Appendix A – Synopsis of the current status and trends for GPS mobile handset technology

NB: The majority of this appendix is derived from GPS and Mobile Handsets Fourth Edition, Berg Insight, Gothenburg Sweden. The Berg report was purchased for purposes of this report and the document is in the possession of the Geography Division. Other sources for the information provided in this appendix include Wikipedia and communication with individuals in the industry.

Introduction

A major objective of our report was to evaluate the current status and future directions for the use of handheld or mobile GPS enabled devices. The main body of the report provides an analysis of how different types of devices are being used to collect and transmit positional information. A major resource in this evaluation was a current market survey GPS and Mobile Handsets Fourth Edition prepared by Berg Insight. Several references to this resource are included in the report. The purpose of this appendix is to provide a brief summary of additional findings and forecasts made by Berg Insight and other sources that may have an impact on mobile activities relating to the GSS initiative.

Executive Summary from Berg Insight

Mobile phones with GPS receivers have been available since the late 1990s. Technical development enabling GPS integration in mass-market handsets was driven by the FCC’s E911 emergency call mandates requiring all US mobile operators to provide high-accuracy location of emergency callers. CDMA [Code division multiple access] and iDEN [Integrated Digital Enhanced Network] operators chose to use GPS location technology for locating emergency callers that led to rapidly increasing penetration of GPS in iDEN and CDMA handsets in North America and other parts of the world where CDMA is widely deployed. Emergency call location regulation is being introduced in other regions as well….Disregarding handsets only available in Japan, as well as operator-specific variants of base-models, the total number of models that are available on the market has grown from 80 in 2008 to more than 180 at the end of 2009. Since 2008, all tier-1 vendors have started to ship GPS-enabled phones for markets worldwide….GPS-enabled handsets sales are estimated to reach about 960 million, or 60 percent of total handset shipments in 2014.

Handset vendors are increasingly focusing on improving the user experience through software and applications. Especially smartphones are receiving more attention from handset manufacturers, mobile network operators, application developers and last but not least users. Smartphones are devices that support installation of native third party applications. In the past, smartphones have been more costly than featurephones, but chipset vendors and handset manufacturers are now developing low cost smartphones with unsubsidized retail prices below € 100 ($133) for launch in 2010. Smartphones costing about € 50 ($66) can be available on the market in 2014.
Encouraged by Apple’s success, major handset vendors and several leading mobile operators have now launched on-device application stores that allow users to download applications directly to their handsets. Many of these applications have some kind of support for GPS location. GPS technology for handsets has matured, offering much better performance in terms of sensitivity, power consumption, size and price than was possible a few years ago. Support for other satellite systems such as GLONASS and Galileo will also be added over time. The first handsets with receivers for GPS and GLONASS are expected to become available in 2011 and mobile phones with Galileo compatible receivers can be expected in greater numbers in 2014 when the new system will become operational.

The OMA [Open Mobile Alliance] SUPL [Secure User Plane Location] A-GPS [Assisted GPS] standard has enabled lower cost deployment of A-GPS services that ensure a better and more consistent user experience necessary for the consumer market. SUPL allows deployment of A-GPS services that reduce the time-to-first-fix, lowers power consumption and enhances the sensitivity of GPS receivers. New business models have also become possible, ranging from hosted services for operators, to services deployed by handset vendors for end-users that cannot get similar services from their network operator. Besides adding support for other satellite systems that ensures more visible satellites and incrementally better performance in urban canyons, handset vendors are also starting to adopt hybrid location technologies to improve indoor performance. These technologies combine GPS with other wireless and sensor-based technologies, including Wi-Fi positioning, accelerometers, gyroscopes or electronic compasses to gradually improve performance in challenging environments where GPS signals are extremely weak or unavailable.

**General Findings (From Berg Insight)**

- New devices blur the line between handsets and mobile computers. As high-end smartphones are being equipped with increasingly large displays and ever smaller mobile computing devices such as Mobile Internet Devices (MIDs) and tablet computers are being launched, it is becoming increasingly difficult to make a clear distinction between the categories. Examples of recent GPS handsets that blur the line between the device categories include the Nokia N900, a mobile computer with ARM-processor running the Linux-based Maemo 5 operating system, the LG GW990 that features an Intel Atom processor running the new MeeGo OS, as well as the Toshiba TG1 and HTC HD2 Windows Mobile smartphones with up to 4.3-inch touchscreens.
- The average price for a host-based GPS chipset in high volumes reached an estimated $2.20 in 2009, down from about $2.50 in 2008.
- Consumers worldwide are showing a growing interest in using their handsets for advanced services beyond basic voice and messaging applications. Handset vendors are now increasing their efforts to develop cost effective handsets that support multiple connectivity technologies and faster cellular data transfer to enable advanced connected services.
• Mobile phones are based on numerous form factors, with varying screen sizes and input methods. However, most devices can be divided into five broad form factor categories:
  - candybar,
  - slide,
  - clamshell,
  - PDA touchscreen
  - QWERTY keyboard handsets.
• The different form factors have different restrictions on possible locations of the GPS antenna as well as distance between antenna and the GPS receiver. Devices with moving parts, such as slide and clamshell devices, pose further challenges since opening or closing the handset can affect reception quality depending on antenna placement.
• First tier manufacturers of mobile GPS enabled computing/communication devices include Nokia, Samsung, LG Electronics, Sony Ericsson, Motorola, Research in Motion, Apple, and HTC [which manufactured the hand held devices for Harris].
• Second tier of main stream computer manufacturers that support GPS functions include: Acer, ASUSTeK, Garmin, Dell, Fujitsu, Hewlett Packard, Huawei, Kyocera Sanyo Telecom, NEC Casio Mobile Communications, Palm, Panasonic, Pantech, Sharp, Toshiba, and ZTE.
• GPS technology for handsets has matured, offering much better performance in terms of sensitivity, power consumption, size and price than was possible a few years ago.
• Support for other satellite systems such as GLONASS and Galileo will also be added over time. The first handsets with receivers for GPS and GLONASS are expected to become available in 2011 and mobile phones with Galileo compatible receivers can be expected in greater numbers in 2014 when the new system will become operational.
• SUPL [Secure User Plane Location] allows deployment of A-GPS services that reduce the time-to-first-fix, lowers power consumption and enhances the sensitivity of GPS receivers.
• The OMA SUPL A-GPS standard has enabled lower cost deployment of A-GPS services that ensure a better and more consistent user experience necessary for the consumer market.
• New business models have also become possible, ranging from hosted services for operators, to services deployed by handset vendors for end-users that cannot get similar services from their network operator.
• Besides adding support for other satellite systems that ensures more visible satellites and incrementally better performance in urban canyons, handset vendors are also starting to adopt hybrid location technologies to improve indoor performance.
• These technologies combine GPS with other wireless and sensor-based technologies, including Wi-Fi positioning, accelerometers, gyroscopes or electronic compasses to gradually improve performance in challenging environments where GPS signals are extremely weak or unavailable.
• Accelerometers that are for instance used for automatic screen rotation and tap gesture recognition are now available in more than 80 GPS handsets – nearly four times as many as in 2008.
• Handset vendors are increasingly focusing on improving the user experience through software and applications. Especially smartphones are receiving more attention from
handset manufacturers, mobile network operators, application developers and last but not least users.

- Smartphones are devices that support installation of native third party applications. In the past, smartphones have been more costly than featurephones, but chipset vendors and handset manufacturers are now developing low cost smartphones with unsubsidized retail prices below € 100 ($133) for launch in 2010.
- Encouraged by Apple’s success, major handset vendors and several leading mobile operators have now launched on-device application stores that allow users to download applications directly to their handsets. Many of these applications have some kind of support for GPS location.
- Today, a high-performance GPS receiver costs about $2.00–2.50 in large volumes. There are also additional costs for the antenna and a few discrete components, in the region of $1.00–2.00 in total. GPS receivers are thus from a cost perspective only being integrated in high-end devices. Further cost reductions can be achieved by integrating GPS cores into cellular and connectivity chipsets.
- Today, GPS receivers are available in four general architectures:
  - standalone chipsets comprise an RF IC and a baseband IC, either as separate chips, single chip SiP or integrated single die. The CPU controls the track loops, decodes and processes the data stream containing the Navigation Message and performs final calculation of the position. Standalone receivers allow easy system integration, requiring minimal software integration with the host system
  - host-based receivers are implemented as discrete chipset or single chip solutions with RF and baseband sections. Compared to standalone receivers, host-based solutions entail more demanding and time consuming software integration with the host system
  - integrated architectures - chipset combo solutions are Bluetooth+FM+GPS ICs from vendors such as Broadcom, ST-Ericsson and Texas Instruments. Qualcomm and Renesas integrate GPS basebands with their cellular baseband processors
  - software-based receivers combine RF ICs with a software baseband, performing all calculations on existing host processors. Software development is usually much cheaper than hardware development and less application specific hardware is required when integrating GPS functionality.

Forecasts from Berg Insight

- Much of the growth in the smartphone segment is likely to come from new low-cost models, but a large share of these new models can be expected to include GPS receivers too and the GPS attach rate is therefore likely to continue to grow fast for smartphones overall.
- Increasing consumer demand for LBS (Location Based Services) and market regulations are likely to drive adoption of GPS also in the featurephone segment.
- Smartphones costing about € 50 ($66) can be available on the market in 2014.
- GPS is being integrated into progressively lower cost handsets. The attach rate for GPS in handsets costing more than € 200 ($266) – a segment dominated by smartphones – surpassed 70 percent in 2009 and is forecasted to reach virtually 100 percent already in 2012.
Nearly all smartphones will be GPS-enabled in 2014, because devices in this category are designed to provide the most compelling services and features regardless of device cost. The attach rate for GPS grew to 6 percent in the GSM/WCDMA featurephone segment and shipments reached an estimated 32 million units.

Sales of GPS-enabled handsets will continue to grow fast, driven by sustained demand for smartphones and value-added services, in addition to emergency call regulations. In the US, the major GSM/WCDMA operators AT&T and T-Mobile are increasingly looking at GPS as the technology of choice for complying with the FCC’s E911 mandates for 3G WCDMA handsets, but also for competing more effectively with the CDMA operators successful location-based services.

Sales of GPS-enabled GSM/WCDMA handsets in North America will increase to around 105 million units in 2014 and the GPS attach rate will reach 94 percent.

Virtually all chipsets, more than half of all multi-mode devices and integrated basebands will support at least one additional GNSS besides GPS in 2014.

Sales of GPS-enabled GSM/WCDMA/LTE handsets will reach 770 million units in 2014 and the attach rate will increase to 55 percent.

As smartphones expand to the mid and low cost segments, the attach rate for GPS will increase rapidly also in the € 101–200 handset segment to reach nearly 90 percent in 2014.

The first GPS-enabled handsets in the € 51–100 price segment will be launched in 2010. This segment is likely to be dominated by cost-effective multi-radio connectivity chipsets, primarily Bluetooth+FM+GPS devices. The attach rate in this segment is forecasted to surpass 60 percent in 2014.

The first handsets with multi-radio GPS devices will become available in mid 2010. Initially these will have Bluetooth+FM+GPS solutions. Handsets with Wi-Fi+Bluetooth+FM+GPS solutions are expected to be launched in early 2011. Bluetooth+GPS devices will primarily be used in featurephones and low cost smartphones, while high-end featurephones and smartphones will rely on Wi-Fi+Bluetooth+GPS devices.

The first GPS-enabled handsets that cost less than € 50 will start to in 2012. The attach rate for GPS in this extremely cost sensitive segment is however likely to grow somewhat slower than for the other segments.

Seven percent of the handsets sold in this (entry level) segment will feature GPS by 2014 as increasingly cost effective solutions become available. By 2014, 55 percent of all GSM/WCDMA/LTE handsets sold are forecasted to be GPS-enabled.

CDMA handset manufacturers will introduce GPS also for low cost handsets aimed at emerging markets in only a few years time to increase competitiveness versus GSM-based handsets.

Web technologies and runtimes will eventually overtake native applications.

GPS chipsets will still be used in handsets such as high-end smartphones requiring the latest generation and highest performing GNSS and connectivity solutions.

The first GLONASS compatible chipsets are likely to be released in 2010 and broader availability of chipsets supporting Galileo will follow around 2013.

Virtually all chipsets, more than half of all multi-mode devices and integrated basebands will support at least one additional GNSS [Global Navigation Satellite System] besides
GPS in 2014. By then, GPS and Galileo are likely to be the primary GNSS supported given that they will be more technically advanced than GLONASS at the time.

- Orders of magnitude improvements in position and heading accuracy in challenging environments such as urban canyons and indoors can be expected from hybrid technologies. By fusing signal measurements from GNSS, cellular and Wi-Fi networks, as well as sensor-based data from accelerometers, gyroscopes, altimeters and electronic compasses, significant performance improvements can be achieved. Many of these technologies are being integrated into handsets to provide connectivity or improve the user interface and can therefore also provide an opportunity to improve location performance at relatively low cost.

Capabilities and trends

- Early smartphone OS including Symbian and Windows Mobile have been joined by proprietary operating systems from RIM BlackBerry, Apple and lately also Samsung’s Bada OS. Several Linux-based operating systems including LiMo, Android, webOS and MeeGo have also been released. Symbian has by far the largest installed base with nearly 340 million devices shipped from eight licensees.
- Windows Mobile also lost market share as sales slowed before the release of Windows Mobile 6.5 in October 2009.
- Apple became the biggest winner in terms of unit growth just ahead of RIM’s BlackBerry OS. Android also enjoyed increased traction from the release of several models from major handset vendors towards the end of the year.
- The Android platform from the Open Handset Alliance, spearheaded by Google, is experiencing rapid uptake. More than 50 Android handsets have been announced by 12 handset vendors and shipments grew to 7.5 million units in 2009. The importance of the user interface as a differentiating feature has been clearly demonstrated by Apple.
- Many other vendors, including HTC, LG, Samsung and Sony Ericsson have developed their own user interfaces for Android and Windows Mobile.

Apple

- Apple’s iPhone OS, Palm’s webOS, RIM’s BlackBerry OS and Samsung’s Bada OS are proprietary operating systems that are not made available to other device manufacturers. The source code is closed, but third party developers can write native applications using development kits and documented APIs.
- With continued success of its iPhone 3G and strong sales of the new iPhone 3GS, Apple reinforced its second position and increased its market share outside Japan to 19 percent.
- The Apple iPhone 3G continued to be the best selling GPS handset also in 2009 with an estimated 15 million units sold, up from 11.2 million in 2008.
- iPhone OS - Apple uses a scaled down and optimized version of OS X on the iPhone and iPod Touch handhelds. As with OS X for the Mac computer platforms, Apple does not license the operating system to other hardware manufacturers. However, Apple released the first iPhone SDK in March 2008 and introduced the App Store application shop in June 2008. iPhone OS has four abstraction layers: the Core OS layer, the Core Services...
layer, the Media layer and the Cocoa Touch layer. Cocoa Touch is based on the Cocoa API for Mac OS X computers. Given the many similarities between OS X and iPhone OS, developers familiar with development for desktop Macs are able to develop for the iPhone with little difficulty. In addition to native applications, the iPhone web browser already supports widgets, i.e. small application-style mini web pages.

- The iPhone does not support Java or Flash. Full multitasking is not supported, since third party applications are not allowed to run in the background, but iPhone OS 3.0 did finally introduce push functionality instead.
- Apple’s success with its App Store has influenced other handset vendors and mobile operators to go in the same direction and launch application stores and attract the developer community to their platforms.
- The importance of a well implemented and easy to use delivery channel has been shown by Apple’s App Store for the iPhone and iPod Touch. In January 2010, about 18 months since launch, over 130,000 applications have been made available through the App Store and the number of downloads has surpassed three billion.

**Microsoft**

- The Microsoft Mobile Operating system continues to be the platform of choice for commercial mobile GIS development
- To simplify the development experience and improve developer productivity, Microsoft delivers a single integrated development environment (IDE) and platform that meets all mobile application developer needs across all Windows Mobile devices. The Microsoft Visual Studio IDE together with either the Windows Mobile 6 Standard SDK, for devices without touchscreen, or the Windows Mobile 6 Professional SDK for devices with touchscreen, provide all tools and libraries needed for application development. Windows Mobile applications can be written using native code, managed code or web based server side code. Development using native C++ code, which interfaces directly with the Win32 environment of Windows Mobile devices, offers the highest performance and most powerful functionality at the cost of forcing the programmer to be more careful regarding resource handling and memory management. Managed code is code that has its execution managed by the .NET Framework Common Language Runtime. The .NET Compact Framework provides a memory manager, as well as a library of functions for commonly performed tasks, thus enabling fast and cost effective programming using the Visual Basic, .NET or C# programming languages.
- **Windows Phone 7** (NB: From Wikipedia – Included for completeness) Windows Phone 7 is a mobile operating system in development by Microsoft, scheduled for release by October 2010, and is the successor to Microsoft's Windows Mobile platform. Microsoft's goal is to create a compelling user experience by redesigning the user interface, integrating the operating system with other services, and strictly controlling the hardware it runs on.
Android

- Announced in November 2007, the Android platform is a complete open, customizable and free mobile platform developed by the Open Handset Alliance with instrumental support from Google. Currently, there are 65 members of the Open Handset Alliance.
- Android 2.0 – introduced improvements such as an overhauled UI and a new version of Google Maps that includes free navigation with turn-by-turn guidance for users in the US.

RIM

- BlackBerry OS Research In Motion (RIM) uses a proprietary multitasking operating system for its smartphones called BlackBerry Device Software. Cumulative shipments of BlackBerry smartphones have now surpassed 80 million units worldwide. The latest version – BlackBerry Device Software v5.0 – includes new features such as an improved BlackBerry Maps application with faster map loading and display of geotagged photos, improved web browser and enhanced media player. The BlackBerry OS is tightly integrated with RIM’s push-email platforms.
- RIM maintained its third position and 15 percent market share.

The Web - The trend toward platform neutral application development

- In addition to smartphone operating systems, there are also application development platforms, such as Java ME and BREW that enable application developers to write applications that can be installed on a wide range of smartphones and featurephones with minimal device specific modifications. The operating systems and application platforms provide APIs – source code interfaces that applications use to make requests for services from the operating system.
- Application developers targeting mobile phones face a highly fragmented market with greatly varying performance and software standards across devices.
- To facilitate development of simple applications and tools, handset operating systems increasingly implement support for Web widgets, i.e. single purpose web pages that run, operate and behave like native applications. Widgets are usually developed with standard Web technologies including HTML, CSS, JavaScript, and Ajax. As handset browser technology and runtimes improve, more developers will adopt mobile web technologies instead of native application development. For instance, JavaScript APIs for accessing hardware resources such as camera, GPS, and sensors are becoming available, resources previously only accessible for native programming. Except for graphic intensive games and other special applications that need access to most platform resources, many other applications can be expected to transition to web technologies over the next three to five years.
HTML5 – During the course of our research for this report it was often reported that the next big technological wave is likely to be movement toward Web 3.0 utilizing HTML 5. A few of the highlights about HTML5 can be found at http://slides.html5rocks.com/. The following is our preliminary assessment (N.B. not from Berg Insight) of some of the possible impacts on HTML5 on the GSS initiative.

- Once the browsers support HTML5, developers will be able to build sophisticated web applications targeted to the mobile platform that do not depend on any third-party browser plug-ins, allowing for mobile web applications to universally take advantage of feature-rich, interactive interfaces that can provide the user not only a sophisticated UI toolset to accomplish the tasks he needs out of the web app (i.e. real-time online digitization/editing of geospatial data), but also one that is intuitive and as streamlined as possible.
- Specifically, this allows for pure HTML5-based web applications to take advantage of user experiences.
- This suggests that there will be drag-and-drop capabilities (i.e. dropping a new spatial layer on a web app’s basemap) and browser state/history control (i.e. do I want a user’s feature edits on the web app to be “erased” server-side when he hits his browser’s “back” button after applying an edit to the database?).
- Offline storage databases- web storage (i.e. storing edits that have not yet been “submitted” to the server-side database within the browser itself, in some cases even after the browser is closed for a period of downtime).
- Geolocation will be enabled through scripted access to the geographical location information associated with the hosting device (all browsers- and the applications running inside of them- will have the ability to geolocate the position of the device, using the best-available location data, including GPS, GSM/CDMA cell IDs (cell tower triangulation, network location), IP address, RFID, Wi-Fi, etc.).
- Native support for the new “Canvas” drawing element and SVG (XML-based file structure for describing two-dimensional, interactive vector graphics).
- HTML5 is currently in draft by the WC3. While it may be as long as ten years before HTML5 becomes a complete standard, aspects of HTML5 have been adopted in the current versions of Mozilla FireFox and Google Chrome. Internet Explorer 9, now in beta, will have significant support for HTML5.
- An example of an early pure-HTML5 web mapping application has been developed by IDV solutions at: http://vfdemo.idvsolutions.com/transportation/. This application only makes use of the small portion of HTML5 that is supported by current browser technology, without the aid of a single plug-in.