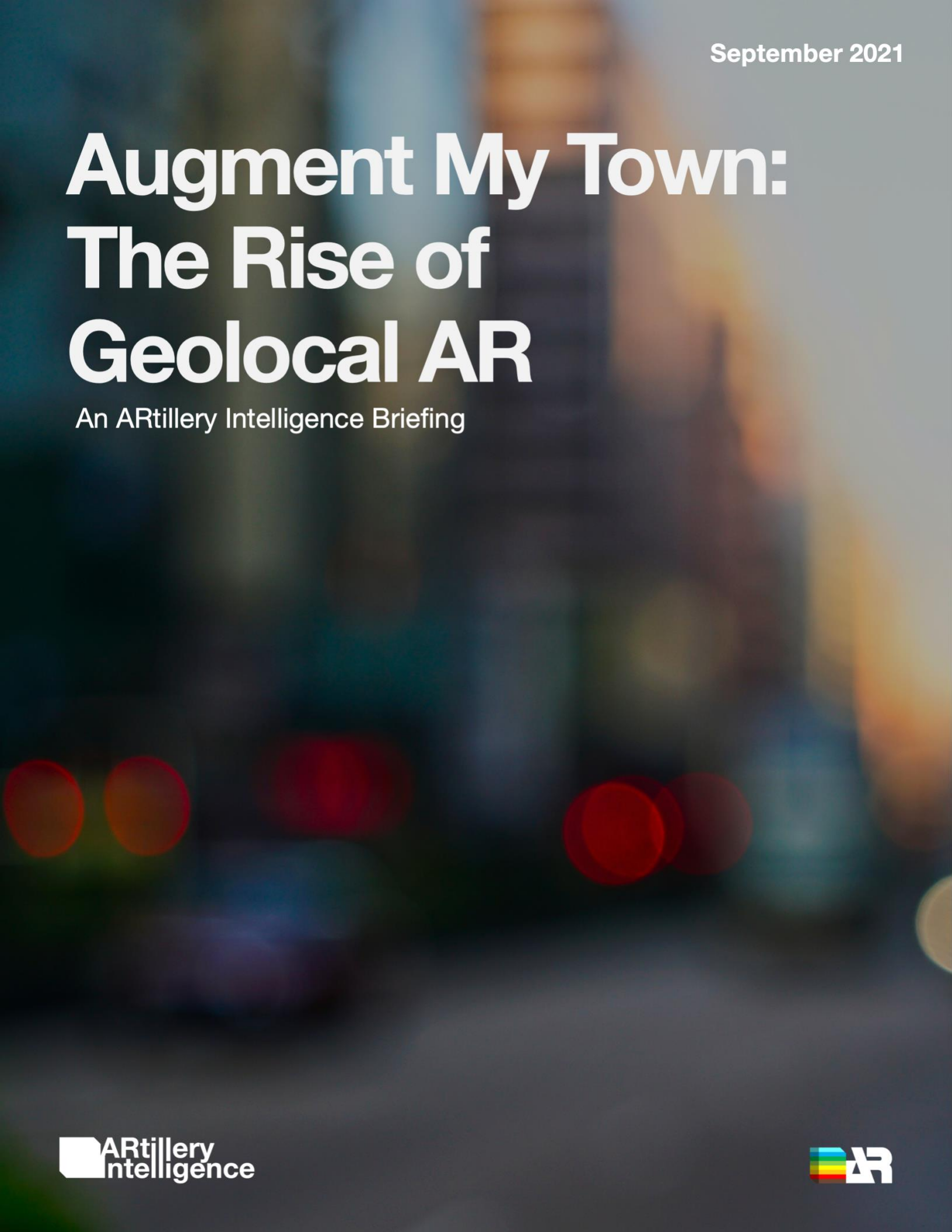

September 2021

Augment My Town: The Rise of Geolocal AR

An ARtillery Intelligence Briefing

ARtillery Intelligence

Executive Summary

One of AR's fundamental properties is to fuse the digital and physical. As such, the real world is a key part of that formula... and real-world relevance is often defined by location. As the saying goes for real estate value, it's all about three factors: *location, location, location.*

With that backdrop, one of AR's battlegrounds will be in augmenting the world in location-relevant ways. That could be wayfinding with Google Live View, or visual search with Google Lens. Point your phone (or future glasses) at places and objects to contextualize them.

As these examples suggest, **Google** has a key stake in this "Internet of Places." It's driven to future proof its core business, where the camera will be one of many search inputs. And it has valuable geo-local data from products like Maps and Street View to support its efforts.

But **Google** isn't alone. **Apple** signals interest in location-relevant AR through its geo-anchors. These evoke AR's location-based underpinnings by letting users plant and discover spatially-anchored digital content. **Facebook** is similarly building "Live Maps" as a component of its multi-sided AR master plan.

Then there's **Snap**, the king of consumer AR. Erstwhile propelled by selfie-lenses, its larger AR ambitions will flip the focus to the rear-facing camera to augment the broader canvas of the physical world. Meanwhile, **Niantic** continues to rule geo-local AR gaming through Pokémon Go as well as its Lightship platform that will geo-enable third-party AR developers.

Beyond tech giants and other usual suspects, there are compelling startups positioning themselves at the intersection of AR and geolocation. These include **Foursquare**, **Gowalla**, **ARWay**, **Resonai**, **Darabase**, **YouAR**, and a growing list of others.

If any of this sounds familiar, it's aligned with a guiding principle for AR's future: The AR cloud. Otherwise known as AR's *metaverse*, this is a conceptual framework in which invisible data layers coat the inhabitable earth to enable AR devices to trigger geo-specific experiences.

But true to the many tech-giant efforts just outlined, it won't just be one *cloud* or *metaverse*, as these singular-tense terms suggest. Multiple geo-located AR networks and experiences will compete. Like the web today, the AR cloud will ideally have standards and protocols for interoperability, while allowing for proprietary content and networks to coexist.

But rather than websites, this proprietary content will be in "layers." The thought is that AR devices can reveal certain layers based on user intent and authentication. You'll activate the *social layer* for social-graph activity, and the *commerce layer* to find products.

There are of course several moving parts. 5G will help achieve millimeter-level precision for geolocated AR. LiDAR will meanwhile unlock advanced optics that can enable the high-scale crowdsourced 3D data needed to spatially map the inhabitable earth. It will be a group effort.

But how will this all come together? What are the missing pieces? And who's doing what so far? We'll tackle these questions throughout this report by profiling the biggest players that are planting their flags for the future of geo-local AR. The goal, as always, is to empower you with a knowledge edge.

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Key Takeaways

- **Given AR's core function to fuse the digital and physical, geo-location is a key value-driver.**
- This can include everything from navigation and wayfinding to geo-anchored content and local discovery.
- This will be one way that AR's *metaverse* materializes, involving synchronous and geo-relevant content.

- **Prior to AR's current stage, geolocation has proved to add value to forbearing technologies.**
- In search for example, click value (CPC) is greater when local intent is signaled by the searcher.
- This local intent has a proven correlation to high-value and transaction-ready consumers.
- Google, Yelp, Foursquare and many others have built businesses around this principle.
- AR now enters the picture and will similarly find elevated value in geo-relevant experiences.

- **Google is one company with clear intentions around geo-local AR, or an "Internet of places."**
- This manifests in Google Lens and Live View which represent visual forms of its core search products.
- Google is also well-positioned for geo-local AR given the data it's assembled over the past 20 years.
- Google Images for example serves as a visual database that fuels object recognition in Google Lens.
- Street View similarly serves as a database for object recognition in its Live View navigation product.
- All these products are meant to gain traction today, with Google-esque monetization to follow later.

- **Google isn't alone: Apple is similarly making moves that indicate its interest in geo-local AR.**
- Apple's motivations are a different, with geo-local AR experiences meant to drive sales of its AR hardware.
- That hardware is iPhones today and AR glasses tomorrow, where it has ample investment on the line.
- By planting seeds for AR experiences (geo-local and otherwise) AR glasses can hit the ground running.
- Apple's geo-local AR products specifically include Geo-Anchors in ARKit and 3D navigation in Maps.
- Other geo-local clues exist, such as Project Gobi, involving AR-triggering markers at retail partner locations.

- **Facebook is meanwhile developing geo-local AR products as part of its broader metaverse play.**
- Facebook's metaverse will take place in VR through fully-immersive worlds, but also involve AR components.
- The first clue for the latter can be seen in its Live Maps which spatially-index the physical world.
- The goal is to have this data unlock interactions and annotations in the form of geo-relevant AR overlays.
- That could include social connections, as well as products and promotional content for Facebook advertisers.
- This makes Facebook's vision similar to Google's "Internet of places" but with a social twist.

- **Speaking of social, the king of consumer AR, Snap, is likewise developing geo-local AR plans.**
- These include Local Lenses, Snap Scan, elements of Snap Map, and a convergence of all these products.
- Snap's broader goal is to extend from selfie lenses to rear-facing camera AR to augment the physical world.
- To compete with the above players in assembling the underlying spatial data, Snap will crowdsource it.
- Given its extensive user base that captures Snaps daily, it hopes to simultaneously capture geo-spatial data.
- This is similar to the crowdsourcing geo-local AR play for another industry leader: Niantic.

- **Speaking of Niantic, its clearly intent on geo-local AR (see Lightship), among other players.**
- This list of others includes Microsoft, which will incorporate geo-local data into its enterprise AR play.
- It also includes Amazon, which is developing geo-local AR to support its core eCommerce business.
- Several startups also populate this list, including Gowalla, ARWay, Resonai, Darabase, and others.

- **Besides the investment of the above tech giants, geo-local AR will have other moving parts.**
- Spatially mapping the inhabitable earth is no small feat: Supporting tech will continue to develop.
- 5G will be a force multiplier for geo-local AR in providing faster speeds and highly-precise device tracking.
- LiDAR will likewise support geo-local AR by empowering the above crowdsourced spatial mapping efforts.
- Altogether, these efforts will get the AR industry closer to its ultimate endgame – a geo-spatial metaverse.

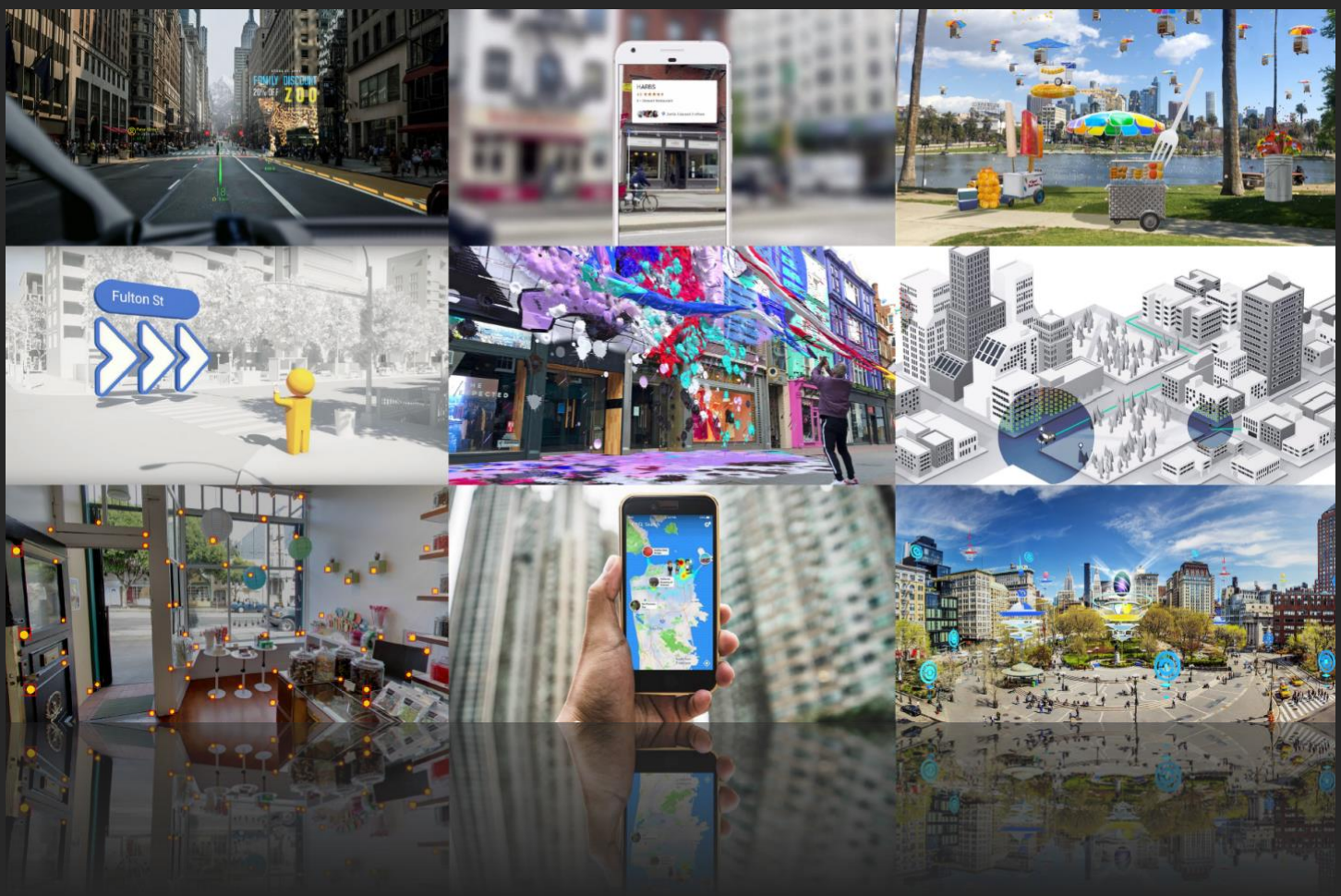
Part I: AR's Metaverse

Because AR's inherent function is to enhance the physical world, its relevance is often tied to specific locations. This is what we call *geo-local AR*. It's all about AR experiences whose value is tied location relevance. We're talking informational overlays on storefronts, or virtual notes you leave in specific places for friends.

If this sounds familiar, it's the foundational principle behind the *AR cloud* – a conceptual framework we've examined in past reports like this. For those unfamiliar, the AR cloud is a data mesh that covers the physical world to inform and empower AR devices to invoke the right content and experiences.

This concept also may sound familiar as it aligns with a buzzword that's run rampant in AR and VR circles lately: *the metaverse*. Though the term is often used in the context of fully-immersive VR, it can also involve synchronous digital experiences tied to real-world places: Call it *AR's metaverse*.

But to fully understand the opportunity at the intersection of AR and geolocation, we must pan back to examine the latter's recent history. In fact, location has been a meaningful value driver in several industries to emerge and advance in the smartphone era, including search, mapping, and social media.



Buy Local

Before AR's recent resurgence, location has been a source of value in forbearing technologies. In web and mobile search for example, click values are higher when transactional local intent is inferred by geo-modifiers (e.g., "near me") in search queries.

Google has correspondingly benefited from small businesses and multi-location brands that want to position themselves in the direct path of high-intent local searchers. Other startups like **Yelp** and **Foursquare** have likewise built businesses around consumer local search and discovery.

With that backdrop, AR enters the picture with potential to add dimension to the products and business models that surround local search. **Google** especially sees opportunity in an "Internet of places" that builds on the local search products that it's spent years building.

In fact, among tech giants pursuing geospatial AR, **Google** could have an inside track. For example, Street View imagery represents an object-recognition database to localize AR devices. This enables such devices to reliably overlay geo-relevant AR graphics.

Orbiting Efforts

But **Google** isn't alone. **Apple** signals interest in developing geospatial experiences as part of its larger AR play. One of the ways it's doing this is through its effort to rebuild Apple Maps with first-party mapping data. As it does that, it's simultaneously capturing 3D spatial maps.

Along with several other orbiting efforts underway from the uber-secretive **Apple**, this mapping data could be the basis for its very own AR cloud. Having its own spatial maps could enhance the utility of its rumored AR glasses, which will need compelling content & experiences to attract mainstream consumers.

Then there's **Facebook** which is similarly pursuing geo-local AR ambitions. And like **Google** and **Apple**, its approach aligns with its core business. This involves interacting with people and places in the real world to deepen connections... as you might expect from **Facebook**.

One of the pillars for this vision is **Facebook's** Live Maps. This conceptual model is **Facebook's** take on an AR cloud. And its advantage in building it is sheer scale: it wants to crowdsource spatial mapping by ingesting data as its users move through the world.

Snap is similarly building Local Lenses and other geospatial AR ambitions, while **Niantic's** Lightship platform will be a key geospatial AR enabler. Meanwhile, **Microsoft** Mesh applies an enterprise spin of all these efforts – enhancing productivity through geo-anchored content for industrial and corporate use cases.

Video Companion

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Part II: Geo-local AR Profiles

With that conceptual backdrop and quick summaries of geo-local AR efforts underway, it's time now to go one level deeper. What is each of these players doing?

And what's driving their investments? The following several pages profile the most notable geo-local AR efforts in greater detail.

Google

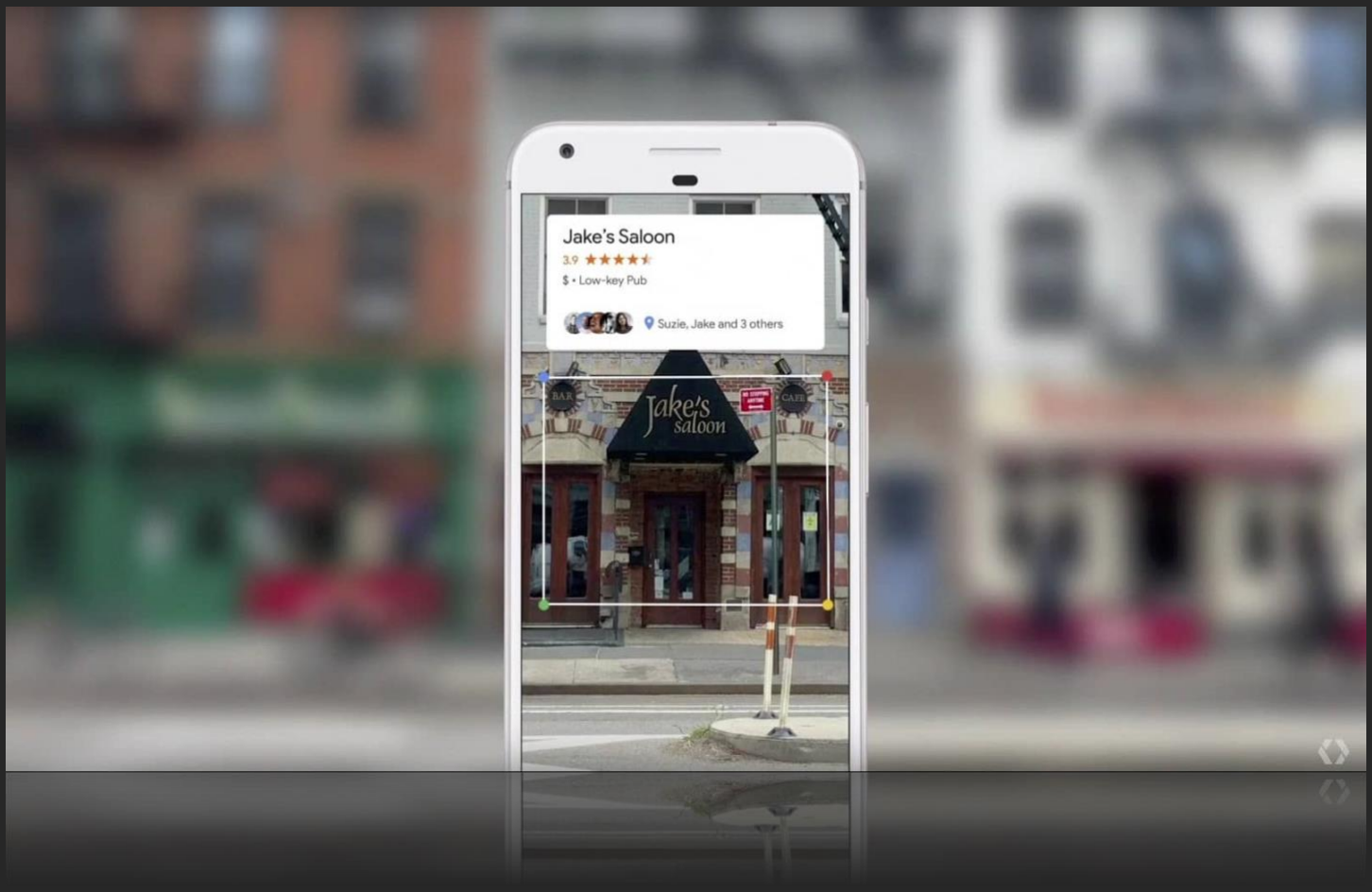
Tech giants see different versions of spatial computing's future. These visions often trace back to their core businesses. As noted, **Facebook** wants to be the social layer of the spatial web, while **Microsoft** wants to be the enterprise productivity layer, and so on.

Where does **Google** fit in all of this? It wants to be the *knowledge layer*. Just like it created immense value indexing the web and building a knowledge graph, it wants to index the physical world and be its relevance authority. This is what we call the *Internet of Places*.

This includes Google Lens, which lets users point their cameras at real-world objects to identify them. This starts with general interest searches like pets and flowers, but the real opportunity is a high-intent shopping engine that's monetized in Google-esque ways.

Live View similarly uses the camera to help users navigate urban areas with 3D walking directions. Instead of the "mental mapping" to translate a 2D map to 3D space, holding up your phone to see directional arrows is more intuitive. And like Google Lens, monetization is on the road map.

Google is uniquely positioned for these efforts as they tap into its knowledge graph and the data it's assembled as the world's search engine for the past 20+ years. Lens taps into **Google's** vast image database for object recognition, while Live View uses Street View imagery and local business listings data.



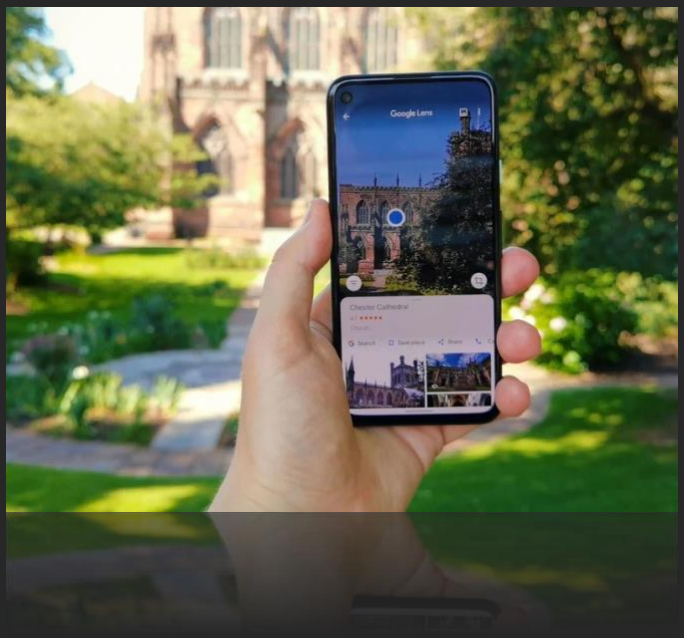
Visual SEO

Bringing together some of the above efforts, **Google's** latest move is to combine Lens and Live View. While navigating with Live View, **Google** now offers small click targets on your touchscreen when it visually recognizes a business or point of interest. When tapped, expanded business information appears.

That information includes details that help users discover and qualify businesses. Attributes include structured data that **Google** has in its Google My Business (GMB) database, such as hours of operation, reviews and other qualifiers. GMB has always meant to index the universe of local businesses.

Elsewhere in **Google's** geo-local AR master plan are the less-discussed Earth Cloud Anchors. This ARCore feature lets users geo-anchor digital content for others to view. This will have standalone social value but could also converge with, and feed into, Google Lens and Live View.

In other words, Cloud Anchors could engender a user-generated component of visual search. It could have social, educational, and serendipitous use cases such as digital scavenger hunts and hidden notes for friends. AR-activated local business reviews could also develop from the same workflow.



That last part – facilitating local commerce – is most aligned with **Google's** DNA. It has become a local search powerhouse, with ample revenue to show. This includes paid local search and free onboarding agents that drive search marketing revenue, such as GMB.

Google's Internet of places could therefore engender a new visual flavor of search engine optimization (SEO). In other words, if visual search and geo-local AR become popular, that could compel businesses to optimize their presence for that channel... just like they do today for web search.

This means that **Google** could have participation and support in building up the data backbone for its geospatial AR efforts by incentivizing businesses to provide some of their own metadata. That's exactly what it's done for years in online local search and SEO.

Add it all together and **Google** is making moves today to ensure its fate as the knowledge layer for the spatial web... just as it has done for 20+ years with its 2D forbear.

Apple

Apple's AR endgame — as with most of its endeavors — is to sell hardware. So unlike **Google's** Internet of places examined above, **Apple's** geo-local AR ambitions are more of a means to an end. It's about cultivating immersive experiences to make its hardware more attractive.

So what are its geospatial AR moves so far? For one, ARkit GeoAnchors evoke AR's location-based potential by letting users plant and discover spatially-anchored graphics that are persistent across sessions and users. This is similar to Google's Earth Cloud Anchors.

GeoAnchors also tie back to the AR cloud, examined earlier. To overlay location-relevant graphics, devices first must understand a scene and localize themselves. That can happen by mapping the contours of the scene or having previously-mapped spatial data.

GeoAnchors will apply the latter by tapping into **Apple's** Street View-like "Look Around" feature. Analogous to **Google's** use of Street View imagery to enable AR, GeoAnchors use this data to localize a device before showing the right spatially-anchored AR graphics.

In addition to Look Around's visual database, **Apple** will localize AR devices using position data (via GPS), directional heading (compass), and movement (IMU). Because **Apple** owns the full tech stack in iPhones, it has sensor fusion on its side. And it recently applied these capabilities to a 3D navigation feature in Apple Maps that's similar to Google's Live View.

This combination of inputs that Apple controls and utilizes also enables power and data efficiency. Spatial mapping and point clouds have data-heavy payloads. So an AR device — in this case an iPhone — can selectively access just-in-time data based on where it is.

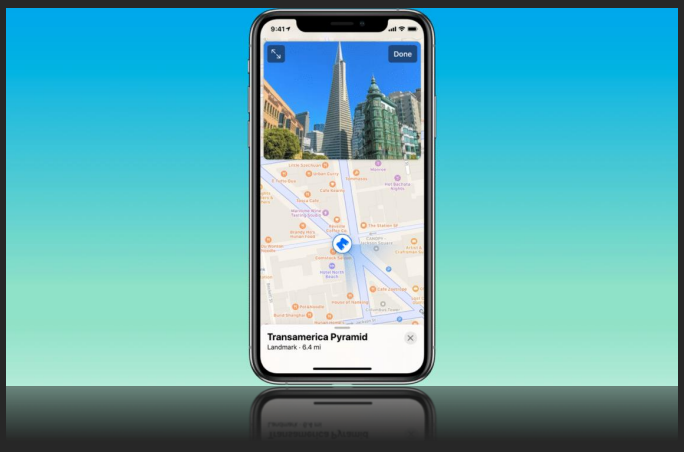
Dual Tracks

Meanwhile, other **Apple** initiatives play into its geospatial AR efforts. As we've examined,[i] project Gobi will sit at the center of an effort to plant QR codes throughout retail partner locations. These will trigger AR information and discounts when activated by an AR camera.

This essentially means **Apple** has dual-tracks for AR. World-immersive AR cloud activations represent one track. Gobi will meanwhile represent a marker-based AR approach. The latter is more rudimentary but also practical and user-friendly for consumers and retailers.

Closely related to this is **Apple's** App Clips. These functions are traditionally housed in full-blown apps and make them more accessible on the fly. So real-world activities like pre-paying a parking meter will no longer require downloading the associated app.

Instead, QR codes — we believe the same ones deployed for Gobi — will let users scan to access mini-app functionality to fill that parking meter… or other use cases that developers build. **Apple's** gravitas and revenue incentives will drive brand and retailer adoption.



Paving the Way

As the above initiatives unfold, AppClips QR codes will begin to populate high-traffic spaces. With that infrastructure in place, **Apple** will have a network of AR activation triggers. Rolling it out in this sequence will also allow the physical infrastructure to expand, while mobile AR adoption gradually grows in step.

Speaking of lead time and long-term thinking, the other wild card is **Apple's** AR glasses which will piggyback on all of the above. **Apple** wants the infrastructure in place by the time its glasses release. That way, there are compelling use cases ready to go.

This applies to both users and developers. Similar to our longstanding narrative around ARkit's very existence, **Apple's** intention is to acclimate users to get the AR demand juices flowing; while getting developers to start thinking spatially and building things.

All of the above could give AR glasses a fighting chance for consumer adoption, and **Apple** has a lot riding on that. Fortunately, its signature halo effect will help. If anyone can pull this off — including planting QR codes across the physical world — it's probably **Apple**.

Coming full circle, **Apple's** geospatial AR efforts aren't a monetization endpoint — as they are for **Google** — but a means to an end. By having architecture and content in place, AR experiences will be more compelling. And that will drive AR glasses and other wearables.

Facebook

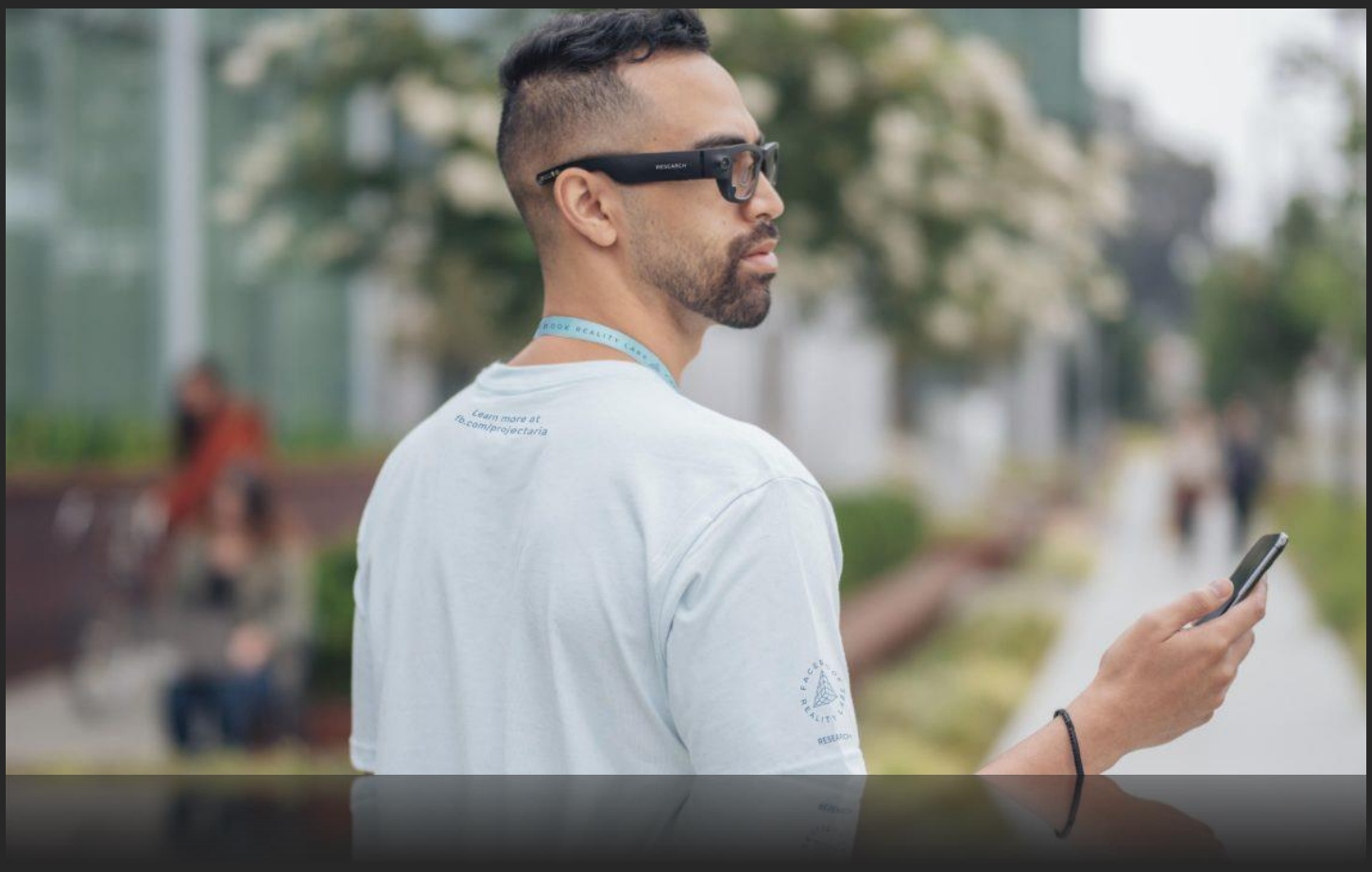
Like the players profiled so far in this report **Facebook's** geospatial AR ambitions trace back to its core business. In broad terms, that mission is to connect the world socially and build network effects that can be monetized through advertising.

So how does that translate to AR products and business moves? **Facebook's** AR play is at earlier stages than its already-commercialized VR activities. But it's also been forthright about its AR ambitions, research underway, and billions in spending to make it happen.

These intentions have trickled out through Mark Zuckerberg interviews and **Facebook** public filings. But the most illuminating glimpse into **Facebook's** AR vision can be gained from the technical deep dives from its Chief Scientist Michael Abrash each year at the **Oculus** Connect conference.

At his most recent appearance, Abrash discussed Project Aria. This is **Facebook's** field research for AR glasses. Devoid of optical displays, these research frames have cameras and sensors so **Facebook** can gain insight into social dynamics and behavior around AR glasses.

But more notable — and related to geospatial AR — is **Facebook's** work to build **Live Maps**. This is its vision for data that's anchored to people and places in order to evoke meaning through AR interfaces. That could include everything from social connections to product details. Think of it as **Facebook's** very own AR cloud.



Understanding Reality

In order to achieve these lofty goals for Live Maps, Abrash points to a critical building block: machine perception. To augment one's reality, a device has to first understand that reality. And that happens on geometric levels (shapes/depth) and semantic levels (meaning).

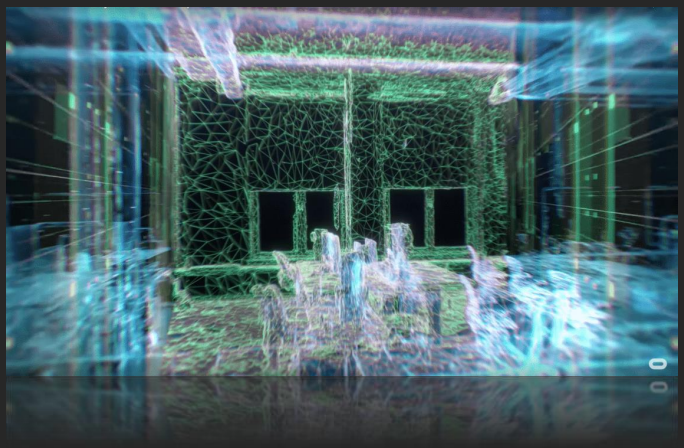
Abrash outlines three key layers, starting with something we already have: location data. Some portion of the heavy lifting can be done by knowing where you're standing.

The second layer is an index layer. Think of this like **Google's** Internet of Places examined earlier This involves the geometry of a given room or space. Like anything else, some will be public and some will be private, and it will be perpetually evolving.

The third layer is content, or what Abrash describes as ontology. These are the more personal and dynamic relationships between objects and their meaning to a given person. This will be the layer that has the most permissioned access, and will do things like help you find your keys.

Collective Cloud

One of the challenges for Live Maps – and other geo-local AR efforts throughout this report – is assembling the requisite spatial data and keeping it accurate and updated.



Facebook's approach goes back to the aforementioned project Aria. Though it will start out as internal research to gain insight on the social dynamics of smart glasses, an eventual version of these glasses could be used to crowdsource the spatial mapping of the inhabitable earth.

As we'll examine next, this is similar to how **Snapchat** will achieve large-scale spatial mapping. It will mine data from Snaps and Spectacles-captured video to power its geospatial AR play. **Niantic** will similarly crowdsource data from Pokémon Go players who scan the world while playing,

All of these cases represent a fourth modality for mapping. After satellites (GPS), cars (Street View), backpacks (exploratory Street View), AR achieves another level of granularity. This will be a key for the "index" layer mentioned above, and to gain first-person perspectives.

You can also think of the crowdsourced approach like **Waze** in that users benefit from the data while collecting it and feeding into the collective cloud. But as you can imagine, the key word here is scale, which **Facebook** has in its sheer user base. That plus billions in spending could give it an edge.

Snap

Sticking with socially-driven AR players, what about **Snap**? It has long-believed that social interaction is tied to the real world. By adding layers of social relevance based on where you are and where you've been, it can deepen connections and engagement.

This thinking drives **Snap's** ongoing investment in Snap Map, which geo-tags users on a map interface. **200 million** Snapchatters use it to find each other, and **Snap** has begun to monetize that engagement by letting local businesses promote themselves.

Snap's AR efforts similarly tie into the goal of driving local commerce. AR is inherently conducive to local commerce, as local search and discovery are unlocked through geo-anchored and location-relevant content.

Like with **Google**, the payoff for these efforts is monetization — via advertising and affiliate revenue — to facilitate local commerce. It's often forgotten that brick & mortar commerce accounts for a commanding majority of consumer spending.[ii]

In total, **Snap's** geo-location AR products include Snap Map, Local Lenses, Snap Minis and Snap ML. These are each notable on their own, but get more interesting when viewed together to extrapolate **Snap's** geo-local AR road map. Let's take them one at a time...

Local Lenses

Starting with Local Lenses, they work towards shared and persistent AR experiences that are associated with physical locations. The "shared and persistent" part is important, as it lets users anchor AR experiences to a location — viewable across sessions and between users.

These are the core tenets of the AR cloud, as noted throughout this report. And **Snap's** efforts to build an AR cloud framework run parallel to efforts profiled in the preceding pages. For example, recall that **Google** uses Street View imagery as an object-recognition database to localize devices.

Snapchat hopes to similarly use data from existing and ongoing Snaps that happen in specific locations. This is meant to form a sort of location database that will feed into its Local Lenses. That way, users can pull out their phones to discover AR content wherever they're standing.

The goal is likewise to give users the ability to leave persistent AR graphics on local spots. The use case that **Snap** has promoted is more about fun and whimsy, including painting streets and buildings with digital graffiti. But it could evolve into commerce-based use cases like storefront details and reviews.

Beyond these efforts that tap into **Snap's** existing assets and user engagement, **Snap** is showing its intentions to accumulate new assets to build its AR cloud. For example, its **$6.7 million** acquisition of 3D mapping startup **Pixel8.Earth** will embolden its spatial mapping efforts with purpose-built technology and data.

Snap Map

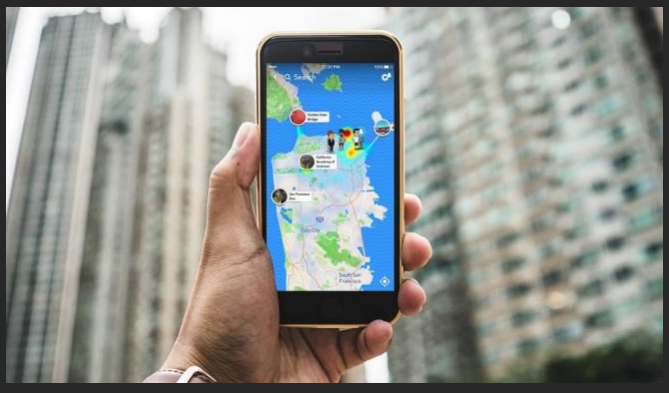
Next on the list of **Snapchat** local commerce ambitions is Snap Map. Once used for social discovery, it now has a commerce-oriented outcome: business listings. Users can discover local businesses using the same tool.

This includes the new MyPlaces feature that brings more structure to local discovery. Users can tag and check into local businesses while sharing their activity. Snap Map's Layers feature likewise organizes local spots through thematic clustering (e.g., "entertainment.")

While **Snap** works on boosting Maps' user engagement through these features, it's meanwhile developing the monetization end. As noted, it offers advertising options to SMBs to promote themselves to **Snap's** commercially attractive Millennial and Gen-Z users.

In fact, **Snap** has more 13-34-year-olds than any other platform, including **Instagram**. Quantifying that value, **Snap** reports that Gen-Z has **$323 million** in direct purchasing power, which will only grow as the generation phases into the workforce.

But how do these Snap Map moves tie back to geo-local AR? Though Snap Map is mostly a non-AR product, users who visit local businesses could subsequently activate lenses in and around their locations. That could involve Local Lenses or other formats **Snap** continues to roll out.



Mini Functions and ML

Moving on to the next piece of evidence in **Snap's** local commerce master plan, it recently launched Snap Minis. These HTML 5-based apps will live in Snapchat's Chat section and include micro-functionality like casual games and utilities. It's similar in concept to **Apple's** AppClips examined earlier.

Launch partners include **Coachella** (coordinate and plan a festival experience); **Headspace** (launch meditation sessions and send to friends); and Movie Tickets by **Atom** (choose showtimes, watch trailers, buy tickets) — collectively demonstrating a wide range of potential use cases.

With that in mind, Minis could be developed to discover, plan, and transact local activities such as dining out. The model here is what **WeChat** has done in China. It's similarly a chat-based app that's become a launchpad for micro-apps and transactional features for local commerce.

Along the same lines, Snap ML lets developers import their own machine learning. Launch partners include **Wannabe** shoe try-ons and **Prisma's** selfie renderings but could evolve into local search and commerce use cases. These efforts could also integrate with Snap Scan – a Google-Lens-like visual search tool.

So like Google Lens, Snap could identify local storefronts. With a training set of local imagery, an ML-fueled tool could allow **Snapchat** users to point their phones at a restaurant to get business info or user-generated content, then reserve a table or invite friends via mini-apps.

Niantic

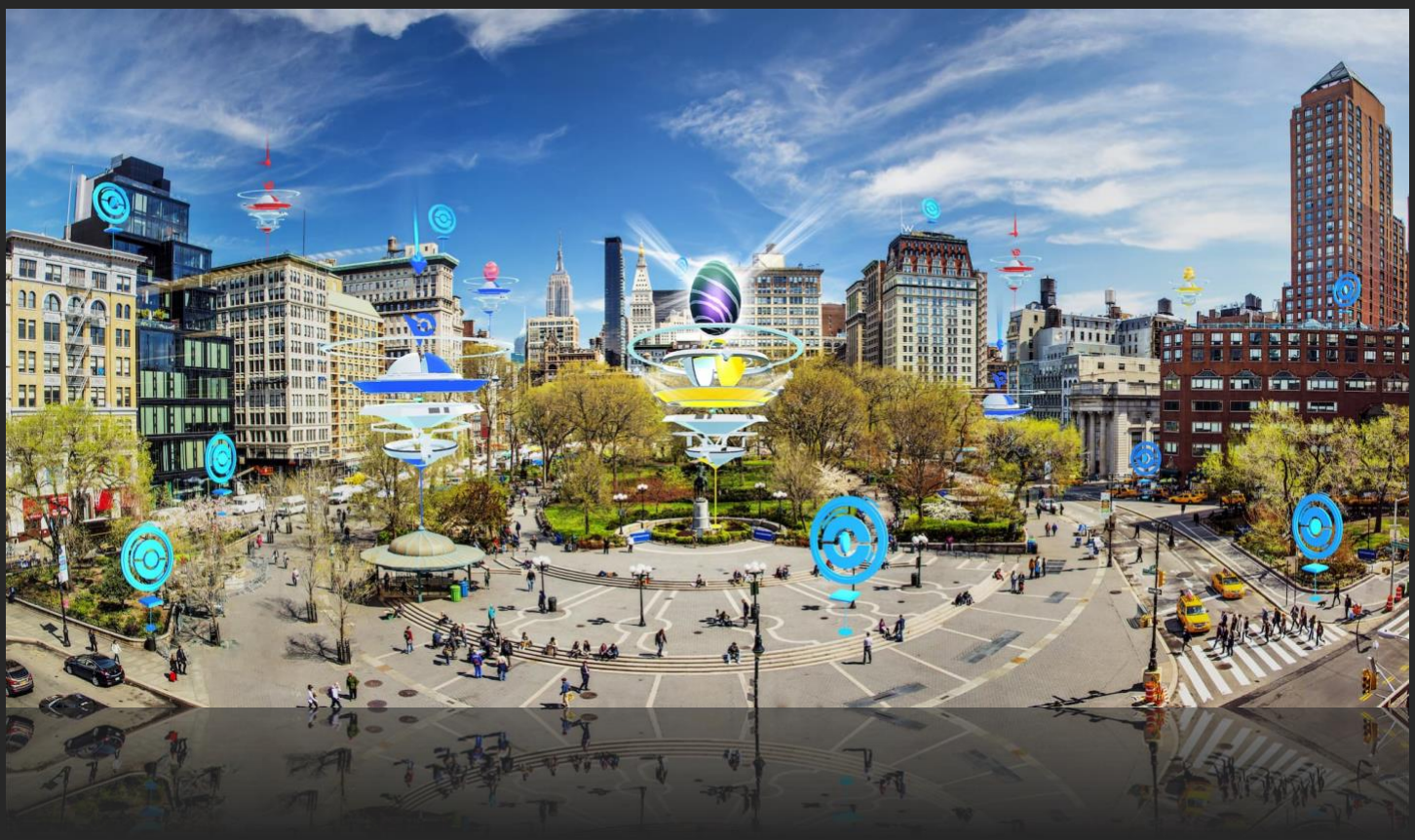
Besides **Snapchat** lenses, the AR experience that has gained the most consumer traction is Pokémon Go. But though this is the way its creator, **Niantic**, has risen to prominence, the company's long-term play may be its location-based AR gaming platform, Lightship.

Lightship takes Pokémon Go's architecture and spins it out as a platform on which other developers can build games and experiences. This could be a valuable utility given that it enables app developers to build experiences on top of the infrastructure that Niantic has spent years building.

These capabilities include scaling up to surges in user behavior, compelling game mechanics and geospatial interactions. For the latter, Niantic has developed considerable aptitude in geolocation as it's a core Pokémon Go function.

Meanwhile, **Niantic's** "mapping tasks" program incentivizes players to scan local waypoints. This is part of an effort to scale up spatial maps for Lightship – similar to **Facebook** and **Snap's** crowdsourced possibilities noted earlier. The goal is to fill in last-mile gaps for richer spatial maps in high-value locales.

Altogether, this advances **Niantic's** vision for "Planet Scale AR." The idea is to combine geospatial data and computer vision to enable meaningful real-world interaction. And all the above is accelerated by **Niantic** acquisitions like **6d.ai**, and underlying tools such as LiDAR.



Business Case

As the above factors converge, Lightship represents an expansion play for **Niantic** in that it productizes its underlying software. In that way, the platform follows the path of one of the greatest enabling tools the tech world has ever seen: **Amazon Web Services**.

Just like **AWS**, **Niantic** built its engine primarily to power its own products. But then it discovered the opportunity to spin it out as a platform. And like **AWS**, Lightship could be a scalable revenue stream, making it both a strong business case for Niantic and a valuable utility for the AR industry.

Altogether, **Niantic** is in a strong position with momentum, good tech and brand equity. It's using that to double down on its positioning as an AR leader. The platform approach also lets it diversify – adding SaaS revenue streams to already-strong in-app purchase (IAP) revenue.

To expand on the latter, our research arm **ARtillery Intelligence** has estimated Pokémon Go's 2020 IAP revenue at **$1.2 billion.**[iii] This marks the game's most successful year to date — a rare feat as mobile games usually don't sustain over such long time periods. This is largely due to **Niantic's** ongoing ingenuity.

Phygital Fusion

Speaking of revenue diversification, **Niantic** has developed a third income stream: local business advertising and promotion. So far, brands like **GameStop** (pre-stock debacle) have paid to designate locations as in-game waypoints. These are the Pokéstops and Gyms where players descend in large numbers.

For players, this can be organic as they work up a hunger through the game's migratory play. And for multi-location brands, it can be more effective than traditional marketing when it comes to driving tangible foot traffic. It's particularly fitting to fast food, coffee, and convenience stores.

Niantic has doubled down on this principle by extending in-game sponsorship to the long tail of SMBs. Its low-friction self-serve ad platform is an offshoot of the Wayfarer program that lets players vote on locations for Pokéstops and Gyms. This lets SMBs pay to boost foot traffic.

Following the program's launch, **Niantic** CEO John Hanke characterized it as both additive to gameplay and supportive of local businesses. Niantic has a penchant for altruism in its mission to get kids out of the house. This adds fuel in supporting local economies.

Stepping back, Pokémon Go is often considered to be AR (though there's some debate). Digital overlays on the real world when catching Pokémon fit the definition. But on another level, driving real-world behavior through mobile gaming is a more meaningful form of physical-digital (phygital) fusion.

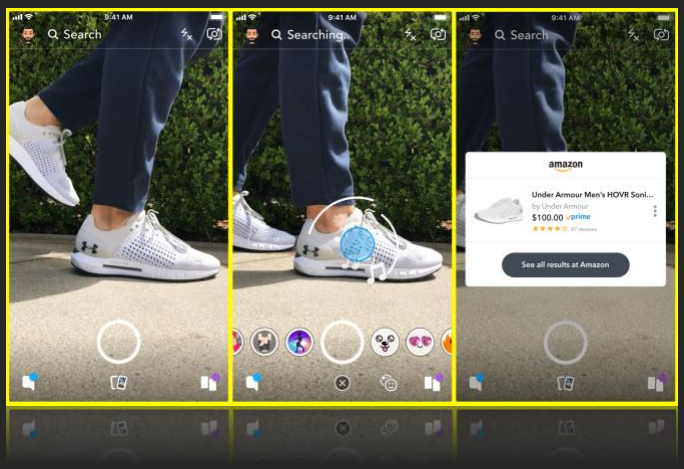
Amazon

After covering AR usual suspects, how does the mighty **Amazon** fit into geospatial AR? Admittedly, its moves and motivations aren't as big as the companies covered so far... simply because offline local commerce isn't its core business. But it is making subtle moves.

Backing up, **Amazon** has dabbled in AR, such as its partnership with **Snap** to power product-based visual searches. Using Snap Scan, users can point their phones at items to identify them. **Amazon** inserted itself in this flow as the product database and transaction engine.

Amazon is also increasingly chasing offline commerce to diversify revenue amidst a maturing e-commerce business. Part of that involves physical-world commerce such as its Amazon Go stores and its landmark acquisition of **Whole Foods**, among other moves.

The latest is its experimental tech-fueled salon. Occupying 1,500+ square feet in London's Spitalfields, it will serve as a testbed for **Amazon's** "Point and Learn," technology. As it sounds, this technology reveals information when shoppers point at a given product.



Retail as a Service

Going deeper on Point & Learn, it uses optical and motion sensors to detect when a shopper points at a product. Information is then shown on flat-panel displays that flank the product, or audio messaging. Consumers can then scan QR codes to order items on **Amazon**.

Doubling down on AR, the salon will feature smart mirrors that let shoppers virtually try on cosmetics for a more informed purchase. This has generally been a leading AR use case — especially during retail lockdowns — to guide online cosmetics purchases.

But anyone following **Amazon's** moves over the past few years knows it isn't interested in getting into the salon business. This is purely an incubation play for Point & Learn, just as Amazon Go stores are primarily to incubate **Amazon's** "just walk out" technology.

This is all part of **Amazon's** broader "retail-as-a-service" (RaaS) plan. Following the AWS playbook, it's developing an internal tool that will eventually get spun out as a service. It's an expansion move for **Amazon**, and several parts of it will involve AR and computer vision.

Augmented Payments

More evidence of the RaaS approach comes from the Amazon One palm-reading POS payments that will speed up transactions at grocery stores. It recently announced that it's rolling out the technology at several **Whole Foods** locations in the Seattle area.

This biometric tracker can authenticate users with a palm scan. In some cases, users scan their palm when entering a store, then "just walk out" when done. Once scanned, a given shopper is associated with a payment method and Prime status, set up on the first use.

The other way that the technology works is directly at the point of sale. Eschewing the store-entry palm scan, this will simply have shoppers scan their palm at the register, just like they would enter a credit or debit card while going through a checkout aisle.

The second method has less friction and is a first step to assimilate the technology. That goes for user comfort levels, as well as retailer logistics. Though **Amazon** is aggressive with tech integration, it knows the world isn't ready to forego checkout aisles altogether.

Touchless Shopping

The timing for all these retail innovations is notable. Both Point & Learn and Amazon One come at a time when the retail world opens back up to potentially apprehensive shoppers. Much will depend on post-Covid demand for physical shopping, and new in-store protocols.

In fact, retailers in the post-Covid world may encounter demand signals for touchless in-aisle interaction technologies. That will depend on several unknowns, such as consumers' desire to get back to physical shopping, and health guidance on behavior in public spaces.

If there is indeed demand for touchless retail environments, AR is a natural fit. It can overlay everything from product descriptions to brand spokespeople that come to life through your smartphone viewfinder. We'll also see AR-adjacent RaaS tech like Point & Learn.

Speaking of adjacency, AR continues to broaden. Its definitions transcend graphics on the physical world to include any physical-digital fusion. That's everything from Zoom backgrounds to "audio AR." **Amazon** will have a part in pushing these boundaries.

Microsoft

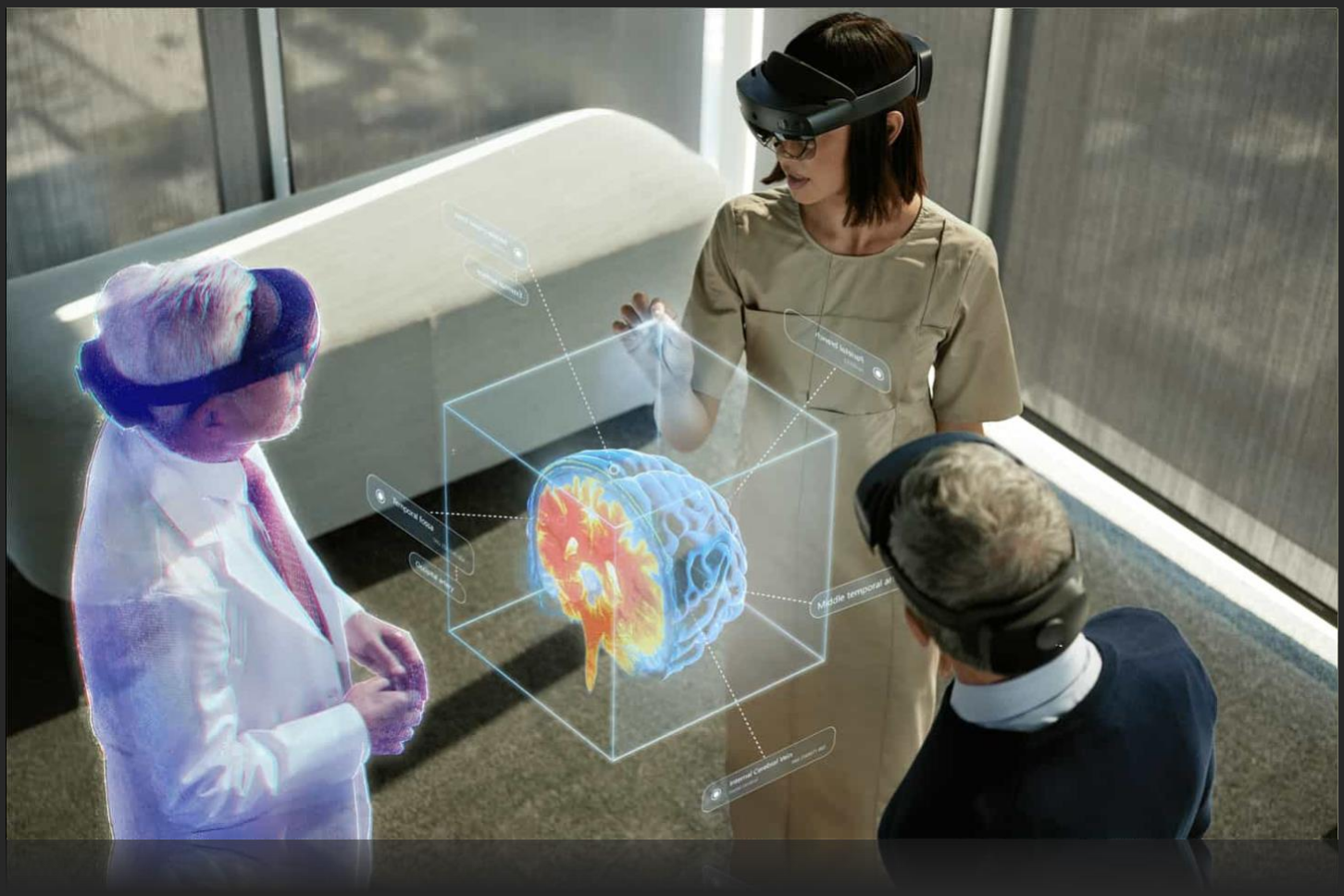
Geospatial AR isn't just about consumer endpoints... What about enterprises? That question can best be answered by examining enterprise AR's leading player: **Microsoft**. But before getting into its geospatial AR moves, how is it positioned generally?

Among tech giants investing in AR, **Microsoft** continues to show strong signs as a leading platform for enterprise productivity. That not only includes its best-of-breed hardware in the HoloLens 2, but an expanding suite of software (it is **Microsoft** after all) for enterprise AR.

This ties to **Microsoft's** DNA, as enterprise productivity has been its core business for 30 years. In that sense, it embodies a common pattern: tech giants' AR trajectories can be projected based on their financial motivations — which trace back to their core businesses.

This pattern holds true for **Microsoft's** work in AR, which can be seen in the enterprise-first HoloLens 2. But how does it apply to the geolocation theme of this report? The answer is Microsoft Mesh: the company's new structure for a productivity-enabling AR cloud.

Mesh represents the culmination of several AR puzzle pieces that **Microsoft** has assembled over the past few years. These include its AR productivity apps such as Spatial Anchors, 365 Assist, and several other components of its full-stack approach to enterprise AR.



Cloud-Forward

As further background for **Microsoft's** AR moves, CEO Satya Nadella is a verdant cloud proponent. In fact, it was under his watch that **Microsoft** defied a classic innovator's dilemma and embraced the cloud, even though it deviated from the structure of its then software business.

It's within that reborn cloud culture that **Microsoft's** AR efforts germinate. And it's those guiding principles that will drive its AR positioning. As noted, **Microsoft** is taking a full-stack approach to AR, owning the hardware (Hololens), operating system (WMR) and cloud data (Azure).

In addition to those foundational components, **Microsoft** is naturally positioning itself at the application layer. Dynamics 365 Assist and Azure Spatial Anchors can be thought of as a sort of Microsoft Office of AR. But with a true platform approach, Microsoft also welcomes developers to build AR apps.

That's where Mesh comes in. It's essentially the culmination of all the pieces outlined above, with some additional functionality such as collaboration through Microsoft Teams. It formalizes and federates these pieces and is now the center of **Microsoft's** AR universe.

Fertile Soil

With that structural and strategic backdrop, what exactly is Mesh? It's a software architecture that enables spatially-oriented computing interactions. It localizes people and objects in space and provides a framework for interactions with and between those entities.

In more practical and plain-spoken terms, it lets users envision objects in their immediate space, such as a product design or architectural model. More importantly, it can do this with "holo-portation" and multi-user functionality. This engenders use cases for collaborative work.

All of this of course resonates during a pandemic, as well as post-Covid "hybrid" work environments. Being able to interact with people and work elements more materially will find fertile soil in that world. Those work elements can be everything from whiteboards to 3D CAD models.

Mesh will also play a part in geo-located enterprise AR use cases such as bridge inspection. These applications incorporate Azure Digital Twins, a key corollary to Mesh. And this will continue to expand into purpose-built applications in high-value (and location-oriented) verticals like construction and real estate.

Startup Roundup

After covering several tech giants and their geo-spatial AR ambitions, what about smaller players that are innovating down-market. There are several such players – too many to cover comprehensively. So we've profiled a representative sample below... starting with the geo-local "OGs."

Foursquare

You may remember **Foursquare** as the late 2000's social/local/mobile (SoLoMo) check-in app. It has since reinvented itself as a B2B location-data powerhouse, but that doesn't mean it's done with consumer app innovations. It accomplishes this today in its Labs division.

The latest is an audio AR experience known as Marsbot for AirPods. This is a virtual assistant that proactively whispers geo-activated recommendations in your ear. That could be a new gastropub in your neighborhood or nearby happy hours when you wander into a new area.

Naturally, the geo-spatial elements are powered by **Foursquare's** place database. As noted, the company is many years into a fruitful pivot to build the "location layer" for the mobile internet.

This provides a rich dataset for AR experiences, congruent with the principles of the AR cloud. In fact, we've long predicted that the AR cloud will benefit from legacy location intelligence players like **Foursquare** with unique data on not only places but nuanced consumer interaction.

But because AR isn't a prevalent consumer behavior yet, **Foursquare** knows that it can make the most impact where there are lower adoption barriers and an installed base of AirPods. That's why Marsbot is an experiment, and **Foursquare** knows that AR will be a moving target.

"The purpose of Marsbot was never to attract millions of users," **Foursquare** founder Dennis Crowley told us, "but rather to showcase how contextually-aware technologies will shape the future of AR and how **Foursquare's** technology can be the foundation [for] those experiences."

Gowalla

Foursquare isn't alone in being an all-star of the late 2000's SoLoMo scene that's entering geospatial AR. Its chief competition from that era is doing similar: **Gowalla**. It's back for more SoLoMo action… this time with an AR focus.

Specifically, it recently received **$4 million** in funding to offer geo-relevant and gamified AR. Signals indicate that this could be built around local discovery with a social twist: Hold up your phone to reveal geo-anchored game elements or notes that friends left for you.

To contextualize this vision, the company takes inspiration from the social side of **TikTok** and the platform side of **Roblox**. The latter could make it a sort of MMO for the real world.

Gowalla also hopes to create stickiness through user incentives. That could be gamified elements such as points & badges (a nod to the original **Gowalla**). And it will monetize in similar ways as Pokémon Go and Fortnite: in-game purchases for digital goods to enhance the experience.

Stepping back, **Gowalla** enters geospatial AR with less reach and spending power than the **Googles** and **Snaps** of the world. But it may have an edge in its competency with location-based experiences. That's likewise an advantage held by **Niantic**, which happens to be one of Gowalla's investors.

ARWay

The third geospatial AR startup we'll examine in this representative sample is **ARWay**. Recently acquired by NexTech AR Solutions,[iv] It provides developer kits to build indoor AR navigation experiences, such as shopping malls and other public spaces. This has implications for valuable utilities and monetizable AR commerce.

One of the biggest challenges according to **ARWay** founder & CEO Baran Korkmaz is platform fragmentation. AR development platforms offer object persistence functions – Google Cloud Anchors, Apple GeoAnchors, Microsoft Spatial Anchors – that don't talk to each other.

ARWay is working towards a sort of translation layer between platforms and devices. The goal is for users to be able to begin navigating visually, without jumping through hoops or hit a brick wall of incompatibility. AR adoption is challenged enough already.

Panning back, this issue of platform fragmentation is a common topic in AR cloud circles. The problem is that tech giants are each building their own AR clouds, as examined earlier. They're investing heavily – incentivized by monetization potential – which sometimes requires walled gardens.

Given the size of these investments, tech giants have the right to maximize returns. But with walled gardens, the key word is *interoperability*, says Korkmaz. The model is the web: there are proprietary interests but common standards, protocols, and languages.

Meanwhile, Korkmaz wants to pick up where **6d.ai** left off. Before being acquired by **Niantic**, it was the pre-eminent tool for building self-contained spatial maps. It's now deployed in Niantic's Lightship platform, leaving a gap for certain commercial AR development.

The Field

The previous three cases are, again, a representative sample of startup-driven geospatial AR efforts. A more exhaustive list would include companies such as, Darabase, Resonai, YouAR and Scape Technologies (acquired by **Facebook**).

Beyond the tech giants we've already examined in this report, these smaller players will fill important gaps in the geospatial AR value chain. That could be focused consumer experiences like **Gowalla**, or critical data and developer tools like **Foursquare** and **ARWay**.

Either way, geospatial AR will be an opportune subsegment of the overall AR world. Indeed, realistically fusing digital and physical worlds requires a hefty dose of spatially-relevant data and understanding. Like many other emerging sectors, there will be several points of entry.

Part III: Filling in the Map

Reaching the geospatial AR endpoints examined throughout this report will require several moving parts and missing pieces. The biggest piece is arguably in place: the commitment and investments of tech giants profiled in this report. But other factors loom... here are a few of them.

3D Location Data.

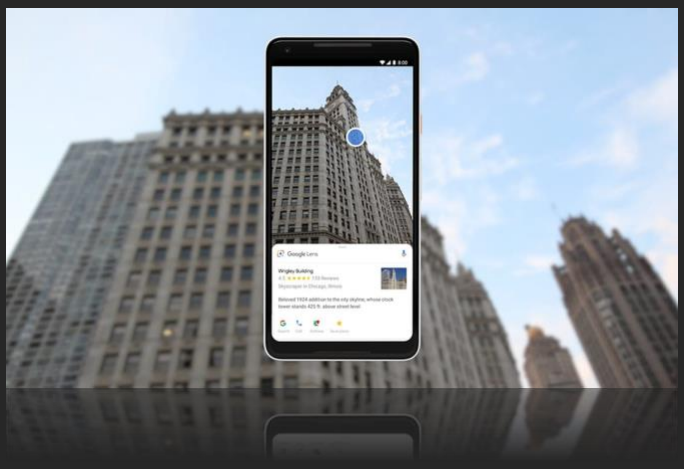
Going back to a point made earlier, accurate location data will be one key puzzle piece for the geospatial AR vision. And because we're talking about 3-dimensional content, the location data itself needs to be more dimensional than traditional GPS readings.

This notion has led to 3D location data from players like **NextNav**. The idea is that most location data we encounter is based on two dimensions: X & Y – or lat/long in GPS terms. 3D location data adds a Z-axis to the mix to define positioning in terms of elevation.

One way this has traditionally been used is targeting mobile ads. GPS lat/long readings don't help ad targeting in places like 3-story shopping malls or 60 story buildings that have commercial businesses on lower floors?

Beyond a marketing context, Z-level accuracy becomes more valuable in emergency response scenarios. When someone calls 911 from the 32nd floor of a 40-story building, being able to get a precise fix on three-dimensional location can save precious minutes.

Meanwhile, use cases continue to expand, including enhancing in-stadium experiences such as ordering food from your seat, or summoning customer service in a multi-level department store or mall.



What About AR?

All the above examples are in traditional mobile contexts… what about AR? For example, in the department store example, could AR navigation and wayfinding be activated (see **ARWay** in the previous section).

As we examined earlier, the AR cloud requires spatial mapping data so devices can localize themselves (know where they are) and overlay the right graphics (know what they're looking at). These functions rely on both visual object recognition and geospatial orientation.

Systems that support Z-Axis positioning feed into that data mix. After all, one fundamental aspect of spatial computing is recognizing and rendering objects in several dimensions. That requires not only understanding depth but, in some cases, elevation.

This could involve playing Pokémon go across topographical planes, or navigating the hills of San Francisco with Google Live View. Whether it's games or utilities — both of which will drive value in AR — Z-axis orientation will be one factor in the continued quest for geo-local AR.

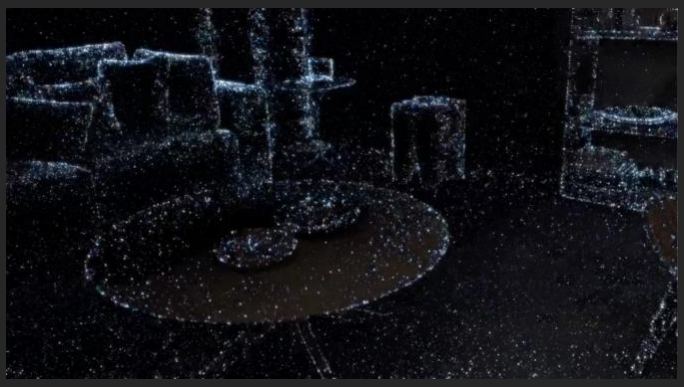
LiDAR

The biggest advancement in AR in 2020 was arguably **Apple's** iPhone LiDAR camera. Though it's only available on the iPhone 12 Pro and Pro Max, LiDAR will trickle down to the rest of the iPhone lineup in the coming years. This will unlock AR's next generation, and better enable geospatial AR.

Short for light detection and ranging, LiDAR involves sensors that track how long it takes light to reach an object and bounce back. This is the state of the art for depth sensing and is how autonomous vehicles achieve computational vision to "see" the road.

This will manifest in the mostly-unseen computational work that happens before AR graphics are shown, such as spatial mapping. LiDAR is better equipped to quickly scan room contours, which is the first step towards "believable" and dimensionally-accurate AR.

That will engender new use cases for AR. For example, it will mean more indoor activations such as spatially mapping your office or bedroom. It also extends AR from the front-facing camera (selfie lenses) to augment the broader canvas of the physical world.



5G

5G has become quite a buzzword in and out of AR circles. But that doesn't mean it won't advance the field. This is especially true in this report's topic of geospatial AR, where 5G could become a critical enabler and force multiplier.

How will it do this? Among other things, we'll zero in on three key factors: speed, edge compute, and location precision.

Starting with speed, 5G offers a wider pipe for AR's (and VR's) polygon-heavy payloads. It will provide the low-latency that AR and VR experiences require, while inspiring innovation and capability for the next generation of bandwidth-intensive spatial experiences.

Beyond connectivity, low-range, high frequency 5G local networks enable edge compute. This importantly lets AR devices offload CPU and GPU needs to the network edge. They can then shed size, heat and cost.

Lastly, 5G enables location precision. Its high-frequency signal achieves millimeter-level precision, compared to GPS' meter-level accuracy. This will be critical for geospatial AR use cases explored earlier, like holding up your phone to identify storefronts and waypoints.

Next Up: The Metaverse

To come full circle, many of the above orbiting parts for geospatial AR are puzzle pieces for a broader conceptual framework: *the metaverse*. This term is a bit vague, as its meaning has been conflated through overuse. But it does have some ties to geospatial AR.

Backing up, 'metaverse' defines digital worlds that host synchronous human interaction. Mark Zuckerberg – intent on making **Facebook** a *metaverse company* – describes it as an "embodied internet," offering the connectivity, utility, and entertainment of the web, but fleshed out in 3D.

This is usually discussed in VR terms. For example, we have digital domains where synchronous interaction takes place between place-shifted participants. Those include **Altspace VR**, **Rec Room**, **VRChat**, Horizons Workrooms and (much earlier) **Second Life**.

But the Metaverse concept also applies to AR. You could say that we just wrote the preceding 26 pages on how it applies. For example, companies like **Niantic** are building platforms to create digital enhancements to a physical world that are synchronous (experienced together at the same time) and persistent (anchored to locations).

This is AR's metaverse – though the definition and manifestation of that vision will continue to evolve over the next several years. Speaking of which, we must be realistic when future-gazing about the metaverse. Many of these principles are years away from materializing.

The Metaverse Stack

But though we're years away, the metaverse's component pieces are being developed today. That will include a sort of *metaverse stack*, with devices, sensors, 5G connectivity, LiDAR spatial mapping, AR cloud rendering and an app (or web) layer. These are all at very early stages and need time to evolve and converge.

Even the metaverse's use cases are unknown, though everyone likes to speculate. Novel use cases often aren't devised until new platforms seep into the developer mindset. Apps like Uber — utilizing the mobile form factor and 4G — weren't imagined when these enabling technologies were first devised or launched.

Rather, it took time and acclimation before developers could start thinking natively. Only then could they build experiences that tap into the unique advantages and capabilities of a new platform or paradigm. The same process will unfold for the metaverse, meaning we have ample innovation to look forward to.

Lastly, this metaverse tangent is partly to tee up next month's report. We'll dive deeper into the metaverse, beyond geo-local AR. What is it? How will it develop? And when? These questions are unknown, but we'll bring together leading voices and signals to pinpoint its position and extrapolate its directions.

Key Takeaways

- **Given AR's core function to fuse the digital and physical, geo-location is a key value-driver.**
- This can include everything from navigation and wayfinding to geo-anchored content and local discovery.
- This will be one way that AR's *metaverse* materializes, involving synchronous and geo-relevant content.

- **Prior to AR's current stage, geolocation has proved to add value to forbearing technologies.**
- In search for example, click value (CPC) is greater when local intent is signaled by the searcher.
- This local intent has a proven correlation to high-value and transaction-ready consumers.
- Google, Yelp, Foursquare and many others have built businesses around this principle.
- AR now enters the picture and will similarly find elevated value in geo-relevant experiences.

- **Google is one company with clear intentions around geo-local AR, or an "Internet of places."**
- This manifests in Google Lens and Live View which represent visual forms of its core search products.
- Google is also well-positioned for geo-local AR given the data it's assembled over the past 20 years.
- Google Images for example serves as a visual database that fuels object recognition in Google Lens.
- Street View similarly serves as a database for object recognition in its Live View navigation product.
- All these products are meant to gain traction today, with Google-esque monetization to follow later.

- **Google isn't alone: Apple is similarly making moves that indicate its interest in geo-local AR.**
- Apple's motivations are a different, with geo-local AR experiences meant to drive sales of its AR hardware.
- That hardware is iPhones today and AR glasses tomorrow, where it has ample investment on the line.
- By planting seeds for AR experiences (geo-local and otherwise) AR glasses can hit the ground running.
- Apple's geo-local AR products specifically include Geo-Anchors in ARKit and 3D navigation in Maps.
- Other geo-local clues exist, such as Project Gobi, involving AR-triggering markers at retail partner locations.

- **Facebook is meanwhile developing geo-local AR products as part of its broader metaverse play.**
- Facebook's metaverse will take place in VR through fully-immersive worlds, but also involve AR components.
- The first clue for the latter can be seen in its Live Maps which spatially-index the physical world.
- The goal is to have this data unlock interactions and annotations in the form of geo-relevant AR overlays.
- That could include social connections, as well as products and promotional content for Facebook advertisers.
- This makes Facebook's vision similar to Google's "Internet of places" but with a social twist.

- **Speaking of social, the king of consumer AR, Snap, is likewise developing geo-local AR plans.**
- These include Local Lenses, Snap Scan, elements of Snap Map, and a convergence of all these products.
- Snap's broader goal is to extend from selfie lenses to rear-facing camera AR to augment the physical world.
- To compete with the above players in assembling the underlying spatial data, Snap will crowdsource it.
- Given its extensive user base that captures Snaps daily, it hopes to simultaneously capture geo-spatial data.
- This is similar to the crowdsourcing geo-local AR play for another industry leader: Niantic.

- **Speaking of Niantic, its clearly intent on geo-local AR (see Lightship), among other players.**
- This list of others includes Microsoft, which will incorporate geo-local data into its enterprise AR play.
- It also includes Amazon, which is developing geo-local AR to support its core eCommerce business.
- Several startups also populate this list, including Gowalla, ARWay, Resonai, Darabase, and others.

- **Besides the investment of the above tech giants, geo-local AR will have other moving parts.**
- Spatially mapping the inhabitable earth is no small feat: Supporting tech will continue to develop.
- 5G will be a force multiplier for geo-local AR in providing faster speeds and highly-precise device tracking.
- LiDAR will likewise support geo-local AR by empowering the above crowdsourced spatial mapping efforts.
- Altogether, these efforts will get the AR industry closer to its ultimate endgame – a geo-spatial metaverse.

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 data to reveal opportunities and dynamics of spatial computing 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's been an industry analyst covering emerging and immersive tech since 2005 and is now Chief Analyst of ARtillery Intelligence and Editor-in-Chief of *AR Insider.*

Mike is a frequent speaker at events such as AWE, VRLA and the VR/AR Global Summit. He has authored more than 150 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' 16 years in tech-sector research and intelligence. This includes the past 6 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 its reports, unless specified in footnotes and endnotes. The production of this report likewise wasn't commissioned. 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.

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Contact

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

Reference

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[i] ARtillery Intelligence Article: **Will iOS 14 Lessen AR Friction?** (sign-in required)
[ii] U.S. Census Bureau: **Share of Consumer Spending that Happens Online**
[iii] ARtillery Intelligence Report: **Mobile AR Global Revenue Forecast, 2020-2025** (sign-in required)
[iv] Disclosure: This report's author owns stock in NexTech AR Solutions.