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EUROPEAN LOCATION STUDY 2010

Positioning technologies: Evolving landscape and opportunities

FULL STUDY

This study has been supported by

Deveryware

Navizon

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ABOUT PTOLEMUS CONSULTING GROUP

PTOLEMUS is the **first strategy consulting firm entirely focused on the location business**. We help our clients apply strategic analysis to this fast-moving ecosystem, across all its industries (consumer electronics, automotive, mobile telecoms, etc.) and on an international basis.

PTOLEMUS, founded by Frederic Bruneteau, operates across Europe and has Partners in Brussels, London and Paris. It has also built a network of location specialists across the world to be able to analyse and address global location and mobility issues.

The authors of this study

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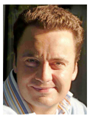

Mr. Bruneteau founded the PTOLEMUS Consulting Group on the conviction that pervasive location and connectivity would revolutionize the business of mobility.

He has 15 years of experience in 10 countries with companies such as TomTom, Vodafone SFR, Arthur D. Little and BNP Paribas.

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OUR SINCERE THANKS

The richness of a study is largely based on the willingness of the "outside world" to co-operate and give their time and knowledge for the benefit of the wider society and economy.

We would like to thank

- Our sponsors, Navizon and Deveryware, which financially supported this study;
- All persons who kindly accepted to respond to our often intrusive questions. A list of the companies we interviewed is available at the end of this study;
- Other contributors, notably Laurent De Hauwere, Karin Dombi and Kevin Pallett;
- Our families for their patience and understanding;
- All respondents to our online survey.

INTRODUCTION

Kant, the German philosopher, used to define **space** and **time** as the two fundamental conditions of our perception.

While time permeates every aspect of our daily lives (starting with our personal watches), we believe that the impact of location has not fully been translated in our daily lives yet.

A large number of influential thinkers such as Thomas Friedmann, the Pulitzer prize-winning author, even believe that the world is becoming "flat" and that the emergence of the Internet is making location completely irrelevant.

In this study, we will explain why we consider that the opposite will be true. **Location will become increasingly omnipresent in our lives and the mobile Internet will drives this revolution.**

Reasons for this are numerous:

- For a start, human beings are not ubiquitous e.g. we cannot attend 2 meetings in different places at the same time. This means that our location is a **key part of our context and is extremely helpful in the efficient and non-intrusive delivery of services**;
- The cost of embedding location capability is becoming so low that **universal penetration of location is to be expected in most portable electronic devices within the next 5 years;**
- The extremely rapid penetration of the mobile internet (over 1 billion 3G users in 2010), together with lower data costs, makes it possible to **combine location with a multitude of cloud-based databases** that will "understand" the user / device to deliver what is most appropriate;
- **Access to basic map data** and to a number of value added applications such as navigation is gradually becoming free, which will **"subsidise" the complete location-based services (LBS) ecosystem;**
- Finally, this would not be true without a few key players of the digital economy such as **Google, Nokia, and Apple, which have put location at the centre of their strategy.**

In this study, we have focused most of our investigation efforts on the following topics:

- Which location technologies will emerge and what will be their business models?
- Which location enabler should be used for what application?
- What role will location technologies play in the shaping of the future LBS and telematics value chains?
- What is the expected market size for these technologies in the next 5 years?

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To conduct this study, we have relied on

- Interviews with nearly 100 executives from all sides of the industry (list attached at the end of this study),
- Over 6 months of desk research and primary research, notably an online survey,
- Building a market model so as to combine strategic and technology analysis with hard figures, and obviously,
- Our own understanding of an industry that we are passionate about.

We believe that the output of our work brings together for the first time

- A **consolidated and critical view and comparison of all location technologies**, from Assisted GPS to IP location,
- **An analysis of the links between** "**upstream**" location technologies and "**downstream**" devices, applications and companies, such as handset vendors or content providers,
- An **in-depth investigation of the Cell-ID and WiFi** positioning technologies,
- A review of **major upcoming telematics applications**, notably eCall and PAYD,
- Numerous tips for investors on **which companies lead the way** in emerging location markets,
- An analysis of the **impact of key evolutions,** in particular free navigation, indoor location, contextual location, etc.
- **A market assessment and quantification focused on Europe**.

It has been a pleasure for us to conduct this study.

We hope that you will enjoy reading it.

Your feedback will always be well received.

Please send your comments to locstudy@ptolemus.com.

Thank you.

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EXECUTIVE SUMMARY

What will you need to remember?

We've tried the impossible, i.e. summarise the study in the following 12 axioms.

1. **Pervasive location and connectivity will revolutionise the business of mobility.**
2. **GPS is dead**. A large number of applications require greater coverage, accuracy and speed from positioning technologies. GPS is not good enough any more.

   Long live GPS! Glonass and then Galileo will refresh the GNSS (Global Navigation Satellite System) industry but will be incorporated with GPS chipsets.
3. **Hybrid location solutions will become the norm** and will include WPS, Cell-ID and motion sensors, best fitted for multiple growth areas such as indoor location services, pedestrian navigation and local search.
4. Google, Nokia and Apple have put location at the centre of their mobile strategy. As a result, by 2014, **mobile phones equipped with navigation** will represent over 85% of all navigation systems or **450 million devices.**
5. **Location-based advertising will become a real business**, revolutionising not only navigation but multiple mobile services.
6. **Embedded car navigation systems and PNDs will continue to grow** if they become connected and open up to the larger ecosystem.
7. **E112** will benefit from wider implementation and increasing accuracy.
8. **eCall, B-Call and Pay as you Drive (PAYD) insurance will drive the in-car telematics ecosystem** and reach **over 100 million vehicles equipped by 2014.**
9. Emulating the successful IP location model, **location provisioning and storage will become a low margin, ultra high volume business**. This will enable location to be used in virtually all mobile services, as a key part of users' and devices' context.
10. **Location-based social networking will become the norm** in the next 5 years, facilitating the complete LBS ecosystem. We will all accept to be located because we will find significant value in doing so.
11. **Privacy will need to be actively managed and transparent**, including by Apple, Facebook and Google! Otherwise, a public backlash against all LBS is inevitable.
12. **Mobile operators will open up the Cell-ID ecosystem** by facilitating access to historical and real-time location data, which will create a completely new revenue opportunity for operators, aggregators and developers.

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A. Existing markets for location enablers

1. Devices using location

a. Cars

The in-car location service market is characterised by two distinct hardware configurations for service access, **OEM line fitted and aftermarket**.

Line fitted products are procured and installed on the production line by the car manufacturer. The aftermarket device is installed at the garage or dealer.

The latter originally spun from the difference in product life cycle between embedded systems and retrofitted options as it takes as much as 6 years for the automotive industry to design and integrate a new in-car navigation and entertainment system as opposed to 6 months for an aftermarket one.

The in-car location opportunity has been addressed by 2 separate technical configurations:

- **Driver-centric services**: those services consumed by the driver whilst driving, such as embedded navigation and entertainment systems. Location is provided through GPS alone as most cars are not connected to a cellular network in Europe. Assistance however comes through the use of extended ephemeris calculation at the chipset level and gyro sensors for dead reckoning.
- **Vehicle-centric services** such as stolen vehicle recovery and other security services, safety services and usage-based charging.

One key differentiation of the automotive platform is a **greater capacity to store and access power**, enabling a more accurate variant of high sensitivity GPS. This configuration of GPS chipset is able to operate on an "always on" basis, whilst increasing the acquisition and processing speed of GPS signals by a factor of 1,000 to offer a reduced time to first fix (TTFF) and greater accuracy.

Telematics systems add cellular connectivity to in-car services. Despite a recent dip in sales, the European telematics market is now rapidly growing and onboard navigation systems are becoming common place in high-end models.

Location is essential for a large number of in-car applications

- Turn-by-turn navigation, which is improved by metre level accuracy for navigating across lanes and safety at road junctions;
- Points of Interests (POIs) located on the map to be used in search or discovery function require reverse geocoding on the map in the vehicle and geo-tagged data updates fed through a connection to a PC or over the air;
- Other location-based services such as proximity alerts, speed camera alerts, location search and suggestions.
- Intelligent vehicle safety (IVS): to prevent or reduce the severity of a collision, IVS systems monitor the driver's behaviour; if a vehicle approaches another too close to another, in-car proximity sensors as well as infrastructure-based location technology such as Radio Frequency Identification (RFID) and Dedicated Short Range Communications (DSRC) automatically detect it. Future systems will include Advanced Driving Assistance Systems (ADAS) integrating information from the map, the engine and the road infrastructure.
- Risk management: telematics-enabled risk management systems provide solution to help insurance companies reduce the costs related to fraud and claim investigation by tracking and recording the instance of an accident. Location technology is critical as it provides speed, acceleration or breaking, direction as well as location on the road.

Full analysis of the car-centric location market Section IV p. 160

b. Personal navigation devices (PNDs)

PNDs have become the single largest access mechanism to in-car navigation in Europe. Sales for the single purpose, stand-alone navigation device are still strong in Europe but 2009 ended many years of sales expansion. As mobile phones will be increasingly sold with navigation functions, we believe that the PND market growth is unlikely to return to its pre-recession levels.

While the PND form factor has invented navigation as we know it, we believe that its current reliance on GPS-only positioning makes it **ill-suited for dense urban environments** with tall buildings, frequent tunnels and indoor car parks.

There are still two major issues related to the choice of GPS positioning for navigation:

- **A long Time to First Fix (TTFF)**, which can prevent the driver from having any itinerary for several seconds or even minutes;
- **Poor accuracy**, often no better than 10-20 meters, which can lead to being positioned on the wrong road, notably in complex junctions.

To alleviate the TTFF issue, PND vendors such as TomTom and Garmin have integrated **assisted technologies** (such as extended ephemeris information of GPS satellites) into their products. Garmin has called it *HotFix* and TomTom *QuickGPSFix.*

This has reduced Time to First Fix (TTFF) from several minutes to less than 60 seconds in most cases.

In our view, however, this is far from being sufficient for most users in urban environments. In order to compete with navigation on mobile phones, we believe that PNDs need to provide more reliable, faster and accurate positioning.

TTFF is frequently over 30 seconds, even with ephemeris information updated, which dampens the user experience. In large cities, in such a time span, the driver may have driven in the wrong direction multiple times. This may lead to significant time and fuel lost.

To improve accuracy, PND vendors have used complementary satellite constellations:

- **WAAS** (Wide Area Augmentation System) covering North America;
- **EGNOS** (European Geostationary Navigation Overlay System) covering Europe.

Each of these two augmentation systems use 3 satellites as well as ground stations. They can improve accuracy down to the metre range in open sky conditions but only in rural areas as the signal of 3 satellites cannot be received in areas with tall buildings.

Full analysis of the PND market Section IV p. 165

c. Basic and feature phones

In this study, we define **a feature phone** as a mobile phone sold based on a specific feature (camera, e-mail, music,…). These phones are branded by device manufacturers or mobile network operators and generally do not have an operating system opened to third party developers.

We define a **basic phone** as a handset whose functions are limited to calling and SMS.

The provision of location-based services on feature phones started in the early 2000 but did not take off in Europe. The location provided by the cellular network was good enough for most applications. However, overall usability was insufficient.

Larger colour screens and an improved user interface (UI) have enabled adequate off-board navigation and text-entry location services such as local search.

Feature and basic phones still represent over 80% of the user base in most countries and despite the faster growth of smartphones, cannot be ignored. Numerous time critical applications such as E112, social networking, people tracking (family and child), dating and gaming can be made available in feature phones to attract large audiences.

Future market penetration of these network-centric applications is in direct correlation to the number of mobile devices equipped. An evidence of this considerable market opportunity is ***LociLoci*** in Scandinavia which uses a paid-for model based on network location aggregated from multiple mobile networks.

However, new simple, popular and wide reaching services such as navigation and mobile geo-tagging of pictures have pushed handset manufacturers, notably Nokia, to include GPS in over 5% of feature phones.

WiFi, notably used for voice over IP (VoIP) and web browsing, is also increasingly present in these terminals. Its integration has grown sharply to 15% in 2009, suggesting a growing number of low-end handsets will be location-enabled in the future.

Full analysis of the mobile phone location market Section IV p. 169

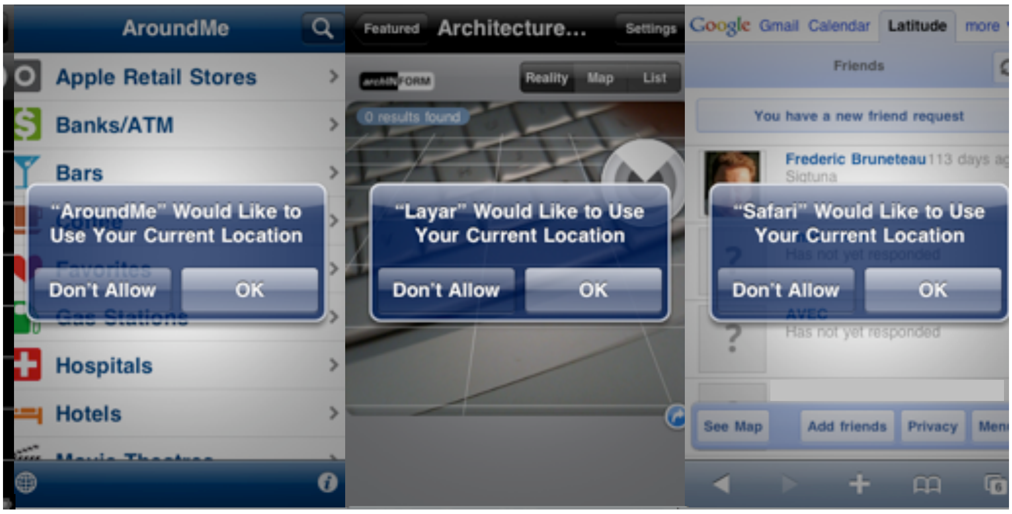
d. Smartphones

In this study, we define smartphones as devices that combine an operating system (OS) allowing the download and installation of new applications and the use of enhanced communications capabilities such as e-mail.

Smartphones are the **fastest growing platform for mobile location services**; we expect smartphone shipments to continue to grow at a 40-50% rate year on year between 2009 and 2012.

We could almost say that, in 2010, **a smartphone is a GPS-enabled handset**. We expect that over 95%of smartphones will be GPS-enabled by 2011. They now represent the biggest market for GPS chipsets providers.

Figure 1: Three examples of handset location: POI finder, Augmented Reality viewer, Mobile Social Networking application



Source: PTOLEMUS

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e. Consumer tracking devices

Personal location applications using dedicated tracking devices are also a fast developing market, notably in the US.

These devices are specific to the applications and there are multiple services generating real benefit besides locating children or pets.

These include notably

- **Tele-health**, an emergency medical response to ambient assisted living (AAL) that remotely monitors the well-being of elderly and handicapped people;
- **Remote patient management** (RPM), which also provides real-time monitoring of critical health conditions. In addition, personal emergency response systems (PERS) track people who are lost, injured or otherwise at risk.

The latest type of service, mobile personal monitoring (MPM) is probably what most people define as "people tracking".

For each of these services, **location is a key enabler** and GPS the most common technology thanks to its low cost and global coverage.

f. Commercial vehicles and employees

Mobile resource management (MRM) is the term used to describe solutions managing any mobile resource (i.e. individuals, vehicles or other assets) by installing an electronic device capable of sending its location to a central service platform.

This enables an organisation to:

- Track the resource in real- or near real-time,
- Assign the correct task to the correct resource and
- Ensure that the right resource is at the right location.

Terminals used include

- **Black boxes**, which are dedicated telematics devices, either pre- or post-installed in the vehicle,
- **Black boxes** combined with a **display screen**, so that the driver can send or receive messages or use other applications such as navigation,
- **Standard** or **ruggedised mobile handsets**.

Vehicle-based mobile resource management (MRM) or commercial fleet management has grown regularly in the last 10 years.

Since 2009, it has experienced serious difficulties in Europe, principally due to the sharp decline in vehicle sales and the economic downturn affecting the rate of leasing contract approvals.

These two factors have reduced the uptake of what is sometimes perceived as a discretionary spend by fleet managers. Fleet managers also view the benefits of managing the assets workload and the constant time and distance calculations required to maximise the time on task as a key skill of a good fleet operations manager. Until recently, a number of Europe's largest fleets have been managed by local infrastructure performance knowledge and a two-way radio.

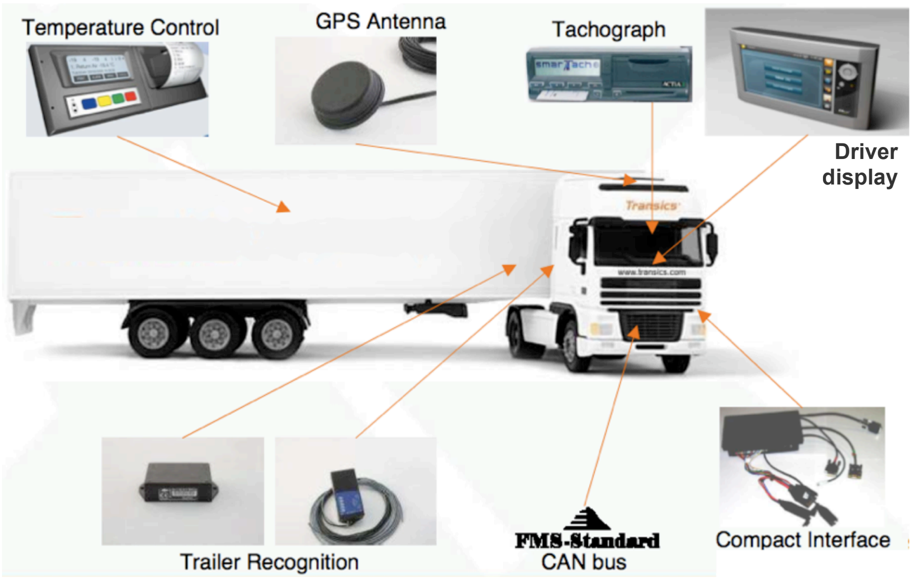
Given the low margin character of the transportation industry, the key development in the benefits of fleet management systems (FMS) has been the ability to **operate a fleet in a more cost effective manner**.

Margins in large fleets are measured in fractions of Euro Cents per kilometre driven. Numerous applications can **leverage telematics to substantially reduce transport companies' most significant costs**:

- **Fuel consumption costs**, notably thanks to eco-driving (i.e. driving behaviour monitoring), connected navigation delivering accurate traffic information and re-routing and fuel monitoring;
- **Staff costs**, thanks to order management, tachograph monitoring, payroll management, etc.
- **Vehicle purchasing and maintenance costs**, thanks to remote diagnosis and maintenance;
- **Insurance costs**, thanks to Pay as you Drive (PAYD) and Pay how you Drive (PHYD) schemes.

Fleet management solutions can both use existing components of the truck IT infrastructure or bring their own components, as the following figure shows.

Figure 2: Components of a full-fledged fleet management system



Source: Transics, 2008

It is important to mention that, although **handheld-based MRM solutions** are under-developed in Europe compared to the US, these are growing in importance, notably in the United Kingdom.

This is notably due to its **lone worker legislation**, whereby employers consider their "duty of care" to remote workers (from truck drivers to postmen).

Managing occupational road risk is now a major priority for all private and public enterprises in the UK.

Health & Safety Executive Guidelines state that: "**Health and safety law applies to on-the-road work activities** and the risks should be effectively managed within a health and safety system".

The Royal Society for the Prevention of Accidents summarises its position on the issue thus: "The human, legal and economic consequences of failure to manage occupational road risk make it an obligation, not an option."

Aside from complying with legislation, managing occupational road risk also:

- Minimises disruptions to normal business activities,
- Reduces direct financial costs,
- Avoids negative publicity,
- Mitigates potential liabilities and reduces the risk of prosecution.

Estimates suggest that up to one-third of all road traffic accidents involve someone driving during the course of their work. These accidents account for more than 20 deaths and 250 serious injuries every week (Source: HSE and UK Department of Transport).

Full analysis of the commercial vehicle location market Section IV p. 198

g. Consumer electronics devices

Location is becoming ubiquitous and is increasingly used in devices whose main function is not around positioning or navigation.

Digital cameras are often seen as the next emerging location-enabled device. This is due partly to the rise and popularity of geo-tagging even though the long term benefits and endurance of that trend are somewhat doubtful.

Camera vendors do not have experience of integrating radio equipment, location technology into their devices. Charging more for a GPS camera is difficult to sustain in a market facing the onslaught of camera phones.

Moreover, camera manufacturers have not yet identified a revenue stream based on the added location feature.

Figure 3: Samsung ST1000BPS is equipped with GPS and WiFi but no WiFi location

Source: PTOLEMUS

For this reason, alternative location technologies such as WiFi have become the fastest growing means of **geo-locating pictures.** WiFi can be embedded into a memory card providing location, data transfer as well as storage. Such solutions have the added benefits to consume less power and take less time compared to standalone GPS.

Another growth market for the location enabler in the consumer electronics field is the combined **Mobile Internet Device (MID)** and **tablet markets**. In Europe, this market is still in its infancy. We expect the iPad to truly create the market and to take the lion's share of the tablet market.

Although the **iPod Touch** is generally not included in the MID category, it has reached significant volumes and needs to be mentioned. iPod Touch users are also considerably younger than other consumer electronic devices, with 78% of them below the age of 25.   The iPod Touch has the same WiFi positioning functionality as the iPhone (and the iPad), which enables all location-based services.

Full analysis of the CE device location market Section IV p. 175

h. Laptops and netbooks

GPS chipsets are increasingly being integrated into laptop computers.

This could seem surprising because connected netbooks can access location in multiple ways (e.g. IP address or WiFi). Also laptops are mostly used in one place at a time suggesting that manual input will last long enough to be a valid proposition.

However, GPS chipset manufacturers estimate a **10% attachment rate by 2011**. This could increase rapidly with the arrival of Chrome OS as well as the effect of tablet PCs.

As in the mobile market, **the search and advertising businesses benefit greatly from location**. It enables **local search** to be significantly more relevant and granular. Keywords, banners, news and other advertising can also become specific to the precise location of the laptop as opposed to the general area position given by IP-based location.

A big factor promoting the growth in computer location is that **the device location data is now accessible through the web browser** and the web service using the W3C GeoLocation API that most browsers support. A simple Java script enables a web-based application to call on the laptop position and use it automatically (after authorisation has been given by the user).

We expect that the growing ability to access location from laptop computers will enable a multitude of location-based services. Local search in a non-connected situation could be one of them. In the medium term, it will enable precise "crumb trail" behaviour monitoring as well as location data analytics.

In any case, **GPS is generally not sufficient to provide location-based services to laptop users**. GPS positioning does not work inside buildings whereas WiFi is prevalent in virtually all notebooks making location data freely available once the right software or browser add-on is installed.

As a result, we expect that **WiFi-based solutions will become prevalent in the coming years**. GPS penetration will increase only slowly (for example, only 2 models were shown at the Consumer Electronics Show in 2010).

We forecast that GPS attachment in laptop computers will grow to 11% in 2013 pushed by 2 factors:

- Laptop cellular connectivity cards will include GPS at the chipset level,
- OEM and chipset manufacturers will deride benefits from integrating GPS with motion sensors enabling better reliability and indoor location.

Applications we expect to benefit from computer location include local search, location-based advertising and promotion, hyperlocal news and media, social networking, geofencing or location-based triggering (laptop settings changing depending on location e.g. home vs. work).

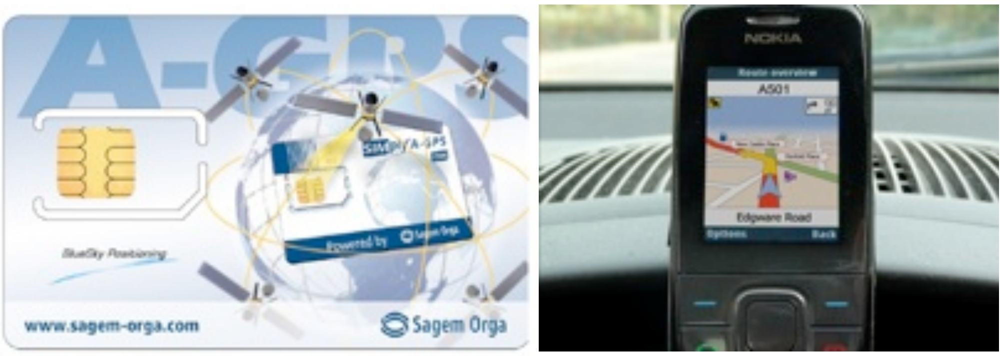
Full analysis of the CE device location market Section IV p. 175

i. SIM cards

BlueSky Positioning, a Luxembourg-headquartered company, **fits a GPS receiver and proprietary antenna inside a SIM card**.

This enables network operators to launch location-based services without relying on network intensive cell-positioning or requiring customers to upgrade to a GPS-capable handset.

Figure 4: BlueSky's A-GPS SIM: will you turn your old Nokia into a navigation device?



Source: PTOLEMUS

This technology allows **integration of A-GPS in almost all existing mobile phones**, thus enabling wireless operators to introduce new value-added services for the mass market based on A-GPS without waiting for mass market deployment of A-GPS handsets.

No software or hardware changes are needed for legacy handsets. The A-GPS SIM supports emergency call positioning and enables SIM, device and network based LBS applications to be installed directly on the SIM card, such as Telmap's recently launched navigation solution.

If BlueSky's technology delivers on its promises, it **could become a highly cost-effective way to deliver E112 services in Europe**.

Its strategic partnerships with Sagem Orga, the SIM card vendor and Telmap, the navigation software provider, seem to indicate that **its technology could have a major impact on the location technology value chain.** The system would be owned and controlled by operators, and location could become a mass-market, even in developing countries.

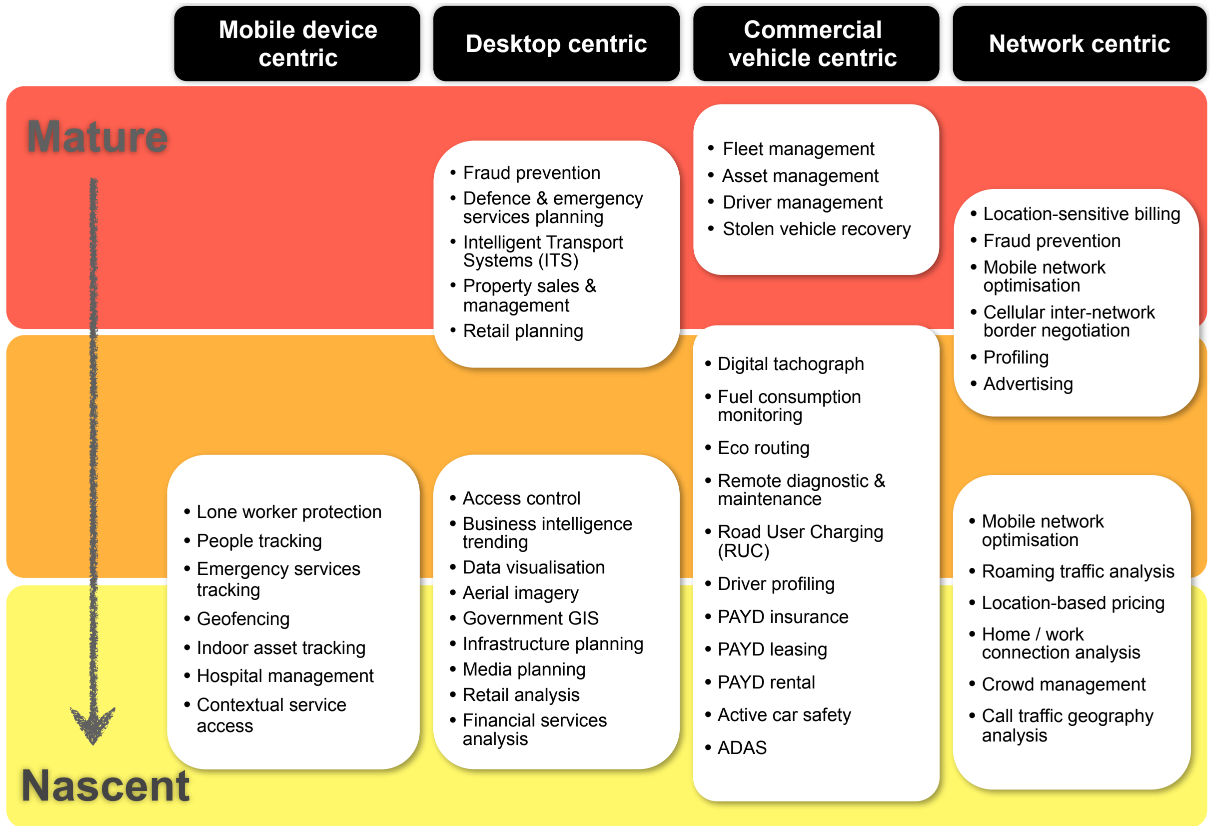
Telia Sonera and EMT Estonia are conducting a technical trial of its SIM cards, but have not reached a commercial deployment phase yet.

2. The spectrum of location-enhanced applications

Listing all applications that use location will soon become impossible due the universal penetration of the location enabler in electronic devices.

However, we believe that it is interesting to list applications that already have reached significant success and those that we expect to take-off in the short- or medium-term.

Figure 5: Location-enhanced applications: business-to-business



Source: PTOLEMUS

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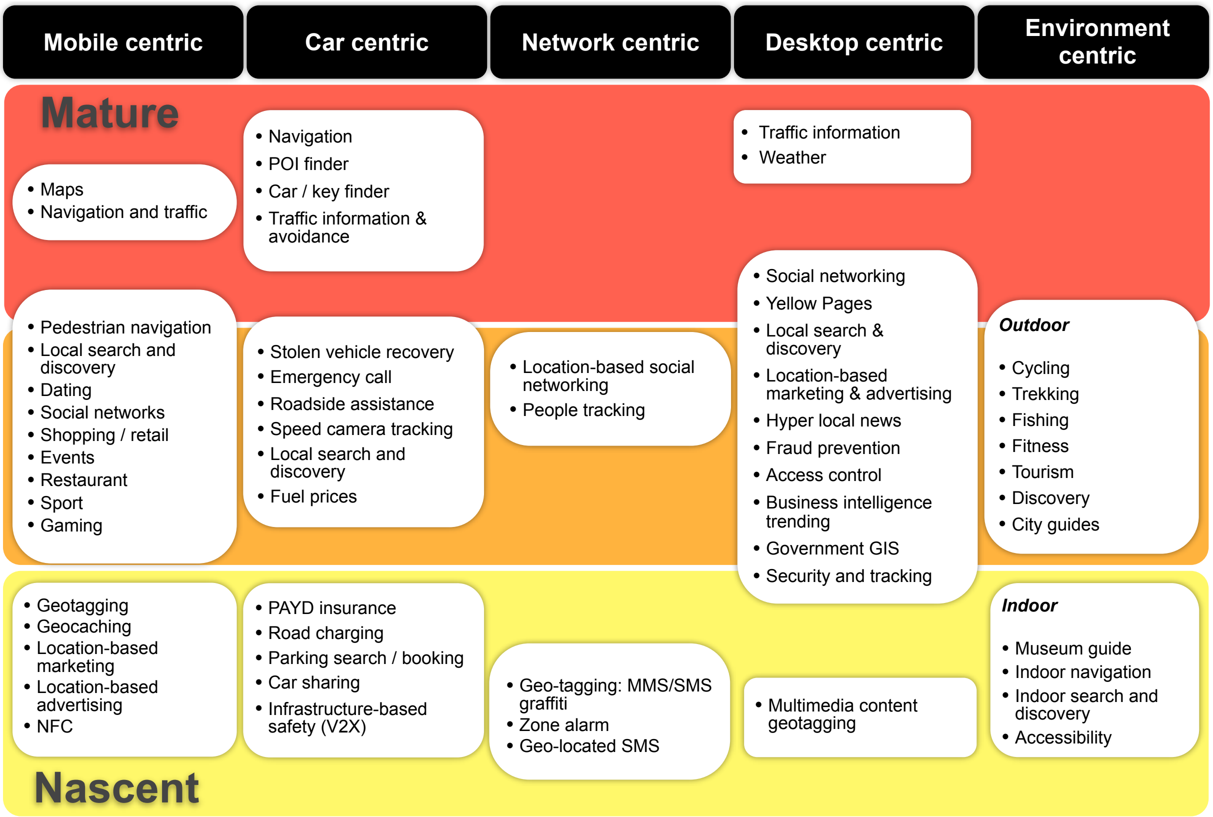
Figure 6: Location-enhanced applications: business-to-consumer



Source: PTOLEMUS

B. Future key markets and applications driving the use of positioning technologies

1. Navigation, local search and contextual location

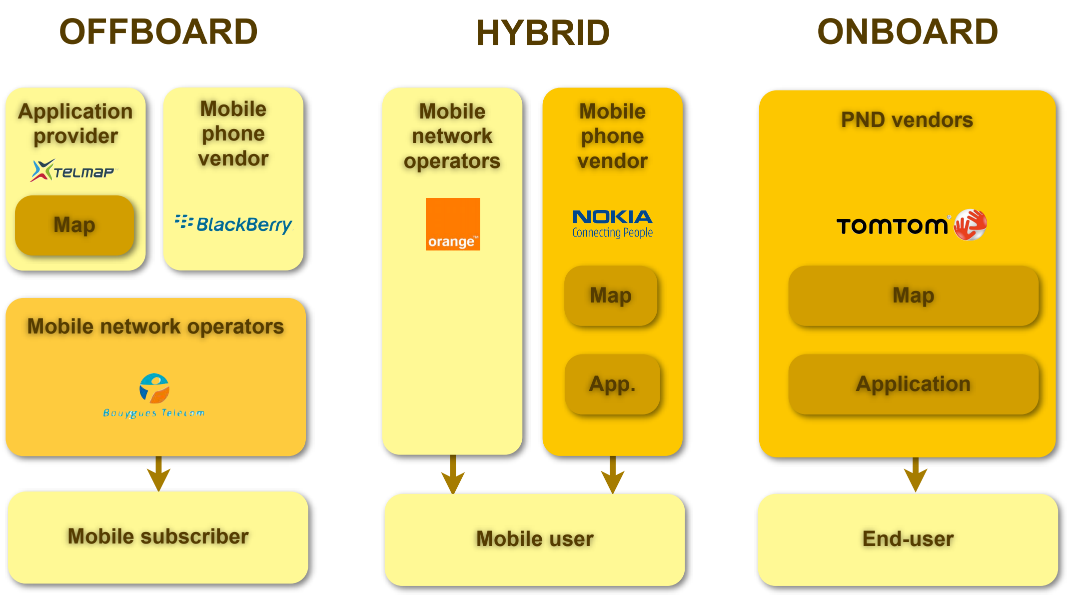
Within 18 months, navigation has moved from a cash cow to a free add-on service, with a growing range of solutions based on multiple form factors.

What has happened?

From navigation to local search

Since the beginning of the decade, 3 models have dominated the navigation domain, as shown in the figure hereafter. These models were respectively dominated by the mobile operator (offboard), the handset manufacturer (hybrid) and the PND vendor (onboard).

Figure 7: Navigation as usual - 3 major business models



Source: PTOLEMUS

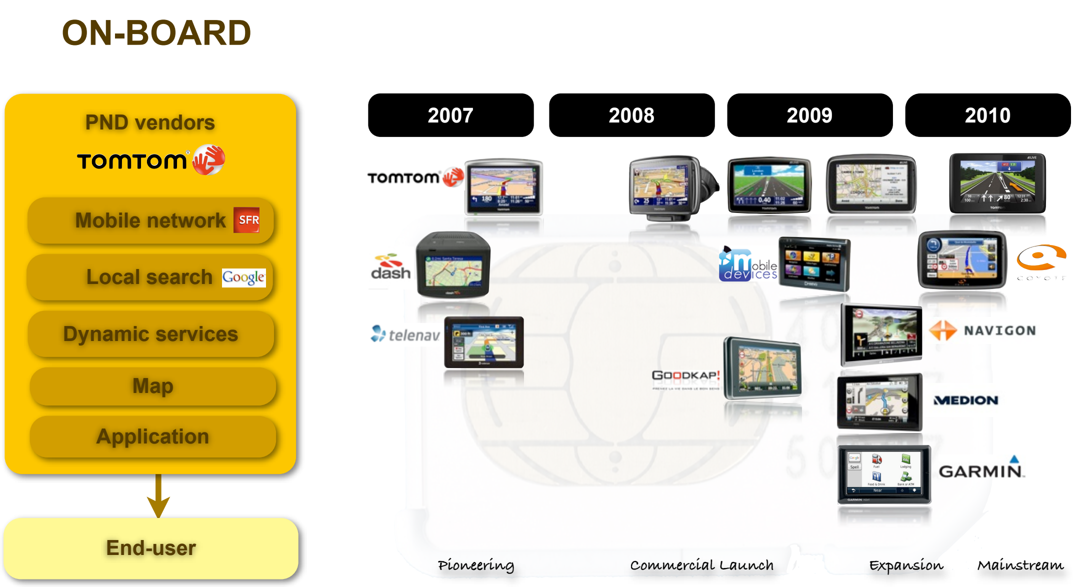
The onboard model became so successful that navigation became the flagship of all location-based services.

In 2008, TomTom launched the first connected device including a complete suite of dynamic services in 5 European countries. Bundled under the LIVE banner were HD Traffic, Local search (by Google), fuel prices, weather and speed camera alerts.

This model, which was relying on a free period and a monthly subscription, was subsequently adopted by the whole PND industry, except Mio. Garmin and Medion chose to include a larger "trial period", which is now also being retained by TomTom.

With 1 million connected devices sold so far, TomTom has proven that connected navigation represents the next stage of the car navigation industry.

Figure 8: The connected navigation business model and its diffusion into the PND industry



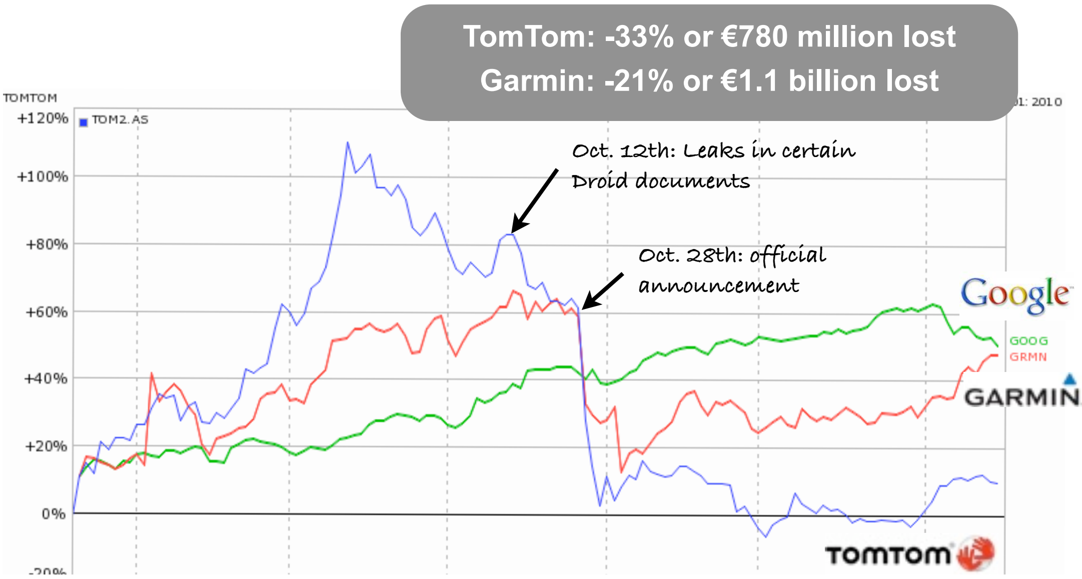
Source: PTOLEMUS

However, Google's announcement on 28th October 2009 that it would give away turn-by-turn navigation to Android users in the US clearly questioned the complete model around car navigation.

As far as Google is concerned, navigation and (local) search are one and the same business.

This statement instantly destroyed over €2 billion of market capitalisation among all PND vendors... and led **Nokia to launch free navigation in 74 countries.**

Figure 9: The Google free navigation effect - €2 billion lost in the air!



Source: Yahoo! Finance, PTOLEMUS

The "**nadvigation" model** is funded mainly by advertising, which is a business model that Google understands fairly well...

Nokia, although it clearly had prepared this by creating Navteq Media Solutions, has primarily a device-maker business model.

The cost of maps and navigation is relative when you own Navteq and when you can recoup the investment by selling a few more million handsets.

Figure 10: The "Nadvigation" model, proposed by Google and Nokia

Source: PTOLEMUS

This nadvigation model puts immense pressure on the PND industry to reinvent its value proposition and business model.

Possible **ways to differentiate** its products include:

- Leverage all location technologies to rely on hybrid positioning models rather than stick to GPS-only,
- Build advanced navigation solutions providing seamless experiences from point A to point B including trip preparation and multimodal navigation combining pedestrian, car and public transportation guidance,
- Truly monetise navigation thanks to smart LBA / LBM (see later section),
- Integrate navigation into user's web of social relationships, notably by permitting to have "friends" as destinations.

From navigation to contextual location

We propose to highlight hereafter what we call **contextual location,** which includes local search but also **location-triggered services and decisions**.

Navigation services are moving towards **contextual location services**, promoting the ability to not only direct the user to a location but also to tell him / her what facilities and points of interest are in the immediate vicinity, **on a dynamic and proactive basis**.

To build such a smart service, navigation companies will need to integrate 5 key factors.

(i) **Highly accurate position**, so that the device can provide the information only when you need it. This will be possible only by aggregating multiple technologies (WiFi for indoor and urban, GNSS for rural, pressure sensors, etc.)

(ii) The signification of location. The position does not just provide the latitude and longitude but the meaning of it, e.g. is the user at work, at home, walking in a shopping area, in the countryside or in town? The location context will influence what service will be needed or unwelcome. For this component, Cell-ID may prove perfect as it is almost always available, even indoors and in the countryside.

(iii) Time. Timing is critical when analysing the location information. For example, a retail district during shopping hours carries a completely different contextual meaning than when all stores are closed. A road used at 7AM on Friday and 3 PM on Sunday will also need to be comprehended differently.

(iv) Activity and choices. The next step in LBS is location-based alerts, such as sending information or reminders about pre-defined query results. These queries can be directly entered by the user or inferred by the service - using past behaviour analysis - or a combining of the two.

Activity is also the “mode we are in”. The user’s social context will affect the type of messages he or she might be more receptive to – if at all.

Once all the contextual criteria are taken into consideration, a footprint of travel and activity can be built up over time. Graham Wallace from ESRI suggests that this behaviour analysis is largely predictable. Much of human activities are habitual, routines are so obvious that it is possible right now to predict where someone is going within 4-5 turns of a wheel being made in a car.

(v) Social networks. For most of us, we can infer what we do based on who we are with. The ability for a device to obtain access to others’ device location is possible only thanks to social networks, where users have agreed who they want to share personal information with.

Actually, the number of applications is infinite. Knowing our “friends” preferences can provide us advice on where to buy something, where to go for dinner, etc. The value of this information often exceeds the value of fact-based sources, which omit emotions, preferences and tastes.

Contextual location will also include **location-based decisions**, for example sending information or reminders about pre-defined query results.

To make contextual location a reality, **location technology providers need to enable the device to have its position consistently** or at least on a highly regular basis.

This will require chipset providers to rethink power management and hybrid solutions embedded at the integrated circuit level. An alternative will be to consider Cell-ID, which uses little power and brings universal coverage.

Forecast of the in-car navigation market Section IV p. 181

2. E112, the European emergency call

E112 is the location-enhanced version of 112, enabling the Public Safety Answering Point (PSAP) to instantly establish the location of an emergency caller. The location information is transmitted by the telecom operator to the emergency centre.

The EU Directive E112 (2003) requires mobile phone networks to provide emergency services with the location information of the mobile user who is dialling 112. At the moment, this means Cell-ID, which is quick but not accurate enough in most cases.

While the 112 service is available in all 27 EU countries, E112 implementation has been more complex.

Main **obstacles to the rollout of E112** have been the following:

- Operator-related costs to provide and send cellular location data to third parties are sometimes perceived as significant, although this is not the case;
- European regulation does not specify the minimum accuracy needed and leaves it to each country to decide the technology used;
- Mobile operators have been unwilling to invest in new systems without a clear business case nor strong national regulatory requirements;
- PSAPs are not always equipped to receive location data from phones (although this is standardised by 3GPP). The EU directive does not require standardisation of the location data type and means to obtain location. Each country can select its technology. Ultimately, we believe that location data will need to be standardised so that each PSAP is able to use location whatever its source;
- There are many different technologies to choose from but the need for the location data to be pulled from the device suggests that network operators will have to take the responsibility of the location provision;
- The system must work indoors, which makes GPS-only not adapted.

Today, according to Gary Machado, Executive Director of the European Emergency Number Association**, E112 is formally available in all countries except Italy**.

However, it is clear that **in a number of countries**, notably Germany, France and Greece, **its implementation does not meet the standards of emergency services**. For example, in Germany and France, the process is not automated and location is obtained either through a call to the relevant mobile operator or via fax. During the week, obtaining call location can take between 5-10 minutes and up to one hour during nights or week ends!

Figure 11: Status of E112 implementation in Europe in 2009 - Red cells indicate a process inadequate with an emergency service

Country	Method of providing mobile caller location	Average time to provide mobile caller location	Type of caller location information	Availability of caller location to international roamers
Austria	Pull – verbal/written request to respective network operator	n.a.	Cell-ID/ Sector-ID	Yes
Belgium	Pull	n.a.	Cell-ID/Sector-ID	Yes
Bulgaria	Push	n.a.	Cell-ID	Yes
Cyprus	Push	n.a.	Cell ID/ Sector-ID	Yes
Czech Republic	Push	n.a.	Depending on MNO, area with radius from 1 to 5 km/ or closest BTS	Yes
Denmark	Push	n.a.	Cell-ID	Yes
Estonia	Pull	23 sec.	Coordinates	Yes
Finland	Pull by electronic request to a centralised mobile positioning database	6 sec. or 3 to 30 seconds depending on operator and traffic	Cell-ID/ Sector-ID or more accurate information depending on operator	Yes- by separate manual request to the operator
France	Pull	about 10 min. during working hours and less than 30 min. otherwise	Postal code of relevant cell BTS (accuracy of a few km)	Yes
Germany	Pull	5 min.	Cell-ID/Sector-ID	Yes
Greece	Pull	From 7 to 60 min.	Cell-ID	Yes
Hungary	Push	n.a.	Cell-ID / Sector-ID	Yes
Ireland	Pull	n.a.	Cell-ID	No
Italy	Push, in the province of Salerno only		Cell-ID	Yes
Latvia	Pull (Push for 2 operators)	10.3 sec.; Provided within 1 min. for 98% requests	Cell-ID / Sector-ID	Yes
Lithuania	Pull (only in Vilnius PSAP),	Provided within 1.5 to 10 sec. and within one minute in all cases	Cell-ID	Yes
Luxembourg	Push	n.a.	Cell ID	Yes
Hungary	Push	n.a.	Cell-ID / Sector-ID	Yes
Netherlands	Pull (from KPN network)	Less than 1 sec.	Cell-ID	It is planned to make it possible
Poland	Pull	13 sec.	Cell-ID / Sector-ID Timing advance technology with accuracy of 100 m to 1 km	Yes

Country	Method of providing mobile caller location	Average time to provide mobile caller location	Type of caller location information	Availability of caller location to international roamers
Portugal	Push	n.a.	Cell-ID Accuracy from 100m in urban areas to 30 Km in rural areas	Yes
Romania	Push	n.a.	Cell-ID/ Sector-ID	Yes
Slovenia	Push in the case of *Mobitel*; Pull in the case of other operators	1.5 hours for 80% of caller location requests	Sector-ID	Yes
Slovakia	Push in the case of Telefonica O2. Pull for other 2 operators	Within 1 min. in case of 94.5% of requests	Cell-ID/ Sector-ID	Yes
Spain	15 Push emergency centres 2 Pull emergency centres	30 sec.	Cell-ID /Sector-ID Accuracy from a few meters in urban areas to a few Km in rural areas	Yes, except in 5 emergency centres
Sweden	Pull from a database	Max. 3-5 sec.	Cell-ID, with or without timing advance	No, discussions started on implementing this facility
United Kingdom	Pull by retrieving caller location from a database to which it is forwarded automatically for every call	Max. 2 sec.	Cell-ID, with or without timing advance	No

Note: MNO = Mobile Network Operator
Source: European Commission, January 2009, PTOLEMUS

It is important to note that although **all European MNOs have Cell-ID capability,** not all have made the investment in location capabilities, for example, acquired a GMLC (Gateway Mobile Location Centre) to make it effective.

We estimate that in March 2010, there were 213 mobile service providers in Europe including 112 mobile network operators in Europe and 99 MVNOs.

A large number of MVNOs do not have access to the GMLC of their hosting network and in many cases do not provide location-based services themselves. In other words, **up to half of European mobile service providers do not support E112 yet.**

Another limitation of current E112 implementation, is international roaming. In most cases, location is not made available when the caller's operator is not in the country where the call is made.

To overcome these difficulties, the European Commission decided to undertake further regulatory action. On 25th November 2009, a **new directive** was issued, reforming the obligations related to the so-called Universal Service.

This directive clearly indicates that

- the **Commission is empowered to recommend higher accuracy location mechanisms**,
- the **location of the caller should be instantaneously available to the PSAP**,
- MVNOs will need to enforce this legislation as soon as a standard is established for the transmission of data.

Figure 12: Extract from Directive 2009/136/EC of 25 November 2009 on Universal Service

Article 26 - Emergency services and the single European emergency call number

1. Member States shall ensure that all end-users (...) are able to call the emergency services free of charge and without having to use any means of payment, by using the single European emergency call number "112" and any national emergency call number specified by Member States.

5. Member States shall ensure that **undertakings concerned make caller location information available free of charge to the authority handling emergency calls as soon as the call reaches that authority. This shall apply to all calls to the single European emergency call number "112"**. Member States may extend this obligation to cover calls to national emergency numbers. **Competent regulatory authorities shall lay down criteria for the accuracy and reliability of the location information provided.** (...)

7. In order to ensure the effective access to “112” services in the Member States, **the Commission, having consulted BEREC, may adopt technical implementing measures**. However, these technical implementing measures shall be adopted without prejudice to, and shall have no impact on, the organisation of emergency services, which remains of the exclusive competence of Member States. (...)

Recitals

(31) The obligation to provide caller location information should be strengthened so as to increase the protection of citizens.

In particular, undertakings should make caller location information **available to emergency services as soon as the call reaches that service independently of the technology used**.

In order to respond to technological developments, including those leading to **increasingly accurate caller location information**, the Commission should be empowered to adopt technical implementing measures to ensure effective access to ‘112’ services in the Community for the benefit of citizens.(...)

Note: BEREC: Body of European Regulators for Electronic Communications

Source: PTOLEMUS

It is important to note that, by definition, the directive is mandatory and any country or mobile service that has not implemented E112 is liable by any EU citizen. Given the fact that the efficiency of emergency services can be directly be translated in lives being saved or not, we believe that governments will need to act relatively promptly.

On 5th May 2010, the European Commission asked the European Court of Justice to fine Italy for failing to implement E112.

We believe that this is going to lead **all 27 countries to adopt E112 capabilities within the next 3 years.** For example, the Netherlands recently adjusted their system to enforce EU regulation.

3. eCall

eCall (which stands for emergency call) is an **extension of E112 for private and light commercial vehicles**.

The European Commission (EC) has initiated a number of activities to define the standards covering the device, minimum set of data and connectivity conditions required to put eCall in place.

Thanks to eCall, the EC aims at reducing the number of fatalities on European roads, which currently stands at 38,000 per year.

eCall automatically contacts the emergency control room at the PSAP, transmitting the vehicle details, location and severity of the accident, enabling emergency services to be dispatched to the exact location immediately, saving valuable time and, consequently, saving lives.

In 2010, 20 EU countries and 3 other countries have signed the eCall Memorandum of Understanding. The UK and France remain the biggest opponents to eCall. It must be said that the automotive, insurance and mobile telecom widely back a mandatory eCall implementation.

It is expected that a directive will be passed in 2010 by the European Council, which will provide a progressive implementation path of eCall.

The Commission expects this service to start being available by 2013, with devices installed on 100% of all new vehicles entering the European market by 2015.

It assumes that it will then take approximately 14 years to replace the average European vehicle park. eCall will also be an open platform enabling a number of vehicle-centric services such as Breakdown Call (B-Call), Stolen Vehicle Recovery (SVR) and Pay As You Drive (PAYD) insurance, tax, leasing and rental.

eCall forms part of the safety and security value-added service portfolio that car manufacturers are keen to offer, as it enables ongoing customer contact.

Services equivalent to eCall have been offered as a premium, subscription-based service by several car vendors since 2005, notably PSA, Volvo, Mercedes and BMW.

Critical issues include

- Harmonisation of processes to send alerts to PSAPs in each country,
- Avoidance or at least reduction of false alerts which lead to significant costs,
- Reduction of eCall telematics device costs to make it affordable in low-end car models,
- Agreement on the format and latency of the Minimum Set of Data (MSD) for third party service provision.

eCall implementation is sometimes viewed as expensive. It reflects the cost of providing the service, including specific in-vehicle hardware and the secure operating centres required to field emergency calls and dispatch the emergency and recovery services.

However, car vendors believe that making eCall mandatory will result in significant economies of scale, thereby reducing the cost of the telematics box.

In our view, mandating eCall could enable a take-off of in-car telematics in Europe.

Figure 13: PSA's eCall experience

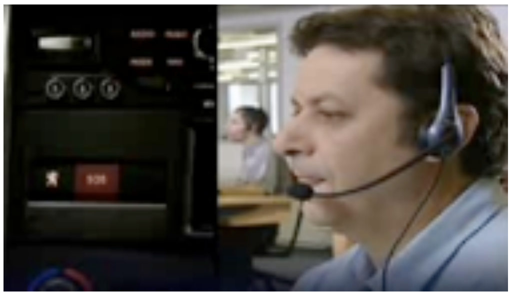
Peugeot launched a joint eCall / B-call service in 2003, starting with high end models.

It now has **over 800 000 cars equipped with the functionality.**

Since 2003, roadside assistance has been provided 3 500 times, including 2 000 times in the context of an automated emergency call.

Peugeot recently decided to broaden the scope of the service by pricing **Peugeot Connect at only €290** and making it accessible to entry-level cars such as 207 and 308.

The service provides assistance in local language on a 24/ 7 basis. It is now available in 10 countries (France, Germany, Italy, Spain, Portugal, Belgium, Luxembourg, the Netherlands, Switzerland and Austria)



Source: Peugeot

We view the success of Peugeot's eCall experience as evidence that the **automotive market will adopt a combined eCall / B-call service on a large scale**. The Commission's initiative may provide additional incentive for car vendors to roll it out faster.

Maybe the fact that **Russia** plans to launch its own eCall project, **ERA Glonass**, using its own constellation, will precipitate a European consensus behind an eCall mandate.

Forecast of the impact of eCall on in-car location services market Section IV p. 184

4. Pay As You Drive (PAYD) car insurance

The traditional method of identifying risk in motor insurance is based on projecting theoretical risk against a pool of similar users.

The motor insurance business has been operating at a loss in most countries in the last 10 years. This is due in particular to

- Over-capacity,
- Commoditisation,
- Lack of pricing innovation.

In most cases, insurance groups have been able to balance these losses against financial gains on capital markets. Given the difficult and uncertain financial situation, this is no longer possible.

PAYD tackles commoditisation and provides pricing innovation. In the short term, PAYD also allows insurers to identify niches which are crudely priced and suitable for more sophisticated pricing using new rating factors.

The traditional method of identifying risk in motor insurance is based on projecting theoretical risk against a pool of similar users. The need to acquire a statistically viable number of users, combined with price pressure from competition, has driven insurance companies to operate their motor insurance business at a loss.

The Pay As You Drive (PAYD) concept enables insurers to **charge drivers an insurance premium based on their actual risk**, as opposed to the projected risk of a user segment based on static criteria such as age, gender, marital status, vehicle type and its garage address.

The technology consists in a GPS-enabled data probe that transmits data – predominantly via the GSM network – to a central server, which uses this data to construct the time distance, location and behaviour of the driver during the journey and measure these factors in terms of risk.

PAYD has delivered a number of proven **benefits**:

- Reduce the size and volume of claims by between 15% and 50%, depending on the customer base,
- Actively manage claims and reduce exposure to third party liability,
- Identify customers with a propensity to change the behaviour and reduce risk,
- Secure customers by better segmentation, pricing of risk on existing book and relationship management.

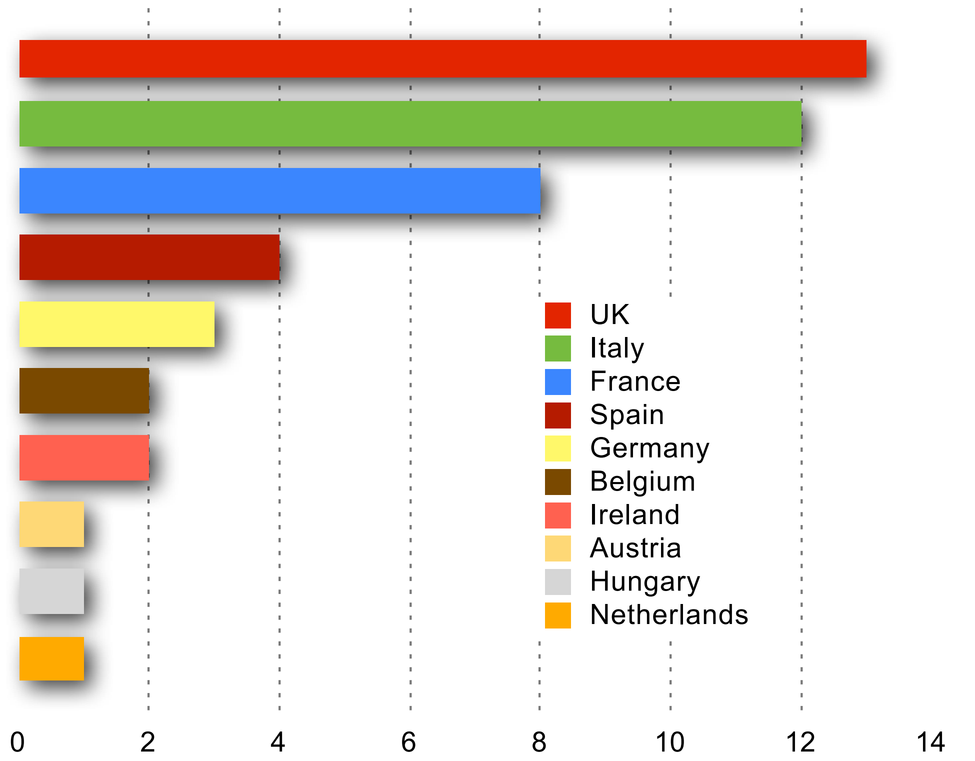
The key hurdles when deploying a PAYD proposition have been costs related to:

- In-vehicle hardware,
- Machine to Machine (M2M) data transfer usually via cellular operators,
- Distribution and installation of the hardware.

Many of these costs are now being mitigated by open access line installed hardware, competition among network operators reducing data tariffs and “lite” installation or self installed hardware.

PAYD insurance is currently being experimented by **more than 60 insurance companies in the world, more than 20 of whom offer it as a commercial product**.

Figure 14: Number of PAYD insurance trials / commercial launches in Europe - by country



Source: PTOLEMUS

Forecast of the PAYD market Section IV p. 204

5. Pay as you drive tax

Most European countries impose what is, effectively, a vehicle usage-based tax in the form of duty payable on fuel.

However, European roads carry high volumes of traffic at certain times of the day and/or in specific locations. Given the limited capacity of the road network, the more traffic on the road, the less efficient it becomes, causing congestion and increasing CO_2 emissions.

Similarly to PAYD insurance, **road user charging** (RUC) or road pricing makes the payment of tax depend on the vehicle location and movement patterns. In its most modern form, it can be performed thanks to an in-vehicle device, the on-board unit (OBU), which records vehicle movements, sends it to a central server for tax computation and user charging.

It addresses a number of key governmental policy objectives, such as:

- **Active traffic management** by higher pricing for road use at peak times, which effectively discourages non-essential journeys and encourages more use of public transport;
- **Reduction of pollution** by reducing the volume of traffic, enabling vehicles on the roads to operate more efficiently.

These policies can be achieved by applying RUC to

- All vehicles nationally, such as in the Netherlands,
- A specific user group, such as heavy goods vehicles (HGVs) in Austria, France and Switzerland,
- A specific location, such as central London or Stockholm congestion charges,
- A subsection of the road network, such as motorways in France,
- A combination of several factors such as HGVs on primary routes, as in Germany.

Putting RUC in place can be controversial for two main reasons:

- It can be, rightly or wrongly, considered as a new tax, which is never popular,
- In its modern, telematics, form, it requires the onboard unit to send users' data, which can be seen as invasive.

Clearly, as any new form of tax, it requires strong political resolve to deliver.

However, it is one of the few tools for actively managing road usage in a way that is fair, provides an advantageous cost/benefit ratio and is sustainable for society and the environment in the long run.

RUC has proven to be a success in Germany, the first country to implement RUC on a large scale. It has led to a refresh of the HGV fleet to more efficient engines, and the enabling of investment in alternative transport systems such as rail and waterways.

Forecast of the impact of RUC on in-car location services market Section IV p. 184
Forecast of the impact of RUC on commercial location services market Section IV p. 202

6. Pay as you drive car leasing

Pricing for leased cars is traditionally based on the car's projected mileage, its future value and the leasing operator's costs. This projected value is open to further external factors such as car production volumes and their future resale value in the open market.

By using the same technology outlined for PAYD insurance and RUC, a **new charging proposition can be offered based on the actual cost per kilometre**, reducing the upfront cost of a subscription-based model.

This can be bundled with additional vehicle-centric telematics services such as remote diagnostics and maintenance, PAYD insurance, safety and security such as eCall or B-Call to offer a compelling and differentiated offering.

For example, such offers have been introduced by PSA Peugeot Citroën and Renault, together with Diac-Location and Masternaut in France.

7. Pay as you drive car rental

A vehicle rental company is well placed to exploit the benefits of telematics as part of its proposition to the end user and for driving efficiency within its own operations. The installation of a telematics system enables a rental company to

- optimise its price structure to attract low mileage drivers,
- better manage its assets in a live environment,
- improve usage efficiency,
- optimise engine servicing and
- monitor security risks such as cross-border movement.

8. Stolen Vehicle Recovery (SVR)

Over the past 20 years, stolen vehicle recovery has been dominated by suppliers of dedicated devices.

These devices emit a radio signal that can be located via triangulation from a number of aerials on a specially equipped vehicle. This requires the search vehicle, such as a police patrol car, to be equipped with an appropriate scanning device and aerial configuration. While some police departments are willing to equip their vehicles, it is not a standard solution worldwide.

Telematics has enabled a far more scalable solution to the problem by covertly installing a GPS and communication network-based device that is integrated into the vehicle (or sometimes its subsystems).

The vehicle is monitored remotely for any incidents such as unauthorised entry or movement. The service provider's secure operating centre can then remotely track the vehicle's progress and task the police to recover the vehicle when it is safe to do so. It is also possible to **remotely immobilise the engine** and stop the vehicle at a safe moment, such as the next time the ignition is switched off.

Several SVR service provider also offer a number of additional vehicle-centric services, such as PAYD insurance and eCall or B-Call.

Forecast of the SVR market Section IV p. 184

9. Indoor location applications

It is a paradox that **most of us spend the largest part of our time indoors** but that no systems or services have been supplied to address this opportunity.

However, this is changing.

Indoor location has recently started to generate substantial interest and investments from location technology providers, venue owners and service providers.

Indoor locations and needs

When investing in location infrastructure, the venue owner needs to consider the opportunities for expanding the use of the technology beyond mere location in order to increase its viability. Location can, in fact, become the added value to an infrastructure, providing security, planning and/or emergency rescue services.

Qubulus, a Swedish start-up indoor location technology provider, ranks venues of interest for public indoor location services based on 3 criteria: the time spent in each location type, the specific solution required, and the ability to provide navigation and security.

The most important sites are considered to be

- Shopping malls and airports, to search for specific goods,
- Airports, to find friends and families,
- Airports and hospitals, for security applications including theft, rescue and exit,
- Trains and underground railways, for location-based content towards travellers.

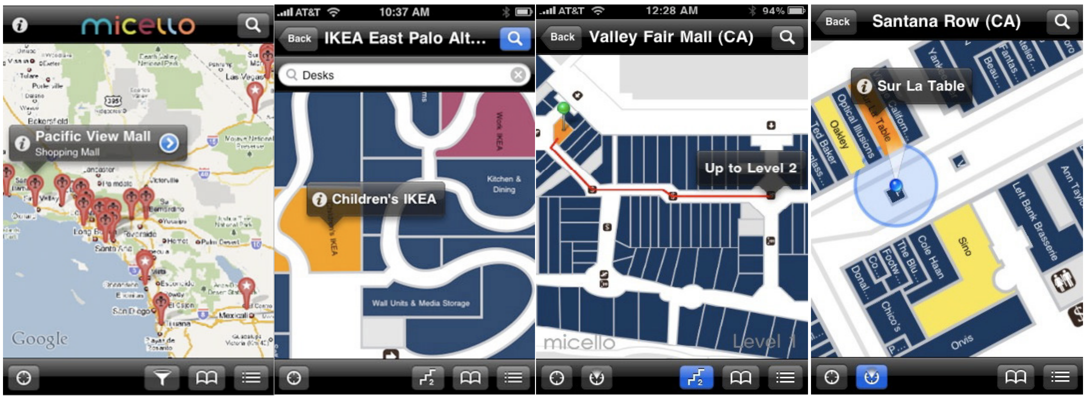
There is a marked difference between business models available in the US and Europe. There are 45 000 shopping malls in the US and the competition between them is fierce. The larger ones already run trials with maps and information for iPhone users, but can only reach 1-2% of their visitors that way.

In Europe, there are 9 000 shopping centres and competition is less of an issue. Their size is also relatively smaller so the impetus to invest is weak. As the mall concept has been incorporated into all international airports, the airports has now a similar problem to follow the visitors and communicate with them. But as it is also a transit area, the main objective remains to direct people from A to B, shopping and services are secondary but can become extremely personal.

Lastly, retail chains with their own stores such as Ikea are to be considered separately. Ikea is one of the largest chains with over 300 stores and almost 9 million m^2 area, complex offerings and high level of service to the customers.

The demand from users to locate products more easily already exists and indoor maps of Ikea shops have already been issued by US company **Micello**.

Figure 15: Micello's iPhone application applied to Ikea stores



Source: PTOLEMUS

Different solutions available for indoor location

It is still in its early stage, and, from a technical standpoint, WiFi is the most deployed solution for public use, whilst certain institutions such as hospitals and museums use Ultra Wide Band (UWB).

The advantages of **WiFi** technology are its standard status, its maturity, relative low cost and the fact that it is being deployed for communication in the first place. WiFi location is already used outdoors in the consumer area, notably by the iPhone.

In urban outdoor environments, it delivers high accuracy but unequal reliability,. In controlled indoor environments, its accuracy can be up **to the 3-metre range**.

The more expensive **UWB** technology offers **accuracy down to centimetres** in controlled environments, such as museums, enabling content to be delivered to a very specific location.

Technologies addressing the wide variety of indoor location requirements include:

- WiFi (companies such as Navizon and Skyhook),
- UWB (Ultra-Wide Band),
- RFID (Radio Frequency IDentification),
- SWB (Super-Wide Band),
- Pseudolites (or Pseudo Satellites), ground-based radio transmitters that transmit a navigation signal i.e. create new signals with the same properties as GPS satellite signals. The first provider of such systems is Insiteo.
- A combination of WiFi, Cell-ID, inertial sensors and GPS (e.g. Pole Star's combined GPS and WiFi solution).

When choosing which technology applies to which indoor application, it is important to consider t**he context of the location**. Behavioural patterns can be used to predict location changes and reduce the need for complex all-encompassing location technology.

Infrastructure-based solutions are only required if the tracked asset or person moves between indoor and outdoor environments often.

There are simple methods of tracking someone indoors. The most basic one is the voice call, after which, if more location data is required, the device-based solution is the cheapest option since increasingly more consumer devices include the necessary sensors.

The successful indoor location provider will need to match the service with the right price for the user's needs, based on choosing the right technology.

RF technology seems to be used in very specific applications where the environment is controlled and the accuracy paramount. UWB has found its niche usage (for example, in museums) but its high cost set-up and implementation make it ill-fitted to become a mass market solution.

In fact, the market for indoor positioning is polarised between technology providers targeting mass market services and those focusing on industrial applications.

Finally, **indoor maps are the missing link**, and a number of map providers are working on this. **Navteq**, which has an aggressive pedestrian coverage strategy, contrary to Tele Atlas, **aims at launching its first indoor maps this year.**

Interestingly, Nokia's Ovi Maps already provides approximate positioning indoors, based on WiFi access points and existing maps.

A number of independent service providers are also compiling maps based on the CAD (computer-aided design) or picture information shared by the indoor space owner.

These maps are generally not navigable directly, and PTOLEMUS expects that a standard for map matching and routing will be necessary if indoor location and navigation services are to become more widely adopted.

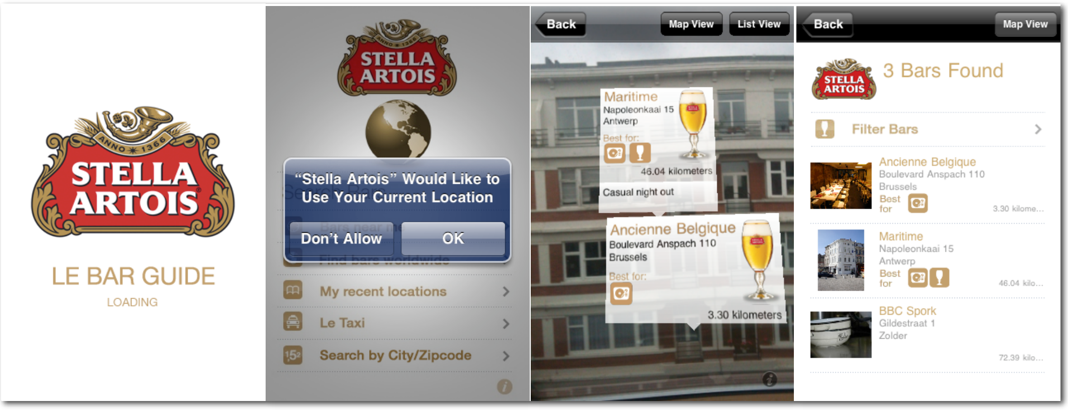
10. Location-based advertising and marketing

Why location-based advertising (LBA) is still limited

Gartner Group is forecasting that the overall mobile advertising segment will become a $7.4 billion market by the end of 2014.

But despite high industry expectations — not least the iAd platform Apple announced in April 2010 — the number of campaigns that have been run successfully remains a tiny portion of the overall advertising market.

Figure 16: Le Bar Guide, the marriage of augmented reality and location-based marketing



Source: PTOLEMUS

Critical issues slowing down LBA growth include

- **Inventory**: when location is added to the targeting criteria, too little space is left for a campaign to be worth running. This is due to the proportionately low number of smartphone users (approximately 20% of the population);
- **Experience and understanding:** marketeers have not yet fully understood how to extract value from the personalisation that mobile advertising offers;
- **Campaign cost:** the agency needs to convince the brand, set up a campaign and define the creative, such as a banner, a splash page or an icon on a map;
- **Lack of a standardised method** to run mobile campaigns that reach scale;
- Lack of uniform methods of **measurement** or understanding of the metrics;
- Difficulty of **tracking the efficiency of mobile campaigns** compared to web campaigns in third-party media planning tools;
- Although location information greatly enhances the value of the targeting process, it creates risks for the brand attached to **privacy and perception.**

Despite these barriers, the race to control mobile advertising has accelerated in 2010. **Location, as a way to make advertising relevant, is a clear differentiator in making mobile advertising pay.**

Opportunities for location data in advertising and marketing

Let us first define the difference between location-based advertising (LBA) and location-based marketing (LBM).

LBA is exemplified by banners or waiting-screen advertising sent to the mobile terminal in accordance with a range of criteria including location.

LBA needs large inventories because campaigns are currently primarily aimed at two audiences:

- Mobile customers browsing the web on their mobile handset and coming across the ad,
- Mobile customers downloading an application and seeing a banner on it while they are using it.

In both cases, the audience need to find the ad and stop what they are doing to see what the banner offers.

LBM is exemplified by an application sponsored by a brand. The audience chooses to use the application because it provides value. In LBM, the agency does not need an advertising network to publish the ad. It creates the application, makes it available for free on application stores and lets users download it. It can be useful to reinforce LBM with a LBA campaign to convert users into customers.

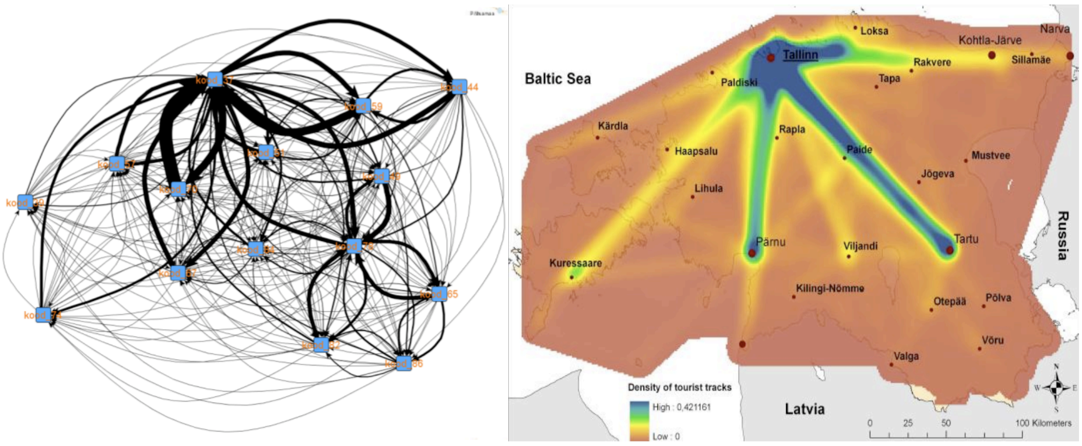
Google has expressly focused on the capacity to target and send messages to the right type of people at the right time, condition and place. Mobile operators might not sell their location data but they are all devising ways to use it for themselves. Google has made it clear that it will use its own Cell-ID database.

If Google owns an application that gathers information about where you are (e.g. Google Maps or Google Latitude), then whatever network you are on, Google will pick up the location data and use it to sell advertising.

Although historically, operators have been afraid of using Cell-ID data, we believe that they are currently changing their mind.

For example, EMT, the Estonian mobile operator and a Telia Sonera subsidiary, has started to investigate the potential of cell-ID location for mobile advertising and other applications.

Figure 17: Examples of Cell-ID applications: knowing your customers' geo-social graph (left) and the population flows of foreign tourists (right)



Source: EMT

Vodafone also conducted in 2009 a LBA trial in the Madrid region. It consisted in sending MMS promotional coupons to opted-in Vodafone customers when they were in the adequate cell areas. The levels of customer acceptance proved extremely high with 96% of users who were happy to receive more advertising messages.

The race to control mobile LBA

The clear understanding that location will be key for LBA has triggered a large number of acquisitions and alliances of the key players in the mobile industry. These are just some of the recent **acquisitions** in the digital advertising market:

- AdMob purchases AdWhirl,
- Google buys AdMob,
- Google acquires Plink,
- Opera acquires AdMarvel,
- Amobee acquires RingRing Media,
- Apple buys Quattro Wireless,
- Navteq acquires Acuity Mobile,
- Millennial Media buys TapMetrics.

In parallel developments, **partnerships** to make LBA a reality include:

- Quattro partners with Mobext on advanced mobile analytics,
- Alcatel-Lucent and Placecast team up on location-based mobile ads,
- Useful Networks partners with MoVoxx on LBS ads,
- Vodafone and Orange partner with Blyk in the Netherlands,
- Centrl becomes first LSBN to use LocationPoint for ads,
- Medio partners with AdMob, T-Mobile and Yahoo!,
- Ace Marketing & Promotions join forces with Blue Bite in proximity marketing,
- Smaato partners with Motally for enhanced metrics and analytics,

This intense activity will not create a boom in location-based advertising in itself. It will however provide the framework for location-enabled marketing, principally through local search but quickly extending into different types of mobile applications.

A number of **influences will push LBA forward**

- More powerful mobile devices in more hands producing faster mobile response,
- Consistent and reliable user experience for location,
- Much richer and more detailed information about what is around and interests the user,
- Better user understanding of what mobile search can generate,
- More intelligent ways to weave advertising into the search and discovery process,
- Operator guidelines defined to embrace NFC (Near Field Communication), WAP billing, alternate billing and similar functions,
- More comprehensive ways of measuring the actual impact of advertising on purchasing,
- Large-scale marketing of brand or entity to drive adoption of location and m-commerce,
- Federations of LBS companies through the GSM Association, the International Advertising Bureau or the Mobile Marketing Association.

Apple upsets the balance

Before seeking the ideal route to the development of LBM and LBA apps, developers must first negotiate their way through an increasingly complicated and distorted mobile advertising environment.

After the acquisition of Quattro Wireless, Apple launched in June 2010 **iAd, an advertising platform, built into iPhone OS4 only**, that allows brands to put ads within an application. This is a big advantage compared to traditional ads on the iPhone, which, when clicked, always require you to leave the application.

Apple has adopted a **new policy on the use of third-party applications on the iAd platform**. In essence, Apple has indicated to developers that they can use AdMob on the iPhone but cannot have access to its metrics. Without the metrics, no advertiser will obtain a budget to post ads on the AdMob network.

Ultimately, the biggest losers will be iPhone developers who are not only forbidden to use third-party analytics, but who also have to surrender **40% of their ad revenues to Apple** if they use iAd for data mining.

Basically, **Apple is trying to replicate on mobile what Google has done on the web, create a complete and exclusive LBA delivery mechanism.**

How to do it right

There is little merit in trying to implement location-targeted advertising in a model unless the message is contextually relevant. If the user can immediately recognise the context, relate with the ad and see the location of the business that placed the message, then the limitations of the device and GPS inaccuracy become irrelevant. It is the geo-content that matters most.

Here the emergence of augmented reality (AR) for the mobile interface can become highly relevant. Although AR has been derided as a gimmick, it can be used as a way to portray geodata and add a layer of advertising or promotion on top. Couponing that makes use of AR would make sense if it was generated from a search.

You can also drop in a virtual billboard in the AR view, as a representative from **Accrossair** mentioned. But the ad network can't drop in the ad, it can only broker the deal. It's up to the developer or publisher to regulate the content and thus make the money.

However, the model for AR is based on LBM, not LBA. Stella Artois, for example, uses an AR marketing app to help beer-lovers find a pub that sells this leading brand of Belgian beer.

Privacy could become an issue if LBA is implemented inadequately. Because the mobile handset is becoming a way to identify us, a too aggressive approach (e.g. unsolicited location-based messages) carries the danger of alienating consumers from the start and thus limit the pickup and return on the campaign. The risk also lies in users switching off the location functionality on their handset.

Operators have options

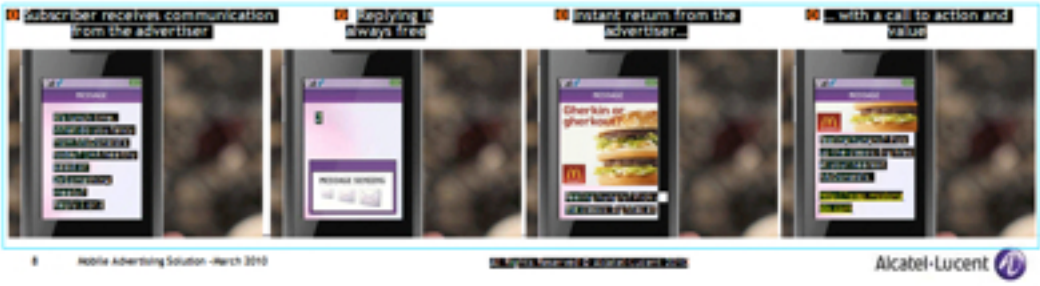
We expect mobile advertising to become a significant business in coming years. Mobile operators will not want to repeat what happened with ISPs, i.e. watch Google generate billions from sponsored ads traversing their “pipes” while bearing most of the costs.

To help operators prevent this, **Alcatel-Lucent** has launched a new advertising solution, together with Placecast.

Figure 18: Alcatel-Lucent's location-based advertising (LBA) solution

The system is based on mobile users opting in — either out of interest or to get a service discount — and the operators deliver text messages, multimedia text messages or even display ads — all served up by Alcatel-Lucent's hardware.

The company will also sign up advertisers, aggregating all users in a given area (i.e. building an ad inventory) and create the advertising management software. The idea is to make the platform worthwhile for advertisers, who are reluctant to manage campaigns across dozens of operators.



For this to work, operators need to integrate the free hardware into their networks — and then share the revenue with Alcatel-Lucent. This enable telecoms operators to avoid investing heavily in additional infrastructure or create their own ad sales team. The system already has its first customer, Orange Austria.

Source: PTOLEMUS

There is more than GPS

While location-based advertising has become one of the key growth areas in the advertising business, it is important to note that **GPS is not the cornerstone of location provision for this market**.

LBS and LBA work best in cities where the penetration of smartphones is high and 3G networks are available. There is also a strong case for LBA indoors, notably inside shops or shopping centres. In these environments, GPS is less than ideal.

We expect **WiFi positioning to play a key role in location-based marketing** as

- it provides high accuracy and enables targeted advertising,
- it is fast and inexpensive,
- it is embedded in a wide range of devices,
- it works indoors.

Agencies looking at LBM applications should therefore look very closely at which location technology they are relying on. For the moment, advertising networks such as AdMob cannot provide better targeting than the metropolitan area level (e.g. London or Berlin). We expect this to change radically within the next 2 years, notably due to the integration within Google.

Device manufacturers that wish to address the LBA and LBM market should also be concerned about the access to location indoors — they must ensure that alternatives to GPS are included in the plan.

11. Location-based social networking (LBSN)

Why location is a key enabler for LBSN monetisation

For social networks, location constitutes the missing link between virtual societies and real-world relationships. For marketeers who wish to monetise social networks, location represents an essential tool for hyper-targeting.

Location-based social networking (LBSN) brings together socio-economic status information with behaviour, time and location, enabling marketeers to identify opportunities to target users based on their current location and predict their behaviour based on past locations.

Consequently, the targeting and timing can be very precise. An advertiser can send an invitation to a football fan who is close to a sports bar, because the system knows that he likes sports, that there is a game in play and that he is not at the stadium. More importantly, the system can extend that invitation to the friends he usually meets on game days. The user enjoys the discount; the customer (the bar) will be ready to pay to attract users to its establishment.

Location also costs money. Companies that collect location information will need to figure out how to access, collect and re-distribute the location data, whilst putting systems in place to secure users' location and security and ensure they clearly understand how their location information is used.

Human mobile probes

When LBSNs enable a platform for people to interact for free, they need to establish who is going to pay the bill. This raises many questions:

- Who has access to and control of the location information?
- Who is serving the ads?
- Who has the relationship with advertisers?
- How to set up the opt-out capabilities?

The real value of the LBSN resides in the data that users can generate and in the ability of the company to monetise it, and, in the case of LBSNs, the idea is to monetise the user's current location.

Facebook recently changed its privacy policy to allow users to share their current location.

Figure 19: Facebook's new privacy policy on location

"When you share your location with others or add a location to something you post, **we treat that like any other content you post** (for example, it is subject to your privacy settings).

If we offer a service that supports this type of location sharing we will present you with an opt-in choice of whether you want to participate…

When you access Facebook from a computer, mobile phone… we may collect information from that device about your… location."

Source: PTOLEMUS

At the user level, the decision to share location information is open, but **Facebook will use the location information and resell it**.

The probe data market

Most companies that understand the importance of location are acquiring probe data.

In the case of **Twitter**, Comcast provides customer care through its Twitter account "ComcastCares". By mapping the location of all customers and pooling the data, it can identify the areas where investment in infrastructure may be required.

The same concept applies to an artist promoting a new record, a political campaign, a company measuring its advertising effectiveness by mapping its buzz according to local advertising efforts, or a PR company looking at real-time mood maps and analysing trends in specific areas.

The accessibility of dynamic location information creates an invaluable tool in real-time business intelligence. Companies like Ogilvy, Arbitron and Nielsen can measure in real-time the effects of events, and provide customers with the capability to make informed decisions about where to invest their PR efforts, and later measuring their effectiveness.

Facebook will become the main player in LBS / LBSN

While Foursquare prides itself on the 1 million users it gathered within a year, this is little in comparison to Yelp's 30-40 million users, and Facebook 400 million users, over 100 million in Europe alone.

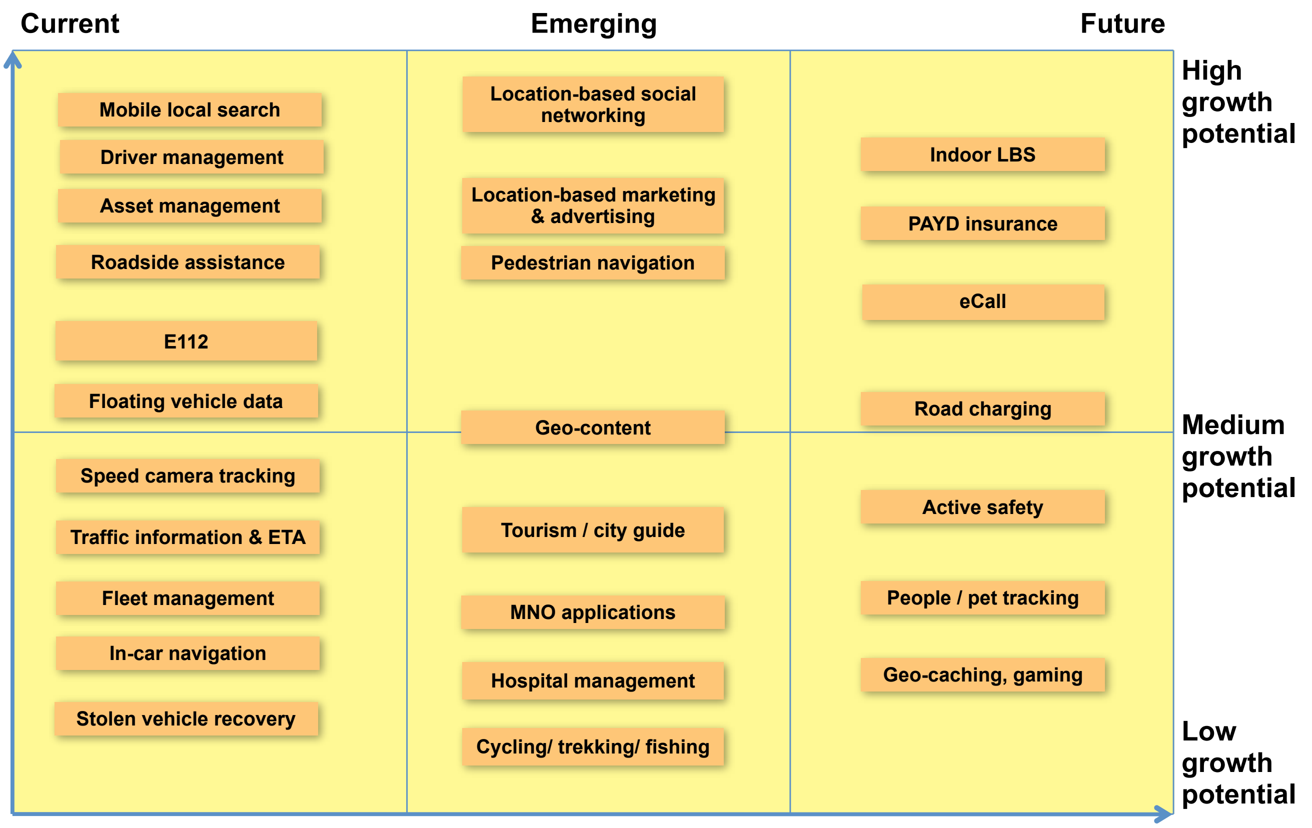
Location-sharing networks (LSNs) will have to offer real economic incentives if they hope to be a mainstream success. Foursquare signs up 10-20 000 new members each day, but it is predicted that Foursquare, Gowalla and others will have to pay $5-$10 per user and $50-$100 per offline business to maintain growth at the pace they need to reach critical mass. According to Dave McClure, a business angel who has run Facebook's incubator, this represents an investment of $100 million.

Finally, one of Facebook's opportunities may lie in its own payment capability. As its users are already comfortable with various virtual currencies, we expect this to be as strong driver of monetisation.

So as to sum up the **evolution of the LBS landscape**, we have mapped for each major location-enabled application

- Its **level of maturity**,
- Our expectations of its **growth potential**.

Figure 20: Maturity and growth potential of location-based services



Source: PTOLEMUS

II. TYPOLOGY OF POSITIONING TECHNOLOGIES

A. Positioning technology requirements

For each application, we have analysed its positioning needs according to the following criteria.

Coverage, defined as the geographical surface (which is equivalent to a percentage of time spent) where a device can obtain its location successfully. Coverage can be global in theory but patchy in practice (e.g. GPS under a tree), or patchy by definition but reliable in practice (like RFID or UWB indoors).

Accuracy, i.e. the expected precision of the location provided by the device used compared to a reference database (generally, a map). Accuracy can vary widely, depending on conditions for any specific technologies. Moreover, quoted accuracy figures are often unreliable and difficult to verify.

Speed, i.e. the number of seconds required to acquire the location information and to provide it the user. It is often called "Time-to-first-fix" and corresponds to the time taken for the receiver to obtain a position from the moment it is switched on.

Reliability / integrity: the percentage of time that location data is available, correct and delivered per location request. This is generally omitted from technical papers, and it is often unclear what the reliability of location positioning actually is. Applications that require reliability are mission-critical services such as aviation, emergency calls, routing of emergency services and military applications. Network assistance is a means to improve reliability for mobile safety services. For aviation and maritime applications, augmentation systems such as EGNOS also provide additional reliability.

Power consumption, which corresponds to the level of energy needed to obtain the device location on a permanent basis. This analysis took the view that low power consumption is good, and the scale was reverted in the following figures, i.e. a high power consumption device obtains a low score. The differential note used in the following tables are based on battery power availability vs. their usage on a daily basis.

Implementation cost: As this is a subjective matter, the comparison in following figures was made between the orders of magnitude of the costs as seen by the main visible purchasers.

Privacy: The requirements for privacy settings have changed dramatically in the past few years. As technology evolves permitting anyone to be tracked and share their location through an ever-increasing array of applications, regulations have struggled to keep up.

In 2009, a number of voluntary agreements on best practices have ensured that developers make it very clear when location is used by an application. Furthermore, authorisation to obtain location information must be requested every time the application is used.

In 2010, a number of national regulations in Europe have again changed the way user location can be used.

1. Location requirements of applications

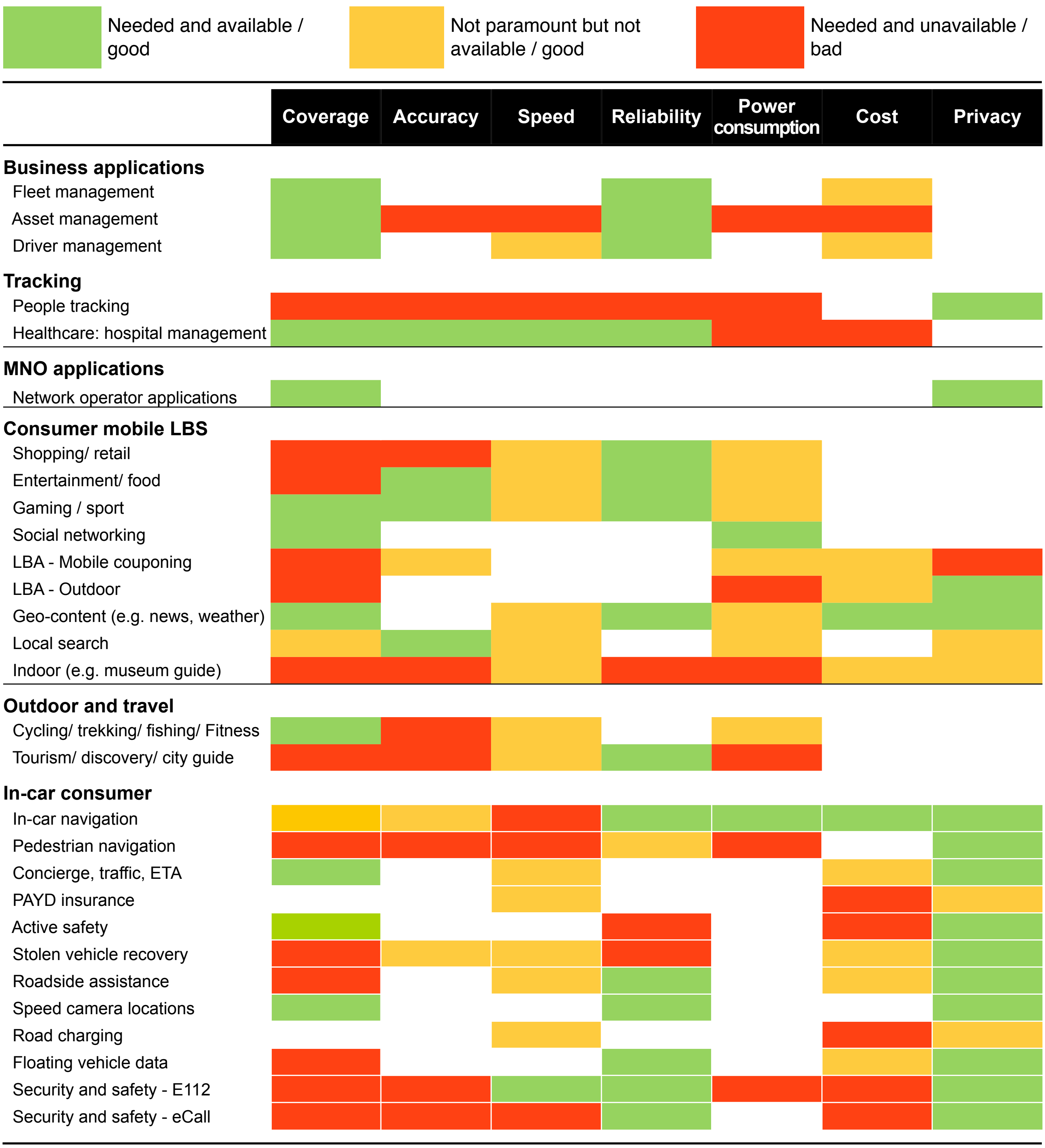
A detailed analysis shows that **the requirements of many applications are not always met by existing location technologies**.

In the table below, for each cell, a mark out of 5 was given for the importance of the criteria and the availability of those criteria. This was based on today's applications using today's location technology.

The difference between the availability and the needs marks gave the **"fulfilment" mark** used in the tables below.

The taxonomy in Figure 21 shows the difference between cases where the need is there but the availability is not and where the need is not great but the availability is underused.

Figure 21: Taxonomy of positioning needs based on today's location technologies



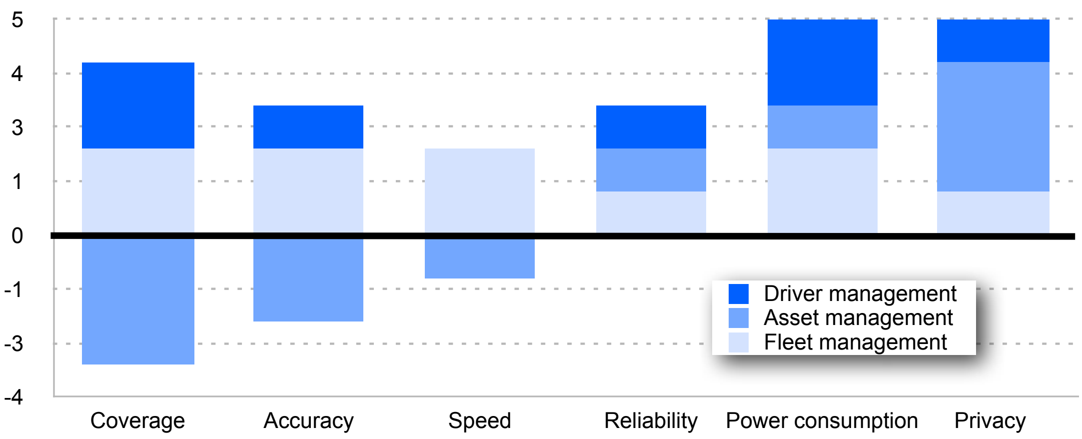
Source: PTOLEMUS analysis

Requirements analysis: Commercial vehicle applications and tracking

In the figures below, **ratings** are issued as the **difference between the availability** of a criterion (marked out of five) and the **estimated need** for that criterion. Therefore,

- If a need is fulfilled, the result will be zero;
- If the need is not satisfied, the score will be negative;
- If the availability exceeds the need, the score will be positive.

Figure 22: How location needs are fulfilled: commercial vehicle applications



Source: PTOLEMUS analysis

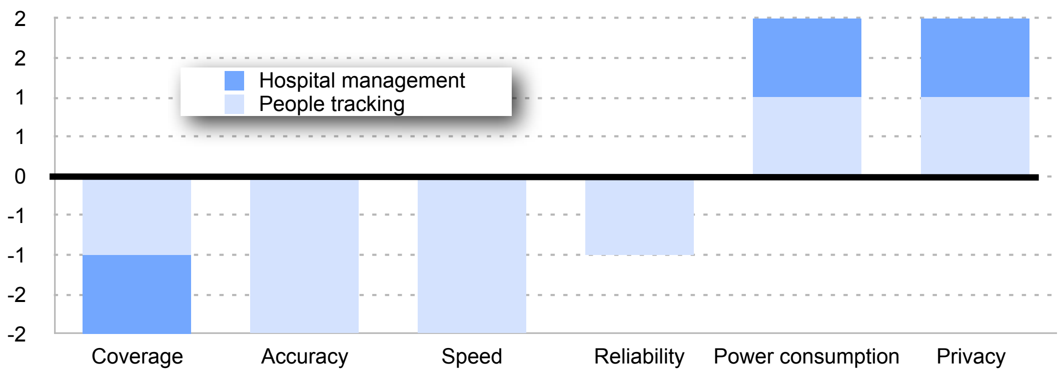
Location coverage and availability is crucial for mobile fleet and asset management, but most fleets operate in pre-determined regions, and generally, national or even city-wide coverage may be sufficient.

There is a range of location technologies available to this sector:

- NFC-based (e.g. RFID) or WiFi for warehouses and large facilities, and
- A-GPS and Cell-ID for national fleets.

Available coverage often exceeds the need but there are still uncovered areas such as urban canyons, tunnels, etc. When Galileo will be in operation, the availability of satellite signals will increase significantly, which will reduce the multi-path problem in urban canyons.

Figure 23: How location needs are fulfilled: tracking applications



Source: PTOLEMUS analysis

The picture changes with people tracking, and with asset and equipment tracking and management. For those applications, coverage is critical, and, in many cases, insufficient. Containers cannot be tracked onboard ships and parcels cannot be tracked whilst in a truck unless substantial investment is made to implement a range of complementary tracking solutions.

Accuracy needs and solutions vary widely from geofencing to snap to map for road-focused applications. Other solutions, such as asset tracking within a warehouse or tracking a specific maintenance vehicle, require greater accuracy. Accuracy is often necessary in people tracking applications to reach efficient protection, but privacy issues often go against accuracy.

Commercial applications are less speed-sensitive, as they tend to use location more often (keeping the fix for longer and enabling the chipset to update its ephemeris more often) as well as for longer periods with no power issues.

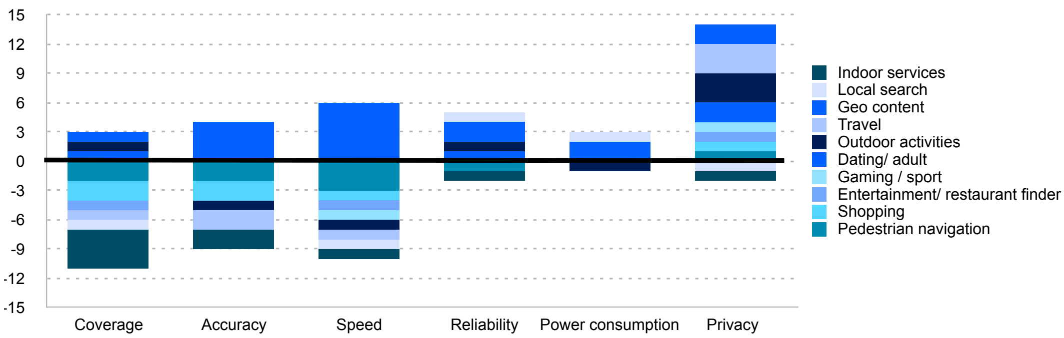
Another requirement is the ability to track a device without it actively transmitting its location. Most GPS units are based on broadcasting location; units using network location are tracked by the network itself.

Requirements analysis: consumer mobile location-based services

The vast majority of consumer location-based applications only require local coverage. Cell-ID, WiFi, A-GPS are the main solutions in use today.

Indoor coverage is, however, not widely available at the moment, and this is **an important limitation to the growth of mobile LBS.**

Figure 24: How location needs are fulfilled: Consumer LBS



Source: PTOLEMUS analysis

Data roaming is also a barrier, since a number of location services are based on travelling to unknown places. Solutions include roaming agreements, global network agreements and caching data in the application. In practice, this domain is under-served, and PTOLEMUS believes that M2M operators would be wise to look at how they could offer value.

TTFF has become an important factor in the GPS industry, borne out of early users' frustration, and it has become one of the marketing messages. Connected devices improve the situation in this regard, since the network is often used to fasten location acquisition. The real speed issue arises when it is combined with usage of the application itself in a human, portable, instant gratification environment.

While network-centric solutions are by far the fastest, with less than 1 second delay, they are often not accurate enough for mobile LBS. Unassisted GPS can push that to 5 minutes in poor conditions, but client-based as well as server-based solutions are being deployed where the expected TTFF for A-GPS is around 10 seconds.

For most consumer use cases, particularly mobile applications, reliability has not been a major concern because the market is still immature and the expectations of smartphone users are not as high as those of a high end car driver.

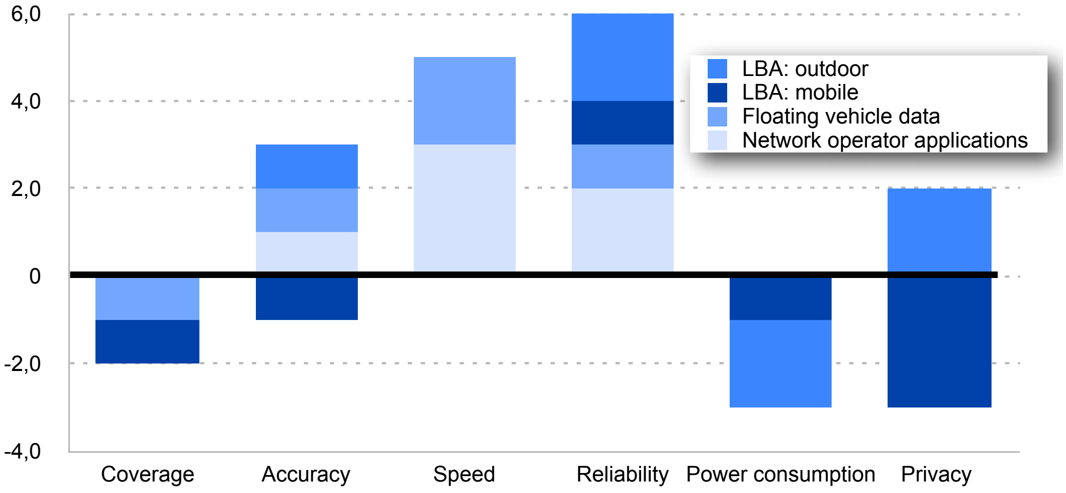
Furthermore, with a large number of mobile LBS applications being free or near-free, users complain about little else but battery life.

PTOLEMUS believes that reliability will be addressed as the market matures, thanks to solutions like EGNOS being available and free.

Requirements analysis: Mobile network operator applications

Indoor coverage, power consumption and privacy are the main outstanding issues to address in the otherwise unchallenged mobile operators' applications spectrum.

Figure 25: How location needs are fulfilled: MNO applications



Source: PTOLEMUS analysis

This confirms the solidity of the technical proposition of network operators. It is a domain in which service delivery is highly reliable and fast. There is much merit in the suggestion that investments be made in improving accuracy and out of town coverage.

Privacy has been at the core of most discussions related to operator-led LBS and LBA. The service delivery mechanisms that operators put in place – as and when LBA becomes widespread – will have a determining impact on privacy concerns.

Requirements analysis: In-car consumer LBS and other services

In-car location based services can be divided into 2 categories, i.e.

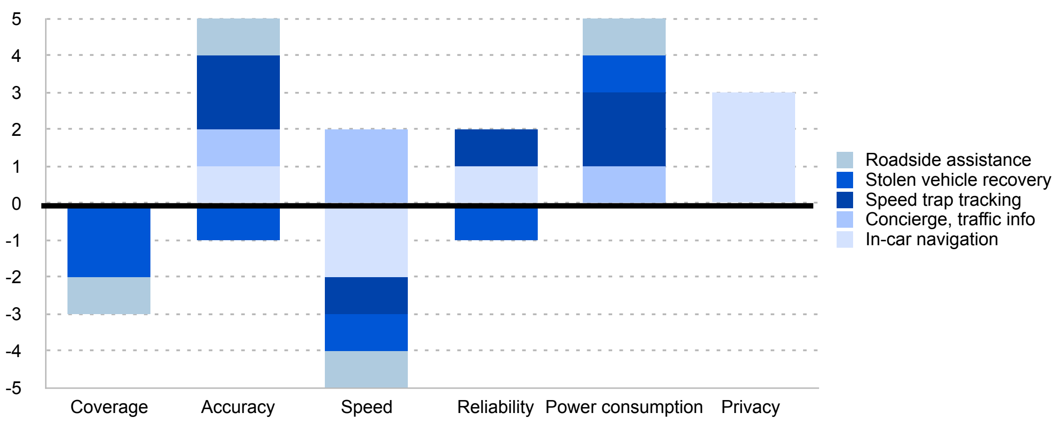
- services for which consumer are often ready to pay themselves, such as speed camera locations,
- services for which pricing will be based on vehicle usage.

The latter are distributed indirectly via a service provider, and include usage-based charging for tax and insurance, safety services such as eCall, and active safety.

The technologies in this relatively mature market are as yet unchallenged, with location enabled by GPS and the communication network (CN) by GPRS. This is due to the nature of vehicle use with a need for wide area location and permanent availability but not constant network communication for eCall.

With in-vehicle power readily available, power consumption issues are eliminated. This impacts the implementation of GPS, enabling either an always-on or a power-hungry high-sensitivity receiver configuration, which accelerates TTFF and enables better accuracy.

Figure 26: How location needs are fulfilled: In-car consumer LBS



Source: PTOLEMUS analysis

For consumer applications, TTFF is primarily a user experience and power consumption issue. Navigation services offered on a nomadic platform are most affected, but only because they were introduced first.

Given the fact that mobile phones are becoming a key delivery mechanism, TTFF and battery consumption are becoming even bigger issues. Chipset manufacturers are focusing on improving this.

Another elegant solution to solve the TTFF issue, as shown by Apple in the iPhone is the use of **WiFi positioning**. Apple leverages Skyhook's **WiFi access points location database**. TTFF can then be reached within less than 1 second, which is a key advantage in urban areas, where GPS satellites are often not visible.

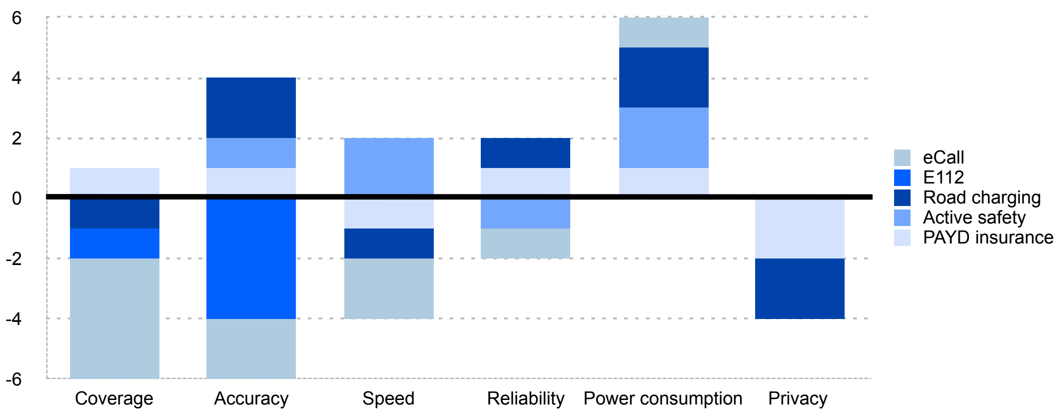
We expect other smartphone vendors but also PND manufacturers and car vendors to have no choice but to start using WiFi-assisted GPS within the coming years.

For safety and security applications, privacy issues are, in theory, irrelevant. The user who wants to be rescued or the authority that needs to evacuate an area would prioritise the best accuracy possible over privacy.

Thus augmented network-centric solutions (U-TDOA) or combined technologies can be used to track mobile phones, for instance.

There is another advantage; no input is required from the user and the cell phone itself does not even need to be switched on.

Figure 27: How location needs are fulfilled: Safety services



Source: PTOLEMUS analysis

Location accuracy is key in the delivery of safety services, including indoors.

However, as vehicles are generally restricted to roads with limited access indoors, location technologies can be augmented by other application-based processes, such as map matching and recording vehicle entry and exit points in buildings and tunnels.

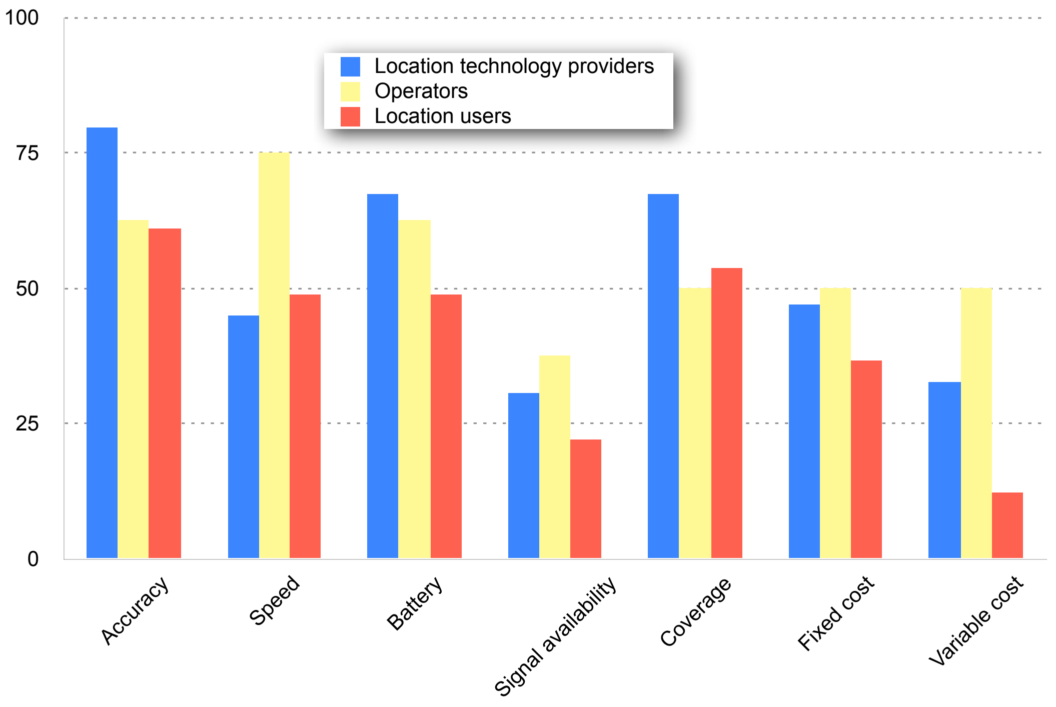
Indoor accuracy is being addressed by sensor-based solutions. Nevertheless, at this stage, these are expensive with limited use case scenarios and, consequently, limited cost benefits.

2. Main challenges faced by positioning technologies

In December 2009, we conducted an online survey of over 100 executives from location technology providers, wireless operators and location users (device manufacturers).

We can conclude that **the needs perceived by location technology providers do not entirely match the experience of device manufacturers**.

Figure 28: Perceived and real needs (% of respondents identifying the needs for end users)



Note: Location users are device vendors and application developers
Source: PTOLEMUS online survey, December 2009

Based on this sample we can suggest that:

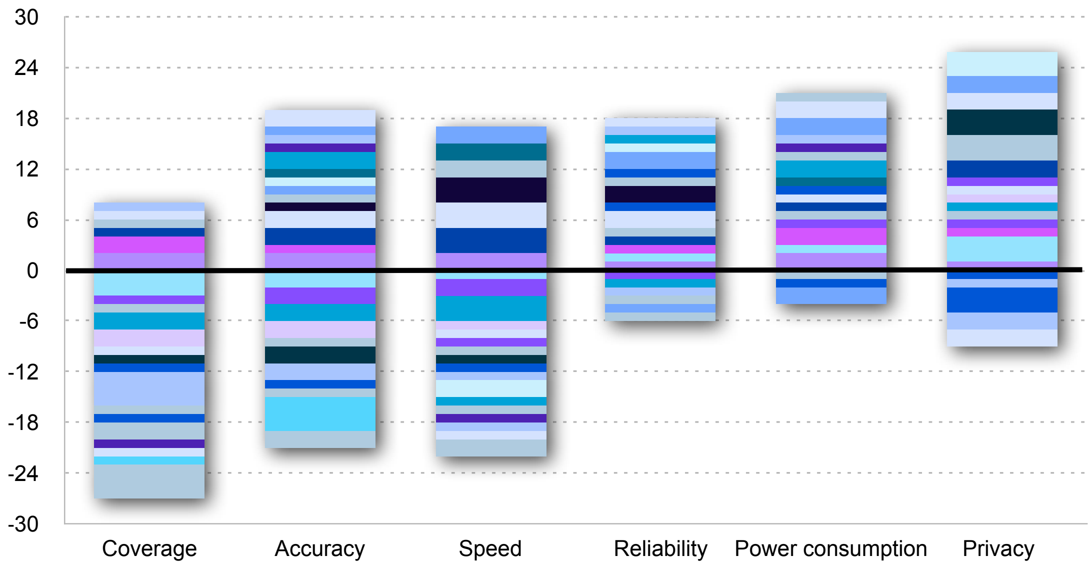
- **Accuracy is seen as the most important end user requirement** by location technology providers but also, to a lesser extent, by users and operators;
- **Speed** is viewed by mobile operators as the most important factor, which reflects the fact that operator executives are aware of the little time most of the customers have when actually using their handset;
- Battery life is perceived less of an issue by location users than by technology providers;
- Fixed costs is less a priority for device vendors than for technology providers.

When we conduct our analysis of the performance of all location-based applications, the overall picture is rather unexpected. **Contrary to predictions, the biggest unfulfilled need is coverage, not accuracy.**

On the whole, coverage issues are not solved by A-GPS, EGNOS or Galileo. And WiFi alone does not tackle coverage issues in all environments.

The technology, or a hybrid of various technologies able to solve coverage issues, will have resonance in most of the LBS markets surveyed in this study. Since the most acute coverage problems are caused to obstructions, multi-path effects and indoor spaces, a **mobile network-centric solution would be the best option**.

Figure 29: How location technology needs are fulfilled across all location-based applications



Source: PTOLEMUS analysis

Overall, **accuracy** is satisfactory in most consumer markets. It only becomes an issue when reliability and speed, together with accuracy, are required for mission-critical applications such as E112.

Our analysis confirms the result of the survey: power consumption, so predominant in commercial speeches of technology providers and in consumer market research, is actually not mentioned as a key issue.

Finally, **privacy is**, in terms of location technology, **available** for implementation in the majority of markets. It seems to indicate that service providers will be entirely responsible for ensuring that end-users are comfortable with privacy settings.

When surveying location-based mobile application providers, the monitoring of user behaviour demonstrates that, in 90% of cases, the location request is accepted as soon as it is received.

However, the risk that location from a mobile device could be used against its users has inspired a push for more defined regulations. In particular, privacy requirements in Europe are currently being redefined.

As a conclusion to this exercise, we have identified **which existing location technology or hybrid solution is the most appropriate for each application**.

Figure 30: Existing optimal location solution for each application

Location-based applications	Optimal solutions available
Commercial vehicle applications	
Fleet management	GPS or WiFi + Cell-ID
Asset management	UWB or RFID + A-GPS
Driver management	GPS
Tracking	
People tracking	GPS or WiFi in urban areas
Healthcare: hospital management	WiFi, UWB or RFID
Network operator applications	
Location-sensitive billing, fraud prevention, etc.	Cell-ID or IP location
Consumer mobile LBS	
Pedestrian navigation	A-GPS + WiFi
Shopping / retail	A-GPS + WiFi
Entertainment / food	A-GPS + WiFi
Gaming / sport	A-GPS + WiFi
Social networking	A-GPS + WiFi + Cell-ID (for status)
Location-based marketing & advertising	Cell-ID or WiFi
Geo-content, e.g. weather, etc.	Cell-ID or WiFi
Local search, e.g. business finder	Cell-ID or WiFi
Outdoor, e.g. cycling, trekking, fishing, fitness	GPS
Travel, e.g, tourism, discovery, city guide	A-GPS or WiFi + Cell-ID
Indoor, e.g. museum guide	WiFi or UWB
In-car consumer LBS	
In-car navigation	A-GPS+EGNOS+WiFi+Pressure sensors
Traffic information and guidance	A-GPS
PAYD insurance	A-GPS
Active safety	DSRC + GPS
Stolen vehicle recovery	GPS+WiFi
Roadside assistance	GPS+EGNOS
Speed camera locations	GPS+EGNOS
Road charging	DSRC, GPS+EGNOS
Floating vehicle data	A-GPS
E112	U-TDOA, A-GPS SIM, Cell-ID
eCall	A-GPS + WiFi

Source: PTOLEMUS

B. Present and future positioning technologies responding to those needs

1. GPS (Global Positioning System)

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in 2000, the US government made the system freely available for civilian use, worldwide.

A GPS receiver generates a position based on the measurement of its distance to 4 or more GPS satellites. To calculate these distances, the receiver measures the time required for the signal to travel from the satellite to the receiver.

The receiver then obtains satellite positions from the satellite broadcasts:

- The **almanac**: information on where GPS satellites will be and when. These are approximate positions used to set approximate satellite search ranges to decrease acquisition time;
- The **ephemeris**: precise position used in trilateration calculations used to improve uncorrected position estimation accuracy.

The receiver then calculates the position using trilateration and corrects for errors (clock bias, noise, propagation delays, etc.) to improve accuracy.

GPS chipsets compete on innovation in terms of:

- Search capacity, resulting in enhanced sensitivity, reduced time-to-first-fix and improved positional accuracy;
- Advanced power management and integrated switched-mode regulation to maintain hot-start conditions with minimal energy;
- MEMS sensor support (for accelerometers and magnetic sensors) to enable greater contextual awareness, more sophisticated energy management and enhanced indoor positioning;
- Active search for and removal of jammers prior to correlation for maximum GPS performance.

We detail hereafter the 3 methods available to enhance the speed at which the receiver alone obtains a fix and calculates the location when real-time access is unavailable**.**

Full analysis of the GPS value chain Section III, p. 134
Full assessment of the GPS chipset market potential Section IV, p. 160

a. Extended ephemeris (EE)

Extended ephemeris consists of satellite orbital data stored for the purpose of accelerating TTFF and reacquisition times.

Extended ephemeris can be calculated on the chipset or downloaded using wired or wireless connections from Internet- or cellular-based servers. The stored data provides tracking ability for **up to 7 days**, minimising the device's need to scan the sky or frequently access networks to obtain real-time location information.

The validity of the ephemeris data can be extended by having multiple sets of the data preloaded on the device.

Chipset manufacturers promote **2 types of extended ephemeris data**:

- **Server-generated** (SGEE): the server can generate the EE as it accesses GPS receivers all over the world and has EE for all the satellites at anytime it the upload to the receivers. This solution is **perfect for mobile phone navigation**;
- **Client-generated** (CGEE): the device needs a seed to obtain the EE, i.e. the current ephemeris of the satellite. The device can only project the ephemeris of the satellite it sees. Then a mathematical calculation model is used. This makes the projection throughput- and memory-intensive. The calculation needs to be done in the background on a larger CPU (Central Processing Unit). This solution is therefore more often used **in PNDs**.

b. Fast location fixes without network assistance

Ephemeris Self-Prediction are based on algorithms that generate satellite ephemeris for up to 5 days, with no network connection.

The aim is to deliver ultra-fast start-up times with enhanced positional accuracy. Cold starts (i.e. without information about ephemeris, almanac and previous position) are aimed to be reduced to 10 seconds.

c. Advanced power domain architecture

The objective is to keep the GPS chip in a state that is always ready to get a hot start fix (i.e. the device remembers its last calculated position, the satellites in view and the almanac information).

In the case of Atheros chipsets, when placed in **"always ready" tracking mode**, the receiver continually monitors its own clock accuracy, and wakes up to recalibrate at periodic intervals to maintain peak starting performance. This delivers the performance of assisted GPS without the need to connect to a network.

d. GPS III

The new GPS III satellites are expected to be **launched from 2014**.

The new functionalities are closely following those of Galileo. GPS III satellites will include additional high-powered, anti-jam military code, along with other accuracy, reliability, and data integrity improvements.

The system is based on a modular open systems architecture, standard interfaces and protocols, and continuous technology refresh to incrementally improve the system capabilities with a low risk of GPS service interruption.

Thanks to a **constellation of 30-32 satellites**, GPS III will have second and third frequencies to contain civilian signals, (L2 = 1 227.60 MHz and L5 = 1 176.45 MHz), more robust signal transmissions, and provide **real-time un-augmented 1 metre accuracy**.

The GPS III program includes an integrated space segment (SS) and control segment (CS) system which defines the Signal-in-Space (SIS) to User Equipment (UE) interface. The GPS III system should facilitate the incorporation of additional mission capabilities (i.e. Blue Force Tracking (BFT), Search & Rescue (SAR) missions, etc.).

Complete analysis of GPS III can be found in Section III, p. 124

2. A-GPS (Assisted GPS)

GPS is often assisted by a range of datasets provided by databases connected through cellular or fixed networks. Initially, assistance servers have been developed to enhance the positioning performance of GPS-equipped mobile phones to satisfy the US Federal Communication Commission's E911 mandate.

Assistance servers provide more GPS orbital data to the handset and help correct atmospheric errors, as well as provide augmentation capabilities.

A-GPS improves positioning in terms of

- higher accuracy, reducing the error margin,
- an increased yield (success rate), and, most importantly,
- a **shortened TTFF** (the time it takes for the receiver to obtain its first positioning), which also results in
- reduced power consumption.

Leveraging the global network of GPS satellites, an **A-GPS platform enables mobile operators to provide high-performance location services without necessarily making major changes to their infrastructure**.

It is important to note that the concept of assistance will also be applicable to Galileo when it is launched, and other constellations. This will be A-GNSS.

a. Control Plane architecture

Control plane is an implementation of A-GPS in which messages are transported over a mobile operator's logical signalling channels. It is standardised by 3GPP.

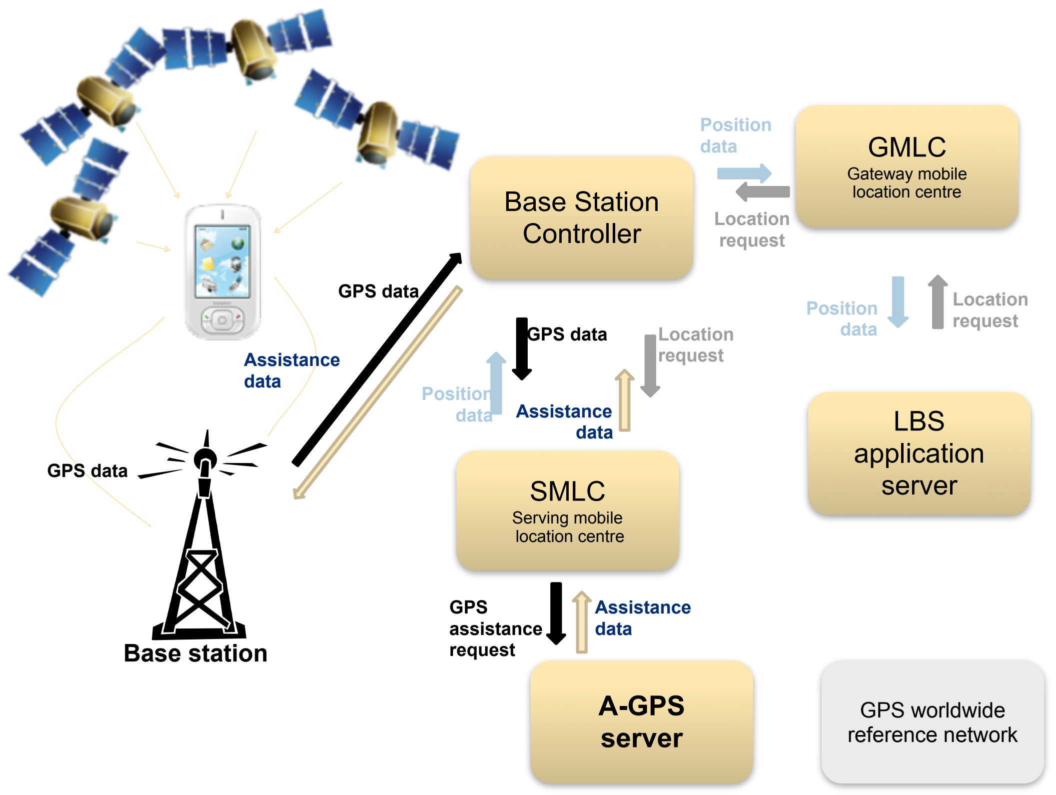
The positioning data is **sent over the mobile network control channel**.

Enabling control plane location **requires upgrades to network elements** (positioning server, gateway server) to handle all standard protocols, but **supports legacy terminals**.

The serving mobile location centre (SMLC) calculates the mobile phone location. The gateway mobile location centre (GMLC) transmits the location with billing and authentication information. The GMLC is based on industry-standard SS7 protocol stacks and works on GSM or 3G networks. GMLC providers can interconnect with third party SMLCs, or can provide both as part of a turnkey solution.

The advantage is that t**he operator can request the location of a phone irrespective of its OS.** The control plane also enables improved reliability and speed as the position is acquired purely by the network and does not rely on the device.

Figure 31: A-GPS Control Plane infrastructure and operations



Source: PTOLEMUS

Control plane is a well-adapted and easily set up architecture for

- Greenfield mobile networks (e.g. in developing countries), where the cost and simplicity of set up as well as immediate access to the data from the operators is more important than accuracy,
- Emergency services such as E112 and eCall, notably because it works even when the mobile user's subscription has expired.

b. SUPL (Secure User Plane Location) architecture

SUPL (Secure User Plane) uses instead **application layers** of the communication system.

The A-GPS infrastructure combines GPS with an OMA (Open Mobile Alliance)-standard SUPL architecture, allowing it to interact with all compliant GPS-equipped mobile phones **using TCP/IP over existing GPRS/EDGE and IP networks**.

Most importantly, **it bypasses the operator's architecture** reusing existing protocols such as SMS or GPRS. The SUPL server provides a set of assisting data, including the ephemeris, the almanac and differential correction (such as EGNOS data for example).

The SUPL server-based A-GPS accuracy is expected to be sub-10-metres and the maximum latency reduced to less than 20 seconds.

In User Plane, the interface between system entities is IP-based, which means it is application-focused, reducing both time to market and deployment costs.

However, roaming is an issue since the mobile always need to interact with the home server.

SUPL is based on the following concepts:

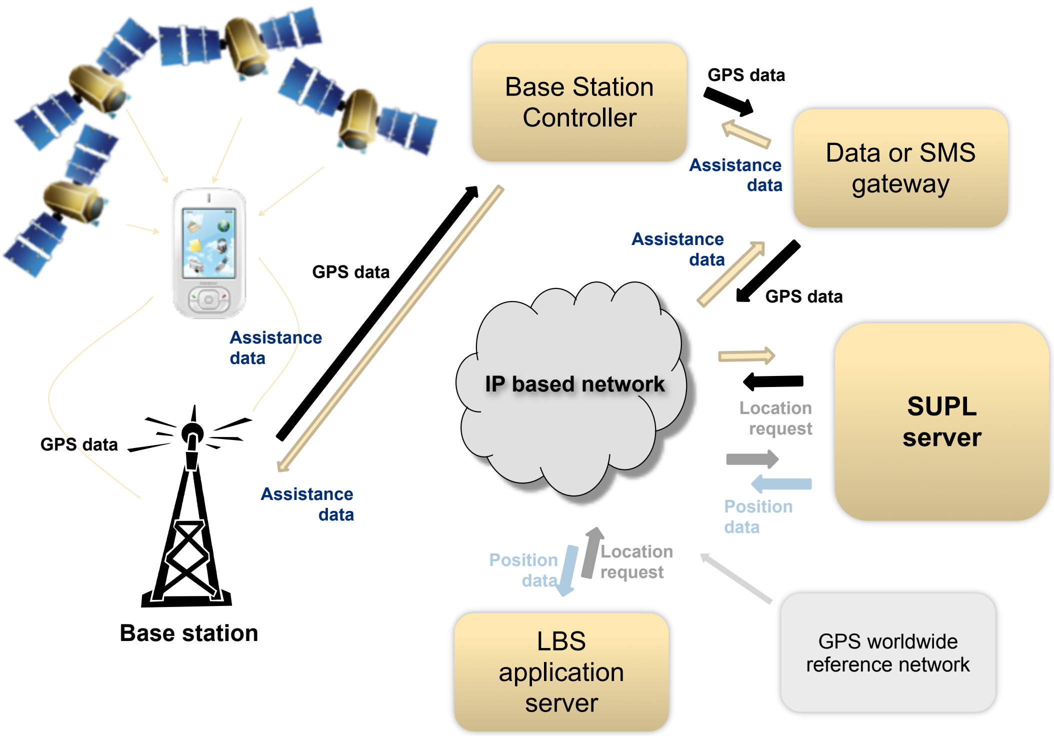
- It is a **bearer independent** (GSM, WCDMA and CDMA) standard. There are no changes required in the underlying network for service deployment, and it guarantees roaming, security and privacy support;
- **The SUPL server supports different types of positioning methods**, including Cell-ID, A-GPS, Autonomous GPS and Enhanced Observed Time Difference (E-OTD). The position determination is initiated by a single call by either the mobile device or the network.

SUPL 2.0 is being set up for initial release at the end of 2010. New features include an array of location-based services directly provided by the server:

- Support for additional bearers: **WiFi**, **LTE**, UMB, HRPD, WiMAX and network measurements for Enhanced Cell-ID (E-CID) positioning;
- Support of **Galileo**, **Glonass**, Modernised GPS and **E112** emergency calls; network initiated SUPL position determination after establishment of an emergency call;

- Support for triggered periodic services (for fleet management/monitoring, parcel tracking, etc.) using periodic position determination of a target device. This can be initiated by either the network or the device;
- Also support for area event service (**geofencing**). The server can detect and notify the requesting entity when a target device enters or leaves a pre-defined geographical target area. Once a device enters or leaves a geofenced area, the device will send periodic updates;
- Support for a third party's ability to request the location of a device, as well as self-location with the ability to transmit the device's position to a third party.

Figure 32: A-GPS User Plane infrastructure and operations



Source: PTOLEMUS

SUPL 3.0 is expected to bring the following features:

- Improved location for IP emergency calls (e.g. support of set initiated emergency calls),
- Improved location performance (e.g. higher accuracy, better TTFF),
- Triggered location enhancement (e.g. new trigger types),
- Improved indoor location accuracy (e.g. hybrid positioning methods),
- Device-to-device location (e.g. streaming of location/measurements),
- Authentication and privacy enhancements,
- Additional access networks (e.g. fixed broadband),
- Support for extended location information (e.g. sensor information).

3. EGNOS (European Geostationary Navigation Overlay Service)

On October 1, 2009, the European Commission declared the official start of operations of the European Geostationary Navigation Overlay Service (EGNOS), with its open service available free of charge to businesses and consumers.

EGNOS is a **satellite-based augmentation system** (SBAS) that improves the reliability of GPS, and later Galileo, over Europe.

SBAS systems are designed to enhance the Navigation System constellation by broadcasting additional signals from geostationary (GEO) satellites and providing differential correction messages and integrity data for the satellites which are in the view of a monitoring station network.

EGNOS was primarily built for the aerospace and maritime business and is the European equivalent to the American WAAS constellation.

The system is composed of transponders aboard **3 geostationary satellites** hovering high above the eastern Atlantic and the European continent, linked to a ground network of about **40 positioning stations and 2 control centres**, all of which are interconnected.

The EGNOS ground stations receive signals sent out by GPS satellites. Information on the accuracy and reliability of these signals is relayed to users via the geostationary satellite transponders.

EGNOS operations are managed by the European Satellite Services Provider, ESSP SaS, a Toulouse-based company that was founded by 7 air navigation services providers. A contract between the EC and ESSP SaS covers management of the EGNOS operations and maintenance until the end of 2013.

Until recently, there was not any communication about consumer devices using the benefits of EGNOS in their marketing messages.

This changed when a number of PND manufacturers started to promote the added accuracy of their products using “Augmented GPS”.

The reality on accuracy

EGNOS was designed to improve the integrity of the signal, provide the correct information to the receiver and communicate the quality of the signal. Within the signal, one can receive differential data that can be used for accuracy – but only sometimes, the terminal needs to be connected all the time to receive the EGNOS data.

Besides maritime and aerospace applications, EGNOS can be used to improve the reliability of consumer devices’ GPS location. Under optimal condition (clear sky, rural environment), EGNOS can improve accuracy down to 1 meter.

For land-based location services, **EGNOS can make a significant difference in terms of accuracy but only in rural areas** and potential suburban areas, when the 3 satellites are visible. We believe that this improved accuracy can be useful for navigation and road user charging (RUC) notably because map-matching does not always compensate for positioning accuracy. It is far from ideal when maps are not correct, as is still too often the case.

Integrity may be useful for road applications, notably road user charging (RUC), Advanced Driver Assistance Systems (ADAS) and potentially PAYD insurance.

Figure 33: EGNOS value added for a number of key applications

- For each service, value added of EGNOS is evaluated based on its actual impact on the service
- Value ranges from 0 (no impact) to 3 (strong impact, critical to improve the service)

Category	Service	Accuracy	Integrity	Availability	TTFF	TOTAL
Handset-based LBS	E112	■ ■	■ ■		■	5
	Pedestrian navigation	■		■		2
Road	eCall	■ ■	■ ■	■	■	6
	Car navigation	■ ■	■	■		5
	Fleet management	■	■	■		3
	RUC	■ ■ ■	■ ■	■	■	7
	PAYD	■ ■	■	■	■	5
Freight tracking	Dangerous goods - perishables	■ ■	■ ■ ■	■		6
	Livestock	■	■ ■	■		4
Aviation	Approach with vertical guidance (APV)	■ ■ ■	■ ■ ■	■ ■ ■		9
	Aircraft - ground vehicle	■		■ ■		3
Rail	Shunting	■ ■	■	■ ■		5
Farming	Precision agriculture	■ ■ ■	■	■ ■		6
Inland waterways	Traffic management & surveillance	■ ■ ■	■ ■	■ ■ ■		8

Source: PTOLEMUS, ESYS, Telespazio

4. Galileo

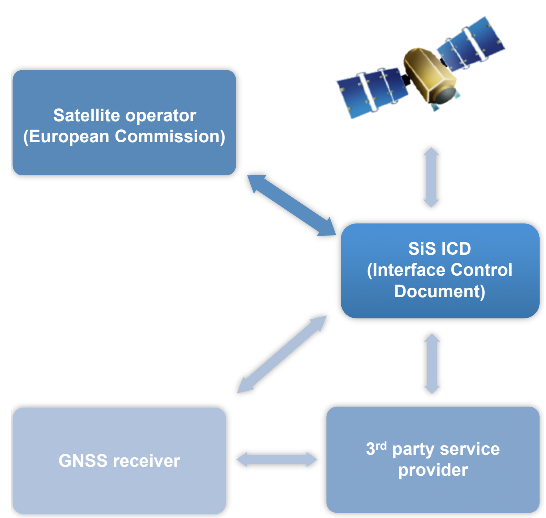
The Galileo program is a joint initiative of the European Commission (EC) and the European Space Agency (ESA).

When it will be **launched in 2014**, Galileo will consist of a **constellation of 30 satellites in 3 orbits broadcasting in 3 frequency bands**.

From a technical point of view, as indicated earlier, Galileo and GPS III functionalities are similar:

- Altitude: GPS III: 20,163 km , Galileo: 23,616 km
- Inclination: GPS III: 55 degrees, Galileo: 6 degrees
- Constellation: GPS III: Walker 24/6/1, Galileo: Walker 27/3/1
- Number of satellites: GPS III: 31, Galileo: 30, including 3 spares

Figure 34: Galileo's communication with the GNSS receiver



(1) The satellite broadcasts the signal.

(2) The signals are defined by the Interface Control Document (ICD). This is the key data set used by chipset manufacturers. The SIS ICD owner is the EC. It will be **published in the months to come free of IP rights** so that the receiver manufacturers can develop the receivers based on ICD

(3) The Galileo system operator ensures the signal is emitted according to the ICD. It follows a number of rules to ensure it is broadcast properly

(4) In the case of the commercial service, a third party service provider will provide the data for the pipeline within the signal.

Source: PTOLEMUS

Listed below are the key advantages of Galileo.

Interoperability with GPS

The system was designed in close cooperation with the GPS system, using the same L1 band. The signals have almost the same characteristics. Therefore the **modifications needed from the receivers will be very minor**.

In fact, Galileo can already be enabled with new firmware on flash-based GPS chips or modules. However, ROM-based receivers cannot be upgraded to Galileo.

As Galileo becomes operational, we expect manufacturers of Galileo-only chipsets to stop their production. In fact, **major chipset manufacturers such as**

ST Microelectronics are already producing dual chipsets, and GPS-Galileo interoperability on the hardware side is expected to be standard.

Signal availability

The immediate advantage of Galileo will be to improve the availability of the L1 signal as it is adding 30 satellites in the sky. Logically this will also improve the Time To First Fix (TTFF) as it will be **easier for receivers to find 4 satellites**.

On average, in cities, the chances of seeing 4 satellites are currently 30-35% of the time. With Galileo, the probability of having signal from 4 satellites **will increase to up to 80%.**

Spatial availability

Galileo includes a second signal in the L1 band, the pilot signal (signal without data). It can be detected even in very noisy radio-frequency environments where interference reduces the availability of GPS. So it will be easier to acquire the signal inside a building for example.

Urban canyon availability

In regards to the issue of multi-path interference (particularly in cities with tall buildings), Galileo improves the situation by increasing the bandwidth of the signal. Receivers will however have to adapt the chipset to acquire the C-boc (complimentary binary offset carrier).

Figure 35: A Galileo satellite

Source: ESA

Galileo will have **3 frequency bands for 4 different types of services**:

- **Open Service**: the equivalent of existing publicly available GPS positioning,
- **Safety of Life Service**: This separate channel will offer a high level of reliability in the data. It will send extra data for reliability on top of the navigation signal. The receiver will need to compute the position and confirm it with the integrity data. It is to be used for maritime and aviation applications.
- **Public Regulated Service**: Encrypted signal. The accuracy will be comparable but the major benefit is continuity. In particular, the location will be available in a jamming environment. The signal will be more robust to spoofing and will be reserved for governmental applications and civil security.
- **Commercial Service**: The system is providing a specific data capacity alongside navigation for a price. How it will be filled is not yet defined. The available 500 bit/sec pipeline will be auctioned on the open market for service providers to bid. An example of commercial services is high accuracy; the nominal accuracy of Galileo is 4 m, **the paid for service will be able to provide an accuracy of below 20 cm even while moving**. Power consumption will not be affected by the signal data rate but the computational power needed to get the accuracy will be power hungry.

Figure 36: Galileo's performance indicators

Services	Horizontal Accuracy* (95%)	Vertical Accuracy* (95%)	Availability*	Integrity
Open Service	1-4 m	<8 m	> 99.5%	NO
Commercial Service	Detailed performance requirements under elaboration (20 cm?)			
Safety of Life Service	1-4 m	<8 m	> 99.5%	YES (LPV200)
Public Regulated Service	1-4 m	<8 m	> 99.5%	YES

* Including system margins
Source: European Commission - Directorate General for Industry and Transport

Complete analysis of Galileo can be found in Section III, p. 126

Full forecast of Galileo chipset market can be found in Section IV, p. 162

5. Glonass

The Glonass programme, started in 1976 as a Russian military counterpart to GPS, has progressed steadily in recent years. It received an allocation of more than 100 billion rubles (nearly €2,6 billion) in funding for its 2002-2011 modernisation effort.

It has an operational service since 1993.

With the 3 newest satellites from last December's launch now in operation, **Glonass has a 23-satellite constellation** — including 19 modernised space vehicles (SVs).

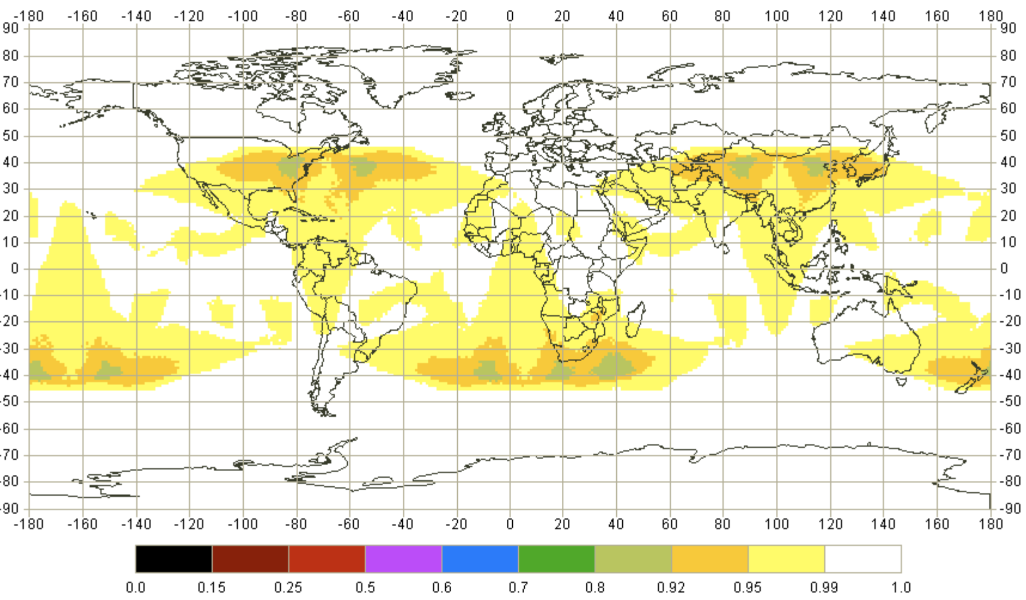
By the end of 2009, Glonass was typically providing a standalone receiver with **5-metre positioning accuracy**.

Regular launches have taken place as scheduled over the past few years, and another 6 satellites in triple launches are due in October and December 2010. If successful, this should bring the **Glonass constellation to full operational capability with 24 satellites on orbit in early 2011.**

The next-generation Glonass-K will begin launching in 2011, and include a CDMA (Code Division Multiple Access) signal on the L3 band, which will more closely align with other GNSS systems.

The stable progress in rebuilding and modernising Glonass has drawn interest from players in the mobile phone industry, including **Nokia**, which is investigating the use of Glonass for its handsets.

Figure 37: Glonass integrated availability during a 24 hour-period (based on 21 satellites)



Note: Area in white is entirely covered
Source: Roscosmos (24th May 2010)

Once Glonass is complete, mobile devices in Europe could rely on 55 satellites (31 GPS and 24 Glonass), which is more than enough to obtain a fix even in dense urban areas. To determine a position in GPS-only mode, a receiver must receive the signal from at least 4 satellites. In combined GPS/Glonass mode, the receiver must receive signal from 5 satellites, at least one being a Glonass satellite.

A number of specialised companies such as NovAtel and Leica already provide precision receivers offering combined GPS / Glonass positioning.

However, **no Glonass-compatible chipsets are available for consumer electronics markets yet.** In particular, their cost and power consumption (0,3-0,9 W) make them ill-fitted for consumer electronics markets.

A Russian company, KB Navis, has announced that it will produce a combined GPS-Galileo-Glonass-Compass chipset. It claims that the size, energy consumption and price of this chipset will be comparable to existing GPS modules.

Complete analysis of Glonass can be found in Section III, p. 126

Full forecast of Glonass chipset market can be found in Section IV, p. 162

6. Proprietary satellite constellations

The success of GPS has restrained the attractiveness of proprietary solutions. However, a few solutions remain, such as Qualcomm's solution, created in the 1990s.

Qualcomm

Qualcomm uses civilian satellites such as Eutelsat in Europe to provide triangulation-based positioning services. Its Qualcomm Automatic Satellite Position Reporting or QASPR system is operated since 1990.

Its accuracy is limited to approximately 300 metres and is used mostly to provide redundancy to GPS.

The QASPR system is part of Qualcomm's OmniTRACS solution, primarily targeted at the transport industry.

7. MEMS (Micro Electro-Mechanical Systems)

Micro Electro-Mechanical Systems (MEMS) are a combination of electronics fused to external sensors of between 1 and 100 micrometers in size. They are primarily manufactured from a combination of silicon, polymers and metals to produce a platform that combines electronic and mechanical measurements and processes. Their functionalities and application are described below.

Accelerometers were first used for crash detection (notably to initiate airbag deployment) and abnormal vehicle movements. They measure degree of movement along a specific directional plane.

Gyroscopes were first used for electronic stability programs and the triggering of the control mechanism in the car. Gyros are also still used in embedded car navigation systems to detect turns combined with differential wheel speeds. In the car, motion is limited, i.e. it is flat on the road and follows a known path. One axis gyroscope is enough.

Pressure sensors were initially used in the engine compartment for controlling engines, to reduce fuel consumption and improve engine effectiveness.

Also, **electronic magnetic sensors** (**electronic compasses**) are now found in portable devices, and are key in assisting orientation, but these would not work without having the positioning related to the earth's surface. That "compass compensation" is provided by the accelerometer. The integration between the two sensors is made through reference design and partnerships with compass manufacturers.

Figure 38: MEMS, from 20 micrometers to 1 mm, and their applications, e.g. AR local search

Source: PTOLEMUS; Layar photograph

MEMS are mainly used when the GPS signal is blocked by an urban canyon or a tunnel.

a. Accelerometers

Hence the potential in mobile devices: the accelerometer can be used to implement a step counter and correlate it to a GPS fix from time to time.

With a very good accelerometer, one can estimate the step length and, through the use of algorithms, can determine the distance travelled without the use of GPS support.

b. Barometric pressure sensors

These sensors detect **altitude changes of less than 1 metre.** Top of the range pressure sensors react to an altitude difference of only 25 cm, but 1 metre accuracy is more prevalent.

The aim is to **match the position and the level of the building the user is in**, using the sensor in the context of an indoor LBS application where an indoor map is present. Despite the fact that GPS chipsets already come out with a pressure sensor port, there are no reported cases of mobile devices using them at the moment, mainly due to their high cost.

GPS and barometric sensors can be linked directly or through an API quite easily, but their cost suggests that these sensors will not be integrated as rapidly as accelerometers for LBS purposes.

c. Combined MEMS and GPS

Combining MEMS and GPS at the die level is possible but unheard of at this stage. Multi-die packages exist and it would be possible to combine the hardware in this way, which would bring reduced size and power savings. In performance terms, the coupling needs to be at the software level.

In order to get the benefit at the hardware level, MEMS and GPS manufacturers need to share their IP rights.

Convergence is already happening, faster than predicted. For example, in June 2010, **u-blox** launched ADR (Automotive Dead Reckoning) enabling positioning calculation from external sensors to be made directly on the GPS chipset.

However, at the software level, there is a tight co-operation between sensor manufacturers as the sensors are complementary. The issue around software co-operation concerns data flow.

From an OS vendor or ODM perspective, it is better if the GPS and MEMS data flows to them directly and separately, since they want to retain control of their suppliers and then let their application providers put things together.

From the GPS chipset manufacturers' perspective, they want the MEMS data to flow to them and then send the combined solution to the OS.

The conflict and tensions around where the added value lies is made more complex by the device manufacturers' need for control and bargaining power.

Ultimately, both routes will be seen in devices depending on the power of the OS on the device (e.g. Apple or Google) and the price and practicalities (tighter feedback loop) offered by the sensor manufacturers.

d. *Combined accelerometers / GPS*

Step counting software and reference algorithms for speed and distance integration are already available.

PTOLEMUS believes it will only be integrated in phones once the total solution reaches the €3-4 mark. The hybrid will become competitive against other assisted technologies within 18 months, because accelerometers are already in 27% of phones, and iSuppli predicts this will rise to about 33% in 2010.

Furthermore, any compass included in forthcoming phones will also require an accelerometer. The cost of adding dead reckoning and MEMS-based enhanced location will ultimately be down to the IP and software integration.

The **main barrier to overcome is the integration** between the GPS functionality, the MEMS (usually running on a host), the baseband and WiFi functionalities.

The launch of Apple's iPhone 4, which integrates a 6-axis motion sensor, indicates that this issue is being addressed.

e. *Barometric pressure sensor / GPS*

By measuring elevation, a pressure sensor can be used to enhance the GPS speed and success rate. It can replace one satellite out of the four needed for a fix to be made (useful in urban canyons). It can be also very useful in correcting location errors due to reflected signals.

The use of these sensors might lead to high-end GPS chipset integration, but the main issue will be the cost of introducing highly accurate sensors, which is far too high for handset manufacturers.

Another model – in theory – suggests a sensor platform including and integrating GPS, MEMS, WiFi and maps, and then reselling it to OEMs.

Full forecast of MEMS market evolution can be found in Section IV, p. 172

8. Cell-ID

Cell-ID location determines the handset's position based on the nearby GSM base stations. Each antenna discloses a signature and identity. **Triangulation** between cells gives an estimate of the phone's location. Precision can range from from 100 metres to several kilometres, depending on cell sizes.

It is important to note that not all mobile phones can use Cell-ID. For example, certain Windows Mobile handsets do not have the proper API enabled to allow for Cell-ID location detection. We understand however that these issues are gradually understood and solved by handset vendors.

The quality of independently-run databases of cellular sites depends on the size of the team that operates it or on the number of equipped terminals running the software.

In the case of **Google Maps**, even if operators change the tower IDs, enough users are able to re-map the GSM network for the service to be updated in a few hours.

Due to the fact that connected devices' SIM cards are owned by the network, **Cell-ID** and its variations are the **only technologies able to track a device without its knowledge**.

The **affordability of network location is a critical factor** in the operators' ability to foster a thriving network-centric LBS market.

The entirely variable business models of the early network-centric services were unsustainable because location look-ups (or "pings") were charged at relatively high prices (over €0.07, which corresponds to the price of an SMS).

But, as shown in **Sweden**, pressure from LBS providers and aggregators pushed operators to enable cross-networks location, reduce their tariffs to approximately €0.03 and allow third parties to distribute the service.

In return, operators were able to secure **revenue-share** deals as well as benefit from selling location in larger volumes. The services became successful because the applications were managed by third parties strongly focused on this business.

Two factors will rapidly accelerate the growth in network-centric location:

- **Improvement in accuracy**: The current level is generally acceptable. However, GPS-like accuracy would open up a whole array of applications such as asset tracking, as well as enable existing services to provide better tracking statistics;
- **Geofencing**: Network-centric geofencing requires an update in most GMLCs and is not available by default. As people tracking is a key network-centric application, geofencing would enable service providers to offer improved quality of service.

We have indicated below the location equipment capabilities of most European mobile networks.

Figure 39: Survey of mobile network location infrastructure in the European Union

Country	Network	Vendor	Location technology available	Middleware
Austria	A1 (Mobilkom)		Cell-ID	
Austria	3	TCS	Cell-ID, AGPS	
Austria	T-Mobile		Cell-ID	
Belgium	Belgacom	Alcatel Lucent	Cell-ID	
Belgium	Mobistar (Orange)	Ericsson	Cell-ID	
Belgium	BASE (KPN)		Cell-ID	
Bulgaria	Mobilkom		Cell-ID	
Croatia	T-Mobile		Cell-ID	
Czech Rep.	Telefonica		Sector-ID or "best BTS server"	
Czech Rep.	T-Mobile		Sector-ID or "best BTS server"	
Czech Rep.	Vodafone		Sector-ID or "best BTS server"	
Cyprus	Cyta		Cell-ID	
Denmark	3	TCS	Cell-ID, A-GPS	
Denmark	Telenor		Cell-ID + TA	
Denmark	Telia Sonera		Cell-ID + TA	
Estonia	Telia Sonera	Ericsson	Cell-ID	Reach-U
Finland	Elisa	Nokia Siemens	Cell-ID	
Finland	Telia Sonera	Ericsson	Cell-ID + NMR	Mobilaris
France	SFR	Nokia Siemens	Cell-ID	
France	Orange	Ericsson	A-GPS	Mobilaris
France	Bouygues		Cell-ID	LocatioNet
Germany	Telefonica / O2		Cell-ID	
Germany	T-Mobile	Ericsson	Cell-ID	
Germany	Vodafone	Ericsson	Cell-ID	
Greece	Vodafone		Cell-ID	
Hungary	Telenor		Cell-ID	
Hungary	T-Mobile	Ericsson	Cell-ID	Mobilaris
Hungary	Vodafone	Nokia Siemens	Cell-ID	
Holland	KPN		Cell-ID + geofencing	
Holland	T-Mobile		Cell-ID	
Holland	Vodafone	Ericsson	Cell-ID (AGPS testing)	
Ireland	3	TCS	Cell-ID AGPS	
Ireland	Telefonica		Cell-ID	
Ireland	Vodafone	Ericsson	Cell-ID	
Italy	Wind	Ericsson	Cell-ID	
Italy	3	TCS	Cell-ID, AGPS	
Italy	TIM	Ericsson	e-Cell-ID	
Italy	Vodafone		Cell-ID	
Latvia	Telia Sonera		Cell-ID +NMR	
Lithuania	Telia Sonera	Ericsson	Cell-ID	Mobilaris
Luxembourg	LUXGSM		Cell-ID	

Country	Network	Vendor	Location technology available	Middleware
Malta	Vodafone		Cell-ID	
Norway	Telenor	Ericsson	eCell-ID	CellVision
Norway	Telia Sonera	Mobile Art	Cell-ID, CAMEL	
Norway	Tele2		Cell-ID	CellVision
Poland	Polkomtel	Nokia Siemens	Cell-ID +TA	
Poland	Orange		Cell-ID +TA	
Poland	T-Mobile		Cell-ID +TA	
Portugal	Optimus	Ericsson	Cell-ID	Genasys
Portugal	Vodafone		Cell-ID +radius	
Romania	Orange	Ericsson	Cell-ID	Reach-U
Romania	Vodafone	Ericsson	Cell-ID	LocatioNet
Slovakia	Orange	Ericsson	Cell-ID	Reach-U
Slovakia	T-Mobile	Ericsson	Cell-ID	
Slovakia	Telefonica		Cell-ID	
Slovenia	Mobitel		Cell-ID	
Spain	3	TCS	Cell-ID AGPS	
Spain	Telefonica	Ericsson	Cell-ID	Genasys
Spain	Orange	Ericsson	Cell-ID	
Spain	Telia Sonera		Cell-ID	
Spain	Vodafone	Schlumberger	Cell-ID (testing A-GPS)	Genasys
Spain	Yoigo		nothing	
Spain	Euskaltel		nothing	
Sweden	3	TCS	Cell-ID AGPS	
Sweden	Telenor	Ericsson	NMR	CellVision
Sweden	Telia Sonera	Ericsson	Cell-ID	Mobilaris
UK	3	TCS	Cell-ID A-GPS	
UK	Orange	Nokia Siemens	Cell-ID	
UK	O2/ Telefonica		Cell-ID	
UK	T-Mobile	Ericsson	Cell-ID	
UK	Vodafone	Ericsson	Cell-ID/ eCell-ID on 2,5G	

Source: PTOLEMUS

Strategic analysis of Cell-ID value chain transformation in Section III, p. 128 and 148
Forecast of Cell-ID market potential in Section IV, p. 174

9. Enhanced Cell-ID (E-CID)

E-CID (Enhanced Cell-ID) incorporates **Timing Advance** (TA) and **Network Management Records** (NMR) from the mobile network to improve the accuracy of Cell-ID.

TA represents the round trip delay between the mobile and the serving BTS (base station). This method adds the measured time between the start of a radio frame and a data burst to improve the location determination. Accuracy depends on the size of cells, but is slightly better than Cell-ID on its own.

E-Cell-ID is already used for roaming and cost calculation.

10.Enhanced Observed Time Difference for GSM (EOTD)

With EOTD, the mobile terminal measures the time difference between the reception of bursts transmitted from the reference BTS and from each neighbouring BTS. Enhanced OTD (E-OTD) is the OTD measurement for positioning purposes.

Essentially, E-OTD is the sum of two components:

- Real-Time Difference (RTD): the synchronisation difference between 2 base stations;
- Geometric Time Difference (GTD): the propagation time difference between 2 base stations.

There are however no implementations of this technology in Europe and we do not expect it to be rolled-out in the future.

11.Time of Arrival (TOA)

Even though a TDOA (Time Difference of Arrival) call flow would look virtually the same as a TOA call flow, there is a difference in how the location is calculated.

TOA differs in the fact that it uses the absolute time of arrival at a certain base station rather than the difference between two stations.

Distance can be directly calculated from the time of arrival because signals travel with a known velocity.

Time of arrival data from two base stations will narrow a position to two points and data from a third base station is required to resolve the precise position.

12. U-TDOA – Uplink Time Difference of Arrival

U-TDOA determines a mobile phone's location by comparing the times at which a cell signal reaches multiple **Location Measurement Units (LMUs) installed at the operator's base stations**.

Accuracy is determined by the network layout and deployment density of LMUs to base transceiver stations (BTSs).

This technology is mainly provided to governments and defence ministries for applications such as border security, critical infrastructure protection and assisting law enforcement through phone tracking and behaviour monitoring.

The deployment of U-TDOA is relatively expensive (tens of millions of Euros to cover a large European country) because it is based on the physical installation of LMUs at the cell sites.

However, **accuracy is high at less than 50 metres, and less than 25 metres if combined with A-GPS**. Being a network-centric solution, it also works on all mobile terminals everywhere (except on handsets that are not compatible with Cell-ID, which are becoming very rare however).

OTDOA is a software only version of U-TDOA.

It uses 4 cell sites, each sending corresponding times. The measurement uses the time of arrival to draw an hyperbolic locus. The intersection of the 2 hyperboles gives the position. The technology is still at standardisation stage but is widely expected to be implemented on LTE networks.

Ericsson, Alcatel Lucent but also Huawei, LGE, Motorola, Nokia, Nokia Siemens Networks, Nortel, Qualcomm and Samsung are working on the standard under 3GPP.

Ultimately, **OTDOA is expected to perform similarly to U-TDOA but will remove the need for LMUs, making the deployment far less expensive**.

Its accuracy can reach 15-150 metres depending on the size of the cells, but also on the implementation method.

13. WiFi positioning (WPS)

The WiFi positioning solution is based on a company building and maintaining a global database of WiFi access point MAC addresses and their precise locations. This data is then used by a WiFi-enabled device to triangulate the user's position.

The market for the WiFi Positioning System (WPS) is dominated by **Skyhook** (50 million users) and **Navizon** (1 million users) worldwide.

Google has also developed its own combined WiFi/Cell-ID database and is making it the default database for Android. Up to now, however, it has been possible for Android developers to use other databases, as the example of Motorola retaining Skyhook demonstrates.

At this stage, Google does not have an API for direct access to its WiFi and Cell-ID databases for non-Android users. We understand it is not planning to license them individually.

Both Skyhook Wireless and Navizon also have the ability to combine this data with cellular base station triangulation (creating a database of base stations of all operators) and GPS to provide **reliable and accurate position data under a wide range of conditions, including tall buildings and indoors**.

Figure 40: Skyhook's coverage map of Europe

Source: Skyhook Wireless

Both companies also rely on their users to update and extend their reach. Skyhook claims 6 location requests per users per day on average. Navizon indicated that the refresh rate on location when used in an application such as mapping is every 10 seconds.

With an increasing number of users carrying GPS/WiFi smartphones, Navizon ensures the quality and growth of its network by incentivizing its most active users financially. Navizon is also working on a solution that will enable them to **continue mapping whilst indoors,** and expects to demonstrate this solution in the 4th quarter of 2010.

Skyhook claims that its database contains **200 million WiFi access points and cellular towers**. It also indicates that there are now **300 million location requests every day to its database**, coming from over tens of millions of mobile devices.

The technology is finding its place in a large number of devices, and the growth of WiFi positioning is mostly due to the increasing number of partnerships.

In addition to the iPhone and the iPod Touch (and presumably the iPad), Skyhook has been successful at integrating its solution into **chipset platforms and handsets**:

- **Qualcomm** has integrated Skyhook's WPS into its GPSOne and QPoint location platforms;
- **Broadcom** has partnered with Skyhook to upgrade its location-based services infrastructure and chipsets;
- **CSR / SiRF** has advanced its own location capabilities on its existing WiFi silicon by combining CSR's UniFi, embedded WiFi chips and GPS location with Skyhook's technology;
- **Samsung** has announced that it would use Skyhook for its Bada-based Wave S8500 handset.

Navizon has partnered with large Internet companies such as **Microsoft** and **Yahoo! Mobile**. It is is also in close partnership with turn-by-turn navigation software providers in the US and Europe, GPS chipset manufacturers and digital camera manufacturers. Finally, it also resells its database to a number of other location providers such as Quova.

In certain cases, WiFi location is given away to developers by the device vendor, the service provider or the chipset vendors who buy in bulk from Navizon or Skyhook.

However, most terminal and OS vendors are not giving location away free to developers. For example, Symbian have no agreement in place with any provider for "low-level geo-conversion". (i.e. convert Cell-ID and WiFi to geographic coordinates).

In Symbian ^3, there will only be an API to add plug-ins for low-level geo-conversions. This means an open possibility for third party Cell-ID database providers to write such plug-ins. Since Symbian is now a freeware, and Symbian Foundation is a non-profit organisation, they will not source commercial databases for geo-conversion. It is up to the handset manufacturers that uses Symbian, to do so.

PTOLEMUS expects that this will change rapidly as all platforms find ways to include location APIs.

Because it works indoors and offers a very fast TTFF in urban environments, WiFi is well placed to be part of the location mix available to developers.

Navizon also provides **Navimote**, a developer's location tool that allows device location on demand. The system requires a client on the device and initialisation with the Navizon network that handles third-party access, identification and authorisation. The location comes straight from the Navizon server using the combined GPS/WiFi/Cell-ID or any of the three available.

The product is currently free to end users and application developers, and is available for all platforms including Java, suggesting that developers could use it as **a way to provide LBS outside the operators' control and at a much lower cost.**

Their model is based on a **fixed cost per device**, and tentative prices announced are $485 a month for up to 1,000 devices and $995 for up to 10,000 devices.

There are 2 methodologies to collect WiFi signal data.

- **Active scanning**: WiFi surveyors driving down a public street send out probe requests that ask every WiFi access point within range to respond. This process is relatively fast. However, busy networks will not respond and might be missed by the surveyor;
- **Passive sniffing**: The mobile device "listens" to all traffic transferred over active WiFi networks, including key identifiers such as SSIDs (network names) and MAC addresses (similar to serial numbers, unique to each WiFi router). The method is slower since routers may be broadcasting on any of a dozen channels, and each must be sniffed individually. It is also very power demanding.

Figure 41: Comparison of Cell-ID / WiFi location providers

	Navizon	Satsis	Location-API	Skyhook
WiFi access points	60 million	40 million	3.5 million	200 million
Cell-IDs	7 million	Ongoing	6.8 million	2 million
Coverage	Global	Country specific	Global (213 countries)	US / Europe
Price per location request	<€0.05 (Navimote)	€0.01	€0.01 - 0.005 100 free requests per day	No per request pricing
Methodology	Active	Passive	Passive	Active
Source	Crowd-sourcing	Sniffing	Sniffing, Partnerships	Surveying, Sniffing
Target markets	End-users Developers Operators OS	Device vendors Operators	Developers Operators OS	Device vendors Developers OS

Source: PTOLEMUS

Offline devices such as non connected PNDs also have the opportunity to use WiFi and Cell-ID location for assistance. **Navizon provides cell tower maps that can be installed on the devices and will provide A-GPS without connectivity to the network**. WiFi databases change a lot as people change their home routers, but Cell-ID is relatively fixed in comparison. Since accuracy is not needed to assist with TTFF, this solution has a clear advantage.

Recent awareness of the benefits of controlling the Cell-ID and WiFi access points triangulation have resulted in **numerous companies starting their own databases**. Access to these databases is aimed at providing fast and inexpensive positioning to devices and applications not covered by Google's and Apple's free APIs. It will enable fallback to WiFi positioning and then to Cell-ID triangulation when GPS is not available.

Combain is such a company. They have accumulated nearly 7 million Cell-IDs worldwide, covering most urban areas globally.

To do that, users of the mobile location software automatically feed back network information to the database whenever they request a location. "Sniffer softwares" update the database on the device with new access points or Cell-IDs.

Nokia has also announced that it has started building its own database of WiFi access points and cellular sites thanks to Navteq surveyors but also through crowd-sourcing.

In the future, we would expect an **increasing number of companies to try to create their own combined GPS, WiFi, Cell-ID database**. Companies who could consider this include:

- Apple, whose acquisition of PlaceBase seem to indicate that it is building its *Apple Maps* product, could easily leverage its base of over 50 million WiFi devices;
- TomTom/Tele Atlas could easily include WiFi access points as one of the fields surveyed by their mapping vans;
- Global operators such as Vodafone or T-Mobile could decide to provide tracking software for free in the handsets they sell.

We detail hereafter one of the **most intriguing model, Navizon**, which is entirely based on crowd-sourcing.

Case study 1: Navizon

Navizon is the biggest crowd-source based WiFi and Cell-ID positioning system provider

Navizon's success is based on an original concept:

- Every registered user participate in growing the location database,
- Active users can earn money from scanning access points,
- Consumers have access to a set of location-based services available on all mobile platforms,
- LBS partners can access the database from an API, SDK or license the complete system including the database engine.

Four service delivery channels

Consumer services

1. **Buddy Finder**
2. **Mobifindr**: enable phone location from any phone based on text- based request.
3. **Local search**
4. **My trail**: record and export location trail
5. **Navizon alert**: Geofence-triggered alerts

Navimote on-demand location

1. Call for a url to get a phone location
2. All mobile and PC platforms
3. Permission mechanism
4. Low battery consumption vs. broadcasting location
5. Solves problem of User plane-based tracking

Client-side SDK and API / **Application developers**

1. Developers choose between WiFi and Cell-ID positioning

or

2. The application sends the location data for the Navizon's server to triangulate

or

3. Or the database and calculation tools are exported under license

Wi-Fi and Cell-ID databases

WPS API	SDK	Licensed database
App developers (Mobile, web and enterprise)	Mobile OS vendors	Mobile devices vendors (Handsets, PNDs...)
Web content providers	Large ASPs (Microsoft)	Other OEMs (Cameras…)
Financial institutions	SUPL vendors	GPS chipset vendors
Content	Services	Hardware

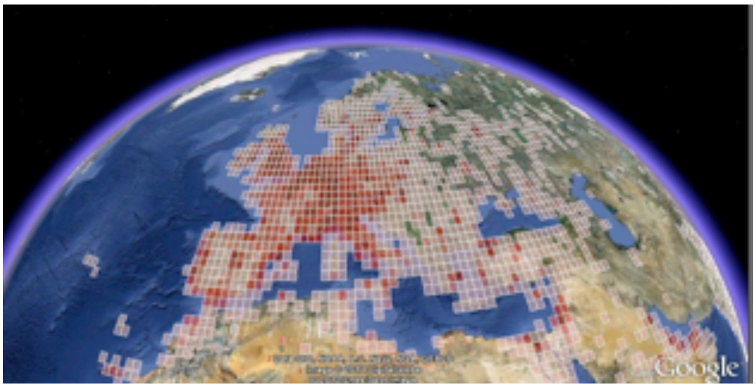
Partnership with IP location through QUOVA

White-label and integrators

There is more to WPS than a large database

Privacy	**Navizon community willingly expands its reach and gets rewarded for it**
Coverage	**1 million sniffers worldwide make for the most extensive database available, refreshed every day**
Power consumption	**Navimote enables request-based ping, minimizing the drain on the mobile device battery**
Crumb trail	**Records location every 10 seconds for turn-by-turn navigation, every hour for Buddy Finder**
Multiple applications	Key applications include: 1. Device tracking (i.e. mobile phones, laptops) 2. Fleet operations solutions 3. Security (geo-fencing alerts) 4. Local search / POI applications 5. Social networking applications 6. Buddy / people finder 7. Location-based advertising solutions

Navizon's high level coverage map of Europe



A unique value proposition

- Truly global – 3 location technologies (Cell-ID, WPS and GPS coordinates)
- Crowd-sourcing approach enables more coverage with less access points globally while keeping comparable accuracy
- Vast array of ready-made consumer services
- Simple and efficient location API for developers

Key strengths

- 50% of European market
- **7 million cell towers worldwide**
- **60 million WiFi access points**
- 1 million registered users scanning and growing the database (300,000 in Europe)
- Partners/customers include: Microsoft, Yahoo!, Absolute Software and LoJack

Source: Navizon, PTOLEMUS

14. GloPos

GloPos is a Finnish start-up which built a **software-based solution that does not require WiFi or GPS**. It claims that its technology **makes any GSM/UMTS mobile phone location-aware provided it has a data connection**.

Glopos is an example of the many independent emerging location technology providers that have the power to unsettle major players.

Very little is known about the technology, but GloPos claims **accuracy of 1-30 metres indoor or in urban settings**, and 10-40 metres in sub-urban geographies.

These claims have been recently validated by a study conducted by VTT, The Technical Research Centre of Finland, in the Helsinki city centre.

If it is able to fulfil its promises, such technology could revolutionise the indoor positioning market.

PTOLEMUS understands that **GloPos is based on the mobile phone collecting signal information from multiple base stations** and then forwarding that unprocessed information through GPRS to the GloPos server, which then calculates the location based on an intelligent probability model and sends it back to the terminal.

During the positioning, a data connection from the mobile phone to the GloPos positioning server is needed, but the amount of data transmitted is only around 100 bytes. At the moment, the GloPos server is a separate server but alternatives like SUPL are being considered.

Interestingly, while **the solution will require software to be downloaded** (and installed) on the device, it does not need to know base station positions as long as it obtains the needed signal information from its own database or other database that can provide the information.

Independent tests conducted in Finland in January also show that it is fast; overall query latency on the server is between 50 and 100 milliseconds (regular network delays related to data connections apply).

The core technology behind GloPos is their Intelligent Probability Model (IPM), which allows accurate positioning wherever the phone is. GloPos is not affected by indoor or urban canyon issues, but because it is network-centric, the accuracy will decrease in suburban and rural areas. On the positive side, the system will become more accurate over time through more users, mapping and self-learning.

15. IP location

IP location is based on the link between an IP address and its corresponding ISP's (Internet Service Provider) routing infrastructure.

Therefore, its accuracy is, at best, at **metropolitan area level**. ISPs have worked on improving the quality of the location by positioning data collection servers at key points of the Internet to constantly assess and monitor the infrastructure of the web. The collection points collect regional network data and can be remotely directed to analyse specific aspects of web traffic and triangulate specific locations across the Internet to more clearly define the location of a user's access point.

IP location can also be used to identify the **position of calls made to emergency services through Voice over IP** (mobile or otherwise), which is of a growing importance for public safety. There is no relationship between the IP address allocated to VoIP users and the physical location. A VoIP caller could be based in one country but his ISP in another.

Traditionally, phone operators have been able to send the landline phone number attached to the emergency call and the physical address was only a look up away. Similarly, emergency services rely on the network data provided by operators to obtain the position of a caller using a mobile network (cf. E112 above). The nature of IP-based telephony makes it even more difficult to track a user's location and, as a result, emergency services are unable to route calls to the nearest call centre.

According to **Andrew Corp**, the problem can be resolved by developing universal IP access location standards, demanding that VoIP services provide appropriate location information for emergency services.

Standard bodies such as the IETF and W3C are in the final stages of publishing international IP regulations for acquiring and conveying location information. This might enable network operators to once more be the primary source of location information for users.

The key to location-enabling a network is the installation of a **location information server** (LIS) supporting the new generation of IP location standards defined by the IETF. The LIS presents a common interface to devices requiring location information, enabling the same device to ask for location in exactly the same way, regardless of the underlying access technology. By doing this, the LIS separates the two functions of providing and determining the location information.

When a device enters a location-enabled network, it is able to discover the LIS using standard discovery procedures in the same way that it can obtain an IP address from a DHCP server, or find a DNS server to resolve host names.

The **market for IP location is currently dominated by an American company called Quova**. The following case study analyses their model in detail.

Case study 2: Quova

Quova provides the location of any connected device based on their database of **2.6 billion IP address locations.**

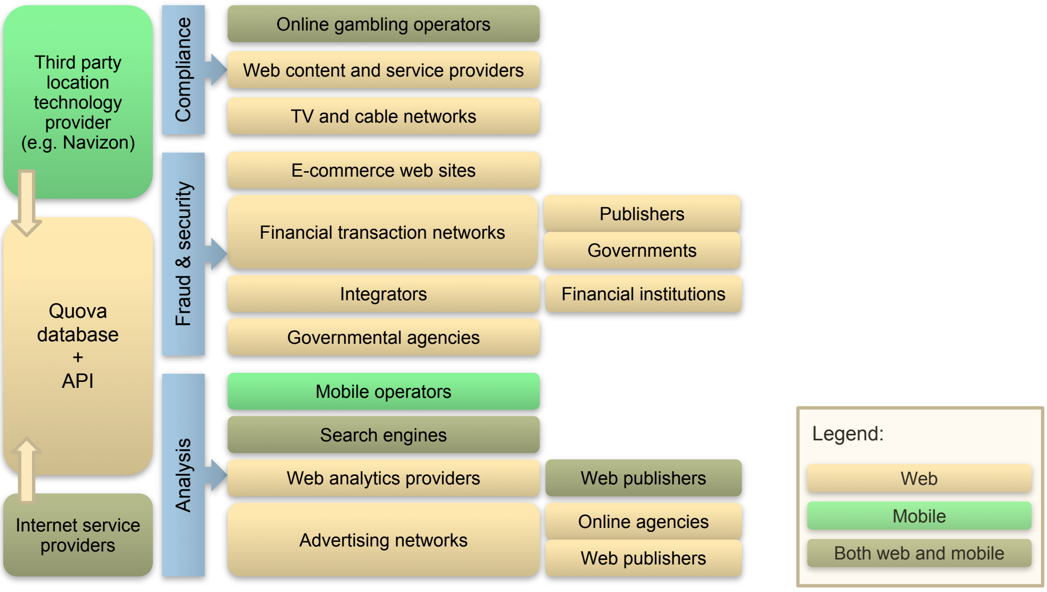
This is used by web sites to increase web page relevancy, reduce page bounce rate, trace user web activity and identify fraud.

Quova provides:

- Real-time, global information, claimed to be 99.99% accurate at country level,
- An exportable and easy to integrate IP location database (No opt-in required from users)
- **Accuracy down to city area (35 - 70 km) on fixed line queries,**
- Accuracy down to **country level on mobile queries,**
- WiFi and Cell-ID hybrid option with Navizon (requiring user opt-in).

Vertical markets	Use cases
Compliance	• Online gambling control • Optimisation of access speed based on location and device
Location-based advertising / marketing	• Mobile and web content ad localisation • Real time traffic assessment for media publishers (web, DSL, broadcast)
Fraud	• Proof of access to unlawful sites • Exception-based alerts such as location or proxy
Security	• Access restriction to unlawful visitors • Network analysis for police forces

❑ Quova's ecosystem reflect the variety of opportunities for IP location



Location case study: QUOVA

QUOVA

❑ Quova's flexible business models enables it to serve very different customers

A) Database license model

- Quova exports the database and keeps it updated
- Fixed annual fee depends on :
  - Data types: latitude / longitude, proxy, country, region, etc.
  - License use: fraud, security, compliance, localisation or ad serving

B) Direct access to Quova's database

- Prices vary according to:
  - Data types: latitude / longitude, proxy, country, region, etc.
  - License use: fraud, security, compliance, localisation or ad serving
  - Commitment: guaranteed minimum of request / month or unlimited model

C) Access to WiFi & Cell-ID locations

- Licensed database exported from Navizon
- Resold per request from Navizon

Location case study: QUOVA

QUOVA

IP location markets are a model for high quantity location requests opportunities

- Location request price varies based on quantity as well as between applications,
- Location database is exported and used outside the responsibility of Quova,
- It is used across consumer and commercial markets,
- **Location requests are counted** in
  - 10th of thousands (fraud services)
  - **Billions** (search engines, web localisation)
- **Prices are under €0.01 per request**

IP location has opened the field of mass location

	IP location	WPS	Cell-ID	GPS
Market size	Billions requests / day	>500 million requests / day	>5 million requests / month (EU)	100 million units (EU)
Price	>€0.01 per request	>€0.9 per device	>€0.5 per request	>€5 per device
Availability	All data-connected devices/ Global	WiFi equipped devices/ WiFi area	All phones/ Global	GPS devices/ Global
Accuracy	★	★★★★	★★	★★★★★
Scope	No opt-in	Opt-in	No opt-in	Opt-in

Source: Quova, PTOLEMUS

16. e-LORAN

e-LORAN is a modernised version of the old LORAN low frequency marine navigation system. It operates at 100 kHz and is synchronised to Co-ordinated Universal Time. It is used to ensure safety in a higher-risk environment in the **maritime sector.**

Initial differential e-Loran trials, conducted at Harwich in 2006 and using the GLAs' test transmitter at Rugby, demonstrated horizontal positioning accuracies better than 9 metres with 95% confidence using modern, miniaturised e-Loran receivers.

Despite claims that the technology could be used over land, the fact that it requires a 20 cm long antenna will make it difficult to penetrate the mobile device market at this stage.

17. Other location technologies

It must be said that there is a large number of other technologies to obtain location, from the most traditional one to the most high-tech one.

These solutions include:

- **User entry location**: quite often, the user is the best placed person to know where he / she is. Voice-recognition technologies from companies such as Loquando and Nuance are starting to be used to ask their destination to drivers. There is no reason why the same could not apply to obtaining the location. Search companies such as Google also have built tremendous know-how in decrypting what we mean with a few words;
- **"Point-to-point location systems"**, i.e. those systems that thanks to a physical or radio interaction can be used to validate a device's or a person's location at certain checkpoints. These include:
  - **RFID** and other NFC technologies, already largely used in logistics,
  - **Credit card payments** and cash withdrawals at ATMs,
  - **Video camera networks,**
  - Radio-wave technologies dedicated to communication between the vehicle and the roadside, such as **DSRC** (Dedicated Short Range Communications), often used by tolling operators,
  - **Bluetooth.**

Depending on the situation, these technologies may also be selected.

C. How do location technologies compare?

1. Technical performance

Figure 42 hereafter evaluates and compares the **different positioning technologies available in Europe by 2012**, using the data from typical network behaviour. Indicated figures are averaged using a sample of results. Of course, measurements can vary widely depending on conditions such as geography and cell density.

This data is difficult to verify since technology providers are generally unwilling to discuss the reliability of their systems and the conditions are variable.

However, PTOLEMUS expects GNSS systems accuracy to improve only slightly beyond what is currently announced by Galileo and Glonass, whereas **network-centric location and WiFi have the potential to become far more accurate before 2014**.

Figure 42: Comparison of existing device-based and device-centric location technologies

	Satellite-based location		Client-based location (device-centric)	
	GPS	A-GPS	WiFi	UWB
Description	GPS triangulation on device	GPS with network and/ handset assistance	WiFi network mapping	Triangulation or TDOA between beacons
Accuracy - suburban	5-25 m	5-10 m	10-100m	1-3 m
Accuracy - urban	5-50 m	5-25 m	n/s	n/s
Speed	Hot start <30 s Cold start >1 min	Hot start <5 s Cold start >30 s	<15 s	1 s
E112 compliance	No	No	No	No
Indoor coverage	No	No	Yes	Yes
Privacy	Poor	Poor	n/a	Good
Success rate outdoor	> 95 %	> 95 %	> 95 %	n/a
Success rate indoor	Poor	Poor	> 95 %	> 95 %
Reliability	Varies	Varies	Good	Very good
Coverage / Availability	Global/ Patchy - GPS equipped devices	Global/ Patchy - GPS equipped devices	Urban area only/ Patchy – WiFi equipped devices	Controlled environment / devices
Additional operator investment	none	yes	no	no

Source: PTOLEMUS

Network-centric location speed will remain faster than that of device location. Assistance has improved the speed of GPS, but as networks evolve from 3G to LTE, PTOLEMUS expects the network positioning to become close to instantaneous.

Our comparison of privacy is based on the ability of the positioning data to be filtered before or after the operator server's firewall.

Figure 43: Comparison of major network-centric location technologies

	Network-centric location technologies							
	Cell-ID	**A-GPS SIM**	**UTDOA**	**UTDOA / GPS**	**EOTD**	**ECell-ID + TA + NMR**	**AOA**	**GloPos**
Description	Cell tower position based on triangulation	Flash based receiver on SIM card	Measure of the timing difference between cells	Network-assisted GPS	Handset measures time difference between cells	Combines enhanced Cell-ID and Timing Advance	Network measure of the angle of arrival	Probability calculation based on cell reading
Accuracy -suburban	200m - 30 km	300-30 m	50 m (2G) / 25 m (3G)	<25 m	200 m to 20 km	>500 m	n/a	1-30 m
Accuracy - urban	100 m - 2 km	300-30 m	50 m (2G) / 25 m (3G)	<50 m	50-200 m	<500 m	100-200 m	10-40 m
Speed	1-2 s	10-60 s	5-10 s	5-10 s	1-2 s	1-2 s	1-2 s	<1 s
E112 compliant	yes	yes	yes	yes	n/s	n/s	n/s	n/s
Indoor coverage	yes	no	yes	yes	yes	yes	yes	yes
Privacy	Good	Good	Very good	Very good	Good	n/a	n/a	n/s
Success rate outdoor	> 95 %	> 95 %	> 95 %	> 95 %	> 95 %	> 95 %	> 95 %	n/s
Success rate indoor	> 95 %	> 95 %	> 95 %	> 95 %	> 95 %	> 95 %	> 95 %	n/s
Reliability	Very good	n/a	Very good	Very good	Very good	Very good	Very good	n/a
Coverage	Global	Global	Global	National	National	National	National	National
Availability	All handsets	All handsets	All handsets	GPS handsets	All handsets	All handsets	All handsets	All handsets

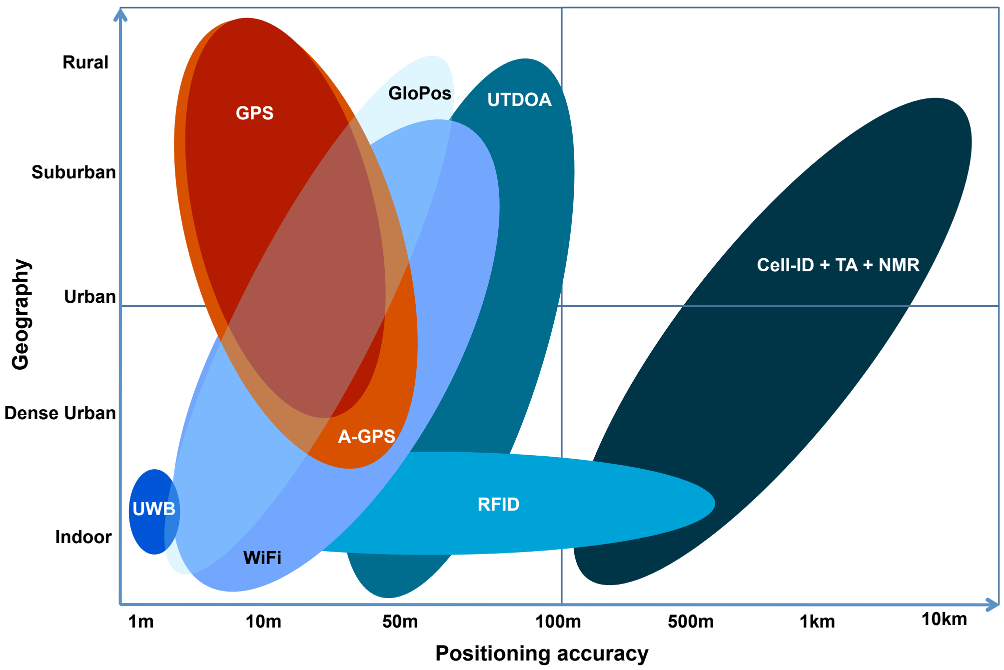
Source: PTOLEMUS

In Figure 44, the accuracy range of major location technologies is represented.
It is striking to **visualise the complementarity of A-GPS and WiFi**:

- A-GPS works best in suburban and rural areas,
- WiFi is best placed to address indoor and urban environments.

The technology set is valid only for Europe, with U-TDOA, GloPos, A-GPS-SIM represented for reference only as they are yet not deployed.

Figure 44: Comparison of the accuracy of location technologies



Source: PTOLEMUS

2. Hardware and service costs

The price of positioning

Comparing the cost of positioning technologies is a difficult exercise.

While access to the GPS open service is free, the chipset is not. End-users buy a device, not a chipset, and positioning is rarely charged as a premium on the device.

Network location is almost free to provide once the network is equipped. How much the operator needs to invest depends on the age of the network and the technology installed. We estimate that costs can reach €0,05-0,09 per location request. Obviously, this entirely depends on the volume of requests as costs are mostly fixed.

In general, the **business model for positioning data provision is expected to be free to the user** – integrated in the overall connection cost. For instance, basic mobile navigation is rapidly becoming offered by device vendors (Nokia), OS developers (Google Android, Microsoft Bing), mobile operators (e.g. T-Mobile Germany), so positioning on its own is not expected to cost anything.

However, free navigation and free positioning suggests that someone other than the user is paying. Figure 45 highlights who will be expected to pay which type of costs.

Figure 45: Who pays what in device-based and device-centric location?

	Satellite-based location (device-based)		Client-based location (device-centric)	
	GPS	A-GPS	WiFi	UWB
Who pays for the location fix?	OEM / ODM	OEM / ODM / MNO	ODM / chipset vendor / 3rd party service provider	End user (venue)
Cost type	CAPEX	CAPEX	CAPEX + OPEX (license or revenue share)	CAPEX + OPEX
Cost per device when identifiable (€)	1- 4	>4	1.50 - 4.50 (license)	300 - 500

Source: PTOLEMUS

GPS costs compare badly with WiFi when they are supported by device manufacturers. However, WiFi is relatively new and reasonably unknown by end-users whereas GPS is global and does not need a network connection (except A-GPS).

Figure 46: Who pays what in network-centric location?

	Network-centric location							
	Cell-ID	A-GPS SIM	UT-DOA	UTDOA / GPS	EOTD	E-Cell-ID + TA + NMR	AOA	GloPos
Additional operator investment	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Who pays for the location fix?	3rd-party service provider	MNO	MNO / gov.	MNO / gov.	Service provider / End-user	3rd-party service provider	3rd-party service provider	n.a.
Cost type	OPEX	OPEX	CAPEX + OPEX	CAPEX + OPEX	OPEX	OPEX	OPEX	OPEX

Source: PTOLEMUS

Other solutions that need to be installed on the device, such as GloPos, will compare even more favourably in terms of cost for the device or OS provider, since they are based on an installed software and server licence contract.

The network-centric solution model is favoured by most mobile operators. Besides having control of the technology and its application, the operators will have a fixed cost per year to provide location to as many device as required.

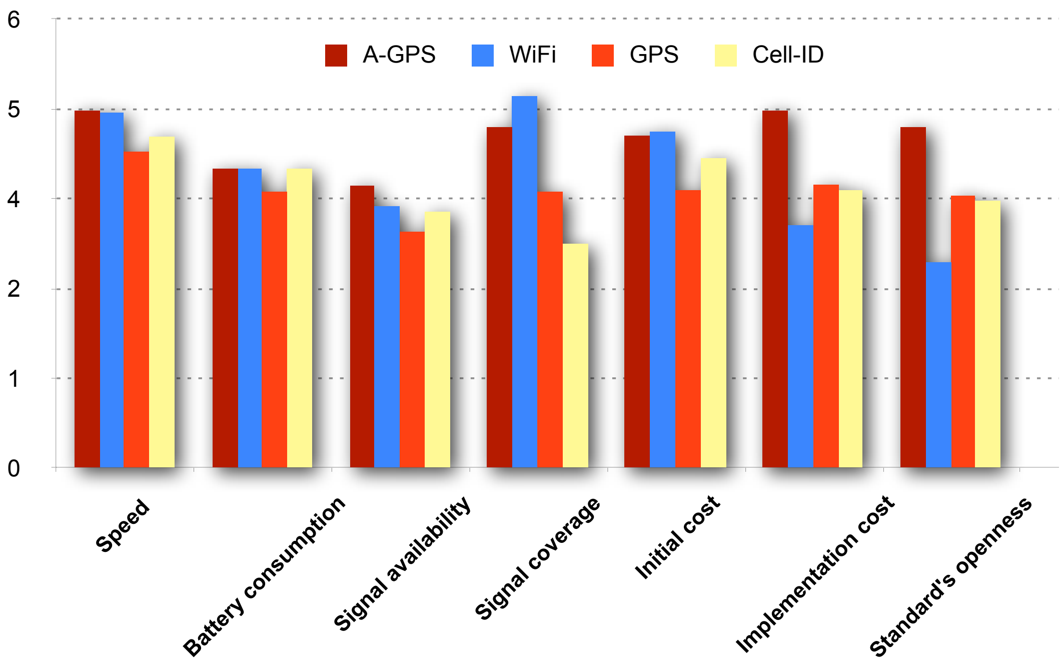
More on prices and business models in Section IV of the Full Report

3. Other key factors to compare positioning technologies

In December 2009, we conducted an online survey on the topic among a balanced sample of users and executives from location technology providers, device vendors and operators.

Respondents were asked, on a score from 0 to 5, how **satisfactory** each location technology was for their purpose.

Figure 47: Main location technologies rated by their users



Source: PTOLEMUS online survey

The perspectives of the responding sample reflect their prior technology choice

- Location accuracy is perceived as relatively satisfactory by the majority of respondents, who were generally more content with Cell-ID accuracy than stand-alone GPS, probably due to the initial expectation of each technology;
- WiFi positioning (WPS) scored highest in terms of availability, as operators and device manufacturers alike favour its ability to work indoors;
- WiFi also scored highest in implementation cost, which the respondents see as cheaper than Cell-ID;
- Battery consumption is perceived as an improvement point across all 4 location technologies. As location provision focuses increasingly on mobile phones, GPS manufacturers must reduce battery drainage to below today's range of 50-500 microamperes of current. Solutions include always-on modes, which enable the device to stay in hot-start mode while using less than 1 mW of power.

Indoor coverage

PTOLEMUS believes that **WiFi location accuracy will soon be at metre level**, thus **opening up the consumer indoor location market**.

As **indoor maps** are expected to become increasingly available by Q3 2010, the 2 innovations will present interesting opportunities for device manufacturers and service providers.

Indoor maps are also being compiled and integrated rapidly by service providers for **emergency services**. Their availability is required by law in certain countries such as the UK. Tracking providers for emergency services, such as iMASS in the UK, are in a key position to access and redistribute them.

Up to now, it seemed that commercial indoor tracking and location would remain a niche market, primarily due to the cost of the infrastructure. Four UWB readers are needed in a room in order to locate an item at less than 1 metre accuracy.

This is useful in very specific settings, such as hospitals or factories, with players such as **AireTrack** being able to respond to accuracy requirements of **2 cm**.

However, the extremely fast growth of WiFi-enabled devices (virtually all forthcoming smartphones and laptop computers) and access points makes it now conceivable to rely on standard WiFi technology for indoor navigation.

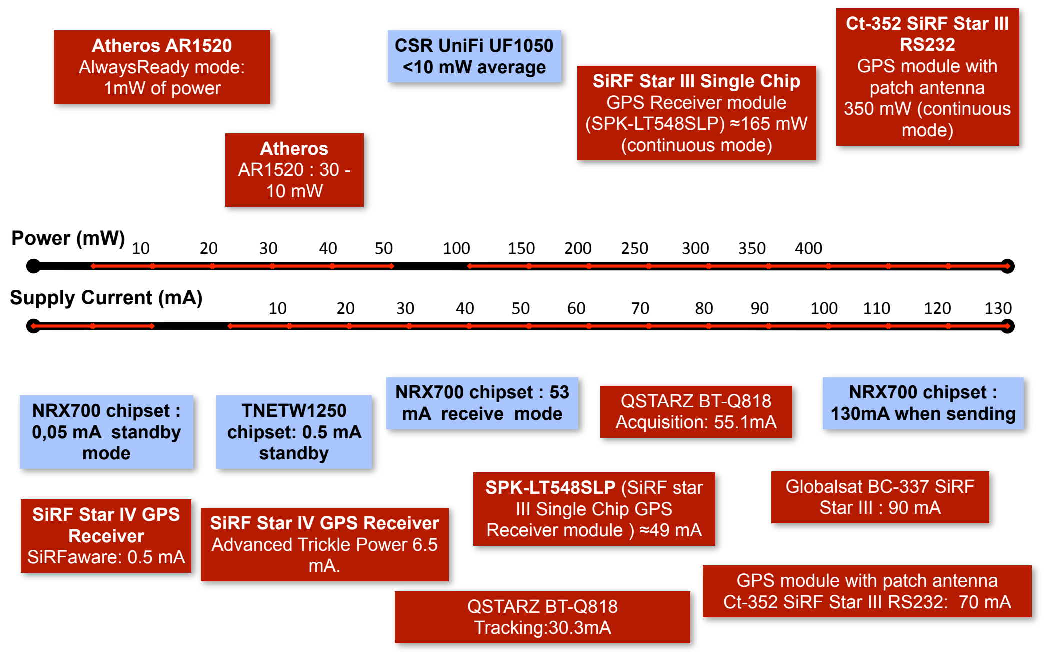
We would expect Skyhook, Navizon and Nokia/Navteq to relatively quickly include a number of venues, such as shopping centres or train stations, in their databases.

Power consumption

Depending on the mode of the chipset and the package in which it is embedded, power consumption varies widely.

GPS and WiFi are, however, on comparable scales when looking at power consumption overall.

Figure 48: Illustrating sample GPS and WiFi power consumption (GPS in red, WiFi in blue)



Source: PTOLEMUS

Obviously, location relying on Cell-ID will consume far less power than GPS or WiFi. This is because permanent communication with the mobile network is already part of cellular network standards.

4. SWOT analysis of each technology

Figure 49: SWOT of GPS positioning

STRENGTHS	WEAKNESSES
✓ **Universal recognition** of the acronym ✓ Well adapted to car navigation, still the most compelling LBS application ✓ **Critical mass of devices**: GPS equips more than 90% of smartphones ✓ **No competition yet for outdoor global positioning with accuracy of <15 metres** ✓ **Low cost** paid by the user (less than €5) when purchasing the device, and then free for life ✓ **Global coverage**	✳ **High power consumption** generally >30 mA ✳ System technology dates back to the 1960s ✳ Not reliable enough for critical applications ✳ Unequal performance depending on environment ✳ **Length of TTFF**, notably in dense urban areas ✳ **Mediocre accuracy**, not ideal for certain applications and probably not sufficient for road user charging ✳ Reliance on the military system of a single country ✳ Higher cost than cell-based solution (cost per handset) ✳ As a hardware solution, it is more complex to integrate than a software solution
OPPORTUNITIES	**THREATS**
★ **Positive impact of free navigation** on penetration ★ Cost and recognition are competitive advantages in new devices integration ★ Advances in technology and hybrid solutions will enable indoor location ★ Decreasing cost of GPS chipsets ★ **Legislation**, eg. eCall or E112 will, at some point, create market growth. In most cases, GPS is a contender as the primary or secondary positioning technology	✦ As GPS is synonymous with positioning, a public backlash against privacy-related issues can damage its perception ✦ **New network-centric location technologies entering the market** could rapidly dominate positioning ✦ **WiFi** is starting to be better understood by users, thus becoming a major challenger in consumer electronics ✦ Unclear path to second generation ✦ **Glonass** then **Galileo** will challenge its GNSS “monopoly” ✦ Risk of decreasing addressable market for GNSS due to growth of WiFi and Cell-ID (e.g. unable to provide for fast emerging **indoor** location applications)

Source: PTOLEMUS

Figure 50: SWOT of Cell-ID positioning

STRENGTHS	WEAKNESSES
✓ **Extremely fast TTFF** ✓ **Very low battery consumption** ✓ **High scalability** – no handset subscription required ✓ **Cheaper** for mobile operators to set up than A-GPS – no device cost ✓ Privacy, billing and authorisation: simple, uniform, and at network, not user level ✓ Passive positioning of handset possible, i.e. no application required on the device to be located ✓ Stronger business case for tracking application vs. broadcasting location	✳ **Low accuracy** ✳ **Not implemented by MVNOs and certain MNOs** ✳ Adds complexity to network infrastructure ✳ Not compatible with certain old handsets from HTC, Motorola, Blackberry and Samsung ✳ **No compelling business case** developed by mobile operators ✳ No location roaming or geofencing by default ✳ Has been particularly monitored by European privacy regulators despite its low accuracy
OPPORTUNITIES	**THREATS**
★ Location provision and control is a differentiating factor for operators ★ **Ability to change pricing from volume-based pricing to revenue-sharing** to create scale effects ★ **Ability to provide always-on location-triggered services** such as location-based advertising and promotion, mobile dating, child tracking, etc. ★ **Ability to derive major statistical information** on population movements, hot spots, traffic jams ★ The Wholesale Application Consortium (WAC), announced in February 2010, includes all key European mobile operators, and will work towards a set of common APIs ★ Contextual location requires a constant location fix that GPS and WPS cannot easily provide currently, due to power requirements	✦ More device-centric location solutions on the market makes the case for network-centric location more difficult ✦ **Network-centric location business case undermined** by Google, Nokia and Apple, since they all offer MNO-independent navigation, routing and location data for free ✦ In Europe, users understand device-based location services, whilst network assistance is not widely understood.

Source: PTOLEMUS

Figure 51: SWOT of A-GPS User Plane (SUPL) positioning

STRENGTHS	WEAKNESSES
✓ **Improves GPS speed, availability and battery consumption** ✓ **Based on transparent and evolving OMA and 3GPP standards** ✓ Can be provided in different ways by different types of players ✓ Does not rely on mobile operator's infrastructure ✓ **Roams** between networks	✳ **Requires combination of GPS on the device, a data plan and cellular coverage** ✳ Tracking requires the input from the tracked device (contrary to Cell-ID) ✳ **Device needs to support GPRS class A** (data and voice transfer working in parallel) ✳ Does not work indoors ✳ Data rates when roaming ✳ Does not run in the background at this stage ✳ Historical data gathering require local storage and data upload ✳ **TTFF still mediocre** (30 s in urban areas) ✳ Limited usage (e.g. Thales Alenia Space: 4 million requests per month end 2008)
OPPORTUNITIES	**THREATS**
★ SUPL 2.0 specifications already finalised; interoperability testing in progress and implementation expected in Q4 2010 ★ E112 functionality supported by SUPL 2.0 ★ WiFi location, LTE and WiMAX bearer supported by SUPL 2.0 ★ Data plans now coming by default with smartphones ★ European Commission plan to eliminate roaming charges within the EU by 2015 ★ Fast growth of A-GPS interoperability tests and request volumes	✦ Combination of WiFi and Cell-ID offered by Skyhook and Navizon reduces the interest of GPS in cities ✦ Independent location technology innovators (e.g. Glopos) ✦ Lack of clear regulations and globally agreed best practice may lead to a public opinion backlash on location if a major privacy breach takes place and is publicised. As GPS is the most visible and understood technology, it is more vulnerable than other technologies ✦ No European legislation or industry-wide code of practice on data usage, transfer and backup

Source: PTOLEMUS

Figure 52: SWOT of WiFi positioning

STRENGTHS	WEAKNESSES
✓ **WiFi becoming pervasive** (3,5 billion devices per year in 2015), from laptops to mobiles to consoles, indicating huge potential for WiFi location providers ✓ **Extremely high density of WiFi access points** in most developed countries ✓ Very flexible configuration (can be set up at the device, platform, browser, chipset and network level) ✓ Availability, reliability and accuracy are improved by more users mapping the network, creating a virtuous circle	✳ **Inappropriate for location outside urban areas and in developing countries** (without dense WiFi networks) ✳ **Lack of indoor mapping, reducing the interest of WiFi location indoors** ✳ Indoor accuracy is currently inadequate ✳ Location-based applications using WiFi can run in the background but then drain the device's battery ✳ Reliability of databases undermined by WiFi owners moving (only in non-dense WiFi areas)
OPPORTUNITIES	**THREATS**
★ Increasing penetration of broadband driving WiFi pervasiveness ★ Possibility of exporting WiFi databases to standalone devices (e.g. non-connected PNDs) ★ More device manufacturers and operators are building their own databases ★ The ability to run in the background in the medium-term will enable new applications ★ Indoor maps to start being delivered by end 2010, creating a major business opportunity	✦ Specific indoor solutions from independent location technology innovators ✦ Competition from growing number of WiFi database providers ✦ Revenues from revenue share models risk vanishing if all mobile phone vendors provide WPS for free ✦ WPS is led by one company, which could easily be acquired

Sources: PTOLEMUS, GIA

Figure 53: SWOT of Glonass positioning

STRENGTHS	WEAKNESSES
✓ **Service commercially available** in precision GNSS receivers offering redundancy to GPS ✓ Thanks to 48 satellites, GPS+Glonass can provide much faster TTFF ✓ New satellites offer comparable performance to GPS	✳ **Lack of commercial-grade Glonass chipsets and receivers** ✳ Glonass works on a different frequency to GPS and Galileo, making an integration expensive ✳ Higher cost of integrating Glonass FDMA signal with GPS compared to Galileo ✳ Less reliable than GPS at the moment
OPPORTUNITIES	**THREATS**
★ Glonass will launch CDMA satellites this year – necessary to make it interoperable with GPS and Galileo ★ Nokia is testing Glonass chipsets ★ Accuracy to be increased ★ Glonass could become Europe's 2nd location technology if Galileo is postponed again ★ Indication from KB Navis that they will build a low-cost GPS-Glonass-Galileo chipset	✦ Galileo has been built to complement GPS from the ground up ✦ GPS chipset manufacturers all pledged support to Galileo, despite the delays ✦ Operated by a non-democratic country which has demonstrated that it could use its resources (e.g. energy) to put pressure on other countries ✦ Risk of decreasing addressable market for GNSS due to growth of WiFi and Cell-ID

Source: PTOLEMUS

Figure 54: SWOT of Galileo positioning

STRENGTHS	WEAKNESSES
✓ **Modern satellite constellation** with functionalities that have been built on experience gained from GPS (this is proven by the fact that GPS III specifications have closely followed Galileo's path) ✓ Not controlled by a defense organization ✓ ST Microelectronics and u-Blox already announced combined GPS-Galileo chipsets	✳ **Multiple roadmap delays, making it available in 2014 at the earliest** ✳ Unproven capabilities
OPPORTUNITIES	**THREATS**
★ **Thanks to 55 satellites, GPS+Galileo will provide much faster TTFF**, notably in dense urban areas ★ **1-metre accuracy** could make applications such as ADAS and RUC possible, while improving all applications (including car navigation) ★ Existence of a high reliability, high accuracy commercial service ★ Availability of specific services for safety of life and public applications ★ Galileo production cost expected to be the same as GPS ★ GPS-Galileo dual chipsets could become the world standard in the long term, thanks to significant markets and high economies of scale	✦ Further delays could make Galileo useless due to GPS III ✦ Risk of decreasing addressable market for GNSS due to growth of WiFi and Cell-ID

Note: ADAS: Advanced Driver Assistance System; RUC: Road User Charging
Source: PTOLEMUS

Figure 55: SWOT of EGNOS

STRENGTHS	WEAKNESSES
✓ Open Service (OS) freely available across Europe ✓ Not controlled by a defense organisation ✓ Most latest GPS chipsets already embed EGNOS ✓ **Can improve GPS accuracy** in rural and suburban areas (**down to 3 m**) ✓ Vertical accuracy (4 m) ✓ **High reliability** (e.g. >> 99.99% between March and August 2009)	✳ **Only 3 satellites, so does not improve TTFF in urban areas** ✳ **Only an augmentation system, not a full constellation** ✳ European coverage only ✳ Does not improve GPS accuracy in urban areas
OPPORTUNITIES	**THREATS**
★ Expansion of EGNOS to Africa ★ Safety of Life (SoL) service to be launched in 2010	✦ Emergence of alternative constellations in Europe will reduce the interest of an augmentation system

Source: PTOLEMUS

Figure 56: SWOT of all existing positioning technologies combined

STRENGTHS	WEAKNESSES
✓ GPS has made almost everybody understand what location means ✓ Mobile location business model and privacy have been proven to exist by Apple's iPhone ✓ Clear and proven ROI of fleet management systems ✓ Decreasing cost of GPS chipsets, ensuring rapid development of the location ecosystem ✓ **Steady growth of in-car connected systems**, from connected cars to connected PNDs ✓ Initial success of PAYD in Southern European countries (Italy, Spain, France)	✳ No satisfactory location solution indoor and lack of indoor mapping ✳ Low uptake of Cell-ID due to high pricing ✳ Far too long TTFF in urban environments ✳ WiFi location only adopted in mobile phones ✳ Location business often perceived as a small market niche hence not attractive ✳ Difficulty to monetize content & services business models in the consumer market ✳ Over-regulation of location privacy in Europe has prevented take-off of applications
OPPORTUNITIES	**THREATS**
★ **Enormous investment made in location by technology leaders** (Apple, Google, Microsoft, Nokia, TomTom, etc.) ★ **Mobile social networking about to make location a mass-market** ★ European directives on safety services such as eCall and E112 would provide significant growth to European location business ★ Integration of GPS in the SIM card, **extending significantly the addressable market** for location ★ Cell-ID interconnection and opening to 3rd party aggregators could have similar effect as SMS interconnection on volumes ★ Improvement of TTFF in cities thanks to Glonass and Galileo ★ Basic map and now basic turn-by-turn navigation becoming free to the end-user, creating a **level playing field for the take-off of value added services** ★ Passive location representing a significant opportunity to generate crowd-sourced data	✦ **Risk of significant value destruction** in the location business due to free models ✦ **Inadequate management of users' data by certain companies** would ruin all efforts to make the claim for "responsible location" credible ✦ Road user charging becoming firstly a political discussion (as in the UK now) ✦ Old technologies such as DSRC could triumph due to push by legacy players

Source: PTOLEMUS

D. The case for network- vs. device-centric positioning

Although GPS and PNDs have made people expect to be located without being connected to a network, we believe that **the growing pervasiveness of connectivity will change the rules of location.**

In the future, **we anticipate that more and more devices and moving objects to use connectivity** in one way or another **to obtain their location**.

There are **3 major drivers** of this evolution in our view:

- Wireless networks are becoming pervasive (e.g. picocells and femtocells), faster (LTE, WiFi 802.11n), more responsive (lower latency) and far less expensive, even in roaming;
- The number of (fixed and mobile) devices connected to the Internet is growing exponentially (e.g. over 1 billion 3G users worldwide in 2010), making information available on the network far greater, relevant and dynamic than the information that can be stored on a device;
- Network and device technologies are evolving radically faster than satellite technology, making satellite-only solutions less competitive in the long run.

In other words, **the location (user) experience will increasingly resemble the mobile handset location experience.**

The location of a mobile device will take place **using both network- and device-based information**.

The real question is **how the architecture of the location data provision will ultimately be organised, and who will control it**. Location data between a device and a location server can take multiple routes. Depending on the technology used, this will radically change the cost and the service strategy.

Network-centric location (e.g. A-GPS Control plane) is very fast and robust. It offers a level of refinement on which the service provider can rely, and guarantees response and accuracy levels.

It also enables interesting features such as

- Permanent geofencing from the network (if the operator is equipped),
- Always on / passive mobile location, (connected devices can be located without interaction),
- Absolute but also relative location (i.e. vs. other reference points or moving objects),
- Triggered location.

When a connected device requests its location from the network, both the device and the operator will have an influence on how the system performs.

For instance, if a SIM on a tracking device is not connected to the network for 2 days, certain operators will temporarily stop its access to the network. The device will appear to be working, but nothing will actually be received. A good device will recognise idiosyncrasies between itself and the network to identify such a problem and force a reboot, but in most cases, the service provider will have to include algorithms in the connected device to control its relationship with the network and manage the data it provides.

The way location is provided also depends on the network operator. For instance, once a first location is given from a device on the Orange network, if the device remains inactive for half an hour, the next fix will automatically revert to the initial location because this is the way the operator chooses to handle the data. This can be very restrictive for the service, and such parameters differ between operators.

This example illustrates how, in control plane, **Cell-ID location's refinement and data delivery settings are in the hands of the operator** and, to a large extent, so is the SLA (service level agreement) the third party service provider is able to offer.

User Plane A-GPS, i.e. device-centric positioning, is gaining more traction. Certain operators outside Europe investing in new location platforms now are choosing the User Plane architecture from the start.

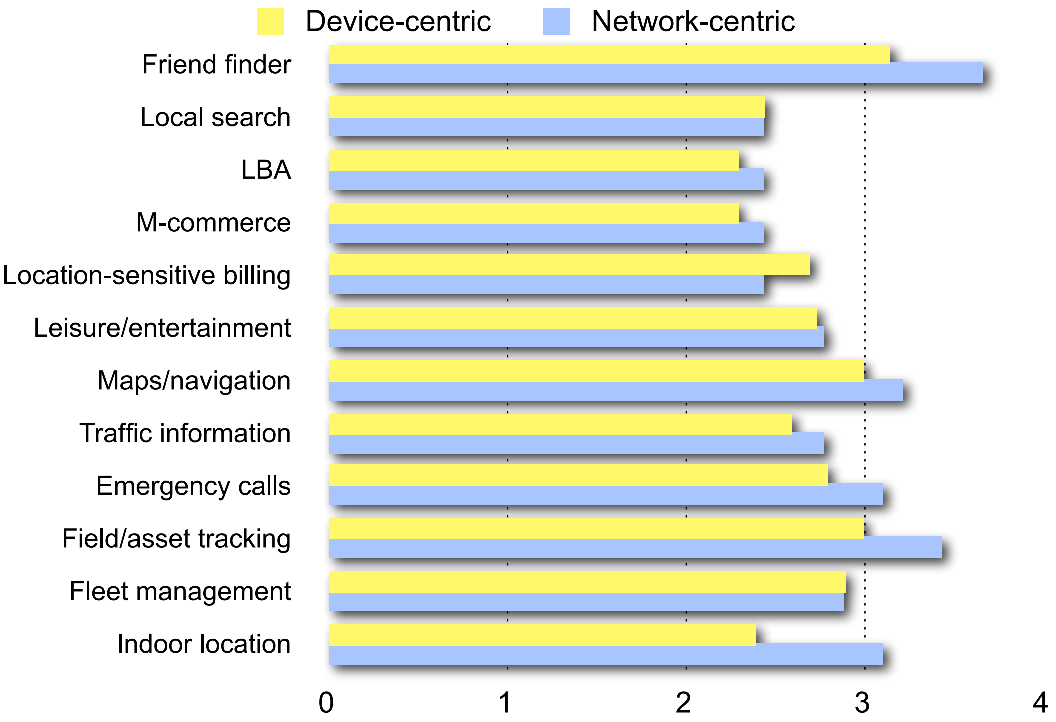
The number of networks providing A-GPS is growing rapidly. As of June 2009, **mobile networks acquiring or investigating the interest of SUPL servers in Europe** included

- 3 UK,
- Bouygues Telecom,
- KPN,
- Orange France,
- SFR,
- Telecom Italia,
- T-Mobile and
- Vodafone.

In User Plane positioning, the service provider must create the connectivity and location quality refinement, check that GPS is working, control power consumption and ensure that privacy is respected. The device, however, still requires a connection to the network and, to a degree, depends on the operator for that.

In terms of applications, survey respondents were asked to suggest which of the 2 types of location was best suited for a range of location-based services

Figure 57: Location architecture best fitted for LBS (Grade from 1 to 5)



Source: PTOLEMUS LBS survey

From our survey of location technology providers and users, it emerges that none of the current solutions clearly dominates the other.

Successes seen in network-centric location applications were originally in friend finding and people tracking applications in the US.

Network-centric solutions had a clear advantage there due to a series of factors:

- First on the market,
- Worked on all devices,
- Could roam between networks,
- Those applications did not require high accuracy,
- Economic and fast deployment,
- Services were generally based on one function alone (e.g., where is my kid?), thus simple to use on any phone,
- Secure, with privacy handled at network level,
- Generally worked indoors.

However, in the short term, device-centric positioning is definitely the fastest growth area.

Services have become more multi-functional (Get proximity alerts, then see it on the map, then text your friend…). This has been helped by the growing device ability to handle complexity and store more information. The consequence was that even traditionally network-centric services such as friend finding and tracking applications are now also offered by device-centric location service providers.

The **business model is also very different** between the two types of solutions:

- In network-centric location, operators charge directly the application provider for each location request;
- In device-centric location, the device or chipset maker pays for the infrastructure and location is included in the overall package.

For professional applications, once the size of the operation has reached a cross-point, it will be cost effective to switch location sources because the investment in a new handset is cheaper than the cost of location queries.

Several platforms (Android, Apple, Nokia, Vodafone JIL, O2 Litmus) provide location data to developers for free or as part of a revenue share arrangement.

Ultimately, we anticipate that the **optimal future solution will be a hybrid of Control and User Plane location**.

- Cell-ID information will be updated through the Control Plane, which will also monitor if the phone is moving;
- The A-GPS fix will be initiated if the phone is moving, using User Plane GPS assistance;
- The position will then come from User Plane pattern matching from GPS, User Plane Cell-ID and Control Plane Cell-ID;
- It will also check for RF signal once an indoor position is detected.

END OF THE FREE LOCATION STUDY

III. LOCATION-ENABLING VALUE CHAINS AND STRATEGIC FORCES AT PLAY

A. Major players

We have performed a detailed mapping of the location value chain.

To do so, we have distinguished **9 steps in the location provision business**:

(1) **Network infrastructure**: Supplies network equipment to mobile operators,
(2) **Location gateway**: Provides location servers, whether GMLC or SUPL,
(3) **Middleware platform**: Provides middleware services such as location aggregation, authorisation, billing, privacy management, etc.
(4) **Location platform / application servers**: Provides an environment and a set of components accessible to the software developer through an API,
(5) **Geo-localised content and applications**: Provides localised content & services to developers such as point of interests (POIs) or GIS data; or applications to mobile operators,
(6) **Geo-application publishing**: Provides an application publishing platform,
(7) **Mapping / routing**: Supplies map data, routing, geocoding and reverse geocoding solutions to developers,
(8) **Geo-located ad platform**: Provides an advertising network where marketeers can define the location of their target,
(9) **Location device**: Designs and manufactures location-enabled devices (tracking device, PND, smartphone, etc.) or device components (micro-processors, operating systems, etc.).

For each type of companies, we have highlighted in red, orange and yellow the providers which currently have the most complete offering.

Location infrastructure components are available from

- Large telecom infrastructure vendors such as Nokia, Ericsson, and Alcatel-Lucent;
- Large international location technology vendors such as TCS or Commscope's Andrew,
- Regional location technology vendors such as Mobile Art, which has focused on Telenor and its affiliates, Creativity Software, which focuses on the Middle East, and Thales Alenia Space, which until now has focused on France and Southern Europe.

Increasingly, the **boundaries between technology vendors and service suppliers are blurring**.

We expect this to continue as location platform contracts will increasingly integrate a revenue share component, which brings *de facto* systems suppliers in the service business.

A number of large telecom equipment groups such as Huawei who have no specific location business unit, generally offer these solutions in partnership with a middleware vendor such as Creativity Software.

Location technology providers have close relationships with infrastructure providers, and companies such as True Position can provide a packaged solution together with network equipment suppliers. True Position, however, does not support A-GPS and uses its SUPL server for demonstration purposes only.

Location platform providers offer **developers** a **gateway to access location and build services.**

For example, Cloudmade provides an environment for developers of all sizes where a single software development kit (SDK) enables access to location, maps, routing engines and POI. While Cloudmade focuses on iPhone applications, DeCarta provides a similar environment for mobile operators applications such as Appello Systems' off-board mobile navigation.

The following table describes the value chain roles assumed by each of the key location solution suppliers.

It clearly shows the **key role that the Nokia Group** (including Nokia Siemens and Navteq) **has acquired in the location business**, **from the base station to the mobile device.**

Figure 58: Location infrastructure & platform providers - Value chain position

	Network infra.	Location gateway	MW platform	Platform / App Servers	Content & Services & Apps.	App publishing	Mapping / Routing / Geocoding	Ad platform	Device vendor
Alcatel Lucent	✓	✓	✓	✓				✓	
Artilium		✓	✓	✓					
Cloudmade				✓	✓	✓	✓	✓	
Commscope	✓	✓	✓						
Creativity Soft.		✓	✓		✓				
Ericsson	✓	✓	✓	✓		✓			✓
ESRI				✓	✓		✓		
Intrado			✓	✓	✓				
Mobile Arts		✓	✓	✓					
Nokia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Openwave	✓	✓	✓						
Polaris		✓	✓						
Qualcomm		✓	✓	✓	✓		✓	✓	✓
Redknee	✓	✓							
RX Networks			✓	✓					
TCS	✓	✓	✓	✓	✓		✓	✓	
Thales Alenia	✓	✓	✓	✓					
TruePosition	✓		✓	✓					

Note: Ericsson includes Sony Ericsson; Nokia includes Nokia Siemens and Navteq; TCS includes NIM and LocationLogic; Qualcomm includes its chipset, LBS and fleet management businesses.

Source: Company reports, PTOLEMUS

Figure 59: Location data & service providers - Value chain position

	Network infra.	Location gateway	MW platform	Platform / App Servers	Content & Services & Apps.	App publishing	Mapping / Routing / Geocoding	Ad platform	Device vendor
CellVision	✓	✓	✓	✓	✓				
Deveryware				✓					
DeCarta				✓	✓		✓		
Genasys			✓	✓	✓		✓	✓	
Google					✓	✓	✓	✓	✓
LocatioNet			✓	✓	✓		✓	✓	
LociLoci			✓	✓	✓				
Mecomo				✓	✓				
Mobilaris		✓	✓	✓					
Mobile Commerce			✓	✓	✓			✓	
Navizon				✓					
Quova		✓	✓	✓					
ReachU			✓	✓	✓				
Skyhook		✓	✓	✓					
Telenity	✓		✓	✓					

Source: Company reports, PTOLEMUS

Location data and service providers fulfil 2 major functions:

(1) Provide c**omplementary services to network infrastructure providers, integrators and sometimes operators directly** with whom they partner in order to deliver an easy- and fast-to-implement LBS solution to mobile operators.

- For example, Artilium offers a software solution to improve the accuracy of Cell-ID and to leverage its data;
- Reach-U delivers both middleware LBS management platforms and LBS applications such as fleet management, LBM, friend finder, etc.

(2) The second function is based on the re-use of their relationship with their national operators to act as a **location broker to third parties** (businesses or application developers)**:**

- Genasys in Spain,
- Mobilaris / LociLoci in Northern Europe,
- Mecomo in Germany and Austria,
- Deveryware in France,
- Mobile Commerce in the UK.

Figure 60: GPS chipset and module manufacturers - Value chain position

	Network infra.	Location gateway	MW platform	Platform / App Servers	Content & Services & Apps.	App publishing	Mapping / Routing / Geocoding	Ad platform	Device vendor
Atheros									✓
Broadcom			✓	✓					✓
CSR / SiRF			✓	✓					✓
Intel									✓
NXP									✓
Qualcomm		✓	✓	✓	✓		✓	✓	✓
Sierra Wireless			✓						✓
Texas Inst.									✓
Trimble				✓	✓		✓		✓
U-Blox				✓					✓

Note: Sierra Wireless includes Wavecom.

Source: Company reports, PTOLEMUS

It is interesting to see that **GPS chipset manufacturers have developed significant upstream capabilities in the value chain**, certainly for differentiation purposes, but also to control the quality of their solution end-to-end.

Qualcomm, Broadcom and CSR/SiRF provide the complete A-GPS set including chipset, software, SUPL server and services.

When off-board assistance is not included, manufacturers offer on-board extended ephemeris calculations.

Figure 61: Location-enabled device vendors and device operating systems (B2C) - Value chain position

	Network infra.	Location gateway	MW platform	Platform / App Servers	Content & Services & Apps.	App publishing	Mapping / Routing / Geocoding	Ad platform	Device vendor
Android					✓	✓	✓	✓	✓
Apple				✓	✓			✓	✓
Garmin					✓				✓
Ericsson	✓	✓	✓	✓		✓			✓
HP						✓			✓
HTC									✓
LG									✓
LiMo									✓
Mitac					✓				✓
Motorola	✓								✓
Navigon					✓				✓
Nokia	✓	✓	✓	✓	✓	✓	✓	✓	✓
RIM			✓	✓	✓				✓
Samsung					✓	✓	✓		✓
Symbian				✓		✓	✓		✓
TomTom					✓	✓	✓		✓
Microsoft					✓	✓	✓	✓	✓

Notes: Ericsson includes Sony Ericsson; Nokia includes Nokia Siemens and Navteq; RIM includes Dash and QNX; TomTom includes Tele Atlas; HP includes Palm.

Source: Company reports, PTOLEMUS

Two handset manufacturers have been instrumental in the adoption of location-based services. Nokia and Apple were the first to equip their handsets with A-GPS. Historically, Nokia's N95 and the iPhone have been the 2 flagship handsets of the LBS industry.

Device manufacturers still decide what type of assistance or location technology their handset models will use. For example, Nokia and Apple have contributed to make A-GPS a standard in smartphones.

Although the LBS market is very well developed in Japan and Korea, **Asian terminal vendors such as Samsung, LG and HTC have not defined and executed location strategies outside of their home markets**.

This is a particularly important issue for HTC, which mainly sells smartphones.

This may also become an issue for Samsung and LG because features phones are increasingly equipped with WiFi and GPS and location-based social networking promises to reach their target audience fairly soon.

With Android however, **Google is trying to make the OS the core of the location intelligence,** e.g. mandating which technology is used in positioning the device as well as providing for the assistance network.

It is no surprise that Asian handset manufacturers, but also Motorola (which has the same weaknesses) have viewed Android as a solution to fill their capability gap in LBS (among other things).

However, it seems that Samsung is afraid to lose too much control, differentiation (and probably value) to Google. Hence the **launch of its own OS, Bada**, which **raises significantly the LBS capabilities of Samsung handsets**. As Bada in general, whose motto is "Smartphone for everyone", Samsung's intention is to bring LBS to the masses.

Figure 62: What does Samsung's Bada OS offer to LBS developers?

Features	Description
Potential addressable market (long term)	220 million Samsung handsets sold in 2009, including 40 million touchscreen phones
Application store	• Reusing Samsung Apps, Samsung's existing store • 70% revenue share to developers • Targets a coverage of 75 countries in 2010
Positioning technologies	GPS and / or **WPS**
Location updates and retrieval	• Periodic location updates • Getting the locations of other devices, such as • Last known or current location • Subscribing to zone and trace services • Privacy protection
Landmark management	• Landmark store management - Create, read, and delete - Device-wide or application-bounded • User-created landmark management (Add, update, delete, and search) • Pre-defined landmark search
Location services from deCarta	• Map rendering, zooming, and panning • Geocoding and reverse geocoding • Directory services • Route services
Control of map user interface	• Map zooming and panning • Overlay and information windows • Event notifications

Source: Samsung

We understand that HTC is also considering the same move. If they were to decide to create their own OS, this would strongly undermine Google's strategy which would then only rely on Motorola and LG.

Figure 63: Location-enabled device vendors and operating systems (B2B) - Value chain position

	Network infra.	Location gateway	MW platform	Platform / App Servers	Content & Services & Apps.	App publishing	Mapping / Routing / Geocoding	Ad platform	Device vendor
Cobra					✓				✓
Digicore					✓		✓		✓
HP						✓			✓
HTC									✓
Masternaut					✓		✓		✓
Microlise					✓		✓		✓
Mix Telematics					✓		✓		✓
Mobile Devices					✓	✓	✓		✓
Octo Telematics					✓		✓		✓
Pointer					✓		✓		✓
Qualcomm		✓	✓	✓	✓		✓	✓	✓
RIM			✓	✓	✓				✓
TomTom					✓	✓	✓		✓
TrafficMaster					✓		✓		✓
Transics					✓		✓		✓
Trimble				✓	✓		✓		✓
Microsoft					✓	✓	✓	✓	✓

Notes: RIM includes Dash Navigation and QNX; TomTom includes Tele Atlas; HP includes Palm.
Source: Company reports, PTOLEMUS

In the B2B domain, there have been less initiatives from companies to develop new capabilities in the location value chain.

Historically, **Microsoft has been a pioneer of location-based services** (before Google), acquiring specialised companies such as

- NextBase, a GIS and consumer route planning software provider in 1995,
- Vicinity, a provider of B2B location-based services in 2002,
- GeoTango, a provider of 3D mapping solutions in 2005,
- Vexcel, a provider of satellite imaging in 2006,
- Multimap, a web route planner in 2007.

Thanks to these acquisitions, Microsoft has built a highly competitive GIS, mapping and routing platform, Virtual Earth, which is now called Bing Maps.

Microsoft has also developed strong capabilities in the telematics arena, notably thanks to Windows Embedded (used by virtually all small PND players) and Windows Embedded Automotive. It has notably convinced Fiat, Ford and Kia to use its software platform.

Although it has developed **strong GIS and telematics capabilities, Microsoft has suffered from its weak mobile strategy**. In the mobile domain, Microsoft has lost ground to RIM, Google and Apple. Its mobile OS has lost many of its biggest supporters, from HTC to Samsung and maybe HP (due to its acquisition of Palm).

On the opposite, **RIM** seems to progressively execute a well-articulated location strategy, acquiring Dash Navigation and QNX Software. Its target seems to be the **connected car area**.

In the fleet management sector, no telematics vendor seems to have a differentiated strategy relying on an innovative approach towards positioning, apart from Qualcomm and Trimble (which are coming from the chipset world).

We believe that in the highly fragmented and commoditised fleet management market, **positioning could be used as a way to propose original offerings**, notably:

- Use Galileo and Glonass to provide higher reliability and accuracy of the tracking services, notably for critical applications such as the transportation of dangerous goods, or safety applications such as police force vehicles,
- Use WiFi for shorter TTFF, higher accuracy and stolen vehicle tracking (works indoors),
- Exploit the greater power storage capacity of the vehicle to deliver always on, high sensitivity GPS,
- Use motion sensors such as accelerometers to provide highly useful driver monitoring data and PAYD accident reconstruction services.

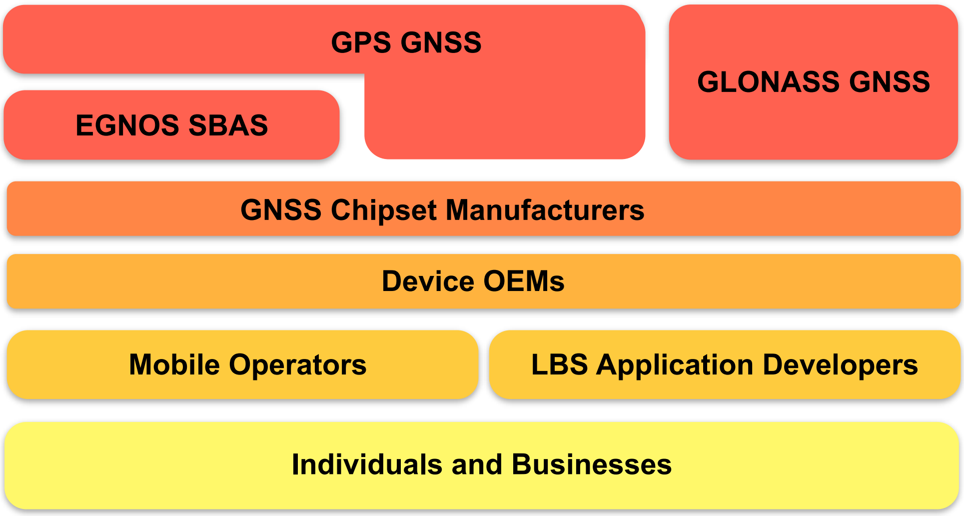
B. Satellite systems' value chain

1. Major steps / roles

The GNSS value chain is relatively simple. The industry is primarily about satellites on one side and GNSS-enabled devices on the other side. This is the main model of PND vendors such as Navigon or Garmin.

For GPS-enabled phones, this is actually slightly more complex because the mobile operators' network is used to provide Assisted GPS. In addition, MNOs control the distribution of handsets and have a recurring relationship with mobile subscribers.

Figure 64: GNSS value chain



Notes: GNSS: Global navigation satellite system; SBAS: Satellite-based augmentation system
Source: PTOLEMUS

2. The strategic landscape and its evolution

GPS

The GPS programme is in the midst of a complete modernisation phase.

The concept of a GPS III programme exists since 1998, during the Clinton administration. It took 10 years to agree on the concept, release a budget to the US Air Force and award the contract.

In May 2008, Lockeed Martin was awarded a $1.4 billion development and production contract for 8 GPS IIIB spacecraft and 16 GPS IIIC space vehicles.

The U.S. government now plans to invest more than $5.8 billion from 2009 through 2013 in GPS space and ground control segments.

In August 2009, a modernised GPS Block IIR satellite was launched. The launch of the first Block IIF spacecraft was scheduled for October 2009, although anomalies discovered in the signal generator of the second IIF now under construction have introduced some uncertainty into the plan.

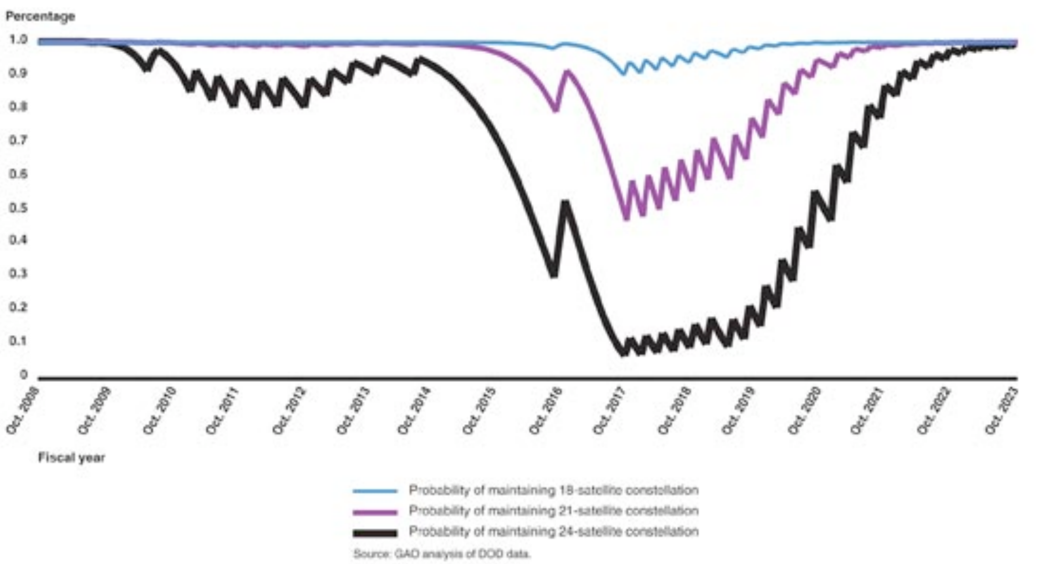
Twelve months into a 72-month schedule from contract award to first launch, the **GPS IIIA program is still on track for a 2014 launch**, according to Lockheed Martin.

However, the schedule is shorter than most other major space programs, and no other major satellite program undertaken in the past decade has met its scheduled goals.

A 2-year delay in the launch schedule would result in the U.S. government operating a GPS constellation of fewer than 24 satellites for 5 years.

In fact, another report suggested that a 2-year delay in the production and launch of the first and all subsequent GPS III satellites would **reduce the probability of maintaining a 24-satellite constellation to 10% by 2018**.

Figure 65: Probability of maintaining a constellation of at least 18, 21, and 24 GPS satellites based on reliability data as of March 2009 and a 2-year GPS III launch delay



Source: US Government Accountability Office

Overall, it is clear that the US government has understood the importance of conducting this modernisation programme.

However, previous GPS, Glonass and Galileo experiences show that it is almost certain that the programme will be at least 2 years late.

This means that we would expect a **number of reliability issues to emerge within the next 5 years**. This reinforces the need for the EGNOS augmentation system (which can check whether the GPS signal is correct) and alternative constellations such as Galileo and Glonass.

Glonass

Russian Space Forces launched 3 new Glonass satellites in March 2010.

Glonass now has a constellation of 23 satellites, although 2 of them are currently out of service for maintenance. Three more triple vehicle launches are expected to take place this year.

The **first code division multiple access (CDMA) signal** will be implemented on the next-generation Glonass-K satellite scheduled for launch this year, which will **make Glonass interoperable with GPS and Galileo chipsets.** However, it will take probably at least 10 years for the whole Glonass constellation to be replaced with these new satellites.

If the 2 additional launches of triple-satellite missions succeed, **Russia should be able to declare full operational capability for Glonass by the end of 2010**.

Glonass performance will then become comparable to that of GPS by the end of 2011.

Galileo

The first phase of the Galileo programme took place between 2005 and 2008. During this in-orbit validation phase, 2 experimental satellites were launched to test the medium-earth orbit environment and the performance of critical equipment (e.g. atomic clocks).

However, the official start of building the Galileo operational infrastructure only started in **January 2010 with the signature of the first 3 contracts for the Galileo full operational capability phase**. The European Space Agency (ESA) signed for the first time on behalf of the European Commission.

Responsibilities for the Galileo program are being reconfigured within the Commission. The 3 satellite navigation units currently under DG-TREN are moving to DG-ENTR, following Antonio Tajani's move to the position of Commissioner for Industry & Entrepreneurship.

Relatively unsurprisingly for a GNSS programme, the Galileo project also faces **new delays** in its schedule.

According to Paul Verhoef, GNSS Programs Manager, European Commission speaking in March 2010:

- The first in-orbit validation satellites will not launch in 2010 as scheduled but in February 2011;
- Questions remain as to whether a Soyuz launcher will be available at the new Arianespace facilities in Kourou, French Guiana;

- **The Galileo schedule for full operational capability** (starting with a 27-satellite constellation) **has now been pushed back to the 2016–18 timeframe**. Instead, a smaller number of spacecraft (16) will be launched by 2013.

The key factor behind the latter delay depends on the ability of the Commission and the ESA to convince European governments to commit additional funds to Galileo.

The Commission had promised not to ask for additional funding before 2012 above the €3.4 billion allocated to build the system, but in order to achieve full operational capability, another €1 billion is required.

Moreover, the annual costs to operate, replenish/sustain, and refresh the Galileo technology are now projected at about €600 million for Galileo itself, and another €100 million for the European Geostationary Navigation Overlay Service (EGNOS).

Despite the delays, "***Galileo Ready*** " will quickly become a marketing term for chipset manufacturers to sell their products. For example, SiRF's StarIV chipset and u-blox' UBX-G5000 are already "Galileo ready".

The GNSS landscape is looking increasingly like a 3-horse race to cover the European market.

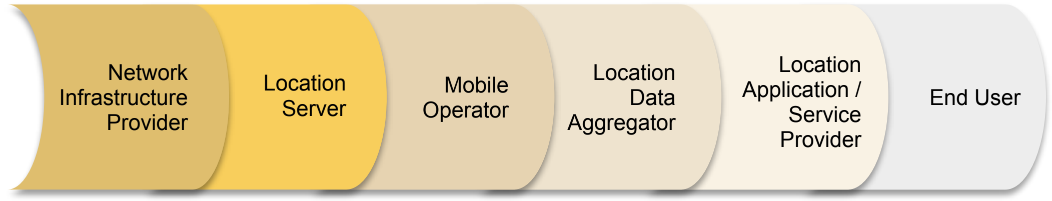
Out of the three, only Glonass will have new satellites in the sky by 2012. These will be in operation 6 years ahead of Galileo. If GPS III is delayed – as has been widely suggested – it is likely that, **by 2014, Glonass might be the most reliable constellation.**

C. Cellular network value chain (Cell-ID)

1. Major steps / roles

Until the launch of the iPhone, mobile operators were playing the leading role in the cellular location value chain, controlling the location infrastructure upstream and applications and clients downstream.

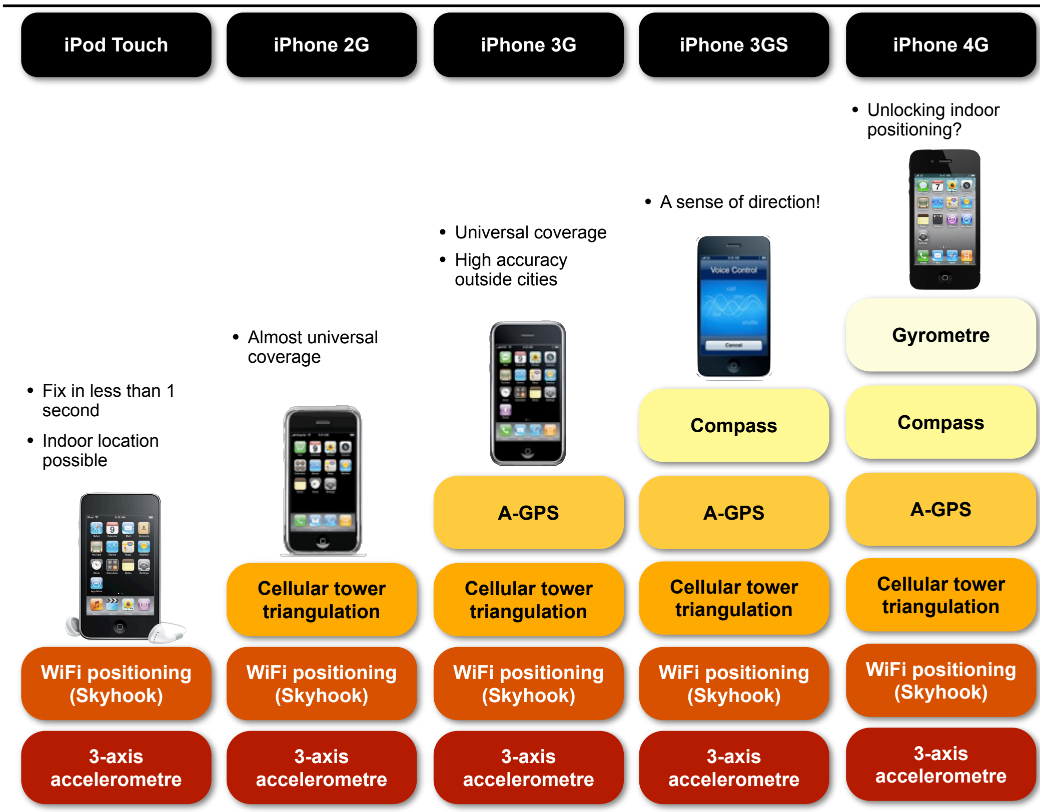
Figure 66: Original value chain for network-centric mobile LBS



Source: PTOLEMUS

Although smartphones existed long before Apple's iPhone, it is clear that **the iPhone has revolutionised the way location is accessed and used**. The figure below shows how Apple has build up the location capabilities of its devices.

Figure 67: Steps of the iPhone location revolution



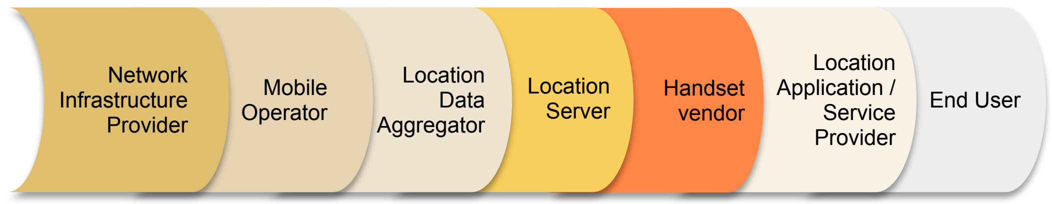
Source: Apple, PTOLEMUS

Cell-ID, WiFi and GPS assistance data are now provided by the location platform, which is no longer owned or controlled by the operator.

The device vendor now controls the provision of both the service and the location data. The 3rd party application provider now has direct access to the user's location.

The web is accessed directly by the user to reach applications and the device's location is fed to web servers, using the W3C Geolocation API.

Figure 68: The mobile LBS value chain, after the iPhone



Source: PTOLEMUS

2. The strategic landscape and its evolution

Within 3 years, Apple managed to completely alter the value chain.

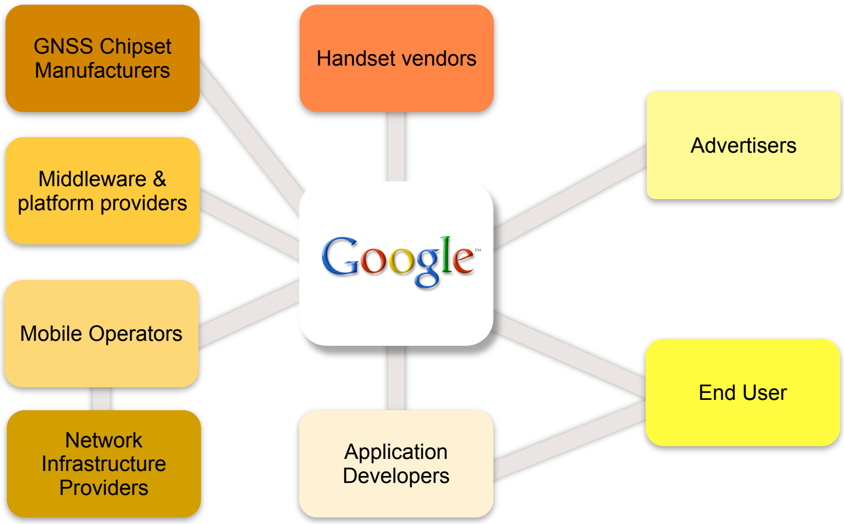
We expect that it will continue to evolve, notably under Google's influence.

In Google's ideal vision of the **Android** model, a Google phone is sold directly to the user without an operator contract, this model has severed the link between the device and operator.

The OS now controls the device, the location platform and the application provision and the user location data, which it can then use to sell location-aware advertising.

Clearly **Google is putting itself at the centre of the location ecosystem**, as the following chart indicates.

Figure 69: Google's target Android value chain: welcome to a Google-centric world!



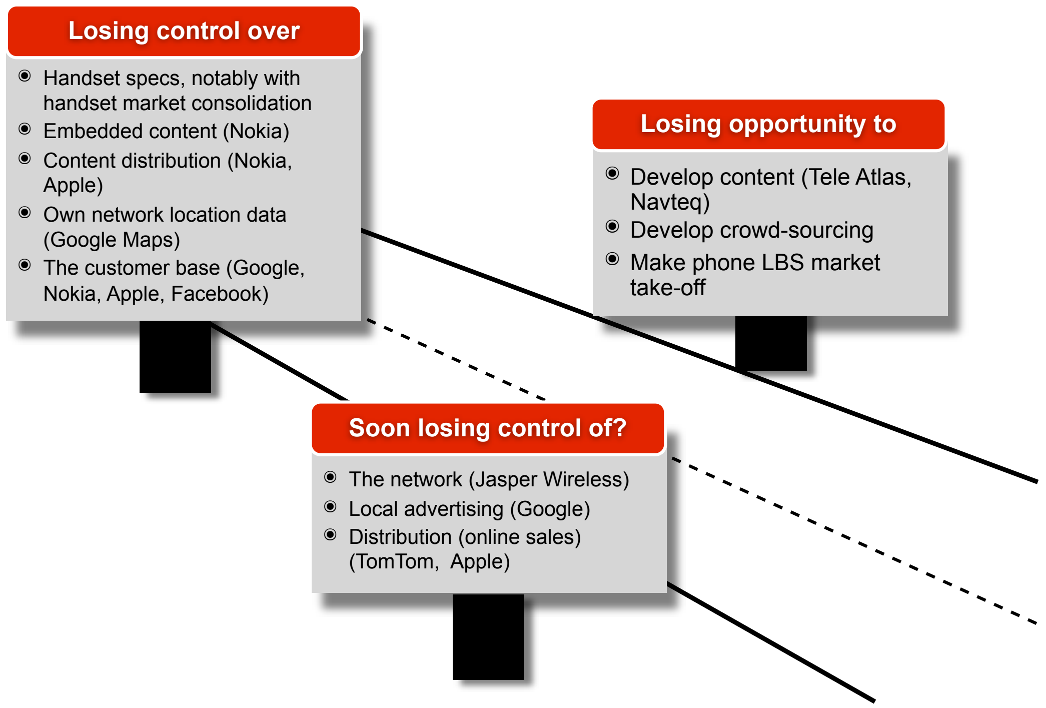
Source: PTOLEMUS

In reality, Google recently stopped selling directly its Android handsets to end users in the US, realising that this model was adapted to "geeks" but not the mass market. It also probably understood the challenges of product logistics in the physical world!

To counter Apple and Google, **Nokia** has, despite the fact that it is present on all steps of the value chain, adopted a **more collaborative strategy towards mobile operators**.

Overall, mobile operators are under intense pressure to innovate and generate new data-related mass markets. Without firm action, their revenues may fall off of a cliff as new players siphon off most of the value.

Figure 70: Will mobile operators fall off a revenue cliff?



Source: PTOLEMUS

One of the key **weaknesses of mobile operators is their fragmentation and the absence of truly worldwide players.**

The largest mobile operator, Vodafone, has operations (including partner networks) in 70 countries. Nokia sells handsets in 160 countries; Google's services are accessible in almost all world countries and are available in 112 languages.

To counter this, 7 mobile operators (AT&T, Vodafone, Orange, NTT DoCoMo, Softbank, Telefonica, T-Mobile) have jointly created the **Wholesale Application Consortium (WAC)**. Interestingly, this is the same mostly European-Japanese alliance that managed to make UMTS-WCDMA the 3G de facto standard.

Through the alliance, which now gathers over 29 members and over 3 billion mobile customers, **operators are trying to regain control of the application and service provision.**

They can capitalise on their existing strengths, notably

- Their purchasing power to specify device functionalities,
- The ownership of the location platform,
- The relationship with their users.

WAC will also leverage the work of the JIL (Joint Innovation Lab) alliance (Vodafone, Verizon, DoCoMo), of BONDI and GSMA's OneAPI initiatives.

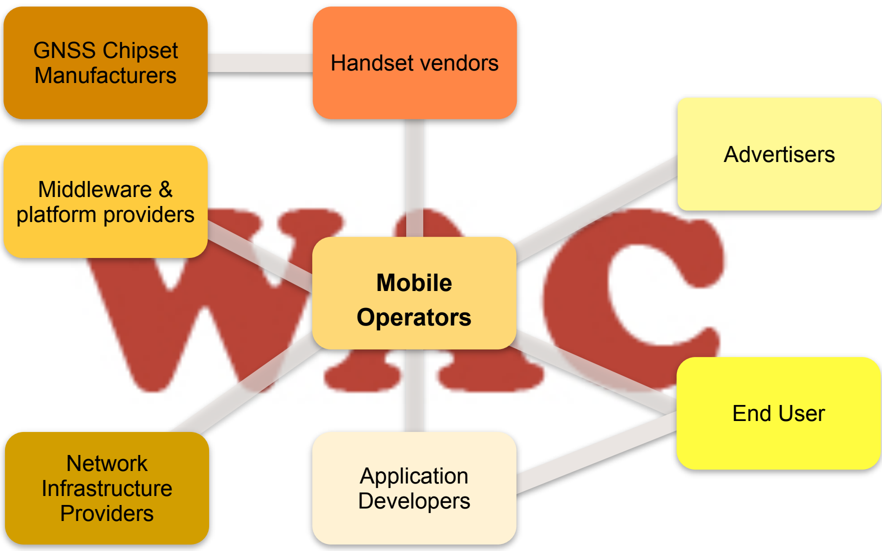
Figure 71: The 29 Wholesale Applications Community (WAC) members

Source: WAC

Central position will be given to the selected advertising network partners which will have access to rich data, the ability to geo-fence from the network and the power to make push marketing work.

In a nutshell, operators are trying to **leverage their combined scale to re-create an ecosystem they can largely control**.

Figure 72: The WAC value chain scenario: operators gaining control again



Source: PTOLEMUS

We believe that this initiative could succeed to “copy” existing models, for example Apple’s App Store.

Mobile operators have been pretty efficient at agreeing on international standards of operations. The GSM roaming framework is an excellent example.

Clearly, the idea of a **one-stop-shop experience for application developers to address 3 billion customers, would be a groundbreaking value proposition**. It would come in stark contrast to the growing OS fragmentation in the mobile world.

What operators will be less good at is dealing with uncertainty and rapid change.

The example of Vodafone’s acquisition of Wayfinder is a case in point. Less than a year after purchasing the company, Vodafone suddenly closes the business, probably influenced by the fact that Google and Nokia had suddenly decided to give away turn-by-turn navigation on mobile.

Therefore, we believe that the chances of success of the WAC initiative are primarily related to the stability of the industry. Rapidly changing business models would prevent such a large organisation to adjust fast enough.

On the opposite, a situation where Google and Apple would acquire most of the value in the mobile industry would actually be a catalyst of operators’ unification.

Operators who wish to set up branded services – or co-branded with a middleware partner – can opt for the User Plane option.

As shown by **Genasys** in Spain, both their SIMlocator service – a geofence set by the SIM – and their location servers pull the Cell-ID information from the operator’s network but calculate the location on a SUPL server installed behind the operator’s firewall.

The main advantage is that a SUPL server is more economic than a GMLC and easier to set up. It requires IP-trained staff as opposed to SS7-trained staff.

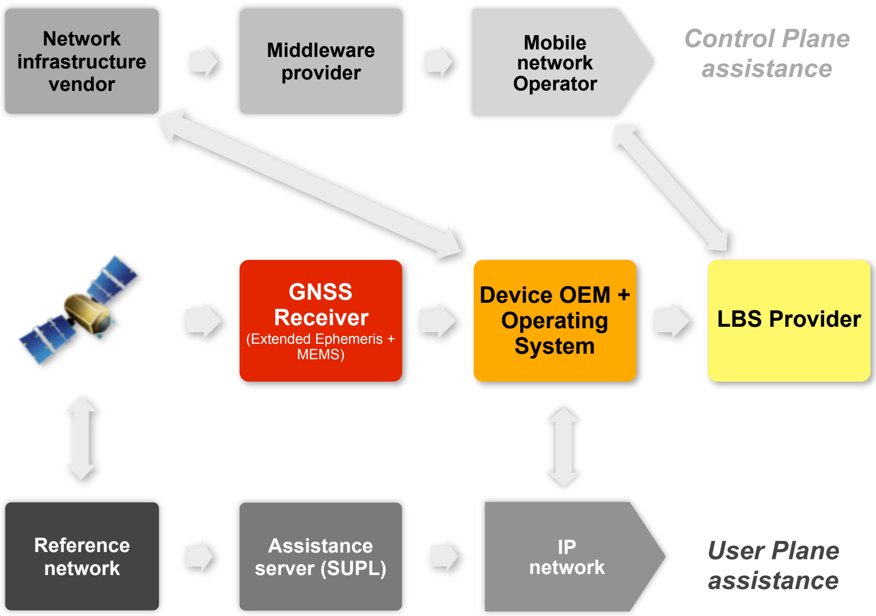
As operators take more control of location service provision under pressure from Google, Nokia and Apple, middleware providers will have to adapt and refocus their propositions towards mobile application provision, local search management or geofencing platforms.

D. A-GPS value chain

1. Major steps / roles

The following figure shows the impact the 2 major A-GPS configurations on the A-GPS value chain.

Figure 73: GPS assistance - Control Plane vs. User Plane



Source: PTOLEMUS

2. Major player types

Today, the **A-GPS value chain is controlled by device manufacturers** who select the location provisioning mechanism.

In the case of Android, Google is obviously deciding in lieu of device vendors.

GNSS receiver manufacturers are now able to provide more standalone assistance through EE (extended ephemeris) and sensors.

SUPL is becoming a key location calculation centre. SUPL ownership is moving from the upstream to the downstream part of the value chain. Infrastructure providers are now selling SUPL to device manufacturers and operators.

The middleware's role is taken over by application publishers and device manufacturers.

As a result, network operators' assistance infrastructure is rapidly becoming less competitive.

3. The strategic landscape and its evolution

Changes at the chipset level

GNSS receiver manufacturers now have their own location platforms and their own location servers with extended ephemeris data, as well as other location databases such WiFi or Cell-ID.

Chipset manufacturers also have the software platform capable of unifying measurement from different radios and sensors into one position output. Chipsets currently connect directly to FM, WiFi, and Bluetooth radios, processor and power management. They can also connect to their servers to provide all the data needed for that calculation.

Server access is sold both to device manufacturers and operators. However, selling an hybrid GPS + sensor + EE (extended ephemeris) + SUPL location proposition requires the device manufacturer or the operator to decide on the business case of the location provisioning process.

We believe that **complete sensor-based assistance for location will not emerge before 2012** as the cost of altimeter is still prohibitive and the integration of the 3 sensors (accelerometer, compass and altimeter) with GPS is complex.

The innovation will come to smartphones first, before finding its way into PNDs and other mobile devices. Compass and accelerometers are already assisting certain location applications and will become pervasive in smartphones.

Major drivers will include the wider use of AR (augmented reality) display and indoor maps.

How chipset assistance is implemented varies widely, depending on the relationship with the device manufacturer, which in turn depends on:

- The relationship between the device OEM and the operating system. If the OS is the "driver" of the device (e.g. in Android or Apple devices), then all service and technology providers compete on the upper layer stack. If the phone is a closed system, most of the technology is pre-embedded;
- The device type: thin clients or smart terminal, connected or stand-alone;

The chipset manufacturers' future ability to provide the assistance service will depend directly on the devices, OS and ultimately the operators' strategies.

SUPL to become a key service centre and strategic stronghold

A SUPL solution is easier and more economic to deploy than a GMLC. It will not replace the old location infrastructure but will provide added benefits as more than 60% of handsets sold in Europe in 2014 will have GPS installed.

Since **Google is providing developers with a free API to access its SUPL server**, operators will quickly follow in their attempt to provide LBS directly to users.

SUPL 2.0 will provide for WiFi-location triangulation as well as LTE and WiMAX support, which makes it very attractive to large service providers as it will eliminate the need for them to deal with operators and WiFi positioning providers.

Also, Qualcomm has decided to support SUPL (as opposed to following the proprietary route) in the US. This will add leverage to the standard and foster a fast rollout.

Impact on mobile operators

GPS assistance can be perceived by mobile operators as having a limited value since it is only a small part of a larger value proposition, for example around navigation or social networking.

However, it will be increasingly used as a **customer experience differentiator**. This superior customer experience will lead in higher customer satisfaction and higher application usage.

When the mobile operator controls the service delivery and is responsible for its usability, then it will have to enable its network with A-GPS.

WiFi location as part of SUPL 2.0 will also enable operators to provide more pervasive location services.

Ultimately, their relationship with brands and advertising platforms is where the benefits of their location investment will come from. Obviously, a higher take-up of the service and an increased usage means more advertising revenue.

Another key operator advantage will come from the fact that **only they have the capability to provide location to all phones.**

E. WiFi value chain

1. Major roles

Open WiFi positioning data is available from mainly 2 companies, **Skyhook Wireless and Navizon**.

Google has also used its Street View surveying cars to build its own database of WiFi access points. Obviously, high quality coverage is limited to Street View-surveyed areas, which is still patchy. While Britain is almost entirely covered, countries such as Belgium or Germany are not yet covered.

In other countries, our understanding is that Google relies on crowd-sourced datasets from mobile Google Maps users. While this can help launch a positioning service, it is subject to a number of errors and cannot be checked.

Figure 74: Example of current Google Street View coverage

Source: Google

In Europe, there are also **a few local open source WiFi and Cell-ID databases** available such as LocationAPI.com, Yahoo Zone Tag, Celldb.org, gsmloc.org or cellspotting.com.

While WPS provision is based on open API access, there are **suggestions that WiFi and/or Cell-ID databases could be installed directly in non-connected devices**.

This makes WiFi positioning extremely flexible and easy to integrate with a wide range of technologies, devices and player types. Most of the integration is done through the open API with content and application providers, but there have been partnerships with many other types of players from browsers to chipset vendors.

2. WiFi positioning in the future

The open provision of WiFi positioning data service is limited to 2 players. We expect that this will change in many ways.

Cell-ID cannot be used for certain applications because of its low accuracy. A-GPS is also not ideal to gather historical data because the device will query the database only when it has moved far enough from the initial fix to require an ephemeris update.

In comparison, Cell-ID location will request a position from the server every 10-15 minutes, depending on how fast the device is moving.

WiFi positioning typically requests a fix from the server every 10 seconds in pedestrian navigation mode and every hour in social networking applications. This is enough to generate substantial behavioural data that could then be used by location search-based advertising companies.

Additionally, mobile operators are under pressure due to the forthcoming SUPL 2.0 standard that will include WiFi location support. The new SUPL database will enable more open access for new players. At the same time, SUPL vendors will need to source WPS technology and databases externally to run it on their servers.

At the application layer, companies such as Google – through their maps and navigation applications – and off-board navigation companies such as Telenav, Telmap or Networks in Motion (NIM, now part of TCS) will also be in a position to collect very precise historical data as the device will require a map update every few minutes. Off-board navigation is also an effective way to build up WiFi location data.

Other companies that can easily develop WiFi databases include mapping companies, i.e. **Navteq** and **Tele Atlas**.

The complexity of adding a WiFi access point surveying capability is extremely low given the fact that already collect over 200 attributes for any given area. They can also leverage their savoir-faire in making sense of large volumes of geographic data. We would not be surprised if they had already started collecting such information.

In fact, **Nokia recently announced that it has built its own WiFi /Cell-ID database,** thanks to both Navteq's surveying cars and end-user uploads. It is also clearly indicating that indicating that indoor mapping is one of its target. Maybe, it is not a coincidence that Navteq will launch its first indoor maps in Q3 2010...

ISPs and telecom operators also hold significant databases of WiFi access points, which they could use for positioning, as the example of Free in France demonstrates.

F. Overall location-enabling strategic landscape

1. What has happened to LBS? the iPhone case study

The extraordinary **growth in consumer mobile location services** in the last 3 years is primarily due to **one company, one device and one ecosystem**, i.e. Apple, the iPhone and iTunes.

While the iPhone success is well known, it is not always clear why it had had such an impact on the LBS industry. Hence the following case study.

Case Study 3: Apple's iPhone

- In January 2007, Steve Jobs said: "**Today, Apple is going to reinvent the phone"**
- 3 devices in 1: an iPod, a phone and an Internet communicator
- Actually, he was right

Why has Steve Jobs succeeded

- In our view, he has learned the lessons of the Apple Macintosh defeat against Microsoft
- Creating an ecosystem is stronger than creating an environment however excellent it is
- With the iPhone, he has actually built **an environment *and* an ecosystem**
- The same way Microsoft has built enormous inertia behind its Windows OS, Apple leverages **network effects**: each new application strengthens the iPhone

Why the iPhone LBS revolution has taken place

Location completely integrated in iPhone's API and user interface	→	• Extremely easy implementation for developers • Strong level of acceptance by end-users
Positioning data free from Google	→	No variable usage costs for application developers
Map provided for free by Google	→	No fixed costs for developers, encouraging the launch of free LBS applications
Availability of Skyhook hybrid location data	→	• High level of accuracy, notably in cities where 90% of usage takes place • Very fast fix, essential for mobile use

Solving the location privacy conundrum

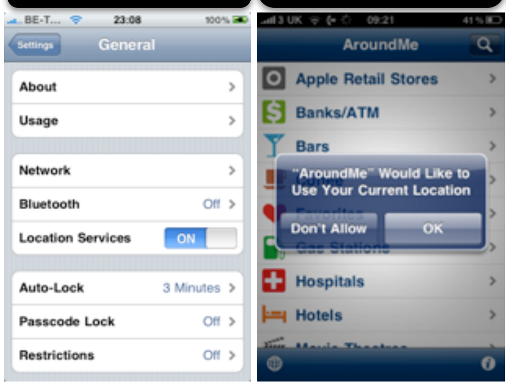
- In 2007, the user experience of most mobile services that required location was complex:
  - Needing formal acceptance for location request
  - Requiring generally at least 2/3 clicks
  - Each location request was costing something to the developer
  - Written in legal language
- Therefore, server-based LBS were very rarely used, which prevents a larger range of services

The iPhone solves all these problems

- Location agreement request is sent as a message
- Agreement requires only 1 click and question is always the same, for all applications
- Agreement is asked in simple language
- Location requests are free

Clear Opt-in / opt-out settings for location

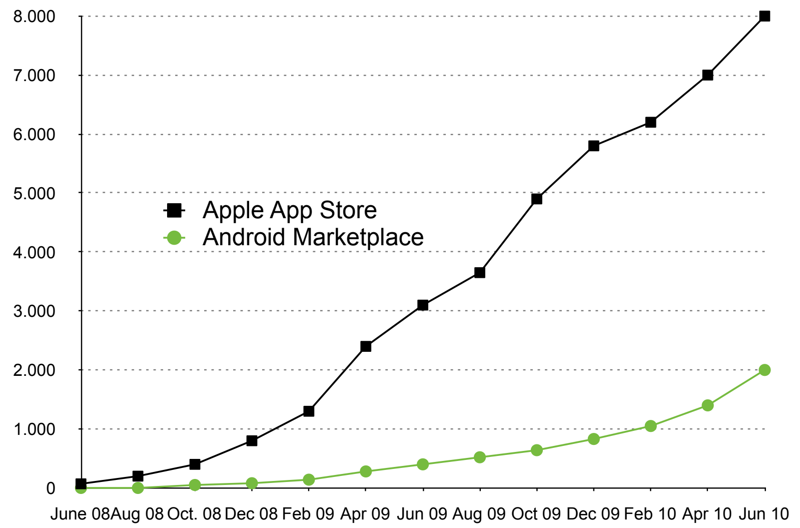
Uniform, 1-click location opt-in across all apps



Source: PTOLEMUS

We estimate that there are now approximately **8 000 location-based applications, or 4% of total, in the App Store**.

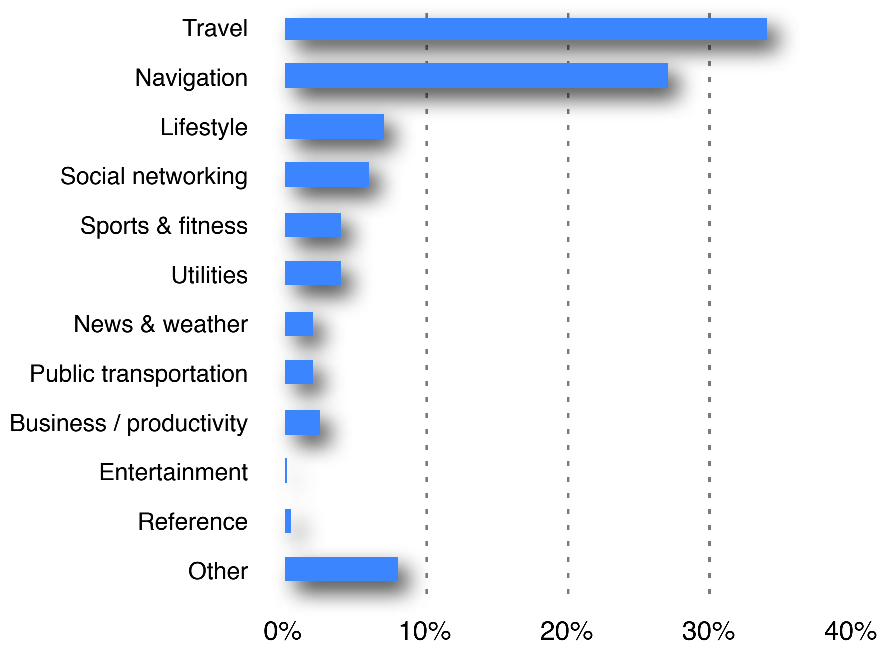
Figure 75: Number of location-based applications - Catching the iPhone high speed train...



Source: Skyhook Wireless, PTOLEMUS

Contrary to the common view, 75% of these applications are paid-for. In comparison, 80% of applications on the Android Marketplace are free.

Figure 76: Breakdown of location-based applications on Apple's App Store



Source: Skyhook Wireless, January 2010

What has happened?

Rather than build the best navigation application such as TomTom, Apple has **built an ecosystem** that allowed 2 500 navigation applications on its platform, making it almost unbeatable. It handles itself 20% of the applications that generate 80% of the value (e.g. e-mail, browser, phone etc.) and let third party developers do the rest.

Rather than manufacture dozens of different devices to cater to all needs such as Nokia, it has created a **single device** for which it controls and guarantees the quality end-to-end (down to external applications).

Rather than accumulate an impressive list of hardware features such as HTC, Apple has focused on delivering value by **integrating perfectly software and hardware**. At the launch of the iPhone, Steve Jobs quoted the computer scientist Alan Kay: "*People who are really serious about software should make their own hardware*".

Rather than rely on hundreds of separate operators to provide location, it has partnered with an international aggregator of location data.

Who will translate these lessons to other location markets, for example in-car telematics or fleet management?

What will come next?

In the last 12 months, Apple made several impressive moves:

- In July 2009, it acquired **Placebase**, a white-label mapping business and competitor of Google Maps for sophisticated mapping applications (e.g. complex customizations that integrate multiple and heterogeneous data sets);
- In January 2010, Apple paid $250-300 million to acquire **Quattro Wireless,** a competitor to AdMob, the ad network earlier acquired by Google;
- In April 2010, it launched the **iPad**, which can be seen as the perfect personal content (and ad) viewer, giving it access to 225 000 App Store applications from day one;
- In June 2010, Apple launched the **iPhone 4**, embedding notably a 6-axis motion sensor and creating the associated CoreMotion high precision position API;
- In June 2010, it launched **iPhone OS4**, its new operating system, including 1500 new APIs, background location capability and access to Microsoft's Bing search engine;
- In July 2010, Apple will launch **iAd**, its own advertising network and restrict access to campaign data for companies with competitive mobile technologies.

In our view, these steps indicate quite clearly that Apple is attempting to bring 2 additional components to its ecosystem:

- **A local advertising network**, with the idea that it will be able to control the end-user experience and prevent intrusive or inadequate ads; given the fact that Apple offers access to users which spend on average 30 minutes per day using the iPhone / iPod Touch applications, we believe this is a highly credible proposition. However, iAd will require iOS4 and therefore be limited iPhone 3G, 3GS and iPhone 4.
- **An "Apple Maps"**, where it can add layers on existing maps (whether Google Maps or Tele Atlas, Open Street Map, etc.) so as to control the user experience. In the mid term run, Apple may be tempted to use its customer base to build crowd-sourced maps.

We also perceive that its video calling service (FaceTime), combined with its 6-axis motion sensor, could be used for numerous **location-based AR applications**, notably

- high precision indoor and outdoor navigation, guidance and local search,
- 3D virtual outdoor ad display (e.g. for special promotions),
- social networking, etc.

Once again, Apple uses its control of hardware and software to introduce ground-breaking applications that differentiate its products from competition.

2. Who controls the value chain?

The influence of Apple's iPhone, Nokia's free navigation and Google's free location API has created **high risk areas in the value chain**:

- **Network operators risk becoming "bit pipes"** unless they succeed in creating a level playing field for location-based services, which could come from a **common service platform**. Latest changes in the phone market have pushed operators out of the location data and service value chain. Control of the customer relationship is also lost as the new application supply chain does not use their own billing system. Credit card payments on IP networks have pushed operators out of the billing loop, removing what operators viewed as a big barrier to entry;
- **Location aggregators** will experience both accelerated growth and an increasing number of competitors or substitutes;
- **Location network infrastructure vendors are under pressure**, as location platforms are rapidly becoming a **commodity**. As SUPL becomes the favoured platform standard, application providers, OS and device makers all want to provide the location service and controlling user's "trail". As a result, vendors charge 5 times less for GMLCs than they did 3 years ago and it is widely expected that SUPL server prices will fall too.
- Positioning technology providers are now having to compete with 'free', i.e. Google's free location API.
- Content providers, such as maps and POI suppliers, are also at risk as Google Maps' offers for free a increasingly large range of services, from mapping to turn-by-turn navigation.

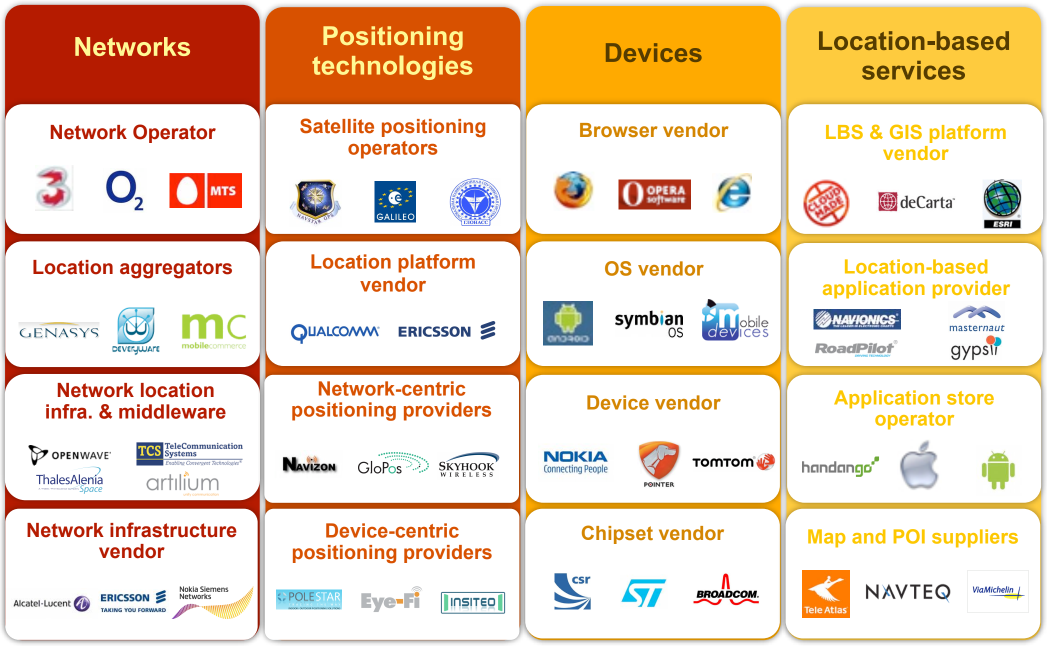
However, the increase in location data understanding and usage will also bring **growth to several areas**:

- GNSS chipset performance will improve significantly thanks to new satellite constellations and improved assistance systems, which will contribute to **develop demand for satellite positioning**;
- Due to its unrivalled ability to provide fast urban and indoor positioning, **WiFi location will continue to develop very rapidly**;
- The decreasing cost of GPS and WiFi chipsets will drive fast growth of WiFi- and GPS-enabled devices, which will in turn propel the market for location-based services and content.

Within the last 5 years, **the balance of power has switched away from infrastructure companies** (platform vendors, mobile network operators and chipset vendors) **to downstream players**. e.g. device / OS vendors and application providers.

While location provision was perceived as a business in itself a few years ago, it is now clear that **enabling location applications is a much larger market opportunity**. Service companies operating their location business as a specific P&L will not succeed unless they have a global business and a very specific offering (e.g. WiFi positioning).

Figure 77: Overall location provision value chain

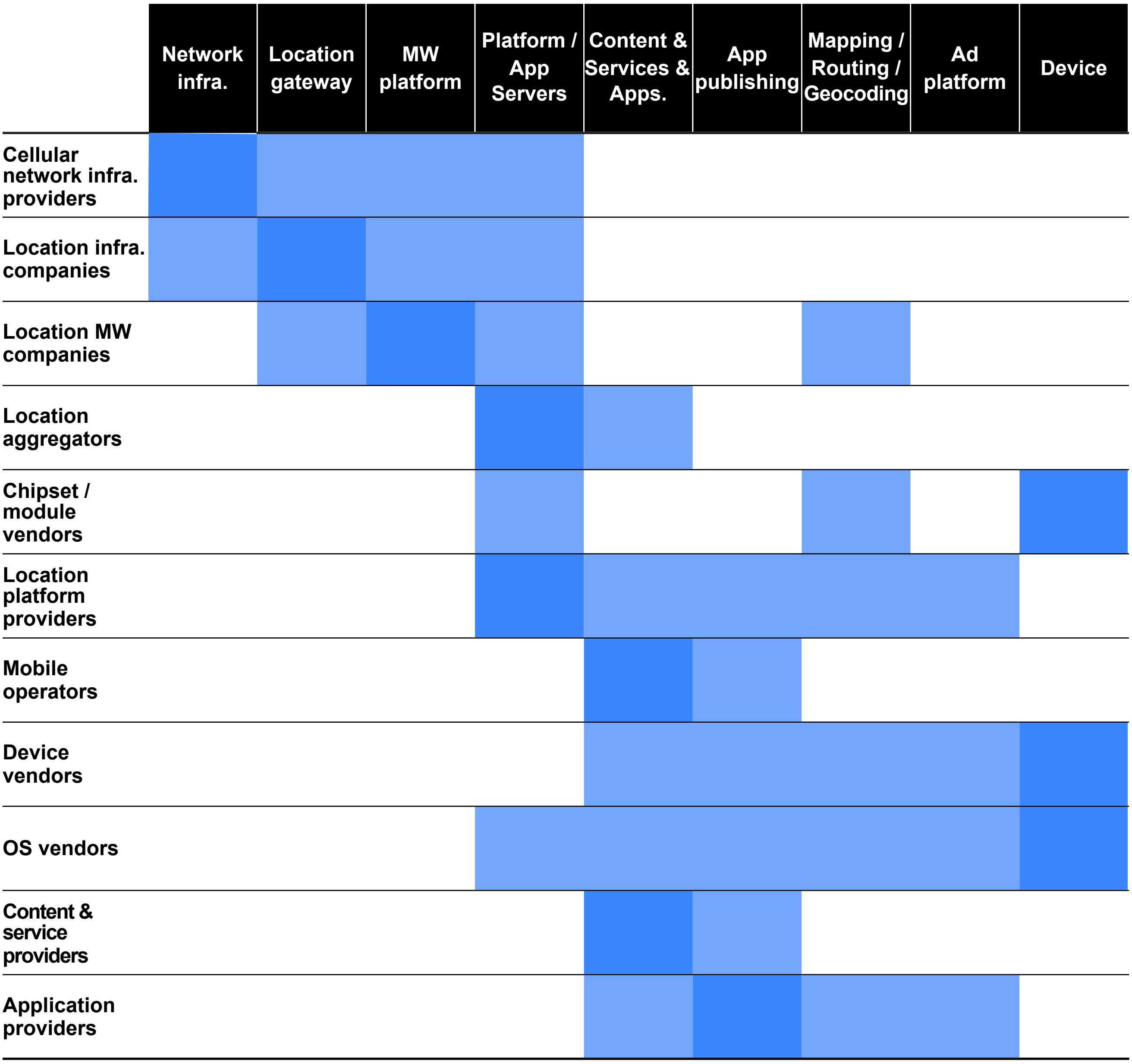


Source: PTOLEMUS

In our view, t**he business case for location should not be seen by mobile operators vertically** ("I need to have a ROI on my location platform") but **horizontally** ("I need to generate a positive ROI across all location applications and services including advertising").

In other words, pricing of location per request is not the optimal model, unless prices become extremely low (e.g. less than €0,001 per request). Fixed-price, unlimited usage bundles or revenue sharing models appear to us as better adapted to help the Cell-ID market take-off.

Figure 78: Co-opetition* reigns and all players have increased the breadth of their capabilities



Note: Blue cells represent functions that are commonly assumed by a company type; Darker blue cells represent their initial activity. Co-opetition is a neologism coined to describe co-operative competition, i.e. two companies can compete and co-operate at the same time, generally on different areas.

Source: PTOLEMUS

As Figure 78 demonstrates, an **increasing number of companies are covering a wider part of the spectrum of activities in the location value chain**.

All players are both competing and co-operating with / against each other as the following examples indicate:

- Nokia, together with Nokia Siemens and Navteq could be said to cover all functions, while Navteq also sells its maps to multiple handset vendors;
- TCS extended its range by acquiring middleware vendor LocationLogic from Autodesk and navigation software vendor Network in Motion;
- In the last 2 years, Google entered the OS part of the chain and also provide free access to its SUPL server. This does not prevent Google to offer the Google Maps service to Apple.

What will increasingly matter will be the **end-result** of this increased scope of activities. Can it enable them to attain the best value proposition for the customers they are targeting? **Success will be brought by smart strategies but also by smart and fast execution**.

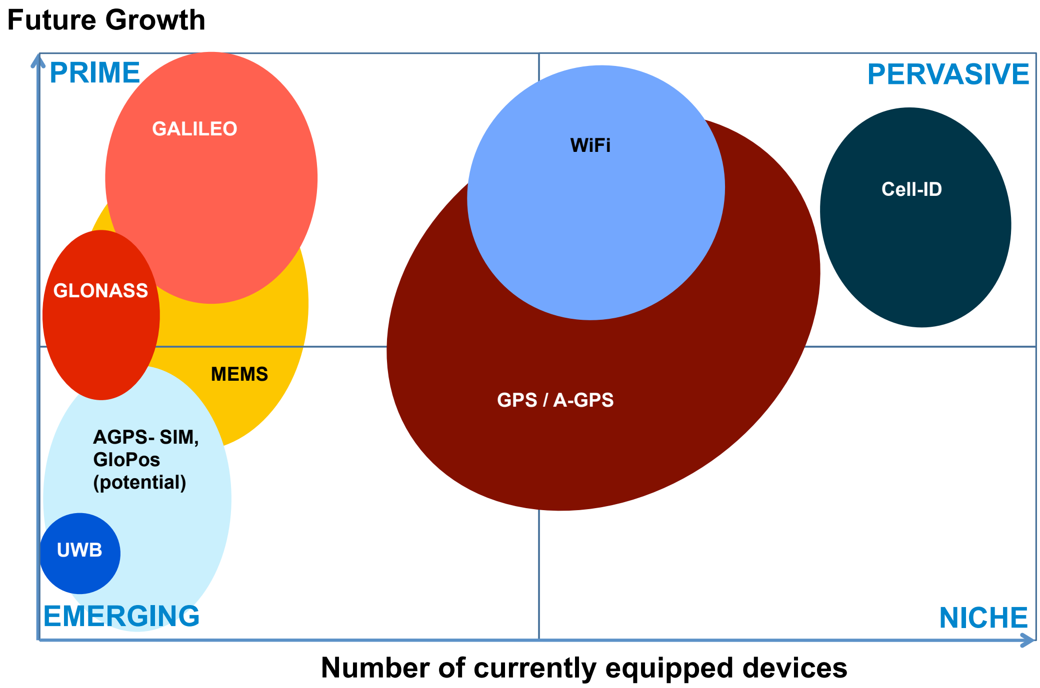
3. Which technologies will become dominant?

During the next 5 years, we expect the 3 most widespread location technologies to become pervasive and a number of new technologies to emerge:

- **Cell-ID**, which benefits from standard support in GSM, UMTS and LTE networks, will be increasingly implemented and used by operators, who will start offering low cost and pan-European tariffs;
- **GPS** will stay on top in terms of number of devices equipped and range of applications and device types and A-GPS will become a standard feature of smartphones;
- **WiFi** will benefit from its extensive penetration in devices, notably thanks to combined Bluetooth / WiFi modules (e.g. from CSR or Broadcom) to become ***the* most important indoor and urban positioning technology**, complementing satellite technologies in suburban and rural areas;
- **Glonass** will start to become used as a complement to GPS for high reliability commercial applications;
- **Galileo** will be gradually integrated in most GPS chipsets as a key differentiator.

Clearly, technologies such as A-GPS SIM and Glopos could also disrupt these forecasts if they deliver on the expectations they have created.

Figure 79: Trends in location technology attachment rate by 2015



Note: Circle size is proportional to number of markets where each technology is present
Source: PTOLEMUS

4. Will location become a commodity?

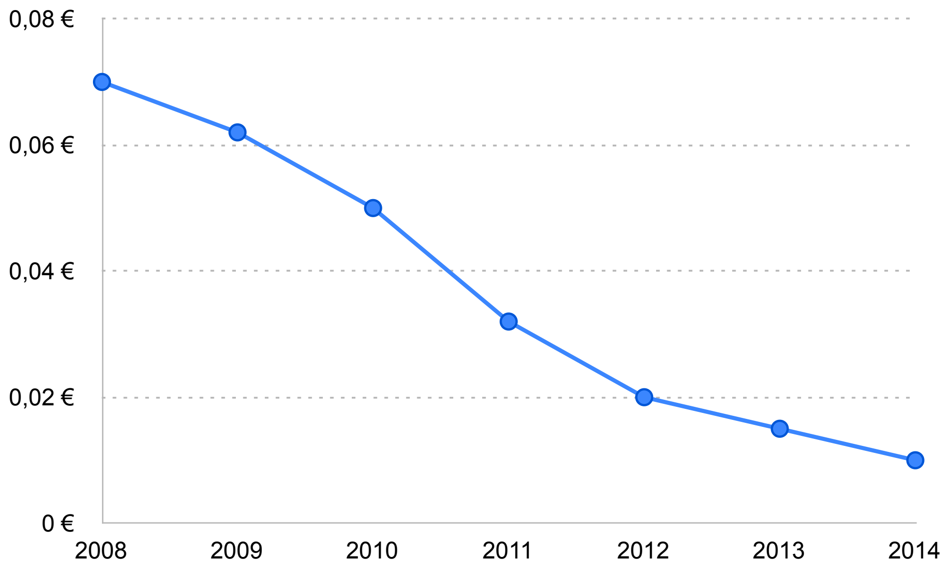
Positioning brings a solid value; business models change but the need is increasing.

Location data, however, has lost its perceived value, and the market is now contemplating the fact that navigation, once a key monetising application, has become a feature in part of a wider set of services.

Location data has become a commodity because the value derived from it is not paid for by the users but through the future model of location-based advertising. There is currently a chasm between the expected value of the "crumb trail", the availability of location data usable for monitoring and the willingness of brands to invest in location-based advertising.

Cell-ID location request prices have come down rapidly in Europe in the last 5 years, as the following figure reveals.

Figure 80: The price (in €) of a Cell-ID request will fall rapidly, so as to "create" the market



Note: Average price of European mobile operators (not volume-weighted)

Source: PTOLEMUS

We expected these to **drop even faster as the market has not taken-off yet**. For example, T-Mobile Germany's price of approx. €0,05 per request (depending on volumes) has not enabled volumes to become significant. This is despite the fact that interconnection between operator platforms has been made between German operators.

In the future, we would expect Cell-ID prices to decrease by a factor of 10, notably through revenue sharing agreements and fixed, unlimited contracts per user. Given the fact that operators have very low marginal costs, **the key about this market should be about volume, not margin!**

In our view, the **value of Cell-ID has not been fully understood by market participants** because the market has remained so small. Similarly to the GPRS data market a few years ago, it requires a radical change in its model to enable operators to generate revenues from it.

Cell-ID has a number of very distinctive features, notably:

- The near-universal penetration of the capability in handsets;
- It is **always-on and ubiquitous**, including inside buildings, tunnels and in many subway stations. This is understood by a navigation provider such as Telmap;
- The very low impact on the device battery, and, as surprising as it sounds;
- Its relative lack of accuracy.

This enables **applications where accuracy is specifically unwanted**, such as

- Location-based advertising and promotion,
- Location-based security tracking applications where precise location can pose a risk,
- Friend finder or family tracking services where less precision is perceived as less intrusive,
- Social network status information (As a default setting, "John is in Mayfair" is more acceptable than "John is at 3 Berkeley Square at the Rolls Royce dealer"),
- Mobile dating, where accuracy can pose privacy issues.

Furthermore, for other applications that require accuracy, **Cell-ID can be improved thanks to a number of techniques**, i.e.

- Device-based learning software (e.g. GloPos),
- Map-matching (as TomTom's HD Traffic cell-based feed demonstrates),
- Matching with context: if a device is moving at 130 km/h, it is highly likely that it is located on a motorway (e.g. Artilium),
- Matching with other device technologies such as GPS or WiFi (e.g. Google Maps).

As a conclusion, we would say that certain market participants, such as Google, are advocating Cell-ID to be free because operators have not demonstrated that there is a market.

Because location is not always a big part of the value proposition, **a mass-market cannot emerge without a radical change in operators' pricing policy**.

So, the answer is yes. **Location data should become a commodity, the same way as oil and wheat are**. This would mean that

- A number of **standardised products** exist, that all market participants understand well and trade freely,
- A **mass market has emerged**, which pushes all value chain players to focus on growing its size rather than on their own short-term margins,
- **Trading places** assist all players in having a clear and transparent vision about the value that other market participants can place upon their products.

This commoditised location data market would be highly beneficial for all parties, including operators who would at last generate a return on their location investment.

A detailed example of how Cell-ID can be monetised using its key differentiator is examined below in the LociLoci case study.

Case study 4: LociLoci

LociLoci is a web and mobile location-based social network originated in Sweden

LociLoci has a compelling service:

- LociLoci offers mobile subscribers to see their friends' location in real time using network location, across 3 countries (Sweden, Norway and Finland)
- The service is accessible to all GSM and 3G subscribers, whatever their handset. No software installation is required.
- Cell-ID low accuracy enables compelling non-infringing tracking on any phones, anytime,
- As a result, LociLoci now has a customer base of **over 20,000 subscribers**, growing regularly.

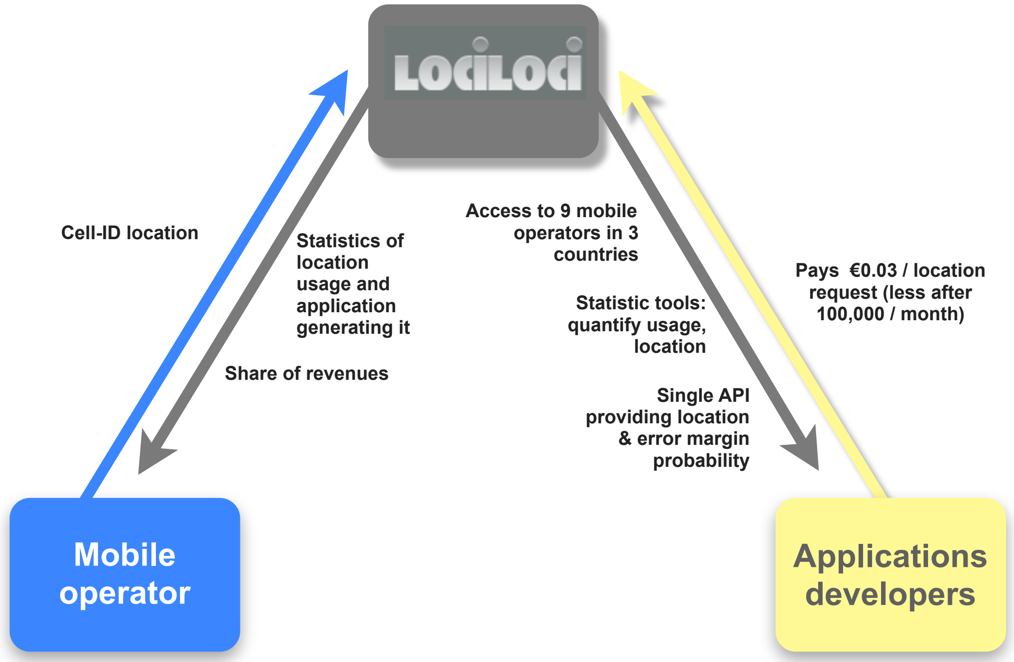
To achieve this LociLoci has built :

- A unique environment,
- A unique ecosystem,
- A unique financial model.

☐ A unique environment

- ✓ Simple, focused service to track the location of children and elderly people
- ✓ Transparent tracking: weekly statistics sent to users on who, when and how often they were tracked
- ✓ Mobile number is used as the login
- ✓ A web-based service at heart, mobile comes second (as Facebook)
- ✓ Subscription paid through existing mobile phone bill

❑ A unique ecosystem



❑ "The ability to locate anyone, anywhere, anytime"

1. Generates value from key operator's asset usually vastly under-utilized
2. Monetises network location without the operator's input, showing that a small company can often be more agile than a large MNO organization
3. Network-centric location technology pulls position from the device on request, providing a service superior than a device-centric technology
4. Authorisation, privacy, billing and access are all managed at network level
5. Privacy and safety issues are minimal thanks to Cell-ID limited accuracy, i.e. the user remains in control

❑ An interesting business proposition

LOCILOCI business is viable because the price of location is lower than 15% of its general revenue

LOCILOCI risks on the variation in location usage and "ping" cost is offset by its wholesale business.

But sustained growth will depend on operator's willingness to :

- Generate sustainable wholesale location prices
- Support location data roaming between European countries

Location case study: LOCILOCI

A unique business model

Revenues

- Subscribers: 20,000
- Subscription: €0.5 to €2.5 per week, depending on geographical market
- Location data resale: €0.03 (volume discount after 100K/ month)

Costs

- Cost of Cell-ID location: < €0.03 per ping (depending on network)
- Operator revenue share: 41%
- SMS aggregator share of subscriber revenue: 6%

Effects of location costs and usage based on the LociLoci model

Cost of request	1 location request / user / day	2 location requests / user / day
0.020	146K cost . 436K profit	292K cost. Profit 290K
0.030	219K cost. 363K profit	438K cost. profit 144 K
0.050	365K cost. 217K loss	730K cost. loss 148K
0.070	511K cost. 71K loss	1022K cost. loss 440K

Based on following assumptions:
- *20,000 users;*
- *Net share of subscribers benef. : 32%;*
- *Subscription fee of €1.75 / week.*

Source: LociLoci, PTOLEMUS

5. Expected strategic moves

Thanks to our detailed analysis of the value chain, we have been able to describe what we expect to be the key strategic moves in the next 2 years.

Location-based services developers

(1) *A few platforms will concentrate most of their development*

The biggest location provision market growth is in smartphones.

Application developers have only a limited potential to write application for multiple OS and handsets so we expect a few platforms to attract the bulk of location-based applications.

Apple's iPhone has the **potential to remain the key OS platform for LBS developers in the US and in Europe** because:

- It offers a single device and a single development environment, worldwide
- It provides free positioning and uses a wide range of technologies,
- Billing is provided by Apple,
- Its Application Store has already 2,300 location-based applications, 755 of which are paid for (Android has 300 with 20% of them paid for),
- It holds a 70% share of mobile browsing in Europe.

Android will probably become the second platform in the US and in Europe thanks to 2 advantages:

- It will be strongly orientated toward generating LBA revenues,
- Android offers background location capabilities.

In other world regions, i.e. Asia and emerging markets, we expect **Nokia and Samsung**, which have wider and more adapted product portfolios, to build the strongest development environments.

(2) *Device vendors and operators will increasingly be a competition to developers in the most valuable domains*

We expect that the balance of power in LBS will be decided by who ultimately dominates a few applications such as location-based social networking.

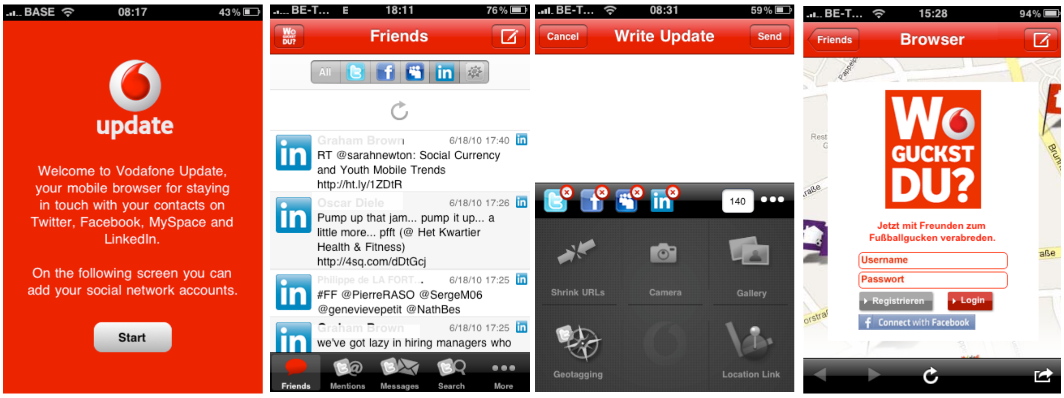
The untold story about Application Stores is that device vendors and operators will increasingly try to develop the 20% of applications that generate 20% of the value. Although they are all committed to attract developers, device manufacturers and mobile operators will have no choice other than increasingly compete with them to provide these key services.

To take a physical world metaphor, device vendors and operators exploit the shopping centres and need to make sure that the flagship stores that draw visitors are better than their competitors'. Their objectives will be to maintain a customer relationship and generate LBA revenues, **leaving the long tail only to developers**.

Examples of this are numerous:

- Nokia Maps, Nokia Point & Find (AR viewer and geo-tagging application)
- Google Maps, Google Latitude, Google Photos (Picasa), etc.
- Apple's iPod function in the iPhone or its e-mail client,
- Vodafone Update, which gathers multiple social networks in a single client.

Figure 81: Vodafone Update multi-social network client



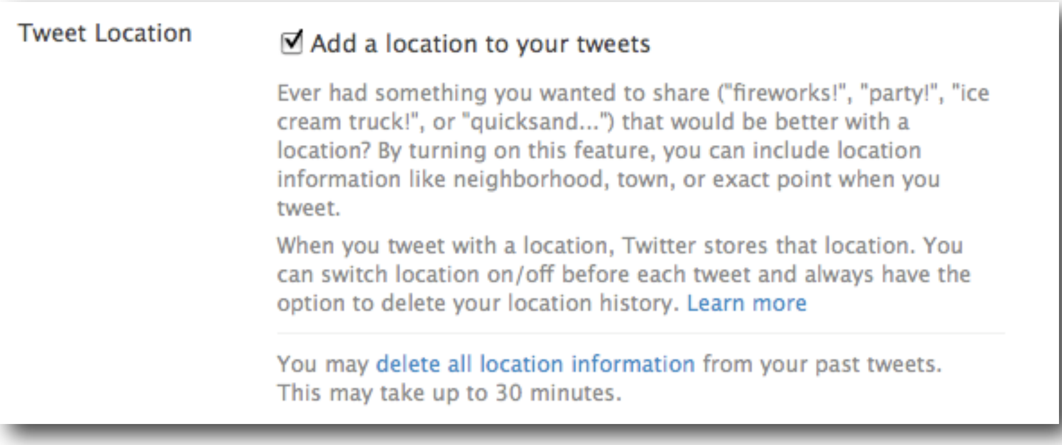
Source: PTOLEMUS

(3) Large providers will purchase their own location infrastructure

For large international web- and mobile-based services such as Twitter, Meetic, Spotify, and Viadeo, it will make economic and strategic sense to control the positioning information provision.

Smaller developers might not have a choice however as the Apple, Nokia and Google vertical "silos" will retain control over the mobile device's location.

Figure 82: Large LBS providers will increasingly use and generate location data



Source: Twitter

Mobile browsers

All mobile browsers will enable web applications and widgets to **access the device's location** directly.

This opens the door for more cloud-based applications running from the provider's servers to be location-enabled without the need to install a client on the device.

Device manufacturers will have a **limited choice** of independent browsers as the market leaves space only for Firefox Fennec and Opera.

Firefox and Opera inlay into Apple Safari, Nokia microB and Google Webkit on their mobile devices will stay **limited and marginal**. Opera Mini only has 30 million users worldwide. Firefox Fennec runs on Nokia's Maemo platform but Nokia just bought Opera's competitor Novarra for its low-end series 40 phones.

GNSS chipset manufacturers

(1) New markets

Strategic opportunities for GNSS chipset manufacturers include new location-enabled devices such as the iPad, netbooks, e-books as well as cameras and other consumer electronics devices.

Another mass market will be driven by regulatory safety initiatives such as eCall and Road User Charging (RUC). Other vehicle usage-based charging services such as insurance, leasing and rental will also become significant markets. In both cases, this will create new customers for chipset vendors, primarily telematics systems vendors such as Octo Telematics, Masternaut or TrafficMaster or integrators such as IBM and Steria.

(2) Location assistance becomes key

GPS chipset manufacturers will combine a number of location technologies and assistance into one service, including on chip as well as server-based assistance. “Combo chips” including Bluetooth, WiFi and GPS will become more widely available. These will also push chipset vendors to partner with WiFi positioning providers.

(3) New partnerships

The need for a combination of motion sensors and GPS in phones and cameras will foster partnerships with MEMS manufacturers. We also expect direct partnerships with OS providers and device manufacturers. Specifying capabilities and SUPL server implementations will enable them to generate their own location environment.

Mobile operators: bit pipes or service providers?

We expect European operators to split in 2 groups:

- **Application and service providers** looking to invest in and control the service and content provision against the competition from the 4 silos. Vodafone and Orange and 3 are examples of such operators;
- **Connectivity and service providers** focusing on keeping the network able to sustain the rise in data traffic: KPN, Bouygues Telecom, etc.

Both groups are expected to **invest in location technology** assistance to provide to application developers as well as directly to users.

Operators have options to control again the value chain, notably

- Making WAC a reality,
- Making Cell-ID technology one of the most used location technologies,
- Creating joint databases of the millions WiFi access points they control to rival existing players,
- Convincing large communities of customers to opt-in to services such as social networking and LBA,
- Better leveraging historical and real-time location data they hold about their customers’ devices.

In our view, however, this will happen only if and when they recognise the key importance of location for their overall business model.

What will Google do?

In the LBS market, Google will continue to drag value away from data and services and into user behaviour. It will continue to **draw the industry towards a free, ad-based model**.

To achieve this objective, Google has an extensive range of tools

- A free location API linking to
    - Its Cell-ID and WiFi databases,
    - A SUPL server with extended ephemeris,
    - Its 2D, 3D mapping and routing engines and Street View,
- Free mapping and turn-by-turn navigation (Google Maps),
- Free location-based social networking (LBSN) – Latitude using Cell-ID, WiFi and GPS location,
- The Chrome browser with Gear Geolocation API and W3C Geolocation API on Android handsets,
- Location search on browsers, iPhone and other (e.g. “Google Suggest” is now location-aware),
- Location-based account security.

Figure 83: Google Earth’ plug-in for Google Maps opens the door to advertising billboards

Source: PTOLEMUS

This suggests a radical change in the relationship between content providers, OS and device providers.

One of the key ways to generate local advertising is to control the provision of the location data, the advertising inventory and the response tracking.

To achieve this, Google

- Acquired **AdMob**, the leading mobile advertising network,
- Secured a patent (US Patent 7,668,832) to incorporate location data into web and mobile advertising services.

This patent offers Google the capability to

- Serve advertisements depending on location, required form and content,
- Enable advertiser partners to target ads by location,
- Enable tracking ad response using location-specific metrics.

Google's strategy on location is summarised hereafter by Jonathan Rosenberg, its Senior Vice President of Product Management.

> "I also sometimes hear that it's not always obvious how some of our big product investments tie together. If you look here at what we're doing with maps and local, you'll see that we have the ad infrastructure, geographical data, Google voice, and place pages, and those things are now all working together to create a very compelling solution for small local businesses.
>
> **So everything is now really finally in place for local businesses to easily connect with customers online**."

IV. THE LOCATION-ENABLING MARKET POTENTIAL

A. Consumer device market potential

1. Addressable base and location penetration of consumer devices

a. Penetration of positioning in cars

In 2008, there were over 220 million cars in use in Western Europe (ACEA). The European car market peaked in 2007 when registrations reached 15,5 million. Since then, it decreased significantly and Carlos Ghosn, President and CEO of Renault Nissan, predicts sales of 12 million cars in 2010.

While the market for embedded navigation systems remained a niche due to high prices (above €2 000 in general), we expect the situation of in-car telematics to change radically.

Three simultaneous causes will provoke an explosion of the in-car location market:

- **Introduction of low-cost navigation systems** (between €500 and €1 000) designed by TomTom and Garmin for Fiat, Renault, BMW, PSA, Toyota, etc.
- **Increasing awareness and understanding** of the benefits of in-car navigation by the general public, notably due to free navigation models by Nokia and Google,
- Effect of **e-call** becoming mandatory by 2014 and other telematics projects such as Pay as you Drive insurance.

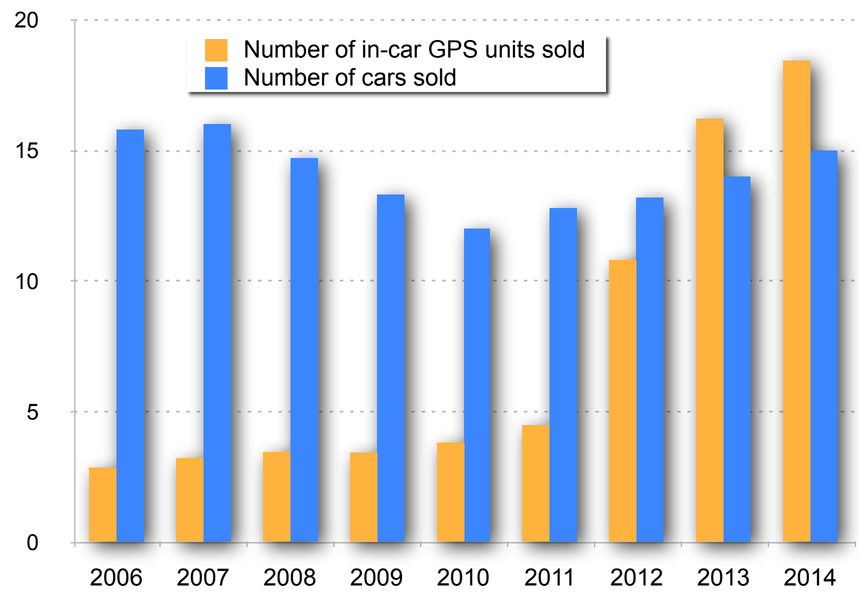
We believe that there is a **high probability that eCall will be mandated by 2012**, which will have an instant impact on the number of vehicles equipped.

There will also be a number of other applications that will contribute to increase the penetration of GPS chipsets in cars:

- **Pay as you Drive (PAYD) and Pay how you Drive (PHYD)** applications, which will increasingly be combined with value added services such as stolen vehicle recovery, roadside assistance, etc., following the winning model introduced by Octo Telematics with Unipol in Italy and Mapfre in Spain;
- **Road user charging (RUC)**, which we expect a number of countries to adopt by 2014, notably the Netherlands and potentially Germany;
- **In-car dynamic services**, following TomTom's model of LIVE bundle of services including advanced traffic, local search, fuel prices and speed camera alerts and reporting;
- Roadside assistance;
- Stolen vehicle recovery.

Overall, taking into account all telematics applications, the **average penetration of GPS chipsets embedded in vehicles is expected to rise above 100% by 2014.**

Figure 84: In-car GPS chipsets will exceed new car sales from 2013



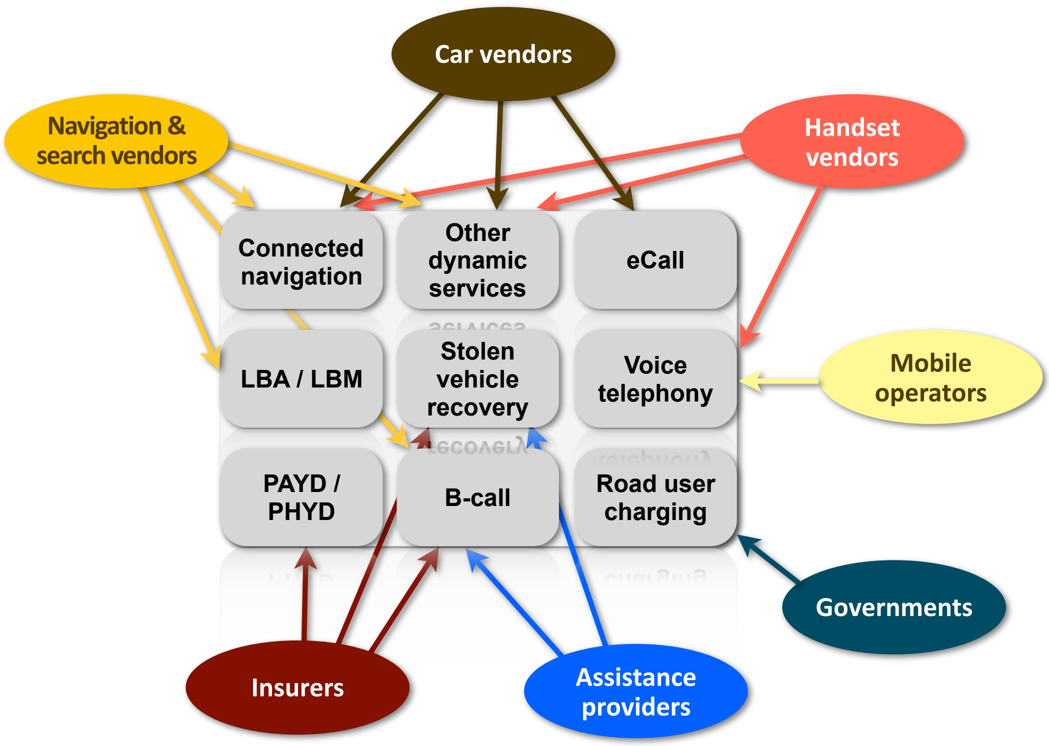
Source: ACEA, PTOLEMUS

This is due to the fact **private vehicles will often be equipped with several individual systems running independently**. This does not include PNDs and GPS-equipped mobile phones being used in the car.

Although we fundamentally believe that the business case of telematics primarily relies on integrating several services into the same box, it is clear that **several players will attempt to become the key entry point to the connected car**.

This will surely include car OEMs and insurers and potentially also mobile operators, assistance companies such as ADAC or Europ Assistance, and governments in the case of RUC.

Figure 85: Who will control the connected car?



Source: PTOLEMUS

The **GPS technology** can be optimised in the in-car environment.

In particular, an embedded GPS module brings higher efficiency in power consumption. The effect is twofold:

- Firstly, it allows the GPS module to be always on (or in a power saving mode), enabling various processes continue to be performed;
- Secondly, it allows a more power-intensive configuration of receivers, with typically can double the number of channels to search for satellites.

Current GPS chipsets generally have 20 channels, as this is the optimal configuration based on cost, size and power consumption. Because size and power consumption are less of a restrictive factor in a vehicle, the number of channels can be increased to around 40.

This configuration brings benefits such as a faster TTFF from ignition on, quicker re-acquisition, higher sensitivity permitting a deep and/or covert installation (such as on-board devices).

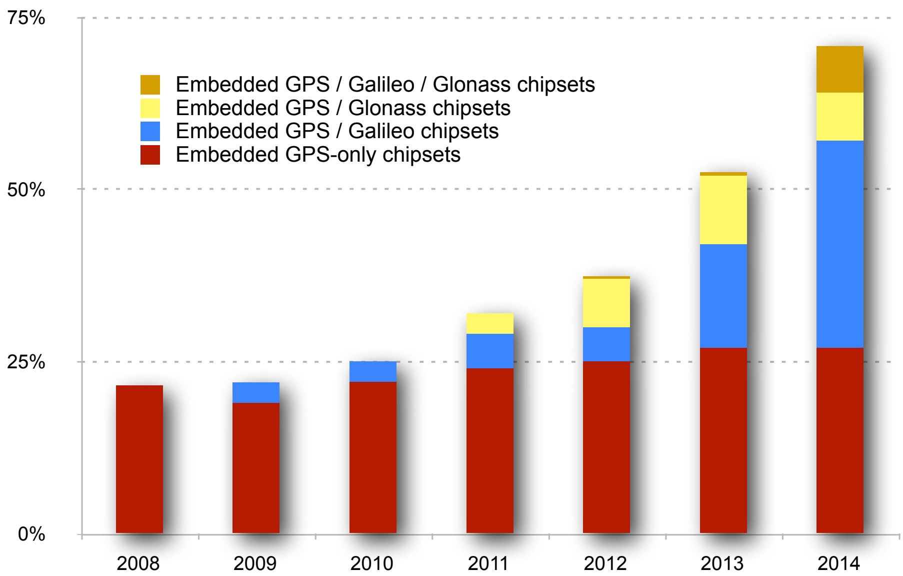
"**Galileo-ready**" has already become a marketing term for chipset manufacturers to sell their high-end models.

The SiRF StarIV chipset and ublox' UBX-G5000 are already "Galileo-ready". Broadcom's BCM4751 is also EGNOS-ready, despite EGNOS's relatively limited impact on ground location accuracy.

We expect **Galileo to become mainstream in cars from 2013 to 2014**, i.e. earlier than its full operational availability, now pushed to 2016-18 because

- It is likely that a Galileo signal will already be available in 2014 and maybe even 2013), before its official launch (the same way EGNOS has been),
- A European car is used on average for 14 years and vendors will prefer to launch "future-proof" models,
- The eCall service, which is likely to be mandated by 2014, will benefit from the improved 1 metre accuracy (which for example can be crucial to know on which side of the motorway an accident has occurred) and potentially the guaranteed integrity provided by Galileo's Safety of Life service,
- In general, Galileo will also bring a faster TTFF and higher accuracy for navigation and prevent current GPS positioning errors (such as location on a nearby road),
- The very low incremental cost of integrating Galileo into a GPS chipset.

Figure 86: The end of the GPS monopoly in car embedded chipsets



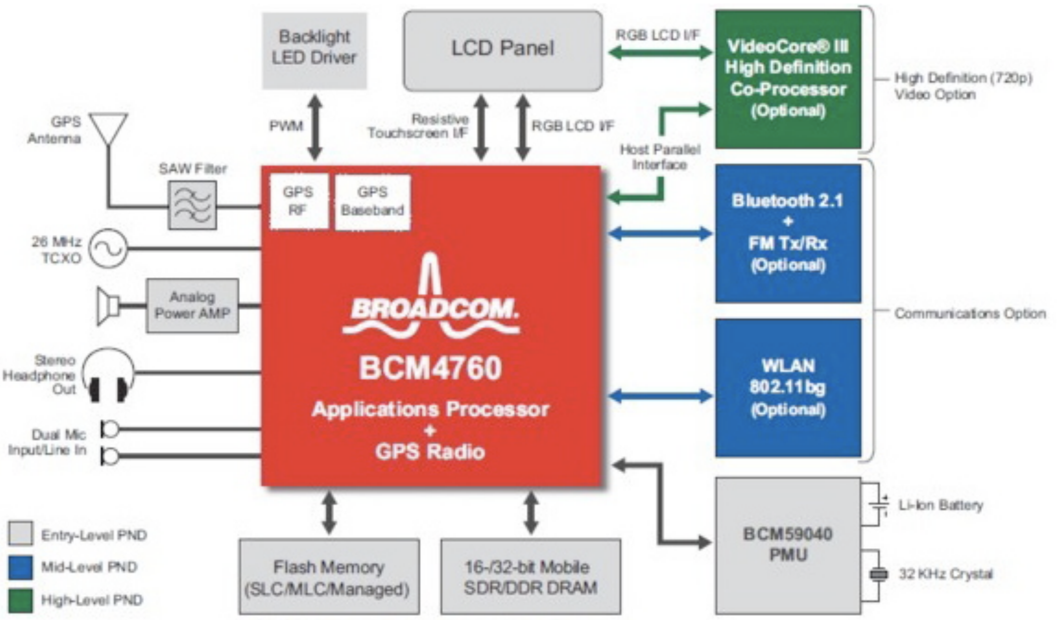
Source: PTOLEMUS

Due to the recent delay in the Galileo project, **Glonass** is expected to benefit from the need for improved availability for European car systems in the short term. By 2014, we expect that almost 15% of cars will be equipped with a dual GPS / Glonass chipset or a combined GPS / Glonass / Galileo chipset.

WiFi in the car has been discussed in industry circles for the past 5 years. Wide scale implementation has not occurred. However, the case for using WiFi positioning in the car is growing stronger as the technology becomes cheaper, more integrated with other RF components and better understood by the end user.

An example of this change is Broadcom's BCM 4760 chipset, designed for the PND market. We believe that this approach could be easily replicated for the automotive market.

Figure 87: Architecture of Broadcom's combined GPS / WiFi / Bluetooth chipset for PNDs



Source: Broadcom

Therefore, we expect a growing number of car vendors to adopt WiFi in the coming years. WiFi positioning brings obvious benefits, notably in cities:

- A faster fix (less than 1 second) in dense urban or underground conditions, which can help save kilometres of driving without a fix,
- Increased availability and reliability (and in the medium term, accuracy).

We are aware that car vendors are considering internal sensors as an alternative to WiFi, which explains their reluctance to adopt WPS.

The in-car services market is being transformed by a **convergence between driver and vehicle centric service access models**, notably due to the entry of PND vendors into the car.

This will require automotive manufacturers to adopt consumer electronics life cycles, similar user experiences and drive adoption of location services in all vehicles. The limit of implementing other location technologies will be driven by costs but also by the need to interact and provide seamless integration with mobile handsets.

In addition, the introduction of electric cars will initiate an inflection point as automotive manufacturers replace traditional vehicle performance marketing messages with a proposition based more on service. This is what we call the **"Car as as Service" model (CAAS).**

b. Portable and aftermarket navigation

In 2009, for the first time since its inception, the European market for PNDs decreased in volumes, by over 10%. This is largely due to the crisis which hurt Christmas sales.

Strong competition from free mobile navigation and affordable embedded navigation will also create a difficult trading environment for PND makers mid-term. Both the low- and the high end of their range will be threatened.

That said, we do not believe in the demise of the PND.

The **PND's main differentiation will come from its operating system, which will remain specific to the in-car environment.** In particular, safety and simplicity will continue to be paramount in the design of the user interface.

We estimate the current penetration rate of PNDs in Europe at 22% of all cars owned. We expect growth to come back in 2011 in the PND market, though at a much slower pace than before 2008.

Although PNDs will be competing with embedded navigation and smartphones, we expect that both low tech drivers and road warriors will stick to the format for the following reasons:

- Ease of use,
- High quality connected navigation including traffic avoidance and road speed profiles,
- Growing availability of third party applications, applying the App Store model to the car environment,
- Multimedia features.

PNDs still have a number of **unique features**:

- Short sales and update cycles, specifically adapted to cars;
- Screen size (increasingly above 5 inches and often 7 inches);
- User interface focused on the most important application, i.e. navigation;
- The ability to run multiple driver-centric applications (traffic, safety cameras, etc.) simultaneously,
- No data costs when roaming.

Ultimately, **smartphone navigation is less than optimal for all drivers**:

- Requires a smartphone and a data subscription, which many are not ready to spend;
- Their user interface is perceived by many users as too rich and complex;
- Contrary to a PND, it cannot be lent to the second driver in the household.

It is also possible that, as in Japan and Korea (highly penetrated by embedded navigation and smartphones), a number of **multimedia features** will help differentiate PNDs.

For example, Mio and Garmin recently launched **PNDs with large screens and embedded TV** (DVB-T / DVB-H), aimed at the long-haul trucking market but also at families.

Smartphones cannot really compete in this domain, at least in Europe. DVB-H networks still need to deployed in most European countries and 3G is expensive and not scalable, thus there will be no low-cost TV on mobile for a long time.

Figure 88: Mio V735 TV, integrating a DVB-T / DVB-H chipset and an EPG*

Source: Mio (EPG: Electronic Programme Guide)

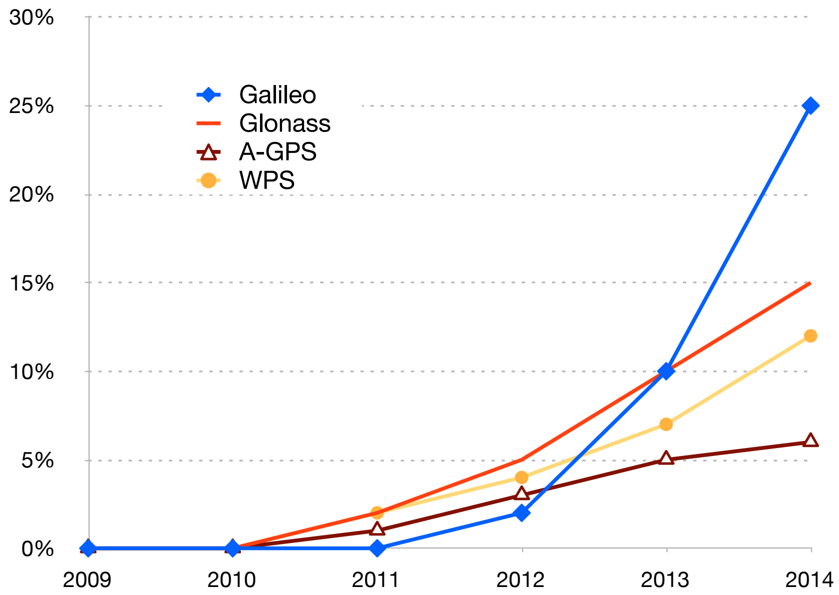
In our view, **positioning performance is not "good enough" any more in PNDs.** The iPhone has demonstrated that a location fix did not need to take 30 seconds and that it could work in cities.

However, up to now, PND manufacturers have almost ignored the importance of positioning accuracy, relying on GPS-only solutions.

Therefore, we anticipate a relatively **slow ramp-up of new location technologies**, which will put PNDs at a disadvantage against both cars and smartphones.

We believe that high end products will start to be equipped with dual Galileo chipsets from 2012.

Figure 89: Penetration of new positioning technologies in PNDs

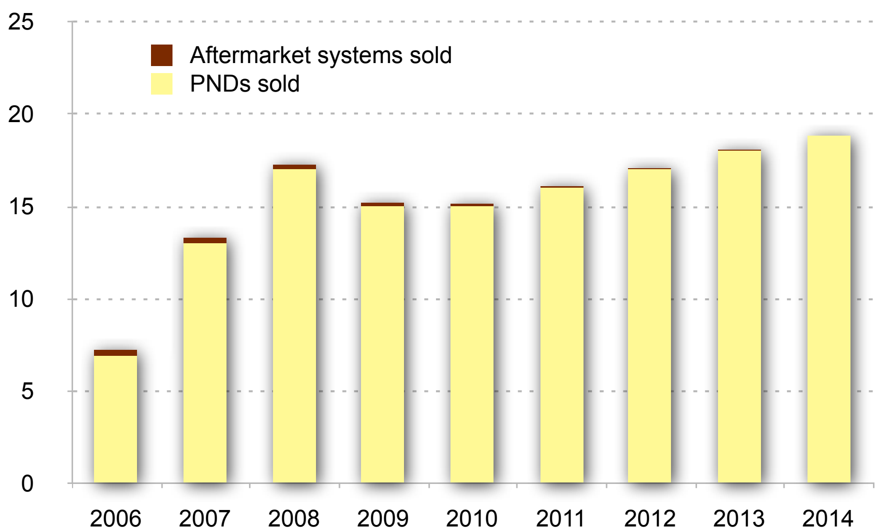


Source: PTOLEMUS

In the long-term, navigation can be expected in all vehicles, but users will choose a different solution for each purpose, perhaps having three different systems available.

We expect **PND volumes to approach 20 million in 2014**. Overall, penetration of the car base will reach 28%.

Figure 90: Aftermarket navigation systems steady and dominated by PNDs (in millions)



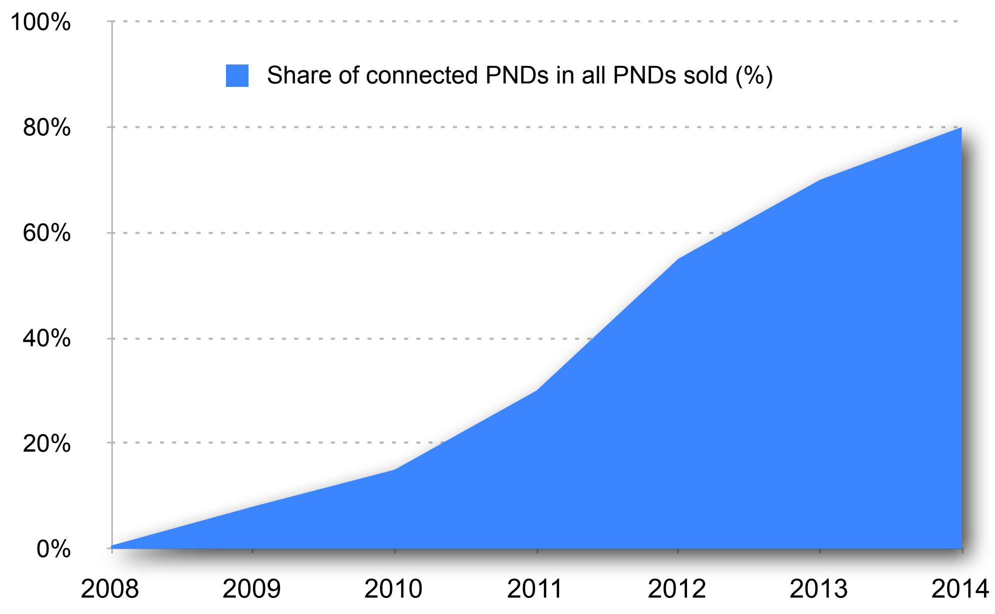
Source: PTOLEMUS

In our view, this growth will not occur without a deep transformation of the PND concept. In particular, we expect the **PND to gradually become closer to the smartphone,** in terms of

- form factor and hardware capabilities: thinner products, larger screens, strong processing capabilities (e.g. Intel's MID format),
- business model: only an opening to third party applications will permit PNDs to develop the long tail of in-car services that is missing today,
- connectivity, notably thanks to GPRS (3G by 2012) and increasingly WiFi.

We expect connected PNDs to gradually become the norm and anticipate that over 50% of the products will be connected.

Figure 91: A paradigm shift towards connected PNDs



Source: PTOLEMUS

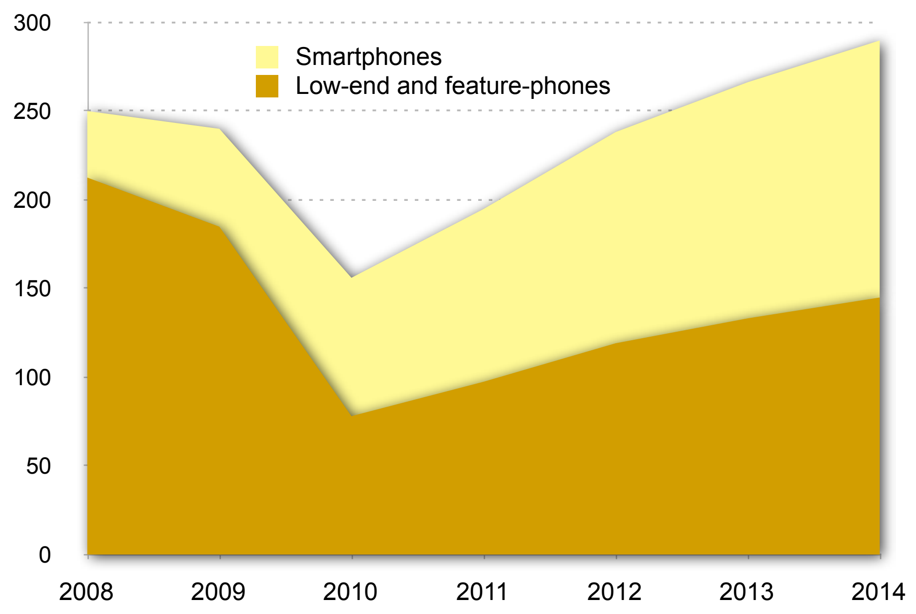
c. Smartphones and feature phones

The mobile phone market is quickly recovering from the 2008 -2009 crisis, reverting to its pre-recession growth rate of 7% due to the rapid uptake in smartphones, strong innovation and the development of large developers' ecosystems.

The smartphone segment is the fastest growing in the consumer electronics market. For example, during the 2009 Christmas period, 75% of handsets sold by Orange France were smartphones, and 90% of those were iPhones!

The smartphone segment's share of the market is expected to rise from 28% in 2010 to 49% in 2014.

Figure 92: The rise of the smartphone - Sales in millions of units



Source: PTOLEMUS

GPS will continue its growth

The penetration of the GPS location feature in new mobile phones sold in Europe is progressing rapidly, **from 50 million devices in 2009 to an estimated 194 million in 2014**.

The penetration of GPS in feature phones in Europe is lower than in the US where E911 regulation accelerated its diffusion.

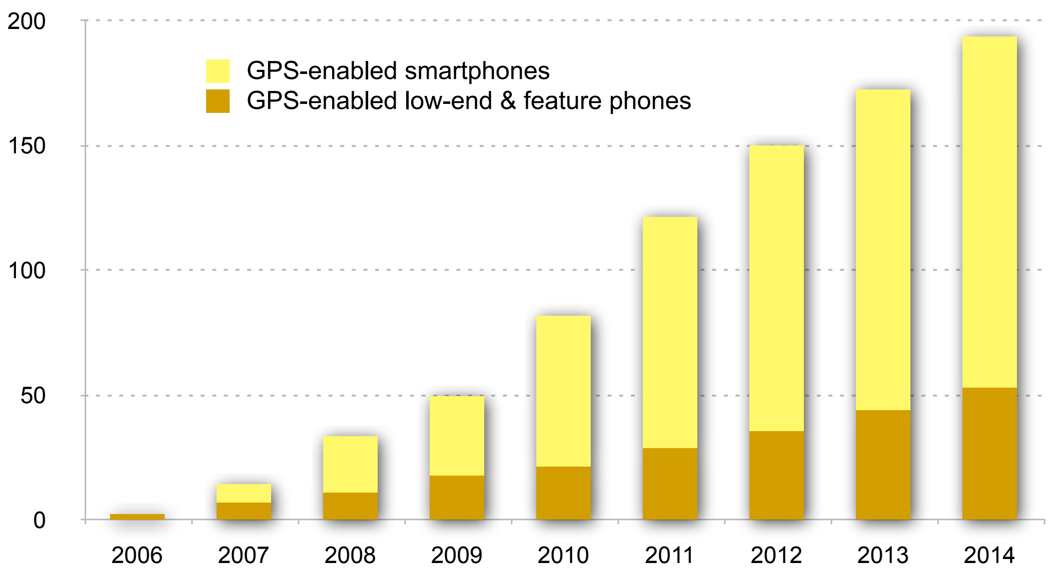
Nokia is playing a key role in making GPS available at low price points.

Today approximately **a third of Nokia's 100 handset models sold in Europe feature A-GPS navigation**. This is less than 3G (about 45%) but more than WiFi (25%).

By contrast, Samsung ranges only 15% of its 65 models with GPS. Similarly, LG offers only two GPS handsets. Even its first Android handset, the GW620, does not integrate GPS!

Only four Blackberry smartphone models currently do not have GPS.

Figure 93: GPS growth mainly comes through smartphones (million units)



Source: PTOLEMUS

The market is moving very fast and **GPS is becoming a standard on almost all newly launched smartphones**.

In particular, the change in Samsung's strategy epitomised by Bada clearly indicates that location-based services will be key to win the mass-market.

On the whole, Nokia remains by far the leader in GPS phones, followed by Blackberry and Apple.

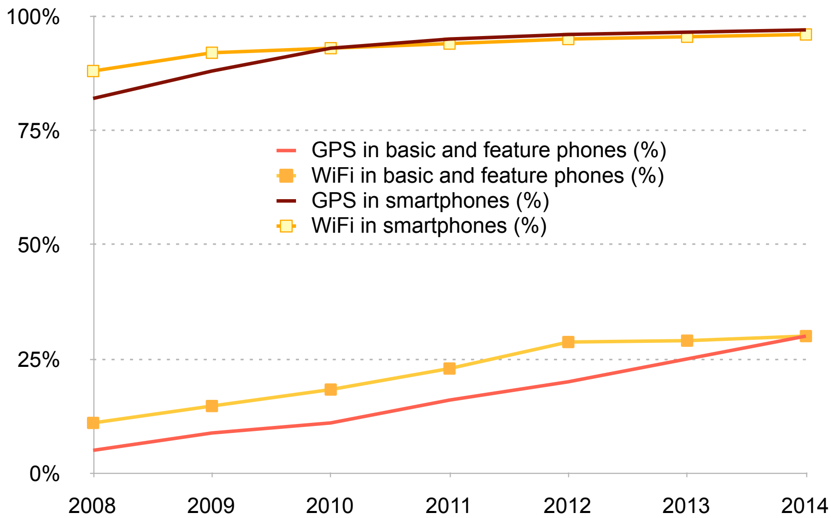
WiFi will become the 2nd positioning technology

The penetration of **WiFi** in smartphones is comparable to GPS.

Main barriers to its diffusion are cost, operators' unwillingness to promote VoWiFi (voice over WiFi) and power consumption issues.

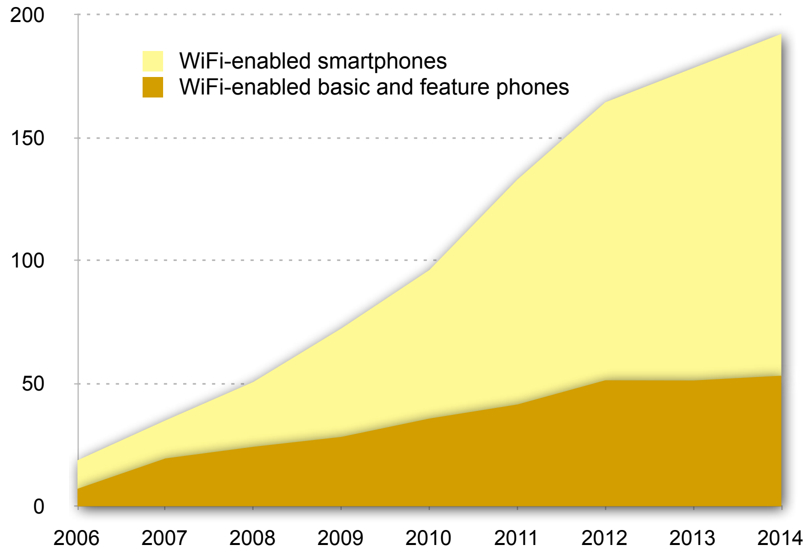
We expect WiFi to be found in 30% of basic and feature phones by 2014, compared with 18% today, and in no less than 96% of smartphones.

Figure 94: Penetration of GPS and WiFi in mobile phones (share of total in %)



Source: PTOLEMUS

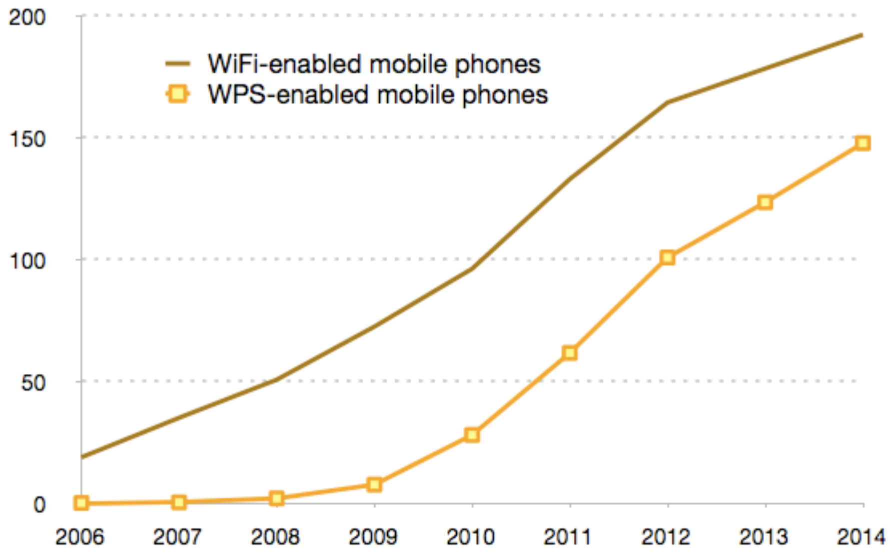
Figure 95: WiFi-enabled mobile phone market size (units sold in millions)



Source: PTOLEMUS

Based on our interviews with Navizon and Skyhook and discussions with a number of chipset, handset and OS vendors, we have built a forecast of the penetration of WiFi positioning in mobile phones.

Figure 96: The "WiFi Positioning System" is becoming mainstream



Note: We define WPS as any WiFi-based triangulation solution to access location, from all providers
Source: PTOLEMUS

MEMS will become common

Above and beyond GPS and WiFi, mobile devices are increasingly able to use **micro-electronic sensors** to determine where they are, how high they are and which direction they are facing.

This is useful for many applications, from navigation to augmented reality display and search. Thus the market is expected to quadruple between 2010 and 2014.

The penetration of **MEMS** (Micro-Electro-Mechanical Systems) in smartphones is growing rapidly, primarily driven by Apple and Google. They bring a large range of benefits, primarily for user experience enhancements. These include:

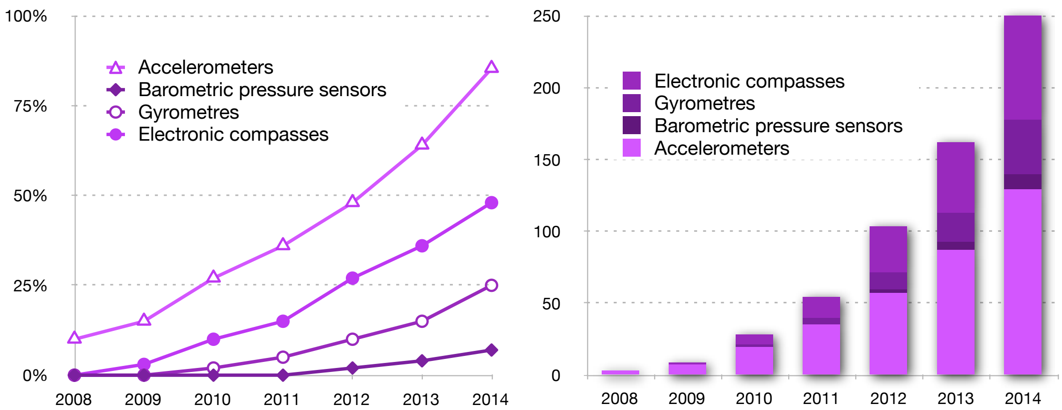
- **Accelerometers** can orientate the display in the right direction, for example in pedestrian navigation or for augmented reality applications,
- **Electronic compasses** dramatically improve pedestrian navigation (although their reliability is still often limited),
- **Gyroscopes** will be used as dead reckoning sensors for indoor or in-tunnel navigation,
- **Barometric pressure sensors** will be used to provide elevation in an outdoor or indoor context.

We expect **accelerometers to become a standard feature in smartphones by the end of the period**. This will be driven largely by the progress of touchscreen phones, augmented reality applications and the mutation of the handheld into a media channel.

Compasses, which are key for navigation, will follow the same trend with a few years of delay. The iPhone 3GS is also the major catalyst for the rapid introduction of digital compasses in smartphones, with penetration estimated to increase from 10% of smartphones today to 48% by 2014.

We expect barometric pressure sensors to follow a slower penetration trend as their value added will be more limited. Moreover, reliability will be complex to ensure for applications such as indoor navigation. Cost (still currently more than €20) and miniaturisation will also be issues.

Figure 97: Penetration of MEMS in smartphones and volumes sold (in millions)



Source: PTOLEMUS

Due to their cost, **we do not expect MEMS to be used in basic and feature phones** (except game-centric handsets) **in the medium term**.

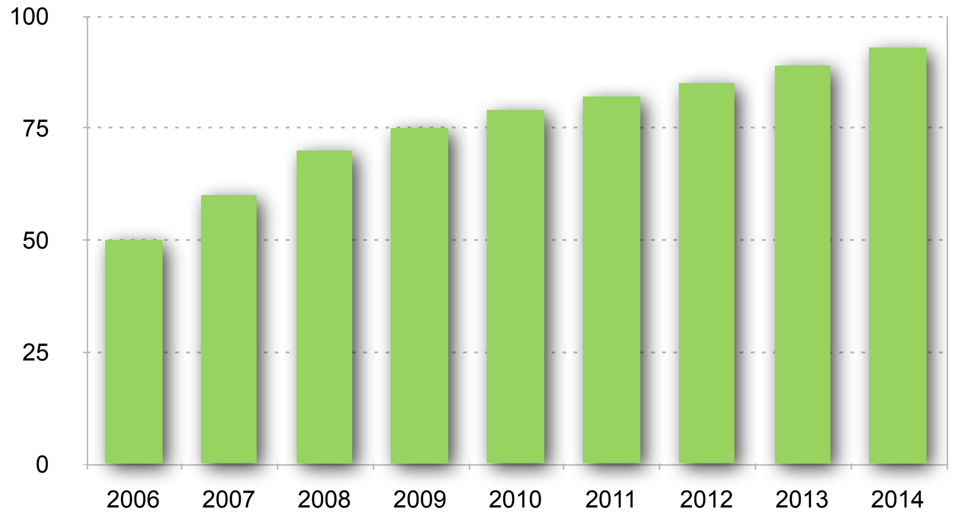
Even if the combined price of these sensors will be close to €5 by 2014, this is still too high. For example, 82% of Nokia's basic and feature phones had an average selling price below €100 in Q3 2009.

Cell-ID will be available on most European mobile networks

Penetration of **Cell-ID** and other network location technologies will also grow, under the influence of E112 implementation and a number of mobile operators who will try to regain control over the provision of location services to their customers.

Also, more precise crowd data analysis will require an element of location in the network infrastructure, and the market of location data analysis based on the cell network is emerging rapidly.

Figure 98: Mobile networks equipped with location servers



Source: PTOLEMUS

The E112 mandate stipulates that operators must to be able to provide mobile phone location information.

However, as indicated in section I, PTOLEMUS' study of the European market suggests that this is not possible for all mobile users in Europe.

In particular, almost half of mobile service providers in Europe (101 out of 213) are MVNOs which often have no access to location data or have deployed their own location infrastructure.

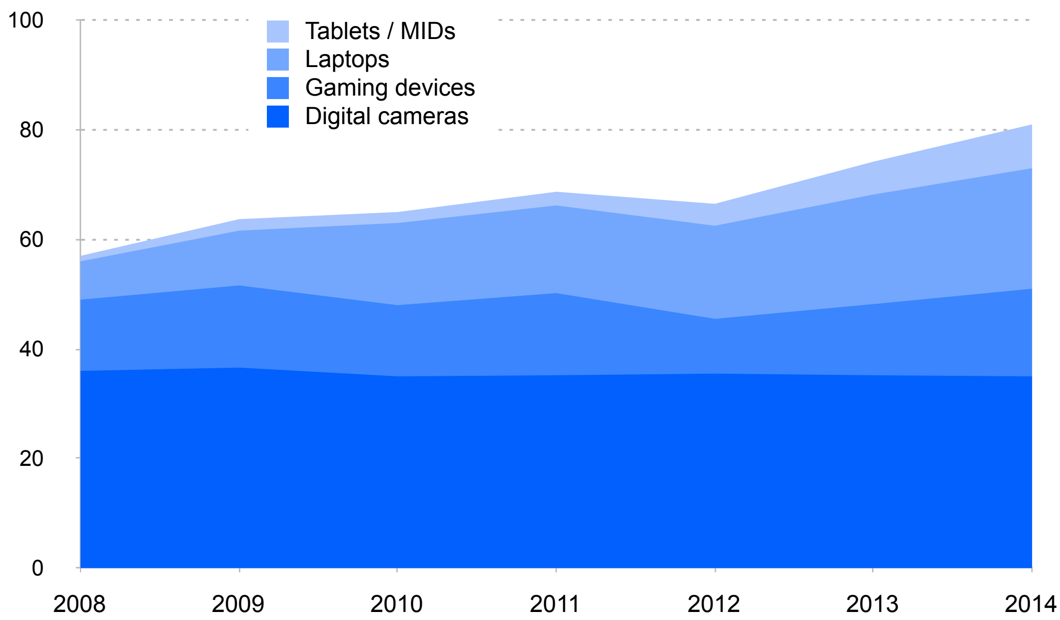
Migration to 3G and LTE infrastructure (often including location platforms by default e.g. Ericsson) and pressure on countries with lagging emergency systems (France, Italy and Germany notably) will drive increasing penetration of location in cellular networks.

We expect that **over 3/4 of European mobile networks will be truly location-enabled by 2014**.

d. Other consumer electronics devices

In the last 20 years, the market for consumer electronics (CE) devices has been shaped by a **trend towards mobility and portability.**

Figure 99: Tablets and netbooks to bring back growth in consumer electronics devices



Source: PTOLEMUS

Numerous new, highly successful formats emerged which all are portable and therefore represent interesting opportunities for location technologies:

- The **digital camera market** is one of the largest new addressable markets for positioning although it is not growing any more;
- The **tablet / e-reader market**, revitalised by Amazon's Kindle, is again being revolutionised by Apple, which sold 3 million iPad devices in 3 months;
- The market for **portable gaming devices** remains largely dominated by the WiFi-enabled Nintendo DS;
- The **laptop market** has been rejuvenated by the arrival of **low cost netbooks** and **ultra-mobile notebooks** of different sizes, weighing less than 2 kg, and with batteries lasting up to 12 hours. This has made the device a lot more flexible, portable and therefore locatable.

  Embedded 3G connectivity is also coming, notably in Nokia's Booklet. Netbooks are sold by network operators, and 3G connectivity is also easily available via dongles, making the netbook a mobile connected device.

Figure 100: Nokia's Booklet and Apple's iPad are redefining the portable computing market. The Booklet and the iPad high-end version are equipped with GPS.

Source: PTOLEMUS

Positioning in the digital camera market

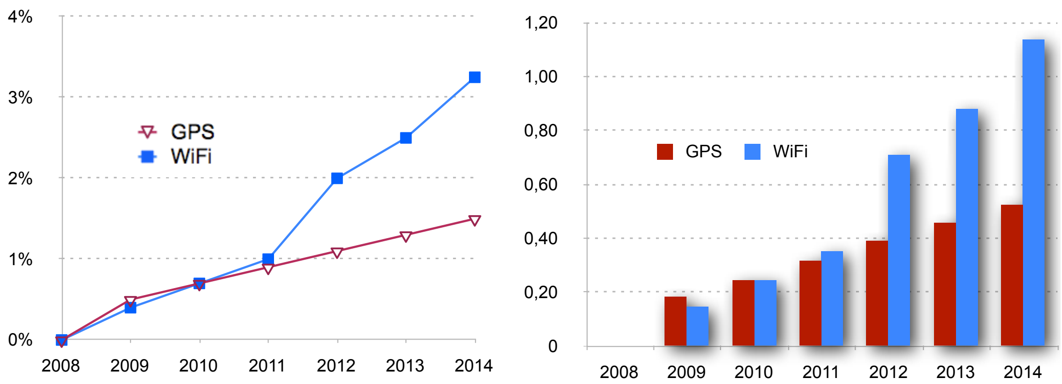
For all their expertise in other electronic components, such as light detection sensors, digital camera vendors lack expertise in GPS. Also, it is surprisingly difficult and proportionately costly to integrate GPS into a digital camera.

While a GPS chipset is inexpensive, its inclusion in the camera's integrated circuit or its installation on a separate module can be costly.

It is surprising that camera makers are not already using WiFi to provide positioning.

Even the Samsung ST 1000, which features WiFi, Bluetooth and GPS, does not. Users can geotag images and transmit them to social networks. At less than €300, the ST 1000 is in direct competition with smartphones.

Figure 101: The slow penetration of GPS and WiFi into digital cameras (in % and in millions)



Source: PTOLEMUS

CSR provided the GPS SiRFstarIII chipset for the Samsung ST 1000 camera but it is unclear whether the chipset also provided WiFi and Bluetooth. However, most GPS chipset manufacturers are working on "combo" solutions suggesting the rise of WiFi and GPS penetration in cameras could evolve in parallel.

WiFi has already entered the domain of the digital camera as a data transfer mechanism, but the leap to using WiFi for location is a big one. Currently, users understand the concept of GPS, but are unaware that location can also be provided by WiFi. However, GPS chipsets can include WiFi, which makes it easier for camera manufacturers to market both functionalities independently.

Embedding WiFi in a digital camera's memory card is seen as a natural progression in the evolution of the memory format. **Eye-Fi Inc**, in partnership with Skyhook, is currently the only company that provides location based on a WiFi-enabled SD card.

However, this solution is expected to become widespread, either through licensing or through innovation by the camera manufacturers themselves.

Figure 102: Eye-Fi 4 Gb cards now also provides location to pictures

Source: Eye-Fi

Positioning in the mobile gaming market

With a market share of more than 80%, **the Nintendo DS has been dominating the mobile gaming arena since 2008**.

Following the example of the newly released Sony PSP Go, the new Nintendo 3DS, previewed in June 2010, will enable the download of games over a WiFi network.

However, the suggestion that the 3DS could also include a SIM card for cellular connectivity has been fuelled by Nintendo's President, referring to Amazon's Kindle e-book business model, which enables users to download content without incurring communication costs. Final specifications of the device, to be launched in March 2011, will be announced later this year.

WiFi is already integrated in each of the 4 versions of the Nintendo DS, and cellular connectivity would open up a range of possibilities for the device, including location capabilities for location-based gaming and child tracking.

Figure 103: Will the Nintendo 3DS include a SIM card?

Source: Nintendo

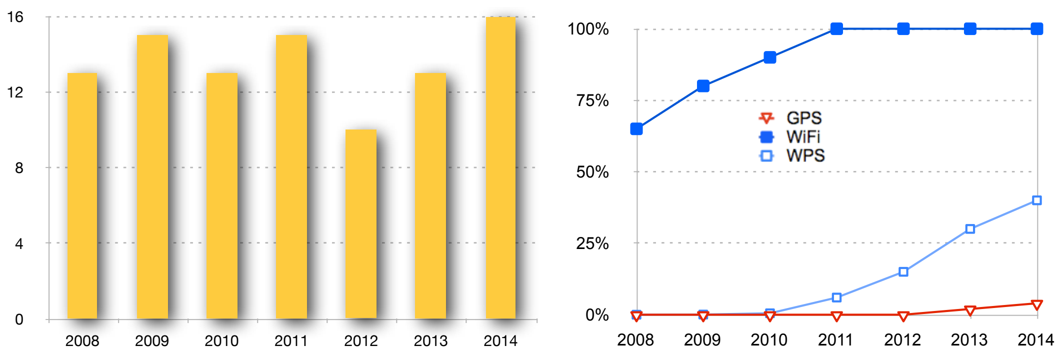
Thanks to 2 front-facing cameras, the 3DS will be 3D-enabled without the need for special glasses, and will include both a gyroscope and an accelerometer. Although augmented reality (AR) makes huge strides in the mobile application market, it is foreseeable that 3DAR will appear in gaming devices first.

The progress of location-based gaming has been slow. WiFi positioning could actually prevent GPS from entering this market. Barriers to location-based gaming include the shortage of such games and the need to be outside to play.

However, location could also be used to create local gaming communities.

Overall, we expect **WPS to gradually penetrate the portable gaming market**, to exceed a fourth of all devices in 2013.

Figure 104: WiFi will remain king in the portable gaming devices market



Note: Units are respectively millions of devices sold and %
Source: PTOLEMUS

Positioning in the laptop market

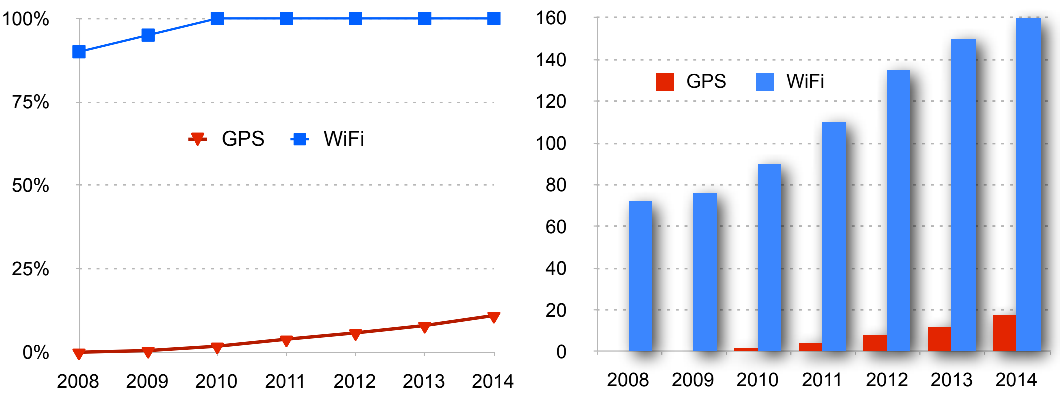
GPS chipset manufacturers see laptops as the next platform for satellite location. However, WiFi and IP location are obvious alternatives which have the advantage of not requiring additional component cost and integration.

WiFi does not mean location for the user yet but laptop manufacturers have the opportunity to change that very quickly by installing a WPS software natively.

We are sceptical about the case for GPS in netbooks because netbooks are used indoors in 95% of cases in most countries (notably because of outdoor light which prevents a comfortable user experience), which makes a satellite technology inadequate.

The main use case we identify for GPS is for rugged laptops such as Panasonic's Toughbook.

Figure 105: The penetration of location technologies in the laptops (incl. netbooks)



Note: Units are respectively % and millions of devices sold
Source: PTOLEMUS

Positioning in the mobile internet devices and tablet markets

Similarly to netbooks, WiFi is the de facto technology to bring location to this platform. The launch of the Apple iPad successfully raised awareness of the device type, which, although common in different shapes and sizes in Asia (called MID, or Mobile Internet Device), failed to take off in Europe and in the US.

Moreover, the iPad expands the range of available positioning technologies:

- WiFi (i.e. WPS thanks to Apple's agreement with Skyhook),
- GPS for the high-end 3G model,
- Cell-ID for the high-end 3G model.

Figure 106: iPad Maps, using Google Maps

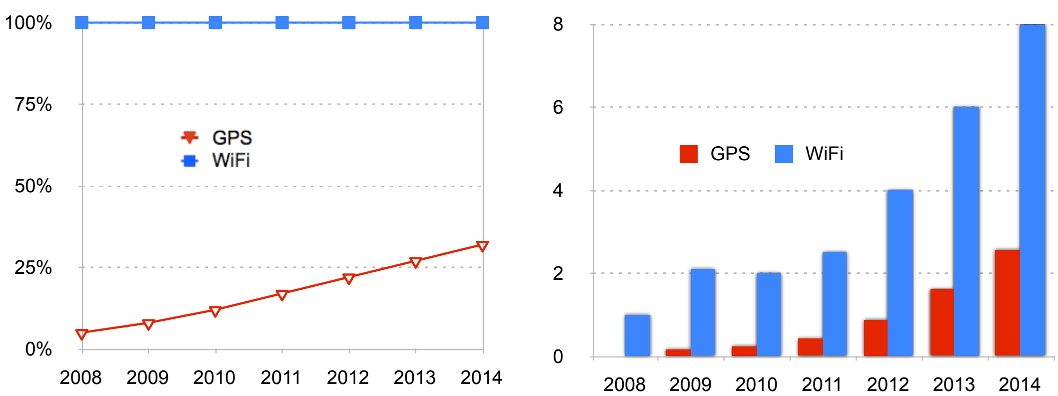
Source: Apple

Up to now, GPS has been the most used location technology to enable the form factor. Tablets are coming out with GPS location first. The iPad is the first tablet with WiFi location built-in.

Android tablets will appear soon, we expect the WePad and Notion Ink's Adam to come out in Q2 2010 with GPS (WePad has GPS on option). Like in the camera business GPS means location to the user. However, this penetration will flatten as the rise of WiFi location perception and understanding mixed with the lower costs for the manufacturers and the growing number of lower range tablets start competing with GPS

Like with cameras and netbooks, WiFi will not always be used for location only and will generally appear alongside GPS. WiFi connectivity is standard in all tablets and MIDs. It will benefit from the surge in popularity of tablets to enable location to an estimated 18 million devices by 2014.

Figure 107: Market for MIDs / tablets and penetration of location technologies



Note: Units are respectively % and millions of devices sold
Source: PTOLEMUS

2. Key applications and their location requirements

a. In-car navigation

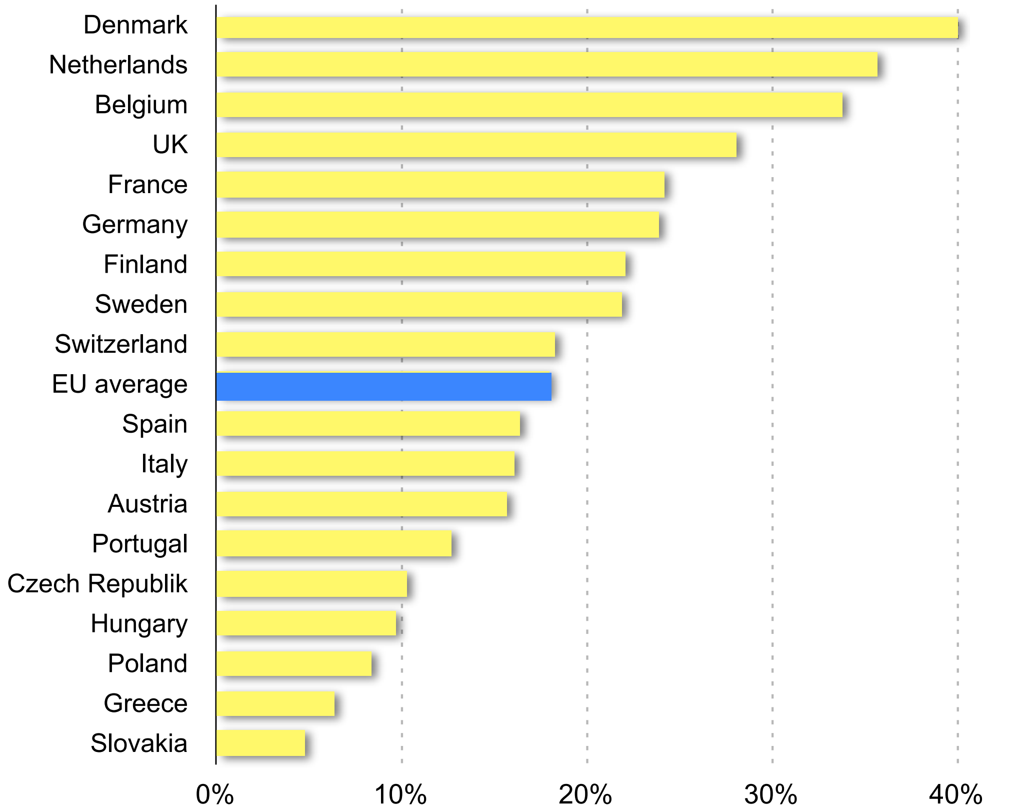
Dedicated car navigation systems

Around 25% of all European cars currently have a system dedicated to car navigation (including PNDs).

There are also **significant discrepancies between Northern Europe on one side and Southern and Eastern Europe on the other side**. The penetration rate in Germany or in the Benelux is twice as high as in Spain or Italy.

This reflects cultural differences, notably the statutory role of cars in Northern Europe but also differing climates and contrasting habits. For example, in the 2006 European Road User Survey, over 35% of drivers in England, Germany and the Benelux were driving more than 30,000 km per year, against only 18% in Italy.

Figure 108: PNDs in use represent less than 20% of European cars



Source: GFK (March 2009), PTOLEMUS

We expect **dedicated in-car navigation systems** (including PNDs) **to gain momentum in the coming years, to reach 50% by 2015**.

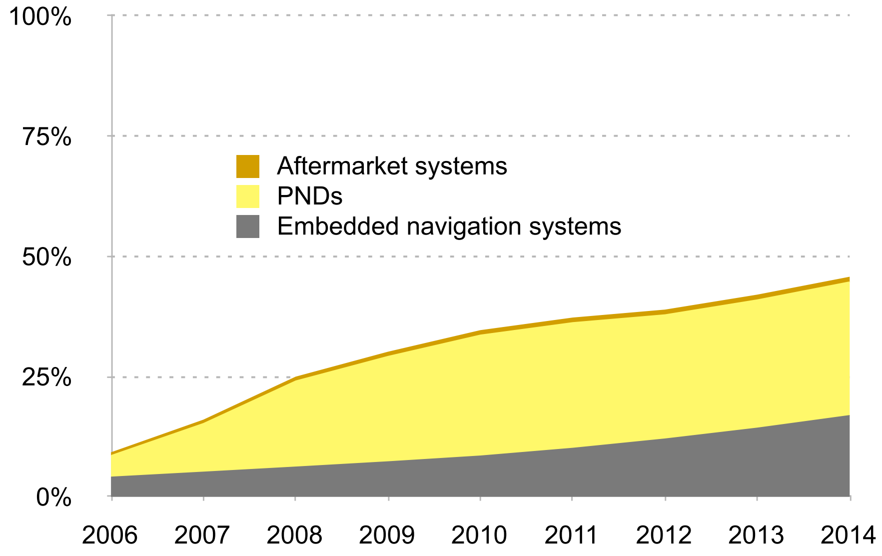
This is primarily due to the growth of line-fitted navigation, which will benefit from navigation becoming a standard feature in high end cars and fast decreasing prices on other models.

Between 2010 and 2014, the **number of embedded systems will double**. This will be driven by low cost "integrated PND" solutions (such as TomTom's product for Renault and Fiat), hardware cost drops and the need for embedded GPS in the car for eCall.

As a result, economical navigation solutions will be offered in all ranges of vehicles.

The PND segment will also start growing again from 2011 but at a lower rate than before the economic recession. This is based on the assumptions that PND vendors successfully transition most of their product portfolio to connected navigation and open up their devices to third party developers.

Figure 109: Almost half of all cars in use will have a dedicated navigation system by 2014



Source: PTOLEMUS

Smartphones for car navigation

Based on unit sales of the different devices with embedded positioning capabilities, and assuming that GPS-enabled phones are navigation-ready, **mobile phones** passed the 50% mark of all navigation solutions sold in 2008.

Mobile terminals will extend their lead to **an 85% market share by 2014**.

This will have a major impact, notably because new navigation-enabled handsets will have large touchscreens.

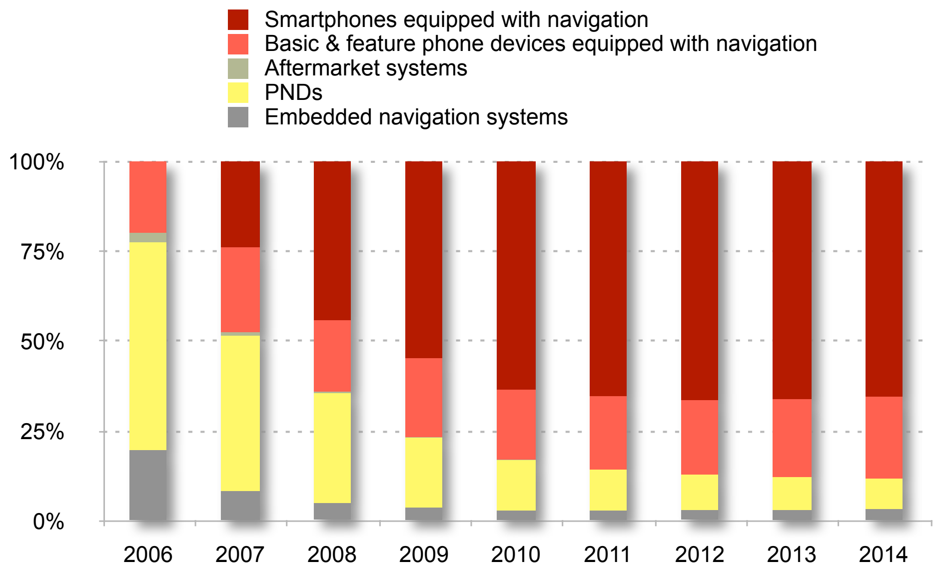
First, a large number of households will have 2 or 3 different systems at their disposal, a situation not dissimilar to what has happened for digital cameras (mobile phone, camera, video camera, etc.).

Secondly, we also expect that handset vendors' execution will also have a major effect on actual usage of handset navigation solutions.

In particular, most Nokia GPS smartphones are now not only shipped with free turn-by-turn navigation but also with a **free car kit**. Nokia's solution is particularly threatening for PND vendors as it relies on an hybrid model (the map is pre-installed, so roaming costs are limited), contrary to Google Maps.

It is quite likely that, as is the case for cameras, **most users will use their mobile for everyday use** (home-work) and their PND when they drive for longer trips (assuming they have no embedded system).

Figure 110: Mobile navigation device volumes will quickly surpass dedicated systems'



Source: PTOLEMUS

b. Other in-car embedded location services

In 2008, the penetration of in-car navigation systems was based on car manufacturers' standard offering. We believe that car OEMs (Original Equipment Manufacturers) will open their data sets to third party service providers in the near future.

The same way mobile operators have benefited from open mobile phone platforms and APIs, OEMs will have much to gain from providing open and standardised access to vehicles' CAN bus (Controller Area Network).

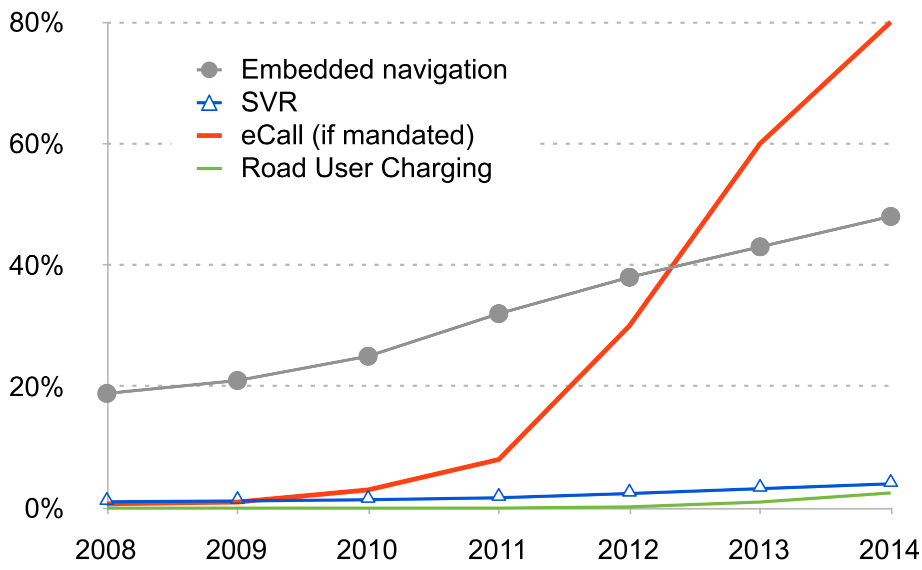
The use of location in the vehicle will also be boosted by the **expected eCall mandate**, forcing OEMs to equip new cars with location and communication device(s).

In August 2009, the European Commission presented a policy document with a strategy for introducing an affordable in-car emergency call system in all new vehicles across Europe by 2014, starting in 2010 or 2011.

The Commission strongly suggested the need to mandate eCall in order to meet the 2014 target date, excluding all other options. This would give car manufacturers in Europe 4 years to have their new models equipped.

It is difficult to predict how many of these on-board units (OBUs) will be integrated with navigation systems, as eCall OBUs will require both connectivity and a GNSS chipset. It will also depend on whether eCall is mandated or not.

Figure 111: eCall will be the largest growth driver in the next 5 years



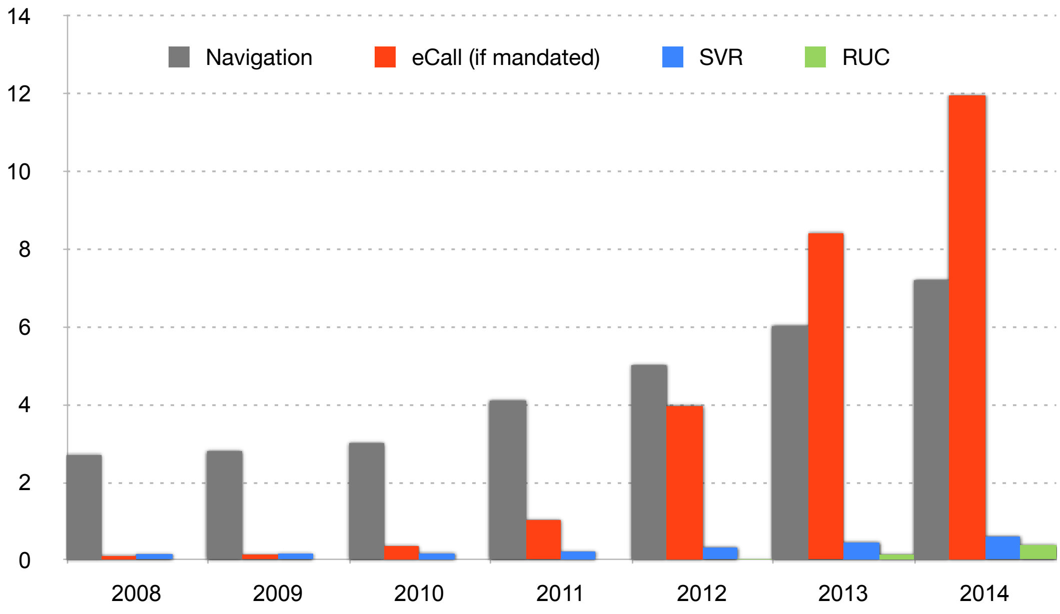
Source: PTOLEMUS

Road user charging (RUC) is still a long way ahead for private and light commercial vehicles.

Although the Dutch project is currently in standby mode due to the change in government, we have assumed that the Netherlands will implement national RUC from 2013, equipping an estimated 7.8 million vehicles with GPS units.

We anticipate that a number of other countries, notably Germany and Belgium, will initiate processes to launch RUC schemes after 2014.

Figure 112: In-line fitted in-car GPS unit sales (in millions)



Source: PTOLEMUS

For all luxury cars, **Stolen Vehicle Recovery** (SVR) is made de facto compulsory by insurers' policy not to cover these vehicles without such a system.

Provided by specialized companies such as Cobra Automotive Technologies, TrafficMaster and Octo Telematics, these units are installed separately from navigation systems.

Their penetration is currently limited to luxury cars, and represented approximately 160,000 units in 2010.

We believe that the **future of SVR lies in the integration of the functionality into other car telematics boxes**. For example, Octo's Italian PAYD success is partly due to the inclusion of the SVR functionality.

The business case is obvious for insurers which can benefit from much reduced costs from car theft claims. Interpol estimated that **the criminal profit generated by car thefts in Europe was almost €7 billion in 2004**. 455 000 stolen cars were not recovered (of 771 000 stolen cars that year).

Although **Pay As You Drive** insurance could be offered by car manufacturers, we have not seen such projects yet.

Up to now, PAYD is sold as an aftermarket service, which reduces the complexity of the technical challenge. When PAYD becomes more mature, OEM could decide to propose the service as part of a wider Car As A Service (CAAS) value proposition.

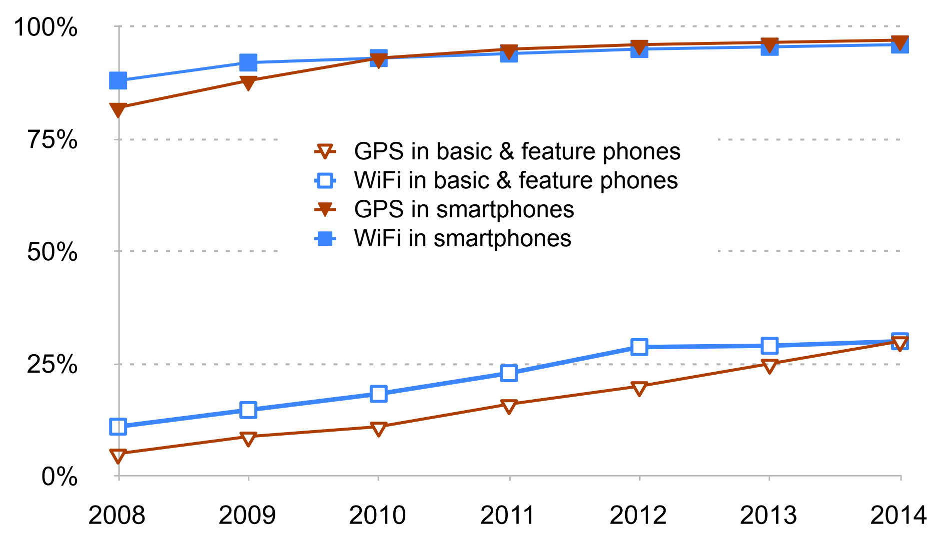
c. Consumer mobile LBS

We have largely covered this topic through other analyses.

We will just highlight the fact that virtually **all smartphones sold in 5 years will be locatable.**

Other mobile phones will also be affected. **A third of basic and feature phones will be equipped with a positioning technology in 2014.**

Figure 113: Penetration of GPS and WiFi in mobile phones (in millions)



Source: PTOLEMUS

3. Penetration of location technologies in consumer devices

Location technologies will increasingly become pervasive. GPS and WiFi will remain the two predominant location technologies for all consumer objects (cars, PNDs, mobile phones, tablets and portable game devices).

a. GNSS-located devices

In 2014, we forecast that **350 million devices** will be **shipped with a GNSS chipset**.

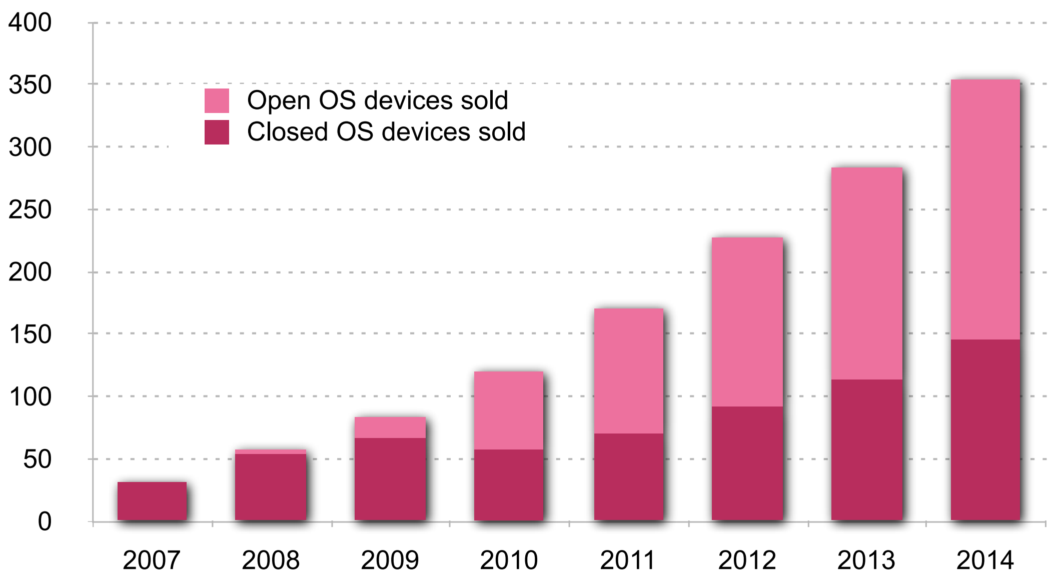
Thanks to smartphones, **over half of these satellite-located devices already benefit from an open Operating System** (OS) on which third parties can write applications.

By 2014, **2/3 of GNSS devices will have an open OS**. This will be driven by the expansion of smartphones but also by the gradual opening of PNDs and in-car systems.

In many devices, there will be more than just one positioning technology, which will pave the way to hybrid location solutions.

The European market for GPS-based GNSS is forecast to more than triple between 2009 and 2014. This will primarily impact GPS but also Galileo and Glonass.

Figure 114: Sales of GNSS-enabled consumer objects will triple in 5 years (in millions)



Source: PTOLEMUS

GPS will remain unchallenged as a base technology in 9 markets: outdoor, road user charging, stolen vehicle recovery, pay-as-you-drive insurance, eCall, consumer tracking devices, PNDs and in-car.

We predict that, in 2014, its predominance in the consumer positioning market will be materialised by

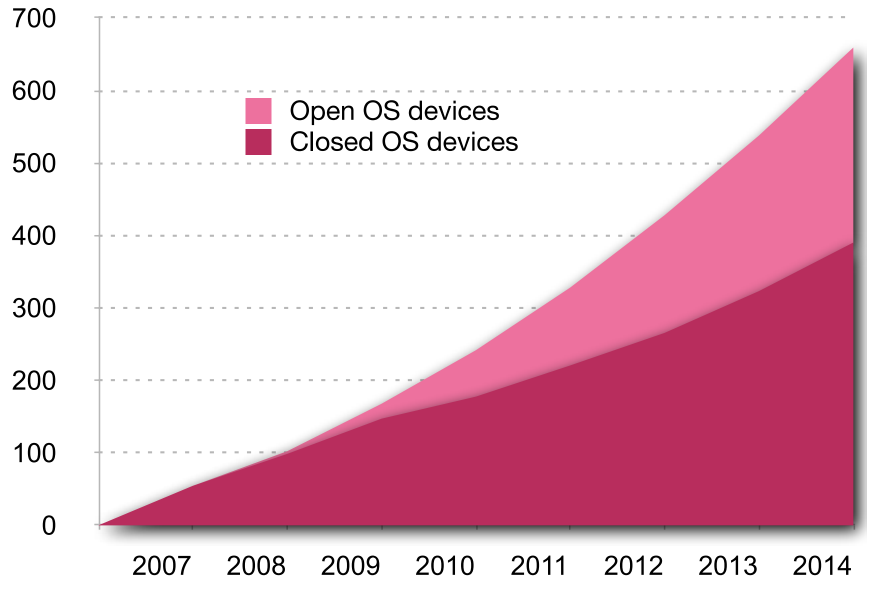
- Nearly 200 million mobile phones,
- Almost 30 million PAYD telematics OBUs,
- 12 million vehicles sold with eCall functionality,
- 2,6 million tablets and other mobile content readers,
- 400 000 vehicles equipped with GPS-enabled road user charging systems.

While these annual volumes are impressive, it is also interesting to examine the evolution of the installed base.

Taking into account device ownership duration, we expect that there will be **almost 700 million mobile objects with GNSS** at the end of the period.

By then, we expect that there will be **270 million open OS GNSS-located devices**. This will represent a fantastic opportunity to generate revenues (direct or indirect) for LBS developers. This will also provide to device vendors a smart way to differentiate their offering.

Figure 115: An installed base of nearly 700 million GNSS-enabled devices including 250 million open to content and services developers by 2014



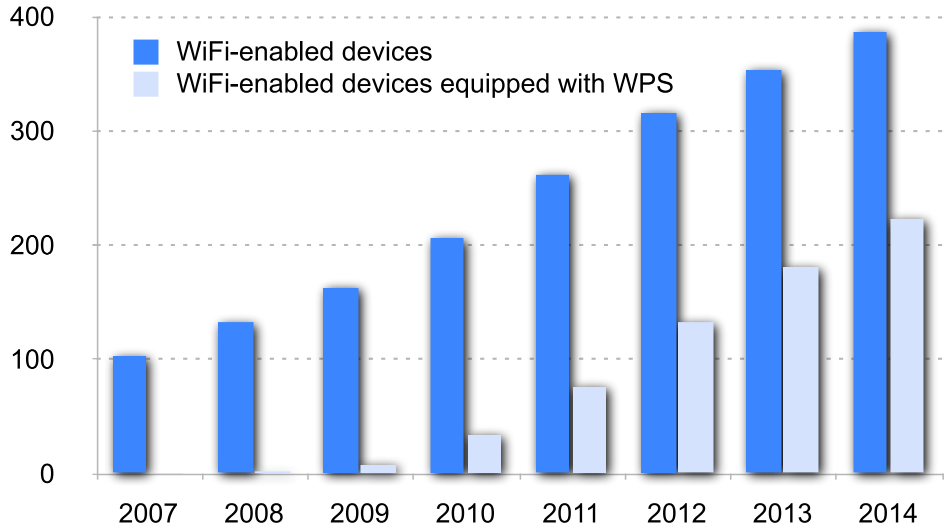
Source: PTOLEMUS

b. WiFi-located devices

Between 2009 and 2014, the **number of WiFi-equipped devices sold will double**, reaching 390 million consumer devices. Almost **60% will benefit from WiFi positioning.**

This often complementary technology to GPS also sees potential growth in key market segments, such as low-end smartphones, game consoles, laptops, tablets and digital cameras.

Figure 116: WiFi consumer location market size



Source: PTOLEMUS

In 2014, WiFi will be a feature present in

- Almost 200 million mobile phones sold this year,
- An estimated 190 million consumer electronics devices sold this year.

WiFi positioning providers are not focusing significant attention on the **car** and **PND** markets at this stage. Although there is potential for WiFi to be used in both environments, WPS does not seem to have traction in those markets.

We believe this is partly due to the (outdated) quest for a single, do-it-all technology (both for connectivity and location) whereas WiFi is by nature a complement to other technologies (in cost and speed to 3G and in urban availability to GNSS technologies).

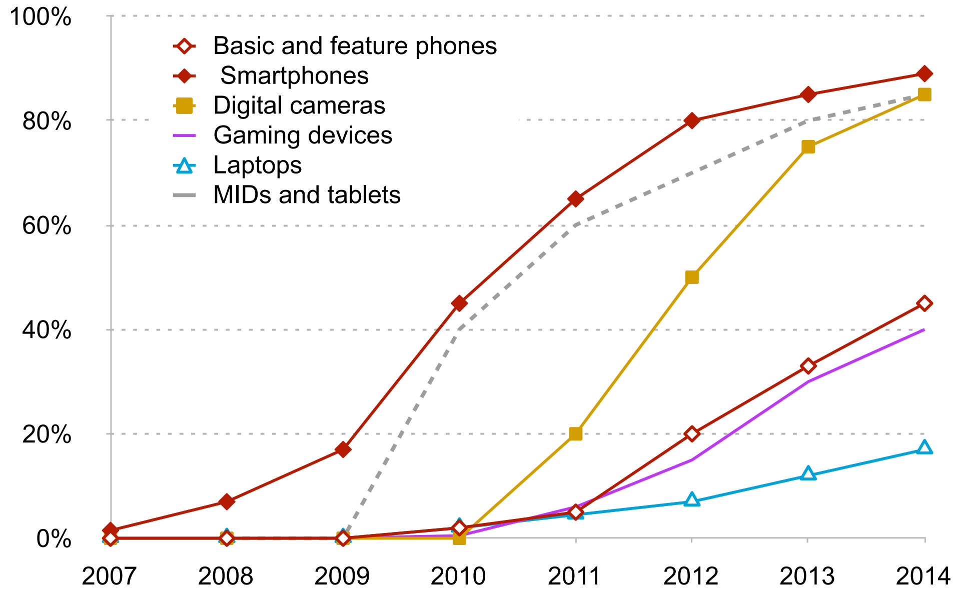
Feature phones will progressively be equipped with WPS, probably starting with Nokia phones, since Skyhook has set its priority on the smartphone market. Cost is also an issue, because users' general awareness about location and navigation is lower than in smartphones. However, chipset vendors' strategy to bundle WiFi with Bluetooth will contribute to WiFi dissemination. WPS will be used for pedestrian navigation, geo-tagging, social networking, etc.

The percentage of WiFi-equipped **smartphones** using WPS will increase dramatically, as Skyhook is concentrating most of its efforts on phone manufacturers and application developers. As the number of devices and applications using WiFi for location increases, the cheaper the provision of location will become, which in turn will boost the development of even more location-aware devices and applications. A virtuous circle which will result in more than 80% of smartphones using WPS by 2014.

As WiFi location perception and understanding grows, **digital camera** manufacturers will quickly realise the advantages of replacing GPS with WiFi or adding WiFi to assist GPS and conserve battery life. Consequently, more than 80% of cameras equipped with WiFi in 2014 will use it for location.

WiFi is available in all **portable gaming devices**, but the most important by far is the Nintendo DS, which holds a global market share of more than 70%. Skyhook is expected to supply Nintendo for its next device – the 3DS (or the next version of the PSP). In any case, once location is in one of them, it is likely to become pervasive in forthcoming new models.

Figure 117: Penetration of WPS in WiFi-enabled devices



Source: PTOLEMUS

Skyhook is putting the accent on **netbooks and laptops**, and is proving the case to manufacturers such as Dell and HP, of embedding WPS natively.

Potential applications include laptop tracking, local search, cinema times, social networks, change of settings depending on location, LBA, work login change or time zone changes.

We think these features are interesting but not compelling enough. They will require lengthy communication for users to take advantage of them once manufacturers agree to pay the per device fee.

Despite Skyhook's optimism, we anticipate that WPS will only reach 20% of laptops by 2014.

WiFi is integral to the concept of **tablets** and **ultra mobile PCs**. Location will be an add-on enabled by the cellular connectivity of many tablets. Stand-alone databases could also be a solution, although this is not being used. Tablets are often marketed as location-aware from the start, and WPS will be part of the technology mix because manufacturers are likely to follow Apple's example.

4. Main revenue generation models

a. The cost of GPS

The cost of plain vanilla GPS chipsets will continue to decrease, albeit at a slower pace.

However, a key trend will be the emergence of "combo" chips. Device vendors will have more functionalities for the same price.

Certain vendors such as Qualcomm, Broadcom and CSR increasingly sell GPS as an add-on to their existing chipset, at a very low incremental cost (close to $1), provided that their customers choose their chipset (which also includes Bluetooth, WiFi, FM, 3G, etc.).

GNSS chipset technology will continue to evolve very fast.

In 2012, GNSS chipsets are expected to all include Extended Ephemeris attributes as well as other on-board technologies such as WiFi and even Cell-ID databases, which will enable much faster TTFF and improved reliability than stand-alone GNSS.

GNSS chipset manufacturers are also working on integrating sensors already present in netbooks and mobile devices in order to complement the location calculation.

Finally, there is a clear **drive from all main manufacturers to provide a service as opposed to a chipset**. All major players are banking on their own location platforms. In the case of Broadcom, this includes WiFi and Cell-ID databases to assist the GPS chipset independently from the operator or the device manufacturer.

From 2011 onwards, MEMS integration in the handset will also play a role, as accelerometers, compasses and, later, altimeters are integrated to provide location assistance and **the cost of sensor bundles drops below €5**.

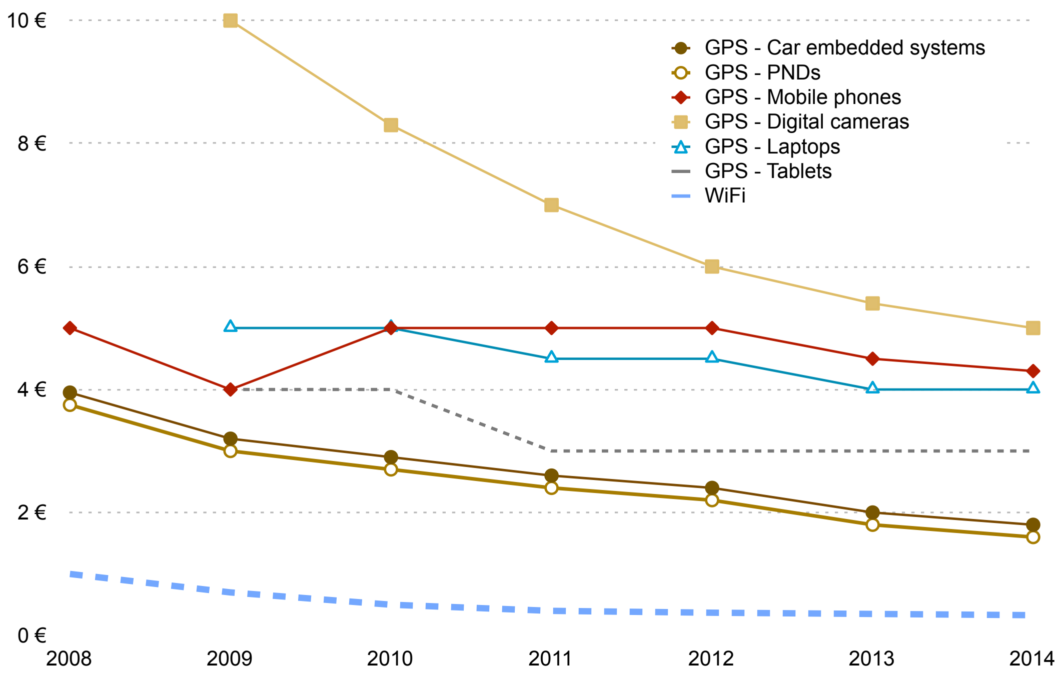
Therefore, on the whole, the average cost of GNSS chipsets will remain stable around $5 until 2012, only decreasing slightly as the new technologies assisting GPS become better integrated.

By 2012, the basic GPS functionality will likely be sold for $1. However, those chipsets will be integrated in phones for marketing purposes in developing countries, and, since their usability is mediocre, the ultimate quantity will not reduce the average global price.

Similarly to PNDs, in-car GPS has not matched the improvement pattern seen in smartphones. Manufacturers have focused their R&D investments on the sector with the highest growth. Also GNSS chipsets in cars do not have additional functionalities such as Bluetooth or WiFi. Consequently, the average price for GPS in vehicles will remain lower than GPS in smartphones – dropping from an average of €3 in 2009 €1.6 by 2012 as the functionality required in the vehicle stays proportionally stable.

A-GPS will not increase the price of chipsets for the in-car market, since the assistance will come from the chipset manufacturers' own servers. Galileo will not influence the price of chipsets, as manufacturers increasingly integrate it as default in new models from 2010 onwards.

Figure 118: Average cost per device chipset (in Euros)



Source: PTOLEMUS

b. The cost of assistance servers

In the US, GMLC technology is considered to be past its prime and prices are dropping.

GMLC costs vary, depending on the operator's prerequisites: transactions per second (TPS), number of licences, the necessary integration with other elements of the network, etc. Hardware architecture requirements can also have a significant effect on costs.

Moreover, the vendor's licensing model can be very different. Based on current feedback, **€1 million can be considered a fairly standard price for the initial fixed cost of a standard GMLC.** Vendors then increase the price based on the number of transactions per second (TPS). For instance, the basic offer can be €1 million for 5 TPS, but if the operator upgrades the GMLC to 10 TPS, there would be an added fixed cost (averaging €300,000) for the server software – on top of any required hardware upgrade and deployment costs.

A SUPL database is more expensive than a GMLC, but the cost of implementation and the difference between the cost of SS7 vs. IP competencies to manage the equipment can ultimately make SUPL more economic. Control plane positioning also requires other elements of the networks to function and may require a VLR and HLR upgrade from the operator.

Based on this, investment in SUPL servers can be more advantageous than investment in GMLCs.

If the vendor can supply both GMLCs and SUPL servers (as Ericsson, Andrew, TCS, Nokia Siemens and several others do), the upgrade from a GMLC to a SUPL server can be performed using the initial hardware equipment and paying only the fixed upgrade fee.

c. The cost of WiFi positioning

The cost of WiFi-based location is never charged to the final users. It is passed on device makers (e.g. Motorola), chipset vendors (e.g. CSR), application providers (e.g. Microsoft) or even other database providers (e.g. Quova).

Possible business models used by WiFi positioning leaders include

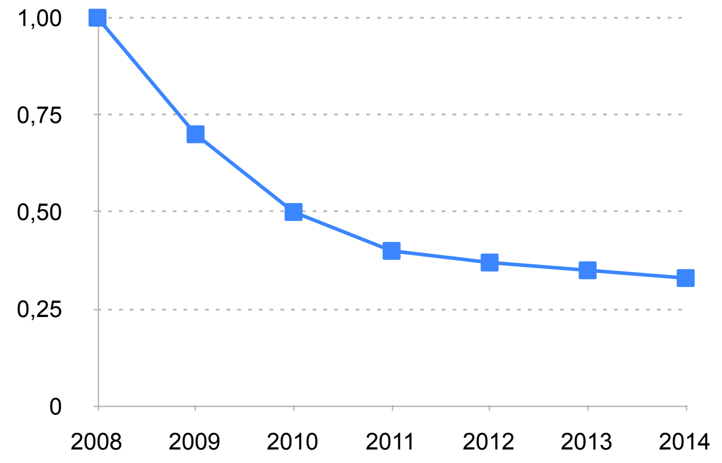
- **Revenue share** with one of the WPS providers for small/medium LBS providers. This is the most commonly used model although potentially risky;
- **Fixed price per device**, e.g. Navizon's on-demand tracking solution is charged per device ($490 for 1,000 devices or $990 for 10,000 devices). This model is used with manufacturers. We estimate the **cost per device in 2010 to be around €0,50 on average**;
- **Licence agreement** for professional applications, such as fraud, financial services, security or tracking;
- **Fixed price** per year for large players, such as device manufacturers**;**

- **Pay per ping (location request) model** for small developers. This early model, estimated to cost €0.1 cent per ping, is no longer used.

In the following figure, we have estimated the average WPS cost per device charged to manufacturers. This cost is expected to decrease fast in the coming years, suggesting that overall revenues from WiFi location could be stable or decrease.

However, volumes will grow very rapidly and WiFi location providers will also benefit from a share of the advertising revenues generated by the applications they enable (although we have not forecast these revenues in this study).

Figure 119: Average cost of WiFi location capability per device (in Euros)



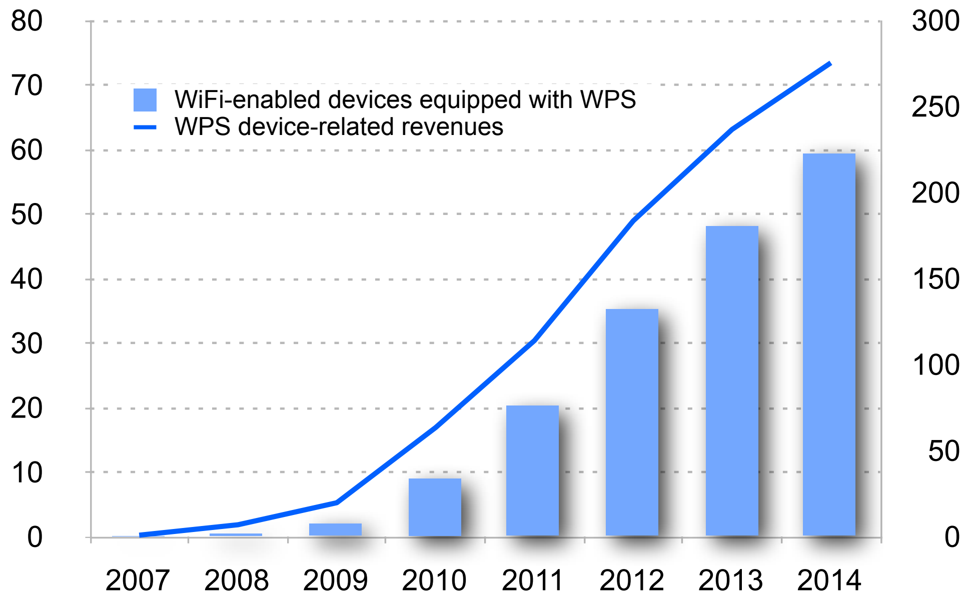
Source: PTOLEMUS

Figure 119 shows only the revenues generated by the cost-per-device models. As the volume of WiFi-equipped devices continues to grow, the expected revenue per device is forecast to fall in 2014 to an average of €0.30 per device.

Overall, the WiFi positioning market value will expand very rapidly until 2014, reaching €70 million. It is important to note that we have included internally-provisioned WPS (e.g. between Navteq and Nokia) in this estimate.

Moreover, as the application market matures, it is expected that the share of advertising revenues will more than compensate for the drop in device-based revenues.

Figure 120: WPS-enabled device volumes will skyrocket, creating a new positioning market



Note: Units are respectively millions of units (right axis) sold and million Euros (left axis)
Source: PTOLEMUS

d. The cost of Cell-ID

Cell-ID location generally requires the installation of a GMLC on the mobile operator's 3G or 3G network, and the services of a middleware provider to control service provision, billing and privacy.

GMLCs are usually installed for an industry standard base price, which covers the hardware, plus an initial fixed cost for the software. Usage is then charged by way of a fixed annual licence, calculated as a cost per capacity (transactions per second) and a cost per feature (e.g. geofencing). Generally, the initial bundled offer will include between 1 and 5 TPS (transactions per seconds), immediate requests, a number of location requests (standard or emergency), and/or triggered location reports.

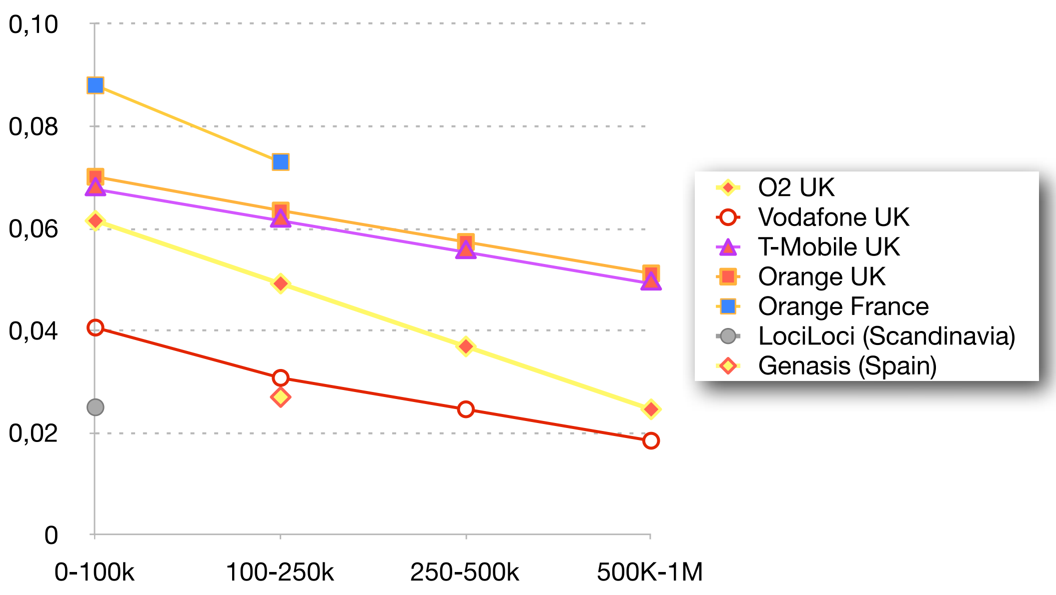
The **estimated cost of running the GMLC ranges between €300,000 and €1 million per year,** depending on the size, loads and feature set.

This corresponds to an **average monthly platform licence fee per subscriber of around €0.005** for a network such as Vodafone Spain or €0.041 for Vodafone Ireland (assuming that all network customers use Cell-ID location). However, we understand that competition from Chinese infrastructure providers such as Huawei or ZTE pushes prices down rapidly.

Operators resell location requests or "pings" with price structures that vary between networks, countries and time. For example, Orange UK charges €0.73 per ping when buying 130,000 location requests on the Orange UK network, whilst other networks charge between €0.38 to €0.95 when selling directly.

Aggregators such as LociLoci and Mobilaris in Sweden, Mobile Commerce in the UK and Genasys in Spain charge less for network location, which can drop below €0.03 depending on volumes.

Figure 121: Sample of Cell-ID location request cost in Europe (in Euros)



Source: PTOLEMUS, Mobile Commerce, LociLoci

When working directly with mobile operators to purchase location data, large application developers have a choice of business models including:

- Per subscriber fees,
- Flat fee,
- Revenue share.

Prices vary according to the network size, the feature set and hosting options.

In the **revenue share** model, if access to location is made through the operator API, the share of the mobile operator stands between 2% and 10% of the revenue earned from end users' service subscription (in addition to the reduced fee per location request). If it is a co-branded application, the mobile operator' share of the service subscription can reach between 10% and 30%.

The sustainability of this location provision and service distribution model is very much in question, and is discussed in further detail in Section III.

5. Estimated end-user location enabling market

The market for positioning technologies will grow extremely fast in the next 5 years.

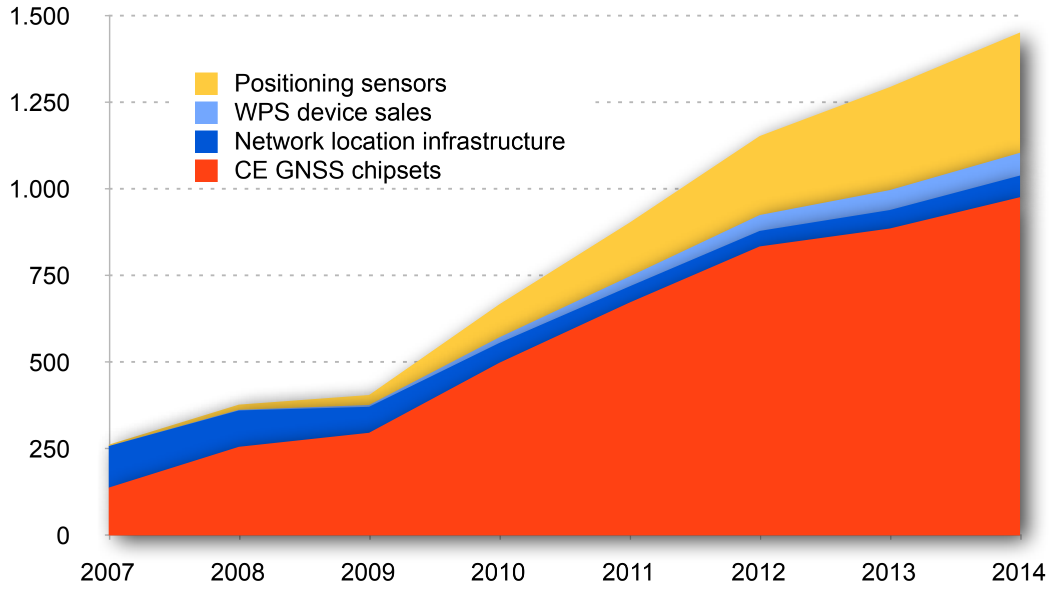
For example, we estimate that the **European market for positioning in consumer devices wil be multiplied by 3,6 between 2009 and 2014**. It will exceed 1 billion Euros of revenues from 2012 onwards.

This growth will mainly be driven by the mobile phone and in-car device markets.

In terms of technology, the **lion's share of the spending will go to GNSS chipset manufacturers.**

Interestingly, MEMS will become the second positioning technology in device component sales after GNSS chipsets from 2010. This is obviously based on our definition that WiFi chipsets are not counted as primarily location chipsets.

Figure 122: Market for location technologies in consumer devices (million Euros)



Note: We have not included here WiFi chipset sales, considering that in most cases, WiFi positioning comes only second after its connectivity capability

Source: PTOLEMUS

Software- and data-based solutions sales, despite their increasing presence in large numbers of devices will remain proportionaly small, notably due to fast price erosion and competition from vendors' own databases (Google and Nokia notably).

However, part of their value will come from the **revenue share models** they are built on.

B. Commercial moving vehicles potential

1. Addressable base of vehicles

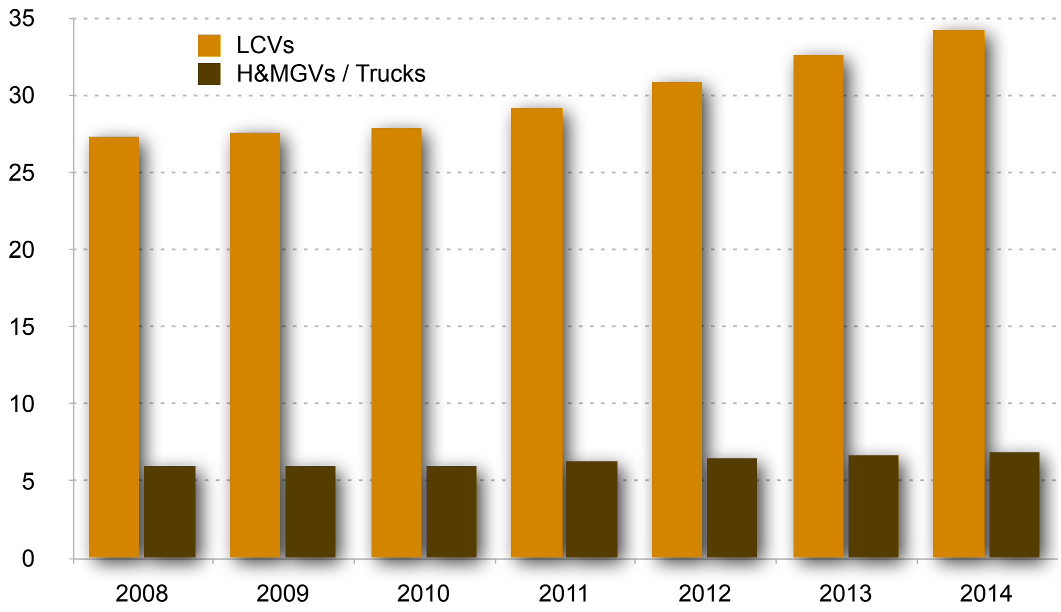
The commercial vehicle market is relatively mature, yet **the penetration of fleet management systems (FMS) is still well below 10%**.

We define here FMS as the generic name for all mobile resource management solutions that are installed on a (commercial) motor vehicle (as opposed to mobile worker-based solutions in particular). These include tracking and tracing, order management, driver management, vehicle management, diagnosis and maintenance, navigation, etc.

The market for location technologies is currently almost entirely limited to GPS, although certain systems such as RFID and UWB are used on a case by case basis.

The penetration of Glonass and Galileo will be linked to chipset manufacturers' decisions and price pressures. It is not a major requirement of fleet managers and FMS providers, for whom availability and accuracy have not been identified as key issues.

Figure 123: Over 30 million commercial motor vehicles in use in Europe



Note: LCVs = Light Commercial Vehicles (<3,5 tons); H&MGVs = Heavy & Medium Goods Vehicles (>3,5 tons) ; EU 23

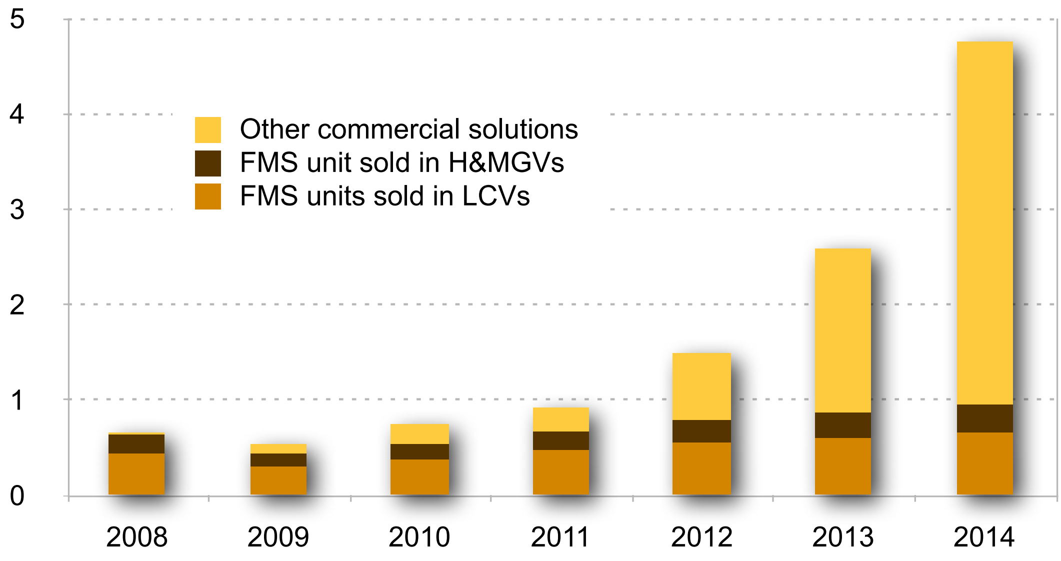
Source: ACEA, PTOLEMUS

However, the **European commercial vehicle landscape will change significantly in the next 5 years.**

We predict that eCall implementation to LCVs and road charging projects in France, Sweden and the Netherlands will significantly alter the dynamics of the marketplace.

As a result, fleet management solutions will represent only a small fraction of the number of location-enabling devices in commercial vehicles.

Figure 124: Annual sales of commercial telematics units (in millions)



Note: LCVs = Light Commercial Vehicles (<3,5 tons); H&MGVs = Heavy & Medium Goods Vehicles (>3,5 tons)

Source: ACEA, PTOLEMUS

We predict that **this unprecedented expansion will benefit to less than 15 FMS providers in Europe**, notably because most of the growth will come from very large contracts with a finite number of insurance and automotive companies.

This will conduct to further **consolidation** of the European market.

2. Key applications and their location requirements

a. Fleet Management Systems (FMS)

The fleet management market has experienced a steady but moderate growth in the last 10 years and has remained mostly driven by local forces. It now counts approximately **2 million equipped vehicles in Europe**.

The fleet management market is slowly recovering from a very strong recession which has 3 effects:

- Many companies suspended their FMS equipment project;
- Numerous fleet management operators, notably in the UK, could not have access to lease financing, which prevented significant volumes,
- OEM vehicle sales as a result of companies' usual cuts on investments at this stage of the economic cycle.

For example, new European truck registrations decreased by 48% in 2009, according to ACEA. In the first part of 2010, the market for trucks stopped its decline, while the market for LCVs (Light Commercial Vehicles) increased 9%.

The **market is expected to return to growth from 2011**, as GPS finds its way into trucks and vans through mobile devices, as well as asset management and driver management applications, and safety applications.

In addition to the economic situation, key drivers of this recovery will be an increased awareness of the technology's abilities, the wider choice and lower cost of telematics devices supporting FMS applications, and a rapid decrease in GPRS connectivity national and roaming costs.

Figure 125: Daimler Fleetboard equipped 8.000 trucks in 2009

Source: Daimler Fleetboard

The **European fleet management market is being transformed rapidly** due to a number of influences:

- The **entry of PND players** into the B2B market, directly (TomTom WORK) or indirectly (via partnerships, e.g. Garmin),
- The **global expansion strategy of certain fleet management companies** such as Qualcomm, Trimble, Mix Telematics and DigiCore,
- **The growing role of Original Equipment Manufacturers** (OEMs), directly (Daimler Fleetboard) or indirectly (via partnerships, e.g. Iveco partnering with Qualcomm or Scania partnering with Mix Telematics),
- A **rapid consolidation**, accelerated by financial investors, which includes
  - Francisco Partners' acquisition of Cybit (which had previously acquired Thales Telematics, Oxloc and Bluefinger),
  - Transics' and then Trimble's attempt to acquire Punch Telematix,
  - Masternaut's acquisition of its UK unit,
  - Vector Capital's acquisition of TrafficMaster,
  - Montezemolo's and Amadeus' investment in Octo Telematics.
- The **emergence of large customers with international footprints** such as insurers (Axa, Generali, etc.), car vendors, car leasing and rental companies (Arval, Avis, Diac, etc.), third-party logistics providers (DHL, UPS, TNT, etc.) and petroleum companies (Shell, Total, etc.),
- Finally, the gradual **development of mass-market B2B2C telematics** applications such as Pay As You Drive (including Pay How You Drive), road user charging and e-call.

Another necessary change is the **emergence of a new and wide-reaching standard application platform**. ABI's Dominique Bonte even suggested "a portfolio of features from which firms can pick and choose those that best suit their size and operations."

A number of data and application managers have begun to deploy open service architecture platforms, such as Oracle and Accenture, that enable off-the-shelf deployment of complex telematics value propositions.

Another original response is proposed by **Mobile Devices**, which offers to fleet management companies such as TrafficMaster or GPS-Buddy an open application environment, based on 2 700 APIs. It indicates that it has now over 2 000 developers using its platform and 180 000 vehicles using its OS and devices.

b. Road user charging

In the last 10 years, several European countries have introduced telematics "pay-per-use" systems for freight on motorways. These include Switzerland (2001), Austria (2004), Germany (2005), the Czech Republic (2007) and lately, Slovakia (2009).

A number of other countries also have plans to deploy road pricing schemes:

- **The Netherlands** are expected to replace their motor vehicle tax with a universal road charging scheme;
- **France, Poland and Hungary** have launched projects to put in place road charging for HGVs above 3,5 tons;
- The **UK**, **Denmark**, **Belgium and Slovenia** are evaluating the possibility of launching RUC projects for freight.

The **2004 EETS** (European Electronics Tolling Systems) **Directive** enables commercial road users to only subscribe to a single contract with an EETS provider in order to pay the charges related to any road charging scheme requiring an on-board equipment.

Mandated by 2012, EETS will contribute to initiate GPS adoption for wide-area tolling, although 3 technologies are allowed (GNSS, GPRS and DSRC).

RUC penetration for commercial vehicles is based on national governments offering a fair cost benefits charging system for the use of national infrastructure. Although commercially proven, it is politically very difficult to roll out. European regulatory intervention, in particular thanks to EETS and the planned replacing of the Eurovignette maximum per day charge for a pay per use scheme by 2016, will boost take-up.

Road user charging has proven to be a success in Germany, raising more than **€5 billion for investment into the transport infrastructure**, including rail and waterways. As the tax is variable, based on the CO_2 output of vehicles, it has motivated operators to upgrade their HGV fleets to more efficient engines.

Figure 126: A Grundig OBU, installed on a truck for the German Toll-Collect system

Source: Grundig

The system is based on the same technology as PAYD insurance, with charges generally calculated on-board and communicated to a central billing system. It eliminates the need for vehicles to stop at tolling plazas, further reducing pollution and congestion.

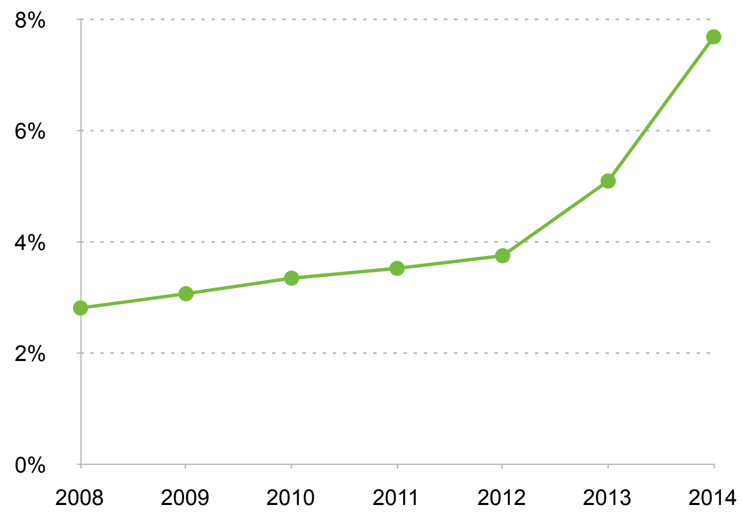
Interoperability between different country systems is currently being established, such as between Germany's Toll Collect and the toll system in the Alsace region in France. The key factor limiting EETS adoption and expansion is the requirement for bilateral commercial relationships between national RUC operators.

Overall, we expect that **satellite-based solutions, which are scalable to all roads and vehicles, will be selected in most RUC countries**.

As shown in the figure below, national schemes and EETS will have an **extremely important impact on the uptake of telematics solution in Europe**.

Although it is not clear whether chosen telematics solution will permit other applications, RUC may accelerate the **emergence of a single European fleet management market**.

Figure 127: Share of commercial vehicles under a telematics road charging scheme



Source: PTOLEMUS

c. PAYD insurance

PAYD insurance has moved from a concept to a viable commercial product, and with the current economic climate placing further financial strains on insurance companies, there is an implicit need to revise the current business model.

We believe that the PAYD insurance market has gone through its cycle of hype and disillusionment. Numerous mistakes have been made and lessons have been learned.

A growing number of insurance companies are now starting to master the complex process of launching a simple and appealing PAYD/PHYD value proposition. Moreover, we believe that the rise of direct / online insurance will accelerate the transition towards usage-based insurance.

Success stories include Unipol in Italy, Mapfre in Spain, Groupama in France, Coverbox in the UK and Progressive in the US. The total **number of PAYD customers worldwide will exceed 1,5 million by the end of 2010.**

Finally, the number of PAYD solution providers has significantly grown. Solutions have become much more sophisticated and, simultaneously, the cost of telematics boxes has dramatically decreased. Besides their level of commitment to make PAYD take off is much higher than in the past.

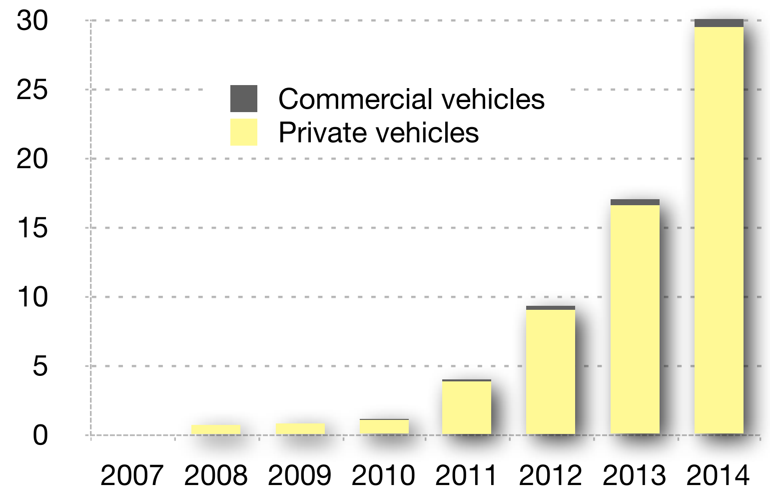
Figure 128: Grow and multiply! The number of PAYD solution providers is growing fast.

Source: PTOLEMUS

Overall, based on detailed analysis of all trials, **we expect the PAYD market to take off in 2011**, starting with private vehicles, and to reach 30 million vehicles in Europe by 2014.

In other words, approximately **20% of all European vehicles will have switched to a PAYD scheme by 2014**.

Figure 129: Number of PAYD systems sold (excluding leasing fleets)



Source: PTOLEMUS

The **commercial vehicle market** will take more time although the business rationale is even stronger. This is due to the fact that insurers have completed less trials for this segment and that the value chain is far more complex. In particular, leasing companies will play a big role in the mid term.

How can PAYD be applied to commercial fleets?

The same way that the leasing model has become the primary business model for business car ownership, we expect that **PAYD will evolve into a key part of the fleet management model.**

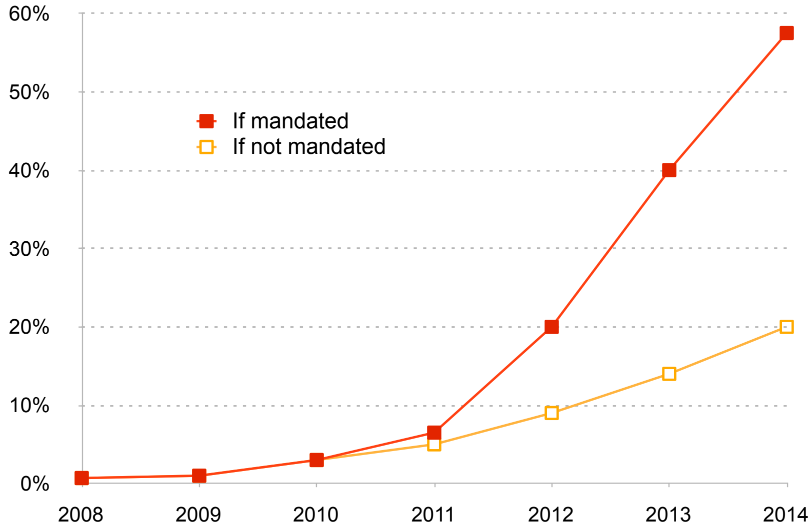
We expect that a number of leasing companies will integrate PAYD insurance as part of wider telematics programmes including remote diagnosis and maintenance.

d. eCall in commercial vehicles

In August 2009, the European Commission called on EU countries and Europe's vehicle and telecommunications industry to speed up the rollout of eCall in Europe. It outlined a strategy for introducing eCall in all new vehicles (categories M1 and N1) across Europe by 2014, starting in 2010, and suggested possible EU legislation should the voluntary approach fail by the end of 2009.

eCall will be introduced first in passenger cars and light commercial vehicles for which an appropriate triggering mechanism exists, and later in other vehicle categories.

Figure 130: eCall mandate's influence on GPS penetration of commercial vehicles



Source: PTOLEMUS

As part of the ACEA (the European automobile manufacturers association), truck companies have been party to the eCall Memorandum of Understanding, but the ACEA working group wrote to the Commission requesting that heavy trucks be excluded from the initial implementation.

At this stage, the Commission has sent to the European country standards groups the standards developed for:

- The **Minimum Set of Data** (MSD): the information sent from the vehicle to the PSAP, and
- The **messaging method**: based on the single European emergency number enhanced with location capabilities, i.e. E112.

The last time a vote was taken, the standards were voted down by Germany and France. This time, it is hoped that all will vote in favour, even if the UK and France have not signed the Memorandum of Understanding.

Assuming that the vote is positive, the Commission will present a **motion to the European Parliament in 2010 making eCall mandatory in all new vehicles within 3 years**. The 3-year period has been requested by the automotive industry in order to allow time for OEMs to implement the systems, and for PSAPs to equip their call centres with the appropriate software and/or hardware required for accepting the voice/data calls sent via in-band modem.

The estimated impact of eCall on the LCV market is based on a European mandate being achieved in 2010.

3. Estimated location-enabling market

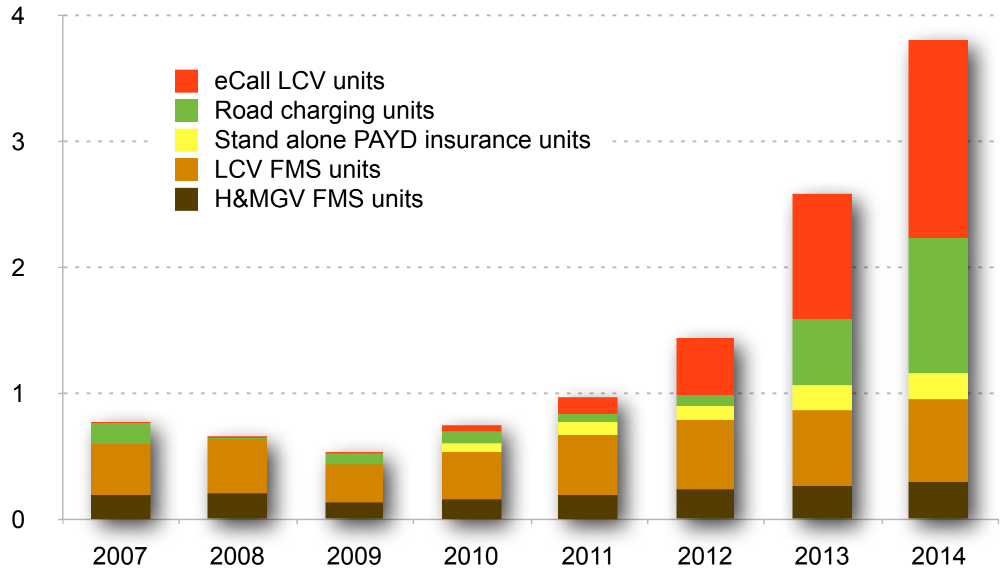
Enabling commercial vehicle location is primarily based on the use of satellite-based systems, notably GPS. By 2014, the share of WiFi- or network-centric positioning is not expected to be significant.

The evolution of the size of the positioning market for commercial vehicles primarily depends on 2 key factors:

- The wider implementation of road charging across Europe,
- The speed at which eCall is implemented in LCVs.

Based on the assumptions that eCall will be mandated and that the Netherlands will go ahead with nation-wide road charging, the **market for positioning in commercial vehicles is expected to quadruple between 2011 and 2014**.

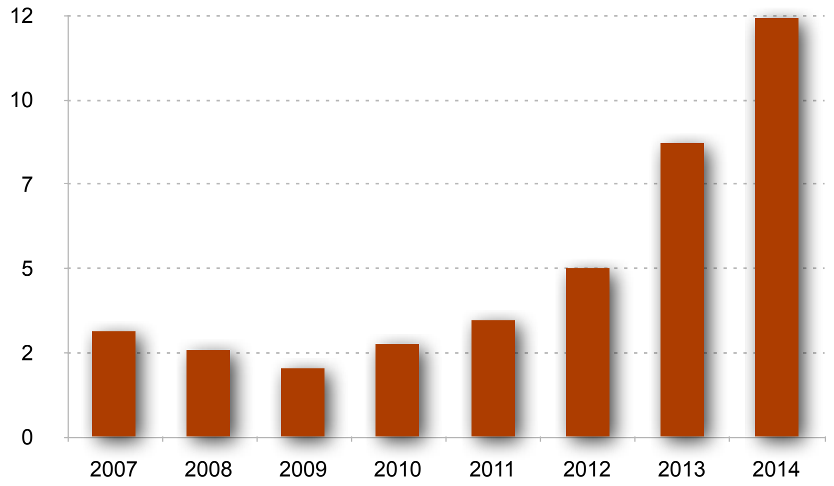
Figure 131: GNSS telematics units installed in commercial vehicles (in millions)



Note: We are assuming that eCall, RUC, FMS and PAYD are not delivered through multi-purpose units
Source: PTOLEMUS

The impact of road charging on the GPS equipment segment is massive because it affects all trucks in use. In the short term, we expect that FMS units will remain distinct from road charging OBUs (on-board units).

Figure 132: GNSS chipset sales from commercial vehicles (Euros, in millions)



Source: PTOLEMUS

V. CONCLUSIONS AND RECOMMENDATIONS

A. Major trends for location in Europe

1. Summary

Location is becoming a commodity. As useful as water and electricity.

It will gradually permeate all connected mobile and fixed devices, all mobile assets of value and all individuals.

Who will pay for location?

- Upstream: Service enablers such as mobile network operators and device manufacturers,
- Downstream: B2B service providers and large B2C LBS players (e.g. social networks, fraud prevention services and search engines). Application developers will share their revenues to fund location.

What positioning technology will be used?

- GPS-only hegemony is coming to an end in the consumer market and will increasingly be challenged in the commercial tracking arena,
- Hybrid solutions are now becoming a standard in smartphones and can be adapted to a large variety of product and service requirements,
- Network-centric **passive location** (e.g. IP location and Cell-ID) **will be used 1,000 more often than active network positioning**.

How big is the market opportunity?

In 2014, we expect the market for positioning technologies to be dominated by GNSS solutions:

- **Almost 300 million GNSS chipsets** will be sold, representing **a €1 billion market**,
- The market for **motion sensors** will grow to €350 million, based on **250 million units** embedded in devices for the purpose of positioning;
- **WPS will equip 220 million devices** and generate a value of over €70 million;
- Network location infrastructure will represent a €60 million market.

2. Key developments

The simplicity of the **GPS monopoly is ending.**

The positioning business is increasingly following the pace of the mobile phone industry, which drives the largest device volumes, thanks to 4,6 billion mobile subscribers worldwide.

As a result, it is becoming more complex. Location technologies and databases will multiply and prosper. The examples of Combain, GloPos and BlueSky Positioning seem to demonstrate that **the world of certainties is over**, in location too.

As the phenomenal success of the iPhone and Google Maps Mobile has demonstrated, a **highly efficient location technology can strongly differentiate a device or a service and contribute to its success**.

In our view, the over-reliance of certain players (such as PND vendors, car vendors, track and trace companies) on the same mature technology, GPS, has contributed to the commoditization of their business.

We expect that WPS will continue to make inroads in a number of GPS-dominated markets, most noticeably in consumer electronics such as tablets, smartphones and cameras.

Whilst being the only truly global positioning technology, **Cell-ID-based location** is under-used but will follow the success of IP location in **web search, fraud prevention, enterprise and government markets** where location requests are in the order of the billions / month.

Assistance data provision will play a key differentiating role as **hybrid location becomes the expected service level** and more devices are location-enabled.

While GPS still dominates the industry, it will increasingly be combined with other satellite technologies (Glonass and Galileo) or network technologies such as WPS and Cell-ID.

LTE will enable more accurate location through an improved network triangulation process (OTDOA).

3. Key factors affecting market growth

a. Access to positioning technology

GNSS chipset vendors, device manufacturers, operators and LBS providers will all have direct access to passive and active positioning technologies:

- Chipset manufacturers will have and provide access to the entire mix of location technologies and integrate their capabilities from **A-GPS, WPS, Cell-ID** or better versions of network based triangulation as well as device-based extended ephemeris and supporting positioning sensors;
- Large telecommunications infrastructure suppliers will use location as a competitive advantage and, we believe, will **provider it by default** to operators upgrading their networks to LTE;
- Global or large LBS providers will have the option to **control their own positioning** server at a much lower cost than mobile operators today.

Today, access to Cell-ID location is still complex and expensive. Operators are however increasingly fighting for developers' attention. We expect that Cell-ID location will soon become part of the tools provided by the operator's environment. Their tariffing structure will become more aligned with those of OS and device vendors.

Certain smart operators, notably in Scandinavia and the UK, are also opening the distribution of Cell-ID data to aggregators. In our view, this is as promising for the Cell-ID business as wholesale SMS has been for the SMS business. Countries which have opened SMS to wholesale first, such as Germany, have experienced much higher usage patterns.

We expect User plane architecture to carry the vast majority of location requests in the consumer segment. Control plane location will be better suited to enable enterprise and passive / automated location services.

We do not believe that there is a high risk of platform monopoly or data ownership monopoly. The 4 "silos" (Apple, Google, Nokia and Microsoft) hold a key advantage thanks to their vertically integrated geo-solutions.

However, the high number of alternative location technologies (e.g. A-GPS SIM) and alternative data players (Facebook, Twitter, Skyhook, TomTom / Tele Atlas, etc.) will contribute to **perpetuate the high level of competition and potential for disruption**.

b. Connectivity

The diffusion of connectivity will play a crucial role in creating a **smart ecosystem of located devices** that can interact with human beings and other devices.

While there are **1,3 billion SIM cards in use in Europe** (including Russia), we roughly estimate the **number of machines to be connected at 16 billion**, from cars to e-books and fridges. This shows the long term growth potential for the industry.

According to Ericsson, **data traffic overtook voice traffic on cellular networks in December 2009** at a crossover point of 140 000 Terabytes per month for both voice and data. This has happened despite the fact that mobile broadband users (i.e. WCDMA, HSPA, HSUPA and LTE) only represent 8% of all mobile subscribers in Europe (including Russia).

c. Speed and capacity

Device processing capacity will continue to grow. Semi-conductor manufacturers are already working on chips with CPUs of 1.6 GHz and beyond.

LTE, which is starting to be experimented by operators, will provide typical data rates of 10-100 Mbit/s downlink and 5-50 Mbit/s uplink, with latency levels much reduced compared to 3G.

The provisioning of cellular network capacity will become increasingly complex and **mobile networks will pursue their historical densification process**. This will contribute to improve positioning services, as the following examples suggest:

- A higher density of cellular sites will improve the accuracy of Cell-ID's network triangulation,
- The opportunity to divert mobile data traffic onto fixed broadband access networks via femtocells or WiFi access points will create more location-enabled nodes.

d. Usability

Augmented reality (AR) will become a key medium to visualise and interact with content and services. Local search (Yelp), social networks (Brightkite), games (EA), discovery, pedestrian navigation and a whole array of application can benefit directly from using AR as the main or a secondary interface.

AR will push content to become geo-located as well as geo-locate content itself as user interact and feedback information through the AR interface.

It may also enter the field of car navigation thanks to head-up displays (HUDs) that certain car vendors, such as BMW and Lexus are starting to launch.

Figure 133: AR entering the car thanks to HUDs - BMW 5 Series Touring optional HUD

Source: BMW

Other advancements will include:

- The growing use of 3D graphics, for example in navigation maps, but also in local search,
- The emergence of contextual location-based automated alerts, particularly for advertising and social networking applications,
- The maturation of voice recognition technologies, applied to local search and people tracking.

4. A key emerging force in location, Facebook

Facebook is an application platform that can compete with the 4 silos. It has over **100 million registered users in Europe** (to be compared with Apple's 15 million iPhones and iPod Touch users) and more frequent user activity than any other social network.

It has managed to become the **trusted platform that manages the digital relationship between friends and family**. It can monetize it for markets where connecting people, tastes and locations is necessary, such as real estate.

Facebook could decides to acquire a POI-centric social network such as FourSquare and Tellmewhere. This would enable its users to share their location preferences (applying buttons such as "like") while building on its colossal database and pool of users. This would also reduce the risk of a public backlash against invasion of users' privacy as the opt-in mechanism is at the level of the check-in application.

It could also create its own comparable service and overtake existing players in a few months...

5. Key markets for positioning

Driven by the fight between Nokia, Google and Apple for smartphone domination and location-enabled chipset price declines, the **mobile phone industry will represent both the largest opportunity and the market that will set the trends of location**.

Location-based advertising (LBA) will become one of the most potent form of location monetization. The battle to control LBA will come from different companies: the 4 silos, large independent (web) application providers (such as Twitter and Facebook) and mobile operators.

One of Google's interesting assets is its patent on location-based advertising and response tracking. It could potentially enable Google to obstruct location advertising efforts by its rivals.

Apple's preemptive response has been to prevent its developers from using another ad platform than iAd by blocking access to ad metrics if they use another platform such as Google's AdMob.

Vehicles represent the second largest location market opportunity.

Nearly 70 million GNSS chipsets will be sold in / for cars in 2014. Vehicles equipped with embedded or PND navigation will represent **over 180 million cars**.

The in vehicle-positioning market will pass €70 million by 2014, pushed by eCall, PAYD insurance and, potentially, road user charging schemes;

Both **RIM** with its acquisition of Dash and QNX and **Nokia** with its ***Terminal Mode*** project in partnership with Alpine, Harman Becker and Fiat are the most advanced to bring local connectivity to the mobile phone in all vehicles.

B. Value creation opportunities

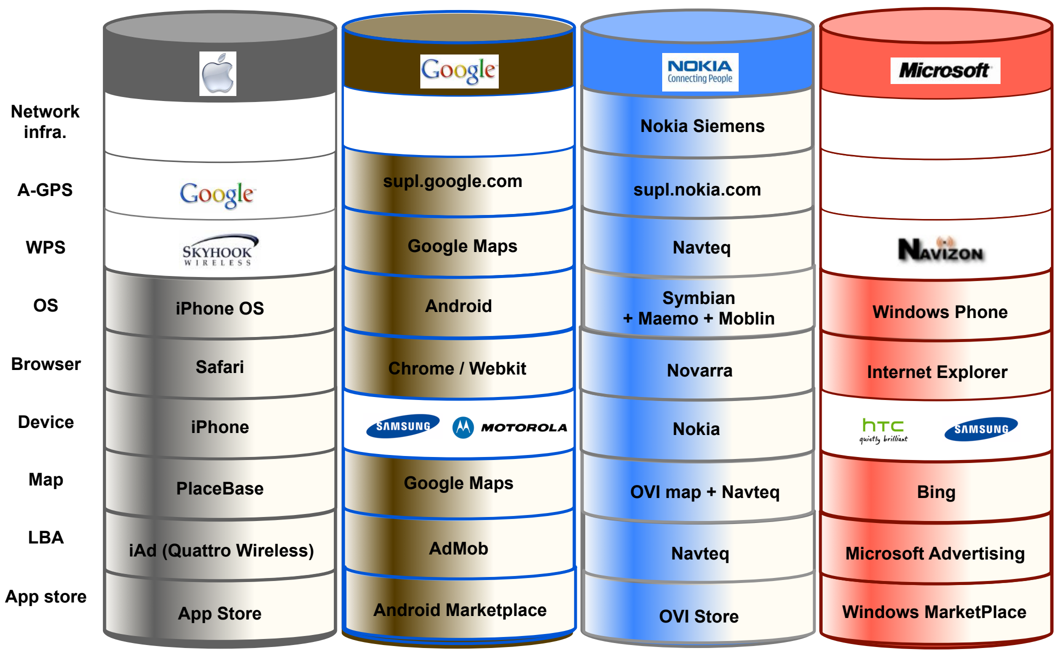
1. The new value chain

Four companies have understood very early the crucial importance of location to user context... and acted on it.

In the last 10 years, they have progressively built up **vertically integrated silos aggregating the complete location value chain**. They have proceeded through acquisitions or internal growth.

The consequence is a value chain based on silos controlling hardware, services and access to these services.

Figure 134: Of the 4 location "silos", Nokia has the most complete one



Source: PTOLEMUS

To a large extent, Apple's iPhone success has moved the device software at the top of visibility pyramid.

We expect the role of mobile devices operating systems to grow significantly, notably due to Android. It will gain increasing recognition in the mass market and may even become the first label in the eyes of the user if Google succeeds in making its OS the "Windows of the mobile world".

2. Risks and opportunities

Privacy still the number one threat

According to John Stansfield, Group Manager Location Based Services, Orange FT Group, operators used to see the need for an horizontal multi-application privacy platform but have changed their mind.

Now, the perception that certain application providers hold too much data about users is exacerbated by their inability to realistically control the extent of the use of the information they are entering and sharing about themselves. This is becoming worse when applications start sharing data between themselves (e.g. LinKedIn and Twitter).

We see **privacy filters and reminders**, at the device or browser level, becoming prominent in the near future. There is also a great opportunity for operators to regain control of the privacy loop while providing next generation network-centric positioning and services.

If not, maybe regulatory authorities will intervene again, as the recent example of the German government requesting control of Google and Apple's user databases indicates.

Billing is an inhibitor on operators' service platforms

Mobile operators' billing and payment systems could be a key differentiator for developers. Instead, these are in general complex, fragmented and expensive (notably due to content aggregators, which create an additional layer in the chain).

They represent a significant barrier to develop on operator platforms, which creates an **opportunity for the WAC (Wholesale Applications Consortium) to forge a global standard for operator payment and billing**.

The WiFi Positioning System (WPS) oligopoly

The size of the database will remain a major differentiator between companies offering location and assistance. Early entrants can use their initial advantage to keep their leadership position.

WPS provision is dominated by one company. If Skyhook were to be acquired by a device manufacturer, the whole ecosystem would change and many application providers who have a revenue share with Skyhook would be the first at risk.

As the second-largest WPS provider, Navizon plays the natural role of the independent challenger and would benefit from Skyhook's acquisition.

C. Recommendations

1. The business model for operators to invest in positioning

Most European mobile operators have invested in infrastructure to provide location and are continuing to do so.

For example, we expect that by the end of 2010, all French operators will be A-GPS equipped by the end of 2010 and that Vodafone will have all its European networks equipped.

From our interviews with European operators, it appears that the long term strategy motivating these investments is still not clearly formulated.

Below are 6 suggestions to obtain a positive ROI from their location infrastructure.

(i) Do not look at LBS as a specific business!

Location is a fundamental enabler but it is only rarely the core of a value proposition to customers. Therefore it does not make sense to analyse LBS as a specific market opportunity or to create a LBS business unit!

Thus, operators should not try to develop a business case for their location platform, the same way they do not build a business case for their network management centre or their SIM cards! Revenues arising from this investment will come from additional sales in other revenue lines, incremental market share and potentially location-based advertising.

To be created, an ecosystem requires a number of enablers. If these enablers are not put in place, no revenues will emerge.

(ii) Control your network location capability

Operators looking to re-initiate a location provisioning strategy will need full control over the network location and assistance.

Investments in SUPL can be made to provide A-GPS (and later the whole range of location assistance) can help operators to become a key player in positioning again.

(iii) Seek location revenues from all devices, not only consumer phones

Let's assume that an operator reinvests 4.5% of the LBS applications revenues in upgrading its location infrastructure and that GMLCs update range between €300,000 and €1 million. To reinvest €300,000 in the infrastructure, the operator would need to be paid for over 22 million location requests per month. This is about 50 times more than the average aggregator is dealing with in Europe!

If the price of location requests is below € 0.02, the break-even point for providing network positioning is above 500 million requests per month.

Applications and services operating in this scale are fraud prevention, CRM and HR integration, web content optimization, real time traffic assessment and such. Cell-ID should be seen as a complementary technology to IP location, not (only) to GPS.

(iv) Upgrade your existing services with location

Providing positioning will not create a service in itself. Location is everywhere, expected and perceived as free. It has become **a feature, not a service**.

Operators should look at the consumer and enterprise services they offer today and add location capability to them. For example, location would be a great extension to enterprise communication suites, workforce management platforms and professional social networking (e.g. LinkedIn or Viadeo).

(v) Monetize the crumb trail

Operator-owned A-GPS servers will be used by mobile applications outside the Google, Nokia and Apple silos. Samsung's Bada platform, for example, is aimed at affordable smartphones better controlled by operators. Controlling the positioning provision mechanism is a natural way to own users' positioning data and to leverage it for behavioural analysis, service improvement or statistical purposes.

Google, TomTom, Navizon but also applications providers such as Inrix or Shazam are creating direct value from the location data extracted out of the use of their service.

Operators can do the same as long as the data is anonymized but without the need to obtain users specific consent, as a number of experiments by Deutsche Telekom and Orange (see figure hereafter) have demonstrated.

Figure 135: Madrid during the 2008 Euro 2008 football championship - Orange / faberNovel's visualisation tool of urban crowds movements, based on Cell-ID

Source: Orange, faberNovel

Companies such as Sense Networks are positioning themselves in the business of ensuring that the data is used properly and the information extracted has high value.

(vi) Integrate location to your future LTE network

LTE will represent a new opportunity for operators to entice the user back, notably thanks to device subsidies or large bundles.

In several countries such as France, Spain or the UK, a single bill for phone and home broadband is becoming a winning offer for users with an Internet connection above 2 Mbit/s.

LTE will also bring the much cheaper OTDOA triangulation solution (software based version of U-TDOA), that promises **accuracy below 100 metres with a Control Plane architecture**. Operators could also give better treatment to the services they control by migrating these first to LTE and integrating location for free.

Fundamental drivers that will make the operator case work include:

(i) Integrate WiFi positioning from the start

WiFi will be part of the SUPL mix. Operators must bring the WiFi location ability in their portfolio. The easiest way is to include it in their forthcoming SUPL 2.0 standard-based location servers.

(ii) Price

Radically lower the price of Cell-ID data to create a lively location ecosystem around you and compete with IP location. This is a high volume business. The objective should not be to sell millions of requests at a high margin a year but billions per month at a small margin. Ensure that your contracts with location infrastructure platform vendors are structured to make this possible.

(iii) Billing

Provide simple and affordable mechanisms for developers to access users' location data history and subscription bill payment infrastructure for developers to easily provide services with it.

(iv) European roaming

Enable hybrid models for applications such as navigation to roam across Europe for added differentiation against offboard applications such as Google Maps. Otherwise, most customers will just switch data off when they are abroad.

(v) Web applications and widgets

Web-based mobile applications can use the W3C geo-location API that gives access to location from the device to the web application. LBS applications do not need to be downloaded on the device.

(vi) HTML5 + LTE

HTML5 will help applications to run directly on the browser, reducing the need for application stores. Operators will then be able to provide positioning, connectivity, web-based services and control the way these are used and billed for.

2. Recommendations to automotive OEMs

(i) The time of closed embedded operating systems is counted

As mobile phones and PNDs offer connected navigation with far greater functionality and integration with other applications, the future of closed systems looks extremely limited.

Car vendors must find a way to introduce the speed of the CE business into the car. PND vendors and speed camera device companies have shown that a single application was sufficient to drive customers to buy a specific device for the car. This will repeat itself in the future if OEMs are not able to **provide access to new services** such as mobile social networking or roadside assistance **across the life of the vehicle**.

(ii) Open embedded platform can deliver a better user experience than handsets and PNDs

An open embedded platform enables either the applications to operate on a nomadic device or the vehicle platform and accessed via the human user interface of the vehicle. Automotive manufacturers are then able exploit the wider application-based market, whilst at the same time offering a unique automotive vehicle centric experience.

Potential solutions include Microsoft Blue & Me, Nokia's Terminal Mode, TomTom's integrated devices or Mobile Devices' platform. The success of the GENIVI initiative, headed by BMW and Intel, remains to be seen.

(iii) Automotive vendors can differentiate through positioning

Automotive manufacturers are uniquely placed to set their systems apart by integrating more refined and power hungry iterations of existing or new technologies to offer greater accuracy, availability, stability and a better TTFF than a nomadic device. These include:

- **High sensitivity, future-proof GNSS chipsets**

  High sensitivity GPS chipsets use an internal method of augmentation as opposed to the external methods of assistance such as A-GPS or EGNOS. By increasing the number of correlators combined with digital signal processing, the receiver is able to pick up signals that are 1,000 times weaker than a standard GPS is able to detect and process.

A high sensitivity GPS receiver is able to acquire satellites that a regular receiver might not even detect providing a greater number of satellites to triangulate a position from. This provides a greater degree of accuracy and reduced TTFF. However, the high processing capability increases high power consumption making it unsuitable for handsets, but of particular interest to larger power sources such as those found in vehicles.

Similarly, car vendors can request from their chipset suppliers to integrate Galileo and / or Glonass so as to have future-proof, higher availability and redundant systems.

- By integrating **MEMS** such as gyroscopes and accelerometers to measure minute movements into a more stable platform, vehicle manufacturers are able to offer greater accuracy than mobile devices for safety and security applications and dead reckoning in covered spaces such as tunnels.
- **Cell-ID** is still available as a back-up technology as many vehicle centric services require a wide area M2M capability and therefore network coverage.
- In the absence of integration with a gyroscope or with internal systems, WPS can be brought in to enable a much faster TTFF in urban driving. Automotive OEMs can take advantage of the developments made in smartphone positioning technology and re-use existing advances into the vehicle such as "combo" Bluetooth / WiFi / GPS chipsets.

(iv) Automotive manufacturers must enable integration of devices

There is an implicit requirement to enable integration of mobile devices / PNDs to enable similar user experiences and service access whilst in a vehicle. This requires manufacturers to enable:

- **Open positioning technology access** – Both handsets and vehicles must be able to access the best positioning technology available, so open access between the vehicle and nomadic device should be considered;
- **Physical or wireless integration of nomadic devices** should be offered at the user interface level to allow soft hand-off between devices and power access to enable continuous and uninterrupted service access;
- **Access to the On-Board Diagnostics** (OBD) port **should be further standardized in Europe** (at least on a passive slave basis) to enable 3rd party vehicle centric service provider access to vehicle integrated MEMS and diagnostic data sets.

(v) Don't wait for the eCall mandate!

Road safety is paramount in the eyes of more and more drivers. Hence a well-implemented eCall function, combined with a navigation system, appears to us as a key differentiator in a highly competitive car market. This is particularly true for entry-level and medium range models, as the very high uptake rate of TomTom's navigation solution on the Renault Clio demonstrates.

Although the business case can appear as difficult, it is about **obtaining high economies of scale for car telematics systems**, to recover a large portion of fixed costs.

Last but not least, it is better to differentiate products through innovation than price cutting!

3. Recommendations to PND vendors

Connectivity is crucial and the form factor will survive only if it can compete with navigation on mobile phones. The fact that **TomTom has sold 1 million connected PNDs** so far shows the trend.

The key challenge will be to **turn connected navigation from a high-end offer to a mass-market solution**, i.e. at an affordable price.

To achieve this, we believe that PND vendors have the opportunity to focus their products on positioning and location in a way that smartphones cannot.

- By integrating WiFi and connectivity into their hardware platform to leverage hybrid positioning technologies, PNDs can at least reach comparable availability and TTFF as smartphones,
- By providing an open platform for 3rd party application and content providers, PNDs can become updatable, upgradable and more relevant to different types of users. The application store model would apply very well to a PND,
- By developing unique features such as larger screens and TV, they are making it impossible for smartphones to compete,
- By leveraging their significant user base to provide services such as PAYD, roadside assistance, stolen vehicle recovery, etc.
- By opening their device to smart, location-based advertising in a controlled manner, they can **increase** the value of their device. A majority of Europeans have been proven to appreciate to receive well-targeted promotions.

4. Recommendations to location technology providers

a. Network-centric solution providers

The strategic, business and financial case for operators to invest in positioning needs to be made clearer and simpler.

Far too little information is now readily available from vendors and the vast majority of it is focusing on the technology, which is understood by 0,02% of operators' staff!

Technology vendors urgently need to be in a better position to **explain the strategic and business benefits of their solutions to MNOs**.

A-GPS and GLMC providers

Location triangulation infrastructure should be offered as part of bundle of services to new and upgrading operators. Infrastructure providers are in a great position to offer added value by offering solutions to handle the analysis of massive amounts of data.

MVNOs often do not have location infrastructure. Given their growing size, they will not be able to escape their responsibilities, notably for E112.

Application providers are the next growing pool of customers for location platform vendors. Efforts should be made to

- Communicate the value of location in terms that make sense to developers,
- Provide easy access, e.g. thanks to automated Internet-based solutions,
- Adapt the offer to the size of the service provider,
- Make it affordable, for example, by agreeing revenue share agreements.

IP location providers

Target the SUPL 2.0 customers' community as speed and cost are the main advantage you can bring to assist GPS.

WiFi location providers

Investigate opportunities in the B2B markets now covered by IP location.

WPS is equivalent in price and is available on all laptops. Moreover, its availability in urban areas is excellent and its accuracy is superior to IP location.

b. Device-based solution providers

GNSS chipset vendors

As the highest growth markets are under control, **focus on the long tail** and make it easier to integrate GPS for any devices, from cameras to handbags!

Do not sell a location technology but a location solution.

The price of GPS-only chipsets will continue to decrease.

Target OS vendors, operators and ISPs with combined sensors / GPS / WiFi / Cell-ID solutions. Cell-ID databases are available globally.

END OF THE FULL STUDY

Disclosure: The recommendations and opinions expressed in this study reflect PTOLEMUS' independent and objective views. However, PTOLEMUS cannot provide any guarantee as to the accuracy of the information provided or the reliability of its forecasts.

INTRODUCTION TO DEVERYWARE

Based in Paris, France, Deveryware provides real-time location of mobile assets, people, and vehicles, relying upon multiple location techniques, namely **GPS, WiFi, Cell-ID** and communication networks.

Various location-based services are offered including

- Tracking of corporate fleet vehicle and employees,
- Tracking of vulnerable people or isolated worker safety,
- Social networks,
- Car-sharing,
- Mobile advertising,
- Homeland security.

Deveryware aggregates and/or fetches positions from

- a wide range of mobile terminal devices including smartphones, and
- mobile network operators to locate any handset indoor/outdoor via Cell-ID.

Smart filtering and running of real-time data, including powerful location-based and/or time-based alerts, are processed on a heavy-duty and high-availability (99.9%) platform which also computes and distributes data.

Location-based services are also offered in **white-label mode**. In that case, Geohub functions can be reached directly through a specific API.

Deveryware's platform, called **Geohub**, currently processes **millions operations a day. Its cumulated traffic is growing exponentially:**

- 300 million in March 2008,
- 1 billion in October 2009,
- 1,7 billion requests in June 2010.

With many academic and industrial partners, Deveryware, a 35-people company, dedicates several million Euros per year in R&D to test and implement innovative location techniques, and processing and ergonomic functions.

In 2009, Deveryware doubled its revenues and was ranked France's 17th growth company by Deloitte's Fast 50 awards.

INTRODUCTION TO NAVIZON

Founded in January 2005, Navizon, Inc., (formerly Mexens Technology) is the maker of Navizon, the first positioning system to combine GPS, Wi-Fi and cellular signals for an optimal geo-positioning experience.

Navizon relies on a global community of **more than 1 million registered users** from all over world to build its database.

Thanks to its innovative technical features and incentive programs such as the rewards and referral programs, Navizon has seen a truly viral growth over the past few years, growing from 50,000 users to more than a million in approximately one year.

In addition to covering all the wireless technologies (Wi-Fi, GSM, CDMA and 3G towers), **Navizon's database is truly dynamic and gets updated every day with a constant flow of more than 500,000 data points every day**.

Navizon is available on most mobile platforms such as Blackberry, iPhone, Android, Windows Mobile, Symbian/S60 and Java phones and across all carriers all around the world.

The **Navizon positioning engine** is available to third parties through Navizon's catalog of Enterprise solutions.

In July 2008, the US Patent Office recognized the innovative nature of Navizon's positioning technology by issuing a patent for its hybrid positioning technology and a second patent in 2010 for its wireless triangulation technology.

The company is headquartered in Miami, Florida.

For more information please visit www.navizon.com/ . To see how Navizon Wireless GPS system works, please see http://www.navizon.com/FullFeatures.asp

LIST OF COMPANIES INTERVIEWED AND MENTIONED IN THIS STUDY

Company	Interviewed	Mentioned
3 Group	x	x
ABI Research	x	
Accrossair		x
Ace Marketing & Promotions		x
Acuity Mobile		x
AdMarvel		x
AdMob		x
AdWhirl		x
AireTrack		x
Alcatel Lucent	x	x
Alpine		x
Altea		x
Amadeus Capital Partners		x
Amobee		x
Andrew	x	x
Android (Google)		x
Apple		x
Arbitron	x	x
Artilium	x	x
Atheros	x	x
Autodesk (TCS)		x
Belgacom		x
Blackberry	x	x
Blue Bite		x
Blue Umbrella Inc.	x	
Bluefinger		x
Bluesky Positioning	x	x
Blyk		x
BMW	x	x
Bosch	x	
Bouygues Telecom	x	x
Brightkite		x
Broadcom	x	x
Cell Vision	x	x
Centrl		x
Cloudmade	x	x
Cobra Automotive Systems		x
Cobra Wunelli	x	x
Combain		x
Coyote Systems		x
Creativity Software	x	x
Cybit		x
Cyta		x
Daimler Fleetboard		x
DeCarta	x	x
Delmas	x	x
Deveryware	x	x
Devicescape Software, Inc.	x	
Digicore		x
EENA (European Emergency Number Association)	x	x
Egnos	x	x
Elisa		x
Ericsson	x	x
ESRI	x	x
Euskaltel		x
Eye-Fi		x
Facebook		x
Fiat		x
FourSquare		x
Francisco Capital Partners		x
Galileo	x	x
Garmin		x
Genasys	x	x
Glonass	x	x
Glopos	x	x
Google	x	x

Company	Interviewed	Mentioned
GPS-Buddy		x
Greenroad		x
Grundig		x
Gypsii		x
Handango		x
Harman Becker		x
HTC		x
Huawei		x
iMASS	x	x
IMS		x
Intel	x	x
Inrix		x
Insiteo		x
Intrado		x
Iridium		x
iSuppli	x	
Iveco		x
KPN	x	x
Layar	x	x
LG		x
LiMo	x	x
Llama		x
Loc-Aid	x	x
LocatioNet	x	x
LocationPoint		x
LociLoci	x	x
Masternaut		x
Mecomo		x
Medio		x
Medion		x
Meetic		x
Micello	x	x
Microlise		x
Microsoft		x
Millennial		x
Mio (Mitac)		x
Mix Telematics		x
Mobext		x

Company	Interviewed	Mentioned
Mobilaris	x	x
Mobile Arts	x	x
Mobile Commerce	x	x
Mobile Devices	x	x
Mobilkom		x
Mobistar		x
Montezemolo & Partners		x
Motally		x
MoVoxx		x
Mozilla Foundation	x	x
MTS		x
Navigon	x	x
Navionics		x
Navizon	x	x
Navteq / Navteq Media	x	x
Nielsen	x	x
Networks in Motion (TCS)	x	x
Nintendo		x
Nokia	x	x
NXP		x
Octo Telematics		x
Ogilvy		x
Open Mobile Alliance	x	x
Openwave		x
Opera	x	x
Optimus		x
Oracle	x	x
Orange group	x	x
Oxloc		x
Palm	x	x
Panasonic		x
Placecast		x
Plink		x
Pointer Telocation		x
Pointinside		x
Polaris	x	x
Pole Star	x	x
Polkomtel		x

Company	Interviewed	Mentioned
Punch Telematix		x
QNX Software		x
Qualcomm	x	x
Quattro Wireless		x
Qubulus	x	x
Quotient Associates Limited	x	
Quova	x	x
ReachU		x
Redknee		x
RIM	x	x
RingRing Media		x
RoadPilot		x
Rosum		x
Rummble	x	
RX Networks		x
Samsung		x
Scania		x
Scope Technologies		x
Sense Networks	x	x
Sensomatix		x
Shazam		x
Siemens		x
Skymeter		x
SFR	x	x
Sirf/ CSR	x	x
Skyhook Wireless	x	x
Smaato		x
Sofialys	x	
Sony		x
Spotify		x
ST Microelectronics	x	x
Statsis	x	x
Steria		x
Stok Nederlands		x
Symbian	x	x
TapMetrics		x
TCS	x	x
Tele2		x

Company	Interviewed	Mentioned
Tele Atlas		x
Telefonica (O2)		x
Telenav		x
Telenity		x
Telenor		x
Telia Sonera	x	x
Telmap		x
Texas Instruments	x	x
Thales Alenia Space	x	x
Thales UWB	x	
The European GNSS Supervisory Authority (GSA)		x
Telecom Italia Mobile		x
Tellmewhere		x
T-Mobile		x
T-Systems		x
TomTom	x	x
Trackaphone	x	x
Trimble	x	x
TruePosition	x	x
Turkcell	x	
Twitter		x
U-Blox	x	x
Useful Networks	x	x
Vector Capital		x
Viadeo		x
Via Michelin		x
Virgin Mobile		x
Visibilly		x
Vodafone	x	x
Wavecom (Sierra Wireless)		x
Wavemarket		x
Wcities	x	x
Wind		x
WirelessCar	x	
Yahoo!	x	x
Yelp		x
Yoigo		x
ZTE		x