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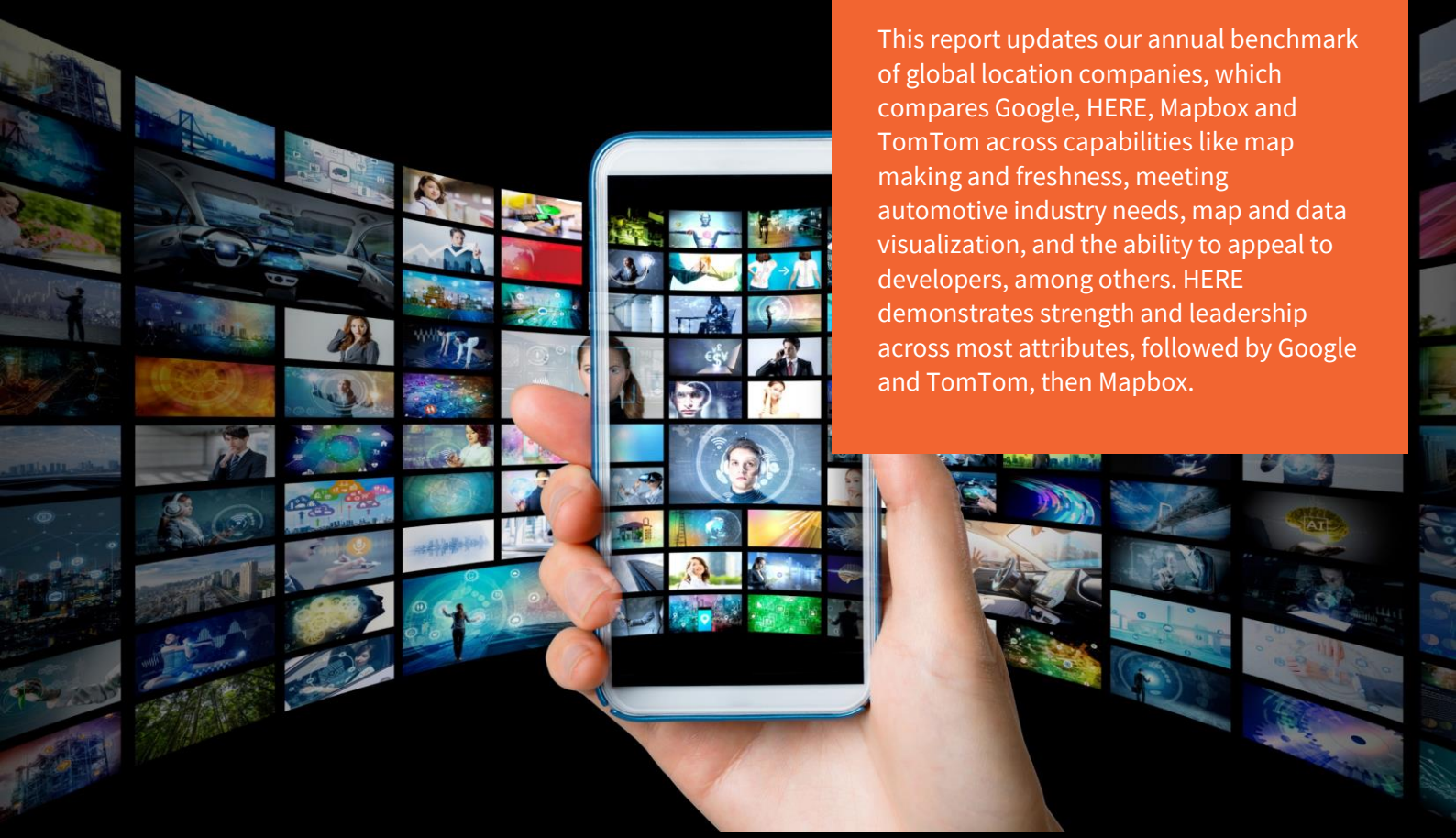
Wireless Media

Location Platform Benchmarking Report: 2021

20 April 2021



Report Snapshot

This report updates our annual benchmark of global location companies, which compares Google, HERE, Mapbox and TomTom across capabilities like map making and freshness, meeting automotive industry needs, map and data visualization, and the ability to appeal to developers, among others. HERE demonstrates strength and leadership across most attributes, followed by Google and TomTom, then Mapbox.

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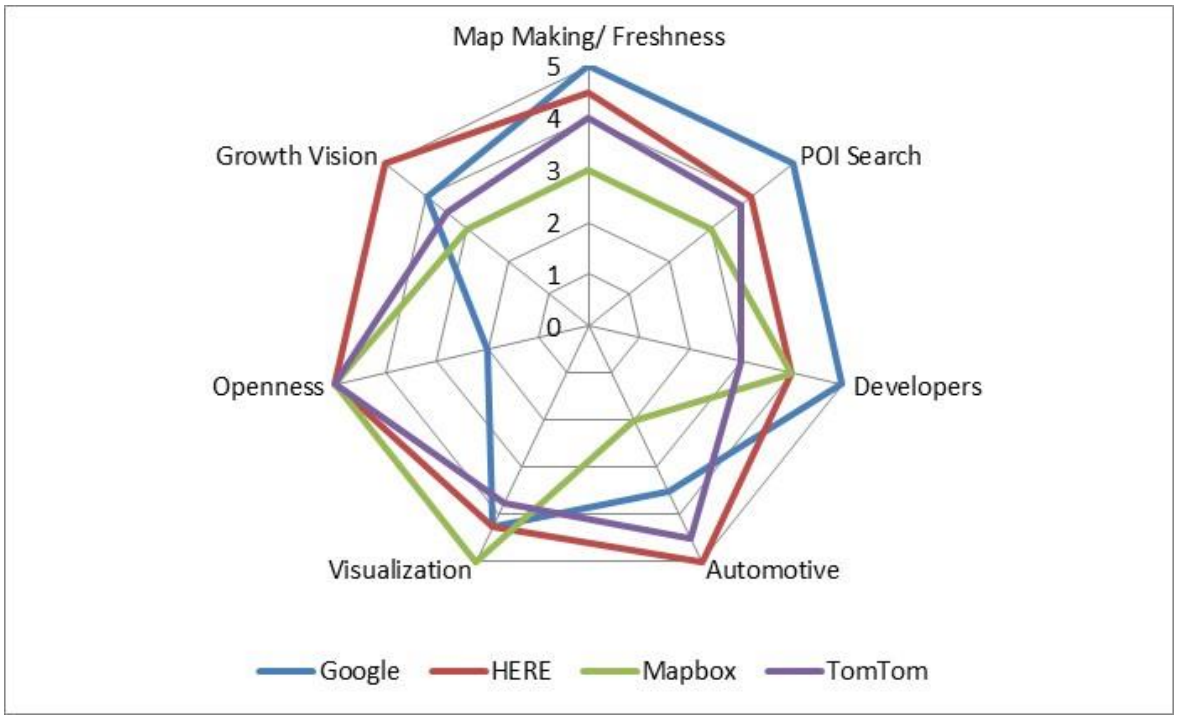
1. Executive Summary

In the 2021 Strategy Analytics' location-platform benchmarking report HERE is a leader and co-leader across many of our seven categories, followed closely by Google and TomTom, and Mapbox in final position. Competition in the location sector remains intense as both use-cases and the nature of demand evolves.

- Strategy Analytics annual benchmarking ranks location platforms, Google, HERE, Mapbox and TomTom across the following seven categories: Map-making and freshness, automotive, POI search, developer community, openness and flexibility, map and data vision, and industry vision/ growth.
- HERE remains a leader in automotive and industry growth vision. It is also a co-leader in openness and scores strongly in other categories, like map-making. HERE's platform approach is beginning to pay dividends and is driving non-automotive growth across target sectors, e.g. transport and logistics, telecoms, media, and technology, among others. Partnerships, its open, multi-platform approach, and tech innovation remain key pillars of its growth strategy.
- Google maintains leadership in map-making and freshness, place search and developer community. The granularity and scale of Google's place search is unrivalled. Its weakness remains a lack of openness and flexibility. Its progress in automotive continues – adding Ford as a customer while Waymo continues to build its autonomous capability. Google has significant resources, tech leadership, and a strong consumer and developer brand in location services as key strengths.
- TomTom is a co-leader in openness and flexibility. TomTom scores strongly in map-making and automotive, and has improved its score in multiple areas, including POI search, developers and visualization. TomTom is a leader in traffic content. TomTom's focus remains on automotive and enterprise and since the last report has announced a raft of orders in these domains, including Ford, Stellantis, Huawei, Verizon, Precisely, and Uber among others.
- Mapbox remains a leader in visualization and a co-leader in openness. Mapbox's reliance on OpenStreetMap (OSM) and probe data enables it

to provide map coverage at scale with low cost. However, community mapping lacks scale, consistency, quality assurance and provenance to satisfy all needs. Mapbox has made some progress in automotive, with BMW a highlight, but has a broad range of customers across other sectors, including Snapchat, Strava, dpd, and Grubhub and Tableau. Its joint venture with Softbank in Japan creates further growth opportunities to support advanced location services.

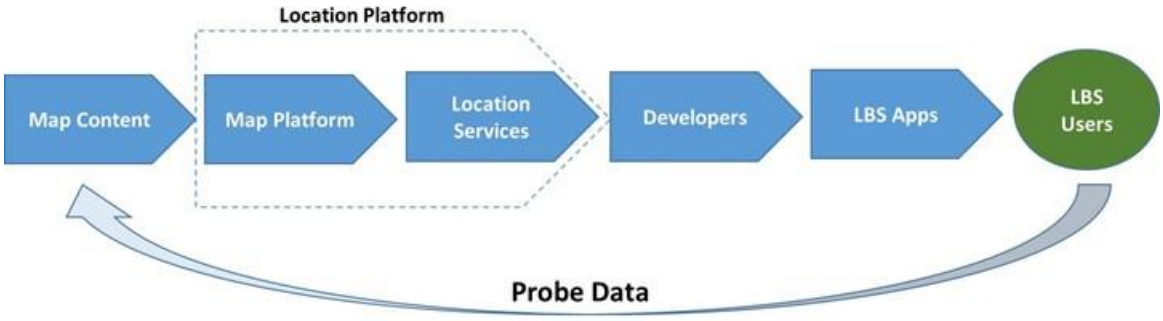


2. Introduction

2.1 Defining Location Platforms

Strategy Analytics defines a location platform as a company which provides customers with access to a range of location services which includes digital map tiles, location content geocoding (converting street names into coordinates and vice-versa), traffic-optimized routing, local businesses or points of interest (POIs) search, traffic flow and traffic incident information, and more. Location platforms enable enterprises and long-tail developers to integrate these horizontal location services into their own apps and services, so developers need not invest their own resources in building and maintaining their own maps and common location service capabilities, Exhibit 1.

Exhibit 1 The Location Based Services Value-Chain



Location-based applications and location services are usually underpinned by a map and supported by geolocation information provided either automatically via positioning technology like GPS, cell tower/ Wi-Fi signal triangulation, or manually (e.g. postcode input).

Location platforms also provide tools for businesses, organizations and developers to customize these location services to their needs. For example, from modifying the style of the map tiles or emphasizing specific details such as railway lines or public transport routes through to fully customized integration of location services into their own apps.

With the proliferation of sensors and connectivity location platforms enable enterprises and developers to integrate first-party data and third-party data with map content and location services to create their own custom maps, data visualizations, or unique location insights. For example, a real-estate agent comparing average property prices across a town or city, or retailers mapping cell tower or GPS data traces to identify high-footfall locations within towns. Location platforms can deliver solutions off-the-shelf or customized depending on customer needs.

2.2 Map Making & Maintenance Evolution

The future of map making continues to evolve towards the capture of reality in sub-meter detail and context with increasing automation and reliability.

The proliferation of sensors, connectivity, computer vision and edge and cloud (ML/AI) processing are all playing a role in creating highly accurate maps with sub-meter precision and scale. As is the falling costs associated with capturing high-definition imagery, lidar and other map data inputs. These maps support a variety of increasingly sophisticated use cases, delivering precision and accuracy to drive competitive advantage for companies which use them.

Map making and map maintenance is complex and requires significant investment and expertise in acquiring, extracting, and orchestrating flows of different datasets and content at scale. Only a handful of companies, including Google, HERE, TomTom and Mapbox, have the capabilities and resources to make and maintain maps at a global level. Over time, map making techniques have become increasingly sophisticated, automated, scalable, and cost effective. Machine Learning (ML) and Artificial Intelligence (AI) assists greater levels of automation in mapping. Modern map-making and maintenance requires normalizing, combining and conflating data from many different sources, each with pros and cons. Sources include imagery and data captured by mapping vans, satellite and arial imagery, crowdsourced data (ranging from manual edits, photographs, and computer vision), GPS probe data, and in future inputs from a broad range of IoT sensors. Imagery from low earth orbit satellites will also assist. Some of the pros and cons of each approach (though not exhaustive) have been outlined in our previous report.

3. Pandemic Opportunities and Challenges

The COVID-19 pandemic has presented both challenges and opportunities to the location industry with restrictions to movement and the closure of large parts of the economy (e.g. leisure and entertainment) lowering demand for location services. Simultaneously, location data and services have been required to assist with the pandemic response and to meet growing demand for home deliveries.

2020 was a challenging year for the location sector. Significantly fewer people travelled as normal, and economic uncertainty led to consumers delaying or cancelling the purchase of big-ticket items, like a new car. Travel has been negatively impacted on several levels with stay-at-home orders, the closure of meeting and entertainment venues, and personal health concerns all playing contributing roles. According to Strategy Analytics' Connected Mobility research, travel behavior has started to adapt. Use of public transport on buses, trains and trams has declined significantly, partly a result of restrictions but also due to fear of the strong potential for virus transmission in busy and enclosed carriages. This has resulted in a boom in sales of private mobility options (e.g. bicycles, scooters) and to membership rates to bike, scooter and car sharing services.

There is evidence that financial uncertainty created by the pandemic hit the consumer automotive market, with sales of new vehicles declining. Consumer research conducted by Strategy Analytics towards the beginning of the pandemic shows that between 22% and 26% of consumers across the Germany, UK and the US indicated they were likely to delay or cancel purchasing a car due to COVID-19. The same figure was 49% in China. Vehicle purchase has shown positive signs of rebounding though has yet to return to pre-pandemic levels.

The fall in personal and business-related travel is reflected in Strategy Analytics' AppOptix USA panel which highlighted sharp year-on-year declines in the use of apps in the transport and travel categories, including taxi hailing apps. It was also reflected in announced workforce cuts by companies operating in the mobility sector, although there are also signs of recovery here:

- In September 2020 Waze laid-off 5% of its staff (30 people) and closed offices in Asia Pacific and Latin America, as advertising demand slumped.
- In June 2020 HERE Mobility announced the closure of its HQ in Israel with 200 job losses.
- Mobility companies such as Uber, and Lyft, and business review site Yelp, also announced job cuts due to the pandemic.

The pandemic has also brought into focus the positive role of location services in supporting the pandemic response in a variety of different ways:

- Governments and public healthcare authorities have relied on map and location services to visualize the spread of the virus across towns, cities, and regions in their countries and to identify potential hotspots.
- GPS probe and cell-tower data have been used to anonymously track the movement of citizens to measure the extent to which the public is complying with lockdown measures.
- E-commerce and home delivery have boomed due to stay-at-home orders, placing greater demand on the transport and logistics sector, particularly last-mile delivery providers. Location services have played a role in enabling delivery drivers to optimise journeys to meet these increased demands.
    - Some local businesses and organizations have been forced to adapt their business model to provide delivery services to respond to the shift to online deliveries.
- Information about changes to store opening times, guidance on peak times in shops or on public transport, the availability of bicycles at bike sharing hubs, and other location intelligence has increased as consumers adapt their behaviour to fit rules and minimise the risk of infection.

Strategy Analytics believes there is reason for optimism that the world will return to some level of normalcy over the next few years due to vaccines, combined with shifting consumer behaviors, like observing social distancing.

4. Evolving Location Sector Demands

Location services and location intelligence can support a diverse variety of use cases across multiple sectors including automotive, fleet management, asset tracking, business intelligence, digital advertising, and consumers applications.

Demand for location services and location enhanced insights continues to expand across all sectors driven by their ability to deliver both operational efficiency and performance benefit for businesses, e.g., improved cost effectiveness, better risk management, and effective decision making.

Location services enable companies to achieve competitive advantage, through cost effectiveness, better risk management and improved decision making.

Even within established use cases the demands on location services and location intelligence are evolving. For example, location services like maps and navigation are core components of the vehicle infotainment system. However, as the automotive industry evolves to support assisted and autonomous driving, and electrical vehicles (EV), location services also need to adapt to meet changing demands.

Sophisticated 3D model with high levels of accuracy and attribution are enabling new experiences via mixed reality e.g. AR navigation and AR place search, and powering digital twins designed to simulate and predict real-word events, and train Artificial Intelligence.

The rest of this section provides examples of the growth opportunities in some of the main areas targeted by companies in the location-sector.

- The automotive industry
- The on-demand and mobility market
- Enterprise – asset management and IoT
- Consumer mobile applications
- Digital advertising and marketing

4.1 The Automotive Sector

Several forces are influencing the evolution of the automotive sector, creating both opportunities and threats for location companies:

- Rising penetration of vehicles with both embedded navigation and data connectivity to meet consumer needs.
- The desire of regulators and carmakers to increase road safety by providing increasing levels of assistance and support to drivers.
- Growing consumer and legislative demand for environmentally friendly electric vehicles (EV).
- Falling levels of car ownership and rising demand for mobility services, particularly in cities.

New vehicles with built-in navigation are becoming standard and will provide an opportunity for growth for in-vehicle navigation suppliers. Furthermore, in-vehicle connectivity (on-board and brought in) is driving the growth of connected navigation services and live location content.

Strategy Analytics expects the attach rate for navigation to rise from 38% of cars sold in 2020 to nearly 70% by 2026.

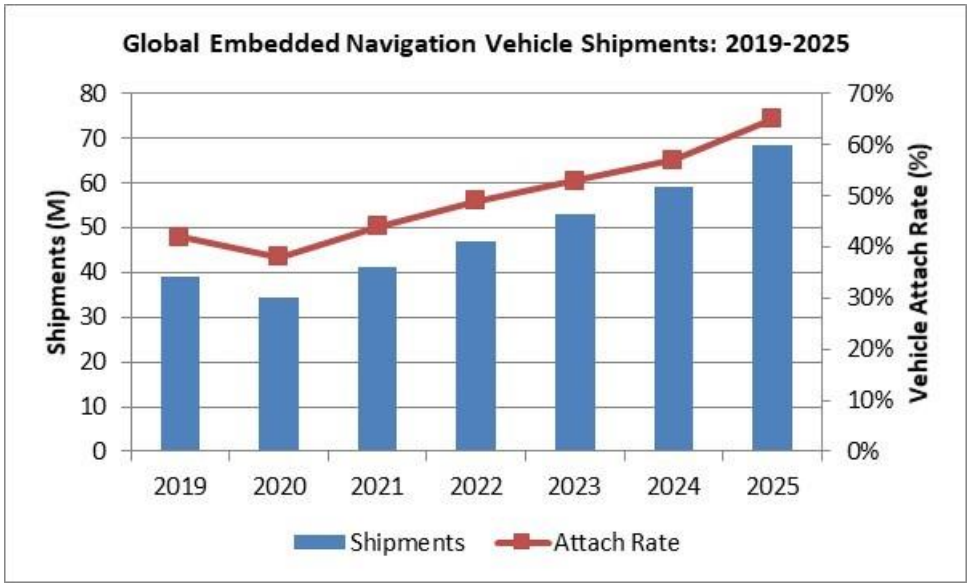
For carmakers, embedded and connected location services, such as turn-by-turn (TBT) navigation, traffic information, point-of-interest (POI) search (including parking and gas stations), will remain an important component of in-vehicle infotainment systems (IVI) over the next five-years. Specifically, navigation systems are becoming common in entry-tier vehicles. Strategy Analytics expects the attach rate for navigation to rise from 38% of cars sold in 2020 to nearly 70% by 2026 creating a significant growth opportunity for suppliers.

A sizeable drop in new vehicle sales in 2020, due to the pandemic, has resulted in more than a 20% decline in navigation unit shipments versus Strategy Analytics pre pandemic estimates, although annual volumes will make a significant recovery by the end of the forecast. Despite the negative impact of the pandemic over the next 5 years, Strategy Analytics' Infotainment and Telematics service estimates annual sales of navigation enabled cars will almost double from over 34.5 Million at the end of 2020 and exceed 68 Million by 2025, Exhibit 3. This total excludes HD maps required to safely guide autonomous cars but includes connected cars which will have the ability to deliver live map-based services to users as part of the connected in-vehicle infotainment (IVI) experience.

Furthermore, Strategy Analytics estimates the penetration of vehicle shipments with embedded cellular connectivity (2.5G and above) will rise from 46% in 2020 to 66% by 2025. Greater connectivity not only enables drivers to get access to up-to-date maps instead of relying on outdated embedded maps, but also routing based on up-to-date traffic conditions, live hazard warnings and potentially real-

time parking availability information. In depth analysis and forecasts of the infotainment services and telematics opportunity is available through Strategy Analytics' Infotainment and Telematics service.

Exhibit 2 Annual Sales of Navigation Enabled Cars: 2019-2025



Source: Strategy Analytics, Infotainment & Telematics

Road safety remains an important priority and responsibility for governments and carmakers. Therefore, the penetration of ADAS capabilities in new vehicles will continue to grow as governments introduce car safety legislation and auto makers promote the safety features of their vehicles to consumers.

As the automotive industry aims to enhance road safety, with the aim of reducing and possibly eliminating accidents caused by vehicles, the provision of sophisticated driver assistance features, known as advanced driver assistance systems (ADAS), will become a common feature in modern cars. For example, Strategy Analytics expects the global penetration of the distance warning feature to reach 76% of light duty vehicles in 2025, with a growing share (likely between a quarter and third) of these relying on an ADAS map. Other examples of ADAS features include distance warning predictive powertrain, intelligent speed assistance, and lane departure alerts.

Strategy Analytics expects the global penetration of the distance warning feature to reach 76% of light duty vehicles in 2025, with a growing share 25%-33% of these relying on an ADAS map

The automotive sector is also moving slowly and steadily towards more autonomous driving, which will be enabled in many cases by some form of high definition (HD) map offering accuracy in the centimetres range.

- However, there are still significant voices casting doubt on the scalability of autonomous vehicles that are reliant on multi-gigabyte HD maps gathered by survey vehicles. Vision-centric companies such as Tesla and Mobileye, although still very much using mapping data, are typically looking to a lighter-weight, user-gathered data set. The aim is to enhance the autonomous ride, not for the vehicle to be 100% reliant on accurate HD mapping data for its operation.

Over the next five to ten years, fully autonomous vehicles will account for a negligible share of vehicles sold. Strategy Analytics only expects the penetration of fully autonomous vehicles light-duty vehicles to start ramping up in the 2030s.

However, the penetration rate of Level 2 (L2) capable vehicles (offering similar capabilities to today's autopilot-enabled Tesla models) will likely have hit over 50% of annual production in 2030. The battle worth winning will be for the maps that these vehicles need to support their operation.

Beyond supporting autonomous vehicles in the real world, accurate and detailed location models of cities and roads can also be used to train and test self-driving AI/ML algorithms in a virtual environment. Google's Waymo states that the AI agent powering its self-driving solution has driven over 20 Million miles in simulation.

The shift to cleaner electric vehicles is being accelerated by both governments aiming to meet environmental targets and vehicle makers responding to a combination of legislation and demand from consumers.

Sales of environmentally friendly electric vehicles (EV) are rising due to a combination of regulations and consumer sentiment. In November 2020 the UK government announced it will bring forward the date for the end of sales of non-electric cars to 2030, five years sooner than its initial guidelines. Japan is aiming for the same goal by 2035. In February 2021 Jaguar announced its aim to only produce electric vehicles by 2025. In January 2021 GM announced similar aims by 2035.

For a growing number of EV owners knowing the effective driving range of their vehicle and finding the location of suitable electric charging points along routes is critical to enabling a worry-free EV driving experience. Therefore, demand for live information relating to the availability of these charging points and EV-friendly parking spots will remain important as EVs become more popular.

The total cost of car-ownership versus alternative transport options, road congestion in urban centres, and environmentally friendly attitudes are all contributing factors to declining rates of car ownership in busy cities. Therefore, a range of mobility services, including taxi-hailing, car sharing, pedal-cycle sharing, e-bike and scooter sharing initiatives have emerged to provide alternative means of transportation and mobility in congested locations.

4.2 The Mobility and On-Demand Sector

The mobility sector covers a broad range of on-demand use cases, including ride-hailing, car sharing, micro-mobility, autonomous shuttles, and the concept of mobility-as-a-service, which aggregates different mobility options into a single interface with the aim of presenting options that best fit traveller needs.

Location content and location services lie at the heart of these mobility use-cases, whether that is in the form of a digital map to enable passengers to locate the nearest car sharing vehicle, via their smartphone, or routing, navigation and traffic services to assist drivers of taxi-hailing services locate passengers, or a dispatch solution for taxi fleets. Furthermore, the growing use of smartphone centric mobility applications has been enabled by increasing smartphones ownership, growing consumer use of mobile payments, and improving access to large bundles of mobile data (4G and 5G), particularly in emerging mobile data markets.

Not surprisingly, the pandemic has had a negative impact on the mobility sector during 2020 due to travel restrictions. With the closure of entertainment and hospitality venues, restricted travel and quarantines, demand for mobility services has plummeted significantly during 2020 but has started to rebound in early 2021. Consumers will understandably exercise greater caution towards public transport options, such as buses and trains. However, Strategy Analytics believes this has benefited mobility services (like taxi-hailing, car-sharing,

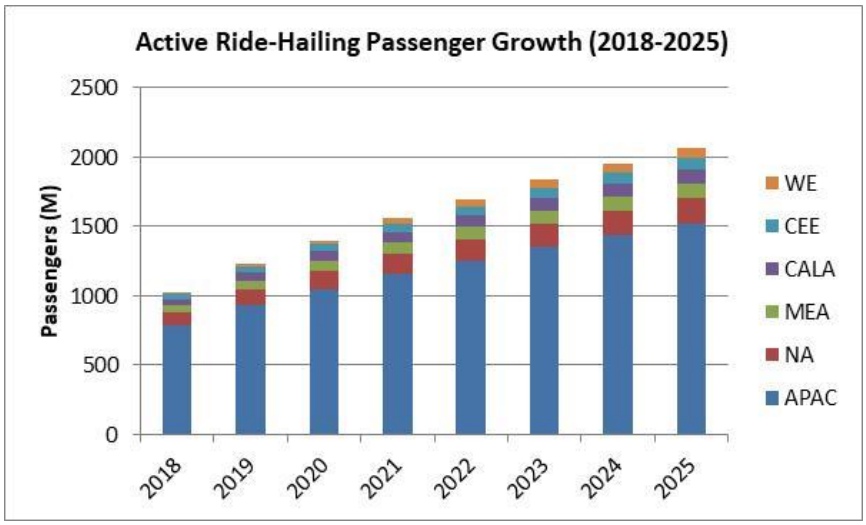
scooter-sharing and bike sharing) because consumers that previously relied on public transport to make journeys have shifted to socially distanced mobility alternatives. As the world returns to normalcy due to the positive impact of vaccines, we expect demand for mobility services to continue to rise across all markets and regions.

Demand for ride-hailing services is being driven by a combination of strong price competition among providers and the convenience of booking rides via smartphone apps. Strategy Analytics Connected Mobility service expects demand for ride-hailing to continue to rise out to 2025, with a doubling in the number of active users of ride-hailing services from just over 1 Billion in 2018 to over 2 Billion by 2025, Exhibit 3. A significant driver of this growth in ride-hailing services will come from Asia, which will account for three-quarters of all active users in 2025. Strategy Analytics' Connected Mobility research provides a deep dive into the mobility sector, including forecasts for ride-hailing and car-sharing.

Demand for ride-hailing will continue to rise to 2025, with a doubling in the number of active users of ride-hailing services from just over 1 Billion in 2018 to over 2 Billion by 2025,

Strong demand for on-demand ride hailing apps, such as Uber, Lyft, Didi and Ola has created a need for traditional taxis-fleets to close the technology gap and offer similar consumer experiences. This includes providing taxi booking apps for consumers which enable consumers to track their assigned car, access details of the make, model, colour, registration number, and driver of the car, and view up-to-the-minute estimated time of arrival (ETA), among other features. Location platforms provide mobility companies with a competitive advantage by providing accurate detailed addressing and ETAs based on live traffic information. Accurate ETAs and slick pick-up and drop-off at target destinations increases the satisfaction of both customers and drivers. Taxi-hailing has been a key battle ground and area of focus of focus location platforms.

Exhibit 3 Global Active Ride-Hailing User Growth: 2018-2025



Source: Strategy Analytics, Connected Mobility

Providers of mobility solutions are looking for partners which can deliver competitive advantage for providers in terms of performance, cost, and user-experience for passengers and drivers. For example, providing traffic optimised routing to enable drivers to maximise the number of trips and passengers with accurate estimated times of arrivals (ETAs).

4.3 Enterprise

Achieving competitive advantage through location insights continues to drive demand for both off-the-shelf and customized location intelligence solutions across different industry sectors and business functions.

The benefits of digitalization is felt at various levels across enterprises, e.g. sales and marketing, operations, strategy, IT management and R&D. Data is being collected and analysed to generate insights that improve decision making, accountability, efficiency, and business performance.

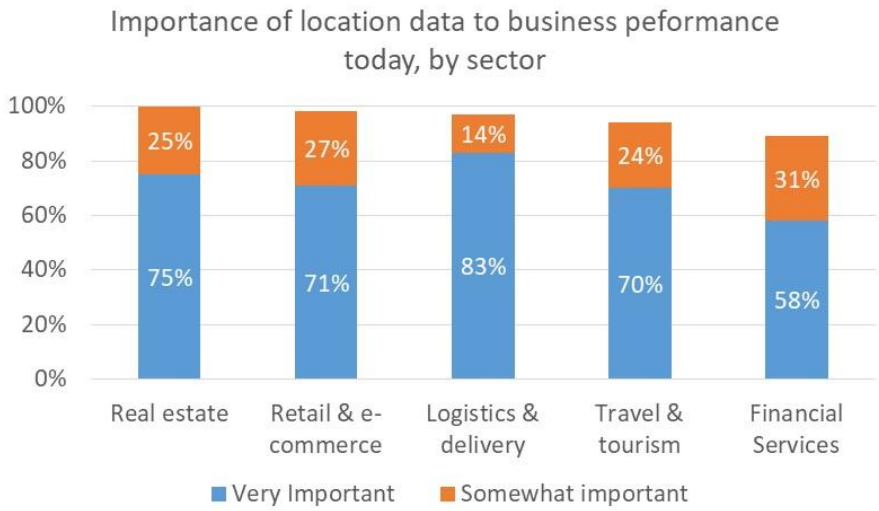
Location intelligence refers to the combination of mapping and geospatial services with a company or organisation's own data. Location intelligence is a subset of business intelligence, whereby a business visualizes data it generates,

e.g. performance data, pricing, and cost data, etc. on a map (or applies location services to it) for improved tactical and strategic decision making.

Use-cases for location intelligence include geo-marketing, location-targeted advertising, site location planning (e.g. retail stores, restaurants, fuelling stations and other infrastructure like mobile radio access networks) and remote equipment performance monitoring. Asset tracking, fleet management, on-demand/ mobility services, and other business functions can also be enhanced with location services.

A BCG global survey on location intelligence for enterprise conducted across 520 in October 2020 shows high levels of importance of location data to business performance across different sectors, including real estate, logistics and delivery, and retail and e-commerce, Exhibit 4. Strategy Analytics plans to assess the status of location service deployments across various verticals through its own enterprise mobility survey later in 2021.

Exhibit 4 Importance of Location Intelligence to Business Performance, By Sector



Source: Global BCG Survey on Location Intelligence for Enterprises (n = 520), October 2020; BCG analysis

Asset tracking and fleet management are covered in more detail below.

4.3.1 Asset Tracking & Fleet Management

Location services including maps, geo-location, geofencing, and others enable assets such as fleets of vehicles, parts, and employees to be tracked across the supply chain. Location services deliver transparency, improved accountability and optimization for both suppliers and buyers.

Vehicle tracking, traffic optimized multi-point routing, assessing driver behaviour, and logging trip information offered by fleet management solution providers are all underpinned by maps and location services. Fleet telematic solution provider, Verizon Connect, surveyed 700 US fleet managers in its 2021 Fleet Technology Trends Report and noted that over 50% of highlighted improvements in customer service and productivity functions after implementing GPS fleet tracking. Furthermore, just under 50% highlighted a positive improvement in routing. The study also noted a 41% improvement in vehicle maintenance for respondents in the transportation sector and a 53% decrease in fuel consumption for those in the services industry.

Vehicle tracking, traffic optimized multi-point routing, assessing driver behaviour, and logging trip information offered by fleet management solution providers are underpinned by maps and location services.

Maps and location services such as geolocation, geocoding, routing, and navigation are useful for tracking products across the supply-chain, from within factories through to delivery to the customer. For example, as parts or assets move from inside to outside the factory, dispatchers can track the position of their vehicles in real time to provide improved guidance to internal and external customers relating to estimated arrival time. Dispatchers can also use information about potential delays due to traffic incidents to provide drivers with alternative routing information. Furthermore, the digitization of the distribution and logistics sector is enabling haulage companies to use location services and real-time information to optimize and maximize fleets of trucks and minimize underutilized capacity.

The economic viability of cellular enabled asset management tags has improved due to a combination of lower priced cellular enabled RFID tags and falling mobile data prices. The battery performance (and therefore lifecycle) of cellular-enabled tags has increased significantly, which is also making them more viable.

Strategy Analytics expects a 12% CAGR in the number of cellular IoT connections between 2020 and 2026 to drive demand for location services. Enterprises need

to monitor the location and movement of assets to deliver greater accountability, enhance customer satisfaction, and to improve decision making.

Strategy Analytics expects a 12% CAGR in the number of cellular IoT connections between 2020 and 2026 to drive demand for location services

Increasing numbers of IoT providers are offering location and tracking out of the box, not just around cellular, but also around unlicensed LPWA technology like LoRaWAN. Customers will increasingly have a choice beyond assisted GPS, depending on power consumption and the level of accuracy required for their solution. Some companies may just need to know where an asset is with basic geo-fencing. For example, warehouse assets like cable drums or the basic position of enterprise fleets to track those assets to a specific depot or location, which may not require a high level of accuracy. In those cases, even unlicensed LPWA technologies like LoRa may be sufficient, as long as the network knows what time a signal is picked up by any number of gateways, so that it is possible to triangulate that to a location with an accuracy of 40-50 meters, perhaps slightly less in dense urban environments.

For greater levels of accuracy, integrated AGPS/cellular/Wi-Fi sniffing will work very effectively, such as specific pallet locations or where in a storage rack an item is located. Some companies are also integrating these capabilities into unlicensed **LPWA solutions**, such as Actility, which has some patented IP around low power GPS (through its acquisition of Abeeway), which is a LoRaWAN equivalent of AGPS (Assisted GPS). The network provides key information to the device preparing to make a fix, which means that the GPS can be active for a shorter period and acquire fewer satellite signals. The position calculations are then processed in the cloud, which reduces the battery impact, while still providing GPS levels of accuracy (in many cases sub-10 meters). If a standard GPS offering has a 1-year battery life and pure LoRaWAN has a 10-year battery life, this solution could give up to 9 years[1]

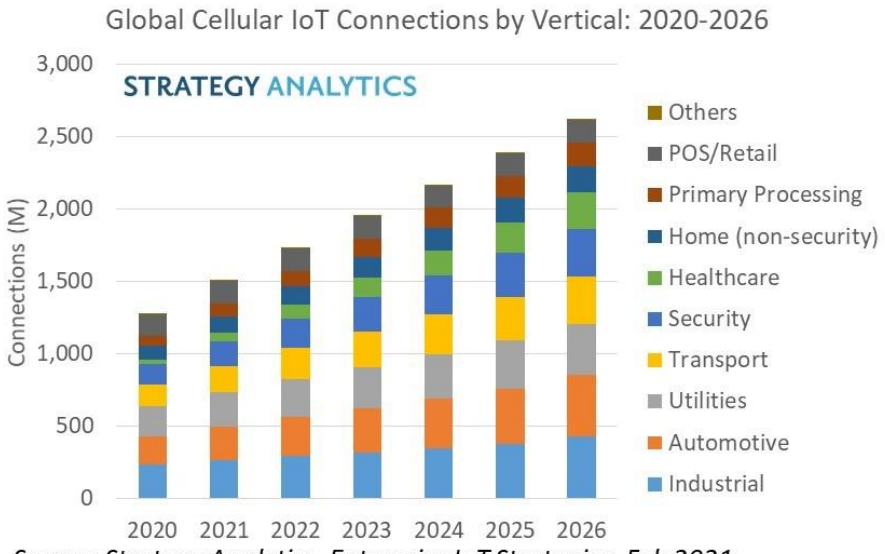
Location services will also be used to enhance augmented reality (AR) which will create a more immersive experience. AR and real-time location services (RTLS) will be combined on a much bigger scale to provide value to businesses and customers. In fact, the trend has already begun with airports and hospitals using

[1] **https://www.actility.com/customer-stories/die-mobiliar/**

BLE Beacons, combined RTLS and Wi-Fi to help staff and passengers find their way through their complex and difficult to navigate spaces.

IoT presents a future growth opportunity for location platforms as the number of devices connected to the internet increases. Strategy Analytics' **Enterprise IoT Strategies** service estimates the number of devices connected over the cellular network is set to grow at a 12% CAGR between 2020 and 2026 across a variety of industry verticals, Exhibit 5. IoT in Healthcare, is set to show the strongest growth, followed by Security, Primary Processing and Automotive. Cellular connectivity will enable enabled equipment to be tracked or monitored, although clearly not all these connected devices will need support from geospatial services e.g. geolocation, directions, or routing.

Exhibit 5 Global Cellular IoT Connections: 2020-2026



Source: Strategy Analytics, Enterprise IoT Strategies, Feb 2021

Fundamentally, where mobility is a core requirement e.g. automotive, or fleet or where assets need to be tracked e.g. in a factory, or across a supply chain, the greater the need for geolocation services. Traceability in the supply chain is becoming a very important element of compliance in many industries to guarantee the source of origin, as well as the integrity of any component. Examples include car parts shipped globally to different suppliers, where location tracking and identification of the origin is vital, especially in terms of liability should there be a safety recall on a particular vehicle component. The

same is also true in terms of food processing, where traceability is vital in guaranteeing the integrity of a finished product, for example, if a fast food chain guarantees customers that chicken nuggets contain 100% chicken breast meat, then suppliers need to ensure they can prove that the chicken nuggets they produce are sourced from chicken breast, or risk a serious breach of an SLA (service level agreement) with a customer.

Data recorded by these connected objects will be able to provide contextual information via alerts and can be visualized. For example, a vending machine which is low on a certain product item, or which has become faulty is able to communicate its status to head office and can be restocked or fixed.

4.4 Mobile Apps and 5G Networks

From a volume perspective mobile phones, and in particular smartphones, remain the primary device through which consumers access location-enabled services, such as map apps, turn-by-turn navigation apps, local business search, taxi-hailing apps, and location-based games, among others.

While all-in-one travel applications depend on location services, many apps are enabled with location awareness to provide contextual relevance. e.g. location sensitive weather and news, or to prevent content being viewed by users outside authorised geographies determined by content rights holders. More broadly, basic location services also include store locators which usually consists of a location input box, a map, markers, and results including travelling distance from the users' postal code.

Over the next 5 years, the rising population of consumers with GPS handsets combined with a growing base of mobile data users and app-stores users will boost the addressable market for different types of consumer LBS.

> The addressable market for consumer LBS will rise. Annual sales of GPS enabled smartphones will grow from just above 1.21 Billion in 2021 to 1.5 Billion by 2025.

GPS handsets: Annual sales of GPS enabled smartphones, which support accurate geolocation, is set to rise from just above 1.21 Billion at the end of 2021 to just over 1.5 Billion by the end of 2025, according to Strategy Analytics' Emerging Device Technologies service.

App-store users: Strategy Analytics estimates the population of users accessing app-stores to download apps and games will rise from just above 3.2 Billion at the end of 2019 to over 3.6 Billion at the end of 2025, thus increasing the addressable market of users able to download location-based applications.

Mobile data users: Apps and services which rely on location-based services served in real-time are dependent on mobile data connectivity when they are out and about. The number of mobile data users is set to exceed 4.4 Billion by 2025.

4.4.1 5G Networks

Mobile operator network planners typically lean on maps, location services, and other segmentation data to plan the deployment of radio access networks (2G, 3G, 4G) at both a macro and micro level. However, with 5G more sophisticated and detailed 3D maps will be required, particularly in dense urban environments where service providers are aiming to deploy 5G using mmWave. Although 5G mmWave offers higher bandwidth, its coverage range is limited and prone to interference from both hard and soft physical features, such as lamp posts and tree foliage, respectively. Consequently, maps providing accurate 3D models in tandem with RF propagation tools will enable mobile operators to optimise the positioning of their 5G RAN to provide the best possible signal and coverage.

5G deployments are continuing to ramp up, which is reflected in 5G subscriber growth forecasts. Strategy Analytics expects strong growth in 5G network deployment over the next 5-years as the number of 5G subscribers expands almost 4-fold from just over 700 Million at the end of 2021 to 2.8 Billion by 2025.

4.5 Location-Based Advertising & Marketing

Geolocation underpins growth of the $470 Billion global digital advertising ecosystem in three ways:

- Audience segmentation: Correlating the geolocation of mobile device IDs (anonymously) against a database of places (and their boundaries) provides audience insights that underpin ad targeting. The places that people visit, along with other contextual information such as time of day

(and inferred home and work locations) can assist digital marketers to build anonymised profiles and personas which support targeted advertising.

- Digital advertising attribution: Accurate user location information allows advertisers to measure the extent to which digital advertising drives in-store visits. Google has been measuring store visits (anonymously) since 2014 and is using this information to demonstrate the uplift in store traffic because of digital advertising campaigns.
- Location and proximity ad-targeting: The direct use of location to target users with messages based on their location or proximity to specific physical locations using geo-fencing. For example, Google AdWords enables advertisers to program their bids for searches on keyword searches conducted within advertiser defined locations. Equally, local business can leverage user location to prevent them from advertising to potential customers located in different towns or cities.

Despite the importance of location data to digital advertising, location fraud remains a key challenge, as highlighted in our previous reports. A study conducted by Location Sciences, a location intelligence company, during 2019 estimates up to 65% of spend on location targeted impressions is outside of the targeted area or based on signals of insufficient quality to meet location targeting needs. Privacy is also becoming an increasingly important issue, with 6 in 10 US respondents to a short directional survey indicating rising concern over the past 12 months. Strategy Analytics also expects Apple's decision to make device identifiers for advertisers explicitly opt-in for each app to have a negative impact on the quality of geolocation data available in ad-exchanges when it is implemented later in 2021.

5. Location Platform Benchmarking

Each of the location companies in our annual benchmark has enhanced, existing offerings, expanded their portfolio of products and solutions, and added partners and clients.

The following (non-exhaustive) highlights for Google, HERE, Mapbox and TomTom during 2020 and early 2021 include:

Google: Google has scored wins with Ford in the automotive sector, in addition to Daimler Trucks and Fiat Chrysler via Waymo its autonomous driving unit. Google's consumer facing app, Google Maps, enables Google to quickly understand changing consumer needs, which it can rapidly address. For example, Google bolstered bike lane content after seeing a spike in searches for cycle routes due to the pandemic. Google has also improved the ability of developers to customise its maps and map content (e.g. POIs) to meet their business needs, e.g. customise zoom levels, POIs and map-styles more conveniently. Google serves a large base of developers, and it has highlighted Green Wheels, Licious, Namco-Bandai, Gojek as a few of many companies using its location capabilities to support their needs.

HERE: with the pandemic halting vehicle production in 2020 HERE's automotive revenues took a hit. However, the company grew its non-automotive bookings in the multiple double-digit range. HERE is positioning for growth in both automotive and non-automotive domains (e.g. transport and logistics, telecoms, media/ advertising and technology, and infrastructure and planning). HERE's location data marketplace gained traction with APCOA, Global Weather Corp., RoadCloud and Zenrin, and others. HERE's platform approach positions it well for a rise in demand for location intelligence capabilities as the proliferation of IoT sensors generates ongoing data. In automotive HERE lost Ford as a map customer to Google. However, Ford is using HERE's Hazard Warning service and is using HERE Workspace to develop its Active Driver Assist (SAE Level 2+) product for North America. During 2020 HERE announced wins and partnerships with a variety of companies with different location needs, including Amazon, Blueshark, and Shebah, among others. HERE's direct developer program has seen double digit growth in the numbers of developers using its platform. Asian remains important to HERE's future growth and will be aided by new investment from Mitsubishi Corp. and NTT in Japan, with both companies holding a combined 30% share of HERE, which closed mid-2020.

Mapbox: Mapbox continues to benefit from its strength in map design and data visualization. Tableau and Arcadia Data are both leaning on Mapbox to power map-based visualizations in their analytics platforms. It has enriched visualization by adding 135 square KM of high-resolution satellite imagery and added rich APIs which can be accessed via the new version of its map API (Mapbox JS GLv2). Mapbox JS GLv2 which it intends to support going forward is

not open source. Mapbox has also noted its Vision SDK mapped and streamed 1 Billion images and refreshed over 15 Million traffic signs in the US. Mapbox also announced a significant win in automotive, with BMW. BMW's navigation solution will be powered by Mapbox navigation software. Mapbox is targeting growth in Japan through a joint venture with its investor, Softbank. Mapbox has grown its monthly active developer base to 170 K from 150 K during 2019 Mapbox's location services are being used by large consumer services including Facebook, Snap, CNN, Yahoo Japan, The Weather Channel, Tableau, Strava and Wordpress, among many others.

TomTom's automotive revenues took a hit in 2020 due to the pandemic, though it notes strong growth in orders during the year will drive revenue for 2021 and beyond. In the automotive space TomTom remains a leader in navigation software with 15 OEMs deploying its NavKit. It has highlighted wins with brands within the Stelantis Group, Mitsubishi Motors, Maserati, Daimler Trucks, to supply navigation and location services. It also claims to have sold over 3M vehicles powered by its ADAS maps. In HD and autonomous driving TomTom a proof of concept with Toyota Research Institute for rapid HD-map development. TomTom has also successfully grown the base of location developers through its portal, and impressively claims over half are being monetised. Beyond automotive, TomTom continues to expand its relationship with Microsoft. TomTom's location services are being used to power Azure Maps, Bing Maps. It is also supporting Huawei's MapKit (and Petal Maps app) and Verizon Direct. TomTom also extended its deal with data intelligence platform, Precisely, and expanded its relationship with Uber. Uber has joined TomTom's certified Map Editing Partnership program to enhance its map maintenance. TomTom's deal with Foursquare for POIs provides a boost its place search capabilities.

5.1 Benchmarking Update & Result Summary

Strategy Analytics benchmarks the relative strengths and weaknesses of Google, HERE, Mapbox and TomTom across seven critical categories that are relevant for a broad range of location services users.

The categories being used to evaluate the location platforms include map making and freshness, POI search, developer community, automotive, map and data visualization, openness and flexibility, and growth and leadership:

Map making and maintenance: Providing reliable, fresh, and up-to-date maps and map content has become table stakes and expected in the era of "on-demand" services. Location platforms which have the capability to deliver near real-time map attribute updates to customers will score highly in this category. As will companies that apply a robust and holistic approach by conflating multiple data sources and applying stringent verification. Platforms that develop maps to meet emerging and future needs (EV, ADAS, autonomous, AR/XR, etc) will also score well.

Search and Point-of-Interest: One of the key location services is the ability to search for local businesses, buildings, and attractions with high levels of real-time accuracy. Therefore, the size, freshness, and accuracy of the database of places provided by location platforms are key metrics. Higher scores in this section are awarded based on a combination of the size of place database, how frequently it is updated, its granularity and ability to customize results for specific use-cases.

Developer community: The location-sector is in the process of evolving from a model where historically enterprises and businesses licensed the map content and services, to a model where they can access a broader set of location capabilities, including map tiles, geocoding, routing, place search, traffic data and more, through application programming interfaces (APIs). A high score in this section is awarded to platforms that have captured a large share of developers of all types, and that provide a broad range of tools for developers.

Automotive: The automotive sector remains a critical source of revenue and demand for the location sector, and therefore the ability to service both current and emerging needs of vehicle makers cannot be ignored. In this category we award higher scores to companies which have announced deals and partnerships to supply key players in the automotive space with location services and solutions.

Map and data visualization: The need to provide customized map views and visualization of location data is likely to vary significantly according to both use-case and company. Some companies may want to provide a highly customized type of map to suit a specific use-case, or to toggle between different visualization options for a specific dataset. In contrast, for other companies it will

be less important to customize either map or data visualization. Companies offering the broadest and most customizable set of data visualization solutions will score highly in this segment.

Openness and flexibility: Providing an open and flexible location platform means enabling companies to layer in their own location data onto the map, or to pick and choose which location services to use from different providers. Also, some companies may want to customize certain features and capabilities, e.g. a retailer filtering the location of its own stores in the results of a search query or customizing some code or an open API request.

Industry growth and leadership: As highlighted in section 4 of the report the opportunities for growth in the location sector will come from supporting autonomous vehicles, the on-demand mobility sector, and a rising demand for location intelligence with respect to asset tracking, fleet management, and IoT as businesses embrace big data. Companies which communicate strong growth ambitions across some of these key location sectors, either directly or through partnerships will score the highest marks.

5.2 Benchmarking Category Results

Competition in each category remains fierce between platforms Google, HERE, Mapbox and TomTom. The importance of different capabilities and strengths varies based on use-case, sector, and individual company requirements with HERE leading overall and Google and TomTom following.

Google: Google is a leader in POI search, map making/ freshness, and developer community. It is also making good progress in automotive infotainment and autonomous driving via Waymo. Google's closed approach to competition in listings, directories, advertising, navigation, and sharing data remains a weakness for businesses and developers seeking openness and flexibility. Google has made progress in data visualisation, map styling and map customisation. Despite leading in breadth and depth of POI and place information, managing fake business listings remain an on-going challenge. Google leads in the developer category by virtue of its base of millions of developers. However, Google's high pricing continues to leave it vulnerable to

competition as HERE, Mapbox and TomTom aiming to attract disaffected Google Map developers looking for alternatives.

HERE: HERE leads the overall scores and remains a leader in automotive and location industry growth vision categories. HERE is a co-leader in openness and scores strongly in map-making and freshness and has improved its score in visualisation. HERE remains an automotive leader in Western Europe and North America, despite the rising threat from Google. Since 2017 HERE has sold 17 Million vehicles that rely on its ADAS supported map functions to power L1 and L2+ automation. HERE is both independent, and open, retaining ambitions to provide a variety of solutions, products and platforms to any enterprise looking to develop, monetize and leverage location intelligence and location data. HERE has strong roots in supplying location content and services to automotive companies and large enterprises, and continues to enhance capabilities (e.g. visualization, map content, developer tools) to address emerging and growth opportunities aligned with its target areas across automotive, transport and logistics, telecommunications, media and technology.

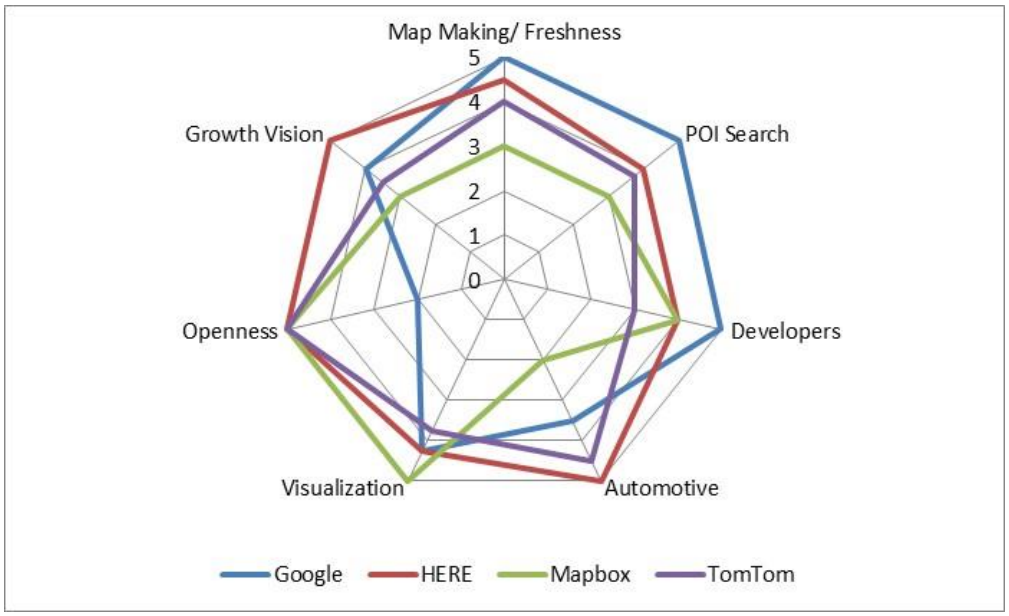
Mapbox: Mapbox is a leader in map design, customization, and data visualization. Mapbox is developer friendly, coming second to Google based on the reported size of its developer community. It is also a co-leader in openness and remains independent and flexible. However, it's worth noting its , Mapbox's reliance on OSM is perceived a weakness for enterprises and industries where the consistency, provenance and quality of map data is considered essential, though this has not prevented Mapbox from gaining traction with businesses across a broad range of sectors. BMW selected Mapbox for its navigation software but Mapbox continues to play at the margins in automotive.

TomTom: TomTom's scores very strongly in map-making and freshness, automotive, and is a co-leader in openness - as an independent player it enables developers to mix and match location and data sources. TomTom has improved its score in visualization and POI search, and it has made progress in attracting developers through its strategic partnership with Microsoft's Azure, Huawei and Verizon Direct. TomTom reports double digit growth in direct developers with over half monetized. Despite challenges due to the COVID-19 pandemic TomTom remains strong in automotive, with leadership in navigation software and reported traction for its ADAS maps among OEMs - over 3 Million ADAS

equipped vehicles shipped. It's automotive customers for navigation and connected services during 2020 include Fiat Chrysler, Ford, Mitsubishi, Alfa Romeo, Subaru, Daimler, and others.

In the table below Exhibit 6 the scores in parenthesis are those awarded in last year's benchmark report.

Exhibit 6 Summary of Location Platform Benchmark Scores



Source: Strategy Analytics

	Google	HERE	Mapbox	TomTom
Map Making/Freshness	5(5)	4.5(4.5)	3(3)	4(4)
POI Search	5(5)	4(4)	3(3)	3.75(3.5)
Developers	5(5)	4(4)	4(4)	3 (2)
Automotive	3.5(3)	5(5)	2(2)	4.5(4.5)
Visualization	4.25(4)	4.25(4)	5(5)	3.75(3.5)
Openness	2(2)	5(5)	5(5)	5(5)
Growth Vision	4(4)	5(5)	3(4)	3.5(3.5)

Source: Strategy Analytics

5.2.1 Map Making and Map Freshness

Google maintains its leadership in the map making and freshness category, followed closely by HERE and then TomTom. All three deploy significant resources, partnerships, and expertise to maintain comprehensive digital maps at scale, while addressing an evolving range of use-cases, including autonomous driving, transport and logistics, mobility services, and industrial use-cases.

	Google	HERE	Mapbox	TomTom
Map Making/Freshness	5(5)	4.5(4.5)	3(3)	4(4)

Modern map making leadership demands the orchestration of different, complimentary data sets to build maps that are detailed and accurate at scale, particularly as digital map requirements evolve towards high-definition and near real-time updates. Validation of map details is essential where accuracy, safety and reliability is critical. Validation of data and content from different sources remains a critical step, particularly as the map-making process becomes increasingly reliant on automation.

Modern location platforms combine data from different sources, including industrial capture, imagery (aerial, satellite, crowdsourced), computer vision, authoritative data sources (government and local authorities), and continuous flows of probe data from hundreds of millions of probes, to maintain, improve and quality check their map databases continually. Since each individual approach has weaknesses it is the ability to combine and conflate vast amounts of data from these different sources at scale that is essential to offering customers comprehensive, reliable, accurate and fresh maps to address a broad number of use-cases. Google, HERE and TomTom have resources to make significant investments in map making and maintenance, while Mapbox is the weakest in this aspect and relies on OpenStreetMap (OSM) as its foundation.

Google: Street view and satellite imagery have been important tools in Google's arsenal for map making. Google claims between 2007 and 2019 its street view 360 cameras (cars, trekkers, trolley, and snow mobiles) have collected more than 170 billion images from 87 countries. Street view cars have covered 10 M miles during this time. The public can also contribute imagery so street view.

Authoritative data from over 1000 sources globally provide geographic information at country and regional level. Google deploys local operations teams to gather imagery and vet authoritative data. It also leverages a community of over 125 M local guides to provide feedback, which is reviewed by local teams and published only if there is a high degree of confidence of its accuracy. Google is increasingly reliant on machine learning to automate its mapping. Google has the largest number of consumer probes of its location platform competitors. Over 1 B Google Map users, with an installed base of over 3.4 B Android powered smartphones which can (potentially) supply probe data to powers its traffic and routing capabilities.

HERE: HERE claims around 5K of its total 8K employees work in its map content team. HERE claims to capture 900 attributes for each road segment across 40-50 layers of its base map (e.g. speed category, vehicle type, prohibited manoeuvres, etc). HERE's 360 mapping approach leverages 176 HERE True vehicles, over 7.6 Billion probe points per day, over 50 Million square KM of satellite imagery, and 3.35 Million KM of crowd sourced imagery. Since 2016 HERE claims its True vehicles have collected over 4 Million KM of data across more than 50 countries and it has received over 90 Million community edits (via Map Reporter, Map Creator) from GIS experts and enterprise partners. Over the same period, it has achieved a 200% increase in auto detected observations to reach a cumulative total of 4.6 Million and has increased its acquisition of data by over 80% to over 46K acquisitions. HERE also proactively monitors the media and relevant content sources for early warnings related to road or lane closures, and other temporary or permanent changes to the road network. HERE is looking to acquire new data pipelines to bolster its map maintenance capabilities as new sensor networks emerge with the growth of IoT.

Mapbox: Mapbox is significantly smaller with over 500 employees globally. Mapbox relies on open sources like OpenStreetMaps (OSM), Microsoft Open Maps, and Wiki Data) and local map data vendors in other markets (e.g. Zenrin in Japan and PSMA in Australia) as its foundation. This enables Mapbox to provide maps and location services with a lower overhead. During 2020 Mapbox notes it has updated 135 Million KM of high-resolution satellite imagery. Mapbox uses ML tools like RoboSat to extract features from ariel and satellite imagery. Mapbox claims its Live Sense SDK, which enables computer vision for cameras, has processed over 1 Billion images and identified and refreshed over 15 Million

traffic signs in the US, covering almost every road sign across the 30 largest US metro areas. Mapbox leverages probe data from 700 Million monthly active users of apps that use its location services to assist with map maintenance and live traffic, up from 640 Million in 2019.

TomTom: TomTom is smaller than HERE with 4.5K employees, with around half dedicated to map making. Beyond its workforce TomTom works with thousands of map production partners in addition to a community of partners. For example, during 2020 TomTom announced its Map Editing Partnership (MEP) program to certify customers like Uber to make map edits when relevant to its needs. TomTom claims the program is delivering significant improvements to its maps and so far, supports over 3 Million edits each month in over 70 countries. TomTom notes its mapping vans drive more than 3 Million KM each year, collecting over 5 Billion pixels per KM. TomTom also collects anonymized probe data from over 600 M connected devices (smartphones, navigation devices and telematics systems) on the road, a rise of 50 Million from 2018. This probe data assists change detection and provides traffic flow information. Like HERE, TomTom also proactively monitors the media and relevant content sources for early warnings related to road or lane closures, and other temporary or permanent changes to the road network.

Mapbox's reliance on OpenStreetMap (OSM) remains a relative weakness for enterprises and use-cases that demand consistent quality control, provenance, security and high levels of assurance that map data cannot be compromised.

Both Google and Mapbox rely on crowd sourced data to differing extents. For example, Mapbox is the only company in our benchmark which does not own its map, which continues to underpin its low score in this category. OpenStreetMap (OSM) is the foundation of Mapbox's map.

- **Inconsistency:** With over 1.5 Million monthly contributors OSM's map detail can be very accurate and granular in certain geographies, but simultaneously, lacking in others. Although Mapbox (along with partner organizations) contribute to OSM, edits to OSM by the long tail of contributors are not always reviewed for errors. This inevitably introduces inconsistency in the quality of edits.

- **Vandalism risk:** Crowdsourced map content remains at risk to vandalism despite significant efforts and intermediate steps designed to prevent erroneous content being published. As noted in previous reports both Google and Mapbox have fallen victim to high-profile malicious map edits in the past, due to this vulnerability.

For crowdsourced inputs Mapbox uses what it calls a "double validation monitoring system" to ensure malicious or erroneous edits made in OSM are prevented from appearing on its maps. Mapbox uses artificial intelligence (AI) system to flag up changes daily for human review and claims that many of its core map layers are not easily edited.

Despite these challenges, it should be noted that well-known consumer apps with large active user bases in the hundreds of millions, including Snapchat, Tinder, Weather Channel, DoorDash, and others continue to embrace Mapbox's map and location services. It's clear that Mapbox's OSM foundation is not a barrier for a range of businesses.

5.2.1.1 Map Freshness

Across automotive, on-demand mobility, and transport and logistics there is a growing expectation for the most up-to-date maps and live content. This demand for fresh maps and map content is driving all location providers to deliver real-time map updates for customers and use-cases that demand live maps.

At a high-level, location platforms are communicating the ability to refresh maps through the number of map changes and edits made daily or over a period of a month. These map change statistics can be viewed in two ways. First, they could reflect the capability of platforms to perform map maintenance at scale. Secondly, large numbers could instead suggest the original map data is in some way inaccurate or not fresh. Furthermore, the definition of a change or edit likely varies for each provider making a direct comparison challenging. For example, a change to a single attribute like a road name can ripple through to changes in other map related content, like addressing and boundaries. Nonetheless, these marketing claims add some insight into capabilities relating to map updates:

- Google claims 25 Million map edits made a day, which equates to over 760 Million map changes per month.
- HERE claims to make an average of 5 Million updates daily and globally.
- TomTom makes 2 Billion changes per month across 75 Million KM of road and 169 countries. TomTom's transactional approach to map updates enables verified map edits to be made available on its platform rapidly.
- Mapbox claims over 100,000 daily changes, which equates to 3 Million per month, while in August 2020 OpenStreetMap reports around 4.5 Million map changes per day, equating to a rate of 135 Million per month.

5.2.1.2 Map and Content Enhancements

Maps and location services need to support a variety of evolving use-cases and demand for live content. The challenge for industry players is to provide maps and location services which support the business objectives of a broad (but often related) set of use-cases and demands, efficiently.

Truck and electric vehicle navigation, mobility services, detailed building boundaries, and high-definition (HD) maps are just some examples of the use-cases which mapping and location platforms support. Beyond road geometry and road attributes modern map making includes providing map content to support a variety of mobility use-cases, including public transport, cycling, ride-hailing, and other content, like buildings footprints.

Google has improved its coverage of bike lanes in response to a rise in demand for cycling directions due to COVID-19. Google has also added greater depth in public transit information. It is worth noting that enhancements to certain element of Google Maps does not necessarily mean developers on the Google Maps Platform have access to the same capabilities.

- Google saw demand for cycling directions spike by 69% between February 2020 and July 2020, with cycling perceived as a COVID-19 safe transport alternative to public transport. In response Google claims to have added 'hundreds of thousands of new bike lanes' during 2020, in addition to end-to-end directions and live bike availability at docked bike sharing stations in 10 cities.
- Google has also added content to its transit information within Google Maps, including accessibility for people requiring extra support on public

transport, temperature data, where trains or buses have sections for women only, the availability of security, and in Japan, the number of available carriages.

HERE has added 3D city and geodata models to target emerging use-cases. It has enhanced its EV charging database to address growing demand of EV vehicles and has expanded its parking capabilities. HERE has increased the number and precision of it point addressing and improvements to its ADAS map.

- HERE has added geodata models of over cities 50 cities which offers sub-1 meter precision to support a variety of emerging use cases, including digital twin, autonomous driving simulation to train AI/ML models in virtual environments, 5G network planning, infrastructure planning, and transport and logistics.
- HERE has also invested significantly in improving data capture to achieve the 90% of speed limit information as part of the EU mandate for Intelligent Speed Assist (ISA). It has increased Electrical Vehicle (EV) charging station database by 60% and covers 200K locations across 91 countries. It has increased its point addressing to cover 430 Million addresses over 98 countries, which further improves its ability to service mobility providers and e-commerce delivery companies. HERE continues to expand its parking database across on-street, off-street, and indoor locations.

Mapbox has enhanced its building coverage across several countries and updated its HD satellite imagery.

- In June 2020 Mapbox claimed it has added 150 Million buildings across the US, Canada, Australia, UAE, Tanzania, and Uganda, a 360% increase on its building coverage. Mapbox relies on Microsoft Maps Team and OpenStreetMap community, and other sources for building footprint data and applies techniques such as multi-source conflation, multi-layer testing, satellite and ariel validation, and manual edits for verification.
- As outlined above, during 2020 Mapbox states it has updated 135 Million KM of high-resolution satellite imagery, which is more than double HERE's 50 Million KM of satellite imagery.

5.2.1.3 Map Countries Coverage

Our rating for map making also considers country coverage supported by vendors. Each provider claims to offer global coverage for basic and navigable maps, although in China, Japan and Korea country regulations act as a barrier to providing location services in those markets, unless specific conditions are met. In China, foreign countries are prohibited from map making unless they work with a local partner. In Korea, map data must reside in Korea, and cannot be exported.

Asia remains an opportunity for the growth of locations services as internet connectivity and smartphone penetration both rise across the region. Google and its location services remain locked out of Asia's largest market, China.

- Google services remain banned in China, and consequently Google is unable to participate in detailed map making while Google Maps is blocked.
- HERE's strength in Asia has been further boosted by investment from NTT (Nippon Telecom) and Mitsubishi.
- In June 2020 Softbank and Mapbox established a joint venture, Mapbox Japan, enabling developers in Japan to access Mapbox's location platform and services.
- TomTom lacks coverage in both China and Japan, although has developed partnerships with Japanese firm DENSO on its software platform for autonomous vehicles. Around 27% of TomTom's employees are based in Asia Pacific.

5.2.2 Automotive Location Services

HERE leads in automotive services, followed by TomTom. Both remain committed to providing innovative and differentiated services to enable vehicle makers address strategic challenges. Google has clearly made headway through Android Auto and Android OS, while Mapbox scored its first major win with BMW.

	Google	HERE	Mapbox	TomTom
Automotive	3.5(3)	5(5)	2(2)	4.5(4.5)

The automotive sector remains a critical source of revenue to HERE and TomTom. Historically, both have a strong position in the automotive industry through licensing map content and traffic services to car OEMs and vehicle infotainment makers for use in vehicle head units. Due to the negative impact of the pandemic on vehicle production TomTom's posted a 14% drop in automotive revenue to €227 M (US$268 M) in 2020, which accounts for around 44% of its total revenue. HERE is privately owned by car makers Audi, BMW, Daimler, with Continental, Intel and Pioneer also shareholders. While HERE does not report its financial performance, its primary revenue is from suppliers and OEMs in the automotive sector and like TomTom negatively impacted.

HERE leads in automotive followed by TomTom. Both remain committed to providing innovative and differentiated services to enable vehicle makers address strategic challenges.

HERE remains a market share leader in providing embedded in-vehicle maps in North America and Western Europe. TomTom remains a leader in navigation software with over 15 OEMs using its solution.

Moving forward both HERE and TomTom are focused on serving growing demand for higher value automotive capabilities e.g. Advanced Driver Assistance Systems (ADAS), HD Maps, and EV, as safety and environmental targets rise in importance and standard definition maps become commoditized.

As discussed in section 4.1 several trends, including electrification, regulations related to vehicle safely, and autonomous driving, are driving evolution in the automotive sector, creating both opportunities and threats for location companies. Ultimately, location companies capable of helping automotive firms to address these evolving demands, while delivering cost leadership or sustainable differentiation will be best positioned to succeed in this sector.

Strategy Analytics believes established global suppliers of location services to vehicle makers, HERE and TomTom, remain well placed to meet the evolving needs of the automotive sector, particularly with respect to navigation and safety systems.

HERE and TomTom's dominance in infotainment is under threat as carmakers, including Ford, GM, Volvo, Renault, Nissan, and Mitsubishi deploy Android OS and Google services (e.g. Maps) in upcoming car models. Notably, Mapbox gained BMW as a navigation software customer.

Google is a relative new entrant as a software and services supplier to car makers but has achieved notable wins. Most recently, in February 2021 Ford and Google announced a 6-year strategic partnership to develop new connected vehicle services and infotainment systems. Ford also selected Google Cloud as its preferred cloud provider for its expertise in data, and AI/ML. The announcement states "millions of Ford vehicles will utilise Android infotainment solutions with Google Apps and services such as Maps built in."

General Motors (GM), Volvo, Renault, Nissan and Mitsubishi have also confirmed they will ship cars with infotainment services built on Android OS. These OEMs have effectively handed control of the in-car experience, and the end user, to Google. The integration of Android in the vehicle will be customized to meet the needs of the car makers, though Google remains in control of data linked to the services it provides drivers, e.g. Google Maps, local search, and Google Assistant. The adoption of Google's vehicle mirroring system, Android Auto, by many car makers demonstrates vehicle makers are prepared to work with non-traditional suppliers of navigation service and components of the vehicle IVI.

OEMs approaches continue to differ. Some car makers (e.g. Volkswagen, Daimler) wish to control the driving experience end-to-end by offering branded interfaces and services, while others are less concerned about fully owning the experience and are prepared to make trade-offs by providing access to popular, user friendly, services from Google at lower cost.

Vehicle makers also wish to remain the guardians of first-party vehicle sensor and safety related. Many car OEMs will also remain wary of Google, and Strategy Analytics expects many OEMs will seek to retain control of safety features and functions in the car, some of which are powered by location services. That said, vehicle makers (e.g. Fiat Chrysler and Daimler Trucks) have committed to leaning on Google's Waymo technology to support their autonomous driving efforts.

HERE and TomTom have both highlighted significant progress in ADAS maps and remain bullish on the role HD maps will play in autonomous driving. Google's Waymo subsidiary remains focused on operating autonomous taxi fleets and is supporting some OEMs ambitions in this domain.

Google's ambitions to power the in-vehicle experience with its consumer-friendly solutions remain a persistent threat in this domain given the popularity of its hardware and ecosystem of services with consumers.

HERE and TomTom continue to believe in the role of HD maps for supporting autonomous driving. HERE's own studies indicate that cameras and computer vision are unable to capture all road sign information due to being obscured (e.g. adverse weather, orientation, placement, etc.), resulting in computer vision delivering accuracy rates of 50%-60% on their own. Furthermore, signs may be missing and along many sections of road speed limits are implied. Therefore, vehicles need to rely on information from the map layer to fill in gaps. TomTom believes HD maps have a complimentary role to play in supporting sensors in vehicles. HD maps can enable sensors e.g. a camera, to look in the right areas to focus its vision, which can improve sensor performance (speed and power).

HERE and TomTom have both highlighted significant progress in ADAS maps and remain bullish on the role HD maps will play in autonomous driving.

While there is uncertainty about the extent to which HD maps will be needed to support autonomous vehicles, there is greater certainty that advanced map features are required to support ADAS functions such as lane departure warnings and intelligent speed assist (ISA), which is being demanded by regulations in the EU. Strategy Analytics Autonomous Vehicle Strategies service provides a deep dive into the HD Mapping sector, in its report "Localization and Mapping for Autonomous Driving".

- Google Maps can be used to support ADAS functions via an interface called the Vehicle Maps Service (VMS), but it is unclear to what extent Google Maps is being used for L1 and L2 capabilities where it has been deployed. Waymo, Google's autonomous driving division, has forged some notable partnerships since the last report. Waymo has entered a broad, global, strategic partnership with Daimler Trucks. It also expanded its partnership with Fiat Chrysler Automobiles (FCA). In July 2020 FCA announced the selection of Waymo as an exclusive strategic partner for L4 fully self-driving technology across FCA's full product portfolio. Waymo is also the exclusive global L4 partner for Volvo Car Group, and affiliates Polestar and Lynk & Co International. Jaguar, Renault, and Nissan also have partnerships with Waymo. Waymo claims its technology has navigated over 20 Million miles on public roads, the vast majority of which is in the US and over 20 Billion miles via simulation.
- HERE claims since 2017 17 Million vehicles sold rely on its ADAS supported map functions to power L1 and L2+ automation in those vehicles. In coming EU regulations mandating ISA (Intelligent Speed Assist) will provide a strong pipeline for future demand for HERE and TomTom, as

highlighted in section 3.1. While Ford plans to use Google for its infotainment services going forwards, Ford is using HERE to support its driver assist program for L2 SAE automation in North America. HERE's other customers for ADAS and HD maps include BMW, Mercedes and others. HERE aims to migrate features of its HD map to its ADAS map over time, e.g. sub-metre precision.

- During 2020 TomTom announced significant recent momentum in the distribution of its ADAS maps. In September 2019 TomTom claimed its ADAS Map powers 1.5 Million SAE (Society of Automotive Engineers) Level 1 and Level 2 automated vehicles and claimed this figure has doubled to 3 Million during Q4 2020. TomTom defines an ADAS Map if it contains one of the five attributes including speed limits, curvature, and elevation.
- Mapbox Drive has been created to support semi-autonomous driving (Level 2 and Level 3) and offers lane guidance. However, Mapbox does not have its own HD Map. Instead, Mapbox's HD vector tile format is being used by Intel to refresh Mobileye's RoadBook ™ maps in vehicles.

Safety features for vehicles are also being monetised at Level 0. Level 0 is where the service provides safety alerts and guidance to the driver rather than the vehicle. In Europe Ford will deploy HERE Hazard warnings on the Ford Puma. Ford Puma owners will receive road condition related hazard warnings based on vehicle sensor data from 80% of new vehicles. TomTom has launched a similar hazard warning service.

Google, HERE, and TomTom are integrating location services and content to address rising demand for Electric Vehicles (EV) and to address range anxiety, one of the barriers to adoption and use of EVs.

As detailed in section 4.1 Strategy Analytics forecasts growth in electric vehicles over the next 5-8 years. Given the anticipated growth in electric vehicle production location platforms have evolved their routing APIs and content to address the specific demands of electronic vehicles.

- Google has partnered with EV charging providers Chargemaster, EVgo, SemaConnect, and Chargepoint so EV drivers can locate available charging stations within Google Maps. In January 2021 it announced the support for smart EV route planning feature within Google Maps. EVs like Polestar 2 and Volvo XC40 Recharge, which use Google software will include this capability.

- HERE announced the launch of a new EV routing API in January 2021 which it claims delivers optimal routes via EV charging stations based on vehicle consumption, vehicle loads, and weather conditions, and takes charging time into consideration. The API leverages HERE's EV Charge Point database which includes information like car brand support, real time charge point availability, along with pricing information. HERE's EV coverage increased 60% in 2020 to reach over 550K EV charging ports in 191.9K locations across 91 countries.
- TomTom claims to provide over 400K EV charging points across 61 countries. It unveiled its EV routing API and EV charging station API in August 2019. TomTom's routing API enables the calculation of reachable range of electric vehicles to deliver the most energy efficient route, taking road type and traffic into consideration.
- Mapbox has not highlighted the availability of EV routing or data as a product for developers. However, Open Charge Map, a crowd sourced open data repository for EV points, use Mapbox to provide its map-based service.

Mapbox continues to play at the margins in the automotive sector. Further up the navigation stack, Mapbox announced that BMW will use its Navigation SDK to design its BMW navigation application in house. BMW is seeking a customized and differentiated navigation experience in its vehicles. Overall, TomTom maintains leadership in navigation software, supplying partner OEMs.

In December 2020 Mapbox announced BMW will use the Mapbox Navigation SDK for Android to design its map styles using Mapbox Studio, in addition to a broader technology partnership, with BMW providing input into advanced features. Mapbox provides the software for navigation and the cloud services to stream live maps in BMW vehicles. However, despite this win we understand that HERE will continue to provide maps and location content rather than Mapbox. Mapbox's customer references in the automotive sector include NNG, Porsche, Mobileye and Samsung.

- TomTom claims leadership in the navigation software space, reporting that 15 OEMs globally use its software navigation with market share twice as large as its rivals. In March 2021 it announced its next generation TomTom Navigation for Automotive (NavKit 2), its cloud-native in-dash navigation solution. The software enables vehicle OEMs to provide navigation purely online, as a hybrid embedded solution, and completely embedded.

TomTom claims leadership in the navigation software space, reporting that 15 OEMs globally use its software navigation with market share twice as large as its rivals.

- HERE claims its Navigation On-Demand navigation software is gaining traction with vehicle OEMs and tier one suppliers, though is unable to disclose customer names.

TomTom expects OEMs will increasing seek to consolidate suppliers of its navigation system overtime as requirement complexity increases (e.g. infotainment and safety) and OEMs look to reduce complexity. TomTom believes its dominance in navigation software leaves it well positioned to increase its market share for mapping, live services, and safety features in future. Conversely, HERE expects OEMs will continue to take a modular approach to their navigation stack, ensuring the market will remain competitive as OEMs seek out the best solutions to meet the needs of specific vehicles across various ranges.

Satisfaction in smartphone mirroring solutions Android Auto and Apple CarPlay remains high among users of these infotainment alternatives. A significant 30%-40% share of respondents in Europe and US claim they are likely to only consider vehicles that support Android Auto of Apple CarPlay for purchase.

Consumer research from our **In-Vehicle UX** service shows an increase in respondents that are likely to only consider vehicles that support Android Auto or Apple CarPlay for their next purchase. For example, in the US just 30% of respondents indicated they would only consider vehicles supporting CarPlay for their next vehicle, down from 33% in 2019, while 41% of US respondents indicated the same for Android Auto, up significantly **from 23% the year before**. Strategy Analytics believes the significant increase in positive sentiment for Android Auto reflects improvements to its UX made in 2019.Directionally, Strategy Analytics witnessed similar results in Western Europe versus 2019. Usage and satisfaction of smartphone mirroring solutions has been assessed in our report **Smartphone Mirroring in 2020: The Battle for "Just good Enough,"** which outlines usage and satisfaction rates for both Apple and Google mirroring systems, along with individual features such as satellite navigation, music/ podcasts, and voice assistant.

5.2.3 POI and Search

TomTom has made improvements in POI through a new partnership with Foursquare and new POI APIs. TomTom is catching up with HERE, but Google remains a leader by providing unrivalled granular information in its POIs, though identifying and removing fake listings remains an on-going challenge.

	Google	HERE	Mapbox	TomTom
POI Search	5(5)	4(4)	3(3)	3.75(3.5)

Google remains a leader by providing unrivalled granular information in its POIs, though identifying and removing fake listings remains an on-going challenge.

Scores for POI and search are based on a combination of the number of POIs offered, the granularity of details provided, and the extent to which these capabilities are made available to developers on its platforms. However, as end-users increasingly expect accurate, granular, and real-time information from searches we take into consideration how frequently the POI information is updated and made available to users of the platform.

Google remains a leader in POI and search covering 200 Million places across over 220 countries. While HERE and Google are almost on parity in total number of POIs, Google provides a granular level of information for its business listings, including opening times, parking availability, place reviews, restroom facilities, and more which is unrivalled by its competitors. Importantly, Google provides guidance on how busy retailers and public locations are across the day, which has become vital information during the pandemic, as more shoppers proactively seek to avoid peak shopping periods. Google claims to have over 120 Million local guide members, no change on last year. Local guide members are users of Google Maps that contribute by answering questions about the places they have visited. Google claims local guides and business owners (via Google My Business) receive over 20 Million contributions per day. Google validates responses based on a threshold number of consistent answers provided by guides before publishing the information. Google's strength in local search advertising was discussed in was covered in our previous report. Despite Google's approach to content validation, including the automated scanning and removal of malicious and erroneous edits, it is inevitable erroneous content will be published. Developers have highlighted to us the superiority of Google's autocomplete feature over competing provider Mapbox, which is another

advantage to Google's search capabilities. Google Places API is priced at a significant premium to reflect these strengths.

However, not all of Google's POI capabilities are exposed for developers to use or can be fully customized to address developer requirements. Through Local Context, which Google launched in beta mode in June 2020, Google has begun to offer some map customization capabilities for businesses to embed customized details into their apps and mobile web app.

HERE's POI database remains at 200 Million. HERE acknowledges it does not provide the type of detailed and granular metadata about venues which Google can provide. However, it has increased the number of point addresses to around 430 Million and is using machine learning to enhance routing so specific address. Improvements to its addressing enables HERE to improve its competitiveness to serve the last mile mobility and delivery sector.

TomTom has made significant steps in POI during 2020. TomTom announced a partnership with Foursquare in June 2020 which will increase both the coverage of TomTom's POI data and its quality. Foursquare's POIs are validated using a combination of machine learning and its community of users. TomTom's POIs are updated depending on how the method of acquisition e.g. from third-party data sources versus crowdsourcing. Crowdsourced POIs are added once they have passed quality checks while paid sources will provide updates on a weekly or monthly basis. TomTom claims its search results can be customized to meet customer requirements e.g. a retailer or business displaying only its stores or premises on a map, respectively. TomTom has also launched two new POI APIs, POI Details API and POI Photos API, to enable developers to build applications containing reviews, ratings, photos and pricing information. TomTom also disclosed over 528 million address points in its navigable map.

Mapbox relies on a combination of OSM place data and partnerships with location content providers, like Foursquare. It has not provided updated figures from the 105 Million place addresses reported in 2018. Mapbox continues to claim it supports 2 Billion search requests per week and states that its search services support companies like Facebook, The Weather Company, Uber, Adobe, Snap and Samsung.

Reliance on crowd-sourced edits, without strong verification, can result in the proliferation of millions of fake business listings which can being used for nefarious purposes or for the publication of malicious content across multiple apps and platforms.

In 2017 Google closed Google Map Maker (its community map editing platform) following a lengthy review which was initiated by several similar abuses of Google Maps. However, business listings and reviews continue to be crowd sourced. Google claims most of the inappropriate crowd sourced content is removed before it is seen by users. However, it is inevitable some may slip through the net. For example, Google received an average of 20 Million contributions per day during 2019, 7 Billion contributions in total during the year. During this period, Google removed 75 Million policy breaking reviews, 4 Million fake business profiles. It removed over 580,000 reviews and 258,000 business profiles because of reports from users.

5.2.4 Developer Community

Google remains the leader in the location developer community due to the large number of developers using its location services. However, from a capability perspective HERE, Mapbox and TomTom offer enterprise and long-tail developers similar, if not better, services.

	Google	HERE	Mapbox	TomTom
Developers	5(5)	4(4)	4(4)	3(2.5)

Developers (small and large) can access a core set of location services directly and indirectly from each location platform to add location capabilities and intelligence to their apps. e.g. map tiles, geocoding, reverse geocoding, place search, routing, live and historic traffic and more. These platforms also provide guidance to developers via blogs, video tutorials, developer events and extensive documentation.

The number of developers using the location platform reflects (to some extent) the strength of its developer location offering, as is the breadth and depth of location capabilities provided to developers.

Google remains a leading location platform for developers largely because of the significant number of developers and apps which use its location platform. During 2020 and 2021 it has improved map customization and increased flexibility for developers while adding new features.

Google has been successful at leveraging its strong Google Maps brand to acquire developers and businesses. Strategy Analytics estimates multiple Millions of developers use Google's map APIs. In recent updates Google has continued to state its Google Map Platform powers over 5 Million active apps and website each week. However, Google has indicated most of these developers operate within its free tier. In May 2018, Google increased pricing for its location services and stated that it expects "most" Google Map developers to have monthly usage that will keep them in its free pricing tier. We expect this still to be the case and therefore Strategy Analytics expects most Google Map developers to be long tail developers e.g. with basic, low volume requirements, such as a local business embedding a static map into their mobile app or webpage.

Google location APIs are available through its Google Cloud Platform and consequently locked out of competing cloud computing platforms like Amazon Web Services (AWS) and Microsoft Azure. In November 2020 Google announced the availability of its Google Maps Platform Gaming solution, which includes Maps SDK for Unity and Playable locations API, enabling game developers to enhance gameplay with immersive real-world maps and 3D buildings. Unity is the number one game developer platform, with 1.5 Million monthly active developers. Game developers such as Bandai Namco, Mirarie Inc, and WGAMES among others have already developed titles that use Google Maps.

From a products and services perspective Google is largely on par with those of its competitors. Core services like map tiles, traffic optimized routing, geocoding and places are available from all platforms. As highlighted in section 4.2.4 above, Google outperforms its competitors in place search granularity. However, it underperforms some of its competitors in other areas like map and data visualization, and openness and flexibility. For example, Google does not expose its location capabilities to developers to the extent that HERE, Mapbox and TomTom do.

HERE and TomTom continued their strategies to expand the distribution of their location services via large developer hubs during 2020. These distribution deals will help both HERE and TomTom to grow the addressable market of developers, and increase both location API use, and location service revenue.

HERE and TomTom also make their location services available via developer platforms and marketplaces. For example, HERE's location services are available for developers to use via Salesforce Marketplace and AWS marketplace. Going a stage further, developer platforms like Microsoft's Azure and Amazon Web Services have partnered with TomTom and HERE respectively to integrate location services as part of their own location solutions (e.g. Azure Maps and Amazon Location Services). These cloud platforms are aiming to close a perceived location gap on Google Cloud Platform and tap into rising developer and enterprise demand for location capabilities. During 2020 both HERE and TomTom announced they are powering location services which Verizon Direct provides to its developer community. Furthermore, TomTom is powering Huawei's MapKit, enabling developers to build native location app for Huawei devices. Therefore, HERE and TomTom can expand the reach to their location services and capabilities to communities of developers beyond the footprint of their own portals.

HERE provides developers and enterprises with a comprehensive and unrivalled set of capabilities and channels to create location products and power local intelligence.

Developers can access location services, such as maps, routing, geocoding, search, and software development (HERE SDK) tools. Additionally, developers also have access to specific fleet telematics services, tracking and positioning tools, venue maps, as well as HERE Platform and HERE Studio. HERE Platform provides a cloud environment for developer to extract and analyse location data via HERE Workspace. Developers can monetise their location data and intelligence by marketing and selling it through HERE Marketplace. HERE Studio allows large data sets to be uploaded and visualised via a map editor.

HERE is committed to making all HERE's products and services available to developers. HERE is still playing catch-up with Google for total developers to its platform. Since the last report HERE has indicated growth in the number of

direct developers in the multiple double-digit range and has not provided an updated figure for in-direct developers, e.g. those accessing HERE's location services via third-party developer platforms.

Mapbox provides the common set of location services provided by all the other platforms (maps, routing, geocoding, search and map SDKs). Additionally, Mapbox also allows developers to access its Vision SDK, which processes road scenes in real-time, including identifying road traffic signs and develop custom maps in Mapbox Studio. Mapbox reports over 175,000 developers build location experiences using Mapbox SDKs and APIs with 45,000 mobile apps powered by its SDK. This compares to 155,000 developers in our previous report, up by 13%. Like Google, Mapbox has been successful at driving location service availability among the game developer community. Mapbox location APIs are also available through to developers of the Unity games platform, to enable developers to add location capabilities into their games. Mapbox location tools are widely available for use through business intelligence and analytics software, including Alteryrx, Power BI, and others. Web developers have been attracted to Mapbox to use its open source browser-based map renderer, Mapbox GL JS. However, in December 2020 Mapbox announced the update, Mapbox GL JS v2, will not be available as open source. Although Mapbox GL JS v1 will remain open source, developers which have built services and capabilities based on this version will need to decide whether to continue to in future given Mapbox will no longer support it going forwards.

TomTom continues to enhance its developer capabilities and remains focused on acquiring higher value developers.

TomTom provides the core set of location service capabilities to developers, including tracking, map SDKs and traffic. TomTom indicates a 30% growth in developers directly using its platform versus last year and a 50% growth in paying customers. Unlike Google and Mapbox, which have both indicated a large proportion of developers do not pay to use location services, TomTom claims it monetizes over half of its direct developers. TomTom states that its initiatives to attract disaffected developers from Google have been successful. Strategy Analytics estimates that the number of direct developers using its APIs and SDKs is rising to the mid to higher tens of thousands range (50K-70K). TomTom has

not specified the number of developers directly or indirectly accessing its location services.

Each of the location platforms in our benchmark continued activities to attract developers, whether through making more location APIs and content available, adding partnerships with third party developer ecosystems, or by making changes to commercial terms.

- Google: During 2020 Google has unveiled new tools and APIs for gamers and for companies offering mobility and last-mile solutions (e.g. preferred routes API, Nearby Drivers API, and Trip and Orders Progress API). It has also introduced a temporary closures API (to provide updated information about pandemic related closures). Google has also increased the level of customization available to developers e.g. in Local Context (in beta mode) and zoom levels.
- HERE: HERE has added several new capabilities for developers including EV routing.
- Mapbox: Mapbox has added new APIs including 3D Maps, a camera API, and Sky API as part of the GLJS v2 update discussed above. It has also launched Mapbox Tiling Service to improve visualization of large data sets in real time.
- TomTom: TomTom has also released new APIs linked to tracking, POI search (which includes a POI Detail API and a POI Photos API) and visualization. TomTom has enhanced its tracking capabilities by revamping its Notifications API and Location History API.

5.2.5 Map and Data Visualization

Mapbox remains a leader in map customisation and design while HERE, Google and TomTom have enhanced their map visualization options and capabilities.

	Google	HERE	Mapbox	TomTom
Visualization	4.25(4)	4.25(4)	5(5)	3.75(3.5)

The growth in the number and variety of IoT sensors over the next 5 years will only serve to increase demand for platforms which allow businesses and authorities to analyse and visualise data geospatially. In sectors like automotive, fleet, logistics and transportation, and mobility the need for location intelligence is more obvious than other industries. However, as highlighted in Exhibit 5,

location intelligence is considered important in areas like real-estate, retail and e-commerce, and finance, among others.

The visualization benchmark takes into consideration the ability of location platforms to enable customers to build customized maps to address their needs, and to visualise location data to gain location intelligence.

Google, HERE, Mapbox and TomTom each provide customers with tools to visualize location data on maps, and to customize maps (e.g. layers and map styles) to meet their needs. For example, HERE enables map customisation and data visualisation through HERE Studio, Mapbox via Mapbox Studio, and TomTom through TomTom Styler. The need to analyse and visualise data gathered from sensors and from simulations on maps will only continue to rise in importance for businesses and authorities as both the number and variety of sensors proliferates.

Mapbox bolstered its leadership position by adding a camera API and a sky API to enhance 3D map visuals, including an update of 135 Million square kilometres of satellite imagery. Mapbox's leadership in map design and customisation is underlined by capturing BMW and Epic Games as customers. BMW is designing its infotainment unit using Mapbox's Navigation SDK and Mapbox Studio while Epic Games is integrating Mapbox into its Unreal Engine for developing human machine interfaces (HMI). Unreal is incorporating map rendering and navigation capabilities into the real-time 3D creation tool. Both BMW and Epic Games offer differentiated experiences to users.

HERE has added to its visualization capabilities by announcing the availability of HERE Premier 3D cities in January 2021. Premier 3D cities consist of indexed and addressed high-definition building models across over 70 cities globally. HERE has also launched geo models which deliver 3D models to sub-meter levels of accuracy. Developers can search and address buildings, attach additional meta data and render them. HERE has highlighted city infrastructure-planning (including 5G networks), gaming and AR/VR as potential use-cases for its Premier 3D cities and geodata model capabilities. 3D models are already available in the Audi A8 navigation app. Large datasets can be uploaded to HERE Data Hub and visualised via a graphical user interface in HERE Studio.

During 2020 Google made several enhancements which have allowed it to better meet developer needs. To improve visualization for developers, Google has introduced 4 map customisation features. First, map customisation and styling has moved to the cloud. Secondly, the process of map customisation has been simplified for marketers (non-developers) to use. Third, it has introduced vector maps which relies on the device GPU for improved rendering – catching up with HERE, Mapbox and TomTom. Finally, Google has increased POI customisation to allow businesses to filter out POI types in their own maps. It has also enhanced customization of map data layers with its zoom function. Separately, Google has enabled GIS data visualisation in Google's Data Studio. Data Studio is a data visualisation service from Google Marketing Platform which connects to Google's data warehouse, called BigQuery, and other data sources.

Google has enhanced its map application to enable users to distinguish between natural features in the environment, such as mountains, dense forests, deserts, and beaches. Google is also adding greater detail to its Street Views in selected cities, enabling greater distinction in road hierarchy, pedestrian islands, and cross walks.

Google's Street View maps are a differentiator and in August 2019 it launched an augmented reality walking directions feature, called Live View, which currently remains in beta. Similarly, HERE's Live Sense SDK enables developers to create AR navigation experiences while Mapbox's Vision SDK also allows developers to integrate Augmented Reality (AR) into navigation-based applications.

While TomTom has not announced enhancements to its visualisation capabilities, we understand it is an area of priority and on-going improvement for the company.

Each platform allow some level of customization. Developers can further modify the look and feel of maps by offering different off-the-shelf map styles, overlaying different markers, changing font styles, font sizes, boundary colours, etc. Google offers a map styling wizard and the ability to control the prominence of roads, landmarks and labels. Mapbox provides some more off-the-shelf variants of its standard 2D Map, offering a light and dark mode. TomTom currently provides developers with the fewest visualization options via its map APIs and SDK,

though TomTom Styler is a clear enhancement. These options include day, night, and labels only.

5.2.6 Openness and flexibility

HERE, Mapbox and TomTom are leaders in openness and provide developers with greater flexibility than Google. As a provider of its own services (e.g. search, advertising and navigation) Google restricts the use of its location services to use-cases where it does not compete.

	Google	HERE	Mapbox	TomTom
Openness/ flexibility	2(2)	5(5)	5(5)	5(5)

Our scores for openness and flexibility remain unchanged from last year. HERE, Mapbox and TomTom enable modular approaches to location services while Google remains the most restrictive.

HERE, Mapbox and TomTom are open and provide developers with greater flexibility than Google. Google restricts the use of its location services to use-cases where it does not compete e.g. advertising and search.

Google applies some notable restrictions on its location services, particularly to avoid potential rivals to its core business using its services. For example, Google does not allow companies providing a listings service or a directory service to use Google Core Map services. Companies are unable to use Google Core Map to augment an existing ad product either. Similarly, Google does not allow developers to use its directions APIs, geo-location APIs, and maps SDK to create a real-time navigation product which provides functionality similar to its Google Maps for Android App. Furthermore, Google Core Map services cannot be used in applications which contain a non-Google map. For example, customers can not display its places listings on a non-Google map, or display street view imagery and non-Google maps in the same application. Furthermore, unlike HERE and TomTom, which are offering location services to power ADAS and autonomous functions, Google's self-driving technology remains proprietary to Waymo, though it has formed strategic partnerships with Daimler and Fiat Chrysler Automobiles (FCA).

Flexibility and openness remain at the heart of HERE's platform approach. Most notably, HERE now allows the map and location services of its competitors (including TomTom and Mapbox) to be used by customers of HERE Workspace. This prevents potential customers that are already licensing maps and location services from HERE competitors from being locked out of using its Workspace

and Marketplace environments. HERE Workspace and HERE Marketplace enable large enterprises to manage, analyze and productize large sets of location data. For example, HERE's location platform is being used to ingest and analyze sensor data from vehicles to provide enriched services such as HERE's Hazards and Road Signs products for automotive companies. HERE also provides access to different map content streams via its Data Layers service.

HERE Studio remains open, a cloud-based location platform which enables developers to ingest large data sets which can be visualized on HERE's maps, including via third-party map rendering tools, including Leaflet, Tangram, and Three.js, among others. The HERE Vector Tile Service uses Web Mercator projections and follows the industry standard for vector tiles (MVT) which is supported by multiple 3rd party and open source map renderers.

With the launch of Mapbox GLJS v2 in December 2020 Mapbox has moved away from its open source roots. Web developers which have been able to deploy Mapbox GLJS for free will now be subject to charges. As an independent location platform Mapbox is not challenged by similar conflicts of interest as Google and does not compete with its customers. An example of its open approach is Mapbox's traffic service, which will work in conjunction with competitor maps like HERE and TomTom.

TomTom makes its APIs available to any developer to use in conjunction with APIs from other services. During 2019 Mapbox opened its traffic service for use with other map providers.

5.2.7 Vision and Growth Leadership

HERE continues to position as a leader in addressing the evolving needs of the location sector, within and beyond automotive. Google is increasing its presence in automotive, and self-driving vehicles. TomTom remains deeply committed to building both its automotive and enterprise developer business.

	Google	HERE	Mapbox	TomTom
Growth Vision	4(4)	5(5)	3(4)	3.5(3.5)

Google is offering solutions targeted at on-demand rides and delivery sectors, game publishers and developers, asset tracking (fleet) and retail experiences. As a leading consumer map provider Google remains focused on adding useful content and capabilities to its Google Map to improve its value to users and developers. For example, Google is applying machine learning (ML) to provide better estimates of delays to bus journey where information from transit authorities is not available. It is also using location data to provide guidance on how full buses are to enable passengers to make more informed journey related decisions. Google also quickly reacted to rising demand for bike routes during the COVID-19 pandemic by adding bike relevant content. Google is gaining traction in automotive through infotainment deployments with Ford, GM, and Renault. Looking to the future it is enabling predictive EV routing and through Waymo the autonomous driving opportunity. Google has also identified the growing need for location intelligence across a range of sectors and is positioning itself accordingly. As a leading global technology provider Google remains at the frontier of innovation relating to mixed reality/ augmented reality, AI/ ML, cloud computing technology, and consumer facing services – which can all support its efforts in the evolving location sector.

HERE continues to position as a leader in addressing the evolving needs of the location sector, within and beyond automotive with its open platform approach.

Mapbox announced a joint venture with Softbank in Japan, enabling Mapbox to target growth opportunities in the Japanese market. Softbank has highlighted automated mobility-as-a-service, AI vehicle dispatch services, delivery services, and robot/ drone navigation as key use-cases it is aiming to enable. Beyond this, Mapbox has not communicated its future vision for location services, but examples of leadership and vision include its VISION SDK, which brings crowdsourced computer vision and machine learning together to deliver location-enhanced insights. In 2019 Mapbox also partnered with Sprint (now T-Mobile) to support location services for its 5G IoT network.

HERE remains committed to its strategy to address location growth opportunities both within and beyond the automotive industry through its content, solutions, and platform approach. More specifically, in addition to automotive HERE is targeting the transport and logistics market, the technology sector, media/ advertising industry and telecommunication sectors, in addition to public sector and infrastructure. HERE noted during an analyst update in November 2020 that its approach in addressing non-automotive use-cases has seen success. HERE's non-automotive bookings during year-to-date 2020

increased by multiple double digits and saw non-automotive pipeline increase in a similar range. Furthermore, despite COVID-19 negatively impacting vehicle licensing its bookings for 2020 reached €1.7 Billion. Looking to the future, HERE's 3D City Models and Geodata Models aims to enable opportunities in emerging use-cases linked to AR and XR, 5G network planning, autonomous simulations to train algorithms with AI and ML in virtual environments, and more. HERE's flexible approach will enable it to play a role in the enablement of geospatial services and location intelligence either by providing a full-scale end-to-end solution, a development platform, or just a single module. HERE recognises to address the broad potential for location services it needs to provide tools to position it as an ideal partner. For example, Deutsche Bahn has used HERE Platform and mapping technology to develop its own proprietary HD map. In automotive HERE has demonstrated leadership in ADAS and HD mapping, and HERE's Navigation On-Demand as a software-as-a-service (SaaS)-based navigation implementation.

TomTom's plan for growth remains to focus in a laser like manner on its core automotive business and a broad range of enterprise needs. Enabling autonomous and assisted (ADAS) driving remain key priorities for its automotive activities, while its Microsoft partnership to power Azure Maps is a key pillar for enterprise growth. TomTom has deployed the next iteration of its navigation software, enabling it to provide both connected and embedded navigation as IVI evolves towards a software-as-a-service (SaaS) based model, away from the historical licensing approach. TomTom's innovation includes IQ Maps. IQ Maps updates maps on-demand, based on the route which users are taking. By only updating the portion of the map relevant to the driver, IQ Maps eliminates the need to download the entire country or region map, which would generate a large volume of irrelevant data. During 2020 TomTom unveiled its Hazard Warning system, following HERE's Hazard Warning services. It was also involved in a proof-of-concept (PoC) with Toyota Research Institute – Advanced Development (TRI-AD) and DENSO to demonstrate fast HD map building to support safer autonomous driving.

6. Strengths and Weaknesses

In the previous section Strategy Analytics highlighted specific capabilities on which to benchmark and score the different location platform providers. However, enterprises of different types will have different needs and requirements for their location platform. In Exhibit 7 we summarise the relative strengths and weaknesses of each of the location platforms.

Exhibit 7 Strengths & Weakness Analysis of Major Location Platforms

	Relative Strengths	Relative Weaknesses
Google	• Very deep pockets (>US$180 B in revenue in 2020) • Strong consumer brand recognition - > Billion monthly active users of Google Maps worldwide • Tuned to consumer trends due to dominance of search. • Large base of GPS traces assist real time map changes • Largest number of POIs and the most granular info • > 120 M Local Guides (2020) contributing POI info • Millions of developers (>5 M apps and websites use Google Map APIs on a weekly basis) • Indoor venue maps – 10K locations • Leadership in AI/ML and cloud tech.	• Still perceived as a strategic threat by some carmakers • No China presence • Fake listings remain an ongoing challenge • Concerns over privacy & use of data for advertising • Its location services are behind a walled garden and less flexible vis-à-vis competitors • Google is locked out of large developer ecosystems like Azure and Amazon Web Services (AWS)
HERE	• Independent and open • Significant resources – 8K employees globally • Leading map provider in North America and Western Europe • Strong ADAS and HD Map momentum • Influential investors and partnerships in key LBS growth areas e.g. automotive, industrial Asia • Global coverage, including China, Japan, and South Korea • Strong growth vision and product lines beyond automotive • Full range of map making tools	• Weak in long-tail developer v Google and Mapbox • Limited consumer brand • Danger of being all things to all people diluting key brand messages

	• Large enterprise customers (e.g. Amazon, MSFT) • Hybrid navigation mode in absence of connectivity • Strong indoor venue marketplace	
Mapbox	• 600 M monthly active location (GPS) probes • Leader in map data visualization • Independent and based on open principles • Location leader in Business Intelligence (BI) sector • Large developer community > 175K monthly active • Used in >45 K apps • Investment from Softbank • Presence in China and Japan via JV	• Fewest employees – over 500 globally • Doesn't control its own map; OSM dependence • Susceptible to malicious map edits • Remains weak in automotive • Weak indoor/ venue coverage
TomTom	• Well resourced. • Strong in map content licensing and automotive • Leader in navigation software with 15 OEMs • Leader in traffic data (live and historic) in North America Western Europe • Focused on automotive and enterprise • Flexible for developers • Aggressive pricing of location services • >600 M active GPS probe points	• Less well-resourced versus Google and HERE • Reliance on Apple for probe data • Weak indoor/ venue coverage • Declining consumer business (PND) risks stability

7. Analyst Contacts

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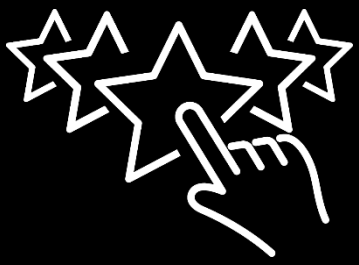
Understand your customer

Business opportunities abound. But which ones are right for you and your customers? Which will give you the advantage?



Optimize your user experience

Optimize your product to give your users the best experience and you the market advantage.

Analyze the market

Understand the size of the opportunity and where your product fits using our unrivalled knowledge and world class data analysis techniques.

Explore your future

Working with us will focus you. With our insight and forecasting expertise you'll make confident strategic decisions that drive success.

Please contact us at custom@strategyanalytics.com with any questions and for further details and solutions on how we can work with you on creating a custom solution to address your specific needs.