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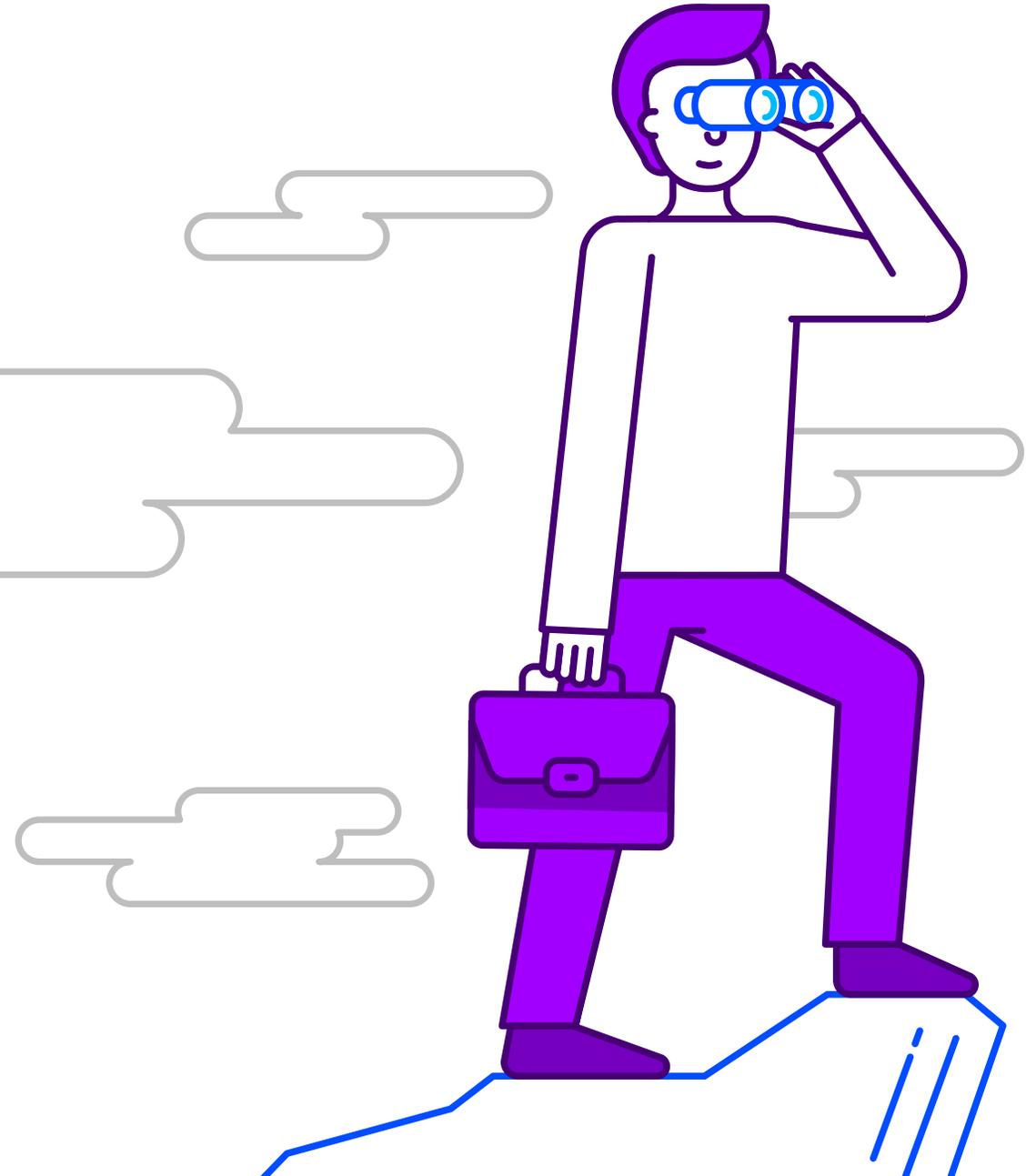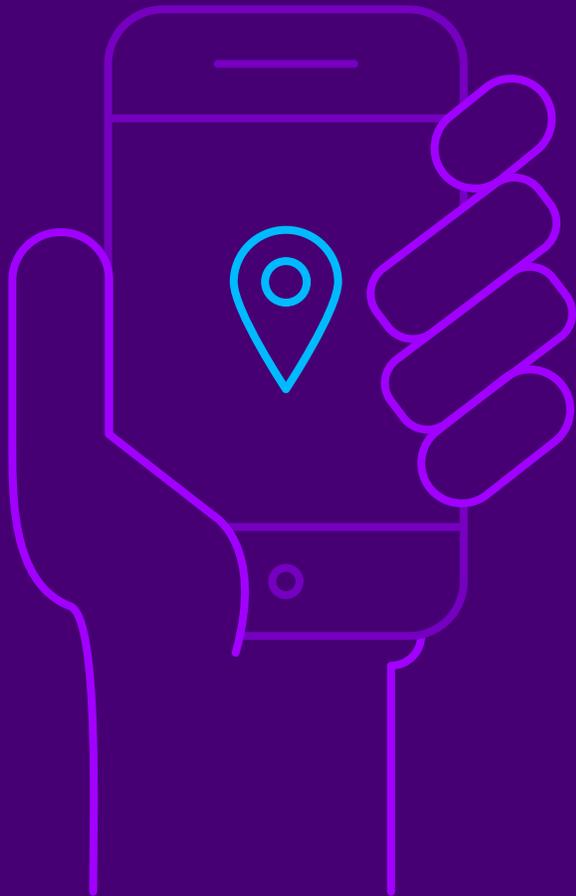## WHERE NOW?
CHARTING A PATH IN GEOSPATIAL

Location is an increasingly important source of value creation.

Cloud computing, mobile devices and sensors, data analytics and machine learning have allowed companies to leverage geospatial data and services to build new multi-billion dollar businesses, fueling a step change in geospatial investment.

The real world changes constantly and the opportunities for exceptional customer experience when the real and digital worlds are aligned are significant. Understanding the evolving and increasingly complex geospatial ecosystem, and executing against a constantly shifting world, are key to ensuring that geospatial becomes a source of competitive advantage.

'Geospatial' broadly covers the content, services and applications that have location at their core, and the data, intelligence and systems that feed them.

THE WORLD OF GEOSPATIAL

For generations, our models of the real world – and the gaps in those models – have driven innovation.

In the age of discovery, explorers saw territory beyond the known world as inspiration to explore and trade. In the same spirit, the lack of a digital map of India spurred Google to mobilize its community to build one, and then to inform, shape and monetize a country's local behavior. And today, Uber, Lyft, DiDi and Grab use their ride sharing apps to shape real world behavior, creating new gathering points to change how we get around efficiently.

'Geospatial' broadly covers the content, services and applications that have location at their core, and the data, intelligence and systems that feed them. Base maps are often the 'store front' for geospatial but there are many layers in play, including relatively permanent road and public transit networks and natural features, points of interest (POI) and their associated attributes (from opening hours to deals and reviews) and highly temporal data like traffic, wait times and the pickup point for a trip.

There is no single definition of what pieces matter.

Ask any two product owners what content and capabilities are core, and you will get two different answers. Content and services, and the characteristics of each, are heavily dependent on scenarios, audience and geography, but can include the following:

Geospatial content

- Local advertising
- Rich content
- POI
- Geocodes
- Transport
- Dynamic layers
- Static layers
- The base map

Geospatial services

- Display
- Geolocate
- Place search
- Local search
- Directions
- Turn-by-turn navigation
- Targeting
- Spatial queries

APIs and Controls

GIS Tools

Consumer applications

- Maps and directions
- Local search
- Navigation
- Social sharing
- Sharing economy
- B2C

New actors and applications

- Autonomous Vehicles and drones
- Shared mobility
- Digital assistants
- Augmented reality
- IOT

Enterprise and public sector

- Asset tracking
- Utilities
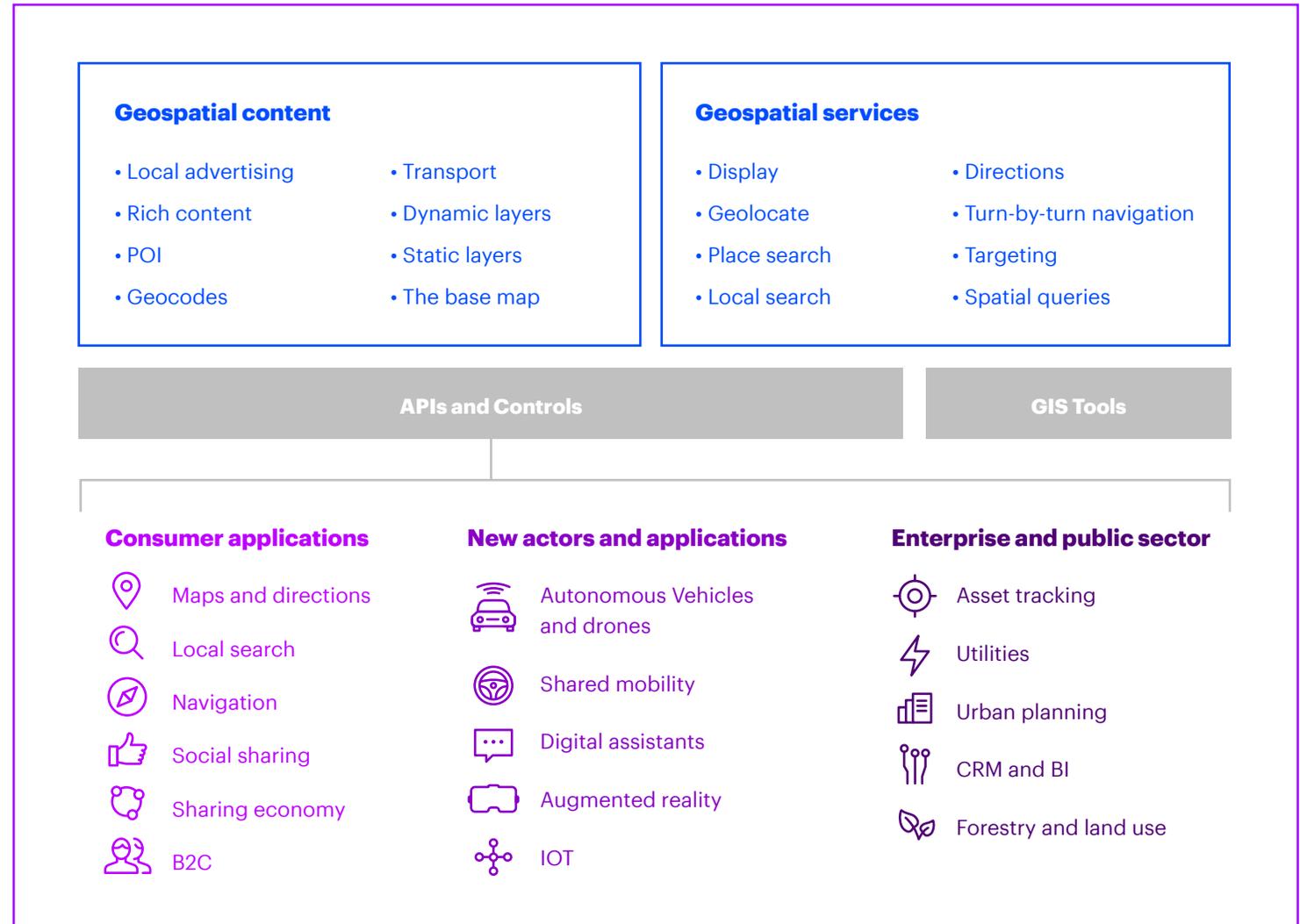- Urban planning
- CRM and BI
- Forestry and land use

Figure 1.

Like the world it describes, the capture, processing and distribution of content in a location-based environment is constantly evolving, driven by new technologies, shifting ecosystems and scale effects.

Geospatial represents the intersection of the constantly changing real world and our digital version of it. When there is a gap between these worlds, customer experience suffers. It may take the form of incorrect wait and travel times, unreliable schedules, or irrelevant recommendations or ads.

In new scenarios with no human in the loop to bridge the gap between real and virtual versions of the world, the quality of data becomes even more critical. Implications can be dramatic when considering autonomous vehicles, drones or other moving objects.

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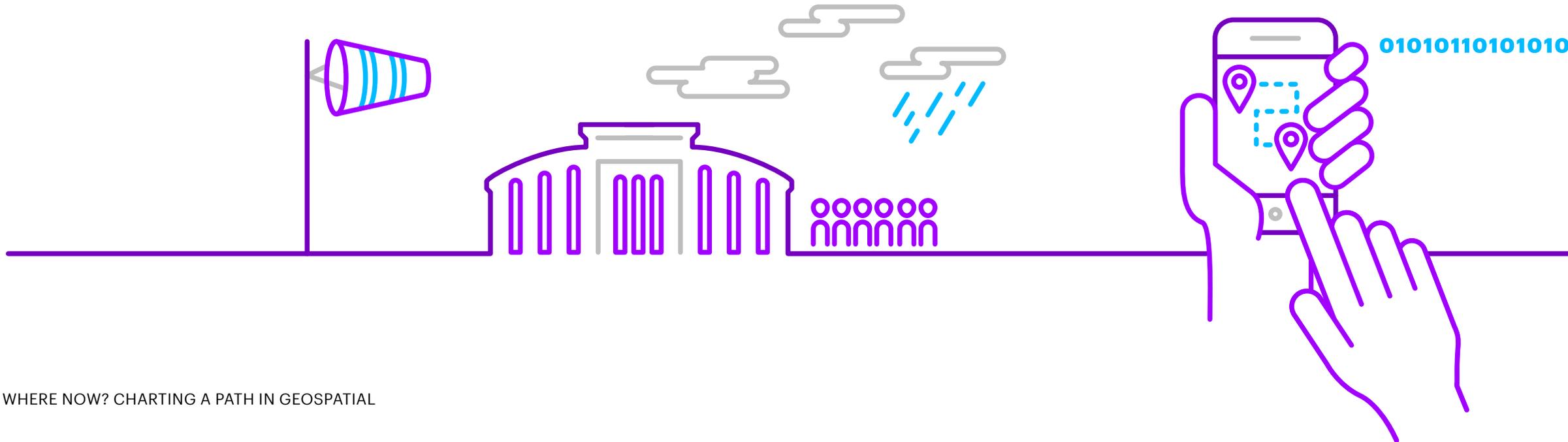
The growing availability of data for real-time feedback promises to help close this gap for leaders in the industry, creating powerful network effects for businesses that can harness data at scale and speed.

In an increasingly competitive real world, the most accurate, information-rich, digital snapshot can make all the difference – for the shortest wait-time for a ride, the best utilized fleet, the most reliable delivery or the most seamless augmented reality experience.

The accelerating digitalization of the real world and our activity within it is driving new opportunities to serve the needs of consumers and professionals, enterprises and organizations. By understanding geospatial opportunities and challenges, organizations can more easily navigate the geospatial ecosystem and realize the value creation potential that geospatial promises.

AN INDUSTRY OF CHANGE, INVESTMENT AND ACCELERATING GROWTH

The first wave of geospatial innovation – 'Where 1.0' – gave rise to the geographic information systems (GIS) industry and global positioning system (GPS) navigation devices. It fueled the growth of companies such as ESRI, TomTom and Garmin (Figure 2). The most recent wave of geospatial opportunity and investment – 'Where 2.0' – was largely built around two milestones: (1) The launch of the iPhone with 'always-on' GPS and data connectivity and (2) Google's integration of maps into its search on-ramp and the launch of a freely available mapping API for developers. Geospatial is now entering a new era – 'Where 3.0' – characterized by order of magnitude investment growth and a slew of new players.

	WHERE 1.0 1980's—2005	WHERE 2.0 2005—2016	WHERE 3.0 2016+
Sensors	PNDs	Commercial fleets, smartphone GPS	Sensor suites (camera, LIDAR, etc) on the road at scale. High res aerial, satellite and drone sensors
Data	Mapping provider duopoly	Ground Truth and local search data	New mapping data ecosystems, step change in volume and richness
Software	Professional GIS community	Mapping APIs	Massive scale data processing and analytics at low cost in the cloud and at the edge
Operations	2 full scale commercial mapping operations	3 full scale commercial mapping operations	Multiple full scale mapping operations
R&D Investment	Limited	Enabling technologies e.g. computer vision	DNNs, compression, sensing, infrastructure...

Figure 2.

Recognizing how critical geospatial will be to their future, platform companies are making major geospatial investments.

In 2016 the head of Uber's mapping effort stated they were "doubling down" on their investment in mapping in order to improve their core product and prepare for future uses.[1] In 2016 Apple opened a 4,000 person office in India to focus on maps development.[2] Google's large and sustained investment in mapping is well known, while the number of companies with geospatial at the core of the user experience – from Snap to Tesla – continues to grow.

Companies are also moving to secure strategic assets in the geospatial ecosystem. The $3.1 billion investment made by BMW, Audi and Daimler in the digital mapping service HERE – and the growth of the consortium to include Intel, Bosch, Continental and Panasonic – demonstrated how critical an asset it was to control.[3] In China, both Tencent and Alibaba either own or have invested in mapping companies.

Significant new investment is flowing into new location startups, motivated by the immediate opportunity and the promise of emerging applications. In October 2017, Softbank led a $164m Series C round for Mapbox, a location data platform for developers.[4] Company investments are complemented by an explosion of sensors to support geospatial, including Lidar, stereo camera, infrared and sonar, which are finding their way into new devices, and driving price points down to unlock further growth.

All of these factors reflect a strong and growing recognition of the importance of geospatial assets. Major players are investing, new startups are emerging, geospatial data and related businesses are well valued, and business and consumer monetization of location is stronger than ever.

THE OPPORTUNITY CREATED BY DISRUPTIVE NEW GEOSPATIAL BUSINESSES

Geospatial's order of magnitude investment growth is underpinned by a growing reality: geospatial data and technology are the fuel for disruptive innovation. Geospatial technology allowed new entrants to quickly upend personal navigation when the launch of the iPhone spurred skyrocketing growth in mobile navigation app users (Figure 3). Similarly the personal transportation industry is being radically redefined by the newer entrants. The ratio of Uber and Lyft drivers to taxi drivers recently passed seven to one in the United States.[5]

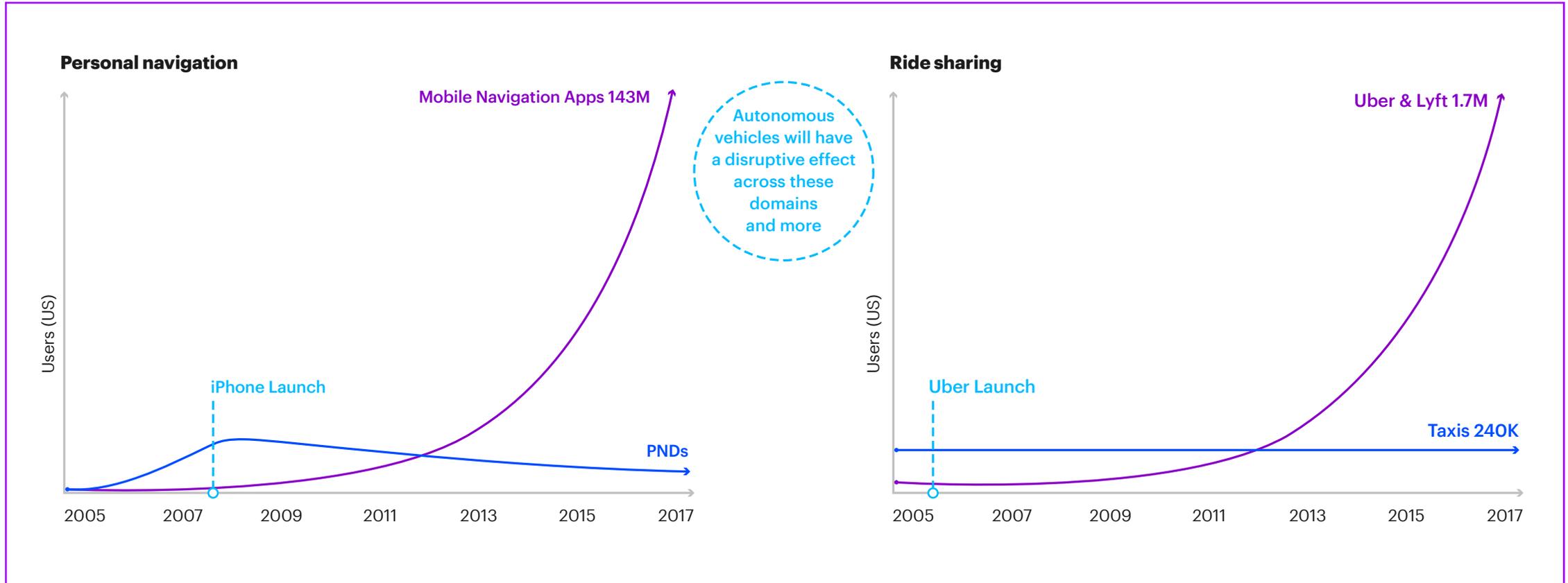# Geospatial data and technology is an enabler of disruption & new value creation

Personal navigation

Mobile Navigation Apps 143M

Users (US)

iPhone Launch

PNDs

2005 2007 2009 2011 2013 2015 2017

Autonomous vehicles will have a disruptive effect across these domains and more

Ride sharing

Uber & Lyft 1.7M

Users (US)

Uber Launch

Taxis 240K

2005 2007 2009 2011 2013 2015 2017

Figure 3.

LOOKING FORWARD,
SIX MAJOR BUSINESS CATEGORIES
EXEMPLIFY THE NEW WAVE
OF VALUE CREATION.

01

SHARED
MOBILITY

02

AUTONOMOUS
VEHICLES

03

LAST MILE
DELIVERY

04

AUGMENTED AND
VIRTUAL REALITY

05

INTERNET OF
THINGS

06

GEOSPATIAL
ANALYTICS

01

SHARED MOBILITY

Geospatial data and decision making are critical to ride, car and bike sharing, and the shared mobility industry investment spans global, national and local players. Recent research by Accenture on customer feedback on ride sharing apps shows the importance of maps and navigation, and geospatial-influenced factors such as wait time and shared rides, on customer satisfaction (Figure 4).

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User feedback categories for major rideshare companies

Maps and navigation 19%
Charging issues 15%
Product features 15%
Wait time 11%
Customer support 11%
Driver issue 11%
Driver cancellation 9%
Shared rides 4%
Product performance 4%
Data security 1%

■ Highly geospatial-related   ■ Geospatial is a key component   ■ Geospatial is not a key component

Note: Study reviewed the App Store's most recent customer reviews and ratings to identify drivers of user dissatisfaction with three rideshare companies. N=300 written reviews with ratings from 1 – 4. % shows proportion of reviews for each company that were attributable to that issue.

"

My [ride] was sent on a goose chase trying to find the location I was at.

—

It said 3 minutes then took 20-25 as they were dropping someone off, stuck in traffic which you'd think [the company] would account for.

—

This app will be set to take me to work and give me a reasonable time, only to pick up three different people in the opposite direction that I'm going.

Figure 4.

AUTONOMOUS VEHICLE

Autonomous Vehicle (AV) perception, decision making and SLAM (Simultaneous Localization and Mapping) require high quality geospatial content and trained algorithms to navigate, follow the rules of the road, anticipate the path beyond sensors, localize, and decrease the cognitive load of processing the environment in real time. Safety and trust are paramount. Drones and autonomous aerial taxis introduce further complexity and data needs with altitude, terrain and weather data.
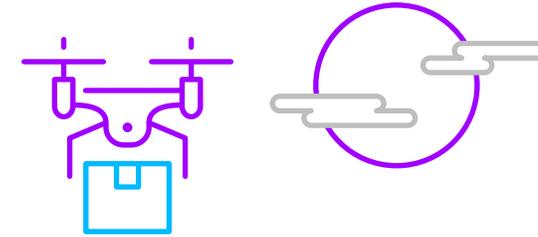
LAST MILE DELIVERY

Customer expectations are changing from two-day to two-hour delivery and better. Such responsive delivery requires highly efficient route optimization across huge networks and accurate supply, demand and traffic forecasting. These factors take on a whole new dimension when the last mile delivery is accomplished by drones. The rewards of winning the delivery war merit massive investment.
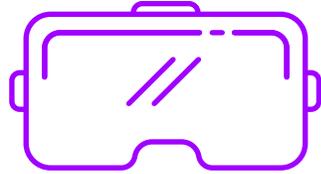
AUGMENTED AND VIRTUAL REALITY

Augmented Reality (AR) is the ultimate hybrid of the digital and real world. AR applications impose very high precision requirements on the data that are integrated into them. Data captured at lower precision with earlier generation tools and technology may not register well in a high fidelity augmented world, introducing an ongoing need to keep content and the digital world in step. Immersive Virtual Reality (VR) requires highly accurate and photo-realistic 3D models for certain scenarios.

INTERNET OF THINGS

Many platforms that enables Internet of Things (IoT) devices must handle a vast amount of geospatial data and provide analysis, interpretation and visualization. From consumer scenarios in wearables and home automation, to critical operation and protection of connected assets in field operations, location is core, including in scenarios where traditional location markers (e.g. roads, POIs) do not suffice such as mines, offshore drill sites, factories and other indoor settings.

06

GEOSPATIAL ANALYTICS

The insights that can be gleaned from real world geospatial data analysis are practically unlimited, from customer demand forecasting to crop yields, from changes in the polar ice caps to changes in traffic flow patterns. Sensor data, including camera and LIDAR, are yielding more insights as petabytes of data can be analyzed increasingly cost effectively and efficiently, as computer vision and machine learning algorithms improve and scale, and as reduced sensor costs and new satellite constellations improve coverage and refresh rates. A number of companies are growing in this space, including Descartes Labs, while companies like Digital Globe expand beyond content to seek to provide an analytics platform at scale. For geospatial asset creation, computer vision, fed by the growing availability of high-res satellite & aerial imagery, works in tandem with mobile sensors for accuracy and freshness. Drones are enabling further analysis, as engineers, construction supervisors, surveyors, and firefighters all rely on 2D and 3D digital reconstruction to enable better and faster decision making.
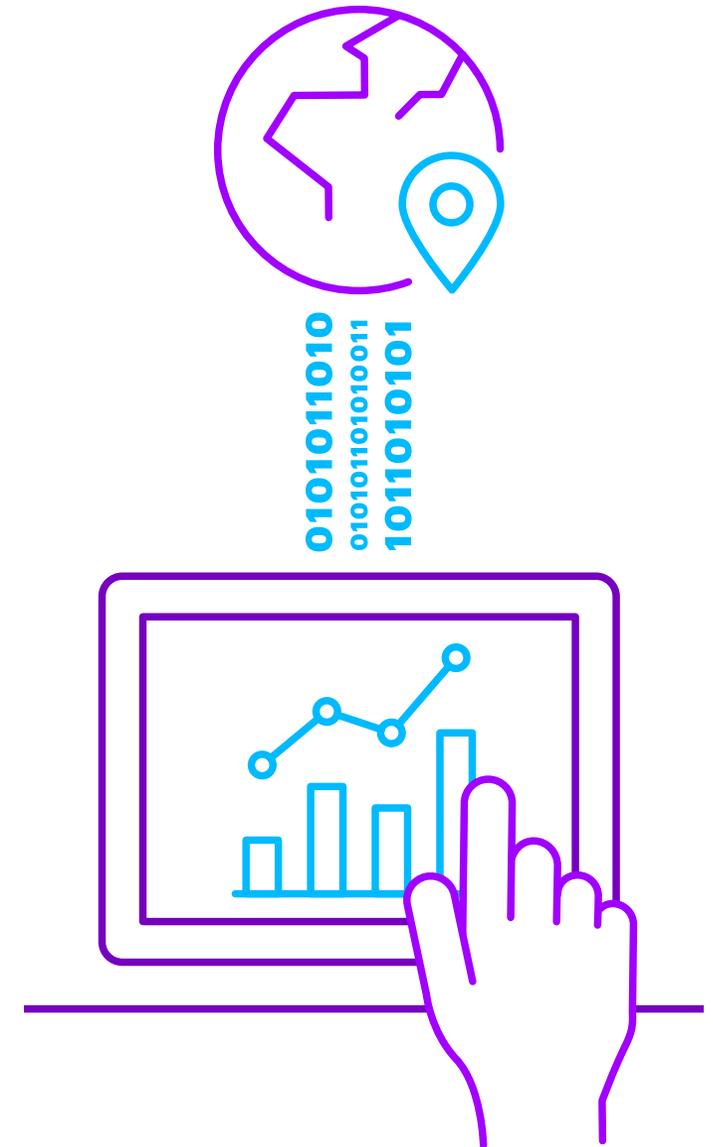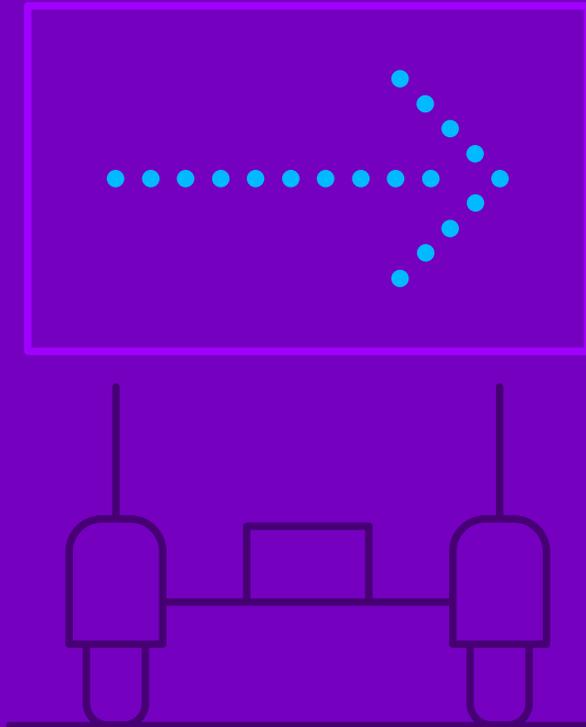
PROCEED
WITH CAUTION

As organizations consider how best to seize the new geospatial opportunity, enthusiasm clearly needs to be tempered by pragmatism and a well planned approach. There are key elements to consider in design to secure long-term advantage, not the least of which are user expectations, privacy, localization, resiliency, asset acquisition and system deployment planning.

FOCUS ON CUSTOMER EXPERIENCE

Quality is paramount in geospatial, as many companies have very publicly discovered.

When the digital world is not aligned to the real one, it is very obvious and the customer experience is directly impacted. Geospatial experiences can have strong feedback loops, including real-time traffic and ride wait times.

However, issues with outdated layers that don't reflect road closures, incomplete or incorrect data, sub-optimal routing algorithms that cause trips to take longer than necessary or fleets to be inefficient, and stagnant systems that don't learn from real-time data, all contribute to customer experience friction or failure.

It is important to ask whether you control the key levers of customer experience, and can execute to close the most important gaps, and keep them closed during growth.
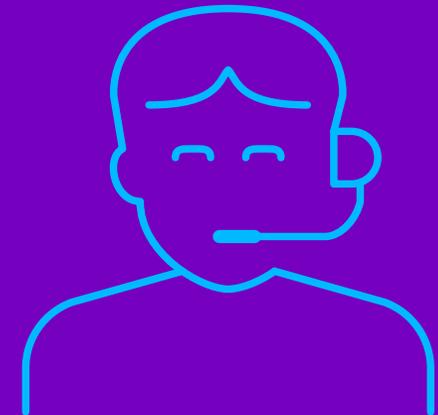
PROTECT TRUST

Personal location data are highly valuable and highly sensitive.

Even anonymized data can be used to infer personal behaviors and identities. Location data needs to be secured, used appropriately and in line with clear permissions. Increasing oversight of data privacy across the industry is perhaps of even greater importance in geospatial, where loss of trust in handling location can quickly result in users shutting off the supply of data and a company's services being rendered useless.

Conversely, designing and delivering highly relevant, useful and delightful experiences based on location can deepen engagement tremendously.

It is important to ensure that data privacy and security reflect local rules, and communication on how data is used reflects a consistent truth throughout the entire system.

RECOGNIZE IT'S NOT ONE WORLD

The diversity of the peoples of the world is mirrored in geospatial.

Addressing systems vary widely, from highly accurate street addresses and postal codes to landmark-based way-finding. Governments assert varying levels of control over the ownership and use of geospatial data. And, many regions remain poorly mapped relative to markets like North America and Europe where maps and navigation have historically been able to sustain investment. Expansion to new markets relies on local knowledge and often local data suppliers.

It is important that operations are designed and resourced to scale, and systems can accommodate geographical diversity with minimal friction.

BUILD FOR CHANGE

It is a truism that the digital version of the world is out of date the moment that it is published.

For example, estimates indicate that 10 to 15 percent of the road network changes every year[6] and that an average of twenty-one major US retail stores closed every day in 2017.[7] China urbanized more people in the last 30 years than the entire US population.[8] Frequent travelers have seen how traffic patterns at airports have changed with the growth in ride sharing pickups. Therefore, resilient and agile processes and systems are needed.

It is important to design and build for constant change in geospatial, and balance investment between setup and maintenance.
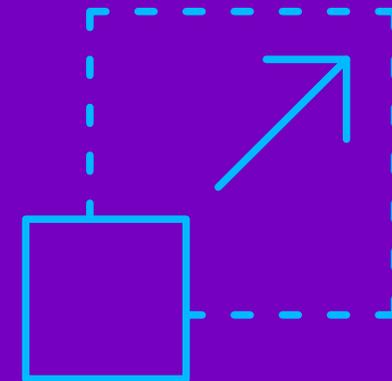
OWN THE RIGHT PIECES

Each company's approach to build vs. buy vs. license will be different based on business and product strategy, the cost equation, capability, and competitive dynamics.

For some, the base map may be a commodity they can build upon – and an increasing number of companies are evaluating the community-maintained Open Street Map as a viable base map – but more real-time data or unique customer data assets may be critical to own. Where a competitor can only refresh its view of the world monthly, a daily or hourly view of the real world may represent a material advantage. Where assets don't exist to support expansion into new geographical markets, businesses may need to invest to create the assets themselves. And where use of a third party service gives a competitor insight into user data, albeit anonymized, that may represent an unacceptable threat. Where dependencies are taken, they should be evaluated rigorously and continuously to remain competitive.

**It is important to clearly evaluate which assets to own, and which to partner for and with whom.**

AVOID HIDDEN TECHNICAL DEBT IN MACHINE LEARNING SYSTEMS

Machine learning has accelerated the pace of innovation by processing large amounts of geospatial data to enable complex prediction systems.

As machines gather more data and use it intelligently to predict trends, such as traffic and user behavior, it becomes increasingly difficult to fix issues at a system level in a live environment. That can result in incorrect data gathered in one system rippling across multiple systems that use the machine learning model data. For example, if an autonomous vehicle mis-observes a street sign and sends that inaccurate observation back to base, it could then propagate broadly, becoming part of a data set used for machine learning in vehicles across the fleet.

It is important to be prudent in how model systems are deployed, and how ground truth data is validated, with an appropriate balance of human and machine.
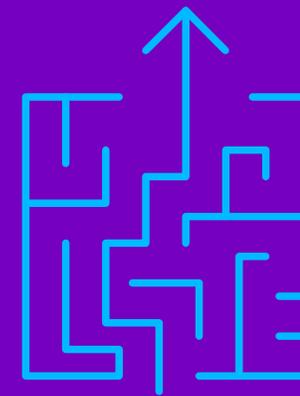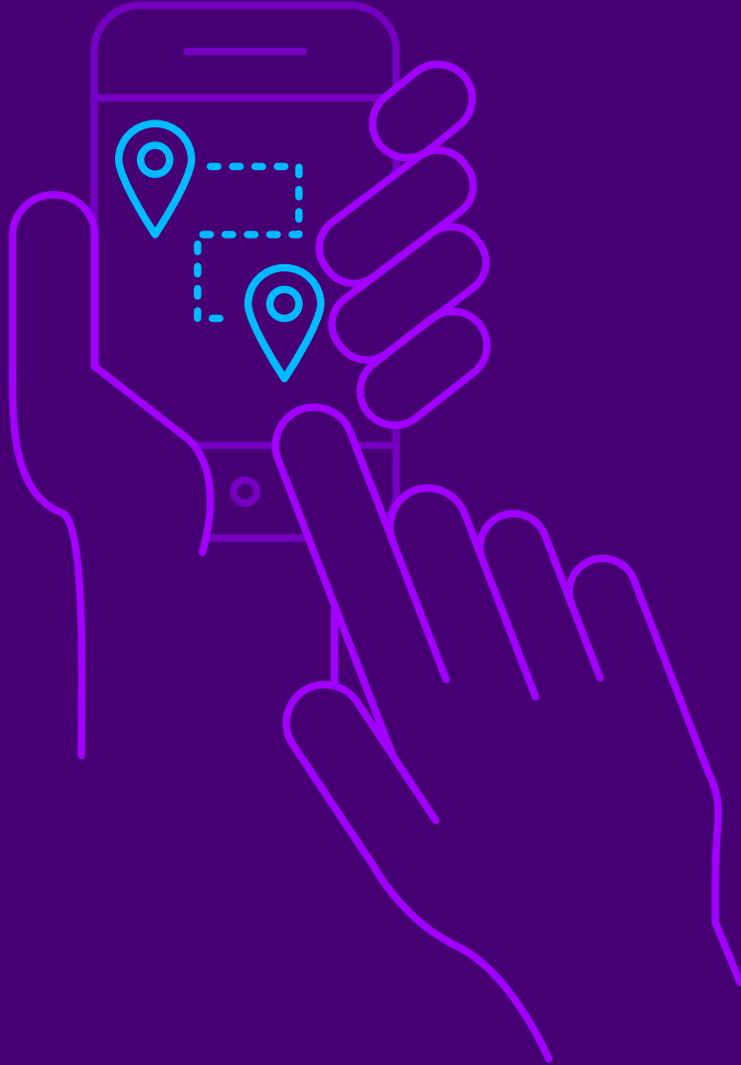
Geospatial's time is now: How will you navigate?

The choices on how and where to deploy geospatial are sizable strategic investment decisions that involve maps, but also machine learning, content, and data about the real world, including user data. If an organization is critically dependent on a third party for its geospatial needs, that may highly constrain its customer experience, product and business innovation strategy. Making the right moves early and with the flexibility to grow could be a significant competitive advantage as market dynamics unfold.

As geospatial integrates deeper with other major technological disruptions such as cloud computing and artificial intelligence, organizations need partners with deep understanding of geospatial business opportunities and associated technological challenges, and the ability to execute at scale.

In this fast moving space there are many new frontiers to explore, from the great indoors, to the more elevated world of drones, to smarter cities. In each of these areas there are new opportunities for geospatial to unlock.

In many growth businesses, data quality and use rights will be important competitive advantages. The Economist recently asserted that "Data are to this century what oil was to the last one: a driver of growth and change."[9] Geospatial data is key. The amount and quality of data and the ability to derive insights and create new products and experiences from it form a competitive moat that will only deepen. Those with access to data, who can put it to use most effectively and constantly adapt, will be well positioned to follow the great explorers in securing new and profitable beachheads.

The value of geospatial has never been higher, the importance of a robust strategy and execution capability designed for scale never greater.

# GEOSPATIAL IMPORTANCE TO CONSUMER TECHNOLOGY TRENDS

Recent research by Accenture involving a survey of 21,000 online consumers, showed the importance of location-awareness and geospatial functionality to major consumer technology trends.

32% of respondents favor self-driving cars to get them from point A to B more efficiently, one of only three tasks where more people feel confident in self-driving cars over human-controlled vehicles today (the others are allowing multi-tasking and entertainment while driving).
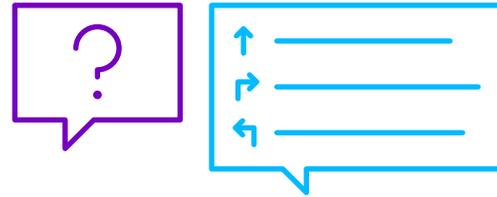
The most popular task for digital voice assistants while on the move was getting directions (40% use embedded DVA, 31% standalone); 21% of respondents use an embedded DVA, and 21% a standalone DVA, to check traffic.
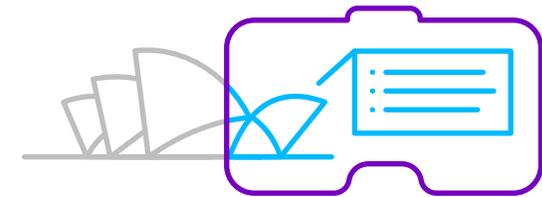
The top AR/VR scenario is learning about a place you are visiting.

AN INDUSTRY BEING RESHAPED

With geospatial as the fabric that underpins new business models, there will be some fundamental shifts in geospatial technology, its availability and use (Figure 5).

Trends in shared mobility, AV & commerce reshaping geospatial
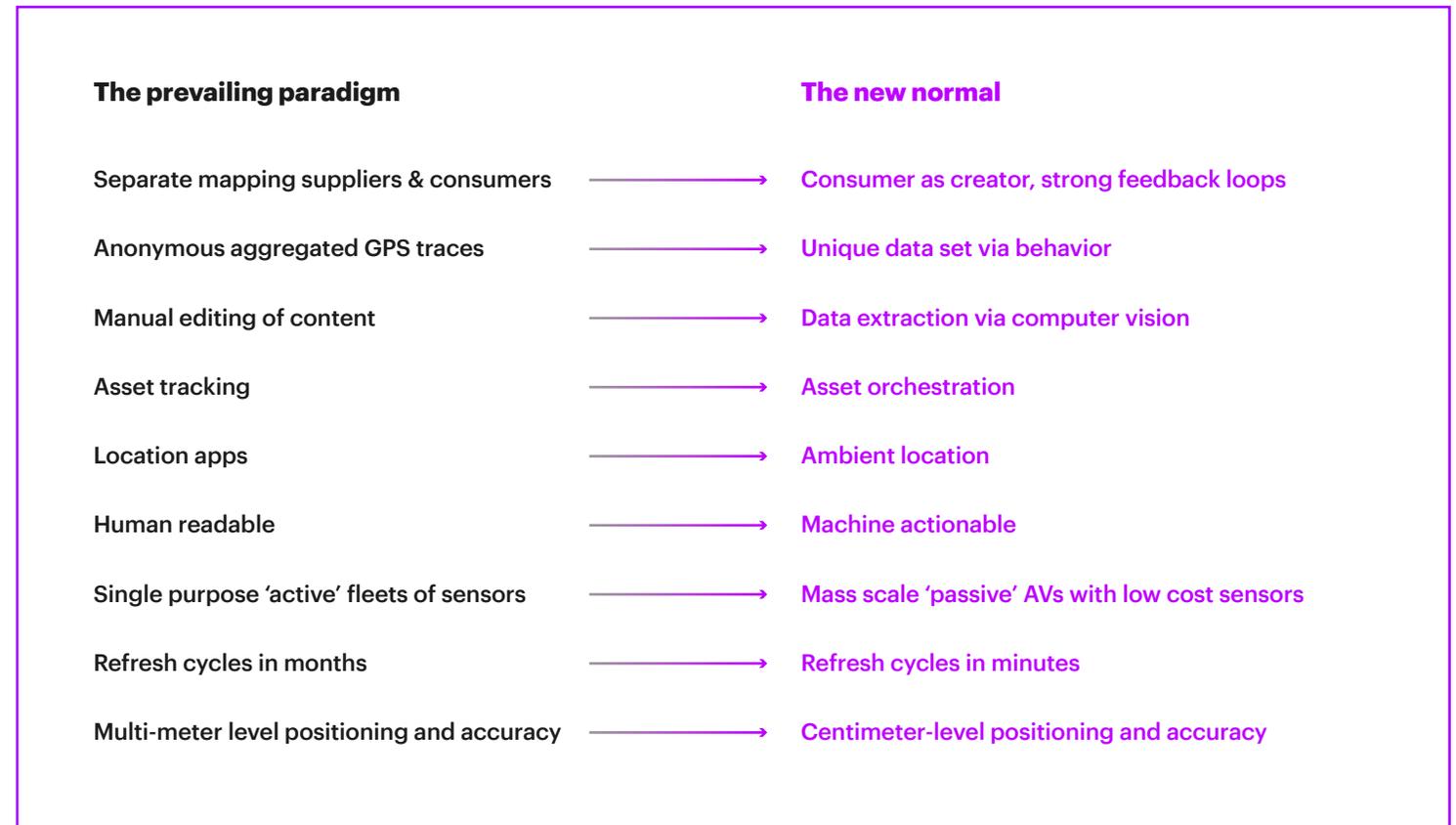
The prevailing paradigm	The new normal
Separate mapping suppliers & consumers	→ Consumer as creator, strong feedback loops
Anonymous aggregated GPS traces	→ Unique data set via behavior
Manual editing of content	→ Data extraction via computer vision
Asset tracking	→ Asset orchestration
Location apps	→ Ambient location
Human readable	→ Machine actionable
Single purpose 'active' fleets of sensors	→ Mass scale 'passive' AVs with low cost sensors
Refresh cycles in months	→ Refresh cycles in minutes
Multi-meter level positioning and accuracy	→ Centimeter-level positioning and accuracy

Figure 5.

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[3] http://www.bmwblog.com/2016/06/27/bmw-audi-mercedes-purchase-maps/

[4] https://blog.mapbox.com/softbank-mapbox-series-c-be207b866b27

[5] Accenture analysis. Sources: CTA, eMarketer, Bureau of Labor Statistics, Reuters, Medium, Business Insider

[6] https://www.tomtom.com/lib/doc/Maps%20White%20paper_UK.pdf

[7] Kelley, Michael, "A staggering amount of U.S. retail stores closed in 2017," Yahoo Finance, January 5, 2018

[8] Notes: World Bank 1985: pop ~1.05B and ~22% urbanized or .23B; 2015: pop ~1.4B and ~57% urbanized or .79B; difference is .56B > US pop.

[9] https://www.economist.com/news/briefing/21721634-how-it-shaping-up-data-giving-rise-new-economy

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