

Location-Based Services (LBS)

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European
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Satellite Systems
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Location Based Services (LBS)

GNSS applications

- **Navigation:** Route planning and turn-by-turn instructions based on GNSS support for both pedestrian and road navigation.
- **Mapping&GIS:** Smartphones enable users to become map creators thanks to the democratisation of digital mapping.
- **Geo marketing and advertising:** Consumer preferences are combined with positioning data to provide personalised offers to potential customers.
- **Safety and emergency:** GNSS in combination with network based methods provides accurate emergency caller location.
- **Enterprise applications:** Mobile workforce management and tracking solutions help companies to improve productivity.
- **Sports:** GNSS enables monitoring of users' performance through a variety of fitness applications.
- **Games/Augmented reality:** GNSS enables a wide range of location-based games on smartphones and tablets. In augmented reality games, positioning and virtual information are combined to entertain the user.
- **mHealth:** In combination with other technologies, GNSS enables a vast array of applications from patient monitoring to guidance systems for the visually impaired.
- **Personal Tracking:** GNSS facilitates innovative tracking solutions, including the deployment of local geofences that trigger an alarm when a user leaves the perimeter.
- **Social networking:** Friend locators embedded in social networks use GNSS to help keeping in touch and sharing travel information.

LBS devices

GNSS-enabled Location-based services comprise a multitude of applications tailor-made to satisfy different usage conditions and needs. These applications are supported by several categories of devices: mainly smartphones and tablets, but also specific equipment such as personal tracking devices, wearables, digital cameras and portable computers.

What you can read in this chapter

- **Key trends:** Ubiquity of GNSS in smartphones is enabling a thriving context-aware apps market.
- **User perspective:** Emerging LBS applications are more demanding in terms of user requirements.
- **Industry:** List of main players by value chain segments.
- **Recent developments:** Asia-Pacific accounted for over 50% of global LBS shipments in 2016.
- **Future market evolution:** Smartphones shipments mature, shifting revenue streams towards added-value services.
- **Focus on European GNSS:** Galileo paves the way for the development of enhanced LBS applications.
- **Reference charts:** Annual evolution of GNSS devices' installed base and revenues by device type and region.



GNSS enabled app revenues quantified in this edition of the GNSS Market Report.



Ubiquity of GNSS in smartphones is enabling a thriving context-aware apps market

Key Market Trends

- Over 90% of context-aware smartphone apps now rely on GNSS and first Galileo smartphones hit the market.
- A growing number of premium smartphones is going beyond dual-constellation by integrating multi-constellation GNSS chipsets, thus further increasing accuracy, availability and time to fix.
- Location-based services in mHealth are driving the diversification and sophistication of wearables and smartphone apps for healthcare.
- Availability of GNSS raw measurements on smartphones opens new possibilities for app developers.

The rise of context-aware apps

Context-aware apps extrapolate information about the user's **context** from the devices' **positioning technologies** and **sensors**. Context-awareness supports navigation, social networking, tracking, search and many other smartphone app categories including location-centric augmented reality games and utility apps that require absolute positioning. While hybrid context-aware smartphone apps for indoor positioning integrate Wi-Fi, Bluetooth and cell-ID location, hybrid and outdoor positioning continue to rely on GNSS as a source of efficient positioning.

Revenues of context-aware smartphone apps will hit €30.6 bln by 2019, up from €11.7 bln in 2015. GNSS penetration in context-aware apps is steadily increasing and reached a weighted penetration of over 90% in 2016, with GNSS-attributable app revenues reaching € 5 bln¹.



App store market becoming less concentrated

The increasing number of app stores and the growing **APAC** market have had a **disruptive** effect on the long-standing global duopoly of Android's Google Play and iOS' Apple App Store. Already in 2016, almost 60% of Chinese Android users downloaded apps from third-party app stores. This trend is likely to continue.

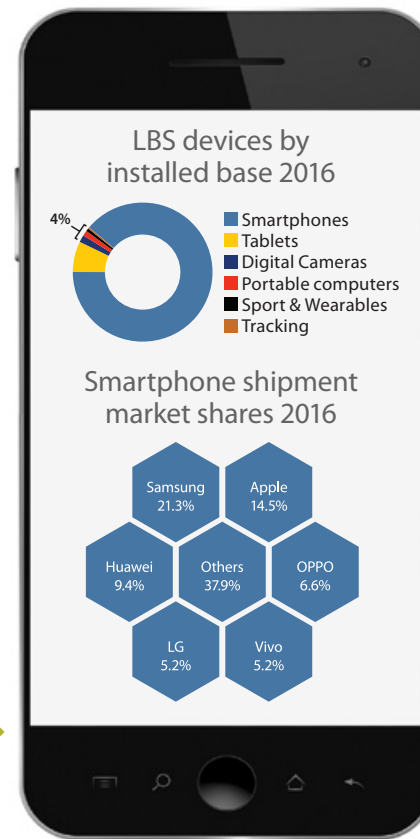


With €28 bln, the Asia-Pacific app market accounted for 56% of global app revenues in 2016 and is forecasted to grow to €57 bln by 2020 (CAGR of 19.4%).

In 2016, **Android** consolidated its leadership in terms of annual global app **downloads**, with over two downloads from Google Play for each **iOS App Store** download. Inversely, the iOS App Store generated twice the revenue of Google play in 2016.

Total unique apps in store

Google Play	2.4 mln apps
Apple App Store	2.0 mln apps
Tencent MyApp	~2.0 mln apps
Windows Phone Store	669 k apps
Amazon Appstore	600 k apps



Users



The global **installed base** of GNSS enabled handsets is expected to rise from 4.1 bln in 2016 to 6.1 bln in 2019 (many users have multiple devices). The strong growth in LBS revenue is primarily driven by the **growing** and **diversifying** usage of apps, rather than by the accruing installed base. Annual revenues of LBS GNSS device sales and services are expected to exceed €115 bln in 2025.

Over the last years, the worldwide **time users spent** in apps almost doubled, with Android users now spending 2 hours per day on average using smartphone apps.

With the rise of context-aware smartphone apps, more and more users are profiting from GNSS-supported LBS such as location-based **aggregation** services, geolocation social media **monitoring** and proximity-based **marketing** applications.

¹ Including €2.9bn revenues generated by smartphone apps for navigation, which are quantified in the Road segment



Emerging LBS applications are more demanding in terms of user requirements

New Augmented Reality apps require higher GNSS performances



A growing number of smartphone apps is using **GNSS** to enable location-based **Augmented Reality (AR)** services. Allowing geo-referenced positioning globally, **GNSS** is an essential technology for AR apps in outdoor environments. The growing complexity of AR apps is driving the evolution of GNSS **user requirements**. Increasingly penetrating both the professional and the mass market, new location-based AR applications require a greater **accuracy** performance than most LBS smartphone apps.

Moreover, the rapidly diversifying portfolio of GNSS-enabled AR apps is driving the need for **authentication** of the position. A growing number of smartphone users is becoming aware of the risks of malicious interferences to GNSS signals thanks to the extensive media coverage on 'cheating' the Pokémon Go app through GNSS spoofing. Authentication can moreover contribute to protecting app developers' streams of revenue.

Driven by ever lower **device prices** and the rapid maturation and diversification of technology, the global AR market is expected to grow dramatically from €5 bln in 2016 to over €81 bln by 2020.



A growing number of LBS applications require higher accuracy and authentication

The **user requirements** of many established **LBS** applications, such as turn-by-turn navigation, infotainment and social networking apps have remained relatively **constant** since their inception, and continue to be satisfied by levels of GNSS accuracy of 5 metres and more. Over recent years, a burgeoning group of new applications has emerged that does require far more **stringent** horizontal and vertical **accuracy** levels. These range from **augmented reality** applications to innovative safety-critical mHealth technologies such as guidance applications for visually impaired, which are among the most demanding types of smartphone apps.

Moreover, application categories such as **geo marketing and advertising**, fraud management and **location-based billing** require **authentication** of the position to protect app users from malicious signal interferences such as spoofing.

mHealth applications are driving innovation in hybrid positioning

Whilst **hybrid positioning** is relevant for many mass-market LBS applications, special user categories such as visually-impaired people or wheelchair users rely on a seamless navigation experience between outdoor and indoor environments to a much greater extent than most other user types. This has implications for **app developers** as pioneers in tackling the seamless positioning challenge.

Large healthcare providers such as hospitals are beginning to invest in hybrid navigation services and smartphone apps that enable staff, patients and visitors to navigate from their house door to a particular location in the facility using specific itineraries for different user categories, e.g. accessible routes for wheelchair users.



LBS applications for healthcare are increasingly gaining ground, with a forecasted **CAGR** of approximately **32%** between 2016 and 2020.

Healthcare **needs** are driving the **diversification** of wearables. As an example, a GNSS-enabled haptic shoe allows visually impaired users to set a destination in the smartphone app. The soles guide the user to the destination by vibrating in the front, back, or sides.

Overview of the main user requirements in LBS

The table depicts, in alphabetical order, the key user requirements as assessed through the GSA's continuous monitoring with the user community. Only high priority requirements are shown, i.e. other requirements might also be relevant for considered applications, and the table is subject to updates. Information on the parameters is provided in Annex 2.

Applications	Lower performance: Navigation, Sports, Tracking, Social networking, Enterprise applications, Infotainment, Games	Higher performance: Augmented reality, mHealth, Geo marketing and advertising, Fraud mgmt and billing, Safety and emergency
Key GNSS requirements	Availability TTFF	Accuracy Authentication Availability TTFF
Other requirements	Connectivity (including short range) Interoperability Power consumption	Connectivity (including short range) Interoperability Power consumption



LBS Value Chain



The European¹ GNSS industry in the global arena

The LBS segment is dominated by non-EU players. With a market share of over 60% in 2015, **North American** companies are leading in the components and receivers market, compared to a market share of less than 6% held by **European** companies such as u-blox. **Asian** companies were able to increase their share of **system integrators** revenues well beyond 50% of global revenues over recent years.

European players continue to perform strongly in **app development**. Of the 5.7 million app developers worldwide, over 22% work in the EU. By 2018, the European app economy is forecasted to contribute €63 billion to the EU economy and employ 4.8 million people.

A **technology-** and **innovation-friendly** environment for LBS in **Europe** has been bolstered by recent EU roaming rules, which oblige mobile telecommunications operators to apply the **domestic retail price** on any EU roaming customer for voice, SMS and data usage from mid-2017 onwards. Already in 2016, roaming in the EU was over 90% cheaper than in 2007. The further **reduction** in roaming charges is likely to boost the already growing usage of **location-based services** and **smartphone apps** beyond national borders.

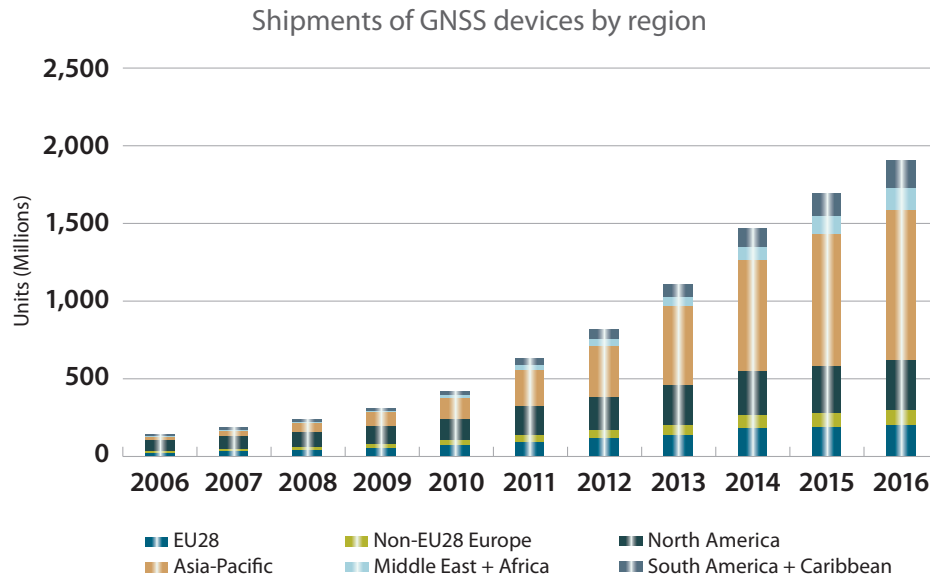
The Value chain considers the key global and European companies involved in the GNSS downstream activities.

* European based companies. The world region is referred to the headquarter of the company, the actual area of activity might be wider.

¹ In the market share analysis, Europe is defined as EU28 plus Norway and Switzerland.



Asia-Pacific accounted for over 50% of global LBS shipments in 2016



The largest regional LBS market since 2011, **Asia-Pacific** accounted for over 50% of global LBS shipments in 2016 with a total of almost 1 bln shipped devices. **North America** and the EU accounted for more than 320 mln and 200 mln respectively.

Smartphones greatly outnumber other LBS devices in terms of shipments. Due their large number of units, smartphones represent a great opportunity for application developers to effectively realise economies of scale. Driven by the growing context-aware smartphone app market, revenues attributable to GNSS grew from €150 mln in 2010 to €5 bln in 2016¹.

Due to the increasing saturation of the mature EU, North American and China markets and slackening global economic growth, the rise in global smartphone shipments has been gradually attenuating, with year-on-year growth in 2016 dropping to 12%, compared to 33% in 2014. The slowdown was underpinned by a rapidly **growing second-hand smartphone market**, which grew from 56 million smartphones traded globally in 2014 to over 100 million devices in 2016.

Other GNSS-enabled devices accounted for around 175 mln units in 2016. With 113 mln units shipped that year, **tablets** represented the second largest application. Their shipments saw a 250% increase between 2012 and 2016, with major regional markets consistently being **North America, Europe and Asia**. Driven by reducing device prices and growing consumer awareness, personal tracking devices witnessed the highest growth rate across all LBS categories, with a CAGR of 70% between 2012 and 2016.

Multi-constellation is broadening the possibilities of GNSS use on smartphones

A growing share of **premium** smartphones is integrating **multi-constellation** GNSS. Whilst many **low-end** smartphones continue to rely on single-constellation A-GPS, the vast majority of new premium smartphones integrate multi-constellation. GPS + GLONASS ranks as the most prominent combination of multi-constellation currently deployed in smartphones. Moreover, a growing number of high-end smartphones is additionally integrating BeiDou, thus further enhancing the benefits associated with multi-constellation devices. In mid-2016, the first Galileo-enabled smartphone entered the market.

With a growing number of premium smartphones using multi-constellation, more users are harnessing the associated benefits of higher **accuracy**, better **availability** in difficult environments and a lower **time to fix**.

As premium smartphones increasingly approximate the performance of low-end **professional-grade** receivers, the technological evolution of multi-constellation smartphones could in the future lead to the **democratisation of some professional activities**, such as rural cadastral surveying, and the "cannibalisation" of dedicated devices.

Different uses of GNSS create new market segments in wearables



The incremental diversification of the GNSS wearables market has created differentiated markets with **distinct uses of GNSS**. GNSS supports diverse categories of wearables, including fitness wearables, smartwatches, healthcare wearables, smart clothes and smart eyewear.

For instance, GNSS Timing & Synchronisation entered the mass-market in 2016, with a growing number of watches drawing on **GNSS-referenced synchronisation**. High-end

models integrate GPS-positioning that allows for automatic adjustment to correct time zones and have been available since 2012. Recently, Apple entered into competition with GNSS wearable market players Garmin and Polar by integrating GPS in its own range of smartwatches.

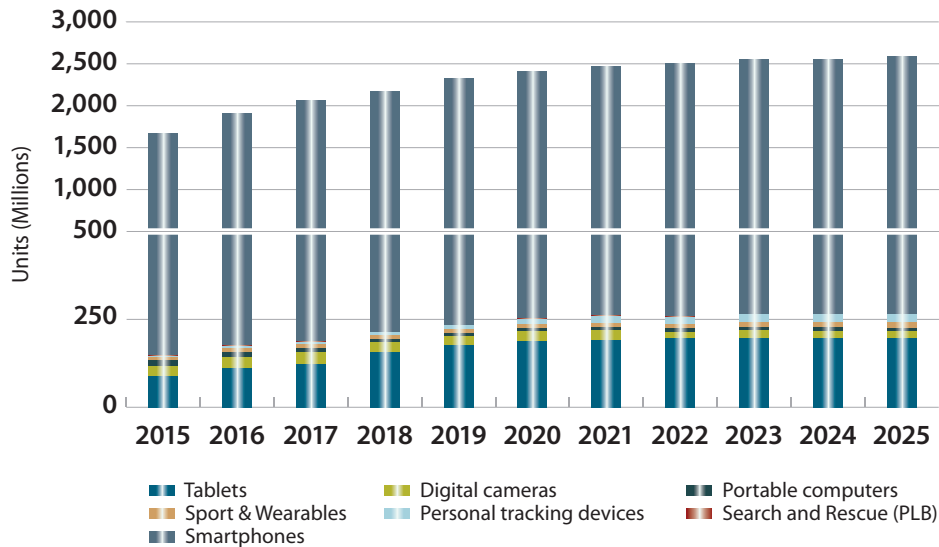
Growing **diversification** and **falling device prices** drove the **growth** of the wearables market over the recent years, with a CAGR of 15% between 2012 and 2016.

¹ Including €2.9bn revenues generated by smartphone apps for navigation, which are quantified in the Road segment



Smartphones shipments mature, shifting revenue streams towards added-value services

Shipments of GNSS devices by type



The growth of the global GNSS market in LBS will remain strong until 2020, followed by a period of attenuated growth due to increasing saturation in the **EU28, North American** and **Chinese** markets. Given the predominance of handhelds in the LBS segment, this slowdown will primarily be driven by the maturing **smartphone** market, which will grow by only 3.2% annually between 2016 and 2025.

In 2017, more than 2 bln units of GNSS devices will be shipped, with annual shipments set to exceed 2.5 bln units in 2025. The **Asia-Pacific** region will continue to be the main motor of growth well into the post-2020 period. Underpinned by the growth and diversification of local search apps and augmented reality games, **app revenues** attributable to GNSS are expected to rise from €5 bln in 2016 to over €13.5 bln in 2020.

Tablets will remain the second most important application in terms of number of shipments, but annual growth rates will gradually decline due to the increasing maturity of the market. Future growth in this segment will be driven by the adoption of multi-constellation and the increasing computing power of tablets.

With a CAGR of 17.9% between 2016 and 2025, **personal tracking devices** will be the fastest growing market in LBS. With 14.1 mln units shipped in 2020, tracking devices are set to quickly overtake **wearables** in terms of units shipped.

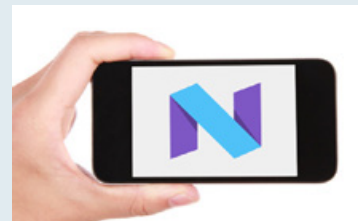
Hybrid positioning - closing the gap between outdoor and indoor LBS

The integration of outdoor and indoor LBS is ushering in the era of **hybrid positioning**, which comprises all services that leverage on both outdoor and indoor LBS technologies to enable a **seamless navigation experience** between outdoor and indoor environments. Hybrid positioning is particularly useful for spatially dispersed venues such as large urban universities or hospitals, whose facilities are often located at different locations in a city.

With indoor LBS increasingly **complementing** GNSS-based LBS for outdoor environments, seamless navigation solutions are forecasted to rapidly become more widespread. Currently, indoor LBS technologies such as Wi-fi, as well as Bluetooth low-energy and virtual beacons, are predominantly deployed by **large venue operators**, including shopping malls and conference centres as well as large public buildings such as airports, train stations, universities and hospitals.

Dubbed “the year of the beacon”, 2016 saw a **skyrocketing** number of beacon manufacturers compete in an increasingly dynamic market. The global indoor LBS market is forecasted to grow at a CAGR of over 43% between 2016 and 2020, set to reach €7.7 bln in 2020.

Availability of pseudoranges could push the boundaries of GNSS performance



In May 2016, **Google** announced that it will make available raw GPS measurements, making **pseudoranges**, carrier phase and Doppler accessible from smartphones and tablets using the new Android operating system depending on how much the chipset layer will release. This will enable **device manufacturers** to enhance their real-life GPS performance testing and potentially enable the development of **more reliable and accurate** GNSS-based positioning using conventional hardware.

App developers are foreseen to be well-positioned to profit from this development in the future, as there is a number of benefits to be derived from **more performant smartphone apps** that draw on the newly released measurements. For app users, the expected benefits comprise higher accuracy and greater reliability, in turn enabling a **better positional performance**.



Galileo paves the way for the development of enhanced LBS applications



Mass market LBS applications require high availability, a fast Time To First Fix (TTFF) and moderate accuracy. Simultaneously, they need to preserve the battery life of the device and keep the cost of the receiver down.

In multi-constellation mass-market LBS devices, Galileo enhances core GNSS performances. By virtue of providing a higher number of available satellites, Galileo benefits users globally by **increasing accuracy, improving availability** in challenging environments such as urban canyons and light indoor environments and **lowering the TTFF**. Galileo improves location-based services and applications for users, ranging from enhanced ubiquitous positioning performances to the development of more sophisticated Augmented Reality applications in outdoor environments.

By furthermore providing signal-embedded authentication, Galileo could become a key enabler of future Location Based Billing services by facilitating the linking of user's location information to a payment for a given service.



EGNOS and Galileo might be employed for improving 112 caller location accuracy

EU funded HELP112 project is a pilot project on the design, implementation and execution of the transfer of **GNSS** data during an **e112 call** to a Public Safety Answering Point (PSAP). Caller location information is one of the **main challenges** that emergency services face nowadays. In practice there is a gap between **citizens' expectations** of location accuracy (5-10 m) and the current emergency location solutions available in EU Member States using mobile cell or sector ID (100m - 40 km).



Accurate and **reliable** caller location leads to considerable gains in human, time and financial resources, and, above all, **lives saved**. The project tests and assesses the use of European GNSS solutions, notably Galileo and EGNOS, to define requirements and recommendations for technologies enhancing caller location information at the European level in a cost effective manner. Improved emergency caller location could save **800 lives** annually and up to **€100 billion** over the next decade, according to a study conducted within the project.

More information on: www.help-112.eu

The first Galileo-ready smartphones are hitting the market



In mid-2016, the Spanish technology company BQ launched the **Aquaris X5 Plus**, the first European Galileo-ready smartphone. Integrating Qualcomm's Snapdragon 652 processor, the Aquaris X5 is a multi-constellation smartphone that is capable of receiving also GPS, GLONASS and BeiDou signals.

In early December 2016, Chinese manufacturer Huawei announced that its new premium models, the

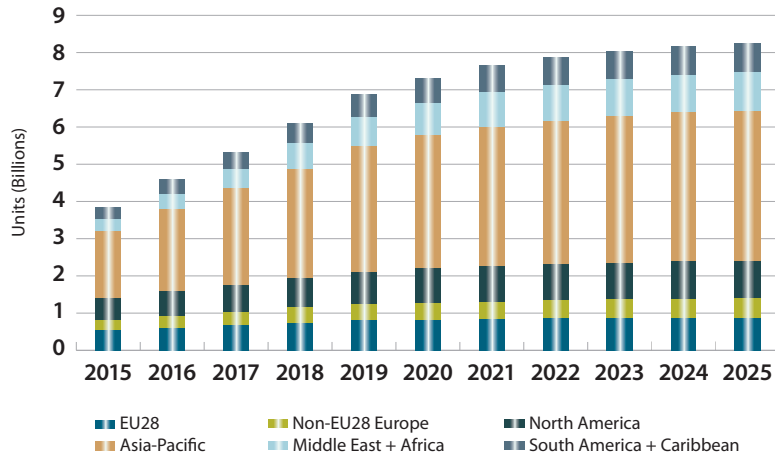
Huawei **Mate 9** and **Mate 9 pro**, will add Galileo support. Additional Galileo-ready smartphone models from Sony (**Xperia XZ Premium**), Huawei (**P10**, **P10 plus**) and Samsung (**S8**) have since hit the market (as of March 2017).

Due to the additional performance provided by an integration of Galileo, it is expected that a steadily growing number of smartphone manufacturers will provide Galileo support for their multi-constellation smartphones.

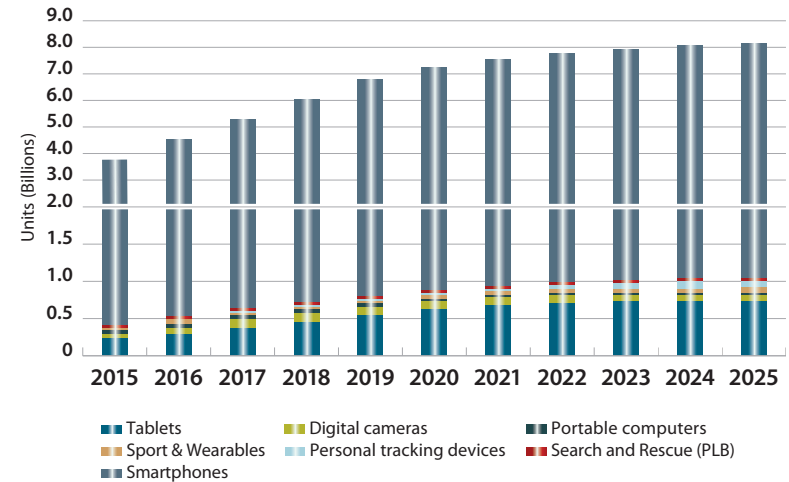
Users can refer to www.usegalileo.eu for the latest information on Galileo-enabled smartphones.



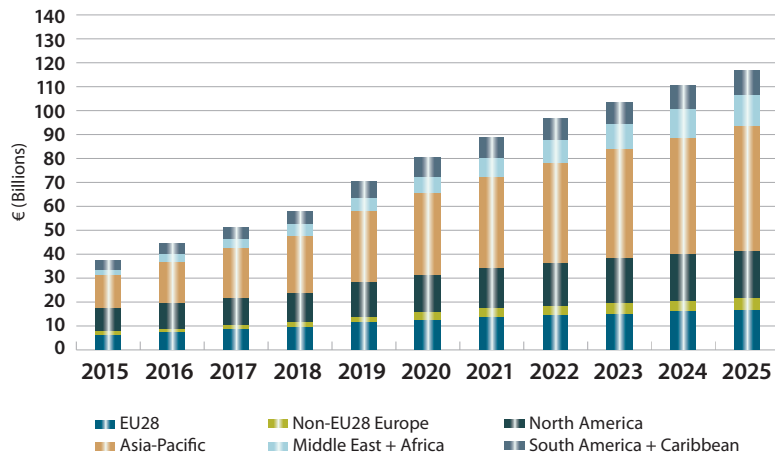
Installed base of GNSS devices by region



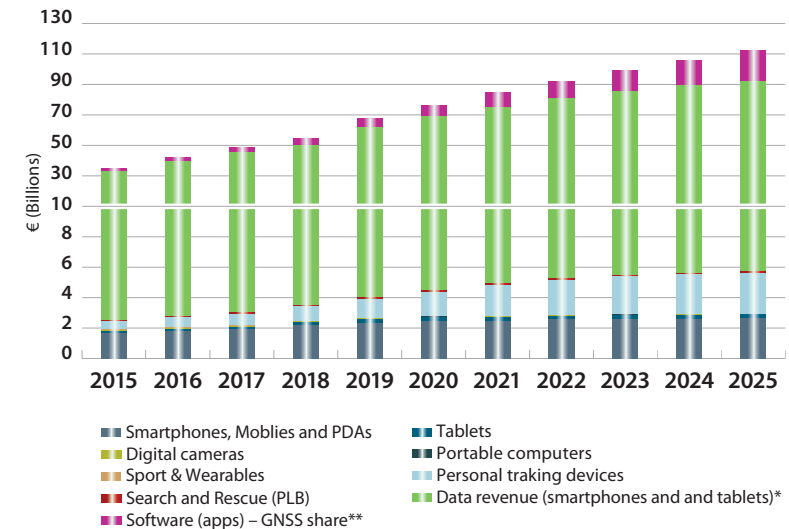
Installed base of GNSS devices by type



Revenue of GNSS device sales and services by region



Revenue of GNSS device sales and services by type



* Only data revenue arising from the use of Location-based services considered

** Pay-to-download, In-app-purchases and ad revenue from social, tracking, search and gaming apps