020.

"In 2007 when Apple launched the iPhone, most of the apps were flashlights," said Escher Reality CTO Diana Hu at TechCrunch Disrupt. "People didn't know what to do yet. And there's going to be this phase of learning. There's a genesis of any technology when people need to experiment."
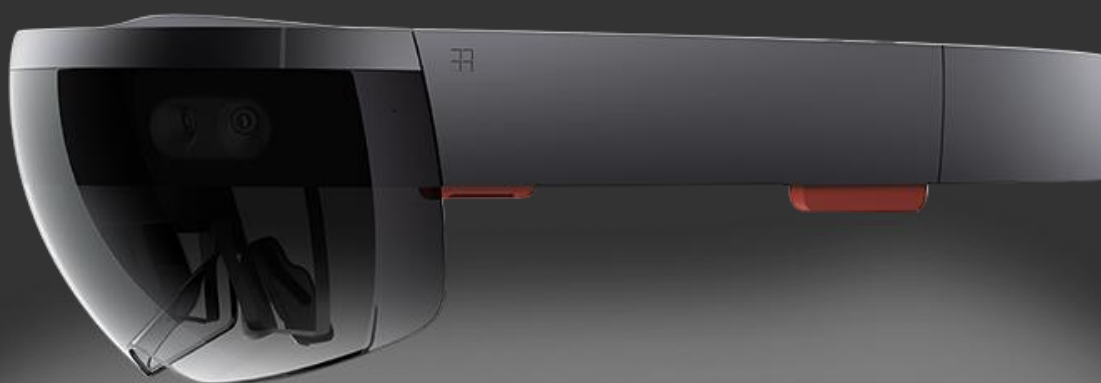
The Enterprise

Though it requires its own report to examine adequately, there were valuable lessons learned in 2018 for Enterprise AR. There continues to be tremendous potential, based on the continually-validated ROI for AR-assisted enterprise production. We project revenues to grow to $28.5 billion in 2022.

But that will start slow due to the inertia and risk aversion that faces enterprise AR deployments. Though there is often adoption and embrace among business leaders and innovation centers in a given organization, AR often fails to win over other key stakeholders, resulting in "pilot purgatory."

Points of resistance include the mandated risk-aversion in IT departments, given headset cameras and levels of proprietary data exchange (e.g. CAD files). It also notably includes end-user employees who have natural fears of new technology, and the degree to which it could impact their job security.

"We're talking about some pretty impressive ROI numbers here," said Scope AR CEO Scott Montgomerie at AWE Europe. "If I'm a worker, I'm thinking the company can do the same bottom line with 50 percent of the workforce… does that mean I have a 1 in 2 chance of keeping my job'?"
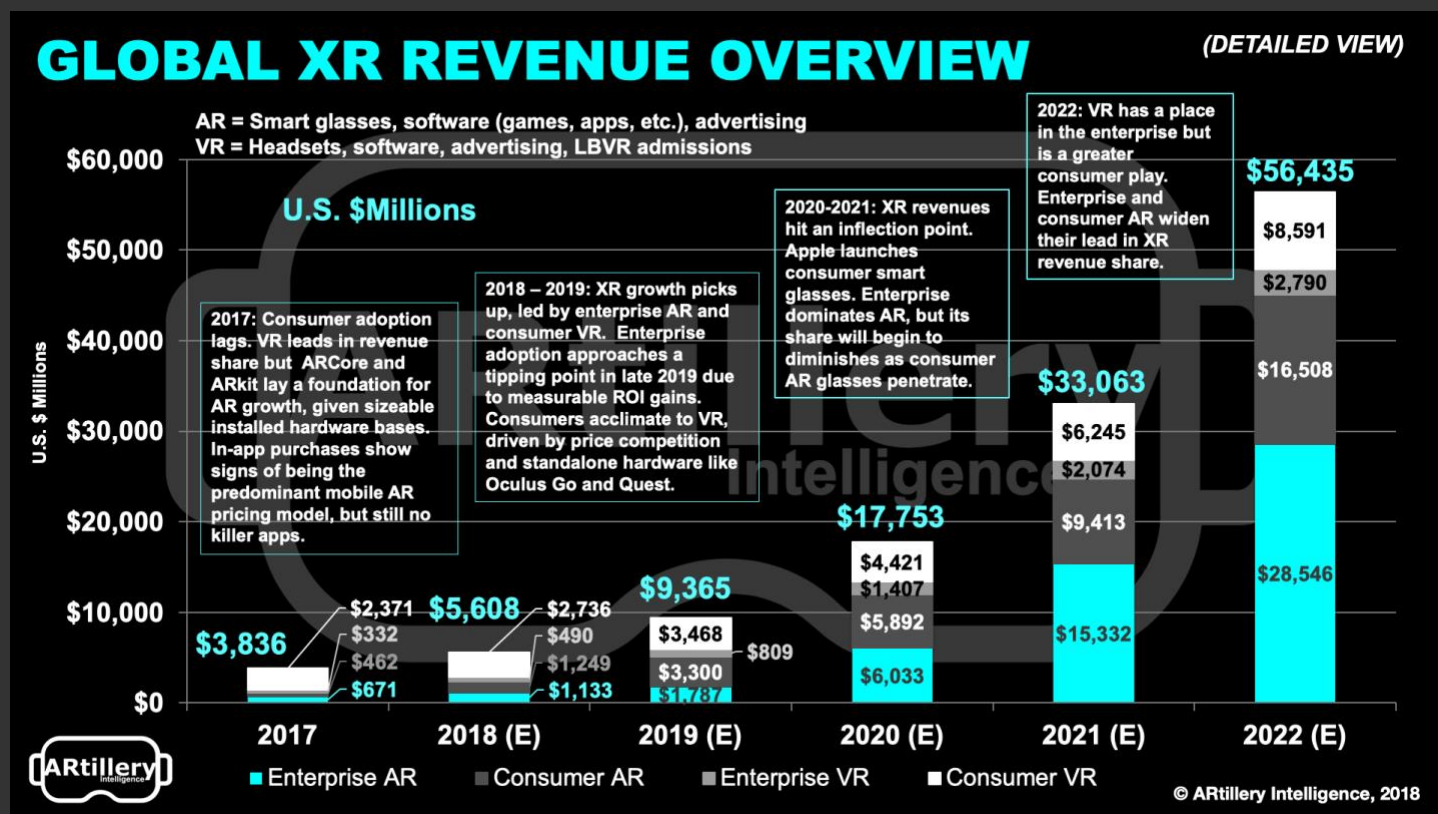
These factors will continue to stunt enterprise AR growth, but will be deteriorated eventually by the momentum, support and ROI realizations that are currently building. A tipping point will come, after which adoption accelerates in a sort of enterprise herd mentality. But that won't be in 2019.

We believe the tipping point will be in 2020, followed by ramping adoption across industrial sectors. This will follow a similar pattern, though on a smaller scale, as enterprise smartphone adoption over the past decade. Like we saw then, it will build slow but then happen fast. Patience is required.

As for the adoption dynamics, near-term Enterprise AR revenues will be hardware-dominant as it's usually the first step in enterprise tech adoption. That hardware growth then creates a cumulative installed base for software, which will dominate enterprise AR in outer years.

Enterprise hardware will also mature as it's established in the enterprise, with replacement cycles outpaced by software refresh rates. As it played out in the broader enterprise software world, the prevailing AR software model will be SaaS, in terms of how it's packaged, priced and delivered.

GLOBAL XR REVENUE OVERVIEW
(DETAILED VIEW)

AR = Smart glasses, software (games, apps, etc.), advertising
VR = Headsets, software, advertising, LBVR admissions

U.S. $Millions

2017: Consumer adoption lags. VR leads in revenue share but ARCore and ARkit lay a foundation for AR growth, given sizeable installed hardware bases. In-app purchases show signs of being the predominant mobile AR pricing model, but still no killer apps.

2018 – 2019: XR growth picks up, led by enterprise AR and consumer VR. Enterprise adoption approaches a tipping point in late 2019 due to measurable ROI gains. Consumers acclimate to VR, driven by price competition and standalone hardware like Oculus Go and Quest.

2020-2021: XR revenues hit an inflection point. Apple launches consumer smart glasses. Enterprise dominates AR, but its share will begin to diminishes as consumer AR glasses penetrate.

2022: VR has a place in the enterprise but is a greater consumer play. Enterprise and consumer AR widen their lead in XR revenue share.

Year	Enterprise AR	Enterprise VR	Consumer AR	Consumer VR	Total
2017	$671	$462	$332	$2,371	$3,836
2018 (E)	$1,133	$1,249	$490	$2,736	$5,608
2019 (E)	$1,787	$3,300	$3,468	$809	$9,365
2020 (E)	$6,033	$5,892	$1,407	$4,421	$17,753
2021 (E)	$15,332	$9,413	$2,074	$6,245	$33,063
2022 (E)	$28,546	$16,508	$2,790	$8,591	$56,435

■ Enterprise AR   ■ Consumer AR   ■ Enterprise VR   ■ Consumer VR

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Boiling it Down: Lessons & Predictions

1. Mobile AR Promising, But Slow

Mobile AR continues to hold the promise of scale, due to almost one billion ARkit and ARCore-compatible (and several more webAR-compatible) smartphones globally. But the more relevant figure is active users, which is much less: 129 million. The medium needs more time to develop, including underlying technology, developers' native footing, and user acclimation – all of which go together. Native development is particularly important to build AR apps that are novel, but novelty alone isn't enough for sustained engagement. The combination of novelty and utility will strike the right balance for mainstream appeal, and we haven't seen that yet – at least for advanced and world-immersive AR. We've learned that success can also come from "AR as a Feature." This is AR functionality that is delivered through already well-traveled apps, such as Amazon's AR View feature within its flagship app. The dominant AR business model so far is in-app purchases (IAP), including Pokémon Go's $2 billion in revenue to date. ARtillery Intelligence consumer survey data also validate the model, given consumers' stated unwillingness to pay upfront for a still-unproven product category.[v]

2019 Prediction: Consumer AR revenue will reach $3.3 billion in 2019, $2.9 billion of which is IAP. The first killer app for world-immersive and SLAM-based AR could be released as early as late 2019. This will be two years after the June 2017 launch of ARkit – the same timeframe after the iPhone 1 when killer apps emerged (Uber, Waze, Foursquare, etc). This is the time needed for developers to gain native footing. Killer app(s) will likely be communications, social or a utility AR experience, all of which have the greatest potential stickiness and frequency of use. Utilities in particular are mundane but could prove most useful and scalable, such as visual search (see Google Lens).
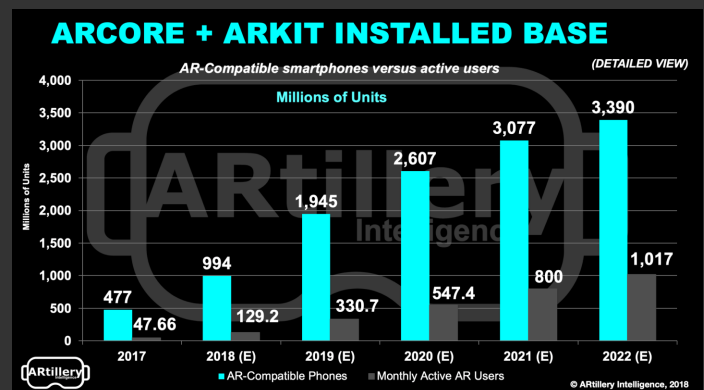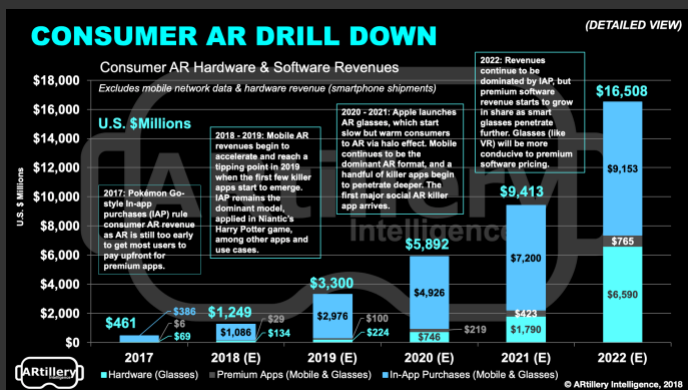
2. AR Cloud is the Lynchpin.

The AR cloud came into the collective consciousness in 2018, after it was apparent that AR apps don't work the way most people expected. The need for multi-player support, persistence and other functions invoked lots of discussion around the AR cloud as the missing puzzle piece. These functions require a cloud data repository to feed AR devices with spatial mapping data, object recognition blueprints and other AR-enabling resources. Several AR Cloud startups launched in 2018 and tech giants formulated different flavors of AR cloud strategies. For example, Google has several foundations for an AR cloud such as object recognition (Images, Street View) and location/spatial data (Maps, Waymo). Despite the AR cloud's singular tense, it will be more of a plurality of cloud entities in different functional areas and market segments. Those will map to the competencies of existing companies (such as Google's visual search and VPS). For those that don't have such foundations, AR as a service (ARaaS) will emerge to provide AR cloud functionality to developers. The first example, emerging in 2018, was Niantic's Real World platform.

2019 Prediction: The breakout category in 2019 won't just be the AR cloud but the broader world of XR enabling-technologies or "building blocks." That includes tools that streamline or democratize XR creation and distribution, such as ARaaS. Graphical assets will be a currency in AR commerce and advertising, so their creation tools will likewise grow in value, such as Amazon Sumerian and Adobe Aero. The AR cloud will broaden and diversify to a diverse mix of data sources, even those outside of AR, such as the dense spatial maps being generated by autonomous vehicles.

3: AR Ads Already Working

Among the XR revenue categories projected over the coming years, one that's already bearing fruit is AR advertising. According to ARtillery Intelligence's latest forecast[vi] , the sector made $418 million in revenue in 2018. This has manifested mostly through branded AR lenses from social apps like Snapchat and Facebook. Building from the social use case of sharing AR selfie masks and lenses, these have been monetized as ways to visualize products in one's space or on their face. It's proving valuable to brand advertisers given the ability for "full funnel" consumer engagement – spanning brand awareness and direct response. This is starting just as the digital ad world did, with display advertising out of the gate first. Following that will be search-based AR advertising which Google will cultivate through its visual search efforts. But despite all these advantages, weakness in mobile AR advertising must be acknowledged such as a relatively low overall user base (see point #1) and inherently short sessions (arm fatigue). In combination, these factors naturally diminish the available ad inventory thus gating its revenue opportunity in the near term.
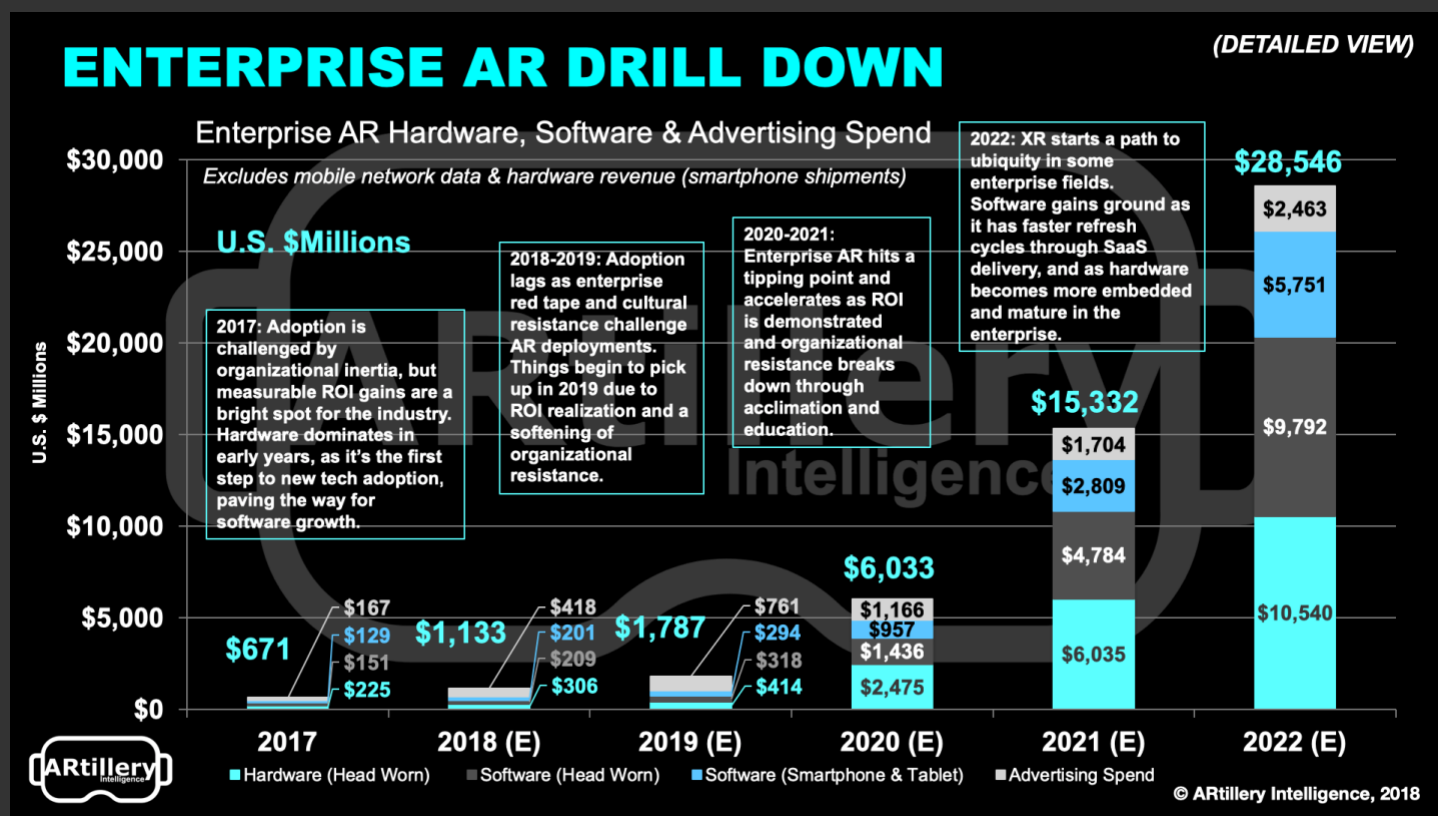
2019 Prediction: AR advertising will reach $761 million in 2019, and we project **it** to grow to $2.4 billion by 2022. This will continue to be dominated by display advertising (social lenses) in the coming year. Visual search will gain ground on display in later years as its complexity will cause it to bloom late. Meanwhile, Facebook will make more of an aggressive push with AR ads as diminishing news feed ad inventory forces it to create other ad opportunities. These will include AR ads in Messenger and, more notably, Instagram. AR display advertising's growth will be strong but gated to some degree by finite ad inventory that results from mobile AR's usage realities referenced above.

GLOBAL AR ADVERTISING BY FORMAT

Global AR ad revenues: search versus display

(DETAILED VIEW)

$US Millions

$ Millions

Year	Total	AR Display Ad Revenue	Visual-Search Ad Revenue
2017	$167	$167	
2018 (E)	$418	$418	
2019 (E)	$761	$752	$10
2020 (E)	$1,166	$1,086	$80
2021 (E)	$1,704	$1,419	$284
2022 (E)	$2,463	$1,753	$710

■ Visual-Search Ad Revenue   ■ AR Display Ad Revenue

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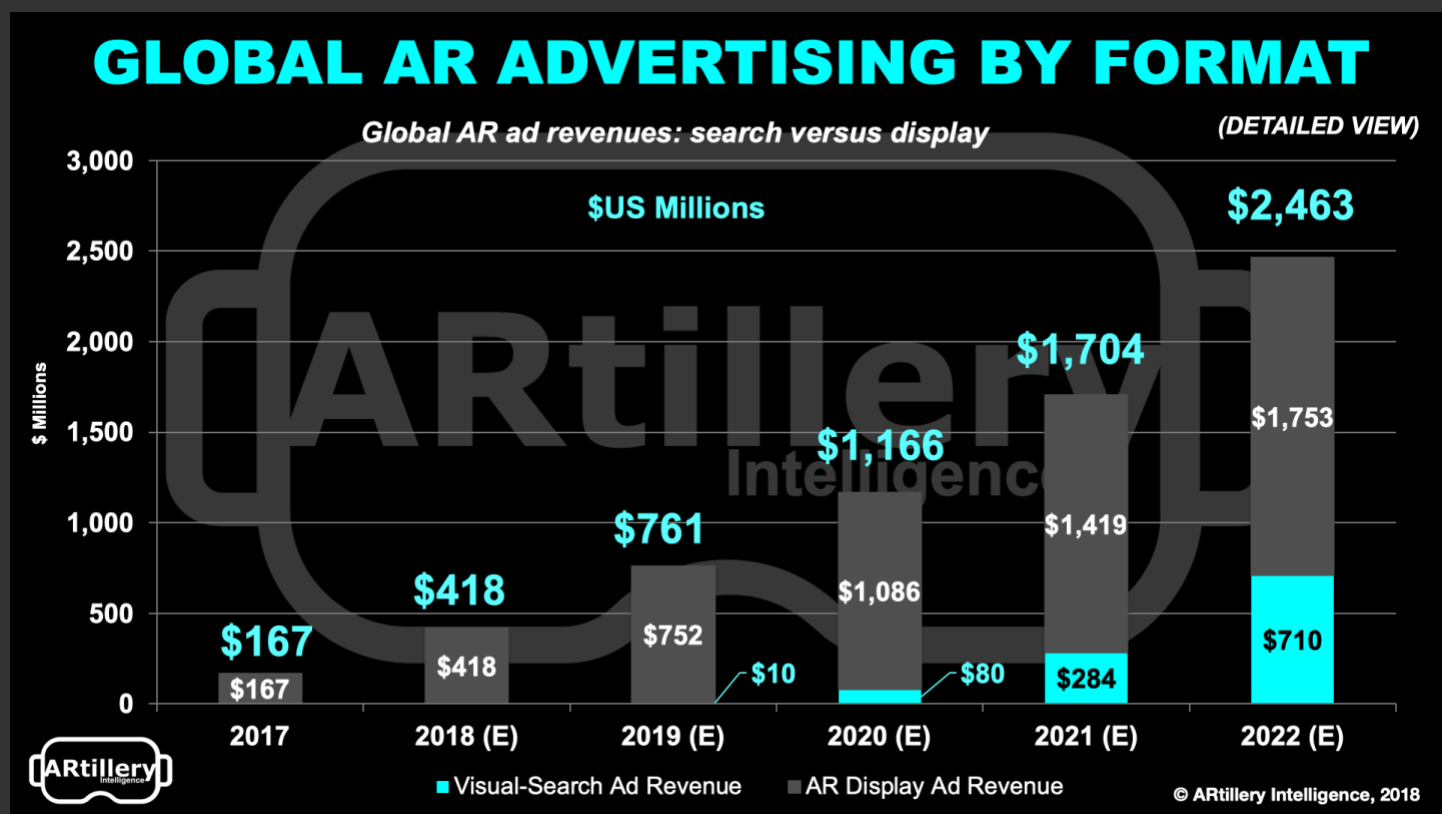
4. Enterprise AR: The Sleeping Giant

Enterprise AR holds tremendous potential, given its proven bottom-line impact. In fact, it's the largest XR sub-sector in the outer years of ARtillery Intelligence's global revenue forecast, reaching $28.5 billion. That will mostly be driven by demonstrable ROI in areas like industrial productivity. But despite that continually-validated ROI story, there's still meaningful enterprise inertia and risk aversion. Though business leaders and innovation centers within organizations are adoptive, AR often gets stuck in "pilot purgatory," as it fails to win other key stakeholders. Those include risk-averse IT departments, given headsets cameras and levels of proprietary data exchange (e.g. CAD files). Points of resistance also include end-user employees who have natural fears of automation technologies and the degree to which it impacts their job security.

2019 Prediction: Enterprise AR inertia will continue into 2019, and be slowly eroded by its momentum and continued ROI proof in vendor case studies. The sector will reach an inflection point, after which adoption accelerates… but that won't be in 2019. Likely happening in mid-2020, it will follow the pattern of adoption we saw with enterprise smartphone adoption over the past decade, though on a smaller scale. This pattern involved accelerated adoption over time through a sort of enterprise herd mentality as resistance breaks down. 2019 revenues will approach $1.8 billion.

ENTERPRISE AR DRILL DOWN
(DETAILED VIEW)

Enterprise AR Hardware, Software & Advertising Spend
Excludes mobile network data & hardware revenue (smartphone shipments)

U.S. $Millions

2017: Adoption is challenged by organizational inertia, but measurable ROI gains are a bright spot for the industry. Hardware dominates in early years, as it's the first step to new tech adoption, paving the way for software growth.

2018-2019: Adoption lags as enterprise red tape and cultural resistance challenge AR deployments. Things begin to pick up in 2019 due to ROI realization and a softening of organizational resistance.

2020-2021: Enterprise AR hits a tipping point and accelerates as ROI is demonstrated and organizational resistance breaks down through acclimation and education.

2022: XR starts a path to ubiquity in some enterprise fields. Software gains ground as it has faster refresh cycles through SaaS delivery, and as hardware becomes more embedded and mature in the enterprise.

	2017	2018 (E)	2019 (E)	2020 (E)	2021 (E)	2022 (E)
Total	$671	$1,133	$1,787	$6,033	$15,332	$28,546
Advertising Spend	$167	$418	$761	$1,166	$1,704	$2,463
Software (Head Worn)	$129	$201	$294	$957	$2,809	$5,751
Software (Smartphone & Tablet)	$151	$209	$318	$1,436	$4,784	$9,792
Hardware (Head Worn)	$225	$306	$414	$2,475	$6,035	$10,540

■ Hardware (Head Worn) ■ Software (Head Worn) ■ Software (Smartphone & Tablet) ■ Advertising Spend

© ARtillery Intelligence, 2018

5. Consumer VR Softens

Though it leads all XR sub-sectors in revenue today – driven by gaming – VR revenues have flattened while other sectors are trending upward. This is mostly due to revenue from early adopters who themselves plateaued in volume. With that realization, price competition took over the sector in 2018 in order to penetrate further into mainstream consumer segments. ARtillery Intelligence consumer survey data with Thrive Analytics[vii] (n=1959) indicate that demand inflects at $200 and $400. Because that's an all-in price point, the standalone VR category emerged in 2018 as a beacon of hope. It's also no coincidence that Oculus Go's pricing ($199) aligns with the above, as does the forthcoming Quest ($399). Oculus, with the benefit of Facebook backing can engage in such aggressive price competition in a sort of loss-leader approach to establish a long-term platform strategy. Winning early market share is the name of the game in platform wars as it attracts developers which grow the content library to in turn attract more users – a virtuous cycle. Based on Facebook's aggressive pricing, margin-dependent hardware competitors have found it difficult to compete on price, and have begun to suffer or even abort VR projects.

2019 Prediction: We'll continue to see aggressive price competition from Oculus, which will cause more contraction in the consumer VR segment. Oculus Go and Quest will pull ahead in 2019 and increase their lead of headset (unit) market share. Oculus Go in particular will reach 2019 sales of 1.8 million, while Quest, launching mid-year, will reach a quarter of a million in unit sales. The overall headset installed base (cumulative units, not annual sales) will reach 31 million in 2019, on its way to 58 million by 2022. This will be steady growth but won't reach the "magic number" of 100 million units during this decade. 100 million is a historically validated milestone for hardware segments to reach a virtuous cycle of incentive for content creation, followed by accelerated consumer adoption.
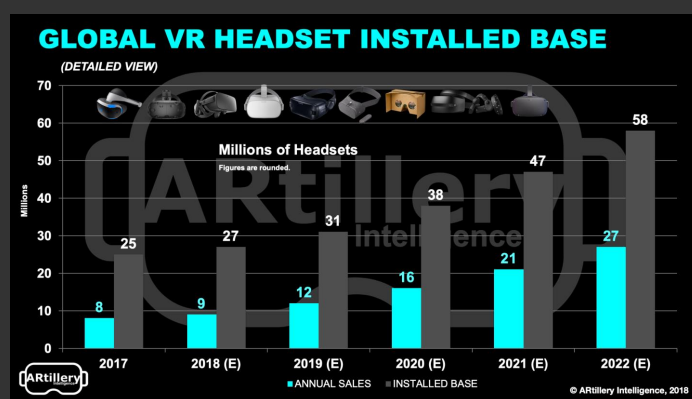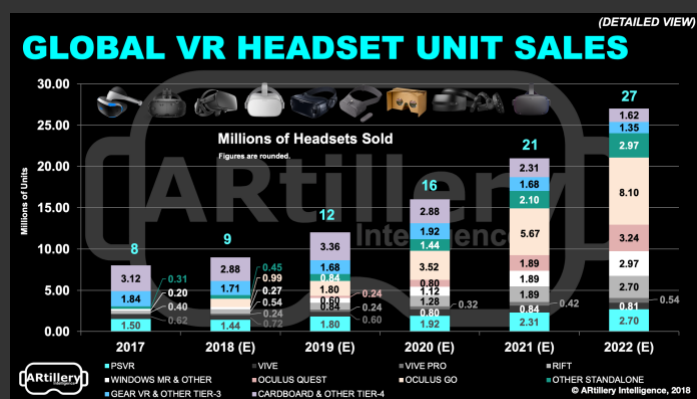
Key Takeaways (redux)

Key takeaways are also highlighted throughout the main body of this report.

- XR and its sub sectors had a reflective and corrective 2018, due to continued market softness.
  - Previous optimism will turn out to be well placed, but in a much longer fulfillment timeframe.
  - Confidence for XRs long-term health and opportunity is reinforced by tech giants' investment levels.

- Mobile AR became the focus in 2018, due to the installed base of 2.6 billion global smartphones.
  - Mobile holds the *capacity* for AR scale, but not yet the reality of sizeable active usage volume.
  - Evolution is required in underlying technology, developers' native footing and consumer acclimation.
  - Native development is particularly important to achieve novel AR, but novelty alone isn't enough.
  - The combination of novelty and utility will strike the right balance for mainstream AR appeal.
  - A killer app could be released in late 2019 – a historically-validated timeframe after ARkit's launch.
  - AR killer apps will be communications, social or utility-oriented, due to recurring/active use cases.
  - "AR as a feature," emerged as a success factor for AR in 2018, as opposed to standalone apps.
  - The dominant business model for AR apps has and will continue to be In-App Purchases (IAP).
  - IAP has been validated by Pokemon Go's $2 billion cumulative revenue, as well as our user survey data.

- The AR cloud came into the collective consciousness in 2018 as a critical but missing puzzle piece.
  - Key attributes include delivering geo-precise spatial mapping and object recognition data.
  - Several AR Cloud startups launched in 2018 and tech giants formulated AR cloud strategies.
  - AR cloud data sources will diversify, including startups and non-AR entities like autonomous vehicles.
  - AR as a service (ARaaS) emerged (e.g. Niantic) to democratize AR cloud functionality for developers.
  - Like the AR cloud, a breakout category in 2019 will be enabling-technologies or "building blocks."
  - These democratize XR creation and distribution, such as creative tools for 3D graphics production.

- Amidst long-term market building, some XR sectors are driving revenue today, such as AR advertising.
  - AR ads made $418 million in revenue in 2018, projected to reach $761 million in 2019.
  - This has mostly been branded AR lenses from social apps like Snapchat and Facebook.
  - Advantages include immersive product interactions, high consumer engagement, and direct response.
  - Disadvantages include relatively low reach and short AR sessions, which diminish ad inventory.
  - AR ads will evolve to include visual search, a user behavior with potentially high commercial intent.

- Wild cards in 2018 include Magic Leap One's launch and rumors of Apple AR glasses on the horizon.
  - Apple will continue to drive ARkit as a developer training ground for an eventual AR glasses era.
  - Despite 2020 rumors, we don't believe world-immersive Apple AR glasses will arrive until 2021-2022.
  - Magic Leap One received mixed reviews and won't have a large commercial impact in 2019.

- Enterprise AR is a sleeping giant in terms of potential for scale and impact, but growth will be slow.
  - Despite continued ROI validation, AR deployments are commonly stuck in "pilot purgatory."
  - This is mostly due to failure to win over stakeholders like risk-averse IT departments and employees.
  - A tipping point will come, followed by accelerated adoption and a herd mentality… but not in 2019.
  - Resistance will break down in 2020, then will follow historical enterprise smartphone adoption patterns.

- Consumer VR leads XR revenues today, but is flattening while other XR sub-sectors trend upward.
  - 2016 and 2017 early adopters have plateaued in volume, while new segments weren't penetrated.
  - With that realization, price competition took over in 2018 to appeal to mainstream consumers.
  - ARtillery Intelligence consumer survey data indicate that demand inflects at $200 and $400.
  - Standalone VR leaders will align with these price points including Oculus Go and Prime.
  - Oculus' loss-leader approach to seed its platform will drive its unit sales growth and contract the market.

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Market Sizing: Two forecasts per year, sizing and forecasting XR revenues (example)
Consumer Surveys: Two reports per year that dive deep on original survey data (example).
Curated Research: We hand pick industry data and reports (let us save you time).
Conference Talks: We watch, select and summarize video from XR events (Raise your XR IQ).
Analyst Access: Deeper discussions, strategic queries and diligence (also available separately).
Executive Introductions: We know top industry influencers and execs (expand your network).
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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 such as AR & VR, 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 VR/AR data and analysis. They synthesize original and third-party data to reveal opportunities and dynamics of VR and AR sectors. In addition to data, 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 LeadsCon. 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 the XR sector. To support the narrative, 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 2.5 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 ad revenue dynamics such as campaign pricing and spending. 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 Intelligence Briefing, *AR Business Models: The Top of the Food Chain*: **https://artillry.co/artillry-intelligence/ar-business-models-the-top-of-the-food-chain-part-i/**
[ii] Search advertising revenues: **https://www.statista.com/outlook/219/100/search-advertising/worldwide**
[iii] See ARtillery Intelligence Briefing, *AR Cloud and the 'Internet of Places'*: **http://artillry.co/artillry-intelligence/ar-cloud-and-the-internet-of-places/**
[iv] See ARtillery Intelligence Briefing: *AR Cloud and the Internet of Places*: **https://artillry.co/artillry-intelligence/ar-cloud-and-the-internet-of-places/**
[v] See ARtillery Intelligence Briefing: *AR Usage & Consumer Attitudes*: **https://artillry.co/artillry-intelligence/mobile-ar-usage-and-consumer-attitudes/**
[vi] See ARtillery Intelligence Briefing: *Global XR Revenue Forecast, Fall Edition*: **https://artillry.co/artillry-intelligence/forecasts/2018-xr-global-revenue-forecast-fall-edition/**
[vii] See ARtillery Intelligence Briefing: *VR Usage & Consumer Attitudes*: **https://artillry.co/artillry-intelligence/vr-usage-and-consumer-attitudes/**