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EUROPEAN LOCATION STUDY 2010

Positioning technologies: Evolving landscape and opportunities

FREE STUDY

This study has been supported by

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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 analyze and address global location and mobility issues.

The authors of this study

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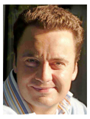

Mr. Bruneteau founded the PTOLEMUS Consulting Group on the conviction that pervasive location and connectivity would revolutionize the business of mobility.

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.

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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.

If you want to purchase the Full Study, just click on Full Study

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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.

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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

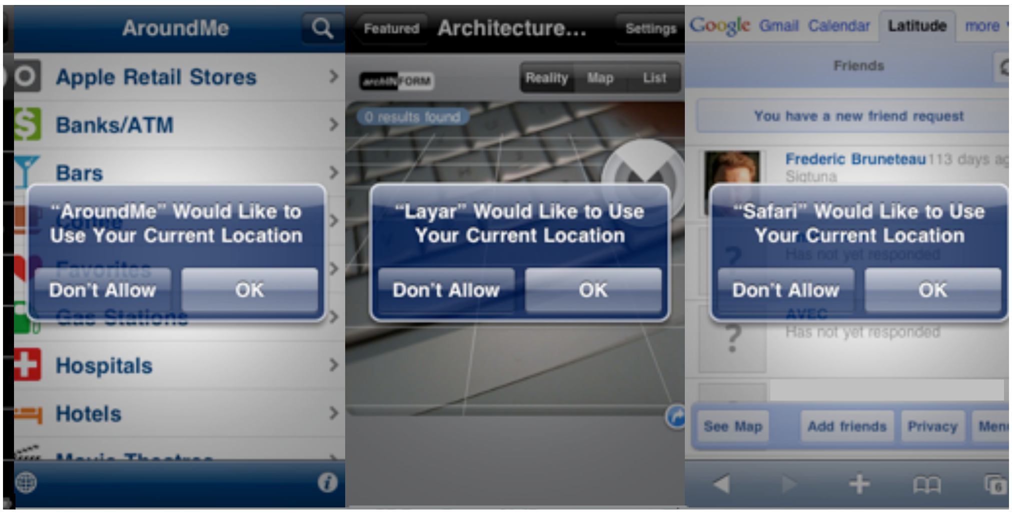
d. Smartphones

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.

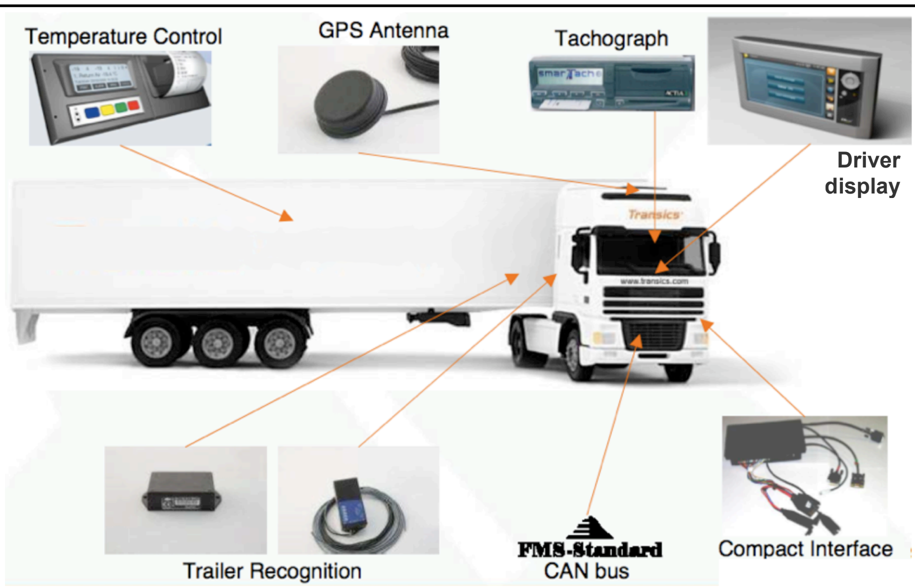
Given the low margin character of the transportation industry, the key development in the benefits of fleet management systems (FMS) has been the ability to **operate a fleet in a more cost effective manner**.

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. 184

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.

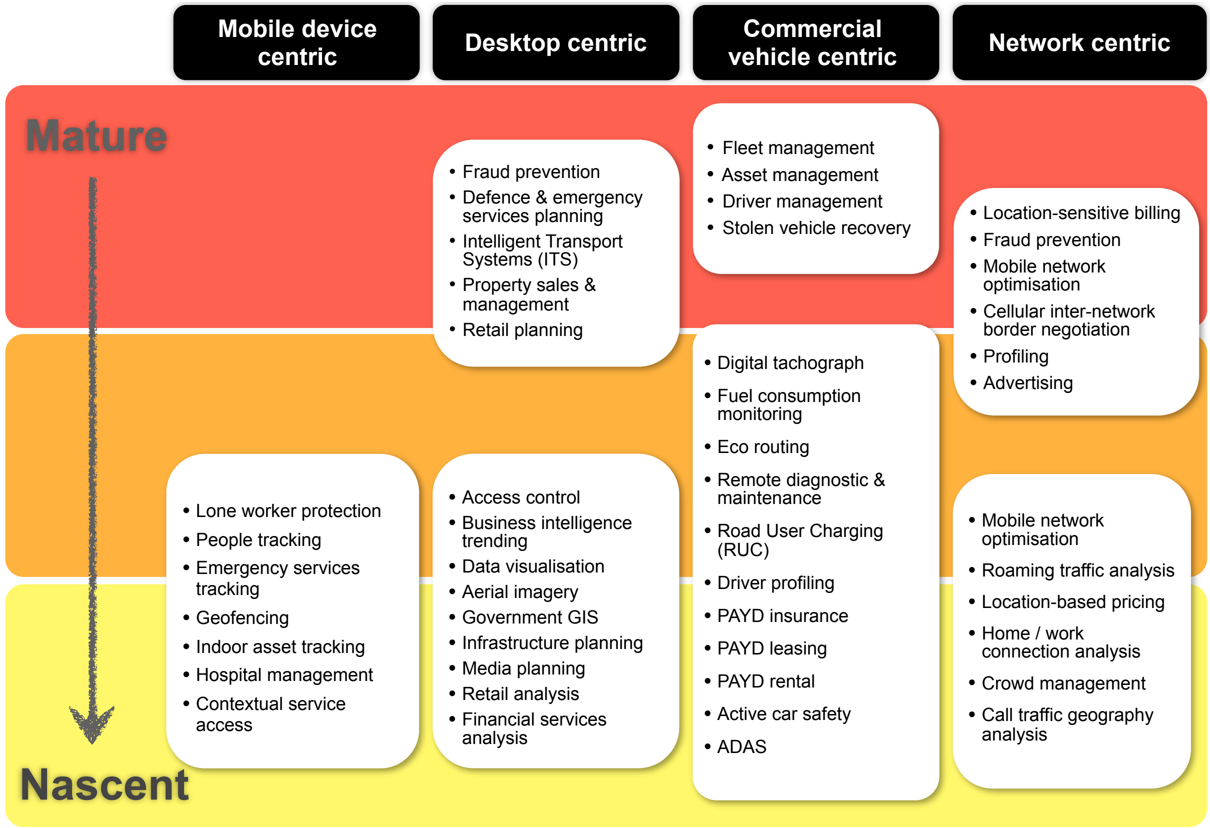
Telia Sonera and EMT Estonia are conducting a technical trial of its SIM cards, but have not reached a commercial deployment phase yet.

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.

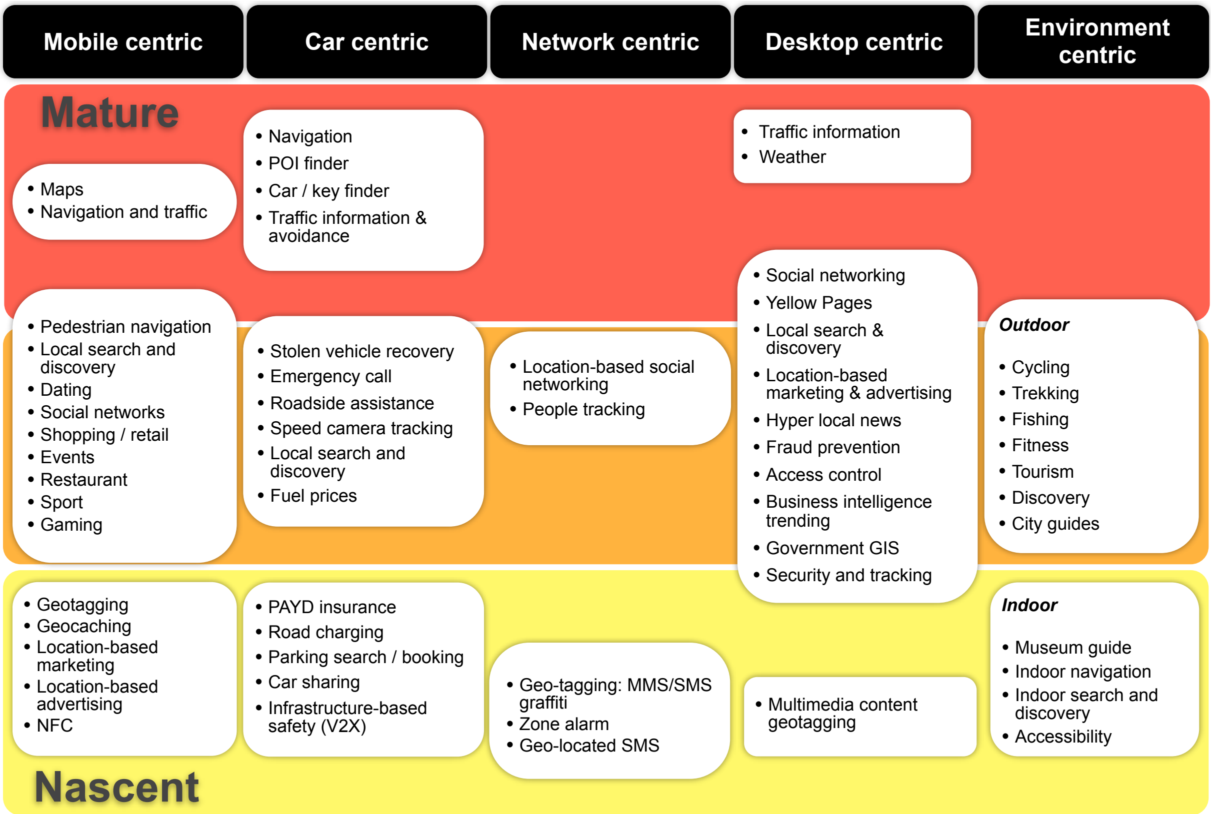
However, we believe that it is interesting to list applications that already have reached significant success and those that we expect to take-off in the short- or medium-term.

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



Source: PTOLEMUS

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

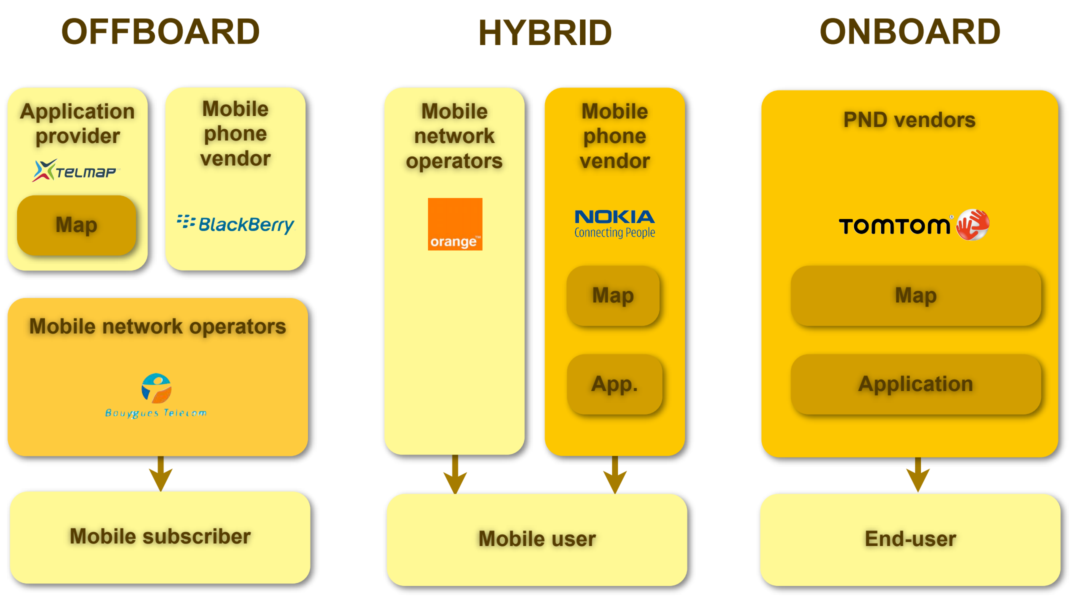
Within 18 months, navigation has moved from a cash cow to a free add-on service, with a growing range of solutions based on multiple form factors.

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

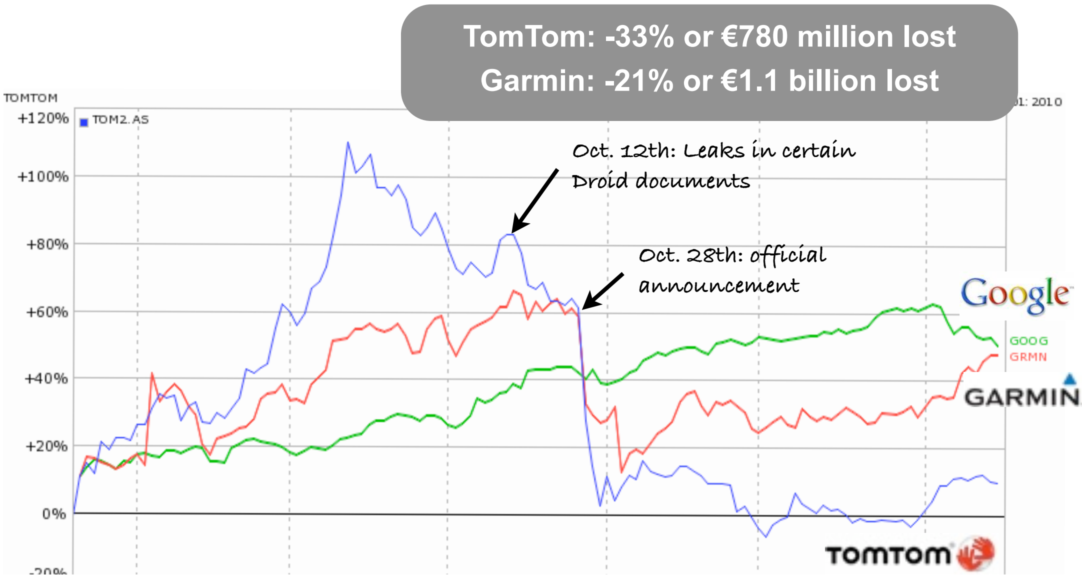
Source: PTOLEMUS

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

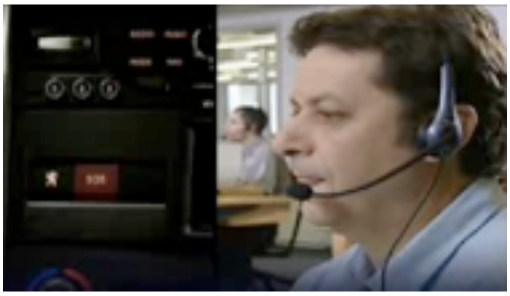
Peugeot launched a joint eCall / B-call service in 2003, starting with high end models.

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.

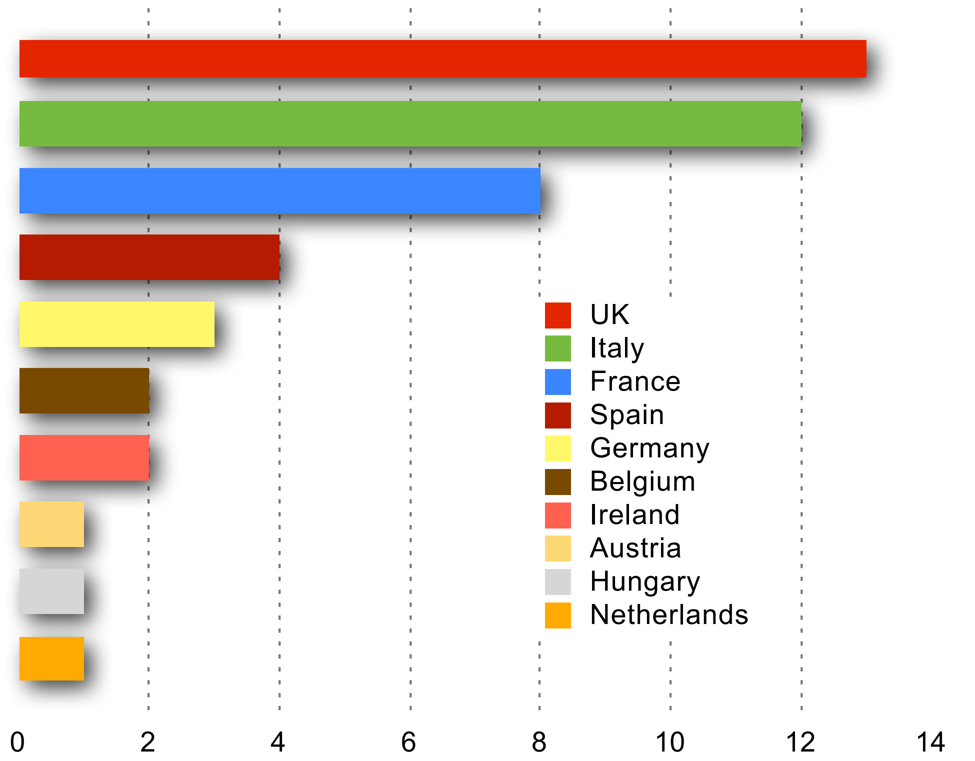
The key hurdles when deploying a PAYD proposition have been costs related to:

- 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 impact of eCall on in-car location services market Section IV p. 184
Forecast of the impact of eCall on light commercial vehicles market Section IV p. 206

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.

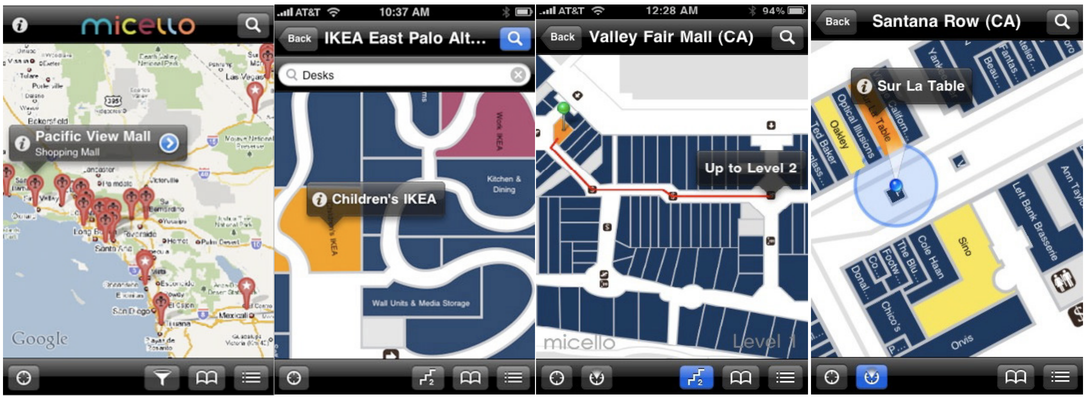
There is a marked difference between business models available in the US and Europe. There are 45 000 shopping malls in the US and the competition between them is fierce. The larger ones already run trials with maps and information for iPhone users, but can only reach 1-2% of their visitors that way.

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.

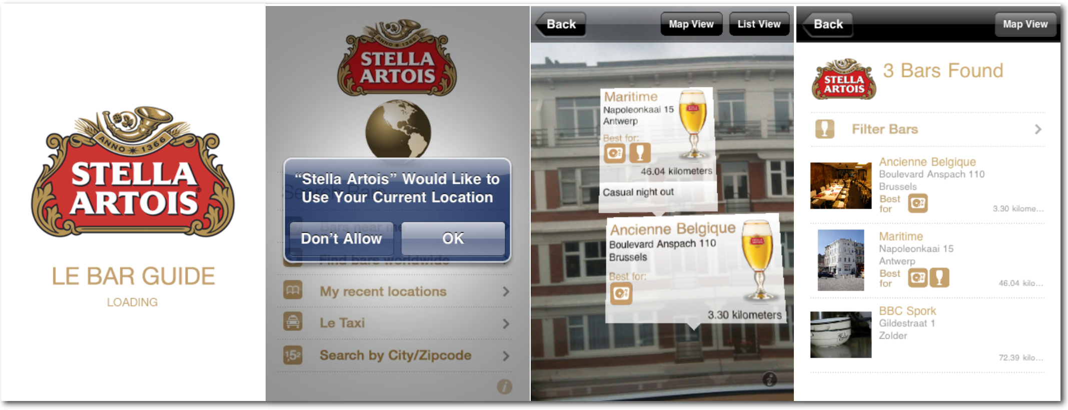
10. Location-based advertising and marketing

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.

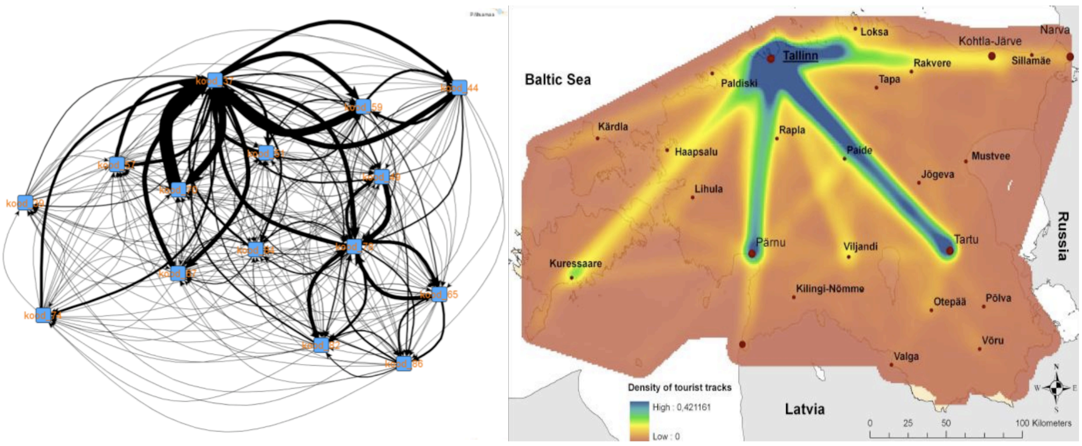
Google has expressly focused on the capacity to target and send messages to the right type of people at the right time, condition and place. Mobile operators might not sell their location data but they are all devising ways to use it for themselves. Google has made it clear that it will use its own Cell-ID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

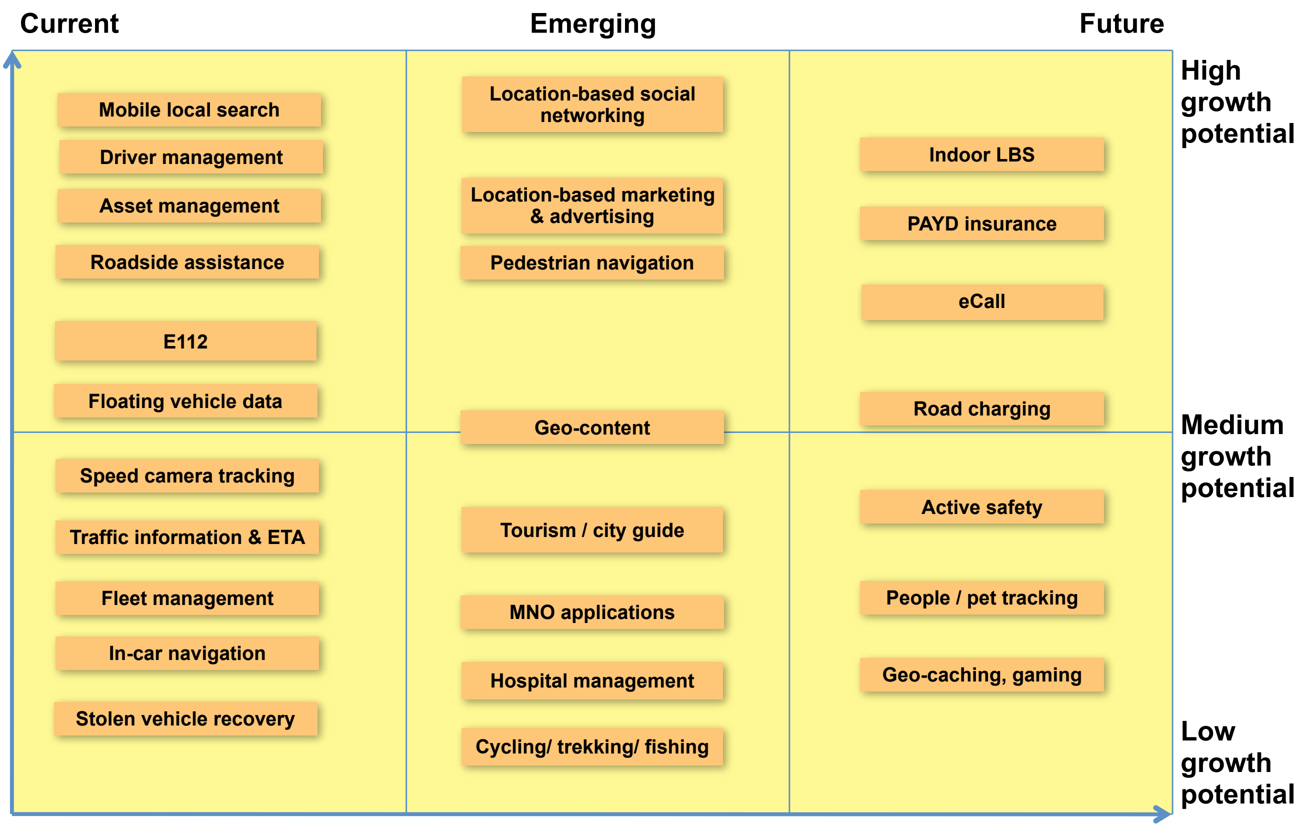
Location-sharing networks (LSNs) will have to offer real economic incentives if they hope to be a mainstream success. Foursquare signs up 10-20 000 new members each day, but it is predicted that Foursquare, Gowalla and others will have to pay $5-$10 per user and $50-$100 per offline business to maintain 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

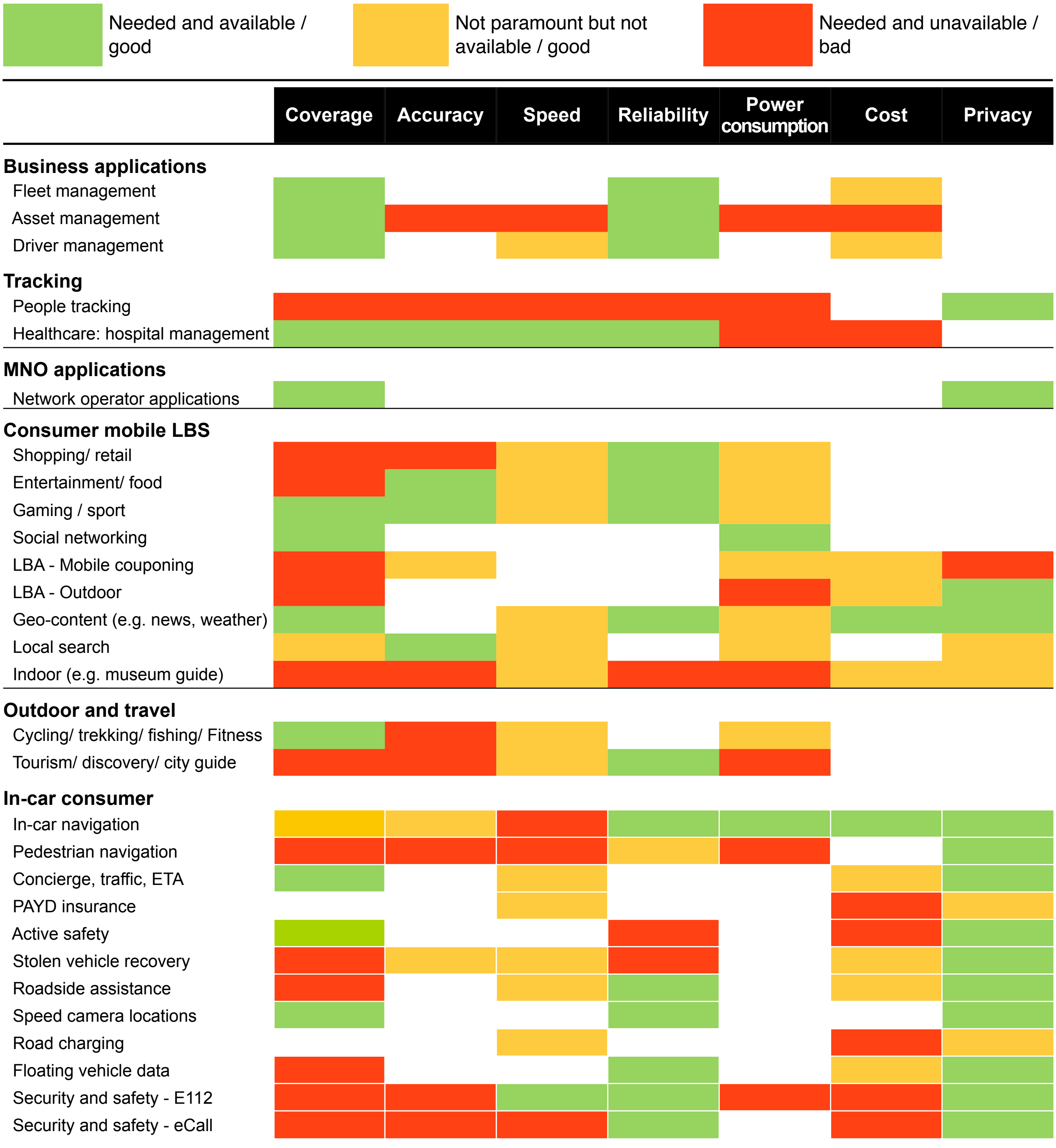
A detailed analysis shows that **the requirements of many applications are not always met by existing location technologies**.

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



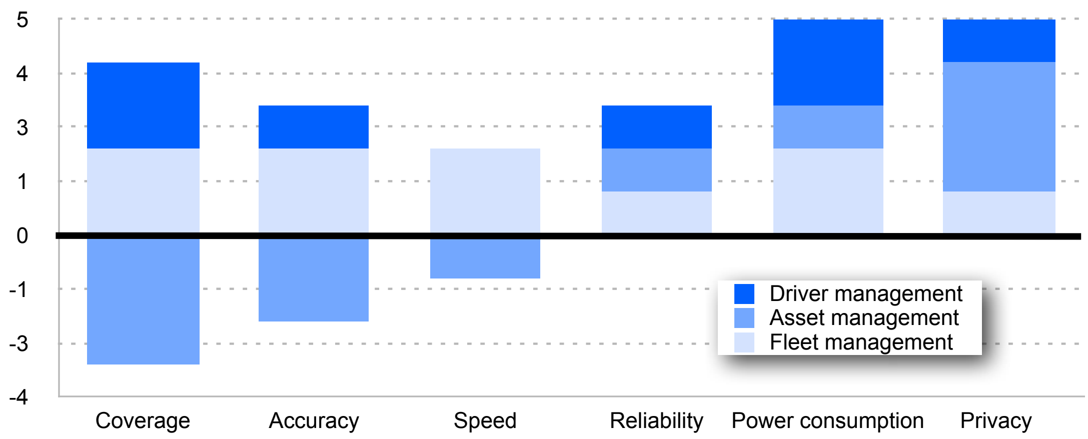
Source: PTOLEMUS analysis

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

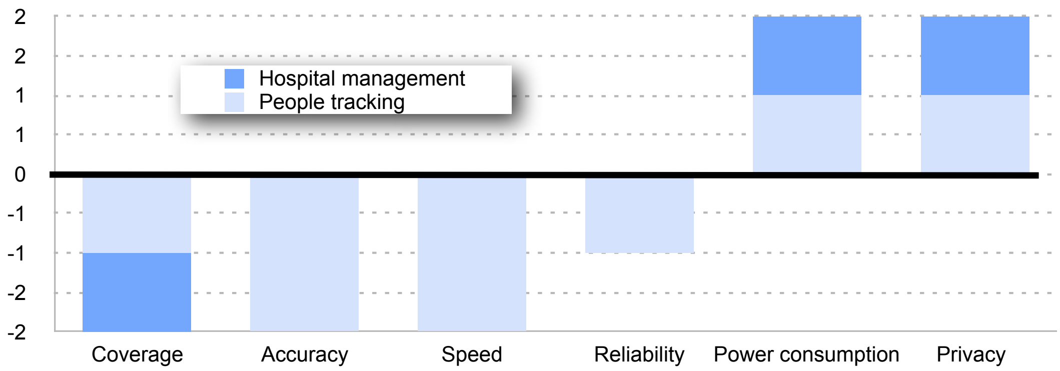
Location coverage and availability is crucial for mobile fleet and asset management, but most fleets operate in pre-determined regions, and generally, national or even city-wide coverage may be sufficient.

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.

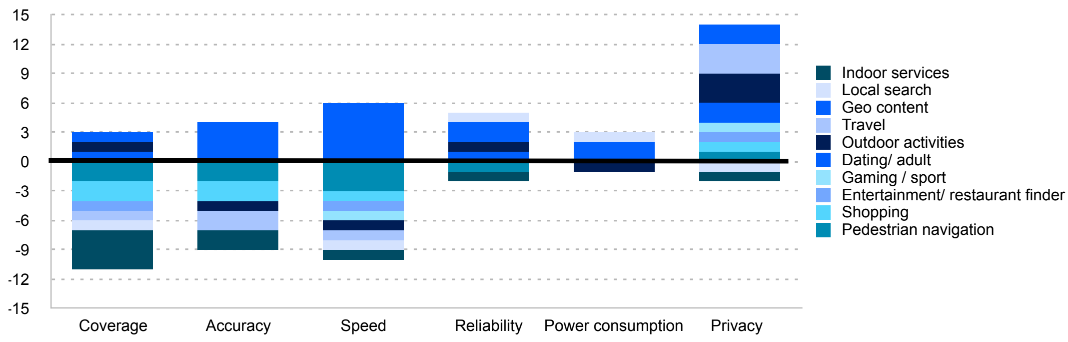
Another requirement is the ability to track a device without it actively transmitting its location. Most GPS units are based on broadcasting location; units using network location are tracked by the network itself.

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.

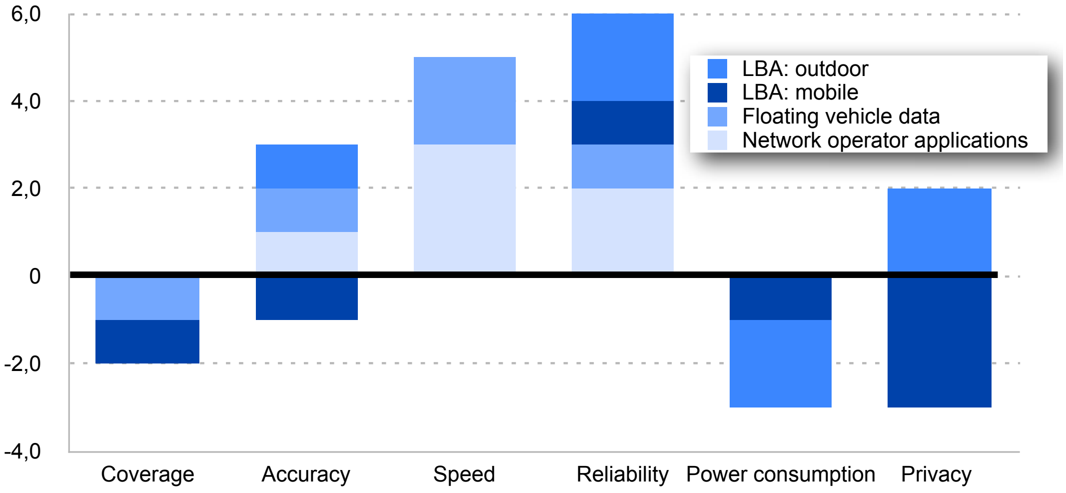
Furthermore, with a large number of mobile LBS applications being free or near-free, users complain about little else but battery life.

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.

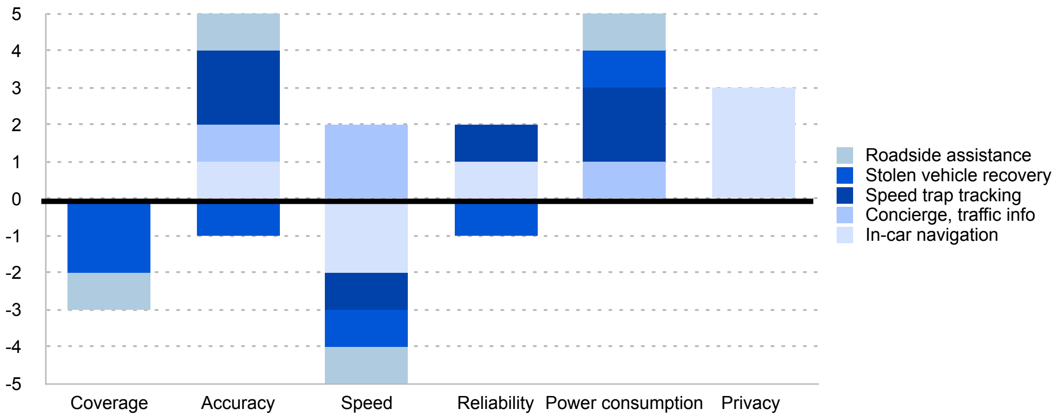
- services for which consumer are often ready to pay themselves, such as speed camera locations,
- services for which pricing will be based on vehicle usage.

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.

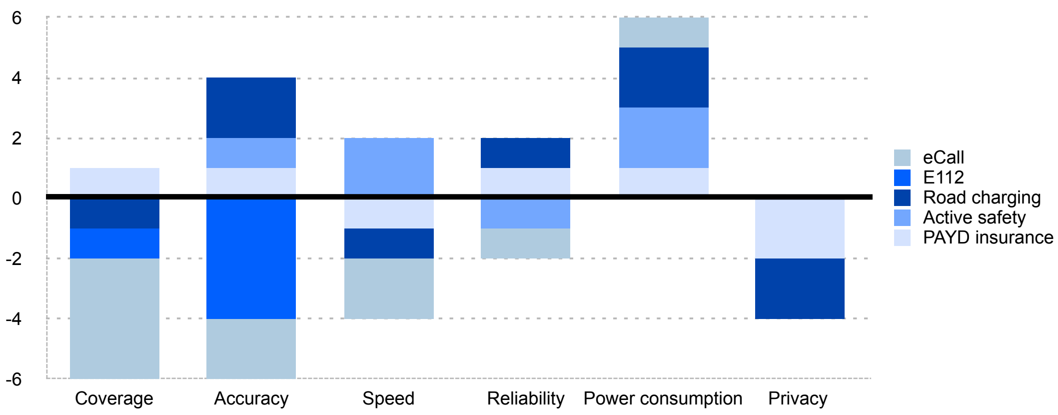
We expect other smartphone vendors but also PND manufacturers and car vendors to have no choice but to start using WiFi-assisted GPS within the coming years.

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.

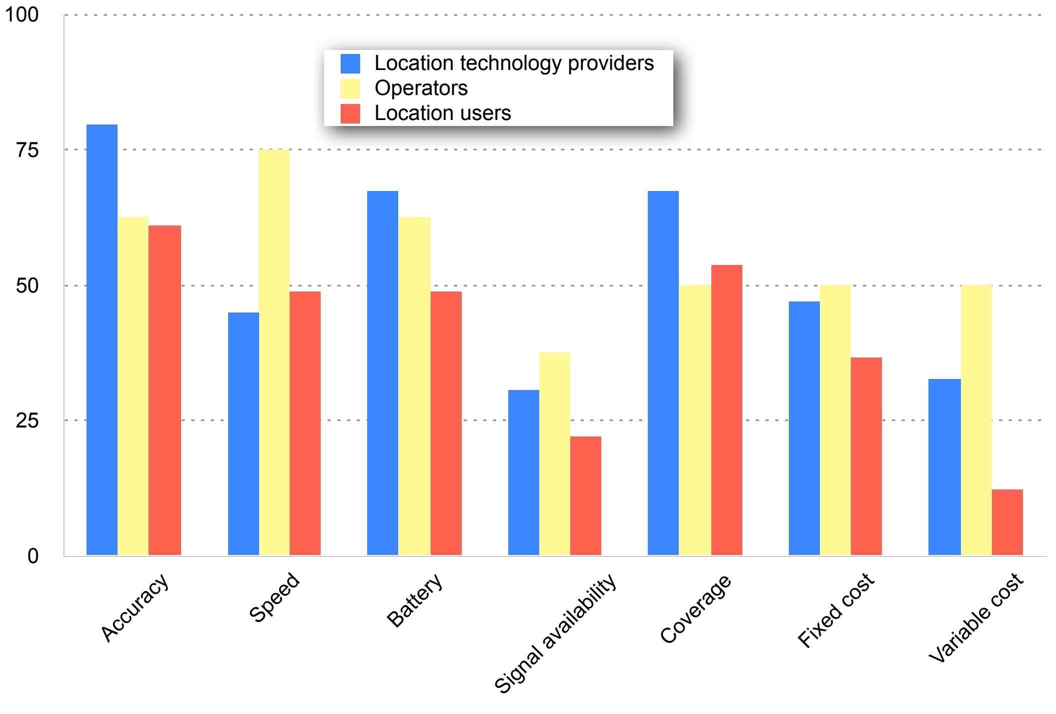
Indoor accuracy is being addressed by sensor-based solutions. Nevertheless, at this stage, these are expensive with limited use case scenarios and, consequently, limited cost benefits.

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:

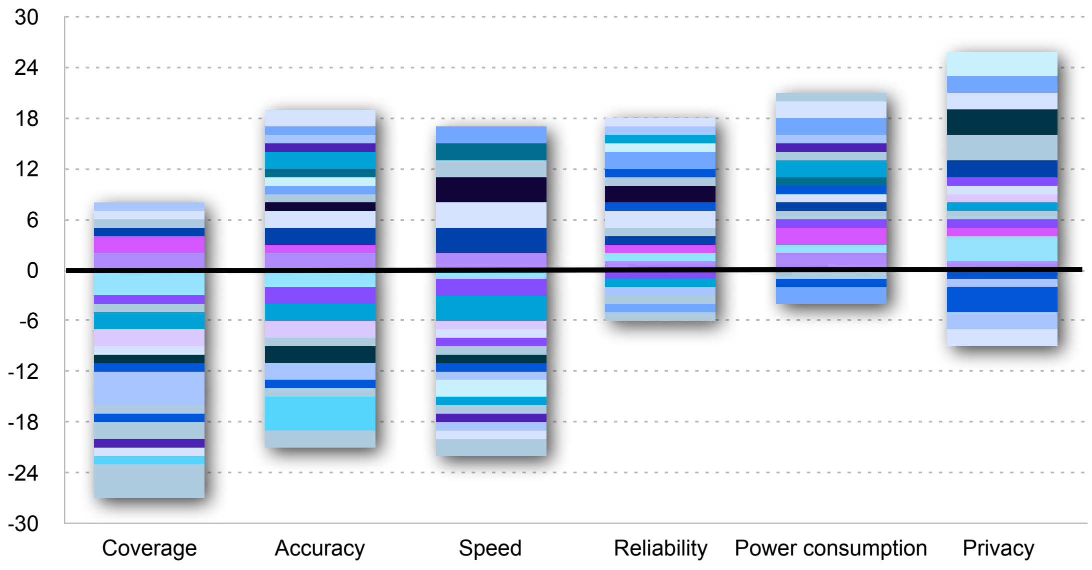
- **Accuracy is seen as the most important end user requirement** by location technology providers but also, to a lesser extent, by users and operators;
- **Speed** is viewed by mobile operators as the most important factor, which reflects the fact that operator executives are aware of the little time 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.

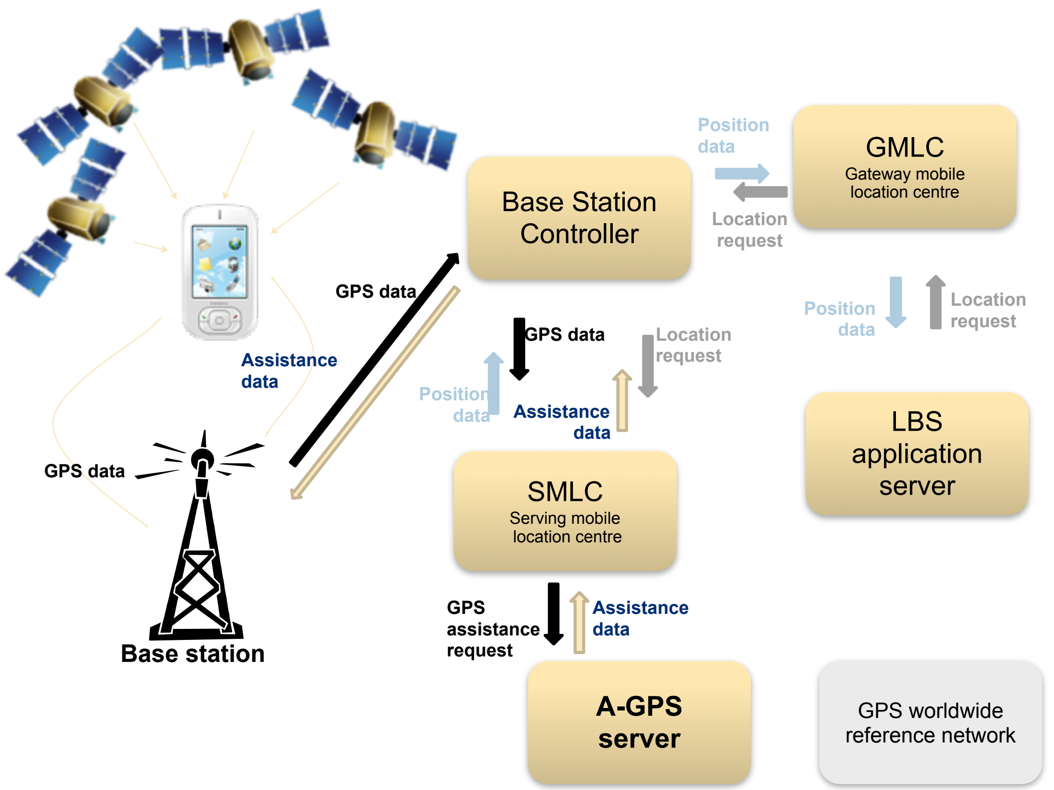
The positioning data is **sent over the mobile network control channel**.

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:

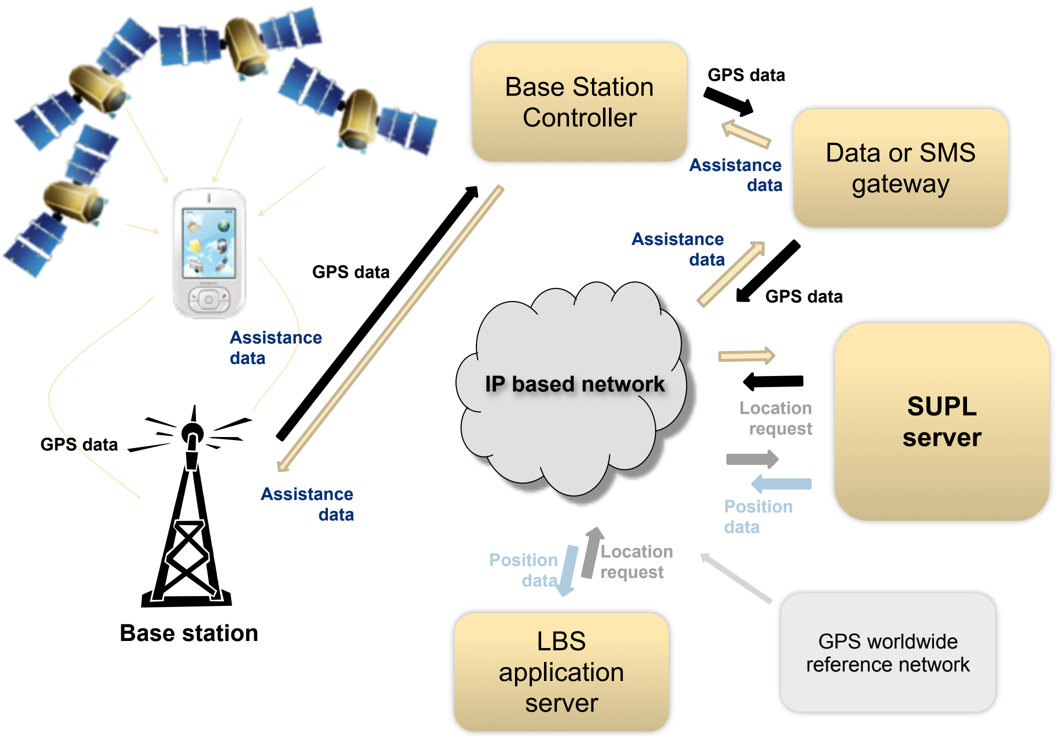
- It is a **bearer independent** (GSM, WCDMA and CDMA) standard. There are no changes required in the underlying network for service deployment, and it guarantees roaming, security and privacy support;
- **The SUPL server supports different types of positioning methods**, including Cell-ID, A-GPS, Autonomous 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

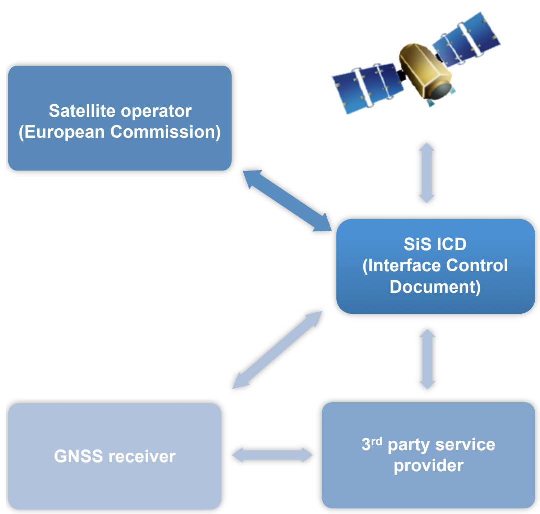
The Galileo program is a joint initiative of the European Commission (EC) and the European Space Agency (ESA).

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).

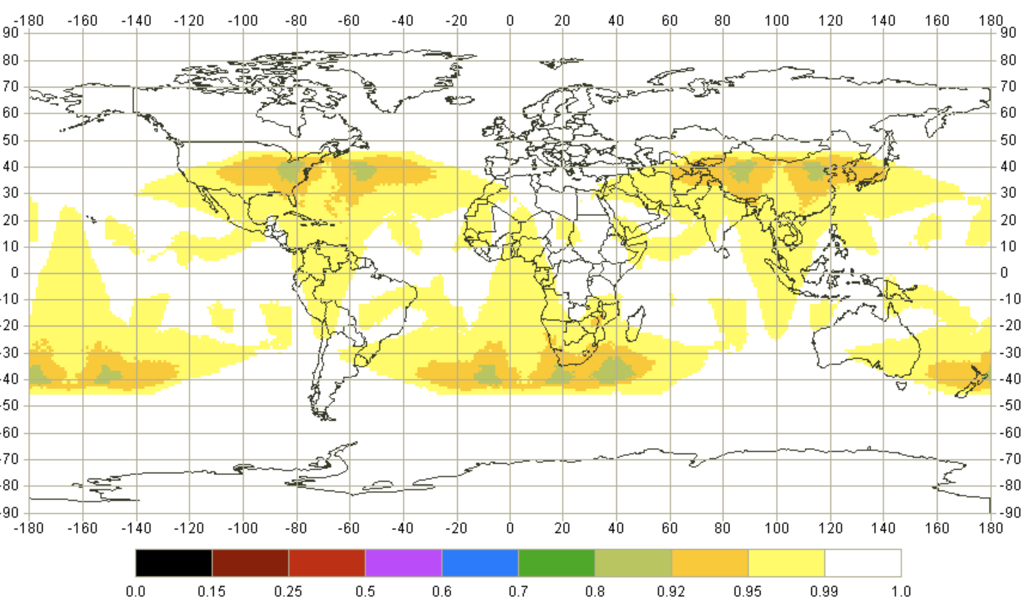
By the end of 2009, Glonass was typically providing a standalone receiver with **5-metre positioning accuracy**.

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.

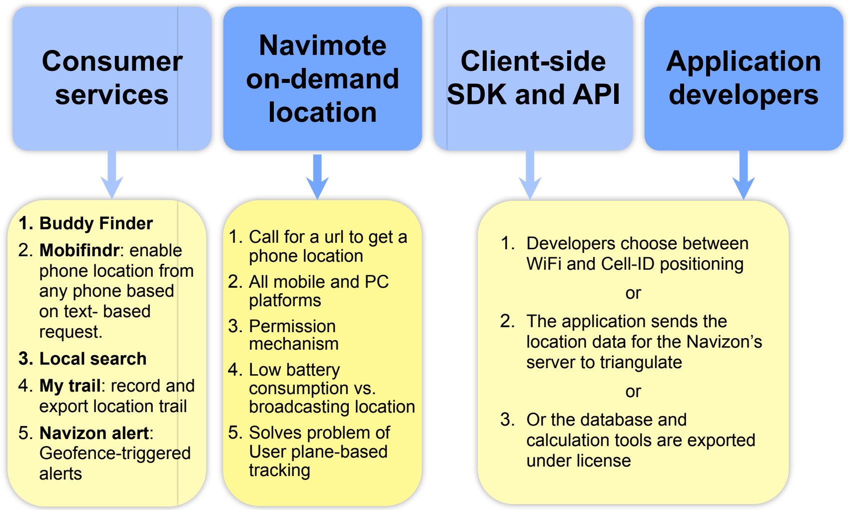
Case study 1: Navizon

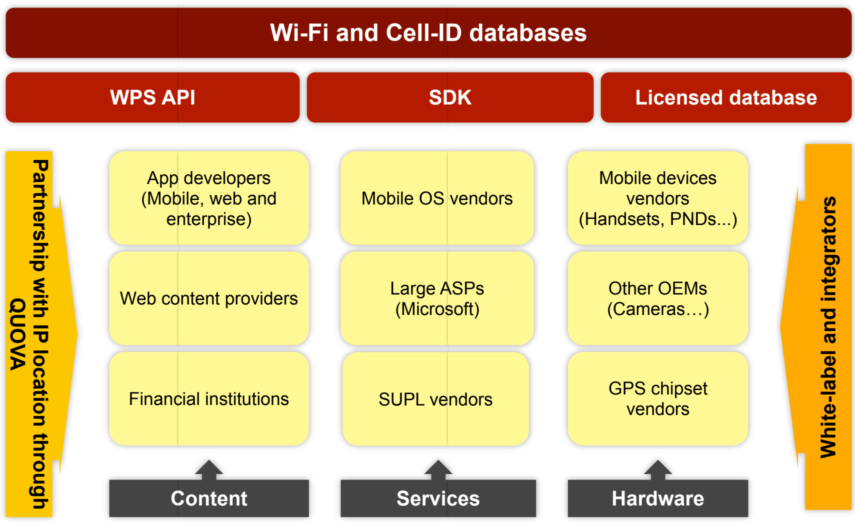
Navizon is the biggest crowd-source based WiFi and Cell-ID positioning system provider

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

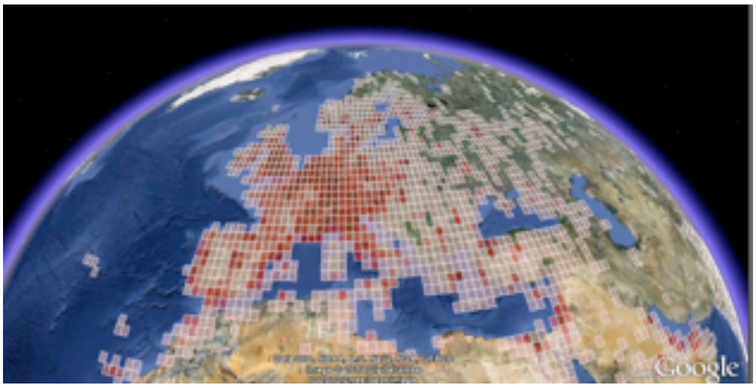




There is more to WPS than a large database

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

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

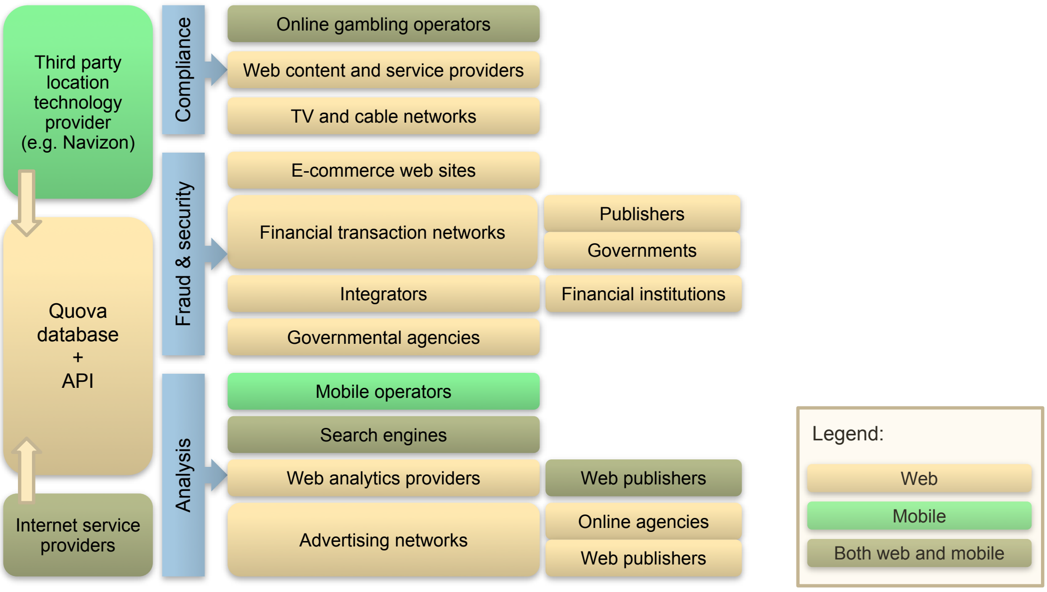
This is used by web sites to increase web page relevancy, reduce page bounce rate, trace user web activity and identify fraud.

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

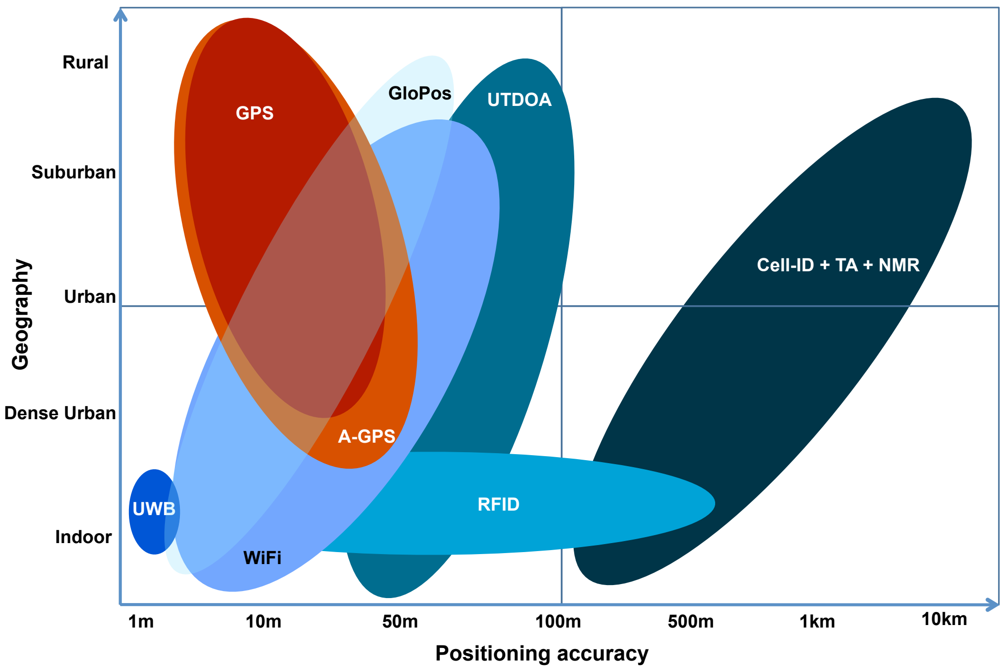
Source: PTOLEMUS

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.

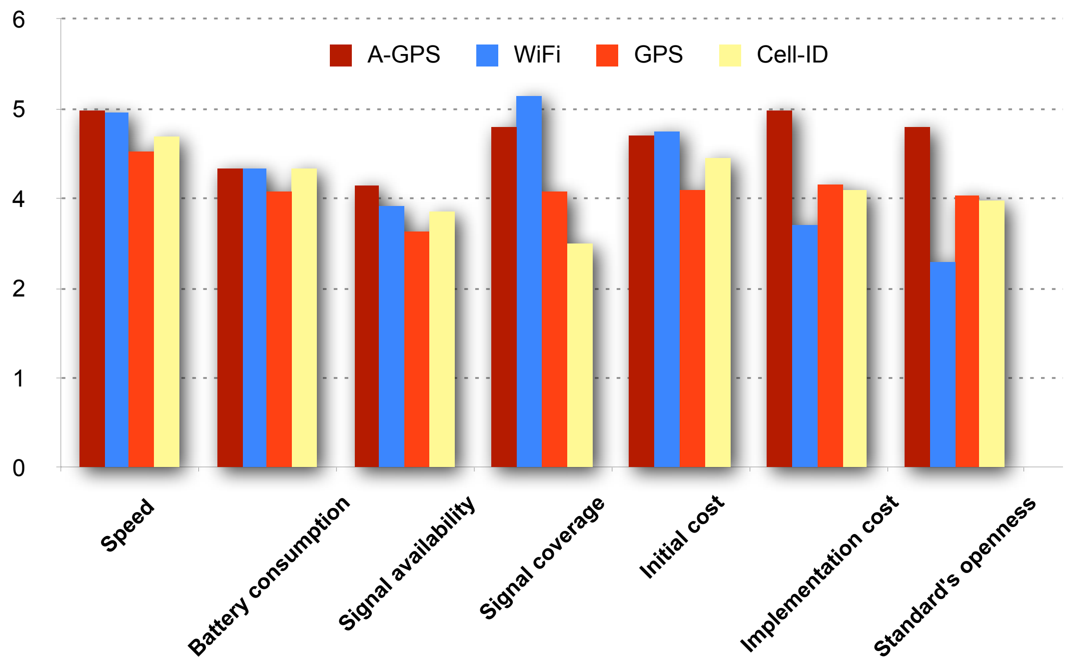
More on prices and business models in Section IV of the Full Report

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.

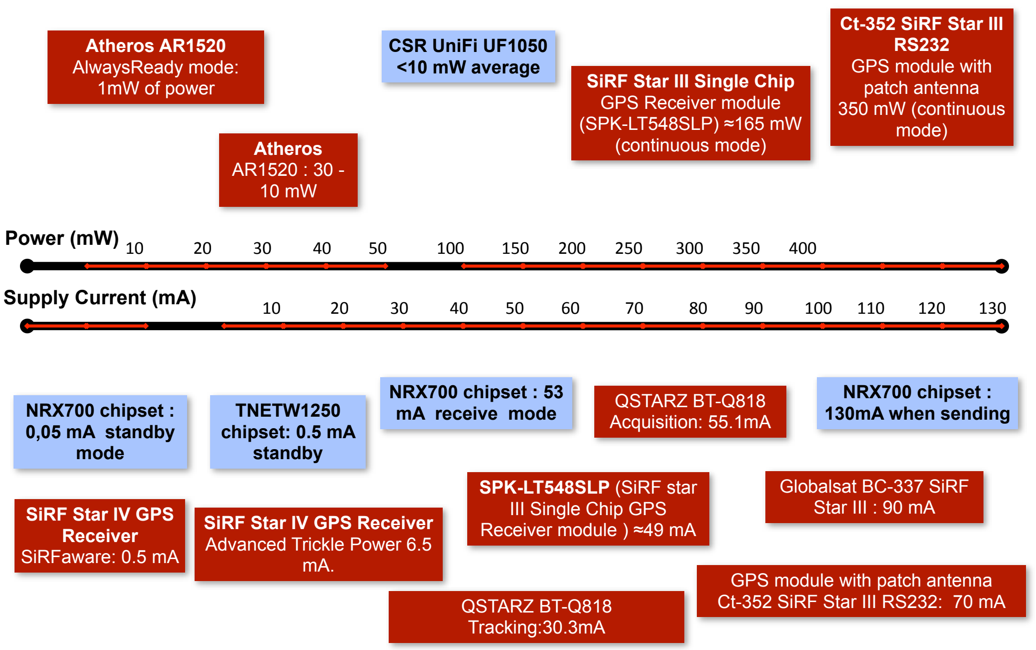
We would expect Skyhook, Navizon and Nokia/Navteq to relatively quickly include a number of venues, such as shopping centres or train stations, in their databases.

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.

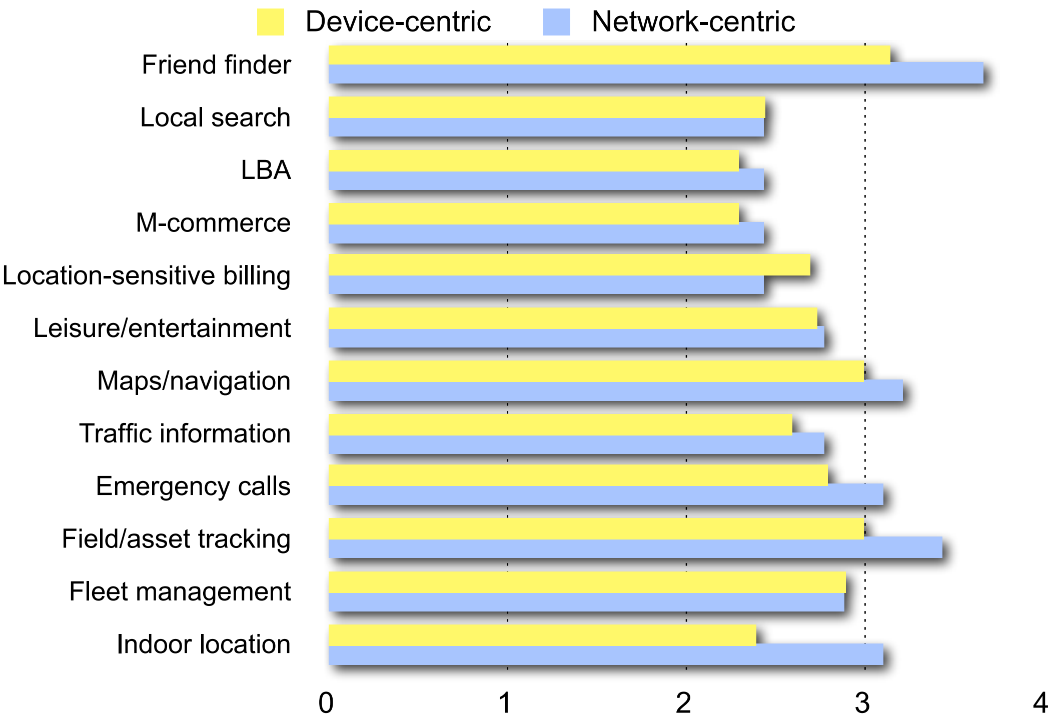
The number of networks providing A-GPS is growing rapidly. As of June 2009, **mobile networks acquiring or investigating the interest of SUPL servers in Europe** included

- 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

In the following sections, we have left certain elements of the Full Study for your appreciation: headlines, figures and a few pages.

To purchase the full study, just click on **Full Study** or go to

www.ptolemus.com/study/fullstudy

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

A. Major players

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

Source: Company reports, PTOLEMUS

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

Source: Company reports, PTOLEMUS

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

Note: Sierra Wireless includes Wavecom.

Source: Company reports, PTOLEMUS

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

Source: Company reports, PTOLEMUS

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

Source: Samsung

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

Source: Company reports, PTOLEMUS

B. Satellite systems' value chain

1. Major steps / roles

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

anomalies discovered in the signal generator of the second IIF now under construction have introduced some uncertainty into the plan.

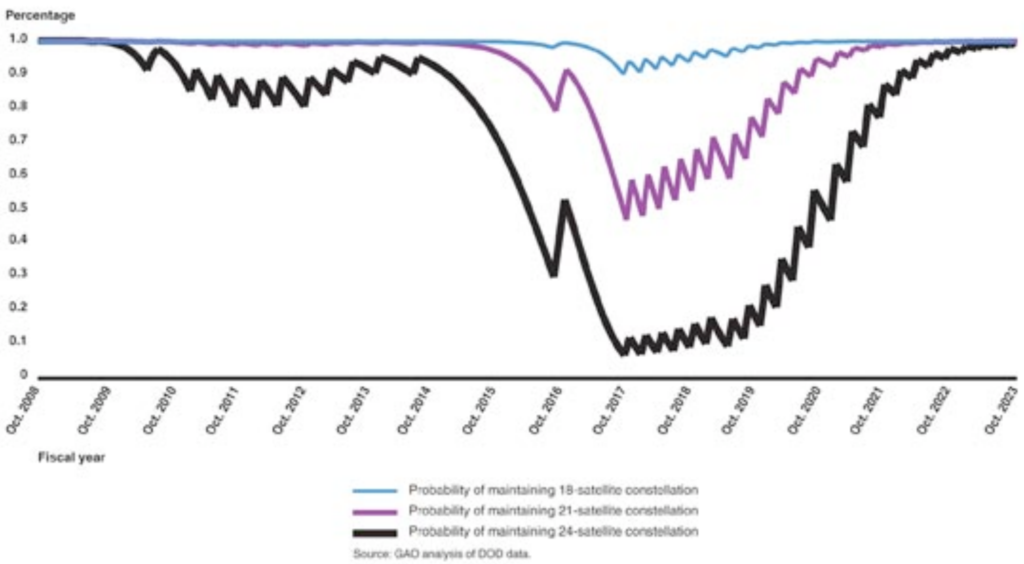
Twelve months into a 72-month schedule from contract award to first launch, the **GPS IIIA program is still on track for a 2014 launch**, according to Lockheed Martin.

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

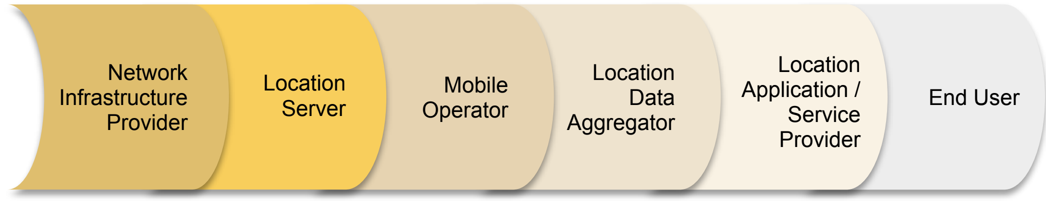
Galileo

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.

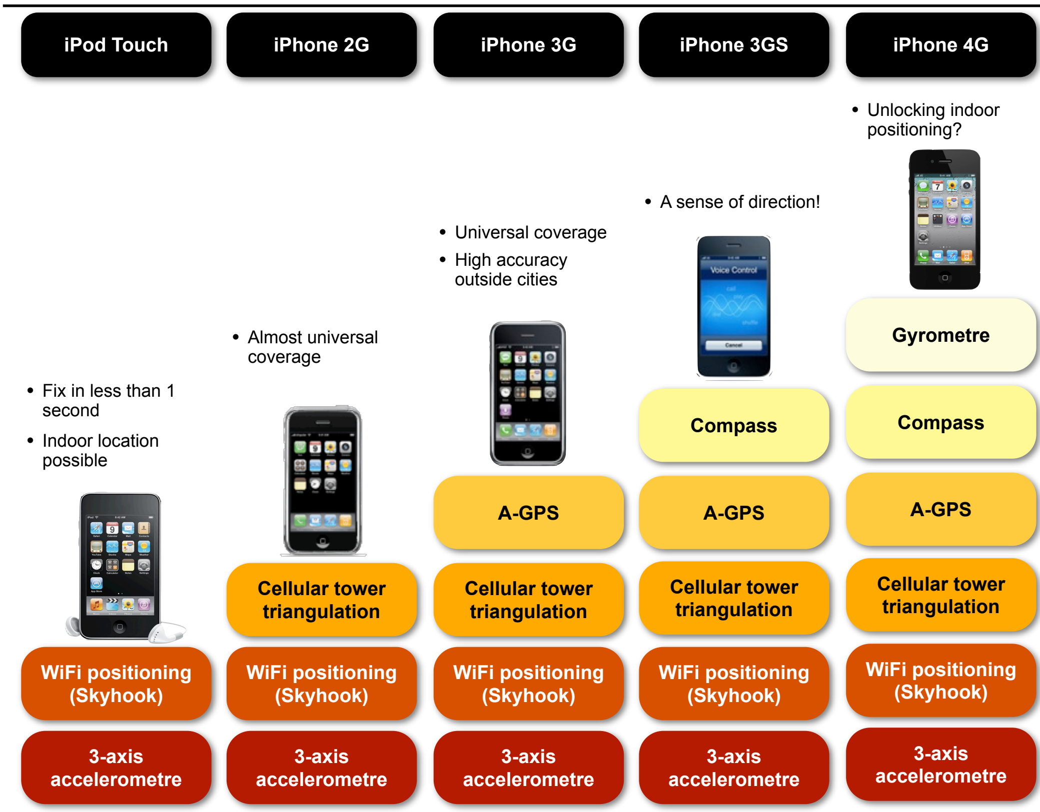
Figure 66: Original value chain for network-centric mobile LBS



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

Figure 68: The mobile LBS value chain, after the iPhone

Source: PTOLEMUS

2. The strategic landscape and its evolution

Figure 69: Google's target Android value chain: welcome to a Google-centric world!

Source: PTOLEMUS

Figure 70: Will mobile operators fall off a revenue cliff?

Source: PTOLEMUS

Figure 71: The 29 Wholesale Applications Community (WAC) members

Source: WAC

Figure 72: The WAC value chain scenario: operators gaining control again

Source: PTOLEMUS

D. A-GPS value chain

1. Major steps / roles

Figure 73: GPS assistance - Control Plane vs. User Plane

Source: PTOLEMUS

2. Major player types

3. The strategic landscape and its evolution

Changes at the chipset level

SUPL to become a key service centre and strategic stronghold

Impact on mobile operators

E. WiFi value chain

1. Major roles

Figure 74: Example of current Google Street View coverage

Source: Google

2. WiFi positioning in the future

F. Overall location-enabling strategic landscape

1. What has happened to LBS? the iPhone case study

Case Study 3: Apple's iPhone

Source: PTOLEMUS

Figure 75: Number of location-based applications - Catching the iPhone high speed train...

Source: Skyhook Wireless, PTOLEMUS

Figure 76: Breakdown of location-based applications on Apple's App Store

Source: Skyhook Wireless, January 2010

What has happened?

What will come next?

2. Who controls the value chain?

Figure 77: Overall location provision value chain

Source: PTOLEMUS

Figure 78: Co-opetition* reigns and all players have increased the breadth of their capabilities

Source: PTOLEMUS

3. Which technologies will become dominant?

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?

Figure 80: The price (in €) of a Cell-ID request will fall rapidly, so as to "create" the market

Source: PTOLEMUS

Case study 4: LociLoci

Source: LociLoci, PTOLEMUS

5. Expected strategic moves

Location-based services developers

Figure 81: Vodafone Update multi-social network client

Source: PTOLEMUS

Figure 82: Large LBS providers will increasingly use and generate location data

Source: Twitter

Mobile browsers

GNSS chipset manufacturers

Mobile operators: bit pipes or service providers?

What will Google do?

Figure 83: Google Earth' plug-in for Google Maps opens the door to advertising billboards

Source: PTOLEMUS

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

Figure 84: In-car GPS chipsets will exceed new car sales from 2013

Source: ACEA, PTOLEMUS

Figure 85: Who will control the connected car?

Source: PTOLEMUS

Figure 86: The end of the GPS monopoly in car embedded chipsets

Source: PTOLEMUS

Figure 87: Architecture of Broadcom's combined GPS / WiFi / Bluetooth chipset for PNDs

Source: Broadcom

b. Portable and aftermarket navigation

Figure 88: Mio V735 TV, integrating a DVB-T / DVB-H chipset and an EPG*

Source: Mio (EPG: Electronic Programme Guide)

Figure 89: Penetration of new positioning technologies in PNDs

Source: PTOLEMUS

Figure 90: Aftermarket navigation systems steady and dominated by PNDs (in millions)

Source: PTOLEMUS

Figure 91: A paradigm shift towards connected PNDs

Source: PTOLEMUS

c. Smartphones and feature phones

Figure 92: The rise of the smartphone - Sales in millions of units

Source: PTOLEMUS

GPS will continue its growth

Figure 93: GPS growth mainly comes through smartphones (million units)

Source: PTOLEMUS

WiFi will become the 2nd positioning technology

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

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

Figure 97: Penetration of MEMS in smartphones and volumes sold (in millions)

Source: PTOLEMUS

Cell-ID will be available on most European mobile networks

Figure 98: Mobile networks equipped with location servers

Source: PTOLEMUS

d. Other consumer electronics devices

Figure 99: Tablets and netbooks to bring back growth in consumer electronics devices

Source: PTOLEMUS

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

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Figure 101: The slow penetration of GPS and WiFi into digital cameras (in % and in millions)

Source: PTOLEMUS

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Figure 102: Eye-Fi 4 Gb cards now also provides location to pictures

Source: Eye-Fi

Positioning in the mobile gaming market

Figure 103: Will the Nintendo 3DS include a SIM card?

Source: Nintendo

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

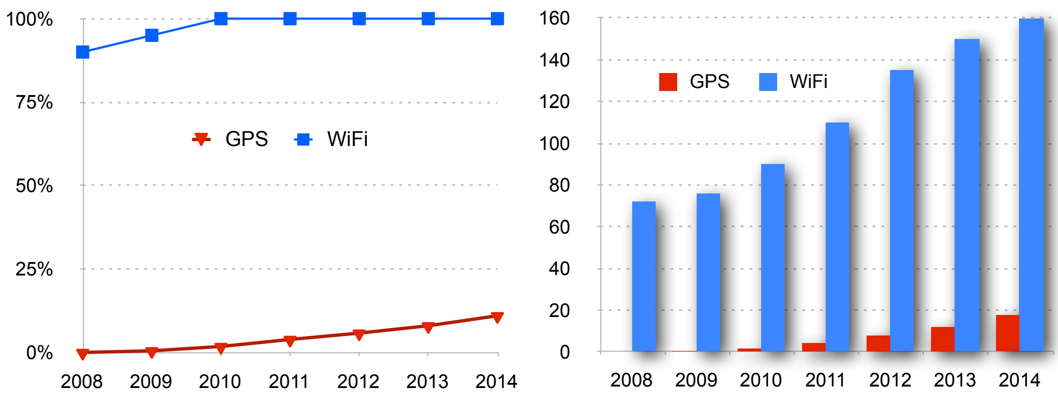
GPS chipset manufacturers see laptops as the next platform for satellite location. However, WiFi and IP location are obvious alternatives which have the advantage of not requiring additional component cost and integration.

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

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

Figure 108: PNDs in use represent less than 20% of European cars

Source: GFK (March 2009), PTOLEMUS

Figure 109: Almost half of all cars in use will have a dedicated navigation system by 2014

Source: PTOLEMUS

Smartphones for car navigation

Figure 110: Mobile navigation device volumes will quickly surpass dedicated systems'

Source: PTOLEMUS

b. Other in-car embedded location services

Figure 111: eCall will be the largest growth driver in the next 5 years

Source: PTOLEMUS

Figure 112: In-line fitted in-car GPS unit sales (in millions)

Source: PTOLEMUS

c. Consumer mobile LBS

Figure 113: Penetration of GPS and WiFi in mobile phones (in millions)

Source: PTOLEMUS

3. Penetration of location technologies in consumer devices

a. GNSS-located devices

Figure 114: Sales of GNSS-enabled consumer objects will triple in 5 years (in millions)

Source: PTOLEMUS

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

Figure 116: WiFi consumer location market size

Source: PTOLEMUS

Figure 117: Penetration of WPS in WiFi-enabled devices

Source: PTOLEMUS

4. Main revenue generation models

a. The cost of GPS

Figure 118: Average cost per device chipset (in Euros)

Source: PTOLEMUS

b. The cost of assistance servers

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c. The cost of WiFi positioning

Figure 119: Average cost of WiFi location capability per device (in Euros)

Source: PTOLEMUS

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

Figure 121: Sample of Cell-ID location request cost in Europe (in Euros)

Source: PTOLEMUS, Mobile Commerce, LociLoci

5. Estimated end-user location enabling market

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

B. Commercial moving vehicles potential

1. Addressable base of vehicles

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

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

2. Key applications and their location requirements

a. Fleet Management Systems (FMS)

Figure 125: Daimler Fleetboard equipped 8.000 trucks in 2009

Source: Daimler Fleetboard

b. Road user charging

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Figure 126: A Grundig OBU, installed on a truck for the German Toll-Collect system

Source: Grundig

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.

Figure 129: Number of PAYD systems sold (excluding leasing fleets)

Source: PTOLEMUS

d. eCall in commercial vehicles

Figure 130: eCall mandate's influence on GPS penetration of commercial vehicles

Source: PTOLEMUS

3. Estimated location-enabling market

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

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

Who will pay for location?

What positioning technology will be used?

How big is the market opportunity?

2. Key developments

3. Key factors affecting market growth

a. Access to positioning technology

b. Connectivity

c. Speed and capacity

d. Usability

Figure 133: AR entering the car thanks to HUDs - BMW 5 Series Touring optional HUD

Source: BMW

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4. A key emerging force in location, Facebook

5. Key markets for positioning

B. Value creation opportunities

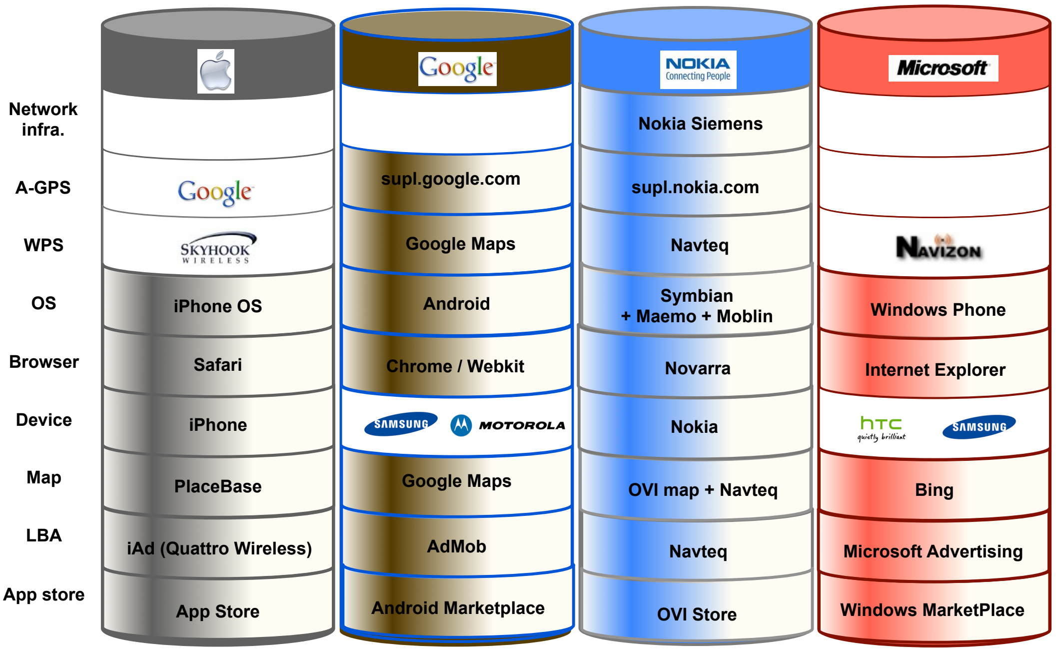
1. The new value chain

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

Billing is an inhibitor on operators' service platforms

The WiFi Positioning System (WPS) oligopoly

C. Recommendations

1. The business model for operators to invest in positioning

(i) Do not look at LBS as a specific business!

(ii) Control your network location capability

(iii) Seek location revenues from all devices, not only consumer phones

(iv) Integrate location to your future LTE network

2. Recommendations to automotive OEMs

(i) The time of closed embedded operating systems is counted

(ii) Open embedded platform can deliver a better user experience than handsets and PNDs

(iii) Automotive vendors can differentiate through positioning

(iv) Automotive manufacturers must enable integration of devices

(v) Don't wait for the eCall mandate!

3. Recommendations to PND vendors

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4. Recommendations to location technology providers

a. Network-centric solution providers

A-GPS and GLMC providers

IP location providers

WiFi location providers

b. Device-based solution providers

GNSS chipset vendors

END OF THE FULL STUDY

To purchase the Full Study, just click on Full Study or go to www.ptolemus.com/study/fullstudy

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

Company	Interviewed	Mentioned
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